THE GEOLOGICAL SURVEY OF WYOMING

HORACE D. THOMAS, State Geologist

BULLETIN NO. 50

MINERAL RESOURCES OF WYOMING

by

FRANK W. OSTERWALD, DORIS B. OSTERWALD, JOSEPH S. LONG, JR.
AND WILLIAM H. WILSON

Revised by
WILLIAM H. WILSON

University of Wyoming
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FOREWORD

In the late 1940's and early 1950's, two geologists, Frank W. Osterwald and his wife, Doris B. Osterwald, spent a great deal of time and effort as staff members of the Geological Survey of Wyoming in compiling a catalog of the known mineral resources of Wyoming. The voluminous data gathered were published as Bulletin 45 of the Geological Survey of Wyoming, titled "Wyoming Mineral Resources."

Many new mineral deposits have been discovered since 1952, and others have undergone development. At the time of publication, no commercial uranium deposits were known in Wyoming, although their discovery was forecast. Bulletin 50 brings up to date the material contained in Bulletin 45.

William H. Wilson, Assistant State Geologist, was in direct charge of the revision, by Joseph S. Long, Jr., devoted most of his time to the project over a period of nine months. The scope of the publication was expanded to include sections on coal, oil shale, and petroleum, and a new chapter on radioactive minerals was added. In 1966, the publication was again revised in order to include pertinent new information on the mineral resources of the State.

Both revisions were made possible through financial assistance lent by the Natural Resource Board of the State of Wyoming. Funds were supplied for the employment of part-time help and to defray printing costs. Members of the staff of the Natural Resource Board undertook the major part of manuscript preparation and of proof reading.

It is realized that a mineral inventory such as this will soon become outdated. It is also known that the amount of information given on any one prospect may not be adequate for certain needs. The Geological Survey of Wyoming and the Natural Resource Board stand ready at any time to supply all available detailed information, or to assist in any way possible in the development and utilization of the mineral resources of Wyoming.

HORACE D. THOMAS
State Geologist

MINERAL RESOURCES OF WYOMING

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FRANK W. OSTERWALD, DORIS B. OSTERWALD,
JOSEPH S. LONG, JR., and WILLIAM H. WILSON

INTRODUCTION

A wide variety of minerals has been found in Wyoming. The State was prospected at least as early as 1842 (501) but in general the production has been small and most ore came from a few scattered mines. Hematite was probably the first mineral produced in Wyoming; it was used by Indians for war paint. The mineral resources of Wyoming consist of both metals and non-metals, but with few exceptions the known metal deposits are usually small and of essentially no economic importance at the present time.

Wyoming has been visited by geologists since the early part of the 19th century; they have written many reports which are scattered throughout the geologic literature. Much of the geological information about Wyoming mineral deposits has never been published. In order to satisfy the demand for information on the various deposits, the Geological Survey of Wyoming undertook the task of compiling all the available data into one volume. The deposits of coal and petroleum are only briefly reviewed in this report.

The task is admittedly incomplete; many prospects are not mentioned because there is no reliable information available concerning them. To complete the work would be impossible without a tremendous amount of expensive and time-consuming field investigations. The authors believe, however, that most recorded localities have been included, and that the described deposits are probably representative of any which will be found within the foreseeable future.

Many difficulties were encountered during the course of the work. In abstracting old papers it was found difficult to separate the author's scientific information from his personal opinions. The writers have attempted to limit their descriptions of the various deposits to observed and measured data, but the vagueness of the older reports sometimes made this very difficult. Old terms are sometimes very hard to put into modern usage, and many terms have obscure meanings. In addition, many old locality names have been changed, which made it hard to locate many deposits. The information contained in this bulletin is believed to be as accurate as possible, but the authors take no responsibility for the validity of data on deposits which they have not personally examined.

Mineral deposits are formed by geologic processes. Any deposit is responsive to its geologic environment, which includes geologic structure of the area, type of country rock, and the composition, temperature and pressure of the mineralizing agents. A deposit also may be changed or altered by changes in environment. Thus a deposit is localized and controlled by geologic factors at its time and place of formation. For this reason deposits of similar minerals are distributed into provinces which are large regions of similar geology. Within a province minerals are localized into deposits by various controls which include favorable rock types, favorable geologic structures (such as folds, faults, joints) and areas of favorable geologic processes. Points of intersection of two or more favorable controls are particularly favorable places for prospecting. Readers interested in these problems are referred to Lindgren (427) and McKinstry (439).

Wyoming can be divided into several geologic provinces as follows:

(1) Mountain cores of pre-Cambrian crystalline rock.

(2) Basin areas of Paleozoic, Mesozoic and Tertiary sedimentary rocks.

(3) The Yellowstone Park—Absaroka Mountain volcanic area in the northwestern corner.

(4) Belts of folded and thrust faulted Paleozoic and Mesozoic sediments in the West and Southwest.

(5) Areas of scattered volcanic stocks and necks.

These provinces are shown on the index map (Fig. I) (566a), and their relations to the different mineral districts may be readily observed by a comparison of map and text.

Because of insufficient space, no glossary of technical terms is included in this paper. Readers not familiar with geologic terms are referred to any standard elementary geology textbook. Longwell, Knopf, and Flint (429), Schuchert and Dunbar (519), and Croneis and Krumbein (158) are particularly recommended. The geology of Wyoming is well summarized by Thomas (555) and anyone not familiar with the general features of this subject is referred to his paper. The general distribution of the more important deposits in Wyoming has been shown on maps published by the U. S. Geological Survey. (152:201a).

Descriptions of the uses, and of the chemical and physical properties of the many minerals, have been treated briefly or omitted. Excellent mineral descriptions are contained in Ford (206) Hurlbut (373), and in Kraus, Ramsdell, and Hunt (419). The most exhaustive work in mineralogy is Palache, Berman, and Frondell (490). Bateman (28) and "Industrial Minerals and Rocks" (4) are recommended for those who desire to know the uses of the various minerals.

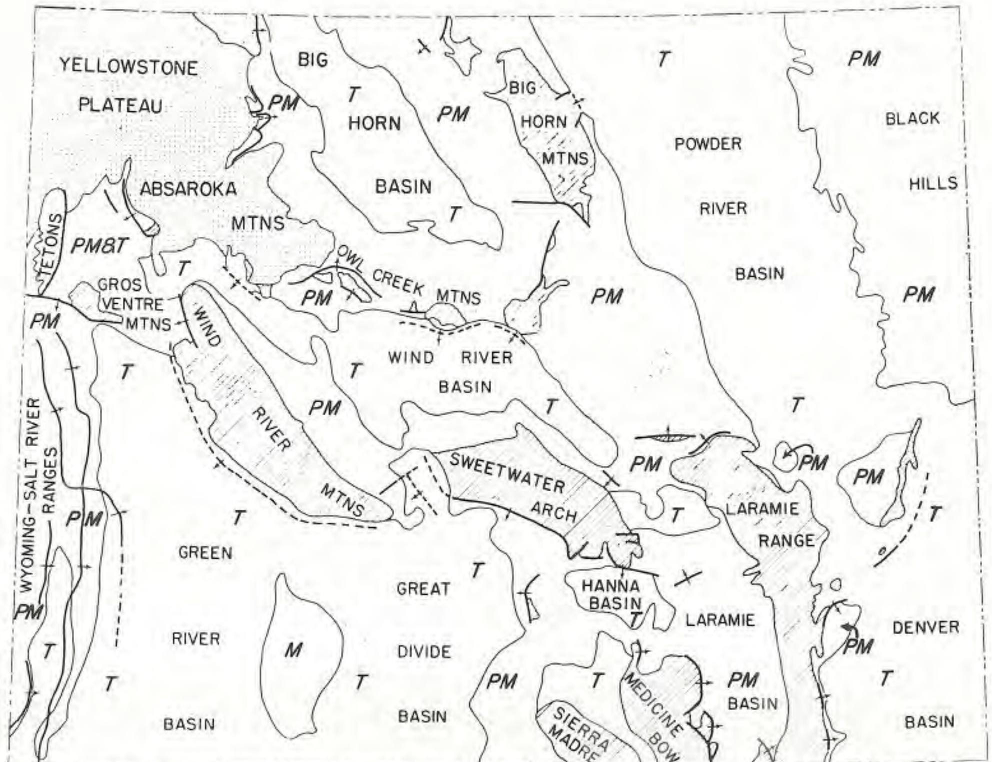

Fig. 1. Generalized geological index map of Wyoming showing major structural features. Pre-Cambrian areas are cross hatched. Paleozoic and Mesozoic areas are indicated by the symbol M. Tertiary areas are indicated by the symbol T. Tertiary volcanics are shown by coarse stipple. Major faults are shown as heavy lines with arrows showing direction of movement of hanging wall of thrust faults (555).

Many Wyoming mineral deposits are valuable, but are commercially undeveloped. Most of these are non-metals. The following factors must be considered in evaluating any deposit:

1. The size and grade of the deposit.
2. The current price of the commodity.
3. The geologic environment of the deposit, which may effect the continuity of the mineralized body in depth.
4. The amenability of the valuable material to concentration and extraction.
5. The cost of mining.
6. The cost of transportation to market. As McKinstry (439, p. 429) has explained ". . . if a zinc prospect is in the sierra of Mexico three days by mule train from a railway, the question whether the average grade is 15% or 18%, or whether the ore in sight consists of 10,000 or 40,000 tons is unimportant."

Joralemon's comparison (389) between a successful mine and a chain is most accurate. As the strength of the chain depends upon its weakest link, so the success of a mining property depends upon its most unfavorable condition. If one of the factors listed above is not satisfied, the rest are of no significance.

In the descriptions of the various deposits the following classification has been attempted. Generally, the deposits are classified into "producing mines," "prospects," and "reported occurrences." A producing mine is a property actually extracting ore, and a reported occurrence is a mere mention that a given mineral has been found. All other deposits are classified as prospects, even though they formerly produced ore. The deposits are further subdivided into counties, and a few commodities are broken down into districts within counties. Within the county subdivisions, the various deposits are listed alphabetically, or numerically according to section, township, and range. To conserve space, detailed descriptions of deposits are given only once.

Where data concerning reserves are available, an attempt has been made to classify them into measured, estimated, and inferred reserves, according to the system proposed by the U. S. Geological Survey and the U. S. Bureau of Mines (570).

An index, appended at the end of the volume, contains the common synonyms for the various minerals and commodities. It is hoped the index will make the work more usable to readers not thoroughly acquainted with mineralogical terms.

ALUM MINERALS

Alum compounds are double salts of aluminum sulfate and potassium sulfate, and result from the action of sulfuric acid on aluminum-rich schistose rocks or argillaceous sedimentary rocks. Tschermigite, the ammonia aluminum sulfate, is associated with lignite coal beds. Alunogen, hydrous aluminum sulfate, is formed by volcanic action and by the decomposition of pyrite in coal beds and slates. The minerals are used in mordant dyes, in medicines, water purifiers, in the tanning industry, in sizing paper, and as a source of nitrogen. An average analysis of tschermigite from Wyoming is (194): Al_2O_3=11.57%, $(NH_4)_2O$= 5.23%, Na_2O= 0.21%, K_2O=trace, MgO=0.13%, SO_3=35.11%, H_2O=47.82%, Insol.=0.06%, Fe_2O_3, CaO, Cl=trace.

Alunite, $KAl_3(SO_4)_2(OH)_6$, is a mineral of widespread occurrence in altered and mineralized volcanic rocks of the western United States. Since early times, alunite (also called alumstone or alum rock) has been used as a raw material in the manufacture of alum. During World War I, alunite was potentially considered as a source of potash, and during World War II as a source of aluminum.

PROSPECTS

Sweetwater County

Aspen Mountain; sec. 26, T. 17 N., R. 104 W. Alunite-bearing claystone is exposed near the base of a bulldozer trench that is 40 feet long, 10 feet wide, and 30 feet deep. Exposures here indicate that the alunite claystone is approximately 12 feet thick and dips about two degrees south. Flame photometer analysis of two samples indicates 32.0% and 29.5% Al_2O_3 and 6.8% and 5.8% K_2O respectively. A similar white claystone, 6 feet thick was penetrated at a depth of 145 feet by a core hole drilled a mile southwest of the alunite trench, but it is not known if this bed is alunite-bearing or not (654).

REPORTED OCCURRENCES

Big Horn County

Alum was reported in Big Horn County by Jamison (377, p. 30).

Crook County

Alum has been found along Alum Creek (453, p. 809).

Fremont County

In sec. 11, T. 39 N. R. 93 W. alum is found with sulfur and is probably derived from hot spring activity (306).

Sweetwater County

Aughey reported that fine specimens of alunogen were found along Bitter Creek (16, p. 57).

About 3½ mi. southwest of Wamsutter, tschermigite crops out for 3 mi. along a ledge or escarpment of Wasatch lignite and shale beds. "Tschermigite forms the cementing material for pure tschermigite, brown bituminous shale, nodules of yellow jarosite, and scattered gypsum crystals" (194, p. 51). Assays of eight 160-pound channel samples gave 2.48% ammonia alum (135).

ANORTHOSITE

Anorthosite is a gray, usually coarse-grained igneous rock which consists almost entirely of plagioclase feldspar and contains from 27% to 30% alumina. Though the rock is relatively rare, individual bodies of anorthosite are usually quite large.

During World War II, the Monolith Portland Midwest Co. devised a process for extraction of alumina from weathered anorthosite. The waste products from this extraction included lime, which was to be used for the manufacture of cement. A plant was built at Laramie and quarries opened in sec. 2, T. 16 N., R. 77 W., in the Laramie Range anorthosite mass, but there has been no production of alumina.

The anorthosite mass extends through most of Tps. 16 to 21 N., Rs. 71 and 72 W., in Albany County (465, p. 2) in an area about 36 mi. long and 10 mi. to 18 mi. wide (152, 615). Most of the rock is plagioclase, though some contains 50% or more ferromagnesian minerals and magnetite-ilmenite (465, p. 2). There are numerous lenses and layers of noritic anorthosite within the main mass which contain 10% to 20% hypersthene, and many contain up to 50% hypersthene.

A typical analysis of the anorthosite from a drill core in the Iron Mountain deposit is: $SiO_2 = 51.91\%$, $TiO_2 = 1.29\%$, $Al_2O_3 = 25.87\%$, $CaO = 9.18\%$, $Na_2O = 4.51\%$, $K_2O = 0.78\%$, $H_2O = 0.04\%$, $H_2O_4 = 0.94\%$, $CO_2 = 0.82\%$, $P_2O_5 = 0.07\%$, $BaO = 0.04\%$ (587).

ANTIMONY

Antimony is used as an alloy with lead for battery plates, as a low melting point alloy in type metal and sprinkler systems, in the manufacture of ammunition, and as a pigment.

The element is not produced in Wyoming at the present time, and only one occurrence is known. Many other minerals contain chemically combined antimony.

REPORTED OCCURRENCE

Albany County

Antimony has been reported in the silver-lead-copper deposits of the east slope of the Medicine Bow Range (8, p. 11).

ARAGONITE

Aragonite is orthorhombic calcium carbonate. It is not of economic interest in Wyoming.

REPORTED OCCURRENCES

Albany County

Pseudomorphs of aragonite after hanksite are common in Satanka shale (217). In sec. 19, T. 12 N., R. 76 W., at Red Mountain, aragonite crystals occur in red sandy shale 20 ft. above a massive gypsum bed, near the base of the formation. The crystals are hexagonal prisms, usually short prismatic to tabular, and in tabular penetration twins (171, p. 24).

Big Horn County

Aragonite crystals are found in the upper part of the Chugwater formation. The crystals are usually pseudo-hexagonal twins, flattened parallel to the basal pinacoid, and penetration twins are common (269, p. 17).

Hot Springs County

Perfect crystals are found near the Bighorn Hot Spring, Thermopolis. (217).

Sweetwater County

In the Leucite Hills, at Badger Teeth, a volcanic neck in SE¼ NW¼ sec. 7, T. 21 N., R. 103 W., platy aragonite crystals and tufts of aragonite needles may be found in a dense, drab, amygdaloidal volcanic dike rock and a green volcanic agglomerate (394, p. 326-7).

ARSENIC

Arsenopyrite, the most common arsenic ore mineral, is associated with gold in the pre-Cambrian metamorphosed sediments in the Atlantic City-South Pass district, and in a pre-Cambrian vein in Goshen County. Chief uses of arsenic compounds are for insecticides, wood preservatives, alloys, clearing agents in glass manufacture, and in paint manufacture.

No producing mines are located in the state.

PROSPECTS

Goshen County

Vaughn or Vulcan claim; NE¼ sec. 26, T. 28 N., R. 65 W. A 126 ft. shaft has been sunk into a 30 ft. body of arsenopyrite. The ore was found as nodules in a muscovite-quartz schist. Assays by the University of Wyoming show iron=29.91%, arsenic=40.02%, sulfur=17.08%, insol. (SiO_2) =12.98% (331).

Lincoln County

A "large deposit" of orpiment and realgar has been reported within 3 mi. of Border Station on the Oregon Short Line Railroad (217).

REPORTED OCCURRENCES

Albany County

Rare arsenic-bearing minerals have been found in the Rambler mine at Holmes; (See COPPER, PLATINUM). Orpiment and realgar are reported and deep red crystals of lorandite ($Tl_2S.As_2S_3$) have been identified (507, pp. 105-6).

Carbon County

Rare arsenopyrite is reported at the east end of the Seminoe Mountains (16, p. 56) and about 6 mi. from the Buzzard Ranch on the north side of the Ferris mountains, near Sand Pass (217).

Fremont County

Atlantic City-South Pass District. The following mines in the district report arsenopyrite, usually associated with orpiment and realgar in the oxidized zone:

B. and H. Mining Co., Empire State Mine; (See GOLD).

Midas Mine; one mile north of Atlantic City; (See GOLD).

Pioneer Carisso Gold Mine; NW¼ sec 21, T. 29 N., R. 100W.; (See GOLD).

Tabor Grand Mine; NE¼ sec. 14, T. 29 N., R. 100 W. The ore mineral is arsenopyrite which occurs in a vertical vein of "altered rock." South wall of the vein is amphibolite which trends N. 85° W. (22).

Laramie County

Arseniosiderite is reported in the Silver Crown District (16, p. 56).

Platte County

Green Hope Mine, in NW¼ sec 26, T. 29 N., R. 65 W. Arsenopyrite is an accessory mineral found in a copper deposit located at the contact of the Paleozic and pre-Cambrian rocks (17 pp. 102-3); (See COPPER).

ASBESTOS

The fibrous variety of serpentine, chrysotile, and various fibrous amphiboles are the two sources of asbestos. Chrysotile is the more important. Commercially valuable asbestos must possess long fine fibers, high tensile strength, and flexibility. Asbestos has many and varied uses as an insulating and fireproofing material. Deposits within the State are in pre-Cambrian metamorphic rocks.

No asbestos is produced in Wyoming at the present time.

PROSPECTS

Albany County

Halleck Canyon area; approx. sec. 18, T. 22 N., R. 71 W. Chrysotile cross-fiber veinlets up to 2 inches in width occur in two small areas of serpentine. The cross-fibers are up to one inch in length and are not excessively brittle. Minor amounts of slip-fibers are developed in other fracture systems which are flat dipping and trend obliquely to the regional foliation (635).

Carbon County

Seminoe Mountains area; secs. 21, 22, T. 26 N., R. 85 W. Two narrow anthophyllite asbestos veins occur in amphibole schist. The veins vary from 2 inches to 1.6 feet in width and are intermittently exposed in several prospect pits along an east-west strike parallel to a regional foliation of vertical dip. The asbestos occurs mainly as mass fibers and some soft and brittle cross fibers up to 2½ inches long (619).

Converse County

Koch Deposit; sec. 15, T. 31 N., R. 77 W., on the north side of the West Fork of Deer Creek. A serpentine lens 1,500 ft. by 500 ft. trends northeast. There are several smaller lenses; all are surrounded by granite. A small amount of amphibole asbestos, one chrysotile veinlet, ¼-in. wide, and two vermiculite lenses have been reported (32, p. 836; 299).

Fremont County

Fire King Deposit; SE¼ sec. 26, T. 30 N., R. 100 W., about 4 mi. due north of Atlantic City. A pre-Cambrian serpentine body strikes northeast and stands vertical; it is associated with chlorite and magnetite schist, quartzite, and gneiss. Later granites cut and invade the metamorphics. Asbestos is found in small lenses in one zone 150 ft. wide and 900 ft. long (32, pp. 816-21). Cross-fiber chrysotile (average ½-in. long) for spinning was produced prior to 1921. A mill was built in 1919 (32, pp. 820-21; 540, pp. 16-18).

Beaver Creek Deposit; sec. 19, T. 30 N., R. 96 W., 5 mi. south of Beaver Hill. Five lenticular serpentine masses, surrounded by granite are well exposed. The western lens is 600 ft. long and 250 ft. wide, the central lens is 800 ft. long and 130 ft. wide. The other lenses are much smaller. Small amounts of cross-fiber chrysotile veinlets (¼ to ½-in. long) in the serpentine strike parallel to the serpentine mass. Vermiculite, talc and anthophyllite also are associated with the serpentine (32, pp. 821-22; 299).

Natrona County

Casper Mountain Asbestos Deposits; sec. 16, 17, T. 39 N., R. 79 W., 8 mi. from Casper. A mill was built in 1910, but there has been little production since that time. A serpentine body, several thousand feet wide trends east-west through the north-central half of secs. 16 and 17. The serpentine is surrounded and cut by granite gneiss, hornblende schist, and metadiabase. Small, parallel cross-fiber chrysotile veins about ⅛- to ¼-in. wide are separated by layers of serpentine. Locally many fractures are filled with cross-fiber chrysotile. Some fibers up to 4 in. long have been reported (32, pp. 822-9; 181, pp. 512-16; 182, pp. 447-8; 31; 123, p. 955; 24, p. 559; 287, p. 4; 351).

Smith Creek Deposit; SE¼ sec. 19, SW cor. sec. 20, NW cor. sec. 29, NE cor. sec. 30, T. 31 N., R. 78 W. Three pre-Cambrian serpentine lenses, one barren of asbestos, contain vertical veins of yellowish-green cross fiber chrysotile, mostly ½ in. in length. The central lens is 650 ft. by 300 ft. The western lens shows fiber ¼ in. long in a zone 75 ft. to 150 ft. in length (32, pp. 832-4).

Teton County

Berry Creek Deposit; at head of Berry Creek approximately 2 mi. east of the Teton range watershed and 6 mi. south of Yellowstone National Park. A tabular, vertical body of altered peridotite strikes east, has a maximum width of 50 ft., and can be traced for 400 ft. along the strike. The peridotite is surrounded by granite gneiss. "Several fractures in altered peridotite contains slip-fiber chrysotile and amphibole less than 1 in. long. Much of the fiber has been destroyed by later replacement." (31, pp. 5-6).

Brown Bear Deposit; secs. 19 or 20, T. 47 N., R. 116 W., has a 400 ft. serpentine dike or sill with stringers of slip-fiber chrysotile and amphibole which strikes north-south, and stands vertically. Some fibers are more than 1 in. long but many fibers have been destroyed by later quartz replacement. A mill was built, but there has been no production (32, pp. 814-15).

REPORTED OCCURRENCES

Carbon County

A deposit of amphibole asbestos is reported to be located about 1½ mi. southwest of Encampment (217).

Converse County

Stardust Claim; sec. 20, T. 32 N., R. 75 W. A small amount of chrysotile is associated with a vermiculite deposit (384, pp. 36-7); (see VERMICULITE).

Fremont County

Abernathy Deposit; sec. 5, T. 7 N., R. 5 W., sec. 32, T. 8 N., R. 5 W., (Wind River Meridian) and sec 7, T. 42 N., R. 104 W. at the west end of the Owl Creek mountains. Amphibole asbestos follows cleavage planes and fractures in a thick diabase dike. The fibers are weedy and brittle, but are longer than the Casper Mountain fibers (430, pp. 4-5); (See VERMICULITE).

Natrona County

Green Hill Deposit; sec. 23, T. 31 N., R. 78 W., 3 mi. east of the Smith Creek asbestos mill. One serpentine lens 1,700 ft. long and 500 ft. wide surrounded by granite has a 1 in. veinlet of harsh, coarse chrysotile. A small amount of harsh, slip-fiber chrysotile was found on the dump (31; 32, pp. 834-5).

Sheridan County

Asbestos is reported in the mountains west of Sheridan (10, p. 390).

Washakie County

Canyon Creek Claim; sec. 25, T. 48 N., R. 86 W. A series of metamorphics (greenstone, hornblende schist, metadiabase) strike N. 15° E. and disappear under Cambrian sediments about 1 mi. south of the claim. These pre-Cambrian metamorphics contain a very small amount of brittle, amphibole asbestos and talc. No chrysotile has been found (32, p. 837).

BARITE

Barite is barium sulfate. The mineral is the chief industrial source of barium compounds which are used chiefly in the paint industry, and as floorings and textiles. Barium sulfate is used as a filler in paper and cloth, and in medical radiology. Crushed barite is used to make heavy drilling muds. Barite is found in viens and as disseminated crystals in sedimentary rocks and as a gangue in mineral veins. It is rare in Wyoming.

REPORTED OCCURRENCES

Albany County

Fine-grained massive pyrite was associated with barite crystals and orpiment at the Rambler Mine, Holmes (507, p. 105); (See COPPER).

Barite is associated with manganese oxides on Sheep Creek, 38 mi. northeast of Medicine Bow, sec. 10, T. 26 N., R. 75 W. "Large tabular crystals" were found in vugs, but are not abundant (388, pp. 57-59; 515, p. 214); (See MANGANESE).

Carbon County

Barite was reported from the Meta Mine, sec. 24 or 25, T. 15 N., R. 86 W., 19 mi. southwest of Saratoga (281).

NW½ sec. 2, T. 12 N., R. 85 W. A pod-like body of barite associated with opal (?) occurs along the northern edge of a shear zone in contact with red quartz monzonite. The outcrop dimensions of the deposit are 40 feet wide and 300 feet long (657).

Crook County

The mineral has been found in the Black Hills (515, p. 214).

Goshen County

Omaha and Gold Hill Copper Prospects; secs. 2, 3, 10, 11, T. 30 N., R. 64 W. Gangue minerals in these prospects included barite (17, p. 106); (See COPPER).

Laramie County

Barite was associated with gold at the Adams' Copper King Mine (16, p. 56). One specimen came from the King David Mine, Silver Crown District (16, p. 56); (See COPPER).

Park County

Barite was a gangue mineral in the gold deposits at Kirwin (365, p. 128) ; (See GOLD).

Platte County

Gangue minerals associated with copper ores at Sunrise, N½, sec. 7, T. 27 N., R. 65 W., included barite (17, pp. 100-101); (See COPPER).

Weston County

Barite crystals have been found on the ridges near Stockade Beaver Creek and Sheep Creek, and near Osage and Newcastle (258).

BENTONITE

The name bentonite is applied to a sedimentary rock which contains at least 75% of the clay minerals, montmorillonite or beidellite. The remainder of the rock consist of varying amounts of other clays and feldspar, micas, zircon, silica minerals and other minerals.

Many bentonites have a high colloid content, and may absorb large quantities of water, thus swelling to several times their original volume. Other bentonites do not swell. Uses of bentonite depend largely upon its swelling capacity. High-swelling types are used as drilling muds, as binder for foundry sands, as binder in pelletizing taconite, as filler for coffer dams, and reservoir linings. The non-swelling types resemble atapulgite clays in their properties and may be used for insecticide fillers, industrial filters, and for many other purposes.

Most Wyoming bentonite is interbedded with Upper Cretaceous shales and sandstones, though a few deposits are of Tertiary age. The rock is probably altered volcanic ash (368; 508; 510; 511). Most deposits are within the Mowry and Frontier formations, and some bentonitic rock may probably be found wherever these beds outcrop. In order to be of commercial value, however, a deposit must fulfill the following conditions: (1) the beds must be relatively undisturbed with horizontal or very gentle dip in order to insure a continuity of readily available clay, (2) overburden must be thin, to reduce mining costs, and (3) adequate transportation to market must be available.

Wyoming produced a total of 1,398,106 tons of bentonite in 1963 (611). The bentonite was quarried from deposits usually located in a 20 mile radius of the

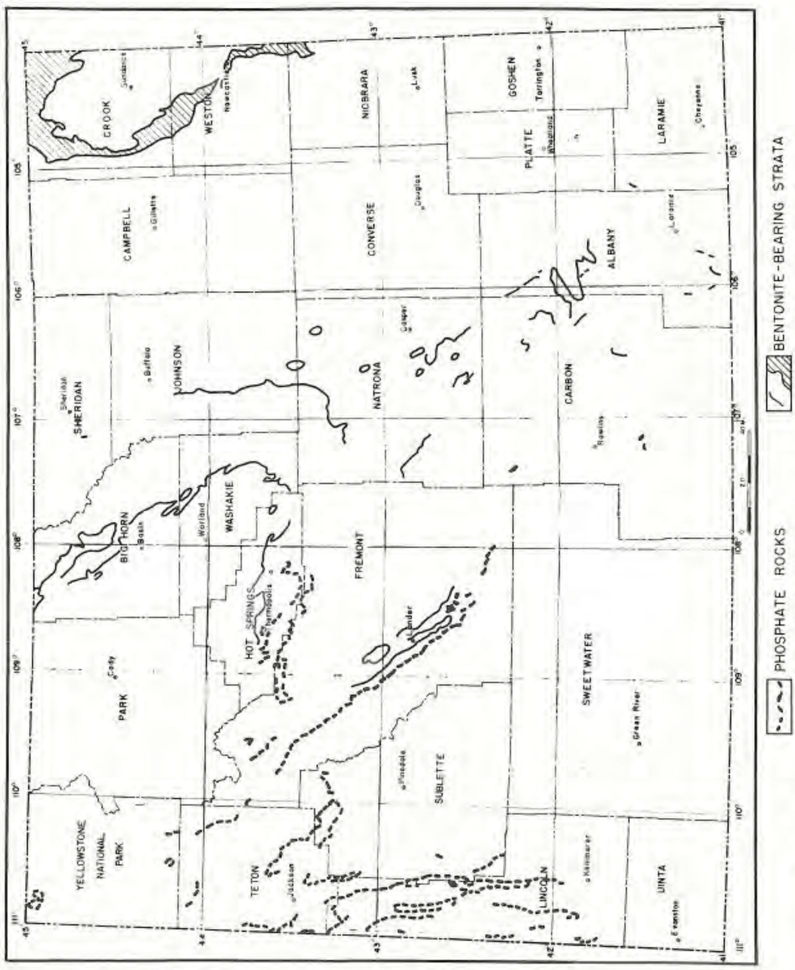

Fig. 2. Outcrop map of bentonite and phosphate bearing strata.

plants; most of which are listed below. The map (Fig. 2) shows the general outcrops and distribution of bentonite in Wyoming. Wyoming produces approximately 70 percent (1966) of the nation's bentonite output.

PRODUCING PLANTS AND AREAS

Big Horn County

Magnet Cove Barium Corp. operates a bentonite mine northeast of Greybull and a 250 ton mill in Greybull. Production during 1963 was 251,739 tons (611).

Wyo-Ben Products Co. operated a bentonite mine and mill north of Greybull. Production during 1963 was 97,828 tons (611).

American Colloid Co. began constructing a new bentonite processing plant east of Lovell in 1965.

Crook and Weston Counties

During 1963, a total of 1,018,227 tons of bentonite were produced from mines of the following: American Colloid Co.; Archer-Daniels-Midland Co.; Black Hills Bentonite Co.; International Minerals and Chemical Corp.; and the National Lead Co., Baroid Div. (611). Bentonite processing plants were operated by American Colloid Co. and Archer-Daniels-Midland Co., at Upton; Archer-Daniels-Midland Co. and National Lead Co. at Colony; Black Hills Bentonite Co. at Moorcroft; and National Lead Co. at Clay Spur. In 1964, the Black Hills Bentonite Co. moved its entire mining operation to near Barnum, Johnson County.

Johnson and Natrona Counties

Black Hills Bentonite Co. operates a bentonite mine near Barnum (Johnson County) and a 600 ton per day mill at Casper (Natrona County).

Benton Clay Co. operates a bentonite mill at Casper, and a mine near Salt Creek (Natrona County). Production during 1963 was 30,312 tons (611).

PROSPECTS

Many bentonite deposits in Wyoming are not of economic value under existing conditions. The list below is of necessity incomplete since it is not feasible to include a discussion of the many miles of outcrop of Frontier and Mowry beds in the scope of this work. The following list is organized according to Township and Range locations. Figure 2 shows the outcrop trace of the important bentonite-bearing beds.

Albany County

McGill Anticline. Bentonite crops out along the south flank of the anticline in sec. 6, T. 21 N., R. 74 W., and in secs. 1, 10, 11, 12, 16, 17, T. 21 N., R. 75 W. The clay is in the Mowry shale and dips 10° S. The bentonite outcrop is up to 15 ft. wide in sec. 6, T. 21 N., R. 74 W. (372, p. 28). *The Linscott Claim* is located in the NW¼ sec. 17, T. 21 N., R. 75 W., on the south flank of the anticline. Prior to 1905 twenty carloads of bentonite were shipped which exhausted the readily accessible supply. The clay has the following composition: SiO_2=66.5%, Al_2O_3=23.9%, Fe_2O_3=3.1%, MgO=1.0%, CaO=0.5%, H_2O=5.0% (533, p. 447; 171, p. 60).

Cosgriff's claim near Chalk Bluff; NW¼ sec. 12, T. 21 N., R. 75 W. Four to five feet of high-swelling bentonite in the Mowry formation dips gently south. An analysis is as follows: SiO_2=64.0%, Al_2O_3=24.0%, Fe_2O_3=3.2%, MgO=1.5%, CaO=0.6%, H_2O=6.7% (533, pp. 446-7; 171, p. 61).

Rock Creek Station; "Taylor Mine." A bentonite layer 4 ft. to 5 ft. thick, ¼-mi. north of the Union Pacific Railroad in the NW¼ sec. 30, T. 22 N., R. 75 W., was developed in 1888, and 5,460 short tons produced (410, p. 600) before 1897. The bed is within the Benton group and dips 4° to 5° S. The clay has the following composition (533, p. 446; 171, p. 59).

SiO_2	59.78%	58.25%
Al_2O_3	15.10	24.70
Fe_2O_3	2.40	2.61
MgO	4.14	1.30
CaO	0.73	1.61
H_2O	16.26	11.00
Sp. Gr.	2.18	

Rock Creek. A 4 ft. to 5 ft. bentonite layer in the Mowry formation north of Rock Creek in the SE¼ NE¼ sec. 14, T. 22 N., R. 76 W. was opened in 1898 (?) and 100 carloads shipped. The clay dips 4° to 5° S. and lies beneath a thin shale overburden (533, p. 447; 171, p. 60).

Cassa Mining Co. Claims (1909); N½ sec. 10, T. 22 N., R. 76 W. Four to five feet of high-swelling bentonite in the Mowry formation dip gently south. The clay has the following composition: SiO_2=60.2%, $Al_2O_3+Fe_2O_3$=26.1%, MgO+CaO=2.5%, Na_2O+K_2O=0.8%, H_2O=10.3% (533, pp. 446-7; 171, pp. 60-61).

Como Ridge; NW¼ sec. 20, T. 22 N., R. 77 W. Some development work was done on this claim along the south slope of Como Ridge by Sam White (533, p. 447; 171 p. 61). These beds are in the Mowry formation and dip 8° to 20° S.

Giddings reported bentonite in the upper Mowry shale in that portion of the Laramie Basin lying north of Como anticline (268, p. 32).

Riverside Ranch; NE¼ sec 14, T. 13 N., R. 76 W. to the SE ¼ sec. 6, T. 14 N., R. 75 W. A bentonite bed in the Mowry formation varies from less than 2 ft. to 4 ft. thick at this location and is much weathered (533, p. 447; 171, p. 61).

Sand Creek. Four feet of bentonite crop out along the east bank of Sand Creek in N½ sec. 2, T. 13 N., R. 75 W. The bed is in the Benton group (533, p. 447; 171, p. 61).

Creighton Lake. A bentonite bed, 3 to 4 feet thick in the Frontier formation crops out on the northwest side of Creighton Lake (171, 533).

Big Horn County

Dry Creek; 8 mi. east of Frannie. A 7½ ft. bed of bentonite in the Thermopolis formation, 100 ft. below the Mowry shale, consists of fine-grained, massive gray clay with green and yellow tints. It is apparently of good quality throughout. A total of 11 ft. of bentonite is distributed through 100 ft. of shales (202, p. 562; 204, p. 57).

Bighorn Bentonite Co. Claims; A 4 ft. layer of bentonite 18 mi. northwest of Greybull, in T. 54 N., R. 95 W., forms an outcrop 50 ft. wide and 1 mi. long. The bentonite is in the Frontier formation, about 3 ft. above the top of the Peay sandstone member, and dips 31° W. (359, pp. 13-14).

Dry Gulch. Near the head of Dry Gulch, 5 mi. north of Cowley, is a 1½ ft. layer of bentonite near the top of the Colorado formation (Thermopolis equivalent) (202, pp. 562-3; 204, p. 57).

Greybull. Cretaceous bentonite beds crop out through a large area in the Greybull region and appear to offer possibilities for commercial production.

Silver Tip Coal Mine; sec. 29, T. 58 N., R. 100 W. Bentonite is found in beds above the Colorado formation near the mine (204, p. 57).

Heathman (359, p. 13) measured an Upper Cretaceous stratigraphic section in sec. 30, T. 58 N., R. 95 W. The Frontier formation contains 5 bentonite seams from 0.7 ft. to 2.0 ft. thick in 820.0 ft. of section, mostly sandstone. Two bentonite seams, each 2.5 ft. thick were found in 95.4 ft. of Mowry shale. The Thermopolis formation contains 15 thin bentonite seams (0.5 ft. to 2.5 ft.) interlayered with shale in 962.4 ft. of rock.

Carbon and Albany Counties

Approximately 4 ft. of bentonite are found at the top of the Mowry shale near Medicine Bow where the dip is high the outcrop is narrow, and the overburden thickens rapidly. Bentonite is exposed east and southeast of the town of Medicine Bow, but at most places where the dips are low and the overburden slight, the bentonite is exhausted (359, p. 18).

Carbon County

Sec. 17, T. 18 N., R. 80 W., and secs. 20, 21, and 29, T. 18 N., R. 81 W. Seams of bentonite up to 2 feet thick occur in the Mowry shale. The dips of these beds range from 10° to 74°, resulting in narrow outcrops and excessive overburden (640).

One to three miles west of Medicine Bow, an 8 ft. bentonite bed at the base of the Mesaverde formation dips 35° W. (217). This bed was once mined.

Rattlesnake Creek Syncline. West, north, and northeast of Elk Mountain and to the south of Sheephead Mountain, the Mowry formation is about 150 ft. thick and contains a few thin bentonite layers in the shales (375, pp. 30-31).

Sage Basin; secs. 11, 12, 13, T. 18 N., R. 87 W. The lower Frontier formation crops out along a low hogback, and contains 3 ft. of gypsiferous bentonite. The dip of the beds is low and 8 ft. of shale overlies the clay (148, p. 32). One bed of bentonite 3 ft. thick in secs. 17, 18, T. 18 N., R. 87 W., is found near the base of the Frontier formation. Dip of the formation is low, and locally the clay forms a dip slope. The bed is usually covered by thin overburden (148, pp. 31-32).

Ferris Mountains; sec. 31, T. 27 N., R. 88 W. Heisey (360, pp. 51-52) measured two 1 ft. bentonite beds in the upper Mowry formation. Total thickness of the formation is 359 ft.; 180 ft. at the base is covered.

Difficulty-Little Shirley Basin area. Thin seams of bentonite are scattered through 150 ft. of Mowry shales (144, p. 6).

Crook County

Northern Black Hills. Bentonite occurs in relatively pure beds and as an ingredient of the shales in all of the marine Cretaceous rocks throughout the Black Hills area with the exception of the Fox Hills sandstone. Beds near the base of the Belle Fourche shale, at the top of the Mowry shale (Clay Spur bentonite bed), and in the Newcastle sandstone, however, contain most of the commercial deposits (664). Subordinate folds which interrupt the broad northwestward plunging anticline in this area, bring bentonite beds to the surface repeatedy resulting in large bentonite resources under light overburden (649). Fisher (202, p. 446) gives an analysis of Crook County bentonite: SiO_2=61.08%, Al_2O_3=17.12%, Fe_2O_3=3.17%, MgO=1.82%, CaO=2.69%, Na_2O=0.20%, SO_3 =0.88%.

Two types of open pit mines are operated in the Clay Spur district (in both Crook and Weston counties): 1) shallow pits dug through the overburden to uncover bentonite beds preserved in small grabens or tilted fault blocks, and 2) successive cuts made along bentonite outcrops around margins of hills. In 1950, the Clay Spur district produced 62 % of all the bentonite mined in Wyoming, however by 1960, production had declined to 23% of the State's total (627).

Sec. 4, T. 56 N., R. 65 W. A light gray to greenish gray bentonite bed crops out 6 feet above the base of the Newcastle sandstone which caps a small mesa. The bed is 5 feet thick and has good swelling properties (628).

Secs. 8, 17, 20, 29, T. 49 N., R. 65 W. Extensive outcrops northeast of Thornton average 2.5 ft. thick dip 3° SW. and have from zero to 20 ft. of overburden. These beds are in the top of the Mowry (359, pp. 9-10).

Secs. 23, 36, T. 50 N., R. 66 W., northeast of Moorcroft. In this area the bentonite layers in the upper Mowry shale average 2.5 ft. thick, have an average dip of 3° SW. and from zero to 20 ft. of overburden (359, pp. 9-10).

Sec. 34, T. 54 N., R. 67 W., northeast of Oshoto. A bed at the top of the Mowry is 4 ft. thick, dips 3° W. and has from zero to 25 ft. of overburden (359, pp. 9-10).

Sec. 4, T. 55 N., R. 60 W. Bentonite at the top of the Mowry shale dips 5° NE. is 4.5 ft. thick and has from zero to 25 ft. of overburden (359, pp. 9-10).

Sec. 10, T. 55 N., R. 61 W. A 3 ft. bentonite seam at the top of the Mowry dips 2° NE. and has from zero to 15 ft. of overburden (359, pp. 9-10).

Sec. 26, T. 55 N., R. 61 W. At the top of the Mowry shale is a discontinuous bed of high-swelling bentonite about 2.5 ft. thick. It crops out along the northern flank of the Black Hills dome, dips 5° NE. and has from 10 ft. to 30 ft. of shale overburden (359, pp. 9-10).

Sec. 9, T. 56 N., R. 61 W. A 3.5 ft. bentonite bed at the top of the Mowry shale dips 3° NE. Overburden ranges from zero to 20 ft. thick (359, pp. 9-10).

Sec. 12, T. 56 N., R. 61 W. A 2.0 ft. bentonite seam at the top of the Mowry dips 3° NE. and has from zero to 15 ft. overburden (359, pp. 9-10).

Sec. 3, T. 56 N., R. 62 W. Outcrops of upper Mowry shale contain a bentonite bed 4.8 ft. thick at this locality. The dip is 3° NE. Overburden ranges from zero to 25 ft. thick (359, pp. 9-10).

Sec. 4, T. 56 N., R. 66 W. A bentonite bed at the top of the Mowry is 2.5 ft. thick, dips 2° NW. and is covered by a few inches to 20 ft. of shale (359, pp. 9-10).

Sec. 8, T. 57 N., R. 61 W. The upper Mowry bentonite bed is 2.0 ft. thick, dips 4° NE. and has from zero to 25 ft. of overburden (359, pp. 9-10).

Sec. 14, T. 57 N., R. 63 W. Bentonite at the top of the Mowry is 3.0 ft. thick, dips 2° NE. and has from zero to 15 ft. of overburden (359, pp. 9-10).

Sec. 25, T. 57 N., R. 66 W. Bentonite at the base of the Mowry is 5.5 ft. thick and lies horizontal. Overburden ranges from zero to 15 ft. (359, pp. 9-10).

Sec. 35, T. 57 N., R. 66 W. A 2.0 ft. seam at the top of the Mowry dips 3° NW. and has from zero to 20 ft. of overburden (359, pp. 9-10).

Sec. 32, T. 58 N., R. 63 W. At this locality, bentonite at the base of the Mowry shale is 5 ft. thick, dips 2° NE. and has from zero to 35 ft. of overburden (359, pp. 9-10).

Sec. 34, T. 58 N., R. 65 W. A bentonite seam 4.2 ft. thick dips 5° N. and has from zero to 25 ft. of overburden. The bed is at the top of the Mowry shale (359, pp. 9-10).

Fremont County

A 2½ ft. and a 3 ft. bed of bentonite at the top of the Mowry follow the line of outcrop of Upper Cretaceous rocks along the northeast flank of Wind River Mountains. The clay is high-swelling but the outcrops are narrow because of high dip. Bentonite has also been found in the upper part of the Thermopolis and in the Frontier formations (359, pp. 13-14).

Sec. 34, T. 31 N., R. 96 W. In 190.6 ft. of Mowry shales exposed in a roadcut, there are 55 thin bentonite seams (0.1 ft. to 2.5 ft.) interlayered. No large outcrops were seen (359, pp. 14-15).

A section of the Mowry measured in sec. 36, T. 30 N., R. 97 W. contains many thin bentonite beds in 450 ft. of section (270, p. 36).

A bentonite deposit 5 ft. to 10 ft. thick has been reported 1 mi. northeast of the Duncan post office (434).

An 11 ft. bed occurs near the top of the steep hill on the north side of White Pass. It is in the uppermost bed of the Wind River formation. Lateral extent is 3 mi. It is primarily montmorillonite (589).

Johnson County

Sec. 36, T. 49 N., R. 83 W. Heathman (359, p. 11) found 4 bentonite seams from 0.5 to 1.5 ft. thick in 47.3 ft. of upper Frontier shales. There are 11 thin (0.5 to 3.5 ft.) bentonite seams in 259.5 ft. of Mowry shale and 7 thin seams in 502.1 ft. of Thermopolis shale. Dip is 15° E.

Laramie County

Iron Mountain. Thin bentonite seams are found in the main shale bed above a 10 ft. sandstone bed in the Mowry. The Mowry is 234 ft. thick (353, p. 21).

Lincoln County

Bentonite is reported at Skull Point Gap by Mr. Chris Vrang of Evanston (469).

Natrona County

Casper Area. Heathman (359, pp. 16-17) measured the upper Thermopolis and Mowry in a roadcut in sec. 32, T. 33 N., R. 80 W. and found a 4 ft. bentonite bed at the top of the Mowry and a series of shales and bentonite seams throughout 206.7 ft. of Mowry and 100.4 ft. of Thermopolis shales. These formations crop out west and southwest of Casper. Fisher (202, p. 447) gives an analysis of bentonite from Natrona County: SiO_2=65.24%, Al_2O_3=15.88%, Fe_2O_3=3.12%, MgO+CaO=5.34%, H_2O=9.17%.

Rattlesnake Hills. Three and one-half feet of high-swelling bentonite at the top of the Mowry shale crops out for 25 mi. along the northeast flank of the Rattlesnake Hills. The beds dip 30° NE. and the upper part of the Mowry has slid down dip to form an irregular ridge containing broken and probably discontinuous bentonite layers (359, p. 15).

Emigrant Gap Area. The Mowry bentonite bed crops out at intervals around an anticline but in sec. 9, T. 33 N., R. 81 W. a 4.5 ft. bed offers the best possibilities for mining. The exposures extend for 4,000 ft. and dip of the bentonite bed varies from 40° to 10° NE. The clay is of the swelling type and contains 90% to 95% clay minerals; index of refraction of the clay is a=1.5112. v=1.5325. Estimated reserves are 277,375 short tons for the entire Emigrant Gap area. In gullies, amount of overburden exceeds a 3:1 ratio (175, pp. 7-8).

NE¼ Sec. 24, T. 33 N., R. 81 W., north of North Platte River. A thin bentonite bed in the Mowry shale strikes N. 20° W. and dips 10° E. Mining conditions are favorable (overburden ratio 3:1) but the deposits are small (175, p. 7).

Secs. 24, 25, T. 33 N., R. 81 W. A 4.8 ft. bentonite bed at the top of the Mowry strikes north-south and dips from 6° to 9° E. The overburden is greater than the proportion of 3:1. There are several gullies which cut through the Frontier shale and expose an inlier of Mowry (175, p. 8).

SE¼ sec. 31, T. 33 N., R. 80 W., *Blue Hill deposits.* A Mowry bentonite bed composed of 85% to 90% clay minerals crops out around small Frontier shale outliers. In the NE¼ of the same section, bentonite crops out around a Frontier remnant 400 ft. wide. The bed strikes N. 25° W., dips 9° E. and is 4.8 ft. thick. It extends for 500 ft. north to south (175, p. 8).

Alcova Area. NE¼ sec. 31, T. 30 N., R. 82 W. Five feet of bentonite in the Mowry formation crops out along the east side of Alcova Reservoir in a southeast plunging syncline. On the southwest limb bentonite dips 5° to 7° N. with very little overburden. The bed strikes N. 60° W. and dips 72° SW. along the northeast limb. The bentonite is light-cream colored and contains scattered selenite crystals. Estimated reserves for the Alcova area are 300,000 short tons (175, pp. 8, 17).

Bentonite forms good outcrops in secs. 25, 36, T. 30 N., R. 83 W. where it dips 6° NE. Away from the reservoir, outcrops are wider and overburden is thironer. A specimen from sec. 36 contains 85% to 90% montmorillonite and the remainder biotite, orthoclase, plagioclase, quartz, glass, and muscovite (175, pp. 8-9).

Bates Park Area: SE¼ sec. 4, SW¼ sec. 3, W½ sec. 10, NE¼ sec. 15, T. 30 N., R. 81 W. Five feet of bentonite crop out around an asymmetric anticline. Dips are steep along the southwest flank, but the northwest flanks have low dips and little overburden. The best exposures are in sec. 10 where the bentonite consists of 90% montmorillonite (175, pp. 9-10). Estimated reserves equal "several million" short tons (175, p. 17).

Bates Creek Area No. 1: sec. 10, T. 31 N., R. 80 W. A bentonite bed 4.8 ft. thick in the Mowry shale crops out on the slopes of several hills in the area. The bed strikes generally N. 60° W. and dips gently southwest. Eighty-five per cent to 90% of the clay in montmorillonite, but the overburden exceeds the 1:3 ratio. Estimated reserves equal 224,800 short tons (175, pp. 10,17).

Bates Creek Area No. 2: SW¼ sec. 31, T. 32 N., R. 80 W., N½ sec. 36, and SE¼ sec. 35, T. 32 N., R. 81 W. A Mowry bentonite bed, 4.8 ft. thick, strikes about N. 60° W. and dips to the southwest. The best outcrop is located in SW¼ sec. 31. Overburden of Frontier shale is thick. Estimated reserves equal 264,000 short tons (175, pp. 10, 17).

Lee Lake Area: secs. 13, 24, T. 32 N., R. 82 W., and secs. 18, 19, T. 32 N., R. 81 W. This locality is the western continuation of the Bates Creek region. Five feet of Mowry bentonite and two thin bentonite beds in the Frontier formation are complexly folded and faulted. Overburden exceeds the 1:3 ratio, which is necessary for a commercial deposit. Estimated reserves are 101,300 short tons (175, pp. 12-13, 17).

Midwest Area. A 9 ft. to 12 ft. bentonite bed is located 300 ft. above the Shannon sandstone in the syncline west of Salt Creek anticline. The bentonite crops out from the northwestern part of T. 39 N., R. 79 W., through T. 40 N., R. 79 W., to the southwestern part of T. 41 N., R. 79 W. Dips are low and the bed is covered by 1 ft. to 25 ft. of overburden. Two miles south of Columbine there is a 2 ft. bentonite bed below the 9 ft. bed. Both beds are not uniform and amounts of selenite and shale vary. Steele formation bentonite from sec. 20, T. 40 N., R. 79 W. contains 95% montmorillonite (175, p. 16).

Natrona Area: SW¼ and N½ sec 4, and N½ sec. 3, T. 36 N., R. 83 W. The Steele formation here contains two bentonite beds separated by limestone; the lower is 5 ft. thick and the upper about 4 ft. thick. The beds strike N. 80° E.

and dip 9° S. Selenite crystals are scattered throughout the clay. Steele bentonite contains 95% montmorillonite and some kaolin. Overburden is relatively thick over most of the area (175, pp. 16-17).

Six-foot bentonite beds in the Mowry have been found north of the Bolton Creek oil field (T. 30 N., R. 81 W. ?) and near the Dolling Ranch on Muddy Creek (T. 26 N., R. 80 W. ?) (495, p. 24).

Park County

On the west side of the Bighorn Basin, bentonite is common through a stratigraphic range of 1,500 ft. in the Frontier, Mowry and Thermopolis formations. In the Frontier formation, there are two zones: (1) from 85 ft. to 140 ft. below the top of the formation and (2) 90 ft. to 140 ft. above the base. There are a great number of thin seams in the Mowry and Thermopolis formations. Bentonite has been mined 4 mi. northwest of Cody (496, pp. 175-176).

Hewett (366, p. 97) measured a section of Cretaceous rocks along Shoshone River and found 35 thin bentonite beds in 392 ft. of Cretaceous shales. Analysis of bentonite from the uppermost Frontier formation is: SiO_2=65.63%, Al_2O_3=13.40%, Fe_2O_3+FeO=2.55%, MgO=2.17%, CaO=0.85%, Na_2O=0.69%, K_2O=0.27%, H_2O=14.33%. (369, p. 56).

Platte County

In the Chugwater Creek-Deadhead Creek area of Platte and Laramie Counties, the Mowry shale is 470 ft. thick and contains several beds of bentonite interbedded with gray and black thin-bedded siliceous shale (355, p. 13).

Sheridan County

In T. 58 N., R. 88 W., two beds, one in the Mowry formation (Clay Spur bentonite bed) and the other in the Cody formation (Soap Creek NE¼ sec. 24, T. 33 N., R. 81 W., north of the North Platte River. A thin bed in the Belle Fourche member) are sources of commercial bentonite. In sec. 20, the Clay Spur bentonite is 5 ft. thick. The Soap Creek bentonite is 20½ ft. thick in sec. 18, and has been mined by the Wyotana Bentonite Mining Co. in secs. 17, 18, and 21 (590).

Sublette and Lincoln Counties

Sec. 15, T. 29 N., R. 115 W. Beds of bentonite up to 2 feet thick occur in the Aspen shale (637, 638). Sec. 21, T. 29 N., R. 115 W. Beds of bentonite, 2 to 8 inches thick occur in the Hillard formation. Both of these formations generally dip in excess of 45° (637, 638). The above beds probably occur further west in T. 28 & 29 N., R. 116 W., since the above formations crop out in this area as well (643, 669).

Teton County

Black Rock Meadows; T. 44 N., R. 110 W., 3 mi. southwest of Togwotee Pass "a large amount" of bentonite was found in lower Eocene rocks (434).

Teton Canyon; 10 mi. south of Togwotee Pass. Bentonite was found in Oligocene rocks (434).

Uinta County

Jamison Claim; sec. 30, T. 14 N., R. 119 W., just west of Meyers Bridge, 6 mi. south of Evanston. Bentonite, from this deposit in the Knight formation, has been used as a reservoir lining, but only a few thin seams of bentonite are now visible (469).

Scully Gap; E½ sec. 2, T. 17 N., R. 117 W. A light-colored hill about 20 ft. high contains bentonite in the base of the Frontier formation. The bentonite bed is 5 ft. thick, strikes N. 10° E., and is exposed along the dip slope of a small hogback. There is no overburden and outcrops are visible for ½ mi. along the strike (469).

Spring Valley. Bentonite has been reported by Mr. Chris Vrang of Evanston, Wyoming (469).

Washakie County

At the head of Bud Kimball Draw, 12 mi. southeast of Tensleep, a 6 ft. bentonite in the Wasatch formation is interbedded with coal and coaly shale (204, p. 57).

T. 45 N., R. 88 W. A 5 ft. bentonite bed at the base of the Frontier formation is well exposed in the cliffs west of No Wood Creek (461, p. 38).

In the northeastern part of Washakie County, beds of commercial bentonite in the Frontier and Mowry formations have been mined and used for dam and ditch linings. The quality of the bentonite is excellent for both foundry and drilling mud uses (596).

Weston County

Weston County bentonite deposits are a continuation of the ones found in Crook County. The beds crop out along the southwestern flanks of the Black Hills Dome. Typical analyses of Weston County bentonites are given below:

	(1)	(2)	(3)	(4)
SiO_2	70.36%	54.31%	63.25%	63.25%
Soluble SiO_2	0.62	......	......	......
$Al_2O_3+P_2O_5$	11.47	......	......	......
Al_2O_3	......	20.22	12.63	17.62
Fe_2O_3	2.48	1.88	3.70	3.70
FeO	......	0.19	......	......
MgO	1.38	0.98	3.97	3.70
CaO	0.26	0.94	4.12	4.12
Na_2O	1.69	2.35	......	......
K_2O	0.75	0.21	3.55	......
H_2O	11.32	18.64	6.91	......
TiO_2	0.10	......	......	......
H_2SO_4	......	......	1.58	......
SO_3	......	......	......	1.53

(1) Bentonite at top of Mowry at Clay Spur Quarry, sec. 30, T. 47 N., R. 63 W. (510, p. 157).

(2) Graneros shale bentonite in sec. 30, T. 47 N., R. 63 W. (366, p. 56).

(3) Graneros shale bentonite at Osage (165, p. 9).

(4) Weston County bentonite, analyzed by W. C. Knight (202, p. 560).

Newcastle area. The Clay Spur bed at the top of the Mowry shale which contains the major reserves of bentonite in the northern Black Hills, is thin and does not appear to contain large reserves. A bentonite bed, 1 to 4 feet thick at the top of the Newcastle sandstone and another bed about 3 feet thick near the top of the Belle Fourche shale may be extensive enough to mine (655).

Sec. 13, T. 41 N., R. 61 W. A 3.0 ft. bentonite seam exposed at the top of the Mowry dips 4° SSW. and has from zero to 25 ft. of overburden (359, pp. 9-10).

Sec. 7, T. 42 N., R. 60 W., near Clifton. Outcrops of upper Mowry shales contain a bentonite bed 2.5 ft. thick at this locality. The dip is 4° SW. and there is from zero to 20 ft. of overburden (359, pp. 9-10).

Sec. 19, T. 43 N., R. 60 W., north of Clifton. Bentonite exposed at the top of the Mowry is 1.3 ft. thick, dips 7° SW. and has from zero to 25 ft. of overburden (359, pp. 9-10).

T. 45 N., R. 62 W. (?); northwest of Newcastle. Bentonite occurs in the Upper Cretaceous Pierre formation. The same bed mined at Ardmore and Buffalo Gap, South Dakota, and it may be the same bed mined at Pedro (467, pp. 39-48).

Clay Spur; sec. 30, T. 47 N., R. 63 W. Bentonite from the top of the Mowry is quarried at this locality (510, p. 157). Four miles west of Osage there is a 3 ft. bentonite bed above the Mowry shale. The property covers 1,300 acres, and includes a large storage building and a drying plant owned by the Silica Products Co. (467, pp. 39-48). An analysis is given on page 17.

Pedro. Twelve feet of bentonite were found near the top of the Niobrara formation ¾ mi. east of Pedro and 1 mi. west of Pedro. The beds dip steeply (165, p. 9). An analysis is given in the table above.

Osage. At Osage, a 4 ft. bentonite bed in the Graneros shale dips gently to the southwest (165, p. 9). An analysis is SiO_2=60.80%, Fe_2O_3=0.97%, FeO=0.41%, MnO=0.12%, Al_2O_3=22.40%, CaO=0.76%, MgO=2.34%, K_2O=0.32%, Na_2O=2.69%, SO_3=0.18%, H_2O+=3.82%, H_2O—=5.08% (467, pp. 47-48).

Secs. 11, 17, 27, T. 47 N., R. 64 W., northwest of Osage. A bentonite seam at the top of the Mowry shale averages 2.5 ft. thick, dips 3° SW., and has from zero to 20 ft. overburden (359, pp. 9-10). In the NE¼ sec. 27, T. 47 N., R. 64 W., 7½ mi. from Upton, two beds of bentonite are found in the upper Benton group. Estimated reserves (with 15 ft. or less overburden) equals 73,000 tons in the lower bed and 45,575 tons in the upper. The beds strike N. 5° E. and dip 40° S. (432).

Jerome Siding; T. 47 N., R. 64 W. One and one-half miles from Jerome Siding, there are 3½ ft. of bentonite above the Mowry shale with little overburden. Two pits were dug, one 400 ft. long and 8 ft. wide, the other small. There were three kiln dryers at the railroad siding (467, pp. 47-48). An analysis of Jerome Siding bentonite is: SiO_2=61.00%, Fe_2O_3=3.04%, FeO=0.34%, MnO=0.10%, Al_2O_3=20.98%, CaO=0.44%, MgO=2.68%, K_2O=0.35%, Na_2O=2.36%, SO_3=0.36%, H_2O+= 3.10%, H_2O—=5.09% (467, pp. 47-48).

Secs. 2, 16, T. 48 N., R. 65 W., east and north of Thornton. A bentonite seam at the top of the Mowry averages 2.5 ft. thick, dips 3° SW. and has from zero to 20 ft. of overburden (359, pp. 9-10).

Colloid Siding; 2 mi. northwest of Upton. A 3½ ft. bed of bentonite lies above the Mowry shale. There is very little overburden. Two pits were dug 100 yds. apart, and a drying mill erected (467, pp. 47-49). An analysis of this bentonite is: SiO_2=61.78%, Fe_2O_3=3.10%, FeO=0.28%, MnO=0.08%, Al_2O_3=21.56%, CaO=0.68%, MgO=2.62%, K_2O=0.31%, Na_2O=2.22%, SO_3=tr., H_2O+=2.98%, H_2O—=4.73% (467, pp. 47-48).

BERYL

Beryl, the most important ore of beryllium metal, is used as an alloying agent in heat-resistant metals, as a neutron moderator in atomic reactors, and in the manufacture of glass and porcelain. Aquamarine, morganite and emerald are the valuable gem varieties of beryl. Beryl is found in pegmatites, granites, mica schists, and in tin ores.

Small quantities of beryl have been found, and occasionally produced in Wyoming, but data regarding total production are not available. Beryl (usually handpicked) is produced as a secondary product from mica and feldspar deposits. Production of beryllium concentrates from the Copper Mountain area, Fremont County, amounted to 9,498 pounds by 1957 (613).

PROSPECTS

Albany County

Many Values prospect; (See MICA).

Converse County

N½ sec. 34, T. 29 N., R. 71 W. Two vertical beryl-bearing pegmatites strike parallel to the foliation of hornblende schist. The pegmatites vary from 2 to 5 feet in width and up to 300 feet in length. Beryl crystals, which vary from ¼ to 3 inches in diameter, comprise less than one percent of the quartz core (639).

Jasper mine (Douglas District); (See COPPER).

Fremont County

Helt claims; secs. 3 & 10, T. 41 N., R. 108 W. Beryl, scheelite, and unidentified radioactive minerals are reported from pegmatites located adjacent to the Warm Springs fault zone (630).

Goshen County

NW¼ sec. 14, T. 27 N., R. 65 W. About 150 pounds of beryl was recovered from a pegmatite, but the downward extension of the deposit was not exploited (658).

Near the Minnie Claim; (See MICA).

Savage Claim; (See MICA).

Beryl crystals 4 ft. long were found in the north-central part of sec. 35, T. 28 N., R. 65 W. (21, pp. 424-425).

Torrington No. 1; (See MICA).

In sec. 1, T. 27 N., R. 65 W., is a beryl- and mica-containing pegmatite, which is 275 ft. long and 90 ft. wide, trending N. 85° E. and with a dip of 80° N. Beryl occurs in yellowish-green crystals ¼ to 1 in. in diameter, and does not make up more than 1% of the pegmatite. Muscovite comprises 20% of the pegmatite and occurs in small books, averaging 2 to 3 in. broad. A small quantity is considered of punch quality, while most is suitable for scrap mica (600).

Natrona County

The International Minerals and Chemical Corp. produced from their Catherine No. 1 mine, in 1956, two short tons of beryl (612).

Niobrara County

Rawhide Buttes area. SE¼ sec. 3, T. 31 N., R. 64 W., beryl crystals, up to 2 inches in diameter and 6 inches long occur in a pegmatite that is about 300 feet long and up to 20 feet wide. The unzoned pegmatite which strikes N. 8° W., and dips 78° NE., is composed chiefly of quartz, and sodic plagioclase with minor amounts of microcline, muscovite, garnet, tourmaline and beryl (662).

Sec. line 2 & 3, T. 31 N., R. 64 W. Beryl crystals, up to 6 inches in diameter, occur in the south end of a pegmatite that is 400 feet long and up to 90 feet wide. The pegmatite strikes approximately north and dips 80° E. (662).

NW¼ sec. 14, T. 31 N., R. 64 W. A concordant pegmatite lens in biotite schist strikes about N. 5° E. and dips about 80° SE. The pegmatite, which is 120 feet long and up to 15 feet wide, is composed of quartz, sodic feldspar, tourmaline, muscovite, apatite, and beryl. Beryl crystals, which are most abundant in the outer portions of the pegmatite, range up to 2 inches in diameter, and from less than 6 inches to one foot in length (662).

SE¼ sec. 34, T. 32 N., R. 64 W. Beryl crystals, up to 3 inches in diameter, occur sparsely in a pegmatite in mica schist. The pegmatite is a concordant body that strikes N. 15° W. and dips 87° NE. Exposures indicate that it is at least 100 feet long and 60 feet wide (662).

REPORTED OCCURRENCES

Albany County

Big Chief Mica Mine; (See MICA).

Muscovite Claim; (See MICA).

Carbon County

A few specimens of aquamarine have been reported from the southeastern Seminoe Range (16, p. 60).

Converse County

Schundler-Glenrock Property; (See FELDSPAR).

Fremont County

W. L. Marion reports a beryl dike near Lander (217).

Goshen County

Chicago Prospect; (See MICA).

Crystal Palace; (See MICA).

New York Prospect; (See MICA).

Ruth Prospect; (See MICA).

BISMUTH

Native bismuth and its compounds are comparatively rare, but have been found in Wyoming in pre-Cambrian metallic veins associated with granite gneiss, and schist. Bismuth is usually associated with cobalt, tin, nickel, or silver deposits. Chief uses are in medicine, diagnostic X-ray work, and cosmetics. Electric fuses and safety plugs in water sprinkler systems use bismuth alloys because of their low melting point.

No mines now produce bismuth in Wyoming.

PROSPECT

Albany County

Bismuth has been mined at the southern end of Jelm Mountain in sec. 24, T. 13 N., R. 77 W. Bismutite, with particles of native bismuth, were found at the surface in a small vein between granite and schist. A 200 ft. shaft was sunk, but very little ore was found in depth. Assays showed from 60% to 80% bismuth (16, p. 8; 172, p. 15; 515, p. 214; 377, p. 32).

REPORTED OCCURRENCES

Albany County

Independence Mine; sec. 15, T. 14 N., R. 79 W. An analysis of ore showed 0.97% bismuth (101); (See GOLD).

Bismuthinite, Bi_2S_3, has been reported near Cummins City (515, p. 214).

Carbon County

Taylor Claim; 6 mi. south of Encampment. Bismite and Bismutite were found in a gold-copper bearing quartz vein (172, p. 16; 217).

Converse County

Jasper Mine; in the Douglas District. Bismuth has been reported (311); (See COPPER).

Northeast Fremont County

Yankee Jack Mine; Bridger District. Fine specimens of native bismuth were associated with argentite (16, p. 8); (See SILVER).

CADMIUM

Greenockite, the only important cadmium ore mineral, is usually found in small amounts in zinc ores. It is used in alloys, photography, paint, rubber, glass, and porcelain.

The only known occurrence in Wyoming is in the Silver Crown District, Laramie County. Cadmium was "detected in minute quantities in the analysis of some of the black ores . . ." (16, p. 55).

CALCITE

Calcite is very common and widely distributed as massive limestone, marble or chalk, and also as crystals in vugs and veins. The wide distribution under varied conditions is due to the ready solubility of calcium carbonate in water containing carbon dioxide. Calcite is one of the principle minerals in hot spring deposits (See TRAVERTINE) and in caves. Calcite is a common alteration product of lime silicate igneous and metamorphic rocks, and is a common gangue mineral in many types of metallic ore deposits.

Calcite is most widely used in the cement industry, as a soil conditioner, and for quicklime. The clear, colorless variety (Iceland spar) is used in optical equipment.

Locations are given below for unusual crystalline varieties and gangue minerals and are admittedly incomplete. For other varieties, see TRAVERTINE, LIMESTONE, and MARBLE, under the heading, STONE.

REPORTED OCCURRENCES

Albany County

Esterbrook Mine; cen. SE¼ sec. 9, T. 28 N., R. 71 W. Calcite veins are associated with schist and diabase (540, p. 63); (See LEAD).

Queen Shaft; center of the west side of sec. 16, T. 15 N., R. 78 W. Small faults in amphibolite and hornblende gneiss are filled with small amounts of calcite gouge (363, p. 133); (See PLATINUM).

Carbon County

Iceland spar has been reported by Aughey (16, p. 57) "in Platte Canyon east of Seminoe mountain."

In a section of Phosphoria and Dinwoody rocks measured in sec. 29, T. 27 N., R. 88 W. is an 11 ft. bed of almost pure, cream-colored, finely-crystalline, massive calcite (360, pp. 27-28).

Meta Mine; sec. 24, or 25, T. 15 N., R. 86 W., 19 mi. southwest of Saratoga.

Calcite and quartz veins fill east-northeast trending fractures (540, pp. 98-99); (See LEAD).

Octavia Prospect; (See COPPER).

Syndicate Property; at the head of a tributary of the Savery River, near the crest of a ridge. A fissure vein of calcite cuts across the strike of quartzite (540, pp. 88-89).

Crook County

In secs. 15, 22, 23, T. 52 N., R. 63 W., 6 mi. north of Sundance, calcite is associated with fluorite (149).

Fremont County

Empire State Mine; B. and H. Mining Co. Crystaline calcite and quartz occur in fissures with arsenopyrite (22); (See GOLD).

West end of Owl Creek Mountains; in sec. 5, T. 7 N., R. 5 W., sec. 32, T. 8 N., R. 5 W. (Wind River Meridian), and sec. 7, T. 42 N., R. 104 W. Veins of calcite are included in weedy amphibole asbestos (430, pp. 4-5); (See ASBESTOS).

Iceland spar was found in canyons of the Popo Agie in Paleozoic limestone (16, p. 57).

Calcite scalenohedrons, rhombohedrons and combinations of both were found (192, p. 157) "in small fissures and druses of carboniferous limestone on Beaver Creek along the east base of the Wind River Mountains."

Laramie County

Great Standard Group; Silver Crown District. Calcite crystals have been found in the gold and copper-bearing quartz veins (68); (See GOLD).

Park County

Kirwin District; T. 45 N., R. 104 W. The gold-bearing veins and fissures contain calcite gangue (365); (See COPPER).

At the Shoshone River, 3 mi. west of Cody, calcite crystals are found in sulfur in an extinct geyser deposit (558); (See SULPHUR).

Sunlight Basin; (See COPPER).

Platte County

Emerald Group; sec. 8, T. 23 N., R. 70 W. Folded and fractured hornblende schist and biotite schist have quartz-calcite stringers which fill fractures (68); (See COPPER).

Sunrise District; north-central portion sec. 7, T. 27 N., R. 65 W. Gangue minerals include calcite and quartz (17, p. 100); (See COPPER).

CHROMIUM

The chief source of chromium is chromite, $FeCr_2O_3$. The ore is found as veins, lenses, pods, or disseminated grains in peridotite and serpentine and may be derived from those rocks.

Important uses of chromite include many alloys, chrome plating, refractory bricks for metallurgical furnaces, photography, paints and dyes.

Between 1918 and 1921 a total of 1,594 short tons of chromite were produced in Wyoming. No producing mines are now located in the state.

PROSPECTS

Albany County

Halleck Canyon area; approx. sec. 13, T. 22 N., R. 72 W. Many small chromite veins and disseminated chromite occur in a steatized rock area east of Mill Creek. The chromite occurs in many small irregular veinlets in an exposed area of serpentinite of approximately 200 feet in diameter. Soil cover may obscure additional deposits. A grab sample of a typical chromite vein indicated 9.3% chromium. A sample of the disseminated chromite contained 0.87% chromium (635).

Converse County

Deer Creek Mine; sec. 11, T. 31 N., R. 77 W., 15 mi. southwest of Glenrock, along the steep-walled valley of Deer Creek canyon. A pre-Cambrian chromite and serpentine belt lies between granite on the east and hornblende schist on the west (183). The chromite is fine-grained, compact, and in places is interlayered with serpentine. Fine-grained, dense chromite crops out at intervals for 150 ft. in a belt 2 ft. to 5 ft. wide (540, p. 78). The serpentine belt trends N. 75° E. and dips 45° W. and is 20 ft. to 30 ft. wide (32, pp. 836-7). Analyses of the ore show 35% to 45% Cr_2O_3 (32, p. 836; 181, p. 515) and from 16% to 20% FeO (183). Rare chromium chlorite minerals, kammererite and wolchonskoite, are associated with the deposit (183). The mine produced 1,080 tons of ore averaging 40% Cr_2O_3 up to 1932 (179a, p. 61).

Casper Mountain; SW¼ sec. 16, SE¼ sec. 17, NE¼ sec. 20, T. 32 N., R. 79 W. Chromite lenses, pods, and disseminated grains are scattered through a pre-Cambrian talc-schist which trends N. 60° E. and has vertical to steep northwest or southwest dips. The main lens is 2,500 ft. long and 350 ft. wide (32, p. 829). A smaller lens 400 ft. east of the main lens is 750 ft. long and 350 ft. wide (371, p. 3). High grade commercial chromite ore contains about 26% Cr_2O_3, but the average ore contains around 15% to 20% Cr_2O_3 (31, p. 831; 371; 302; 217; 543, p. 170; 526; 570, p. 154). Trenching and drilling of the Casper Mountain deposits by the U. S. Bureau of Mines (390, p. 4; 541, p. 86) revealed inferred reserves of 575,000 tons of chromite averaging 8.7% Cr_2O_3, thus the deposit is not of commercial value at the present time because of its low grade; (See ASBESTOS; VERMICULITE).

REPORTED OCCURRENCES

Albany County

The Iron Mountain titaniferous magnetite deposits contain 2.45% Cr_2O_3 (179a, p. 61).

Fremont County

Chromite is reported along Rock Creek in the Atlantic City-South Pass district (179a, p. 93).

CLAY (Except Bentonite)

Clay is a very fine-grained, very soft, earthy substance that is usually plastic when wet and coherent when dry. The chemical composition, color and other properties depend upon the finely divided mineral particles present; hydrated aluminum silicates (kaolinite), the montmorillonite group of minerals, finely divided micas, chlorites and other micaceous minerals are the usual constituents. The particles in clay usually are between 0.005 mm. and 0.002 mm. in diameter. Clays are classified as residual (formed in their present location), and sedimentary (transported to their present position).

Clay is one of the commonest rocks in Wyoming, but because of inadequate testing little information is available on quality and types.

BRICK CLAY

Clay suitable for bricks and tiles should contain up to 30% sand and silt so that shrinkage will not be too great on firing. Such clays are widely distributed over Wyoming. The color and texture of bricks depend upon the impurities in the argillaceous materials used.

PRODUCING PLANTS AND AREAS

Big Horn County

The Lovell Clay Products Co., of Lovell, used 11,356 tons of shale in 1962, and 9,105 tons in 1963 to make glazed sewer pipe, drain pipe, flue lining and wall coping, brick, and structural clay tile. The open pit mine is located in the N½ T. 56 N., R. 95 W., about 5 mi. east of Lovell on the west side of Little Sheep Mountain anticline. The clay pit is located in the variegated clay beds of the Cloverly formation which dips 45° W. (217, 611, 672).

Uinta County

In 1963, Interstate Brick Co. mined 36,688 tons of miscellaneous clay north of Evanston for manufacturing building brick in a plant in Utah (611, 613).

In 1963, International Pipe and Ceramics Corp. mined 13,500 tons of fire clay which was shipped to Salt Lake City, Utah, for processing and marketing (611, 613). Geological data on both deposits are unknown.

OTHER LOCALITIES WHERE BRICKS WERE FORMERLY PRODUCED

The towns of Basin, Gillette, Encampment, Lander, Thermopolis, Cody, Green River, and Worland formerly had small brick plants (499, p. 17). Prior to 1899, plants were started at Cheyenne, Wheatland, and Sheridan, but no recent records are available (411, pp. 546-7). At Parco, in Carbon County, a plant was started in 1927 with a capacity of 250,000 bricks per month (179, pp. 53-54). The U. S. Geological Survey map (152) shows a quarry for clay used in the manufacture of brick and tile at Douglas. It was opened before 1899 (499, p. 17). The Laramie Valley Brick and Tile Co. of Laramie, produced structural brick and tile at their plant in West Laramie. The clay was quarried 1½ mi. west of Laramie and also about 6½ mi. northwest of Laramie in the lower Benton shale (171, p. 66; 217).

PROSPECTS

Carbon County

Rawlins area; sec. 25, T. 21 N., R. 88 W. A 5 foot-thick brown carbonaceous shale bed occurs in the Mesaverde formation. This bed has a P.C.E. (pyrometric cone equivalent) of 18-19 and is suitable for the manufacture of low duty refractory brick (684).

Sheridan County

Sheridan Press Brick and Tile Co. has manufactured fire brick more-or-less continuously since 1914. The open pit mine is located in N½ T. 57 N., R. 85 W. The clay is mined from a 4- to 6-foot thick bed overlying the Masters 2 coal bed which occurs in the lower member of the Ft. Union formation (672).

Sweetwater County

The Lewis shale of the Montana Group which crops out around the Rock Springs dome is a potential source of clay. The Lewis shale is 750 ft. thick and contains some highly gypsiferous shales (522, p. 223).

Uinta County

A plant was started prior to 1899 in Evanston (411, pp. 546-547). Alluvial clays are rather common in the vicinity of the town of Evanston, but the deposits are small, scattered, and the quality of the clay varies considerably (469). Sec. 19, T. 16 N., R. 120 W. Clay occurs in the Evanston formation. A sample representative of a 3- to 4-foot bed of gray clay shale had a P.C.E. of 31 indicating that it might be suitable for the manufacture of high-duty firebrick. The deposit occurs about 5 to 10 feet above a coal bed that has been extensively mined (672).

S½ sec. 12, T. 16 N., R. 121 W., ¾ mi. north of Bear River bridge is an alluvial clay of limited areal extent that is interbedded with a sandy clay. Total thickness is about 5 ft. (469).

Quaternary clay deposits up to 250 ft. thick are common throughout central Uinta County. The clay is usually derived from the weathering of underlying shales in Mammoth Valley. This clay has been used to make bricks at Glencoe. There are no outcrops north of Glencoe (521, p. 214).

Weston County

Good pressed bricks can be made from the clay found at Cambria (411, pp. 546-547).

FIRE CLAY

Refractory clay that is nearly free from alkalies or alkaline earths is best for fire clay. Such clays are often found as under-clays below coal seams or in association with lacustrine deposits.

REPORTED OCCURRENCES

Big Horn County

The Cloverly formation in the Bighorn Basin has characteristics of a good fire clay, but has never been tested (204, p. 60).

Platte County

The Dakota formation near Hartville may contain good fire clay (536, p. 6).

Weston County

"Excellent fire clay underlies the coal at Cambria" (167, p. 397). Ricketts, in his Territorial Report of 1890, states that brick was being made from Mount Zion fire clays (506, p. 80).

OTHER CLAYS

REPORTED OCCURRENCES

Albany County

Near the town of Albany, an impure Tertiary clay bed up to several tens of feet thick overlies pre-cambrian granite (401).

Natrona County

Pottery clay has been found in T. 35 N., R. 79 W. in the immediate vicinity of Casper (499, p. 55).

Park County

In T. 54 N., R. 102 W. (sec. 7 or 8?) along the Sunlight Basin road northwest of Cody, ceramic clay occurs in the Cloverly (?), interbedded in sandstone.

Ten feet of clay extends for at least 1 mi. along the outcrop. Strike is northwest-southeast and dip is 30° E. This clay has been fired at 1,200° C. and could be used for pottery, earthenware, modeling clay and similar products (233).

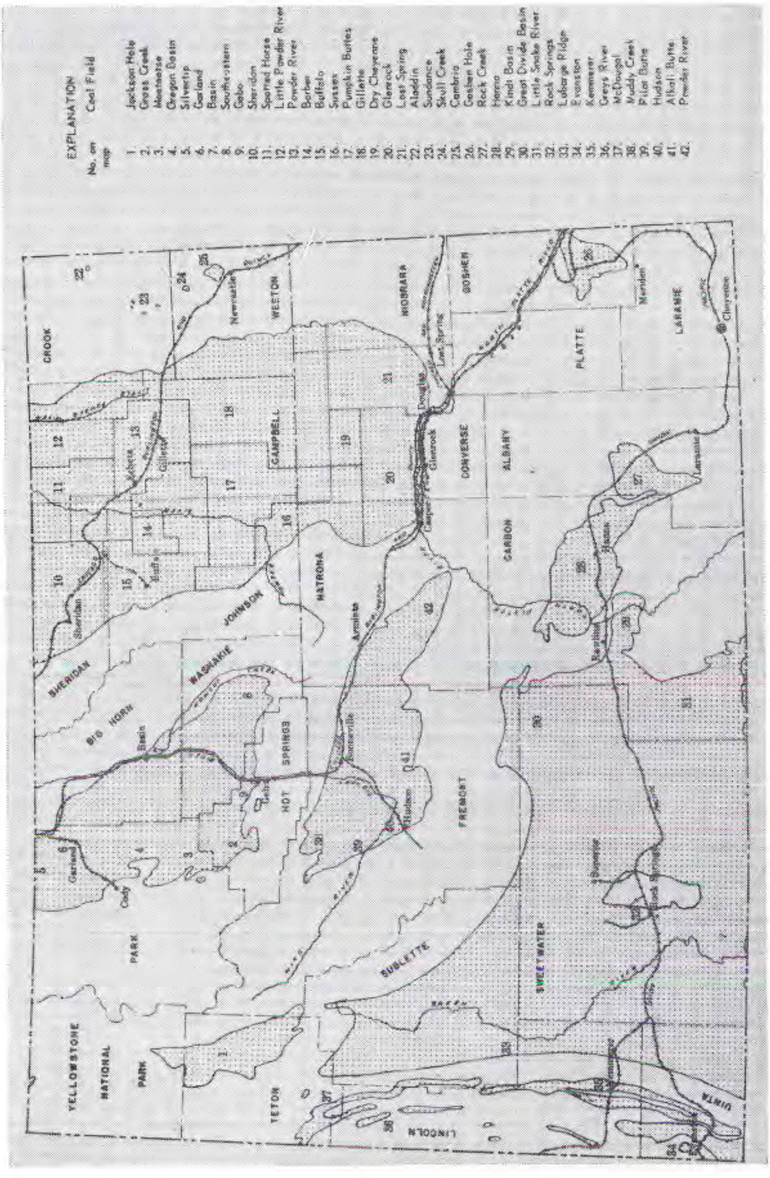

Fig. 3. Coal fields of Wyoming (After Berryhill, et al., 1950 U. S. Geol. Surv. Circular 81.

COAL

By Joseph S. Long, Jr.

INTRODUCTION

The State of Wyoming contains an estimated 121,553,850,000 tons of coal ranging from lignite to high volatile A bituminous in rank. The major portion is of bituminous and sub-bituminous rank. Most of the coal occurs in rocks ranging in age from Upper Cretaceous (Mesaverde formation) through Eocene (Wasatch formation) which crop out around the peripheries of the intermontane basins of Wyoming (Fig. 3).

The major coal bearing areas in Wyoming are the Green River region (Rock Springs field), the Powder River Basin area, the Hanna Basin (Hanna field), and the Hams Fork region, in that order (Fig. 3). Individual fields within these major regions are briefly discussed in this summary.

Most of the information on the coal of Wyoming was obtained from United States Geological Survey Circular 81. "The Coal Resources of Wyoming," by H. L. Berryhill, D. M. Brown, Andrew Brown, and D. A. Taylor, 1950. A selected bibliography is included for reference to detailed information on the areas mentioned in this report.

COAL FIELDS

Black Hills Region, Crook and Weston Counties

Minable coal in this area is found in one bed at the base of the Lakota sandstone.

Cambria field: The Cambria field is located near Newcastle, in northern Weston County. Over an area of about 12 sq. mi. the coal beds are 3 to 10 ft. thick. The coal is of high volatile C bituminous rank. Total estimated reserves are 36.52 million short tons.

Other fields: Small quantities of coal, similar to the above, are found in the Skull Creek field, near the corner of Ts. 47 and 48 N., Rs. 62 and 63 W.; the Sundance field about 25 mi. north of the Skull Creek area; and the Aladdin field in T. 54 N., R. 61 W. Total estimated reserves for the above fields are 4.57 million short tons.

Powder River Basin

Sheridan field: The Sheridan field covers 1,100 sq. mi. in Sheridan County. Coal of economic value occurs in the Fort Union (Paleocene) formation. This unit contains 9 coal beds which range in thickness from about 6 to 36 ft. These beds dip from 1° to 4°. Small amounts of coal also occur in the Wasatch (Eocene) formation. Coal in the field is of sub-bituminous C and B rank, and total estimated reserves are 16,298.35 million short tons.

Powder River field: The Powder River field is southeast of the Sheridan field and covers about 1,000 sq. mi. in Campbell, Johnson, and Sheridan counties. The coal in this field is mostly flat-lying and of a sub-bituminous C or B rank. Five beds ranging from 3 to 106 ft. thick, occur in the Fort Union formation. Two beds with thicknesses of clean coal up to 22 ft. thick occur in the Wasatch formation. Estimated reserves of the field are 25,566.17 million short tons.

Spotted Horse field: The Spotted Horse field covers 270 sq. mi. The Fort Union formation contains 2 coal beds, ranging from 2 to 13 ft. thick. Three beds, ranging from 2.5 to 29 ft. in thickness, occur in the Wasatch formation. Rocks of this field are flat-lying. The coal is of sub-bituminous C rank. Estimated reserves of the field are 5,866.17 million short tons.

Little Powder River field: This field includes 540 sq. mi. in Campbell County. The minable coal reserves consist of 10 coal beds in the Tongue River member of the Fort Union formation. The most persistent beds are 6.5 and 10 ft. thick. One bed is 24.5 ft. thick. Tongue River member coal is between lignite and sub-bituminous. Estimated reserves are 3419.90 million short tons.

Gillette field: The Gillette field covers more than 3,000 sq. mi. in parts of Campbell, Crook, Weston, Niobrara, and Converse counties. Commercial coal beds are found in the Fort Union formation. The beds average about 8 ft. in thickness with maximum thicknesses ranging from 35 to 65 ft. The coal beds of the Gillette field generally dip 5° or less. Most of the coal is sub-bituminous C rank, though some lignite is present. Estimated reserves of the field are 14,764.76 million short tons.

Pumpkin Buttes field: The Pumpkin Buttes field covers about 1,410 sq. mi. in Campbell and Johnson counties. About half of the field is not mapped. Coal beds in the mapped region occur in the Wasatch formation and average about 9 ft. thick. In general, the dips of the coal beds are low and the coal is of sub-bituminous rank. Total estimated reserves of the Pumpkin Buttes field are 12,617.19 million short tons.

Dry Cheyenne field: The Dry Cheyenne field covers an area of 290 sq. mi. in Converse County. Two coal beds of the Fort Union formation are exposed in this field. The beds average about 3 ft. in thickness. Estimated reserves for this field are 151.07 million short tons.

Lost Spring field: The Lost Spring field includes about 1,600 sq. mi. at the southeast end of the Powder River Basin, in Converse and Niobrara counties. Coal in the Lost Spring field is confined to two zones in the Lebo member of the Fort Union formation. The beds range from 6 to 9.5 ft. in thickness. Dips of the coal beds range from 1° to 4°. The coal is of sub-bituminous rank with the beds of the upper zone being higher quality than those in the lower zone. Total estimated reserves are 885.49 million short tons.

Glenrock field: The Glenrock field covers an area of 1,500 sq. mi. in Converse and Natrona counties. Four coal zones are exposed in this field. The 2 upper beds are minable and thicknesses are 5 ft. and more. Total estimated reserves are 399.74 million short tons.

Sussex field: The Sussex field includes about 1,300 sq. mi. in parts of Johnson, Natrona, and Converse counties. Beds which reach 50 ft. in thickness occur in the Wasatch formation. The thick beds thin rapidly, but are of minable thickness along most of the outcrop. The coal of the Sussex field ranges from sub-bituminous C to sub-bituminous B in rank. Total estimated reserves are 818.46 million short tons.

Buffalo field: The Buffalo field covers 900 sq. mi., mostly in Johnson County. The most extensive coal beds are in the Wasatch formation. Thicknesses of the beds range from 7 to 18 ft. Rocks in the Buffalo field dip gently, except near the Big Horn Mountains. The coal is of sub-bituminous C rank, and estimated reserves are 2,782.56 million short tons.

Barber field: The Barber field covers 250 sq. mi. in Johnson County, east of the town of Buffalo. Coal in the Barber field occurs in four zones in the Wasatch formation. The coal beds range from a few inches to 18 ft. in thickness. The rocks of the Barber field are flat-lying and the coal is of sub-bituminous C rank. Estimated reserves are 1,539.89 million short tons, which is probably a low figure as the area has not been completely mapped.

Central Part of the Powder River Basin: In the central part of the Powder River Basin is an area of 580 sq. mi. (no number on map) in which geological evidence indicates the presence of considerable coal at depth. Inferred reserves are 9,717.08 million short tons.

Goshen Hole Field

The Goshen Hole field covers about 250 sq. mi. in southern Goshen County. No coal bed more than 2.5 ft. thick is known to occur on the surface. In the southern part of the Goshen Hole field one bed of 4 or 5 ft. thickness, less than 1,000 ft. below the surface, has been reported. Coal in the Goshen Hole field is presumably of sub-bituminous rank, but no reserves are estimated.

Big Horn Basin

Silvertip field: The Silvertip field is located on the Montana-Wyoming state line in Park County. Coal in the Silvertip field occurs in the Eagle sandstone (Cretaceous). This unit contains two minable beds, which range from 2 to 2.5 ft. in thickness. The beds dip about 20°. Coal is of high volatile C bituminous rank. Total estimated reserves for the field are 22.55 million short tons.

Garland field: The Garland field is located in T. 56 N., R. 99 W., Park County, Coal of minable thickness (6.3 ft. maximum) is found in one bed, which occurs near the contact of the Fort Union and Lance formation. The coal is of sub-bituminous A rank. Total estimated reserves for the field are 37.75 million short tons.

Basin field: The Basin field is located in Big Horn County. Only one bed (8.5 ft. maximum) in the Fort Union formation is of minable thickness. Locally the bed consists of 6 ft. of clean coal. The coal is sub-bituminous A rank. Total estimated reserves for the field are 17.28 million short tons.

Southeastern field: The Southeastern field includes part of the Big Horn Basin, east of the Big Horn River and south of the Basin field. Coal crops out in a band 6 to 10 mi. wide, extending southeast from T. 49 N., R. 92 W., to T. 44 N., R. 94 W. The coal occurs in rocks of Cretaceous age and is of sub-bituminous rank. The presence of 15 beds just east of the river has been established by drilling. Total estimated reserves for the field are 88.44 million short tons.

Gebo field: The Gebo field is in Hot Springs County. Coal occurs in the Mesaverde formation (Cretaceous). One bed has a maximum thickness of 11 ft. and is 5 ft. thick along 4 mi. of outcrop. Several other less extensive beds are of minable thickness. The maximum dip of the beds is 25°. Coal of the Gebo field is of sub-bituminous B and A rank. Total estimated reserves for the field are 154.36 million short tons.

Grass Creek field: The Grass Creek field is located in Hot Springs County. Minable coal occurs in the Mesaverde, Meeteetse, and Fort Union formations. Beds range from 1.5 to 5 ft. in thickness and are mostly lenticular but minable at the outcrop. The dips of the beds in the Grass Creek field range from 10° to 50°, with the coal being of sub-bituminous B and A rank. Total estimated reserves of the field are 104.75 million short tons.

Meeteetse field: The Meeteetse field extends from the northern border of T. 46 N. to the northern border of T. 49 N., Rs. 99-102 W. Minable coal occurs in the Mesaverde, Meeteetse, and Fort Union formations and ranges from 1.2 to 8.8 ft. in thickness. Coal of the Mesaverde formation is of sub-bituminous B and A rank, and the average dip of the beds is 15°. Total estimated reserves of the field are 97.61 million short tons.

Oregon Basin field: The Oregon Basin field includes parts of Ts. 50-53 N., Rs. 100-102 W. Coal occurs in the Mesaverde and Meeteetse formations. Maximum thicknesses of beds in each formation are 8.2 and 3.5 ft., respectively. The coal is of sub-bituminous B rank. Total estimated reserves of the Oregon Basin are 58.94 million short tons.

Wind River Basin

Muddy Creek field: The Muddy Creek field covers about 430 sq. mi. in Fremont County, and contains coal in the Mesaverde, Meeteetse and possibly the Fort Union formations. The thickest bed is 17.4 ft. and most are lenticular but minable. Total estimated reserves are 42.50 million short tons.

Pilot Butte field: The Pilot Butte field is located in Fremont County. Coal is obtained from a 2.8 ft. thick bed of clean coal in the Mesaverde formation. Total estimated reserves are 360,000 short tons.

Hudson field: The Hudson field is located in Fremont County. Three lenticular beds occur in the Mesaverde formation. About 14 ft. of clean coal is exposed in the thickest bed. One bed is persistent and extends at minable thickness for more than 3.5 mi. The rocks of the area generally dip 13° NE. Coal in the Hudson field is of sub-bituminous B rank. Total estimated reserves are 58.97 million short tons.

Alkali Butte field: The Alkali Butte field is located in Fremont County. Two coal beds occur in the Mesaverde formation. The upper and lower beds contain 12 and 16.8 ft. of coal, respectively. The upper bed extends at minable thicknesses across the southern part of T. 34 N., R. 94 W. The lower bed extends for more than 2 mi. with a thickness of 10 ft. The rocks of this field average about 30° in dip and the coal is of sub-bituminous rank. Total estimated reserves are 89.50 million short tons.

Coal in Ts. 33 and 34 N., R. 96 W.: Logs from drill holes in the Beaver Creek oil field show estimated reserves of 507.47 million short tons at depths less than 3,000 ft. The coal is of sub-bituminous rank.

Powder River field: This field includes about one-third of the total area of the Wind River Basin and is located in Natrona and Fremont counties. Most of the coal occurs in the Mesaverde formation, but minable coal also is present in the Lewis, Lance and Fort Union formations. All the beds are lenticular. The thickest bed contains 9.8 ft. of clean coal, and some beds persist for 2 mi. at minable thickness. Dips of the beds range from 20° to vertical. Total estimated reserves are 176.86 million short tons.

Hanna Field

The Hanna coal field covers about 750 sq. mi. in Carbon County. Coal is found in the Mesaverde, Medicine Bow, Ferris, and Hanna formations. At least 69 coal beds are more than 3 ft. thick in the field. One bed contains 23.4 ft. of clean coal. Coal in the Mesaverde formation is of high volatile C bituminous rank; that in the Medicine Bow and Hanna formations is of sub-bituminous A rank. The Ferris formation also contains coal of sub-bituminous rank. Total estimated reserves of the Hanna field are 3,917 million tons.

Rock Creek Field

The Rock Creek field covers about 450 sq. mi. in Albany and Carbon counties. Five minable coal beds occur in the Mesaverde and Hanna formations. The thicknesses of the beds range from 4 to 7 ft. and dips are between 8° and 20° SE. The coal of the field is sub-bituminous B rank. Total estimated reserves are 305.18 million short tons.

Green River Region and Western Wyoming

Kindt Basin field: The field covers about 200 sq. mi. in west-central Carbon County. Coal occurs in the Mesaverde formation and ranges from 2 to 6 ft. thick. The beds are lenticular and dips are between 11° and 75°. The coal is of high volatile C bituminous rank and estimated total reserves are 3.42 million short tons.

Great Divide Basin field: This field covers about 1,800 sq. mi. in Sweetwater, Fremont, and Carbon Counties. The Mesaverde, the approximate equivalents of the Lance and Fort Union, and the Wasatch formations contain minable coal beds.

Average thicknesses of the beds are between 4 and 6 ft. The maximum thickness is 20.7 ft. and dips of the rocks in the field are, in some places, between 25° and 80°. Coal in the field is of high volatile C bituminous rank and estimated total reserves are 1,279.88 million short tons.

Little Snake River Field: The Little Snake River field includes more than 1,500 sq. mi. in parts of Ts. 12-20 N., Rs. 87-95 W. The strata generally dip at angles ranging from nearly horizontal to 35°. Coal occurs in the Mesaverde formation in rocks of Lancian age and in rocks of Paleocene and/or Eocene age. Thicknesses of the coal beds are between 2 and 8 ft. The coal ranges from sub-bituminous C to A in rank. Total estimated reserves are 1,938.93 million short tons.

Rock Springs field: The Rock Springs field covers about 3,000 sq. mi. in Sweetwater County. Coal-bearing rocks in the Rock Springs field include the Mesaverde, Lance, Fort Union, and Wasatch formations. Numerous beds, with an average of 5 and 6 ft. of clean coal, occur in each formation. One bed, in the Fort Union formation, is 26 ft. thick. Drill holes also show 78 beds at depth of less than 3,000 ft. north of Rock Springs. Coal in the field ranges from sub-bituminous C to A in rank. Total estimated reserves for the Rock Springs region are 12,726.68 million short tons.

Western part of the Green River Region: The only field in this region is the Labarge field in Lincoln and Sublette Counties. Coal occurs in the Adaville and Frontier (Upper Cretaceous) and Evanston (Paleocene Lower Cretaceous) formations. The beds average nearly 5 feet in thickness. Dips in part of the field are between 20° and 50°. The coal ranges from sub-bituminous B to A in rank. Total estimated reserves for this region are 6.97 million short tons.

Kemmerer field: The Kemmerer field is located in Uinta and Lincoln counties. Coal is found in both the Frontier and Adaville formations. The beds range from 1.3 to a maximum of 89.6 ft. thick. Coal in the field is mostly high volatile sub-bituminous B and A rank. Total estimated reserves for the Kemmerer field are 4,442.33 million short tons.

Greys River field: Coal of the Greys River field, in Lincoln County, occurs in the Frontier formation. Two beds measured 3 ft. thick with dips ranging from 30° to 80° W. Estimated total reserves are 68,000 short tons.

McDougal field: The McDougal field in Teton and Lincoln Counties, contains coal in the Adaville and Frontier formations. The beds range from 1.2 to 20 feet in thickness. Estimated coal reserves are 117.08 million short tons.

Evanston field: The Evanston field is located in Uinta County. Evanston field coal occurs in the Evanston (Paleocene) formation. It contains one bed with a maximum of 41 ft. of coal with four partings. The coal ranges in rank from sub-bituminous B to A. Total estimated reserves are 314.45 million short tons.

Jackson Hole field: The Jackson Hole field covers about 700 sq. mi. in Teton County and Yellowstone National Park. Rocks of the Jackson Hole field that contain coal are of Upper Cretaceous, Paleocene, and Eocene age. Most of the coal beds range from 2.5 to 10 ft. in thickness. One bed with numerous shale partings is 63 ft. thick. The strata of the field do not dip more than 45° and the coal appears to be of sub-bituminous rank. Total estimated reserves are 121.49 million short tons.

COKING COAL

Rock Springs field: Coal from one bed could possibly be used as a poor grade coking coal. Total reserves of this bed are estimated to be 899,440,000 tons.

Kemmerer field: One bed in this field, averaging 4.2 to 4.9 ft. thick, contains coking coal. Estimated reserves of this bed are 159,965,000 short tons.

SELECTED REFERENCES

Andrews, D. A., Preliminary geologic and structure maps and coal sections, Willow Creek coal area, Lincoln County, Wyoming: U. S. Geol. Surv., 1944.

Ball, M. W., The western part of the Little Snake River coal field, Wyoming: U. S. Geol. Surv. Bull. 341, 1909, pp. 243-255.

.........................., and Stebinger, Eugene, The eastern part of the Little Snake River coal field, Wyoming: U. S. Geol. Surv. Bull. 381, 1910, pp. 186-213.

Berta, J. O., The Hanna coal field: Wyo. Geol. Assoc. Guidebook 6th Ann. Field Conf., 1951, pp. 88-91.

Darton, N. H., Coal of the Black Hills, Wyoming: U. S. Geol. Surv. Bull 206, 1905, pp. 429-433.

Davis, J. A., The Little Powder River coal field, Campbell County, Wyoming: U. S. Geol. Surv. Bull. 471, 1917, pp. 423-440.

Dobbin, C. E., and Barnett, V. H., The Gillette coal field, northeastern Wyoming: U. S. Geol. Surv. Bull. 796, 1927, pp. 1-50.

.........................., and Bowen, C. F., Hoots, H. W., Geology and coal and oil resources of the Hanna and Carbon Basins, Carbon County, Wyoming: U. S. Geol. Surv. Bull. 804, 1929.

Fisher, C. A., Coal of the Big Horn Basin, in northwest Wyoming: U. S. Geol. Surv. Bull. 225, 1904, pp. 345-362.

Hewett, D. F., Geology and oil and coal resources of the Oregon Basin, Meeteetse and Grass Creek Basin quadrangles, Wyoming: U. S. Geol. Surv. Prof. Paper 145, 1926.

Hunter, W. S., The Kemmerer coal field: Wyo. Geol. Assoc. Guidebook, Southwest Wyoming, 1950, pp. 123-132.

Hose, R. K., Geology of the Crazy Woman Creek area, Johnson County, Wyoming: U. S. Geol. Surv. Bull. 1027-B, 1955.

Knight, W. C., Coal and coal measures of Wyoming: U. S. Geol. Surv. Ann. Rept. 16, pt. 4, 1895, pp. 208-215.

Mapel, W. J., and Schopf, J. M., Gill, J. R., A thick coal bed near Lake DeSmet, Johnson County, Wyoming: U. S. Geol. Surv. Circ. 228, 1953.

Mapel, W. J., Geology and coal resources of the Buffalo-Lake DeSmet area, Johnson and Sheridan Counties, Wyoming: U. S. Geol. Survey Bull. 1078, 1959.

Olive, W. W., The Spotted Horse coal field, Sheridan and Campbell Counties, Wyoming: U. S. Geol. Surv. Bull. 1050-E, 1957.

Parsons, F. W., The coal-mining situation in northern Wyoming: Engr. Min. Jour. 84, 1907, pp. 930-935.

.........................., Coal mines of southern Wyoming: Engr. Min. Jour. 85, 1908, pp. 118-120.

Schultz, A. R., Coal fields in a portion of central Uinta County, Wyoming: U. S. Geol. Surv. Bull. 316, 1907, pp. 212-241.

.........................., The southern part of the Rock Springs coal field, Sweetwater County, Wyoming: U. S. Geol. Surv. Bull. 381, 1910, pp. 214-281.

.........................., A geologic reconnaissance for phosphate and coal in southeastern Idaho and western Wyoming: U. S. Geol. Surv. Bull. 680, 1918, 84 pp.

Shaw, E. W., The Glenrock coal field, Wyoming: U. S. Geol. Surv. Bull. 341, 1909, pp. 151-164.

Shurick, A. T., The Diamondville coal field, Wyoming: Engr. Min. Jour. 85, 1908, pp. 116-118.

Simmons, Gene, The Cambria coal field in Wyoming: Coal Age I. 1912. pp. 766-768.

..............................., The Sheridan, Wyoming, coal field: Coal Age I, 1912 pp. 866-868.

Smith, E. E., The eastern part of the Great Divide Basin coal field, Wyoming: U. S. Geol. Surv. Bull. 341, 1909, pp. 220-242.

Swann, C. E., The geology of the Rock Springs coal field, Sweetwater County, Wyoming: Min. Cong. Jour., vol. 16, no. 2, Feb., 1930, pp. 97-99.

Thom, W. T., Jr., The Minturn district in the northwestern part of the Gillette field, Wyoming: U. S. Geol. Surv. Bull. 796, 1927, pp. 50-64.

Thompson, R. M., and White, V. L., The coal deposits of the Alkali Butte, the Big Sand Draw, and the Beaver Creek fields, Fremont County, Wyoming: U. S. Geol. Surv. Circ. 152, 1952.

Van Lennep, David, Great Green River coal deposits: Pan-Amer. Geologist, vol. 39, no. 4, May, 1923, pp. 297-316.

Veatch, A. C., Coal and oil in southern Uinta County, Wyoming: U. S. Geol. Surv. Bull. 285, 1906, pp. 331-353.

..............................., Coal fields of east-central Carbon County, Wyoming: U. S. Geol. Surv. Bull. 316, 1907, pp. 244-260.

..............................., Geography and geology of a portion of southwestern Wyoming, with special reference to coal and oil: U. S. Geol. Surv. Prof. Paper 56, 1907.

Voorhees, Gerald E., Upper Cretaceous stratigraphy and overthrusting in the Deadman, Blind Bull, and Horse Creek area, Lincoln County, Wyoming: unpub. M.S. thesis, Univ. Wyoming library, 1963.

Washburne, C. W., Coal fields of the northeast side of the Big Horn Basin, Wyoming, and of Bridger, Montana: U. S. Geol. Surv. Bull. 341, 1909, pp. 165-199.

Wegemann, C. H., and Gale, S. H., The Buffalo coal field, Wyoming: U. S. Geol. Surv. Bull. 381, 1910, pp. 137-169.

..............................., The Sussex coal field, Johnson, Natrona, and Converse counties, Wyoming: U. S. Geol. Surv. Bull. 471, 1912, pp. 441-471.

..............................., The Barber coal field, Johnson County, Wyoming: U. S. Geol. Surv. Bull. 541, 1914, pp. 419-452.

Wegemann, C. H., Howell, R. W., and Dobbin, C. E., The Pumpkin Buttes coal field, Wyoming: U. S. Geol. Surv. Bull. 806, 1928, pp. 1-14.

Winchester, D. E., The Lost Spring coal field, Converse County, Wyoming: U. S. Geol. Surv. Bull 471, 1912, pp. 472-515.

Woodruff, E. G., The Lander coal field, Wyoming: U. S. Geol Surv. Bull. 316, 1907, pp. 242-243.

..............................., Coal fields of the southwest side of the Big Horn Basin Wyoming: U. S. Geol. Surv. Bull. 341, 1909, pp. 200-219.

..............................., The coal field in the southeastern part of the Big Horn Basin, Wyoming: U. S. Geol. Surv. Bull. 381, 1910, pp. 170-185.

..............................., and Winchester, D. E., Coal fields of the Wind River region, Fremont and Natrona Counties, Wyoming: U. S. Geol. Surv. Bull. 471, 1912, pp. 516-564.

COBALT

Traces of cobaltite, CoAsS, erythrite, $Co_2AS_2O_88H_2O$, and linnatite, Co_3S_4, have been found in some of the pre-Cambrian copper-gold ores in southern Wyoming. No cobalt has been produced in Wyoming, and very little in the United States. Uses of cobalt include permanent magnet alloys, high temperature cobalt-chromium-tungsten alloys, as a pigment in coloring pottery, enamel and glass, and in cutting tools.

REPORTED OCCURRENCES

Albany County (See COPPER).

The Medicine Bow Mines Co. at Holmes reported cobalt in the copper and gold ores (515, p. 215; 92).

Carbon County

Creede Property (Encampment District): located 2 mi. northwest of Bridger Peak and about ¼ mi. east of the road from Rudefeha to Saratoga. "Pyrrhotite ores carrying copper, nickel, and cobalt occur in country rock of hornblende schists near a large dike of norite" (539, p. 36); (See COPPER).

Leighton-Gentry Prospect (Encampment District); located near the Continental Divide at the head of Jack Creek. Assays show 0.67% cobalt or nickel (539, pp. 87-88).

Converse County

Trail Creek Mine; (See URANIUM).

Laramie County

Erythrite was reported "on Middle Crow Creek, Silver Crown District." (16, p. 55).

An analysis of the Silver Crown ores shows traces of linnaeite (16, p. 55).

COLUMBITE-TANTALITE

Columbite and tantalite form an isomorphous series which has the general formula, (Fe, Mn) $(Nb, Ta)_2O_6$; columbite is the niobium-rich member, and tantalite is the tantalum-rich member. These minerals are found as crystals and compact masses in granite and pegmatite.

Tantalum was formerly used for filaments in electric light bulbs. At present it is used in the chemical industry, in some tool steels, for electronic tubes, and as a catalyst in making synthetic rubber. Columbium is used as a stabilizer in stainless steels, and is beginning to be used in alloys.

The columbite-tantalite produced in Wyoming was a by-product from the mining of pre-Cambrian tin-bearing pegmatites, or was associated with beryl in pegmatites. No data on production are available. It is estimated that Wyoming has produced at least 325 lbs. of columbite-tantalite (354, p. 2).

PROSPECTS

Albany County

SE¼ sec. 13, T. 13N., R. 78 W., a columbite-bearing pegmatite may be as much as 200 feet wide and approximately 1300 feet long. Surface exposures show that quartz and feldspar make up 95% of the rock with columbite occuring in trace amounts (663).

Many Values Prospect; (See MICA).

Fremont County

Bridger Mountains Area, Whippet Nos. 1 and 8; (See FELDSPAR).

REPORTED OCCURRENCES

Albany County

Muscovite Claim; (See MICA).

Converse County

Jasper Mine, Douglas District; (See COPPER).

Crook County

Nigger Hill District; (See TIN).

Goshen County

Ruth Prospects; (See MICA).

COPPER

Copper is widely distributed in the earth's crust. It is disseminated throughout many types of rocks and is also found in varying quantities in plants and animals. The first metal to be utilized by man in the construction of tools was probably copper, because it can be easily reduced and worked. Native copper has been found at many localities but the principal ores are carbonates, sulfides, and oxides.

There are many types of copper deposits; a few of them include: (1) Veins and replacement bodies associated with igneous intrusions; (2) disseminated deposits in igneous rocks; (3) cavity fillings and replacements in basaltic lavas; (4) disseminated deposits in sedimentary rocks; and (5) low temperature veins and replacement bodies.

Copper deposits are frequently enriched by downward percolating meteoric water, which leaches values from the deposit above the water table and concentrates them immediately below it in a zone of secondary enrichment. Many Wyoming deposits are of this type and exhaustion of the enriched zones has been, without a doubt, an important factor in closing many former mines.

No copper mines are located in Wyoming at present; however, in the interval between 1899 and 1908, 23,564,297 lbs. of copper were produced, mostly from the Encampment district, and the state was one of the leading copper producers in the nation. Copper production again increased during World War I, and 5,491,256 lbs. were produced in 1916-1918, mostly from the Hartville area (130). Since that time, copper production has been small to negligible. Total production of copper in the state between 1882 and 1942 was estimated at 28,856,729 lbs. by Thomas (553). Copper production in 1957 amounted to 48 tons from Converse County and 21 tons from Carbon County mines (613).

In order to more adequately describe conditions at the various prospects, the following discussions have been organized into districts. These are not mining districts, but merely areas of similar geology which lend themselves to a unified discussion of the several prospects.

PROSPECTS

Albany County

Jelm Mountain Area (Old Cummins City Area); secs. 10, 15, 16, 19, 20, 21, 22, 27, 28, 29, 30, 32, 33, 34, T. 13 N., R. 77 W.; secs. 4, 5. 6, T. 12 N., R. 77 W. There are many copper prospects that occur in quartz veins, shear zones, pegmatite, and gneissic bodies in this area. Minerals identified on prospect dumps include traces of malachite, cuprite, and chalcopyrite (646).

NW¼ sec. 10, T. 13 N., R. 77 W., a quartz copper vein occurs in quartz-hornblende gneiss (663).

SE¼ sec 21, T. 14 N., R. 77 W., a quartz-copper vein lies along the contact of pink aplite with pink coarse-grained granite (663).

Annie Mine. Three veins in granite contain chalcopyrite and quartz. The veins are about 150 ft. apart; one dips 60° N., the other 70° S. They average 3 ft. to 6 ft. wide, and are about 2,250 ft. to 3,000 ft. long. The granite is interlensed with "diorite" (Several early authors use "diorite" for diabase and other dark rocks) and with hornblende and tourmaline schists. Limonite, hematite, malachite and azurite stain the veins at the surface; "red talcose material" borders the veins. Some of the quartz is gold-bearing (92, pp. 57-58). Five hundred lbs. of ore from 100 ft. depth yielded 6.3% copper. A 2 ft. high-grade streak at 135 ft. depth assayed 29% copper and $2.30 gold per ton (date of prices not given) (405).

Colorado Shaft-Wyoming Queen Co. A body of chalcopyrite, with stringers of native copper was found in gneiss and schist at the bottom of a 250 ft. shaft (92, pp. 54-56).

Copper Queen; located ½ mi. southwest of the former settlement of Cummins City. A "fissure" 24 ft. thick strikes northwest and dips southwest. An 80 ft. shaft revealed chalcocite, cuprite, tenorite, and other copper sulfides. Native copper was found at the bottom of the shaft. One streak of "ore" 18 in. thick assayed 65% Cu with a little gold and lead (16, p. 8).

Pelton Creek Area (Copper Ridge district). Copper King mine located in SE¼ sec. 9, T. 12N., R. 79 W. consists of a 60-foot shaft sunk in quartz monzonite gneiss. No mineralization was observed on the dump, but the shaft was presumably driven to intersect a molybdenite- and chalcopyrite-bearing pegmatite cropping out a short distance to the northwest (670).

Esterbrook Area—Laramie Range

Big Five; SW¼ SW¼ sec. 10, T. 28 N., R. 71 W., 2,500 ft. north-northeast of the Three Cripples Mine (See GOLD). The dump near a 50 ft. shaft contained mostly pyrrhotite, with only bunches of chalcopyrite associated with quartz and feldspar (540, p. 63). Traces of sphalerite also reported (639).

Brenning Prospect; located in Tps. 28, 29 N., R. 76 W., on the line between Albany and Converse Counties. Hornblende schist contains large massive pieces of chalcocite associated with epidote (540, pp. 76-77).

Copper King; located 30 mi. southwest of Douglas on Crazy Horse Creek. Lenticular bodies of quartz 300 ft. long within schist, and a quartz vein in granite carry abundant oxidized copper minerals at the outcrop. Where the vein is widest, chalcopyrite is abundant. Two tunnels 600 ft. long were dug, and about 50 tons of ore produced (540, pp. 74-75).

Eureka Prospect; secs, 9, 16, T. 28 N., R. 71 W. A quartz vein at the contact of schist with "trap" (probably diabase) trends generally north, and is about 8 ft. to 20 ft. wide. Limonite stains the vein at the surface. Pyrrhotite masses, disseminated grains, and streaks of varying width were found at depths of less than 12 ft. Chalcopyrite is scattered through the quartz, and also in the pyrrhotite. Gold was found in the gossan (47).

Hoosier Group; located 10 mi. southwest of Esterbrook, and 8 mi. northwest of Laramie Peak, in the southeast corner of T. 28 N., R. 73 W. Narrow diabase dikes in granite on which the claims were staked trend N. 70° E. Quartz veins with the same strike contain small amounts of chalcopyrite. The Kentucky Bell shaft opened "considerable" chalcopyrite, and chalcocite (540, p. 71).

Maggie Murphy; a 107 ft. shaft was sunk on the north side of Horseshoe Creek, in the east-central part of sec. 21, T. 28 N., R. 71 W. "Rusty schist" at the surface gave way to a heavy, shallow body of pyrrhotite. A northeast trending graphite-pyrrhotite schist 1 ft. to 2 ft. thick underlies the pyrrhotite mass with a little chalcopyrite. Hornblende and quartz were mixed with pyrrhotite (540, pp. 60-61); (See PYRRHOTITE). Traces of sphalerite also reported (639).

Oriole Belt; 1 mi. northwest of the Copper King line of prospects. A shaft sunk on quartz veins associated with a diabase schist in granite revealed relations similar to the Copper King. The veins showed copper stains at the outcrop. (540, pp. 75-76).

McGhee; SW¼ sec. 10, T. 28 N., R. 71 W. Minor amounts of chalcopyrite and traces of sphalerite occur in quartz-pyrrhotite mineralized zones of north-northeast strike and vertical dip (639).

War Bonnet Group

Pyramid Vein. The War Bonnet Claims are located on a line trending northeast through T. 28 N., R. 74 W. A 30 ft. shaft was sunk on a "pyramid-shaped" vein which strikes N. 53° E. and is vertical. The rock on the dump contained 5% copper. At another nearby shaft the dump contained disseminated pyrrhotite in schist, but no copper minerals (540, pp. 72-73).

Mammoth; located 1 mi. southwest of the Pyramid on a similar schist body. A quartz vein 50 ft. wide and 2,000 ft. long cuts the schist but showed no iron stains. It contained local copper sulfides (540, p. 73).

Tenderfoot; center of sec. 3 on a line between secs. 3 and 10, T. 28 N., R. 71 W., ½ mi. east of the Esterbrook Mine. A sulfide belt not less than 2,000 ft. wide trends northeast; the outcrops are iron-stained. Schist layers and "diorite" dikes cut granite. The claim was located on a vein, near the contact of "diorite" and schist. The vein was 1 ft. to 3 ft. wide in the shaft and contained pyrite and bunches of chalcopyrite below the gossan, as well as silver and gold (540, p. 65; 55). Traces of sphalerite also reported (639).

Three Cripples Mine; (See GOLD).

Keystone-Holmes Areas, Medicine Bow Mountains

Albany mine; NE¼ sec. 10, T. 14 N., R. 79 W. A 360-foot shaft was sunk in 1903 on a west-northwest trending vein. Covellite was reported at a depth of 150 feet (626).

Blanche Prospects; located near the Rambler Mine, in sec. 32, T. 14 N., R. 79 W. Sheared "black dioritic granite" contains a small amount of quartz in gouge and in shear zones. The quartz carries hematite, limonite, and a little copper. The shaft struck copper carbonates and chalcopyrite at 120 ft. (92, p. 45; 48).

Cuprite mine; NW¼ sec. 11, T. 14 N., R. 79 W. In 1900, a 954-foot drift was driven off a 65-foot shaft located on a west-northwest-striking vein. The mineralized zone, whose width was reportedly slightly less than the width of the drift, contained native copper, cuprite, pyrite, chalcopyrite, gold and silver. The vein reportedly assayed 3 to 28% copper, a trace to 2.56 oz. per ton of gold, and a trace to 2 oz. of silver per ton. Cobalt and chromium were also reported. The vein coincides with the trend of the Albany vein (626).

Douglas mine (or Douglas Gold and Copper Co.); SE¼ sec. 9, T. 14 N., R. 79 W. This mine was originally located as the Morning Star claim in 1868 and 1871, consisted of a 150-foot inclined shaft with 80 feet of drifts and crosscuts. A mineralized zone, 7 feet wide was encountered at the 35-foot level and reportedly contained native copper, copper carbonates, chalcopyrite, chalcocite, cobaltite, and gold. Three veins, 6 inches to 2 feet, 2 to 3 feet, and one foot were reported encountered at deeper levels (9,626). The surface workings were obliterated when the present road was constructed along the west bank of Douglas Creek.

Gold Crater Group; secs. 15, 22, T. 14 N., R. 69 W., near Keystone, on a small branch of Douglas Creek. A layer of "quart diorite" which cuts "gray dioritic granite" trends east-west through the group. Small quartz veins cut the dike and the granite, and have varying strike and dip. Limonite and copper carbonates stain the quartz. A vein 10 in. to 12 in. wide in a tunnel carried bunches and spots of pyrite and chalcopyrite. The material varied in tenor, but the average was "1 ft. of $20.00 ore" (88).

Independence mine; SW¼ sec. 15, T. 14 N., R. 79 W. The prospect was originally called the Mammoth. In the early 1900's, an 80-foot shaft with 100 feet of crosscuts were driven near the intersection of an east-west quartz vein with a northwest-striking shear zone containing auriferous pyrite and chalcopyrite. One-fourth of a mile west of the shaft an eastward-driven adit encountered a chalcanthite-mineralized zone (Monarch vein?) which reportedly averaged 13.5% copper (626).

Kansas Group; sec. 12, T. 13 N., R. 79 W., on Lake Creek, about 6 mi. southeast of Keystone. A 6 ft. quartz ledge in "diorite granite" trends S. 70° E. and dips south. The ledge contains limonite and copper stains. Some samples yielded a little gold (114).

Lake Creek mines; SE¼ sec. 2, T. 13 N., R. 79 W. Copper-gold mineralization occurs in silicified mylonite seams within a broad east-west shear zone (626).

Maudem Group; SW¼ sec. 1, T. 13 N., R. 79 W., on Lake Creek, 3 mi. above its junction with Douglas Creek. Biotite and hornblende granite and gneiss, interlayered with an occasional schist lens, are cut by a quartz vein which shows heavy limonite and copper stains. The dump contained samples of chalcocite and chalcopyrite. The owners assay sheets showed "considerable gold values" (70).

Medicine Bow Mines Co.; near Holmes. A tunnel 954 ft. long cut "a number of bodies of ore, and values in cobalt, copper, and gold are reported in these ores" (92, pp. 45-47).

Rambler Mine (Holmes); near the head of Douglas Creek, just east of the Carbon-Albany county line, SW¼ sec 33, T. 15 N., R. 79 W. The mine has produced 6,080 tons of copper ore carrying platinum, palladium, gold, and silver, and was in intermittent production between 1900 and 1918 (561, p. 2). Fissures generally trend northwest and dip 40° E., though they are quite variable; they consist of "jaspilite" veinlets with limonite and hematite in "gray dioritic granite." Nuggets and dendrites of native copper were seen, as well as azurite, malachite, chrysocolla, cuprite, tenorite, and melaconite. "Quantities" of very fine-grained chalcocite contained minute specks of chalcopyrite. Covellite was quite abundant and contained 1.4 oz. per ton of platinum and palladium. Ore was found scattered through siliceous and limey gangue. Brilliant vermillion red cuprite crystals were found, sometimes reduced to native copper (92, pp. 39-41; 191, p. 97); (See SILVER, PLATINUM, PALLADIUM).

The country rock at the shaft is gneiss, weakly foliated, and jointed. A dirite dike cuts the gneiss. The minerals seem to be localized only on the footwall side of a fissure, and U. S. Bureau of Mines engineers think the ore is independent of the fissure veins. They suggest that any ore bodies found will dip west, in an area west of the present workings (561).

Rosebud Claim; located on Muddy Creek, about 1½ mi. southwest of Tenderfoot Mountain. Material found in a 55 ft. vertical shaft assayed a maximum of 50% copper and 1 oz. silver per ton (9).

Southern Laramie Range

Bartlett Copper King; sec. 24, T. 14 N., R. 70 W., 22 mi. west of Cheyenne. The material assayed about 3% copper, and one return gave $28.00 per ton (priced prior to 1932) (217).

Bucaneer Group; sec. 10, T. 12 N., R. 71 W., 6 mi. south of Sherman. An 8 ft. vein of quartz cuts red granite and crops out for several hundred feet. The granite is associated with "diorite dikes," schists, and gneiss, all of which are crushed and broken. Locally the quartz outcrop contains malchite and azurite, and some masses of "iron and copper sulphide ores." This prospect is a part of the Portland Group (94).

Copper Float Group (Tie Siding); SW¼ sec. 29, T. 13 N., R. 72 W. Native copper was found in surface mantle, which led to the original prospecting. The contact of red granite and limestone localized copper. A "bed of conglomerate of fine quartz, etc." lies at or near the contact, and varying amounts of copper carbonates and native copper impregnate the entire contact. The contact dips N. 45° E. (97).

King Solomon Claim; NE¼ sec. 15, T. 12 N., R. 73 W. "Copper stains" and a small amount of native copper impregnate arkose between pre-Cambrian granite and the Casper formation (171, p. 67).

Strong Mine; sec. 4, T. 16 N., R. 71 W., sec. 32, T. 17 N., R. 71 W., near the head of Horse Creek. The mineral deposit is associated with "diorite and gabbro dikes," and layers of gneiss and schist in red granite and anorthosite. At the mine the dikes and granite are fractured, and quartz fills the fractures. Limonite, hematite, azurite, and malachite stain the quartz outcrops. The veins also contain a small amount of native copper and sulfides. In the upper level, the chief minerals were copper carbonates, with a lesser amount of chrysocolla, cuprite, and native copper. Below this level the ores were chalcopyrite and bornite, with some chalcocite. The vein is 6 ft. wide at the surface, and 14 ft. wide at 50 ft. depth; it dips east above the 150 ft. level and west below this level.

The bottom of the shaft in 1907 was in gabbro which contained disseminated minerals. The mineral vein was 7 ft. 8 in. wide on the 100 ft. level; on the 150 ft. level the width varied from 1 ft. to 9 ft. The south drift on the 250 ft. level cut 125 ft. of a crushed quartz vein which contained chalcocite, bornite, and chalcopyrite. Another drift showed (in 1907) a face of 30 ft. of bunches, streaks, and masses of chalcopyrite in a "cross-vein." In the north drift, about 15 ft. of chalcopyrite apparently replaced granite. Assays for gold and silver were higher in the north drift than elsewhere. Streaks and spots of chalcocite were found in the north drift on the 350 ft. level; a "high-grade streak" was 10 in. wide. Minute quantities of molybdenum and lead were also found on this level (93).

In 1943, the mine was reopened under a Reconstruction Finance Corp. loan (217; 557; 243), apparently for scheelite. According to M. L. Trover (personal communication, 1946) small amounts of scheelite are localized at the intersections of granite dikes in anorthosite. Scheelite was discovered on the 350 ft. level, and a shipment of 100 tons made to the Metals Reserve Company stockpile (234). Assays of ore shipped to Boulder Tungsten Mills, Boulder, Colorado, are given below (249):

Date	Weight	Type	Value	Description
12/4/43	10,650 lbs.	crude	0.44% WO_3	
12/4/43	16,660	crude	0.49	
12/8/43	10,250	coarse	0.44	
12/8/43	14,940	coarse	0.49	
12/10/43	11,980	fines	0.44	
4/13/43			0.25% WO_3	Hole south of shaft
4/13/43			Trace Au, Ag, MoO_3 and 0.28% Cu	From Dump
5/8/43			0.20 WO_3, 0.31 Cu	Tailings
7/3/43			0.53 WO_3	First lot from mine
12/23/43			Coarse 0.49 WO_3, fines 0.44 WO_3	

The mine was closed in 1944 and has not reopened.

Beeler (124, p. 5) gives the following list of assays, made by W. C. Knight, University of Wyoming:

No.	Depth	Gold	Silver	Copper
1	9 ft.	0.68 oz.	0.88 oz.	19.03 %
2	9	T	7.86	19.85
3	11	T	13.72	5.08
4	11	0.01	3.20	13.33
5	13	0.04	6.86	38.81
6	15	T	7.70	32.91
7	15	T	T	43.12
8	15	T	4.00	35.48
9	21	0.08	3.68	7.55
10	25	T	5.30	19.93
11	25	T	5.10	39.96
12	26	T	5.40	34.76
13	28	0.04	6.76	30.37
14	38	0.16	3.60	20.56
15	49	0.18	3.50	51.56
16	50 (12' in crosscut)	T	2.90	16.02
17	50 (14' in crosscut)			22.00
18	54	T	2.50	25.26
19	58	T	T	26.02
20	58	T	3.70	26.24
21	58	T	2.95	36.82
22	80			68.00
23	80			68.50
24	85			26.64
25	85			45.50
26	90			20.50
27	92			29.50
28	100 (12' in drift)			22.80
29	100 (12' in drift)			42.00

These assays show a high percentage of copper; but as suggested by Beeler, they probably represent picked specimens, and are not true samples of the ore values.

Sherman Group; Sec. 23, T .13 N., R. 71 W. Quartz veins at the contacts of gneiss, schist, "diorite" and gabbro have been weakly mineralized. The limonite-stained veins near the surface assayed up to $2.00 per ton in gold (1907 prices). A shaft 75 ft. deep showed 2 ft. of quartz with disseminated copper sulfides. Three-hundred feet south of the shaft is an iron-stained "gabbro-diorite" dike 25 ft. wide (112).

Ulcahoma; near the Strong Mine; (See GOLD).

Wyoming Copper Co.—Percis Claims, 4 claims located in sec. 1, T. 18 N., R. 73 W., and 2 claims in sec. 12, T. 18 N., R. 73 W., near the mouth of Wallrock Canyon. Malachite, chalcocite, and cuprite replaced chert in the Casper limestone and are very erratic and spotty. A small amount of ore was prouced prior to 1942 (292).

In secs. 10, 15, and 22, T. 16 N., R. 72 W., small amounts of copper mineralization are found in limestone of the Casper formation. The mineralized bodies are small irregular replacement veins lining fractures. Chief minerals are malachite, chalcocite, chrysocolla, brochanite, and bornite. Mineralization appears to pinch out at shallow depth (598).

Carbon County

Ferris Mountains

Cherry Creek Prospect. This prospect occurs in pre-Cambrian biotite granite in sec. 26, T. 27 N., R. 88 W. A mineralized quartz vein within the granite strikes north and dips 80° east. The vein varies from 6 to 18 in. wide. Malachite is the most abundant mineral and occurs as coatings on fracture surfaces of the quartz. Scheelite, chalcopyrite, pyrite, and allanite also occur in the vein (605).

Medicine Bow Mountains

Cumberland Group; near the head of South Fork of Lake Creek, on the south end of Coad Mountain, 14 mi. east of Saratoga. A series of quartz-biotite schists, hornblende schists, and tourmaline-garnet-mica schists dip 15° NW. A quartz vein 15 ft. wide conforms to the schist and contains limonite and malachite stains, with some chalcocite. The quartz contains a little gold and silver. Most of the vein is crushed and broken (62).

Elk Mountain Mining and Milling Co.; secs. 22, 23, and 28, T. 19 N., R. 82 W. The vein is one of a series of north-trending fractures in limestone. The vein consists of up to 2 ft. of limestone breccia; the iron, copper oxides and copper carbonate are disseminated through it, though some copper minerals are found in the adjacent limestone. Bunches and streaks of gold- and siver-bearing chalcocite vary from mere specks to masses weighing several hundred pounds (92, pp. 53-54; 46). Along the north side of Pass Creek, bunches of chalcocite are scattered along the contact of "upper Carboniferous limestone" (Madison) and pre-Cambrian schist and granite. Chalcopyrite lies below the chalcocite (46).

Fox Group; Cooper Hill. A 70 ft. shaft was sunk on a 12 ft. "body" of sulfide-bearing rock. "Black sulfides" and a thin layer of tellerium were found at the bottom of the shaft. Some samples assayed $24.00 to $52.00 of gold per ton (1896 prices) (8, pp. 13-14).

Hamilton Group; sec. 36, T. 14 N., R. 80 W., near Devils Gate, about 6 mi. southwest of Keystone. A "huge ledge of altered diorite" 2 mi. long trends east, and is in contact with limonite, malachite, and azurite stained quartz veins (113).

Raven Group; secs. 15, 21, 22, T. 14 N., R. 80 W., on Iron Creek, a tributary to French Creek, 25 mi. east of Encampment. Siliceous material with much limonite and hematite separates altered schist and quartzite. The schist is largely replaced by silica, and quartzite is iron-stained. The belt of siliceous material trends northeast; is 2 mi. long and 30 ft. to 70 ft. wide, and contains specks of copper minerals (64).

A shaft was sunk (115) which passed through the oxidized zone. The primary minerals in the siliceous rock were pyrrhotite, and a little chalcopyrite. The "vein" showed about 5 ft. of quartz and pyrrhotite, with a lesser amount of the same minerals impregnating the schist 20 ft. south of the shaft.

Waterloo Prospect; southeast part of T. 16 N., R. 80 W., near the Carbon-Albany County line, on the headwaters of French Creek. A badly crushed northeast-trending quartz vein in mica schist includes pieces of schist. There is a hard clay-like gouge on the north side of the vein. The schist is interlayered with granite and quartzite. Limonite stains are common in the vein, as well as copper carbonate stains and small "bunches" of sulfides. The quartz contains a little gold (51).

SW¼ sec. 35, T. 15 N., R. 80 W. Poorly exposed copper veins occur in pre-Cambrian granite. As exposed in several trenches, the veins strike a few degrees north of west, are essentially vertical ,and vary from one to 3 feet wide. In one vein, the mineralized zone consisted of malachite, azurite, and chrysocolla (?) within a width of 2 to 6 inches (659).

NW¼ sec. 5, T. 18 N., R. 78 W. Malachite-impregnated quartzite occurs on the dump of a caved adit (647).

Seminoe Mountains

Junk Creek Mines; sec. 20, T. 26 N., R. 85 W. Malachite, bornite, and chalcopyrite occur as fracture fillings and coatings in a brecciated quartz vein and altered amphibole schist exposed in a near-vertical shaft. About 650 feet southwest of the above shaft is a caved prospect where malachite, bornite, and covellite occur as fracture coatings in altered granite (619).

Long Creek area; sec. 26 (?), T. 26 N., R. 85 W. Abundant malachite, bornite, chalcopyrite, and chrysocolla occur on the dump of a caved shaft which was driven into a fault in altered amphibole schist. Native copper has been reported from this prospect. X-ray fluorescence analysis of samples from this prospect indicates lead, gold, silver, uranium, and iron, as well as copper (619).

Sec. 32, T. 26 N., R. 85 W. Malachite, chrysocolla, bornite, and chalcopyrite occur in 3 prospects that are located in a quartz vein in amphibole schist (619).

Sec. 29, T. 26 N., R. 85 W. Several copper prospects occur in a massive quartz vein emplaced in a fault zone in amphibole schist. Malachite and chrysocolla occur as fracture fillings and coatings in the vein (619).

Sierra Madre

Alma Property; on the divide between Spring Creek and South Spring Creek, ½ mi. beyond the boundary of the Encampment Quadrangle map, southwest of the Meta Mine. A quartz vein 18 in. thick trends east-northeast, dips 40° to 60° N., and cuts black schist, diorite, quartzite, and alaskite dikes. The vein contains galena, chalcopyrite, and siderite (539, p. 99).

Batchelder Mine; sec. 18, T. 14 N., R. 86 W., near Dillon. A series of quartzite, schist, and diorite layers strikes east-west. The rock is replaced by "lime and silica" near the "gabbro-schist" contact, and "lime and silica" fill a few fissures. "Copper sulfide rock" in a drift from the bottom of a 100 ft. shaft dipped north, while at the surface the rocks dip south (Beeler's description of this relationship is rather confused; the ore may lie in a syncline).

The sulfides are enclosed in a quartz vein which varies in width from very narrow to 10 ft. (85).

Beulah Prospect; one mile north of Battle. Altered schists of varying composition strike east-west, dip 45° to 50° N., and contain bands and stringers of quartz. A tunnel cut 15 ft. of malachite stained quartzite which contained iron and copper sulfides in spots and streaks. "Altered diorite" contained a layer of light-colored "siliceous lime material" with "iron and copper sulfides" at intervals (36).

Big Chief Group; sec. 18, T. 14 N., R. 85 W., and secs. 13, 24, T. 14 N., R. 86 W., on Bridger Mountain. Quartz veins, stained by copper carbonates cut schists and diorite. The largest (?) vein is about 15 ft. wide, and has a 4 in. to 5 in. gouge zone on the south wall; the heaviest mineralization was in a streak about 1 ft. wide next to the gouge. The schists strike east-west and dip from 45° S. to vertically (45).

Big Creek Mine; on Big Creek, southeast of Encampment, on the Platt Ranch. A "pegmatite vein," probably quartz, contains chalcocite, baronite. Chalcopyrite, and azurite, and an occasional phantom smoky quartz crystal. Crystalized garnets have been found "a short distance up the hill" (498).

Bonita Prospect; secs. 25, and 26, T. 15 N., R. 85 W. Quartz veins cut micaceous schist and red granite. One vein 2 in. to 8 in. thick has limonite, hematite, malachite, and a small amount of gold (38).

Bridger Mine; on the Continental Divide, several miles north of the Sierra Madre. The country rock is quartzite and diorite (meatgabbro) which is schistose in many places. Many outcrops exhibit quartz veins which contain sulfide minerals. These veins strike northwest and dip 25° to 55° SW. The richest ore-bearing rock is near the surface, and consists of galena and chalcocite. Tellurium and selenium were also found (593, pp. 99-100).

Cascade Mine; east side of the Encampment River, near the mouth of Cascade Creek. A large pegmatite which strikes N. 20° W., and dips south, parallels the enclosing complex of sheeted granite and diorite. Copper sulfides are distributed throughout the pegmatite but the greatest amounts of sulfides are localized near the footwall. Sulfides are partly later than other minerals, as they crystallized after the pegmatite was fractured (539, pp. 96-97).

Century Group; secs. 32, and 33, T. 13 N., R. 85 W., on Harrison Creek, 7 mi. south of Battle. A 50 ft. shaft was sunk in altered hornblende schist and diorite which contained hematite with bornite and chalcopyrite. The schist strikes northwest and stands vertically. A gossan, containing copper carbonates, limonite and hematite, quartz and schist fragments overlies the protore (116).

Charter Oak; sec. 24, T. 15 N., R. 85 W., 6½ mi. northwest of Encampment. the country rocks are gneissis to schistose granite and metamorphosed basic rocks similar to gabbros which have the composition of diorite. The prospect is located in a quartz vein on the east side of a broad syncline. Near the prospect, the rocks are twisted and faulted. The vein quartz contains varying amounts of iron and copper minerals, and sufides impregnate the fractured wall rock. The primary mineral is chalcopyrite. Secondary minerals include chalcocite, bornite, azurite, hematite, and limonite (539, pp. 82-85).

The vein strikes north, and dips west. Ore-bearing rock crops out for 2 mi.; the width varies from 14 ft. at the shaft to 100 ft. elsewhere. Siderite is scattered throughout the vein. An open cut near the top of the Puzzler Hill shows a "huge ledge of mineralized diorite" which is stained by copper carbonates and limonite (98).

Colorado Belle Group; on Miner Creek, 4 mi. south of Encampment. Very fine-grained schists and slates trend northwest. Miner Creek follows a fault fissure, which contains a very small amount of copper minerals (99).

Continental Group; sec. 18, T. 14 N., R. 85 W., on Cow Creek, 12 mi. west of Encampment. "Diorite" dikes cut a series of northeast striking schists and conglomerates which dip at a low angle. Quartz veins which show copper carbonates and limonite cut dikes and country rocks (121).

Copper Gem Prospect; on Dunkard Creek, in Purgatory Gulch, 8 mi. from Encampment. An incline was dug on a gouge zone, which varies from 1 in. to more than 1 ft. wide, in granite and micaceous schist. The gouge is spotted with malachite, and contains hematite and a little gold (39). A quartz vein 1 ft. to 2 ft. wide in schist was followed by a 358 ft. shaft. Within the vein there were small specks and streaks of chalcocite and chalcopyrite. Black graphite schist north of the vein contains scattered grains of sulfides (65).

Copper Rock Group; secs. 27, 28, T. 14 N., R. 85 W., 8 mi. west of Encampment. Schists, slates and quartzites cut by "gabbro (diorite) dike" strike east-west and dip 45° S., though there are local variations. Limonite and copper stains are visible in the outcrop. Limonite and hematite were found at various depths in the three shafts; copper sulfides were found in the middle shaft (87).

Cox Mine; near Encampment. Assays showed 2.3% copper to 74.5% copper, plus a little silver and gold (217).

Creede Property; 2 mi. northwest of Bridger Peak, about ¼ mi. east of the road from the Rudefaha Mine (Ferris-Haggerty) to Saratoga. The contact of intrusive norite with coarse-grained hornblende schist, localized magnetite and pyrrhotite-bearing copper, nickel, and cobalt, with lesser chalcopyrite. The schists strike east-west and dip south (539, pp. 54, 86).

D and L Group; secs. 27, 28, T. 14 N., R. 85 W., 2 mi. east of Battle. Small pockets of chalcocite and considerable hematite lie beneath a gossan (86).

Doane-Rambler Mine; sec. 24, T. 14 N., R. 86 W. or in sec 30, T. 14 N., R. 85 W., near the old town of Rambler. Near the mine the country rocks are pre-Cambrian quartzite and diorite which are not interlayered. The stratified rocks strike east-west and dip 65° to 75° N., opposite to the usual dip of metasediments in the Sierra Madre. The intersections of fracture planes with bedding in quartzite have localized chalcopyrite, bornite, chalcocite, and a little covellite. The fractures strike north and dip steeply west. Sulfides fill fractures and zones of brecciation in quartzite. The outcrop of the ore zone is stained at the surface by limonite, malachite, azurite, and chrysocolla (539, pp. 61-71).

Dreamland King Group; secs. 1 and 2, T. 14 N., R. 86 W., on South Spring Creek, 3 mi. northeast of Dillon. Parallel layers of quartzite and schist, interlayered with an occasional lens of gabbro, strike east-west and dip south. Limonite, malachite, and azurite stain a quartz vein which cuts schist and gabbro; the vein contains a little pyrite. The gossan and the pyrite contain a little gold (83).

Ferris-Haggarty Mine; 2 mi. west of Bridger Peak on the east side of Haggarty Creek near the center of sec. 16, T. 14 N., R. 86 W. The metasediments strike east-west and dip 35° to 50° S. The ore-body is overlain by 35 ft. of gossan. The gossan contained kernels and bunches of sulfide minerals below 35 ft. depth. The ore, mostly chalcocite and chalcopyrite with lesser bornite and covellite, was found at the contact of quartzite and a hanging wall of schist. The ore-body was a lens-shaped mass, with projections along north-south fractures into quartzite. Chalcopyrite, the primary ore, was secondarily enriched near the surface. The ore-body was about 250 ft. to 300 ft. long, and was opened to a depth of about 300 ft. (1903). The thickness varied from a few inches up to 30 ft. (539, pp. 72-82).

Gertrude Mine; 1 mi. east of Battle, on the Encampment road. A quartz vein in altered schist dips south at varying angles (average about 45°) and strikes east-west. It contains much hematite, some of which is specular, and occasional specks and stains of copper minerals. Occasionally "lime" substituted for quartz in the vein (35).

Gibraltar Copper Mining Co.; claims called the *Express Nos.* 1 *to* 6, 18 mi. southeast of Encampment on the north and west sides of Big Creek. Granite contains a broad belt of mica schist, which in turn contains quartz stringers and veins. The rocks strike east-west, and dip gently north. A vein showed limonite and hematite stains, with a lesser amount of malachite and azurite, and a small amount of native copper in a 53 ft. shaft. At a slight depth pyrrhotite, bornite, chalcopyrite, and a little covellite were found. The minerals were scattered at intervals through a vein 1 ft. to 2 ft. wide. The shaft bottomed in barren quartz (59).

Gold Coin Prospect; SW¼ sec 11, T. 15 N., R. 87 W. The claim was located south of the Bridger Property on the Continental Divide, several miles north of the Sierra Madre. A quartz and calcite vein 1 ft. wide contained bunches of galena, pyrite, and chalcopyrite, as well as some silver and gold. The minerals filled a fissure striking N. 75° E., and dipping steeply south, cutting across the schistocity of "black diorite" (539, pp. 100-101); (See LEAD).

Hidden Treasure Tunnel; sec. 28, T. 14 N., R. 85 W., 1 mi. east of the old town of Battle, and ½ mi. from the Gertrude Claim. A vein strikes N. 70° E. and dips steeply south. The country rock is schist, quartz schist, quartzite, and altered diorite, all of which are mashed and brecciated; they strike northeast and dip south. The vein was found near the center of an intrusive diorite mass in quartzite. The rocks were mineralized at many places, but the introduction was probably earlier than the crushing. The vein contains mostly chalcopyrite, chalcocite, malachite, and a small amount of specular hematite in a gangue of quartz, calcite, siderite, and a lesser feldspar (539, pp. 93-94).

Hinton Mine; sec. 32, T. 13 N., R. 85 W., 7 mi. south of the old town of Battle. Chalcopyrite and magnetite were found in a zone of hornblende schist which contained much garnet and epidote beneath a shallow gossan of spongy iron oxides and iron-stained garnets. The silicate minerals interlock with chalcopyrite and magnetite, and all probably crystallized at the same time. An analyzed sample contained 8.18% copper, $00.40 per ton in gold (1906 prices) (539, p. 53, 98).

Independence Group; located somewhere in secs. 11, 12, 13, and 14, T. 12 N., R. 86 W., about 14 mi. from the old town of Battle, and near the Colorado-Wyoming state line. A quartz vein at the contact between diorite and schist strikes N. 60° W., and dips 60° SW. Limonite stained the vein in the upper part, which contained a little gold and silver. The diorite footwall contained pyrite and chalcopyrite (90).

Iron King Prospect; sec. 15, T. 14 N., R. 85 W., 3 mi. north of the old town of Battle, on Cow Creek. A quarz vein 15 ft. wide at the surface strikes northeast and dips 30° S. It contains copper and iron oxide minerals at the surface, and sulfides at depth. The vein cut altered schist and "diorite dykes" (37).

Island City Group; (See PYRRHOTITE).

Itmay Mine; sec. 14, T. 13 N., R. 85 W., near the head of Roaring Fork and south of Huston Park. Chalcopyrite is localized along the walls of an altered basic dike intruded into quartz diorite. The dike, about 10 ft. wide, trends N. 70° E. and dips steeply south; much of it is impregnated with sulfides.

Along the hanging wall, the sulfide streak was 3 in. to 10 in. wide. Three feet of chalcopyrite crop out at the surface. An analyzed dump sample contained 17.92% copper and $1.00 per ton of gold (1906 prices) (539, p. 97).

King of the Camp Prospect; sec. 36, T. 14 N., R. 83 W., about 5 mi. south of Encampment, on the South Fork of Encampment River. A 5 ft. quartz vein cuts mica schist, trends northeast and dips 45° NW. at the outcrop. In the shaft, the dip of the quartz vein is 20° NW. The quartz was stained with iron oxides and contained pyrite and chalcopyrite below the oxidized zone. Traces of azurite and malachite were scattered through the vein. "This vein carries gold in varying quantity . . .." (60). The tunnel cut many faults, and the country rocks are crushed and broken. Six quartz veins from 2 ft. to 4 ft. wide were cut during the tunneling. The quartz was stained with iron oxides, and contained streaks and bunches of iron sulfides and copper sulfides; some of which weighed many pounds. A 15 ft. vein was cut by a shaft at a depth of 100 ft. and yielded $4.00 to $6.00 per ton of gold (1904 prices) (69).

Newton Group; secs. 13, 24, T. 14 N., R. 85 W., and secs. 18, 19, T. 14 N., R. 84 W., 6 mi. from Encampment. The claims were located on an east-west trending layer of "'diorite' or gabbro" lying between a bed of conglomerate to the south, and quartzite schists to the north. On the Copper Queen claims, a 140 ft. shaft followed a quartz vein in the " 'diorite' or gabbro." The vein contained much limonite, hematite, cuprite, malachite, azurite, and chrysocolla near the surface. Hematite and limonite stains impregnated the quartz. At depth, chalcopyrite, bornite, and chalcocite were found (91).

North Fork Group; sec. 13, T. 12 N., R. 86 W., 14 mi. south of Battle. A dike of granite and "diorite" strikes northwest and dips northeast; it is cut by a quartz vein which strikes N. 45° W., and dips 70° NE. The vein is 6 in. to 26 in. wide at a depth of 160 ft. Near the surface, limonite, malachite, and azurite were associated with the quartz; the vein contained pyrite and chalcopyrite at depth. Another vein cut the first; it strikes N. 88° E. and dips north. This vein, up to 23 ft. wide, consisted of stringers of quartz and country rock, and contained mostly pyrite and chalcopyrite with a little galena. The galena contained 600 oz. of silver per ton. Assays of the oxidized ores showed 33 oz. and 73 oz. of gold per ton. An average of the "workable ore" gave $36.39 per ton in gold, silver, and lead (1905 prices). Trial shipments averaged $42.00 per ton in all metals. The material also contained a little zinc (89).

Octavia Prospect; west Fork of Savery Creek, about 5 mi. west of the old town of Battle. A quartz vein strikes northwest and dips 30° SW., cutting a limy, altered schist. The quartz contains occasional calcite crystals, in addition to specks and small streaks of pyrite and chalcopyrite, limonite, hematite, and malachite. The minerals were isolated in bunches and were not continuous (34).

Kurtze-Chatterton Mine; on Copper Creek, 5 mi. west of Encampment. Several veins 3 ft. to 10 ft.wide strike "north of west," and dip steeply north, cutting chlorite schist which is also cut by granite dikes. The schist lies between granite and quartzite; the quartzite strikes east-west, the schist more "northerly." Near the surface the veins contain chalcocite, but chalcopyrite was found in a tunnel. The vein contained mostly quartz and some feldspar (539, p. 95).

Leighton-Gentry Prospect; near the Continental Divide, at the head of Jack Creek. At the surface a 3 in. gossan was found; below it 4 ft. of black, crumbly mica schist. The schist was underlain by a norite sill, which overlay a limy quartzite 11 ft. thick. Pyrite, pyrrhotite, and chalcopyrite were found along bedding planes and disseminated through the limy quartzite. Limestone below the quartzite contained no sulfides. The rocks strike N. 80° W., and dip 30° S.

An assay showed 3.07% copper, 0.67% nickel and cobalt, and a trace of zinc. The mineral occurrence is similar to the Ferris-Haggarty (539, pp. 87-88).

Lena Shields Group; sec. 12, T. 14 N., R. 86 W., near the head of the main fork of Cow Creek. A series of fine-grained micaceous schists and dikes of "diorite" are fractured, fissured, and altered in many places. A quartz vein strikes N. 70° W. and with interlaminated schist, make an aggregate thickness of 5 ft. to 15 ft. The vein contains limonite, azurite, malachite, and pyrite at the surface (54).

Mohawk Prospect; NW¼ sec. 20, NW¼ sec. 35, T. 14 N., R. 85 W. At the contact between granite and altered schist, some brown iron-stained, siliceous, and limy material occasionally contains a little malachite (49).

Portland and Hercules Mines; sec. 29, T. 14 N., R. 85 W., ½ mi. south of the old town of Battle, a short distance from the top of the range. The country rock is red granite to the south, and massive pre-Cambrian quartzite to the north, with limestones, and red shales intruded by basic igneous rocks (metamorphosed to chlorite schist) between the granite and quartzite. The metasediments strike east-west; they are faulted against the granite. The schists strike N. 65° E. and dip north. Some rich chalcocite was found near the surface, but in depth, only a small amount of scattered chalcopyrite impregnated the limestone (539, pp. 90-92).

Standard Mine; NE¼ sec. 13, T. 13 N., R. 86 W. Samples from a large dump near a water-filled shaft are dark, fine-grained rocks containing pyrite, chalcopyrite, and traces of bornite. The original rock type is unknown, but large mafic inclusions and mafic dikes crop out in the area (650).

Sun Anchor and Sweet Claims; located on a "zone of metamorphism" in a series of east-west trending hornblende schists along the north face of Green Mountain which cross the south branch of "North Fork." The zone contains an appreciable amount of epidote, and small bright red garnets, with a little magnetite and chalcopyrite (539, pp. 94-95).

Syndicate Property; sec. 26, T. 15 N., R. 87 W., near the head of a tributary of Savery River, near the crest of a ridge which continues northwest from a bend in the Continental Divide toward Dexter Peak. Pre-Cambrian quartzite strikes east-west and dips south. A calcite vein crosses the bedding in irregular fissures, and a diorite sill 150 ft. wide crops out 30 ft. south of the shaft. The vein strikes east-west, dips south more steeply than the bedding, and consists of calcite filling a brecciated zone in quartzite. Small grains of chalcocite are disseminated through the calcite, and some is found in quartzite fragments (539, pp. 88-89).

Tennant Property; sec. 22, T. 14 N., R. 84 W., 4 mi. from Encampment. A fissure vein about 6 ft. wide contains copper and a small quantity of gold. Six tons of ore from the claim netted $400.00 (copper at $0.20 per lb.) (227).

Three Forks Group; located somewhere in secs. 11, 12, 13, 14, T. 12 N., R. 86 W., about 14 mi. from the old town of Battle. Smoky quartz veins in schist contain a small amount of copper minerals and some lead and zinc. The veins contain hematite near the surface; the quartz and hematite contain gold. The galena is argentiferous, and some cerargyrite is present (90).

Umslopagus Group; secs. 19 and 30, T. 14 N., R. 85 W., near the old town of Rambler. A series of schists and quartzites are cut by dikes of "diorite or gabbro," and all strike northwest. A 9 ft. to 22 ft. limonite zone lies between hanging wall schist and footwall quartzite. Malachite and azurite are associated with the limonite. Copper sulfides were found below the gossan (82).

SW¼ sec 9, T. 12 N., R. 84 W. Malachite occurs at the intersection (contact?) of amphibolite and pegmatite. Two shafts have been sunk here (657).

Sec. 24, T. 14 N., R. 84 W. A caved shaft driven on the contact of a quartz vein in amphibolite shows bornite and minor chalcopyrite on the dump (634).

NE¼ sec 20, T. 14 N., R. 83 W. A 40-foot shaft sunk into an orthoamphibolite dike cut by a quartz-feldspar vein, 8 to 18 inches wide shows chalcopyrite and minor bornite near the contact. Most of mineralization occurs in fractures (634).

SW¼ sec. 24, T. 14 N., R. 84 W. Chalcanthite encrustations occur on the walls and back of an adit driven in gneiss in contact with an orthoamphibolite dike (634).

SE¼ sec. 28, T. 14 N., R. 83 W. Crusts and stains of malachite occur on quartz and amphibolite fragments in a prospect pit (634).

Converse County

Northern Laramie Range

Cottonwood Creek Prospects; T. 32 N., R. 74 W., 12 mi. west and a little south of Douglas, and northwest of La Prele reservoir. A sandstone bed 20 ft. to 40 ft. thick overlies black and green pre-Cambrian schists, and is overlain by a massive limestone bed. The sediments, probably of the Cambrian Deadwood formation, dip north-northeast and are broken by a north-south trending fault along Cottonwood Creek. The vertical displacement on the fault is about 100 ft., and the eastern block is downthrown. Shallow workings revealed malachite, azurite, and chalcocite within 50 ft. of the fault (540, pp. 79-81).

French Joe Prospect; in French Joe Park, on West La Bonte Creek. A schist lens in granite encloses a series of northeast trending quartz stringers. The stringers enclose pieces of schist and contain limonite stains, some malachite, and azurite, together with small amounts of pyrite and copper sulfides (56).

Hazenville Prospects; T. 32 N., R. 73 W., 2 mi. east of La Prele reservoir. About 1900 a shaft and tunnel opened a small copper-bearing quartz vein in black schist (540, p. 81).

Hoosier Boy Group; 15 mi. northwest of Laramie Peak, and 30 mi. from Douglas, A red granite contains layers of schist and dikes of "diorite." A "ledge" (probably a quarz vein) contains limonite, hematite, malachite, azurite, and chalcopyrite (72).

Horace Greeley Group; about 18 mi. southwest of Douglas, on a branch of La Prele Creek. Broad, interlayered lenses of granite, gneiss, and schist strike north-south and are cut by "diorite dykes" and quartz veins. A vein in the tunnel varied from 1 ft. to 2 ft. in width and had considerable iron oxide and lesser "copper stains." Locally the rocks are sheared (58).

Jasper Mine (Douglas District). Malachite, azurite, and cuprite constitute fracture fillings and replacement bodies near the top of the Cambrian Deadwood formation, on the west side of a hill. The Cambrian rocks underlie the Madison limestone, which dips 26° N. The old workings produced eleven carloads of copper ore during World War I. Beryl was also produced, probably from a nearby pre-Cambrian pegmatite. The pegmatite also contains mica, tantalum, garnet, lepidolite, and bismuth (311).

Kreisley Prospect; SW¼ sec. 35, T. 29 N., R. 71 W. Minor amounts of chalcopyrite and traces of sphalerite occur in pyrrhotite-quartz veins in north-northeast striking mineralized zones of vertical dip (639).

Maverick group; secs. 22, 23, T. 29 N., R. 71 W. Red granite contains occasional schist and gneiss layers, and is cut by "diorite dikes." Quartz veins cut all rocks. One quartz vein, 2 ft. to 6 ft. wide, contains limonite stains, a small amount of malachite, and a few "kidneys" of chalcopyrite. In the shaft, iron-stained mica schist borders the vein walls (78).

Oriole Group; sec. 10, T. 29 N., R. 75 W., near the head of La Prele Creek, 30 mi. northwest of Laramie Peak. Red granite contains layers of schist, gneiss, and other rocks. Quartz veins and "dykes of diorite" cut the schists, and occasionally are altered and replaced by limonite and copper and iron sulfides. Copper carbonates stain some of the veins. Chalcopyrite was encountered at 75 ft. (73).

Perry Claim; 8 claims centering in NE cor. sec. 33, T. 29 N., R. 76 W. Schistose dikes and several vein-like bodies of quartz cut pre-Cambrian granite, but are not metalliferous (540, p. 77).

Saul's Camp (Esterbrook Area); NE¼ SE¼ sec. 22, T. 29 N., R. 71 W. Hornblende schist and an altered diabase dike strike N. 45° E. The gossan contained cerrusite and chalcocite. A little pyrite and chalcocite were found in the shafts and drifts (540, pp. 66-67).

Snowbird Group; NW¼ NE¼ sec. 21, T. 29 N., R. 71 W., on the north slope of Elkhorn Mountain, east of La Bonte Creek. Red granite contains two narrow greenish schist layers that are probably sheared diabase dikes. The schist strikes north-south and is 150 ft. wide at the workings. Quartz veins 6 ft. to 8 ft. wide in the schist contain limonite, specular hematite, spots of copper carbonates, and some gold. Pyrite and chalcopyrite with some carbonates filled fractures, seams, and gouge zones in the quartz and schist at the bottom of a 75 ft. shaft (540, pp. 68-69; 117).

Swede Boy Vein; T. 31 N., R. 76 W., 16 mi. south of Glenrock and 4 mi. southwest of Boxelder, between Boxelder Creek and Deer Creek. A quartz vein in granite strikes N. 5° W., and dips 60° E. Some ore was shipped from an inclined shaft on the vein (540, p. 77).

Trail Creek Group; NW¼ SE¼ sec. 10, T. 29 N., R. 71 W., about 25 mi. south of Douglas, near the head of Trail Creek. Interlayered granites and schists strike northeast and dip gently northwest. The granite is very siliceous, and "often grades to quartz veins." Dikes of "dioritic rocks" are conformable to the granites and schists. The quartz veins contain limonite, hematite, and schist inclusions, and are fractured. Locally the veins show masses of azurite and malachite, and small amounts of copper and iron sulfides (57). Spencer (540, pp. 70-71) reported malachite and chalcocite on the outcrops, but found little mineralization in the tunnel.

Crook County

Copper Prince Mine; located approximately 8 mi. northwest of Sundance, in the Bear Lodge Mountains, a short distance north of the Hutchins Claims. The dump material contains malachite and chrysocolla, with scattered small particles of native gold (380); (See GOLD).

Fremont County

Atlantic City-South Pass District

Anderson Ridge area; NW¼ NW¼ sec. 17, T. 28 N., R. 101 W. A few truck loads of copper were mined from a prospect located in pre-Cambrian granite. Malachite occurs in fractures in granite (678).

Mechanic and Emerald Lodes; located about ½ mi. northeast of Atlantic City. Hornblende schist dips north and strikes northeast. A quartz vein cuts the schist, and contains pyrite and chalcopyrite. Copper carbonates crop out 1,000 ft. west of the shaft (118).

Overland District; located 35 mi. south of Lander. Quartz veins and trachyte dikes cut basaltic dikes and other volcanic rocks; all are probably of pre-Cambrian age. The veins contain copper sulfides, carbonates, and oxides. Assays showed 5% to 54% copper, $85.00 to $975.00 per ton of gold (1913 prices), and variable amounts of silver (392).

Wyoming Copper Mining Co.; located about 1 mi. west of South Pass. A quartz vein in schist contained 4% to 16% copper, $2.00 to $10.00 gold per ton (1911 prices), and 1½ oz. to 40 oz. of silver per ton. The vein is 40 ft. wide (378).

Bridger District

Charter Oak; location of the deposit not given by Aughey. A vein bearing copper oxides and carbonates increased from 1 ft. thick at the surface to 7 ft. at the bottom of a 100 ft. shaft. The veins assayed 25% copper, 3 ft. from the surface (16, p. 8).

Copper Glance Group; located in T. 40 N., R. 92 W., 18 mi. northeast of Shoshoni, in the Copper Mountain area. "Dikes of diorite" cut red granite which locally is "heavily mineralized." One "mineralized ledge" trending northeast is 30 ft. wide in places, and is nearly vertical. The "ledge" contains mostly quartz with chalcocite, and lesser malachite, azurite, cuprite, chrysocolla, and chalcopyrite. The quartz contains a little native copper and gold. A 31,209 lb. ore shipment on August 4, 1906, yielded $65.54 in gold, $61.21 in silver, and $874.67 in copper. Another lot of 809 lbs. of ore returned $3.64 in gold, no silver, and $127.89 in copper. All are 1906 prices (100).

Fremont Group; northeastern part of Fremont County, about 15 mi. north of Shoshoni on the crest of Copper Mountain. A biotite schist layer 1 mi. to 2 mi. wide with interlayered quartzite strikes east-west. Quartz veins cut the schist, some at an acute angle, and some more nearly perpendicular to the layer. The veins which cut the schist at an acute angle are mineralized; the ones intersecting it at a large angle are barren. The vein at the shaft is 4 ft. to 6 ft. wide, and dips gently south. Forty-three feet from the surface, the vein is 6 ft. to 9 ft. wide, and contains malachite, azurite, limonite, and hematite, all associated with "some" chalcocite. All the minerals are found in bunches and streaks. Chalcopyrite was found in a tunnel at a short distance downhill from the shaft. The vein bears a slight amount of gold (66).

Mascotte Claim; (See SILVER).

Riverton Mining Co.; (See GOLD).

Williams-Luman Mine; located on Copper Mountain, about 15 mi. north of Shoshoni. A 575 ft. tunnel intersected the veins 200 ft. below the surface; a raise followed a vein to surface. A 610 ft. shaft was sunk from the tunnel level, with about 11,000 ft. of drifts and cross-cuts. Two northeast striking veins intersect at the surface. The north vein is 5 ft. wide, and contains quartz with malachite, azurite, limonite, hematite, chalcocite, and native copper. The country rocks are "altered diorite" and schist. Seventy-two feet of vein sampled with an average width of 5 ft., from a point in the raise 20 ft. below the surface, yielded 2.32% copper. Twenty-five feet above the tunnel level on the southwest drift, the ore is 5 ft. across; two assays showed 3.10% copper (2 ft. sample) and 2.02% copper (sample 45 ft. long, 3 ft. wide). Two feet of schist with native copper in the northeast drift was sampled for 8 ft.; the result was 3.48% copper. A 6 ft. vein in the southwest drift contained chalcocite, chalcopyrite, and pyrite; a 1 ft. sample from the footwall yielded 1.30% copper, 5 ft. of vein material with pyrite gave 1.68% copper, and a sample across 6 ft. of vein in the floor of the drift showed 3.46% copper. The material carried

$1.50 to $2.00 gold per ton (1918 prices). Assays from the tunnel showed $2.80 gold per ton (1918 prices) and 0.30 oz. to 0.80 oz. per ton silver (133).

Goshen County

Hartville Uplift

Copper Belt Mines Co.; located ½ mi. west of the highest peak of the Rawhide Buttes, at the corner of secs. 2, 3, 10, 11, T. 30 N., R. 64 W., and included the Omaha, Gold Hill, and Emma claims. The country rock is pre-Cambrian limestone, schist, granite and pegmatite, which strike northeast. An incline 288 ft. deep had a footwall of iron-stained schist and a hanging wall of limestone; the rocks dip 45° SE. Two mineralized lenses in the schist lie beneath the hanging wall limestone. The lenses of mineralized rock are about 1 ft. to 6 ft. thick, and are about 15 ft. broad. They were apparently continuous from the surface to the bottom of the incline. Within the lenses, the rocks contain ramifying veinlets and stringers of malachite and chrysocolla; chalcopyrite appeared at 50 ft. depth. These veinlets are cut by later ones of calcite and quartz. The lenses contain about 2% to 8% copper, and the schist surrounding the lenses contain $1.00 to $12.00 in gold per ton (average $3.00) and from 2 oz. to 5 oz. of silver per ton (prices prior to 1907) (17, pp. 106-107).

Edwin Hall (352, p. 10) reported that the shaft was 640 ft. deep, and that there were 3,500 ft. of underground workings. Hall had earlier been president of the company (17, p. 106).

The Omaha and Gold Hill shafts were located on a layer of schist between 7 ft. and 20 ft. wide, which is folded into an "S" shape between the shafts. At the Gold Hill a southwest dipping vein fills a fracture. The vein is 6 ft. wide; a 2 ft. belt of iron-stained schist beneath it assayed $4.00 in gold per ton (1906 prices). Veinlets of malachite, chrysocolla, and lesser chalcocite are found within the vein, parallel to and cutting across the schistosity. Fractures in a shattered quartz vein parallel to the schistosity contain stringers and masses of chalcocite and bornite partially altered to malachite, chrysocolla, and azurite.

The Omaha showed chrysocolla, malachite, azurite, chalcocite, and chrysocolla, and barite gangue in stringers which lie parallel to and obliquely across the foliation of the schist. The zone of stringers is about 4 ft. wide and assayed 2% copper. The mineralized zone was traced for about 204 ft.

A fracture zone in the Emma open cut contains quartz lenses paralleling the schistosity. The stringers contained malachite, green and brown chrysocolla, azurite, chalcocite, and chalcopyrite. The zone averaged 3% to 30% copper; masses of chalcocite weighing up to 47 lbs. were found (17, pp. 106-107).

Copper Bottom; south-central part of SE¼ sec. 23, T. 29 N., R. 65 W. The claim was located on a fissure vein in yellowish pre-Cambrian limestone which is cut by thin seams of hematite. The vein is vertical and strikes N. 20° W. It is 4 in. wide at the surface, and 22 in. wide at 15 ft. depth. Assays showed a trace of gold, 2 oz. per ton of silver, and 24.64% of copper. The metallic minerals are chrysocolla and some malachite. A few irregular masses of tennantite up to 1 ft. long were found (17, p. 96).

Charter Oak; near the center of SE¼ sec. 26, T. 27 N., R. 65 W., on the south side of McCann's Pass. A 4 ft. zone of fractures in pre-Cambrian muscovite schist and gray quartzose beds contains malachite, chrysocolla, and chalcocite. Another 4 ft. vein cuts across vertical schist. The schist near the vein assayed from $00.80 to $27.00 in gold (1907 prices), and 2 oz. to 5 oz. of silver per ton (17, p. 96).

Green Hope; NW¼ sec. 26, T. 29 N., R. 65 W., in the upper slope of a valley. A coarse, conglomeratic sandstone at the base of the Guernsey formation overlies a rough, uneven surface of pre-Cambrian limestone which shows enlarged joint planes, sink holes, and other solution features. Malachite, chrysocolla, azurite, and chalcocite replaced the cement of the sandstone, and locally attacked limestone pebbles. Sometimes these minerals, as well as olivenite, fill fractures. Tufted crystal aggregates of malachite, and botryoidal masses of chrysocolla were found in solution cavities. White or yellowish calcite incrusts these minerals, and films of bluish-white chalcedony commonly cover the calcite. Thin stringers of malachite, chrysocolla, and azurite extend downward into the pre-Cambrian limestone (17, pp. 102-103).

Center of NE¼ sec. 26, T. 27 N., R. 65 W., near Haystack Peak. Chalcopyrite and chalcocite "rather abundantly" cement a breccia of schist fragments. The minerals contained a trace of silver, but no gold, cobalt, or nickel (17, p. 97).

Hot Springs County

McGowan-Le Claire Group; secs. 3, 4, T. 6 N., R. 3 E. (Wind River Meridian) in the Willow Creek Basin, 18 mi. southwest of Thermopolis. Limonite and "copper" stain east-west trending quartz veins in granite. The veins are associated with "diorite dikes" and schist layers (110).

Mountain View, Liberty and Orebin Claims; sec. 7, T. 6 N., R. 3 E. (Wind River Meridian) on the crest of the Owl Creek Mountains. Vertical "diorite" dikes in granite strike east-west. The claims were located on the dike, where it is cut by quartz veins at a zone of shearing and serpentinization. The veins carry limonite, malachite, and azurite at the surface, with a few specks of "copper sulfide" (559).

Johnson County

Bull Camp Group; sec. 26, T. 47 N., R. 84 W., 7 mi. south of Hazelton. Red and gray granites contain dikes and schist layers. A quartz vein dips 60° N., and follows the contact between red granite on the north, and gray granite to the south. The vein is 14 in. to 20 in. wide; several small stringers join it from the south side. The north side of the vein contains limonite and copper carbonates at the surface, and small bunches of chalcopyrite and bornite below 46 ft. A small amount of pyrite is distributed through the footwall granite in veinlets, lenses and specks (77). Darton (169, p. 114) reported minute veins "widely scattered through the rocks."

Powder River Pass; SE¼ sec. 4, T. 48 N., R. 85 W., on a ridge just north of U. S. Highway No. 16 at Powder River Pass. A quartz vein (maximum thickness 6 in.) cuts strongly foliated, isoclinally folded oligoclase-biotite-hornblende gneiss. The vein contains malachite at scattered intervals, and isolated anhedra of pyrite up to ⅜ in. in diameter. Fold axes and lineation in gneiss plunge N. 30° E., 60° E.; the vein strikes N. 65° E., parallel to gneissic layering (481).

Roe Brothers Group; sec. 15, T. 49 N., R. 83 W., 17 mi. from Buffalo. "Dark colored lime dyke rock" cuts red granite which contains quartz, limonite, hematite, and a few isolated green stains. The assays show small amounts of gold, but Beeler believed the deposit was of no commercial value (76).

Top Hand Group. East of the Bull Camp Group, in T. 47 N., R. 84 W. Red granite, and lesser amounts of gray granite contain layers of gneiss, schist, and dark dikes. A biotite layer strikes northwest and dips northeast. All rocks are cut by quartz veins, which contain limonite and malachite stains at intervals (78).

Laramie County

Silver Crown District

Arizona Mine; secs. 25, 26, T. 15 N., R. 70 W., about 4 mi. from Granite Canyon. Granites and schists are cut by a dike of diorite, which has been extensively fractured and sheared parallel to its strike. Fractures in the dike contain small quartz veinlets with gold and copper. The width of the mineralized dike is 200 ft. on the surface; it was not measured on either the 80 ft. or the 130 ft. levels. Assay reports for the State Geologist are given below (379):

	Gold oz.		*Silver* %		*Copper* oz.		*Total*
Shaft, 20 ft. below surface	0.42	$8.40	0.70	$0.42	2.43%	$6.71	$15.53
130-ft. level, east drift face	0.06	$1.20	0.40	$0.24	0.22%	$0.61	$2.05

Bon Brothers Mine; in Silver Crown District. A shaft sunk on gossan encountered copper sulfide-bearing material at 20 ft. which contained 6% copper and small values in gold and silver (5).

Copper King Mine (Adams); (See GOLD).

Eagle Mountain Group; located 2½ mi. west of Hecla Post Office, and consists of the *Rambler, Covellite,* and *Gertrude* claims. "Diorite" dikes cut red granite containing layers of schist and gneiss. Limonite and malachite stain the rock at the surface. Solid rock contains unaltered sulfides "where surface waters have not penetrated." A 4 ft. zone of mineralized material on the south side of the fissured area, contains spots and bunches of pyrite, chalcopyrite, and some bornite with limonite and malachite (63).

Eureka Lode; (See GOLD).

Fairview Claim; location uncertain. A fissure 8 ft. to 14 ft. wide contained chalcocite and other copper minerals at the bottom of a 20 ft. shaft; all were argentiferous (16, p. 4).

Globe Prospect; secs. 13, 14, T. 14 N., R. 70 W. A 4 ft. quartz vein cuts layered granitic rocks, strikes north-south and dips west. The quartz pinches and swells and contains chalcopyrite and lesser pyrrhotite. Quartz contains "bunches" and small stringers of chalcopyrite; both pyrrhotite and chalcopyrite are disseminated in granite near small fissures. Outcrops of quartz contain malachite (53).

Good Hope; secs. 1, 35, T. 13 N., R. 70 W., 23 mi. west of Cheyenne, and 2 mi. north of Granite Canyon. Reddish granite contains layers of schist, gneiss, and "diorite" dikes. Schist layers and veins of quartz show copper sulfides and carbonate stains, trend east-west, and dip gently to the north (95).

Great Standard Group; 2 mi. north of Granite Canyon; (See GOLD). Two million tons of possible ore is present in a mineralized zone 500 ft. long, 100 ft. wide and 500 ft. deep in the N½ NW¼ sec. 36, and S½ SW¼ sec. 25, T. 14 N., R. 70 W. Copper minerals are chalcopyrite, pyrite, native copper, bornite, malachite, and azurite. Mineralization sampled by drill holes assayed $13 per ton (1954) (592). A rough average assay from three Bureau of Mines drill cores was 0.09 oz. Au/ton, 10 oz. Ag/ton, and .06% Cu/ton (594).

Hecla; sec. 24, T. 14 N., R. 70 W. Copper minerals are associated with gold and silver in a 4 ft. vein. A leaser shipped twenty tons in March, 1916, and received $413.00 after deduction of freight and smelter fees (223).

Kopper Krown Group; SW¼ sec. 36, SE¼ sec. 35, T. 14 N., R. 70 W., NW¼ sec. 1, NE¼ sec. 2, T. 13 N., R. 70 W., 3½ mi. from Granite Canyon. Red granite contains a little schist and weathered quartz veins. The rocks are badly sheared; the shears contain bornite and chalcopyrite with lesser chalcocite. The schist contains disseminated specks and streaks of sulfides. Outcrops are limonite-stained, and also contain azurite and malachite with smaller amounts of copper sulfides and pyrite; the leached zone is shallow. The "ore" dips about 80° S., and strikes east-west. A 160 ft. shaft was sunk following the mineralized zone, which varies from 2 ft. to 4 ft. wide (106).

Rambler; sec. 22, T. 14 N., R. 70 W. Pyrite and a slight amount of chalcopyrite are contained in veins in granite. Epidote is prominent where the rocks are mineralized. The principal vein is 4 ft. wide; at depth it contains more chalcopyrite, sphalerite, and some specularite (291).

Lincoln County

The Cockscomb; T. 19 N., R. 120 W., 25 mi. north of Evanston, and 5 mi. from Bear River. Gray sandstone in the Beckwith formation contains copper carbonates at 3 places along the axis of an overturned anticline (573, p. 163). Veatch (573, p. 50a) says the copper is in a yellow sandstone in the Twin Creek formation.

Griggs Mine; on Hobble Creek, sec. 33, T. 29 N., R. 117 W., 32 mi. north of Cokeville. Copper minerals (probably carbonates) are known in this vicinity. Some ore was shipped in 1919; 15 tons of ore brought $1,180.00. Lauckey Young reports both copper and silver minerals in quartzite. According to newspaper reports of November, 1942, considerable road work was necessary before machinery could be taken to the prospect, and ore removed. The reports state that the ore assayed $18.00 per ton average value (217).

T. 22 N., R. 118 W.; just north of Watercress Canyon. The Weber quartzite contains a small amount of copper carbonates. The rocks are gray and white brecciated quartzitic sandstones (573, p. 50a).

Rock Creek Valley. Rock Creek, a tributary of Bear River, is 15 mi. west of Kemmerer, and 6 mi. north of Nugget Station on the Oregon Short Line Railroad (Union Pacific). Brecciated sandstones just below the "Permo-Carboniferous" redbeds contain copper carbonates (573, p. 163).

Niobrara County

NW¼ sec. 6, T. 33 N., R. 63 W. Pre-Cambrian mica schists containing several pegmatite sills strike about N. 4° E., and dip 70° to 80° SE. A mineralized zone at least 30 feet thick is conformable to the attitude of the schists and is exposed for about 150 feet along the strike in several prospect pits. Abundant malachite and sparse chrysocolla occur as fracture coatings and disseminated in pegmatite and schist. Malachite is most abundant along pegmatite-schist contacts and in more coarsely grained schist. About 300 feet north of this zone, an adit has been driven near a granite-schist contact. The adit trends about N. 6 E., parallel to the contact and strike of the mica schist. Malachite occurs on the adit dump as fracture coatings and disseminated in schist (662).

Park County

Crouch Prospect; (See GOLD).

Kirwin; T. 45 N., R. 104 W., near the headwaters of the north fork of the Wood River, 38 miles southwest of Meeteetse. The river is at an elevation of 9,200 feet; the ridges rise to more than 12,000 feet. About 4,000 feet of andesite flows and breccias of the Wiggins formation constitute the country rock. These are intruded by two granodiorite stocks, several smaller andesite plugs, and numerous andesite and dacite dikes. The rocks are fractured, and the fissures are filled with quartz. The vein minerals include pyrite, galena, sphalerite, chalcopyrite, chalcocite, tetrahedrite, molybdenite, stephanite, and specular hematite. In the oxidized zone, the veins contain limonite, malachite, anglesite, molybdite, native copper, azurite, cuprite, and native gold (677).

Hewett (365) described several of the prospects which he visited. The Bryan vein was opened by three tunnels 80 ft., 480 ft., and 880 ft. long. Twelve hundred feet of drifts were run from the lowest tunnel, and four veins were cut, two of which were explored. Vein No. 3 attains a maximum width of 4 ft., and contains two layers of sulfide minerals at its widest part. Vein No. 4 is a 10 in. fracture filling, with well-defined walls. Sulfide ratio was estimated as follows: pyrite: chalcopyrite: sphalerite=20 : 5 : 1, with traces of galena and molybdenite.

The Pickwick vein was cut by a crosscut tunnel 610 ft. long from a drift which follows the vein for 300 ft. The vein has a maximum width of 14 in., and is a simple fracture filled with pyrite. Proustite was reported from the surface workings.

The Oregon vein was cut by a tunnel 340 ft. long. The vein varies between 4 in. and 20 in. wide; it has well-defined walls. The sulfide ratio was estimated as sphalerite:galena:pyrite=10:3:2, with traces of chalcopyrite. The gangue is siderite and quartz. Assays reported as much as 200 oz. in silver per ton.

Several small adits and a shallow shaft were sunk on the Illonies claim located at the base of Bald Mountain. Rather numerous films of molybdenite fill fractures in a white medium-grained silicified intrusive rock and quartz. The rock contains scattered grains of chalcopyrite and bornite (?), usually altered to malachite, azurite, and chrysocolla. Other sporadic exposures of chalcopyrite-molybdenite occur on Bald Mountain in altered andesitic rock. The Bald Mountain area was diamond drilled during the summers of 1963, '64, '65. (486, 487, 677).

Stinking Water Region; sec. 18, T. 47 N., R. 106 W.; near the confluence of Needle Creek with the South Fork of the Shoshone River. Multiple intrusions of granodioritic to dioritic rocks have domed, fractured, and metamorphosed the igneous rocks of the Early Basic Breccia, Early Basalt Flows and the Wiggins formation. A mineralized area covering approximately 4 square miles lies within the adjacent to the intrusive rocks on the northwest slope of Crater Mountain and on the southwest slope of Needle Mountain. Topography is exceedingly rugged with elevations varying from 7,000 to 12,000 feet.

There are two types of mineralization:

(1). The first type is best exposed adjacent to Needle Creek at the base of Needle Mountain and also about 900 feet above the mouth of Needle Creek on the northwest slope of Crater Mountain. This a fractured, silicified, and oxidized area of alteration covering approximately one square mile and containing disseminated pyrite, chalcopyrite, and molybdenite. Limonite is a common mineral within oxidized zones, along with minor amounts of malachite, azurite, and molybdite (?). Molybdenite and pyrite also occur on fracture surfaces and in quartz veinlets throughout this zone.

(2) The second type of mineralization crops out as narrow, steeply dipping fissure veins of northeast and northwest trend. These contain pyrite, galena, molybdenite, chalcopyrite, and sphalerite. These veins cut the altered zone mentioned above and also the unaltered intrusive rocks, the Early Basalt Flows, and the Wiggins formation on Needle and Crater Mountains. The altered zone was diamond drilled in 1965 (609, 636).

Sunlight Basin District

General description: Sunlight Basin is in the Absaroka Mountains, about 50 mi. northwest of Cody and 35 mi. southeast of Cooke, Montana. The region is very rugged and only winding dirt roads lead into the district. The U. S. Geological Survey Crandall Quadrangle, which covers this area, has been described by Hague (350). The mineral deposits are probably of no commercial importance under present economic conditions. Most of the rocks are volcanic; intrusive stocks, sheets, and dikes cut andesite breccias and flows (187). Copper and lead sulfide minerals are found in fissures, mineralized dikes, and bodies of low grade disseminated ore. According to Hague (350) the minerals are localized between syenite and syenite-porphyry and intrusive dikes. The porphyritic mineralized dikes cut all formations (187). Most of them strike east-west, but some trend north-south. The low grade deposits are always associated with fissures (187). Quartz and sulfides fill most of the veins which are 1/8 in. to 3 in. wide.

Parsons (491) has classified the various deposits as follows:

(1) *Quartz-pyrite veins.* The veins are largely a series of vugs and crustifications in fractures, and consist of quartz and limonite stains and are the highest temperature deposits in the region. They are found in or very close to actual stocks. The average of two sampled deposits was 0.03 oz. of gold per ton.

(2) *Complex gold-silver-tungsten deposits* (491, pp. 847-848).

The veins fill shear zones in volcanic breccia, near the contact of stocks; most are near Lower Copper Lake. The common minerals are pyrite, wolframite, tetrahedrite, and lesser sphalerite. Chalcopyrite and bournonite are rare. The gangue is entirely quartzose, and the wall rock contains much pyrite. Dump samples from these deposits average 0.54 oz. gold per ton, and 13.46 oz. silver per ton.

(3) *Chalcopyrite veins.* These veins consist of quartz and carbonate gangue in about equal amounts, and range up to 10 ft. wide. They contain varying amounts of chalcocite and bornite, and fill shear zones and faults in volcanic breccia. Small amounts of tetrahedrite, famatinite, bornite, and galena are also present. Dump samples from the Copper King Claim (no location given) assayed 0.04 oz. gold per ton, 0.62 oz. silver per ton, and 3.35% copper (491, p. 848).

(4) *Argentiferous galena veins.* These veins are very similar to the chalcopyrite type, but contain only coarse galena in an iron carbonate gangue. Calcite and pyrite are secondary wall-rock minerals. A dump sample from the Hoodoo Claim (location not given) yielded 0.02 oz. gold per ton, 1.98 oz. silver per ton, and 9.40% lead with a trace of copper (491, p. 848).

(5) *Chalcopyrite-pyrite-gold veins.* These veins fill shear zones at dike contacts in volcanic breccias. The gangue is quartz with a small amount of calcite and adularia. Metallic minerals include chalcopyrite and pyrite in approximately equal amounts, with microscopic tetrahedrite, galena, and, rarely, sphalerite. Sylvanite and rare grains of native gold are scattered through the material (491, p. 848). Material from the outcrop of the Big Goose Vein (no location given) contained 0.82 oz. gold per ton, and a trace of silver.

(6) *Complex silver veins.* Deposits in this class are found in fault and shear zones in volcanic breccias near the "basaltic explosion plugs." The gangue minerals are calcite, ankerite, siderite, and barite; values are galena and argentiferous tetrahedrite, associated with proustite and stromeyerite. Small amounts of chalcopyrite and pyrite are present. Wall rocks have been sericitized. A sample from the dump of the Tip Top Claim (no location given) assayed

0.02 oz. gold per ton, 7.14 oz. silver per ton, 0.60% lead, and a trace of copper (491, p. 849).

(7) *Barren carbonate veins.* These veins are the extension of pinched-out zones, and only gangue remains except for scattered specks of galena. The vein minerals are ankerite, siderite, and calcite, with small amounts of quartz. An assay from the vein outcrop at the Morning Star Claim (no location given) is as follows: 0.01 oz. of gold per ton, 0.23 oz. silver per ton (491, p. 849).

Beeler's description (111) is somewhat at variance with those of other observers. He reports that the Sunlight District veins cut andesites and other volcanic rock types, but that the veins contain metallic minerals only where they cut andesites.

Bluff Vein; located in a high bluff on the north side of Sulphur Creek, in the south-central rectangle of the Crandall quadrangle (111). The vein is 30 ft. wide, with bunches of copper sulfides. Smaller particles of metallic minerals are disseminated throughout the entire vein. On each side of the vein is a zone of low grade disseminated protore in the andesite breccia wall rock (187, p. 1155).

Beeler (111) described the Bluff Vein as a series of interconnected smaller veins and stringers which vary from a foot or two wide to 12 ft. wide.

Butte Claim; no location given by Parsons. The vein is of the "Chalcopyrite type" and assays gave 0.22 oz. of gold per ton, 3.14 oz. of silver per ton, and 4.43% of copper (491, p. 848).

Evening Star Claim; no location given by Parsons. The deposit is of the "Complex silver vein type;" assays from the outcrop gave 0.02 oz. gold per ton, 91.44 oz. of silver per ton, 1.40% of copper, and 1.30% of lead (491, p. 847).

Greenhorn Vein; no location given by East (187). A porphyritic dike is slightly altered and contains disseminated chalcopyrite; heaviest mineralization is near the walls.

Hardee's Claim; no location given by Parsons. The deposit is of the "Argentiferous galena vein type." A dump sample assayed 0.04 oz. of gold per ton, 20.24 oz. of silver per ton, 62.23% lead, and a trace of copper (491, p. 847).

Hargrave-Newton-LaFond Mine; located somewhere on Sunlight Creek. A fissure which cuts porphyritic rock contains malachite, chalcocite, and chalcopyrite. The fissure shows evidence of secondary enrichment (187).

Joe Vein; located on the divide between Fall Creek and Sulphur Creek, in the south-central rectangle of the Crandall Quadrangle, 1,500 ft. northeast of the Malachite Claim. The map (395) shows the vein outcrop to be 900 ft. long. The prospectus (7) states the vein is exposed for 2,000 ft. vertically, but contours on the map show it to be only 700 ft.

Hague (350, p. 6) states that the mineralization took place along the contacts of intrusive dikes with syenite and syenite porphyry, and that the metallic minerals are "mainly sulfides of copper and lead with silver."

Malachite Vein; located on the divide between Fall Creek and Sulphur Creek, in the south-central rectangle of Crandall Quadrangle (350, p. 6; 111; 187; 7; 395). The deposit is very similar to the Joe Vein. A stock prospectus (7) reports the vein to be 10 ft. to 12 ft. wide, while Beeler (111) reports it to be only 6 ft. wide with a streak of "high grade chalcacite of varying width." According to the prospectus, the "high grade streak" is 18 in. wide. The vein crops out for a horizontal distance of 2,100 ft. (by map, 395), and 1,800 ft. vertically (by prospectus). East (187) reports the vein to be a fissure filled with malachite, azurite, and seams of chalcocite.

Marvin Deposit; no location given by East. An area 250 ft. by 2,200 ft. by 1,000 ft., uncovered by glacial erosion, shows "seams" of minerals which strike east-west, and also north-south. The area is reported to be evenly mineralized but of low grade (187).

McClung Mine; at base of Stinking Water Peak and Bear Tooth Mountain. A tunnel 150 ft. long showed galena mixed with chalcopyrite in a fissure vein cutting quartz porphyry. The vein also carried gold and silver (187).

Novelty Claim; no location given by Parsons. The deposit is of the "Complex silver vein type." An assay of dump sample gave 0.06 oz. of gold per ton, 19.00 oz. of silver per ton, 13.10% lead, and 0.75% copper (491, p. 847).

Painter Mine; located in Silver Tip Basin, on the west side of the Stinking Water (Shoshone) divide. The metallic mineral is chalcopyrite bearing gold, silver, and some lead (187).

Silvertip Claim; no location given by Parsons. The deposit is of the "Chalcopyrite vein type." A dump sample assayed 0.06 oz. of gold per ton, 4.62 oz. of silver per ton, and 3.85% copper (491, p. 847).

Wild Goose Group; located at the head of Sulphur Creek. "Porphyry intrusions" and stringers of quartz and calcite contain copper sulfides and iron stains, with some black copper oxides (103).

Winona Mine; no location given by Parsons. The deposit is of the "Chalcopyrite-pyrite-gold type." An assay of a dump sample showed 0.58 oz. of gold per ton, and 0.88 oz. of silver per ton (491, p. 847).

Platte County

Hartville-Guernsey Area

Green Mountain Boy; located ½ mi. east of Guernsey, at the head of a broad valley. About 300 to 500 tons of ore were produced prior to 1906 which averaged 37% copper. The chalcocite contains a varying amount of silver. The country rock is the upper part of the Guernsey limestone; it contains lenticular masses of brown flint nodules 2 in. to 4 ft. long, and ½ in. to 6 in. wide. The original lens of chalcocite is reported to have been 60 ft. long, 30 ft. wide, and 5 ft. to 9 ft. thick, and probably replaced flint nodules. A few stringers led out from the lens, but there was no other ore, except for scattered patches of malachite in limestone (17, p. 97; 26, p. 3).

Hagner (324) reports copper "nuggets" which weigh 25 lbs. to 30 lbs. in sand and gravel. In the shaft, he found 28 ft. of sand and gravel, 6 ft. to 7 ft. of quartzite, and then "phonolite" with occasional pockets of ore. The dump material in 1943 contained chrysocolla, malachite, cuprite, and chalcocite.

Jehosophat Prospect; (See IRON).

Michigan Mine; located in Muskrat Canyon. Low grade copper minerals with a large amount of hematite are disseminated in finely-bedded quartzite or slate (505, p. 67).

Sunrise Mine; located in the north-central part of sec. 7, T. 27 N., R. 65 W., in the south facing slope of a steep hill. The mine yielded a total of 1,395,287 lbs. of copper from ore which averaged 15% copper. The ore also yielded 2 oz. to 3 oz. of silver per ton. Chrysocolla, malachite, azurite, chalcocite, and native copper filled lenticular or pear-shaped masses in pre-Cambrian hemetite schist and jasper, beneath a blanket of Guernsey limestones. The copper minerals occupied joint planes, irregular fractures and cavities, and sometimes could be traced upward into the Paleozoic limestones. Gangue minerals were quartz, calcite, and more rarely, chalcedony, selenite, and barite. These copper deposits are probably exhausted, and no copper is produced with the iron ore mined at the present time (17, pp. 99-101); (See IRON).

Laramie Range Area

Cooney Hill Prospect; sec. 20, T. 23 N., R. 69 W., in the Cooney Hills. A series of quartz lenses (not a continuous vein) lie in a gray granite which contains layers of gneiss and mica-hornblende schist. At 155 ft. depth, one quartz lens 4 ft. wide, was impregnated with bunches and streaks of chalcopyrite and bornite. The quartz is broken and granulated, and contains streaks of mica and pyrrhotite. Approximately 65 tons of ore were mined (1901), with an average value of about $9.00 per ton (1901 prices). The ore contained small gold values (41).

Whippoorwill Claim; (may be identical with Cooney Hills Prospect) sec. 20, T. 23 N., R. 69 W., on the south side of the Cooney Hills, 15 mi. southwest of Wheatland. Red and gray granites contain occasional layers of schist and dikes of "diorite." Quartz veins cut all rocks. Biotite schist strikes northwest and dips northeast at the claim. A quartz vein 15 ft. wide contains limonite, hematite, and malachite at the surface. Below 40 ft. depth, it showed pyrite and chalcopyrite. The "vein" consists of streaks and stringers of quartz in schist. Assays showed a maximum of $6.60 gold, several percent copper, and some silver (80).

Emerald Group; sec. 8, T. 23 N., R. 70 W., 23 mi. southwest of Wheatland. Folded hornblende and biotite schists contain a vein of quartz and calcite at a point where the strike changes from northeast to northwest. Folding was accompanied by fracturing, and quartz-calcite stringers in fractures "pitch" northwest. The quartz veins contain limonite and copper carbonates near the surface, chalcopyrite, bornite, and chalcocite below (79).

Independence Group; (See PYRRHOTITE).

Lucky Gus Prospect; 12 mi. west of Wheatland, in the Cooney Hills. Quartz veins in red granite strike east-west and dip gently south. One vein crops out for 500 ft. along the surface; the outcrop is 4 ft. to 7 ft. wide. The quartz contains limonite and copper carbonates, associated with bunches and streaks of pyrite, chalcopyrite, chalcocite, bornite, and a small amount of native copper. In the bottom of a shaft the "vein matter" encloses a horse of barren rock and only 2 ft. of "ore" remains (61).

Sheridan County

South Fork of Wolf Creek; southwest of Walker Mountain. A 56 ft. shaft was sunk on a 15 ft. quartz vein in granite. The protore is mostly malachite in irregular stringers in quartz, with a little galena. Part of the vein assayed $3.50 to $4.00 of gold per ton (1906 prices). The quartz vein extends 3 mi. southwest and 3 mi. east of Wolf Creek (169, p. 114).

Walker's Mine. The vein referred to above is 25 ft. wide at its northeastern end. A small amount of pyrite extracted yielded small gold values (169, p. 114).

SW¼ sec. 5, T. 54 N., R. 87 W., on the ridge above the old workings known locally as the Taylor Mine. A 15 ft. diabase dike at the crest of the ridge trends N. 80° E. and dips 85° N. The footwall contact is against a red pegmatite granite which is seamed by narrow epidote veins less than ⅜ in. in width. A shaft was sunk on the dike; the dump material consists of altered diabase with fracture fillings of magnetite, hematite, limonite, malachite, chrysocolla, and quartz, with a little chalcocite (476).

On the line between secs. 1 and 12, T. 55 N., R. 85 W., on a low ridge ½ mi. south of Bear Lodge Resort. A prospect hole was dug in a large siliceous crush zone in granite. The crush zone trends north-northeast. Fractures in the siliceous material contain a little chalcocite and malachite (474).

NE¼ sec. 24, T. 55 N., R. 88 W. A shaft was sunk on a zone of silicified and epidotized crushed granite, a short distance northwest of the *Madalynna Claim*

(See GOLD). The shear zone trends N. 40° W., and at the shaft intersects a diabase dike trending N. 80° W. The dump consists of diabase in varying degrees of alteration containing irregular masses and fracture fillings in the siliceous material contain a little chalcocite and malachite (474).

NW¼ sec. 28, T. 56 N., R. 88 W.; (See PYRITE).

Teton County

Thirty miles southeast of Yellowstone National Park, on Buffalo Fork of Snake River, granite, schist, and diorite contain several copper sulfide veins. The average value of the material is 4% to 7% copper. Several hundred feet of shafts and drifts have been dug (352, p. 13).

REPORTED OCCURRENCES

Albany County

La Plata District (Centennial); (See LEAD).

Sec. 16 (?), T. 11 N., R. 73 W. A 130 ft. shaft sunk on a 2 ft. vein yielded 2,000 to 3,000 lbs. of ore which averaged 6% copper with a maximum of 16% (217).

Silver King Copper Mine; sec. 20, T. 16 N., R. 72 W. Produced some ore in 1946 (217).

Native Copper

". . . on Douglas Creek." (16, p. 54).

". . . near Granite Canyon, Sherman, and the region north and south of the above." (16, p. 54).

Carbon County

Beaver Group; secs. 14, 23, T. 13 N., R. 83 W. (283).

Cooper Hill; (See GOLD).

Gold Coin Prospect; (See LEAD).

Meta Mine; (See LEAD); veins contain chalcopyrite, azurite, malachite, and chrysocolla (281).

Spanish Trails Group; (See LEAD).

Secs. 22, 23, 26, T. 19 N., R. 82 W. Several small copper deposits at this location are of "no commercial value." (375).

Sec. 21, T. 14 N., R. 84 W., 4½ mi. from Encampment; (See GOLD).

Azurite

"The result of decomposition of chalcopyrite in the Seminoe Mountains" (192, p. 157).

Bornite

". . . Blacksnake and Viper Mines" (16, p. 55).

Chalcopyrite

". . . in Copperhead, Blacksnake, and Rattlesnake mines on the upper Plate, south of Fort Steele. Generally carries silver and gold" (16, p. 55). Small quantities were reported in the mines of "Seminoe Hills" (192, p. 157). "East Seminoe Mountains . . . generally carry silver and gold" (375, pp. 54-55).

Seminoe District

Deserted Treasure Mine; (See GOLD).

King Mine; (See GOLD).

Star and Hope Mine; (See GOLD).

Covellite

East Seminoe Mountains (16, p. 54).

Cyanotrichite

Found in Cambrian sandstones north and northwest of Rawlins (16, p. 55).

Native Copper

Found in "reddish Triassic quartzite" near the summit of the Rawlins uplift, associated with malachite and calcite, and near the hematite deposits; (217) (See IRON).

Olivenite

In Cambrian sandstone, northwest of Rawlins (16, p. 55).

Tenorite

". . . also on upper Platte, south of Fort Steele" (16, p. 55).

Tetrahedrite

Reported from the Sierra Madre Mountains (217).

Crook County

Azurite

Warrens Peak (358, p. 214).

Cuprite

Cuprite was associated with "hard carbonate ore" formerly mined at Black Buttes and Inyan Kara Mountain (358, p. 215).

Widely scattered carbonate and oxide deposits are found northwest of Sundance, on Warrens Peak (515, p. 12).

Fremont County

Azurite and malachite

Found in the Bridger Mountains; (See PEGMATITE).

Chalcopyrite

Small quantities are found in the mines at South Pass City (453, p. 157).

Laramie County

Aurichalcite

Lenox Mine, Silver Crown District; (See ZINC).

Bornite

King David Mine, Silver Crown District (16, p. 55).

Chalcocite

"King David Mine, Fairview Mine, and other mines in Silver Crown . . . This ore . . . carries silver." (16, p. 54).

Chalcopyrite

"Metcalf Mine, Copper King (Professor Stanton's), Copper King (Mr. Adams'), King David Mine, Fairview, etc. in Silver Crown District . . ." (16, p. 54).

Covellite

King David Mine, in Silver Crown District (16, p. 54).

Cuprite

". . . Copper King Mine (Mr. Adams'), King David, in Silver Crown District" (16, P. 55).

Freibergite

King David Mine, in Silver Crown (16, p. 54).

Malachite

"Common at the surface of lodes in Silver Crown . . ." (16, p. 55).

Native Copper

Copper King Mine; (See GOLD).

Tenorite

"Occurs sparingly at surface in some of the copper mines in Silver Crown . . ." (16, p. 55).

Natrona County

Limestone is impregnated with copper (287, p. 3).

Platte County

Tenorite

Michigan Mine (453, p. 810; 358, p. 217).

Weston County

NW¼ sec. 27, T. 44 N., R. 60 W. Copper and gold are reported to occur in a heavy mineral suite sampled from the breccia unit, 37 feet below the top of the Permian part of the Minnelusa formation (633).

CORDIERITE

Cordierite is a complex Mg, Fe, Al silicate found in a wide variety of rocks including metamorphic gneisses and schists, in granites, volcanics, or in sediments that have been subjected to heat. When cordierite is heated above 1440° C. it changes into a mixture of sillimanite and glass.

Uses for cordierite include thermocouple insulators, industrial burner tips that must withstand high temperature, oil burner ignition insulators, chemical stoneware containers that must withstand quick heating and cooling cycles, automotive parts, many types of electrical appliance parts, low inductance coil forms, and high-frequency parts that are exposed to great temperature changes. The cordierite deposits in the Laramie Range contain iron which limits its usefulness. It can, however, ". . . be used successfully for low thermal expansion bodies when strength, dielectric properties, and color are not critical factors." (143, p. 446).

PROSPECTS

Albany County

Secs. 13, 14, 24, T. 17 N., R. 72 W., secs. 17, 18, 19, 20, T. 17 N., R. 71 W. The cordierite deposits in the Laramie Range occur as lenticular or tabular layers in metanorite, syenite, and syenite-diorite gneiss. The bodies range in size from a few inches long and wide to 240 ft. long and 30 ft. wide (464, pp. 7, 11). Cordierite content of the metanorite is from 50% to 80% (464, p. 13). The cordierite bodies or layers strike generally east or northeast, and dip steeply to the south. There are 500,000 short tons estimated reserves of cordierite in the combined deposits.

One of the largest deposits is in the center sec. 20, T. 17 N., R. 71 W. on a ridge at least 300 ft. above the surrounding country. Here the cordierite is localized near the center of a fold. Analyses of high grade cordierite-bearing rocks are (464):

SiO_2	50.10%	51.66%
Al_2O_3	29.70	28.24
FeO	10.90	7.94
MgO	6.82	5.90
CaO	1.77	2.48
	99.29%	96.22%

REPORTED OCCURRENCES

Albany County

Grizzly Creek Area; (See KYANITE).

Carbon County

Cordierite as almond-shaped masses in schist have been reported southwest of Encampment (259).

Johnson-Campbell Counties

Cordierite crystals are often found in the baked clays, shales, and slag veins above burned out coal beds (27).

CORUNDUM

The varieties of corundum include (1) the transparent to translucent gem varieties—sapphire and ruby, (2) dull, dark-colored translucent corundum, and (3) emery, a black or grayish granular corundum which contains magnetite or hematite (206, p. 482).

Corundum is a common accessory mineral in gneiss, schist, mica or chlorite slates, and granular limestone or dolomite. In Wyoming, corundum in the pre-Cambrian metamorphic rocks is usually associated with hornblende schist or vermiculite. A few specimens have been used for gem stones, but there has been no actual production.

Corundum is largely used for watch jewels, bearings in electrical apparatus, and as a polishing agent. Most abrasive corundum is now made artificially.

REPORTED OCCURRENCES

Albany County

Roff Deposit; sec. 18, T. 24 N., R. 70 W. Accessory corundum and kyanite are associated with vermiculite in biotite schist. The schist is surrounded by gneissic granite and is cut by a pegmatite dike (337, p. 25); (See VERMICULITE).

Carbon County

Sec. 15, T. 15 N., R. 83 W. at *Baggot's Rock.* Specks of corundum are associated with kyanite and sillimanite in a vermiculite deposit (337, p. 19); (See VERMICULITE).

Aughey in 1886 reported one specimen of corundum from east Seminoe near the Platte River, and one ruby from limestone on southeast Seminoe Mountain (16, p. 56).

Fremont County

W. L. Marion, and L. B. Curtis Jade Claim; 59 miles southeast of Lander in secs. 13, 18, T. 30 N., Rs. 92, 93 W. Two ledges of mica schist contain pale red corundum crystals (139, p. 80). The original crystals were about ¼ in. by 1 in. in size, but are now largely altered to a green mica. None of the corundum seen is of gem variety (340).

Abernathy Deposit; T. 30 N., R. 96 W. A 4 ft. biotite schist lens in granite has been contact metamorphosed; gray and blue, poor quality corundum nodules have been formed in the schist. The crystals are fractured and altered around the edges. The schist and granite strike N. 25° E. (314).

Marion Claim; T. 31 N., R. 96 W. Pale to bright-red rubies are found in a pre-Cambrian mica schist. Some specimens have been cut into gems (434a).

T. 32 N., R. 91 W. A placer deposit of abundant bright red ($>$1 in. in diameter) fractured rubies has been located. The source is not known (434). Deep red to purplish red "sapphires" without cracks or flaws have been found on the Sweetwater Divide near Splitrock. They are associated with mica schist and serpentine (231).

DOLOMITE

Dolomite is double carbonate of calcium and magnesium, $Ca, Mg(CO_3)_2$, and theoretically consists of 45.7% $MgCO_3$ and 54.3% $CaCO_3$ if pure. A pure dolomite contains over 13% metallic magnesium or 21.9% MgO.

The term "dolomite" usually refers to a massive light-colored, cryptocrystalline carbonate rock which contains the mineral dolomite. Dolomites are inter-layered with other sedimentary rocks and probably result from the replacement of limestone. In Wyoming, the Ordovician Bighorn dolomite is the most widespread source of dolomite. It is 300 ft. thick in northern Wyoming, but thins out southward and is absent south of the southern Wind River Mountains (552, p. 2).

Isolated masses of crystalline dolomites are found in pre-Cambrian rocks. They represent limestones that have been recrystallized during regional metamorphism. Pre-Cambrian dolomites are often associated with serpentine and other magnesium-rich rocks. A few metallic mineral veins contain crystalline dolomite gangue.

Uses include ornamental and building stone, lining for open hearth steel furnaces, production of metallic magnesium, for terrazzo and stucco, and in fertilizers.

No dolomite has been produced in Wyoming, except for crushed rock. The U. S. Geological Survey map (152) shows the general distribution of dolomite and dolomite limestone in Wyoming.

PROSPECTS

Albany County

Laramie Range; Tps. 18, 19 N., R. 72 W. Pre-Cambrian crystalline dolomite inclusions are found in the granites of the range (552, p. 2).

Medicine Bow Mountains; Tps. 16, south edge 17 N., Rs. 78, 79 W. Blackwelder (128, pp. 642-644) has identified a dolomitic marble 2,300 ft. thick in the pre-Cambrian metamorphic rocks which trend northeast-southwest through the Medicine Bow Peak quadrangle. This bluish-gray massive dolomite is called the Ranger dolomite. It contains some slaty beds and questionable algal domes.

The Nash marble and dolomitic marble, another pre-Cambrian metamorphic unit named by Blackwelder (128, pp. 636-641), is 2,400 ft. thick and trends northeast-southwest similar to the Ranger dolomite. It also contains questionable algal domes.

S½ sec. 32, SE¼ sec. 31, T. 17 N., R. 72 W., 8½ to 11 mi. northeast of Laramie. Dolomitic limestone and limestone in the Casper formation strike north to north-northwest and dip 10° to 20° W. Some beds are silicified, arenaceous, argillaceous, brecciated, finely crystalline and thick bedded. The overburden of hill wash is thin over much of the section but overlying sandstones restrict the amount of rock which could be quarried readily (178).

Big Horn County

Five Springs Area; W½ sec. 30, T. 56 N., R. 92 W., about 20 mi. east of Lovell. The Bighorn formation strikes 40° to 50° W. and is overturned 40° to 65° E. along a thrust fault. The basal member, 225 ft. thick, is massive, finely crystalline and contains much chert and thick nodular argillaceous beds (178).

Little Sheep Mountain; SE¼ sec. 16, T. 56 N., R. 95 W., 5 mi. east of Lovell. Sporadic dolomite in the Phosphoria formation probably contains much silica and alumina and is not uniform in composition (178).

Shell Creek Canyon; sec. 16, T. 53 N., R. 90 W., about 22 mi. east of Greybull. The basal 225 ft. of the Bighorn formation is dolomitic limestone. This bed strikes N. 10° to 18° W., and dips 15° to 20° W. All the dolomite is calcareous and most is argillaceous. Some is siliceous with pure chert nodules (178).

Carbon County

Bell Springs Canyon; N½ sec. 21, T. 23 N., R. 88 W., 16 mi. north of Rawlins. The Amsden and Phosphoria formations crop out along a fault block. Thin beds of dolomite are interlayered with thicker beds of other rock (178).

Fremont County

Analyses of dolomites in Fremont County (1):

Location	CaO%	MgO%	SiO_2%	Al_2O_3%	Fe%	CO_2%
15 mi. N. of Shoshone						
Bighorn dolomite	32.2	20.3	0.6	0.5	0.10	47.2
13 mi. N. of Shoshone	31.2	20.7	1.4	0.55	0.05	47.0
Bighorn dolomite						
Bighorn dolomite	32.5	20.3	0.6	0.55	0.5	47.5

Bull Lake, Wind River Mountains; T. 2 N., R. 3 W. (Wind River Meridian). Bighorn dolomite from this locality has been analyzed by J. G. Fairchild (552): CaO=29.35%, MgO=20.19%, SiO_2=2.30%, $Al_2O_3+Fe_2O_3$=1.50%, CO_2=45.00%, Insol.=3.80%, Undet.=1.06%.

Bald Mountain Locality; NE ¼ sec. 17, T. 2 S., R. 2 W. (Wind River Meridian), 20 mi. from Ft. Washakie, 16 mi. west of Lander. The Bighorn and Darby formations contain dolomite along the crest of a ridge on the northeast side of Bald Mountain. No transportation is available (178).

Middle Fork of Popo Agie; SW¼ sec. 13, T. 32 N., R. 101 W. The Bighorn dolomite, the Darby and lower Madison formations all contain dolomite along the east dip slope of the Wind River Mountains. The locality is 10 mi. southwest of Lander on a dirt road (178).

South end of Wind River Canyon; SE¼ sec. 16, T. 5 N., R. 6 E. (Wind River Meridian), 20 mi. south of Thermopolis. Folded and faulted dolomite beds 10 ft. to 100 ft. thick in the Bighorn and lower Madison formations crop out in the canyon, adjacent to the Chicago, Burlington and Quincy Railroad and U. S. Highway No. 20 (178).

Hot Springs County

Analyses of dolomites in Hot Springs County (1):

Location	CaO%	MgO%	SiO_2%	Al_2O_3%	Fe%	CO_2%
6 mi. S. Thermopolis on Wind River. Dip slope, no overburden.						
Embar fr. Base + 12'	35.7	11.8	5.8	4.35	0.45	40.7
" 12' to 24'	29.0	15.7	10.4	3.5	0.60	39.5
" 24' to 36'	24.7	14.8	20.0	2.5	0.10	35.4
" 36' to 48'	32.7	18.7	2.0	0.85	0.15	45.9
9 mi. S. Thermopolis in Wind River Canyon						
Bighorn dol. Top to 20'	32.2	21.1	0.4	0.45	0.05	48.2
" 20' to 40'	32.0	20.3	1.4	0.55	0.15	47.1
" 40' to 60'	31.7	21.1	0.6	0.35	0.05	47.8
" 60' to 80'	31.8	21.1	0.8	0.3	0.10	47.8
" 80' to 100'	31.8	20.8	0.8	0.5	0.10	47.5
" 100' to 120'	30.6	20.9	2.0	0.65	0.35	46.7

E½ sec. 19, T. 7 N., R. 6 E. (Wind River Meridian), 5 mi. south of Thermopolis. Gently dipping beds of dolomite, 6 ft. to 16 ft. thick and separated by beds of chert, limestone and calcareous sandstone 15 ft. to 75 ft. thick, are found in the Phosphoria formation on the north flank of the Owl Creek Mountains (178).

NE¼ sec. 9, T. 6 N., R. 6 E. (Wind River Meridian), approximately 13.5 mi. south of Thermopolis. About 335 ft. of dolomite in the nearly flat-lying Bighorn and Madison formations is exposed along U. S. Highway No. 20. Cliffs of Madison limestone rise above the dolomites (1, 178).

Johnson County

NW¼ SE¼ sec. 4, T. 50 N., R. 83 W.; 7.5 mi. west of Buffalo, along U. S. Highway No. 16. Bighorn dolomite and Madison beds strike N. 45° W. and dip 76° NE. to overturned 58° SW. The dolomite is finely crystalline calcareous finely arenaceous cherty and leached in many places (178).

Natrona County

Analyses of dolomites in Natrona County (1):

Location	CaO%	MgO%	SiO_2%	Al_2O_3%	Fe%	CO_2%
10 mi. SW. Casper						
Alcova ls. middle	46.3	0.87	11.4	2.6	0.40	37.0
" " S. end	47.9	1.08	8.6	2.15	0.35	38.5
" " N. end	49.0	0.94	7.6	1.85	0.35	39.2
Minnekahta ls.						
Base to 11'	42.9	5.8	8.2	2.0	0.20	39.8
Casper ls.						
Top to 15'	34.3	18.2	1.6	0.7	0.10	46.6
15' to 30'	32.1	20.2	1.6	0.55	0.05	47.0
Casper ls. (?) or Madison (?) Top to 30'	41.5	12.3	1.2	0.35	0.05	45.8

Platte Canyon; secs. 16, 21, T. 29 N., R. 83 W., 40 mi. from Casper. Five ft. to 20 ft. units of dolomite in the Casper formation are separated by 4 to 8 ft. beds of limestone, shale, and sandstone. Beds strike northwest and dip 8° to 10° NE. (178).

Park County

Red Butte; NE¼ sec. 19, T. 53 N., R. 102 W., 7 mi. from Cody. The Phosphoria formation crops out on the east dip slope of Rattlesnake Mountain. Dolomite beds from 18 ft. to 36 ft. thick are separated by cherty limestone and sandy shale beds 15 ft. to 25 ft. thick. These units vary in composition along the strike (178).

Shoshone Canyon; NW¼ sec. 5, T. 52 N., R. 102 W., 4 mi. west of Cody. The Bighorn and lower Madison formations contain mottled tan and buff, finely crystalline and nearly pure dolomite interbedded with thin shales and dolomitic limestones (178).

Analyses of dolomites in Park County (1):

Location	CaO%	MgO%	SiO_2%	Al_2O_3%	Fe%	CO_2%
Small spring deposit SW. of Cody	30.4	20.9	2.4	0.65	0.15	47.5
Bighorn dol. W. of Shoshone dame Base to 25'	40.7	10.9	3.0	1.5	0.50	42.6
25' to 50'	41.3	12.0	0.8	0.4	0.20	45.3
50' to 75'	39.8	13.5	0.8	0.5	0.1	45.8
75' to 100'	41.2	12.5	0.8	0.5	0.1	45.8
100' to 125'	39.7	12.0	4.0	0.7	0.1	44.1
125' to 150'	41.1	12.6	0.6	0.3	0.1	45.8
300' to 325'	30.9	20.0	0.4	0.55	0.25	45.9
325' to 350'	46.1	6.5	2.4	1.2	0.3	43.1
350' to 375'	30.9	21.3	0.6	0.6	0.2	47.3
Bighorn dol. W. of Bridge						
Base to 25'	30.6	20.6	1.0	1.05	0.15	46.3
25' to 50'	46.4	7.1	1.0	0.6	0.2	43.9
50' to 75'	45.4	8.1	0.8	0.55	0.15	44.2
75' to 100'	44.2	9.4	0.6	0.55	0.15	44.7
100' to 125'	44.1	9.5	0.6	0.45	0.05	44.8
125' to 150'	38.2	14.6	1.0	0.6	0.2	45.7
4 mi. S. of Cody						
Embar fm. without limestone nodules	31.5	18.2	3.0	6.45	0.35	44.4
Embar fm. with limestone nodules	35.3	16.6	1.2	0.65	0.05	45.6

Platte County

Analyses of dolomites in Platte County (1):

Location	CaO%	MgO%	SiO_2%	Al_2O_3%	Fe%	CO_2%
18 mi. SW. of Wheatland Pre-Cambrian marbleized dolomite. West side	25.8	11.2	17.4	1.5	0.30	32.4
Middle	31.1	17.9	5.0	0.85	0.45	43.8
East side	31.1	18.8	3.2	0.6	0.40	44.8
30 mi. S. of Wheatland Pre-Cambrian marbleized dolomite. East side	35.2	16.3	8.2	0.55	0.15	45.3
Middle	33.5	18.3	7.0	0.5	0.10	46.1
West side	30.0	16.6	11.6	1.05	0.05	41.5

E½ of NW¼, NW¼ of NE¼ sec. 6, T. 21 N., R. 69 W.; 20 mi. southwest of Wheatland. Pre-Cambrian crystalline dolomite "roof pendants" in the Laramie Range are associated with gneiss and schist. The dolomite is very coarsely crystalline and nearly pure white in color. It is not uniform in composition and ranges from calcareous dolomite to nearly pure dolomite. The deposit contains large amounts of tremolite, chert, and some finely disseminated silica (178).

Romsa Dolomite Deposit; SE¼ sec. 5, T. 22 N., R. 70 W., 26 mi. southwest of Wheatland in the Laramie Range. Very coarsely crystalline, thick- and thin-bedded, nearly pure white pre-Cambrian dolomite is associated with granite and hornblende schist (178). The dolomite is not uniform in composition and contains tremolite and chert (295).

Sec. 13, T. 23 N., R. 70 W.; about 16.3 mi. southwest of Wheatland. The geology of the pre-Cambrian dolomite in this deposit is very similar to that of the Romsa deposit (178).

Central part sec. 3, T. 24 N., R. 70 W. Another pre-Cambrian crystalline dolomite body is associated with pre-Cambrian granites (178).

SE¼ sec. 25, T. 27 N., R. 66 W.; about 2 mi. northeast of Guernsey. A siliceous dolomite contains irregular bands and nodules of chert, a few crystals of tremolite and irregular masses of pale-gray quartzite and impure chert. These pre-Cambrian (Whalen Group) dolomites strike N. 65° to 70° E., dip 70° to 75° W. and are overlain by the Guernsey limestone at the southern end of the deposit (178).

Analyses of dolomites from the Guernsey-Hartville Area (180, p. 10):

Location	Mg%	MgO%	$MgCO_3$%
150 ft. E. of Gage Station, Guernsey. 200 ft. ledge dips steeply NE.	11.57	19.14	40.03
In Whalen Canyon, Keystone	10.34	17.11	35.78
Hartville, E. side of pavement, ½ mi. S. of town.	10.86	17.89	37.60
L. T. Sisson, dolomite deposit	10.07	16.67	34.86

Sheridan County

Dayton Area; NW¼ sec. 27, SE¼ sec. 20, T. 56 N., R. 87 W., 14 mi. by road from Dayton. The lower 135 ft. of the Bighorn formation contains siliceous dolomite and dolomitic limestone with much brown chert in nodules and bands (178).

Teton County

Dolomite along Leigh Creek (552) in the Teton Mountains has been analyzed by W. C. Wheeler: CaO=30.43%, MgO=20.85%, CO_2=47.10%, Insol.=0.42%, Undet.=1.32%.

REPORTED OCCURRENCES

Carbon County

Pre-Cambrian dolomite has been reported in the Sierra Madre Mountains (552, p. 2). Small amounts of pearl spar, or crystalline dolomite have been found as float in breaks at the Medicine Bow River, 6 mi. northwest of Medicine Bow (217).

Park County

Kirwin mining district. Dolomite gangue has been identified in veins (365).

FELDSPAR

The feldspar group of minerals is found in many types of rocks but commercial deposits are usually restricted to pegmatites. Orthoclase and microcline are the potassium-rich feldspars, the plagioclase feldspars form an isomorphous series between albite, $NaAlSi_3O_8$, and anorthite, $CaAl_2Si_2O_8$. Orthoclase and microcline are more widely used in industry than plagioclase. Chief uses are in the ceramic industry for glass, enamel and pottery. Feldspars are used in soaps, abrasives, and in the manufacture of false teeth. Labradorite, a calcium-rich plagioclase, often shows a play of colors and is used for ornamental stone, and as moonstones or sunstones.

In 1948, Wyoming produced 16,760 long tons of crude feldspar valued at $78,080.00 (459, p. 508) and in 1949, only 3,298 tons (583). Hanley, Heinrich and Page (354, p. 2) estimated that Wyoming has produced at least 87,000 long tons of feldspar. Between 1938 and 1949, 41,547 long tons of feldspar were sold (130). During 1955, only 103 tons of feldspar were produced. Production rose to 1,370 tons in 1956 (611). In 1962, production amounted to 433 tons (611).

PROSPECTS

Albany County

Big Chief Mica Mine; (See MICA).

Hermosa Prospect; in sec. 19 or 20, T. 13 N., R. 72 W., about 1 mi. from Hermosa siding. There are a few undeveloped pits. Analysis: $SiO_2=67.10\%$, $Al_2O_3=22.86\%$, $Fe_2O_3=0.14\%$, $MgO=0.79\%$, $Na_2O + K_2O = 8.86\%$, loss = 0.25% (222).

Ione Prospect; sec. 32, T. 13 N., R. 78 W. This pegmatite is in pre-Cambrian schist and contains chiefly quartz, microcline and muscovite, with accessory albite (354, p. 108). Punch and scrap quality mica is visible in a pit 25 ft. to 30 ft. long, 8 ft. to 10 ft. wide and 3 ft. to 4 ft. deep. The dike trends N. 55° W. (320).

Muscovite Claim; (See MICA).

Tie Siding Area; Tps. 12, 13 N., Rs. 71, 72 W. Pre-Cambrian Sherman granite contains a number of small potash-rich, pod-like pegmatites. The largest pegmatite in the area is in the north-central part sec. 11, T. 12 N., R. 72 W., 500 ft. east of U. S. Highway No. 287. It is irregularly zoned with a quartz core surrounded by a microcline zone, and a wall zone with large biotite masses and accessory garnet. Some feldspar was shipped to Denver (503).

The second largest pegmatite is in the center, sec 6, T. 12 N., R. 71 W. It is a microcline-rich body (503).

Another smaller pegmatite is located in the NE. corner, sec 1, T. 12 N., R. 72 W. Small microcline pegmatites are also located in the NW. corner, SW¼ NE¼ sec. 35, and near the center, sec. 1, T. 13 N., R. 72 W. (503).

Horse Creek Area; sec. 36, T. 16 N., R. 71 W. A pit 40 ft. by 50 ft. in pegmatite produced 1,632 tons of feldspar from December, 1942, to May, 1943. No more recent records are available (328). More quartz is present than in the nearby Beaver Claim in Laramie County.

Carbon County

Sec. 1, T. 13 N., R. 84 W.; near Encampment. "There is an outcrop of feldspar carrying muscovite. This outcrop is 1,600 ft. long and will average 100 ft. wide" (227).

Converse County

Schundler-Glenrock Prospect. A feldspar pit was opened south of Glenrock. Pink microcline in granite intruded schist and in places quartz mingles with the microcline. A few beryl crystals have been found. Prior to 1942, 14 or 15 carloads of crude feldspar were shipped (309).

Fremont County

Copper Mountain District; Whippet Prospects. The prospects are in an area about 4 mi. long from east to west and 2 mi. wide, about 15 mi. north of Shoshoni. The pegmatites intrude pre-Cambrian basic schists, amphibolites, and gneisses, the foliation of which strikes N. 70° to 80° E., and dips 50° to 60° SE. (354, p. 109).

Whippet No. 1 Prospect, east-central part sec. 28, T. 40 N., R. 93 W. The pegmatite dike trends N. 65° E., dips 10° to 60° NW., and can be followed for 320 ft. It is very irregular and averages 4 ft. to 6 ft. thick. The northeast part is thinner and contains much coarse-grained potash feldspar, albite, and muscovite associated with beryl and tantalite. The southwestern part is almost entirely quartz. Directly north of the beryl-bearing pegmatite is another pegmatite with numerous books of sheared mica, and small, pale-lavendar flakes of lepidolite. Columbite-tantalite, (48% Ta_2O_5 and 34% Nb_2O_5) and some euhedral beryl were sold between 1938 and 1942. No more recent records are available (354, p. 111).

Whippet No. 8 Prospect, south-central part sec. 22, T. 40 N., R. 93 W. intrudes amphibolite. The northeast body crops out for 400 ft. and is 300 ft. wide. It is separated from the southwest pegmatite by a valley partly filled with alluvium. The northeastern pegmatite contains the largest amount of tantalite of any prospect in the region; average is 75% to 80% Ta_2O_5. Tantalite is associated with beryl in zones and streaks. About 250 lbs. of tantalite and some beryl have been sold in the past, and estimated reserves total about 2,250 tons of tantalite-bearing pegmatite. The southwestern pegmatite is 180 ft. by 25 ft., has an average thickness of 10 ft. and is not as well zoned. The potash-feldspar is coarse-grained, white to blue-gray. Small muscovite books and fine-grained mica aggregates are found near the center. Scattered, irregular, small masses of petalite are associated with the albite pegmatite zone. Tourmaline is a minor accessory mineral (354, pp. 109-11; 307).

Goshen County; Haystack Range.

Chicago Prospect; (See MICA).

Crystal Palace Project; (See MICA).

Haystack No. 1 Claim; sec. 1, T. 27 N., R. 65 W. This pegmatite has very poor surface exposures but the most predominant mineral is microcline, with scattered quartz and a small number of muscovite books less than 1 in. in diameter. A few euhedral garnet crystals have been found (354, p. 119).

Haystack No. 2 Claim; sec. 1, T. 27 N., R. 65 W., north-northwest of the Haystack No. 1 prospect. Two pegmatites crop out. The eastern one strikes N. 75° W. and dips 65° NE. It is 6 ft. wide and about 15 ft. deep and is mostly mined out. The western pegmatites is 6 ft. wide and 10 ft. deep. Both are rich in quartz, potash feldspar, and mica, with muscovite concentrations near the hanging wall. Mica makes up about 25% of this pegmatite but is suitable for scrap mica only. Euhedral garnet crystals up to 1 in. in diameter have been found (354, p. 121).

New York Prospect; (See MICA).

Ruth Prospect; (See MICA).

Savage Prospect; (See MICA).

Torrington No. 1; (See MICA).

White Star Prospect; (See MICA).

Laramie County

Bear Deposit; Tps. 15, 16 N., Rs. 70, 71 W., 37 mi. by road from Cheyenne. This deposit has been mined by the Wyoming Feldspar Company, of Laramie. Pegmatite in this deposit is chiefly pink microcline, quartz, and biotite. A small amount of fluorite has been produced from one pit (See FLUORITE). Feldspar constitutes about 80% of the pegmatite (217). In 1948, 3,995 tons were shipped and in 1949, 601 tons (583).

Beaver Claim. Sec. 26, T. 16 N., R. 70 W. The M. and S. Co., Inc., Denver, Colorado, own this deposit. A pegmatite dike 10 ft. to 12 ft. wide contains good quality microcline with some quartz and a little biotite. Crude feldspar has been shipped to Denver and used for porcelain and glass manufacture; 12,302 tons were produced in 1948 and 2,697 tons in 1949 (327).

Natrona County

Koch Deposit; Casper Mountain, secs. 17, 18, 20, T. 32 N., R. 79 W. A fairly large pegmatite up to 50 ft. wide trends north-south for about a mile between two quartz layers. Two pits and a quarry reveal light gray, good quality, microcline, muscovite, and quartz. The pegmatite is associated with asbestos deposits nearby (305); (See ASBESTOS).

REPORTED OCCURRENCES

Albany County

At Gold Hill, on the west flank of the Medicine Bow Mountains, 3 mi. due west of Medicine Bow Peak, euhedral oligoclase up to 1 in. long (elongated in the direction of b axis) line the walls of an irregular vein of dark-colored metaquartzite (157).

Twenty miles west of Wheatland, a series of dikes are believed to contain plagioclase (217).

Fremont County

Sec. 18, T. 30 N., R. 96 W. Orthoclase crystals up to 12 in. long have been found in a pegmatite (246).

FLUORITE

Fluorite, CaF_2 is widely distributed in veins, in sedimetary dolomites and limestones, and as an accessory mineral in granites and pegmatites. Many lead, zinc, silver, and tin ores contain fluorite.

The mineral is used in metallurgy as a flux and as an electrolyte. Other important uses are in the steel industry, the manufacture of hydrofluoric acid, opal glass, enamel ware, and sometimes as ornamental stone. High quality fluorite is used for lenses and other optical equipment.

There are scattered deposits of fluorite in Wyoming, but those in Crook County are the only ones of known potential economic importance. Nineteen short tons of fluorite were shipped from Wyoming in 1944 (130).

PROSPECTS

Crook County

Bear Lodge District. The fluorite deposits in the Bear Lodge Mountains are located in Black Hills National Forest, 10 mi. north of Sundance. The limestones containing fluorite trend north and south for about 3 mi. in a zone ½ mi. wide. Average assays show 36% CaF_2, although the outcrops at the northern end of the deposit assayed 70 to 78% CaF_2. About 800 lbs. of fluorite have been taken out (563).

SW¼ sec 27 and SE¼ sec 28, T. 52 N., R. 63 W., near the crest of an east-west trending ridge, which is the divide between Ogden and Tent Creeks. Oldest rocks in the area are crystalline limestones or marbles. Three discontinuous, fluoritized masses of limestone have been invaded by Tertiary trachytic porphyry; there is some breccia. The porphyry is widespread and contains massive, relatively siliceous, fluorite bodies. Fine-grained disseminated fluorite grains are found at or near the contacts of limestone (marble) and the trachytic porphyry. Three phonolite dikes cut the porphyry and limestone, but contain no fluorite (274; 275; 330). A mineralized zone of fine-grained fluorite disseminated in marble is estimated to contain 5%-10% CaF_2. Siliceous fluorite-bearing veins in intrusive rocks are as much as 2 ft. wide in a breccia zone that strikes N. 10° W. and dips steeply west (156, pp. 5-6).

Royal Purple Nos. 1, 2; 1½ to 2 mi. west from south side of Warren's Peak, along Middle Fork of Houston Creek, near the boundary between sec. 5, T. 51 N., R. 63 W., and sec. 32, T. 52 N., R. 63 W. A Tertiary phonolite or andesite-porphyry sill 50 ft. to 75 ft. thick, intrudes Minnelusa sandstone (Pennsylvanian) along bedding planes. Both the sill and sandstone trend north-south and dip 20° to 30° west. Deep purple to black fluorite grains are disseminated in the Minnelusa from 50 ft. to 75 ft. from the porphyry contact. On the north side of the creek the sandstone encloses 5 or 6 lenses of fluorite 1 ft. to 2 ft. wide and 8 ft. to 10 ft. long, associated with calcite, quartz, and siderite (?) (274). Cox (156, pp. 11-12) estimates that a faulted zone between porphyry and limestone contains 20%-30% CaF_2 and that a zone of fluorite disseminated in coarse-grained soft limestone and a vein between limestone and sandstone contain about 30% CaF_2.

Sec. 15, T. 52 N., R. 63 W., on the north slope of a flat-topped ridge. The Pahasapa formation (Mississippian) contains flat-lying lenses of fluorite. The Pahasapa is a massive, blue-gray, to black, fossiliferous limestone which strikes east-west and dips 25° to 30° N. Pits reveal 3 ft. to 4 ft. of massive deep-purple fluorite which replaces limestone along bedding planes. A lenticular discontinuous breccia in the limestone contains limestone fragments; the matrix is fluorite (275). The U. S. Bureau of Mines (29, pp. 25-27) describes the ore as an intimate intergrowth of fluorite, calcite, quartz, and orthoclase. The fluorite grains pass through the 65 to 270 mesh screen. An analysis (29, pp. 25-27):

CaF_2=78.1%, $CaCO_3$= 3.2%, SiO_2=9.6%, Fe=0.35%, Ba-MgO=0.1%, Ba_2O=1.6%.

Petersen deposits, secs. 15, 23, T. 52 N., R. 63 W., near South Redwater Creek, 6 mi. north of Sundance. The Pahasapa limestone strikes northwest and dips 29° to 40° NE. (29, p. 2). The limestone contains disseminated grains of fluorite (29), and lenses of fluorite which dip generally parallel to the bedding. Some pits showed 3 ft. to 4 ft. of massive, deep-purple fluorite, though most exposures showed considerably less. In a few pits the lenses contain about 60% to 90% fluorite, especially in the central part of the lenses. Fluorite lenses grade into limestone on both the hanging-wall and foot-wall. The margins of the masses show interlayered fluorite and limestone with individual layers about ¼ in. to ½ in. thick. "Nothing in the available exposures suggests steeply dipping fissure veins" (275).

Laramie County

Bear Deposit; SW¼ NW¼ sec. 5, T. 15 N., R. 70 W. A triangular area, 150 ft. by 150 ft. by 100 ft. contains fluorite masses 1 ft. to 5 ft. long. A pre-Cambrian pegmatite in granite contains fluorite. Clear grains of fluorite ⅛ in. to 2½ in. across contain interstitial feldspar. Twenty tons of fluorite were stockpiled in 1944 as a by-product during feldspar mining by the Wyoming Feldspar Co. (217).

REPORTED OCCURRENCES

Carbon County

Aughey (16, p. 57) reported fluorite in the limestone south of the Seminoe Mountains.

Crook County

D. B. Hilton (235) reported fluorite in the Minnelusa sandstone in about sec. 24 or 25, T. 52 N., R. 64 W.

Fremont County

Fluorite was reported "in limestone in Little Popo Agie Canyon" (16, p. 57).

Natrona County

Aughey (16, p. 57) reported fluorite at the north end of the Rattlesnake Mountains.

GARNET

Garnet is a common and widespread mineral in many types of metamorphic rocks and an accessory mineral in some igneous rocks. It is a common contact metamorphic mineral. Because of its resistance to weathering, rounded garnets are often found in river and sea sands, usually near the source of the original garnet-rich rock. There are six main sub-species that vary in chemical composition and specific gravity. They include:

Pyrope	$Mg_3Al_2(SiO_4)_3$	Grossularite	$Ca_3Al_2(SiO_4)_3$
Almandite	$Fe_3Al_2(SiO_4)_3$	Andradite	$Ca_3Fe_2(SiO_4)_3$
Spessartite	$Mn_3Al_2(SiO_4)_3$	Uvarovite	$Ca_3Cr_2(SiO_4)_3$

Garnet crystals are used in industry for making garnet paper, grinding stones, and other abrasives. Deep-red unfractured individual crystals 3/16 in. diameter or larger are preferred (422, p. 31). Clear, flawless garnets of various colors are used as semi-precious gem stones. Production of garnet in the United States has greatly declined because of the manufacture of artificial abrasives.

PROSPECTS

Goshen County

Several hundred clear crystals from a deposit in about sec. 11, T. 27 N., R. 65 W. have been cut, polished, and sold as gem stones (325).

Platte County

"In the Cooney Hills, near Wheatland, is a large deposit of garnet, from which a small shipment has been made" (221).

REPORTED OCCURRENCES

Albany County

Jelm Mtn. Large numbers of low grade garnets occur in weathered, brown mica schists along the west side of Jelm Mountain, immediately south of Wood's Landing bridge (252).

Many Values Prospect; (See MICA).

Muscovite Claim; (See MICA).

Owen Creek area; secs. 9, 16, T. 25 N., R. 71 W. In the NW¼ sec. 16, in a gully tributary to Owen Creek, garnets up to ¼ in. in diameter have weathered out of an adjacent biotite-schist body. The Mg-amphibole schist body just west of the Big Chief Mica Mine contains garnets (pyrope-almandite) with a specific gravity of 3.99 and 0.72% MnO (468).

Tie Siding Area; (See FELDSPAR).

Utopia Tunnels, sec 9, T. 15 N., R. 78 W. Garnets in a hornblende schist have been found in this gold prospect (163); (See GOLD).

Ione Prospect. Large garnets, some of which weigh over 2 lbs. have been found in a biotite schist body near the Ione Prospect. Most crystals do not show good crystal faces, and are not of gem quality (13, p. 381); (See FELDSPAR).

Carbon County

Encampment area; sec. 14, T. 14 N., R. 84 W.; 2 or 3 mi. south of Encampment. Large perfect garnet crystals have been found. Analysis: $SiO_2=38.94\%$, $Fe_2O_3+Al_2O_3=52.43\%$, $CaO=1.76\%$, $MgO=5.27\%$, loss on ignition=1.61% (222).

Converse County

Jasper Mine, Douglas District; (See COPPER).

Mormon Canyon; secs. 11, 12, 13, 14, T. 32 N., R. 76 W. A scheelite-bearing quartz vein contains abundant garnets and other lime silicate minerals (308); (See SCHEELITE).

Crook County

Nigger Hill Area. Abundant, small, red garnets have been found in this gold placer district (374, p. 179); (See GOLD).

Fremont County

Abernathy Claim; (See SCHEELITE).

Dawn Claim. On a ridge between two branches of Hoodoo Creek, lime silicate rocks at a scheelite prospect contain accessory garnet. (562, p. 10); (See SCHEELITE).

Hoodoo Creek Claims; S½ sec 22, T. 40 N., R. 93 W. Garnet is an accessory mineral in scheelite claim (562, p. 9); (See SCHEELITE).

Roberson-Muirhead Claim; (See SCHEELITE).

Stardust Claim; S½ SW¼ NW¼ sec. 22, T. 40 N., R. 93 W. Scheelite crystals are embedded in a zoisite, epidote, and garnet matrix (562, p. 9); (See SCHEELITE).

Copper Mtn. area; SW¼ sec. 22, T. 40 N., R. 92 W., 20 mi. north of Shoshoni. Locally, garnet, epidote and actinolite are associated in the country rock at a scheelite prospect (217); (See SCHEELITE).

Sweetwater area. Garnets "were accidentally discovered in large quantities in the bed and alluvial bottoms of the Sweetwater River at camp 13" (154, p. 104).

This location is about 10 mi. upstream from "Burnt Ranch," and the point where the old Camp Stambaugh road crossed the river.

Wind River Range. Near Lander a scheelite prospect contains garnet in a metamorphosed quartz vein (217); (See SCHEELITE).

Goshen County

Crystal Palace Prospect. Contains accessory garnet; (See MICA).

Haystack Hills, Haystack Claims Nos. 1 and 2; (See FELDSPAR).

Jay Em Area. Large, fractured garnets have been found in an outcrop about 12 mi. west and 8 mi. north of Jay Em, and northwest of Rawhide Creek (260).

Platte County

Rabbit Creek Area; secs. 23, 24, 25, 26, T. 26 N., R. 60 W. Euhedral almandite garnet crystals from 1.3 mm. to 1.5 mm. are abundant in a garnetiferous hornblende schist in the area. Round, weathered garnets with a specific gravity of 4.22 are found in a dry creek bed in sec. 26 (492, pp. 10-11); (See GRAPHITE).

Bartlett (26, pp. 3-4) reported a surface deposit of garnet ½ mi. long, and 20 ft. to 30 ft. thick.

GLASS SAND

Glass sand is a high-silica sand that contains very little iron oxide or other impurities. Mining is simplified if the deposit is in unconsolidated beds, but underground methods are often used on consolidated sandstones.

There are several areas in Wyoming which are potential sources of glass sand. The only recorded production was in 1892-93 for use in a plant in Laramie.

PROSPECTS

Albany County

Laramie area; 3 mi. east of Laramie, in sec. 25, T. 16 N., R. 73 W. A soft, friable sandstone in the Casper formation (Pennsylvanian) contains a small amount of iron oxide and carbonaceous material (171, pp. 65-66). The outcrop is 2 ft. to 4 ft. thick, with overburden from zero to 10 ft. thick.

A partial stratigraphic section by Knight (400) is:

Limestone cap rock	2 ft. to 3 ft. thick
Flaggy calcareous sandstone	7 ft. to 8 ft. thick
Glass sand, white, friable	15 ft. thick
Red sandstone	2 ft. to 4 ft thick

An analysis by the Natural Resources Research Institute, University of Wyoming, in 1946 gave 0.24% Fe_2O_3 and 5.13% CaO (239). Other analyses include (400): SiO_2=99.04% and 97.92%, Fe_2O_3=0.73% and 2.01%. One hundred thousand boxes of glass were manufactured at Laramie during 1892-3 (400).

Big Horn County

Lovell areas. Potential glass sand deposits occur in large channel-like sandstones of the Himes member of the Cloverly formation (Lower Cretaceous). The three deposits examined and described below have no overburden and are readily accessible from major highways or secondary roads. All can be easily quarried (676).

SW¼ SE¼ and SE¼ SW¼ sec 11, NW¼ sec 13, NE¼ 14, T. 57 N., R. 95 W. Massive sandstone, averaging about 30 feet in thickness, is exposed over a width of approximately 400 feet and extends along the strike for a distance of approximately one mile. This bed, which strikes N. 50° W., and dips 23° SW., crops out as a hogback. The rock, as exposed, is a yellowish-gray fine-grained cross-bedded soft and poorly cemented quartz sandstone. Samples from the lower 20 feet of this bed were analyzed as follows: SiO_2=96.08%; Fe_2O_3=0.16%; Al_2O_3=0.09%. A second sample, taken from a location one-third of a mile north of above, was analyzed as follows. SiO_2=96.92%, Fe_2O_3= 0.10%; Al_2O_3=0.10%.

SW¼ sec. 27, NE¼ and NW¼ sec 34, T. 58 N., R. 95 W. A bed of sandstone, similar to that of above, but of somewhat poorer quality, strikes N. 32° W., and dips 5°-15° NW. The bed crops out as a well-exposed dip slope with no overburden.

E½ sec. 15, T. 55 N., R. 95 W. Sandstone averaging 30 feet thick crops out for approximately one mile along a hogback ridge. The outcrop, which is approximately 300 feet wide, strikes N. 43° W., and dips 22° to 30° SW. No overburden is present. The rock is a yellowish-gray fine-grained moderately hard and well-cemented cross-bedded quartz sandstone. The upper half of the outcrop is thin-bedded, while the lower half is massive or thick-bedded. A composite sample taken from a small quarry in the lower massive bed and from the outcrop of the upper thin-bedded unit was analyzed as follows: SiO_2=95.10%; Fe_2O_3=0.28%; Al_2O_3=0.22%. The quarry in the lower massive unit was the source of glass sand used in the Lovell glass factory, which was operated during the period 1918 to 1927. In 1926, it was reported that the Salem Company Cooperative Glass Co. manufactured window glass at Lovell utilizing sandstone from this deposit. Note; all of the above analyses were performed by the Natural Resources Research Institute at the University of Wyoming.

Carbon County

Along the eastern end of the Ferris Mountains in Tps. 25, 26 N., Rs. 86, 87 W., extensive Quaternary sand deposits contain 99.79% quartz, and 0.21% iron minerals. A washing operation will reduce the iron content to 0.04%. The sand is stabilized by a sparse growth of sagebrush over most of the area, but some dune sand is moving from the southwest to the northeast (151, pp. 41-42). Recent analytical work by the Union Pacific Railroad indicates that the percentage figures for quartz are incorrect; they report that these sand deposits contain from 20 to 50% feldspar, some of which is plagioclase.

REPORTED OCCURRENCES

Carbon County

Freezout Hills; Tps. 25, 26 N., R. 79 W., 25 mi. north of Medicine Bow. A soft, white, porous, medium-grained sand in the Jurassic Morrison formation crops out in this area. There is no iron stain visible (434).

Fremont County

East Fork Sheep Creek; T. 6 N., R. 2 E., (Wind River Meridian). A white, soft, medium-grained, non-ferruginous bed of sand more than 100 ft. thick crops out in the Jurassic Morrison formation along the creek, and may be traced some distance along the strike (568).

Platte County

Cassa area; secs. 33, 34, T. 29 N., R. 69 W., 8 mi. west of Cassa. A 70 ft. thick, white, medium-grained, soft, porous, Jurassic sandstone is a potential source of glass sand (434).

GLAUCONITE

Glauconite is a hydrous iron and potassium silicate, usually found in small rounded grains or lumps in marine sediments deposited near continental shores. It is probably the alteration product of augite, mica, hornblende, and/or other silicate minerals. These "greensands" are used for water softeners, mainly. The mineral, however, carries variable percentages of potash and is a potential source for that compound. Because of its high specific gravity, it is readily separable from associated quartz grains.

Glauconite is found in Wyoming in thin, but persistent beds in the upper part of the Sundance formation. These beds are especially rich and thick near Lander. Some Cambrian and Cretaceous sandstones are also glauconitic. It is impossible to list all the locations where glauconitic sandstones have been found because of lack of space. The state geologic map (566a) shows the general distribution of Jurassic rocks.

GOLD

Gold is found in both vein and placer deposits. Because it is a chemically inert element, it is usually native, or alloyed with silver when found in veins. Less frequently gold is combined with tellurium in the minerals sylvanite, krennerite and calaverite. Placer gold is always native, though its fineness (percent of alloyed metals) varies. Because of its high specific gravity, placer gold is usually caught in the low places in a stream bed or in places where currents were less active, usually somewhere near the stream channel bottom.

Small gold deposits are widespread in Wyoming, chiefly in the pre-Cambrian rocks in the mountain cores. Many present streams contain low-grade gold placers and, in several areas, Tertiary gravels bear a little gold. Gold tellurides are reported from the Black Hills area, associated with Tertiary intrusive rocks.

Gold was first discovered in the Sweetwater District in the 1840's (413) and intermittent production has continued to the present. S. H. Knight (407, p. 24) estimated total production between 1869 and 1874 (years of greatest activity) from the Sweetwater mines at approximately $2,000,000. Most other gold prospects in the state are low grade and of small size. In addition, many placers contain finely divided gold that is difficult to recover. A few ounces of placer gold, however, is usually produced each year in Wyoming.

PROSPECTS

Albany County

Albany Placers. The claims begin in sec. 16, T. 14 N., R. 79 W., and extend north up Douglas Creek for about 5 mi. Douglas Creek gravels lie on red and gray granite which contains an occasional layer of schist and gneiss (102). Beeler reported in 1905 (102) that Douglas Creek gravel averaged $0.50 per cu. yd. in gold. Most of the gold was coarse and jagged in appearance, with considerable "flour gold," and was .890 to .959 fine. In 1906 Beeler (92) stated that the gravel averaged $1.25 per cu. yd. Other tests were as follows: Moore's Gulch gravel, $1.00 per cu. yd. (102); Dave's Gulch, $1.60 per cu. yd. (92).

Beeler (92, p. 29) quoted M. N. Grant, who estimated the average depth of the gravel at 6 ft., with a total of over 3,000,000 cu. yds. available which were expected to average $0.50 per cu. yd. Grant is also reported to have estimated 60,000 cu. yds. of gravel in Moore's Gulch which averaged $1.00 per cu. yd. Beeler also reported (92, pp. 31-32) that in places on bed rock, the gravel pans "from $0.50 to $2.50 per pan, and many nuggets were taken out weighing from one to twenty penny-weights . . ." and that "I made a test on bench land or rim rock between this creek (Dave Creek) and Douglas Creek. We ran twenty-five cubic yards of gravel through sluice boxes, and cleaned up 31 pennyweights of gold of value of $29.45. In the black sands we found about $5.00 or $6.00 worth of platinum . . . The gold is from 0.900 to 0.950 fine and generally bright and easy to amalgamate." The placers also contain a small amount of palladium (92, p. 29).

The references to Albany County gold placers are very vague, and no accurate locations are given. The names as used in this report were taken from the original works, but the present authors can take no responsibility for the accuracy of the locations given for the various workings (see also *Douglas Creek Placers, Douglas Consolidated Placers, Home Placers,* and *Spring Creek Placers*).

Albatross Claim; in the "Lake Creek district." A vein of "jasper-iron quartz" 7 ft. wide contains $6.00 in gold per ton (1900 prices) and 4% copper. A 30 ft. shaft was sunk on the property (9, p. 15).

Annie Mine; Jelm Mountain; (See COPPER).

Antlers Mine; 12 mi. southeast of Laramie in the "Black Hills Range" (Laramie Range). Beeler states that the mine is located in "an immense 'blowout' or chimney and is purely of eruption origin. It is elliptical in form and is about 300 ft. wide by 500 ft. long." The mineralized material is mostly quartz and feldspar, with limonite, and assayed up to $15.00 in gold per ton (1906 prices). Beeler estimated the whole ore body would average $8.00 in gold per ton, and that "there are 1,000,000 tons of ore in the first 100 ft. of depth" (92, pp. 65-66). The authors are of the opinion that this type of ore pipe is not likely to be found in the Laramie Range.

Centennial Ridge; sec. 9, T. 15 N., R. 78 W. Small gold bodies have developed in quartz veins in hornblende schist and chlorite schist, and are probably genetically related to granite pegmatites, according to Vahrenkamp (572).

Copper Queen; Jelm Mountain; (See COPPER).

Copper King; (See LEAD).

Douglas Creek Placers. The first placers in the region were discovered in Moore's Gulch in 1868, and about $8,000.00 worth of gold was taken out in 1869 (92, p. 14). The gold was found in Lake Creek, Muddy Creek, Spring Creek, Keystone Creek, Beaver Creek, Lone Gulch, Horse Creek, Gold Run, Joe's Creek, Moore's Gulch, Dave's Creek, Ruth's Creek, Bear Creek, and Willow Creek, in an area 15 mi. long and 10 mi. wide (92). The gold was coarse and jagged and many particles had considerable quartz attached to them. The nuggets weighed from 15 to 68 dwts. The gravel beds are from 3 ft. to 10 ft. thick; the average is about 5 ft. (92). There was a little platinum associated with the gold, according to Beeler (92).

Douglas Consolidated Placers. On Douglas Creek, extending from sec. 10, T. 13 N., R. 80 W., to sec. 2, T. 13 N., R. 79 W., a distance of about 8 mi. and on Muddy Creek for a distance of about 5 mi. from Douglas Creek to the south line of sec. 18, T. 14 N., R. 78 W. The gravel averages 6 ft. thick, and lies on schist and granite. Beeler quoted Grant, who claimed the gravel averaged $0.35 per cu. yd. (1906 prices), with about 25% coarse gold. Pan tests varied from $0.70 to $1.75 per cu. yd. in sec. 19, T. 13 N., R. 79 W., to $0.92½ to $1.05 per cu. yd. in sec. 15, T. 14 N., R. 78 W. Pan tests in sec. 25, T. 14 N., R. 79 W., yielded $0.49 to $1.25 per cu. yd. of gold which varied from 0.911 to 0.950 fine. One sample from this locality contained platinum (92, pp. 17-26).

Esterbrook Mine; (See LEAD).

Eureka Prospect; Esterbrook Area; (See COPPER).

Fairview Claim; on top of Tenderfoot Mountain, sec 6, T. 13 N., R. 79 W. A vein 44 in. wide assayed 28.5% copper and $16.50 in gold per ton at 8 ft. depth (9, p. 14).

Florence Mine; near Keystone, SE¼ sec. 22, T. 14 N., R. 79 W. Auriferous pyrrhotite is contained in a quartz vein 3 ft. to 5 ft. wide, but the gold is difficult to concentrate (92, pp. 49-51). The shaft was 160 ft. deep, with 120 ft. of drift at the 30 ft. level, and a short drift at 100 ft. "A large amount of ore was stoped from the upper level." The protore consisted of irregular kidneys and bunches of "white iron sulphide" in granite (405, p. 12).

Golden Crown Mining Syndicate; sec. 9, T. 15 N., R. 78 W., about 2 mi. from Centennial. Dikes of quartz pegmatite and "diorite (several early authors use 'diorite' for diabase and other dark rocks) and veins" cut pre-Cambrian hornblende schist. Schists, dikes, and veins strike east-west, and are vertical. At the surface "honeycombed quartz" contains free gold, and the mineralized portions are "associated with dikes." The material assayed between $1.60 and $66.80 per ton in gold and platinum. About one-half of the samples assayed less than $10.00 per ton (164).

Home Placers; secs. 10, 15, 21, 22, 27, and 34, T. 14 N., R. 79 W., on Douglas and Beaver Creeks. The gravel is of varied composition and amount; above the mouth of Beaver Creek, it contains boulders of granite 1 ft. to 4 ft. in diameter, is 80 ft. to 250 ft. wide, and is not favorable to work. The gravel is less coarse below Beaver Creek, and in a willow flat 600 ft. to 800 ft. wide and 2,000 long, the gravel is 3 ft. to 8 ft. thick, with boulders from 1 in. to 12 in. in diameter. Most of the gold was found at bedrock, and averaged $0.18 to $0.24 per cu. yd. (1901 prices) (42).

The bedrock is granite, which contains layers of schist and "diorite" cutting across the stream channel. One nugget weighed 69 dwts. (104).

Hub Lode Claim; sec. 15, T. 14 N., R. 78 W. Either the gold was associated with a pegmatite, or it was a placer in Tertiary gravels (217).

Independence Group; sec. 15, T. 14 N., R. 79 W., 1 mi. above Keystone. Gray "dioritic granite" and fine-grained schists are in contact with a quartz vein 8 ft. to 10 ft. wide. The vein contains malachite, hematite, and limonite at the surface. At 335 ft. depth, the vein was still leached and altered (101).

Independence Mine; near Centennial. An analysis of "mine-run ore" showed 0.08 oz. of gold and 0.22 oz. of silver per ton (217).

Kansas Group; Keystone-Holmes area; (See COPPER).

Keystone Mine; at Keystone on Douglas Creek, NW¼ sec. 22, T. 14 N., R. 79 W. A shaft was sunk to a total depth of 365 feet on a gold-quartz vein (9, p. 13) and about 5,000 feet of drifts were run (405, p. 12). In 1890, a 40-ton stamp mill was placed in operation (626). Full-scale operations ceased in 1893 (626); however, in 1899, the mine was reported to have 100,000 tons of ore in sight and 6,000 tons on the dump (9, p. 13). The vein was 2 to 6 feet wide. Average value of the ore was $23.50 per ton (date of prices not given by Knight), and total production was estimated at $96.000 (405, p. 12). Cleanup operations were conducted in 1916 and 1939, and the mine plant dismantled and shaft sealed in the 1950's. (626).

La Plata District; Centennial.

Big Strike Claim; (See LEAD).

Copper King Claim; (See LEAD).

Maudem Group; Keystone-Holmes area; (See COPPER).

Medicine Bow Mines Co.; Keystone-Holmes area: (See COPPER).

Rambler Mine; (See SILVER).

Rising Sun Claim; (See LEAD).

Sherman Group; southern Laramie Range; (See COPPER).

Spring Creek Placers. Three and one-half miles of gravel on Spring Creek were reported to vary between 50 ft. and 150 ft. wide, and to average 4 ft. thick. In 1895 1,200 yds. of gravel yielded $1,000. The gold was coarse and jagged and confined to bedrock. Nuggets weighing between 1 dwt. to 17 dwts. made up $400 of the $1,000 (92, p. 24).

Strong Mine; southern Laramie Range; (See COPPER).

Tenderfoot Group (War Bonnet Group); (See COPPER).

Three Cripples Mine; Esterbrook district, NE¼ sec. 16, T. 28 N., R. 71 W. A 90-foot shaft was sunk on a "large lead of pyritic iron" (pyrrhotite?), which contained values in copper, gold, silver, and traces of nickel (352, p. 11). Traces of sphalerite are also reported from here (639).

Ulcahomo; near the Strong Mine in T. 16 or 17 N., R. 71 W. A 150 ft. shaft was sunk on a quartz vein which contains pyrite and chalcopyrite. The vein material carried up to $1,000 in gold, with some silver, nickel, and copper, according to Beeler (92, p. 63), but this probably represents a picked sample.

Utopia Tunnels; sec. 9, T. 15 N., R. 78 W. A small amount of gold is associated with shear zones in the hornblende schist. The gold is reported by Dart to be associated with garnets, and also to be in quartz streaks. The mineralized zone is supposedly cut off by a flat fault (163).

Big Horn County

Bald Mountain Area; T. 56 N., R. 91 W. The basal gravels of the Deadwood formation contain fine-grained free gold where they are mixed with the disintegrated portions of the underlying granite. The values are reported to be low (169, pp. 112-113) and are irregularly distributed. These rocks crop out on the summit of the Bighorn Range, near the Montana-Wyoming line (189, pp. 66-67). The highest assays reported are $2.00 in gold per ton. The mills proved to be unprofitable to operate (168, p. 307).

Fortunatus Mill; T. 56 N., R. 91 W. "Some of the small intrusive dikes or chimneys about Fortunatus Mill are reported to contain some gold, but the value is low and the extent of mineralization small" (168, p. 307).

Carbon County

Albion Claim; (See LEAD).

Big Creek Mine; (See COPPER).

Bridger Mine; Sierra Madre Area; (See COPPER).

Bonita Prospect; Sierra Madre Area; (See COPPER).

Charlie's Glory Hole; sec. 29, T. 26 N., R. 84 W. Free gold occurs in a quartz vein emplaced in a small fault zone in chlorite-muscovite schist (619).

Cooper Hill; T. 18 N., R. 78 W. Beeler reports that the float from Cooper Hill is very rich in gold, galena, and copper ("up to $34,000.00 per ton," 1906 prices). In a mill test, the tailings were richer in galena and gold than the original ores (92, p. 60). A large dike of "sugar" quartz extends along the west side of the hill, and contains free-milling gold which averages $2.00 to $2.50 per ton (1906 prices). Beeler's statement about the richness of the float probably refers to a picked sample and hence is not typical of the entire deposit (92, pp. 59-61).

Copper Gem Prospect; Sierra Madre Area; (See COPPER).

Cumberland Group; Medicine Bow Mountains; (See COPPER).

Deserted Treasure Mine; Seminoe District; Free-Milling gold quartz also contains gold-bearing chalcopyrite and pyrite (16, p. 5).

Dreamland King Group; Sierra Madre Area; (See COPPER).

Elk Mountains Prospect; Medicine Bow Mountains; (See COPPER).

Fox Group; Medicine Bow Mountains; (See COPPER).

Gold Coin Prospect; Sierra Madre Area; (See LEAD and COPPER).

Independence Group; Sierra Madre Area; (See COPPER).

Itmay Mine; Sierra Madre Area; (See COPPER).

King Mine; Seminoe District. A gold-quartz vein 5 ft. thick strikes southeast and dips northwest. The vein also contains some chalcopyrite and pyrite. Seventy tons of ore run through a quartz mill produced $700.00 in gold (1886 prices); none of the pyrite was saved (16, p. 5).

King of the Camp Prospect; Sierra Madre Area; (See COPPER).

Meta Mine; Encampment Area; (See LEAD).

North Fork Group; Sierra Madre Area; (See COPPER).

Pease Placers; located somewhere in secs. 11, 12, 13, and 14, T. 12 N., R. 86 W., about 14 mi. from the old town of Battle, and adjacent to the Three Forks and Independence Groups; (See COPPER). Gold and silver have been washed from the gravels, but no figures are available on the value (90).

Shirley District; (See HEMATITE).

Shirley Mountains; sec. 3, T. 25 N., R. 83 W. A tunnel was driven into granite "with the hope of striking a gold or silver vein at depth." A few quartz veins crop out in the vicinity (530, p. 62).

Snake River; southwest and west of Baggs. A belt of gravels 40 mi. by 30 mi. extends along the Snake River, in Colorado and Wyoming. The gravels vary from 2 ft. to 20 ft. thick, but average 9 ft. and contain some placer gold (537, p. 102).

Spanish Trails Group; (See LEAD).

Star and Hope Gold Mines; Seminoe District. A vein 4½ ft. thick dips 15° W. or NW. at the surface, and 55° at 80 ft. depth. The vein is "free-milling ore" which also contains auriferous pyrite and chalcopyrite (16, p. 5).

Spring Creek; T. 14 N., R. 86 W., at the head of Spring Creek, 25 mi. from Encampment. A quartz vein lies between a hanging wall of schist and a footwall of rhyolite. The highest values were found in a gouge streak lying between vein quartz and the hanging wall (217). The assays are as follows:

Location	Gold, oz. per ton
Breast, right side, 2½ ft.	1.18
Breast, left side, 3 ft.	0.06
5 ft. from breast, 5 ft. wide	0.84
10 ft. from breast, 4 ft. wide	0.92
Mill bin	0.08
Anaconda No. 4, dump sample	0.12
Anaconda No. 2, dump sample	0.06

Sunday Morning Mine; SE¼ sec. 29, T. 26 N., R. 85 W. Two shafts have been driven in a white to rusty massive southeast-trending quartz vein. The vein which bifurcates on the northwest end is locally characterized by hydrous iron oxide-filled box work structure. Free gold and chalcopyrite were observed on the dumps (619).

Tennant Creek Area; sec. 21, T. 14 N., R. 84 W., 4½ mi. from Encampment. The claim is located on a body of schist 500 ft. wide. Three quartz veins lie within the schist, and are parallel to its strike. The higher values were found in the quartz, but some of the schist assayed $2.50 to $3.70 of gold per ton (1927 prices). The quartz contained gold, silver, and lead, and assayed from $15.00 to $112.00 per ton (1927 prices). (227).

Tennent Creek Area; sec. 22, T. 14 N., R. 84 W. Sierra Madre Area (See COPPER).

Three Forks Group; Sierra Madre Area; (See COPPER).

Waterloo Prospect; Medicine Bow Mountains; (See COPPER).

Converse County

Snowbird Group; (See COPPER).

Crook County

Bear Lodge Mining District; 8 mi. northwest of Sundance. Fluorite veins are reported to carry up to $120.00 per ton of gold (1910 prices). "Pegmatites" also carry free gold and assay "$5.00 or more per ton" (352, p. 2).

Copper Prince Mine; (See COPPER).

Hutchins Consolidated Gold Mining Co.; secs. 17, 18, 19, 20, T. 52 N., R. 63 W., 8 mi. north of Sundance, in the Bear Lodge Mountains. Pre-Cambrian granite is associated with Tertiary syenite-porphyrys, and a few tinguaite dikes. Phonolites intrude the syenite-porphyry. A series of mineralized fissures strikes northwest and dip northeast; width of individual fissures is less than 4 in. Fissures are filled with fluorite and quartz, with limonite at the surface. The gold is either native or in the telluride minerals. Pyrite is ubiquitous in all rocks, but contains no gold. There is one "massive vein" of psilomelane and pyrolusite (380).

Nigger Hill. "The Nigger Hill placers are comparatively small but numerous and have yielded rich returns for the area minded . . . [Gold is] mingled with great quantities of tourmaline and cassiterite and innumerable small red garnets . . . while many nuggets and grains of gold are found attached to fragments of glassy quartz, and . . . talcose schist" (374, p. 179).

Warren Peaks; T. 52 N., R. 63 W. "Half a mile northeast of the central peaks, a gold-bearing ledge was discovered and traced in a northwest and southeast direction for several hundred yards . . . and merging on all sides into the adjacent trachyte rocks . . . The prevailing rock was a coarsely-crystalline feldspar-porphyry, with a fine porcelain-like matrix, breaking with a sharp conchoidal fracture . . . and large masses of rock in the middle of the 'ledge' were made up of feldspar, intermixed with irregular mass of limonite iron ore and black oxide of manganese."

"No gold could be detected . . . by the eye; but . . . specimens collected showed the presence of a decided trace of gold, probably contained in the iron and manganese oxides" (385, p. 287).

Fremont County

Bridger District

Copper Mountain. Free gold, partly in quartz veins and partly in association with copper ores, is found in pre-Cambrian rocks (169, p. 113); (See COPPER).

Fremont Group; (See COPPER).

Riverton Mining Co.; secs. 20 and 21, T. 40 N., R. 93 W., at the head of the east branch of Tough Creek, about 18 mi. north of Shoshoni. Copper Mountain has a granite core, with many schist layers which strike east-west and dip about 45° S. The schists are cut by granite and "diorite" dikes, and by quartz veins. Small copper stains and disseminated chalcopyrite are associated with quartz veins in schist. Average samples of quartz and schist carry $0.80 per ton or less of gold and $0.80 per ton or less of silver, with a little copper. Beeler did not consider this prospect favorable for development (122).

Wyoming Copper Mining Co.; (See COPPER).

Atlantic City-South Pass District

Raymond (501, pp. 325-338) has given an excellent description of the early history of the district, and the difificulties of the pioneer miners. According to him, free gold occurs as flecks and stringers within quartz, in a series of metamorphic rocks.

In the Atlantic City-South Pass area, gold and arsenopyrite are found in pre-Cambrian metamorphic sediments. The rocks strike northeast, dip steeply, and have been isoclinally folded. The folds are overturned to the northwest and plunge northeast. The area is cut by east-west and north-south faults; the east-west faults contain gold and arsenopyrite in quartz veins and shear zones; (See ARSENOPYRITE).

Anderson Mine; SE¼ SE¼ sec. 13, T. 31 N., R. 93 W., about 10 mi. north of Rongis, and 1 mi. northeast of Tincup Springs. Small gold values are found in quartz veins in schist, associated with pegmatites. The veins strike N. 80° E. and dip south (431).

B. and H. Mining Co.; sec. 22, T. 29 N., R. 100 W., 1½ mi. east of South Pass City. Metamorphosed slates and schists strike N. 60° E., and are vertical. Nearly vertical quartz veins containing native gold and small disseminated crystals of arsenopyrite parallel the strike of metamorphic rocks in shear zones and fissures (22). Ore minerals are distributed in zones along the fissures. Adjacent to the veins the schists are silicified and contain arsenopyrite and gold. Some veins contain crystalline quartz and calcite. Some of the claims have three to four distinct veins separated by 10 ft. to 30 ft. intervals, but within the same shear zone. Assays made in April, 1929, are given below: (22)

	oz. gold	oz. silver
General run from Emma Gold Nugget, Caroline	0.70	0.20
General run from El 1, El 7, Mc 2	1.30	4.00
General run from leads of El 1, El 7, Mc 2	1.36	2.00

One of these claims is now called the Empire State Mine, located in the center of sec. 22, T. 29 N., R. 100 W. A two-compartment, 110 ft. shaft has been sunk, with 120 ft. of drift from the bottom. The mine produced 600 tons of ore averaging 0.75 oz. of gold per ton. Veins can be divided into two systems which strike east-west and north-south; individual veins vary from a few inches up to 6 in. wide. The quartz contains arsenopyrite, and tourmaline with the gold. The north-south veins are high in pyrite (15, pp. 51-53).

Big Nugget Claim; secs. 31, 32, 33, T. 29 N., R. 98 W., and sec. 6, T. 28 N., R. 98 W., along Strawberry Creek and Big Nugget Ditch. Five "good-sized nuggets" are reported to have come from the property (285).

Black Rock-Long Creek Area; north of the Sweetwater River, near Rongis. The geology is similar to that of the South Pass area. Schist layers in granite trend east-west, and consist of hornblende schist and mica schist. The rocks contain "diorite" dikes, but no pre-Cambrian sediments, and are cut by iron-stained quartz veins. The King Solomon Claim (sec. 36, T. 31 N., R. 92 W.) contained northeast trending veins which were stained by limonite and malachite (105).

Carrie Shields Mine; SE¼ sec. 21, T. 29 N., R. 100 W. Total estimated production for this mine prior to 1916 is $35,000. The average grade of the ore was $20.00 of gold per ton. The vein zone is 3 ft. to 4 ft. wide; it is a belt of fractures with discontinuous quartz stringers. The veins cut a gray to greenish biotite schist which strikes N. 65° E. and dips 85° S. Veins strike N. 65° E. and dip 65° S. The mine is located outside a zone of major faulting (15, pp. 61-62).

Diana Mine; about 1½ mi. southwest of Atlantic City. Gold is associated with quartz veins in a micaceous schist. One sulfide zone has been opened which contains arsenopyrite and "free" gold. One vein contains pyrolusite. The White Horse Mining Co. reports the ore averages $25.00 per ton in gold, with some assays up to $100.00 per ton (579).

Duncan Mine; one mi. south of Atlantic City. The vein varies from 18 in. to 5 ft. wide, and dips 76° S. The value of the ore varies from $5.00 per ton to $100.00 per ton. The ore is contained in a quartz vein cutting schist and diabase (378, p. 76). In 1956, 3,000 tons of ore were shipped from the mine at $12.00 per ton (217).

Armstrong (15, pp. 54-55) reports the mine is located in NW¼ sec. 14, T. 29 N., R. 100 W., and that it produced $40,646.66 in gold between 1911 and 1913. About 12 tons of ore were shipped in 1946 which yielded 6.34 oz. of gold and 0.08 oz. of silver per ton. The ore is in a fault which cuts amphibolite.

Ground Hog Group; one-half mile north of the Duncan Mine. A dike of "altered diorite" 20 ft. to 100 ft. wide contains several small quartz veins. The zone is reported to contain $5.00 to $8.00 of gold per ton (378, p. 77).

Lander Belle Mine. A dike of silicified quartz porphyry lying between granite and schist is about 200 ft. wide, and contains between $2.50 and $5.00 in gold per ton (1911 prices) (378, p. 79).

Mary Ellen Mine; NE¼ sec. 14, T. 29 N., R. 100 W. The estimated production up to 1916 from this mine is $125,000. The vein is reported to be stoped out for 240 ft. down the dip. Quartz veins cut granodiorite and trend N. 40° W., dip 35° SW. and also N. 40° E., dip 30° SW. (15, p. 58). The best ore is found at the intersections of the two sets of fractures. Jamison reports (378, p. 77) that the ore was in lenses, and had an average value of $8.00 per ton (1911 prices).

Midas Mine; one mile north of Atlantic City. The mine is reported to have produced $48,000 in 1934 (15, p. 62). A polished section of Midas ore shows that late gold and arsenopyrite entered along fractures in the quartz (22).

Miner's Delight Group; sec. 32, T. 30 N., R. 99 W., 30 mi. south of Lander. Gold-bearing quartz veins are associated with dikes which cut schist, quartzite, and slate. The dikes and metamorphic rocks strike northeast and dip southwest. The native gold is scattered through the matrix, and in cavities. Limonite and manganese (?) stain quartz within the veins. The main vein is 3 ft. to 14 ft. wide, and may be up to 2,000 ft. long (421).

The mine is located at the east end of a schist body, just west of the sedimentnary (Paleozoic?) rocks. Most work (in 1907) had been done on a vein which cut across the rocks and other veins; it dips 55° (119).

Pioneer Carissa Gold Mines, Inc., NW¼ sec. 21, T. 29 N., R. 100 W. The Carissa Mine has produced gold intermittently since the middle 1800's. In 1954, 407 oz. of gold were produced and in 1955, only 52 oz. were produced (594).

The mine is located in a shear zone in quartz-biotite-hornblende schist. The veins are conformable with the schist, and strike N. 70° E., and dip 85° N. to vertical (160). The veins are somewhat variable, and are usually branching (15, pp. 43-50). Vein intersections localized the ore shoots within the veins which usually rake 85° SW. The quartz contains free gold, associated with arsenopyrite, and a small amount of pyrrhotite. A small amount of orpiment, realgar, and scorodite ($FeAs_2 . 2H_2O$) have been produced by alteration (540, p. 32). Total production has been estimated (1946) between $100,000 and $500,000 (15, p. 46).

According to Curran (160) the mine has been high-graded at $15.00 per ton, and 75,000 tons of $7.75 ore reserves (1925 prices) remained at the time of this examination. Production since 1925 would probably lower these reserves.

Riverton-Kinnear area; Tps. 1 & 2 N., R. 2 E. Placer gold values at four localities in the Wind River gravels near Neble ranged from 26 to 56 cents per yard. Thirteen to 28 miles upstream from Riverton, gold values in the Wind River gravels are reported to range up to 32 cents per yard (621).

Rock Creek Placers; along Rock Creek. Between 1933 and 1944, 3,000,000 cu. yds. of gravel were moved, which averaged $0.12½ per cu. yd. Seventy-five per cent of the gold was found within 1 ft. to 3 ft. of bedrock, in a concentrate which is not a black sand. No gold is found in gravel over schist, but only over blocky amphibolite. The richest gravel is 1 mi. below Atlantic City, near the place where a large fault crosses Rock Creek (15, pp. 63-65). In the S½ secs. 20, 21, 22 and N½ secs. 27, 28, 29, T. 30 N., R. 100 W., are three gold and mica claims. The mica is found in small flakes, 1/10" to ⅛" in diameter. The gold averages $.55/yard, with some spots assaying $41.00/yard. In 1953, it was mined by the Wyoming Mica and Metals Corporation (603).

Tabor Grand Mine; (See ARSENOPYRITE).

Wind River Reservation

Boysen area; Tps. 5 & 6 N., R. 6 E. Several narrow quartz veins in pre-Cambrian rocks, near the entrance of Wind River Canyon, were explored for gold (621).

St. Lawrence Creek in the Wind River Mountains; T. 1 N., Rgs. 3 & 4 W. Gold is reported in irregular quartz lenses and stringers, up to 4 feet wide, in pre-Cambrian granite and schists (621).

Willow Creek in the Owl Creek Mountains; T. 6 N., R. 3 E. Quartz veins associated with diorite dikes in pre-Cambrian granite and schist are reported to contain copper carbonates with minor amounts of copper sulfides and gold and silver (621).

Wind River Mountain District

Clarke's Camp; sec. 33, T. 42 N., R. 108 W. Placer gold was found in the gravels of Warm Spring Creek, but is finely divided and difficult to take out

(545, pp. 230-231), (see THORIUM). South of Warm Spring Creek, placer gold is reported in the gravels of Dinwoody, Dry, and Meadow Creeks, in the Wind River Range (621).

Union Pass; T. 41 N., R. 108 W. Finely divided placer gold was found (545, p. 230).

Gold-bearing stream deposits are found along Warm Spring Creek between the two road crossings. The deposits were worked by Clark's placer mines in the early 1900's. The gold is very fine and probably derived from quartz ledges exposed in the granite and schist near the headwaters of the stream (584a).

Goshen County

Goshen Hole Placers; T. 19 N., R. 61 W., 65 mi. northeast of Cheyenne, and 6 mi. west of the Nebraska-Wyoming boundary. Gravel, probably from an old stream, contains extremely finely-divided gold. The gravel bed includes an area of about 10,000 acres, and is covered by 3 ft. to 12 ft. of Brule and Arikaree beds (542).

Copper Belt Mines Co.; (See COPPER).

Hot Springs County

Owl Creek; southwest of Washakie Needles, on the headwaters of Owl Creek. Indians drove prospectors out of the area in 1867, 1877, and in 1884 and 1885. "Rich placers, but lack water." Gold quartz veins are reported on the headwaters of the creek (16, p. 7-8).

Johnson County

Kelly Creek; at the head of the creek, southwest of Buffalo. The basal sandstone of the Deadwood formation contains placer gold. A mill was built and put into operation, but it was found to be unprofitable (168, pp. 307-308).

Powder River Mine; SE¼ NW¼ sec. 20, T. 47 N., R. 85 W. Quartz veins in hornblende schist contain gold and manganese. The schist contains numerous small quartz stringers. A 110 ft. shaft was sunk, and a mill installed.

After running the mill for an hour, the mercury plates were reported to have been coated with manganese, the gold going off in tailings (317); (See MANGANESE).

Roe Brothers Group; (See COPPER).

Laramie County

Agat Prospect. One-fourth mile northwest of the Julia Lode, in the Silver Crown District. Ores assayed 1 oz. to 2 oz. of gold per ton. One "exceptionally rich specimen" yielded $280.00 worth of gold and $14.00 of silver per ton (16, p. 4).

Arizona Mine; (See COPPER.)

Bon Brothers Prospect; (See COPPER).

Colorado Lode (formerly Metcalf). Chalcopyrite contains gold. In depth, the vein contained argentiferous galena (16, p. 4). The claim was located "west of the King David."

Copper King Mine (Adams?). The ore body is 300 ft. wide, and 2,600 ft. long, averaging less than 1% copper at the surface. A pay streak 8 ft. wide at the 130 ft. level contained 11% copper and 2½ oz. of gold; the same streak was found in the 80 ft. level. The vein contained chalcopyrite, copper oxides and native copper, with a little carbonate and barite (16, p. 3).

Eureka Lode; located just north of the King David Mine. The vein contains chalcopyrite which yielded $12.00 in gold per ton (1886 prices). One specimen yielded 8% lead and $60.00 in gold per ton (1886 prices). (16, p. 4).

Great Standard Group; two miles north of Granite Canyon, in the Silver Crown District. Red granite contains schist and gneiss layers, and dikes of "diorite" and gray granite. The claims are located on quartz veins, which occasionally contain calcite crystals. Limonite and copper carbonates stain the outcrops which contain a little pyrite and rarely copper sulfides. Six samples were taken, of which four were vein samples and two were dump samples. Assays show an average of 0.03 oz. of gold per ton, a trace to 0.14 oz. silver per ton, and zero to 0.25% copper (68).

Hecla; sec. 24, T. 14 N., R. 70 W., (See COPPER); sec. 22, T. 14 N., R. 70 W. (See ZINC).

Horse Creek Placer; 8 mi. west of the Wyoming-Nebraska boundary and 45 mi. north of the Colorado-Wyoming boundary. Traces of gold were reported in Tertiary stream gravels, but Keating (391) thought the "proposition" was good only for growing sugar beets.

Julia Lode; in the Silver Crown district, ¼ mi. southwest of the Lenox Mine, close to the bank of Middle Crow Creek. A vein of "free-milling gold ore" 2½ ft. to 3 ft. wide at the surface was 20 ft. at the bottom of a shaft. The material assayed ½ oz. of gold per ton (16, p. 4).

Lenox Mine; (See LEAD).

Yellow Bird Mine, (Helca District). A 100 ft. shaft was sunk in a hornblende granite, but pyrite was the only metallic mineral visible on the dump. Traces of gold have been reported (290).

Lincoln County

Davis Claim; SW¼, T. 38 N., R. 116 W., on a terrace along the east side of Snake River, from the mouth of Baily Creek, ½ mi. north. Very finely-divided flour gold which is hard to recover is found in terrace gravels, and in deposits of boulders, gravel, and sand which fill channels, or in the beds of Snake River and its tributaries (520, p. 77).

A terrace at the mouth of Pine Creek, on the South Fork Snake River, 1 mi. long, 1/12 mi. to ⅛ mi. wide and 40 ft. to 50 ft. above the water level, has been worked. The gravel ranged from $0.07 to $2.00 in gold per cu. yd. (1914 prices), (525, pp. 127-128).

Horse Creek; T. 34 N., Rs. 114, 115 W. A few shallow pits have been dug in Jurassic rocks. A sample from one claim assayed $66.00 in gold per ton, and $18.00 in silver per ton. The rocks are bluish-gray shale and limestone with gray and yellow sandstone interbedded with dark-gray shale. The beds dip 35° to 45° W., and are slightly brecciated. They contain small calcite seams and some pyrite. The Cretaceous rocks are also reported to contain small gold flakes (520, pp. 74-75).

Pine Bar Diggings; northwest corner of T. 37 N., R. 116 W., at the mouth of Pine Creek, on the south side of the Snake River. Very fine flake gold streaks are found on top of gravels immediately below 8 ft. of barren material (520, pp. 78-79).

Park County

Crouch Gold Prospect. This deposit consists of six claims (1955) in SW¼ sec. 20, T. 51 N., R. 109 W. Gold has been reported to occur in ¼-½ in. veinlets, which are contained in a highly altered silicified rock. The veins also contain pyrite, galena, sphalerite, and chalcopyrite. Gold was produced from this area in the 1930's (606).

Kirwin; (See COPPER).

Stinking Water Region; (See COPPER).
Sunlight Basin; (See COPPER).

Platte County

Independence Group, on Slate Creek, 22 mi. west of Wheatland; (See PYRRHOTITE).
Cooney Hill Prospect; (See COPPER).
Whippoorwill Claim (Cooney Hill Group); (See COPPER).

Sheridan County

Gold Standard Placers; T. 56 N., R. 91 W., near the headwaters of Little Bighorn River. About 650 acres of gravel were marked off along the stream course. The gravel contains boulders and pebbles of granite, "diorite" and quartz; the thickness of the bed is not known. Gold within the gravel was in fine flat grains with jagged edges, "entirely free from water wearing and present sharp jagged edges when noted closely under a glass." (120).

Madalynna Claim; NE¼ sec. 24, T. 55 N., R. 88 W. A shaft was sunk at the contact of a diabase dike and granite. The dike contains small quartz veins in shears (479).

Mosaic Claim; T. 54 N., R. 87 W. Mineralization has taken place in granites, granite gneisses, and quartz veins which are iron-stained. Material contains from a trace to \$10.00 in gold per ton (\$35.00 per oz), 1% V_2O_5, and traces of lead and copper. A 1 ft. to 2 ft. wide gouge zone in a tunnel 300 ft. west of the claim contains scheelite (348). Assays made for the State Geologist, by C. O. Parker Co., Denver, Colorado, are given below (404, p. 3):

Sample No.	Gold, oz./ton	Silver, oz./ton
4	0.04	0.36
5	0.02	0.50
6	0.025	0.40

The Research Chemistry Division, University of Wyoming, made further analyses of two samples showing 0.10% (Sample No. 6) and 0.26% (Sample No. 2) tungsten "oxide" (404, p. 3).

Samples from which the various analyses were made are given below:

No. 2—Average grab sample of rusty band 15 in. wide on northwest end of SW face of cut; No. 4—Average grab sample (quartered to 2 lbs.) of 5 ft. zone across SW face of open cut; No. 5—Average grab sample (quartered to 2 lbs.) of 5 ft. zone adjacent and SE of 5 ft. zone of No. 4; No. 6—Average grab sample of a 3 ft. zone adjacent to and SE of 5 ft. zone of No. 5.

Under the microscope the quartz-rich rocks contain iron-oxide veinlets, plus a little wolframite and tungstite.

East Fork, Big Goose Creek. Near the headwaters of East Goose Creek a quartz vein connected with diabase dikes in granite contains a little free gold. The rock is dark-gray and contains some pyrite and a little copper (169, p. 113). A tunnel 350 ft. long encountered very little mineralization. In one opening, \$12.00 of gold and \$7.00 of silver per ton (1906 prices) were found (168, p. 308).

Nickel and Copper Refining Co.; sec. 28, T. 56 N., R. 88 W., on a ridge southwest of the mouth of South Fork Tongue River. A 180 ft. shaft was sunk along the contact of a periodotite dike and a quartz vein, but very little mineralization was found (168, p. 308).

Sweetwater and Carbon Counties

Little Snake River; about 20 mi. west of Baggs, in Fourmile Gulch and Dry Gulch. Wasatch gravels which cap mesa tops contain gold. No gold is found in the stream valleys (213, pp. 84-85).

Teton County

Gold and mercury occur in the Pinyon conglomerate (Paleocene), conglomerates and finer-grained rocks of the Harebell formation (late Cretaceous), and in alluvial deposits derived from these formations. Preliminary sampling tests indicate that the gold content ranges from less than 20 ppb. (parts per billion) to 660 ppb. ($1.08/yd.$_3$), and the mercury content from less than 10 ppb. to 120 ppb. (616).

A small amount of placer gold is found in the gravels of the Hoback River near its confluence with the Snake (545, p. 201).

Weston County (See COPPER)

Cambria area; gold has been reported from some of the coal mined from the Jumbo and Antelope 1 & 2 mines. Samples from 31 cars of coke showed an average of $2.46/ton of gold and $0.28/ton of silver (1912 prices). The coal occurs in the lower part of the Lakota formation (655).

REPORTED OCCURRENCES

Albany County

Jelm Mountain. "Exceptionally rich free-milling gold occurred in surface deposits. Owing to the broken and faulted character of the country, the rich leads were lost when sinking commenced. . ." (16, p. 9).

Medicine Bow Mountains. Gold placers have been worked in the range near timberline at 10,000 ft. to 11,000 ft. "The gold is sought after in gulches, formed by the little streams that flow from the Medicine Bow and other snowy mountains . . . We labored for two days to discover the quartz seams, which we supposed to be the source of the stray lumps of gold, but the great thickness of superficial drift which covers all these mountains concealed them from our view. The gold, as far as known in this district, seems to be confined to the lower glacial drift." (358, p. 129).

Bluegrass Creek. Placer gold has been reported from Bluegrass Creek, but is too finely divided to be saved under present methods of treatment (217; 26).

Big Horn County

Sylvanite: Reported from the Bighorn Mountains, northeast of Basin. The authors doubt that sylvanite occurs in the Bighorn Mountains (460).

Carbon County

Calaverite: ". . . detected in minute points in Deserted Treasure Mine, Seminoe Mountain." (16, p. 54).

Ferris Mountains; (See LEAD).

Fremont and Hot Springs Counties

Owl Creek District. "On the headwaters of South Owl Creek. Placer deposits." (16, p. 8).

Placer gold has been reported in gravels along Wind River, Bighorn River and Popo Agie River as very finely divided flakes (518).

Laramie County

Sylvanite and petzite: ". . . in minute quantities in the western part of the Silver Crown district." (16, p. 54).

Nagyagite: "In minute quantities and rarely in the Carbonate Belle, Silver Crown district." (16, p. 55).

Natrona County

Koch Deposit; probably close to the Koch manganese and feldspar claims in T. 32 N., R. 79 W., 11 mi. south of Casper. A seam of black material which carries gold and silver cuts granite. Gold and silver values have been found in a dolerite dike in the granite (300).

Park County

Placer gold is found along Clark's Fork, in the vicinity of Clark, and on the Shoshone River below the mouth of Alkali Creek (204). A black sand containing gold has been reported along Wood River near Meeteetse. The sand lies about 15 ft. beneath the surface (217).

Placer gold has been reported two miles north of the Crouch gold prospect, which is located in sec. 20, T. 51 N., R. 109 W. (606).

Platte County

Cooney Hills. A shipment of ore was reported to contain $50.00 per ton.

Placer gold is reported in the sands of the Arikaree formation near Uva (6).

A gold and silver claim is reported in sec. 22, T. 25 N., R. 66 W. in pre-Cambrian rocks (593).

GRAPHITE

Graphite is a soft, greasy, metallic-looking mineral consisting entirely of the element carbon. In Wyoming, all known graphite is in pre-Cambrian metamorphic schists, gneisses, and crystalline limestones. It is found as isolated scales embedded in these rocks, as large irregular masses, and in veins. The origin of graphite is obscure and not fully understood. It may be derived through the metamorphism of carbonaceous matter or through the chemical breakdown of limestone ($CaCO_3$).

Graphite is used in the manufacture of pencils, dry lubricants, paints, for foundry facings, polishes, in electroplating, and in the manufacture of refractory crucibles. Most graphite is produced artificially. Graphite rock as mined usually contains between 20% and 50% graphite. One small shipment of graphite was made in 1926 (217), but there is no other recorded Wyoming production.

PROSPECTS

Albany County

Halleck Canyon Area; sec. 26, T. 22 N., R. 71 W., 25 mi. west of Wheatland, 30 mi. north of Laramie. Irregular seams of amorphous graphite a few inches wide cut pre-Cambrian metamorphosed limestones which stand at high angles. The limestone is surrounded by granite and gneiss. Some high-grade graphite is on the dump, but generally the mineral contains many impurities (531, p. 345).

Secs. 35 & 36, T. 23 N., R. 71 W. Grapite schists occur associated with quartzite. The largest occurrence of these graphite-bearing bodies is only 4 to 6 feet wide and about 30 feet long. Other scattered bodies occur in the above sections, but these are only 1 to 2 feet wide and less than 20 feet long (644).

Laramie Range; sec. 12, T. 19 N., R. 72 W., in a canyon east of Plumbago (Western States Mining and Milling Co. deposit). Crystalline graphite occurs in schist and limestone in layers from 2 ft. to 5 ft. wide that pinch and swell. Assays show 6% to 18% graphite; the average is about 12% (288).

Plumbago Canyon; SW. corner T. 20 N., R. 72 W. Narrow bands of graphite schist stand nearly vertical and are interbedded with other types of schist and probably contain less than 15% graphite. Graphite (2% to 3%) also is found as thin seams filling fractures in quartzite (217).

Carbon County

Heath Peak; Nos. 1, 2, 3, and 4; secs. 14, 23, and 24, T. 27 N., R. 84 W. These graphite claims are relatively inaccessible and no reliable information regarding them is available (217).

Goshen County—Haystack Hills

South side of the gap in the center, NE¼ sec. 1, T. 27 N., R. 65 W. Graphitic schist about 2 ft. wide strikes N. 70° E. and stands vertical. It can be traced several hundred feet. Pegmatitic bodies are found about 25 ft. to 35 ft. north and south of the graphite schist band. Contorted quartz veins in the graphitic schist lower the grade of the material (20, p. 427).

Center, SW¼ SE¼ sec. 23; the NW corner of sec. 26; the north-central part of NE¼ sec. 26, and the NE corner, sec. 27, T. 27 N., R. 65 W. Graphite claims in pre-Cambrian schists are located in this area (20, p. 427).

Center of the W½ sec. 14, T. 28 N., R. 65 W. High grade graphitic schist has been found on the dump of this prospect (20, p. 427).

Sec. 26, T. 28 N., R. 65 W., (Vaughn Claim). Good quality graphite in graphitic schist has been found. Plumbojarosite is associated with the graphite (323).

Sec. 26, T. 28 N., R. 65 W., on the north side of McCann's Pass, 2,000 ft. east of the summit. Two outcrops of graphite schist, 4 ft. wide and 2 ft. apart are interlayered with muscovite schist and granite. The layers strike N. 55° E. and dip 70° NW. The graphite body varies in composition from coarsely schistose muscovite graphite to a gray-black graphitic schist. Up to 5% graphite is present as finely disseminated grains with quartz and tourmaline, and traces of muscovite, biotite and feldspar. Fine grinding would be necessary to separate (20, pp. 426-429).

Muskrat Canyon area; NW¼ sec. 19, NW¼ NW¼ sec. 30, T. 30 N., R. 64 W., and SE¼ SE¼ sec. 24, T. 30 N., R. 65 W. At least three graphitic schist layers crop out in the walls of Muskrat Canyon. These layers, which vary in thickness from less than one foot to 10 feet, are interlayered with dolomite and hematitic schist. Because of talus, most layers cannot be traced much over 150 feet; however, some can be inferred up to 600 feet as based on prospect pit data. Richer graphitic layers are black, very fine-grained, and soft, and show great changes in thickness and grade along strike. A chip sample from a prospect pit assayed 5.0% carbon. Small quantities of malachite and chrysocolla occur as surface coatings, stringers, and weakly disseminated in nongraphitic schists that are associated with the graphite prospects (662).

NE¼ SE¼ sec. 11, T. 30 N., R. 64 W. A 2- to 2½-foot thick, very soft, fine-grained, contorted and much brecciated graphite schist is exposed in a small prospect pit on the northwest edge of Rawhide Buttes (662).

NE¼ NE¼ sec. 11, T. 30 N., R. 64 W. A 2- to 4-foot thick zone of graphitic schist can be traced for several 10's of feet across a low saddle on the northwest edge of Rawhide Buttes. Graphite occurs as films and seams parallel to the foliation of contorted, limonite- and hematite-stained quartz-muscovite schist (662).

NE¼ SE¼ and SE¼ NE¼ sec. 2, T. 30 N., R. 64 W. Graphite schist, aggregating at least 22.4 feet thick occurs along the walls and in the bottom of a steeply incised ravine. The graphite-bearing sequence consists of about 40 feet of interlayered graphite schist, and barren muscovite and biotite schists. The sequence is laterally continuous where exposed, but one graphite layer ranges from 0.4-2.5 feet in thickness, indicating that thin layers may be absent in some intervals. A few shallow pits and adits have been driven in this sequence which assays 3.2 to 11.8% carbon (662).

SE¼ NW¼ sec. 2, T. 30 N., R. 64 W. Fifteen feet of dark gray to blue-black, fine-grained, soft hematite- and limonite-stained graphite-muscovite-quartz schist is exposed in a shallow trench. Thin layers and stringers of quartz are common in the schist. A chip sample across this unit assayed 2.7% carbon (662).

NW¼ NW¼ sec. 2, T. 30 N., R. 64 W. Dark gray layers of graphite schist, 0.5 to 1.5 feet thick, occur interlayered with hematite-stained muscovite-quartz schist (662).

Platte County

Rabbitt Creek Area; sec. 22, T. 26 N., R. 70 W., 20 mi. northwest of Wheatland. A graphite schist body about 5 ft. wide trends northwest for 4,720 ft. Amorphous graphite makes up to 20% of the graphite schist. Estimated reserves are 277,500 cu ft. (492, p. 68). A 60 ft. shaft two tunnels, and numerous small holes have been opened on the four claims (332).

Sec. 17, T. 23 N., R. 70 W., 15 mi. southwest of Wheatland. A graphite schist, hornblende schist, and mica schist zone trend northeast for about ½ mi. The graphite schist pinches and swells and averages 6 ft. to 8 ft. thick. Nearly all ore is amorphous. Four or five pits have been dug, disclosing a small amount of crystalline graphite (294).

Texan Lode; SE¼ SE¼ NE¼ sec. 10, T. 23 N., R. 69 W. Fine-grained, massive graphite, 7 feet thick occurs at the contact with a fine-grained white granite gneiss as exposed in several small prospect pits (622).

NE¼ SE¼ sec. 19, T. 23 N., R. 69 W. Poor quality, fine-grained graphite schist occurs in several prospect pits. The unit is highly fractured with quartz fracture fillings (622).

George Creek; NE¼ NW¼ sec. 17, T. 23 N., R. 70 W. Small lenses of highly fractured graphite and disseminated graphite in micaceous graphite occur exposed in a prospect pit (622).

NW¼ SW¼ sec. 17, T. 23 N., R. 69 W. Graphite schist, approximately 10 feet thick, associated with quartz and amphibolite is exposed in an adit and several prospect pits (622).

REPORTED OCCURRENCES

Albany County

Esterbrook Area; Maggie Murphy Claim, east-central part of sec. 21, T. 28 N., R. 71 W. A graphite-pyrrhotite schist was encountered at 107 ft. depth (540, p. 61); (See COPPER).

Albany County (?)

A fairly large, high quality deposit is reported to be in the Medicine Bow Mountains, but is inaccessible (217).

Carbon County

Graphite has been reported near the old town of Battle in the Encampment District (217). In the Copper Gem Prospect on Dunkard Creek, 8 mi. from Encampment, a graphite schist body was encountered in the shaft (65).

Fremont County

Miner's Delight—Dietz (179, p. 74) reported amorphous graphite to be "extensive."

GYPSUM

Most commercial gypsum (rock gypsum) is a massive white (but often stained) material which contains not less than 64.5% by weight of $CaSO_4 \cdot 2H_2O$ (428, p. 436). An earthy form of gypsum, *gypsite,* is the result of disintegration and

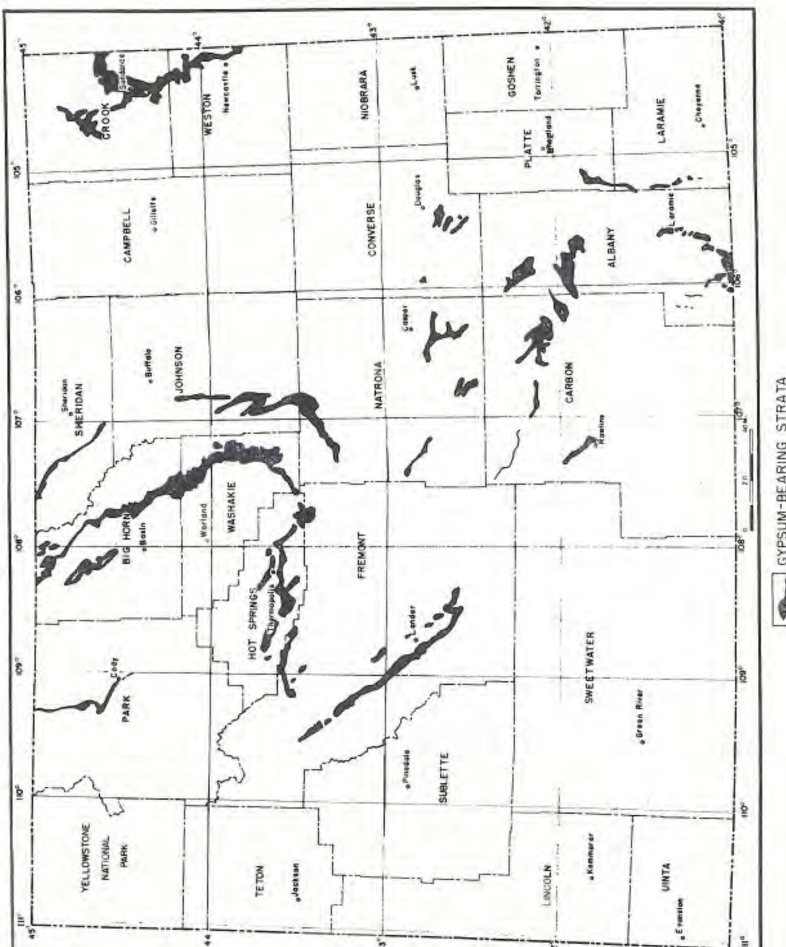

Fig. 4. Outcrop map of gypsum-bearing strata.

re-disposition of rock gypsum in regions of little rainfall and fast evaporation. It contains many small gypsum crystals intimately intermixed with clay or sandy loam. Other varieties of gypsum include *alabaster* (a fine-grained massive marble-like form), *selenite* (crystalline gypsum) and *satin-spar* (a fibrous variety with a silky luster). Anhydrite $CaSO_4$, is similar to gypsum but contains no water.

Gypsum is deposited mainly from sea water, but also from saline lake waters or hot spring waters; it is also derived from anhydrite. Gypsum is often a product of volcanic activity, and it may be a gangue mineral in metallic mineral veins.

Uses for crude gypsum are many and varied. It is used as a fertilizer or soil-conditioner, as filler for paper textiles, and as a retarder in Portland cement. Calcined gypsum is used for molding, casting, pottery, and dental plasters, and in building materials such as plaster board, plaster, Keene's cement, tiles and blocks.

The thick extensive rock gypsum beds in Wyoming lie mainly in the Permian, Triassic and Jurassic redbeds—the Goose Egg, the Chugwater (Spearfish) and Gypsum Spring formations. There are scattered layers in other formations. The gypsum beds in these formations thicken and thin over short distances; they are usually discontinuous and gypsum occurs at many horizons. Gypsum in Wyoming deposits is remarkably pure and contains no salt (141, pp. 222-223). The accompanying map (Fig. 3) shows the approximate outcrops of gypsum-bearing rocks in the state. Small plants to satisfy local demand for gypsum products have operated intermittently in the state since 1890.

PRODUCING DEPOSITS

Albany and Carbon Counties

The Monolith Portland Midwest Co. obtains gypsum for use at the Laramie cement plant from the gypsum-bearing Goose Egg formation north of Como Bluff near Medicine Bow. Production for 1962 and 1963 was 9,018 and 7,128 tons respectively (611).

Big Horn County

Gypsum occurs in the Chugwater, Goose Egg, and the Gypsum Springs formations. A thick-bedded gypsum unit, which varies from 0-50 feet in thickness, occurs in the lower unit of the Gypsum Springs formation and analyzes at more than 85% $CaSO_4$. Gypsum Products of America is constructing (1966) a gypsum wall board plant at Himes (W½ T. 55 N., R. 94 W.) They intend to mine a 52 million ton deposit in the Gypsum Springs formation that occurs near the surface in a gentle northwesterly plunging syncline (656).

Park County

Gypsum beds in the lower part of the Middle Jurassic Gypsum Springs formation crop out southward from the Montana-Wyoming border to 10 miles south of Cody. This bed, which ranges from 0-80 feet thick, contains more than 4 million tons of outcrop reserves (625).

Secs. 13 & 14, T. 52 N., R. 102 W. Gypsum is mined from a quarry in the lower part of the Gypsum Springs formation cropping out in Horse Center anticline (625). The raw material is processed into plasterboard by the Big Horn Gypsum Company at Cody. Production for 1962 and 1963 was 62,585 and 72,908 tons respectively (611).

PROSPECTS

Albany County

Gypsum is locally abundant around the Laramie Basin margins in the Satanka, Forelle, and Chugwater formations, but most deposits are lenticular in shape.

The most important localities are at Red Mountain near the Colorado-Wyoming state line, and in the McGill, Como, and Flattop anticlines in northwestern Albany County. Gypsite was quarried near Laramie for many years.

Red Mountain Area. Thick, lenticular beds in the Satanka crop out through portions of secs. 3, 4, 7, 8, 9, 10, T. 12 N., R. 76 W. (See Fig. 3) along the foot of the north slope of Red Mountain. The base of the gypsum beds is marked by a 1 ft. fossiliferous limestone. A section measured in sec. 9, T. 12 N., R. 76 W., shows the maximum amount of gypsum present: (532, p. 404; 171, pp. 56-7; 547, p. 307).

Red gypsum rock, nearly pure	6 ft.
Red shale	35 ft.
Gypsum	3 ft.
Red shale	10 ft.
Gypsum	4 ft.
Reddish shale	55 ft.
Banded gypsiferous rock	5 ft.
Red sandy shale (aragonite crystals)	88 ft.
Massive gypsum	67 ft.
Fossiliferous limestone	1 ft.
	274 ft.

Laramie Area; SW¼ sec. 2, T. 16 N., R. 73 W., 5 mi. northeast of Laramie. The upper part of the Satanka contains a lens 10 ft. thick of pure gypsum in a prospect pit (171, p. 22) at the northern base of a small hill (532, p. 404; 171, pp. 22, 58). This deposit was worked a short time in 1949 by the Monolith Portland Midwest Co. of Laramie (217).

Red Buttes Area; sec. 21, T. 14 N., R. 73 W. At the site of an abandoned plaster mill, 1 mi. south of Red Buttes, the Satanka contains two gypsum beds about 25 ft. apart which were opened in 1890. The lower bed is 15 ft. thick; the upper is 10 ft. thick (171, p. 22). Analysis: $CaO=32.5\%$, $Al_2O_3=0.3\%$, $SiO_2=0.2\%$, $SO_3=46.3\%$, $H_2O=20.8\%$ (171, p. 57).

Sportsman Lake; one mile east of Sportsman Lake near the middle of the north side of sec. 7, T. 13 N., R. 73 W. A small pit reveals 4 ft. to 5 ft. of pure rock gypsum; at the base is the Forelle limestone (532, p. 404; 171, p. 57).

Sand Creek. Gypsum is present along Sand Creek in beds 2 ft. to 4 ft. thick. It is associated with and replaces gypsiferous limestone (171, p. 25).

Centennial Valley. A thin gypsiferous limestone bed lies in the upper Forelle but it is discontinuous (171, p. 25).

Como Bluffs. In the N½ sec. 35, S½ sec. 26, T. 23 N., R. 77 W., the Chugwater dips from 20° N. to 10° S. and contains extensive gypsum deposits (186, p. 34).

Marshall area. The Embar and Chugwater formations contain scattered gypsiferous beds in the region southwest of Marshall in T. 26 N., Rs. 75, 76 W. The Chugwater is 450 ft. to 600 ft. thick in the area (418, pp. 17-18).

Gypsite in Albany County

Gypsite or earthy gypsum, is very abundant just south of the Laramie city limits and covers almost all of sec. 4, T. 16 N., R. 73 W. The deposits are easily recognized by the clumps of greasewood and by the whiteness of the soil (534, p. 4). The bed is 9 ft. thick, and the gypsite is very finely divided, requiring no grinding or screening (532, p. 405). These deposits contain about 20% impurities. The upper 7 ft. is pure gypsite; below is a 5-in. red layer, followed by 1 ft. or more of white gypsite resting on gravel or red clay (171, p. 58). A plaster mill operated from 1896 to 1948.

Other localities where gypsite is found:

One mile northeast of Laramie in SE¼ sec. 28, T. 16 N., R. 73 W.

On Soldiers Creek, 1 mi. below and 2 mi. above the location of old Ft. Sanders.

NE¼ sec. 21, T. 14 N., R. 73 W., 1 mi. southeast of Red Buttes in the valley of Harney Creek. Gypsite is 5 ft. to 6 ft. thick. It was formerly used with rejected rock gypsum to make cement plaster.

Secs. 33, 34, T. 14 N., R. 74 W.

An extensive bed crops out in the lower 2 mi. of the valley of Willow Creek to its junction with Lone Tree Creek, then 2 mi. below that junction (532, p. 405; 171, p. 58; 547, p. 307; 172, p. 14).

Big Horn County

The redbeds that encircle the Bighorn Mountains contain much nearly pure gypsum, usually at the base of the Chugwater formation (169, p. 114). Gypsum mills have operated at Basin, Kane, and Stucco (217).

Hyattville Area. In the NW¼ NW¼ sec. 33, T. 49 N., R. 89 W., gypsum is found in 7 beds from 1 ft. 8 in. to 13 ft. thick, with a total thickness of 43 ft. in the Chugwater. Analysis: $CaO=32.92\%$, $SO_3=45.74\%$, $H_2O=19.99\%$, $SiO_2=0.05\%$, $MnO=0.44\%$, $Al_2O_3+Fe_2O_3=0.03\%$ (436, p. 148).

Zeisman Ranch. Near the Zeisman Ranch, in SE¼ sec. 34, T. 49 N., R. 89 W., a number of gypsum layers 4 ft. to 10 ft. thick are interlayered with red shale and limestone in the Embar formation. Analysis: $CaO=32.72\%$, $SO_3=45.18\%$, $H_2O=20.03\%$, $SiO_2=0.06\%$, $MnO=0.42\%$, $Fe_2O_3+Al_2O_3=0.05\%$ (436, p. 151).

Paintrock Area. Along Paintrock Creek, the upper Chugwater contains a 10 ft. gypsum bed, below which is a 16 ft. limestone layer and 60 ft. of red sandy shales. Some thin gypsum beds are found near the base of the Chugwater (169, p. 39).

Shell Creek. At the mouth of Shell Creek Canyon, T. 53 N., R. 91 W., there is a 12 ft. gypsum bed in the Chugwater (547, p. 301) 24 ft. from the base of the formation (169, pp. 38-39).

Cloverly Area. In Red Gulch, east of Cloverly, at the base of the Chugwater just above the Tensleep sandstone, there are 125 ft. of red shales interbedded with gypsum (169, p. 39).

Stucco; T. 53 N., R. 94 W. Gypsum has been mined from eight separate beds from 1 ft. to 1½ ft. thick in the upper part of the Chugwater formation. A total of 26 ft. of gypsum lies in 70 ft. of redbeds. Analysis: $CaO=33.74\%$, $SO_3=43.92\%$, $SiO_2=0.01\%$, $MnO=0.98\%$, $Fe_2O_3+Al_2O_3=0.17\%$, $H_2O=19.50\%$, (547, p. 302; 436, pp. 147-148). A mill was built in 1916 to make stucco blocks.

Greybull Area. Three miles north of Greybull on the north side of Shell Creek. A total of 47 ft. of gypsum is found 120 ft. from the top of the Chugwater formation. The underlying Goose Egg formation contains irregular veinlets of coarsely-crystalline gypsum, 3 ft. to 4 ft. thick. This deposit was worked prior to 1920 (436, pp. 148, 150; 547, p. 302).

Carbon County

Extensive redbed deposits along Flattop anticline and in the basin between the Freezeout Hills and the Shirley Mountains contain gypsum of varying amounts and thickness (547, p. 306; 415, p. 82). Scattered localities elsewhere in the county contain a little gypsum.

Flattop anticline. The Chugwater formation crops out for several miles along Little Medicine Bow River, north of Medicine Bow. A section measured at the west end of Flattop Mountain shows 60 ft. of gypsum in 7 layers, 4 ft. to 19 ft. thick in 1,000 ft. of Chugwater formation beds (547, p. 306). In sec. 18, T. 23 N., R. 78 W., the Satanka shale contains a 28.7 ft. bed of white gypsum near the middle of the formation. The gypsum weathers to a purplish-gray color (217). The Chugwater formation in secs. 13, 14, T. 23 N., R. 79 W. contains 74.4 ft. of brick-red shale and gypsum at the base. The Little Medicine tongue of the Dinwoody formation contains 14.5 ft. of gray porous limestone and pink gypsum. The Freezeout tongue of the Chugwater, which is the middle unit, contains 4.8 ft. of gray sandy shale and pink gypsum (417, pp. 13-14).

Freezeout-Seminoe area. In secs. 11, 14. T. 24 N., R. 79 W., south of Freezeout Mountain, the Chugwater contains a 25 ft. bed of orange shale and white gypsum with red and pink streaks. This bed is overlain by 25 ft. of interstratified shale and gypsum. The gypsiferous sequence near the bottom of the formation is of good quality. The lower 65 ft. of the Embar formation contains good quality gypsum (445, pp. 9-10).

The Goose Egg forms a sinuous outcrop pattern through portions of Tps. 24, 25 N., Rs. 80, 81, 82 W., and contains numerous gypsum beds of varying thickness purity, and color (200, p. 10).

In the SE¼ sec. 25, T. 25 N., R. 83 W., a fault zone contains lenses of quite pure, white gypsum 8 ft. to 10 ft. thick. The gypsum cuts the Phosphoria and Amsden formations. The limits of the deposit and size are difficult to determine because of poor exposures (201).

Elk Mountain. Knight (415, p. 82) reports extensive gypsum beds that are nearly covered with Tertiary debris. Chugwater formation crops out along the west side of Elk Mountain, in a faulted area north of Bear Butte, and to the southeast and north of Sheep Head Mountain (375, pp. 18-22).

Freezeout Hills. Gypsum, in the form of gypsite, alabaster, and lesser amounts of selenite and satin-spar, is found in outcrops of the Goose Egg formation in secs. 1 and 12, T. 25 N., R. 80 W. The deposits are of commercial quantity and are easily accessible (586).

Converse County

South of Douglas on Wagon Hound and La Bonte Creeks, in T. 31 N., Rs. 71, 72 W., "there is considerable gypsum" near the base of the Chugwater formation (547, p. 305).

Gypsum is reported at the base of the Chugwater in sec. 14, T. 30 N., R. 72 W., in secs. 4, 5, T. 29 N., R. 72 W. and in secs. 30, 31, 32, T. 30 N., R. 72 W. (462, p. 78).

Local massive gypsum lenses 10 ft. to 20 ft. thick in the upper Chugwater crop out in SE corner, sec. 9, W½ sec. 15, E½ sec. 16, NW¼ sec. 21, T. 32 N., R. 76 W. (125, p. 27 and figure 1).

Crook County

Along the northwestern portion of the Black Hills Dome, the Spearfish formation (500 ft. to 600 ft. thick) contains gypsum beds about 100 ft. to 120 ft. above the base of the formation.

Two miles northwest of Beulah, in T. 53 N., R. 61 W., there are massive, white gypsum beds 2 ft. and 4 ft. thick. Beds averaging 15 ft. thick crop out continuously through Government and Redwater valleys (547, p. 298).

Along the Belle Fourche River near Devil's Tower, the Spearfish formation contains several thin gypsum beds (547, p. 298).

Gypsum crops out from Oil Creek (in Weston County) north to Sundance. The main bed is 5 ft. thick around Inyan Kara and Strawberry Mountains, and encircles Green Mountain and Gypsum Buttes (547, p. 298; 166, p. 3).

Northeast of Sundance, a deposit contains large slabs of crystalline gypsum. Pieces 2 ft. by 3 ft. by 4 in. to 6 in. are common (377, pp. 34-35).

Fremont County

Thick redbeds crop out for 100 mi. along the east base of the Wind River Mountains. The gypsum-bearing beds at the top, once included in the Chugwater formation, are now classed as the Gypsum Springs formation. Dips are moderate to the northeast and there are thick gypsum beds in the sequence (415, p. 84).

Near the Lander Experiment Farm, 40 ft. gypsum beds are found near the "top of the Chugwater formation" (378, p. 84).

Along Sage Creek, T. 1 N., R. 1 W. (Wind River Meridian), near Ft. Washakie, a gypsum bed 61 ft. thick with thin shale layers crops out along the bank of Little Wind River (547, p. 304). A plaster plant was built in 1911, but there was no production (377, p. 84).

North and east of Lander a 40 ft. gypsum bed in the "Chugwater" crops out in an anticlinal fold (547, p. 304).

The type locality of the Gypsum Springs formation is in sec. 16, T. 6 N., R. 3 W. (Wind River Meridian), in the southern Absaroka mountains. The formation is about 250 ft. thick; the lower half is nearly pure gypsum (270, pp. 28-29).

Forty miles west of the Rattlesnake Hills, along Connant Creek is an anticline in which gypsum was found in the redbeds (415, p. 83).

Maverick Springs Area; sec. 22, T. 6 N., R. 2 W. An analsyis of gypsum from the Gypsum Springs formation indicated $CaSO_4=96.1\%$. In secs. 22, 23, and 26, T. 6 N., R. 2 W., the gypsum bed (in the Gypsum Springs fm.) amenable to stripping along the crest of Maverick Springs anticline ranges from 10 to 60 feet thick. Total reserves amount to 14,333,400 tons (621).

Secs. 29 and 32, T. 7 N., R. 1 E. A 50- to 80-foot bed of gypsum at the base of the Gypsum Springs formation is well-exposed, dips gently east, and is suitable for strip mining (651).

Secs. 19, 20, and 30, T. 7 N., R. 1 W. An 80-foot bed of relatively pure gypsum near the base of the Gypsum Springs formation could be readily strip-mined (648).

Hot Springs County

The Soil Sulphaid Distributing Co. of Thermopolis produced gypsum associated with sulfur from the hot springs deposits 2½ mi. west of Thermopolis. In 1949, 3,015 tons of gypsum were produced, but the company was shut down in 1950 (583; 217).

Two gypsum beds crop out on the northern flanks of Red Spring anticline in SW¼ sec. 21, T. 43 N., R. 93 W.; the upper is 10 ft. thick and is separated from the lower by 33 ft. of shales. The lower bed is 42 ft. thick. Analysis: $CaO=34.20\%$, $SO_3=45.50\%$, $H_2O=20.00\%$, $SiO_2=0.25\%$, $Al_2O_3+F_2O_3=0.10\%$ (436, pp. 149-150).

The "Chugwater" encircles most of the Owl Creek Mountains and contains gypsum beds 30 ft. to 40 ft. thick, 100 ft. below the top of the formation (547, p. 303).

Secs. 28 and 29, T. 43 N., R. 93 W. The Dinwoody formation in this area is almost entirely gypsum (667).

Johnson County

Red Fork Powder River Area. The Goose Egg consists of 140 ft. alternating red shales and gypsum. Some gypsum is also present in the lower Chugwater. The redbeds crop out throughout most of the E½, T. 43 N., R. 84 W., the SE¼, T. 44 N., R. 83 W., and in a V-shaped area in Tps. 43, 44 N., R. 83 W. (150, pp. 26-27, and pl. 2), but do not everywhere contain gypsum (436, p. 155). In Secs. 14, 15, T. 44 N., R. 83 W. the top of the Goose Egg, 119 ft. thick, contains gypsum beds interlayered with shales and limestone (504, p. 19).

In the northwest corner of T. 45 N., R. 83 W., along the North Fork Powder River near the Webb Ranch, the Embar formation (100 ft. above the chert beds) contains 40 ft. of white and pink banded gypsum interlayered with red shale (547, p. 300; 436, p. 154).

One-half mile north of the South Fork Crazy Woman Creek, in T. 46 N., R. 83 W., there is a total of 90 ft. of gypsum in the Goose Egg, including several shale layers (547, p. 300; 436, p. 154).

In the ravine near Beaver Creek, in T. 47 N., R. 83 W., there is a large amount of gypsum above and below the purplish chert member of the Goose Egg formation. Gypsum beds in the Chugwater are from 25 ft. to 40 ft. thick (547, p. 300; 436, p. 154).

One of the thickest gypsum deposits on the east slope of the Bighorns is on the north side of Middle Fork Crazy Woman Creek Valley in T. 47 N., R. 83 W. Here the Goose Egg contains beds of gypsum and thin red shale that total at least 150 ft. thick. Chugwater gypsum beds are from 25 ft. to 40 ft. thick. The white gypsum layers are fine textured and free of clastic sediment. Analysis: $CaO=32.81\%$, $SO_3=45.42\%$, $H_2O=20.40\%$, $SiO_2=0.07\%$, $Fe_2O_3+Al_2O_3=0.11\%$ (547, p. 300; 436, pp. 153-154).

Natrona County

The principal redbed deposits in Natrona County that contain gypsum are Permian in age (Goose Egg formation) and lie at the northern and northwestern ends of Casper Mountain, near Alcova, and along the northeast flanks of the Rattlesnake Mountains.

At the east end of Casper Mountain, on Muddy Creek, there are 8 ft. gypsum beds in the upper part of the Chugwater which stand at steep angles (547, p. 305).

Jenkins (381, pp. 63, 69) found white, finely-crystalline, massive gypsum beds 4 ft. to 7 ft. thick in the Sundance formation in sec. 13, T. 30 N., R. 80 W. and in secs. 34, 35, T. 31 N., R. 80 W.; overburden is thick in the area.

The Goose Egg formation in sec. 15, T. 32 N., R. 81 W. contains clean, white, pure, thin-bedded to massive gypsum, in places interbedded with red shales. The dips are low and a small amount of overburden (199, p. 48) overlies the gypsum.

At Alcova thick gypsum beds in the Goose Egg trend northwest. Southwest of Alcova near the head of Platte Canyon, gypsum-bearing beds also trend northwest for 5 mi. to 6 mi. (547, p. 305; 415, p. 82).

The gypsum beds along the northeast base of the Rattlesnake Mountains dip 25° to 30° NE. and extend for about 20 mi. along the mountain front (415, p. 83).

Tp. line, T. 31-32 N., R. 79 W. A massive white gypsum bed, 3-8 feet thick, occurs in the Goose Egg formation on the northwest flank of Muddy Mountain (665).

Park County

The Interstate Chemical Co., near Cody, produced 1,800 tons of gypsum in 1949 from open pit deposits associated with sulfur. Capacity of the mill is ten tons per hour (217; 451; 583); (See SULFUR).

The Wyoming Mineral Products Co. produces gypsum from a plant located southwest of Cody. The gypsum is associated with sulfur in extinct hot springs deposits. A total of 1,520 tons of sulfur and gypsum were produced in 1949 (217; 451; 583); (See SULFUR).

The redbeds formerly placed in the Chugwater formation, but now recognized as Gypsum Spring formation, contain gypsum from Trail Creek, west and northwest of Cody, north to the Montana-Wyoming line. A gypsum bed along Trail Creek is 30 ft. thick, massive and quite pure (547, p. 302; 415, p. 84; 161, pp. 34-35). Fisher (204, p. 58) measured the gypsum:

Sundance formation	
Green shale with thin limestone layers	3.5 ft.
"Chugwater formation"	
Red sandy shale with thin layers gypsum	12.0 ft.
White massive gypsum	30.0 ft.
Red sandstone—redbeds	

In T. 53 N., R. 102 W. at the foot of Rattlesnake Mountain, on the north side of the Shoshone River, a deposit of anhydrite contains 25 million tons estimated reserves. Five miles southwest of Cody on the old Smith Creek road there is a good quality gypsum deposit. In 1945, both of these deposits were being developed by the Wyoming-Midland Gypsum Co. (238).

Fisher (204, p. 20) gives a stratigraphic section of the Chugwater and Goose Egg formations measured along the south side of Clark's Fork Canyon in about T. 56 N., R. 103 W. as:

White massive gypsum	25 ft.
Soft, red massive sandstone with gypsum layers	725 ft.
Greenish sandy shale with thin limestone layers	10 ft.

Platte County

Glendo Area. In the lower part of the Chugwater gypsum beds range from a few inches to as much as 40 ft. in thickness (434). Along Horseshoe Creek, about 6 mi. southwest of Glendo, a bed crops out for ¾ mi. and varies from 45 ft. to 50 ft. thick. An analysis shows 99.61% $CaSO_4$ (372a).

Along the east flank of the Laramie Range, a narrow strip of Permian redbeds extends from T. 19 N. to 22 N. and in Rs. 69, 70 W. following the drainage of Deadhead Creek. Sporadic, lenticular gypsum beds up to 20 ft. thick are scattered throughout the area (355, p. 9; 383, p. 35).

Sheridan County

Gypsum crops out almost continuously in the base of the Chugwater from Pass Creek, near the Wyoming-Montana border, south to Little Goose Creek (547, p. 299). Gypsum was previously mined and milled at Dayton.

In the center of sec. 23, T. 56 N., R. 87 W. on U. S. Highway No. 14 about 11 mi. southwest of Dayton, gypsum 24 ft. above the base of the Chugwater strikes N. 15° W. and dips 21° S. The gypsum sequence is: (584, pp. 38-39).

Lower Chugwater	
Siltstone	
Gypsum	7.7 ft
Red Siltstone	5.2 ft
Gypsum	3.3 ft.
Shale	1.0 ft.
Gypsum	7.0 ft.

Washakie County

Three miles northeast of No Wood, where No Wood Creek enters the canyon in T. 42 N., R. 88 W. the upper Goose Egg (redbed equivalent of Phosphoria formation) is largely massive beds of white gypsum with interbedded red shales (436, p. 153).

The Goose Egg contains a 42 ft. bed of gypsum at a point 1½ mi. southwest of No Wood, where the creek emerges from a small canyon (436, p. 153).

In T. 43 N., R. 87 W., 2 mi. southwest of Redbank, along the valley of Cherry Creek, a 30 ft. lenticular gypsum bed lies in the upper Embar, beneath nodular chert. Beneath this thick gypsum bed are a few thin layers of red shale followed by eight massive gypsum beds 2 ft. to 4 ft. thick scattered through 50 ft. of red shale (436, p. 152; 547, p. 301).

At the mouth of Buffalo Creek in sec. 1, T. 44 N., R. 88 W., 50 ft. from the top of the "Chugwater" is a 48 ft. bed of white, pure gypsum (436, p. 149; 547, p. 301).

In secs. 4, 9, 16, 17, T. 45 N., R. 87 W. there are outcrops of a 32 ft. massive gypsum bed in the Gypsum Spring formation (461, pp. 16-38).

In T. 47 N., R. 88 W., on the north side of Tensleep Creek near Burke's ranch, are many gypsum layers 2 ft. to 4 ft. thick interbedded with red shale beds that have a total thickness of 90 ft. The principal bed is 240 ft. above the Tensleep sandstone (547, p. 301; 436, p. 152; 169, p. 39).

Two miles northwest of Tensleep in T. 47 N., R. 88 W., along the west side of No Wood Creek and the north side of the Tensleep-Worland road, there are 74 ft. of gypsum 15 ft. from the top of the Chugwater. The upper 20 ft. are impure (436, p. 149). The upper Goose Egg contains 90 ft. of gypsum interlayered with thin red shale beds, all of which dip 10° W. (547, p. 301).

Weston County

There are extensive gypsum deposits in the basal Spearfish formation along Stockade Beaver Creek, southeast, east and northeast of Newcastle (19, p. 238). Thirty-foot gypsum beds at the top and 40-ft. beds near the base of the Spearfish formation crop out east of Newcastle. Extensive exposures of gypsum are found a short distance northeast of the LAK ranch, in the middle of the Spearfish formation (547, p. 297).

In the valley 2 mi. southeast of Mt. Pisgah, 10 mi. north of Newcastle, gypsum is present in the basal Spearfish beds (547, p. 297).

The Spearfish formation contains a 25 ft. bed of gypsum along Oil Creek in T. 47 N., R. 62 W. (547, p. 298).

Newcastle Area; NW¼SW¼ and NW¼NE¼ sec. 8, T. 48 N., R. 60 W. A 21-foot thick bed of gypsum occurs in the lower part of the Permo-Triassic Spearfish formation and is suitable for the manufacture of cement. Several tens of million tons occur near the land surface. An anlysis yielded the following: $CaO=32.4\%$; $MgO=1.6\%$; $SO_3=42.1\%$; $H_2O=15.8\%$; $Fe_2O_3=0.2\%$; $Al_2O_3=0.3\%$; $SiO_2=1.8\%$ (660).

REPORTED OCCURRENCES

Big Horn County

Gypsum is probably present in Horse Creek Canyon in T. 54 N., R. 91 W., though talus covers most of the area (436, p. 151).

Carbon County

J. R. Johnson of Laramie reports finding white alabaster along the Medicine Bow River, 6 mi. northwest of Medicine Bow (261).

Large amounts of alabaster are reported in the Seminoe Mountains, 12 mi. north of North Platte River (225).

Anhydrite is found occasionally in the Dakota formation in the Seminoe Mountains (16, p. 57).

Fremont County

Along the Popo Agie and Little Wind Rivers, in the Wind River Range, anhydrite is present in the redbeds (16, p. 57).

White, yellow and red alabaster is found along Little Popo Agie Creek in the lower Chugwater (192, p. 157).

The Wasatch shales of the Sweetwater district contain selenite crystals "up to several inches thick and a foot in diameter" (192, p. 149).

Narrow seams and veins of satin-spar cut across redbeds below the junction of Twin Creek and Little Popo Agie Creek. They are associated with thin gypsum beds (192, p. 149).

Hot Springs County

Selenite crystals are often found in the travertine terrace deposits around Thermopolis. The selenite is "apparently an alteration product due to the action of the sulfur waters." (See STONE), (582, p. 377; 170, pp. 194-200).

Natrona County

Midwest Area; sec. 20, T. 40 N., R. 79 W. A great quantity of selenite masses and crystals up to 3 in. long is associated with bentonite and is scattered throughout the Steele formation without any orderly distribution (175, p. 16).

In the SW¼ and N½ sec. 4, N½ sec. 3, T. 36 N., R. 83 W., the Steele formation contains abundant selenite crystals associated with bentonite (175, pp. 16-17).

Sheridan County

Selenite crystals are abundant in the Tertiary rocks along the bluffs immediately southeast of Sheridan County High School (489).

Sublette County

Just west of Union Pass "in the lignite beds and vicinty are great quantities of selenits and silicified wood." (545, pp. 457; 357).

Sweetwater County

Gypsite deposit in T. 25 N., R. 94 W.

Weston County

Alabaster has been reported in the Spearfish formation east and north of Newcastle (258).

IRON

Iron is the basic metal for modern civilization. One of the prime requirements for the maintenance of a modern nation is an adequate supply of iron ore, with a nearby source of coal suitable for smelting. Without coal and iron a nation cannot survive.

The Sunrise Mine, in Hartville Mining District, Platte and Goshen Counties, Wyoming, is one of the most important iron mines west of the Mississippi River. The soft variety of hematite from the Hartville region was first utilized by Indians in mixing war paint (211, p. 2). Exhaustion of copper ores in the district led to active iron mining in 1898; it has been continuous since that time, except for brief periods. Iron ore production from Colorado Fuel and Iron Corp.'s Sunrise Mine in 1962 amounted to 431,590 tons, and in 1963 it amounted to 468,695 tons (611). In late 1964, CF&I completed a new beneficiation plant at their Sunrise Mine which was designed for an annual capacity of 600,000 tons of iron ore concentrates.

In the Atlantic City-South Pass area of Fremont County, the Columbia-Geneva Steel Division of U. S. Steel Corporation has operated a large open-pit iron mine since 1962. This operation is designed to produce 4,000 tons of iron agglomerates per operating day. Production in 1962 and 1963 amounted to 1,043,111 and 3,782,488 tons respectively (611).

Plicoflex, Inc. (formerly Magnetite Products Corp.) operates an open-pit magnetite mine on the northwest part of Iron Mountain, Albany County. This product is shipped out of state for use as heavy aggregate in concrete for underwater pipe coating and for shielding fissionable materials. Production in 1962 and 1963 amounted to 42,318 and 52,898 tons respectively (611).

MAGNETITE

PROSPECTS

Albany County

Several deposits of magnetite-ilmenite are associated with the pre-Cambrian anorthosite rock complex of the Laramie Range. According to Newhouse and Hagner, (465) there are three mineralogic types of potentially commercial ore: (1) massive magnetite-ilmenite with minor spinel, (2) magnetite-ilmenite with olivine and occasional plagioclase in addition to spinel, (3) magnetite-ilmenite with apatite. The "ore" is frequently layered; bands rich in olivine alternate with olivine-free layers. Deposits of apatite magnetite-ilmenite are small and found only in the northernmost part of the anorthosite mass (465, pp. 4-5). The "ore" bodies are lenticular or tabular in shape, and are frequently arranged in *en echelon* manner. Individual lenses are usually parallel to layering in anorthosite, though a few lenses are oblique to the layering. Most of the bodies of titaniferous magnetite lie within 1 mi. of the anticlinal axis marked by layering in anorthosite, probably in small folds along the axis. Most of the deposits are small; the larger ones are described below:

Iron Mountain Deposit (465, pp. 9-16); secs. 22, 23, 26, and 27, T. 19 N., R. 71 W., approximately 47 mi. northeast of Laramie and 9 mi. northwest of Farthing Station on the Colorado and Southern Railroad. Titaniferous magnetite crops out for about 5,000 ft. along the crest of a northward-trending ridge. Associated rocks "include several types of anorthosite and granite" (465, p. 10). Newhouse and Hagner have divided the "ore" into three grades as follows: (465, p. 11).

> "Grade 1 consists of massive magnetite-ilmenite with from 0% to 35% by volume of silicates, chiefly olivine and minor spinel. The TiO_2 percentage ranges from 16% to 23% inclusive."
>
> "Grade 2 consists of magnetite-ilmenite with 35% to 65% by volume of silicates, chiefly olivine and minor spinel, plagioclase, and hypersthene. The TiO_2% ranges from 10% to 16%. "Ore" of this grade rarely crops out. . . ."
>
> "Grade 3 consists of magnetite-ilmenite with 65% to 85% by volume of silicates, largely plagioclase with minor olivine and hypersthene. The TiO_2% ranges from 5% to 10%."

They estimate the reserves at the Iron Mountain deposit as follows: (465, p. 16) grade (1), 3,000,000 short tons indicated, 600,000 short tons inferred; grade (2), 1,600,000 short tons indicated, 1,310,000 short tons inferred; grade (3), 900,000 short tons indicated, 1,740,000 short tons inferred.

According to maps and sections accompanying the report by Newhouse and Hagner, dip of the Iron Mountain ore bodies varies between 65° and 40° SE. Length and width of individual "ore" outcrops are quite variable resulting in irregular shape; there are numerous bodies of different sizes located along the length of Iron Mountain. An analysis of Iron Mountain "massive ore" is given: (465, p. 7) Al_2O_3=8.12%, Fe_2O_3=26.26%, FeO=41.80%, MgO=3.62%, TiO_2= 19.30%, MnO=.09%.

Frey (208) states that a combination low-intensity magnetic separation of titaniferous magnetite and electrostatic separation of ilmenite from olivine is the most advantageous method of treatment for Iron Mountain "ore." The material must be closely sized to a —20 mesh. Recoveries of 72% to 96% of the iron and titanium were obtained by this method from material which assayed 50% Fe, 19% TiO_2 and 3% to 4% SiO_2.

The U. S. Bureau of Mines conducted metallurgical tests on two general classifications of mineralization; massive magnetite-ilmenite, and disseminated magnetite-ilmenite. Resources of the former are estimated at 30 million tons with an average grade of 45.0% Fe, 20.0% TiO_2, 0.64% V_2O_5, 10.0% SiO_2, and little or no phosphorus or sulfur. Resources of the disseminated type are estimated at 148 million tons with an average assay value of 20.2% Fe, 9.7% TiO_2, 0.17% V_2O_5, and 35.6% SiO_2 (631).

Shanton Deposit (177, pp. 11-13); NE¼ SW¼ sec. 8, T. 18 N., R. 71 W., about 5 mi. southwest of Iron Mountain. According to R. A. Diemer's map (177, p. 12) five bodies of magnetite-ilmenite are found at this location; the largest is approximately 350 ft. long and 150 ft. wide. Massive anorthosite surrounds the "ore" bodies.

Seventy-one samples from 5-foot jack-hammer holes in the Shanton bodies were assayed by the U. S. Bureau of Mines (209). The results show that the "ore" is quite uniform; iron content varies between 49.3% and 53.0%, TiO_2 between 15.6% and 22.4%, V_2O_5 between 0.66% and 0.86% and P_2O_5 between 0.01% and 0.08%. Frey reports the "iron ore" to be massive magnetite intimately associated with ilmenite. Olivine is the chief gangue mineral with lesser amounts of quartz, biotite, chlorite, and spinel, An analysis from Newhouse and Hagner's report is: (Analyst, Norman Davidson) SiO_2=0.26%, Al_2O_3= 5.13%, Fe_2O_3=38.34%, FeO=32.66%, MgO=2.93%, CaO=0.10%, Na_2O= 0.54%, K_2O=0.40%, H_2O=0.02%, H_2O+=0.34%, TiO_2 = 19.56%, MnO= 0.14%, S=0.03%, P_2O_5=0.01%, V_2O_5=0.40% (465, p. 7).

Taylor Deposit (177, pp. 13-14); SE¼ sec. 35, T. 21 N., R. 71 W. A total of 8 separate lenses of ilmenite-magnetite crop out at this locality. The lenses are relatively high in ilmenite and contain up to 60% apatite. Diemer's map (177, p. 14) shows three bodies about 100 ft. to 150 ft. long and 50 ft. to 75 ft. wide. In addition there are 5 smaller lenses of "ore" shown on the map. An analysis of Taylor "ore" from Newhouse and Hagner (465, p. 7) is: (I. Warshaw, analyst) SiO_2=0.36%, Al_2O_3=3.10%, Fe_2O_3=26.15%, FeO=36.31%, MgO=1.85%, CaO=0.21%, Na_2O=0.20%, K_2O=0.22%, H_2O−=0.03%, H_2O+=0.43%, TiO_2=30.84%, MnO=0.08%, S = 0.01%, P_2O_5 = <0.01%, V_2O_5=0.27%.

Smaller deposits. Diemer (177) has numbered the smaller deposits:

Deposit No. 1 (177, pp. 14-15); SW¼ sec. 22, T. 21 N., R. 71 W., 1500 ft. north of Wyoming Highway No. 27. An irregular body of magnetite-ilmenite from 5 ft. to 10 ft. wide and 400 ft. long crops out along the crest of a high ridge of anorthosite. A partial analysis is as follows: V_2O_3=0.34%, TiO_2=19.0%, Fe=47.0%, P_2O_5=2.12%.

Deposit No. 2 (177, p. 15); NW¼ sec. 26, T. 21 N., R. 71 W., 50 ft. south of the boundary between secs. 26 and 23. The magnetite body strikes east for a distance of 600 ft., and is 5 ft. to 20 ft. wide. The contacts of magnetite with anorthosite are not visible in the field. The "ore" is very similar to that at Iron Mountain.

Deposit No. 3 (177, p. 15); NE¼ sec. 1, T. 20 N., R. 71 W. A small, poorly defined lens of magnetite-ilmenite strikes N. 70° E; it is 20 ft. long and 3 ft. wide. The material is very similar to Iron Mountain "ore."

Deposit No. 4 (177, p. 15); SW¼ sec. 2, T. 20 N., R. 71 W. Two lenses of magnetite-ilmenite along the abandoned Laramie-Wheatland highway strike N. 80° E. The larger lens is about 75 ft. by 10 ft., the smaller 8 ft. by 5 ft.

Deposit No. 5 (177, p. 15); SE¼ sec. 32, T. 20 N., R. 72 W., 1000 ft. west of southeast corner of sec. 32, 100 ft. north of the township boundary. A lens of magnetite-ilmenite 30 ft. long and 1 ft. or 2 ft. wide crops out along the crest of an eastward trending ridge.

Deposit No. 6 (177, pp. 15-16); NW¼ sec. 4, NE¼ sec. 4, T. 19 N., R. 72 W. Five separate bodies of magnetite-ilmenite are found in anorthosite which is cut by "quartz syenite." The lens in NW¼ sec. 4 is about 300 ft. by 100 ft. The lenses are layered, with varying amounts of labradorite, pyroxene, and apatite.

Deposit No. 7 (177, p. 16); S½ NE¼ sec. 7, T. 19 N., R. 72 W. The deposit extends 1500 ft. along the southeast side of a northeast trending ridge, but is not continuous. The strike is northeast and width of the bodies varies up to 10 ft. Contact of magnetite-ilmenite with anorthosite is sharp, and schistosity in country rocks is parallel to the trend of the magnetite body. No ilmenite was seen in a polished section of material from this deposit.

Deposit No. 8 (177, pp. 16-17). Six bodies of magnetite-ilmenite are found along the boundary between sec. 14, T. 19 N., R. 71 W. and sec. 15, T. 19 N., R. 71 W. Massive anorthosite encloses the bodies, but the contacts are not visible in the field. A granite dike cuts the magnetite-ilmenite body near the center. The material is similar to the magnetite-ilmenite at Iron Mountain.

Deposit No. 9 (177, p. 17). Patches of magnetite-ilmenite extend 400 ft. along the west flank of a northward-trending ridge in the S½ NE¼ sec. 26, T. 19 N., R. 72 W. The maximum width is 3 ft. Small stringers of magnetite-ilmenite extend into anorthosite, and both are cut by granite pegmatite.

Deposit No. 10 (177, p. 17); SW¼ sec. 33, T. 19 N., R. 71 W. A lens of magnetite-ilmenite on the crest of an anorthosite knob strikes east for 330 ft., then north for 350 ft. The lens is 110 ft. to 150 ft. wide. The material is similar to that at Iron Mountain.

Deposit No. 11 (177, p. 17); NW¼ sec. 3, T. 18 N., R. 71 W. Two lenses of magnetite-ilmenite strike north on the crest of a high ridge. The larger lens is 150 ft. by 8 ft.; the smaller is 15 ft. by 1 ft.

Deposit No. 12 (177, p. 17); NW¼ sec. 15, T. 18 N., R. 71 W. A lens of magnetite-ilmenite strikes north. It is 30 ft. long and 25 ft. wide at the north end, and 2 ft. wide at the south end. The contacts between magnetite and anorthosite are sharp and dip outward near the south end of the lens.

Deposit No. 13 (177, p. 17); SE¼ sec. 17, T. 18 N., R. 71 W. A lens of magnetite-ilmenite in anorthosite strikes N. 20° E. for 180 ft., and is 40 ft. to 80 ft. wide.

Deposit No. 14 (177, p. 18); SE¼ sec. 14, T. 18 N., R. 71 W., 1000 ft. west of the outcrop of Paleozoic sedimentary rocks. Anorthosite contains ten lenses of magnetite-ilmenite along ridges which trend northeast. The largest lens is 300 ft. long by 50 ft. wide. Contacts are not visible in the field.

Deposit No. 15 (177, p. 18); SE¼ sec. 31, T. 18 N., R. 71 W. A lens of magnetite-ilmenite in anorthosite resembles the Iron Mountain "ore." The lens is 50 ft. long by 2 ft. to 3 ft. wide. Contacts between the lens and anorthosite are not visible in the field.

Cobar No. 1; sec. 2, T. 21 N., R. 71 W. Magnetite Products Corp. (now Plicoflex, Inc.) formerly mined magnetite from an open-pit. In 1962, the company moved its operations to Iron Mountain.

Halleck Canyon Area; NE¼ T. 21 N., R. 72 W. Small veins of massive magnetite occur within a N. 40° E.-striking shear zone that dips 70° to 80° S. The shear zone separates massive hornblende-andesine gneiss (on the southeast) from quartz monzonite gneiss on the northwest. The magnetite is relatively persistent along the strike of the shear zone for almost one mile. Where exposed, the magnetite veins range from 2 inches to 2 feet thick within a 10-foot wide shear zone. Two grab samples analyzed by X-ray fluorescence, indicated 26% and 36% Fe (635).

Approx. sec. 31, T. 22 N., R. 71 W.; magnetite veinlets occur in a one-foot-wide zone striking N. 30° E. and dipping 70°-80° SE. within quartz monzonite gneiss (635).

T. 22 N., R. 71 W., three-fourths of a mile north and slightly east of the McGill ranch, small pods and veinlets of magnetite occur in hornblende-andesine gneiss (635).

Lake Owens Area; S½ T. 14 N., Rgs. 77 & 78 W., N. part T. 13 N., Rgs. 77 & 78 W. A reconnaissance dip-needle survey indicated a magnetic high in a narrow east-west-trending zone southeast of Lake Owens. Although magnetite occurs as an important accessory mineral throughout the pre-Cambrian mafic complex, it is more highly concentrated in the gabbroic rocks rather than in the olivine-bearing mafic rock. Within the ¼x1 mile-zone of magnetic anomaly, magnetite crops out occasionally in stringers and small fist-sized pods. Petrographic analyses of the samples from this zone show disseminated magnetite to average 10%. The pods average 80% magnetite; however, these are not common (668).

Pelton Creek Area; SW¼ sec. 33, T. 13 N., R. 79 W. Magnetite-ilmenite occurs in a small dark-colored periodotite body. X-ray fluorescence analysis indicates approximately 11% Fe. (670).

Carbon County

Hinton Mine; (See COPPER).

Converse County

Douglas Mining and Milling Company; about 2½ mi. southwest of Crazy Horse Creek, a tributary of La Prele Creek. Two schist layers are separated by about 250 ft. of granite; the layers are 80 ft. to 100 ft. wide. Locally the schist contains quartz. Narrow seams of magnetite cut some of the quartz. In one place chalcopyrite is associated with the magnetite. At one place about 2½ mi. southwest of the Copper King Claim (location not given) there is a small deposit of nearly pure magnetite. An area approximately 100 ft. square is covered by boulders of magnetite, but the outcrop is hidden.

"About three-fourths of a mile southwest of Crazy Horse Creek, a 2-foot layer of magnetite schist was noted in a 10-foot prospect pit" (540, p. 74).

Fremont County

Atlantic City Area; S½ T. 30 N., R. 100 W. The iron-bearing rocks in this area are folded and faulted metasedimentary rocks of pre-Cambrian age which occupy a narrow, northeastward-trending belt in the vicinity of Rock and Beaver Creeks north of Wyoming State Highway 28. The main iron formation, which ranges from 140-160 feet thick, is composed of three units: a lower chlorite-amphibole-magnetite-garnet schist, a middle iron-bearing unit, and an upper chlorite-garnet schist. The iron formation is gray or black, fine-grained, hard and laminated rock that contains magnetite, quartz, and amphibole. Proven reserves are reported to be 121,200,000 tons assaying 28-32% Fe. (617).

Columbia-Geneva Steel Division of U. S. Steel Corp. has performed considerable drilling and test work on these deposits since 1956. In 1957, a limited tonnage was mined from a 700-foot adit and shipped to Minnesota for test purposes (217). Full-scale mining operations began in 1962.

Copper Mountain Area; T. 40 N., Rgs. 92, 93 & 94 W. Pre-Cambrian metasedimentary rocks contain magnetite-bearing quartzites and schists that are interlayered with abundant amphibolites. Iron-bearing rocks form a discontinuously outcropping zone ½ to ¾ mile wide which trends east and northeast transversely across Copper Mountain for at least 8 miles. This zone may extend in the subsurface about 3½ miles west of Copper Mountain because similar magnetite-bearing rocks occur in the east wall of Wind River Canyon along U. S. Highway 20.

The metasedimentary rocks strike southeast to northeast and dip from 45° to 70° S. Magnetite-bearing layers are commonly 5 to 10 feet thick, but some are over 30 feet thick. Moreover, closely spaced iron-bearing layers yield essentially magnetic units 15 to 50 feet thick with some units about 100 feet thick. These units may be separated by over 100 feet of essentially barren rock.

At least two series of iron-bearing rocks crop out. The lower series (northernmost outcrops) is separated from the upper series (southern outcrops) by several hundred feet of essentially barren quartzites, amphibolites, and a few layers of muscovite, muscovite-andalusite (?), and muscovite-biotite schists. Both series are present and apparently continuous; however, the lower series is poorly exposed. The lower series is about 150-200 feet thick and is composed of gray to black, poorly color-banded, platy, fine-grained, magnetic quartzite abundantly interlayered with black fine-grained amphibolite. The upper series consists of quartzite, greenschist, some thin muscovite schist and biotite schist and four distinct magnetic units which occur in most places. The iron-bearing layers are greenschist, some of which contain magnetite crystals over ¼ inch long; and dark poorly color banded, very fine-grained quartzites containing magnetite. A section of the upper series measured in SE¼ NE¼ sec. 15, T. 40 N., R. 94 W., shows about 125 feet of magnetite-bearing rock distributed through an interval about 375 feet thick. Magnetic units, containing some barren rock, are 15 to 90 feet thick and may be separated by as much as 160 feet of essentially barren amphibolite, schist, and quartzite. Seven grab samples taken from secs. 12, 13, & 23, T. 40 N., R. 93 W., were analyzed for total iron content by X-ray fluorescence methods, ranged from 20.06% to 30.40% Fe. The average was 25.25% total Fe. (661).

Sublette County

Clear Creek Area; south central T. 39 N., R. 107 W. Taconite occurs in a cirque in the Clear Creek drainage at an elevation of more than 11,000 feet. Surface exposures of the body comprise 60-70% of the outcrop area of 1,600 by 2,500 feet. The taconite occurs in parallel layers 5 to 30 feet thick that are synformal (syncline-like) in structure. Pre-Cambrian gneiss and migmatite separate the layers. Migmatite and amphibolite surround the taconite. Estimated iron content is 20%. Other minerals include quartz, pyroxene, and garnet (679).

REPORTED OCCURRENCES

Fremont County

A large body of magnetite was reported to be located just northeast of the Atlantic City Post Office. The samples "appear to be low grade" (217).

Natrona County

Areas of fibrous magnetite (pseudomorphous after chrysotile) are associated with areas of serpentine and asbestos on Casper Mountain. The magnetite veinlets are granular in the center and fibrous near the walls (494).

HEMATITE

PRODUCING MINE

Platte County

Sunrise Mine (See IRON).

PROSPECTS

Carbon County

Gertrude Property; located just north of an old road, and ½ mi. east of the old town of Battle. A 2½ ft. to 9 ft. bed of hematite in quartzites strikes east-west and dips 40° S. The hematite may be gossan material. The bed assayed $7.00 gold per ton (See COPPER). (539, pp. 92-93).

Kearns Prospect; on the head of Beaver Creek, 4 mi. from Downington. A siliceous "ledge" 12 ft. wide lies between red granite and "granitoid gneiss," and strikes east-west. Dip is to the south. The ledge weathers to hard banded material which resembles jaspilite iron ores. The siliceous hematite becomes softer with depth (40).

Rawlins Area; sec. 31, T. 21 N., R. 87 W., secs. 4, 5, 8, 9, T. 22 N., R. 87 W., 9 mi. north of Rawlins. Several small deposits of hematite in sandstone (Cambrian) capped by limestone (Madison) are located 2 mi. north of Rawlins (409, p. 174; 435, pp. 210-213). An analysis is: Fe_2O_3=94.22%, SiO_2=1.71%, S=1.24%, P=tr, water=0.37%.

According to Boyle (136) the richest ore is found in pockets, pod-shaped masses, lenses, and other irregularly shaped masses within a shaly limestone bed. Some of the masses were more than 20 ft. in length. The ore replaced rock within a closely restricted stratigraphic horizon, and the masses are probably bedding plane deposits. The hematite is variable; some is massive, hard, and blue material, and some is partly granular and earthy. Boyle inferred reserves of 1,000,000 tons.

Assays of the ore are given below:

SiO_2	9.63%	1.68%	10.43%	40.44%
Al_2O_3	5.10	2.46	——	——
Fe_2O_3	80.30	93.30	53.82	5.33
MnO	0.75	0.65	——	——
CaO	0.71	0.38	1.46	7.91
P_2O_5	——	——	0.132	0.0396
CO_2	0.61	——	——	——
H_2O	2.68	——	——	——
Loss	——	0.22	0.15	——

An average of 9 assayed carloads of ore gave the following result: $Fe=64.94\%$, $SiO_2=3.16\%$, $P_2O_5=.013\%$, $SO_3=.011\%$, $CaO=1.46\%$, $CO_2=2.84\%$ (435, p. 214).

Production to 1890 was estimated by Lovering (435) to be about 100,000 tons; little has been produced since 1890. The tonnage in sight in 1926 was small.

Most of the deposits are associated with east-northeast striking cross-faults. The pits dug in sec. 31, T. 21 N., R. 87 W., contain associated malachite, azurite, chrysocolla, and chalcocite with hematite in fractured Madison limestone. Brochanite has replaced the cement of a sandy limestone bed. An inaccessible shaft shows a considerable amount of moss-green olivenite (?) in limestone (488).

Seminoe Mountains; secs. 1, 12, 13, T. 25 N., R. 86 W., and secs. 7, 18, T. 25 N., R. 85 W., about 27 mi. north of Rawlins. An iron formation (jasper) lies between two series of greenstones; all are intruded by igneous rocks. The maximum thickness of the iron formation is about 300 ft. It is discontinuous, probably because of folding and faulting. Lovering thought the iron formation a series of lenticular hot spring deposits. The iron-bearing rocks are low phosphorous hematites, though some beds contain magnetite. The iron content reaches a maximum of about 35%. Both hard and soft "ores" are present; up to 20 ft. of hard ore with 60% Fe have been found. These hard ores are probably high temperature replacements of ferruginous jasper (435, pp. 220-224). Lovering believed the iron-bearing beds were cut off by a thrust fault at depth.

Recent work by Blackstone (620) in the Bradley Peak area (parts of secs. 6, 7, & 18, T. 25 N., R. 85 W., and secs. 1, 12, & 13, T. 25 N., R. 86 W.) indicate that pre-Cambrian iron deposits occur in a large landslide which overlies the Cretaceous Lewis shale. This 3 square mile, gravity emplaced mass is composed of individual iron deposits which have been derived from the Seminoe iron formation cropping out in the hanging wall of the Bradley Peak thrust. Barren ground is often jumbled in with the iron-bearing rocks in the landslide mass. The thickness of the mass as a whole ranges from less than 100 feet to a maximum of 300 feet. The outcrop pattern of the iron formation is shown on a recent map by Bayley (618).

Hendricks (362) made an early examination of the deposits; his report describes 7 lode claims: the *St. Louis, Calcator, Rex Oxide, Domingo, New Year, Boston, Frozen Finger,* and 4 placer claims: the *Midnight Iron Placer, Grant Iron Placer, Greely Iron Placer, Hayes Iron Placer.* He describes the "ore" as soft hematite, varying from "pure blue ore" to more impure types. Most is mixed with jasper, iron schists, and chloritic and "dioritic" schists. The iron formation is highly disturbed by faulting and dips "in all directions." The continuity and quality of the "ore" could not be determined. He estimated 1,000,000 tons of 60% ore. His assays, made by the Lake Superior Iron Company Laboratory, Ishpeming, Michigan, August 6, 1902, are given below:

Sample, fired at 212°	Claim	Iron	Phosphorous	Silica
Wyo. No. 1	Hayes Placer	33.45	0.137	49.66
Wyo. No. 2	Frozen Finger	31.40	0.085	48.77
Wyo. No. 4	Frozen Finger	32.70	0.107	48.95
Wyo. No. 5	Domingo	28.70	0.087	53.91
Wyo. No. 6	Hayes Placer	31.40	0.057	53.26
Wyo. No. 7	New Year	44.10	0.188	13.51
Wyo. No. 8	E. end, Greely Placer	66.30	0.223	1.37
Wyo. No. 9	Boston	40.35	0.055	40.46
Wyo. No. 10	Midnight Placer	38.75	0.067	42.09
Wyo. No. 11		56.05	0.249	16.50
Wyo. No. 12	Midnight Placer	33.90	0.094	49.75
Wyo. No. 13	Midnight Placer	63.30	0.129	3.81
Wyo. No. 14	Calcator	61.80	0.168	6.38
Wyo. No. 15	Calcator	68.55	0.074	.91
Wyo. No. 16	St. Louis	56.45	0.144	15.98
Wyo. No. 17	Calcator	37.85	0.154	37.18
Wyo. No. 18	Calcator	58.65	0.190	13.71
Wyo. No. 19	Calcator	45.00	0.143	33.41
Wyo. No. 20		60.05	0.149	8.25
Wyo. No. 21		56.30	0.036	15.25

Dickman (176, p. 1) reported the rocks strike "west of south" to the center of sec. 12, T. 25 N., R. 86 W. East of this point the strike changes to the east, and the iron formation splits into three belts. He also found iron-bearing rocks north of Bradley's Peak in sec. 31, T. 26 N., R. 85 W., and sec. 36, T. 26 N., R. 86 W. A sample of an 8 ft. "ledge" at that locality assayed as follows: Fe=35.50%, P_2O_5=.125%, SiO_2=5.50%, Au=0.02 oz. per ton, and Ag=0.50 oz. per ton. Dickman's reports on various claims within the region are summarized in the following paragraphs.

SE corner NE¼ sec. 18, T. 25 N., R. 85 W. Fifteen feet of "ore" were found in place between greenstone and "diorite." The material assayed 28.8% Fe, 35.80% SiO_2, and 0.356% P. (176, p. 4).

SW¼ sec. 18, T. 25 N., R. 85 W. Several small cuts and a shaft were examined and gave the following assays (176, p. 4):

	Fe%	SiO_2%	P%
Pit 20 ft. deep, ore 18 ft. wide, av.	65.80	1.00	0.181
Shaft 50 ft. deep in extreme SW corner of section 12 ft. of ore exposed.	62.00	7.60	0.090

SE¼ sec. 12, T. 25 N., R. 86 W. Numerous knolls in this area show iron float. An average dump sample yielded 45.00% Fe, 33.60% SiO_2, and 0.080% Phosphorous (176, p. 2).

NW¼ sec. 12, T. 25 N., R. 86 W. A wide belt of iron-bearing rock is visible on the surface, but it may be "slide." Samples intended to represent commercial averages gave the following assays (176, p. 2):

	Fe%	SiO_2%	P%
Pit W½ NW¼	34.00	48.00	0.091
same	41.00	39.70	0.061
Pit E½ NW¼	53.00	20.50	0.64
same	64.60	1.80	0.179

SE¼ sec. 1, T. 25 N., R. 86 W. A tunnel 250 ft. long cross-cuts 64 ft. of iron formation. The foot-wall is greenstone and the hanging-wall jasper mixed with calcareous material. "Analyses show a siliceous non-Bessemer ore very low in Fe." The "best selected sample shows" Fe=40.00%, Silica=40.80%, and P_2O_5 =0.070% (176, p. 2).

NE¼ sec. 18, T. 25 N., R. 85 W. A tunnel was run in "wash and slide." Iron formation from the tunnel assayed as follows (176, p. 4):

	Fe%	SiO_2%	P%
cut in wash	37.50	36.15	0.119
cut in wash	64.60	1.75	0.096
ore apparently in place	33.00	53.20	0.082

NW¼ sec. 7, T. 25 N., R. 85 W. A shaft 104 ft. deep was sunk in a draw between two hills, but bottomed in detrital material. The ferruginous detritus assayed as follows (176, p. 4): Fe=37.00%, SiO_2=28.00%, P=0.058%.

Ricketts (506, pp. 61-62) reports the rocks at the south base of Bradley's Peak are chlorite schist and ferruginous quartzite which are cut by dikes. Lenticular bodies of hematitic material are found in the schist and quartzite. The hematite assayed as follows:

Metallic Fe	55.30%	29.50%	63.56%	68.60%	61.35%
O_2	23.91	25.50	27.25	——	——
SiO_2	20.10	15.00	2.68	4.30	0.006
Titanic acid			0.03	trace	——
S	——	——	——	trace	——

W. C. Knight (416) gives the following assays:

Sample No.	Iron %	Silica %	Sulfur %	Phosphorous %
1	32.20	48.04		
2	57.86	14.40	tr	0.040
3	56.75	5.77	tr	
4	38.10	42.38		
5	35.18	47.50		
6	60.25	9.66	tr	0.0822
7	58.82	15.27		

(Only a few samples were analyzed for sulfur and phosphorous).

Secs. 19, 20, & so T. 26 N., R. 85 W. Jaspery and iron-bearing quartzite crop out with northeast strike (619).

Shirley District; sec. 18, T. 26 N., R. 81 W., 25 mi. north of Hanna, in the east end of the Shirley Mountains. Hematite is scattered throughout pegmatite dikes in granite. One of the dikes is ½ mi. long. Locally there is a central seam 1 ft. to 2 ft. wide of pure hard blue hematite. Where the dike cuts through a body of syenite, the rock has been impregnated for 100 ft. away from the dike. Impregnated syenite contains nearly 20% Fe (435, pp. 216-219).

Converse County

American Mining Co. Property; secs. 4 and 5, T. 31 N., R. 72 W. Hematite is interbedded in the Casper (?) sandstone, associated with a little chert. A pit 5 ft. long, 5 ft. wide and 5 ft. deep has been dug in hematite. Several hundred feet up the valley an outcrop and small pit show 4 ft. of hematite with about 5% of the face made up of chert. The hematite bodies strike north-south and may be traced for about ¾ mi. along the strike (310).

Deer Creek—Little Deer Creek. No accurate location is given by Berryman. Angular fragments of hematite up to 4 in. in diameter are embedded in red shaly sandstone, about 60 ft. above the contact of the Casper and Madison formations (125, p. 25).

Olin Brothers Property; sec. 8, T. 31 N., R. 74 W. Masses of hematite occur in the Amsden formation on the slopes of a hill crested by Tensleep sandstone. The hematite contains a small amount of chert, sometimes coating the silica nodules and sometimes replacing them. The deposit is irregular (304).

Fremont County

The Amsden formation along the Wind River Range and adjacent areas in northeastern Wyoming contains a discontinuous layer of pisolitic hematite nodules, about 20 ft. to 35 ft. above the base of the Darwin sandstone member. Thickness of the pisolitic unit varies considerably. The individual pisolites have concentric rings around nuclei of anhydrite or gypsum, or clastic sand grains. They are set in a matrix of red shale, anhydrite and massive hematite. Where the pisolitic unit is thickest it is massive and ill-defined; where thin it is pisolitic and well-bedded. A few fossils are completely replaced by hematite. Scattered pisolites are found in beds above and below the unit (126, pp. 19-22).

Red Creek Area; secs. 32 & 33, T. 40 N., R. 105 W. The Amsden formation contains thin, discontinuous layers of hematite and limonite nodules. A composite sample of a 1- to 7-foot thick bed containing oolitic limonite nodules analyzed as follows: 13.3% Fe, 18.6% Fe_2O_3. Other individual samples over a 2- to 12-foot width from the same unit contained from 2.4 to 19.6% iron. Pisolitic hematite in red shale is reported in the lower part of the formation (621).

Copper Mountain Area; NW¼ sec. 32, T. 40 N., R. 92 W. Specular hematite disseminated in pre-Cambrian granite occurs in at least 3 separate outcrops. Two of these crop out on small knolls and are lens- or pod-like bodies. The largest is approximately 90 feet long, 20 feet wide, with an exposed depth of 15 feet. The smaller body is about 40 feet long with an exposed depth of 20 feet. A third hematitic zone is exposed in a 10-foot deep partially caved shaft which was sunk on a 7-foot wide zone of hematite-impregnated altered granite. The length of this zone is unknown, since it is not exposed along the strike beyond the shaft (673).

Goshen County

W½ E½ sec. 23, T. 29 N., R. 65 W. Poorly exposed iron formation occurs on the east flank of an apparently north-plunging fold. The rock sequence is probably overturned here. The iron formation consists of red to black, very fine-grained quartzite not exceeding 150 feet in thickness, and is overlain by chlorite and chlorite-biotite schists, some layers of which show cubic casts after pyrite (?). The chief iron mineral is hematite although some magnetite is probably present. The iron formation occurs about 100 feet above the thick dolomite and is underlain by iron-poor quartzite (662).

SE¼ SE¼ sec. 14, T. 29 N., R. 65 W. Chlorite schist, magnetic quartzite, conglomeratic quartzite and dolomite are exposed in a series of small folds which trend N. 35° E. to N. 50° E. and dip 35° to 80° SE. The magnetic quartzite is iron gray, black, and red, mostly very fine-grained, thin layered, and composed chiefly of quartz, magnetite and hematite. The strongly magnetic layers weather primarily black and show sparse hematite. The moderately magnetic layers weather black and red and show abundant hematite. Two grab samples assayed 17.1% total Fe and 15.9% total Fe (662).

NW¼ sec. 13, T. 29 N., R. 65 W. Thin layers of hematitic quartzite and hematitic schist are exposed along a N. 47° W. strike for about 1,200 feet. The iron-bearing rocks are mostly light red to light gray, very fine- to fine-grained quartzites. Hematite is the most abundant iron mineral; however, some magnetite is present. A grab sample assayed 13.0% total Fe. (662).

SW¼ sec. 12, T. 29 N., R. 65 W. Hematitic schist occurs in outcrop and float along a distance of about 2,400 feet, the layers of which strike N. 22° E., and dip 80° to 85° NW. Most of the exposures are poor; however, the iron formation is probably in contact with chlorite and amphibole schist to the west and concealed by Tertiary rocks to the east. The iron-bearing rocks are red to light gray, extremely fine-grained, commonly hematitic-spotted schists that, in places, are strongly magnetic. Hematite is the chief iron mineral observed (662).

Muskrat Canyon Area; SW¼ sec. 13, W½ and SE¼ sec. 24, T. 30 N., R. 65 W.; W½ sec. 19, S½ sec. 18, NW¼ sec. 17, S½ and NE¼ sec. 8, T. 30 N., R. 64 W. Iron formation crops out in the walls of Muskrat Canyon and along the headwaters of Wildcat Creek to the north. Iron formation outcrops are discontinuous around the perimeter of a large, north-south-trending fold, and consist of hematitic quartzite, hematite schist, and extremely fine-grained quartzite interlayered with dolomite, graphite schist, barren quartzite, biotite schist and muscovite schist. Iron-bearing layers can be found for about 5 miles along strike and in places over a surface width of 1,200 feet. Most iron-bearing layers on the west limb of the large fold are around 20 feet thick, and consist of quartzites and schists. Layers on the east limb in Muskrat Canyon are mainly schist, up to 80 feet thick. Along the head of Wildcat Creek, abundant black, brown, and buff, thin, extremely fine-grained quartzites are interlayered with hematitic quartzite, schist, and dolomite. A grab sample of red, very fine-grained hematitic quartzite assayed 13.1% total Fe. (662).

Sec. 26, T. 28 N., R. 65 W. Hematite occurs in mica schist along the McCann fault in the vicinity of McCann Pass (668).

SE¼ NE¼ sec. 12, T. 27 N., R. 65 W. An east-west-trending belt of hematitic schist about 50 to 75 feet wide transects mica schist. The hematitic schist is concealed on the south, east, and west by overlying rocks (658).

Laramie County

Limonite nodules ranging in size from an ounce to several hundred pounds are found in the coal-bearing Tertiary (?) rocks in large quantities, about 12 mi. south of Cheyenne. The nodules resemble the "iron-ores of Maryland and Pennsylvania" (356, p. 78).

Lincoln County

In the SW¼ sec. 11, T. 33 N., R. 116 W., on the north side of Sheep Creek Canyon, a bed of iron-bearing conglomerate lies between beds of white sandstone of Pennsylvania age. The pebbles are mostly hematite. The generalized stratigraphic column is given below (525, p. 130):

sandstone, bluish gray	
conglomerate, hematite pebbles	4 ft.
shale, iron-bearing	6 ft.
sandstone, whitish	

Sec. 12, T. 29 N., R. 117 W. A pisolitic hematite bed 5 to 6 feet thick occurs in the lower part of the Pennsylvanian Wells formation. The bed is probably discontinuous (637).

Niobrara County

NW¼ sec. 28, T. 31 N., R. 64 W. Hematitic schists and quartzites interlayered with dolomite strike about N. 20° E., and dip about 85° SE. to vertical. The rocks are poorly exposed in a narrow, north-trending, discontinuous outcrop and partially concealed by rocks of Paleozoic age. The iron-bearing formation is apparently in contact with granite on the west and with a thick, buff to pink, dolomite sequence to the east. Southernmost exposures are primarily jasperoidal quartzites of low iron content interlayered with dolomite. Northern exposures include some red and black banded, partially jasperoidal quartzites and hematitic schist (662).

Rawhide Canyon Area; NW¼ sec. 4 & 5, T. 30 N., R. 64 W.; S½ and NE¼ sec. 29, SE¼ sec. 30; NE¼ sec. 31, 32, and SW¼ sec. 33, T. 31 N., R. 64 W. A poorly exposed granite pluton occurs along the headwaters of Rawhide Creek, and contains numerous remnants of metamorphic rock which are greatly oxidized and heavily hematitic in places. The remnants, which may be weathered iron formation, form narrow, sinuous, shallow trenches, which strike from N. 10° E. to N. 25° W., and dip 70° to 85° E. Most of these range from 20 to 50 feet wide, and some can be followed for a distance of 1,000 feet along strike before they become concealed by Paleozoic and Tertiary rocks (662).

Park County

Iron King Claims. In SW¼ sec. 9, T. 54 N., R. 103 W., a deposit of hematite occurs in the "red beds" of the Amsden formation. It is contained in a 23-ft. zone, which strikes N. 46° W. and dips 35° NE. Grab sample assays show 45.60% Fe (602).

Platte County

Hartville District. The pre-Cambrian sedimentary rocks of the Hartville District contain interbedded hematite schists. The hematite schists form the orebodies which are mined at the Sunrise Mine, as well as the idle Chicago Mine and Good Fortune Mine. Hematite-bearing rocks are found in a zone 2 mi. to 3 mi. wide, which trends northeast for about 10 mi. to 12 mi. from Guernsey. The pre-Cambrian rocks are strongly folded and the Sunrise ore is found in a steeply plunging syncline. The ore bodies are lenticular and usually lie within a short distance of a dolomite footwall. The pre-Cambrian rocks are capped by gently dipping Paleozoic sediments which sometimes contain fragments of iron-bearing rocks. Good general descriptions of Hartville geology are given by Ball (18) and Smith (536). The ores are generally of three types, according to Ball (18, pp. 196-197): (1) hard gray ore with numerous cavities lined with finely crystalline specular hematite, (2) soft "greasy" brownish-red ore, which contains minor amounts of siderite and limonite, as well as calcite, quartz, qypsum, chalcedony, barite, and copper minerals, and (3) secondarily derived ore in the base of the Guernsey formation, the base of the Hartville formation, and in Tertiary and Pleistocene rocks.

Good Fortune Group; secs. 4, 8, 17, T. 27 N., R. 65 W., on the east side of Whalen canyon. Red hematite lenses are found in slate, immediately above the uppermost limestone of the "older pre-Cambrian series." A thin shell of siliceous iron-stained schist separates the ore from the underlying limestones (210). The area surrounding the Good Fortune Group is magnetically low (211), but the U. S. Bureau of Mines detected no correlation between magnetic anomalies and the structure or mineralization.

In 1953 and 1954, the Schroeder Mining Co. mined and shipped iron ore from the Good Fortune mine. A heavy-medium plant was constructed in 1954 to reprocess material from an old tailings dump (217).

Sunrise Mine. The ore body originally mined at Sunrise was lenticular and dipped steeply. It was folded into syncline, and was S-shaped in map view. The lens was about 2100 ft. by 500 ft. in horizontal dimensions. Soft ore was found in the upper 200 feet of the deposit, but gradually was replaced by hard ore in depth. According to the U. S. Bureau of Mines (174) the hard ore is predominantly hematite, limonite, and goethite. The hematite is in the form of small acicular crystals. Limonite forms the cement for rounded quartz grains, and goethite shows colloform and banded structures. Various assays of the ore are given below:

	(538)	(538)	(174)	(513, av. of 1937 production)
Metallic Fe	67.55%	68.41%	55.92%	56.44%
Al_2O_3	1.42	1.86		
SiO_2	1.50	1.82	10.76	
S	0.054	0.019		
P	0.008	0.035	0.013	0.068
Na, Mg	tr.	——		

SE¼ sec. 28, T. 27 N., R. 65 W. Hematitic schist, partially concealed by the Guernsey formation, crops out on the south side of a small hill (658).

Sublette County

Tosi Creek Basin; secs. 30, 31, T. 39 N., R. 111 W. On the east side of Tosi Creek Basin, at an elevation between 9,500-10,000 feet, a pisolitic hematite zone occurs in the basal red shale, just above the Darwin sandstone member of the Amsden formation. The zone, which is approximately 10 feet thick, crops out in a continuously exposed bluff for a distance of one to 1½ miles. The pisolitic beds also occur on the west side of Tosi Creek Basin, at the base of Hodges Peak (645).

REPORTED OCCURRENCES OF HEMATITE

Carbon County

Ak-sar-ben Group; (See MANGANESE).

Bradley's Peak (16, p. 56) Itabiryte, a micaceous hematite, is reported "south of Bradley's Peak."

Charter Oak; (See COPPER).

Copper Gem Prospect; (See COPPER).
Copper Rock Group; (See COPPER).
Creede Property; (See COPPER).
D & L Group; (See COPPER).
Hidden Treasure Tunnel; (See COPPER).
Octavia Prospect; (See COPPER).
Raven Group; (See COPPER).
Three Forks Group; (See COPPER).

Converse County

Hoosier Boy Group; (See COPPER).
Trail Creek Group; (See COPPER).

Fremont County

Hematite is found at the contact between Madison and Amsden formations on the Lander-South Pass road (217). A belt of hematite schist trends east-west across the Lander-Farson road about 2 mi. south of the Beaver Creek bridge. The belt extends westward, south of the old asbestos mill on Rock Creek (217).

In the SE¼ NW¼ sec. 15, T. 7 N., R. 5 W. (Wind River Meridian), a granite dike which is partially covered by Wasatch shale contains hematite reported to assay 60% Fe (430, p. 5).

Wind River Range. Specular hematite is found "in veins cutting granites of Wind River Range on the upper drainage of the Little Sandy" (192, p. 158).

Laramie County

Rambler Group; (See COPPER, ZINC).

Lincoln County

Hematite is found on the divide between Gray's River and Green River, 5 mi. to 6 mi. from Gray's River Road (217).

Natrona County

Koch Deposit; probably located "close to" T. 32 N., R. 79 W., 32 mi. to 33 mi. from Casper. A quartz-specularite vein trends north for 1 mi., disappears for 1 mi., and then appears again. The vein cuts granite. Vein material yields assays of 30% Fe, 32% Fe, 1-2% Cr (1 sample), and 1-2% Mn (1 sample) (298).

In sec. 21, T. 32 N., R. 79 W., three pits show red hematite associated with and replacing chert. The hematite is locally covered by several feet of soil overburden (303).

Platte County

Jehosephat Prospect; sec. 12, T. 27 N., R. 66 W. Siliceous dolomite encloses hematite. The rock is weathered to limonite. A small amount of malachite was found in a small hole, near the top of the iron oxides.

Assays are given below (43):

East side shaft, near bottom	43.3% metallic iron
West side shaft, near bottom	33.6% metallic iron

Michigan Mine; (See COPPER).

Sheridan County

SW¼ sec. 5, T. 54 N., R. 87 W.; (See COPPER).

In the SE¼ sec. 20, T. 54 N., R. 88 W., on a low ridge north of West Fork South Tongue River, a small pit in pre-Cambrian granite showed quartz and hematite in a network of minute fracture fillings. Float of similar rock, with slickensides, can be traced about 1 mi west-northwest, passing into a fault in Paleozoic rocks (473).

In the NW¼ NE¼ sec. 11, T. 55 N., R. 89 W., sheared, silicified, and epidotized granite contains a lens of quartz (480). The granite and the quartz both contain thin films of specularite in fractures. A shallow shaft has been dug on the quartz lens.

NE¼ sec. 24, T. 55 N., R. 88 W.; (See COPPER).

ILMENITE

REPORTED OCCURRENCES

Reported in the Snake River gold concentrates (See GOLD, Lincoln County), (517, p. 127).
Reported in the Wind River gold gravels (517, p. 132).

LIMONITE

REPORTED OCCURRENCES

Hayden (192, p. 158) reported limonite in Cretaceous shales on the Little Popo Agie River, and in small deposits in "ferruginous strata" of the Upper Cretaceous Rocks.

MARCASITE

REPORTED OCCURRENCES

Park County

Sunlight District. "Iron sulphide, probably marcasite, occurs as a thin incrustation on spheroidally weathering nodules of the lavas in the vicinity of two of the sulphur incrusted fractures" (364, p. 355).

PYRRHOTITE

Pyrrhotite sometimes contains commercial quantities of nickle.

PROSPECTS

Albany County

Maggie Murphy Group; SW¼, T. 28 N., R. 71 W., in the northeast corner of Albany County, 6 mi. north of Laramie Peak. Quartz veins cut red granite which contains mica and hornblende schist layers. The veins are 10 ft. to 40 ft. wide; they strike north-south and dip gently east. Near the surface they contain limonite and hematite, as well as malachite and azurite stains. A shaft encountered a 5 ft. vein of pyrrhotite beneath the oxidized zone. Another shaft encountered pyrrhotite mixed with coarse-grained marcasite and a small amount of disseminated chalcopyrite. At 50 ft. the pyrrhotite became quartzose. The pyrrhotite vein passed out of the shaft at 60 ft. (71; 81; 96).

Three Cripples Mine; NE¼ NE¼ sec. 16, T. 28 N., R. 71 W. A pink granite contains thin layers of black schist which are probably metadiabase dikes. Dump material showed massive pyrrhotite rock similar to the Maggie Murphy. An analysis gave the following result (540, p. 62): Insol.=28.38%, Fe=41.80%, Cu=0.23%, Co=trace.

Carbon County

Creede Prospect. Hornblende schist contains pyrrhotite which bears copper, nickle, and cobalt near a large dike of norite in sec. 10, T. 14 N., R. 86 W. (539, p. 36).

Island City Group; secs. 3 and 10, T. 14 N., R. 86 W., on the north side of Bridger Mountain, near the head of North Spring Creek, 2 mi. northeast of the old town of Dillon. At 60 ft. depth a "strong showing" of pyrrhotite was found at the contact between norite and schist. Limonite and copper carbonates stain the vein, which contains a small amount of copper sulfides (75).

Lorain Group; secs. 11 and 12, T. 15 N., R. 80 W., at the junction of Iron Creek and French Creek. Pyrrhotite was found below the oxidized zone in a shaft sunk in graphite schist which is limonite stained at the surface (74).

Monarch Group; secs. 32 and 33, T. 14 N., R. 85 W., 1½ mi. southeast of the old town of Battle. Interlayered schists and "quartz diorites" trend east-west and are vertical. The rocks are altered and silicified, and are mineralized with pyrrhotite. Near the surface they are weathered to hematite and limonite. No copper was found (50).

Converse County

Kreisley Deposit; SW¼ SW¼ sec. 35, T. 29 N., R. 71 W. Several large bodies of pyrrhotite are found in 11 veins. The pyrrhotite is mixed with hornblende and quartz. The deposit is covered by a red and yellow jasper capping (540, p. 65).

Platte County

Independence Group; on Slate Creek, a tributary of the Laramie River, about 22 mi. west of Wheatland. A layer of schist 1 mi. wide in granite trends northeast and dips 30° to 40° NW. It consists of fine-grained biotite schist, garnet-mica schist, muscovite schist, and hornblende schist. Several quartz veins conform to the schist, and contain limonite, malachite, azurite, and bornite, as well as marcasite and pyrrhotite. Assays are reported to show copper, nickle, gold, and silver (67).

Welcome Mine; northeast of Frederick, and at the east base of a granite hill. Granite contains banded bronze-colored pyrrhotite with intermingled chalcopyrite (536, p. 5).

REPORTED OCCURRENCES

Albany County

Found at old village of Cummins City (16, p. 56).

Eureka Prospect; secs. 9 and 16, T. 28 N., R. 71 W.; (See COPPER).

Florence Mine; (See COPPER).

Carbon County

Gibralter Copper Mining Co.; (See COPPER).

Leighton-Gentry Prospect; (See COPPER).

Raven Group; (See COPPER).

Fremont County

Pioneer Carissa Gold Mines, Inc.; (See GOLD).

Laramie County

Globe Prospect; (See COPPER).

Platte County

Cooney Hills Prospect; (See COPPER).

Hartville District. "Large amounts" of pyrrhotite are found on the east side of the Haystack Range of the Hartville Uplift (217).

Sheridan County

NE¼ sec. 35, T. 56 N., R. 89 W., at the old "Leopard Rock" quarry (see STONE) south of Twin Buttes. A red fine-grained rock at the hanging-wall of the dike contains a small amount of disseminated pyrrhotite. Phenocryst-free layers of the dike also contain a small amount of pyrrhotite (475).

PYRITE

REPORTED OCCURRENCES

Albany County

McGee Claim; SE¼ NW¼ sec. 10, T. 28 N., R. 71 W., 1200 ft. north of the Big Five Claim. Gray schist contains pyrite (540, p. 63).

Rambler Mine (Holmes). Pyrite was the primary sulfide mineral; it has been largely replaced by covellite; (See PLATINUM).

Ulcahomo; (See GOLD).

Big Horn County

Two large dikes southeast of Willet Creek contain pyrite with galena (169, p. 113); (See LEAD).

Carbon County

Deserted Treasure Mine; (See GOLD).

Gold Coin Prospect; (See LEAD).

Independence Group; (See COPPER).

King Mine; (See GOLD).

Lena Shields Group; (See COPPER).

Meta Mine; (See LEAD).

North Fork Group; (See COPPER).

Spanish Trails Group; (See LEAD).

Star and Hope Gold Mines; (See COPPER).

Carbon, Fremont, and Sweetwater Counties

"Concretionary in the shales of the younger sedimentary groups" (192, p. 158).

Converse County

French Joe Prospect; (See COPPER).

Maverick Claim; on the line between secs. 33 and 34, in the central part of the sections, T. 29 N., R. 71 W. Irregular quartz veins 3 ft. to 10 ft. wide parallel schist which strikes N. 45° W. to N. 55° W. Several narrow pegmatite dikes are found in the vicinity. Rock on the dump is mostly quartz with bunches of pyrite (540, pp. 65-66).

Snowbird Group; (See COPPER and HEMATITE).

Crook County

Hutchin's Consolidated Gold Mining Co.; (See GOLD).

Fremont County

Bridger Mountains; (See FELDSPAR).

Empire State Mine; (See GOLD).

West End, Owl Creek Mountains; (See ASBESTOS).

Johnson County

Bull Camp Group; (See COPPER).

Powder River Pass; (See COPPER).

Laramie County

Eagle Mountain Group; (See COPPER).

Great Standard Group; (See GOLD).

Natrona County

Koch Deposit; (See GOLD).

Rattlesnake Hills; SE¼ SE¼ sec. 3, T. 32 N., R. 87 W. The lower unit of the Sundance formation contains "BB-sized" pyrite crystals in buff very fine-grained, friable, sandstone. The unit is about 6.7 ft. thick (131, pp. 32, 37, 38).

Park County

Kirwin District; (See COPPER).

Platte County

Lucky Gus Prospect; (See COPPER).

Sheridan County

NW¼ sec. 28, T. 56 N., R. 88 W. A shaft sunk at the intersection of a large east-west trending dike of porphyritic diabase ("Leopard Rock") and a north-northeast trending zone of shearing and silicification shows massive pyrite on the dump. The diabase is altered and contains stringers and masses of quartz, with occasional chrysocolla and a little disseminated pyrrhotite. Other similar prospects are found in the vicinity (478).

SIDERITE

REPORTED OCCURRENCES

Aughey (16, p. 56) reported siderite in "Laramie" beds associated with coal, "large quantities in Fort Benton group of the Cretaceous," and beds of rounded and kidney-shaped boulders on South Powder, and on Salt Creek.

Fremont County

Heyroth's Lode. "A few miles south of Atlantic City" a vein of siderite 2 ft. to 4 ft. wide cuts schists. The outcrop is altered to limonite, and the vein contains clay (192, p. 148).

KAOLIN

The "Board of Trade of Laramie City, 1883" mentioned kaolin near Laramie, but such deposits have not been recognized by later workers. Pure kaolin was reported (515, p. 216) near the soda lakes in Carbon County. Kaolin is reported in the Vermiculite Sales Corp. Deposit No. 1 in Fremont County; (See VERMICULITE).

KYANITE, SILLIMANITE, and ANDALUSITE

Kyanite, sillimanite, and andalusite all are Al_2SiO_5, but vary in crystal form and other physical properties. These minerals are usually found in metamorphic gneisses, or schists, commonly associated with corundum, tourmaline, or garnet. They are restricted to pre-Cambrian rocks in Wyoming.

When heated to moderately high temperatures, these three minerals decompose and form mullite, ($3Al_2O_32SiO_3$) and free silica. Mullite is used in alumina-Silica refractories such as spark plugs, electric furnace linings, electrical porcelain and chemical porcelain.

PROSPECTS

Albany County

Grizzly Creek Prospect; sec. 35, T. 24 N., R. 71 W. Kyanite and sillimanite rich schists occur in a zone 300 feet wide by 5,000 feet long. These schists, which crosscut at a gentle angle gneiss and hornblende schists, coincide with a fault zone several miles long. The deposit probably contains several thousand tons of kyanite (132; 152; 642).

Carbon County

Encampment Area; sec. 20, T. 14 N., R. 83 W., near the head of Cottonwood Creek about 5 mi. east of the Union Pacific Railroad at Encampment. There are four claims:

Carlton, Big Chief, Pinyon, and Pardelco. Rock types in the area include pre-Cambrian hornblende schist, amphibolites, garnet amphibolites and acidic granitic rocks.

Carlton Group. Kyanite rock contains from 13% to 68% kyanite by volume as white to very pale-blue coarse-textured flat-bladed crystals (282). The kyanite is associated with a brown mica and vermiculite. A high rate of recovery may be possible by screening, crushing and tubing (342).

Big Chief Nos. 1 and 2. Cornflower-blue kyanite crystals up to 6 in. long (av. 1 in.) are abundant in a muscovite-kyanite schist. The muscovite is of roofing grade, and the rock contains from 40% to 50% kyanite. Associated with the muscovite-kyanite schist is a light blue kyanite in a pegmatitic matrix and some light green tourmaline (?) (282).

Pinyon Claims. Disseminated emerald-green kyanite within an acidic rock matrix is present in prospect holes. High grade sericite is also present (282).

The above kyanite deposits indicate a possible reserve of 25,000 tons (282). Kyanite deposits also crop out in secs. 19 & 30, T. 14 N., R. 83 W.; kyanite float occurs in sec. 36, T. 14 N., R. 83 W. Kyanite-bearing pegmatites occur in secs. 1 & 11, T. 13 N., R. 83 W. (634).

REPORTED OCCURRENCES

Albany County

Roff Deposit; sec. 18, T. 24 N., R. 70 W.; (See VERMICULITE).

Carbon County

Union Asbestos and Rubber Co.; sec. 15, T. 15 N., R. 83 W. This deposit contains both sillimanite and kyanite; (See VERMICULITE).

Fremont County

Sec. 1, T. 29 N., R. 100 W. "Near the Rose mine and on the west side of Rock Creek, 1 mi. north of Atlantic City, there are sandy beds that carry knots of chiastolite about the size and shape of almond kernals. This rock is known locally as peanut rock" (540, p. 15).

Platte and Albany Counties

Kyanite has been reported in the metamorphic rocks west and southwest of Wheatland associated with andalusite (?), feldspar and mica (152; 217).

LEAD

There are no producing deposits of lead in Wyoming at the present time. Small quantities of lead minerals, mostly galena, are scattered through the mountain areas of the state, both in the pre-Cambrian rocks and in the Tertiary volcanics adjacent to Yellowstone National Park. The galena usually contains a little gold and silver.

The total recorded production of lead in Wyoming is about 32 short tons. Fifteen short tons were produced between 1932 and 1945; 5 short tons were produced in 1932 and the remainder scattered through the other years.

PROSPECTS

Albany County

Big Strike Mining Claim; near the Telephone and North American Claims, in the La Plata (Centennial) district. The deposit consists of a "strong vein of galena assaying \$10.00 to \$60.00 in silver and 47% in lead" (8, p. 12).

Copper King; T. 19 N., R. 78 W., on Rock Creek. A 7 ft. "ore" body in gneiss and granite contains gold, silver, and galena (8, pp. 12-13).

Esterbrook Mine; center of SE¼ sec. 9, T. 28 N., R. 71 W. Granite and schist are cut by a siliceous vein 2 ft. to 4 ft. wide, which contains cerussite and galena in bunches and streaks of varying size. The vein contains malachite and azurite at the bottom of a 188 ft. shaft, and it cuts a dark-colored dike rock at an acute angle (44).

Spencer (540, pp. 63-65) describes the prospect as a tabular body of quartz and calcite which contains cerussite at the outcrop and galena in depth. The strike of the rocks is N. 30° E., at the south end and N. 15° E. at the north. The hornblende schists are associated with white pegmatite dikes and altered diabase dikes. Shoots of solid galena 6 ft. wide were reported to Spencer. An assay of 17 tons of ore shipped before 1904 is: silver, 1.4 oz. per ton; gold, 0.035 oz. per ton; lead, 34.65%; SiO_2, 34.00%; FeO, 7.00%.

Strong Mine; southern Laramie Range; (See COPPER).

Rising Sun Claim; on Jelm Mountain, northeast of the Boston Claim, which was 3,000 ft. north of the Colorado shaft. A vein in gneiss and schist contains galena bearing gold and silver (92, p. 54).

Telephone and North American Claims; La Plata (Centennial) district; (See SILVER).

Big Horn County

"Considerable prospecting has been done in two large diabase dikes southeast of Willet Creek (in the Big Horn Mountains). The dikes contain galena and pyrite in small streaks in quartz stringers along the diabase contacts" (169, p. 113).

Carbon County

Albion Claim; near the middle of Cooper Hill, on the west side. An inclined tunnel 70 ft. deep exposed a body of white quartz and cerussite 5 ft. to 9 ft. wide. Selected samples assayed \$85.00 to \$110.00 in gold per ton (1896 prices) and 50.0 oz. in silver per ton, in addition to the lead (8, p. 36).

Alma Property; Sierra Madre area. Galena and chalcopyrite are found in a vein 18 in. wide; (see Copper).

Bridger Mine; Sierra Madre area; (See COPPER).

Broadway Claim; on Coon Creek, in sec. 7, T. 13 N., R. 83 W. An irregular zone containg sphalerite trends northeast along the contact of granite and a series of gneisses and amphibolites. The sphalerite probably replaced amphibolite in a zone which is about 1000 ft. long and 50 ft. wide, averaging 3% to 35% sphalerite.

Associated minerals are galena, chalcopyrite, chalcocite, and covelite, with malachite and chrysocolla near the surface. The dump from one shaft contains a gray and white gneissic rock with 1% to 5% finely disseminated chalcocite, chalcopyrite and bornite. Dip of the mineralized zone varies from 50° SE. to 50° NW. One channel sample taken by the U. S. Bureau of Mines assayed 12.5% zinc, 1.9% lead, 0.02% copper and 7.65% sulfur. Other samples contained lesser amounts of metals. A trace of some platinum group metal was identified by spectrograph, according to the U. S. Bureau of Mines (472).

Hog Park Area; southcentral sec. 36, T. 13 N., R. 85 W. Galena occurs in small cavities and as coatings on quartz crystals adjacent to the contact (?) of quartzite and pegmatite (657).

Cooper Hill; (See GOLD).

Ferris Mountains; near the line between Tps. 26 and 27 N., R. 86 W., 2 mi. west of the Sand Creek road, 11 mi. from Ferris Camp, and 48 mi. from Rawlins. A vein 2 ft. to 4 ft. wide dips about 80° W., and was opened by a shaft 40 ft. deep. The vein contains small quantities of silver-bearing galena and seems to become leaner with depth. Near the surface the vein contains a slight amount of secondary cerussite, malachite, and azurite. A composite picked sample contained 0.01 oz. of gold per ton, 18.20 oz. of silver per ton, and 31.70% lead per ton (222).

Gold Coin Prospect; SW¼ sec. 11, T. 15 N., R. 87 W., near the head of Savery Creek. A fine-grained green mica schist is cut by basic dikes and a 3 in. to 2 ft. vein of quartz. All the basic dikes strike east-west, and dip gently south. The quartz vein contains bunches and streaks of galena which vary in size from tiny specks to lumps of several pounds. Near the surface the vein contains secondary cerussite, limonite, azurite, and malachite. Pyrite and a little copper sulfide are associated with the galena. On the north side of the vein some "fine-grained white siliceous lime material" contains pyrite with small gold values. The wall-rock became softer and more broken in depth, and pockets of quartz and copper sulfides were found in gouge on both sides of the vein (52); (See COPPER).

Tennant Creek Area; sec. 21, T. 14 N., R. 84 W.; (See GOLD).

Sec. 5, T. 12 N., R. 83 W., about 16 mi. from Encampment. The material is reported to assay \$30.13 per ton (prices prior to 1927) and to be silver-bearing (225).

Meta Mine; near the head of a branch of South Spring Creek, 1 mi. north of the boundary of the Encampment Quadrangle, in sec. 24 or 25, T. 15 N., R. 86 W., 19 mi. southwest of Saratoga. Nearly vertical fractures cut dark-colored quartz-biotite schist and gneiss, and a finer-grained gray to greenish schist. The rocks strike northeast and dip 20° to 25° N.; the vein strikes nearly east-west and is vertical. Other fractures strike northeast and are vertical at the surface but dip 60° S. at 40 ft. depth; these fractures are not mineralized.

The mineralized fractures contain quartz, calcite, and metallic minerals in veins up to 7 in. wide. Metallic minerals include argentiferous (?) galena, anglesite, cerussite, some sphalerite, pyrite, chalcopyrite in addition to azurite, malachite, chrysocolla, hematite, limonite, calamine (?), and smithsonite (?). A little barite is found in the quartz gangue. According to Haff the workings were still in the oxidized zone (1944), hence the continuation in depth is problematical. The ore is drusy and brecciated; massive ore shows partially replaced schist fragments. Six or seven carloads of ore shipped during a 10 year period yielded 27% to 54% lead, about 8% zinc, and $20.00 to $30.00 in gold and silver per ton (prices prior to 1944); (539, pp. 98-99; 281).

North Fork Group; Sierra Madre area; (See COPPER).

Spanish Trails Group; secs. 5 and 6, T. 26 N., R. 86 W., near the head of South Fork Miner Creek, a tributary of Sand Creek. A metalliferous quartz vein cuts schists (mainly chlorite, biotite, and actimolite-quartz schists, and serpentine). The schists have been intruded by course-textured, strongly porphyritic granite. The veins strike N. 30° W., dip 85° W., and vary from 2 in. to 4 in. wide. The aggregate thickness of veins in the mineralized zone is 12 in. to 18 in. Only a few inches of galena are visible at the surface, but the thickness is reported to increase to 2 ft. in depth. The ore is galena associated with pyrite, chalcopyrite, limonite, and traces of azurite and malachite, in a gangue of quartz with lesser epidote and actinolite.

Prior to 1890, the claim produced some free-milling gold. Assays show $50.00 to $58.00 in lead and zinc per ton and $0.07 in gold. The "ore" was reported to be "high" in silver.

Haff stated that the claim was in a "structurally favorable environment" with "evidence of strong mineralization. . ." (284).

Three Forks Group; Sierra Madre area; (See COPPER).

Crook County

Black Butte Deposit; secs. 23, and 26, T. 50 N., R. 62 W., 10 mi. southeast of Sundance. Cerussite and a rare lead carbonate, with a small amount of galena, are found cementing brecciated Paleozoic limestone and as replacement bodies in limestone. The mineralization is localized at the contact of limestone and intrusive andesite porphyry and is erratic, pockety, and unpredictable. Approximately $300.00 worth of ore had been shipped prior to 1943. An assay is (319): Gold 0.002 oz. per ton; silver 2.0 oz. per ton; lead 13.9% by weight; copper, 0.02%; insol., 33.2%; Fe, 6.5%; Mn, 0.3%; S, 4.0%; Zn, 5.7%; As, 0.05%; Sb, 0.05%; and CaO, 9.5% by weight.

Black Buttes; T. 50 N., R. 62 W.; (See SILVER).

Fremont County

Battle Creek; located somewhere in the Bridger District. A vein of galena 15 ft. wide in "porphyritic trap," was followed by an 80 ft. shaft. Gouges of "yellow clay" were found on each wall, and one was in the middle of the vein. The vein material was reported to contain 12 oz. to 70 oz. of silver per ton (16, p. 8).

Laramie County

Colorado Lode, (formerly Metcalf); (See GOLD).

Eureka Lode; (See GOLD).

Lenox Mine; northwest of Simmons' ranch, on Middle Crow Creek. The orebody trends north-northwest and dips northeast. The vein is 6 in. wide at the surface and 30 in. wide at 40 ft. depth. It consists of cerussite and galena, which bears silver; a little gold was found at the bottom of the shaft. Assays showed 10% to 60% lead, 40 oz. to 60 oz. in silver per ton, and 1/3 oz. in gold per ton (16, pp. 3-4).

Park County

Kirwin District; (See COPPER).

Sunlight Basin; Evening Star Claim, Hardees Claim, Hoodoo Claim and Painter Mine. Wilson's Claim, located across the creek from the Malachite Vein, is reported to contain 4 ft. of "solid steel galena. . ." (218); (See COPPER).

REPORTED OCCURRENCES

Albany County

Jelm Mountain. Galena is reported near Jelm Mountain (217).

Centennial (La Plata) District. "The richest ores, carrying argentiferous galena carbonates of lead, chloride and oxide of silver, are found on the east side of the range (Medicine Bow), while the free-milling gold-bearing ores are found at Gold Hill, on the west side. . ." (8, p. 12).

Esterbrook. A fissure vein 3½ ft. to 5 ft. wide is reported to contain galena and chalcopyrite which carry gold and silver. The vein crops out for 1000 ft. Assays show $10.00 to $47.00 per ton (metal content not given); (217).

Carbon County

Galena is reported "At Ferris Mountain, Seminoe Mountain, etc." (16, p. 55).

Fremont County

"One of these (prospects), at the head of Popo Agie Creek, not far from Wilson's Mill, is reported to be rich in galena" (16, p. 7).

Laramie County

Galena is reported from the Silver Crown District (16, p. 55).

Clausthalite is reported ". . . sparingly in Silver Crown, and in the Carbonate Belle, Grant, Pacific and other lodes. . ." (16, p. 55).

LITHIUM

Nearly all lithium is produced from minerals found in pegmatites. Spodumene, $LiAlSi_2O_6$ (lithium feldspar) and lepidolite, $K_2Li_3Al_4Si_7O_{21}$ $(OH,F)_3$ (lithium mica) are the most important ores, but amblygonite, $Li(Al,F)PO_4$, and petalite, $LiAl$ $(Si_2O_5)_2$ are also used.

Chief uses of lithium are in medicines and in alloys of aluminum, magnesium, lead, and zinc to give greater hardness and strength. It is used as a stable agent for certain organic reactions (the synthesis of antihistamine drugs), for cosmetics, in porcelain enamels, ceramics, and greases.

Two shipments of lithium (spodumene ?) were reported from claims located 60 miles east of Riverton, Fremont County, in 1954.

PROSPECTS

Natrona County

Black Mountain Spodumene Prospect; SW¼ sec. 1, T. 32 N., R. 89 W., on the north spur of Black Mountain in the Rattlesnake Hills. This prospect is located just above the old King Solomon gold mine. Bluish-gray, greenish, or pale lavender spodumene crystals up to 8 in. thick and 18 in. long are localized in the wide parts of a 5 ft. pegmatite. It is estimated (354, p. 121) that spodumene (6% to 6.3% lithia) makes up 50% of the pegmatite near the hanging-wall and 10% near the foot-wall. The quantity of spodumene is small, though there are many beautiful crystals. Tourmaline is an accessory mineral. Most of the pegmatite is made up of bluish-gray potash feldspar, and albite partly altered to montmorillonite.

REPORTED OCCURRENCES

Converse County

Jasper Mine, Douglas District; (See COPPER).

Fremont County

Bridger Mountains Area, Whippet No. 1, No. 8; (See FELDSPAR).

W. L. Marion of Lander, at the Lander Mining Congress, exhibited a 107 lb. violet-colored crystal of lepidolite from his beryl claim (217).

Laramie County

Triphyllite was found in the Carbonate Belle and Pacific Lodes of the Silver Crown district (16, p. 56).

MAGNESIUM

Magnesium forms about 2.1% of the earth's crust. It is found in dolomite, $(Ca,Mg)(CO_3)_2$; magnesite, $MgCO_3$; brucite, $MgO.H_2O$; carnallite, $MgCl_2.KCl.6H_2O$; epsomite, $MgSO_4.7H_2O$; and in the silicates olivine, serpentine, pyroxene, and amphibole.

Brucite is richer in magnesium than any other magnesium-bearing mineral but is reported in Wyoming from only one locality. Magnesite is rare. Dolomite and epsomite are the potentially commercial magnesium ores in Wyoming; (See DOLOMITE, SALINE DEPOSITS).

Most magnesium is produced by calcining MgOH from sea water and from dolomite, brucite or magnesite. Uses include a wide variety of alloys, in photography, paint, electric and steel furnace linings, chemicals and medicines, and in the fertilizer and textile industries.

REPORTED OCCURRENCES

Laramie County

Aughey reported magnesite in the rocks of the Silver Crown District, probably as an alteration product of magnesium silicate rocks (16, p. 57).

Natrona County

Magnesite has been reported in the pre-Cambrian rocks of Casper Mountain (217).

Natrona or Fremont County

Brucite has been reported as an alteration mineral north of the west end of Rattlesnake Mountain (16, p. 57).

MANGANESE

More than 100 manganese minerals are known, but pyrolusite and psilomelane are the common ores. These oxides are of secondary origin; they are concentrated by weathering from other manganese minerals more sparsely distributed in veins. Most deposits are irregular bodies in residual clays. Psilomelane and pyrolusite are frequently found in alternating layers in the same deposit. Dentritic psilomelane often coats other minerals and rocks. Barite and calcite are commonly associated with manganese deposits.

The chief uses for manganese are in the steel industry, but large amounts are also used for dry batteries, fertilizers, chemical compounds, in decolorizing and coloring glass, porcelain enamel, pottery and tile, in insecticides, bricks, plastics, and welding rods.

A small amount of manganese has been produced in Wyoming but no deposits are operating at the present time. Recorded production of manganese ore is as follows: 1917, 30 long tons; 1918, 92 long tons; 1919, "some"; 1920, 40 long tons; 1943, 60 short tons; and "some" in 1946 (130).

PROSPECTS

Albany County

J. B. C. Mining Co. Deposit; 44 mi. northeast of Rock River. Psilomelane and pyrolusite are interlayered with quartz and chalcedonic rock. The low grade material contains much chert (529). This type of manganese deposit is not amenable to concentration, but the U. S. Bureau of Mines tests recovered 93.6% of the manganese from ore which assayed 28.7% Mn (516, p. 38). An analysis is as follows:

Mn=28.7%, insol.=47.2%, SiO_2=43.4%, CaO=1.7%, Fe=1.35%, P=0.024%, Al_2O_3=0.5%, Ba=0.85%, Zn=0.10%.

Poverty Mining Co. Claims; sec. 10, T. 26 N., R. 75 W., 4 mi. southeast of Marshall, near the head of Sheep Creek. Production from this mine totaled 112 tons through 1920. The ore is manganite and pyrolusite in two chert beds which range in thickness from 1 ft. to 8 ft.; average thickness is 6 ft. They are interbedded with limestones and sandstones of the Casper formation. Mamillary crusts and nodular aggregates of manganese minerals replace chert. No psilomelane is present. The source of the ore is probably the dark chert. The ore is very siliceous (388, pp. 57-59).

SW¼ sec. 32, T. 14 N., R. 77 W. A manganese oxide vein occurs in quartz-andesine gneiss (663).

Carbon County

Ak-sar-ben Group; sec. 15, T. 14 N., R. 80 W., 25 mi. east of Encampment, near Iron Creek. An 80 ft. shaft was sunk on an outcrop of siliceous hematite. In the alteration zone, a graphitic schist contains iron oxides and manganese (84).

Crook County

Caulkins-McGuckin Property; 10 mi. north of Sundance. The manganese minerals, pyrolusite and braunite, are associated with iron oxide in a vein cutting rhyolite porphyry. It is possible to produce a limited amount of +48% Mn ore, but separation of manganese from the iron is expensive. An analysis of the ore is as follows: Mn=31.6%, Fe=18.6%, Mn+Fe=50.2%, insol.=7.3%, SiO_2=5.2%, Al_2O_3=9.7%, P=0.175%, Zn=0.35%, CaO=1.2% (529). Tests by the U. S. Bureau of Mines recovered 85% of the Mn from ore assaying 31.6% Mn (516, p. 38).

Warren's Peak; 9 mi. northeast of Sundance. Manganese oxide minerals in an altered porphyry assayed 40% Mn. Two carloads were shipped (330). Jenny said of this general area, ". . . boulders of iron and manganese which would weigh several hundred pounds were scattered over the surface of the ground. The mineral was solid, compact, and exceedingly heavy, but the two oxides were distinct in the mass, though often closely intermixed. Manganese and limonite occurred filling the spaces between the large feldspar crystals and impregnating the rocks irregularly throughout until it resembled a breccia." (385, p. 287); (See GOLD).

Fremont County

J. H. Carpenter Prospect; T. 28 N., R. 102 W., 2 mi. west of Pacific Springs. Pyrolusite in an Eocene grit bed 12 ft. thick assays 19% to 35% manganese. The sediments dip gently to the south. Much quartz is present (347).

Johnson County

Powder River Prospect; SE¼ NW¼ sec. 20, T. 47 N., R. 85 W. The manganese is associated with gold in quartz veins and in hornblende schist (317); (See GOLD).

A manganese prospect located 50 mi. from Buffalo, on Beaver Creek shows assays from 23% to 73% Mn. There are fourteen claims in the area (232).

Taylor Prospect; sec. 19, T. 47 N., R. 85 W. Thin ($<$1 in.) streaks, stains, and fracture fillings of psilomelane and pyrolusite have entered along fractures and between chunks of the Bighorn dolomite. There are a few patches of rock with high-grade manganese ore. Assays show 15 oz. of silver per ton and 45% manganese (probably a hand-picked sample). Some chert is present (317).

In NW¼ sec. 32, T. 47 N., R. 83 W., is a deposit of pyrolusite-impregnated sandstones of the Flathead formation. The ore is in lenses 30 to 50 ft. thick and 150 ft. long. An assay of representative samples shows 8.9% MnO_2. In the overlying White River formation is nodular pyrolusite which occurs in clays just above the contact (601).

In the N½ sec. 30, T. 47 N., R. 83 W., is a related deposit of nodular pyrolusite in the White River formation. There are also some stringers and lenses in the pre-Cambrian and Flathead, respectively. An analysis of the nodular pyrolusite showed an average of 33.8% MnO_2 (601).

In sec. 29 (?), T. 47 N., R. 83 W., a reserve of 300,000 to 1,000,000 tons, with assays as high as 60% MnO_2, has been reported. The deposits, secondary in nature, is found in the Flathead and Wind River formations (601).

Natrona County

A pit in the NE¼ sec. 30, T. 32 N., R. 79 W., 11 mi. from Casper, in the Casper limestone revealed pyrolusite in patches and pockets. The Casper formation dips 20° to 25° SE. More work is necessary to determine the extent of the deposit (301).

Washakie County

Gheen Nos. 1 and 2 Claims; in the northeast corner of Washakie County. Pyrolusite, psilomelane, and braunite are intimately associated with quartz in a silicified limestone. Very fine grinding would be necessary to recover any manganese (529). Tests by the U. S. Bureau of Mines recovered 37.7% of the manganese from ore assaying 13.8% Mn. Analysis: Mn=13.8%, Fe=1.9%, SiO_2=68.9%, insol.=7.18%, P=0.022%, Al_2O_3=2.0%, CaO=1.0% (516).

Weston County

In lot 4, sec. 10, T. 45 N., R. 60 W., a 4-ft. thick zone of mineralization strikes N. 85° W. and dips 11° N. Manganese occurs as powdery cavity fillings, as pods and lenses of silicified manganese (pyrolusite), or as coatings on calcite. The deposit is of a pinch and swell nature. Hand-picked specimens assayed 50% manganese (607).

REPORTED OCCURRENCES

Carbon County

Aughey noted manganese dendrites in the mines of Seminoe Mountain and Ferris Mountain (16, p. 56).

Crook County

Hutchins Consolidated Gold Mining Co.; (See GOLD).

Fremont County

Braunite or manganite has been reported in the Marion-Maxwell dike near Bonneville (265).

Pyrolusite has been reported in a matrix of arkosic conglomerate in about sec. 35, T. 28 N., R. 102 W. Assays show 19% to 35% Mn (254).

Laramie County

Aughey reported pyrolusite to be ". . . common in the Silver Crown district." (16, p. 56).

Psilomelane is reported in the Carbonate Belle, Thunder Cloud and Pacific mines of the Silver Crown district (16, p. 56).

Natrona County

Mr. Clarence Metz reported a black wad (manganite) deposit 2½ mi. long, 25 ft. wide and 45 ft. deep at Arminto (265).

MERCURY

The mineral cinnabar, HgS, the main mercury ore, is usually associated with Tertiary or Recent volcanism, but may be localized in many types of rock.

Uses of mercury are in various types of electrical apparatus, agriculture, catalysts, pharmaceuticals, munitions, paint, thermometers, mercury-vapor lamps, dental materials as well as in many other industries. The element is rare in Wyoming.

PROSPECT

Fremont County

Secs. 12, 14, 24, T. 39 N., R. 93 W., northeast of Bonneville. A pit dug in gravels of the Wind River formation is reported to have shown a small amount of mercury. The gravel consists of diorite, granite, schist, gneiss, and quartzite fragments. About 1 mi. north of the prospect are alum and sulfur which probably represent former hot spring activity. The mercury at the pit may be related to hot spring activity and to meteoric leaching. An average of fourteen picked samples contained 1 lb., 8.48 oz. of mercury (306; 447).

Teton County; (See GOLD).

REPORTED OCCURRENCES

Laramie County

Aughey (16, p. 54) "detected mercury in minute quantities in some of the black ores from the western part of the Silver Crown district."

Native mercury was reported in 1886 in the sands of the Big Horn River (16, p. 54).

MICAS

Muscovite, the potash-rich mica, is found in all types of rocks, but large crystals (books) are restricted to pegmatites. Biotite is also a constituent of many kinds of rocks, but is less widely used in industry because of its high iron content. Phlogopite is similar to biotite but contains a little magnesium and iron; it is usually found in areas of metamorphosed rocks. Phlogopite is fairly rare in Wyoming; (See SERICITE). The deposits in Wyoming are of the sheet, punch, and scrap mica quality.

Mica is used for molded electric insulation, house insulation, Christmas tree snow, in the manufacture of wallpaper, lubricants, textiles, in oil-well drilling, and as a fire-proofing material.

In 1923, 100 short tons of scrap mica were shipped from Wyoming. Between 1938 and 1945, small amounts of scrap and sheet mica were produced. No more recent records are available (130).

PROSPECTS (See BERYL)

Albany County

SE¼ sec. 8, T. 12 N., R. 79 W. Muscovite books, 0.4 inches thick and 2 inches in diameter occur in a pink pegmatite dike (670).

Big Chief Mica Mine; just north of the line between secs. 9 and 16, T. 25 N., R. 71 W. Most of the pegmatite is quartz and potash feldspar with minor plagioclase and muscovite. A pit at the north end of the body produced a small amount of punch mica. The hanging-wall of actinolite schist strikes generally north-northeast and the contact dips 70° SE. The foot-wall is hornblende schist. Mg-amphibole schist, and quartz-actinolite schist. Small ($<$1 in.) pale blue crystals of beryl occur near pegmatite in fractures in the hanging-wall of actinolite schist (468).

Ione Prospect; (See FELDSPAR).

Many Values Prospect; SE¼ sec. 32, T. 13 N., R. 78 W. The pegmatite cuts pre-Cambrian tourmalinized mica schist and gneiss. There are two open pits and two timbered shafts. The pegmatite strikes N. 50° E. and dips 85° NW., with exposures for 140 ft. Seventy-five feet north of the main pegmatite body is a quartz-potash feldspar-mica-plagioclase pegmatite which strikes north and is vertical; it is apparently not connected with the larger body. Cover prevents an accurate estimate of the extent of the pegmatite beyond the workings. Muscovite is abundant near the hanging wall in the larger pegmatite. The books are light-green speckled with magnetite, and ruled. Only a small quantity is of sheet quality; about 10% is punch quality. Up to 1943, 38,000 lbs. of scrap mica, 2,500 lbs. of punch and 500 lbs. of rifted mica were produced. Two tons of beryl (12.39% BeO) were shipped up to 1942. The beryl crystals are corroded. Small tantalite crystals (45% Ta_2O_5) are rare in this district; about 85 lbs. were recovered up to 1943. Minor accessory minerals include fergusonite (?) and pink euhedral garnets and orange subhedral garnets about 13mm. in diameter (354, p. 108).

Muscovite Claim; W½ SE¼ sec. 32, T. 13 N., R. 78 W. A granite pegmatite dike strikes N. 50° E. and cuts pre-Cambrian metadiabases, hornblende schist, and gneisses for a distance of 600 ft. Maximum width of the dike is 70 ft.; the average is 40 ft. (30). In places, quartz and white feldspar show a graphic structure. Fine-grained aggregates of quartz and feldspar enclose some pink microcline crystals several inches in diameter. Some muscovite books are up to a foot wide but contain numerous dark iron spots. Tantalite-columbite crystals are associated with green beryl along fractures in the wall rock. Black tourmaline crystals up to several inches long are found in metadiabase and schist wallrock and as fine-grained veinlets in the pegmatite. Andradite (?) garnet is a minor accessory mineral (30; 320).

Carbon County

Sec. 1, T .13 N., R. 84 W., (See FELDSPAR).

Big Chief Nos. 1, 2; sec. 20, T. 14 N., R. 83 W.; (See KYANITE).

Baggot Hills Area; 7 mi. north of Encampment along the Union Pacific Railroad. A tunnel 200 ft. long disclosed phlogopite mica. Nearby a ledge 50 ft. wide contains phlogopite (266).

Sec. 14, T. 14 N., R. 84 W.; 2 mi. from Encampment. Biotite and some phlogopite are associated with garnet and zinc in a vein 6 ft. to 20 ft. wide. Assays show 6.5% Zn (228).

Fremont County

Bridger Mountains Area, Whippet Prospects; (See FELDSPAR).

Atlantic City-South Pass Area; (See MICA).

Goshen County

Haystack Range District. The area is located 10 mi. northeast of Guernsey and covers about 2 sq. mi. The pegmatites are concordant lenses in the pre-Cambrian Whalen schists and gneisses and have a general trend of N. 60° E. with steep dips to the northwest. There is a pronounced narrowing of the pegmatites with depth. The bodies are mainly potash feldspar, quartz, muscovite, black tourmaline, and beryl (354, pp. 112-113). Mining first started in 1881 and ceased in the early 1900's.

Chicago Prospect; 2900 ft. east of the Crystal Palace Prospect. This pegmatite is about 215 ft. long and up to 23 ft wide with a bulbous western end. It trends N. 72° E. and dips 50° to 80° NW. The border zone is less than 2 in. wide; the wall zone contains quartz, muscovite, plagioclase, and black tourmaline, and the core is quartz and microcline. The muscovite books range up to 9 in. by 18 in. in size, are clear, and not highly ruled or crumpled. Muscovite may make up from 5% to 10% of the wall rock zone. A small amount of beryl has been found and black tourmaline is found in the wall zone. Twenty to thirty feet northwest of the Chicago Prospect, another pegmatite contains quartz, microcline, and plagioclase (354, p. 116).

Crystal Palace Prospects on line between secs. 34, 35, T. 28 N., R. 65 W. There are three pegmatites which conform to the foliation of the Whalen schists. They strike N. 52° E., dip 45° to 60° NW., and plunge 50° to 75° N. 12° W. One poorly zoned pegmatite crops out in an area 70 ft. by 10 ft. and probably pinches out. A zoned pegmatite contains 15% muscovite along the hanging-wall and 10% or less along the foot-wall. Some books are up to 8 in. in size, clear, slightly ruled, but highly crumpled. Black tourmaline is an accessory mineral in the wall rock. Another pegmatite, 100 ft. northeast of the Crystal Palace prospect is 180 ft. by 14.0 ft. in outcrop size. It strikes N. 55° E., dips 60° to 70° NW., and plunges 40° to 60° N. 23° W. This pegmatite shows much better zoning. The wall zone contains muscovite books up to 5 in., some of which are wedged and have "A" structure (354, p. 114).

Minnie Claims southwest of the center sec. 25, T. 28 N., R. 65 W. The largest sheets of mica are about 8 in. in diameter (21, pp. 324-5).

New York Prospect; 2850 ft. east-northeast of the Crystal Palace prospect. This pegmatite is "tad-pole" shaped; it is 85 ft. long and 35 ft. wide at its broadest point. It is clearly zoned with a border 6 in. thick, a mica-bearing wall zone 2 ft. to 3 ft. thick, and a core of quartz-microcline pegmatite with large microclene crystals. This pegmatite lens strikes N. 72° W. and dips 50° to

85° NE. Muscovite books up to 10 in. by 18 in. are highly ruled, tied, and crumpled. Tourmaline is found in the mica-bearing wall zone, and a trace of beryl was identified (354, pp. 115-116).

Ruth Prospect; 3300 ft. by air line southeast of Crystal Palace prospect. The Ruth pegmatite is oval shaped; the axis of the oval trends N. 85° E. It is about 155 ft. long and 80 ft. wide. The foot-wall dips 50° to 80° N., and the hanging-wall dips 75° N. to vertical. The pegmatite has a narrow border zone, an irregular wall zone of graphic granite, and a thin, discontinuous intermediate zone of quartz-muscovite pegmatite with beryl. Highly curved, ruled, and warped muscovite books up to 8 in. by 2 ft. occur in the intermediate zone. Accessory minerals include black tourmaline, green apatite, a small amount of beryl and some columbite (?) (354, p. 116).

Savage Prospects near the center of S½ sec. 26, T. 28 N., R. 65 W., 4000 ft. northeast of the Crystal Palace prospect. This long, narrow unzoned lens is about 220 ft. by 20 ft., and narrows to 5 ft. near the ends. It trends N. 80° E. and dips 75° NW. Two faults are present; one on the southwest shows a 12.5 ft. horizontal displacement. The movement is thought to be rotational. The second fault is parallel to the pegmatite and dips 75° NW. The northwestern side is downthrown. The muscovite is small, clear, highly ruled and crumpled. The pegmatite contains potash feldspar and accessory beryl, black tourmaline and plagioclase (354, p. 119).

Torrington No. 1. (formerly the Denver Prospect); 1450 ft. northeast of the Crystal Palace prospect. This pegmatite is 400 ft. long, 30 ft. wide, trends N. 65° E., and dips 60° NW. It is concordant with the Whalen schist. The pegmatite becomes coarser-grained near the center with muscovite concentrations and euhedral beryl crystals (10.5% to 11.0% BeO). Black tourmaline is scattered throughout (354, p. 115).

White Star Prospect; 1150 ft. southeast of the Crystal Palace prospect. The pegmatite trends N. 45° E., and dips 75° NW. and is up to 1000 ft. long and 60 ft. wide. Several schist septa are enclosed in the pegmatite. The small amount of muscovite will yield scrap mica only. The minerals are chiefly mottled microcline, quartz and muscovite. Black tourmaline is an accessory mineral (354, 119).

Platte County

Near Guernsey, the Western Mineral Products Co. opened a mine in 1929 or 1930 in a pegmatite dike containing good grade mica and feldspar (217).

Mica Hill Mining Co.; 20 mi. west of Wheatland. Mica at the north end of a pegmatite dike, and along the eastern contact of the dike with mica schist, is warped and jointed and averages 15% to 20% usable material (217).

REPORTED OCCURRENCES

Carbon County

Sec. 9, T. 15 N., R. 83 W., near Baggott's Rock at the head of Rainbow Canyon. The mica in this prospect gave the following analyses (228):

SiO_2	36.00%	41.00%	47.22%	60.50%
Fe_2O_3	8.72	5.90	10.23	3.92
Al_2O_3	23.88	16.26	10.46	12.25
CaO	0.80	6.77	8.48	9.34
MgO	24.20	25.89	13.59	9.05
Alk	6.15	4.18	9.35	4.94
Loss	0.25	....	0.67	....

Natrona County

Damourite, a hydro-mica, was reported from the west end of the Rattlesnake Range (16, p. 56).

Hayden reported phlogopite as a constituent mineral in the Wind River Range granites (192, p. 158).

MOLYBDENUM

The only molybdenum-bearing mineral of economic value is molybdenite, MoS_2. Molybdenite is a fairly common accessory mineral in granites, gneisses, schists, quartz veins, marble, and in pegmatite and aplite dikes. It is also found in pneumatolytic contact deposits with cassiterite, scheelite, wolframite, and fluorite. There has been no recorded production of molybdenum in Wyoming.

Uses for molybdenum are mainly in ferro-molybdenum alloys where hardness and toughness are desired. It is also used as filament supports for electric lights and grid elements in radio tubes, as a catalyst, in the ink and dye industries, and in the production of glass enamel.

PROSPECTS (See COPPER)

Park County

Kirwin; (See COPPER).

Stinking Water Area; (See COPPER).

Sublette County

Temple Peak Deposit. About 1/4 mi. southwest of Rapid Lake in SC sec. 24, T. 32 N., R. 104 W., a 3.5 ft. zone on biotite schist, containing quartz pods and molybdenite, strikes N. 17° E. and dips 73° SE. An assay of a chip sampled showed 2.03% Mo (604).

In W1/2 sec. 30, T. 32 N., R. 104 W., is a 5 ft. wide molybdenum-bearing granite dike, which strikes N. 30° E. and dips 80° SE. The dike is exposed for several hundred feet. Molybdenite is diseminated as small clots and veinlets within the granite (604).

Teton County

Gros Ventre Mountains; approx. NW1/4 sec. 34, T. 40 N., R. 113 W. Molybdenite occurs in pods and coating fractures in a light gray medium crystalline granite of pre-Cambrian age near Swift Creek (653).

REPORTED OCCURRENCES

Albany County

Strong Mine; (See COPPER).

Converse County

Mormon Canyon Scheelite Claim; (See SCHEELITE).

Laramie County

Aughey (16, p. 55) reported wulfenite crystals from the Lenox Mine, Silver Crown district; (See GOLD).

Monte Cristo Mine; (Hecla District). A 90 ft. to 100 ft. shaft was sunk in hornblende granite. The granite contains small occasional stringers of molybdenite (289).

Lincoln County

Salt River Deposits; (See VANADIUM).

Platte County

Bartlett (26, p. 3) reports molybdenite in a pre-Cambrian metamorphic sandstone of the Cooney Hills.

Sublette County

Molybdenite has been reported in quartz veins cutting granite in the Temple Pass area in the Wind River Range (254).

Molybdenite bearing float has been reported within 2.5 mi. of the Temple Peak deposit and also along the drainage of the Popo Agie River (604).

NATURAL SLAG OR CLINKER

Throughout much of northeastern Wyoming, the hills, mesas, ridges, and buttes are capped by baked clays, shales, and other rocks that have been metamorphosed by the burning of underlying Tertiary coal beds. Locally, intense metamorphism has produced cordierite and magnetite from the originally argillaceous rock (27, pp. 408-412). The beds probably were ignited by spontaneous combustion and the burned out areas are now masses of dark gray to black "clinkers" or "scoria." Locally the heated rock has flowed into small pipes. Above the burned coal beds the rocks are many shades of red, yellow, brown, and even purple, giving the countryside a peculiar but distinctive appearance. A recent U.S. Geological Survey map (152) shows the general distribution of the clinker or slag beds. The descriptions below are of necessity, very generalized.

The slag, or clinker is used for railroad ballast, road metal, and as a local building material.

PRODUCING DEPOSITS

Sheridan County

The Tongue River Stone Co. produced 3,812 tons of "scoria" in 1962, and 3,003 tons in 1963 (611). The "scoria" was used as railroad ballast (613). A quarry has been opened adjacent to the Chicago, Burlington and Quincy Railroad, about ½ mi. south of Acme (489).

PROSPECTS

Campbell County

Sec. 27, T. 50 N., R. 71 W.; southwest of Minturn. The Chicago, Burlington and Quincy Railroad quarried crushed rock for railroad ballast. The pit was first opened in 1890 for track ballast but the deposit is exhausted now. The slag is 40 ft. to 50 ft. thick and occurs in the Tongue River coal group of the Fort Union formation (184, p. 12; 546, p. 118).

Tps. 53, 54, 55, 56, 57, 58 N., Rs. 71, 72, 73 W.; in the area west of Little Powder River. The Roland coal member of the Fort Union formation has been extensively burned and clinker deposits are scattered over much of the area (173, p. 425).

Tps. 49, 50 N., Rs. 70, 71 W. This area is covered by several billion cubic yards of clinker beds produced by burning of the Roland coal member (184, p. 12).

Converse County

T. 38 N., Rs. 67, 68 W. Clinker and slag caps the buttes and ridges in these townships (580, p. 475).

Johnson and Sheridan Counties

Tps. 50, 51, 52, 53 N., Rs. 80, 81, 82 W. The Ulm group of coal beds lies nearly horizontal over most of these townships. Outcrops of the coal beds have been extensively burned. Red capped summits of buttes, mesas, and ridges and slag-covered slopes form prominent parts of the landscape in this vicinity (546, p. 139).

Sheridan County

Tps. 54, 55, 56, 57 N., Rs. 79 to 85 W. Thick clinker beds cap the buttes, mesas, and hills over much of this area (548, p. 125).

Sweetwater and Carbon Counties

T. 20 N., R. 94 W.; between Wamsutter and Hadsell. Large quantities of clinker beds have formed from coal beds which burned near their outcrops (434).

NEPHELINE-SYENITE

Nepheline-syenite is a rare igneous rock composed of nepheline, potash feldspar or albite, and iron-bearing minerals. Quartz is absent. Accessory minerals usually include sphene, zircon, iron ores, apatite or corundum. Pegmatites in contact with nepheline-syenites usually contain many rare and unusual minerals.

The alumina content of nepheline-syenites is between 20% and 30% as compared to 17% and 20% for most dominantly feldspathic rocks; thus the rock is valuable to the glass and ceramic industries (458, p. 479).

In Wyoming, one stock-like mass has been located and 10 claims were staked out by 1944. No production is known.

PROSPECTS

Crook County

Bull Hill; sec. 20, T. 51 N., R. 60 W. The Lookout Nos. 1, 2, 5, 8, the Nick, and the Nick Nos. 1 and 2 claims are located along Bull Hill. A few of these claims are in secs. 19 and 29, T. 51 N., R. 60 W. Nepheline-syenite forms a nearly continuous outcrop for ¾ mi. on the higher slopes and ridge of Bull Hill. The rock is a light-gray color when fresh and has a gray, chalky appearance when weathered. Minerals include nepheline, orthoclase (?), albite, hornblende, and accessory sphene; the rock appears to have a uniform composition. Three joint systems have been developed—two at steep angles and one fairly flat. There is little overburden and the rocks are not badly weathered. In 1944 the area was relatively inaccessible (276).

NEPHRITE (Jade)

Nephrite, a calcium-magnesium silicate, belongs to the amphibole group of minerals. Jadeite is an aluminum-sodium silicate and belongs to the pyrozene group of minerals. Both minerals are termed jade. Color of jade varies from white to black; various shades of green are most prized as jewelry. Nephrite is a tough fibrous aggregate while jadeite is usually granular.

These minerals have been used since pre-historic times in the manufacture of weapons, utensils, ornaments, bells, and jewelry.

Wyoming jade is the nephrite variety and varies in color from black to light-green; the darker shades of green and olive-green predominate. The mineral was first found in 1936 as float over a wide area southeast of Lander in Fremont County. Later nephrite was found in place in the pre-Cambrian metamorphic areas in the southeastern corner of Fremont County. One boulder weighed 119 lbs., but the average float sample weighs about 10 lbs. to 12 lbs. (139, p. 79). No record has been kept of the amount of nephrite which has been cut, polished and used in jewelry.

PROSPECTS

Carbon County

Seminoe Mountain Area; black and green jade float is common in the pediment gravels north of the Seminoe Mountains (619).

Sec. 12, T. 26 N., R. 83 W. Black jade occurs in an epidote-monzonite inclusion in pre-Cambrian granite. The inclusion, which is about 60 feet long and 20 feet wide, strikes north-eastward. X-ray analysis indicates that the jade is actinolite (619).

Secs. 23, 26, & 28, T. 26 N., R. 85 W. Jade occurs in these three areas, but geological and mineralogical data are lacking (619).

Fremont County

Abernathy Claims; 40 mi. southeast of Lander. The nephrite mass in a diorite dike (?) within granite is 36 ft. long and 3 ft. to 5 ft. thick; it strikes N. 40° W. and dips steeply northeast. Aplite lies on both sides of the jade-diorite mass. The nephrite lens fills the west limb of a fold which plunges N. 60° E. The nephrite contains some quartz crystals up to several inches long and ¾ in. across. Other associated pre-Cambrian metamorphic rocks are chlorite schist, hornblende schist, actimolite schist and serpentine. The nephrite is an alteration product of serpentine (339). Branham reports that some black jade is found at this deposit (140, pp. 9-10); (See CORUNDUM).

Curtis and Marion Claims; secs. 13, 18, T. 30 N., Rs. 92, 93 W. Black nephrite crops out erratically at this deposit for about 700 ft. in a narrow lens 1 in. to 15 in. wide which trends northwest. The nephrite may have originally been a basic dike. It is now in contact with a green rock, which is in contact with hornblende schist. An olive-green jade outcrop is ½ mi. southwest of the black jade deposit. Here the olive-green jade is found at the contact of hornblende schist and a white to light-gray fine-grained aplite. A green rock associated with the jade may be a transitional alteration product between hornblende schist and jade. Surrounding rocks include narrow outcrops of anthophyllite, tremolite, actinolite, and serpentine, probably altered from the hornblende schist (139; 340; 12).

Lucky Strike Claim; secs. 19, 20, T. 30 N., R. 92 W., 61 mi. from Lander. Olive-green nephrite (pieces average 7 in. by 17 in.) in a gray and green aplite-serpentine rock lies at the apex of a minor fold. The jade contains much quartz, similar to the other deposits (except the black jade deposit). Other rocks in the area include granite, granite gneiss and hornblende schist, in part chloritized (343).

Rhoads Deposit; 66 mi. from Lander. Nephrite jade is in contact with granite or granite pegmatite which trends northeast. It parallels black hornblende diorite found up the slope from the jade. The other pre-Cambrian rocks in the area are anthophyllite, serpentine, tremolite, actinolite and talc (341).

Teton County

Gros Ventre Mountains; approx. NW¼ sec. 34, T. 40 N., R. 113 W. Black and dark green jade occur adjacent to the contact of light-colored granite with a biotite-rich ultramafic rock of pre-Cambrian age near Swift Creek (653).

REPORTED OCCURRENCES

Carbon County

Nephrite has been found on the Rawlins golf course. It is probably float from a pre-Cambrian area (343).

Fremont County

Light green jade float has been reported near Morton Lake, 40 mi. from Lander, and also at Moneta (343).

The Copper Chief Gold Mine, 3 mi. northeast of Atlantic City contains some jade (250).

An outcrop of olive-green jade has been reported on East Fork, northeast of Dubois and northeast of the Circle Ranch (343).

Black jade float is scattered over a large area south of the upper drainage of Sulfur Creek, 30 mi. west of Baroil (217).

Jade float has been found along Beaver Creek, 25 mi. southeast of Lander along U. S. Highway No. 287 (217).

Small amounts of jade have been found in the Green Mountains, 20 mi. west of Baroil (217).

Natrona County

A. Bartlett reports jade at Pathfinder Dam (343).

H. K. Diehl found jade on Dry Creek in the Rattlesnake Mountains (343).

Sweetwater County

R. I. Martin reports finding jade along the Colorado-Wyoming line. The black jade has a specific gravity of 3.119; the olive-green jade a specific gravity of 3.00 (343).

NICKEL

Nickel is rare in Wyoming. Traces have been found in some pre-Cambrian gold and copper ores and in pyrrhotite.

Nickel is used in both ferrous and non-ferrous alloys, high temperature and electrical resistance alloys, catalysts, ceramics, and in the chemical industry.

REPORTED OCCURRENCES

Albany County

Esterbrook Area; Three Cripples Mine; (See GOLD).

Ulcahomo; (See GOLD).

Carbon County

Sierre Madre Area

Creede Property; (See COPPER, COBALT).

Leighton-Gentry Prospect; (See COPPER).

Fremont County

Nickel has been reported in the South Pass district (257).

Laramie County

Nickel has been found in the pre-Cambrian rocks near Ozone (251).

Platte County

The Plaga-Judd Prospect in the Cooney Hills is reported to have a small amount of nickel. The area is about 1/4 mi. southeast of the sericite deposit (338); (See SERICITE).

Sheridan County

Cooper Claim; NW1/4 sec. 32, T. 56 N., R. 88 W. This claim is reported to contain nickel. The shaft is at the contact of "cortlandite" and granite (477; 279).

NITRATES

Natural nitrate deposits are salts of potassium or sodium. Nitrate minerals are rare in the United States. The largest amounts of nitrates are used in fertilizers, in the chemical industry and in munitions.

REPORTED OCCURRENCES

Sweetwater County (Leucite Hills)

North Table Butte. Nitrate is found in a "cavity or recess with over-hanging rocks, several feet in length and depth." Some specimens are several inches in diameter. Analysis shows the material is nearly pure K_2NO_3 (159; 444, p. 99).

Boar's Tusk. A scanty white sodium nitrate coating covers protected surfaces of the breccia at the Boar's Tusk. The material also contains a trace of K_2NO_3 (444, p. 99).

Washakie County

"R. G. Newborne, of Louisville, Kentucky, reported to the (U. S.) Geological Survey in 1917 that he had obtained sodium and potassium nitrate from the sandstone ledges on the flank of the Bighorn Mountains above Tensleep, but that he thought the nitrate occurred in 'pockets' and not of sufficient quantity in any place to be of commercial value" (444, p. 99).

OIL SHALE

Oil shale, a potential source of petroleum products, is of widespread occurrence throughout the world. The most extensive deposits, from a future economic aspect, are in the United States and in Brazil. The largest and most important oil shales in the United States are in the Green River formation, of Eocene age, which underlies approximately 16,000 square miles in Colorado, Utah and Wyoming.

Oil shale can be defined as a fine-grained sedimentary rock containing organic matter derived chiefly from aquatic organisms, waxy spores and pollen grains. These beds are some shade of brown, usually weather a bluish-gray on the outcrop, and are commonly laminated. Actually, most of the rich beds of oil shale in the Green River formation are organic-rich dolomitic marlstones. These beds were deposited in lakes in the Colorado-Utah-Wyoming area.

The Green River formation, which occurs in the Green River, Great Divide, Washakie, and Fossil Basins of southwestern Wyoming, consists of the following members or tongues, in ascending order, Luman shale, Tipton shale, Wilkins Peak member, and the Laney shale. All of these contain oil shale; however, most observers believe that the richest and largest reserves occur within the Tipton and Laney shales. Data from the U.S. Geological Survey and Bureau of Mines indicate that potential reserves of oil in the shale beds that are more than 15 feet thick are approximately 400 billion barrels of oil from shale yielding 10-25 gallons of oil per ton, and about 30 billion barrels of oil from shale yielding 25-65 gallons of oil per ton. The reserves are based on oil shale beds ranging from 0-3,000 feet in depth, depending upon the location in the Green River Basin.

Other oil shales are reported in the Phosphoria formation of western Wyoming, in the Wasatch formation of southwestern Wyoming, and in beds of Eocene age in the southeastern and southwestern parts of the Bighorn Basin.

Most of the field and laboratory research on oil shale in Wyoming has been carried on by the U.S. Geological Survey and Bureau of Mines. The Bureau of Mines Petroleum Research Center at Laramie, conducts studies on the characteristics and extent of the oil shale deposits, composition of shale oil, methods for producing oil and gas from shale oil, in-situ retorting, and refining of shale oil.

Further data on the oil shale deposits may be found in the following publications.

ANONYMOUS, The synthetic liquid fuel potential of Wyoming and Idaho: Report for the U.S. Bureau of Mines, Corps of Engineers, Department of the Army, Sept. 10, 1951.

BRADLEY, W. H., Geology of Green River formation and associated rocks in southwestern Wyoming and adjacent parts of Colorado and Utah: U.S. Geol. Survey Prof. Paper 496-A, 1964.

CULBERTSON, W. C., Stratigraphy of the Wilkins Peak Member of the Green River formation, Firehole Basin Quadrangle, Wyoming: U.S. Geol. Survey Prof. Paper 424-D, 1961.

.................., Lany Shale Member and Tower Sandstone Lentil of the Green River Formation, Green River area, Wyoming: U.S. Geol. Survey Prof. Paper 450-C, 1962.

.............., Oil shale resources and stratigraphy of the Green River Formation in Wyoming: The Mountain Geologist, vol. 1, no. 3, 1964.

.............., Tongues of the Green River and Wasatch Formations in the southeastern part of the Green River Basin, Wyoming: U.S. Geol. Survey Prof. Paper 525-D, 1965.

DEARDORF, D. L., Stratigraphy and oil shales of the Green River formation, southwest of the Rock Springs Uplift, Wyoming: unpub. M.A. thesis, Univ. Wyoming Library, 1959.

DONNELL, J.R., Geology and oil shale resources of the Green River formation: in First Symposium on Oil Shale: Colo. School Mines Quart., vol. 59, no. 3, July, 1964.

DUNCAN, D. C., Oil shale deposits of the United States: Independent Petrol. Assoc. Am. Monthly, vol. 29, no. 4, 1958.

DUNCAN, D. C., and SWANSON, V. E., Organic-rich shale of the United States and world land areas: U.S. Geol. Survey Circular 523, 1965.

LOVE, J. D., Uraniferous phosphatic lake beds of Eocene age in intermontane basins of Wyoming and Utah: U.S. Geol. Survey Prof. Paper 474-E, 1964.

MILLICE, E. R., Stratigraphy of the Green River formation in the southeastern Bridger Basin, Wyoming: unpub. M.S. thesis, Univ. Wyoming Library, 1959.

ROEHLER, H. W., Early Tertiary Depositional Environments in the Rock Springs Uplift Area: Wyo. Geol. Assoc. Guidebook, 19th Field Conf., 1965.

SCHRAMM, E. F., Notes on the oil shales of southwestern Wyoming: Am. Assoc. Petrol. Geol. Bull., vol. 4, no. 2, 1920.

SCHULTZ, A. R., Oil possibilities in and around Baxter Basin, and in the Rock Springs uplift, Sweetwater County, Wyoming: U.S. Geol. Survey Bull. 702, 1920.

STUART, W. J., Jr., Stratigraphy of the Green River formation west of the Rock Springs Uplift, Sweetwater County, Wyoming: unpub. M.S. thesis, Univ. Wyoming Library, 1963.

THORNE, H. M., STANFIELD, K. E., DINEEN, G. U., and MURPHY, W.I.R., Oil-shale Technology, a review: U.S. Bur. Mines I. C. 8216, 1964.

WINCHESTER, D. E., Oil shale of the Rocky Mountain region: U.S. Geol. Survey Bull. 727, 1923.

PETROLEUM AND NATURAL GAS

BY HORACE D. THOMAS

Petroleum and natural gas constitute one of Wyoming's most important natural resources. Even though the State ranked fifth in the nation in petroleum production in 1965, with an annual output exceeding 130 million barrels, it appears certain that many oil and gas pools remain to be discovered.

The first oil produced in Wyoming came from surface seeps and was used in the 1840's to grease the axles of wagons traversing the Mormon Trail. The first producing oil well was drilled in Fremont County in 1884 and was located near an oil seep which had been noted by Captain Bonneville in 1833. Oil seeps were known in the vicinity of Salt Creek prior to 1880. In 1889 a well drilled down-dip from an outcrop of oil-saturated sandstone on the north plunge of the Salt Creek anticline discovered the Shannon field. The Shannon field itself had little importance, but its discovery led later, in 1908, to the drilling of a well a few miles to the south but on the crest of the Salt Creek anticline. This well discovered the famous Salt Creek field, which, to date, has produced over 400 million barrels of oil. This discovery led to the drilling of wells on other anticlines, and by 1916 such well-known fields as Big Muddy, Lost Soldier, Elk Basin, Garland, Grass Creek, and others had been discovered.

Since those early days, new fields have been found each year until, at present, there are about 500 named fields scattered over the State. All but two of the 23 counties produce oil—Teton in the northwestern part and Platte in the southeastern part. There is no geological reason why these counties should not also become productive. Cumulative production has been about 2.6 billion barrels of oil. The proved reserves are about 1.5 billion barrels of oil and have essentially doubled since 1950.

There are many unusual points regarding Wyoming oil production. There have been 200-barrel wells producing from depths as little as 265 feet. Conversely, there has been production from a sand deeper than 16,000 feet in the West Poison Spider field. There is commercial production from reservoir rocks as old as Cambrian and as young as Tertiary, representing every geological period except Silurian and Quaternary. There is one field, Lost Soldier, in which there are 14 distinct reservoirs ranging downward from Cretaceous to Cambrian. Even the weathered pre-Cambrian granite below the sedimentary rocks is oil-saturated.

Wyoming has been an example par excellence of the anticlinal accumulation of oil and gas. All the large fields discovered in the early days were anticlinal in nature, and exploration was directed toward finding anticlines by surface mapping or, later, by seismograph. Within more recent years, important fields of other types have been found. One of Wyoming's larger fields, Cottonwood Creek, in the Big Horn Basin, is a stratigraphic type in which oil accumulation is related to an up-dip loss of porosity in the Ervay dolomite (Permian). Other fields, such as South Glenrock, produce oil from sands which up-dip become shaly and lose porosity and permeability. Some fields, like the Clareton pool, are related to large, isolated sand bodies. Many fields in northeast Wyoming produce from buried hills below an erosion surface developed during Permian time.

Natural gas occurs either in association with petroleum or as fields which produce nothing but gas. Gas-producing fields are scattered over the State, and a network of pipelines is utilized in marketing the gas. In the Big Horn Basin some of the natural gas contains enough hydrogen sulfide to make the gas a commercial source of sulfur. The proved reserves of natural gas in Wyoming exceed 4.25 trillion cubic feet, and new gas fields continue to be found.

Much has been published on petroleum in Wyoming, and more detailed descriptions of all phases may be found in the publications of the United States Geological Survey, the Bureau of Mines, the American Association of Petroleum Geologists, the Wyoming Geological Association, and the Geological Survey of Wyoming. U.S. Bureau of Mines Bulletin 582, "Petroleum and natural gas fields in Wyoming," 1960, is an especially useful reference.

PEGMATITE MINERALS

Pegmatites represent a late stage in the crystallization of large igneous granitic intrusives. The minerals are extremely coarse-grained and often show quartz and microcline intergrown to form *graphic granite*. Rare minerals are often concentrated in pegmatites because the rarer elements do not fit into the space lattices of more common minerals. Pegmatites often show well-defined mineral zones (354). The early minerals in pegmatites are usually microcline, micas, and quartz, followed by garnet and black tourmaline. Later albite, lepidolite, gem tourmaline, beryl, spodumene, topaz, fluorite, etc. crystallize. Rarer minerals such as columbite, monazite, molybdenite and tantalite probably crystallize last.

In this report, the different minerals found in Wyoming pegmatites are classified according to their mineral or commodity name (See INDEX).

PHOSPHATE

Phosphate rock is a marine sedimentary deposit formed under a wide variety of conditions. The rock is a combination of amorphous and colloidal phosphates and the mineral collophane, $10\ CaO.3P_2O_5.CaF.CO_2$. Such rocks may form in several ways: (1) the accumulation of animal and plant remains on sea floors, (2) the leaching of $CaCO_3$ from phosphatic limestones or marls by carbon dioxide-bearing waters, leaving a residue of phopshate, or (3) the percolation of phosphoric acid solutions (derived from the weathering or leaching of igneous rocks rich in apatite or other phosphate-rich minerals, from guano, or from animal bones) through phosphatic limestone beds and enriching them to a "phosphate rock."

Phosphate rock is used primarily as a fertilizer to enrich phosphorus-poor soils. A small amount is used in the manufacture of elemental phosphorus, from which many other chemical compounds are made. Phosphates and phosphorus are used in ceramics, beverages, dental cements, photography, fireproofing compounds, sugar refining, baking powder, incendiary bombs, and smoke screens.

In Wyoming, phosphate rock is found in the Permian Phosphoria formation which crops out in west-central and western Wyoming. The Phosphoria formation in western Wyoming, is subdivided, from base to top, into the following, the lower chert, Meade Peak phosphatic shale, Rex chert, Retort phosphatic shale, and the Tosi chert members. The Meade Peak member, which is 60 to 75 feet thick in western Wyoming, pinches out eastward in the vicinity of the Wind River Range. The upper and lower phosphorite beds of the member are separated by dark mudstone and carbonate rock. The Retort phosphatic shale is similar to the Meade Peak in that it consists of a thick mudstone between two thin beds of phosphorite. It attains a maximum thickness of 50 to 60 feet in the eastern Gros Ventre Range and in the central and southern Wind River Range (666). The thickness of the Phosphoria formation varies from 225 feet to 500 feet; it increases westward in thickness and phosphate content (438, p. 49). McKelvey has reviewed the general geology and occurrence of phosphate rock in Wyoming, Idaho, and Utah (438a). Fig. 2 shows the approximate outcrop traces of phosphate-bearing rocks in Wyoming.

In Wyoming, phosphate rock is found in the Permian Phosphoria formation composed of a lower phosphatic shale member, and the Rex member, a cherty limestone, above. The shale member contains phosphate rock at two principal horizons; one near the base, and the other 20 ft. to 60 ft. higher, near the middle of the formation (443, p. 353). The shale member also contains small amounts of vanadium (See VANADIUM). The Rex chert member is more resistant and forms prominent ledges. The thickness of the Phosphoria formation varies from 225 ft. to 500 ft.; it increases westward in thickness and phosphate content (438, p. 49). McKelvey has recently reviewed the general geology and occurrence of phosphate rock in Wyoming, Idaho and Utah (438a). Fig 2 shows the approximate outcrop traces of phosphate-bearing rocks in Wyoming.

Beds which contain over 65% $Ca_3(PO_4)_2$ (Bone phosphate of lime, or B. P. L.) are potentially commercial deposits (382, p. 190). Low grade phosphate rock contains 30% to 50% $Ca_3(PO_4)_2$, medium grade from 50% to 70%, and high grade rock 70% or more. In some analyses the phosphate content is given as P_2O_5 (phosphorus pentoxide). To convert P_2O_5 to B. P. L. multiply by 2.18 (216, pp. 12-13).

The bulk of the phosphate rock in Wyoming is on public lands which have been withdrawn from entry. The phosphate land withdrawals, as of July 31, 1927, amounted to 996,539 acres (442 a, p. 214). Leasing of phosphate lands is under the jurisdiction of the Bureau of Land Management. Information in pamphlet form regarding phosphate leases and use permits may be obtained from the Department of the Interior, Bureau of Land Management, Washington, D. C.

PRODUCING DEPOSITS

Lincoln County

The San Francisco Chemical Company operates a phosphate strip mine at Leefe, about 25 mi. west of Kemmerer, near the main line of the Union Pacific Railroad. A large crushing, pulverizing and bagging plant is located in the center of the stripping operations. First production was in 1947, and the 1950 output was about 175,000 tons (583); all rock has been marketed in the raw form. The deposits lie in the Beckwith Hills, Tps. 21 and 22 N., R. 120 W., and present operations have been on a 6-ft. bed of high grade rock carrying from 71.9% to 75.6% B. P. L. ("A" bed). Slightly leaner rock (61.0% B. P. L.) 5 ft. thick ("B" bed) underlies the high grade bed. Two feet below is a 76-in. bed averaging 54.5% B. P. L. A bed 1.8 ft. thick carries 74.1% B. P. L. and lies about 10 ft. below the "B" bed. The mining operations have been described by King (395a); the geology of the general area by Gale and Richards (214, pp. 509-13).

In 1957 the company placed a new 1,000 ton flotation mill into operation in order to upgrade and utilize lower grade phosphate rock (613).
Phosphate rock production for 1962 and 1963 amounted to 117,849 tons and 163,609 tons respectively (611).

PROSPECTS

Fremont County

Condit, in 1924 (158), studied and sampled the phosphate beds of the Phosphoria formation along the northeast flank of the Wind River Range. The formation is from 200 ft. to 300 ft. thick in that region (396, p. 1); the lower phosphate zone is about 40 ft. above the base and the upper zone is about 100 ft. below the top. The beds dip northeast at relatively low angles, commonly around 12°. The following data pertaining to areas from the southern end of the Range to the Lander area are summarized from Condit's map (155, pl. 3).

Beaver Creek; sec. 5, T. 29 N., R. 97 W. The lower phosphate rock bed of the Phosphoria formation is 10 in. thick and contains 33.3%, 43.83% and 34.3% B. P. L.

NE¼ sec. 7, T. 29 N., R. 97 W. Here the upper phosphate bed is 5 ft. 3 in. thick and contains 45.9% B. P. L.

NE¼ sec. 9, T. 30 N., R. 97 W. The upper phosphate zone along a fault is 4 ft. thick with 27.5% B. P. L.

Sec. 10, T. 30 N., R. 97 W.; east of center line, near Beaver Creek. The upper phosphate bed is 5 ft. 6 in. thick and has 29.34% B. P. L.

SE¼ Sec. 12, T. 30 N., R. 97 W. The upper phosphate bed at this location contains 19.2% B. P. L. and is 5 ft. 8 in. thick.

NW¼ sec. 20, T. 30 N., R. 98 W. At this location the upper bed is 3 ft. 8 in. thick and has 45% B. P. L.

Usher Creek; sec. 24, T. 30 N., R. 99 W. The lower phosphate zone is 4 ft. thick and contains 61% B. P. L. This lens thins and disappears south of Usher Creek but crops out for about 15 mi. along the strike, northwest of Usher Creek (155, p. 33).

Twin Creek. The Bureau of Mines recently drilled 8 core holes totaling 717 ft. in sec. 11, T. 30 N., R. 99 W. (398). Condit earlier had shown that in this general area the lower bed is 4 ft. thick and contains 60.9% B. P. L. and that the upper bed is 4 ft. thick, carries only 37.0% B. P. L. (155, pp. 28-9). Analysis of the cores taken by the Bureau of Mines indicates that the highest grade rock is 6 ft. thick and carries 54.7% B. P. L. Most samples showed a B. P. L. content of about 49% (398, p. 8).

On the north-south section line between secs. 2 and 3, T. 30 N., R. 99 W. The upper phosphate rock zone contains three thin beds, 9 in. thick, 1 ft. 8 in. thick, and 11 in. thick. B. P. L. content varies between 36% and 42%.

NE¼ sec. 36, T. 31 N., R. 98 W. At this locality the upper phosphate bed is 11 ft. thick.

Lander area. The phosphate rock resources of the area about Lander were studied by King (395a) in 1947. The Phosphoria formation was mapped between Cherry Creek on the southeast, in sec. 17, T. 31 N., R. 99 W., and Baldwin Creek on the northwest, in sec. 13, T. 33 N., R. 100 W., a distance of about 16 mi. Trenches were dug and samples taken at a number of places. On the basis of the data obtained, the upper phosphate zone was estimated to contain 100 million tons of phosphate rock 3 ft. to 6 ft. thick and averaging 35% B. P. L., above drainage level. An additional 13,825,000 tons was estimated for each 100 ft. vertically below drainage level. The lower phosphate bed was estimated to contain, above drainage level, 30,000,000 tons of phosphate rock 3 ft. to 4 ft. thick averaging about 52% B. P. L. An additional 3,780,000 tons were estimated for each 100 ft. below drainage level. Eighteen possible mining blocks were described and the reserves and grade of the rock given for each block.

Later the Bureau of Mines drilled 3 core holes totaling 871 ft. in secs. 8, 9, T. 31 N., R. 99 W., along the Little Popo Agie River, in the area indicated by King's work to contain the thickest and richest development of the lower zone (398). Core hole #1 showed 4.8 ft. containing 56.4% B. P. L., core hole #2 showed 3.9 ft. containing 55.2% B. P. L., and core hole #3 showed 3.05 ft. containing 58.0% B. P. L. (398, p. 8).

The following localities between Baldwin Creek, in the southeast and sage Creek, on the northwest, are summarized from Condit's map (158, pl. 3).

NE¼ sec. 11, T. 33 N., R. 101 W.; along a tributary to Popo Agie River. The upper phosphate zone includes three 1 ft. beds with 34.8% B. P. L.

SW¼ NW¼ sec. 2, T. 33 N., R. 101 W. The Phosphoria formation forms good outcrops along the North Fork Popo Agie River. The upper phosphate zone has three thin beds that contain 40.6% B. P. L. The lower zone contains one bed 1 ft. 6 in. thick with 52.6% B. P. L.

Sec. 18, T. 2 S., R. 1 W. (Wind River Meridian), south-central part. The upper zone has a 7 in. layer with 37% B. P. L. and a 2 ft. 8 in. bed with 39% B. P. L.

North Fork Popo Agie River; in T. 2 S., Rs. 1, 2 W. At this location a solid bed of phosphate rock 4.5 ft. thick contains 42.4% B. P. L. (155, p. 21).

NE¼ sec. 9, T. 30 N., R. 97 W. The upper phosphate zone along a fault is 4 ft. thick with 27.5% B. P. L.

Sec. 10, T. 30 N., R. 97 W.; east of center line, near Beaver Creek. The upper phosphate bed is 5 ft. 6 in. thick and has 29.34% B. P. L.

South Fork Little Wind River; on the north side of a valley in the SW¼ sec. 17, T. 1 S., R. 2 W. The Phosphoria formation at the locality is 285 ft. thick. The upper phosphate zone has two beds, 1.3 ft. and 1.5 ft. thick with 41.74% and 43.74% B. P. L. respectively. The lower zone has three thin beds with 36.51%, 48.13% and 39.92% B. P. L. (155, p. 19).

NW¼ sec. 35, T. 1 S., R. 2 W. The upper phosphate zone has three beds; a 7 in. one with 35% B. P. L., a 1 ft. 3 in. bed with 32.6% B. P. L., and a 1 ft. 5 in. bed with 28.3% B. P. L.

SE¼ sec. 21, T. 1 S., R. 2 W.; along the north-south section line. The upper zone has beds 10 in., 1 ft. 5 in., and 6 in. thick and averages 42.0% B. P. L.

SE corner sec. 1, T. 1 S., R. 3 W. The upper phosphate zone has a 1 ft. 4 in. and an 11 in. bed with 37.7% B. P. L.

NW¼ sec. 21, T. 1 N., R. 3 W. At this locality the upper phosphate zone has a 2-ft. bed with 46.1% B. P. L. (155, p. 18). The dip at the locality is from 15° to 40° NE.

SW¼ sec. 4, T. 1 N., R. 3 W. The upper phosphate zone has a bed 2.5 ft. thick that contains 41.2% B. P. L. (155, p. 18).

Trenching and sampling was carried on during 1950 by the U. S. Geol. Survey at two localities in the northeast part of the Wind River Range and at one locality in the southern part of the Absaroka Range, and the results are given below (457).

Bull Lake; sec. 6, T. 2 N., R. 3 W. Sampling of the Phosphoria formation near the head of Bull Lake indicates that there are only two beds classed as high grade rock and both are less than 1 ft. thick. One bed of medium grade rock 3.1 ft. thick carries 32.7% B. P. L. (457a, p. 30).

Dinwoody Canyon; sec. 6, T. 5 N., R. 4 W. No high grade beds were found in 46.3 ft. of sampled section. Two thin beds showed a little more than 37.0% B. P. L. (457a, p. 19).

Burroughs Creek; sec. 14, T. 43 N., R. 107 W. A bed 1.1 ft. thick showed the highest content, 29.4% B. P. L., of 57.8 ft. of sampled section. Many of the beds are barren and the best are of low grade only (457a, p. 12).

Lincoln County

Sec. 28, T. 22 N., R. 118 W. A trench along a fault block on the north side of a draw, ½ mi. east of Rock Creek, and 2 mi. north of Nugget Station disclosed an upper phosphate bed with a large amount of B. P. L. (438, pp. 123-127).

T. 22 N., R. 117 W.; north of Fossil, and northwest of Kemmerer. Kivi reported finding 7 ft. of phosphate rock with 78.5% B. P. L. (399, pp. 6-7).

Commisary Ridge. A sample from a pit in the phosphate-bearing bed in Sec. 9, T. 23 N., R. 116 W. contained 33.9% B. P. L. (525, p. 134). Phosphate Fertilizer, Inc., of Kemmerer operated an underground phosphate mine on Commisary Ridge during 1948-49. The company installed a mill with a capacity of 200 tons of phosphate rock per day (217; 583).

Sec. 27, T. 24 N., R. 116 W. Some prospect pits have been dug near the east base of Absaroka Ridge (525, p. 134).

Pine Creek Area. Two sections in the Pine Creek area, T. 25 N., R. 118 W., were recently sampled by the U. S. Geol. Survey (438b). The detailed sections show one 5.4 ft. interval averages about 59% B. P. L., one 2.15 ft. bed averages 71.9% B. P. L., and one 3.3 ft. interval averages 70.4% B. P. L. Thin rich units are scattered through the section.

Cokeville Area. At one time the Stauffer Chemical Co. operated a phosphate mine at Rocky Point, just east of Cokeville, but the mine has long been abandoned and workings have caved and buildings deteriorated. The bed mined is 4 ft. thick and dips 60° NE. (399, p. 89). The total reserve in this area is not large because the Phosphoria formation is terminated by a fault not far northwest of the mine. The U. S. Geol. Survey has sampled this area and reports 8 beds ranging from a fraction of a foot up to 7 ft. thick classed as high grade rock (528a; 438, pp. 113-118).

Coal Canyon Area; sec. 7, T. 26 N., R. 119 W. The Meade Peak phosphatic shale member of the Phosphoria formation is 143 feet thick and consists of dark thin-bedded phosphorites and carbonate and quartz-silicate rocks. The average P_2O_5 content is 10.6%. Vanadium, selenium, and uranium are important minor constituents (641).

Sublette Ridge (See VANADIUM); The geology and phosphate rock resources of Sublette Ridge have been described by Mansfield (442a, pp. 288-291, pl.53). This north-south ridge extends northward from Cokeville for some distance but the phosphoria formation is exposed only in parts of Tps. 26 and 27 N., R. 119 W. In Francis Canyon, sec. 19, T. 26 N., R. 119 W., Mansfield indicates a 2 ft. 4 in. bed carrying 71.8% B.P.L. and a 3 ft. 4 in. bed carrying 71.2% B.P.L. (442a, pl. 53). In York Canyon, sec. 18, T. 26 N., R. 119 W., a 5 ft. 10 in. bed carries 76.7% B.P.L. and a 4 ft. 6 in. bed carries 75.1% B.P.L. The United States Phosphate Company operated a mine in York Canyon from 1913 to 1917 (442a, p. 291). In Jackson Canyon, sec. 7, T. 26 N., R. 119 W., a bed 5 ft. 10 in. thick contains 76.7% B.P.L. and another bed 4 ft. thick contains 75.1% B.P.L., according to Mansfield. Recent sampling by the U. S. Geol.

Survey in Coal Canyon, also in sec. 7, shows one 5.6 ft. interval containing from 68.6% to 71.7% B.P.L. In this interval a bed 1.9 ft. thick averages 71.7% B.P.L.; other thin rich intervals are present (438b). It is also indicated that in Raymond Canyon, sec. 6, T. 26 N., R. 119 W., there is a 3.1 ft. bed which yielded 70.1% B. P. L., but recent sampling suggests that the B. P. L. content of this bed is but 54.5% (528a, p. 57). Mansfield (442a, p. 292) states that this township has a reserve of 25 million tons of phosphate rock.

In the next township north, T. 27 N., R. 119 W., one section shows a 6-ft. bed with 84.5% B. P. L., but Mansfield says that elsewhere in the township the bed is thinner and of lower grade (442a, pp. 288-89). He gives a reserve of 46,588,000 tons of phosphate rock for the township. Recent sampling in Leyland Canyon by the U. S. Geol. Survey shows that there is one 5.8-ft. interval which carries from 64.5% to 68.7% B. P. L.; one 3.8-ft. interval which averages 65.6% B. P. L.; and one 5.4-ft. interval which shows from 56.7% to 68.4% B. P. L. (438b).

Poison Creek. Recent sampling by the U. S. Geol. Survey near the head of Poison Creek, sec. 23, T. 30 N., R. 117 W., shows a 1.6 ft. interval carrying from 68.7% to 70.2% B.P.L.; a 1.6 ft. interval carrying 68.7% to 75.8% B.P.L.; a 2.4 ft. bed carrying 75.0% B.P.L.; and a second 2.4 ft. bed carrying 74.5% B.P.L. (547a, pp. 34-36).

Other localities farther north in Lincoln County are given below.

T. 31 N., R. 117 W. The phosphatic shale member of the Phosphoria formation crops out at a waterfall near the Cottonwood Creek-Corral Creek trail. One bed, 1.2 ft. thick near the base of the vanadiferous zone contains a large percentage of B.P.L. (438, pp. 104-107).

Center sec. 2, T. 31 N., R. 118 W. A thin bed of phosphatic shale strikes north-south and dips 70° W., but probably disappears due to faulting in the area (442, pl. XII).

NW¼ sec. 10, T. 31 N., R. 118 W., east of Osmond along Dry Creek. Phosphate rock at this locality contains 72.7% P. P. L. (442, pl. XII).

NW¼ sec. 25, T. 32 N., R. 118 W.; on Afton Creek. Shultz found float from the upper phosphate bed which contained 67.4% B.P.L. (525, p. 62).

Swift Creek Area; SW¼ sec. 21 and NW¼ sec. 28, T. 32 N., R. 118 W. The Phosphoria formation in this area strikes nearly north-south and dips 83° W. (442, pl. XII). In the NE¼ sec. 23, T. 32 N., R. 118 W. another bed strikes north-south and dips 85° E. (442, pl. XII). Trenching uncovered 60 ft. of phosphatic oolitic shale which contains 45.4% B.P.L., and a phosphatic chert bed contains 36.0% B.P.L. (438, pp. 96-103; 399, p. 13).

Center, sec. 33, T. 32 N., R. 117 W. Phosphate rocks form ledges just east of the head of South Fork Swift Creek and contain 69% B.P.L. (442, pl. XII).

South Cottonwood Creek-Sheep Creek Divide; SW¼ SE¼ sec. 29, T. 33 N., R. 115 W. A bed of phosphate rock 1.5 ft. thick at the top of the phosphatic shale member of the Phosphoria formation yielded 0.01% V_2O_5 and 70.9% B.P.L. The upper phosphate bed has a hard oolitic layer 1.3 ft. thick with 0.02% V_2O_5 and 70.9% B.P.L. Below is a 1 ft. siltstone bed and 1 ft. of oolite and clay shale with 0.17% V_2O_5 and 42.1% B.P.L. The vanadiferous zone has a soft fissile shale bed 0.5 ft. thick that contains 0.02% V_2O_5 and 78% B.P.L. Three thick phosphate beds near the base of the vanadiferous zone contain about 54.6% B.P.L. The lower phosphate bed, 1.3 ft. thick, has 0.02% V_2O_5 and 70.9% B.P.L. (438, pp. 93-95).

McDougal's Pass; center sec. 9, T. 33 N., R. 117 W., on the divide between the heads of Willow Creek and Strawberry Creek. Phosphatic shales strike N. 11° W. and dip 16° W.; the lower phosphate bed is 16 ft. above the base and is 2½ ft. to 3 ft. thick with 48.86% B.P.L. The upper bed, 1 ft. thick, is 24 ft. above the base and contains 68.4% B.P.L. (399, pp. 15-16; 442, p. 340).

Center sec. 18, T. 33 N., R. 117 W. A small part of the Phosphoria crops out at this location, but most of the formation is cut off by a fault (442, p. 347 and pl. XII).

SW¼ NE¼ sec. 14, T. 33 N., R. 118 W.; on Willow Creek. The Phosphoria formation contains three phosphate beds totaling 5 ft. 2 in. thick in 41.2 ft. of stratigraphic section. An oolitic phosphate rock 1.7 ft. thick at the top of the formation contains 26% to 44% B.P.L. A second phosphate bed near the middle of the section is a 1.6 ft. thick, medium-grained oolitic rock with 45.77% B.P.L. (442, p. 339).

NW¼ sec. 6, T. 33 N., R. 117 W. The south side of Dry Canyon has been extensively prospected. Float samples picked up in the area contained 72.7% B.P.L. (442, p. 340).

NE¼ sec. 32, T. 39 N., R. 116 W.; above Snake River Canyon. Near the base of the Phosphoria formation, a black shale bed contains phosphate (525, p. 133).

Sublette County

T. 31 N., R. 115 W. On a mountain south of South Fork of North Piney Creek, phosphatic shales in the Phosphoria formation total 62.5 ft. A 1 ft. bed at the top of the formation has 52.8% B.P.L. (399, pp. 38, 39). Kivi reports this location as R. 114 W., but since the outcrop of the Phosphoria is in the next township west it is assumed that a typographic error exists.

Tosi Creek-Bartlett Creek Area; T. 38 N., R. 111 W. The U. S. Geological survey recently trenched and sampled in sec. 23 in this township (Bartlett Creek) and in sec. 17, T. 39 N., R. 110 W. (Tosi Creek). Only two beds are rich enough to be classed as high grade; one is 1 ft. thick and carries 57.8% B.P.L. and the other is 2.3 ft. thick and averages 62.3% B.P.L. (547a, p. 21).

Gypsum Creek. Recent trenching and sampling by the U. S. Geol. Survey on Gypsum Creek, in sec. 22, T. 38 N., R. 109 W., indicates no beds in this section contain more than 29.2% B.P.L. (547a, pp. 27-29).

Teton County

Talbot Canyon; "Unsurveyed land about 1/3 mi. up the canyon and about 2 mi. southeast of a place where Teton Pass highway crosses the Idaho- Wyoming boundary" (216, p. 32). The phosphatic shale member of the Phosphoria is 38.4 ft. thick and contains 10 thin layers of phosphate rock. The best rock is 2.8 ft. thick and contains 64.5% B.P.L. The average B.P.L. content is 56.9% (216, p. 33).

Unsurveyed Land; about 3/8 mi. east of the southeast corner sec. 20, T. 3 N., R. 46 E. (Boise Meridian), and a few hundred feet north of Moose Creek. The Phosphatic shale member here is 21.7 ft. thick with 4 beds of phosphate rock that average 60.2% B.P.L. The best phosphate rock is 2 ft. thick and contains 68.8% B.P.L. (216, p. 33).

T. 41 N., R. 118 W.; 1 mi. west of Teton Pass. A highway road cut disclosed a 2 ft. bed of oolitic shale with 58.9% B.P.L. (399, p. 23).

T. 38 N., R. 116 W.; ¼ mi. above the junction of Martin Creek with Snake River. Two phosphate beds 9 ft. and 70 ft. to 90 ft. above the base of the Phosphoria formation yielded an average of 61% B.P.L. The rocks are probably faulted (399, p. 20).

Buck Creek. A sampled section in Buck Creek Canyon, in sec. 1, T. 38 N., R. 115 W., shows a 2 ft. bed and a 2.7 ft. bed each containing 45.3% B.P.L. and a 2.5 ft. interval containing from 61.0% to 66.5% B.P.L. (547 a, pp. 25-26).

Snake River Canyon; sec. 32, T. 39 N., R. 116 W. Eight phosphate rock beds interlayered in 60 ft. of black shale are present in this area (525, p. 133). Work by the U. S. Geol. Survey shows that a 3.6-ft. bed contains from 46.7% to 51.5% B.P.L. and that two separate layers less than 1 ft. thick contain 63.0% and 75.8% B.P.L. (547a, p. 24).

Flat Creek; sec. 6, T. 41 N., R. 114 W. Three beds less than 1 ft. thick contain from 57.1% to 65.0% B.P.L. A 2.7 ft. bed contains 70.6% B.P.L. (547a, pp. 17-18).

Crystal Creek; sec. 34, T. 42 N., R. 113 W. No high grade rock was found in samples from 50 ft. of strata (547a, p. 16).

Gros Ventre Slide; sec. 5, T. 42 N., R. 114 W. In the lower part of the Phosphoria a 2.5 ft. bed contains 54.3% to 67.4% B.P.L. (547a, p. 14).

Togwotee Pass; T. 44 N., R. 111 W. A sampled section of 40.7 ft. contained no beds rich enough to be classed as high grade rock. Thin beds contain from 26.6% to 43.8% B.P.L. (547a, p. 11).

URANIFEROUS PHOSPHATIC DEPOSITS

In the 2,500 square miles of the southeastern part of the Green River Basin, Sweetwater County, the Wilkins Peak member of the Green River formation contains 10 to 50 abnormally radioactive zones. Twenty-five of these were analyzed chemically. These averaged about 0.005% uranium and 2.2% P_2O_5. The maximum uranium content was reported to be 0.15% uranium and 18.2% P_2O_5. (652).

Fremont County

Beaver Divide Area. Seven or more uraniferous phosphate zones occur in the Wagon Bed formation of middle and upper Eocene age. These beds, which range in thickness from a few inches to 2 feet, contain a maximum uranium content of 0.042% and a maximum P_2O_5 content of 5.67% (652).

Fremont and Hot Springs Counties

Lysite Mountain Area. Seven uraniferous phosphate zones were sampled in an oil shale and analcitized tuffaceous lacustrine sequence of middle to late Eocene age. The maximum uranium content reported was 0.040% and P_2O_5 was 7.25%. The maximum oil shale content was 38 gals./ton; the average for a thickness of 7 feet was 23 gals./ton. (652).

Sweetwater County

Pine Mountain Area. A uraniferous phosphatic zone, a few inches to more than 4 feet thick, occurs in sandstone and siltstone in the lower part of the Cathedral Bluffs tongue of the Wasatch formation. The average of 20 samples analyzed from this zone is 0.06% uranium and 5.7% P_2O_5. The maximum uranium content is 0.24% and P_2O_5 is 19.04% (652).

REPORTED OCCURRENCES

Bighorn Mountains

Darton (169, p. 54) reported spherical concretions composed of impure lime phosphate in the lower part of the Colorado formation. The concretions are from 1 in. to 1½ in. in diameter, have a radiated internal structure, and probably are pseudomorphs after marcasite.

Hot Springs County

South of Thermopolis, in Wind River Canyon, the Phosphoria formation contains dark phosphate granules and nodules embedded in a gray limy matrix.

The upper portion is 2½ ft. thick and has 34.4% B.P.L.; the lower portion has 14.9% B.P.L. (127, p. 480).

PLATINUM AND PALLADIUM

Native platinum is never chemically pure but usually contains varying proportions of ruthenium, rhodium, palladium, osmium, or iridium. Platinum may also contain traces of gold, copper, silver, iron, chromium or nickel. The platinum group of minerals is widely distributed throughout the world, but commercial deposits are usually associated with basic or ultra-basic rocks, most commonly with dunites. Associated minerals are olivine, chromite, magnetite, zircon, corundum, and other platinum group minerals. Most of the world's platinum has come from placer deposits concentrated from adjacent rocks.

Platinum and palladium are widely used in the manufacture of jewelry. These elements are also used in electrical apparatus, as catalysts for many types of laboratory equipment, in dental metal and surgical instruments, and in photography.

The reported platinum minerals in Wyoming are found in the Medicine Bow Mountains in Albany County, in the Snake River gold gravels, and in other scattered localities. In 1902, $6,000.00 was paid for platinum ores from the Rambler Mine at Holmes and there were small amounts produced between the years 1915 and 1920.

PROSPECTS

Albany County

Rambler Mine; at Holmes, near the head of Douglas Creek just east of the Carbon-Albany County line. Emmons in 1903 (191, pp. 94-97) first identified sperrylite, $PtAs_2$, associated with the copper ores of the Rambler. Covellite and pyrite contain well-defined crystals of sperrylite. The covellite replaces pyrite. Emmons believed the sperrylite to be an original constituent of the rock.

W. C. Knight (414, p. 696) reported that platinum and palladium were present in nearly equal amounts. Assays show traces of iridium and osmium with the platinum and palladium, and averaged 3 oz. of platinum and palladium per ton. The Rambler shaft was in an altered pyroxenite (363, pp. 134-5). Taft reported diorite and peridotite in the mine (549, p. 900); (See SILVER, COPPER).

Centennial Ridge. Platinum and palladium are scattered in small amounts in the hornblende schists, biotite gneisses, and granites of the area. These metamorphic rocks have been cut by quartz veins which contain small pockets of sulfide and arsenide minerals (363, pp. 128-134).

Independence Mine; near Keystone. An analysis of "mine-run" ore showed 0.27 oz. of platinum per ton, as well as 0.46 oz. of iridium, 0.0302 oz. of rhodium and 0.1002 oz. of osmium per ton of ore (217); (See GOLD).

Queen Shaft; middle of west side of sec. 16, T. 15 N., R. 78 W. The shaft was sunk on amphibolite and hornblende gneiss. Small faults filled with gouge and calcite cross the amphibolite. The gouge material assayed 0.03 oz. per short ton in platinum, 0.05 oz. per short ton in iridium, less than one oz. per short ton in silver, and a trace of gold (363, p. 133).

Wyoming Gold and Platinum Mining Co.; at Centennial. U. S. Bureau of Mines assays show 11 oz. of palladium per ton and traces of nickel (25, p. 5). The ore fills small cross-fractures which cut the schists, gneisses, and basic dikes at right angles (25, pp. 20-21).

REPORTED OCCURRENCES

Albany County

Albany Placers; (See GOLD).

Douglas Consolidated Placers; (See GOLD).

Douglas Creek Placer Mines; (See GOLD).

Carbon County

Broadway Claim; (See LEAD).

Laramie County

Aughey detected minute quantities of palladium in the gold and silver ores of the Silver Crown district (16, p. 54).

Teton County or Lincoln County

Platinum has been reported in the gold-bearing gravels of Snake River. A concentrate assay gave 4.54 oz. of platinum per ton (520, p. 87; 525, pp. 126-130).

POTASH

There are many minerals which contain potassium, but commercial extraction is feasible only from the salts sylvite, langbeinite polyhalite, carnallite, and kainite. Potash is often obtained from caliche deposits and might be obtained from alunite, orthoclase, or leucite. Some studies on possible uses of wyomingite have been made (370; 437).

Leucite-bearing volcanic rocks mostly wyomingite and orendite, are abundant in Wyoming in the Leucite Hills, Sweetwater County. The potash content varies from 9.81% to 11.91%. Orendite is a light straw-yellow rock with megascopically visible micas. Wyomingite is a dark-gray, fine-grained rock. Schultz and Cross in 1912 estimated 1,973,496,177 tons of leucite-bearing rocks in the Leucite Hills. The average K_2O and Al_2O_3 content is 10%, thus there are 197,349,617 tons of Al_2O_3 and 197,349,617 tons K_2O available (524, p. 35). Orendite contains less Al_2O_3 than wyomingite. A quarry was opened during World War I and some KCl was produced between 1918 and 1920 at Green River, Wyoming. No alumina was recovered (550, p. 17).

PROSPECTS

Sweetwater County

The Leucite Hills are a series of volcanic cones, necks, plugs, lava flows, and sheets in the northern part of the Rock Springs uplift in Tps. 21, 22, 23 N., Rs. 102, 103 W. These volcanics rest on Tertiary Green River, Wasatch, and on Cretaceous sediments. The area was first examined by S. F. Emmons for the U. S. Geological Survey of the 40th Parallel (524, pp. 7; 393; 394). The following descriptions include the more prominent leucite-bearing mesas and cones (524, pp. 16-34).

Badgers Teeth; SE¼ NW¼ sec. 7, T. 21 N., R. 107 W. The Badgers Teeth are five tooth-like volcanic necks which project through "Montana" sediments. Measured reserves of leucite-bearing rock are 379,800 tons, or 37,980 tons of K_2O. Inferred reserves are 17,461,305 tons of leucite-bearing rocks, or 1,784,110 tons of K_2O (524, pp. 20-21).

Black Rock Mesa; secs. 13, 24, T. 22 N., R. 101 W. Black Rock Mesa rises about 450 ft. above the level of the surrounding Wasatch beds. The lava is basaltic and has crude columnar structure. The mesa top includes about 12 acres of wyomingite. Indicated reserves total 4,557,600 tons of leucite-bearing rock, or

455,760 tons of K_2O. Inferred reserves of potash-bearing rock total 152,679,600 tons, or 15,267,960 tons of K_2O (524, pp. 28-29).

Boar's Tusk; SE¼ SW¼ sec. 16, T. 23 N., R. 104 W. A volcanic neck or plug of estimated 1.6 acres surface area contains 1,866,384 tons inferred reserves of leucite-bearing rock or 186,638 tons of K_2O. Surrounding the plug are other masses of rock which contain indicated reserves of 8,900,000 tons of leucite-bearing rock, or 890,000 tons of K_2O. Below the level of Killpecker Valley, to a depth of 3000 ft., the inferred reserves of leucite rock total 18,228,000 tons, or 1,822,800 tons of K_2O (524, pp. 19-20).

An analysis of the rock is given below (524, p. 11):

SiO_2=50.23%, TiO_2=2.27%, Al_2O_3=11.22%, Fe_2O_3=3.34%, MgO=7.09%, CaO =5.99%, Na_2O=1.37%, K_2O=9.81%, H_2O=2.65%, P_2O_5=1.89%, SO_3=0.74%, F=0.50%, other 1.68%.

Cross Mesa; NE¼ secs. 34, 35, T. 22 N., R. 103 W., and into the NE¼ sec. 2, T. 21 N., R. 103 W. Cross Mesa is capped by one of the principal flows, 50 ft. thick, 400 ft. above the valley floor of "Montana" sediments. The surface flows contain indicated reserves of 70,832,700 tons of leucite rock, or 7,083,270 tons of K_2O. Rising above the top of this surface lava sheet is a cone of reddish pumice, south of the center of sec. 35. The cone contains 7,899,840 tons inferred reserves of leucite rock, which contain 789,984 tons of K_2O (524, pp. 22-23).

Emmon's Cone; secs. 3, 4, 9, 10, 11, T. 21 N., R. 102 W. The lava flows cover 440 acres, and are about 50 ft. thick. They rise about 162 ft. above the surrounding area. A prominent cone projects above the north-western part of the mesa. Indicated reserves total 83,556,000 tons of leucite rock, or 8,355,600 tons of K_2O in the lava cap. The cone contains 11,074,968 indicated tons of rock, or 1,107,496 tons K_2O (524, p. 25).

Endlich and Hague Hills; secs. 7, 8, 17, 18, T. 22 N., R. 102 W. These two hills appear to be remnants of lava sheets. Endlich Hill is north of Hague Hill and southwest of Table Mountain. It contains indicated reserves of 206,584 tons of leucite rock, or 20,658 tons of K_2O. Hague Hill contains indicated reserves of 376,712 tons of leucite rock, or 37,671 tons of K_2O (524, p. 34).

Hallock, Iddings, and Weed Buttes; volcanic necks in NE¼ sec. 18, T. 22 N., R. 102 W. Weed Butte lies in a depression between the other two buttes. Hallock Butte consists of orendite with the following composition (524, p. 11):

SiO_2=51.07%, TiO_2=2.13%, Al_2O_3=9.93%, Fe_2O_3=2.72%, FeO=1.19%, MgO =10.31%, CaO=4.87%, Na_2O=0.82%, K_2O=9.92%, H_2O=4.23%, P_2O_5= 1.53%, SO_3=0.33%, other 0.61%.

Hallock Butte has indicated reserves of 5,697,000 tons of rock, or 56,970 tons K_2O, and inferred reserves of 11,394,000 tons of rock, or 1,139,400 tons K_2O. Iddings Butte has indicated reserves of 132,930 tons of leucite rock above ground level, or 13,293 tons K_2O. Weed Butte has indicated reserves of 37,980 tons of rock or 3,789 tons K_2O in deposits above the surface and 11,394,000 tons of inferred reserves of leucite rock, or 1,139,400 tons of K_2O between the surface and 3,000 ft. depth (524, p. 34).

Hatcher Mesa; S½ sec. 33, T. 22 N., R. 102 W. This is a conspicuous flat-topped hill ¼ mi. in diameter; the lava cap is 50 ft. thick and 420 ft. above the valley floor. It covers 27 acres. The indicated reserves are 5,127,300 tons of leucite rock, or 512,730 tons of K_2O (524, pp. 24-25).

Mathews Hill; SE¼ NE¼ and NE¼ SE¼ sec. 21, T. 23 N., R. 104 W. Mathews Hill is a low rounded knoll which rises 40 ft. above the surrounding area. It probably is a volcanic neck which has been extensively eroded. The hill has a surface area of about 1.5 acres, and has an average of 11.08% K_2O. Indicated reserves of potash-rich rock above the level of Killpecker valley total 428,690 tons, or 42,869 tons of K_2O. Inferred reserves total 17,091,000 tons of leucite rock, or 1,709,100 tons of K_2O (524, pp. 17-18).

North Table Mountain; south of the center of sec. 36, T. 23 N., R. 103 W. and north of the center of sec. 1, T. 22 N., R. 103 W. North Table Mountain is a flat-topped mesa with a surface area of 80 acres; it is rimmed by a prominent scarp about 50 ft. high. Total indicated and inferred reserves are 15,192,000 tons of leucite rock, or 1,519,200 tons of K_2O (524, pp. 31-32).

Orenda Mesa; secs. 19, 20, 29, 30, T. 32 N., R. 102 W. Orenda Mesa covers 369 acres and is made up of several flows which seem to have a common vent near the center of the mesa. The rock is orendite; it is in contact with Wasatch and "Laramie" sediments. Three cones on the mesa are composed of reddish-yellow fragmental pumice. The average thickness of the flow at the base of the cones is 100 ft.; it probably contains indicated reserves of 140,355,600 tons of rock, or 14,035,520 tons of potash. The three cones contain indicated reserves of 9,320,584 tons of rock, or 932,058 tons of K_2O (524, p. 27).

Osborn Mesa; SW¼ SE¼ and SE¼ SW¼ sec. 6, T. 21 N., R. 102 W. The typical orendite lava cap of Osborn Mesa has an area of about 15 acres; the conduit is not visible at the surface. Total inferred reserves are 5,697,000 tons of leucite rock, or 569,700 tons of K_2O (524, pp. 23-24).

Pilot Butte; NE¼ sec. 10, NW¼ sec. 11, T. 19 N., R. 106 W. Pilot Butte is a flat-topped mesa which rises about 450 ft. above the surrounding horizontal Green River beds. The lava cap is about 100 ft. thick (159, p. 127). Inferred reserves in the lava cap include 6,080,000 tons of leucite rock, or 486,400 tons of K_2O in rock with 8% K_2O (524, pp. 16-17).

South Table Mountain; sec. 1, T. 22 N., R. 102 W. Lava flows 100 ft. thick cover about 8 acres of Wasatch beds. The mountain also includes a remnant of a volcanic neck with crude columnar structure. Indicated reserves total 3,038,-400 tons of leucite rock, or 303,840 tons of K_2O. Inferred reserves in the volcanic neck below the level of the valley total 105,736,320 tons of leucite rock, or 10,573,632 tons of K_2O (524, pp. 32-33).

Steamboat Mountain; secs. 8, 9, 10, 11, 15, 16, 17, T. 23 N., R. 102 W. Two distinct wyomingite flows with 1,019 acres surface area rest on Green River beds. The surface is very irregular and the thickness of the flows varies. Three cones of hard lava on top of the mesa are similar to those on Zirkel Mesa. Inferred reserves of lava, (est. 50 ft. thick) total 193,508,100 tons of rock, or 19,350,810 tons of K_2O. The cones are estimated to contain 206,181 tons of rock, or 20,618 tons of K_2O (524, pp. 29-31).

Table Mountain; SW¼ sec. 6, T. 22 N., R. 102 W. This mesa rises 1300 ft. above the surrounding valley and is the most conspicuous landmark in the Leucite Hills. The mesa has a surface of 22 acres, and the lava averages 50 ft. thick. Total indicated and inferred reserves are 4,177,800 tons of leucite rock, or 417,780 tons of K_2O (524, pp. 33-34). Typical orendite along the north cliff has the following composition:

$SiO_2 = 54.08\%$, $TiO_2 = 2.08\%$, $Al_2O_3 = 9.49\%$, $Fe_2O_3 = 3.19\%$, $FeO = 1.03\%$, $MgO = 6.74\%$, $CaO = 3.55\%$, $Na_2O = 1.39\%$, $K_2O = 11.76\%$, $H_2O = 3.50\%$, $P_2O_5 = 1.35\%$, $SO_3 = 0.29\%$, $F = 0.49\%$, other 1.03% (524, p. 11).

Zirkel Mesa; E½ T. 21 N., R. 102 W., and into the W. part of T. 21 N., R. 101 W. Zirkel Mesa is the largest in the region. Complex flows appear to have issued from several conduits. The lavas rest on rocks of "Montana" age which have been cut by at least three faults; therefore the flows are later than the faulting. There are four cones of fragmental pumice on the mesa and one of consolidated lava (524, p. 26). The mesa covers 3,300 acres, and the lava has an average thickness of 75 ft. The rock in the nearly horizontal part of the mesa has indicated and inferred reserves of 940,005,000 tons of leucite rock, or 94,000,500 tons of K_2O. Irregularities such as cones, protuberances, etc., contain 102,336,276 tons of rock, or 10,233,627 tons of K_2O (524, pp. 25-27).

An analysis of rock from Zirkel Mesa is given below:

SiO_2=53.70%, TiO_2=1.92%, Al_2O_3=11.16%, Fe_2O_3 = 3.10%, FeO = 1.21%, MgO=6.44%, CaO=3.46%, Na_2O=1.67%, K_2O = 11.16%, H_2O = 3.41%, P_2O_5=1.75%, SO_3=0.06%, F=0.44%, others 0.92% (153, p. 74).

REPORTED OCCURRENCES

Park County

Hague found float of a basic volcanic rock in the gorge of Ishawooa River which contained considerable microscopic leucite (349, p. 44).

Sweetwater County

T. 22 N., R. 96 W.; (See SODIUM SULFATE AND CARBONATE).

PUMICE-PUMICITE

Pumice is a whitish or light gray very cellular or frothy pyroclastic igneous rock composed mainly of volcanic glass. Since it is very light, it will usually float on water. The term pumice is applied to rock fragments greater than four millimeters in diameter to avoid confusion with the term pumicite. Pumicite is actually volcanic ash, and this term is applied to uncemented or loosely cemented volcanic glass debris composed of fragments of less than four millimeters in diameter.

Pumice and/or pumicite, has, or has had the following uses: in abrasives, lightweight aggregate, building stone, additive in the manufacture of concrete, in insecticide carriers, cleansing compounds and soap, as a diluent in paints and rubber goods, mixed with portland cement for use as a lining for aqueducts, and used in the production of roofing and accoustical granules for sound proof plaster. There has been no recorded production of pumice or pumicite in Wyoming.

PROSPECTS

Big Horn County

SW¼ sec. 2, T. 56 N., R. 94 W. Pumicite is exposed in two small pits about 100 yards apart. In the larger pit, pumicite is about 20 feet thick and occurs as alternating consolidated thin beds separated by beds of loosely cemented pumicite. Individual beds are very light gray in color and are composed of abundant glass shards, traces of quartz and an unidentified green mineral cemented by calcite. Individual very light gray pumice fragments, up to 8 millimeters in diameter, occur disseminated in the pumicite matrix (674).

SW¼SW¼ sec. 36, T. 57 N., R. 94 W. Pumicite crops out as an irregular body approximately 300 feet long by 275 feet wide. The thickness ranges from less than 6 inches to approximately 16 feet. As exposed in a small pit excavated at the north end of the deposit, the pumicite is composed of very light gray, alternating hard and soft beds which vary from slabby to "pipey"-like in appearance. Individual beds are composed of medium- to coarse-grained aggregates of pumice grains, volcanic glass, and traces of quartz and lithic fragments enclosed in a calcite cement. Intercalated within these beds are lenses of a coarse-grained aggregate of the above constituents with discrete pebbles of white pumice up to 1¼ inches in diameter (674).

NE¼SE¼SW¼ sec. 17, T. 53 N., R. 90 W. Pumicite is reported to occur overlying alluvial gravels which overlie the Goose Egg formation at the top of a ridge (674).

Fremont County

Beaver Rim Area; SW¼ sec. 26, and NE¼ sec. 34, T. 33 N., R. 89 W. Pumice blocks, up to 8 inches long, occur in a lapilli tuff in the upper part of the Wagon Bed formation (671).

SE¼ sec. 3, T. 30 N., R. 96 W. The White River formation contains thin beds of vitric tuff suitable for use as abrasive pumicite (671).

Sweetwater County

SW¼NW¼ sec. 16, T. 20 N., R. 92 W. A pumicite deposit approximately ½ mile long and about 390 feet wide with an average thickness of 4½ feet has been exposed in a number of trenches and pits. A maximum thickness of 14 feet of pumicite is exposed in a large pit located near the southeast edge of the deposit. Here the pumicite is exposed as crossbedded and alternating hard and soft beds composed of poorly cemented aggregate of volcanic glass, traces of quartz and other unidentified dark minerals (674).

QUARTZ

Quartz, or silica, is SiO_2. It is perhaps the most common mineral known and is found in very many varieties. Quartz is common in acidic igneous rocks, in metamorphic rocks and in sediments. Many mineral veins are mostly quartz. Because the silica minerals are so common, it has not been possible to list all localities where they are found.

Uses of quartz include jewelry and ornaments, balance weights, pivot supports for balances and other delicate instruments, agate mortars, optical equipment, radio oscillator plates, millstones, abrasives, polishing material, glass manufacture, and many others.

AGATE

Agate is variegated chalcedony which is a cryptocrystaline variety of quartz. Moss agates have visible impurities of maganese dioxide which form patterns resembling moss. The curved, banded varieties of agate represent layers built up by intermittent deposition.

PROSPECTS

Platte County

Moss agates have been quarried from a deposit at Hartville and sent to Germany for cutting and polishing. The agates were found in a ledge 6 in. thick in limestone 5 ft. thick. Prices (1895) were quoted at $200.00 per ton (420, p. 601; 217). Red banded agate and moss agate have been mined intermittently in the Wilde and Deer Corne Mines, located about 2 mi. northwest of Guernsey (217).

REPORTED OCCURRENCES

Albany County

Agates have been reported in the foothills of the Laramie Range, 35 mi. northeast of Medicine Bow (264).

Carbon County

Agates have been collected along Wyoming Highway No. 130, 14 mi. south of Walcott Junction (263).

From Saratoga north to the Union Pacific Railroad, the "flats. . . are literally strewn with small sections of agatized and opalized woods." The inner wood structure is lacking. These specimens fluoresce green (446).

Agatized wood fragments have been found on both sides of Como Bluff anticline (261).

Converse County

Moss Agate Hill; about 22 mi. southwest of Douglas, on the Cold Springs road. This hill contained agates at one time, but now is practically barren (217; 190, p. 172).

Crook County

Agates have been found in the Nigger Hill gold placer deposits (374, p. 178).

Fremont County

Beautiful rainbow agates have been found along Wind River near Riverton (231).

"Very fine moss agates occur north of the Sweetwater, at Agate Lakes" (192, p. 158).

Agates and moss agates are plentiful in a large area in southeast Fremont County, southeast of Wind River and north of the Sweetwater River (263; 217), and along Sage Hen Creek, 18 mi. northwest of Split Rock (190, p. 173).

Johnson County

Moss agates have been reported between Ft. Reno, an abandoned U. S. Army post, and Crazy Woman Creek (217).

Laramie County

Moss agates have been found in the gravels west of Cheyenne (253).

Sweetwater or Lincoln Counties

Agate is abundant in the bad lands on Ham's Fork of the Green River (217).

Sweetwater County

Petrified or agatized wood in various colors has been found west of Wamsutter, along the old road to Baggs (264).

Agatized wood has been reported along the continental divide near the Fremont-Sweetwater county boundary (263).

A 2 in. moss agate from the Sweetwater district contained inclusions of an unidentified yellow radioactive mineral (147, p. 301).

The ground near Church Buttes was "literally paved with small agate fragments" during the 1870's (358, pp. 40-41). Now the region is nearly barren of agates.

Weston County

Poor quality agatized wood has been reported south and west of Newcastle, on the hills and flats (217).

AMETHYST

Amethyst is purple or bluish-purple crystallized quartz. The color is probably due to manganese contained within the quartz crystals. Amethyst is rare in Wyoming.

REPORTED OCCURRENCES

A large geode 24 in. in diameter and weighing 310 lbs. was found in "southern Wyoming." The lining was composed of quartz and amethyst crystals up to 3 in. long (14, p. 162).

Aughey reported amethyst to be rare in the Owl Creek range and East Seminoe Mountains (16).

Small amounts of low quality amethyst occur in large, log-like concretions which weather out of the Sundance formation on the west side of Sheep Mountain in Albany County (16).

CARNELIAN OR SARD

Carnelian is clear pale- to deep-red chalcedony. It has been found near Table Mountain in the Silver Crown District (217, 16, p. 59) and between Poison Spider Creek and South Casper Creek (16, p. 59).

CHALCEDONY

Chalcedony is a cryptocrystalline variey of cilica and is usually white, gray, bluish brown, or dark-gray to black in color. The mineral is common in Wyoming, particularly in Tertiary rocks.

REPORTED OCCURRENCES

Carbon County

Large chalcedony fragments are scattered on the north side of Como Bluffs anticline. The colors range from black to pink or red (261).

Fremont County

"Found in large quantities in the Carboniferous limestone and Pliocene marls north and northwest of the Granite Hills" (192, p. 158).

Sweetwater County

Six miles west of Carter's Station, in a railroad cut, a bed of plastic clays contained flinty concretions filled with seams of chalcedony (358, p. 146). Steamboat Mountain in the Leucite Hills (T. 23 N., R. 102 W.) contains some amygdaloidal lavas that are occasionally lined with beautiful crusts of chalcedony. The amygdules are from 3 in. to 6 in. long and are about half as wide as they are long (394, pp. 325-326).

Teton County

Hayden reported chalcedony from Jackson Lake (358, p. 182).

CRISTOBALITE

Cristobalite is a high temperature white octahedral form of silica. It is present in many siliceous volcanic rocks. Gruner (273, pp. 867-75) has studied Wyoming bentonites and found low temperature cristobalite in good quality bentonite near Casper, near Gillette, and near Sheridan. The Casper deposit contains up to 25% cristobalite. The bentonite near Sheridan is made up of montmorillonite and 30% cristobalite (273, p. 870). The cristobalite is in microscopic grains.

CHRYSOPRASE

The apple-green variety of chalcedony, chrysoprase, has been reported north of Poison Spider Creek, on the south side of Sand Creek, a tributary of Beaver Creek, and on the Little Wind River (16, p. 58).

FLINT, CHERT, JASPER

Flint, chert, and jasper are varieties of chalcedony and are more opaque and have duller colors than other varieties. They are found over much of Wyoming in small amounts. Many linestone formations contain much chert, particularly the Phosphoria, Madison and Bighorn formations.

HELIOTROPE

Heliotrope is a green variety of chalcedony which contains small red spots of jasper. It has been found near Chugwater, in Laramie County (217), and north of the Rattlesnake Mountains in Triassic rocks (16, p. 59).

HYALITE

Hyalite was reported from Jackson Lake, Teton County, in 1873 (492a, p. 181).

OPAL

Opal is silica which contains 3% to 9% H_2O, and other impurities. It is a mineral gel found in many types of rocks. True opals are rare in Wyoming. Aughey recognized several specimens from the north side of the Sweetwater River, near the place known as Lankins Ranch in 1886 (16, p. 59), along the Sweetwater River, on Sage Hen Creek, and at Agate Lakes. Hayden had previously found "excellent specimens . . . near Jackson's Lake, Wyoming Territory" (492, p. 181). Hagner identified opal concretions in Tertiary rocks near Smith Creek, in Carbon County (his specimens are in the University of Wyoming collections).

QUARTZ CRYSTALS

Small crystals of quartz, both clear and clouded, are common in pre-Cambrian pegmatites and in other igneous rocks, as well as in mineral veins. They have been found at many localities in Wyoming which are not listed in this volume because of their great number and because of the widespread distribution of the mineral.

REPORTED OCCURRENCES

Albany County

Quartz crystals are abundant in the feldspar pits south of Laramie near the Colorado-Wyoming border (261). Many of the crystals, however, are fractured and not well formed (489).

Carbon County

Platt (498, pp. 227-230) reports small crystals of all colors along cracks in granite and in geodes, south of Battle Lake.

Converse County

Sandstones and limy sandstones in Box Elder Canyon contain small quartz crystals in geodes. The crystals are set in a layer of chalcedony (358, p. 24).

Aughey reported rose quartz near the place then known as Lankins Ranch in the Sweetwater district (16, p. 58).

TRIPOLI AND TRIPOLITE

Tripoli is a porous fine-grained light-colored earthy substance composed almost entirely of silica. Tripoli is formed by the weathering of siliceous limestone, cherty limestone, or cherts. Tripolite, or diatomaceous earth, is formed by deposition of siliceous parts of diatoms. The materials are used as abrasives.

REPORTED OCCURRENCES

Crook County

Extensive deposits of tripolite have been reported 35 mi. west of Sundance, and on Skull Creek, near Stockade (453, p. 809).

Laramie County

Small white nodules of tripoli with agate cores can be found on the gravel flats west of Cheyenne (217).

Platte County

Tripoli deposits in porous light-weight layers are abundant in the "Carboniferous formations" 8 mi. to 10 mi. north of Sunrise. These deposits are the result of the decomposition of highly siliceous limestone (26, p. 54).

RUTILE

Rutile, TiO_2, is rare in Wyoming. Kemp and Knight (394, pp. 325-6) report finding rutile and apatite in wyomingite on Steamboat Mountain in the Leucite Hills.

Aughey reported finding one specimen on the east end of Seminoe Mountain near the Platte River (16, p. 55).

SALINE DEPOSITS

The saline deposits in Wyoming are brines and solid salts found in depressions or undrained basins where the evaporation rate approximately equals the rate of water flow into the basin. The deposits are numerous throughout the state especially where Mesozoic and Cenozoic rocks crop out. The salts in the "soda lakes" are the same as the salts contained in the soil of the surrounding region, and probably accumulate by leaching. The salts form alkali crusts as they are drawn from the soil and left behind by evaporating water (412, p. 106). The lakes are also fed by brine springs. The thickness of the "lake" deposits is very irregular; usually the thickest deposits are near the center of the "lake."

The lakes are of two types: (1) sodium sulfate-sodium carbonate type or (2) sodium sulfate-magnesium sulfate type. The commonest salts in Wyoming "soda lakes" are glauberite, $Na_2SO_4.CaSO_4$; mirabilite, $Na_2SO_4.10H_2O$; and thenardite, Na_2SO_4. Natron or sal-soda, $Na_2CO_3.10H_2O$, and trona, $Na_2CO_3.HNaCO_3.2H_2O$, are common carbonate salts. Epsomite, $MgSO_4.7H_2O$, is abundant in several deposits, and salt NaCl, is common in the salt springs of Weston and Uinta counties. All are surface deposits except trona, which is found from 1,500 ft. to 1,600 ft. below the surface in a solid bed (99% pure) in Sweetwater county.

Uses for sodium carbonate compounds have increased greatly. Largest tonnages are used in the glass and cleanser industries. The alkalies are used in synthetic rubber, acrylic resin, insecticides, pharmaceuticals, fire extinguishers, foods, ceramics and many other items. Sodium sulfates are used as cattle tonics, kraft (wrapping) paper, glass, in the dye industry, and chemical industry, in electroplating, as a flux in metallurgy, and in detergent soaps. Magnesium compounds are used in medicines, synthetic rubber and the chemical industry (500).

Production from the Wyoming saline deposits started in the late 1800's, but has been recorded only since 1917. Sodium sulfate production was 7,426 tons in 1947, 5,347 tons in 1948, and 4,971 tons in 1949. A small amount of epsomite was produced and 30,404 tons of trona were produced during 1949 (583). Wyoming produced 1,200, 525 tons of trona and 1,329 tons of sodium sulfate in 1963 (611).

SALT (Halite)

Sweetwater County

Salt occurs in 16 widespread evaporite beds in the lower Wilkins Peak member of the Green River formation. Thirteen of these are known to contain salt associated with trona. Although the salt is usually mixed with trona, thin pure salt units, a few inches thick occur as part of a larger bed of mixed salt and trona (629). Love (652) however, states that one salt (halite) bed is 20 feet thick but does not indicate as to whether it is mixed with trona. The salt areas are located in the central part of the trona depositional basin (629).

SODIUM SULFATE-SODIUM CARBONATE

PRODUCING DEPOSITS

Natrona County

William E. Pratt of Casper produced 1,329 tons of sodium sulfate from saline deposits in the region around Natrona in 1963 (611).

PROSPECTS

Albany County

Downey Lakes. Three lakes occupy a northeast trending depression 2 mi. long and 1/2 mi. wide in Triassic rocks. The deposits are of the sodium sulfate-magnesium sulfate type and cover about 100 acres between the zero and 12 ft. depths (571; 219; 576, pp. 28-29).

North Downey Lake; SW1/4 sec. 15, T. 13 N., R. 75 W. The deposit covers 25.9 acres. The salt varies from zero to 8 ft. thick. Knight (402, p. 2) estimates 125,000 tons of available salt as 80% to 90% mirabilite and 5% to 10% epsomite. Insoluble residues total 7,000 tons and other salts about 2,000 tons. Analyses are as follows (402, p. 4):

Depth	Percent $Na_2SO_4.10H_2O$	Percent $MgSO_4.7H_2O$	Percent Residue	Percent Combined water as $MgSO_4.H_2O$
2 ft.	82%	8%	8.40%	1.18%
4 ft.	88	4	5.16	0.66
6 ft.	95	4	0.87	0.64
surface	92	1	0.39	0.18
2 ft.	90	4	7.03	0.59
4 ft.	87	6	5.25	0.90

	1	2	3	4	5
$Na_2SO_4.10H_2O$	50.90	92.54	26.61	47.18	95.46
NaCl	0.50	0.28	5.28	3.17	0.28
$NaCO_3$				0.18	
$MgSO_4$	48.60	5.29	70.11	49.47	4.26
$CaSO_4$		1.89			

(1) Crystallized salt in the middle of North Downey Lake.

(2) Clear crystal mixed with mud and water 6 in. below the surface.

(3) Solution above sample No. (2).

(4) Solution in blast hole from (2).

(5) Pure crystal at the north end of Downey Lake (523, p. 579).

Middle Downey Lake; SW¼ sec. 15, NW¼ sec. 22, T. 13 N., R. 75 W. In 1939, the lake was free of brine to a depth of 6 ft. in the thicker portion of the deposit. The deposit covers 32.8 acres and varies in thickness from zero to 12 ft. There are 222,027 estimated tons of salt, exclusive of the salt in the underlying mud bed. Analyses are as follows (402, p. 6):

Depth	Percent $Na_2SO_4.10H_2O$	Percent $MgSO_4.7H_2O$	Residue in assay sample	Combined water as $MgSO_4.H_2O$
Surface	96%	2%	0.16%	0.29%
2 ft.	86	9	7.61	1.44
4 ft.	83	7	10.56	0.95
6 ft.	70	8	15.04	1.05

Southern Downey Lake; located 3,000 ft. southwest of Middle Downey Lake, is the largest of the three. Surface area is 38.3 acres. A thin salt crust covers the surface; below the crust mud is mixed with salt crystals. Analyses are as follows (402, pp. 6-7):

Depth	Residue%	CaO%	MgO%	SO_3%	Cl%	Na_2O%	Combined H_2O as $MgSO_4.H_2O$
Surface	28.25	3.04	5.22	36.45	0.3	19.63	2.33
Dark muck 3 ft.	0.39	0.00	13.76	54.56	0.18	23.34	6.14

Shultz (523, p. 579) gives the following analyses from Southern Downey Lake:

	$Na_2SO_4.10H_2O$ Percent	NaCl%	Na_2CO_3%	$MgSO_4.7H_2O$ Percent
S. Lake	47.74%	1.86%	0.24%	50.16%
Crystallized salt from ditch in S. Lake	39.18	1.00		59.82

Union Pacific Lakes; Big Lake, Track Lake and Red Lake, secs. 2, 3, 4, 5, T. 14 N., R. 75 W., 13 mi. southwest of Laramie. In 1885 the Union Pacific Railroad built a spur to the lakes and salt cake, soda ash and caustic soda were produced at Laramie for several years. Some salt was also used for glass manufacture (576, pp. 30-31). Analyses of Union Pacific Lake salts are as follows:

	1	2	3	4	5
Na_2SO_4	96.37%	94.23%	44.58%	41.44%	39.78%
NaCl	1.58	3.14			
$MgSO_4$	2.05	2.63			
H_2O			54.98	54.79	59.66
Insol.			0.47	3.80	0.56

(1) Marketable dried soda. Analysis by Slosson (523, p. 579).
(2) Same. Analysis by Pemberton and Tucker (523, p. 579).
(3, 4, 5) Analyses in report (505, p. 48).

The four deposits cover about 60 acres and are from zero to 12 ft thick. Rocks of the Benton group underlie the lakes. Many small depressions near the lakes contain small quantities of alkaline waters or salts (523, p. 577). The subsequent construction of an irrigation canal resulted in seepage into the lakes and drain ditches were excavated. It is probable that salts have been flushed from the original lakes but there is no analytical information to support this belief.

Carbon County

Bull Lake; secs. 22, 23, 26, 27, T. 25 N., R. 89 W., 25 mi. north of Rawlins. Bull Lake covers approximately 82 acres and is underlain by rocks of Upper Cretaceous age. The salt bed ranges from 2.5 to 26 feet thick and is almost pure mirabilite. Mud and sand are the main impurities (583a). Iowa Soda Products Co. and Sweetwater Chemical Co. (succeeded Iowa Soda Products Co., April, 1957) produced sodium sulfate from the deposit almost continuously from 1928 to 1961 (583a, 613).

Dillon. These salt deposits are located in T. 22 N., R. 86 W., 7 mi. northeast of Rawlins and are underlain by Cretaceous rocks. The surface of these salt deposits have 88.92% $Na_2SO_4.10H_2O$, 2.35% NaCl and 8.73% $MgSO_4.7H_2O$ (523, p. 579).

Morgan Lake; T. 28 N., R. 88 W., a few miles south of the Sweetwater River. The deposit covers about 160 acres and is 12 ft. thick, as shown by pits. The soda (carbonate and sulfate) is clear and transparent when fresh, but effloresces when exposed to the air (505).

Rankin; 3 mi. northeast of Brown's canyon in T. 22 N., R. 86 W. The underlying rocks are Cretaceous. The sodium sulfate and carbonate deposits cover several acres and are usually under water (523, p. 577).

Percy; 5 mi. south in T. 21 N., R. 82 W. A small pond contains salines in a clay. An analysis by Woodward gives: $CaSO_4$=4.45%, $MgSO_4$=48.28%, $NaSO_4$=46.27%, NaCl=0.74% (576, p. 30).

Fremont County

Endlich (192, p. 150) described an "alkaline efflorescence deposit" 7 mi. west of St. Mary's station in the Sweetwater valley. The analysis showed 88.93% Na_2SO_4 and 11.63% NaCl.

A deposit near Pacific Springs contained 82.23% Na_2SO_4, 3.95% NaCl, and 14.82% Na_2CO_3 (192, p. 150).

Saline residue of water from a pond near the Big Sandy River has the following composition (192, p. 150):

	1	2	3
Na_2SO_4	64.65%	94.92%	100.00%
NaCl	35.46	5.23	

(1) From upper part of the bank where deposition commenced.

(2) From half way between the upper and lower limits of the deposit.

(3) From the lowest part of the pond.

Johnson County

Lake de Smet; T. 52 N., R. 82 W. An analysis of the lake water showed Na_2SO_4 with some $MgSO_4$ and $CaCO_3$. The salinity, however, is only 6,708 parts per million. The waters feeding the lake are more dilute and carry $CaCO_3$ (576, pp. 20, 29-30). Analysis: Cl=0.86%, SO_4=61.55, CO_3=1.00, HCO_3=7.99, Na=20.00, K=1.22, Ca=1.05, Mg=6.06, SiO_2=0.21, Fe_2O_3=0.05 (576, p. 20).

Natrona County

Independence or Dupont Deposits. These deposits comprise the Berthaton claims and the Dupont claims and are located in two old channels of the Sweetwater River, somewhat north of its present course, near Independence Rock. The deposits are superficial (1 ft. to 2 ft. thick) and rest on Tertiary rocks. The Dupont claims lie along the southern channel; the Berthaton claims along the northern channel (523, p. 577; 576, p. 29).

Berthaton Claims; NE¼ T. 30 N., R. 86 W. Two lakes cover from 80 to 640 acres in an area of Tertiary rocks. Analyses of samples collected by W. C. Knight in 1897, and analyzed by Slosson (523, p. 579; 412, p. 121; 408, p. 6), show the deposits to be of the sodium sulfate-sodium carbonate type.

	1	2	3	4
Na_2SO_4	17.26%	37.36%	34.27%	20.44%
NaCl	11.69	6.30	6.16	13.84
Na_2CO_3	55.50	50.26	59.57	65.72
$NaHCO_3$		6.08		

(1) Sample of brine from upper Berthaton lake.
(2) Surface sample—clear crystals.
(3) Representative sample of deposit in Yale lake.
(4) Solution from upper lake.

New York and Philadelphia Claims. These claims, in sec. 12, T. 29 N., R. 87 W., are both on one solid "lake" covering a total of 110 to 160 acres. The salts are from zero to 20 ft. thick. The deposits "are very near the granite exposures that extend north from Devil's Gate" (412, p. 100). Weeks, in 1885, put down two bore holes; one 50 ft. from shore which disclosed 4 ft. of solid soda; the other hole, 230 ft. from shore, passed through 14 ft. of solid soda (574, p. 553). Three analyses by Slosson in 1899 are given below (412, p. 123; 523, p. 579; 574, pp. 551-54).

	1	2	3
Na_2SO_4	78.86%	70.66%	95.58%
NaCl	8.20	11.62	1.80
Na_2CO_3	12.94	17.72	2.62

Omaha Soda Deposit; in about sec. 34, or 35, T. 30 N., R. 86 W. The deposit covers from 4 acres to 20 acres and is zero to 8 ft. thick. This deposit has a greater percentage of sodium carbonate and bicarbonate than other nearby lakes. The salt was used by the Latter Day Saints for raising bread during the nineteenth century (523, p. 577). Analyses:

	1	2	3	4
Na_2SO_4	41.51%	12.67%	9.49%	16.36%
NaCl	7.74	0.09	4.84	4.05
Na_2CO_3	43.02	87.24	85.67	60.62
$NaHCO_3$	7.73			18.97
Water				
Insol.				
	5	**6**	**7**	**8**
Na_2SO_4	37.20%	17.02%	59.29%	65.08%
NaCl	3.14	0.81	0.65	0.32
Na_2CO_3	59.66	80.60	27.60	16.70
$NaHCO_3$				
Water			5.63	
Insol.			1.20	

(1) through (5) analyzed by Slosson (412, p. 121).
(1) Surface sample collected in 1897.
(2) Average of upper 10 in., collected in 1897.
(3) Average 10 in. to 14 in., collected in 1897.
(4) Average 14 in. to 17 in., collected in 1897.
(5) Depth 2 ft., collected in 1897.
(6) through (8) collected in 1885 or earlier (574, pp. 553-554).
(7) Near the surface.
(8) Five feet below the surface.

Wilmington and Wilkesbarre Deposits; secs. 2, 3, 10, 11, T. 29 N., R. 86 W. The Wilmington covers 160 acres of alkaline lake water and is separated from the Wilkesbarre by a small ridge to the east. The Wilkesbarre deposit covers about 20 acres. The soda is in solution in both deposits (523, p. 580).

	1	2	3
Na_2SO_4	55.14%	95.80%	24.40%
NaCl	7.47	0.60	17.71
Na_2CO_3	37.42	3.60	57.89

(1) Shore sample.
(2) Bottom of lake.
(3) Lake water, specific gravity, 1.104.

Morgan Deposit; 7 mi. below Split Rock post office and south of the Sweetwater River in T. 28 N., R. 88 W. The deposit covers about 100 acres, is zero to 15 ft. thick and rests on Tertiary rocks. This lake lies in a narrow depression south of the Sweetwater river. The following analyses by D. H. Attfield were first published in 1895 in the Jour. Soc. Chem. Ind. (523, p. 580):

	Top crust	New deposit	Old deposit
Na_2SO_4	91.60%	96.14%	95.24%
NaCl	1.68	1.68	1.33
Na_2CO_3	6.72	2.18	3.43

Secs. 19 and 20, T. 29 N., R. 88 W. A small mud lake has a thin crust of Na_2SO_4 which covers about 100 acres but only 6 acres contain salts to an "appreciable depth." Impure mirabilite with about 25% sand and mud makes up most of the deposit (576, p. 30).

An alkali lake 2 mi. east of Independence Rock was analyzed prior to 1877: Na_2SO_4=73.17%, NaCl=3.85%, Na_2CO_3=22.98% (192, p. 150).

Sweetwater County

In T. 23 N., R. 104 W., east of Boar's Tusk and also north and east of Black Rock, in T. 22 N., R. 101 W. are numerous alkali flats which contain sodium carbonate and traces of sodium sulfate salts. The salts were probably derived from the Green River shales (523, pp. 572-575), (See REPORTED OCCURRENCES).

Green River Area. Numerous wells in the area around the town of Green River encountered Na_2CO_3 at depths from 125 ft. to 300 ft. A plant, constructed before 1900, produced 100 tons of caustic soda and 150 tons of washing soda in 1904 (523, pp. 583-588). The project was abandoned long ago. An analysis of Green River soda is as follows: SiO_2=0.51%, $Fe_2O_3+Al_2O_2$= 0.42%, CaO=0.64%, MgO=0.27%, Insol.=0.23%, water=22.57%, Na_2CO_3 =75.36% (523, p. 587).

T. 22 N., R. 96 W. A brine layer 20 ft. thick under a playa lake at the head of Black Rock Creek contains 7.7% total salts—K_2O with 20% or slightly more Na_2O (220).

REPORTED OCCURRENCES

Albany County

Mirabilite was found with gypsum and bentonite at the old quarry ¼ mi. north of Rock Creek Railroad station (410, pp. 600-1).

Carbon County

A U. S. Geological Survey map (152) shows symbols for sodium sulfate and carbonate deposits at the following general locations. No other data are known regarding these deposits:

(1) SE¼ T. 25 N., R. 88 W.; (2) In the south-central part of T. 26 N., R. 89 W.; (3) At a lake in T. 23 N., R. 87 W.; (4) SW¼ T. 22 N., R. 84 W.

Converse County

A U. S. Geological Survey map (152) also shows alkaline salt deposits in T. 36 N., R. 76 W., near the head of Sage Creek in NW¼ T. 35 N., R. 73 W., and the SW¼ T. 34 N., R. 71 W., northeast of Orpha Station.

Hot Springs County

"Glauber's salt (mirabilite) was identified as the principal mineral in a sample of material sent the U. S. Geological Survey from Thermopolis" (576, p. 30).

Park County

Holmes Lake, in T. 53 N., R. 102 W., 2½ mi. northwest of Cody is reported to contain mirabilite. This lake covers about 5 acres (576, p. 29).

Southwest of Cody in sec. 14, T. 52 N., R. 102 W., a small lake is reported to contain sodium sulfate (576, p. 29).

Sublette County

A lake in about T. 35 N., R. 109 W., due north of Pinedale, contains Na_2SO_4 and Na_2CO_3 salts (152).

Sweetwater County

Many small alkali flats and depressions in the Red Desert area contain sodium carbonate salts. No detailed work has been published on these deposits and very little actual data are known. A U. S. Geological Survey map (152) shows the following locations:

(1) Center of T. 24 N., R. 99 W.; (2) Three deposits in the E½ T. 24 N., R. 97 W. (probably a series of lakes); (3) NW¼ T. 24 N., R. 96 W.; (4) A lake in the SW corner of T. 24 N., R. 75 W.; (5) Near the center of T. 23 N., R. 93 W.; (6) At a lake along Black Rock Creek in T. 22 N., and on a line between Rs. 100 and 101 W.; (7) Near the center of T. 22 N., R. 99 W.; (8) At the southwest corner of T. 23 N., R. 98 W.; (9) Along the line between T. 20 N., Rs. 103 and 104 W.; (10) In the extreme northeast corner of T. 19 N., R. 103 W. along the Union Pacific Railroad; and (11) East-central part of T. 19 N., R. 110 W. along the Union Pacific Railroad.

MAGNESIUM SULFATE (EPSOMITE)

PROSPECTS

Albany County

Downey Lakes. These lakes carry from 5% to 10% $MgSO_4$; (See SODIUM SULFATE-SODIUM CARBONATE).

Pazeka Lake, 16 mi. northeast of Medicine Bow (probably part of the Rock Creek group of lakes). This lake contains 99.5% $MgSO_4.7H_2O$ (217).

Rock Creek Lakes; secs. 20, 21, 28, 29, T. 23 N., R. 76 W. 12 mi. east of Medicine Bow, north of the Union Pacific Railroad. Twenty-six small lakes occupy a depression in the Triassic Chugwater shales and sandstones. The lower parts of the depressions contain more $MgSO_4$; the higher parts contain Na_2SO_4 (523, p. 577; 403, pp. 1-3). Recent development work has been done by Epsom Downs, Medicine Bow, a firm organized to exploit the deposits. As yet there have been no shipments made, although a considerable tonnage has been stockpiled.

Brooklyn Lake; SW¼ sec. 28, and NW¼ sec. 3, T. 23 N., R. 76 W. This lake covers 116.4 acres. The surface has a salt crust from zero to 6 in. thick, and a layer of black mud from zero to 6 ft. thick contains salt. Analyses are as follows (403, pp. 3-6):

	1	2	3	4	5
Na_2SO_4	7.7%	3.0%			
$MgSO_4$	83.6	88.4			
Residue	0.0	0.0	0.11%		
Combined H_2O					
as $MgSO_4.H_2O$	11.6	12.2	49.75		
SO_3			33.08		
MgO			16.26		
NaCl			0.21	0.69%	5.28%
Na_2O			0.43		
Recast:					
$Na_2SO_4.10H_2O$			0.03		
$MgSO_4.7H_2O$			96.8		
Na_2SO_4				22.13	25.61
$MgSO_4$				77.18	70.11

(1) Sample at surface of Brooklyn Lake (403, p. 3).
(2) Same.
(3) Sample of pure salt collected by Rickets in Dec. 1887 (403, p. 3).
(4) Sampled Feb. 1898 by W. C. Knight (403, p. 5).
(5) Sample collected in 1903 by W. C. Knight (403, p. 5).

S. H. Knight (403, p. 5) estimated that there are 1,500 tons of mirabilite, $Na_2SO_4.10H_2O$, on the surface and 100,000 tons in the black mud, and 25,000 tons of epsomite, $MgSO_4.7H_2O$, on the surface and 150,000 tons in the black muds.

Philadelphia Lake; SW¼ sec. 21, and SE¼ sec. 20, T. 23 N., R. 76 W. Soft black mud covered the lake as late as 1935 and sodium salts were scattered over the mud surface. The lake covers about 40 acres and has an irregular outline.

	1	2	3
Insol. residue	3.38%	1.39%	60.26%
Water	48.90	11.48	1.50
SO_3	31.33	51.98	17.48
MgO	15.62	24.85	3.35
NaCl	0.44		
Na_2O	0.07	8.79	2.88
CaO			6.94
Cl		1.28	0.60
% mirabilite		21.00	13.00
% epsomite		75.00	17.00

(1) Ricketts analysis of salts in 1880 (505, p. 54).
(2) Knight (403, p. 8) analysis of Philadelphia Lake surface sample.
(3) Knight (403, p. 8) analysis of mud.

Other lakes in the Rock Creek group include Nos. 1, 2, 3, and 4 (403, pp. 7-8) with the following analyses:

	Lake No. 1	Lake No. 2	Lake No. 3	Lake No. 4
% residue	0.0%	0.05%	0.11%	0.46%
MgO	24.8	21.00	28.25	27.91
SO_3	54.5	52.85	55.07	55.77
Cl	0.8	1.80	0.76	0.34
Na_2O	4.5	12.19	1.97	2.92
Combined H_2O				
as $MgSO_4.H_2O$	11.2	9.36	12.60	12.46
% epsomite	79.5	65.00	89.00	87.00
% mirabilite	12.3	28.00	5.00	8.00

Union Pacific Lakes; Big Lake, Track Lake, and Red Lake, secs. 2, 3, 4, 5, T. 14 N., R. 75 W., 13 mi. southwest of Laramie. In 1885 the Union Pacific Railroad built a spur to the lakes and salt cake, soda ash and caustic soda were produced at Laramie for several years. Small amounts of $MgSO_4$ are shown in the analyses of these deposits; (See SODIUM CARBONATE-SODIUM SULFATE).

Carbon County

Bothwell Lake; (See SODIUM SULFATE-SODIUM CARBONATE).

Dillon Deposit; (See SODIUM SULFATE-SODIUM CARBONATE).

"Near Medicine Bow, Wyoming is located a playa lake deposit of $MgSO_4$ upon which our consulting chemist has returned an analysis: $MgSO_4$=53.89%, $MgCl_2$=0.38%, H_2O=45.67%, insol.=0.60%. An analysis in U. S. Geol. Survey Bulletin 364 gives $MgSO_4$=51.22%, water=47.83%, NaCl, CaCl, and $MgCl_2$=0.42%, Fe=trace, insol.= 0.08%, loss=0.45%" (229).

Morgan Lake; (See SODIUM SULFATE-SODIUM CARBONATE).

Percy Deposit; (See SODIUM SULFATE-SODIUM CARBONATE).

Converse County

Poison Lake; 17 mi. southwest of Douglas. Reported to contain 53% $MgSO_4$ (217).

SODIUM CHLORIDE

PROSPECTS

Albany County

Downey Lakes; (See SODIUM SULFATE-SODIUM CARBONATE).
Union Pacific Lakes; (See SODIUM SULFATE-SODIUM CARBONATE).

Carbon County

Bothwell Lake; (See SODIUM SULFATE-SODIUM CARBONATE).

Fremont County

Deposit near Pacific Springs; (See SODIUM SULFATE-SODIUM CARBONATE).

Pond near Big Sandy River; (See SODIUM SULFATE-SODIUM CARBONATE).

Lincoln County

"The springs occur in the valley bottoms in barren patches of stoney clay or gravel, which are rendered soggy by the contained brine." The brines in this region are associated with late Cenozoic red clays and in Pleistocene valley deposits (142, p. 562). The salt was probably leached by groundwater from the red sandstones, conglomerates, and shales of the Beckwith formation and concentrated along small anticlinal axes (142, pp. 566-567).

SW¼ sec. 26, T. 29 N., R. 119 W., 7 mi. or 8 mi. northeast of Green's Ranch, on Salt Creek. Analysis of the Idaho-Wyoming salt deposits are: $NaCl=98.90\%$, $CaSO_4=0.817\%$, $KCl=0.261\%$, $MgCl_2=0.22\%$ (142, p. 558; 525, p. 136).

Crow Creek (near Afton) Deposit. Rock salt occurs in a basin-like depression about 100 yds. in diameter and lies only 1 to 3 ft. below the surface. The salt is clear, hard, glossy and relatively pure below. Production and shipments from the deposit have been spasmodic and local (442a, p. 339).

Peale (493, p. 645) noted halite in the springs in Salt River valley and on Smoking Creek (now called Stump Creek). The monthly production in 1877 was 200,000 lbs. but there has been none for many years.

Natrona County

Independence Group

Berthaton Claims; (See SODIUM SULFATE-SODIUM CARBONATE).

New York and Philadelphia Claims; (See SODIUM SULFATE-SODIUM CARBONATE).

Omaha Claim; (See SODIUM SULFATE-SODIUM CARBONATE).

Wilmington and Wilkesbarre; (See SODIUM SULFATE-SODIUM CARBONATE).

Morgan Deposit; (See SODIUM SULFATE-SODIUM CARBONATE).

Uinta County

Peale reported halite in springs at Evanston (493, p. 200).

Weston County

Sec. 4, T. 46 N., R. 61 W.; 5 mi. northeast of Cambria, at the head of Salt Creek. The brine creek issues from the red shales of the Spearfish formation and has a flow of one gallon per second, or 35,000 lbs. of salt every 24 hours (167, p. 392). Analysis: $NaCl=5\%$, $K_2O=0.20\%$, $MgO=0.04\%$, $Na_2O=2.73\%$, $SO_3=0.36\%$, $Cl=0.15\%$ (165, p. 9).

Sec. 9, T. 46 N., R. 61 W.; 9.1 mi. north of Newcastle and 1.8 mi. north of Cambria Museum on U. S. Highway No. 85. The rocks in the walls and bottoms of canyons are redbeds and white gypsiferous beds of the Spearfish formation. Three wells in the area discharge salt brine about 75 ft. below the top of the Spearfish formation. Regional dip is south-southwest (277).

TRONA

BY H. D. THOMAS

Trona is a mineral composed of hydrous sodium carbonate and sodium bicarbonate or, in a general way, it is a mixture of washing soda and baking soda. Technically it is known as sodium sesquicarbonate and its chemical formula is $Na_2CO_3.NaHCO_3.2H_2O$.

Sodium carbonate brines were discovered in the early days in the vicinity of the town of Green River, Sweetwater County, and a well drilled in 1896 struck a flow of alkali water at a depth of 125 ft. The early development and utilization of these sodium carbonate brines, between 1896 and 1910, are described by Schultz (523, pp. 583-588). For some time caustic soda and washing soda were produced at Green River but the industry eventually failed.

In 1938, the Mountain Fuel Supply Company drilled its No. 1 Hay well, in sec. 2, T. 18 N., R. 110 W., between Green River and Granger. Cores taken in the Green River formation, a succession of lake deposits of Eocene age, showed "sodium salt" crystals and stringers between 1190 ft. and 1820 ft. At a depth of 1590 ft. a 16 ft. bed of this material was cored. Dr. W. T. Nightingale, of the Mountain Fuel Supply Company, noted the salt and sent samples to the U. S. Geological Survey. Chemical analyses indicated the material to be nearly pure trona (272, pp. 1799-1800). In 1940 the Union Pacific Railroad drilled two core holes which penetrated solid trona and outlined a body of trona of minable thickness over an area of approximately 12 mi. In 1941 two additional core holes were put down which further confirmed the extent of the deposit.

Soon thereafter the Westvaco Chlorine Products Company undertook a development program to recover trona. Attempts were made first to obtain it from brine wells, but this method proved impractical and was abandoned. In 1947, this concern completed the sinking of a 1600 ft. shaft along the Union Pacific Railroad at a siding now known as Westvaco, in sec. 15, T. 19 N., R. 110 W., a few miles east of the town of Granger. Surface facilities consisting of equipment for sizing and for calcining were later completed. In 1953 this company, now known as Food Machinery Chemical Corporation, completed a second shaft to the trona horizon along with greatly expanded surface facilities for the production of refined soda ash. Various improvements, including a third shaft have been completed, and the production capacity now stands at 900,000 tons per year of refined soda ash with an anticipated increase to 1.25 million tons annually. The mine and surface operations are noted for their modern and efficient equipment and methods.

The trona bed where being mined by FMC, lies at about the 1500-foot level, is substantially horizontal and is about 11 feet thick. The rock is not chemically pure, but contains shale inclusions, ordinarily aggregating less than 5% by weight. In addition to trona, Bradley (138, p. 642) has listed other carbonate minerals known from the Green River formation. These are shortite, pirssonite, northupite, gaylussite, bromlite and bradleyite which occur either as beds of evaporates or as crystals that grew in muds.

Drilling of wells in the Church Buttes gas field along the Sweetwater County and Uinta County line, about 16 mi. southwest of the Westvaco area, in Tps. 16 and 17 N., R. 112 W., indicates that the trona extends at least that far westward. In the Church Butte field the trona lies at dephs ranging from 2600 ft. to 2800 ft. Two wells along the western margin of the field did not show trona, suggesting that the wells were located to the west of the limit of deposition of trona. There are 23 major trona beds, one of which has a thickness of 40 feet, in the Wilkins Peak member of the Green River formation (652). Approximately 360 square miles in the Green River Basin is underlain by trona.

Mr. John R. MacDermott (245), of Rock Springs, since 1949 has been engaged in the drilling of wells yielding flowing sodium carbonate brines. The information here presented has been given by Mr. MacDermott. Four wells have been drilled in the vicinity of Eden, in the northwest part of T. 23 N., R. 106 W. and the eastern part of T. 23 N., R. 107 W. The first well is said to have flowed about 5,000 bbls. of sodium carbonate brine a day from a depth of 477 ft. The second well had a somewhat smaller flow from a depth of about 515 ft. The last two wells encountered trona brines at similar shallow depths. Tests on the brines from the first three wells made for Mr. MacDermott by Roland I. Andreau, Chemical Engineer, Sherman Oaks, California, indicate an average composition, based on 44 analyses, as follows: Specific gravity=1.06%; Na_2CO_3=4.46%; $NaHCO_3$ =1.01%; and K_2CO_3=0.03%. Traces of calcium carbonate, magnesium carbonate, chlorides, sulphates and borates are present. According to Andreau, this is equivalent to 5.47% anhydrous sodium carbonate in the solution, or translated into anhydrous soda ash the percentage would be 5.01%. Although the total potentialities of the trona brines so far encountered in the Eden area can not be definitely decided as yet, it appears that a large volume of brine carrying from 4% to 5% sodium carbonate is available in that region.

In 1962, Stauffer Chemical Company started full operation of its trona mine, and are currently producing 400,000 tons annually from an ore body at a depth of 900 feet. In 1966 the company intends to double its production capacity. Allied Chemical Company's mine and plant is expected to be in operation in 1966, with an initial production of 300,000 tons of soda ash per year. Because of these developments, the Green River is now the largest producer of soda ash and products from trona in the United States.

Soda ash, produced through calcining trona, has many uses but the largest amounts are used in the manufacture of glass, inorganic chemicals, water softeners, soap and detergents, textiles, dyes, pulp and paper, and in the petroleum industry.

The following papers may be consulted for further generalized information pertaining to the trona in the Green River Basin. Bradley has discussed the composition and origin of the sodium salts in the Green River Shale (138). Fahey has described three new minerals from the Wyoming trona deposits; shortite (195), bradleyite (198), and loughlinite (196). In addition, Fahey has described the searlesite in the Green River formation (196, p. 148). Greene has briefly described the early exploration for trona in the Green River Basin (272, pp. 1799-1800). Brief discussions of trona in Wyoming are given by Ralston (500, pp. 945-964), by Smith (535, pp. 32-34), and Mendenhall (450, pp. 11-12). A comprehensive unpublished report prepared by P. L. Brown, "Occurrence and origin of the known trona deposits, Sweetwater and Uinta Counties, Wyoming," may be consulted in the University of Wyoming Library (145). Recent work by Lindeman (591) covers the factors which may affect the development of the brine and trona deposits of Sweetwater County. Other papers of interest on trona, include those by Bradley (623), Deardorf (629), and Love (652).

SELENIUM

PROSPECT: (See URANIUM)

Fremont County

Poison Draw area; sec. 34, T. 40 N., R. 90 W. In 1955, 11 holes were drilled by the Bureau of Mines in a seleniferous tuff deposit in this region. Two hundred and six drill samples were assayed. Eight showed 0.005% Se and 2 showed 0.012% Se. Selenium mineralization is erratically distributed in small irregular bodies and is not confined to any one tuff bed. The deposit could be cheaply mined (585).

SERICITE

Sericite is a very fine-grained, greasy-feeling form of muscovite found in metamorphic schists. It is a low temperature mineral probably formed by hydrothermal alteration of feldspar. This finely-divided form of muscovite is used as a fireproofing material, as a lubricant, as a heat insulator, and as an active flux in the ceramic industry.

PROSPECTS

Albany County

Friday No. 2 Prospect. There are four claims in sec. 6, T. 23 N., R. 69 W. A number of pits have been dug in a sericite-quartz schist that trends roughly north-south and dips steeply to vertically. The schist zone varies from "several feet" up to 40 ft. wide and contains interlayered granite dikes and quartz veins (293).

Nipper No. 1 Prospect; (see TALC).

Carbon County

Paine Deposit; (See VERMICULITE).

Pinyon Claims; sec. 20, T. 14 N., R. 83 W., 6 mi. from Encampment. A high-grade sericite zone 2 ft. wide contains associated kyanite in an acidic rock matrix (282); (See KYANITE).

Natrona County

Vermiculite Sales Corp. Deposit No. 1; (See VERMICULITE).

Platte County

Collins and Groves Deposit; secs. 5, 8, T. 23 N., R. 70 W. Between 300 tons and 350 tons of sericite have been shipped from this deposit, some of which was used as insulation in the concrete floors of the Remington Arms Plant near Denver (now the Denver Federal Center). According to the owners of the claim, there are 150,000 tons estimated reserves of sericite. The sericite is soft, pure, and lies in a zone from 2 ft. to 5 ft. wide that trends northeast and stands vertically. The sericite schist is interlayered with hornblende schist, granite pegmatite and quartz stringers (326).

SHERIDANITE

Sheridanite is a distinct well-foliated, talc-like variety of chlorite (581). It is named after Sheridan County, where it was first found and identified.

PROSPECTS

Sheridan County

Little Falls Claim: sec. 10, T. 53 N., R. 84 W., about 150 yds. downstream from the lower falls on North Piney Creek. Well-foliated soft, greasy-feeling, dark green to light-tan sheridanite is associated with dark-gray fine-grained cataclastic rocks along the south bank of Piney Creek. The sheridanite body strikes N. 50° E. and dips 85° NW. to vertically; it crops out for about 200 ft. in ledges up to 35 ft. wide (471). An analysis is: $SiO_2=28.81\%$, $Al_2O_3=26.43\%$, $Fe_2O_3=0.24\%$, $MgO=31.21\%$, $FeO=0.40\%$, $H_2O=12.62\%$, $Na_2O=0.35\%$, $K_2O=0.14\%$ (581, pp. 475-476).

SILVER

There are no producing silver mines in Wyoming. A small amount of silver has been produced from ores associated with copper and lead deposits; total production is estimated at 58,019 troy ounces, most of which probably was a by-product from copper ores.

Silver minerals are widely scattered through the pre-Cambrian mountain cores and in the Tertiary volcanic rocks near Yellowstone National Park. Because of transportation difficulties and the small size of most of the deposits, it is not likely that large scale production can be undertaken in the near future.

PROSPECTS

Albany County

Big Strike Mining Claim; La Plata—Centennial—District; (See LEAD).

Copper King; (See LEAD).

Copper Queen; Jelm Mountain area; (See COPPER).

Esterbrook Mine; (See LEAD).

Independence Group; (See GOLD).

Rambler Mine; at Holmes. A gossan contained about 9 oz. of silver per ton with a trace of gold. Copper has been entirely leached from the gossan, but below it copper silicates and carbonates were found (191, p. 97); (See COPPER, ARSENIC, PLATINUM and PALLADIUM).

Rising Sun Claim; (See LEAD).

Strong Mine; southern Laramie Range area; (See COPPER).

Tenderfoot Group; War Bonnet Group; (See COPPER).

Three Cripples Mine; Esterbrook area; (See GOLD).

Telephone and North American Claims; La Plata (Centennial) district. Vein material from these claims is reported to have assayed up to 2000 oz. of silver per ton (33, p. 12).

Ulcahomo; (See GOLD).

Carbon County

Albion Claim; (See LEAD).

Cumberland Group; Medicine Bow Mountains area; (See COPPER).

Elk Mountain Prospect; Medicine Bow Mountains area; (See COPPER).

Ferris Mountains; (See LEAD).

Fox Group; Medicine Bow Mountains area; (See COPPER).

Independence Group; Sierra Madre area; (See COPPER).

Meta Mine; (See LEAD).

North Fork Group; Sierra Madre area; (See COPPER).

Pease Placers; Sierra Madre area; (See GOLD).

Spanish Trails Group; (See LEAD).

Three Forks Group; Sierra Madre area; (See COPPER).

Sec. 5, T. 12 N., R. 83 W.; (See LEAD).

Sec. 21, T. 14 N., R. 84 W.; 4½ mi. from Encampment; (See GOLD).

Converse County

Saul's Camp; (See COPPER).

Crook County

Black Buttes; central part of T. 50 N., R. 62 W. A small amount of galena with silver minerals is found in limestone along the contact with phonolite (166, p. 12); (See LEAD).

Fremont County (See GOLD)

Battle Creek; (See LEAD).

Copper Glance Group; Bridger District; (See COPPER).

Duncan Mine; Sweetwater District; (See GOLD).

Mascotte Claim; Bridger District. A 1 ft. vein and 2 ft. of hard slaty shale strike northwest and dip southwest; they carry limonite and copper oxides. The vein contains 20 oz. of silver per ton (16, p. 8).

Riverton Mining Co.; Bridger District; (See GOLD).

Wyoming Copper Mining Co.; Atlantic City-South Pass area; (See COPPER).

Yankee Jack Mine; Bridger District. A "fissure" 13 ft. wide strikes northwest and dips 70° SW; it contains an ore body 1 ft. to 3 ft. thick which is rich in silver, mostly "silver sulfide." The fissure also contains some "fine specimens of native bismuth." The foot-wall is talcose slate, the hanging-wall chlorite slate (16, p. 8).

Goshen County

Copper Belt Mining Co.; Hartville area; (See COPPER).

Laramie County

Arizona Mine; (See COPPER).

Agat Prospect; (See GOLD).

Bon Brothers Prospect; (See COPPER).

Colorado Lode (formerly Metcalf); (See GOLD).

Fairview Claim; (See COPPER).

Great Standard Group; (See GOLD).

Hecla; (See ZINC, COPPER).

Lenox Mine; (See LEAD).

Lincoln County

Hobble Creek; (See COPPER).

Park County

Kirwin District; (See COPPER).

Sunlight Basin District; (See COPPER).

Platte County

Charter Oak; (See COPPER).

Copper Bottom; (See COPPER).

Green Mountain Boy; (See COPPER).

Haystack Peak; (See COPPER).

Independence Group; (See PYRRHOTITE).

Whippoorwill Claim; (See COPPER).

REPORTED OCCURRENCES

Albany County

Argentite; reported with other ores near Laramie Peak (515, p. 214).

Big Horn County

In sylvanite; (See GOLD).

Carbon County

Argentite; Ferris Mountains in minute quantities (16, p. 54).

Converse County

Reported from the Runningwater Mine (377)

Fremont County

Cerargyrite; associated with other minerals in the Wind River Mountains Mines (515, p. 214).

Johnson County

Sec. 5, T. 48 N., R. 85 W., on the southwest slope of a high ridge north of U. S. Highway No. 16, at timberline. A large area of Felsenmeer contains blocks of pre-Cambrian gneiss up to the size of houses. A claim has been staked for silver on top of one of the blocks (482).

STONE

"Stone" is a term applied to any natural material used as dimension stone (cut to specific sizes and shapes), or crushed or broken stone. Industrial stones are classified according to their composition and texture. The stones used commercially in Wyoming include: (1) granite, (2) basalt or other dark basic rock, (3) sandstone and quartzite, (4) limestone, (5) cement rock, and (6) marble.

Chief uses for dimension stone are building and monumental purposes, paving blocks, curbing material and flagging. Stone used for buildings and monuments should contain no minerals (pyrite) that will stain the stone on weathering. Uses for crushed stone include the cement industry, railroad ballast, road metal, riprap, in agriculture, as an asphalt filler, in sugar refining and glass manufacture, as roofing granules, poultry grit, and in concrete blocks.

The supply of most types of stone in Wyoming is unlimited and production can be expanded to meet demand. The larger better-known quarries are discussed below. In 1955, 1,370,296 tons of stone, including sand and gravel, were produced in the State, and in 1956, 1,533,476 tons were produced (611). The Union Pacific Railroad, the Chicago and Northwestern Railroad and the Chicago, Burlington and Quincy Railroad used a total of 1,181,726 cu. yds. of crushed stone in 1948, and 1,354,473 cu. yds. in 1949. There is no record of the amount of stone used locally for small projects (583).

CRUSHED ROCK

PRODUCING QUARRIES

Laramie County

Granite Canyon; NW¼ T. 13 N., R. 69 W., along the Union Pacific Railroad tracks and U. S. Highway No. 30. The large open pit in the Sherman granite has been operated by Morrison-Knudsen Company since 1944 and is the source of track ballast for the Union Pacific Railroad. The rock is a coarse-grained reddish granite which lacks tenacity (451, p. 265) and is easily shattered. In 1963, 422,746 tons of crushed granite were produced (611).

Platte County

Guernsey Area; S½ sec. 25, T. 27 N., R. 66 W. Siliceous dolomite and diabase of pre-Cambrian age are quarried by Peter Kiewit and Sons for use mainly as railroad ballast by the Chicago, Burlington, and Quincy Railroad. More than 250,000 tons per year are produced (658).

The Guernsey Stone Company operated a quarry at Guernsey. In 1963, 118,203 tons of siliceous dolomite were produced (611).

GRANITE

In the stone industry, most coarse-grained igneous rocks with a pleasing color are called granite, regardless of their composition. Granite is used for monumental and building stone, railroad ballast, riprap, aggregate material and road metal.

The spacings between joints in granite used as dimension stone should be between 10 ft. and 30 ft. for best quarrying operations (134, p. 314). This property is not common in Wyoming granites, as joint planes are relatively close. Most granite produced in the state is crushed for ballast by the railroads.

Pre-Cambrian granite and other igneous rocks are found in the cores of most of the mountain ranges of the state. The number and location of most small quarries in Wyoming is not known, but several monument makers probably use native stone.

PRODUCING QUARRIES

Laramie County

Granite Canyon. (See CRUSHED ROCK).

PROSPECTS

Carbon County

Standard Park; SW¼ sec. 7, T. 13 N., R. 85 W. A porphyritic hornblende body of rock, 80 feet long, 30 feet wide, and of unknown thickness, trends northeast-southwest, and is surrounded by granodiorite gneiss. The rock consists of ovoid black amphibole crystals up to 1.5 centimeters long in a red, pink, or white groundmass. The distinctive pattern may be suitable for ornamental stone (650).

Fremont County

Sinks Canyon; 10 mi. southwest of Lander in Washakie National Forest. Monumental stone was produced prior to 1945 or 1946. There are no more recent records. The granite has an attractive light-gray color (237).

Niobrara County

South of Lusk, along a low hill, pre-Cambrian granite was tested for use as building stone. The granite shatters, and is difficult to quarry (205).

Park County

"Granite in Shoshone Canyon, west of Cody, is dark-gray, moderately coarse-grained, firm, and durable." According to Fisher (204, p. 60), the granite was to be used in the construction of Shoshone Dam.

Sheridan County

Along the drainage of North Tongue River and South Tongue River, a coarse-grained, foliated, pre-Cambrian granite is abundant. The color ranges from tan to brown to reddish. The rock is a potential source of dimension stone (152; 485).

BASALT

The term "basalt" includes any dark-colored compact fine-grained basic rock. The chief uses of such rocks are for dimension stone, concrete aggregate, road metal, and railroad ballast. No basalt is now produced in Wyoming and there is only one area known where such stone has been quarried.

PROSPECT

Sheridan County

Sec. 25, T. 56 N., R. 89 W.; ½ mi. northeast of Burgess Ranger Station. A porphyritic diabase dike rock, locally called "Leopard Rock" has been quarried for an ornamental and building stone, highway culvert construction, and riprap (276). The diabase contains large white subhedral plagioclase aggregates (86% Anorthite) up to 8 in. in length. The phenocrysts are not everywhere present within the dike, which crops out from the NE¼ sec. 25, near North Tongue River, almost continuously to the center of sec. 24, T. 56 N., R. 88 W., east of Cutler Creek. The dike strikes N. 80° W. and dips 80° to 85° S.; the width varies from 30 ft. to 60 ft. (485).

SANDSTONE AND QUARTZITE

Sandstone is a sedimentary rock composed of clastic quartz grains bound by silica, calcium carbonate, or iron oxide cement. The color of the rock depends to a large extent on the cement. Quartzite is metamorphosed sandstone. Sandstone can be distinguished from quartzite by noting the fracture; in a sandstone fractures pass around the individual sand grains while in a quartzite the fractures pass through the grains. Many quartzites have a conchoidal fracture. Bluestone is a thin-bedded, easily cleavable sandstone often termed flagstone or cleftstone (134, p. 329).

Sandstone is mainly used as a building stone; it is also used for walks, steps, abrasives, laundry tubs, electric switchboards, linings for acid tanks, and for lining metallurgical furnaces. Quartzites are used for grinding pebbles and lining tube and ball mills (134, p. 329).

Many Cambrian to Cretaceous formations in Wyoming contain hard thick-bedded sandstones which offer a plentiful supply of stone for all purposes. A small amount of sandstone has been quarried from Cretaceous and Tertiary rocks. There is no record of all the sandstone quarried for local building purposes, and only the larger quarries are listed below. Pre-Cambrian and Cambrian quartzites are less common in Wyoming; they have been quarried at Rawlins and Guernsey. Formations which include good, useable sandstones are the Flathead, Wells, Casper, Tensleep, Minnelusa, Dakota, Lakota, and Cloverly beds. The Tertiary sandstones are softer and more friable, but have been used at several places in the state as they are easily worked.

PROSPECTS

Albany County

Halleck Canyon Area; approx. sec. 27, T .22 N., R. 71 W. A pre-Cambrian greenish quartzite crops out along the Halleck Canyon road. The quartzite occurs in lenses or beds up to 50 feet thick and several hundred feet in length. The green color is believed due to the presence of a chromium-bearing mica (fuchsite ?) (635).

Sec. 36, T. 23 N., R. 71 W. Green quartzite occurs as discontinuous patches within light gray quartzite layers. The unit is 15 to 20 feet thick and is continuous over a 2 mile area. The quartzite has a brilliant grassy green color which is due to the presence of the chromium-bearing mica fuchsite. The quartzite is fine-grained with a finely laminated schistose texture. It breaks into slabs 2 to 4 feet thick. The unit strikes N. 15° E., and dips 60° W. (644).

A coarse-grained, friable, gray sandstone was quarried 6 mi. east of Como for use in building the Union Pacific railroad stations at Laramie and Cheyenne. Many plant fossils were found in these sandstones (358, p. 130).

A small quantity of sandstone was quarried at Laramie (518, p. 347). Pre-Cambrian quartzite is found in the Medicine Bow Mountains in T. 16 N., R. 79 W. (128).

Carbon County

Along the Rawlins uplift, north of Rawlins, a pink uniform Cambrian quartzite has been quarried for use as a dimension stone. The upper part of the quartzite layer consists of a porous angular-grained quartzite which has been used as a grindstone. This rock won honorable mention at a World's Fair (San Francisco, 1915?) for its uniform texture and free-splitting properties (136; 411, p. 546).

SE¼NW¼ sec. 4, NE¼NE¼ sec. 5, T. 20 N., R. 87 W.

The largest sandstone quarry in Wyoming is located south of Rawlins 4 mi. from the Union Pacific Railroad. This sandstone, commercially termed "Rawlins sandstone" is quarried from the basal Mesaverde formation. The stone is a light-gray uniform color, is soft when excavated but hardens on exposure, and can be quarried in blocks of any size. This stone crushes at 10,000 lbs. It is easily worked, as it will break as well across the bedding planes as with them. The state penitentiary at Rawlins and the Federal building at Ogden, Utah, were built of Rawlins sandstone. The sandstone has been used as trim on Old Main, University of Wyoming at Laramie. It has been shipped as far as San Francisco, California, and Kearney, Nebraska (411; 506; 217).

Crook County

Sandstone was quarried in the vicinity of Aladdin (152; 518, p. 347).

Fremont County

A sandstone quarry was formerly operated at Lander (152; 518, p. 347).

Goshen County

Candy Rock Claims; SW¼SW¼ sec. 1, T. 29 N., R. 65 W. An ornamental or building stone occurs within the lowest member of the Mississippian (?) Hartville formation. The rock is a finely laminated crossbedded sandstone that is composed of alternating maroon and white laminae of pleasing appearance. Exposures in a small quarry indicate that the bed is about 5 feet thick and is overlain by 5 or more feet of overburden (662).

Hot Springs County

Sandstone was quarried at Thermopolis (152; 518, p. 347).

Laramie County

Horse Creek. The Cloverly sandstone, a fine- to medium-grained siliceous stone with vertical dip was used for a building stone, mainly in Cheyenne (152; 411, p. 546; 217; 271, p. 21).

Sandstone has been quarried near the center of T. 19 N., R. 70 W., north of Underwood (152; 518, p. 347).

Sandstone quarries are located in T. 14 N., R. 69 W. west of Silver Crown (152).

The Cloverly sandstone was quarried for a time in sec. 4, T. 18 N., R. 70 W. The beds dip steeply to vertically (353, p. 44).

Lincoln County

The Frontier sandstone was used as a building stone at Kemmerer. The quarry is located between Waterfall and Oakley (573, p. 50a). U. S. Geological Survey Bulletin 624 states that quarries were opened at Cumberland, Oakley, Frontier, and Glencoe (518, p. 374).

Park County

Sandstone has been quarried at Cody (152; 518, p. 347).

Sheridan County

Dietz, Absawkee Park, Monarch and Arno had sandstone quarries. The Arno quarry is along the Chicago, Burlington, and Quincy Railroad in SW¼ NE¼ sec. 19, T. 56 N., R. 82 W. (152; 518, p. 347).

Uinta County

There is a sandstone quarry at Evanston (518, p. 347).

Weston County

The U. S. Geological Survey map (152) of construction materials and nonmetallic deposits shows a quarry near Newcastle.

LIMESTONE

Limestone is a sedimentary rock composed predominantly of calcite, but impurities and foreign matter are common. There are many varieties classified according to the principal impurities. *Oolitic limestone* contains small spherical concretions. *Travertine* is a calcareous deposit associated with hot springs. If such a deposit is porous, it is known as *calcareous tufa*. *Chalk* is a limestone composed of tiny foraminiferal shells. *Coquina*, or shell rock, is a mass of partly compacted and cemented fossil shells and shell fragments. It hardens and resembles concrete on exposure to the air.

Limestones are widely distributed in Wyoming but only a few stones have been found suitable for building purposes. Many limestones are used in the manufacture of cement, as crushed rock, road metal, aggregate, and in sugar beet factories where a pure limestone is necessary as a source of lime and carbon dioxide. Limestones are used as soil fertilizers, as paint fillers, and in glass manufacture.

The larger quarries and sources of limestone are discussed below, but there is no way to estimate the amount of limestone produced for small, local uses.

PRODUCING QUARRIES

Albany County

Sec. 3, T. 16 N., R. 72 W. The Monolith Portland Midwest Company quarries limestone which averages about 90% $CaCO_3$, in the Casper formation, just east of Laramie. This quarry was opened in 1945 (451). Production for 1962 and 1963 was 123,267 and 136,979 tons respectively (611). Casper limestone is quarried in sec. 5, T. 16 N., R. 72 W. and has been used in all major buildings constructed on the University of Wyoming campus since 1925. The stone has a pleasing buff to tannish color and weathers to a darker tan or brown (217).

Laramie County

Great Western Sugar Co. Horse Creek Mine, SE¼ T. 17 N., R. 70 W. along the Colorado and Southern Railroad, 36 mi. northwest of Cheyenne. Two massive limestone beds in the Casper formation average 23 ft. thick and are separated by 300 ft. of red and white sandstone and calcareous sandstone. The beds strike N. 68° W. and dip 78° NE. An analysis shows: $CaCO_3$= 97.00%, insol. Fe and Al oxides=1.90%, $MgCO_3$=1.10%. "The hanging-wall is hard, massive, red sandstone which stands unsupported over large areas" (185, p. 91). The foot-wall is dolomite. Underground mining was started in 1926.

Over 2,000,000 tons of limestone have been mined since 1912, mainly for the Great Western sugar beet factories in Wyoming, Colorado, and Nebraska. In 1962, 125,484 tons were produced, and in 1963, 141,951 tons were produced (611).

Teton County

Fox Creek; sec. 32, T. 4 N., R. 46 E. (Boise Meridian). The Utah-Idaho Sugar Company quarries limestone at this location for use in beet sugar manufacture at their Idaho Falls, Idaho plant (451). In 1963, 25,617 tons of limestone were produced (611).

PROSPECTS

Albany County

The Casper formation crops out along the western flank of the Laramie Range and is one of the best sources of limestone for cement, building stone, riprap, and other uses. The Forelle limestone is also a potential source of stone near Laramie. Analyses of Albany County limestones are listed below:

	1	2	3	4	5	6
$CaCO_3$	98.83%		96.08%	95.62%	98.06%	
$MgCO_3$	.45		.72	.53	.76	
Fe_2O_3	.02					
Al_2O_3	.43	.10%				.21%
FeS_2	.10		.34			
SiO_2	.05	.43	1.02	3.96	1.28	22.22
H_2O		.05				.14
CaO		55.34				43.24
MgO		.21				.15
CO_2		43.73				33.94

(1) Casper limestone quarry 2 mi. east of Laramie (171, p. 66).

(2) Casper limestone 3 mi. east of Laramie (188, p. 331).

(3) Forelle limestone (?) near Laramie (228).

(4) Forelle limestone (?) near Laramie (228).

(5) Forelle limestone (?) near Laramie (228).

(6) Red Buttes, Jurassic (?) limestone (188, p. 331).

Carbon County

Rawlins Area. Limestone has been quarried at the north end of the Rawlins uplift, in T. 23 N., R. 88 W. (152). Limestone from a quarry near Rawlins has been used for a flux and for building stone (518, p. 345). Analyses of several limestones near Rawlins are given on following page (228):

	1	2	3
$CaCO_3$	99.03%	97.88%	98.75%
$MgCO_3$	.48	.44	tr.
Fe_2O_3, Al_2O_3			.40
SiO_2, Insolubles	.45	.44	.65

(1) Sec. 1, T. 21 N., R. 88 W., estimated 3,600,000 tons.
(2) Sec. 3, T. 21 N., R. 88 W., estimated 3,000,000 tons.
(3) Sec. 31, T. 22 N., R. 87 W., estimated 3,400,000 tons.

Crushed limestone was produced from the Alcova limestone just east of U. S. Highway No. 87 in the south-central portion of SW¼ sec. 34, T. 28 N., R. 89 W. The bed is 7 ft. to 8 ft. thick and has vertical dip (527, p. 50).

Hot Springs County

A limestone quarry at Thermopolis is shown on a U. S. Geological Survey map (152) and is mentioned in Bulletin 624 (518, p. 345).

Laramie County

Porous, easily worked, but durable Tertiary limestones crop out near Cheyenne (356, p. 78).

Excellent quality lime was obtained from white Carboniferous limestones 16 mi. west of Cheyenne (356, p. 78).

Iron Mountain. The Niobrara limestone crops out in a hill which lies east of the end of the Bradley spur of the Colorado and Southern Railroad, across a narrow flat, and has been quarried. The Minnekahta limestone crops out ½ mi. west of the Bradley station; it strikes N. 80° W., and dips 65° S. Analyses of Laramie County limestones are listed below:

	1	2	3	4
SiO_2	6.44%	10.52%	6.49%	1.52%
Al_2O_3	1.46	.46		
Fe_2O_3	2.32	1.55	.37	.31
MnO	.11	.14		
CaO	45.90	43.30	54.16	54.18
MgO	2.65	3.53	.15	.15
SO_3	.07	.06		
K_2O	.66	.70		
Na_2O		.05		
H_2O	.88	.50		
Loss	39.71	39.22	43.68	43.69

(1) Niobrara formation at Iron Mountain (19, pp. 240-242).
(2) Minnekahta limestone at Iron Mountain (19, pp. 240-242).
(3) Tertiary limestone, 5 mi. south of Cheyenne (188, p. 331).
(4) Same.

Platte County

Ingleside Quarries; SW¼SW¼ sec. 12, NW¼NW¼ sec. 13, T. 27 N., R. 66 W. The upper beds of the Mississippian Guernsey formation have been quarried for limestone. The material was a light pink and gray, very finely crystalline limestone containing thick gray chert nondules and layers (518). A grab sample of limestone taken from about 20 feet below the top of the Guernsey formation was assayed by the Natural Resources Research Institute at the University of Wyoming contained $CaO = 55.4\%$, with the remainder mainly CO_2.

Sheridan County

Limestone was quarried at Sheridan (152; 518, p. 345).

Sweetwater County

An Eocene building stone has been quarried at Green River (518, p. 345); analyses are given below (188, p. 331):

SiO_2	23.49%	23.47%
Al_2O_3	6.17	6.27
Fe_2O_3	2.16	2.20
CaO	33.79	33.83
MgO	.62	.74
Na_2O, K_2O	.38	.38
CO_2	27.08	27.03
H_2O	6.27	6.20

Uinta County or Sweetwater County

An Eocene limestone from Turtle Bluffs, on the north side of Henry's Fork has the following composition (188, p. 331):

SiO_2	31.28%	31.45%
Al_2O_3	1.83	1.58
Fe_2O_3	.22	.21
CaO	34.20	34.18
MgO	.11	.08
K_2O, Na_2O	.51	.61
CO_2	26.79	26.82
H_2O	4.64	4.64

Weston County

Ball (19, pp. 235-236) investigated cement materials in northeastern Wyoming and found the Minnekahta and Pahasapa limestones to be possible sources of limestone for cement. The analyses are given on the following page:

	1	2	3
SiO_2	4.02%	1.08%	1.42%
Al_2O_3	.10	.33	.68
Fe_2O_3	.94	.77	.40
MnO	.22	.46	.11
CaO	36.68	53.40	52.85
MgO	14.14	.57	.72
SO_3	.05	.12	.12
Na_2O	.33	.36	.76
K_2O	.09	.16	.30
H_2O	.25	.20	.10
Loss	43.65	42.92	42.98

(1) Pahasapa limestone exposed in a thin band about 1½ mi. west of Stockade Beaver Creek.

(2) (3) Minnekahta limestone, 1½ mi. and 2¾ mi. north and little east of the LAK ranch on the east side of Stockade Beaver Creek and the road. Beds are less than 40 ft. thick, thin-bedded, light-gray or purplish color and have gentle dips to the west.

Newcastle Area. The Permian Minnekahta limestone crops out and covers large land areas along the east side of Stockade Beaver Creek and in the southern part of Canyon Springs Prairie along U.S. 85, about 19 miles northeast of Newcastle. Three samples of this limestone were analyzed as follows:

SE¼NE¼ sec. 8, T. 44 N., R. 60 W.; thickness interval of 21 feet, CaO=53.7%, MgO=0.4%, SO_3=0.5%, Fe_2O_3=0.3%, Al_2O_3=0.1%, SiO_2=3.3%, loss =41.1%.

NW¼NW¼ sec. 5, T. 44 N., R. 60 W.; thickness interval of 19.1 feet, CaO=54.1%, MgO=0.3%, SO_3=0.1%, Fe_2O_3=0.2%, Al_2O_3=0.4%, SiO_2=2.3%, loss =42.4%.

NW¼NW¼ sec. 11, T. 47 N., R. 61 W.; thickness interval of 21.5 feet, CaO=55.0%, MgO=0.6%, SO_3=0.5%, Fe_2O_3=0.1%, Al_2O_3=0.5%, SiO_2=1.5%, loss =41.7% (660).

Most of the Pahasapa limestone of Mississippian age in the Newcastle area contains too much magnesia and silica for most chemical and industrial purposes (660).

Fanny Peak Quadrangle. Samples from the Minnekahta limestone cropping out on the east side of Stockade Beaver Creek indicate that the limestone contains about 95% CaCO (624).

TRAVERTINE

REPORTED OCCURRENCES

Hot Springs County

Travertine terrace deposits are found near Thermopolis along the Bighorn River and at "short intervals on the crest and slopes of the anticline between the river and Owl Creek" (582, p. 376). The beds are not thick but are widely distributed, and contain selenite crystals. The travertine is a mixture of $CaCO_3$ and $CaSO_4$ and also contains some isolated crystals or small nodules of native sulfur (582, p. 377; 170, pp. 194-200). No commercial use of this stone has been recorded.

Park County

Three miles west of Cody, a "broad travertine terrace covering several acres and smaller areas are found along the east side of Cedar Mountain from Shoshone River, south for about 2 mi." The section includes (204, p. 61):

Travertine	20 ft. thick
Quaternary gravel	30 ft. thick
Embar limestone	

Sublette County

Big Fall Creek. A travertine deposit, 15 feet thick, 350 feet wide, and about 1½ miles long crops out on the upper part of Big Fall Creek (637).

CEMENT ROCK AND AGREGATE

Portland cement is composed of 75% $CaCO_3$ (limestone), 13% SiO_2, 5% Al_2O_3 and small amounts of $MgCO_3$ and Fe_2O_3. The limestone is finely pulverized, mixed with ground clay or shale (the source of the SiO_2 and Al_2O_3) and calcined. The resulting clinker is then pulverized and up to 3.5% crude gypsum is added as a retarder. When water is added to cement, hydrous calcium aluminum silicates are formed which causes the cement to "set" (4).

Cement rock is a low-magnesium clay containing limestone that needs few if any additional raw materials for the manufacture of cement. Such rock is found at several places in Wyoming. The best known cement rock in the United States is quarried at Jacksonville in the Lehigh Valley of New York and has the following chemical analysis (4, pp. 165-166):

$CaCO_3$	69.00%	74.05%
$MgCO_3$	5.70	4.09
Al_2O_3	5.40	5.19
Fe_2O_3	....	1.87
SiO_2	19.82	12.66

PRODUCING QUARRY:

Albany County

Sec. 6, T. 14 N., R. 74 W., 12 mi. southwest of Laramie. The Monolith Portland Midwest Company has taken cement rock from this deposit in the Niobrara formation since 1928. Cement rock quarried from this deposit in 1963 totaled 166,704 tons (611).

PROSPECTS

Albany County

Twelve miles south of Laramie, Great Western Aggregates, Inc., quarried shale from the Mowry formation. In 1957, 120,000 tons were produced. The shale used for aggregate consisted of the following properties (217):

Size	Sp. Gr.	Surface Absorption	$Wt./Ft._3$
—3/4 5/16	1.34	6.57	47
—5/16 No. 8	1.41	6.80	52
—No. 8	1.80	3.85	67

The aggregate is sized before being calcined at 2100° F. in a 12 x 266 ft. rotary kiln. Production exceeds 30 tons per hour (217).

The finished product is expanded shale, which is a lightweight aggregate used to replace sand and gravel in concrete, making it possible to reduce the dead weight of concrete at least one-third and still maintain sand and gravel concrete strength.

A process for calcining the same shale into a pozzolan was begun in 1958. The pozzolan is used to reduce the reactivity of aggregates in concrete primarily by reducing the heat created in large pours of the concrete. Estimated production of shale for pozzolan in 1958 is 75,000 tons (217). Production ceased in late 1964.

A 15 ft. pure marl bed is found in the Niobrara formation 8 mi. southwest of Laramie (518, p. 343). The Niobrara is widespread in the Laramie Basin and is a good source of cement rock (171, p. 65).

Laramie County

The Graneros shale member of the Benton formation, the Pierre shale, and the Niobrara formation are all possible sources of cement rock. The Graneros shale and the Niobrara formation outcrops at Iron Mountain have been analyzed:

	1	2
SiO_2	63.60%	62.34%
Al_2O_3	14.66	21.98
Fe_2O_3	7.44	7.92
MnO	.20	.26
CaO	.78	1.28
MgO	.46	.73
SO_3	.53	.36
Na_2O	.37	.19
K_2O	1.79	1.71
H_2O	2.86	1.83
Loss	7.64	1.77

(1) Sample from the middle 40-ft. interval of the lower 115 ft. of the Graneros shale which crops out at the end of the Railroad Spur at Bradley (19, p. 242).

(2) Pierre shale outcrop ¾ mi. northwest of the Bradley station on the west side of the railroad track (19, 243).

Weston County

The following analyses of rocks in the vicinity of Newcastle have been made. The first analysis most nearly resembles a true cement rock.

	1	2	3	4
SiO_2	18.10%	45.78%	58.82%	67.55%
Al_2O_3	6.26	12.92	16.43	17.58
Fe_2O_3	.80	3.96	4.47	.47
MnO	.50	.33	.24	.18
CaO	37.57	.56	.54	.36
MgO	.76	.73	1.68	.74
SO_3	.27	.42	1.32	.50
Na_2O	2.14	.64	.33	.21
K_2O	.92	.50	2.18	.79
H_2O	1.25	8.26	6.38	——
Loss	31.58	26.32	7.93	11.68

(1) Graneros shale 2¼ mi. southeast of Newcastle along the railroad on a small whitish colored hill (19, pp. 234-235).

(2) Morrison shale at a coal prospect on the east bank of Salt Creek, 3 mi. above the mouth of the stream. 20 ft. of Morrison shale is exposed (19, p. 236).

(3) Graneros shale outcrop 2¼ mi. southeast of Newcastle between a road and the railroad (19, p. 237).

(4) Graneros shale outcrop where the Newcastle-LAK ranch road crosses Salt Creek (19, p. 237).

MARBLE

Commercial marble is any lime silicate or carbonate rock that can be highly polished. However, there are three main types of "marble" used for building and ornamental stone. *Recrystallized limestone,* the result of heat and pressure, during metamorphism is an important source of marble. If perfectly pure, it is snow white, but more often it is colored due to impurities. *Onyx marble* or Mexican onyx results from the chemical precipitation of $CaCO_3$ from cold water calcareous springs. These marbles are usually highly colored and banded. *Serpentine marbles* are usually green colored and show ornate patterns due to the minerals present (134, pp. 332-333).

Marble is used for floor tile, stairways, columns, counters, statuary, novelties, monuments, buildings, and memorials. Marble used outside must be free of impurities that could stain or corrode the surfaces. Scattered deposits of marble are known in Wyoming, but production has been small. The better known deposits are discussed below.

PROSPECTS

Albany County

Secs. 5, 6, T. 22 N., R. 71 W. An irregularly-shaped marble deposit, 800 feet wide and about 3,000 feet long is enclosed in a hornblende schist. The unit is light gray in color and highly fractured. Thin section study indicates that the marble contains diopside, wollastonite, tremolite, quartz and calcite. Small discontinuous marble xenoliths also occur in hornblende syenite (644).

Carbon County

Medicine Bow Mountains; sec. 32, T. 18 N., R. 78 W.; secs. 5, 6, & 8, T. 17 N., R. 78 W. A light brown, medium-grained marble crops out in this area. The marble is characterized by thin silica-rich bands ranging from a fraction of, to one inch in thickness which may be in a linear direction or in large ptygmatic folds (647).

Goshen County

NE¼NE¼ sec. 11, NW¼ sec. 12, T. 30 N., R. 64 W. Marble occurs interlayered with pre-Cambrian mica schists and recrystallized dolomite. The average strike of the layers is N. 15° E., and these dip about 75° E. The marble layers, which range from 50 to 200 feet in thickness, are a mottled white and gray color and medium to coarsely crystalline in texture (662).

Jay Em Quarry; T. 29 N., R. 63 W. A mottled brown onyx marble of pleasing appearance has been produced by the Jay Em Stone and Gem Corporation. No recent records are available (217).

Muskrat Canyon; T. 30 N., R. 65 W. A fine-grained compact, variegated reddish to whitish marble was quarried in the canyon. The stone takes a good polish and is quite hard (451, p. 119).

Lincoln County

Rich, amber-colored onyx was quarried near Cokeville at one time. The stone was used for building purposes and compared quite favorable with Mexican onyx (411, p. 546).

Platte County

Sec. 3, T. 24 N., R. 70 W., SW¼SE¼ sec. 34, T. 25 N., R. 70 W. Four extensive pre-Cambrian marble deposits crop out on relatively narrow ridges in the vicinity of Marble Quarry Creek. No overburden is present on the marble outcrops; however, areas between individual exposures are covered with an indeterminate thickness of gravels derived from Precambrian crystalline rocks. Most of the marble is white or white with a bluish cast and is coarsely crystalline. Most exposures are well-jointed to sheeted which causes the marble to weather into crude blocks of varying dimension (675).

A few shipments of onyx marble were made from a Carboniferous limestone cavern deposit near Hartville. The onyx was obtained from stalactites and stalagmites. The deposit was first opened in 1894 (26, p. 4; 411, p. 546).

A "large" dolomitic marble deposit is located 15 mi. to 20 mi. northwest of Wheatland, along the Laramie River (411, p. 546). The stone is massive, free of joints, and varies in color from pure white to gray (506, p. 78).

REPORTED OCCURRENCES

Albany County

Pre-Cambrian dolomitic marble and marble crop out in a narrow band in the Medicine Bow Mountains in T. 16 N., R. 79 W. (128, pp. 636-641; 518, p. 346). Marble is reported along the west flank of the Laramie Range (518, p. 346).

Big Horn County

Darton (169, p. 115) believed some of the Madison formation contains marble suitable for a building stone.

Carbon County

"White and greenish marbles of good quality have been stated to occur . . . in the Savery section in the extreme west . . ." (451, p. 119).

Converse County

Red, good quality marble has been reported near Douglas (518, p. 346).

Crook County

Marble has been reported along the west flanks of the Black Hills (518, p. 346).

STRONTIUM

Strontium minerals are rare in Wyoming and are reported from only two localities. Strontium compounds are used mainly in red flares, tracer bullets, medicines, and as fillers.

REPORTED OCCURRENCES

Converse County (?)

Traces of strontium have been reported in rocks from the Little Deer Creek property near Glenrock (217).

Natrona County

Aughey (16, p. 58) reported finding celestite, $SrSO_4$ and strontianite, $SrCO_3$ ". . . in geodes in Triassic beds on the north side of Rattlesnake Mountain, on the head of Rogers Creek."

SULFUR

Sulfur is common and widely distributed. Volcanic areas contain native sulfur; sulfates (gypsum, barite, etc.) are common in sedimentary and igneous rocks, and sulfides of many metals are found in mineral veins. The most common sulfide mineral is pyrite, FeS_2.

The chemical industry is the largest consumer of sulfur; most is used to manufacture sulfuric acid and many other compounds. Sulfur is used extensively in fertilizers, insecticides, the pulp and paper industry, explosives, coal-tar products, dyes, rubber, paint, varnish, rayon and cellulose filler, foods, and drugs.

Sulfur was first produced in Wyoming in 1906 and production continued through 1921; there is no record available of total production. The Wyoming surface deposits are either associated with volcanic rocks and hot springs deposits or have resulted from the decomposition of hydrogen sulfide (H_2S) gas. Some sulfur-bearing gypsum has been produced from extinct hot springs deposits.

Current production of sulfur in Wyoming is from natural gas which contains H_2S at Riverton Dome and Beaver Creek field in Fremont County; and Elk Basin, Garland, Silver Tip, and Worland oil fields in the Bighorn Basin. All plants, with the exception of one use a modified Claus process (613). Total production of sulfur for 1964 was 55,550 tons. Sulfuric acid plants utilizing Wyoming sulfur are operated by Western Nuclear at Jeffrey City and by the Susquehanna Corp. at Riverton, both in Fremont County.

PRODUCING DEPOSITS

Big Horn County

Kern County Land Co. operates a sulfur extraction plant at Garland.

The Jefferson Lake Sulphur Co. formerly operated a 125 ton per day sulfur plant at Manderson.

Fremont County

Atlantic Refining Co. operates a sulfur recovery unit at Riverton Dome, and Pan American Petroleum Corp. operates a sulfur extraction plant in the Beaver Creek field.

Park County

The Pan American Petroleum Corp.'s wells at Elk Basin produce H_2S-bearing gas from which elemental sulfur is extracted. The extraction plant is located at Elk Basin and a pulverizing plant is at Powell.

Ralston Processors Associates at Ralston produces sulfur from the Silver Tip field.

Washakie County

Pure Oil Company wells in the Worland oil field 12 miles north of Worland produce H_2S gas from wells about 10,000 feet deep. The Texas Gulf Sulphur Company completed an extraction plant at Worland that has a capacity of 300 long tons of sulfur per day (215).

Pan American Petroleum Corp. formerly produced sulfur from its Cottonwood Creek plant, and Signal Oil and Gas Co. small sulfur-processing unit at Neiber Dome near Worland has been discontinued. Signal's unit from the one-well Stockham Federal lease was discontinued in 1957 (613).

PROSPECTS

Hot Springs County

Brutch Sulfur Deposits (formerly the Wyoming Sulfur Co.); 3½ mi. northwest of Thermopolis along Wyoming Highway No. 120, in the SE¼ sec. 20, N¼ sec. 28; NW¼ NE¼ SW¼, S½ NE¼ SW¼, SE¼ SW¼, and W½ SW¼ sec. 21, and the SE¼ NW¼, S½ NE¼ and NE¼ SE¼ sec. 28, T. 43 N., R. 95 W. The sulfur deposits are in travertine and alluvium along both flanks of a northwest trending asymmetrical anticline. Embar and Tensleep beds crop out in the crest of the anticline. The sulfur is associated with travertine which overlies the Permian and Triassic rocks (441, p. 2).

"The minable sulfur (1908) is in altered Embar limestone immediately below the travertine." The sulfur is in "pockets" which represent extinct hot springs; these deposits rarely exceed 100 ft. in horizontal diameter (582, p. 377). Low grade sulfur is also found as incrustations along solution channels and as dark brown to black masses disseminated through limestone. Gypsum is probably an alteration product of the limestone and sulfur (441, p. 3; 315). Analyses in 1907 showed from 31.85% sulfur and about 0.05% arsenic (109, p. 5). Sampling by the U. S. Bureau of Mines in 1945-46 disclosed a trace to 41.7% sulfur. An analysis: total S=32.0%, elemental S=27.8%, Insol.=47.2%, SiO_2=41.6%, Fe=0.75%, CaO=6.3%, Al_2O_3=4.9%, H_2O sol. Al_2O_3=1.0% (441, pp. 5-6).

Lincoln County

Sulfur is found in sec. 23, T. 33 N., R. 119 W. Free sulfur is found on the rims of small pools associated with hot springs. The major deposits are found in travertine around the large pools. The waters also contain calcium, sodium, and chlorine (599).

Park County

Cody Deposits; 3 mi. west of Cody along U. S. Highway No. 20, in secs. 3, 10, T. 52 N., R. 102 W., south of Shoshone River. These deposits were worked during the early 1900's. Fisher believed the sulfur to be "deposited by heated waters and gas from the numerous geysers that once existed in this region" (203, p. 315). "The sulfur occurs in veins in the travertine overlying the Cody and Powell terraces, as disseminated deposits in sandstone, and as cavity fillings in the Phosphoria formation" (496, p. 177). The deposits are irregular, pockety, and have 2 ft. to 10 ft. of overburden (582; 318; 558).

Sunlight Basin Deposits. Surficial sulfur deposits lie in a line northwest-southeast from Sulfur Lake, near Sunlight Creek. There are two fairly large deposits on the slope northwest of the lake, four smaller deposits along Yellowstone Gulch, southwest of the lake, and two deposits along Iron Creek. The sulfur cements surface debris and incrusts irregular open fractures in bleached rhyolite. These recent deposits probably formed from H_2S gas which issued from cracks and fractures (364, p. 354; 367; 217).

Sweetwater Creek Deposit; about 2 mi. north of the junction of Sweetwater Creek with the North Fork of Shoshone River in Shoshone National Forest. This deposit probably does not exceed 20 acres. The sulfur cements surface debris. These recent deposits are the result of decomposition of H_2S gas which issued from the crevices in rocks of the area (367, p. 479; 217).

REPORTED OCCURRENCES

Fremont County (See ALUM).

Park County

Sulfur crystals in caverns in Madison limestone have been found in the U. S. Bureau of Reclamation tunnel west of Cody (434a).

Deposits of sulfur are shown on the U. S. Geological Survey map (152). One is in the south-central part of T. 50 N., R. 104 W. just east of a tributary to South Fork Shoshone River, the other is in the SW¼ T. 54 N., R. 101 W. north-northeast of Cody. No other information is available.

Uinta County

Sulfur has been reported along Sulfur Creek, near the Wyoming-Colorado boundary line, about 30 mi. southeast of Evanston (452, p. 759; 453, p. 810).

TALC AND TALCOSE SCHIST

Talc is a magnesium silicate, probably formed by the alteration of ferro-magnesium silicates. The purer talcs are usually alteration products of $MgCO_3$ rocks and have the composition, $H_2Mg_3(SiO_3)_4$. Talcose schists of commercial value may contain admixtures of other minerals such as tremolite, serpentine, chlorite, anthophyllite, olivine, carbonates and/or vermiculite. Talc is found chiefly in crystalline schists as a result of regional metamorphism.

Uses of talcs depend upon grain size, shape, color, chemical and mineral composition, weight per unit volume, oil absorption, and hardness (193, p. 1035). The paint industry uses the most talc. The ceramic, roofing and cosmetics industries use large quantities; talc is used for foundry facings, as steam-pipe and boiler coverings, for electric switchboards, laboratory table tops, and in paper manufacture.

There is no record of production of talc in Wyoming.

PROSPECTS

Albany County

Halleck Canyon Area; approx. sec. 13, T. 22 N., R. 72 W. Talc, approximately 100 feet long by 5 to 7 feet wide, occurs in a steatized serpentine zone. The deposit is well foliated, steeply dipping unit that strikes approximately due north. The deposit grades into a steatized chlorite-rich rock to the north. The talc-rich layer contains numerous zones of tremolite which makes it brittle and of poor quality (635).

Nipper No. 1 Claim; SE¼ sec. 32, T. 25 N., R. 73 W. Talc schist strikes N. 55° W. and dips 65° N. Apparently a hornblende schist altered along a zone of weakness to talc. Sericite and quartz are associated with the talc schist (344).

Nipper No. 2 Claim; W½ NE¼ and E½ NW¼ sec. 32, T. 25 N., R. 73 W. A contorted talc schist body trends N. 25° to 45° W. and stands vertically (344).

Nipper No. 3 Claim; NE¼ sec. 32, T. 25 N., R. 73 W. A talc schist, actinolite schist and anthophyllite schist strike N. 45° E. and dip 65° S. The talc schist is about 20 ft. wide at the prospect pit, but narrows to several inches (344).

Nipper No. 4 Claim; S½ SE¼ sec. 29, and N½ NE¼ sec. 32, T. 25 N., R. 75 W. A talc schist contacts hornblende schist along the northeast slope of a hill. The schists strike N. 25° E. and dip 65° E. (344).

Palmer Canyon; sec. 1, T. 24 N., R. 71 W. A talc lens has formed between hornblende schist and granite. The lens of good quality talc is 6 ft. thick at the surface, but narrows with depth; it is a very small deposit. Anthophyllite has altered to vermiculite (296).

Carbon County

A deposit 1 mi. south of Encampment consists of high-grade chlorite mica that grades into talc (217).

Platte County

Collins Deposit; 500 ft. from south quarter corner, sec. 15, T. 27 N., R. 70 W. Country rocks at this prospect are hornblende schist, granite, and quartz veins. Good grade crumpled and metamorphosed talc is found in the main pit but the quantity is small as the talc pinches and swells (297).

Teton County

Badger Creek Deposit; sec. 5, T. 6 N., R. 117 W. Massive soapstone and fibrous talc are found in an olivine diabase that has been intruded by granite and quartz (32, p. 816).

Washakie County

Canyon Creek Talc Deposit; sec. 25, T. 48 N., R. 86 W. Talc schist and fibrous talc are associated with folded hornblende schist, olivine metadiabase, and a small amount of brittle amphibole asbestos. The rocks strike N. 15° E. (32, p. 837).

REPORTED OCCURRENCES

Albany County

In sec. 3, T. 25 N., R. 71 W. a lens of talc-like mineral, "Mg-amphibole schist" is about 1½ mi. long and 1/3 mi. wide. The foliated type of schist is a mass of interwoven acicular pseudomorphs of Mg-amphibole after hornblende (468); (See GARNET, MICA).

Carbon County

Foliated talc was reported from the Deserted Treasure Mine in the Seminoe Mountains (16, p. 61).

Converse County

Badger Prospect; (See VERMICULITE).

Smith Prospect; (See VERMICULITE).

Fremont County

Abernathy Deposit; (See VERMICULITE).

Soapstone was found by Aughey on "north side of Rattlesnake Mountains, on headwaters of S. Powder" (16, p. 61).

TELLURIUM

REPORTED OCCURRENCES

Carbon County

Bridger Mine; Sierra Madre Mountains; (See COPPER).

Fox Group. A thin layer of tellurium was found at the bottom of a 70-ft. shaft (8, pp. 13-14).

TIN

Cassiterite, SnO_2, the most abundant tin-bearing mineral, is found throughout the world but most deposits are not large enough to be profitably mined. Most primary tin ores are high-temperature deposits associated with granites, pegmatites, or quartz veins. Cassiterite has a high specific gravity and is resistant to weathering and abrasion, hence it is often concentrated in placer deposits.

Tin is valuable because of its easy fusibility, its malleability, resistance to corrosion, readiness to alloy with other metals, and its attractive color.

Cassiterite is found in Crook County, Wyoming, in placers and in a pegmatitic granite. The deposits are not commercially important under present economic conditions.

PROSPECTS

Crook County (Nigger Hill District).

On a divide between Bear Gulch and Sand Creek, pre-Cambrian granitic and pegmatitic veins in a Tertiary porphyry contain cassiterite. The cassiterite grains (1/8 in. to 1/2 in diameter) are imbedded in white feldspar and in a quartz-mica granite. Columbite, tantalite, and scattered tourmaline and wolframite are associated with the cassiterite (374, p. 96; 454, pp. 530-531).

Bear Gulch Placer, gravels in T. 51 N., R. 60 W. contain small angular grains ($<$1/2 in. diameter) of cassiterite derived from the nearby granites on Nigger Hill (166, pp. 11-12).

Sand Creek, T. 51 N., R. 60 W., contains stream tin, or cassiterite, similar to the Bear Gulch placers (129, p. 694).

REPORTED OCCURRENCES

Fremont County (?)

Tin has been reported in the Wind River Mountains (217).

Goshen County

Aughey reported cassiterite "in northern Wyoming near Rawhide Buttes, in minute quantities. . ." (16, p. 55).

Laramie County

Small amounts of cassiterite were detected in the Silver Crown district (16, p. 55).

TITANITE (SPHENE)

Aughey, in his annual report to the Governor of Wyoming, 1886, p. 61, reported sphene, $CaTiSiO_5$, from the head of Chugwater Creek in the Laramie Mountains.

Sphene is also an accessory mineral in the Bull Hill nepheline-syenite deposit of Crook County; (See NEPHELINE SYENITE).

TITANIUM BEARING BLACK SANDSTONE DEPOSITS

By William H. Wilson

All deposits, unless specifically mentioned otherwise, occur in the Mesaverde formation of Late Cretaceous age. Most of the deposits are believed to be oriented with their long direction approximately north-south, parallel to the strand line of Late Cretaceous seas. The exposed dimensions of individual deposits, however, are such that often the actual length and orientation are not apparent to the observer. All deposits are somewhat radioactive but are not considered commercially valuable for uranium.

The following description of individual deposits has been summarized from Geol. Survey Wyo. Bull. 49. titled "Titaniferous black sandstone deposits of Wyoming." Additional information is also listed in a U. S. Bureau of Mines publication by Dow and Batty (632).

Albany County

Sheep Mountain Deposit; SE¼ sec. 10. T. 15 N., R. 77 W. The deposit is exposed at intervals over a distance of about 1900 ft. in a northwest-southeast direction with a width of outcrop about 50 ft. Strata containing the deposit strike N. 30-45° W. and dip 25-35° NE. A maximum thickness of 17.0 ft. is exposed in a cross-cutting prospect pit near the northwest end of the exposure, and this tapers to 2 ft. at the southeastern end. The deposit is thought to lie in the lower part of the Mesaverde formation.

Six samples have been analyzed petrographically and averaged 63.0% heavy minerals. Of this fraction 84.2% were opaque minerals and 10.3%, zircon. Seven samples collected from a prospect pit (northwest end) were analyzed and averaged 15.6% TiO_2 and 40.4% total Fe_2O_3. The heavy mineral, titanium, and iron content diminish towards the southeast end of the deposit.

Big Horn County

Cowley Deposit; sec. 1, T. 56 N., R. 97 W. The deposit appears to be an erosional remnant of a much larger concentration. The maximum dimension is 900 ft. in a northwest direction with a maximum thickness of 3.5 ft. The average thickness is about 1 ft. The deposit lies in a 50-ft. thick sandstone bed which strikes N. 60° W. and dips 9° SW. The deposit is covered by alluvium at the south end. A chemical analysis showed 3.0% TiO_2 and 33.8% total Fe_2O_3.

Lovell Deposit; sec. 7, T. 55 N., R. 95 W., and sec. 12, T. 55 N., R. 96 W. The deposit consists of two erosional remnants with a combined length of 5,000 ft. The south remnant is 3,000 ft. long in a northwest direction. The larger of the two deposits averages 3 ft. thick with a maximum thickness of 4 ft. at the north end. The axis of the deposit, as presently exposed, trends N. 45°-50° W. Host rock is a light-buff fine-grained sandstone that strikes N. 34° W. and dips 11° SW. Overburden is slight. A chemical analysis of a selected sample showed 15.1% TiO_2 and 71.09% total Fe_2O_3.

Hot Springs County

Grass Creek Deposit. This deposit crops out in two isolated segments, one on either flank of the Grass Creek anticline. The northern segment is located in secs. 8, 9, and 16, T. 46 N., R. 98 W., on the northeast flank of the anticline, and the southern segment is located in secs. 33 and 34, T. 46 N., R. 98 W., on the southeast flank.

The Grass Creek deposit is believed to be two erosional remnants of a once-continuous deposit. The northern segment can be traced for a distance of 5,600 ft. Northward the black sandstone body is covered with overlying strata, and its true extent is not known. The deposit has a maximum width of 680 ft. and a maximum measurable thickness of 17 ft., but the average is about 10-12 ft. The deposit trends 15° W., and strata containing the deposit strike about N. 25° W. and dip about 15° NE. Approximately three-fourths of this deposit is covered by overburden which ranges from 75-100 ft. thick in the northern part of the segment.

The southern segment is poorly exposed and faulted and crops out sporadically for a distance of over 1,600 ft. in an east-west direction. The black sandstone has a maximum exposed thickness of 3.5 ft. near the eastern end of the outcrop but thins to the east. Five feet of black sandstone is exposed at the base of the deposit at the western end, but the upper part is largely concealed by talus. Strata containing the deposit strike N. 80° W. and dip 30°-35° S.

Petrographic analysis of 12 samples averaged 30.0% heavy minerals. Of this fraction, opaque minerals=78%, zircon=18.0%, and monazite= 1.0%. Chemical analyses of this deposit averaged 16.0% TiO_2 and 23.0% Fe_2O_3. The zircon content of the bulk samples averaged approximately 6%. The Grass Creek deposit is the largest of the high grade, heavy mineral black sandstone deposits known in Wyoming.

Cottonwood Creek Deposit; SE¼ sec. 26, T. 45 N., R. 97 W. The deposit, which is 9.7 mi. southeast of the southern segment of the Grass Creek deposit, is on the northeast flank of the Waugh anticline. The deposit is a remnant, forming an irregular patch 150 ft. in a northwest direction and 150 ft. in a northeast direction. The maximum exposed thickness of the deposit is 9 ft. The strata containing the deposit strike N. 43° W. and dip 20° NE.

Chemical analyses of 4 samples averaged 9.7% TiO_2 and 38.4% total Fe_2O_3.

Natrona County

Coalbank Hills Deposit; sec. 5, T. 34 N., R. 88 W. The deposit is exposed in two localities 700 ft. apart. If these are connected, the length will be in excess of 1,400 ft. with a thickness of 5 ft. at the southeastern end. The deposit occurs in the uppermost sedimentary unit of the basal sandstone of the Mesaverde formation, which strikes N. 40° W. and dips 23° NE.

Clarkson Hill; sec. 20, T. 31 N., R. 82 W. The deposit has an exposed length of 150 ft. in an east-west direction with a maximum width of outcrop of about 20 ft. These are probably not true dimensions but only a cross section. The strata strike N. 80° E. and dip 38° N. The maximum thickness of the deposit is 5.6 ft. The deposit makes up the upper part of the Parkman sandstone member of the Mesaverde formation. A chemical analysis showed 4.8% TiO_2 and 26.1% Fe_2O_3.

Poison Spider Deposit; NE¼ NE¼ NE¼ sec. 1, T. 33 N., R. 84 W., and SE¼ SE¼ SE¼ sec. 36, T. 34 N., R. 84 W. This deposit has a maximum thickness of 7 ft. and is traceable along its outcrop for about 300 ft. The long dimension and bedding strike N. 42° W., and the bedding dips 70° SW.

The Poison Spider deposit is the only one known in the Lewis shale (Upper Cretaceous) and the stratigraphic succession that contains the deposit is comprised of rocks lithologically similar to those making up the mesaverde formation.

An average of 13 samples analyzed chemically showed 5.2% TiO_2 and 21.7% total Fe_2O_3.

Sublette County

Cliff Creek Deposit; center of south line sec. 33, T. 38 N., R. 114 W. The black sandstone zone is 3.7 ft. thick and lies 19.8 ft. below the top of the Stump sandstone of Late Jurassic age. Four samples, chemically analyzed, varied from 0.70% to 20.15% TiO_2 and 5.7% to 54.93% total Fe_2O_3.

Sweetwatetr County

Red Creek Deposit; NE¼ sec. 22, T. 12 N., R. 105 W. The exposed part of the deposit measures a maximum of 800 ft. in an east-west direction, but dense concentration of heavy minerals is restricted to about 125 ft. of this distance. The higher grade rock occurs at the western end of the exposure and is 6 ft. thick. The eastern end and largely lower grade rock tapers from 4 ft. to a wedge-edge. Bedding in rocks adjacent to the black sandstone strikes essentially east-west and dips about 20° N. The down dip extension of the deposit is concealed by overlying strata. The deposit is an irregularly shaped lens which fills a channel cut into the underlying white sandstone. The black sandstone lens is channeled in the basal unit of the Ericson formation (Mesaverde group), which is about 60 ft. thick here.

Four samples were analyzed petrographically and averaged 27.5% heavy minerals. This fraction averaged 82.8% opaque minerals, 13.7% zircon and 1.0% rutile. Eight bulk samples were assayed and averaged 14.3% TiO_2 and 19.0% total Fe_2O_3.

Salt Wells Creek Deposit; SE¼ sec. 7, T. 14 N., R. 103 W. Only two dimensions of the deposit can be seen because of overlying strata. The length is about 250 ft. in a northeast-southwest direction with a maximum thickness of 3.0 ft. in the central part. Bedding adjacent to the deposit strikes N. 82° E. and dips 5° S. The black sandstone fills a lenticular channel at the top of the basal 60 ft. of massive white buff sandstone of the Ericson formation.

Four samples were analyzed petrographically and showed 55.5% heavy minerals. Of this fraction, opaque minerals=85.0%, and zircon=12.4%. Analyses of two bulk samples showed an average of 22.5% TiO_2 and 25.5% total Fe_2O_3.

Black Butte Deposit; approximate location, sec. 30, T. 18 N., R. 101 W., and sec. 1, T. 17 N., R. 102 W. The larger (sec. 30) of the two deposits sporodically crops out and is exposed in two prospect pits at each end of the deposit, 1,500 ft. apart in an east-northeast direction. The zone is 4 ft. thick in the eastern pit and as much as 3 ft. thick in the western pit. Bedding in adjacent rocks strikes N. 40° E. and dips 7° SE.

The smaller deposit (sec. 1) is poorly exposed and about 1 ft. thick. Both deposits are in the basal sandstone of the Ericson formation.

Three samples from the larger deposit averaged 24.0% heavy minerals, of which 84.0% were opaques and 11.1% zircon. Three bulk samples were chemically analyzed from the larger deposit and averaged 14.0% TiO_2 and 15.0% total Fe_2O_3.

Uinta County

Cumberland Gap Area; W½ sec. 25, T. 18 N., R. 117 W., and secs. 18, 19, and 30, T. 18 N., R. 116 W. The deposits occur in the lower part of the Frontier formation (Upper Cretaceous). The tops of the two major heavy mineral-bearing sandstone beds lie at 120 ft. and 355 ft. above the basal contact of the Frontier formation with the underlying Aspen shale. The longest exposure is about 600 ft. in a direction parallel to the strike of the bedding. The thickness is about 15 ft. Host rocks strike N. 42° E. and dip 15° NW.

Three samples from the upper black sandstone, and two from the lower black sandstone averaged 9.2% heavy minerals. An average analysis for two bulk samples from the upper black sandstone yielded 9.5% TiO_2 and 20.0% total Fe_2O_3. For the lower black sandstone, two samples averaged 7.1% TiO_2 and 27.0% total Fe_2O_3.

Washakie County

Dugout Creek Deposit; secs. 34 and 35, T. 45 N., R. 89 W., and secs. 2 and 11, T. 44 N., R. 89 W. This is the largest individual deposit thus far reported in Wyoming. The length is about 2.6 mi. in a north-northeast direction with a maximum exposed width of about 1,400 ft. The body dips northwestward beneath younger rocks. The exposed thickness of the black sandstone ranges up to 25 ft., but probably averages between 10 and 15 ft. The strike of the bedding and the trend of the long axis of the deposit are both N. 15° E. with a dip of 3°-5° NW. The deposit occurs in the uppermost sedimentary unit of the basal sandstone of the Mesaverde formation, which is at least 50 ft. thick and forms a broad dip slope. Composite analyses of thirteen samples averaged 5.9% TiO_2 and 38.9% total Fe_2O_3. Two selected samples averaged 10.5% TiO_2 and 62.2% Fe_2O_3.

The northern half of the deposit has large areas of exposed black sandstone; however, the southern half has a considerable amount of overburden. Stripping ratio would not greatly increase here because of the relatively gentle westerly dip. The opaque minerals, which make up 91.0% of heavy mineral concentrate, yielded 60.0% TiO_2.

Mud Creek Deposit, sec. 19, T. 44 N., R. 91 W. The deposit has an exposed length of about 1,500 ft. in a west-northwest direction with a maximum exposed width of about 100 ft. The strata strike N. 70° W. and dip 10° N. The upper high grade zone at the eastern end of the deposit is 4.5 ft. thick. The lower high grade zone is 3.0 ft. thick. The two are separated by 3.5 ft. of rust-brown fine-grained barren sandstone. The lower high grade zone is underlain by 3.5 ft. of rust-brown fine-grained barren sandstone and this is underlain by typical basal Mesaverde sandstone. Along the exposure, 200-300 ft. of overburden is present in several places.

TOURMALINE

Tourmaline is a common accessory mineral in pegmatites and metamorphic rocks. The mineral is a semi-precious gem stone with colors that vary from olive-green, pink to red, and blue. Nearly all the tourmaline found in Wyoming is black and of no economic importance. The following list is admittedly incomplete.

REPORTED OCCURRENCES

Albany County

Muscovite Claim. Large, black tourmaline crystals are found in the pegmatites immediately south of the Wood's Landing bridge (260); (See MICA).

Crook County

Nigger Hill District; (See TIN).

Fremont County

Bridger Mountains Area, Whippet No. 8 Prospect; (See FELDSPAR).

Empire State Gold Mine; (See GOLD).

Goshen County (Haystack Range District).

Chicago Prospect; (See MICA).

Crystal Palace Prospect; (See MICA).

New York Prospect; (See MICA).

Ruth Prospect; (See MICA).

Savage Prospect; (See MICA).

Torrington No. 1 Prospect; (See Mica).

White Star Prospect; (See MICA).

2000 ft. east of the Summit of McCann's Pass; (See GRAPHITE).

Natrona County

Black Mountain Spodumene Prospect; (See SPODUMENE).

Platte County

Vaughn-Hyslop Deposit; (See VERMICULITE).

TUNGSTEN

Tungsten minerals of commercial importance include wolframite, (FeMn)-WO_4; scheelite, $CaWO_4$; ferberite, $FEWO_4$; and hubnerite, $MnWO_4$. Most commercial ore is scheelite or wolframite. Scheelite fluoresces a light-blue color under ultra-violet light. All tungsten of any importance in Wyoming is found as the mineral scheelite in quartz veins and pegmatites associated with pre-Cambrian metamorphic rocks. Scheelite is usually found in high-temperature veins associated with granitic rocks. It is associated with cassiterite, fluorite, molybdenite, wolframite, and gold.

Most tungsten is used as a hardner in the manufacture of "high-speed" steels used in razor blades, knives, armor plate, valve seats, and tools. Tungsten is used as filament in electric light bulbs, in spark plugs, cemented tungsten carbide (the hardest artificial substance known), in fire-proofing, in the chemical industry, in dyes and paints, and in fluorescent materials for X-ray photography.

There are several tungsten prospects in Wyoming and small amounts of ore have been shipped, but there is no recorded commercial production.

PROSPECTS

Converse County

Mormon Canyon; secs. 11, 12, 13, 14, T. 32 N., R. 76 W. Scheelite is associated with garnet, quartz, actinolite, glaucophane and epidote in a northwest trending quartz dike or vein 500 ft. long and from 30 ft. to 100 ft. wide. There is no evidence of contact metamorphism between the scheelite-bearing rock and the lime silicate rocks. The pit contains molybdenite, powellite, Ca $(MoW)O_4$ and scheelite. Assays show 0.33% to 1.0% WO_3 (308).

Fremont County

Copper Mountain Area

Comet Claim; S½ SW¼ NE¼ sec. 22, T. 40 N., R. 93 W. There are two zones which contain scheelite-bearing rock. The northern zone is about 183 ft. long and has an average width of 1½ ft. The southern zone is 140 ft. from the northern zone; it is limited in length, width, and scheelite content (562, p. 10).

Dawn Claim; on a south sloping nose of a ridge between two branches of Hoodoo Creek. A quartz-epidote-garnet rock with actinolite contains scheelite.

The average tenor of the rock is probably a fraction of 1% WO_3. Locally the scheelite is in pockets and streaks up to 18 in. wide. The zone of scheelite-bearing rock is wider than at the Stardust or Comet claims, but is limited in length (562, p. 10).

Dry Creek; T. 40 N., R. 93 W., on the summit of the east canyon wall of Dry Creek, north of the Fuller Ranch. Pegmatites and black metadiorites (?) cut schists and gneisses which strike N. 55° E. Metadiorite also cuts pegmatite. Specks and pods of scheelite can be seen in bull quartz, and a small lens is found in schist. A very little trenching was done in 1943 (554).

Hoodoo Creek Claims; S½ sec. 22, T. 40 N., R. 93 W. High-grade scheelite is associated with an elongated series of connected lenses and pods of epidote-zoisite-quartz-rock. Some scheelite is in larger more massive bodies (562, p. 9). In 1956, the Warren Oil and Uranium Corporation produced 1.88 short tons of 60% WO_3 from the Hoodoo claims (612).

Keahey Mines; secs. 20, 21, 22, 27, 28, 29, T. 40 N., Rs. 92, 93 W., 20 mi. north of Shoshoni. The scheelite is spotty and erratic and low grade. Three thousand nine hundred pounds assayed 3.82% WO_3 and 1,300 lbs. assayed 4.69% according to the owners (333).

Crystals, disseminated grains, and fracture fillings of scheelite are associated with lime silicate rocks and quartz veins. Black dikes of hornblende diorite, lenses of quartz-muscovite schist, and gneiss constitute the country rock. Foliation strikes N. 70° E. to east-west, and dips 55° SE. or SW.; joints dip about 45° N. Hagner obtained the following summary from the U. S. Bureau of Mines (reference not available) (334).

Claim	Outcrops	Total Width	Total Length	Projected Depth	Tonnage	% WO_3	Units WO_3
Romur I							
Arlene		12'	100'	20'	2,400	—0.5	1,200
Arlene Gp.	1	1.5'	200'	10'	300	—0.5	150
Whippet	1	2.0'	150'	10'	300	—0.5	150
Victory		3.0'	60'	10'	180	—0.5	25
Arlene 5	6	2.0'	50'	10'	100	—0.5	50
June 1	6	3.	60'	10'	180	—0.5	90
Olive Gp.	7	2.0	80'	10'	160	1.0	160
Totals	21	25.5	700	80'	3,580	—0.5	1,915

Olive 5 Claim; near the Keahey and Romur Claims. Scheelite-bearing rock is found between hornblende diorite and basalt in a badly fractured zone of lime silicate rocks and biotite schist. The zone is about 5 ft. wide and dips 55° SSE. The uppermost lens of the zone produced 25 tons of ore which contained 2.56% WO_3 (336).

Romur Claim; SE¼ sec. 20, T. 40 N., R. 93 W. A zone of pre-Cambrian lime silicate schists and gneisses has been cut by numerous basic dikes and granite pegmatites (212, p. 4); the zone contains scheelite in three lenses and pods of quartz-epodite-zoisite rock and trends east-northeast. The rock is barren between the scheelite-bearing pods. The richest scheelite (2% to 3% WO_3) is found in the middle lens (562, pp. 8-9). In May, 1943, 40 tons of crude ore assayed 3% WO_3 (212, p. 3) and in September, 1,600 lbs. assayed 1.57% WO_3

(335). In 1945, the indicated and inferred ore reserves were 1,268 tons of 1.50% WO_3 ore. There is also a small reserve of medium to high grade ore (390, p. 25).

Shooting Star Claim; N½ sec. 29, T. 40 N., R. 93 W. An 18 in. vein parallels the foliation of the metamorphic rocks and contains a rich pocket of scheelite. Scheelite is also found in a quartz vein 10 ft. long and from 3 ft. to 4 ft. wide, and in a narrow zone 60 ft. to 80 ft. long, and 16 in. to 18 in. wide in a dark gray-green to black schist (562, p. 8).

Stardust Claim; S½ SW¼ NW¼ sec. 22, T. 40 N., R. 93 W. Scheelite in this claim is found in two northeast-trending zones which are separated by 20 ft. of schist. The northernmost zone is more continuous and richer, but terminates against a basic dike. Width of the northern zone is from zero to 6 ft.; average is from 2 ft. to 3 ft. and it may be up to 600 ft. long. The scheelite crystals are imbedded in a matrix of zoisite, epidote, quartz, and garnet. The southern zone crops out for about 40 ft. (562, p. 9).

Victory Claim; S½ sec. 20, T. 40 N., R. 93 W. This deposit is very similar to the Stardust claim. Two vein zones contain scheelite in scattered, small pockets and pods. The northern vein, along the western crest of a ridge, contains scheelite localized in a shear zone in a basic dike (562, p. 8).

Wind River Range Area

Abernathy Claim; southwest of Lander, 1 mi. beyond Granier Meadow where the road forks. Three pits have been dug. Pit No. 1 (farthest northeast on the claim) is 2 ft. long and 4 ft. wide in a quartz vein which trends northeast and contains garnet, epidote and scheelite. Other rocks are granite, hornblende schist and quartzite. Pit No. 2 (135 ft. southwest of Pit No. 1) is about 6 ft. long and 5 ft. wide. The rock fluoresces, but no garnet or epidote are evident. Pit No. 3 (southwest of No. 2) is 10 ft. long, 4 ft. wide, and 5 ft. deep and encounters scheelite in an altered granite (?) (312).

Maxwell Claim; at Lewiston. Scheelite, as specks, streaks, and small pockets is erratically distributed throughout a quartz vein which cuts a diorite (?). A shaft and tunnel disclose scheelite from about 25 ft. (346).

Metterling Prospect; no location known, but it is thought to be near the Maxwell property. A 30 ft. shaft was sunk on a quartz vein in diorite (?). The scheelite zone varies from a few inches to several feet; it is fairly uniformily distributed in small specks and streaks (345).

Burr Mine; sec. 5, T. 28 N., R. 98 W.; Scheelite occurs in small stringers, veinlets, lenses, pods, and specs, ranging from microscopic size to 6 in. in length. Assays are reported to vary from 2.5 to 70% WO_3. Enough gold is believed present to pay for the mining operations (597).

Washakie County

NW¼SW¼ sec. 24, T. 41 N., R. 87 W.; near the headwaters of Middle Fork Powder River. Massive quartz veins contain disseminated scheelite in small pods and lenses (up to 1½ in. in diameter). The veins strike N. 75° W., and dip 70° NE. A pit 25 ft. long, 6 ft. wide, and 12 ft. deep has been dug; the foot-wall of quartz-biotite schist has no scheelite. The scheelite-bearing material is lenticular, hence it probably pinches out in depth (578).

REPORTED OCCURRENCES

Albany County

Wolframite has been reported in small stringers in a copper mine near Holmes (518, p. 348).

Crook County

Nigger Hill; (See TIN).

Fremont County

Lewiston district; Scheelite has been found on the dumps of the Amanda, Hidden Hand, and Iron Duke mines (217).

Sheridan County

Mosaic Claim; T. 54 N., R. 87 W. A 25 ft. shaft in granite and quartz encountered some scheelite in a gouge zone 1 ft. to 2 ft. wide (348); (See GOLD).

Teton County

Tungsten minerals were reported in 1907 in the Jackson Hole placer gravels (455, p. 713).

URANIUM, THORIUM AND RARE EARTHS

By William H. Wilson

URANIUM DEPOSITS

Introduction

Significant uranium deposits were first discovered in Wyoming at the Silver Cliff mine near Lusk in 1918. In 1936, schroeckingerite (formerly called dakeite) was discovered in the Lost Creek area of Sweetwater County. The first discovery of minable uranium ore deposits was made in the Pumpkin Buttes area in October, 1951. These were later followed by discoveries in the Aladdin, Carlile, and Hulett Creek areas, Crook County; Crooks Gap and Gas Hills areas, Fremont County; Baggs-Poison Basin area, Carbon County; southern Powder River Basin area, Converse County; and the Little Mountain area, Big Horn County, during the years 1952 through 1955. Later important discoveries resulted in the production of uranium ore in 1960, from the Shirley Basin area of Carbon County.

During the earlier years of the uranium boom in Wyoming, the principal production came from the deposits in the Lower Cretaceous Inyan Kara group in the Black Hills area; now, however, most of the current production comes from the Eocene Wind River formation in the Gas Hills area. Nearly one-half of Wyoming's uranium reserves are located in this area.

As of December, 1965, there were five uranium mills operating in Wyoming. Federal-Gas Hills Partners, Utah Construction and Mining, and Western Nuclear operate mills in Fremont County, Union Carbide in Natrona County, and Petrotomics in Carbon County. Uranium ore from the Powder River Basin is shipped to the Mines Development mill at Edgemont, South Dakota, where vanadium is recovered as a byproduct. A sixth uranium mill operated by Susquehanna Corp. (formerly Fremont Minerals) at Riverton, closed in May, 1963.

Wyoming is considered to have the second largest reserves of uranium in the United States; New Mexico ranks first. As of January, 1963, the U.S. Atomic Energy Commission estimated that Wyoming contained 36% of the nation's 25 million short tons of uranium containing 0.24% U_3O_8. In 1964, 1,490,353 tons of ore averaging 4.4 pounds of uranium were produced (613).

There are known occurrences of uranium (excluding uraniferous coal, phosphate, and carbonaceous shale) in 20 of the state's 23 counties. In addition to pre-Cambrian vein-type deposits, local concentrations of uranium occur in at least 33 different formations which range in age from Cambrian to Pliocene. Uranium has even been reported from Quaternary pediment gravels near Saratoga (A-95) and in alluvial clays in the Lost Creek area. Most of the uranium ore production, however, has come from the Madison formation of Mississippian age, the Fall River and Lakota formations of Lower Cretaceous age, the Wasatch and Wind River formations of Eocene age, and the Browns Park formation of Miocene (?) age.

Most of the uranium deposits in Wyoming, irrespective of the type of deposit, are clustered: (a) where large northwestward-trending structures, such as major basins and mountain ranges, are intersected by later northeastward-trending structures; (b) the intersection of northwestward-trending structures by enechelon faults and folds; or (c) near the axial parts of major basins (A-71, A-72). Individual deposits are localized along structural terraces, monoclines, anticlinal crests, synclinal troughs, faults, joints, regional unconformities, regional and local lithologic changes and chemically and physically favorable host rocks.

The principal uranium-bearing minerals in Wyoming are autunite, metaautunite, carnotite, schroeckingerite, tyuyamunite, metatyuyamunite, uranophane, uraninite and coffinite. The deposits in the Powder River Basin and Black Hills areas are composed mainly of uranium-vanadium minerals with some vanadium minerals and uranium silicates, while those in the other major producing areas contain uranium phosphates, arsenates, carbonates, and silicates with minor occurrences of vanadium minerals (A-12). Selenium is known to occur in all the producing areas with the possible exception of the Little Mountain area in Big Horn County.

The original source of uranium is still subject to controversy, and the problem will not be discussed further; suffice to say that the majority of the evidence supports the "volcanic ash leash" hypothesis. The interested reader is advised to consult publications A-112 and A-113 listed at the end of the bibliography for further information on this topic. There can be no doubt, however, of the influence of ground water movement and position of the ground water table with respect to local structural features in localizing the uranium deposits.

In addition to the deposits listed in the following pages of this bulletin, low-grade uranium deposits are known to occur in the Permian Phosphoria formation which crops out in various areas in the western half of the State. The maximum uranium content increases areally from east to west as the total phosphate of the phosphatic members increases. Analyses from the upper phosphate zone, Sublette Ridge, Lincoln County, are reported to contain a maxima of 0.010 to 0.018% uranium (A-53). Most of the uranium is in dispersed form in the phosphate beds and is mainly concentrated in the carbonate-fluorapatite grains (A-53). Because of the large tonnages of these low-grade deposits, it is possible that some uranium could be recovered in the future as a by-product of the manufacture of triple super-phosphate.

Finally, uraniferous coals and carbonaceous shales have been reported from the Auburn area, Lincoln County; Evanston area, Uinta County; Burnt Fork area, Sweetwater County; Cambria coal mines, Weston County; Powder River Basin area, Campbell, Converse, and Johnson Counties (A-19, A-42, A-96); as well as the Red Desert area, Sweetwater County (which is described in the following pages).

Future exploration for uranium will undoubtedly be directed toward the deeper parts of the sedimentary basins in the State. Additional vein-type deposits may be found in the pre-Cambrian rocks, since many of these areas have been little prospected because of their remoteness. Finally, in view of the uranium occurrences on Little Mountain in Big Horn County, it would seem that some attention should be directed toward exploring the Madison-Tensleep sequence on the west flank of the Big Horn Mountains.

At the present time most of the uranium is being used for military requirements; however, some is being utilized in reactor programs. The future for nuclear fuel is very bright, particularly for those countries where shortages of water resources and fossil fuels exist. Civil applications of nuclear explosions may be useful in the following: construction of harbors, production of artificial aquifers for replenishing water tables, breaking up of low-grade ore deposits prior to leaching, increased recovery of oil fields, direct recovery of oil shales and tar sands by loosening and heating, and production of fill and riprap for road construction. Radioactive isotopes are being used in medicines and surgery and in determining rates of wear in machines and various mechanical devices.

Two items of significant interest to the uranium prospector in Wyoming should be recognized: (1) the Supreme Court of Wyoming has indicated that radiation counter readings are, in themselves, held to be insufficient proof of a discovery to justify staking a lode mining claim; and (2) a discoverer of a mineral deposit may, in lieu of a discovery shaft, drill one hole, or holes, to aggregate at least 50 feet of which no hole shall be less than 10 feet, and at least one shall cut or explore deposits of valuable minerals.

The writer wishes to acknowledge the cooperation of various members of the U. S. Atomic Energy Commission and U. S. Geological Survey, who made available much unpublished data used in compiling this section on uranium deposits. The writer has endeavored to make it as complete and as representative as possible; however, it is also recognized that there are undoubtedly occurrences of uranium in the state for which no data are available.

PRODUCING AREAS

Big Horn County

Little Mountain Area: T. 58 N., R. 94 W. The Little Mountain area is a long anticlinal ridge trending northwest-southeast between East Pryor Mountain, Montana, and the main mass of the Big Horn Mountains in Wyoming. Rocks cropping out on Little Mountain consist mainly of the upper part of the Madison limestone of Mississippian age, and are overlain by remnants of the Amsden and Tensleep formations of Pennsylvanian age.

Uranium mineralization occurs in the upper part of the Madison formation, which consists of gray dense crystalline brecciated limestone with abundant caverns and Amsden redbed fill. The ore deposits range up to 5,000 to 8,000 tons in size and occur as enrichments of silt-clay-rock fills of caverns and solution cavities. The deposits conform to the size and shape of the cave or cavity in which they are contained. Most deposits are less than 500 tons in size, and many contain only a few tons or pounds of ore. The tenor usually exceeds 0.50% U_3O_8.

The major ore deposits consist of tyuyamunite and metatyuyamunite associated with calcite interstratified with silts and clays within caverns and solution cavities. Uranium minerals associated with crystalline calcite also form encrustations on thin slabby limestone collapse blocks, debris on the floors, and through the solution breccias.

The east ore body of the Fusner mine (Lisbon Uranium Corporation) was one of the largest deposits mined in the area and produced about 5,000 tons of ore averaging about 0.80% U_3O_8. The ore occurred in an irregular cavern whose western side terminated against a north-south trending joint. The length of the cavern followed this joint for about 150 ft., and the width varied from about 35 to 80 ft. The floor and back paralleled essentially flat-lying bedding with an average height of 20 to 25 ft. Tyuyamunite and metatyuyamunite occurred in a fanlike deposit, which was composed of reddish-brown 'Amsden derived' silts and angular limestone fragments, as well as in two separate interstratified beds in the intercavern sediments. The lower ore bed varied in thickness from 1 to 3 ft., and the upper ore bed varied in thickness from 2 to 8 ft. (A-33). Lisbon Uranium Corporation has been the major producer in the area; however, early in 1958, Modern Mines Development Company sank a 740-ft. inclined shaft to open up a newly drilled ore body, 13 ft. thick, 100 ft. wide and 260 ft. long.

Major production from this area ceased in 1963; however, an occasional shipment is made from the smaller deposits.

Campbell and Johnson Counties

Pumpkin Buttes Area. The Pumpkin Buttes uranium area consists of about 350 sq. mi. near the center of the Powder River Basin. Uranium mineralization was discovered in the area in October, 1951 (A-43).

The Pumpkin Buttes area lies along the axis of a broad anticline that plunges gently northwest. The major part of the area is underlain by the Wasatch formation of Eocene age and this is unconformably overlain by thin remnants of the White River formation of Oligocene age. The Wasatch formation is about 1,200 ft. thick and consists of lenses of sandstone that are dispersed throughout a sequence of drab siltstone, claystone, and carbonaceous shale beds.

The uranium deposits are associated with, and occur within, the boundary of the area of the red sandstone lenses in the lower half of the exposed Wasatch (A-86). All known deposits occur within 150 ft. of the surface and do not extend more than a few feet below the water table. Minable deposits may be classified into two general types, based on size, grade, and mineralogy:

(1) Small high-grade concretionary deposits usually containing less than 25 tons of uranium ore with an average grade of 1% and over. The concretions are composed of uraninite associated with manganese or iron oxides and surrounded by uranophane and/or secondary uranium vanadates. The majority of mines in the Pumpkin Buttes area were developed in this type of deposit (A-61).

(2) Deposits containing as much as 5,000 tons of ore averaging about 0.50% uranium. This type of deposit occurs in the buff-colored sandstone at the contact with the pink to red sandstone. Uranium minerals occur as a shell, varying from several inches to several feet thick, representing the furthermost penetration of red coloration and transecting all sedimentary features. The uranium vanadates, where the contact is irregular, are also disseminated throughout the area between the red-colored stringers and may attain a thickness of 8 to 12 ft. Small high-grade uraninite pods associated with pyrite and selenium (A-21) are found in the buff sandstones at or near the contact. To a lesser extent, the uraninite-manganese-iron oxide pods are found in the red sandstones at the contact (A-61).

At least 200 uranium occurrences are known within the Pumpkin Buttes area. The first ore was shipped by Jenkins and Hand in July, 1953. As of January, 1958, there have been 62 producers, of which six are still intermittently active. The total production from each deposit mined has varied from less than 100 to 1,000 tons. More than 5,000 tons of ore has been mined by one operator. The ore is shipped to the Mines Development mill at Edgemont, South Dakota.

Carbon County

Baggs-Poison Basin Area; secs. 2, 3, 4, 5, 8, 9, 10, 11, T. 12 N., R. 92 W., secs. 32, 33, 34, 35, T. 13 N., R. 92 W. Uranium mineralization occurs in the Browns Park formation of Miocene age. The Browns Park formation, which covers much of the topographic basin that coincides with the asymmetric westward plunging Poison Basin syncline, is an outlying remnant here and consists of 300 ft. of conglomerate, highly cross-bedded sandstone, and tuffaceous sandstone and quartzite.

Uranophane, metaautunite, and schroeckingerite are erratically distributed through a strongly cross-bedded sandstone overlying the basal conglomerate of the Browns Park formation. The uranium in many places, is usually so finely disseminated in the sandstone that little or no mineralization is visible even in strongly radioactive samples (A-74).

Select samples of uranophane-bearing sandstones contain as much as 3.21% uranium (A-132).

Uraninite and coffinite, associated with pyrite and ilsemannite (hydrous molybdenumoxide), occur in the unoxidized or "blue" zone at depths of 20 to 70 ft. (A-75). These deposits, which occur in a pale to moderate blue argillaceous very fine to fine-grained sandstone, are up to several feet in thickness and are in the shape of gently dipping blankets following the bedding (A-23). Faults in the area have also been instrumental in determining the shape of some deposits.

The blue pyritic sandstone, which is usually found below the local water table, is believed present under many square miles of the Poison Basin area.

Selenium is associated with the uranium deposits as an unknown compound and appears in greater concentrations in the unoxidized rather than in the oxidized zone (A-75).

Intermittent production has occurred from Shawano Development Corporation's and Basin Engineering's operations since the discovery of mineralization in October, 1953.

Shirley Basin Area. Ts. 27 and 28 N., R. 78 W. Shallow subsurface uranium mineralization was discovered in 1954; however, the discovery of minable deposits occurred in 1957. The uranium deposits occur in a mineral belt which has a known length of 7 miles in a northwestward direction and as much as 1½ miles wide. This trend parallels a buried Cretaceous ridge. Uraninite, the principal mineral mined, occurs in tongue-like bodies in poorly consolidated sandstone units of the Eocene Wind River formation. The uranium deposits occur in the contact zone between the greenish-yellow altered sand and the gray unaltered sand along the sides, tops and bottoms of these large elongate tongues (A-115, A-120, A-123). The uranium material being mined, contains about 0.60% U_3O_8, with selected samples as high as 10% U_3O_8 (A-120).

Utah Construction and Mining Co. formerly operated an underground mine here until 1963; however, this was shut down because of adverse groundwater problems. Both the mine and wells adjacent to the mine pumped more than 5,000 gpm. of water at times during operation (A-115).

Petrotomics Co. currently (1965) operates an open-pit mine believed to be located on the up-dip side of the same sandstone mined by Utah. In 1962, Petrotomics placed a 500 ton per day mill into operation adjacent to their uranium mine.

Converse County

Southern Powder River Basin Area

The most prominent uranium deposits here occur in the Monument Hill area in the Dry Fork area of the Cheyenne River and in the Box Creek area to the south. A few scattered uranium prospects, such as the Turner Crest area, lie between the Monument Hill area and the Pumpkin Buttes area to the north.

In general, the geology of the area is similar to that previously described for the Pumpkin Buttes area, in that the area is predominantly underlain by the Wasatch formation of Eocene age. These rocks, which dip gently northwest, are underlain by the Fort Union formation of Paleocene age. The Wasatch formation varies from 500 to 1,000 ft. thick and consists of claystone and siltstone beds interbedded with irregularly spaced sandstone lenses, and coal and carbonaceous shale beds. The uranium deposits occur in the central part of the area of Wasatch outcrop where the lenses of sandstone are reddish in color.

The yellow uranium minerals, tyuyamunite, carnotite, uranophane, and locally, liebgite, are disseminated in the sandstone. Small masses of uraninite and pyrite-cemented sandstone, commonly rimmed by thick halos of yellow oxidized uranium minerals, also occur in places (A-87).

Monument Hill Area. Uranium mineralization in the Monument Hill area was discovered by an AEC airborne radiometric survey in October, 1952. The uranium deposits occur in the bottom 100 to 120 ft. of a Wasatch sandstone unit, of which the lower 65 ft. is a red ferruginous stained sandstone. Here, the most productive deposits occur in a north-trending belt about ½ mi. wide by 6 mi. long. With the exception of two, all mines are in the buff to white sandstone as much as several hundreds of feet from the red-buff contact (A-59).

The ore bodies are generally irregularly tabular with the long axes parallel to the red-buff contact in a rude north-south direction. They are apparently confined to a relatively narrow zone and may occur at various elevations within the zone. These bodies pinch and swell and may be connected by areas of submarginal mineralization (A-61). Much of the mineralization is in the form of roll ore bodies with a sharp contact between altered and ore-bearing feldspathic sandstone. These are concave towards the altered material (A-124). The average size of an ore body is approximately 100 ft. long, 70 ft. wide and 9 ft. thick; however, one body was 1,000 ft. long, as much as 400 ft. wide, and as much as 50 ft. thick. The deposits range in size from a few hundred tons to as much as 50,000 tons of ore with grades averaging between 0.2 and 0.3% uranium (A-61).

Carnotite and tyuyamunite are the most common minerals and occur as dusty grain coatings or are disseminated interstitially in the sandstone. The uranium vanadates also occur as secondary haloes surrounding uraninite and as replacement of carbonaceous material and clay galls. Uraninite-pyrite-calcite concretions occur locally. In some cases uranite is found as a cementing material forming small tabular masses that may weigh as much as several hundred pounds. Uranophane, gummite, liebigite, metaautunite, and, occasionally, native selenium have also been reported from this area (A-59, A-61). All of the mineable deposits are reported to be located above the water table (A-124).

More than 16 producers have been active in this area; some of them include Jenkins and Hand, Loma Uranium Corp., Vern Mrak, Susquehanna-Western, and Western Nuclear.

Crook County

Hauber Mine; SW¼ sec. 3, T. 55 N., R. 67 W. The uranium deposits occur in the basal sandstone of the Lakota formation at or just above the contact wih the underlying Morrison formation. The ore deposit is adjacent to and apparently parallel to a northeast-trending normal fault of about 30 feet maximum displacement. The ore zone, which varies in depth from 290 to 360 ft. below the surface is a dark gray to black medium-grained carbonaceous sandstone which in some places is conglomeratic (A-88, A-128). The uranium minerals are believed to be uraninite and coffinite (A-88). The ore deposit has been mined underground since 1958, by the Homestake Mining Company.

Fremont County

Crooks Gap Area; secs. 8, 9, 16, 17, 20, 21, 28, 29, T. 28 N., R. 92 W. The uranium mineralization, which was first discovered by a private airborne radioactive survey in December, 1953, occurs on the east side of Crooks Gap in a northerly trending belt 4 miles long by 2 miles wide.

Rocks, ranging in age from pre-Cambrian to Miocene, crop out in the Crooks Gap area. Asymmetric anticlines and thrust faults characterize the pre-Tertiary rocks, while gentle folds and normal faults occur in the Tertiary rocks. The major structural feature of the area is a northward-dipping thrust fault zone which trends somewhat west-northwest at the northern edge of the area.

Most of the uranium deposits occur through a stratigraphic range of as much as 1,500 feet in the lower member of the Battle Spring (formerly called Wasatch) formation; however, uranium ore has been mined (sec. 9, T. 28 N., R. 92 W.) along the plane of a high angle reverse fault which places the Triassic Chugwater on the Cretaceous Cody shale (A-91, A-130). Additional uranium occurrences are reported from the overthrust Cambrian rocks in the northern part of the area. Uranophane, metaautunite, and autunite, which are the principal uranium minerals, occur in the latter deposits.

The uranium mineralization in the Wasatch (Battle Spring?) formation occurs in six or sometimes more zones in the lower part of the formation (A-58). Minerals identified are uranophane, uraninite, coffinite, becquerelite, phosphuranylite, and metatyuyamunite (A-58). The mineralized bodies appear to be localized along axes of shallow synclinal troughs (which may be sedimentary channels) that are superposed at right angles to, and situated on the flanks of, a northerly trending anticline. Other factors that appear to control the localization of deposits are: (1) presence of carbonaceous material. (2) changes in permeability of host or surrounding rocks, and (3) synclinal structures and faults. The latter control the movement of uranium-bearing groundwater and hence influence the deposition of uranium in the area. Mineral deposits are known to occur at depths of approximately 470 ft. in this area.

Open-pit mining operations have been intermittent. The Coke River Development Company, mining and Sno-Ball claims (now owned by Western Nuclear Corporation) in sec. 29, T. 28 N., R. 92 W., were the earliest uranium producers in the area. Trial shipments were also made by Wyoming Uranium, Gaddis Mining, San Juan and Split Rock Mining companies. Recent exploration by the Green Mountain Uranium Corporation (Phelps-Dodge Corporation) on Wyoming Uranium's property has indicated a reserve of over a million and one-half tons of potential uranium ore. In 1957 and 1958, Continental Materials Corporation was the principal producer in the area, mining from a deep pit on the Gaddis claims.

At the present time (1965), Continental Uranium and Green Mountain Uranium (Phelps-Dodge) Corp.'s operate underground mines in the area. In 1965, Western Nuclear Corp. sank an 800-foot shaft in order to develop their Golden Goose underground mine near Jeffrey City.

Fremont and Natrona Counties

Gas Hills Area; NW¼ T. 32 N., R. 90 W.; NE¼ T. 32 N., R. 91 W.; T. 33 N., Rs. 89, 90 W.; SE¼ T. 33 N., R. 91 W. Uranium mineralization was first discovered in the area on September 9, 1953, by Neil McNeice, of Riverton, Wyoming. A month later, additional discoveries were reported as a result of reconnaisance studies of the U. S. Geological Survey (A-44).

The uranium deposits, with the exception of two minor occurrences in underlying Mesozoic rocks and in upper and middle Eocene rocks (A-44), occur in the upper part of the Wind River formation of Lower Eocene age. The Wind River formation dips gently south and rests unconformably on rocks ranging in age from Cambrian to Late Cretaceous. Overlying the Wind River formation are tuffaceous rocks of middle and late Eocene and Oligocene ages.

Both the upper and lower units of the Wind River formation vary considerably in thickness because of deep and irregular pre-Wind River erosion and post-Miocene normal faulting. The upper coarse-grained unit, in which the ore deposits are found, varies from 300 to 800 ft. in thickness and consists dominantly of coarse-grained sandstones, commonly cross-bedded, and some mudstone, carbonaceous shale and siltstone beds. Conglomerate beds, 10 to 15 ft. thick, are common in the western part of the area (A-111).

Two periods of normal faulting appear to have been important in affecting the uranium deposits of the Gas Hills area. Early Eocene age normal faults (which generally trend in a northeasterly direction) appear to be pre-ore in age and may have acted as barriers to the flow of uranium-bearing ground water solutions. Post-Miocene and later normal faults, which trend from east-west to northwesterly, have controlled the present position of the water table and caused secondary enrichment of some of the deposits by damming up ground waters and with the precipitation of uranium near the top of small perched water tables (A-108). A small belt or horsts and grabens, the largest of which is a graben with over 300 ft. of vertical displacement, occurs in secs. 16, 17, 20, 21, T. 31 N., R. 89 W. Several deposits, such as those at the P-C and Ranrex mines, occur in the horstlike structures, and the tops of the deposits coincide with the tops of the perched water tables.

In addition to structure, the following controls appear important in localizing uranium deposits in the area: (1) changes in permeability at the contact of the upper coarse-grained part of the formation with that of the fine-grained lower part, and the interbedding of permeable and impermeable sediments in the upper part of the formation, (2) faults acting as solution dams, and (3) presence of carbonaceous material, iron oxide and calcium carbonate. The mineralized bodies vary in depth from surface exposures to more than 600 feet. The ore bodies generally range from one to 10 feet thick and contain from 0.15 to 0.35% U_3O_8; however, thicknesses of 20 to 40 feet and grades exceeding 0.7% U_3O_8 have been reported.

Autunite, metaautunite, phosphuranylite, and metatyuyamunite are the most common ore minerals in the oxidized zone and generally occur as interstitial fillings in irregular blankets in brownish-red to gray coarse-grained arkosic sandstone. Uraninite, coffinite and pyrite are predominant in the unoxidized black to gray zones. Some secondary enrichment of uranium mineralization occurs at the interface between oxidized and unoxidized zones. Among the other uranium minerals found in the area are: liebigite, rutherfordine, uranospinite, becquerelite, metatorbenite, metazeunerite, uranophane, sabugalite, tyuyamunite, and carnotite (A-110).

Native selenium occurs as interstitial material in lenses above, below, and adjacent to lenses of uranium ore in the oxidized zone of the Lucky Mc mine. Two channel samples from this zone are reported to contain 0.24 to 2.73% selenium. Selenium is also reported from oxidized ore zone at the Upetco and Vitro mines (A-109). Ilsemannite (hydrous molybdenum oxide), is reported to occur in both the oxidized and unoxidized uranium ore at the Lucky Mc mine and in the unoxidized zone at the Vitro mine (A-109). Selenium, associated with arsenic and pyrite, has also been reported from the unoxidized ore of newly discovered deposits (A-108).

Major known uranium ore reserves in the Gas Hills area are controlled by four companies: Federal-Gas Hills Partners, Union Carbide Corp. (formerly Globe Mining Co.), Utah Construction and Mining Corp. (Formerly Lucky Mc Uranium Co.), and Western Nuclear Corp. In addition to the companies listed above, important uranium production has come from the operations of Atlas, Bengal, Globe, Dale B. Levi, P-C, Radorock, Ran Rex, Vitro and Joe Wentz mining companies. Almost all operations have been open-pit. Some subsurface operations were initiated but were abandoned because of groundwater problems in the area.

PROSPECTS

Albany County

Metatyuyamunite has been found in the upper and lower sandstone of the Lower Cretaceous Cloverly formation in sec. 9, T. 13 N., R. 76 W. (A-50). Where exposed in an 8-ft. pit, the mineralization occurs disseminated in, and localized along, fractures and bedding planes of a 6-ft. thick highly carbonaceous ferruginous fine-grained thin-bedded sandstone. A selected sample from the lower sandstone contained as much as 0.8% U_3O_8; however, random samples from three nearby hand-picked stockpiles from the same sandstone contained 0.1 to 0.14% U_3O_8 (A-50).

Night Owl Claims; sec. 12, T. 28 N., R. 77 W. Uranium occurs along a narrow breccia zone 5 ft. thick in the basal Pennsylvanian part of the Casper formation. The uranium mineral questionably identified as staffelite (uraniferous carbonate fluroapatite), is disseminated in a pale botryoidal apatite up to several mm. in size (A-84).

In the Marshall area, T. 26 N., R. 75 W. (?), uranium occurs in a cherty manganiferous limestone of the upper part of the Casper formation (Pennsylvanian age). A random sample yielded 0.14% U_3O_8 (A-46).

Albany County No. 1 Claim (?); sec. 19, T. 27 N., R. 73 W. Uranophane occurs as coatings along north-northeast trending, vertical joint surfaces which are adjacent to a N. 53° E. striking vertical fault vein in pre-Cambrian granite. Uranophane also occurs in small clay fillings localized along horizontal joint surfaces (A-28).

Diamond Bell Mine (?); sec. 27, T. 28 N., R. 71 W. Uranophane occurs sparsely disseminated in a sheared diabase dike that is about 50 ft. long and 2 ft. wide. The dike lies with irregular contact along several exposures of biotite and chlorite schists, phyllite, and tactite. Both occur along the contact of two large granitic bodies (A-28).

Coffinite occurs at the Maggie-Murphy mine 3 miles south of Esterbrook (A-28).

Big Horn County

Reeves Ranch; SE¼ sec. 11, T. 52 N., R. 92 W., 10 mi. east of Greybull and 3 mi. southeast of Shell Creek. The Morrison formation strikes N. 45° W. and dips 8° SW. at the east wall of a gulch 40 ft. deep. Radio-active material is found in dinosaur bones at the base of a 12-ft. lens of gray medium-grained cross-bedded sandstone. The bones are composed of a black medium-grained crystalline material with very little internal structure left. Fossil logs in the same bed are not radioactive.

Assay reports in possession of the owners show 0.2% to 0.8% U_3O_8 in the bone material. A specimen analyzed by the Natural Resources Research Institute, University of Wyoming, for the Geological Survey of Wyoming yielded 0.14% U_3O_8 (A-70).

Radioactive concretions occur in the Lower Cretaceous Cloverly formation, and anomalous radioactivity occurs in the Jurassic Morrison formation cropping out east, northeast, and northwest of Greybull (A-12, A-104).

Campbell County

There are many prospects in the Wasatch formation in the Pumpkin Buttes area; see discussion under producing areas.

Carbon County

Sec. 11, T. 24 N., R. 82 W. Crystal aggregates of carnotite occur in both sandstone and claystone of an erosional remnant of the Tertiary North Park (?) formation. A 1-ft. channel sample of the claystone contained 0.051% U_3O_8 (A-49).

Secs. 30, 31, T. 25 N., R. 81 W., and sec. 36, T. 25 N., R. 82 W. Metatyuyamunite associated with vertical calcite veins occurs in the gray fine-grained cross-bedded Tensleep formation of Pennsylvanian age. The calcite veins average 3 ft. in thickness with some as wide as 24 ft. Some of the veins are more than 1,000 ft. long, and some are exposed vertically for more than 500 ft. A 2-ft. channel sample across the vein, exposed in a test pit, assayed 0.03% U_3O_8. Selected samples from other pits assayed 0.89% and 0.39% U_3O_8 (A-48).

Little Man Mine; NW¼ NE¼ SE¼ sec. 14, T. 27 N., R. 84 W. Exposures in a 30-ft. adit driven in pre-Cambrian rocks show a 6-ft. graphite bed underlain by a thin gray quartzite and intruded and surrounded by gray and brown granite. Yellow uranium minerals including kasolite (A-51), occur along fractures and are disseminated through weathered granite within 4 to 6 ft. of the graphite bed. The quartzite is less mineralized. Below the weathered zone, the bluish-gray unweathered granite contains disseminated uraninite, molybdenite and pyrite (A-48). Other minerals identified are uranophane, chalcopyrite, and galena (A-21). A small shipment of uranium ore was made from this mine in 1954.

Saratoga Area; secs. 7, 18, 19, T. 16 N., R. 83 W., and secs. 13, 14, 15, T. 16 N., R. 84 W. Uranium mineralization occurs in the Tertiary North Park formation (A-47).

North of Saratoga, approximately in secs. 15, 22, T. 18 N., R. 84 W., carnotite occurs in fractures in a thick cliff-forming sandstone in the Tertiary Browns Park formation (A-47).

Miller Hill Area; approximate location, SW¼ T. 17 N., R. 87 W., and SE¼ T. 17 N., R. 88 W. Erratic uranium mineralization occurs in the fresh water limestone beds in what Vine has called the North Park (?) formation of probable Miocene age (A-97). Uranophane occurs as vug fillings and is localized along fractures in the silicious, brecciated limestone and sandy limestone beds. Several hundred tons of rock averaging about 0.02 to 0.03% uranium are believed present in the area (A-97).

Ketchum Buttes; sec. 9, T. 15 N., R. 89 W. Uranophane occurs in the lower part of what Vine has called the North Park (?) formation of probable Miocene age (A-97). On the east side of the easternmost "Butte," the mineralization occurs sparsely disseminated in the sandstone. A grab sample assayed 0.031% U_3O_8. Near the top of the western-most "Butte," a small prospect pit shows uranium mineralization in 3-ft. thick limonite-stained claystone. A 3-ft. channel sample in the claystone assayed 0.32% U_3O_8 (A-94).

Doane-Rambler Mine (See COPPER); NE¼ sec. 25, T. 14 N., R. 86 W. A sample of malachite-bearing quartzite from the dump assayed 0.04% U_3O_8 (A-51).

Shirley Basin Area; approximate location, Ts. 27, 28 N., R. 78 W. Uranium mineralization occurs at depths of 10-70 ft. in the upper part of the Wind River formation of Eocene age. Metatyuyamunite occurs coating sand grains in the Arbob claims (NE¼ sec. 3, T. 28 N., R. 78 W.). AEC assays of drill cuttings in a coaly shale indicated 0.27% U_3O_8 (A-84).

Uranium, believed to be a disseminated constituent of lignitic beds, has been reported on the Martha claims in NE¼ sec. 11, T. 27 N., R. 78 W. (A-84).

Autunite (?) occurs in a gray, carbonaceous, finely pyritic sandstone of the upper Wind River formation in the center of sec. 34, T. 28 N., R. 80 W. (A-84).

Deeper drilling in the area, with depths up to 400 ft., has disclosed additional uranium mineralization, but geological details were lacking at the time of publication.

Converse County

Trail Creek Mine; sec. 10, T. 29 N., R. 71 W. A small lens of uraninite mineralization in wall rock of fresh unaltered hornblende schist occurs 8 ft. below the adit floor at the junction of two vertical-dipping shear zones that trend north and northeast. Both shear zones are radioactive where intersected by the adit. The uraninite, which is coated by erythrite (cobalt bloom), occurs as botryoidal and sooty coatings along shear zones and as disseminations in the hornblende schist (A-28).

Shawnee Area. N½ secs. 33, 34, T. 32 N., R. 69 W. Uranium mineralization occurs in steeply dipping fault zones which displace gently dipping rocks of Oligocene-Miocene age. The fault zones average about 4,000 ft. long and 8 ft. wide, and the mineralized bodies are discontinuous lenses which vary from 1-6 in. wide, 2-20 ft. long and of undetermined depth. The uranium minerals generally occur as coatings on chalcedony and calcite, and as cavity fillings in the middle of the brecciated fault zones (A-27). Uranium minerals in the Shawnee area are believed to be metatyuyamunite and some carnotite (A-27).

In SW¼ sec. 32, T. 32 N., R. 69 W., uranium mineralization occurs in an Oligocene-Miocene sandstone channel (A-27). Several occurrences of uranium (in NE part T. 32 N., R. 69 W.) are disseminated interstitially in a 6-ft. thick gray to buff sandstone in the Fort Union formation of Tertiary age (A-27).

Box Creek Area; see discussion of producing uranium deposits of Southern Powder River Basin area.

Crook County

Aladdin Area; SE¼ SE¼ sec. 7, NW¼ NW¼ sec. 17, NE¼ NE¼ sec. 18, T. 54 N., R. 60 W. Uranium mineralization is reported to occur in three stratigraphic units; the lower 30 to 50 ft. of the Fall River sandstone, the upper one-third of the Fuson shale and the upper one-third of the Lakota sandstone; all of Lower Cretaceous age. Carnotite and autunite are the principal uranium minerals (A-20). Several small mines were operated in the area.

Busfield Mine; SW¼ sec. 26, T. 56 N., R. 66 W. The ore deposit was an irregular lens-shaped body in sandstone which occurs in the upper unit of the Lower Cretaceous Fall River formation. As outlined by drilling, the ore deposit was 700 feet long with a maximum width of 200 feet, narrowing abruptly to an average of about 50 feet at the eastern end. The thickness ranged from 2 to 10 feet. Most of the ore body as mined laid almost entirely in the unoxidized zone which contained coffinite and uraninite; however, carnotite and metatyuyamunite occurred in the oxidized zone; the upper 30 feet of sandstone. The uranium content ranged from 0.03% to 1.63% and the V_2O_5 content from less than 0.05% to 1.63%. Mining operations conducted by the Sodak Uranium and Mining Co. were both open cut and underground. Up to Oct., 1957, the Busfield Mine had produced approximately 9,000 tons of ore containing 0.17% U_3O_8 (A-52, A-119).

Carlile Mine; W½ sec. 26, T. 52 N., R. 66 W. Prior to mining, four uranium ore bodies occurred in a sandstone lens in the upper unit of the Lakota-Fuson formations undivided, of Early Cretaceous age. Carnotite and tyuyamunite are the principal ore minerals, and samples high in uranium are also high in selenium and arsenic.

Mining operations, both open cut and underground, by Homestake Mining Company ceased in 1955. At that time samples from underground workings varied from a trace to 1.93% U_3O_8; those from surface workings 0.005-0.34% U_3O_8 (A-3).

Hulett Creek Area; sec. 3, SE¼ sec. 4, sec. 10, T. 55 N., R. 67 W. (A-78). The uranium deposits mined in this area occur in the upper sandstone unit of the Fall River formation of Lower Cretaceous age. A gentle north-plunging anticline, about one mile and a half long and a mile wide, cut by a series of steeply dipping northeast-trending normal faults, crosses the area.

The ore deposits occur near the base or along the edges of a sandstone lens and are generally elongate parallel to the margins of this lens. The greatest known mineralization is localized in a synclinal trough that abuts against and dips towards a normal fault (A-79).

Mineralized areas are 200 to 1,200 ft. long, 5 to 400 ft. wide, and trend in a northwesterly direction. Individual ore bodies are 5 to 200 ft. long, 5 to 80 ft. wide, and a few inches to 10 or more feet thick. Minable deposits are made up of one or more ore bodies.

Depending upon the position of the water table, the deposits consist of the oxidized minerals, carnotite, metaautunite, and metatyuyamunite, or the unoxidized uraninite-coffinite association. These minerals fill the interstices between, and coat sand grains, or are disseminated in the carbonaceous material.

Most of the production has come from the six open pits of the Homestake Mining Company; however, Sodak Uranium and Mining Company has mined a nearby deposit.

Total production from this area, up to Jan., 1958, was 15,000 tons containing 0.24% U_3O_8 (A-128).

Jubilee Mine; sec. 15, T. 54 N., R. 66 W. Carnotite and a fluorescent uranium mineral occur in the Fuson shale of Early Cretaceous age (A-13).

Poison Creek; sec. 12, T. 54 N., R. 67 W. Sabugalite and zeunerite reported; no geological formation listed (A-21). These minerals probably occur in the Inyan Kara group.

Thorn Divide; N. part sec. 27, T. 52 N., R. 66 W. In 1954-55, 45 holes were drilled of which 5 indicated 0.1% to 1.07% U_3O_8. Black, sooty, uranium mineral concentrations occurred in sandstones of the Lower Cretaceous Lakota formation at average depths of 186 and 269 feet (A-3, A-116).

SW¼ sec. 26, T. 52 N., R. 66 W. A yellow uranium mineral which assayed 0.18% uranium and 0.23% V_2O_5 occurs in the lower 3 feet of the upper sandstone sub-unit of the Lakota formation. Several holes were drilled here, but the results of this exploration are unknown (A-116).

Vickers Mine; NW¼ sec. 26, T. 56 N., R. 66 W. Uranium ore occurs in lenses 4 to 5 feet thick at or near the bottom of the upper sandstone in the upper unit of the Fall River formation. Coffinite is the principal uranium mineral. The deposit was mined by the Hilmer-Tessem Uranium Corp., and up to Oct., 1957, had produced between 9,000 to 10,000 tons containing 0.18% U_3O_8 (A-9, A-119).

SW¼ sec. 21, T. 52 N., R. 65 W. Carnotite and tyuyamunite are disseminated in discontinuous pod-shaped bodies in the basal part of the Lakota formation. In 1958, approximately 20 tons of ore containing an average of 0.15% U_3O_8 were mined from open cuts. Trenching and drilling in the area have not revealed additional significant ore bodies (A-125).

NW¼ sec. 18, SE¼ sec. 7, T. 54 N., R. 60 W. Carnotite (?) and tyuyamunite (?) occur disseminated in small discontinuous pods in sandstone in the upper part of the Lakota formation on the west flank of La Flamme anticline. In 1954, the deposits were mined from two small open pits (A-128).

SE¼ sec. 15, T. 54 N., R. 66 W. A yellow uranium mineral occurs in sandstone and seams of carbonaceous material in the lower part of the Fall River formation on the north side of Barlow Canyon. The deposit is about 3 feet thick and 200 feet long (A-128).

Fremont County

Gas Hills Area, see discussion under producing areas.

Copper Mountain Area

Uranium mineralization occurs in an area of about 14 sq. mi. lying between Cedar Ridge and Copper Mountain. Most of the known deposits occur in

Tertiary rocks; however, local concentrations occur in pre-Cambrian granite, schist, gneiss, and dikes. These are irregular, scattered, and vary in depths up to 100 ft. (A-41).

Arrowhead (Little Mo) Mine; NW¼ sec. 29, T. 40 N., R. 92 W. Uranium mineralization occurs in rocks of late Eocene age, and also in adjacent deeply weathered pre-Cambrian granitic rock. The Tepee Trail (?) formation here consists of a generally well decomposed arkosic eluvial and clayey material with abundant granitic boulders up to 4 to 5 ft. in diameter. Uranophane and metaautunite occur throughout the clayey matrix and granitic boulders as streaks and intergranular and fracture fillings and coatings.

Much of the mining (1955) has been from the underlying zone of decomposed pre-Cambrian granitic rock which contains pods of clay, hornblende-biotite schist, and pegmatite. Uranophane, metaautunite, coffinite and uraninite occur disseminated in, and as streaks and specks in, the decomposed zone (A-105).

Mining operations from an open-pit were initiated by the Little Missouri Mining Company in early 1955. Later production was by Susquehanna-Western Inc., who ceased operation in Oct., 1964.

Bonanza Mine; sec. 4, T. 39 N., R. 92 W. Uranium mineralization occurs in the Wind River formation about 30 to 70 ft. below the bentonitic late Eocene Tepee Trail (?) formation. The ore deposits are associated with pyritic and carbonaceous siltstones which were deposited in a shallow trough eroded in pre-Cambrian rocks. Autunite and metaautunite occur in the oxidized zone which is in a buff to yellow medium-grained sandstone. The average grade is 1.3% U_3O_8. Uraninite and coffinite occur in the unoxidized zone about 30 to 45 ft. below the oxidized zone (A-14). Ore estimates from drilling total 30,000 tons. The deposit was formerly mined in 1958, by the Shoni Uranium Corp.

NW¼ sec. 3, T. 39 N., R. 92 W. Several hundred tons of uranium ore were shipped from Kermac mine in the summer of 1955 (A-41).

NW¼NE¼ sec. 32, T. 40 N., R. 92 W. A small, subsurface uranium deposit was reportedly blocked out by drilling in the Eocene Tepee Trail (?) formation (A-133).

Sheep Mountain Area; sec. 31, T. 31 N., R. 97 W. A yellow carnotite-type of mineral is disseminated in, and impregnated in, the more porous sections of a fine-grained sandstone in the Tensleep formation of Pennsylvanian age (A-69).

Secs. 7, 10, T. 30 N., R. 97 W. Yellow-green uranium minerals coat fractures and vugs in a cherty dolomite of the Phosphoria formation of Permian age (A-38, A-68).

Sec. 24 (?), T. 41 N., R. 108 W. A radioactive dull-yellow and light-greenish mineral coats fracture planes in north-south trending quartz-feldspar veins in light colored pre-Cambrian granite gneiss (A-65). The minerals have been identified as uraninite, allanite and uranophane (A-22).

Sec. 22, T. 40 N., R. 92 W. Uranium mineralization occurs in an inlier of schist and gneiss in pre-Cambrian granite. Uranophane occurs as coatings on granite layers and autunite coats fractures in schist (A-40).

Sec. 20, T. 28 N., R. 90 W. Autunite (?) occurs in fault gouge in pre-Cambrian granite (A-35).

Sec. 7, T. 7 N., R. 5 W. A 5-ft. thick zone of radioactivity occurs in a fine-grained sandstone bed of the Aycross formation of Eocene age (A-66).

Whiskey Mountain; sec. 13 (?), T. 40 N., R. 107 W. Carnotite occurs in cavernous silicified rocks of Cambrian age (A-92).

McComb Area; SE¼ NE¼ NW¼ sec. 3, T. 39 N., R. 92 W. Metaautunite occurs abundantly (?) in green bentonitic plastic claystone and green bentonitic coarse-grained arkosic sandstone of the Tepee Trail (?) formation of Eocene age. A sample contained 0.80% U_3O_8 (A-47).

NW¼ SE¼ sec. 27, T. 40 N., R. 92 W. A yellow nonfluorescent uranium mineral appears sporadically along the walls of a 15-ft. shaft. The mineralization occurs in a claystone and sandstone matrix between granitic, mafic, and quartzite boulders of the upper part of the Tepee Trail (?) formation of Eocene age (A-47).

NW¼ NW¼ SE¼ sec. 2, T. 39 N., R. 92 W. Schroeckingerite (?) occurs in a coarse-grained arkosic gray sandstone in the Tepee Trail (?) formation of Eocene age (A-47).

De Pass (Williams-Luman) Mine; sec. 14, T. 40 N., R. 92 W. Uraninite is reported from the dump (A-51).

Beaver Rim Area; sec. 6, T. 32 N., R. 94 W. Uranium occurs in a tuffaceous silstone one-foot thick in the upper part of the Eocene Wagon Bed formation (A-131).

Sec. 3, T. 32 N., R. 94 W. Uranium mineralization occurs in asphaltic sandstone and medium-gray arkosic conglomeratic sandstone of middle and upper Eocene rocks (A-106, A-109). Limited ore shipments from open-cut operations were made in 1955 by the Cheyenne Mining and Uranium Company.

Fremont and Natrona Counties

Split Rock Area. A sample collected from a limestone deposit of Pliocene (?) age contains 0.023% uranium. One-half mile northeast of the limestone outcrop, a white tuffaceous shale, believed to be stratigraphically below the lenticular limestone, assayed 0.013% uranium (A-46).

Goshen County

South Copper Belt Mine; sec. 1, T. 30 N., R. 64 W. Radioactivity has been reported from the dump and is associated with fracture surfaces of pre-Cambrian rocks that contain secondary copper minerals (A-39). Radioactivity, mainly confined to fault zones in pre-cambrian rocks, is also reported from the other old copper mines in T. 30 N., R. 65 W., and T. 31 N., R. 64 (?) W. (A-55).

Johnson County

See discussion of Pumpkin Buttes under Producing Areas.

Mayoworth Area; NE¼ NW¼ SW¼ sec. 3, T. 44 N., R. 83 W. Metatyuyamunite occurs along fracture planes and replaces oolites in the basal limestone of the Sundance formation of Late Jurassic age (A-45). Radioactivity also occurs in the limestone north and south of the above area. Samples from these deposits range from 0.017 to 0.32% U_3O_8 (A-29).

NE¼ sec. 14, T. 44 N., R. 83 W. Radioactive dinosaur bones occur in a medium-grained gray and brown sandstone in the middle part of the Morrison formation of Late Jurassic age (A-45).

Sec. 4, T. 43 N., R. 83 W. Coffinite has been identified in the Tensleep formation of Pennsylvanian age (A-22).

Laramie County

Autunite and torbernite are reported from the Silver Crown mining district, in the Carbonate Belle, Thunder Cloud, Hermosetta, Grant, Pacific and other mines (A-1).

Lincoln County

Two coal beds that crop out along U. S. Highway 30, 0.4 mi. west of Sage, contain as much as 0.013% U_3O_8 in the ash (A-4).

Natrona County

East Gas Hills Area; see discussion under Gas Hills producing areas.

Hiland Area; secs. 26, 27, T. 37 N., R. 88 W. Uranium occurs in a lenticular arkosic sandstone channel at the base of the upper drab sequence of the lower fine-grained facies of the Wind River formation. The lens is about 2,400 feet long and 300 feet wide; however, the uranium occurs in a zone 10 feet wide, 1 to 5 feet thick, and 2,000 feet long. Samples from this zone range from 0.001 to 0.58% uranium (A-76, A-127).

Clarkson Hill Area; sec. 17, T. 31 N., R. 82 W. A zone of high radioactivity occurs about 35 feet above the base of the Wind River formation in an area about 500 feet long and 300 feet wide near the base of Clarkson Hill. Maximum uranium content in a 10-foot thick carbonaceous siltstone and sandstone is 0.01% (A-76, A-127).

Sec. 4, T. 31 N., R. 83 W. Uranium occurrences are reported in the Oligocene White River formation (A-77, A-127).

Sec. 17, T. 31 N., R. 82 W. Metaautunite (A-21) is reported in the Wind River (?) formation.

Schroeckingerite (A-21) is reported 20 mi. southwest of Casper in the Poison Spider area.

Sec. 33, T. 32 N., R. 83 W. A green fluorescent uranium mineral occurs in a buff medium-grained sandstone of the Wind River formation (A-26).

S½ sec. 9, T. 32 N., R. 81 W. A zone of radioactivity, adjacent to a small fault, occurs in a shale bed at the top of the Jurassic Morrison formation (A-25).

Sec. 35, T. 33 N., R. 82 W. A radioactive zone of 0.5 to 5.0 milliroentgens per hour occurs in exposures and pits in a 0.5- to 2-ft. thick black carbonaceous mudstone lying above the basal conglomerate of the Lower Cretaceous Cloverly formation (A-7).

Sec. 33, T. 35 N., R. 79 W. Carnotite (A-21) occurs on partings and splits and as erratic disseminations with carbonaceous shardlike fragments in a carbonaceous shale which is up to 2 ft. thick. Yellow uranium minerals also occur in a sandstone bed adjacent to the shale. The occurrences are in the Mesaverde formation of Late Cretaceous age (A-67).

Pine Ridge Area; secs. 5 and 8, T. 39 N., R. 77 W. Uranium mineralization occurs in the Lance (?) formation of Late Cretaceous age. Carnotite- or tyuyamunite-type minerals occur in a pink to red sandstone that strikes N. 12° E., and dips 10° E. Approximately 1,200 tons of uranium ore were mined from the deposit in 1957 by the Globe Mining Company (A-60).

Niobrara County

Silver Cliff Mine; sec. 7, T. 32 N., R. 63 W.; located near the top of a hill about 150 ft. high; about ½ mi. west of Lusk. Most of the hill is composed of pre-Cambrian metamorphic rocks, unconformably overlain by a southeast-dipping calcareous sandstone of Cambrian (?) age.

The uranium deposits lie in and adjacent to a high-angle reverse fault that strikes N. 15° E. Uranophane, secondary copper minerals, and native silver occur in the fault zone. Samples of the fault zone material vary from 0.001 to 0.12% U_3O_8. Uranium mineralization also occurs in two types of sandstone in the footwall of the fault. The most radioactive is a brown to black sandstone that contains pitchblende, gummite, uranophane, chalcocite, secondary copper minerals, and native silver. The uranium content varies from 0.61 to 1.48%. The more common type of uraniferous sandstone is light-buff to rust-brown and contains uranophane and minor quantities of metatorbernite, azurite, and malachite. The uranium content in this zone varies from 0.001 to 3.39% (A-101).

The mine was opened about 1880, and worked for silver and copper on a small scale (A-2). Between 1918 and 1922, six carloads containing about 3% U_3O_8 were shipped to the Radium Company of Denver, Colorado (A-101).

Rawhide Buttes Area; SW¼ NW¼ sec. 23, T. 31 N., R. 64 W. Uranium mineralization, believed to be pitchblende, occurs in a narrow fault zone in pre-Cambrian mica schists. Ten tons of 0.1% ore were reported shipped in June, 1955 (A-24).

Lance Creek Area

Sec. 25, T. 36 N., R. 65 W. Uranium minerals, tyuyamunite and metazippeite, are concentrated along the northern margin of a fault which strikes N. 80° W. and dips 70° N. The mineralized zone is confined to a 2-ft. thick, poorly consolidated, conglomeratic hematite sandstone of the White River formation of Oligocene age (A-8).

Secs. 19, 20, T. 35 N., R. 65 W. Uranium minerals, carnotite and tyuyamunite occur in a 15-ft. thick, fractured, well cemented conglomeratic sandstone in the White River formation (A-8).

Sec. 24, T. 34 N., R. 67 W. Radioactive mineralization occurs in a lignitic coal lens in the Fort Union formation of Paleocene age (A-8).

Sec. 24, T. 36 N., R. 65 W. Abnormal radioactivity occurs in the steeply dipping Fox Hills sandstone of Cretaceous age on the northern flank of the Lance Creek anticline. No uranium minerals were observed (A-8). Central part T. 37 N., R. 62 W., and sec. 17 (?), T. 36 N., R. 62 W. Uranophane (A-21) and carnotite are reported from the Dakota formation of Early Cretaceous age near Old Woman anticline.

Park County

Secs. 18, 24, 30, T. 52 N., R. 101 W. Metaautunite is sparsely and erratically distributed through both the Lower Cretaceous Cloverly formation and underlying Jurassic Morrison formation (A-32).

Secs. 2 or 3, T. 50 N., R. 104 W. Autunite occurs in the base of the Cloverly formation and top of the Morrison formation. Samples varied from .0708 to .177% U_3O_8 (A-11).

Dead Indian Creek Area; SE¼ NW¼ sec. 8, T. 55 N., R. 104 W. Anomalous radioactivity occurs localized along a N. 34° W. striking joint set in brown-weathering massive hard quartzite of the Flathead formation of Cambrian age. No uranium minerals were identified, but two grab samples assayed .059 and .378% U_3O_8 (A-102).

Russell Creek Area; NE¼ sec. 31, T. 56 N., R. 104 W. Anomalous radioactivity of 0.24 milliroentgens per hour was recorded from a ferruginous-stained sandstone bed in the Flathead formation. No uranium minerals were identified (A-103).

Platte County

Big Mac Claim; sec. 19, T. 23 N., R. 69 W. Radioactivity of 1.0 milliroentgens per hour was recorded from the bottom of a small prospect pit excavated in pre-Cambrian graphite schist. No visible uranium minerals were observed; however, pyrite, chalcopyrite, malachite, and azurite are present in the deposit (A-89).

Sublette County

Union Peak; sec. 2 (?), T. 40 N., R. 108 W. A uranophane-like (A-21) mineral occurs as coatings on fractures in, and a crystalline black mineral is impregnated in, a dark gray pre-Cambrian granite gneiss on the east side of the mountain (A-63).

Radioactive pre-Cambrian granite occurs in N½ SE¼ secs. 17, 21, T. 32 N., R. 107 W. However, assays of these specimens are relatively low in uranium content (A-48).

Sweetwater County

Lost Creek Area; secs. 29-33, T. 26 N., R. 94 W.; sec. 25, T. 26 N., R. 95 W. The schroeckingerite deposits lie east of Lost Creek, along the southern limb of a syncline, partly within and partly north of the Cylcone Rim fault zone. The deposits are of irregular distribution, and the depth of occurrence is limited to the groundwater level. Most of the uranium deposits occur in a zone 2 to 8 feet below the ground surface in northward-dipping Eocene (Wasatch?) rocks. Some deposits occur in or partly within Quaternary surficial material.

A typical shale-sandstone type of mineralized body ranges from 2 inches to about 7 feet thick and are commonly less than 10 feet wide. (A-129). The majority of the deposits are probably less than 10 feet in length; however, a trench along the strike of such a body exposed mineralization for a length of 150 feet (A-107).

The schroeckingerite occurs as (1) platy crystals in round aggregates and pellets up to ¾ in. in diameter; (2) individual, small flaky crystals; and (3) very thin layers of numerous small crystals that coat grains of quartz, of efflorescent salts (A-107). Samples of schroeckingerite vary in grade from 0.001 to 0.26% UO (A-129).

Red Desert Area; Radioactive coal deposits are located near the central part of the Great Divide Basin, extending from a few miles south of Wamsutter north-northwest to a few miles south of the Lost Creek area. The outcrop pattern as is presently known, trends northwest over an area 24 miles long and 12 miles wide (A-57). The radioactive coal, which occurs in the Battle Spring (formerly called Wasatch) formation of early Eocene age, is subbituminous B to subbituminous C in rank (A-57, A-73, A-126).

Measured and indicated coal reserves for beds 2.5 feet thick or more, total about 730 million short tons. The beds contain about 2,700 short tons of uranium in coal or about 2,500 tons of uranium in coal ash. In beds beneath 60 feet or less of overburden, there are about 250 million short tons of coal containing 1,100 short tons of uranium in coal or about 650 tons of uranium in coal ash. The most uraniferous coals occur on the east flank of a syncline near the southwesternmost edge of the Battle Spring formation (A-126).

In the eastern part of the Red Desert area, in beds averaging 7 feet in thickness, the coal reserves are estimated at 690 million short tons which contain 24,000 short tons of uranium at a grade of 0.003% or more. The highest uranium concentration occurs in the Battle Spring flat area, where the Sourdough No. 2 bed averages 2.8 feet in thickness and contains 2 million tons of coal with an average uranium content of 0.010%, or coal ash containing an average of 0.030% uranium (A-122).

Sec. 15, T. 26 N., R. 96 W. Metaautunite occurs in conglomeratic beds of the Cathedral Bluffs tongue of the Wasatch formation (A-126).

Secs. 3, 6, 9, 10, T. 24 N., R. 93 W. Uranophane and becquerelite (A-21) have been identified in the Wasatch formation of Eocene age.

Sec. 2, T. 20 N., R. 102 W. Schroeckingerite and metaautunite (A-22) have been identified in the Ericson sandstone of Late Cretaceous age. Unidentified yellow uranium minerals have also been reported in the Ericson sandstone at the following localities: sec. 18, T. 15 N., R. 102 W.; sec. 28, T. 18 N., R. 101 W.; sec. 22, T. 18 N., R. 101 W.; sec. 34, T. 19 N., R. 101 W.; sec. 13, T. 20 N., R. 105 W.; sec. 35, T. 21 N., R. 102 W. (A-82).

Sec. 35, T. 25 N., R. 95 W. A carnotite-like mineral is reported in the Wasatch formation (A-82).

West Side of Rock Springs Uplift. Four low-grade uraniferous zones occur in the Laney shale tongue of the Green River formation (A-50).

Teton County

Sec. 5, T. 4 2N., R. 113 W. An unidentified uranium mineral associated with carbon trash occurs in a 1½-ft. by 75-ft. lens in the Morrison formation of Jurassic age. The formation strikes east-west and dips 15° north (A-85).

Gros Ventre River. In the Morrison formation, near Kelly Slide, dinosaur bones have been found which contained 0.13% U_3O_8 (A-90).

Uinta County

Sec. 28, T. 14 N., R. 119 W. Tyuyamunite occurs in calcareous sandstones and conglomerate beds of the Jurassic-Cretaceous Beckwith formation, or the Cretaceous Bear River formation, on the steeply dipping east limb of the Fossil syncline and on the Absaroka fault. The formation strikes about N. 60° E. and dips about 85° north (A-62).

Washakie County

Secs. 21, 22, T. 47 N., R. 89 W. Autunite occurs in the Morrison formation of Jurassic age. In March, 1955, 46,775 lbs. of uranium averaging 0.02% were reported shipped from the property (A-34).

Sec. 26, T. 48 N., R. 86 W. Anomalous radioactivity occurs in the Flathead formation of Cambrian age (A-64).

Weston County

Wicker-Baldwin Prospect; NE¼ sec. 16, T. 42 N., R. 60 W. In the Elk Mountain area, uranium minerals occur in the middle sandstone unit of the Lower Cretaceous Fall River formation (A-5, A-117). Metatyuyamunite (A-21) associated with pyrite and pods of lignitic material occurs in rusty-brown sandstones. In 1955-56, the prospect was explored by 340 feet of underground workings (A-117).

Alray Prospect; NW¼ NE¼ sec. 8, T. 42 N., R. 60 W. Radioactive anomalies occur in the middle channel sandstone unit of the Fall River formation. One of these, explored by a tunnel, shows both yellow and black unidentified uraniferous material (A-118).

THORIUM AND RARE EARTH DEPOSITS

Introduction

Thorium and rare earth minerals usually occur as accessory minerals in granitic, pegmatitic, and alkalic igneous rocks; however, some deposits occur in hydrothermal veins and placers or placer-type deposits. Thorium is more plentiful than uranium with respect to distribution in the earth's crust and approximates lead, molybdenum, and some rare earths in abundance. More uranium than thorium deposits are known principally because of the more concentrated exploration expended on uranium during the past decade.

The rare earth elements, although little known metals, constitute about one-sixth of the known elements. Because they possess similar chemical and physical characteristics, the rare earths are always associated with thorium and varying amounts of yttrium.

Most of the thorium compounds are reproduced from monazite (rare earth-thorium phosphate) and thorite-type (thorium silicate) minerals while rare earth compounds are generally produced from monazite and bastnaesite (fluo-carbonate of the cerium rare earths group). Neither the thorite mineral group nor bastnaesite has been reported in Wyoming. Deposits containing monazite, allanite (calcium-iron-cerium-aluminum-yttrium silicate), euxenite (niobate and titanate of yttrium, cerium, erbium, uranium and iron), fergusonite (niobate and tantalate of yttrium, with erbium, cerium, uranium, etc.), and samarskite (similar to euxenite) have been reported from various areas in the State. All these minerals contain minor amounts of thorium and/or uranium and hence are radioactive.

There are three major uses of thorium: (1) manufacture of incandescent gas mantles, (2) manufacture of magnesium-thorium alloys which have excellent mechanical strength at high temperatures and are used in jet engine castings and air frame structures, and (3) as a possible substitute for uranium in nuclear reactors. Thorium is also used in refractories, catalysts, optical glass, reagent chemicals, thoriated tungsten for electric tube and lamp use, and as cathode coatings in electronic tubes.

Rare earth mixtures are used as cores for high-luminosity carbon electrodes, dryer for paint and ink, textile waterproofing and dyeing, preparation of misch metal and ferrocerium, and as an additive to special high alloy steel. The individual rare earth elements have applications in the glass industry as colorizing and decolorizing agents, polishing agents, ultraviolet absorbency without affecting the color of the glass, ingredients in highly refractive optical glass, etc. Other uses include neutron absorbers in nuclear reactor construction, low temperature transistors, electrically conductive ceramics, as tracers in medical research, small portable X-ray units, etc.

Potential prospecting areas in Wyoming include the pegmatites in the many pre-Cambrian mountain areas; alkalic igneous rock areas such as the Leucite Hills, Bear Lodge and Rattlesnake Mountains; stream deposits, especially those draining areas of pre-Cambrian rocks; and conglomerates and coarse-grained sandstones ranging in age from Cambrian to Quaternary. In addition, some of the titanium-bearing black sandstone deposits of Wyoming carry significant amounts of uraniferous and rare earth bearing zircons and minor amounts of monazite. All are radioactive to some extent. These deposits are located in the Bighorn Basin; eastern part of the Wind River Basin; Sheep Mountain, in the Laramie Basin; Rock Springs uplift; Cumberland Gap, south of Kemmerer; and Gibbs Creek, 20 mi. south of Jackson. With the exception of one, all the deposits occur in rocks of Upper Cretaceous age. Additional details on these deposits are listed in Wyo. Geol. Survey Bull. 49, titled "Titanium-Bearing Black Sandstone Deposits of Wyoming."

PROSPECTS

Albany County

Many values Prospect; SE¼ sec. 32, T. 13 N., R. 78 W. Minor quantities of fergusonite (?) occur in a pegmatite that cuts pre-Cambrian tourmalinized mica schist and gneiss. The pegmatite strikes N. 50° E. and dips 85° NW., with exposures for 140 ft. The pegmatite was mined for mica, beryl, and tantalite in 1942 and 1943 (A-30).

Allanite has been found in a pre-Cambrian pegmatite near Albany, near the line between secs. 3 and 10, T. 14 N., R. 79 W. (A-81).

Sec. 2, T. 18 N., R. 72 W. A 4-in. allanite crystal was found in a pre-Cambrian pegmatite in the Laramie Range and is associated with 4-in. labradorite crystals and graphic granite. The allanite is highly radioactive (A-17).

Sec. 2, T. 15 N., R. 71 W. Euxenite (?) associated with feldspar, biotite and beryl occurs in a 75-ft. wide pegmatite that cuts pre-Cambrian granite (A-99). The deposit has been mined intermittently for feldspar and mica.

Big Horn and Sheridan Counties

Bald Mountain Monazite Deposit; T. 56 N., R. 91 W. The deposit occurs in the basal conglomerate of the Deadwood formation of Middle Cambrian age. The conglomerate, which varies between 2.5 to 10 ft. in thickness, rests unconformably on pre-Cambrian granitic rocks, and ranges from a well cemented pale-buff fine-grained sandstone to a deep-red soft conglomerate containing well-rounded quartz pebbles. The latter contains the greater concentrations of heavy minerals and monazite.

Microscopic analysis of heavy mineral concentrates from samples of better portions of the deposit contain the following: ilmenite, 38.3%; monazite, 8.7%; magnetite, 4.0%; zircon, 0.2%; impurities, 48.8%.

In 1952, ninety-two holes, averaging 22 ft. and totaling 2,020 ft. were drilled and sampled by the U. S. Bureau of Mines. Four hundred twenty-seven samples were taken and reduced to 216 by compositing. This resulted in a weighted average of 2.162 lbs. of monazite per ton by panning. Samples from individual holes ran as high as 19.484 lbs. of monazite per ton. An average analysis of six samples of pure monazite from the deposit yielded 8.8% ThO_2. The average ilmenite content is 4 to 5 times greater than monazite as indicated by microscopic examination of concentrates from the samples. An average gold assay from 6 samples yielded 0.003 oz. per ton (A-54).

Carbon County

T. 13 N., R. 81 W. Rare earth bearing pegmatites in pre-Cambrian rocks were discovered in 1956 by the Ralph Platts, Jr. and Sr. The pegmatites occur in a hornblende gneiss unit that has interbedded felsic gneisses and local areas of metasomatic granite gneiss and gneissic granite (A-37).

SW½ sec. 3, T. 13 N., R. 81 W. Niobium, yttrium, and uranium oxides occur in a pegmatite that has been mined since 1956. In addition to the ordinary pegmatite minerals, the following are known to occur: euxenite, monazite, columbite, and allanite. Euxenite is the most abundant rare earth mineral. The pegmatite, which is 160 ft. long by 70 ft. wide has been mined to a depth of 75 ft. (A-37). In 1957, 3,115 pounds of euxenite valued at $5,297 were produced from this deposit (A-114).

Sec. 9, T. 27 N., R. 80 W. A zone of radioactivity, about 100 ft. in diameter, occurs in an arkosic sandstone in the upper part of the Wind River formation (A-47). No uranium minerals were observed, but monazite (A-51) has been tentatively identified in samples.

Sec. 29, T. 27 N., R. 80 W. A zone of radioactivity at least 180 ft. long occurs in an arkosic sandstone in the upper part of the Wind River formation (A-47). No uranium minerals were observed but monazite (A-51) has been tentatively identified in samples.

King Claims; sec. 32, T. 13 N., R. 81 W. Samarskite (?) has been reported from pre-Cambrian granite (A-22).

Crook County

Bear Lodge Mountains; Tps. 51, 52 N., Rs. 63, 64 W. Thorium, uranium, and rare earth oxides occur essentially in iron-maganese veins that fill fractures in monzonite and syenite porphyries and in zones of intensely altered igneous rocks. The iron-manganese veins occur in the area covered by the Inum and Climax group of claims, located somewhat north of Warren Peak. One set of veins trends predominantly northwest and dips 12° to 30° NE.; another set trends northeast and dips 60° to 85° NW. They range in width from 1 in. to 2 ft. and are exposed for as much as 300 ft. along the strike. No discrete uranium, thorium, or rare earth minerals have been observed although monazite was detected by X-ray analysis. It is believed that these elements occur as absorbed salts on clays or the iron and manganese oxides (A-100).

Analytical results of six samples show that the U_3O_8 content varies from 0.005 to 0.018% and the rare earth oxide content from 0.20 to 12.99%. The ThO_2 content is approximately 10 times greater than the U_3O_8 content (A-100).

Beneficiation and utilization of the material may be difficult.

A diamond drilling program for rare earth oxides was completed by the U. S. Bureau of Mines in July, 1950. Ten holes, varying from 26 to 87 ft., were drilled with an aggregate footage of 844 ft.

The Climax No. 8 claim has about 4,000 indicated tons of 3.9% rare earth oxides. The Climax No. 10 claim has about 40,000 tons of 1.5% rare earth oxides indicated (A-93).

Fremont County

S½ secs. 28, 29, and N¼ sec. 33, T. 42 N., R. 108 W. Monazite-bearing alluvial deposits occur along Warm Spring Creek above the Union Pass road and along South Fork at least as far upstream as its junction with Cow Creek. The monazite-bearing sands are reported in terrace deposits along Warm Spring Creek as well as in the alluvial material in and adjacent to the creek. The alluvial deposits on Warm Spring Creek vary from ¼ to 5/8 mi. in width and are about 1 2/3 mi. long. The highest terraces are more than 100 ft. above the creek bottom (A-10).

The alluvial material on South Fork is several hundred feet in width and extends for more than 3 mi. Thickness of both deposits is unknown (A-10).

A portable sluice box was operated as a test operation in 1957 by the Little Jim Mining Company. Radiometric assays of six samples reported by the above company varied from 1.3 to 2.33% ThO_2 (A-18).

Johnson County

North line sec. 6. T. 46 N., R. 83 W. Allanite occurs in a vein-type of structure in pre-Cambrian granitic rocks, the vein, which is concordent with the foliation in the granite, strikes N. 70° W., and dips about 65° NE. Radiometric studies indicate that the vein is at least 100 ft. long with a maximum width of 7 ft. as exposed in a prospect pit. The mineral assemblage is complex and includes the following: calcite, diopside, garnet, soda amphibole, epidote, oligoclase and magnetite. Epidote is banded parallel to the foliation in the country rock, and the allanite occurs as irregular masses feathering into the epidote and country rock (A-36).

Assays report 10% to 11% CeO_2, and 1.5% combined oxides of La, Di, Yt, etc. One sample yielded 0.7% ThO_2 (A-15).

Natrona County

Allie Claims; secs. 12, 13, T. 39 N., R. 88 W., and secs. 7, 18, T. 39 N., R. 87 W.; 37.6 mi. north of Waltman. Allanite crystals, varying in size from ¼ in. to 3 in., are found in a pegmatite in pre-Cambrian gneiss. The allanite usually occurs in the crests of folds. Indicated reserves of all grades, 0.1% to 0.5% allanite-bearing rock, total 4,700,000 tons (A-80).

Platte County

Allanite occurs in a pre-Cambrian pegmatite 14 mi. northwest of Wheatland. The analysis is as follows: ThO_2, 1.28%; CeO_2, 14.63%; $(La, Di)_2O_3$, 7.34%; U_3O_8, 0.02% (A-98).

REPORTED OCCURRENCES

Carbon County

Monazite is reported in the black sands of the Bald Mountain district (A-83).

Laramie County

Allanite associated with a feldspar deposit in pre-Cambrian rocks is reported from the east flank of the Laramie Range (A-16).

Park County

Sec. 25, T. 56 N., R. 104 W. Allanite and radioactive rare earth bearing pegmatite has been reported in pre-Cambrian rocks (A-31).

Unknown Locality

Eight hundred pounds of samarskite an Fe, Ca, U, Ce, Y niobate were reported shipped to California in 1931. No location or other information is available (A-56).

REFERENCES CITED

A-1 AUGHEY, SAMUEL, Annual report of Territorial Geologist to the Governor of Wyoming, Boomerang Printing House, 1886, Laramie, Wyoming, 61 pp.

A-2 BALL, S. H., Contributions to economic geology, 1906, Part I, Copper deposits of the Hartville uplift. Wyoming: U. S. Geol. Surv. Bull. 315-B, 1907, pp. 93-107.

A-3 BERGENDAHL, M. H., and IZELDT, G. A., Geologic investigations of radioactive deposits, Semiannual progress report, December 1, 1956 to May 31, 1957: U. S. Geol. Surv. TEI-690, pp. 230-239; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-4 BERONI, E. P., and McKEOWN, F. A., Reconnaissance for uraniferous rocks in northwestern Colorado, southwestern Wyoming and northeastern Utah; U. S. Atomic Energy Comm. TEI-308A, 1952.

A-5 BROBST, D. A., Geologic investigations of radioactive deposits. Semiannual progress report, December 1, 1956 to May 31, 1957: U. S. Geol. Surv. TEI-690, p. 222; issued by U. S. Atomic Energy Comm., Tech Inf. Serv., Oak Ridge, Tenn.

A-6 BROMLEY, C. P., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DEB-RRD-2072, Dec. 30, 1954.

A-7 ...., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DEB-P-2-2099, Apr. 15, 1955.

A-8 ...., Preliminary geologic reconnaissance in the Lance Creek area. Niobrara County, Wyoming: U. S. Atomic Energy Comm. RME-1066 (Rev.), 1955.

A-9 DAVIS, R. E., Geologic investigations of radioactive deposits, Semiannual progress report, June 1 to November 30, 1956: U. S. Geol. Surv. TEI-640, pp. 92-95; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-10 DUNNEWALD, J. B., Geology of the Fish Lake Mountain area, Fremont County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1958.

A-11 FAY, LEO F., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. B-28, 1955.

A-12 FINNELL, T. L., and PARRISH, I. S., Uranium deposits and principal ore-bearing formations of the central Cordilleran foreland region: U. S. Geol. Surv. Min. Inv. Field Studies Map MF 120, 1958.

A-13 ...., Oral communication, 1958.

A-14 FORD, ROBERT, Written communication, May 22, 1958.

A-15 Geol. Surv. Wyo. files: Letter to H. D. Thomas from E. D. Goldring, Aug. 24, 1945.

A-16 Geol. Surv. Wyo. files: Sample examined by F. W. Osterwald for L. C. Thomas, Oct. 5, 1949.

A-17 Geol. Surv. Wyo. files: sample examined by F. W. Osterwald for M. L. Troyer and D. S. Turner, Dec. 5, 1949.

A-18 Geol. Surv. Wyo. files: Analysis data from Little Jim Mining Company, Nov. 1957.

A-19 GILL, J. R., Search for and geology of radioactive deposits, Semiannual progress report, December 1, 1952 to May 31, 1953: U. S. Geol. Surv. TEI-330, p. 118: issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-20 GRAY, JOSEPH R., and TENNISSEN, ANTHONY C., Uranium investigations near Aladdin, Crook County, Wyoming: U. S. Atomic Energy Comm. RME-4016.

A-21 GRUNER, JOHN W., *et al.*, Annual report for April 1, 1955 to March 31, 1956, Part II: U. S. Atomic Energy Comm. RME-3137 (Pt. II), 24 pp.

A-22 ...., and KNOX, JAMES A., Annual report for April 1, 1956 to March 31, 1957: U. S. Atomic Energy Comm. RME-3148.

A-23 GRUTT, E. W., JR., Environment of some Wyoming uranium deposits: Paper No. 57 NESC-69 in 2nd Nuclear Engineering and Science Conference, March 11-18, 1957: The American Society of Mechanical Engineers, New York, N. Y., 1957.

A-24 GUILINGER, R. R., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DEB-P-2-2629, Sept. 7, 1955.

A-25 ...., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DEB-P-2-2654, Sept. 21, 1955.

A-26 ...., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DEB-P-2-2655, Sept. 30, 1955.

A-27 ...., Geologic studies with results of airborne reconnaissance in the Shawnee-Lance Creek districts: Unpublished U. S. Atomic Energy Comm. report, Mar., 1956, 33 pp.

A-28 ...., Uranium occurrences in the North Laramie Peak district, Albany and Converse Counties, Wyoming: Unpublished U. S. Atomic Energy Comm. report, Mar., 1956, 23 pp.

A-29 ...., and THEOBALD, P. K., Uranium deposits in oolitic limestone near Mayoworth, Johnson County, Wyoming: U. S. Geol. Surv. Bull. 1030-K, 1957, p. 342.

A-30 HANLEY, J. B., HEINRICH, E. W., and PAGE, L. R., Pegmatite investigations in Colorado, Wyoming and Utah: U. S. Geol. Surv. Prof. Paper 227, 1950, pp. 107-108.

A-31 HART, O. M., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. BH-B-88, Feb. 28, 1955.

A-32 ...., U. S. Atomic Energy Comm., Unbublished Prelim. Reconn. Rept. BH-B-94, May 10, 1955.

A-33 ...., Uranium deposits in Pryor-Bighorn Mountains, Carbon County, Montana, and Bighorn County, Wyoming: Unpublished U. S. Atomic Energy Comm. report.

A-34 ...., and FAY, L. F., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. BH-B-97, July 20, 1955.

A-35 HOLMQUIST, GEORGE V., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DEB-P-2-2788, Mar. 29, 1956.

A-36 HOSE, RICHARD K., Geology of the Crazy Woman Creek area, Johnson County, Wyoming: U. S. Geol. Surv. Bull. 1027-B, 1955, pp. 88-89.

A-37 HOUSTON, R. S., The Big Creek pegmatite area, Carbon County, Wyoming: Geol. Survey Wyo. Prelim. Rept. No. 1, 1961.

A-38 KING, DAVID, U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Repts. DEB-P-2-2687 and DEB-P-2-2688, Sept. 22, 1955.

A-39 KING, R. U., and BERONI, E. P., Search for and geology of radioactive deposits, Semiannual progress report, December 1, 1952 to May 31, 1953: U. S. Geol. Surv. TEI-330, p. 212; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-40 LOOMIS, TOM H. W., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DAO-P-2-3087, June 20, 1956.

A-41 ...., and MARKS, LAWRENCE Y., A study of the uranium deposits in the Copper Mountain area, Fremont and Hot Springs Counties: Unpublished U. S. Atomic Energy Comm. report Oct. 1957.

A-42 LOVE, J. D., Uranium-bearing sandstone and coal deposits in Pumpkin Buttes area, Powder River Basin: Summary of uranium-bearing coal, lignite and carbonaceous shale investigations in the Rocky Mountain region during 1951: U. S. Geol. Surv. TEM-341A, pp. 24-25; issued by the U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-43 ...., Preliminary report on uranium deposits in the Pumpkin Buttes area, Powder River Basin, Wyoming: U. S. Geol. Surv. Cir. 176, 1952, 37 pp.

A-44 ...., Preliminary report on uranium in the Gas Hills area, Fremont and Natrona Counties, Wyoming: U. S. Geol. Surv. Cir. 352, 1954, 11 pp.

A-45 ...., Uranium in the Mayoworth area, Johnson County, Wyoming: U. S. Geol. Surv. Cir. 358, 1954, 7 pp.

A-46 ...., Geologic investigations of radioactive deposits, Semiannual progress report, June 1 to November 30, 1953: U. S. Geol. Surv. TEI-390, pp. 65-66; issued by U. S. Atomic Energy Comm. Tech. Inf. Serv., Oak Ridge, Tenn.

A-47 ...., Geologic investigations of the radioactive deposits, Semiannual progress report, December 1, 1953 to May 31, 1954: U. S. Geol. Surv. TEI-440, pp. 175-179; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-48 ...., Geologic investigations of radioactive deposits, Semiannual progress report, June 1 to November 30, 1954: U. S. Geol. Surv. TEI-490, pp. 227-230; issued by U. S. Atomic Energy Comm. Tech. Inf. Serv., Oak Ridge, Tenn.

A-49 ...., Geologic investigations of radioactive deposits, Semiannual progress report, December 1, 1954 to May 31, 1955: U. S. Geol. Surv. TEI-540, pp. 209-210; issued by U. S. Atomic Energy Comm., Tech. Inf. Service, Oak Ridge, Tenn.

A-50 ...., Geologic investigations of radioactive deposits, Semiannual progress report, June 1 to November 30, 1955: U. S. Geol. Surv. TEI-590, pp. 184-186, 263; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-51 ...., Oral communication, 1958.

A-52 MacPHERSON, BRUCE A., Geology of the Busfield deposit in northwestern Crook County, Wyoming: U. S. Atomic Energy Comm. RME-1074, July 26, 1956, 14 pp.

A-53 McKELVEY, VINCENT E., Uranium in phosphate rock; Contributions to the geology of uranium and thorium by the U. S. Geological Survey and Atomic Energy Commission for the United Nations International Conference on peaceful uses of atomic energy, Geneva, Switzerland, 1955: U. S. Geol. Surv. Prof. Paper 300, 1956, pp. 477-481.

A-54 McKINNEY, A. A., and HORST, H. W., Deadwood conglomerate monazite deposits, Bald Mountain area, Sheridan and Big Horn Counties, Wyoming: U. S. Atomic Energy Comm. RME-3128, Mar., 1953.

A-55 MALLORY, N. S., and MAGLEBY, D. N., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. ED-R-1181, July 29, 1953.

A-56 MARZEL, J. G., Sixteenth annual report of State Geologist, October 1, 1930 to September 30, 1932, Cheyenne, Wyoming, 114 pp.

A-57 MASURSKY, HAROLD, *et al.*, Geologic investigations of radioactive deposits, Semiannual progress report, December 1, 1953 to May 31, 1954: U. S. Geol. Surv. TEI-440, p. 117; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-58 MELBYE, CHARLES E., Structural control of Crooks Gap U_3O_8 gives clues for Wyoming prospectors: Mining World, vol. 19, no. 12, Nov., 1957, pp. 56-57.

A-59 MESCHTER, DANIEL Y., Stratigraphic and lithologic controls of uranium deposits in the Monument Hill area, Converse County, Wyoming: Unpublished U. S. Atomic Energy Comm. report, May, 1957.

A-60 MRAK, VERNON A., Unpublished report for Globe Mining Company.

A-61 ...., Uranium deposits in the Tertiary sediments of the Powder River Basin, Wyoming: Wyo. Geol. Assoc. Guidebook, 13th Ann. Field Conf., 1958.

A-62 MYERSON, B. L., and COHENOUR, R. F., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. SL-153, Nov. 9, 1956.

A-63 NORTON, DAVID L., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DEB-P-2-2764, Oct. 26, 1955.

A-64 ...., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DAO-P-2-3086, July 10, 1956.

A-65 ...., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DAO-P-2-3057, July 24, 1956.

A-66 ...., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DAO-P-2-3126, Mar. 28, 1957.

A-67 ...., and GRUTT, E. W., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DEB-RRD-1367, Aug. 26, 1954.

A-68 ...., and KING, DAVID, U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DEB-P-2-2666, Sept. 1, 1955.

A-69 ...., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DEB-P-2-2685, Oct. 10, 1955.

A-70 OSTERWALD, F. W., Notes on the occurrence of uranium in the Morrison formation near Greybull, Wyoming: Unpublished report for Geol. Surv. Wyo., July, 1950, 2 pp.

A-71 ...., Relation of tectonic elements in pre-Cambrian rocks to uranium deposits in the Cordilleran foreland of the western United States; Contributions to the geology of uranium and thorium by the U. S. Geological Survey and Atomic Energy Commission for the United Nations International Conference on peaceful uses of atomic energy, Geneva, Switzerland, 1955: U. S. Geol. Surv. Prof. Paper 300, pp. 329-335.

A-72 ...., and DEAN, B. G., Preliminary tectonic map of Wyoming, east of the overthrust belt, showing the distribution of uranium deposits: U. S. Geol. Surv. Min. Inv. Field Studies Map MF 127, 1958.

A-73 PIPIRINGOS, GEORGE N., Uranium-bearing coal in the central part of the Great Divide Basin, Sweetwater County, Wyoming: U. S. Geol. Surv. Bull. in preparation.

A-74 PRICHARD, G. E., and CHISHOLM, W. A., Geologic investigations of radioactive deposits. Semiannual progress report, December 1, 1954 to May 31, 1955: U. S. Geol. Surv. TEI-540, pp. 125-128; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-75 ...., Geologic investigations of radioactive deposits, Semiannual progress report, June 1 to November 30, 1955: U. S. Geol. Surv. TEI-590, pp. 174-176; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-76 RICH, E. I., Geologic investigations of radioactive deposits, Semiannual progress report, June 1 to November 30, 1955: U. S. Geol. Surv. TEI-590, pp. 171-174; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-77 ...., Geologic investigation of radioactive deposits, Semiannual progress report June 1 to November 30, 1956: U. S. Geol. Surv., TEI-640, pp. 121-125; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-78 ROBINSON, CHARLES S., and GOODE, HARRY D., Preliminary geologic map of the Hulett Creek uranium mining area, Crook County, Wyoming: U. S. Geol. Surv. Min. Inv. Field Studies Map MF 121, 1957.

A-79 ...., Geologic investigations of radioactive deposits, Semiannual progress report, December 1, 1956 to May 31, 1957: U. S. Geol. Surv. TEI-690, pp. 239-246; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-80 RUSSELL, R. T., and DeVORE, G. W., Report on field examination of allanite deposit, Natrona County, Wyoming: Unpublished report for Geol. Surv. Wyo., Aug. 1948, 6 pp.

A-81 SANFORD, S., and STONE, R. W., Useful minerals in the United States: U. S. Geol. Surv. Bull. 585, 1914, 250 pp.

A-82 SCHNEIDER, E. E., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Repts. DAO-P-2-2798, Apr. 24, 1956; DAO-P-2-3013, May 11, 1956; DAO-P-2-3055, June 8, 1956; DAO-P-2-3056, June 11, 1956; R-DAO-P-2-3050, July 10, 1956; R-DAO-P-2-3052, July 11, 1956; R-DAO-P-2-3054, July 11, 1956.

A-83 SCHRADER, F. C., STONE, R. W., and SANFORD, S., Useful minerals of the United States: U. S. Geol. Surv. Bull. 624, 1916, 412 pp.

A-84 SCHULTE, JOHN J., Reconnaissance of Tertiary stratigraphy and uranium occurrences in Shirley Basin area, south-central Wyoming: Unpublished U. S. Atomic Energy Comm. report.

A-85 SHARP, B. J., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. SL-122, Oct. 19, 1955.

A-86 SHARP, W. N., and WHITE, A. M., Preliminary geologic map of the Pumpkin Buttes area, Campbell and Johnson Counties, Wyoming, showing location of uranium occurrences: U. S. Geol. Surv. Min. Inv. Field studies Map MF 98, 1957.

A-87 ...., and GIBBONS, A. B., Geologic investigations of radioactive deposits, Semiannual progress report, December 1, 1956 to May 31, 1957: U. S. Geol. Surv. TEI-690, pp. 246-257; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-88 SLAUGHTER, A. L., Written communication, Mar. 11, 1958.

A-89 SMITH, EDWARD W., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DEB-RRD-1094, Mar. 31, 1954.

A-90 SMITH, KENNETH G., and BRADLEY, DANIEL A., Radioactive fossil bones in Teton County, Wyoming: Geol. Surv. Wyo. Rept. Inv. 4, 1954, 12 pp.

A-91 STEPHENS, J. G., Geologic investigations of radioactive deposits, Semiannual progress report, June 1 to November 30, 1955: U. S. Geol. Surv. TEI-590, pp. 179-183; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-92 THEOBALD, P. K., and KING, R. U., Geologic investigations of radioactive deposits, Semiannual progress report, June 1 to November 30, 1954: U. S. Geol. Surv. TEI-490, p. 225; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-93 U. S. Dept. of Interior, Progress, an annual report of the Dept. of Interior on the Missouri River Basin, June 1951, 235 pp.

A-94 VINE, J. D., U. S. Geol. Surv., Unpublished Prelim. Reconn. Rept. F-1045, July 19, 1954.

A-95 ...., Geology of uranium in the basins of Tertiary age in Wyoming and the northern Great Plains; Contributions to the geology of uranium and thorium by the U. S. Geological Survey and Atomic Energy Commission for the United Nations International Conference on peaceful uses of atomic energy, Geneva, Switzerland, 1955: U. S. Geol. Surv. Prof. Paper 300, 1956, pp. 337-344.

A-96 ...., and FLEDGE, ROBERT F., JR., Reconnaisance during 1952 for uranium-bearing carbonaceous rocks in parts of Colorado, Utah, Idaho, and Wyoming: U. S. Geol. Surv. TEI-336A, pp. 8-10; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-97 ...., and PRICHARD, G. E., Geology and uranium occurrences in the Miller Hill area, Carbon County, Wyoming: U. S. Geol. Survey TEI-227, May, 1956, 77 pp.

A-98 WELLS, R. C., Allanite from Wyoming: Am. Mineralogist, vol. 19, no. 2, 1934, pp. 81-82.

A-99 WHALEN, J. F., and SHEPARD, R., U. S. Atomic Energy Comm., Unpublished Prelim. Reconn. Rept. DEB-RRD-2065, Dec. 8, 1954.

A-100 WILMARTH, V. R., and JOHNSON, D. H., Preliminary reconnaisance survey for thorium, uranium and rare-earth oxides, Bear Lodge Mountains, Crook County, Wyoming: U. S. Geol. Surv. TEI-172, Apr., 1953, 26 pp.

A-101 ...., Uranophane at Silver Cliff mine, Lusk, Wyoming: U. S. Geol. Surv. Bull. 1009-A, 12 pp.

A-102 WILSON, W. H., Notes on uranium prospects near Dead Indian Creek, Park County: Unpublished report for Geol. Surv. Wyo., June, 1955.

A-103 ...., Notes on the Russell Creek uranium prospect, Park County: Unpublished report for Geol. Surv. Wyo., Nov. 9, 1955.

A-104 ...., Unpublished personal field notes, May 23, 1955.

A-105 ...., Unpublished personal field notes, Oct. 11, 1955.

A-106 ...., Unpublished personal field notes, Feb. 15, 1958.

A-107 WYANT, DONALD G., *et al.*, Reconnaisance study of uranium deposits in the Red Desert, Sweetwater County, Wyoming: U. S. Geol. Surv. Bull. 1030-I, 1956, pp. 237-308.

A-108 ZELLER, H. D., Geologic investigations of radioactive deposits, Semiannual progress report, June 1 to November 30, 1956: U. S. Geol. Surv., TEI-640, pp. 115-116; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-109 ...., and SOISTER, P. E., Geologic investigations of radioactive deposits, Semiannual progress report June 1 to November 30, 1955: U. S. Geol. Surv. TEI-590, pp. 165-168; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-110 ...., *et al.*, Geologic investigations of radioactive deposits, Semiannual progress report, December 1, 1954 to May 31, 1955: U. S. Geol. Surv. TEI-540, pp. 123-125; issued by U. S. Atomic Energy Comm., Tech. Inf. Serv., Oak Ridge, Tenn.

A-111 ...., Preliminary geologic map of the Gas Hills uranium district, Fremont and Natrona Counties, Wyoming: U. S. Geol. Surv. Min. Inv. Field Studies Map MF 83, 1956.

A-112 KLEPPER, M. R., and WYANT, D. G., Notes on the geology of uranium: U. S. Geol. Surv. Bull. 1046-F, 1957.

A-113 PAGE, LINCOLN R., *et al.,* Contributions to the geology of uranium and thorium by the United States Geological Survey and Atomic Energy Commission for the United Nations International Conference on peaceful uses of atomic energy, Geneva, Switzerland, 1955: U. S. Geol. Surv. Prof. Paper 300, 1956.

A-114 Wyoming Mineral Industry, 1957: U. S. Bur. Mines Production Statistics, Geol. Surv. Wyo. files.

A-115 BAILEY, R. V., Applied geology in the Shirley Basin uranium district, Wyoming: Univ. Wyoming Contr. to Geology, vol. 4, no. 1, 1965.

A-116 BERGENDAHL, M. H., DAVIS, R. E., IZETT, G. A., Geology and mineral deposits of the Carlile quadrangle, Crook County, Wyoming: U. S. Geol. Survey Bull. 1082-J, 1961.

A-117 BROBST, D. A., Geology of the Dewey quadrangle, Wyoming-South Dakota: U. S. Geol. Survey Bull. 1063-B, 1961.

A-118 CUPPELS, N. P., Geology of the Clifton quadrangle, Wyoming-South Dakota: U. S. Geol. Survey Bull. 1063-H, 1963.

A-119 DAVIS, R. E., & IZETT, G. A., Geology and uranium deposits of the Strawberry Hill quadrangle, Crook County, Wyoming: U. S. Geol. Survey Bull. 1127, 1962.

A-120 HARSHMAN, E. N., Paleotopographic control of a uranium mineral belt, Shirley Basin, Wyoming: U. S. Geol. Survey Prof. Paper 424-C, 1961.

A-121 ...., Alteration as a guide to uranium ore, Shirley Basin, Wyoming: U. S. Geol. Survey Prof. Paper 450-D, 1962.

A-122 MASURSKY, H., Uranium-bearing coal in the eastern part of the Red Desert area, Wyoming: U. S. Geol. Survey Bull. 1099-B, 1962.

A-123 MELIN, R. E., Description and origin of uranium deposits in Shirley Basin, Wyoming: Econ. Geol., vol. 59, no. 5, 1964.

A-124 MILLS, R. K., Petrography of uranium ore rolls in the Powder River Basin, Wyoming: unpub. M. S. thesis, Univ. Wyoming Library, 1965.

A-125 PILLMORE, C. L., and MAPEL, W. J., Geology of the Nefsy Divide quadrangle, Crook County, Wyoming: U. S. Geol. Survey Bull. 1121-E, 1963.

A-126 PIPIRINGOS, G. N., Uranium-bearing coal in the central part of the Great Divide Basin: U. S. Geol. Survey Bull. 1099-A, 1961.

A-127 RICH, E. I., Reconnaissance geology of Hiland-Clarkson Hill area, Natrona County, Wyoming: U. S. Geol. Survey Bull. 1107-G, 1962.

A-128 ROBINSON, C. S., MAPEL, W. J., and BERGENDAHL, M. H., Stratigraphy and structure of the northern and western flanks of the Black Hills uplift, Wyoming, Montana, and South Dakota: U. S. Geol. Surv. Prof. Paper 404, 1964.

A-129 SHERIDAN, D. M., MAXWELL, C. H., and COLLIER, J. T., Geology of the Lost Creek Schroeckingerite Deposits, Sweetwater County, Wyoming: U. S. Geol. Survey Bull. 1087-J, 1961.

A-130 STEPHENS, J. G., Geology and uranium deposits at Crooks Gap, Fremont County, Wyoming: U. S. Geol. Survey Bull. 1147-F, 1964.

A-131 VAN HOUTEN, F. B., Tertiary geology of the Beaver Rim area, Fremont and Natrona Counties, Wyoming: U. S. Geol. Survey Bull. 1164, 1964.

A-132 VINE, J. D., and PRICHARD, G. E., Uranium in the Poison Basin area, Carbon County, Wyoming: U. S. Geol. Survey Circular 344, 1954.

A-133 WILSON, W. H., Unpublished field notes, Dec., 1960.

VANADIUM

Potential sources of vanadium in Wyoming are in the vanadium-bearing phosphate rocks (See PHOSPHATE) in Lincoln and Teton counties, and the vanadium-bearing uranium deposit (See URANIUM) in Big Horn, Campbell, Converse, Crook, and Fremont counties. Most vanadium, however, is produced from a carbonaceous mineral, patronite, found in Peru. Vanadinite, $Pb_5Cl(VO_4)_3$; carnotite, $K_2(UO_2)_2.8H_2O$; and roscoelite, $K_2V_4Al_2Si_6O_{20}(OH)_4$, are low-grade ores that have been worked intermittently in the United States.

Significant quantities of vanadium have been recovered from Wyoming uranium ores that have been shipped to Colorado and South Dakota mills for processing (613).

About 90% of the vanadium produced is used in ferro-vanadium alloys; the remainder in the chemical industry and as a pigment known as "vanadium bronze."

Producing Areas (See URANIUM)

PROSPECTS

Lincoln County

The U. S. Bureau of Mines has investigated the vanadium producing potential of the Permian Phosphoria formation in Lincoln County. Ninety trenches were dug along 20 mi. of outcrops; 7 adits, and 4 shafts were sunk in their studies. Ore reserves in the Phosphoria formation are estimated at 20,000,000 tons of ore averaging 0.9% to 1.0% V_2O_5. Treatment of this ore may include the production of phosphorus (390, p. 33; 512, p. 87). See PHOSPHATE for a map of the distribution of the Phosphoria formation and for analyses.

Salt River Range; east and southeast of Afton. The vanadium-bearing bed is a thin black carbonaceous shale or mudstone within the lower phosphatic shale member of the Phosphoria formation which crops out for about 25 mi. in the basins of Swift, Dry, and Cottonwood Creeks. The lower phosphatic shale member is about 70 ft. to 90 ft. thick. The overlying Rex chert and underlying Wells formation are resistant to weathering, hence they form 2 ft. to 50 ft. of heavy talus which covers the vanadiferous beds at most localities. The rocks are sharply folded and faulted.

Vanadium is contained in 6 or more thin beds which are usually soft and black in weathered zones and locally iron-stained. Field tests or assays are necessary to detect the vanadium, which is concentrated in the central 2 ft. to 3 ft. of the zone. Seventy percent to 90% of the V_2O_5 is in 1 ft. to 2.5 ft. of stratigraphic section. The rock also contains small amounts of phosphates, fluorides, and molybdenum. No leaching or enrichment is apparent. The average V_2O_5 content of 18 mi. of outcrop is 0.866%; the vanadium mineral has not been identified (3, pp. 3-5); (See PHOSPHATE).

Sublette Ridge; in portions of Tps. 26, 27 N., R. 119 W. A vanadium-bearing black carbonaceous shale, 2.5 ft. to 4.3 ft. thick, is located in the Phosphoria formation 50 ft. below the base of the Rex chert member. The outcrop trends through two separate areas for about 6.5 mi.; it is faulted out for about 1.5 mi. between the two areas, north of Petereit Canyon. The rocks are sharply folded. The dip of the beds in Evans Canyon is N. 50° W. 60° SW., in Coal Canyon, N-S. 70° E., and in Raymond Canyon vertical, flattening to 50° in Francis Canyon. The line of outcrop extends over a vertical range of several hundred feet. The vanadiferous bed averages 3.3 ft. thick and contains an average of 0.746% V_2O_5; the upper 30 in. contains 1.0% V_2O_5. The vanadiferous rock weathers soft and friable; underground it is "medium-hard" (2).

The U. S. Bureau of Mines (2, p. 4) described two types of "ore": (1) laminated shale-like material, and (2) "lenticular fragments up to 6 inches in diameter."

"1. Thin sections of the laminated ore show the presence of very small particles of quartz, feldspar, and calcite, with sporadic occurrences of chlorite. The distribution of these minerals in the groundmass is uniform, but their grain size varies from a maximum of approximately 280-mesh to 1,600-mesh. The areas between the quartz, calcite, and feldspar grains are opaque and comparable in size to that of the transparent minerals. Many of the non-metallics are stained cinnamon brown by inclusions of micron-size particles."

"2. Sections of the lenticular phase of the ore show that it is harder and more compact than the laminated ore and, also, that it is relatively high in lime, almost to the exclusion of silica. Occasional veins of secondary calcite occur as a filling in fractures, and rhombohedral crystals of calcite are common. This phase of the ore appears to be a replacement of limestone, and the fragments of calcite are uniformly scattered through the carbonaceous material" (2, p. 4).

A typical analysis of the vanadiferous rock is given below (2, p. 5):

	Assay, percent		Assay, percent
Insoluble	57.8 %	V_2O_5	0.61 %
SiO_2	43.6	SO_4	0.05
Fe	3.10	Loss in ign.	15.4
CaO	9.30	Pb	0.05
S	3.85	Cu	0.025
CO_2	6.80	MgO	1.85
Al_2O_3	12.55	Au	0.00
C	9.90	Ag	0.26
P	0.83		

Because the carbonaceous material adheres closely to the calcite fragments, grinding to —200 mesh is required to separate the vanadium. Sulphides (pyrite, and a softer dark mineral similar to chalcopyrite or pentlandite) are uniformly distributed throughout the "ore," and are about —1600 mesh size (2, p. 5).

REPORTED OCCURRENCES

Albany County

The titaniferous- magnetite deposits at Iron Mountain contain less than 1% V_2O_5; (See MAGNETITE).

Fremont County

The Phosphoria formation which forms long outcrop belts along the east flank of the Wind River Range may contain vanadium. Few analyses showing V_2O_5 content are available; none show more than 0.1% V_2O_5 (396, p. 13).

Natrona County

Vanadium-bearing rock is reported from sec. 17, T. 32 N., R. 79 W. on Casper Mountain (217).

Sheridan County

Mosaic Claim; (See GOLD).

VERMICULITE

Vermiculite is a soft, pliable micaceous magnesium-aluminum-iron silicate that varies greatly in color, composition, and general appearance. When heated or acid-tested, it exfoliates into long, worm-like shapes; the volume may increase as much as twenty times. "X-ray data indicate that the vermiculites contain silicate layers similar to talc with water molecules between the layers" (337, pp. 8-9).

The Wyoming deposits are associated with pre-Cambrian biotite schist, hornblende schist, diorite, meta-diorite, hornblendite, serpentinite, granite gneiss, aplite, granite pegmatite and quartz (337, p. 10). The metamorphic rocks associated with vermiculite deposits are strongly folded; contacts between metamorphics and vermiculite with intrusive granitic rocks are usually vertical or steeply inclined (337, p. 15).

The mineral is extremely fireproof and lightweight, and thus is well-suited for insulating purposes. Expanded vermiculite is used in home insulation, concrete aggregate, plaster aggregate, in horticultural work, insulating refractory bricks, lubricants, and as a filler.

Production of Wyoming vermiculite from 1935 to 1943 was between 5,000 tons and 5,500 tons (337, p. 1). In 1947, 2,452 tons were produced and in 1948, 65 tons. There was no production in 1949, 1950, 1954, 1955, and 1956. Ten tons were shipped in 1957 (613). Between 1958 and 1965, production was spasmodic; however, limited tonnage of vermiculite was produced, mainly from the Encampment area of Carbon County.

PROSPECTS

Albany County

Long Jack Claim; sec. 6, T. 24 N., R. 70 W. Vermiculite is formed at the contact of granite pegmatite and serpentinite (?) and is closely associated with actinolite and chlorite. About 40 tons of vermiculite have been shipped (337, p. 24).

May Deposit; sec. 1, T. 24 N., R. 71 W., 5 mi. up Palmer Canyon. Anthophyllite has been altered to vermiculite at the contacts between granite pegmatite and anthophyllite. The vermiculite is irregular and spotty and is found between nodules of anthophyllite. About 5 tons of vermiculite have been taken from a pit 15 ft. long, 6 ft. wide, and 4 ft. to 6 ft. deep (337, p. 25).

Palmer Canyon deposits; (See TALC).

Roff Deposit; sec. 18, T. 24 N., R. 70 W. Vermiculite is contained in biotite schist associated with chlorite, kyanite and corundum. The schist xenolith, surrounded by gneissic granite, strikes N. 80° W. and dips 65° SW. (337, p. 25).

W½ sec. 7, T. 13 N., R. 78 W. A shallow pit has exposed amphibole gneiss partially altered to vermiculite (626).

Carbon County

Paine Deposit; sec. 9, T. 15 N., R. 83 W. This deposit is probably a continuation of the Union Asbestos and Rubber Company deposit across the Encampment river. Narrow discontinuous bodies of vermiculite have formed at the contact between granite pegmatite and hornblende schist and biotite schist. "Originally the property was operated for sericite which occurs in a hydrothermally altered pegmatite. An open-cut, a caved-in tunnel, and the remains of a mill indicate that the dike was once worked . . ." (337, pp. 19-20).

Union Asbestos and Rubber Co. Deposit; sec. 15, T. 15 N., R. 83 W., near the Encampment River at Baggott Rocks. This deposit was formerly owned by the Mikolite Company. Three shafts, a drift and several pits have produced 1000 tons of hand-sorted vermiculite from 1937 to 1941. Vermiculite is found along the contact of pegmatite and hornblende schist, and is associated with chlorite, tremolite-actinolite, kyanite, sillimanite and a trace of corundum. The chloritic material is talcose and interferes with the utilization of much of the vermiculite (337, pp. 18-20).

Union Asbestos and Rubber Co. Deposit; on the Platt Ranch, in sec. 3, T. 13 N., R. 82 W. A hornblende-quartz diorite has been cut by granite pegmatite and vermiculite has formed along the contacts. Between 1941 and March 1944, 1,076 tons of vermiculite were produced (337, pp. 20-21). The composition of vermiculite from this deposit is: SiO_2=39.82%, TiO_2=0.11%, Al_2O_3=15.42%, Fe_2O_3=4.77%, FeO=1.48%, MnO=0.12%, CaO=1.74%, MgO=19.86%, Na_2O=0.35%, K_2O=0.71%, water—130°C=7.20%, water+130°C.=7.54% (337, p. 9).

SW¼ sec. 29, T. 13 N., R. 83 W. A small vermiculite deposit grades eastward into a kyanite-bearing pegmatite dike. Approximately 44 tons were mined from this deposit in 1928-29. All the vermiculite of economic grade was mined out (634).

Converse County

Badger Prospect; sec. 29, T. 32 N., R. 75 W. A pegmatite dike strikes N. 30° W. Vermiculite is associated with the dike and with talc-schist, metadiabase, and some serpentine (337, p. 29).

Beach Prospect; sec. 33, T. 32 N., R. 75 W. A small amount of vermiculite is associated with a gray and pink granite (337, p. 29).

Lucky Lode Claim; sec. 13, T. 32 N., R. 76 W. Vermiculite is found in basic rocks cut by younger granite pegmatites (337, p. 29).

Smith Deposit; sec. 20, T. 32 N., R. 75 W. From 1938 to 1943, 1,539 tons of vermiculite were produced. A body of serpentinite cut by hornblendite, hornblende-quartz diorite, and granite pegmatite dikes, contains vermiculite at the contacts of serpentinite and pegmatite, and at the contact of hornblende rocks and pegmatite. Chlorite, tremolite, actinolite, anthophyllite, talc, minor magnetite, biotite and hornblende are present in the contact zones (337, pp. 27-28). An analysis from this deposit is: SiO_2=37.40%, TiO_2=0.19%, Al_2O_3=16.86%, Cr_2O_3=trace, Fe_2O_3=12.15%, FeO=4.70%, MnO=0.27%, NiO=0.06%, CaO=2.10%, MgO=15.38%,Na_2O=0.42%, K_2O=1.01%, P_2O_5=1.12%, H_2O—130°C.=3.00%, H_2O+130°C.=4.64% (337, p. 9).

Stardust Claims; sec. 20, T. 32 N., R. 75 W. Vermiculite is found in several rock types at this prospect. Masses and lenses of vermiculite are found in altered serpentine, in bands and flakes scattered through impure talc schist, in clusters in large intergrown crystalline masses consisting of feldspar, and quartz in a granite pegmatite (382).

McCoun, Wells, and Rhoads Deposit; secs. 13, 14, T. 32 N., R. 76 W. Pegmatite cuts serpentinite and an altered hornblendite or hornblende diorite; vermiculite formed at the contacts. Vermiculite encloses kidneys and nodules of serpentinite. A total of 450 tons of vermiculite has been produced (337, pp. 28-29).

Fremont County

Abernathy Deposit; sec. 19, T. 30 N., R. 96 W., 38 mi. southwest of Lander. Vermiculite is found along the contacts between serpentine and pegmatite dikes. There is a tunnel 70 ft. long, but there has been no recorded production (1944) (337, pp. 31-32). Asbestos and talc are also present but are of poor grade (217).

Natrona County

Koch Deposit; sec. 15, T. 31 N., R. 77 W. Serpentine is in contact with granite pegmatite dikes; the border zones contain vermiculite up to 8 in. wide (337, p. 31).

Vermiculite Sales Corp. Deposit No. 1; sec. 9, T. 30 N., R. 87 W., 28 mi. west of Alcova in the Sweetwater uplift. Vermiculite is found as bands and lenses at the contacts of granite and granite pegmatite with hornblende schist. Sericite and kaolin are alteration products of biotite and vermiculite. The vermiculite contains appreciable quantities of biotite (337, pp. 30-31). Accessory minerals include biotite, apatite, garnet, zoisite, and chlorite. In 1941, 225 tons were produced.

Vermiculite Sales Corp. Deposit No. 2; sec. 6, T. 31 N., R. 86 W., 26 mi. west of Alcova. Vermiculite is formed by hydrothermal alteration of hornblende to biotite schist in contact with granite pegmatite. In 1941, about 70 tons were produced (337, p. 31).

Platte County

Dixie Queen Claim; sec. 17, T. 25 N., R. 70 W. Vermiculite is formed at the contact of pegmatite and serpentinite (?). Talc is present in a nearby pit. Actinolite and chlorite also occur with the vermiculite. A total of 25 tons of vermiculite has been shipped (337, p. 24).

J. B. C. Deposit; sec. 9, T. 23 N., R. 69 W. The main pit has produced between 300 tons and 400 tons of vermiculite. Discontinuous narrow vermiculite layers have formed at the contacts between granite pegmatite with hornblende schist and biotite schist. This vermiculite expands 8 times to 9 times. An analysis is as follows: $SiO_2=39.00\%$, $TiO_2=0.14\%$, $Al_2O_3=17.32\%$, Cr_2O_3=trace, $Fe_2O_3=9.84\%$, $FeO=3.96\%$, $MnO=0.10\%$, $NiO=0.05\%$, CaO 1.84%, $MgO=16.27\%$, $Na_2O=0.85\%$, $K_2O=1.71\%$, $P_2O_5=0.34\%$, water—130°C.=3.08%, water+130°C.=5.20% (337, pp. 9, 22-23).

McDougal Deposit; sec. 8, T. 23 N., R. 69 W. About 100 tons of vermiculite have been produced from several pits. The geologic relations are similar to those of the J. B. C. deposit (337, p. 23).

Palmer Canyon Deposit; sec. 8, T. 24 N., R. 70 W. A lens of vermiculite within biotite-chlorite granite contains much chlorite. About 50 tons to 60 tons of vermiculite have been shipped (337, pp. 24-25).

Roff Deposit; sec. 9, T. 23 N., R. 69 W. Vermiculite has formed at the contact between granite pegmatite and hornblende schist. Relations are similar to the J. B. C. Deposit. From 70 tons to 90 tons of vermiculite have been shipped (337, p. 23).

Vaughn-Hyslop Deposit; sec. 28, T. 25 N., R. 66 W. Rather extensive prospect pits disclose a vermiculite body from 2 ft. to 7 ft. wide. "Granite pegmatite has intruded hornblende schist and altered the hornblende to vermiculite." A small amount of tourmaline is present. About 200 tons of ore have been produced from this deposit (337, p. 26).

SE¼ sec. 10, T. 23 N., R. 69 W. Fine-grained vermiculite gradational with amphibolite is exposed in two prospect pits and a shaft. Vermiculite also occurs along the contact of amphibolite and granite gneiss or granite pegmatite (622).

NE¼NW¼ sec. 14, T. 23 N., R. 69 W. Vermiculite gradational with amphibolite is exposed in a shaft located along the contact with white granite gneiss (622).

NE¼NW¼SW¼ sec. 8, T. 23 N., R. 69 W. An inclined shaft has exxposed vermiculite at the contact of amphibolite and granite pegmatite (622).

NE¼NE¼SW¼ sec. 17, T. 23 N., R. 69 W. Vermiculite has formed as an alteration product of granite pegmatite and amphibolite. Some vermiculite was mined from a prospect pit (622).

SE¼NW¼NE¼ sec. 18, T. 23 N., R. 69 W. Minor vermiculite occurs at the contact between amphibolite and granite gneiss as exposed in three closely spaced prospect pits (622).

Vermiculite was mined from a pre-Cambrian outcrop in sec. 28, T. 25 N., R. 66 W. (593).

Sheridan County

Grubstake Syndicate (Black Bird Mining Claim); 29 mi. southwest of Sheridan. Small amounts of vermiculite have formed at the contact between hornblende schist and granite (337, p. 32).

REPORTED OCCURRENCES

In the Laramie Peak district of Albany County, at Saratoga in Carbon County, and the Antelope Hills, Fremont County (337, p. 32).

VOLCANIC ASH

(See Pumice-Pumicite)

Volcanic ash deposits are very fine-grained, unconsolidated accumulations of pumice. This material is sometimes called pumicite. Both rock types are abundant in areas of Tertiary and Quaternary volcanic rocks.

Many areas in Wyoming contain volcanic ash and pumice; only the better known deposits are listed below. The uses for volcanic ash are essentially the same as those for pumice. Small amounts have been used locally for abrasives and lightweight aggregate.

PROSPECTS

Albany County

NW¼ sec. 6, T. 13 N., R. 73 W. A Tertiary or Quaternary deposit of pure white, massive, soft, fine-grained volcanic ash is located along the southern end of a low mesa, 1 mi. northeast of Sportsman Lake. The stratigraphic section is:

Buff sandstone and conglomerate	1 ft.
Volcanic ash	4 ft.—5 ft.
Red Clay	5 ft.
Volcanic ash	5 ft.
Red shale to bottom of slope	5 ft.

The composition of the ash is as follows:

SiO_2=67.0%, Al_2O_3+Fe_2O_3=16%, CaO=1.0%, Na_2O=2.8%, K_2O=5.0%, H_2O=8.2% (171, p. 65; 377, p. 38).

Corner of Fremont, Carbon and Natrona Counties

Volcanic ash from the Tertiary rocks in T. 29 N. (?), Rs. 89, 90 W., 2 mi. to 3 mi. southeast of Split Rock, has been used locally for abrasives. The deposit is composed almost entirely of basic glass shards interlayered with augite andesites (434).

Carbon-Natrona Counties

A series of volcanic ash beds lies above the Chadron formation of the White River group. The ash beds contain some interlensed channel sandstones and conglomerates. The ash beds are very resistant and contain chalcedony veins ¼ in. to 3 in. thick (495, pp. 42-44).

Fremont County

Center sec. 35, T. 27 N., R. 101 W. Volcanic ash deposits encircle Continental Peaks, Oregon Buttes, and are present along the Continental fault described by Nace (463, pp. 21-24). The ash is composed of dacitic andesitic glass which is high in soda-lime content.

Near center of sec. 8, T. 27 N., R. 101 W. The upper Chadron formation contains fine-grained partially devitrified volcanic glass with traces of quartz (463, p. 35).

SE¼ sec. 5, T. 3 N., R. 4 E. (Wind River Meridian); 16 mi. north of Riverton, and 16 mi. west of Shoshoni. A bed of volcanic ash crops out along the western edge of a gravel topped butte, and averages 5 ft. thick, although the range is from 2 ft. to 7 ft. thick. Overburden is sand and gravel from 10 ft. to 30 ft. thick (241).

Sec. 3, T. 7 N., R. 5 W. (Wind River Meridian); 16 mi. north of Riverton. A volcanic ash bed 2 ft. to 7 ft. thick is overlain by 10 ft. to 30 ft. of sand and gravel which caps a butte. The ash is quite pure, and may be suitable for light-weight aggregate material (569).

Fremont and Teton Counties

T. 43 N., R. 110 W.; on Lava Mountain, 2 mi. south of Twogwotee Pass. An unconsolidated deposit of scoria and ash 500 ft. thick covers an area of about 1 sq. mi. This is a recent deposit and is located near U. S. Highway No. 287 (433a).

Natrona County

Secs. 24 and 25 (?), T. 39 N., R. 89 W.; 2 mi. west of abandoned Badwater Post Office. An Oligocene or younger volcanic ash deposit is composed almost entirely of basic glass shards (569).

Sec. 19, T. 30 N., R. 83 W.; south of Wyoming Highway 220. A pumice claim in the upper White River formation has been staked, but there has been no production (528, p. 35).

Sweetwater County

Zirkel Mesa. In 1950 the Superior Pumice Company opened quarries on Zirkel Mesa about 3 miles by road from Superior. Production of pumice ceased after a few years of operation, however.

Pumice was supplied either granulated or sawed. The sawed stone was reported to be an attractive decorative stone and an effective insulative stone. Physical properties and other data concerning the pumice are given below (435a).

Physical Properties of Superior Pumice

Unit Wt. (lbs. per cu. ft.)	Constant dry loose
1½" to No. 4	48.2
¾" to No. 4	43.7
No. 4 to dust	64.2

Bulk Specific Gravity—Saturated surface dry	
1½" to No. 4	1.60
¾" to No. 4	1.62
No. 4 to dust	2.20

Concrete Mix Data

100% Superior Pumice Aggregate

Maximum size aggregate	¾"	¾"	¾"	1½"
Sacks cement per cu. yd. concrete	6	7	8	7
Slump	3"	3"	2.75"	3.25"
Wt. per cu. ft. (saturated)	103.00	105.29	108.64	104.87
Compressive strength—7 days	1928	2340	3290	2452
Compressive strength—28 days	3060	3437	4485	3461
Wt. per cu. ft. (constant dry)		99.52		99.08
Modulus of elasticity		1,566,700		1,458,800
Thermal conductivity (K. factor)		3.15		

Pumice also occurs in two volcanic cones resting on leucitic lava flows in secs. 13 and 14, T. 21 N., R. 102 W. on Zirkel Mesa (614).

Emmons Mesa. In sec. 4. T. 21 N., R. 102 W., about four miles north of Superior, pumice occurs in a volcanic cone on top of a leucitic lava flow (614).

Cross Mesa. In sec. 35. T. 22 N., R. 103 W., about five miles northwest of Superior, pumice is found in a volcanic cone resting on leucite lava (614).

Teton County

Sec. 8 (?), T. 45 N., R. 114 W., 1 mi. north of Moran. A Miocene volcanic ash deposit along U. S. Highway No. 287 consists of very pure, white, soft, glass shards (434).

WAVELLITE

Endlich reported light-green wavellite, $Al_3(OH)_3(PO_4)_2.5H_2O$, in shales near Separation in Sweetwater and Carbon counties (192, p. 158).

WOLLASTONITE

Aughey in his annual report to the Governor of Wyoming, 1886, p. 59, reported wollastonite, $CaSiO_3$, in granular limestone north of Rattlesnake Mountain in Natrona County.

ZEOLITES

The zeolites are a large group of secondary minerals found in cavities or amygdules in basic igneous rocks, in certain ore veins, and in cavities in limestone. The different minerals all are hydrous aluminum silicates with sodium and calcium, or rarely barium and strontium. The minerals are used in water softeners.

PROSPECT

Fremont County

Beaver Rim Area. Clinoptilite and erionite occur in the upper part of the Wagon Bed formation (middle Eocene). Clinoptilite is reported as a common constituent in pale olive bentonitic mudstone, an abundant mineral associated with montmorillonite in pale greenish-gray mudstone, in pink biotite-rich claystone surrounding chert, as thin laminae in varved shale, and as cryptocrystalline aggregates composing entire layers of pale yellowish-gray altered tuff. Some beds contain a mixture of clinoptilite and erionite (671).

REPORTED OCCURRENCES

Park County

". . . in a large area south of Sunlight Creek, best shown in the upper basic group of lavas. The vesicles of the basalt flows, which range in diameter from a small fraction of an inch up to 5 in., contain thompsonite, heulandite, and analcite. Analcite was also found as an alteration product of the feldspars in rocks of the lower group of andesitic flows. Stilbite was found incrusting small fissures which cut both the lower and upper flows" (364, p. 354).

Rouse (509, p. 144) found thompsonite crystals (average ½ in. long) in the central decayed quartz diorite porphyry zone of a laccolith located on a branch of Deer Creek. Deer Creek joins the South Fork Shoshone River at Valley.

Sweetwater County

In a quarry in sec. 15, T. 18 N., R. 107 W., northwest of Green River, cavities in the Green River formation are lined with glauberite, anhydrite, and analcite (?) (137, p. 5).

ZINC

No zinc production has been recorded from Wyoming except for a small amount mined with the hematite at Sunrise (515, p. 218). A number of prospects scattered throughout the state contain varying amounts of zinc, usually associated with lead minerals. Zinc minerals are found in the pre-Cambrian mountain cores and in the Tertiary volcanic areas in the Absaroka Range of northwest Wyoming.

PROSPECTS

Albany County (See COPPER)

Carbon County

Broadway Claim; (See LEAD).

Three Forks Group; Sierra Madre Area; (See COPPER)

Meta Mine; (See LEAD).

Spanish Trails Group; (See LEAD).

North Fork Group; Sierra Madre Area; (See COPPER).

Sec. 14, T. 14 N., R. 84 W.; (See MICA).

Crook County

Black Buttes Deposit; (See LEAD)

Laramie County

Hecla; Sec. 22, T. 14 N., R. 70 W., 7 mi. from Granite Canyon. The Hecla area consists of the Rambler, Coming Day, Big Elephant, and Monte Cristo Groups. An assay shows 0.62% zinc, 0.08% copper, 0.01% lead, \$3.00 in gold per ton, and \$2.40 in silver per ton (prices prior to 1927). The Monte Cristo is reported to contain molybdenum (224).

Other "average assays" show 5.2% zinc, with lesser amounts of silver, lead, and copper (217).

Park County

Kirwin District; (See COPPER).

Sunlight Basin; (See COPPER).

REPORTED OCCURRENCES

Carbon County

Sphalerite; "In minute quantities on Seminoe Mountains; also on Ferris Mountain" (16, p. 55).

Laramie County

Aurichalcite; "Lenox mine, Silver Crown" (16, p. 55).

ZIRCON (See Titanium)

Zircon, $ZrSiO_4$, has been identified in Bridger Mountain pegmatites and in some hornblende and micaceous schists near old Camp Stambaugh, Fremont County (192, p. 158).

The Wind River gold gravels contain some pink zircons (517, pp. 131-132).

BIBLIOGRAPHY

(1) ALLSMAN, P. T., Preliminary report on dolomite as a source of magnesium in Wyoming, Unpublished report, 1942, 21 pp. Copy in Geol. Surv. Wyo. files.

(2) ...., *et al.*, Sublette Range vanadium deposits, Lincoln County, Wyoming: U. S. Bur. Mines Rept. Inv. 4476, June 1949, 8 pp.

(3) ...., *et al.*, Investigations of Salt River Range vanadium deposits, Lincoln County, Wyoming: U. S. Bur. Mines Rept. Inv. 4503, Aug. 1949, 18 pp.

(4) Am. Inst. Min. and Met. Eng., *Industrial Minerals and Rocks,* New York, 1949, 1156 pp.

(5) Annual Report of State Geologist to the Governor of Wyoming for 1910; in Geol. Surv. Wyo. files, 11 pp.

(6) Anonymous, Mineral resources of Platte County, Wyoming: Unpublished report in Geol. Surv. Wyo. files.

(7) ...., Prospectus of Winona Gold-Copper Mining and Milling Company, undated, 5 pp. Copy in Geol. Surv. Wyo. files.

(8) ...., Albany County, Wyoming, Mineral Resources: The Laramie Mining and Stock Exchange, Laramie, Wyoming, 1896, 51 pp.

(9) ...., Great mineral belt encircling Laramie, Wyoming: Laramie, Wyoming, 1900, 25 pp.

(10) ...., Min. Sci., vol. 60, Oct. 28, 1909, p. 390.

(11) ...., The Seminoe iron deposits in Carbon County, Wyoming, owned by the Empire State Oil Company, Casper, Wyoming: Unpublished report in Geol. Surv. Wyo. files, May, 1931, 27 pp.

(12) ...., Nephrite in Wyoming: Rocks and Minerals, vol. 14, no. 7, July 1939, pp. 210-211.

(13) ...., Rocks and Minerals, vol. 14, no. 12, Dec., 1939, p. 381.

(14) ...., Mineralogist, vol. 8, no. 4, 1940, p. 162.

(14a) ...., Superior Pumice, Brochure of Superior Pumice Co., Rock Springs, Wyo., 1951.

(15) ARMSTRONG, F. C., Preliminary report of the geology of Atlantic City-South Pass Mining District: U. S. Geol. Surv. Open file report in Geol. Surv. Wyo. files, 1945, 64 pp.

(16) AUGHEY, SAMUEL, Annual report of Territorial Geologist to the Governor of Wyoming, Boomerang Printing House, 1886, Laramie, Wyoming. Typewritten copy in Geol. Surv. Wyo. files, 61 pp.

(17) BALL, S. H., Contributions to economic geology, 1906, Part I, Copper deposits of the Hartville uplift, Wyoming: U. S. Geol. Surv. Bull. 315-B, 1907, pp. 93-107.

(18) ...., Contributions to economic geology, 1906, Part I, The Hartville iron-ore range, Wyoming: U. S. Geol. Surv. Bull. 315-D, 1907, pp. 190-205.

(19) ...., Contributions to economic geology, 1906, Part I, Portland cement materials in eastern Wyoming: U. S. Geol. Surv. Bull. 315-F, 1907, pp. 232-244.

(20) ...., Contributions to economic geology, 1906, Part I, Graphite in the Haystack Hills, Laramie (Goshen) County, Wyoming: U. S. Geol. Surv. Bull. 315-M, 1907, pp. 426-428.

(21) BALL, S. H., Contribution to economic geology, 1906, Part I, Mica in the Hartville uplift, Wyoming: U. S. Geol. Surv. Bull. 315-M, 1907, pp. 423-425.

(22) BANE, J. R., Report on B and H Mining Co., Geol. Surv. Wyo. files, 1929, 10 pp.

(23) BARR, JAMES A. JR., Chapter 36, "Pumice and Pumicite," *Industrial Minerals and Rocks,* Am. Inst. Min. Met. Eng., New York, 1949, pp. 748-755.

(24) BARROW, F. H., Asbestos industry in central Wyoming: Eng. and Min. Jour., vol. 90, Sept. 17, 1910, p. 559.

(25) BARTLETT, A. B., 13th Biennial report of the State Geologist, Geol. Surv. Wyo. files, Oct. 1, 1924, to Sept. 30, 1926, 28 pp.

(26) ...., Mineral resources of Platte County, Wyoming: Min. Jour. (Phoenix, Ariz.), vol. 11, no. 21, Mar. 30, 1928, pp. 3-4, 52-53.

(27) BASTIN, E. S., Baked clays and natural slags in eastern Wyoming: Jour. Geology, vol. 13, 1905, pp. 408-412.

(28) BATEMAN, A. M., *Economic Mineral Deposits,* 2nd edition, John Wiley and Sons, Inc., New York, 1950, 916 pp.

(29) BATTY, J. V., *et al.,* Concentration of fluorite ores from Arizona, California, Idaho, Montana, Nevada, and Wyoming: U. S. Bur. Mines Rept. Inv. 4133, Nov. 1947, 29 pp.

(30) BECKWITH, R. H., Report on the geology of the Muscovite and Ione Mining Claims, Unpublished report for Geol. Surv. Wyo., Aug. 1937, 5 pp.

(31) ...., Asbestos in Wyoming: in S. H. Knight, Natural Resources Committee report, 1938, Geol. Surv. Wyo. files, pp. 5-8.

(32) ...., Asbestos and chromite deposits of Wyoming: Econ. Geology, vol. 34, no. 7, 1939, pp. 812-843.

(33) BEELER, H. C., Albany County, Wyoming, Mineral Resources: The Laramie Mining and Stock Exchange, Laramie, Wyoming, 1896, 51 pp.

(34) ...., Unpublished report no. 1 for Geol. Surv. Wyo., July 27, 1901, 3 pp.

(35) ...., Unpublished report no. 2 for Geol. Surv. Wyo., July 27, 1901, 4 pp.

(36) ...., Unpublished report no. 3 for Geol. Surv. Wyo., July 29, 1901, 2 pp.

(37) ...., Unpublished report no. 4 for Geol. Surv. Wyo., July 29, 1901, 2 pp.

(38) ...., Unpublished report no. 5 for Geol. Surv. Wyo., Aug. 27, 1901, 3 pp.

(39) ...., Unpublished report no. 6 for Geol. Surv. Wyo., Aug. 28, 1901, 3 pp.

(40) ...., Unpublished report no. 7 for Geol. Surv. Wyo., Aug. 24, 1901, 3 pp.

(41) ...., Unpublished report no. 8 for Geol. Surv. Wyo., Sept. 5, 1901, 5 pp.

(42) ...., Unpublished report no. 10 for Geol. Surv. Wyo., July 30, 1901, 4 pp.

(43) BEELER, H. C., Unpublished report no. 11 for Geol. Surv. Wyo., March 5, 1902, 3 pp.

(44) ...., Unpublished report no. 12 for Geol. Surv. Wyo., May 17, 1902, 6 pp.

(45) ...., Unpublished report no. 13 for Geol. Surv. Wyo., June 19, 1902, 4 pp.

(46) ...., Unpublished report no. 14 for Geol. Surv. Wyo., July 19, 1902, 4 pp.

(47) ...., Unpublished report no. 15 for Geol. Surv. Wyo., Aug. 11, 1902, 3 pp.

(48) ...., Unpublished report no. 16 for Geol. Surv. Wyo., Aug. 25, 1902, 3 pp.

(49) ...., Unpublished report no. 17 for Geol. Surv. Wyo., Sept. 2, 1902, 3 pp.

(50) ...., Unpublished report no. 18 for Geol. Surv. Wyo., Sept. 2, 1902, 3 pp.

(51) ...., Unpublished report no. 19 for Geol. Surv. Wyo., Sept. 15, 1902, 4 pp.

(52) ...., Unpublished report no. 20 for Geol. Surv. Wyo., Sept. 16, 1902, 4 pp.

(53) ...., Unpublished report no. 21 for Geol. Surv. Wyo., Oct. 21, 1902, 4 pp.

(54) ...., Unpublished report no. 22 for Geol. Surv. Wyo., Oct. 27, 1902, 3 pp.

(55) ...., Unpubilshed report no. 23 for Geol. Surv. Wyo., May 9, 1903, 5 pp.

(56) ...., Unpublished report no. 24 for Geol. Surv. Wyo., May 9, 1903, 3 pp.

(57) ...., Unpublished report no. 25 for Geol. Surv. Wyo., May 9, 1903, 5 pp.

(58) ...., Unpublished report no. 26 for Geol. Surv. Wyo., May 9, 1903, 3 pp.

(59) ...., Unpublished report no. 27 for Geol. Surv. Wyo., May 27, 1903, 5 pp.

(60) ...., Unpublished report no. 28 for Geol. Surv. Wyo., May 28, 1903, 3 pp.

(61) ...., Unpublished report no. 30 for Geol. Surv. Wyo., June 11, 1903, 3 pp.

(62) ...., Unpublished report no. 34 for Geol. Surv. Wyo., July 30, 1903, 5 pp.

(63) ...., Unpublished report no. 35 for Geol. Surv. Wyo., Aug. 3, 1903, 4 pp.

(64) ...., Unpublished report no. 36 for Geol. Surv. Wyo., Sept. 30, 1903, 4 pp.

(65) ...., Unpublished report no. 37 for Geol. Surv. Wyo., Sept. 30, 1903, 3 pp.

(66) ...., Unpublished report no. 38 for Geol. Surv. Wyo., Oct. 22, 1903, 6 pp.

(67) BEELER, H. C., Unpublished report no. 40 for Geol. Surv. Wyo., Jan. 10, 1904, 5 pp.

(68) ...., Unpublished report no. 41 for Geol. Surv. Wyo., Feb. 16, 1904, 4 pp.

(69) ...., Unpublished report no. 42 for Geol. Surv. Wyo., March 10, 1904, 5 pp.

(70) ...., Unpublished report no. 43 for Geol. Surv. Wyo., March 21, 1904, 3 pp.

(71) ...., Unpublished report no. 44 for Geol. Surv. Wyo., May 31, 1904, 5 pp.

(72) ...., Unpublished report no. 45 for Geol. Surv. Wyo., May 31, 1904, 4 pp.

(73) ...., Unpublished report no. 46 for Geol. Surv. Wyo., June 1, 1904, 5 pp.

(74) ...., Unpublished report no. 48 for Geol. Surv. Wyo., July 15, 1904, 3 pp.

(75) ...., Unpublished report no. 50 for Geol. Surv. Wyo., Oct. 11, 1904, 3 pp.

(76) ...., Unpublished report no. 51 for Geol. Surv. Wyo., Oct. 29, 1904, 2 pp.

(77) ...., Unpublished report no. 52 for Geol. Surv. Wyo., Oct. 29, 1904, 4 pp.

(78) ...., Unpublished report no. 54 for Geol. Surv. Wyo., Dec. 31, 1904, 4 pp.

(79) ...., Unpublished report no. 55 for Geol. Surv. Wyo., Jan. 30, 1905, 4 pp.

(80) ...., Unpublished report no. 56 for Geol. Surv. Wyo., Feb. 17, 1905, 5 pp.

(81) ...., Unpublished report no. 57 for Geol. Survey Wyo., May 11, 1905, 4 pp.

(82) ...., Unpublished report no. 58 for Geol. Surv. Wyo., Aug. 9, 1905, 5 pp.

(83) ...., Unpublished report no. 59 for Geol. Surv. Wyo., Aug. 10, 1905, 3 pp.

(84) ...., Unpublished report no. 60 for Geol. Surv. Wyo., Aug. 10, 1905, 5 pp.

(85) ...., Unpublished report no. 61, for Geol. Surv. Wyo., Oct. 9, 1905, 5 pp.

(86) ...., Unpublished report no. 62 for Geol. Surv. Wyo., Oct. 2, 1905, 3 pp.

(87) ...., Unpublished report no. 63 for Geol. Surv. Wyo., Oct. 10, 1905, 6 pp.

(88) ...., Unpublished report no. 64 for Geol. Surv. Wyo., Oct. 17, 1905, 6 pp.

(89) ...., Unpublished report no. 65 for Geol. Surv. Wyo., Aug. 30, 1905, 6 pp.

(90) ...., Unpublished report no. 66 for Geol. Surv. Wyo., Oct. 31, 1905, 8 pp.

(91) BEELER, H. C., Unpublished report no. 67 for Geol. Surv. Wyo., Oct. 2, 1905, 3 pp.

(92) ...., Mineral and allied resources of Albany County, Wyoming, Laramie, Wyoming, 1906, 80 pp.

(93) ...., Unpublished report no. 68 for Geol. Surv. Wyo., Feb. 10, 1906, 16 pp.

(94) ...., Unpublished report no. 69 for Geol. Surv. Wyo., June 6, 1906, 5 pp.

(95) ...., Unpublished report no. 70 for Geol. Surv. Wyo., May 19, 1906, 4 pp.

(96) ...., Unpublished report no. 71 for Geol. Surv. Wyo., April 9, 1906, 4 pp.

(97) ...., Unpublished report no. 72 for Geol. Surv. Wyo., June 4, 1906, 4 pp.

(98) ...., Unpublished report no. 73 for Geol. Surv. Wyo., June 26, 1906, 10 pp.

(99) ...., Unpublished report no. 75 for Geol. Surv. Wyo., July 21, 1906, 3 pp.

(100) ...., Unpublished report no. 77 for Geol. Surv. Wyo., Aug. 23, 1906, 7 pp.

(101) ...., Unpublished report no. 78 for Geol. Surv. Wyo., Oct. 27, 1906, 6 pp.

(102) ...., Unpublished report no. 79 for Geol. Surv. Wyo., Oct. 31, 1906, 6 pp.

(103) ...., Unpublished report no. 80 for Geol. Surv. Wyo., Oct. 22, 1906, 5 pp.

(104) ...., Unpublished report no. 81 for Geol. Surv. Wyo., Sept. 21, 1906, 5 pp.

(105) ...., Prospecting in the Black Rock-Long Creek vicinity, Sweetwater River, Fremont Co., Wyoming: State Geologist's Office, Cheyenne, Wyoming, June, 1907, 12 pp.

(106) ...., Unpublished report no. 82 for Geol. Surv. Wyo., Feb. 1, 1907, 12 pp.

(107) ...., Unpublished report no. 84 for Geol. Surv. Wyo., March 2, 1907, 6 pp.

(108) ...., Unpublished report no. 85 for Geol. Surv. Wyo., March 2, 1907, 6 pp.

(109) ...., Unpublished report no. 89 for Geol. Surv. Wyo., July 13, 1907, 6 pp.

(110) ...., Unpublished report no. 90 for Geol. Surv. Wyo., Sept. 6, 1907, 4 pp.

(111) ...., Unpublished report no. 91 for Geol. Surv. Wyo., Sept. 19, 1907, 5 pp.

(112) ...., Unpublished report no. 92 for Geol. Surv. Wyo., Sept. 20, 1907, 3 pp.

(113) ...., Unpublished report no. 93 for Geol. Surv. Wyo., Sept. 30, 1907, 4 pp.

(114) ...., Unpublished report no. 95 for Geol. Surv. Wyo., Oct. 9, 1907, 3 pp.

(115) BEELER, H. C., Unpublished report no. 96 for Geol. Surv. Wyo., Oct. 23, 1907, 5 pp.

(116) ...., Unpublished report no. 97 for Geol. Surv. Wyo., Oct. 23, 1907, 4 pp.

(117) ...., Unpublished report no. 99 for Geol. Surv. Wyo., Oct. 26, 1907, 7 pp.

(118) ...., Unpublished report no. 101 for Geol. Surv. Wyo., Nov. 12, 1907, 3 pp.

(119) ...., Unpublished report no. 102 for Geol. Surv. Wyo., Dec. 21, 1907, 7 pp.

(120) ...., Unpublished report no. 103 for Geol. Surv. Wyo., July 31, 1908, 17 pp.

(121) ...., Unpublished report no. 106 for Geol. Surv. Wyo., Sept. 22, 1908, 4 pp.

(122) ...., Unpublished report no. 108 for Geol. Surv. Wyo., Feb. 3, 1909, 5 pp.

(123) ...., Asbestos in Wyoming: Eng. and Min. Jour., vol. 90, Nov. 12, 1910, p. 955.

(124) ...., A brief Statement of conditions noted at the Strong Mine 16 miles northeast of Laramie, Albany County, Wyoming: Unpubilshed report, Geol. Surv. Wyo. files, Nov. 28, 1942.

(125) BERRYMAN, R. J., Geology of the Deer Creek-Little Deer Creek area, Converse County, Wyoming: Unpublished M. A. thesis, Univ. of Wyoming Library, 1942, 51 pp.

(126) BIGGS, C. A., Stratigraphy of the Amsden formation of the Wind River Range and adjacent areas in northwestern Wyoming: Unpublished M. A. thesis, Univ. of Wyoming Library, 1951, 121 pp.

(127) BLACKWELDER, E., Contributions to economic geology, 1910, Part I, A reconnaissance of the phosphate deposits in western Wyoming: U. S. Geol. Surv. Bull. 470-H, 1911, pp. 452-481.

(128) ...., Geology of the Medicine Bow Mountains: Geol. Soc. America Bull., vol. 37, no. 4, 1926, pp. 615-658.

(129) BLAKE, W. P., The tin ore veins in the Black Hills of Dakota: Am. Inst. Min. Eng. Trans., vol. 13, 1884-85, pp. 691-696.

(130) BOGRETT, J. W., Unpublished data on Wyoming mineral production for Geol. Surv. Wyo., 1950.

(131) ...., Geology of the northwest end of the Rattlesnake Hills, Natrona County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1951, 83 pp.

(132) BOOS, C. M., and BOOS, M. F., Personal communication to F. W. Osterwald, Jan. 24, 1951.

(133) BOWDIN, HERBERT, Report on Williams-Luman copper mine at Depass, Wyoming: Unpublished report in Geol. Surv. Wyo. files, Nov. 26, 1918, 7 pp.

(134) BOWLES, O., Chapter 14, "Dimension Stone," *Industrial Minerals and Rocks*, Am. Inst. of Min. and Met. Engineers, New York, 1949, pp. 313-344.

(135) BOYLE, A. C. JR., Report for Union Pacific Railroad on a deposit of ammonium alum near Wamsutter, Wyoming: Unpublished report in Geol. Surv. Wyo. files, Oct. 10, 1923, 6 pp.

(136) BOYLE, A. C. JR., Excerpt from report on Rawlins, Wyoming, iron ore deposits: Typewritten copy in Geol. Surv. Wyo. files, undated, 14 pp.

(137) BRADLEY, W. H., Shorter contributions to general geology, 1929, The occurrence and origin of analcite and meershaum beds in the Green River formation of Utah, Colorado, and Wyoming: U. S. Geol. Surv. Prof. Paper 158-A, 1930, pp. 1-7.

(138) ...., Limnology and the Eocene lakes of the Rocky Mountain region: Bull. Geol. Soc. America, vol. 59, no. 7, 1948, pp. 635-648.

(139) BRANHAM, ALLAN, Jade found in Wyoming: Mineralogist, vol. 9, no. 3, 1941, pp. 79-80.

(140) ...., Jade: Wyoming and oriental: Mineralogist, vol. 12, no. 1, 1944, pp. 9-10.

(141) BRANSON, E. B., Origin of thick gypsum and salt deposits: Geol. Soc. of America Bull., vol. 26, no. 2, 1915, pp. 231-242.

(142) BREGER, C. L., Contributions to economic geology, 1909, Part I, The salt resources of the Idaho-Wyoming border, with notes on the geology: U. S. Geol. Surv. Bull. 430-I, 1910, pp. 555-569.

(143) BROWN, B. W., Preliminary investigation of Wyoming cordierite: Am. Ceramic Soc. Bull., vol. 27, no. 11, 1948, pp. 443-446.

(144) BROWN, O. P., Geology of the Difficulty-Little Shirley Basin area: Unpublished M. A. thesis, Univ. Wyo. Library, 1939, 20 pp.

(145) BROWN, P. L., Occurrence and origin of known trona deposits, Sweetwater and Uinta Counties, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1950, 82 pp.

(146) BROWN, R. A., *et al.*, Recovery of aluminum from Wyoming anorthosite by the lime-sinter process: U. S. Bur. Mines Rept. Inv. 4132, 1947, 127 pp.

(147) BUDDHUE, J. D., Uranium and the Sweetwater agates: Mineralogist, vol. 7, no. 8, 1939, pp. 301-302.

(148) BUEHNER, J. H., Geology of an area north of Sierre Madre, Carbon County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1936, 37 pp.

(149) BURHAM, W. C., Exploration of the Bear Lodge fluorite property, Crook County, Wyoming: U. S. Bur. Mines Rept. Inv. 3877, April, 1946, 7 pp.

(149a) CAMPBELL, M. R., *et al.*, Geologic map of Wyoming: U. S. Geol. Surv., 1925.

(150) CARLSON, C. E., Areal geology and stratigraphy of the Red Fork Powder River area, Johnson County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1949, 59 pp.

(151) CARPENTER, L. C., Geology of the eastern end of the Ferris Mountains, Carbon County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1951, 65 pp.

(152) CLAUBAUGH, S. E., *et al.*, Map of the construction materials and nonmetallic resources of Wyoming: U. S. Geol. Surv. Missouri Basin Studies Map No. 9, 1946.

(153) CLARKE, F. W., Analyses of rocks and minerals from the laboratory of the United States Geological Survey, 1880 to 1914: U. S. Geol. Surv. Bull. 591, 1915, 376 pp.

(154) COMSTOCK, T. B., and JONES, W. A., Report of the reconnaisance of northwestern Wyoming made in the summer of 1873; U. S. 43rd Congress, 1st session, House Executive Document 285, Washington, 1874, pp. 85-184.

(155) CONDIT, D. D., Phosphate deposits in the Wind River Mountains, near Lander, Wyoming: U. S. Geol. Surv. Bull. 764, 1924, 39 pp.

(156) COX, D. C., Memorandum on the occurrence of fluorspar deposits in the Bear Lodge Mountains, Crook County, Wyoming: U. S. Geol. Surv. Unpublished report, Nov. 28, 1945.

(157) CRAWFORD, A. L., Euhedral oligoclase of the Medicine Bow Mountains, Wyoming: Am. Mineralogist, vol. 11, no. 19, 1926, pp. 239-246.

(158) CRONEIS, CAREY, and KRUMBEIN, W. C., *Down to Earth*, Univ. of Chicago Press, Chicago, 1936, 501 pp.

(159) CROSS, WHITMAN, Igneous rocks of the Leucite Hills and Pilot Butte, Wyoming: Am. Jour. Sci. 4th ser., vol. 4, 1897, pp. 115-141.

(160) CURRAN, H. T., A general report on the Carissa Mining property, owned by the Federal Gold Mining Company: Unpublished report in Geol. Surv. Wyo. files, Jan. 31, 1926, 9 pp.

(161) DAKE, C. L., Western Park County area, Unpublished report, Geol. Surv. Wyo. files, 1916, 38 pp.

(163) DART, A. C., Report on the Utopia Tunnels of the Utopia Mining and Milling Company: Geol. Surv. Wyo. files, June 15, 1929, 10 pp.

(164) ...., Report on the property of the Golden Crown Mining Syndicate, Centennial mining district: Unpublished report, Geol. Surv. Wyo. files, June 5, 1930, 5 pp.

(165) DARTON, N. H., Description of the Newcastle, Wyoming-South Dakota quadrangles: U. S. Geol. Surv. Geol. Atlas, Folio No. 107, 1904, 9 pp.

(166) ...., Description of the Sundance Quadrangle, Wyoming-South Dakota: U. S. Geol. Surv. Geol. Atlas, Folio No. 127, 1905, 12 pp.

(167) ...., Preliminary report on the geology and underground water resources of the central Great Plains: U. S. Geol. Surv. Prof. Paper 32, 1905, 433 pp.

(168) ...., Contributions to economic geology, 1905, Mineral resources of the Bighorn Mountain region: U. S. Geol. Surv. Bull. 285, 1906, pp. 303-310.

(169) ...., Geology of the Bighorn Mountains: U. S. Geol. Surv. Prof. Paper 51, 1906, 129 pp.

(170) ...., Hot Springs at Thermopolis: Jour. Geology, vol. 14, no. 3, 1906, pp. 194-200.

(171) ...., and SIEBENTHAL, C. E., Geology and mineral resources of the Laramie Basin, Wyoming: U. S. Geol. Surv. Bull. 364, 1909, 81 pp.

(172) ...., BLACKWELDER, E., and SIEBENTHAL, C. E., Description of the Laramie-Sherman, Wyoming, quadrangles: U. S. Geol. Surv. Geol. Atlas, Folio No. 173, 1910, 18 pp.

(173) DAVIS, J. A., Contributions to economic geology, 1910, Part II, The Little Powder River coal field, Campbell County, Wyoming: U. S. Geol. Surv. Bull. 471-F, 1912, pp. 423-440.

(174) DEAN, R. S., *et al.*, Progress Reports-Metallurgical Division 4, Studies in direct production of iron and steel from ore: U. S. Bur. Mines Rept. Inv. 3229, 1934, 65 pp.

(175) DENGO, G., Geology of bentonite deposits near Casper, Natrona County, Wyoming: Geol. Surv. Wyo. Bull. 37, 1946, 25 pp.

(176) DICKMAN, R. H., Report on the iron ore development of the Seminoe mining district, north from Rawlins, Wyoming: Unpublished report, Geol. Surv. Wyo. files, June 12, 1906, 7 pp.

(177) DIEMER, R. A., Titaniferous magnetite deposits of the Laramie Range, Wyoming: Geol. Surv. Wyo. Bull. 31, 1941, 23 pp.

(178) DEISS, C. F., unpublished report on dolomite in Wyoming: In files of U. S. Geol. Surv., 1942.

(179) DIETZ, C. S., Developed and undeveloped mineral resources of Wyoming: Geol. Surv. Wyo. Bull. 21, 1929, 194 pp.

(179a) ...., The electrometallurgical resources of the North Platte River basin, Wyoming: Geol. Surv. Wyo. Bull. 23, 1932, 235 pp.

(180) ...., Processes for the reduction of magnesium from dolomitic rocks at Guernsey, Wyoming, Mimeographed copy, Geol. Surv. Wyo. files, June, 1942, 34 pp.

(181) DILLER, J. S., Contributions to economic geology, 1910, Part I, The types, modes of occurrence, and important deposits of asbestos in the United States: U. S. Geol. Surv. Bull. 470-K, 1911, pp. 505-524.

(182) ...., The occurrence of asbestos in Wyoming: Min. Sci., vol. 63, 1911, pp. 447-448.

(183) ...., Recent studies of domestic chromite deposits: Am. Inst. Min. Met. Eng. Trans., vol. 63, 1920, pp. 105-149.

(184) DOBBIN, C. E., and BARNETT, V. H., Contributions to economic geology, 1927, Part II, The Gillette coal field, northeastern Wyoming: U. S. Geol. Surv. Bull. 796-A, 1928, pp. 1-50.

(185) DUDGEON, J. W., Mining and preparation of high calcium limestone: Colorado Mining Association, 1948 Mining Yearbook, Denver, 1949, pp. 91-94.

(186) DUNBAR, R. O., Geology of the Como Bluff anticline, Albany County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1942, 40 pp.

(187) EAST, J. H. JR., The Sunlight mining district, Wyoming: Eng. and Min. Jour., vol. 91, 1911, pp. 1155-1156.

(188) ECKEL, E. C., Cement material and industry of the United States: U. S. Geol. Surv. Bull. 243, 1905, 395 pp.

(189) ELDRIDGE, G. H., A geological reconnaissance in northwestern Wyoming: U. S. Geol. Surv. Bull. 119, 1894, 72 pp.

(190) ELLERMEIER, G. B., Sweetwater River moss agates: Rocks and Minerals, vol. 11, no. 9, 1936, pp. 172-73.

(191) EMMONS, S. F., Contributions to economic Geology, 1902, Platinum in copper ores in Wyoming: U. S. Geol. Surv. Bull. 213, 1903, pp. 94-97.

(192) ENDLICH, F. M., Geology of the Sweetwater District: U. S. Geog. and Geol. Survey of the Territories 11th Annual Report, (F. V. Hayden in Charge) 1877, pp. 5-158.

(193) ENGLE, A. E. J., Chapter 48, "Talc and ground soapstone," *Industrial Minerals and Rocks,* Am. Inst. Min. Met. Eng., New York, 1949, pp. 1018-1041.

(194) ERICKSON, E. T., Tschermigite from Wyoming: Wash. Acad. Sci. Proc., vol. 12, no. 13, 1922, pp. 49-54.

(195) FAHEY, J. J., Shortite, a new carbonate of sodium and calcium: Am. Mineralogist, vol. 24, no. 8, 1939, pp. 514-518.

(196) ...., Searlesite from the Green River formation of Wyoming: Am. Mineralogist, vol. 32, nos. 3-4, 1947, p. 198.

(197) ...., Laughlinite, anhydrous magnesium silicate: Am. Mineralogist, vol. 33, 1948, p. 195.

(198) ...., and TUNNEL, G., Bradleyite, a new mineral, $Na_2(PO_4)_3$-$MgCO_3$: Am. Mineralogist, vol. 26, no. 11, 1941, pp. 288-289.

(199) FAULKNER, G. L., Geology of the Bessemer Mountain-Oil Mountain area, Natrona County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1950, 63 pp.

(200) FERREN, J. E., Geology of the southeast part of the Shirley Mountains, Carbon County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1935, 43 pp.

(201) FINNELL, T. L., Unpublished personal field notes, August, 1950.

(201a) FISCHER, R. P., *et al.,* Map of metallic mineral deposits of Wyoming: U. S. Geol. Surv. Missouri Basin Studies Map No. 17, 1947.

(202) FISCHER, C. A., Contributions to economic geology, 1904, The bentonite deposits of Wyoming, U. S. Geol. Surv. Bull. 260, 1905, pp. 559-563.

(203) ...., Contributions to economic geology, 1905, Mineral resources of the Bighorn Basin: U. S. Geol. Surv. Bull. 285-F, 1906, pp. 311-315.

(204) ...., Geology and water resources of the Bighorn Basin, Wyoming: U. S. Geol. Surv. Prof. Paper 53, 1906, 72 pp.

(205) FISK, H. G., and BROWN, B. W., Personal communication to F. W. Osterwald, Feb. 1950.

(206) FORD, W. E., *Dana's Textbook of Mineralogy,* 4th edition, John Wiley and Sons, New York, 1932, 851 pp.

(207) FOWLER, K. S., The anorthosite area of the Laramie Mountains, Wyoming: Am. Jour. Sci., vol. 19, 1930, pp. 305-315, and 373-403.

(208) FREY, EUGENE, Exploration of Iron Mountain titaniferous magnetite Deposits, Albany County, Wyoming: U. S. Bur. Mines Rept. Inv. 3968, 1946, 37 pp.

(209) ...., Exploration of the Shanton iron ore property, Albany County, Wyoming: U. S. Bur. Mines Rept. Inv. 3918, 1946, 5 pp.

(210) ...., Good Fortune Iron Mine, Platte County, Wyoming: U. S. Bur. Mines Rept. Inv. 4089, 1947, 7 pp.

(211) ...., Hartville Iron District, Platte County, Wyoming: U. S. Bur. Mines Rept. Inv. 4086, 1947, 3 pp.

(212) ...., and WILSON, S. R., Investigations of Romur Tungsten deposits, Fremont County, Wyoming: U. S. Bur. Mines Rept. Inv. 4629, Jan., 1950, 9 pp.

(213) GALE, H. S., Contributions to economic geology, 1907, Part I, Gold placer deposits near Lay, Routt County, Colorado: U. S. Geol. Surv. Bull. 340-A, 1908, pp. 84-95.

(214) ...., and RICHARDS, R. W., Contributions to economic geology, 1909, Part I, Preliminary report on the phosphate deposits in southeastern Idaho and adjacent parts of Wyoming and Utah: U. S. Geol. Surv. Bull. 430-H, 1910, pp. 457-535.

(215) GARBUTT, IRVING, Article on the sulfur producing plant at Worland in the Casper Tribune-Herald, Sunday, Feb. 19, 1950, p. 19.

(216) GARDNER, L. S., Contributions to economic geology, 1943-44, Phosphate deposits of Teton Basin area, Idaho and Wyoming: U. S. Geol. Surv. Bull. 944-A, 1944, 36 pp.

(217) Geol. Surv. Wyo. files.

(218) Geol. Surv. Wyo. files: Letter to H. C. Beeler from L. Cavnah, President of Winona Gold-Copper Mining and Milling Company of Wyoming, dated Aug. 29, 1906.

(219) Geol. Surv. Wyo. files: Report of F. E. Warren, Governor of Wyoming, to the Secretary of the Interior, 1889, quoted by the State Geologist in a letter to Hon. C. D. Clark, Washington, D. C., Feb. 22, 1911.

(220) Geol. Surv. Wyo. files: Letter to H. S. Gale from L. W. Trumbull, May 16, 1916.

(221) Geol. Surv. Wyo. files: Press Notice, June, 1924.

(222) Geol. Surv. Wyo. files: Letter from E. C. Hoag, Industrial agent, Union Pacific R. R. to T. J. Cahill, Wyoming Comm. and Industry Commission, Nov. 10, 1927.

(223) Geol. Surv. Wyo. files: Copy of questionnaire sent to Mr. Adams by the Union Pacific R. R., accompanied by letter from E. C. Hoag, dated Nov. 10, 1927.

(224) Geol. Surv. Wyo. files: Copy of questionnaire sent to Mr. Ashley by Union Pacific R. R., accompanied by letter from E. C. Hoag, dated Nov. 10, 1927.

(225) Geol. Surv. Wyo. files: Copy of questionnaire sent to B. E. Benson by Union Pacific R. R., accompanied by letter from E. C. Hoag, Nov. 10, 1927.

(226) Geol. Surv. Wyo. files: Anonymous report, sent by E. C. Hoag to Dept. of Commerce, Cheyenne, Wyoming, Nov. 10, 1927.

(227) Geol. Surv. Wyo. files: Copy of questionnaire sent to Mr. Tennant by the Union Pacific R. R., accompanied by letter from E. C. Hoag, dated Nov. 10, 1927.

(228) Geol. Surv. Wyo. files: Letter from E. C. Hoag, Industrial Agent, Union Pacific Railroad, to T. J. Cahill, of Wyoming Commerce and Industry Commission, Dec. 1927.

(229) Geol. Surv. Wyo. files: Letter to State Geologist from E. C. Hoag, Union Pacific Railroad, Aug. 2, 1929.

(230) Geol. Surv. Wyo. files: Summary report on the occurrence of phosphate, potash, coal, oil, and gas in southwestern Wyoming. Compiled by the Geol. Surv. Wyo., Sept. 1937, 24 pp.

(231) Geol. Surv. Wyo. files: Letter to H. D. Thomas from L. B. Curtis, Feb 2, 1943.

(232) Geol. Surv. Wyo. files: Letter to H. D. Thomas from M. S. Mead Jr., Buffalo, Wyoming, April 20, 1943.

(233) Geol. Surv. Wyo. files: Letter to H. D. Thomas from Daniel Rhodes, Sept. 5, 1943.

(234) Geol. Surv. Wyo. files: Typewritten copy of news item from Mining Journal, October, 1943.

(235) Geol. Surv. Wyo. files: Letter to H. D. Thomas from D. B. Hilton, Sundance, Wyoming, March, 1944.

(237) Geol. Surv. Wyo. files: Letter to H. D. Thomas from P. G. Arthur, Nov. 23, 1945.

(238) Geol. Surv. Wyo. files: Letter to H. D. Thomas from B. B. Thompson, Wyoming Midland Gypsum Co., 1945.

(239) Geol. Surv. Wyo. files: Letter to H. D. Thomas from the Natural Resources Research Institute, 1946.

(240) Geol. Surv. Wyo. files: Letter to H. D. Thomas from Herbert F. Coates, Newcastle, Wyoming, April 27, 1947.

(241) Geol. Surv. Wyo. files: Press release to Laramie Republican and Boomerang, Laramie, Wyoming, Jan. 3, 1948.

(244) Geol. Surv. Wyo. files: Letter from Mr. Laurence Henderson, 1949.

(245) Geol. Surv. Wyo. files: Records and information from Mr. J. R. McDermott, Dec. 1950.

(246) Geol. Surv. Wyo. files: Letter to H. D. Thomas from Dr. Forbes Robertson, Montana School of Mines, Butte, Montana, Feb. 1951.

(247) Geol. Surv. Wyo. files: Anonymous undated report, 1 page.

(248) Geol. Surv. Wyo. files: Assays for J. H. Carpenter, Atlantic City, Wyoming.

(249) Geol. Surv. Wyo. files: Assay reports from Strong Mine.

(250) Geol. Surv. Wyo. files: Sample given A. F. Hagner by Don Birch of Atlantic City, Wyoming.

(251) Geol. Surv. Wyo. files: Personal communication to H. D. Thomas from Sidney Bartlett, July 1943.

(252) Geol. Surv. Wyo. files: Personal communication from C. Bass, Jay Em, Wyoming.

(253) Geol. Surv. Wyo. files: Personal communication from Mr. Jack Brightman, Cheyenne, Wyoming.

(254) Geol. Surv. Wyo. files: Personal communication from J. H. Carpenter of Atlantic City, Wyoming.

(255) Geol. Surv. Wyo. files: Personal communication from W. L. Covey, 1949.

(256) Geol. Surv. Wyo. files: Personal communication from Mrs. E. Ebsen, Laramie, Wyoming.

(258) Geol. Surv. Wyo. files: Personal communication from Mr. Laurence Henderson, Newcastle, Wyoming.

(259) Geol. Surv. Wyo. files: Personal communication from P. S. Hoyt.

(260) Geol. Surv. Wyo. files: Personal communication from C. M. Johnson, Laramie, Wyoming

(261) Geol. Surv. Wyo. files: Personal communication from J. R. Johnson, Laramie, Wyoming

(262) Geol. Surv. Wyo. files: Personal communication from Mr. N. Judd of Wheatland, Wyoming.

(263) Geol. Surv. Wyo. files: Personal communication from T. Kazmerchak, Rawlins, Wyoming.

(264) Geol. Surv. Wyo. files: Personal communication from R. I. Martin, Saratoga, Wyoming.

(265) Geol. Surv. Wyo. files: Personal communication from Clarence Metz.

(266) Geol. Surv. Wyo. files: Anonymous report of Wyoming Mica, undated.

(267) Geol. Surv. Wyo. files: Unpublished data.

(268) GIDDINGS, H. J., Geology of a portion of the Laramie Basin lying north of Como anticline, Albany County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1935, 45pp.

(269) GOLDRING, E. D., Aragonite crystals from Wyoming: Mineralogist, vol. 9, no. 1, 1941, pp. 16, 18.

(270) GOOLDY, P. L., Geology of the Beaver Creek-South Sheep Mountains area, Fremont County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1947, 75 pp.

(271) GRAY, L. O., Geology of the east flank of the Laramie Range in the vicinity of Horse Creek, Laramie County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1947, 25 pp.

(272) GREENE, R. G., Exploration for evaporite salts in Green River Basin, Wyoming: Bull. Amer. Assoc. Petrol. Geologists, vol. 25, no. 9, 1941, pp. 1799-1800.

(273) GRUNER, J. W., Abundance and significance of cristobalite in bentonites: Econ. Geology, vol. 35 no. 7, 1940, pp. 867-875.

(274) HAFF, J. C., Royal Purple fluorite claims, Bear Lodge Mountains, Crook County, Wyoming: Unpublished report for Geol. Surv. Wyo., June 25, 1944, 2 pp.

(275) ...., E. W. Peterson, fluorite claims, Bear Lodge Mountains, Crook County, Wyoming: Unpublished report for Geol. Surv. Wyo., July 1, 1944, 2 pp.

(276) ...., Nepheline-syenite at Mineral Hill area: Unpublished report for Geol. Surv. Wyo., July 3-4, 1944, 3 pp.

(277) ...., Cambria salt springs, Black Hills, Weston County, Wyoming: Unpublished report for Geol. Surv. Wyo., July 5, 1944, 3 pp.

(278) ...., Porphyritic Diabase: Unpublished report for Geol. Surv. Wyo., July 11, 1944, 3 pp.

(279) ...., Report on Cooper nickel claim: Unpublished report for Geol. Surv. Wyo., July 22, 1944, 2 pp.

(280) ...., Report on the Buckeye claims, Sierre Madre Mountains, Wyoming: Unpublished report for Geol. Surv. Wyo., July 31, 1944, 2 pp.

(281) ...., McKillip Lead-Zinc (Meta) Claim: Unpublished report for Geol. Surv. Wyo., Aug. 1, 1944, 3 pp.

(282) HAFF, J. C., Cottonwood Creek kyanite deposits: Unpublished report for Geol. Surv. Wyo., Aug. 2, 1944, 3 pp.

(283) ...., Report on the Beaver Group of claims, Encampment District: Unpublished report for Geol. Surv. Wyo., Aug. 4, 1944, 2 pp.

(284) ...., Report on Spanish Trails Lead-Zinc Claim: Unpublished report for Geol. Surv. Wyo., Aug. 10, 1944, 3 pp.

(285) ...., Big Nugget gold placer claims: Unpublished report for Geol. Surv. Wyo., Aug. 13, 1944, 2 pp.

(286) ...., The Ogden Creek fluorite deposits, Bear Lodge Mountains, Crook County, Wyoming: Unpublished report for Geol. Surv. Wyo., Sept. 2, 1944, 11 pp.

(287) HAGANS, G. R., Mineral resources of Natrona County, Wyoming: Min. Jour. (Phoenix, Ariz.), vol. 11, no. 15, 1927, pp. 3-6, 52-53.

(288) HAGNER, A. F., Western States Mining and Milling Co., graphite deposit: Unpublished field notes for Geol. Surv. Wyo., June 8, 1942.

(289) ...., Monte Cristo mine: Unpublished field notes for Geol. Surv. Wyo., Aug. 1, 1942.

(290) ...., Yellow Bird mine: Unpublished field notes for Geol. Surv. Wyo., Aug. 1, 1942.

(291) ...., Rambler Mine: Unpublished field notes for Geol. Surv. Wyo., Aug. 1, 1942.

(292) ...., Percis claims (Tom Rees and S. Tohoski): Unpublished field notes for Geol. Surv. Wyo., Aug. 3, 1942.

(293) ...., Friday No. 2 sericite claim of Otto Plaga and N. Judd: Unpublished field notes for Geol. Surv. Wyo., Aug. 5, 1942.

(294) ...., Collins graphite deposit: Unpublished field notes for Geol. Surv. Wyo., Aug. 5, 1942.

(295) ...., Romsa Ranch dolomite deposits: Unpublished field notes for Geol. Surv. Wyo., Aug. 6, 1942.

(296) ...., Palmer Canyon talc: Unpublished field notes for Geol. Surv. Wyo., Aug. 8, 1942.

(297) ...., Collins talc deposit: Unpublished field notes for Geol. Surv. Wyo., Aug. 8, 1942.

(298) ...., Koch siliceous iron prospect: Unpublished field notes for Geol. Surv. Wyo., Aug. 14, 1942.

(299) ...., Koch asbestos and vermiculite prospect: Unpublished field notes for Geol. Surv. Wyo., Aug. 14, 1942.

(300) ...., Koch gold and silver prospect: Unpublished field notes for Geol. Surv. Wyo., Aug. 14, 1942.

(301) ...., Koch's manganese prospect: Unpublished field notes for Geol. Surv. Wyo., Aug. 15, 1942.

(302) ...., Casper Mountain chromite deposit: Unpublished field notes for Geol. Surv. Wyo., Aug. 15, 1942.

(303) ...., Koch hematite prospect on Casper Mountain: Unpublished field notes for Geol. Surv. Wyo., Aug. 15, 1942.

(304) ...., Olin Brothers hematite prospect: Unpublished field notes for Geol. Surv. Wyo., Aug. 15, 1942.

(305) ...., Koch feldspar deposit: Unpublished field notes for Geol. Surv. Wyo., Aug. 15, 1942.

(306) HAGNER, A. F., Bonneville Mercury prospect: Unpublished field notes for Geol. Surv. Wyo., Aug. 16, 1942.

(307) ...., Kin Sabe or Whippet No. 8 prospect: Unpublished field notes for Geol. Surv. Wyo., Aug. 16, 1942,

(308) ...., Mormon Canyon scheelite: Unpublished field notes for Geol. Surv. Wyo., Aug. 17, 1942.

(309) ...., Schundler-Glenrock prospect: Unpublished field notes for Geol. Surv. Wyo., Aug. 17, 1942.

(310) ...., Douglas iron deposit of American Min. Co.: Unpublished field notes for Geol. Surv. Wyo., Aug. 19, 1942.

(311) ...., J. A. Brady and T. J. Sullivan deposit: Unpublished field notes for Geol. Surv. Wyo., Aug. 19, 1942.

(312) ...., Abernathy tungsten claim: Unpublished field notes for Geol. Surv. Wyo., Aug. 26, 1942.

(313) ...., Abernathy asbestos and vermiculite claim, Unpublished field notes for Geol. Surv. Wyo., Aug. 27, 1942.

(314) ...., Abernathy sapphire deposit: Unpublished field notes for Geol. Surv. Wyo., Aug. 27, 1942.

(315) ...., Lin I. Noble sulfur deposit: Unpublished field notes for Geol. Surv. Wyo., Aug. 28, 1942.

(316) ...., Roberson-Muirhead scheelite claim: Unpublished field notes for Geol. Surv. Wyo., Aug. 29, 1942.

(317) ...., Taylor lease: Unpublished field notes for Geol. Surv. Wyo., not dated.

(318) ...., Cody sulfur deposit: Unpublished field notes for Geol. Surv. Wyo., Aug. 31, 1942.

(319) ...., Summary report, field examination of Black Butte lead deposit, Crook County, Wyoming: Unpublished report for Geol. Surv. Wyo., Sept. 12, 1942, 4 pp.

(320) ...., George Funk mica deposit: Unpublished field notes for Geol. Surv. Wyo., Nov. 4, 5, 1942.

(321) ...., Reisenwever tungsten deposit: Unpublished field notes for Geol. Surv. Wyo., Nov. 15, 1942.

(322) ...., Andreg and Cooper nickel claim: Unpublished field notes for Geol. Surv. Wyo., Nov. 15, 1942.

(323) ...., Vaughn graphite claim: Unpublished field notes for Geol. Surv. Wyo., April 4, 1943.

(324) ...., Vaughn Green Mountain Boy deposit: Unpublished field notes for Geol. Surv. Wyo., April 4, 1943.

(325) ...., Vaughn arsenopyrite claim: Unpublished field notes for Geol. Surv. Wyo., April 4, 1943.

(326) ...., Sericite, Platte County: Unpublished field notes for Geol. Surv. Wyo., April 17, 1943, and May 19, 1944.

(327) ...., Beaver Claim: Unpublished field notes for Geol. Surv. Wyo., May 4, 1943.

(328) ...., State lease no. 01504, feldspar claim: Unpublished field notes for Geol. Surv. Wyo., May 4, 1943.

(329) ...., Black Hills fluorite deposits: Unpublished field notes for Geol. Surv. Wyo., June 30, 1943.

(330) HAGNER, A. F., Black Rock manganese claim: Unpublished field notes for Geol. Surv. Wyo., June 30, 1943.

(331) ...., Vaughn or Vulcan claim: Unpublished field notes for Geol. Surv. Wyo., July 2, 1943.

(332) ...., Rabbitt Creek graphite: Unpublished field notes for Geol. Surv. Wyo., July 14, 1943.

(333) ...., Keahey Mines & Co., Inc.; Unpublished field notes for Geol. Surv. Wyo., Sept. 10, 1943.

(334) ...., Geologic report on the Keahey tungsten property at Copper Mountain, Wyoming: Unpublished report for Mr. John Keahey, 1943 (?), 22 pp. Copy in Geol. Surv. Wyo. files.

(335) ...., Romur tungsten claim: Unpublished field notes for Geol. Surv. Wyo., Sept. 11, 1943.

(336) ...., Olive 5 claim: Unpublished field notes for Geol. Surv. Wyo., Sept. 12, 1943.

(337) ...., Wyoming vermiculite deposits: Geol. Surv. Wyo. Bull. 34, March 1944, 47 pp.

(338) ...., Plaga and Judd nickel prospect: Unpublished field notes for Geol. Surv. Wyo., Dec. 13, 1944.

(339) ...., Abernathy jade: Unpublished field notes for Geol. Surv. Wyo., May 17, 1945, June 10, 1945.

(340) ...., Marion and Curtis jade claim: Unpublished field notes for Geol. Surv. Wyo., May 18, 1945.

(341) ...., Rhoads jade deposit: Unpublished field notes for Geol. Surv. Wyo., May 19, 1945.

(342) ...., Carleton kyanite claims: Unpublished field notes for Geol. Surv. Wyo., June 9, 1945.

(343) ...., H. K. Diehl, A. Branham, etc. jade deposit: Unpublished field notes for Geol. Surv. Wyo., June 12, 1945.

(344) ...., Garrett and Nipper claims: Unpublished field notes for Geol. Surv. Wyo., Oct. 8, 1945.

(345) ...., Metterling scheelite claim: Unpublished field notes for Geol. Surv. Wyo., Aug. 27, 1942.

(346) ...., Maxwell tungsten claim at Lewiston: Unpublished field notes for Geol. Surv. Wyo., Aug. 27, 1942.

(347) ...., J. H. Carpenter manganese property: Unpublished field notes for Geol. Surv. Wyo., undated.

(348) ...., Mosaic gold claim: Unpublished field notes for Geol. Surv. Wyo., undated.

(349) HAGUE, ARNOLD, Leucite Rock in the Absaroka Range, Wyoming, Am. Jour. Sci., 3rd ser., vol. 38, 1889, pp. 43-47.

(350) ...., Description of the Absaroka Folio: U. S. Geol. Surv. Geol. Atlas Folio No. 52, 1899, 7 pp.

(351) HALL, EDWIN, Report on the property belonging to the U. S. Asbestos Mining & Fiberizing Co., Casper, Wyoming: Unpublished report no. 109 for Geol. Surv. Wyo., Feb. 22, 1907, 3 pp.

(352) ...., Annual Report of the State Geologist to the Governor of Wyoming, 1909, 17 pp. Copy in Geol. Surv. Wyo. files.

(353) HAMMOND, C. R., Geology of the east flank of the Laramie Range, in the vicinity of Iron Mountain, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1949, 63 pp.

(354) HANLEY, J. B., HEINRICH, E. W., and PAGE, L. R., Pegmatite investigations in Colorado, Wyoming and Utah: U. S. Geol. Surv. Prof. Paper 227, 1950, pp. 107-121.

(355) HAUN, J. D., Geology of a portion of the east flank of the Laramie Range: Unpublished M. A. thesis, Univ. Wyo. Library, 1949, 40 pp.

(356) HAYDEN, F. V., Second annual report of the United States Geological Survey of the Territories embracing Wyoming: U. S. Gen. Land Office report, Washington, 1868, pp. 111-120, 220-225.

(357) ...., Geological report of the exploration of the sources of the Missouri and Yellowstone Rivers, under the direction of Capt. W. F. Reynolds, 1859-60, U. S. 40th Congress, 2nd session, Senate Document 77, Washington, 1869, 174 pp.

(358) ...., Preliminary report of the United States Geological Survey of Wyoming and portions of contiguous Territories, Washington, 1871, 511 pp.

(359) HEATHMAN, J. H., Bentonite in Wyoming: Geol. Surv. Wyo. Bull. 28, 1939, 20 pp.

(360) HEISEY, E. L., Geology of the East Ferris Mountains, Carbon County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1949, 80 pp.

(361) HENDRICKS, C. E., Report on the Eastman Properties, Wyoming: Unpublished report in Geol. Surv. Wyo. files, July 9, 1902, 4 pp.

(362) ...., Report on iron in part of the Seminoe Mountains, Wyoming: Unpublished report in Geol. Surv. Wyo. files, July 9, 1902, 5 pp.

(363) HESS, F. L., Contributions to economic geology, 1925, Part I, Platinum near Centennial, Wyoming: U. S. Geol. Surv. Bull. 780-C, 1926, pp. 127-135.

(364) HEWITT, D. F., Contributions to economic geology, 1911, Part I, Sulfur deposits of Sunlight Basin, Wyoming: U. S. Geol. Surv. Bull. 530-O, 1913, pp. 350-362.

(365) ...., Contributions to economic geology, 1912, Part I, The ore deposits of Kirwin, Wyoming: U. S. Geol. Surv. Bull. 540-C, 1914, pp. 121-132.

(366) ...., Contributions to economic geology, 1912, Part II, The Shoshone River section, Wyoming: U. S. Geol. Surv. Bull. 541-C, 1914, pp. 89-113.

(367) ...., Contributions to economic geology, 1912, Part I, Sulfur deposits in Park County, Wyoming: U. S. Geol. Surv. Bull. 540-R, 1914, pp. 477-480.

(368) ...., The origin of bentonite and the geologic range of related materials in Bighorn Basin, Wyoming: Washington Acad. Sci. Jour., vol. 7, 1917, pp. 196-198.

(369) ...., Geology and oil and coal resources of Oregon Basin, Meeteetse, and Grass Creek Basin Quadrangles, Wyoming: U. S. Geol. Surv. Prof. Paper 145, 1926, 107 pp.

(370) HIGNETT, T. P., and ROYSTER, P. H., Smelting of leucite (wyomingite) and phosphate rock in the blast furnace: The Am. Fertilizer Review, vol. 73, no. 7, 1930, p. 20.

(371) HORTON, F. W., and ALLSMAN, P. T., Casper Mountain chromite deposit: U. S. Bur. Mines Rept. Inv. 4512, Aug., 1949, 26 pp.

(372) HOULETTE, K. N., Geology of the McGill anticline, Albany County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1947, 39 pp.

(372a) HUGHES, W. J., Wheatland, Wyoming, Personal communication, March 28, 1947.

(373) HURLBUT, C. S. JR., *Dana's Manual of Mineralogy,* 15th edition, John Wiley and Sons, Inc., New York, 1941, 480 pp.

(374) IRVING, J. D., with contributions by Emmons, S. F. and Jaggar, T. A. Jr., Economic resources of the northern Black Hills: U. S. Geol. Surv. Prof. Paper 26, Part II, 1904, 222 pp.

(375) ISBERG, J. T., Geology of a portion of east-central Carbon County north and west of Elk Mountain: Unpublished M. A. thesis, Univ. Wyo. Library, 1937, 59 pp.

(377) JAMISON, C. E., The mineral resources of Wyoming: Geol. Surv. Wyo. Bull. 1, Series B, 1911, 40 pp.

(378) ...., Geology and mineral resources of a portion of Fremont County, Wyoming: Geol. Surv. Wyo. Bull. 2, 1911, 90 pp.

(379) ...., Otego Mining Co., Silver Crown district, Arizona Mine: Unpublished report for Geol. Surv. Wyo., Feb. 20, 1912, 5 pp.

(380) ...., Report on the property of the Hutchins Consolidated Gold Mining Co., Crook County, Wyoming: Unpublished report for Geol. Surv. Wyo., 1912, 24 pp.

(381) JENKINS, C. E., Geology of Bates Creek-Corral Creek area, Natrona County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1950, 80 pp.

(382) JENKINS, O. P., Mineral Commodities of California: State of California, Dept. of Natural Resources, Div. of Mines Bull. 156, 1950, 443 pp.

(383) JENKINS, P. T., Geology of a portion of the eastern side of the Laramie Range, Albany, Laramie, and Platte Counties, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1938, 40 pp.

(384) ...., Vermiculite deposits south of Glenrock, in Knight, S. H., Natural Resources Committee Report, 1938, Geol. Surv. Wyo. files, pp. 36-37.

(385) JENNY, W. P., and NEWTON, HENRY, Report on the geology and resources of the Black Hills of Dakota, Chapter IV, Mineral Resources: U. S. Geol. and Geog. Survey of the Rocky Mountain Region (J. W. Powell in charge) Washington, 1880, 566 pp.

(386) JOHNSTON, J. C., and KIVI, W. J., Report on the occurrence of phosphate in the vicinity of Nugget Station, Uinta County, Wyoming: Unpublished report for Geol. Surv. Wyo., 1939, 3 pp.

(387) JONES, C. C., Opening a new phosphate field in the United States: Am. Inst. Min. Met. Eng. Trans., vol. 47, 1914, pp. 192-216.

(388) JONES, E. L. JR., Contributions to economic geology, 1920, Part I, a deposit of manganese ore in Wyoming: U. S. Geol. Surv. Bull. 715-C, 1921, pp. 57-59.

(389) JORALEMON, I. B., The weakest link, or saving time in a mine examination: Eng. and Min. Jour., vol. 125, 1928, pp. 536-540.

(390) JULIHN, C. E., and MOON, L. B., Summary of the Bureau of Mines exploration projects on deposits of raw material resources for steel production: U. S. Bur. Mines Rept. Inv. 3801, Mar., 1945, 35 pp.

(391) KEATING, D. E., Report on the Horse Creek placer, Laramie County, Wyoming: Unpublished report in Geol. Surv. Wyo. files, Dec. 1, 1897, 7 pp.

(392) KEETON, C. G., Report for the Mother Lode Gold & Copper Co.: Unpublished report in Geol. Surv. Wyo. files, Oct. 6, 1913, 3 pp.

(393) KEMP, J. F., The Lucite Hills of Wyoming: Geol. Soc. America Bull., vol. 8, 1897, pp. 169-182.

(394) ...., and KNIGHT, W. C., The Leucite Hills of Wyoming: Geol. Soc. America Bull., vol. 14, 1903, pp. 305-336.

(395) KIMBALL RUSSELL, Map of Sunlight Basin district, the Malachite and Joe veins: Copy in Geol. Surv. Wyo. files.

(395a) KING, D. L., Surface strip phosphate mining at Leefe, Wyoming, and Montpelier, Idaho: Am. Inst. Min. Met. Eng. Mining Trans., vol. 184, Aug. 1949, pp. 284-287.

(396) KING, R. H., Phosphate near Lander, Wyoming: Geol. Surv. Wyo. Bull. 39, 1947, 84 pp.

(397) ...., Iron deposits near Atlantic City, Wyoming: Unpublished report for Chicago and Northwestern R. R., 1949, 10 pp.

(398) KING, W. H., and SCHUMACHER, J. H., Investigations of the Lander phosphate deposits, Fremont County, Wyoming: U. S. Bur. Mines Rept. Inv. 4437, April 1949, 12 pp.

(399) KIVI, WILHO J., Stratigraphy of the Phosphoria formation of western Wyoming, with notes on the occurrence of phosphate: Unpublished M. A. thesis, Univ. Wyo. Library, 1940, 59 pp.

(400) KNIGHT, S. H., Unpublished report on glass sand, 1922, Geol. Surv. Wyo. files.

(401) ...., Summary report on the occurrence and character of a clay bed underlying the Townsite of Albany, Albany County, Wyoming: Sept. 1932, 2 pp., Unpublished rept. for Geol. Surv. Wyo.

(402) ...., The saline deposits of Wyoming, Part I, The Downey Lakes, Albany County, Wyoming: Geol. Surv. Wyo. Rept. Inv., March, 1939, 8 pp.

(403) ...., The saline deposits of Wyoming, Part II, The Rock Creek Lakes, Albany County, Wyoming: Geol. Surv. Wyo. Rept. Inv., March, 1939, 8 pp.

(404) ...., Report of the Mosaic gold claim: Unpublished report for Geol. Surv. Wyo., Aug., 1939, 4 pp.

(405) ...., Known mineral resources of Albany County, Wyoming, Part I, The metallic minerals: Prepared for the Albany County Council of Defense, April, 1942, 24 pp. Copy in Geol. Surv. Wyo. files.

(406) ...., and GILBERT, C. S., The geological occurrence, chemical composition and optical properties of a new uranium mineral: Unpublished report for Geol. Surv. Wyo., 1947, 4 pp.

(407) ...., Estimate of gold produced from that portion of the Sweetwater Mining District within the original boundary of the Shoshone Indian Reservation between the years 1869 to 1874, inclusive: Unpublished report, Geol. Surv. Wyo. files, undated, 24 pp.

(408) KNIGHT, S. H., Saline lake deposits of Wyoming, The "Dupont" or Independence deposits, Natrona County, Wyoming: Geol. Surv. Wyo. mimeographed report in Geol. Surv. Wyo. files, undated, 8 pp.

(409) KNIGHT, W. C., Notes on the mineral resources of the State: Wyo. Exper. Station Bull. 14, 1893, pp. 103-212.

(410) ...., Mineral soap: Eng. and Min. Jour., vol. 63, 1897, pp. 600-601.

(411) ...., Building stone and clays in Wyoming: Eng. and Min. Jour., vol. 66, 1898, pp. 546-547.

(412) ...., and SLOSSON, E. E., Alkali lakes and deposits: Wyo. Exper. Sta. Bull. 49, 1901, pp. 71-123.

(413) ...., The Sweetwater mining district, Fremont County, Wyoming: Wyo. Univ. school of Mines Bull. 5, 1901, 35 pp.

(414) ...., Notes on the occurrence of rare metals in the Rambler mine: Eng. and Min. Jour., vol. 73, May 17, 1902, p. 696.

(415) ...., Gypsum deposits in the United States, Gypsum in Wyoming: U. S. Geol. Surv. Bull. 223, 1904, pp. 79-85.

(416) ...., Report of Wyoming Central Association, Copy in Geol. Surv. Wyo. files, undated.

(417) KNIGHT, W. H., Geology of the west part of Flattop anticline, Carbon County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1944, 30 pp.

(418) KONKEL, P., Geology of the northeast portion of the Laramie Basin-Little Medicine district: Unpublished M. A. thesis, Univ. Wyo. Library, 1935, 59 pp.

(419) KRAUS, E. H., HUNT, W. F., and RAMSDELL, L. S., *Mineralogy*, 4th edition, McGraw-Hill Book Co., New York, 1951, 664 pp.

(420) KUNZ, G. F., Precious Stones: Sixteenth Annual Report, pt. 4, U. S. Geol. Surv., 1895, pp. 595-605.

(421) KYNER, TALLMADGE, Report on the geology of Miner's Delight Group: Unpublished report in Geol. Surv. Wyo. files, undated, 10 pp.

(422) LADOO, R. B., Chapter 1, "Abrasives," in *Industrial Minerals and Rocks*, Am. Inst. Min. and Met. Eng., New York, 1949, pp. 1-54.

(423) LAKES, ARTHUR, Asbestos deposits and mills: Min. Sci., vol. 60, Oct. 28, 1909, pp. 388-90.

(425) LARSEN, E. S. JR., Dakeite, a new uranium mineral from Wyoming: Mineralogist, vol. 5, no. 2, 1937, p. 7.

(426) ...., and GONYER, F. A., Dakeite, a new uranium mineral from Wyoming: Am. Mineralogist, vol. 22, no. 5, 1937, pp. 561-563.

(427) LINDGREN, WALDEMAR, *Mineral Deposits*, 4th edition, McGraw-Hill Book Co., New York, 1933, 930 pp.

(428) LIPPARD, T. R., Chapter 20, "Gypsum" in *Industrial Minerals and Rocks*, Am. Inst. Min. and Met. Eng., New York, 1949, pp. 436-447.

(429) LONGWELL, C. R., KNOPF, ADOLPH, and FLINT, R. F., *Outlines of Physical Geology*, 2nd edition, John Wiley and Sons, Inc., New York, 1941, 381 pp.

(430) LOVE, J. D., The geology of the west end of the Owl Creek Mountains, Wyoming: Geol. Surv. Wyo. Bull. 24, 1934, 33 pp.

(431) ...., Geological report on the Anderson mine, Tin Cup district, Fremont County, Wyoming: Unpublished report for Geol. Surv. Wyo., 1935, 3 pp.

(432) ...., Geologic report on Peterson bentonite deposit, Weston County, Wyoming: Report for Niagara Sprayer and Chemical Co. Inc., 1935, 7 pp. Copy in Geol. Surv. Wyo. files.

(433) ...., Personal communication, Geol. Surv. Wyo.

(433a) ...., *et al.*, Tertiary stratigraphy of Jackson Hole area, Wyoming: U. S. Geol. Surv. Prelim. Chart 27, 1947.

(434) ...., *et al.*, Geology of the Glendo area, Wyoming: U. S. Geol. Surv. Prelim. Map 92, 1949.

(434a) ...., Personal communication, Geol. Surv. Wyo.

(435) LOVERING, T. S., Contributions to economic geology, 1929, Part I, The Rawlins, Shirley, and Seminoe iron-ore deposits, Carbon County, Wyoming: U. S. Geol. Surv. Bull. 811-D, 1930, pp. 203-235.

(435a) LUCAS, JOHN JR., Personal communication, 1952.

(436) LUPTON, C. T., and CONDIT, D. D., Contributions to economic geology, 1916, Part I, Gypsum in the southern part of the Bighorn Mountains: U. S. Geol. Surv. Bull. 640-H, 1917, pp. 139-157.

(437) McCARTHY, C. E., GREEN, S. J., and STERN, A. G., Potassium carbonate from wyomingite: Am. Inst. Min. Met. Eng. Tech. Pub. 1738, 1944.

(438) McKELVEY, V. E., Preliminary report on the stratigraphy of the phosphatic shale member of the Phosphoria formation in western Wyoming, southeastern Idaho, and northern Utah: U. S. Geol. Surv. Open file report 1946, 162 pp. 7 plates, 5 figures, on file with Geol. Surv. Wyo.

(438a) ...., Geological studies of the western phosphate field: Am. Inst. Min. Met. Eng. Mining Trans., vol. 184, Aug., 1949, pp. 270-279.

(438b) ...., Stratigraphic sections of the Phosphoria formation in Wyoming: U. S. Geol. Surv. Open file rept., July 1951, on file with Geol. Surv. Wyo.

(439) McKINSTRY, H. E., *Mining Geology,* Prentice-Hall, Inc., New York, 1948, 680 pp.

(440) McLAUGHLIN, T. G., Pegmatites of the Bridger Mountains, Wyoming: Am. Mineralogist, vol. 25, no. 1, 1940, pp. 46-68.

(441) MAJORS, F. H., Exploration of the Brutch sulfur deposits, Hot Springs County, Wyoming: U. S. Bur. Mines Rept. Inv. 3964, Oct. 1946, 15 pp.

(442) MANSFIELD, G. R., Contributions to economic geology, 1915, Part I, A reconnaissance for phosphate in the Salt River Range, Wyoming: U. S. Geol. Surv. Bull. 620-O, 1916, pp. 331-349.

(442a) ...., Geography, geology and mineral resources of part of southeastern Idaho: U. S. Geol. Surv. Prof. Paper 152, 1927.

(443) ...., Some problems of the Rocky Mountain phosphate field: Econ. Geology, vol. 26, no. 4, 1931, pp. 353-374.

(444) MANSFIELD, G. R., and BOARDMAN, L., Nitrate deposits of the United States: U. S. Geol. Surv. Bull. 838, 1932, 107 pp.

(445) MARAVICH, M., Geology of Freezeout Mountain-Bald Mountain area, Carbon County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1940, 20 pp.

(446) MARTIN, R. I., Agates of Carbon County, Wyoming: Mineralogist, vol. 5, no. 7, 1937, pp. 11-20.

(447) MARZEL, J. G., Report of the State Geologist on the area northeast of Bonneville, Fremont County, Wyoming, on possible mercury and gold deposits: Unpublished report in Geol. Surv. Wyo. files, Sept. 1, 1927, 3 pp.

(448) ...., Fourteenth biennial report of the State Geologist for period Oct. 1, 1926 to Sept. 30, 1928, Cheyenne, Wyoming, 1928, 110 pp.

(449) ...., Sixteenth Annual report of State Geologist, Oct. 1930 to Sept. 30, 1932, Cheyenne, Wyoming, 114 pp. Copy in Geol. Surv. Wyo. files.

(450) MENDENHALL, W. C., Occurrence of a deposit of trona: Science, new ser., vol. 91, no. 2349, 1940, pp. 11-12.

(451) MERRILL, G. P., *Stones for Building and Decoration,* 2nd edition, John Wiley and Sons Inc., New York, 1897, 506 pp.

(452) Mineral Resources U. S., 1882, U. S. Geol. Surv., 1883, 813 pp.

(453) Mineral Resources U. S., 1887, U. S. Geol. Surv., 1888, 832 pp.

(454) Mineral Resources U. S., 16th Annual Report, 1894, Pt. III, U. S. Geol. Surv., 1895, 646 pp.

(455) Mineral Resources U. S., 1907, pt. I, U. S. Geol. Surv., 1908, 743 pp.

(456) Mineral Resources U. S., 1914, pt. II, U. S. Geol. Surv., 1916, 1122 pp.

(457) Mineral Resources U. S., 1915, pt. II, U. S. Geol. Surv., 1917, 1084 pp.

(458) Minerals Yearbook, 1946, U. S. Dept. of Interior, Bureau of Mines, Washington, 1948, 1629 pp.

(459) Minerals Yearbook, 1948, U. S. Dept. of Interior, Bureau of Mines, Washington, 1950, 1652 pp.

(460) MORGAN, G. B., Summary of the mineral resources of Wyoming: Geol. Surv. Wyo. Press Bull. no. 10, 1920, 15 pp.

(461) MORGAN, J. K., Geology of the Otter Creek area, Washakie County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1951, 55 pp.

(462) MORT, F. P., Geology of an area between La Bonte and La Prele Creeks, Converse County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1936, 16 pp.

(463) NACE, R. L., Geology of the northwestern part of the Red Desert, Sweetwater and Fremont Counties, Wyoming: Geol. Surv. Wyo. Bull. 27, 1939, 51 pp.

(464) NEWHOUSE, W. H., and HAGNER, A. F., Cordierite deposits of the Laramie Range, Albany County, Wyoming: Geol. Surv. Wyo. Bull. 41, 1949, 18 pp.

(465) ...., Geologic map of anorthosite areas southern part of Laramie Range, Wyoming: U. S. Geol. Surv. Map, MF 119, 1957.

(467) O'HARRA, C. C., Bentonite, its properties, occurrence, and uses: Black Hills Engineer, vol. 17, no. 1, 1929, pp. 39-48.

(468) OSTERWALD, F. W., Metasomatism and mineral facies in relation to structure in northeastern Albany County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1947, 65 pp.

(469) ...., Natural resources in the vicinity of Evanston, Wyoming: Unpublished report for Geol. Surv. Wyo., June 16, 1947, 3 pp.

(470) ...., Occurrence of pumice in the southern part of the Leucite Hills, Sweetwater County, Wyoming: Unpublished report for Geol. Surv. Wyo., June 16, 1947, 2 pp.

(471) ...., An occurrence of sheridanite near Story, Sheridan County, Wyoming: Unpublished report for Geol. Surv. Wyo., Aug. 31, 1947, 2 pp.

(472) ...., Report of geologic investigation of the Broadway lead-zinc claim, Carbon County, Wyoming: Unpublished report for Geol. Surv. Wyo., Aug. 31, 1947, 3 pp.

(473) ...., Unpublished personal field notes, July 3, 1948.

(474) ...., Unpublished personal field notes, July 11, 1948.

(475) ...., Unpublished personal field notes, July 23, 1948.

(476) ...., Unpublished personal field notes, July 25, 1948.

(477) ...., Unpublished personal field notes, July 26, 1948.

(478) ...., Unpublished personal field notes, Aug. 12, 1949, Aug. 31, 1948.

(479) ...., Unpublished personal field notes, Aug. 19, 1948.

(480) ...., Unpublished personal field notes, Aug. 21, 1949.

(481) ...., Unpublished personal field notes, Aug. 22, 1949.

(482) ...., Unpublished personal field notes, Aug. 27, 1949.

(485) ...., Structural and petrologic studies in the northern Bighorn Mountains, Wyoming: Unpublished Ph.D. thesis, Univ. of Chicago Library, 1951, 155 pp.

(486) ...., Unpublished personal field notes, Aug. 14, 1951.

(487) ...., Unpublished personal field notes, Aug. 15, 1951.

(488) ...., Unpublished personal field notes, Aug. 19, 1951.

(489) ...., Unpublished personal field notes. Undated.

(490) PALACHE, CHARLES. BERMAN, HARRY, and FRONDELL, CLIFFORD, *Dana's System of Mineralogy,* 7th edition, vol. I, John Wiley and Sons, Inc., New York, 1944, 834 pp.

(491) PARSONS, W. H., The ore deposits of the Sunlight Mining district, Park County, Wyoming: Econ. Geology, vol. 32, no. 6, 1937, pp. 832-854.

(492) PATTERSON, K. D., Origin of graphite in western Platte County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1950, 77 pp.

(492a) PEALE, A. C., Catalogue of minerals: U. S. Geol. Survey of Territories, 6th Ann. Rept., for 1872 (F. V. Hayden in charge), Washington, 1873, pp. 179-182.

(493) ...., Report on the geology of the Green River district: U. S. Geol. and Geog. Survey of Terr. 11th Ann. Report, for 1877 (F. V. Hayden in charge), Washington, 1879, pp. 511-646.

(494) PERRY, E. L., Fibrous magnetite after chrysotile: Am. Jour. Sci., 5th ser., vol. 20, 1930, pp. 177-179.

(495) PETERSON, A. F., Geology of Shirley Basin and Bates Hole region, Carbon and Natrona Counties, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1935, 70 pp.

(496) PIERCE, W. G., and ANDREWS, D. A., Contributions to economic geology, 1940, Geology and oil and coal resources of the region south of Cody, Park County, Wyoming: U. S. Geol. Surv. Bull. 921-B, 1941, pp. 98-180.

(497) PIKE, R. D., Proposed manufacture of monopotassium phosphate at Green River, Wyoming: Ind. and Eng. Chemistry, vol. 25, 1933, pp. 256-261.

(498) PLATT, R. E., A little known Wyoming locality: Mineralogist, vol. 15, 1947, pp. 227-230.

(499) Preliminary outline of the mineral resources, State of Wyoming: Chicago and Northwestern Railroad, 1942, 89 pp.

(500) RALSTON, O. C., Chapter 44 "Natural sodium carbonate and sodium sulfate," in *Industrial Minerals and Rocks,* Am. Inst. Min. Met. Eng. New York, 1949, pp. 945-964.

(501) RAYMOND, R. W., Statistics of mines and mining in the states and territories west of the Rocky Mountains: 41st Congress, 2nd session, House Doc. No. 207, Washington, 1870, pp. 445-468.

(502) REES, TOM, Oral communication to F. W. Osterwald, Oct. 1949.

(503) REYNOLDS, W. E., Unpublished personal field notes, 1950.

(504) RICHARDSON, A. L., Geology of the Mayoworth region, Johnson County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1950, 59 pp.

(505) RICKETTS, L. D., Annual report of Territorial Geologist to the Governor of Wyoming: Cheyenne, Wyoming, 1888, 87 pp.

(506) ...., Annual report of Territorial Geologist to the Governor of Wyoming: Cheyenne, Wyoming, 1890, 80 pp.

(507) ROGERS, A. F., Lorandite from the Rambler Mine: Am. Jour. Sci., 4th ser., vol. 33, 1912, pp. 105-106.

(508) ROSS, C. S., and HENDRICKS, S. R., Shorted contributions to general geology, 1943-45, Minerals of the montmorillonite group; their origion and relation to soils and clays: U. S. Geol. Surv. Prof. Paper 205-B, 1945, pp. 23-79.

(509) ROUSE, J. T., Structure, inclusions and alterations of Deer Creek intrusives: Am. Jour. Sci., 5th ser., vol. 26, no. 152, Aug., 1933, pp. 139-146.

(510) RUBEY, W. W., Shorter contributions to general geology, 1928, Origin of the siliceous Mowry shale of the Black Hills region: U. S. Geol. Surv. Prof. Paper 154-D, 1928, pp. 153-170.

(511) RUBEY, W. W., Shorter contributions to general geology, 1930, Lithologic studies of fine-grained Upper Cretaceous sedimentary rocks of the Black Hills region: U. S. Geol. Surv. Prof. Paper 165-A, 1931, pp. 1-54.

(512) ...., Vanadiferous shale in the Phosphoria formation, Wyoming and Idaho (abstract): Econ. Geology, vol. 38, no. 1, 1943, p. 87.

(513) RUPP, G. H., Block Caving at the Sunrise Iron Mine, Wyoming: Am. Inst. Min. Met. Eng. Mining Tech., vol. no. 3, 1939, 16 pp.

(515) SANFORD, S. and STONE, R. W., Useful minerals in the United States: U. S. Geol. Surv. Bull. 585, 1914, 250 pp.

(516) SCHACK, C. H., and POOLE, H. G., Benefication of western manganese ores: U. S. Bur. Mines Rept. Inv. 4117, Sept. 1947, 38 pp.

(517) SCHRADER, F. C., Contributions to economic geology, 1913, Part I, Gold placers on the Wind and Bighorn Rivers, Wyoming: U. S. Geol. Surv. Bull. 580-G, 1915, pp. 127-145.

(518) ...., STONE, R. W., and SANFORD, S., Useful minerals of the United States: U. S. Geol. Surv. Bull. 624, 1916, 412 pp.

(519) SCHUCHERT, CHARLES, and DUNBAR, C. O., *Outlines of Historical Geology*, 4th edition, John Wiley and Sons, Inc., New York, 1941, 291 pp.

(520) SCHULTZ, A. R., Contributions to economic geology, 1906, Part I, Gold developments in central Uinta County, Wyoming, and at other points on Snake River: U. S. Geol. Surv. Bull. 315-A, 1907, pp. 71-88.

(521) ...., Contributions to economic geology, 1906, Part II, Coal fields in a portion of central Uinta County, Wyoming: U. S. Geol. Surv. Bull. 316-D, 1907, pp. 212-241.

(522) ...., Contributions to economic geology, 1908, Part II, The southern part of the Rock Springs coal field, Sweetwater County, Wyoming: U. S. Geol. Surv. Bull. 381-B, 1910, pp. 214-281.

(523) ...., Contributions to economic geology, 1909, Part I, Deposits of sodium salts in Wyoming: U. S. Geol. Surv. Bull. 430-I, 1910, pp. 570-589.

(524) ...., and CROSS, WHITMAN, Potash-bearing rocks of the Leucite Hills, Sweetwater County, Wyoming: U. S. Geol. Surv. Bull. 512, 1912, 39 pp.

(525) ...., Geology and geography of a portion of Lincoln County, Wyoming: U. S. Geol. Surv. Bull. 543, 1914, 141 pp.

(526) SHANNON, E. V., Analyses of chromium-bearing chlorites from California and Wyoming: U. S. Nat. Mus. Proc., vol. 58, 1920, pp. 371-379.

(527) SHARPE, C. F. S., Geology of the vicinity of Whiskey and Muddy Gaps, Wyoming: Unpublished M. A. thesis, Columbia Univ. Library, 1931, 55 pp.

(528) SHEFFER, B. D., Geology of the western Alcova area: Unpublished M. A. thesis, Univ. Wyo. Library, 1951, 74 pp.

(528a) SHELDON, R. P., *et al*, Stratigraphic section of the Phosphoria formation in Wyoming 1949-50: U. S. Geol. Surv. Circ. 307, 1953.

(529) SHIBLER, B. I., and SNEDDEN, H. D., Beneficiation of oxide on silicate manganese ores from Crook, Albany, and Washakie Counties, Wyoming: U. S. Bur. Mines Rept. Inv. 4445, Apr. 1949, 16 pp.

(530) SHOEMAKER, R. W., Geology of the Shirley and Seminoe Mountains area, Carbon County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1936, 65 pp.

(531) SHUE, F. W., Graphite in the United States: Min. Sci., vol. 60, 1909, p. 345.

(532) SIEBENTHAL, C. E., Contributions to economic geology, 1905, Gypsum deposits of the Laramie district, Wyoming: U. S. Geol. Surv. Bull. 285-K, 1906, pp. 404-405.

(533) ...., Contributions to economic geology, 1905, Bentonite of the Laramie Basin, Wyoming: U. S. Geol. Surv. Bull. 285-L, 1906, pp. 445-447.

(534) SLOSSON, E. E., and MOUDY, R. B., The Laramie cement plaster: 10th Annual Report of the Wyoming College of Agriculture and Mechanics, Laramie, Wyoming, 1900, 18 pp., Abstract, Eng. & Min. Jour., vol. 70, 1900, p. 518.

(535) SMITH, H. I., Trona in Wyoming: Am. Inst. Min. Met. Eng. Tec. Pub. 1489, July 1942, 3 pp; reprinted in Am. Inst. Min. Met. Eng. Trans., vol. 148, 1942.

(536) SMITH, H. T. U., Description of the Hartville Quadrangle, Wyoming: U. S. Geol. Surv., Geol. Atlas, Folio No. 91, 1903, 6 pp.

(537) SNOW, E. P., Fourmile placer fields in Colorado and Wyoming: Eng. and Min. Jour., vol. 60, 1895, pp. 102-104.

(538) ...., Hartville iron ore deposits in Wyoming: Eng. & Min. Jour., vol. 60, 1895, pp. 320-321.

(539) SPENCER, A. C., Copper deposits of the Encampment District, Wyoming: U. S. Geol. Surv. Prof. Paper 25, 1904, 107 pp.

(540) ...., The Atlantic Gold district and the north Laramie Mountains, Fremont, Converse, and Albany Counties, Wyoming: U. S. Geol. Surv. Bull. 626, 1916, 85 pp.

(541) Staff, U. S. Bur. Mines. Progress reports, Metallurgical Division, ore testing studies; Chromite concentration tests: U. S. Bur. Mines Rept. Inv. 3320, Feb., 1938, 178 pp.

(542) STANTON, R. B., Report of examination of Goshen Hole Placers: Unpublished report in Geol. Surv. Wyo. files, April 1903, 19 pp.

(543) STEPHENSON, E. L., Geophysical and geological investigations of the Casper Mountain chromite deposit, Wyoming: (Abstract) Washington Acad. Sci. Jour., vol. 31, no. 4, 1941, p. 170.

(544) STERRETT, D. B., Mica deposits of the United States: U. S. Geol. Surv. Bull. 740, 1923, 342 pp.

(545) ST. JOHN, ORESTES, Report on the geology of the Wind River district: Part I, 1883, U. S. Geol. and Geog. Surv. of Territories, 12th Annual Report (F. V. Hayden in charge) Washington, pp. 321-508.

(546) STONE, R. W., and LUPTON, C. T., Contributions to Economic Geology, 1908, Part II, The Powder River Coal Field, Wyoming, adjacent to the Burlington Railroad: U. S. Geol. Surv. Bull. 381-B, 1910, pp. 115-136.

(547) STONE, R. W., and others, Gypsum deposits of the United States: U. S. Geol. Surv. Bull. 697, 1920, 326 pp.

(547a) SWANSON, R. W., *et al.*, Stratigraphic sections of Phosphoria formation measured and sampled in 1950: U. S. Geol. Surv. Open file rept. Nov., 1951, on file with Geol. Surv. Wyo.

(548) TAFF, J. A., Contributions to Economic Geology, 1907, Part II, The Sheridan Coal Field, Wyoming: U. S. Geol. Surv. Bull. 341-B, 1909, pp. 123-150.

(549) TAFT, H. H., A Wyoming platinum mine: Eng. and Min. Jour., vol. 106, no. 21, 1918, p. 900.

(550) THOEMAN, J. R., Economics of potash recovery from wyomingite and alunite: U. S. Bur. Mines Rept. Inv. 3190, 1932, 78 pp.

(551) THOMAS, H. D., Personal communication.

(552) ...., Memorandum on the occurrence of dolomite in Wyoming: Unpublished report for Geol. Surv. Wyo., Feb. 10, 1942, 7 pp.

(553) ...., Summary of Wyoming copper production: Unpublished mineral memorandum, Geol. Surv. Wyo., April 1943, 6 pp.

(554) ...., Memorandum on Dry Creek scheelite deposit, Fremont County, Wyoming: Unpublished report for Geol. Surv. Wyo., June 27, 1943, 3 pp.

(555) ...., The geological history and geological structure of Wyoming: Geol. Surv. Wyo. Bull. 42, 1949, 28 pp.

(556) ...., Wyoming rich in mineral reserves: *Colorado Mining Association*, 1951 Mining Yearbook, Denver, 1951, pp. 67-70.

(557) TROYER, M. L., Geology of the Strong Mine and vicinity: Unpublished preliminary report, Geol. Surv. Wyo. files, 1946, 1 page.

(558) TRUMBULL, L. W., Sulfur mining and refining: Mines and Minerals, vol. 27, no. 7, 1907, pp. 314-316.

(559) ...., Unpublished report no. 120 for Geol. Surv. Wyo., June 13-14, 1914, 5 pp.

(560) U. S. Bureau of Mines, Mineral Industry Surveys: Metal Mining in Wyoming, 1941—Preliminary Annual figures, Mineral Market Report No. MMS-954, Jan. 10, 1942, 2 pp.

(561) U. S. Bureau of Mines, Rambler Mine, Albany County, Wyoming: War Minerals Report 17, Nov., 1942, 7 pp.

(562) U. S. Bureau of Mines, Romur tungsten property, Fremont County, Wyoming: War Minerals Report 70, 1943, 11 pp.

(563) U. S. Bureau of Mines, Bear Lodge fluorspar property, Crook County, Wyoming: War Mineral Report 170, 1944, 8 pp.

(564) U. S. Dept. of Interior, *Progress*, a quarterly report on the Missouri River Basin, Jan., 1950, 38 pp.

(565) U. S. Dept. of Interior, *Progress*, a quarterly report on the Missouri River Basin, Dec. 1950, 69 pp.

(567) U. S. Geological Survey, Press Release issued by the Geologic Branch; Tungsten deposits of Copper Mountain, Fremont County, Wyoming, March 25, 1943, 1 p.; 4 maps on two sheets. Deposits studied by S. W. Dobbs.

(568) U. S. Geological Survey, Press Release, Oil and Gas possibilities in the Maverick Springs area, Fremont County, Wyoming, Sept. 30, 1944, 1 p.; Preliminary Map 13, Geologic and structure contour map of Maverick Springs Area, Fremont County, Wyoming: 1:48,000, 1944.

(569) U. S. Geological Survey, Press Release issued by the Geologic Division: Northeastern part of Wind River basin, Wyoming has good possibilities for new discoveries of oil and gas: Oil and Gas Investigations, Preliminary Chart 22, Sept. 23, 1946.

(569a) U. S. Geological Survey.

(570) U. S. Senate, Investigations of Natural Resources, Hearing before a subcommittee of the Committee on Public Lands, 80th Congress, 11th session, U. S. Gov. Printing Office, Washington, 1947, 338 pp.

(571) U. S. Tariff Commission, Sodium sulphate, survey of United States production, consumption, and foreign trade with particular reference to factors essential to tariff consideration under general provisions of sec. 332, title 3, pt. 2, tariff act of 1930: Report 124, 2nd series, 1937, 57 pp.

(572) VAHRENKAMP, F. H., Report on property of Messrs. McCune, Greshley, and Logan in Centennial mining district: Unpublished report in Geol. Surv. Wyo. files, Sept. 12, 1912, 8 pp.

(573) VEATCH, A. C., Geography and geology of a portion of southwestern Wyoming, with special references to coal and oil; U. S. Geol. Surv. Prof. Paper 56, 1907, 178 pp.

(574) WEEKS, JOS. D., Glass materials: Mineral Resources U. S., 1885; U. S. Geol. Surv., 1886, pp. 550-555.

(575) WEEKS, F. B., and FERRIER, W. F., Contributions to economic geology 1906, Part I, Phosphate deposits in the western United States: U. S. Geol. Surv. Bull. 315-P, 1907, pp. 449-462.

(576) WELLS, R. C., Sodium sulfate: its sources and use: U. S. Geol. Surv. Bull. 717, 1923, 43 pp.

(578) WILSON, W. H., Demer and Keys scheelite deposit in the southern part of the Bighorn mountains, Washakie County, Wyoming: Unpublished report for Geol. Surv. Wyo., June 17, 1951, 2 pp.

(579) ...., Report on the Atlantic City-South Pass Mining district: Unpublished report for Geol. Surv. Wyo., July 20, 1951, 1 pp.

(580) WINCHESTER, D. E., Contributions to economic geology, 1910, Part II, The Lost Soldier coal field, Converse County, Wyoming: U. S. Geol. Surv. Bull. 471-F, 1912, pp. 471-515.

(581) WOLFF, J. E., A chlorite from northern Wyoming: Am. Jour. Sci., 4th ser., vol. 34, 1912, pp. 475-476.

(582) WOODRUFF, E. G., Contributions to economic geology, 1908, Part I, Sulfur deposits near Thermopolis, Wyoming: U. S. Geol. Surv. Bull. 380-M, 1909, pp. 373-380.

(583) Wyoming State Board of Equalization, Production figures for the years 1948, 1949. Copies in Geol. Surv. Wyo. files.

(583a) YOUNG, W. A., Investigation of sodium sulfate deposits in Bull Lake Carbon County, Wyoming: U. S. Bur. Mines Rept. Inv. 4816, Sept., 1951, 9 pp.

(584) ZAKIS, W. N., Geology of the east flank of the Bighorn Mountains near Dayton, Sheridan County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1950, 138 pp.

(584a) DUNNEWALD, J. B., Geology of the Fish Lake Mountain area, Fremont County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1958.

(585) EVERETT, F. D., and BAUERLE, L. C., Investigations of the tuffs near Lysite, Wyoming, for selenium: Bur. Mines Rept. Inv. 5296, Jan., 1957.

(586) GIST, J. G., Geology of North Freezeout Hills and adjacent areas, Carbon and Albany Counties, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1957.

(587) HAGNER, A. F., Anorthosite of the Laramie Range, Albany County, Wyoming, as a possible source of alumina: Geol. Surv. Wyo. Bull. 43, 1951.

(588) HOUSTON, R. S., and MURPHY, J. F., Titanium-bearing black sandstone deposits of Wyoming: Geol. Surv. Wyo. Bull. 49.

(589) KEEFER, W. R., The geology of the DuNoir area, Fremont County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1952.

(590) KNECHTEL, M. M., and PATTERSON, S. H., Bentonite deposits in marine Cretaceous formations, Hardin district, Montana and Wyoming: U. S. Geol. Surv. Bull. 1023, 1956.

(591) LINDEMAN, H. B., Sodium carbonate brine and trona deposits in Sweetwater County, Wyoming: U. S. Geol. Surv. Circ. 235, 1954.

(592) McGRAW, R. B., Jr., Geology in the vicinity of the Copper King mine, Laramie County, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1954.

(593) McGREW, L. W., The geology of the Grayrocks area, Platte and Goshen Counties, Wyoming: Unpublished M. A. thesis, Univ. Wyo. Library, 1953.

(594) MULLEN, D. H., PARKER, BRECK, and RANSOME, A. L., The mineral industry of Wyoming: Reprint from Bur. Mines Minerals Yearbook, 1955.

(595) SOULE, J. H., Investigations of the Copper King copper-gold-silver deposits, Silver Crown mining district, Laramie County, Wyoming: U. S. Bur. Mines Rept. Inv. 5139, 1955.

(596) TROTTER, J. F., Geology of the Nowood Creek- Tensleep area, Washakie County, Wyoming: Unpublished M.A. thesis Univ. Wyo. Library, 1953.

(597) WILSON, W. H., A scheelite deposit near Lewiston, Fremont County, Wyoming: Unpublished report for Geol. Surv. Wyo., Sept. 1951.

(598) ...., An occurrence of copper in the Laramie Mountains, Albany County, Wyoming: Unpublished report for Geol. Surv. Wyo. Sept. 14, 1951.

(599) ...., A sulphur deposit near Auburn, Lincoln County, Wyoming: Unpublished report for Geol. Surv. Wyo., Oct. 1951.

(600) ...., A beryl and mica pegmatite in the Haystack Range, Goshen County, Wyoming: Unpublished report for Geol. Surv. Wyo., Nov., 1951.

(601) ...., Beaver Creek manganese deposit, Big Horn Mountains, Johnson County, Wyoming: Unpublished report for Geol. Surv. Wyo., Nov. 4, 1952.

(602) ...., A hematite deposit on Pat O'Hara Mountain, Park County, Wyoming: Unpublished report for Geol. Surv. Wyo., Jan., 1953.

(603) ...., Notes on the Wyoming Mica and Metals Corporation, Lander, Fremont County, Wyoming: Unpublished report for Geol. Surv. Wyo., Aug. 26, 1953.

(604) ...., Temple Peak molybdenum deposit, Sublette County, Wyoming: Unpublished report for Geol. Surv. Wyo., June 13, 1955.

(605) ...., Cherry Creek prospect, Carbon County, Wyoming: Unpublished report for Geol. Surv. Wyo., Nov. 30, 1955.

(606) ...., Crouch gold prospect, Park County, Wyoming: Unpublished report for Geol. Surv. Wyo., Jan. 17, 1956.

(607) ...., Manganese prospect, Weston County, Wyoming: Unpublished report for Geol. Surv. Wyo., Feb. 20, 1957.

(608) ...., Notes on manganese and allanite in Johnson County, Wyoming: Unpublished report for Geol. Surv. Wyo.

(609) ...., Unpublished personal field notes, Aug. 13-16, 1956.

(610) ...., Unpublished personal field notes, May, 1958, and October, 1958.

(611) Wyoming State Board of Equalization, Production figures for the 1955, 1956, 1962-63: Geol. Surv. Wyo. files.

(612) Wyoming Production Statistics for 1956: U. S. Bur. Mines Production Statistics, Minerals Yearbook, vol. III, 1956.

(613) Wyoming Mineral Industry, 1957 & 1964: U. S. Bureau of Mines Minerals Yearbook for years of 1957 & 1964.

(614) JOHNSTON, RICHARD, and SMITHSON, SCOTT, Unpublished M. A. thesis, University of Wyoming Library, 1959.

(615) NEWHOUSE, W. H., and HAGNER, A. F., Geologic Map of Anorthosite Areas, Southern Part of Laramie Range, Wyoming, U. S. Geol. Surv. Min. Inv. Field Studies Map MF 119, 1957.

(616) ANTWEILER, J. C., and LOVE, J. D., Preliminary sampling of Jackson Hole conglomerates for gold and associated elements: U. S. Geol. Survey Prof. Paper 550, 1966.

(617) BAYLEY, R. W., A preliminary report on the pre-Cambrian iron deposits near Atlantic City, Wyoming: U. S. Geol. Survey Bull. 1142-C, 1963.

(618) ...., Preliminary geologic map of Bradley Peak quadrangle, Carbon County, Wyoming: U. S. Geol. Survey open-file map, 1965.

(619) BISHOP, D. T., Retrogressive metamorphism in the Seminoe Mountains, Carbon County, Wyoming: Unpublished M. S. thesis, Univ. Wyoming Library, 1964.

(620) BLACKSTONE, D. L., Jr., Gravity thrusting in the Bradley Peak-Seminoe Dam quadrangles, Carbon County, Wyoming, and the relationship to the Seminoe iron deposits: Geol. Survey Wyo. Prelim. Rept. No. 6, 1965.

(621) BOLMER, R. L., and BIGGS, P., Mineral resources and their potential on Indian lands, Wind River Reservation, Fremont and Hot Springs Counties, Wyoming: U. S. Bureau of Mines Prelim. Rept. 159, October, 1965.

(622) BOTHNER, W. A., The petrologic, structural and economic aspects of the Cooney Hills, Platte County, Wyoming: Unpublished Ph. D. thesis, Univ. Wyoming Library, (in preparation).

(623) BRADLEY, W. H., Geology of Green River formation and associated Eocene rocks in southwestern Wyoming and adjacent parts of Colorado and Utah: U. S. Geol. Survey Prof. Paper 496-A, 1964.

(624) BROBST, D. A., and EPSTEIN, J. B., Geology of the Fanny Peak quadrangle, Wyoming-South Dakota: U. S. Geol. Survey Bull. 1063-I, 1963.

(625) BULLOCK, J. M., Gypsum deposits in the northwestern part of the Bighorn Basin, Park County, Wyoming: Unpublished M. S. thesis, Univ. Wyoming Library, 1964.

(626) CURREY, D. R., The Keystone gold-copper prospect area, Albany County, Wyoming: Geol. Survey Wyo. Prelim. Rept. No. 3, 1965.

(627) DAVIS, J. C., Bentonite deposits of the Clay Spur District, Crook and Weston Counties, Wyoming: Geol. Surv. Wyo. Prelim. Rept. No. 4, 1965.

(628) DAVIS, R. E., and IZETT, G. A., Geology and uranium deposits of the Strawberry Hill quadrangle, Crook County, Wyoming: U. S. Geol. Survey Bull. 1127, 1962.

(629) DEARDORF, D. L., Eocene salt in the Green River Basin, in Symposium on Salt: Northern Ohio Geological Society, pp. 176-195, 1963.

(630) DORAN, E. F., written communication, 1965.

(631) DOW, V. T., Magnetite and ilmenite resources, Iron Mountain area, Albany County, Wyoming: U. S. Bur. Mines I.C. 8037, 1961.

(632) DOW, V. T., and BATTY, J. V., Reconnaissance of titaniferous sandstone deposits of Utah, Wyoming, New Mexico and Colorado: U. S. Bur. Mines R. I. 5860, 1961.

(633) EPSTEIN, J. B., Geology of part of the Fanny Peak quadrangle, Wyoming-South Dakota: Unpublished M. S. thesis, Univ. Wyoming Library, 1958.

(634) FERRIS, C. S., Jr., Petrology and structure of the pre-Cambrian rocks southeast of Encampment, Wyoming: Unpublished Ph. D. thesis, Univ. Wyoming Library, 1964.

(635) FIELDS, E. D., pre-Cambrian rocks of the Halleck Canyon area, Albany County, Wyoming: Unpublished M. S. thesis, Univ. Wyoming Library, 1963.

(636) FISHER, F. S., Tertiary instrusive rocks and mineralization in the Stinkingwater mining region: Unpublished Ph. D. thesis, Univ. Wyoming Library, 1966.

(637) FRUCHEY, R. A., Overthrusting in Mt. Thompson and adjacent areas, Sublette and Lincoln Counties, Wyoming: Unpublished M. A. thesis, Univ. Wyoming Library, 1962.

(638) FURER, L. C., Overthrusting in the Thompson Pass area, Lincoln and Sublette Counties, Wyoming: Unpublished M. A. thesis, Univ. Wyoming Library, 1962.

(639) GREELEY, M. N., Geology of the Esterbrook area, Converse and Albany Counties, Wyoming: Unpublished M. S. thesis, Missouri School of Mines and Metallurgy Library, 1962.

(640) GRIES, J. C., The structure and Cenozoic stratigraphy of the Pass Creek Basin area, Carbon County, Wyoming: Unpublished M. S. thesis, Univ. Wyoming Library, 1964.

(641) GULBRANDSEN, R. A., Petrology of the Meade Peak phosphatic shale member of the Phosphoria formation: U. S. Geol. Survey Bull. 1111-C, D, 1960.

(642) HAGNER, A. F., and SPANSKI, G. T., Unpublished report on Grizzly Creek Kyanite deposit, Geol. Surv. Wyo. files.

(643) HAUF, C. B., Overthrusting in the upper Fontenelle-LaBarge Creek area, Lincoln and Sublette Counties, Wyoming: Unpublished M. S. thesis, Univ. Wyoming Library, 1963.

(644) HODGE, D. S., Petrology, gravity and structure of the Bluegrass Creek area in the Laramie Mountains, Albany County, Wyoming: Unpublished Ph. D. thesis, Univ. Wyoming Library, 1966.

(645) KEEFER, W. R., Oral communication, 1966.

(646) KING, J. R., Geology of the Boswell Creek area, Albany County, Wyoming: Unpublished M. A. thesis, Univ. Wyoming Library, 1961.

(647) KING, J. S., Petrology and structure of the pre-Cambrian and Post-Mississippian Rocks of the northeastern Medicine Bow Mountains, Carbon County, Wyoming: Unpublished Ph. D. thesis, Univ. Wyoming Library, 1963.

(648) KISLING, D. C., Geology of the Antelope Ridge area, Fremont and Hot Springs Counties, Wyoming: Unpublished M. S. thesis, Univ. Wyoming Library, 1962.

(649) KNECHTEL, M., and PATTERSON, S. H., Bentonite deposits of the northern Black Hills district, Wyoming, Montana, and South Dakota; U. S. Geol. Survey Bull. 1082-M, 1962.

(650) LACKEY, L. L., Petrography of metavolcanic and igneous rocks of pre-Cambrian age in the Huston Park area, Sierra Madre, Wyoming: Unpublished M. A. thesis, Univ. Wyoming Library, 1965.

(651) LONG, J. S., Jr., Geology of the Phlox Mountain area, Hot Springs and Fremont Counties: Unpublished M. S. thesis, Univ. Wyoming Library, 1959.

(652) LOVE, J. D., Uraniferous phosphatic lake beds of Eocene age in intermontane basins of Wyoming and Utah: U. S. Geol. Survey Prof. Paper 474-E, 1964.

(653) ...., Oral communication, 1966.

(654) LOVE, J. D., and BLACKMON, P. D., Alunite on Aspen Mountain, southwestern Wyoming: U. S. Geol. Survey Prof. Paper 450-D, 1962.

(655) MAPEL, W. J., and PILLMORE, C. L., Geology of the Newcastle area, Weston County, Wyoming: U. S. Geol. Survey Bull. 1141-N, 1963.

(656) MAX, M. D., Gypsum deposits in the northeastern part of the Bighorn Basin, Big Horn County, Wyoming: Unpublished M. S. thesis, Univ. Wyoming Library, 1965.

(657) MERRY, R. D., Pre-Cambrian geology, shear zones and associated mineral deposits of the Hog Park area, Carbon County, Wyoming: Unpublished M. S. thesis, Univ. Wyoming Library, 1963.

(658) MILLGATE, M. L., The Haystack Range, Goshen and Platte Counties, Wyoming: Geol. Survey Wyo. Prelim. Rept. No. 5, 1965.

(659) ...., Unpublished Rept. Geol. Survey Wyo. files, Oct. 28, 1965.

(660) ...., Unpublished Rept. Geol. Survey Wyo. files, Dec., 1965.

(661) MILLGATE, M. L., and GLIOZZI, J., Reconnaissance of the iron formation in the Copper Mountain area, Fremont County, Wyoming: Unpublished Rept. Geol. Survey Wyo. files, 1966.

(662) MILLGATE, M. L., Geology of the Rawhide Buttes, Niobrara and Goshen Counties, Wyoming: Geol. Survey Wyo. Prelim. Rept. No. 8, (in preparation).

(663) ORBACK, C. J., Geology of the Fox Creek area, Albany County, Wyoming, Unpublished M. A. thesis, Univ. Wyoming Library, 1960.

(664) ROBINSON, C. S., MAPEL, W. J., and BERGENDAHL, M. H., Stratigraphy and structure of the northern and western flanks of the Black Hills Uplift, Wyoming, Montana, and South Dakota: U. S. Survey Prof. Paper 404, 1964.

(665) SCHWARBERG, T. M., Jr., The geology of the Muddy Mountain, southeast Natrona County, Wyoming: Unpublished M. A. thesis, Univ. Wyoming Library, 1959.

(666) SHELDON, R. P., Physical stratigraphy and mineral resources of Permian rocks in western Wyoming: U. S. Geol. Survey Prof. Paper 313-B, 1963.

(667) SHLEMON, R. J., Geology of Red Spring anticline, Hot Springs County, Wyoming: Unpublished M. S. thesis, Univ. Wyoming Library, 1959.

(668) STENSRUD, H. L., Geology of the Lake Owens mafic complex, Albany County, Wyoming: Unpublished M. A. thesis, Univ. Wyoming Library, 1963.

(669) SUYDAM, R. B., Overthrusting in the South LaBarge Creek area, Lincoln and Sublette Counties, Wyoming: Unpublished M. A. thesis, Univ. Wyoming Library, 1963.

(670) SWETNAM, M. N., Geology of the Pelton Creek area, Albany and Carbon Counties, Wyoming: Unpublished M. S. thesis, Univ. Wyoming Library, 1961.

(671) VAN HOUTEN, F. B., Tertiary geology of the Beaver Rim area, Fremont and Natrona Counties, Wyoming: U. S. Geol. Survey Bull. 1164, 1964.

(672) VAN SANT, J. N., Refractory clay deposits of Wyoming: U. S. Bur. Mines Rept. Inv. 5652, 1961.

(673) WILSON, W. H., Unpublished field notes, Dec., 1960.

(674) ...., Pumicite deposits in Big Horn and Sweetwater Counties, Wyoming: Unpublished Rept., Geol. Survey Wyo. files, 1960.

(675) ...., Geologic notes on a marble deposit west of Wheatland, Platte County, Wyoming: Unpublished Rept., Geol. Survey Wyo. files, 1961.

(676) ...., Silica sand deposits in the Lovell area, Big Horn County, Wyoming: Unpublished Rept., Geol. Survey Wyo. files, 1962.

(677) ...., The Kirwin mineralized area, Park County, Wyoming: Geol. Survey Wyo. Prelim. Rept. No. 2, 1964.

(678) WORL, R. G., Superimposed deformation in pre-Cambrian rocks near South Pass, Wyoming: Unpublished M. A. thesis, Univ. Wyoming Library, 1963.

(679) ...., A taconite occurrence in the northern Wind River Range, Wyoming: Unpublished Rept., Geol. Survey Wyo. files, Jan. 1966.

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