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by

W. Dan Hausel and Gregory S. Holden

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MINERAL RESOURCES OF THE WIND RIVER BASIN AND ADJACENT PRECAMBRIAN UPLIFTS

W. DAN HAUSEL AND GREGORY S. HOLDEN[1]

The Wind River Basin and adjacent Precambrian uplifts include parts of Fremont, Natrona, and Hot Springs Counties located near the center of the state. The sediments of the topographic and structural basin host a variety of mineral deposits ranging from agates to zeolites. Although some of these deposits are insignificant in quantity, the basin's uranium, bentonite, phosphate, nephrite, gypsum, sodium sulfate, and zeolite deposits are important commodities, which are either being produced or may be considered as prospects for future mining ventures.

Structurally, the Wind River Basin is bounded by Precambrian uplifts to the north, south and west, and by a broad structural upfold to the east. To the north, the Owl Creek Mountains represent a source of uranium, precious metals, pegmatite ores, sulfides and iron. The iron ore and precious metal deposits of the Wind River Mountains, located along the western margin of the basin, are well known to prospectors and geologists. The Sweetwater Uplift, bounding the basin on the south, is considered a source of uranium for the Tertiary deposits in the Gas Hills District, and is extensively prospected each year by rock hounds hunting for prizes of nephrite, rubies, sapphires, and agate. Along the eastern margin of the basin, rock units rise in a broad upfold called the Casper Arch, which creates favorable conditions for extracting bentonite.

In the following summaries, those mineral commodities which are actively mined or offer good mining potential, are discussed in more detail than those not presently mined or possessing slight development potential.

AGATE

Agate has relatively little importance in the state; however, the banded chalcedony provides a source of income for several rock shops and rock hounds within Wyoming. Rainbow agates are collected along the Wnd River on the western edge of the basin, and moss agate, which contains impurities of manganese or iron oxide, is found in the Agate Lake area north of the Sweetwater River, and northwest of Split Rock in the Agate Flats area (Plate 1), (Osterwald and others, 1966).

ALUM

Alum compounds are hydrous double sulfate of potassium and aluminum which can be recognized by their astringent sour taste and colorless to white crystals. One occurrence of alum is known in the Wind River Basin. Hagner (1942) recognized alum in association with sulfur near the base of Copper Mountain on the extreme northern margin of the basin (Plate 1). This deposit is believed to represent possible hot spring activity in the recent geological past.

ASBESTOS

Asbestos is a general name given to several varieties of fibrous silicate minerals which have either serpentine or amphibole crystal structures. The bulk of commercial asbestos fiber is the serpentine mineral, chrysotile ($Mg_6Si_4O_{10}$ $(OH)_8$). However, the fibrous amphiboles, anthophyllite, amosite and crocidolite are also exploited as asbestos.

Chrysotile is produced by hydrothermal reactions within serpentine rock, forming veinlets with fibers either perpendicular to vein walls (cross-fiber veins) or parallel to vein walls.

Asbestos is commercially important as a source of heat resistant fibers. Crude fiber is graded according to fiber length, purity, and composition. The longest fibers are spun into fabrics for use as insulative coverings and friction surfaces. The less valuable short-fibers find use as composition board for strengtheners for cement, asphalt, and plastics.

Asbestos deposits in Wyoming occur primarily as thin chrysotile veinlets in Precambrian serpentine bodies. Attempts have been made to develop several Wyoming deposits (especially during the years 1905 to 1921), but despite considerable initial optimism, none has been successful to any extent and no asbestos production has been reported for the state in recent years.

Three known asbestos deposits occur within the Wind River Basin; all in Fremont County. The Fire King Deposit is located in Sec. 26, T30N, R100W, within the Atlantic City-South Pass District on the eastern Flank of the southern Wind River Mountains. Two large serpentine bodies occur in steeply dipping (70-80°SE) chlorite and sericite schists. Chrysotile forms several thin parallel cross-fiber veinlets (less than 1 foot thick) along the northwest border of the larger serpentine body. Fiber length is generally ½ inch with some longer fibers reported. The property was prospected in 1914, and several carloads of crude fiber were shipped in 1918 and 1919. A 72-foot shaft with collateral drifts was sunk and a mill operated for a short time during 1919, but no production has been

[1] Geological Survey of Wyoming, Laramie, Wyoming 82071

reported since 1920. Although the bulk of the fiber was short and tonnage was low, the fiber was relatively pure and may be useful at some future date.

The Beaver Creek asbestos deposit, located in Sec. 19, T30N, R96W, 38 miles southeast of Lander, is localized in one of five, clustered serpentine bodies in Precambrian granite gneiss. Thin cross-fiber chrysotile veinlets contain fibers reported to range in length from ¼ inch to 1¼ inch. No production has been reported from the site, and none is likely because of the average short length and low tonnage of the asbestos fiber present. A third deposit, the Abernathy Prospect (Sec. 7, T42N, R104W), in the western Owl Creek Mountains, contains small amounts of asbestos fiber of the amphibole variety. Low quality and tonnage will probably preclude any development of this deposit (Beckwith, 1939).

BENTONITE

Wyoming's unique sodium-rich bentonites are used extensively in the manufacture of drilling additives for use in the well-drilling industry, and for pelletizing iron ore in the taconite industry. The most economically important beds occur in the Upper Cretaceous Mowry Shale. Less important bentonite units are found in the Steele, Frontier and Thermopolis Formations.

Bentonites crop out along all four margins of the basin. Nearly all of these units dip too steeply for mining. On the eastern edge of the basin, however, a few bentonites dip gently (less than 5 degrees), are covered by shallow overburden, and are thick enough and high enough in quality to be minable.

Within the Wind River Basin area and adjacent uplifts, production of bentonite is restricted to the Kaycee Bentonite Company's location about 20 miles north of Natrona. Production last year amounted to about 200,000 tons from this mine. Nearly all of Wyoming's bentonite is produced in Big Horn and Crook Counties outside of the Wind River Basin.

FELDSPAR

Feldspar and associated pegmatitic minerals have been prospected and mined sporadically in the Copper Mountain area since the early part of the 1900's (Plate 1). Prior to 1970, muscovite, lepidolite, beryl, tantalite and feldspar were mined in small tonnages along Hoodoo Creek. Since 1970, mining activity has centered on the Quien Sabe and Blue Spar mines for the extraction of feldspar.

A description of the geology in the vicinity of the feldspar mines is summarized by Hanley and others (1950) and is described in detail by McLaughlin (1940), and will only be briefly discussed in this paper. The geologic history of the mines' area was dominated by the intrusion of two separate phases of Precambrian pegmatite into hornblende schist country rock. This schist contains 80 to 85 per cent hornblende, 15 to 20 per cent labradorite, and minor assessory minerals. The first group of pegmatites are concordant with the strike and dip of the foliation of the schist, with a small percentage of dikes intruded along fractures in the schist. The second phase of pegmatites crosscut the pre-existing foliation.

Most of the early prospecting in the area was in search of hydrothermally altered mineralized zones in younger pegmatite dikes. Pockets and veins of muscovite, lepidolite, tourmaline, garnet, beryl, cleavelandite, braunite, columbite-tantalite and petalite represent the hydrothermal mineralization (McLaughlin, 1940).

Mining activity since 1970 has been for feldspar and has centered primarily on older, microcline-rich pegmatites. These pegmatites contain 70 to 85 per cent microcline feldspar and 15 to 30 per cent quartz, as opposed to younger dikes which contain 55 to 65 per cent microcline and 15 to 30 per cent quartz.

In 1970, Northwestern Feldspar Company opened the Quien Sabe Mine in Sec. 22, T40N, R93W and extracted feldspar for the manufacture of dental and other related products (Figure 1). Because high quality feldspar was needed for the product, the ore was hand-sorted, adding high labor costs to mining expenses. Two years later, Modern Mining and Development Company purchsed Northwestern's interests and began producing a lower grade feldspar ore to reduce mining costs. Production continued at the Quien Sabe; and more recently, Modern

Figure 1. — The upper level of the Quien Sabe Mine. This figure shows a contact between the black hornblende schist and the white pegmatite dike.

Figure 2. The Blue Spar Mine.

Mining opened the Blue Spar Mine in Sec. 27 (Figure 2). A chemical analysis of the potash feldspar is given in Table 1.

The mined ore is transported by truck from the mine site to the 100 ton-capacity mill at Bonneville, located approximately 10 miles south-southwest from the mine. At the mill the ore is processed through a series of crushers and size sorters to produce a 325 mesh powder. Following milling, the powder is placed in storage bins to await shipment by rail to Kansas City. At Kansas City the feldspar powder is used in Bon Ami detergents. A small percentage of the feldspar powder is processed into Bon Ami cake soap at a pilot plant located next to the mill at Bonneville.

In 1977, production from the Blue Spar Mine was 4,767 tons of ore. The 1978 production may exceed 5,000 tons. Although there are no known reserve estimates, several virgin pegmatite dikes are available to Modern Mining and Development for future mining.

GOLD, SILVER, AND COPPER

Abandoned gold and copper prospects are dispersed throughout the Precambrian rocks in the Wind River and Owl Creek mountains. The scattered mine dumps and headframes in the South Pass-Atlantic City District are evidence of Wyoming's gold rush days in the 19th century. In the Copper Mountain District, active prospecting and mining in the early 1900's exposed several copper veins; none of which amounted to significant tonnages.

The first discovery of gold in the state was reported from placers along the Sweetwater River in 1842. Subsequent prospecting led to the discovery of the Carissa lode in the South Pass-Atlantic City District in 1867 (Plate 1), which in turn, initiated the first gold rush to the state. Total gold production from the South Pass-Atlantic City District is unknown. Jamison (1911), Trumbull (1914), and Bartlett and Runner (1926) suggest that production amounted to nearly $6 million in gold (280,000 oz.); whereas, Spencer (1916), and DeLaguna (1938) reasoned that $1.5 million (72,500 oz.) and $2.0 million (86,000 oz.), respectively, were more realistic figures. A more recent estimate of the total gold production of the district is 70,000 ounces (Koschmann and Bergendahl, 1968). This estimate agrees most closely with Spencer's estimate. Since 1968, no production has been recorded.

In the South Pass-Atlantic City District, disseminated gold and arsenopyrite mineralization is found in quartz veins. Nearly all the mineralized quartz veins occupy shear zones in a steeply dipping northwest-trending metagabbro (Armstrong, 1948). A later stage of mineralization occurs in calcite-quartz-chalcopyrite veins stained by malachite and limonite. This later stage of mineralization is found in shear zones which commonly displace the gold-bearing quartz veins. No production has resulted from these later-stage mineralized veins (Bayley, et. al., 1973).

Future exploration for gold in the Wind River Mountains should probably concentrate on finding soil-covered mineralized veins. The intimate association of arsenopyrite with gold suggests that geochemical prospecting for arsenic in soils may lead to the discovery of new mineralized veins.

In the Copper Mountain District, minor amounts of gold and silver were mined along with copper. Copper minerals in the district include chalcocite (Cu_2S), malachite ($Cu_2CO_3(OH)_2$), azurite ($Cu_3(CO_3)_2(OH)_2$), cuprite (Cu_2O), chrysocolla ($CuSio_3 \bullet 2H_2O$), chalcopyrite ($CuFeS_2$) and native copper (Osterwald and others, 1966).

Table 1. Chemical analysis of representative potash feldspar from the Modern Mining and Development Company pegmatites. Wyoming Geological Survey Mineral Files.

Oxide:	SiO_2	Al_2O_3	K_2O	Na_2O	Fe_2O_3	Ignition Loss (1000°C)	Total
Per Cent Oxide:	69.2	18.1	10.7	3.9	0.07	0.22	102.2

GYPSUM

Calcium sulfate deposits are generally mixtures of anhydrite ($CaSO_4$) and gypsum ($CaSO_4 \cdot 2H_2O$). Minable material generally contains 85 to 90 per cent gypsum with quality dependent upon purity. Calcium sulfate readily loses and gains water of crystallization. Thus, gypsum, when heated in a process known as calcining, dehydrates to Plaster-of-Paris ($CaSO_4 \cdot 1/2H_2O$). When mixed with water, Plaster-of-Paris hardens back to the dihydrate (gypsum) form. This product, usually called stucco, has numerous uses in the construction industry. Uncalcined gypsum is used as a retarder for cement, as filler, and as a soil conditioner.

Important gypsum deposits in Wyoming are generally restricted to Permian, Triassic and Jurassic redbeds: the Goose Egg, Chugwater (Spearfish) and Gypsum Springs Formations. Individual gypsum layers which are quite thick, can thicken and thin over short distances and can often be discontinuous.

Redbed facies contain significant amounts of gypsum within the Wind River Basin, primarily along the northeast flank of the Wind River Mountains and along the southern flank of the Owl Creek Mountains. Considerable gypsum is present in the Triassic Dinwoody and Chugwater Formations, but the most voluminous and economically significant reserves lie in the Jurassic Gypsum Springs Formation, which overlies them. This formation contains a single massive gypsum bed from 40 to 100 feet thick, over an exposed length of 100 miles. Sampling indicates that the layer is high-grade, averaging 96 per cent gypsum (Westervelt, 1969).

Overburden above the layer is variable in thickness, and although the gypsum layer is often steeply dipping, much of it would be amenable to strip mining techniques and much more could be recovered by underground methods. Development of gypsum deposits on the Wind River Indian Reservation was seriously discussed in 1961. Exploration permits were issued, but to date there has been no significant gypsum production from Fremont County.

Thick strippable gypsum deposits, all within the Gypsum Springs Formation, are intermittently exposed along the northeast base of the Wind River Mountains with thicknesses up to 125 feet along Bull Lake Creek. Elsewhere significant deposits are found along the East Fork of Sheep Creek (T6N, R2E), west of Boysen Reservoir (T6N, Rs3, 4E), in the Maverick Springs area (T6N, R2W), along Red Creek (T6N, Rs 3,4W), in the Circle Ridge Dome (T7N, Rs 2,3W), in the Antelope Ridge area (T7N, R1W), and in the Red Antelope Basin (T7N, R2W), (Westervelt, 1969).

IRON

Iron-rich silicate rocks in the Owl Creek and Wind River mountains are Precambrian crystalline metasedimentary rocks commonly called "taconite" (Plate 1). Taconite is a term used primarily in the United States and applies to low-grade iron silicates. In Wyoming, taconite is applied to banded or disseminated silicious magnetite-bearing rocks which have at least 25 per cent iron content, so that through benefication the rock can be concentrated into low-grade iron-ore pellets. In the Wind River Mountains, these low grade iron silicates are stratigraphically restricted to the Iron Formation Member of the Goldman Meadows Formation.

The Iron Formation Member is a hard, dense rock with regularly alternating iron-rich, low-silica, and silica-rich, low-iron layers. Sometimes the layers are so thin that the magnetite and chert are finely disseminated. Approximately 90 per cent of the rock is quartz and magentite; the remaining 10 per cent is composed of varying amounts of grunerite, actinolite, chlorite and garnet (Bayley, et. al., 1973).

U.S. Steel Corporation's Atlantic City open pit iron mine is located on the western, nearly vertical limb of a deep synclinal feature, dipping between 70° to 80° southwest in the vicinity of the Atlantic City Mine (Bayley, 1965). The average thickness of the iron formation is about 150 feet. At the Atlantic City Mine the ore is greatly thickened to widths of 300 feet to 1,200 feet by complex folding and faulting.

The taconites of the Iron Formation Member crop out in the southern Wind River Mountains near Lewiston and at Atlantic City, and in the northern Wind River Mountains at the Union Pass District, approximately 75 miles northwest of Atlantic City. A strong aeromagnetic anomaly suggests that the iron formation may also extend under Paleozoic and Mesozoic rocks to the northeast of Atlantic City in the Sheep Mountain area (Harrer, 1966).

Taconite deposits in the Owl Creek Mountains crop out at Birdseye Pass, and at the head of Tough, Hoodoo and Dry Creeks, and extend past the abandoned McGraw Copper Mine in sec. 7, T40N, R92W. Seven chemical analyses of the taconites range from 23.1 to 36.8 per cent iron with an average of 31.6 per cent (Harrer, 1966).

The origin of taconites is little understood. Any theories explaining their petrology must consider the alternate layering of magnetite and chert, their association with pillow lavas, and their remarkable similarity in age throughout the world, almost exclusively dated at 2.2 billion years. The interested reader is referred to the ideas of Govett (1966), James (1966), Cloud (1965), Sakamoto (1950), Krauskopf (1956), Cullen (1963), Bochert (1960), and Goodwin (1964). Bayley and others (1973) suggested that the Goldman Meadows taconites are the product of chemical sedimentation and diagenesis.

Mines in the State of Wyoming presently contribute about 2½ per cent of the U.S. total production of iron ore. The Atlantic City Mine in the Wind River Mounains provides more than 90 per cent of the State's total production: production last year from the mine was 4,909,965 tons of taconite ore. Published reserves for Atlantic City are 111 million tons of proven reserves (30% Fe) (Engineering and Mining Journal, 1965, p. 84) and 300 million tons of indicated ore (22 to 35% Fe) (Mining World, 1960, p. 27). Since 1965, Atlantic City has mined more than 52.6 million tons of ore. This indicates that the original proven reserves are nearly half depleted.

LIMESTONE

Economically useful limestone is very nearly pure $CaCO_3$. Although it is used as a basic building material as for the manufacture of cement, the primary use of lime in Wyoming has been as a component in the sugar beet refining process.

There has been no reported commercial mining of limestone from the Wind River Basin in recent years although some material is probably produced for purely local use. However, the Madison Limestone crops out over large areas at the margins of the basin and may one day be quarried. Areas described as high-grade Madison Limestone occur near Dubois (Sec. 11, T41N, R107W), along the Middle Fork Popo Agie River (Sec. 13, T32N, R101W), and in Wind River Canyon (Sec. 16, T5N, R6E) (Minobras, 1975). Abundant usable limestone is present at many other sites and depends only on a local use for exploitation.

NEPHRITE (WYOMING JADE)

Nephrite, commonly called Wyoming jade, is a light green to black, dense calcium-magnesium-iron silicate, varying in composition from tremolite to actinolite. Small deposits of nephrite are found as vein deposits in the Precambrian terrain of the Wind River Mountains and of the Sweetwater Uplift. Nephrite in these deposits originated from the hydrothermal metamorphism of ultrabasic dikes and veins. Additional nephrite deposits occur as rounded boulders and pebbles in Tertiary strata and Quaternary alluvium derived from uplifted Precambrian rocks (Plate 1).

The majority of the deposits are found within an 18 mile radius of Jeffrey City in an area extending north into the Sweetwater Arch and Gas Hills, and south into the Green Mountains. A few collecting sites occur along the Sweetwater River near Antelope Hills. Jade has also been collected 18 miles west-northwest of Alcova, and within the Moneta area. In the Wind River Mountains, nephrite is reported 3 miles northeast of Atlantic City and 15 to 20 miles east of Big Sandy on the western flank of the range.

In general, jade collecting sites have been picked over by rock hounds through the years, leaving only small amounts of the ornamental stone. Descriptions and locations of several jade deposits within the Sweetwater Uplift are given by Love (1970), Sherer (1969), and Osterwald and others (1966).

The sale of nephrite provides a source of income for both rock houns and rock shop owners. A survey of 1978 prices for jade is listed in Table 2.

Table 2. Survey of 1978 prices for Wyoming jade.

Nephrite	Price Per Pound
Apple-green jade	\$200.00 to \$100.00
Olive jade	50.00 to 40.00
Black jade	40.00 to 30.00
Snowflake jade	20.00 to 5.00
Snowflake jade with quartz inclusions	.50 to .25

PHOSPHATE ROCK

Ninety per cent of world phosphate production is utilized in the manufacture of fertilizers. In light of current world food shortages, consumption of phosphates for this purpose will likely rise steadily in the near future. Phosphate occurs in igneous rocks as fluorapatite, and as francolite in sedimentary deposits. All Wyoming deposits are of the sedimentary type, which, if of minable grade (greater than 24% P_2O_5) is termed phosphorite (Emigh, 1975).

Phosphate deposits in Wyoming and the surrounding states of Idaho and Utah are found in the Permian Phosphoria Formation. The formation is composed of a lower phosphatic shale (Meade Peak Member), the overlying Rex Chert and the higher Retort phosphatic shale, overlain by the Tosi Chert Member. The shale layers consist of fine-grained phosphatic siltstone and shale interbedded with harder, dark-gray phosphatic oolite, limestone and cherty limestone (McKelvey, 1946). The Phosphoria sea, which centered to the west of Wyoming, extended only into the central portion of the state, and hence, the Phosphoria Formation is restricted to western Wyoming and thins eastward.

King (1947) found the Phosphoria Formation to be 280 to 290 feet thick at Baldwin Creek on the eastern flank of the Wind River Mountains, seven miles west of Lander. It is composed of alternating argillaceous and calcareous units, few of which are composed of a single constituent. Phosphorite occurs in two discrete layers: a lower, 1 to 4 feet thick, medium-grade (22-26% P_2O_5) layer located 40 feet above the base; and a higher, low-grade (15 - 20% P_2O_5) 3 to 6 feet thick zone located 100 feet above the base. The beds dip northeasterly at about 12 degrees. King estimated that along a 15 mile stretch of outcrop, the upper zone contains roughly 100 million tons of accessible phosphate rock averaging 16.5 per cent P_2O_5. The lower zone contains an estimated 30 million tons of medium-grade phosphate rock averaging 24.5 per cent P_2O_5.

Although there has been no reported production of phosphate rock from Fremont County, phosphorite deposits similar in grade and form to those described above are present in many areas of the Wind River Basin. These areas lie in a band of exposed Phosphoria Formation along the eastern base of the Wind River Mountains from Bull Lake Creek to the Sweetwater River. This band includes the Lander deposits. Some of the more significant areas that have been described are: at Beaver Creek (T29N, R97W, thin units with maximum grade 20 per cent P_2O_5), at Twin Creek (T30N, R99W, 6 feet thick phosphorite layer with 26% P_2O_5), and along the North Fork of the Popo Agie River T2S, Rs1, 2W, 4.5 feet thick layer of 20% P_2O_5) (Osterwald and others, 1966). These deposits, although close to transportation centers, are currently of marginal grade, but may one day be exploitable in an expanding world phosphate market.

SAPPHIRES & RUBIES

Sapphires and rubies are transparent to translucent rhombohedral crystals of corundum (Al_2O_3). The most coveted varieties of corundum are the star rubies and sapphires. The stars appear on a polished surface as three rays in intersecting light forming 120° angles to one another. Such asterism is the result of light reflecting off the surfaces of tiny included crystals of rutile that have been exsolved from solid solution and oriented in three planes at 120° to each other.

In Wyoming, rubies and sapphires are found in mica schists of the Sweetwater Uplift and in weathered boulders in the Wind River Formation. Several prospects are found southeast of Lander and on the Sweetwater Divide near Splitrock (Plate 1).

In T32N, R91W, several pounds of deep red to purplish-red star sapphires were recovered from placer claims. One of the largest reported crystals was a perfect hexagon one inch in diameter. These crystals are reportedly associated with mica schist and serpentine (Curtis, 1943). Other gem quality crystals are reported from the Marion claim (T31N, R96W). Several crystals on this claim are pale to bright-red rubies located in a Precambrian schist, (Osterwald and others, 1966).

Two other localities are described by Osterwald and others (1966), as having poor quality corundum crystals. While the Abernathy deposit (T30N, R96W) is characterized by fractured, gray and blue altered corundum crystals, corundum from the Marion and Curtis jade claims (Secs. 13, 18, T30N, Rs. 92, 93W) is described as pale red, largely altered crystals exposed in two mica schist ledges. No gem quality crystals have been found on either of these deposits.

SODIUM SULFATE

Near the town of Natrona on the eastern edge of the basin, sodium sulfate is mined from the Pratt Mine, which is situated in an undrained depression fed by brine springs (Plate 1). X-ray diffraction analysis of the salt crystals indicate that the crystals are mirabilite ($Na_2SO_4 \bullet 10H_2O$), a decahydrate consisting of 24.8 per cent SO_3, 19.3 per cent Na_2O and 55.9 per cent H_2O. Mirabilite occurs both as massive forms and as long needle-like monoclinic crystals up to 15 millimeters in length.

Salt extraction at the Pratt Mine is fairly simply. In the fall, water from the brine-filled depression is drained into a holding pond to the east of the soda lake. The draining exposes a new layer of salt which is extracted using a crawler loader. The ore is loaded on a truck and hauled about one half mile to a storage shed along U.S. Alternate Highway 20 and 26 where the salt is stored until it is shipped by rail (Figure 3). During the winter months, four to six train carloads of salt are shipped to buyers in the corn belt of Iowa and Indiana where it is used as a feed and mineral additive for livestock. The ore is valued at more than $30 a ton, and production last year totaled 3,040 tons. The Pratt Sodium Company has been mining sodium sulfate from various brine lakes in Wyoming since 1925.

Figure 3. Sodium sulfate storage shed along U.S. Alternate 20, 26 near Natrona.

TITANIUM-BEARING SANDSTONES

Titanium metal is economically important because of its high strength, low weight and its resistance to corrosion. However, the major use of titanium is in the form titanium dioxide, which is an unequaled whitener for paper, paints and plastics. Titanium occurs in Wyoming both as an ilmenite-magnetite deposit associated with the Laramie Anorthosite and as numerous (19 described in the literature) black sand deposits scattered throughout the state. Black sands are strongly layered sediments which contain heavy minerals such as ilmenite ($FeTiO_3$), magnetite (Fe_3O_4), rutile (TiO_2), monazite and zircon, which were originally concentrated as placers. The Wyoming black sands are found primarily in rocks of late Cretaceous age. Two of these black sand deposits, the Coalbank Hills and Poison Spider Creek deposits, are located along the eastern margin of the Wind River Basin in Natrona County.

The Coalbank Hills deposit (center, Sec. 5, T34N,R88W) is located about 18 miles south of Waltman. It occupies a channel in the upper part of the basal sandstone unit of the Mesaverde Formation. The black sandstone, which trends N40°W and dips 20° to 30° NE, is composed of quartz, feldspar, titanium minerals, magnetite and zircon, and is cemented by hematite and carbonates (Dow and Batty, 1961). The main deposit is 4 feet thick, 1400 to 2500 feet in length, and 50 to 150 feet wide where exposed. Assays of five samples of the sand indicate an average of 12.5 per cent TiO_2 and 1.4 per cent ZrO_2 by weight. Although a formal evaluation has not been made, Houston and Murphy (1962) suggest that if inferred trends are correct, a considerable tonnage of minable material may be present. No commercial production has been reported from the site.

The Poison Spider Deposit (Sec. 1, T33N, R84W) is located 3 miles west of the Poison Spider oil field. The black sand (34.1% heavy minerals) occurs in a sandstone unit of the Lewis Formation, which strikes N45°W and dips 68°SW. The deposit is 4 feet thick and is exposed for 300 feet along strike. Assays of the ore indicate an average of 7.3 per cent TiO_2 and 0.7 per cent ZrO_2 by weight. No production has been recorded from this deposit (Dow and Batty, 1961).

TUNGSTEN

Tungsten occurs primarily as the mineral scheelite ($CaWO_4$). Several scheelite prospects and deposits are found in pegmatites and quartz veins in the Wind River and Owl Creek mountains (Plate 1). In general, these are small, low-grade deposits. In 1956, 1.88 short tons of 60 per cent WO_3 were produced from the Hoodoo Claims at Copper Mountain.

At the old Burr Mine east of South Pass City in the Wind River Range, calcium tungstate occurs as small stringers and veinlets up to 6 inches in length in a steeply dipping biotite schist. Assays reportedly show 2½ to 70 per cent WO_3 with associated gold (Osterwald, and others, 1966).

URANIUM

In the Wind River Basin uranium mineralization is found in rocks of practically every age, including the crystalline rocks of adjacent Precambrian uplifts. Economically, the significant uranium deposits are those of the Gas Hills District (Plate 1). It is the intention of this paper to only briefly discuss these deposits because they are to be discussed in detail by C. D. Snow in this guidebook.

Uranium deposits, in the Gas Hills District, occur in the Eocene Puddle Springs Arkose Member of the Wind River Formation. These deposits occur in typical roll-front type deposits which are discussed by several authors (see, for instance; Files, 1972, Rackley, 1972, and Anderson, 1969). Ore, in roll-fronts, occurs at a tongue-shaped interface between oxidized and reduced rock. Last year, production from these ore fronts, in the Gas Hills District amounted to more than 1.6 million tons of ore.

Precambrian uranium mineralization is recognized in rocks of the Sweetwater Uplift (Love, 1970), and in granites and quartz monzonites in the Copper Mountain District (Malan and Sterling, 1969). Neither of these areas produced ore last year; however, exploration is underway in both areas.

VERMICULITE

Vermiculite is a soft, micaceous, hydrated aluminum silicate clay which has the unique property of expanding into worm-like masses when heated rapidly or acid treated. It is used primarily as insulation for heat and sound, and as a filter in paper and paint products. Vermiculite is found in Precambrian crystalline rocks where the alteration of aluminum silicates has occurred.

Scattered small deposits of the clay are found in the Sweetwater Uplift (Plate 1). Nearly 300 tons of the clay were produced from deposits located in Sec. 9, T30N, R87W and in Sec. 6, T31N, R86W, during 1941 (Osterwald and others, 1966). No production of vermiculite has been recorded in the Wind River Basin since 1941.

ZEOLITES

Zeolites are hydrated aluminosilicates of calcium, sodium, magnesium and potassium. The open alluminosilicate framework of the zeolite structure contains wide channelways in which water molecules and cations are loosely bound and can move about without disrupting the structure. The unique property of zeolites which enables them to substitute ions and absorb foreign ions is utilized in a number of commercial and industrial products. When used in water softeners, zeolites absorb calcium cations from hard water and replace them with sodium ions, which produces soft water. Zeolites are also used in the manufacture of catalysts, and as moisture absorbants. It is projected that they will be used on a large scale for the extraction of radioactive products from radioactive wastes.

Zeolites are abundant in the Cenozoic rocks of the Wind River Basin where volcanic glass in tuffaceous rocks has been altered by reaction with saline brines. They are found in the tuffaceous sandstones of the White River Formation (Oligocene), the Wind River Formation (Eocene) and the Wagon Bed Formation (Eocene) (Surdam, 1972).

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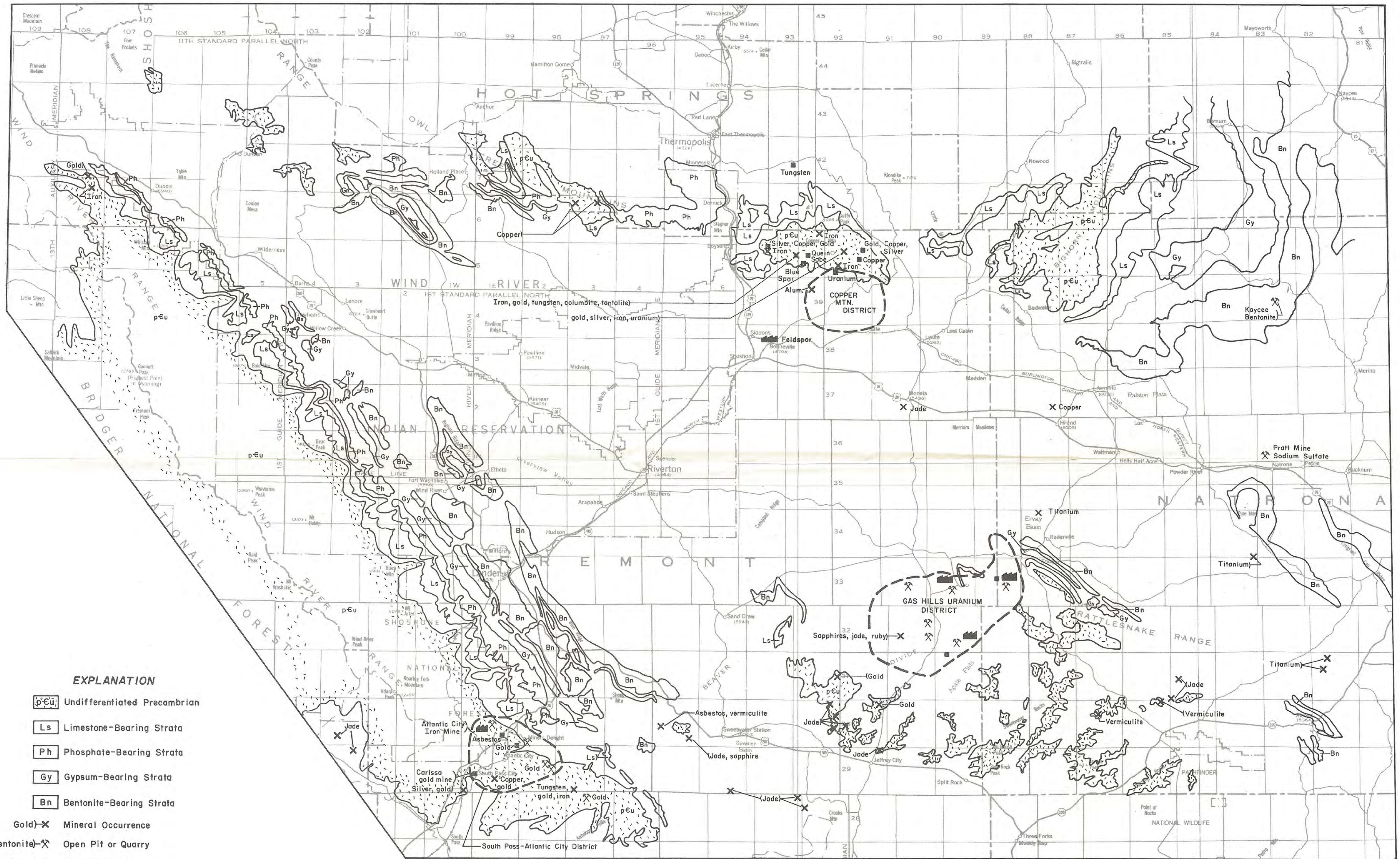

EXPLANATION

p€u	Undifferentiated Precambrian
Ls	Limestone-Bearing Strata
Ph	Phosphate-Bearing Strata
Gy	Gypsum-Bearing Strata
Bn	Bentonite-Bearing Strata
Gold)—✕	Mineral Occurrence
Bentonite)—⚒	Open Pit or Quarry
Feldspar)—■	Underground Mine
(mill symbol)	Mill
(COPPER MTN. DISTRICT)	Mining District

Plate 1. — Mines and minerals occurrences of the Wind River Basin and adjacent uplifts. Adapted from the, "Mines and Minerals Map of Wyoming," Wyoming Geological Survey, 1970.

Scale : 500,000

10 5 0 10 Miles

W. Dan Hausel & Gregory S. Holden