GEOLOGICAL SURVEY OF WYOMING
MINERAL REPORT # MR38-1

# NATURAL RESOURCES COMMITTEE

Progress report of the sub-committee

on mineral resources other

than coal and oil

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by

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## INTRODUCTION

The following report contains brief descriptions prepared by S. H. Knight of what is known of the occurrence, character and extent of a number of mineral deposits other than coal and oil in Wyoming. The reports also include information on past developments, uses and markets. All of the known mineral deposits are not included. Subsequent reports on other occurrences will be prepared as time permits. The report also contains a bibliography of published reports descriptive of mineral occurrences of the state.

Considerable effort has been expended in attempts to develop many of the occurrences of minerals within the state. In a number of instances these efforts have not been successful. The reasons for these failures are numerous. Some of them are: (1) many of the deposits are not sufficiently extensive to warrant large scale operations, (2) the deposits in some cases are not sufficiently high grade in their native state to meet market demands, (3) cost of recovery, (4) cost of processing, (5) distance to consuming centers, (6) competition with substitute minerals, (7) competition with manufactured substances of like nature such as sodium sulphate, graphite, etc.

Intelligent approach to development of mineral resources involves:

(1) Field surveys, including the assembling of all available data as to the extent, geological occurrence, etc. of the known deposits. Such surveys are being conducted by the United States Geological Survey and the Geological Survey of Wyoming as time and resources permit. In some instances subsurface explorations are necessary before the extent of a deposit can be evaluated. This work is costly and is as a rule beyond the means of existing fact-finding agencies.

(2) Chemical and petrographical analyses to determine the extent and mineralogical associations of the elements in the deposits. Some work of this nature is being carried on by both surveys. Although the Geological Survey of Wyoming does not maintain an analytical laboratory, the Department of Research Chemistry of the College of Agriculture of the University of Wyoming has cooperated in investigations carried on by the Geological Survey of Wyoming.

(3) Research on the treatment of the raw materials in attempts to determine the feasibility of processing, to discover if low grade deposits can be economically concentrated to meet market demands.

(4) Studies of possible new uses.

(5) Studies of an industrial engineering nature to determine mining, reduction, transportation and marketing costs. Investigations leading to the establishment of local industries, etc.

WYOMING MINERAL PRODUCTION

The total value of all minerals produced in Wyoming from 1865 to 1936 inclusive was approximately $1,247,500,000.* The value of the energy producing fuels (petroleum, coal, natural gas, and natural gas gasoline) was $1,191,200,00 or 95.5% of the value of the total mineral production. The metals (gold, copper, iron, etc.) were valued at $33,700,000 or 2.7% of the total. Non-metals (clay, gypsum, rock, etc.) were valued at $22,600,000 or 1.8% of the total.

The value of mineral production rose gradually from $2,400 (estimate) worth of coal produced in 1865 to some ten million dollars in 1909. The annual values ranged from eleven and a half million to thirteen and a half million from 1900 to 1915 inclusive. Annual values increased rapidly from nineteen and a half million in 1916 to eighty-three million in 1920, owing to extensive development of the oil industry. During the decade from 1921 to 1931 annual values ranged from forty-six and a half million to seventy-eight million. They dropped to twenty-two million in 1933 and rose to thirty-four million in 1936.

Wyoming produced eight tenths of one percent of the total mineral wealth of the nation for the year 1936, and ranked twenty-fourth in mineral production.

*All statistical data included in this report were compiled from information contained in the "Mineral Resources" published annually by the United States Geological Survey from 1882 to 1931 inclusive and the "Minerals Yearbook" published annually by the U. S. Bureau of Mines from 1932 to 1936 unless otherwise stated. A summation of the value of the various minerals produced from 1865 to 1903 and the published annual totals from 1904 to 1936 gave a value of $1,243,157,666.

average annual production - 1865-1936 - $17,600.000

## ASBESTOS

During the summers of 1934 and 1935 the Geological Survey made a detailed field study of all the known occurrences of asbestos in the state. These studies included the Casper Mountain, Smith Creek and Deer Creek occurrences in Natrona County; the Fire King and Abernathy deposits in Fremont County; the Berry Creek and Badger Creek deposits in Teton County and the Canyon Creek deposit in Washakie County. A summary description of these deposits is included in this report. A detailed report will be available in the near future.

A recent brief description of the occurrence of asbestos in Wyoming appearing in "Asbestos" by Olive Bowles, U. S. Bureau of Mines Bulletin No. 403, p. 25, 1937, follows:

"A small production of chrysotile was reported from Wyoming in 1892 and from 1906 to 1912. Asbestos occurs in a serpentine area of approximately 4½ square miles on Casper Mountain about 8 miles south of Casper and in the Smith Creek area of about 7 square miles 20 miles southeast of Casper, both in Natrona County. The mineral occurs principally as cross-fiber veins, few of which are more than an inch across, but a minor quantity of slip fiber appears in places. In 1910, the Wyoming Consolidated Co. operated a small mill in the Smith Creek area, handling about 30 tons of ore a day. A mill was built on Casper Mountain in 1911. Very little fiber has been produced in either locality, but the Patee Asbestos Shingle Co. reported production of 200 tons in 1934 from its Casper Mountain property.

"Occurrences of spinning-grade asbestos near Lander and Atlantic City, Fremont County, were reported in 1919, but the properties have not been developed. A small quantity was obtained at Wheatland, Platte County, in 1920. Chrysotile has been found in several other places, but most of the occurrences throughout the state are relatively low-grade, short fibers."

The 200 tons of asbestos reported to have been produced by the Patee Asbestos Shingle Company in 1934 was serpentine rock rather than chrysotile asbestos. It was mined for use in the manufacture of chimney building blocks.

### VARIETIES OF ASBESTOS

In a discussion of asbestos it should be born in mind that "asbestos is a name applied to several different minerals. Chrysotile is a hydrous magnesium silicate ($H_4Mg_3Si_2O_9$), a fibrous serpentine. The strength and flexibility of the longer fibers are such that it can be spun. Chrysotile constitutes the bulk of the world's production of asbestos. The Wyoming occurrences are for the most part of this variety.

Anthophyllite ($(Fe.Mg)\ SiO_3$) is a variety of asbestos belonging to the amphibole group of minerals. Usually it is brittle and of low tensile strength. No extensive deposits of anthophyllite in Wyoming are known to the Geological Survey.

Mountain Wood is a mineral which is frequently mistaken for asbestos. It is a compact fibrous amphibole. The fibers are brittle and cannot be readily separated. It has no known commercial value. It occurs extensively at various localities in Wyoming.

There are several other varieties which occur elsewhere, chiefly in Africa and Italy.

Domestic production of asbestos in 1937 was 13,284 short tons of chrysotile and 6½ short tons of amphibole. The average value of domestic asbestos sold or used by producers in 1937 was approximately $29.00 a short ton. Imports for 1937 were 307,188 short tons, with Canada supplying 227,078 tons, Africa 5,346 tons and Russia 6,422 tons.

The province of Quebec has been the principal producer of asbestos. The entire output is derived from cross-fiber veins ranging from hair lines to 4 or 5 inches. Most of the production is from veins [illegible] to $\frac{1}{2}$ inches across. The yield is 5% of the total rock mined. Quebec reserves are very large. Combined mill capacity is over 1,000 tons of rock an hour. Capital in mines and mills is extimated at nearly $2[illegible],000,000.

# ASBESTOS IN WYOMING

By R. H. Beckwith

## INTRODUCTION

During the summers of 1934 and 1935 the Geological Survey of Wyoming carried on an investigation of the asbestos and chromite deposits of the state. The writer spent 7 weeks in the field and was assisted by R. C. Shoemaker and H. H. Olinger. Approximately 8 square miles were mapped on a scale of 1 inch = 1,000 feet or 1 inch = 300 feet. The results of the investigations are in process of preparation for publication. The material below is a statement of some of the generally known facts about asbestos and a resume' of the writer's findings on the deposits of Wyoming.

## PROPERTIES

Asbestos is the name given to various fibrous minerals of which the two most important are chrysotile ($H_4Mg_3Si_2O_9$), a fibrous variety of serpentine, and anthophyllite ($(Mg.Fe)\ SiO_3$), a member of the amphibole group. The fiber of certain varieties of chrysotile is long, strong and pliable and, therefore, can be spun. Other varieties in which the magnesium is partly replaced by iron give more brittle and less flexible fiber. The fiber of amphibole asbestos is coarse, brittle, has a low tensile strength and cannot be used for spinning.

## MODE OF OCCURRENCE

All of the deposits examined are of one type associated with ultrabasic igneous rocks of pre-Cambrian age. Both chrysotile and amphibole asbestos occur in fractures from a small fraction of an inch to several inches wide in masses of rock serpentine formed by hydrothermal alteration of ultrabasic igneous rocks, such as peridotite and picrite. Fiber which lies at right angles to the walls of the fracture is called cross-fiber; that which lies parallel to the fracture walls is called slip fiber. Both chrysotile and amphibole are found in some of the deposits in Wyoming, but the second variety is found only in subordinate amounts.

## USES

The principal use of chrysotile fiber which is long and flexible enough to spin is in the manufacture of automobile parts such as brake-band linings and clutch facings. Spinning fiber is also used for the manufacture of asbestos cloth, fire-proof curtains and clothing. Mill fiber, that which is too short or brittle for spinning, is used in the manufacture of shingles, paper, wall-board, pipe and boiler coverings, and for many purposes in chemical laboratories.

## DESCRIPTION OF DEPOSITS

### Teton County

Berry Creek Deposit.--The claims are located on the head of Berry Creek approximately 2 miles east of the watershed of the Teton Range and 6 miles south of Yellowstone Park. The nearest rail point is Lamont Siding, Idaho. From here a road extends 10 to 12 miles eastward to the vicinity of the state line. From here to the asbestos deposits, a distance of 16 miles, the road has been washed and obstructed by fallen trees so that it can be travelled only on foot or horseback.

A few hundred feet stratigraphically below the Cambrian sediments is a tabular mass of partially altered peridotite standing on edge and enclosed by granite gneisses. The peridotite mass strikes east, has a maximum width of 50 feet and can be traced along strike about 400 feet. Several fractures in the altered peridotite are occupied by slip-fiber chrysotile and amphibole of fiber length less than 1 inch. Much of the fiber has been destroyed by subsequent replacement by quartz.

Badger Creek Deposit.--The mineral deposit in sec. 5, T. 6 N., R. 117 W., on Badger Creek in the western part of the Teton Range contains a fibrous variety of talc and no asbestos.

Fremont County

Fire King Deposit.--The property is located in secs. 22 and 27, T. 30 N., R. 100 W., Atlantic Gold District, near the crest of the southern part of the Wind River Range. The nearest rail point is Lander. From here 9 miles of the road distance to the deposit is over oiled highway. The remaining 20 miles is over poor dirt road with steep grades.

A generally tabular mass of serpentine standing vertically and striking northeast lies between a succession of quartzites, green chlorite schists, and black magnetite schists on the southeast and granite gneisses on the northwest. The mass is widest, about 800 feet, at the southwest end where the serpentine passes under the alluvium of Rock Creek. From here the width decreases northeastward, and the serpentine body pinches out 2,500 feet northeast of Rock Creek. About 100 feet northeast of the thin edge of the main mass is a lens of serpentine 400 feet long and 80 feet wide. The serpentine of the main mass is intimately fractured in a ramifying pattern, principally in a zone extending inward 200 to 300 feet from the northwest contact. The fractures strike generally parallel to the contact, dip steeply to the southeast and are occupied by cross-fiber chrysotile. Most of the fiber over 1/8 inch long occurs in a zone not more than 50 feet wide and 800 feet long lying along the northwest edge of the main mass at the northeast end.

The chrysotile fiber is fine, flexible and strong. Fiber up to $1\frac{1}{4}$ inches long has been taken from the deposit. Most of it is, however, under $\frac{1}{2}$ inch in length.

The asbestos-bearing rock has been mined from an open cut and a cross-cut tunnel and shaft. On the property there is a mill, now largely dismantled, for separation of the shorter lengths of fiber from the rock. Hand-cobbed crude fiber was produced and shipped from Lander during the World War. The property has not been worked in the last ten years.

Abernathy Deposit.--The claims are located in the SE$\frac{1}{4}$ sec. 19, T. 30 N., R. 96 W., 38 miles southeast of Lander and 5 miles south of Beaver Hill on the highway from Lander to Rawlins. The area including the claims and the road to the highway is one of low relief. Most of the quarter section in which the deposits are located is underlain by stratified white volcanic ash of the White River group. In the northwest part of the quarter section the volcanic ash has been eroded, exposing pre-Cambrian granites and gneisses which surround four lenticular masses of serpentine. The largest one is 600 feet long and 250 feet wide. The next in size is 900 feet long and has a maximum width of 130 feet. The two smallest serpentine lenses are less than 300 feet long and 50 feet wide. In a few places the serpentine is cut by fractures, which strike generally parallel to the contact between the granite and serpentine, dip steeply, and are filled with fine, flexible cross-fiber chrysotile. The longest fiber seen in place by the writer was $\frac{1}{4}$ inch long. The owner reports finding fiber up to $1\frac{1}{4}$ inch long in one of the prospect trenches.

Granite pegmatite dikes cut the serpentine of the southern part of the longest lens. Two prospect trenches across the contacts of different dikes show that the serpentine has been altered to vermiculite for a distance of at least two feet. Surface cover made it impossible to obtain information on the lengths of the two vermiculite zones parallel to the dike contacts.

## Natrona County

Casper Mountain.--The area of pre-Cambrian rocks containing serpentine and, in various places chrysotile is located in secs. 16, 17, 18, 19, 20 and 21, T. 32 N., R. 79 W. There are numerous secondary roads suitable for trucking within the area and from the north edge a county road extends 8 miles north to Casper.

Casper Mountain is an eastward-trending anticline bounded at its northern base by a southward-dipping thrust fault. Both east and west of the area investigated Cambrian and Mississippian sediments cross the axial plane of the anticline. Over the area investigated erosion has removed the sedimentary cover and exposed the pre-Cambrian core of the anticline. The oldest pre-Cambrian rocks are serpentine, talc schists, hornblende schists and metadiabases, which probably represent both intrusive and extrusive phases of a period of basic and ultrabasic igneous activity. The older basic and ultrabasic rocks were invaded by granites and granite pegmatites. Some of the hornblende schists were injected by granitic material and converted to gneisses. Some of the granite pegmatite dikes are several thousand feet long and vary in width up to 200 feet. They consist of quartz and microcline and locally contain muscovite in crystals up to 2 inches across. It is not probable that the pegmatites could be worked profitably for muscovite, but they might possibly be for feldspar.

Nearly half of the pre-Cambrian area is underlain by serpentine. In a belt several thousand feet wide extending northeastward across the northern part of the area in sec. 17 and the NW$\frac{1}{4}$ sec. 16 the serpentine is locally intimately fractured and cross-fiber chrysotile has developed along the fractures. Fiber up to $1\frac{1}{2}$ inches long is known, although most fiber is much shorter. The Chrysotile is wine yellow in color, and coarser and more brittle than the best grades.

The asbestos belt was thoroughly prospected by trenches and shafts in the early part of the century. In 1910 a mill was built in the NE$\frac{1}{4}$ sec. 17. Since then the mill and most of the claims have been abandoned. A number of the claims for which private ownership title was acquired during the period of development are now occupied by summer cabins of Casper residents.

Smith Creek.--The deposits are located in secs. 19, 20, 29 and 30, T. 31 N., R. 78 W., 28 miles southeast of Casper. Five miles of the road from Casper is oiled highway, 13 miles is graded county road, and 10 miles is poor secondary road.

Three lenses of serpentine are enclosed in granites and granite gneisses. The dimensions of the lenses are 900 feet by 300 feet, 700 feet by 280 feet, and 600 feet by 180 feet. Surface exposures on the largest lens show no asbestos. The two smaller serpentine lenses are cut by fractures with a general westward strike. Some of the fractures are occupies by cross-fiber chrysotile. Along others the serpentine has been replaced by a black metallic mineral, probably magnetite. The longest fiber seen was 3/4 inch long. The chrysotile is of a variety closely similar to that found on Casper Mountain and is coarser and more brittle than the best varieties.

The two smaller serpentine lenses have been thoroughly prospected by shallow trenches and shafts, and a trench 50 feet long and 20 feet deep at the deeper end is cut into a hillside along one of the larger fracture zones. Near the large trench is a three-story mill reported by local residents as having been built in 1906. A small conical tailing pile 15 feet high and 30 feet in diameter indicates that only a small tonnage of asbestos-bearing rock was milled up to the time of abandonment of the property. Much of the milling machinery has been removed, and the building and remaining machinery are of little or no value.

Deer Creek.--The deposits are located in sec. 23, T. 31.N., R. 78 W. southeast of Casper. The road distance to Casper is 30 miles. At least half of the road is poor secondary road with steep grades.

A lenticular mass of serpentine 1800 feet long and 800 feet wide is enclosed in massive granites enclosing xenoliths of metadiabase. The serpentine is intimately jointed. The predominant strike of joints is northeast parallel to the longer sides of the lens. Along some of the joints the serpentine has been replaced by a black mineral, probably magnetite. Over most of the area there is no chrysotile exposed at the surface. Two shallow trenches in the southwest part of the mass near several pegmatite dikes expose a vein-like body of slip-fiber chrysotile one inch across. The fiber is coarser and more brittle than the best grades of chrysotile.

Washakie County

Canyon Creek.--The claims are located on Canyon Creek in the higher part of the Bighorn Range in sec. 25, T. 48 N., R. 86 W., a few hundred feet west of the west boundary of Johnson County. The nearest town is Buffalo. From here the road distance is 42 miles on U. S. Highway 16 and 7 miles over poor secondary road.

The claims are on highly folded metadiabases, gray phyllites, and greenstones forming a northward trending band about 3,000 feet wide lying between granite injection gneisses. At the time of the writer's visit in 1934 ten or twelve men were putting down a shaft in the SE$\frac{1}{4}$ sec. 25 on property of the Wyoming Asbestos Mining Company. The shaft had reached a depth of 25 feet. No chrysotile had been encountered. The only fibrous minerals exposed were minor seams of fibrous talc and amphibole.

BENTONITE

Bentonite is a clay material which has found numerous uses in industry in recent years. Some of the principal uses are bonding agent, oil well drilling mud, bleaching agent, in the manufacture of cement products, ceramic products, soaps, paper, cosmetics, water softeners, paints, medicinal emulsions, sealing agents, etc.

The bentonite deposits of Wyoming are of widespread occurrence throughout the state. No attempt has been made to determine the available tonnage, but it is known to be sufficiently large to satisfy the market demand at the present rate of output for many years. Bentonite clays occur in seams from a few inches to several feet in thickness. The seams have wide lateral extent. The most valuable seams occur in the Mowry formation or a short distance above or below it. They are upper Cretaceous in age.

Bentonites produced in the United States are of two classes, (1) those which swell several times their original volume when in contact with water, and (2) those which swell no more than ordinary plastic clays. Most of the Wyoming bentonites belong to the first class and are used for the standard for the United States. The commercial value of a bentonite deposit depends upon a number of factors, chief of which are (1) the type or class of bentonite, (2) thickness and purity of the seam, (3) the amount of overburden and (4) proximity to shipping points. Seams lying at low angles with relatively small amounts of overburden can be developed more economically than seams standing at steep angles.

Present production is limited to areas in Weston, Crook and Bighorn Counties. The principal Weston-Crook County area is from one to three miles wide and extends from Osage to the Belle Fourche River some seven miles northeast of Moorcroft. A smaller area lies south of Newcastle near Clifton. Production in this area is from a seam having a regional dip of less than 5 degrees and an average thickness of 30 inches. The thickness of the overburden removed to recover the bentonite averages 7 feet. Mining methods consist of stripping the overburden with tractors. The bentonite is loaded into trucks with power shovels. Owing to freezing, all mining is done during the summer months. Stock piles are accumulated for winter milling. In some instances, the clay is trucked twenty-five miles to mills.

The Bighorn County area lies from ten to eighteen miles north of Greybull. Here the bentonite is exposed on the back slopes of hogbacks, the overburden having been removed by erosion for some distance down the dip slope. The bentonite is shoveled into trucks by hand.

Bentonite was first produced in Wyoming in 1888 when a small amount was shipped from Rock Creek, Albany County. Production began in Weston County in 1897. Production was less than 1,000 tons annually until 1925. There was a rapid rise in production from 2,584 tons in 1925 to 25,006 tons in 1930. In 1932 productions dropped to 12,632 tons. From 1933 to 1932 there was a marked increase in production. Last year (1937) production rose to 67,958 tons having a value of $659,111.

Bentonite (both class 1 and class 2) sold during 1937 in the United States amounted to 194,768 tons having a value of $1,500,758. Wyoming, therefore, produced 34.5% of the total tonnage. The value of Wyoming bentonite sold during 1937 was 44% of the nations output for that year. Five mills are engaged in processing (grinding and drying) bentonite is $22.00 per ton. Price varies according to the type and processing.

A recent press notice states that a process has been perfected at the Massachusetts Institute of Technology for the making of paper from bentonite. The notice did not state the type of bentonite used. Further information on this subject is awaited with interest.

## CHROMITE

The occurrence of chromite in the Casper Mountain and Deer Creek areas has been known for some years. The Geological Survey made a detailed field study of the Casper Mountain occurrence in 1934 and 1935. A brief summary of the survey's findings is included herewith. A more detailed report together with maps is in preparation. Available exposures of this occurrence are such that it is impossible to make adequate estimates of the tonnage of various grades of ore. The Geological Survey of Wyoming has recently accepted an offer from the U. S. Geological Survey to assist in further investigations to determine the possible economic value of this deposit. It is anticipated that this work will be carried on next spring and will consist chiefly of trenching operations.

The following description of an occurrence of chromite in the Deer Creek area is taken from the U. S. Geological Mineral Resources for 1918:

"Chromite was discovered on Deer Creek 16 miles southwest of Glenrock, Wyoming, about 1908, and a small quantity of the ore, possibly as much as 700 long tons, has since been mined and shipped. Operations ceased years ago until 1918, when the Ferro Alloy Co., of Denver, obtained control of the property. The chromite occurs in a belt of serpentine about 25 feet wide between granite and hornblende schist. It crops out about midway on the steep slope of Deer Creek canyon, which is nearly 1,000 feet deep. The body of chromite exposed in 1917 showed an irregular thickness of 2 to 5 feet and a more or less continuous length for 150 feet.

"Chrome chlorites occur abundantly, forming veins and lining cavities in the chromite. In composition the chromite ranges from 35 to 44 per cent of chromic oxide with 16 to 20 per cent of iron oxide. Tests of the ore for furnace lining are reported to have shown it too easily fusible for that purpose. The Ferro Alloy Co. uses it in the manufacture of ferrochrome."

Due to the greatly augmented demands of war conditions the mine was operated in 1918, 1919 and 1920, during which time 1,594 tons of ore containing from 35% to 45% chromic oxide having a value of $44,428 were shipped. There has been no production since 1920.

Only 315 tons of a total of 2,321 tons of chromite shipped from mines in the United States in 1937 was ore containing from 35% to 45% chromic oxide. The remainder was ore containing 45% or more of chromic oxide. The chromite imported into the United States in 1937 (553,916 long tons) contained 44.6 chromic oxide. The highest contained 55% and the lowest 32% chromic oxide.

Further information as to the nature and character of the ore and its occurrence in this area will be necessary before any statements can be made as to the possible ore reserves. Information at hand indicates that they are not large. The acquiring of additional information would necessitate trenching or core drilling.

# CHROMITE IN WYOMING

by

R. H. Beckwith

## INTRODUCTION

During the summers of 1934 and 1935 the Geological Survey of Wyoming carried on an investigation of the asbestos and chromite deposits of the state. The writer spent 7 weeks in the field. Most of this time was spent in an investigation of asbestos, the results of which are given elsewhere. The writer wishes to express his thanks to Mr. H. F. Eppson of the Research Chemistry Department of the Agricultural Experiment Station, University of Wyoming, for the chemical analyses of chromite samples given below.

## PROPERTIES

Chromite is a black to brown mineral which commonly occurs in octahedrons, has a metallic to submetallic luster and specific gravity around 4.5. The theoretical composition is $FeCr_2O_4$ equivalent to 32% FeO and 68% $Cr_2O_3$. Chromite containing as high as 68% $Cr_2O_3$ is seldom found, since chromite is isomorphous with magnetite ($FeO.Fe_2O_3$), picotite ($MgO. Al_2O_3$), and other members of the spinel group.

## MODE OF OCCURRENCE

Primary deposits of chromite are invariably found in ultrabasic igneous rocks such as peridotite, picrite, and dunite or in their altered and metamorphosed equivalents. Chromite bodies are commonly in the form of dikes, irregular bodies near the contact of the enclosing mass, or streaks (schlieren) in an ultrabasic intrusive mass. Chromite also occurs in disseminated granular form in ultrabasic igneous rocks, serpentine, and their metamorphosed equivalents.

## USES

The largest part of the chromite produced at present is used for preparation of the alloy ferrochrome and for making of chromite fire brick. A smaller amount is used in the paint and chemical industries. Chromite acceptable for preparation of ferrochrome should contain more than 45% of $Cr_2O_3$ and less than 5% of $SiO_2$. The phosphorus content must be less than 0.2% and sulfur less than 0.5%. For fire brick use the $Cr_2O_3$ content can be lower than 45%, but a high iron content is undesirable because of the tendency of iron compounds to fuse at a low temperature. Ore for the paint and chemical trade must be of much the same quality as that for the manufacture of ferrochrome.

## DESCRIPTION OF DEPOSITS

### Natrona County

Casper Mountain.--The general geology of Casper Mountain is described elsewhere in connection with the description of the asbestos deposits of the area. Enclosed in granite gneisses and metadiabases in the SW$\frac{1}{4}$ sec. 16, SE$\frac{1}{4}$ sec. 17, and NE$\frac{1}{4}$ sec. 21, T. 32 N., R. 79 W., is a lens of chromite-bearing talc schist. The longer axis of the lens extends in the general direction N 60° E and is 2,500 feet long. The maximum width is 350 feet. The foliation of the schist strikes generally parallel to the long axis of the lens and stands vertically or dips at high angles to the northwest and southeast. The chromite occurs in lenses or beds up to several feet across, with their shortest axes lying normal to foliation, and as fine granular material disseminated through the schist. The writer believes that the chromite deposit was formed as follows:

The talc schist was originally an ultrabasic igneous rock intruded during the period of igneous activity represented by the serpentine masses of the area and was probably a part of the larger mass to the northwest. The chromite was formed by crystallization from the ultrabasic magma in the early stages of consolidation and was concentrated in its present position by sinking of the heavier chromite crystals to the bottom of the magma basin or by diffusion to a cooler lateral margin. During a later pre-Cambrian orogeny the ultrabasic igneous rock was locally metamorphosed to a talc schist and the lens was separated from the larger parent mass by invading granites.

Character of the ore.--The writer did not carry on systematic sampling of the ore. Most of the area is covered by soil and more extensive prospecting would have to be done before any conclusions would be drawn as to tonnage of ore present. A few typical samples were collected and submitted to H. F. Eppson, whose analytical results are given below.

| No. | $Cr_2O_3$% | FeO*% | MgO% | $Al_2O_3$% | $SiO_2$% |
|---|---|---|---|---|---|
| 585 | 13.7 | | | | |
| 585A | 26.6 | 63.0 | | | |
| 588 | 26.7 | | | | |
| 588A | 26.6 | 36.0 | 4.9 | 11.0 | nil |
| 587 | 3.6 | | | | |

585 and 588 are crude ore of the best grade. 585A and 588A were prepared respectively from 585 and 588 by crushing through a 115-mesh screen and treating the fraction caught on a 250-mesh screen with Thoulet solution of specific gravity 3.3. Microscopic examination of the resulting concentrates showed that there was less than 5% of the lighter minerals left. 587 is talc schist containing disseminated chromite.

The following conclusions can be drawn from the analyses:

1. The ore which the writer considered, on the basis of field examination, as the best available contains nearly 50% of gangue minerals. Removal of gangue minerals from 585 and 588 approximately doubled the $Cr_2O_3$ content.

2. Some of the chromite concentrates contain sufficient $Cr_2O_3$ for use in the manufacture of ferrochrome. 585A, however, is too low in $Cr_2O_3$ for this purpose and is extraordinarily high in iron. A large part of this iron is probably in individual grains of the mineral magnetite, since 585A is much more strongly magnetic than 588A. The fact that chromite and magnetite have nearly the same specific gravities would present serious difficulties in a commercial separation of these two minerals by a process depending on specific gravity.

3. The chromite content of some of the talc schist in which disseminated chromite is easily visible with the naked eye is low.

*Ferrous and ferric iron were not determined separately. The total iron was calculated as FeO.

EPSOMITE

Epsomite is hydrated magnesium sulphate (Epsom Salts = $MgSO_4$ 7 $H_2O$). This salt is recovered from natural brines and is made artificially by adding sulphuric acid to magnesite ($MgCO_3$ ) or dolomite ($MgCO_3.CaCO_3$). Domestic magnesium salts are recovered from natural brines (Michigan), bittern waters (San Diego Bay), sea water, salt wells (Michigan) and deposits of epsomite (Washington).

The epsomite deposits of the Rock Creek Lakes, Albany County, have attracted considerable attention in past years and efforts have been made to market them. Field examinations of these lakes were made by the Geological Survey in 1933 and 1935. The lakes were mapped and the thickness of the surface salt deposits were determined at various stations. Chemical analyses of 13 samples were made.[1] From the results of this survey it was determined that the larger lake of the group (Brooklyn Lake) is the only one which contains a considerable amount of epsomite.

Tonnage estimates on the basis of field data from this lake are as follows:

| | | Approximate tonnage of surface deposits | Approximate tonnage in black mud | Approximate tonnage of salt. |
|---|---|---|---|---|
| Epsomite | | 21,000 | 150,000 | 171,000 |
| Mirabilite | | 1,300 | 100,000 | 101,300 |
| | Total | 22,300 | 250,000 | 272,300 |

The total amount of epsomite contained in the surface incrustation and the underlying mud bed at the time the lake was surveyed was calculated to be 171,000 tons. The black mud of this lake is underlain by sand, a sample of which yielded 2.79% MgO and 2.60% $Na_2O$. The salts of the brine contained in this sand floor of the lake are not included in the above estimate.

Mention has been made of the possibilities of utilizing the magnesium salts in this deposit as a possible source of metallic magnesium. The total amount of magnesium in this deposit is 17,000 tons, one pound of epsomite yielding approximately one tenth of a pound of metallic magnesium.

The magnesium sold or used by the producers in the United States amounted to 2,270 tons in 1937. All domestic magnesium is produced by electrolysis of magnesium chloride. Approximately 4 pounds of anhydrous magnesium chloride yields 1 pound of metal. Approximately 5 pounds of anhydrous magnesium sulphate would yield 1 pound of metal.

There are no other deposits of epsomite known to the Geological Survey in which epsomite predominates over the other salts in the deposit.

Approximately 2,000 tons of epsom salts were imported for consumption in the United States in 1937. The value of the imported material was approximately $30 a ton. The average value of natural magnesium salts (chiefly sulphate and chloride) producedfrom brines and sea water and sold or used in the United States in 1937 was approximately $24.50 a ton.

1. For a detailed discussion of the Rock Creek Lakes see accompanying report.

GOLD

Wyoming has not been an important gold producing state. The total amount of gold actually produced is not definitely known owing to lack of records during the earlier years of production. Annual production records (including estimates of production from 1867 to 1895) published by the United States Geological Survey and the U. S. Bureau of Mines credit Wyoming with having produced $1,743,548 worth of gold. A critical study of the early history and development of the Atlantic City-South Pass Mining district from 1867 to 1874 leads the writer to believe that the above figure is conservative.

The South Pass-Atlantic City district in southern Fremont County has been the principal gold producing area. The production from this district has exceeded the total production from the rest of the state. Recent improvements in the recovery of placer gold together with the increase in the value of gold gave rise to increased production from the placer gravels in the Atlantic City district. From 1920 to 1930 gold production averaged less than $1,000 per year. Production rose from 51 oz. having a value of $1,165 in 1931 to 4,871 oz. having a value of $170,254 in 1934, and dropped to 1,776 oz. having a value of $62,160 in 1937. Dragline placer operations on Rock Creek accounted for the greater part of the recent production. (87% in 1937).

In 1937 one lode mine in Albany County shipped 7½ tons of gold ore containing 4.61 oz. of gold. Two lode mines in Fremont produced 9 tons which yielded 160 oz. of gold. A total of 24.17 ounces of gold was recovered from scattered placer operations in Albany, Carbon, Sheridan and Teton Counties during 1937.

The total value of the gold produced in the five years from 1933-1937 inclusive was $487,424 compared with only $17,300 in the years ending in 1932. Lode gold produced during the five year period ending in 1937 was 3,955.73 oz. and placer gold produced during the same period was 6,716,75 oz. The average gold value of ore produced during the five year period ending in 1937 was $9.50 per ton.

The most extensive known gold bearing gravels occur in the Atlantic City-South Pass district and in the Medicine Bow Mountains, Albany County. Numerous attempts to recover gold from the gravels in the Medicine Bow Mountains have not been wholly successful. Improved methods may yield more satisfactory returns. The recovery from such deposits can only be determined under actual operating conditions.

Lode mining was stimulated by the increase in the price of gold. During the five year interval from 1933 to 1937, 13,795 tons of ore were produced which yielded $131,310 worth of gold. Only 17 tons of ore were sold or treated during 1937, however.

GRAPHITE

During the 1880's considerable interest was shown in occurences of graphite in pre-Cambrian rocks of the Laramie Range and the Hartville Uplift. Considerable prospecting was done altho there is no record of any shipments of graphite ore. Several members of the staff of the Department of Geology of the University of Wyoming have investigated at various times the geology of the Plumbago and Halleck canyon areas, which were two of the areas prospected for graphite. Sydney H. Ball,[1] of the United States Geological Survey has reported on the graphite occurrences of the Haystack Hills (Hartville Uplift). The geological occurrence and character of these occurrences is summarized below.

The known graphite occurrences in Wyoming are associated with pre-Cambrian igneous and metamorphic rocks. They are in no sense derived from the alteration of coal beds, as they were formed scores of millions of years before coal-forming vegetation was established upon the earth.

The Plumbago canyon area lies adjacent to Highway No. 51, twenty-six miles north of Laramie. There is present in this area narrow bands of graphitic schist standing at nearly vertical angles and interbedded with other types of metamorphic schist. No quantitative analyses have been made of samples from these bands. It is probable that the graphite content does not exceed 15%. To be of commercial significance an ore should contain 80% graphitic carbon. There is also present in this area graphitic carbon occurring as thin seams filling fractures in quartzite. These seams vary in width from a fraction of an inch to two inches, and they cut across the quartzite in irregular patterns.. In one occurrence which is open to observation the ratio of graphite to quartzite is estimated at 2 or 3 percent. There are no known deposits of graphite, nor is it believed that any occur in this area which would yield a commercial graphite ore.

The Halleck Canyon area lies on the south flank of the Halleck Canyon five or six miles west of where Highway 51 crosses Bluegrass Creek. Here irregular seams of amorphus graphite a few inches in width (possibly wider in some places) cut across metamorphosed limestone. The seamsstand at high angles. An examination of the graphite taken from the occurrence appears, on inspection, to be too high in foreign matter to be of marketable grade. An examination of the graphite on the dumps of prospect pits which have been opened on the seam reveals the presence of some graphite which might make an acceptable ore.

Ball reports the occurrence of several bands of graphite schist in T. 27 and 28 N., R. 65 W., in the rugged hills around Haystack Peak. These bands range in thickness from two feet to ten feet. The richest specimens contained up to 16% of carbonaceous matter having the microscopic habit of graphite. Other specimens were estimated to contain from 6 to 8% graphite.

It is possible that other occurrences are to be found in the pre-Cambrian rocks of southeastern Wyoming. Those described above are believed to be representative of what might be expected in other localities.

It is exceedingly improbable that these deposits can be worked at a profit under conditions which govern the graphite trade. The graphite mining industry of the country remained virtually dormant in 1936 and a small amount of natural

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1. Ball, Sydney H., Graphite in the Haystack Hill, Laramie, Wyoming, U. S. Geol. Survey Bull. 315, pp.426-428, 1907.

graphite was produced in 1937. Imports in 1937 aggregated 29,593 tons valued at $752,315. Mexico supplies 13,381 tons of amorphus graphite which carries 80% graphitic carbon and costs $25 to #30 a ton delivered in New York. Domestic production of artificial graphite has been maintained steadily for many years.

## MANGANESE

The only occurrence of manganese of possible economic value known to the Geological Survey is located in Sec. 10, T. 26 N., R. 75 W., 4 miles southeast of Marshall P. O. and 38 northeast of Medicine Bow, Albany County. This occurrence has been described by E. L. Jones in U. S. Geological Survey Bulletin No. 715, pp. 57-59. The following information has been taken for the most part from this report.

An attempt was made to recover manganese from this deposit by the Poverty Mining Company in 1917 under the stimulus of war time demand. When visited by Jones (Oct. 5th, 1917) the workings consisted of a drift 150 feet long and a shaft 25 feet deep. Approximately 200 tons of 40% manganese lay on the dump. Shipments of ore containing 35 per cent of manganese or more were as follows: 1917, 30 tons; 1918, 42 tons; 1919, no shipment; 1920, 40 tons. The 1920 shipment was valued at $2,800. There is no reported shipment since 1920.

The ore consists of manganese oxide manganosite ($MnO$) and pyrolusite ($MnO_2$). It is contained in two chert beds separated by an interval of a few feet. The chert beds range in thickness from 1 to 8 feet and have an average thickness of 6 feet. The cherts are inter-bedded with limestones and sandstones. The ore occurs as mammellary crusts and nodular aggregates which have wholly or partly replaced the chert, and to a less extent the beds which enclose it. The highest grade ore was obtained from the upper parts of the beds. Jones estimated that two feet of ore could be sorted from each bed. However, the greater part of the manganiferous chert is too siliceous to be of marketable value without concentration by the removal of the siliceous gangue.

The failure of the attempt to produce a large tonnage of manganese ore from this occurrence can be accounted for by (1) the limited amount of commercial ore per foot of drift, (2) the problem of sorting, (3) the long haul to rail, (4) freight to market.

Samples from Fremont County carrying 26% manganese have recently been reported.

MICA

Muscovite mica occurs in association with feldspar and quartz in pegmatite dikes which cut the pre-Cambrian rocks at numerous localities in the state. These dikes are coarsely and unevenly crystallized segregates. They vary greatly in shape and size. They may be 100 feet to 200 feet in width and several hundred feet in length or only a few feet across. Such occurrences are the sole source of sheet mica. Some scrap mica is recovered from mica schists and by washing mica bearing sands.

The muscovite occurs as crystals (books) varying in size from less than an inch to twenty inches across and from a fraction of an inch to several inches thick. To recover the muscovite books the entire mass of the pegmatite must be mined. As a rule, the muscovite books make up only a small (10 to 20) per cent of the pegmatite.

The value of sheet mica depends upon (1) the size of the flat sheets into which it can be split (2) whether it is clear or stained (3) whether the crystals are rumpled or distorted (4) accessibility. Spotted or stained mica is worth less than clear. Rumpled or distorted crystals split imperfectly.

Tyler[1] cites the following to show the effects of staining on prices:

Sheet mica 3 to 6 square inches in area as listed by dealers in 1935

| | Price per pound |
|---|---|
| Clear or slightly stained (high grade India Ruby $5) | $2.14 |
| Fair stained | 1.69 |
| Good stained | 1.47 |
| Stained | .54 |
| Black spotted | .33 |

Mica occurring in pegmatites which has been subjected to distortion by movements of the rock mass are as a rule rumpled. Rumpled books will not split perfectly and are less valuable than undistorted books. The pegmatites of Wyoming have been subjected to varying degrees of movement of the rock mass subsequent to the crystallization of the mica. Consequently many, especially the larger crystals, are rumpled.

Ball[2] describes the occurrence of clear muscovite in pegmatite dikes lying to the north of Haystack Peak in the Hartville Uplift (sec's. 25, 26, 27, 34, 35 and 36, T. 28 N., R. 65 W., and sec's. 1, 2 and 3, T. 27 N., R. 65".). The first mica claims were located in this area in 1881 and development work was carried on intermittently for 25 years. With an unimportant exception, no mica has been shipped from the area. Ball estimates that the mica makes up from 10 to 15 per cent of the pegmatite. Books of clear mica up to 20 inches across and three to four inches thick were recovered. The larger sheets are, however, commonly

1. Tyler, Paul M. - Marketing Mica, U. S. Bureau of Mines Inf. Cir. 6997, 1938, p. 3.
2. Ball, Sydney H. - Mica in the Hartville Uplift, U. S. Geol. Survey Bull. 315, 1907, pp. 423-425.

rumpled. In one prospect flawless sheets were obtained in sizes up to 11 inches by 13 inches. In another the largest flawless sheets were 6 inches to 8 inches in diameter. Quartz and feldspar lie between the mica sheets in some of the places. Some of the prospects have been trenched a distance of 60 feet or more along the dike.

Considerable effort was put forth some fifteen years ago to develop mica occurring in a pegmatite vein in the vicinity of Fox Park, Albany County. Here the mica was both stained and crumpled. The effort was not successful.

Ground mica is used extensively in industry. In 1937, 27,245 tons were sold to various industries in the United States. Almost 80% of all ground mica is sold for roll-roofing. Considerable is used in the manufacture of asphalt shingles and in the rubber industry. Much of the net ground mica is recovered from mica schists and from clay washing. The average price for scrap mica in 1937 was $14.08 per short ton F.O.B. mines. Prices of dry-ground mica average around $23 F.O.B. plant or $30 delivered at consuming points.

The intricacies of marketing mica are such that prices must be determined chiefly by negotiation between buyer and seller on a given lot of material.

PHOSPHATE ROCK

The extent of the rich phosphate reserves of Wyoming is not yet entirely known. Additional field examination and analyses will be necessary before figures of the total available tonnage can be compiled. The latest estimate of measured reserve credited Wyoming with 115,754,000 tons of available rock. This figure will be greatly augmented when all the occurrences have been measured. The richest reserves are located in Lincoln County. Extensive occurrences of less rich rock are found in Fremont County. These deposits occur as interbedded successions of phosphate rock, shale, clay and limestone. The beds have wide lateral extent and vary from a few inches to several feet in thickness. In its occurrence the phosphate is comparable to coal.

The outstanding phosphate withdrawals on public lands within the state on July 31, 1927 aggregated 996,539 acres. These withdrawals are being surveyed and classified by the U. S, Geological Survey.[1] Classification is based upon (1) the quality of the rock, (2) the thickness of the bed, and (3) the depth of the bed below the surface.

The ownership of phosphate lands are vested in (1) the U. S. government, (2) the state, (3) private and (4) Indian lands. A comprehensive study of the ownership of all phosphate lands of Wyoming must await the completion of field surveys. It is concluded that ownership of by far the greater tonnage of western phosphate is vested in the federal government.

The phosphate reserves of the state constitute a mineral resource of great future value.

The following is a summary of the occurrence of phosphate deposits adjacent to the Oregon-Short Line R. R. in Lincoln County. Other occurrences lie in the Salt River Range to the north.

1. Mansfield, G. R., U. S. Geological Survey, P. P. 152, p. 292.

# THE SALINE LAKE DEPOSITS OF WYOMING

## II

## THE ROCK CREEK LAKES

Albany County, Wyoming

by

S. H. Knight
State Geologist

### INTRODUCTION

The Geological Survey of Wyoming is engaged in the study of saline lake deposits of Wyoming. This report is the second of a proposed series. The first report of the series treats with the Downey Lakes, Albany County, Wyoming.[1]

### LOCATION

The Rock Creek Lakes are located in west-central Albany County in sections 20, 21, 28 and 29, T. 23 N., R. 76 W. They are twelve miles east of the town of Medicine Bow on the Union Pacific Railroad. The index map (figure 1) shows the location of the lakes.

### PURPOSE OF THIS SURVEY

Numerous inquiries have been received by the Geological Survey for information on the salt deposits in these lakes. The general character of the salts has been known for many years, but no reliable estimates of the quantity of the various kinds of salts have been available. The purpose of this survey was to make both qualitative and quantitative determinations of the salt deposits. The lakes were briefly described by Ricketts[2] in 1888 and by Knight and Slosson[3] in 1901 and Knight[4] in 1903.

### ACKNOWLEDGMENTS

The writer wishes to express his appreciation to Professor R. H. Beckwith of the Department of Geology of the University of Wyoming who volunteered his assistance in both field and office investigations. He wishes to thank Mr. Charles E. Bradford, Mr. Joseph Neely and Mr. David Love of the staff of the

1. The Downey Lakes, Albany County, Wyoming, by S. H. Knight. The geological Survey of Wyoming, Report of Investigations No. 1, 6 pages, 2 plates, 1934. Copies of this report will be sent you upon request.
2. Louis D. Ricketts, Annual Report of the Territorial Geologist to the Governor of Wyoming, Cheyenne, Wyoming, 1888.
3. W. C. Knight and E. E. Slosson, Alkali Lakes and Deposits, University of Wyoming Experiment Station Bull. No. 49, Laramie, Wyoming, 1901.
4. W. C. Knight, Epsom Salts in Wyoming, Engineering and Mining Journal, Vol. 75, p. 259, 1903.

Geological Survey for their assistance. The writer is indebted to Professor O. A. Beath, Research Chemist of the University of Wyoming, and to his assistants, Mr. Harold Eppsom and Mr. Kenneth Stanfield, for the chemical analyses.

## FIELD WORK

Field examinations of these lakes were made during October and November, 1933. The lakes were mapped by plane table on a scale of 1 inch = 500 feet. The respective thicknesses of the surface salt layer and the underlying black mud deposit were determined at various stations. Samples of the surface salt and the underlying black mud were also collected at various stations.

## GENERAL DESCRIPTION

The Rock Creek Lake deposits occupy numerous small shallow depressions which have been excavated in a larger undrained depression, the bottom of which lies approximately one hundred feet below the level of the surrounding plateau. This depression is excavated in the red shales and sandstones of the Chugwater formation. The western side of the basin is flanked by outcrops of the Morrison and Cloverly formations. The position and the outlines of the various lakes examined are shown on the accompanying map (Plate I).

## BROOKLYN LAKE

This lake is the largest and the most southern of the group. It is located in the SW¼ sec. 28 and the NW¼ sec. 33, T. 23 N., R. 76 W. The area of this lake is 116.4 acres. When examined the lake was dry with the exception of an area of approximately 5 acres in the northeast portion of the lake, which was covered by one to two inches of brine.

Surface Salt Deposit.-Most of the surface was covered with a thin crust of salt varying from 0 to 6 inches in thickness. The map (Plate 2) shows the varying thickness of the salt layer as determined from measurements made at 20 stations. The computed volume of the salt is 490,240 cubic feet. Assuming that the average specific gravity of the salt is 1.75 there would be 24,480 short tons of salt in the surface deposit.

Composition of the Surface Salt Deposit.-The following is a summary of the analyses of two samples of the surface deposit taken at stations No. 4 and No. 16 in which sodium is computed to be present as mirabilite ($Na_2SO_4 10 H_2O$) and the magnesium as epsomite ($MgSO_4 7 H_2O$).

Brooklyn Lake

(Samples collected Oct. 10, 1933)

| Sample No. | Station No. | % $Na_2SO_4 10 H_2O$ | % $MgSO_4 7 H_2O$ | % Residue in sample | % Combined water as $MgSO_4H_2O$ |
|---|---|---|---|---|---|
| 3 | 4 | 7.7 | 83.6 | 0 | 11.6 |
| 4 | 16 | 3.0 | 88.4 | 0 | 12.2 |
| Average | | 5.3 | 86.0 | | |

Previously Published Analyses of the Brooklyn Lake Deposits:

Ricketts gave the following analysis of a sample of pure salt collected from Brooklyn Lake in December 1887:

| | Per cent |
|---|---|
| Insoluble residue | 0.11 |
| Water | 49.75 |
| Sulphur trioxide | 33.08 |
| Magnesia | 16.26 |
| Sodium Chloride | 0.21 |
| Sodium Oxide | .43 |
| Total | 99.84 |

A recast of the above analysis yields 0.03% mirabilite and 96.8% epsomite.

A sample collected by Dr. W. C. Knight in February 1898 gave the following analysis calculated as dry alkali salts:

| | |
|---|---|
| Sodium sulphate ($Na_2So_4$) | 22.13 |
| Sodium chloride (Nacl) | .69 |
| Magnesium sulphate ($MgSo_4$) | 77.18 |

Another analysis published by W. C. Knight in 1903 is as follows:

| | |
|---|---|
| Sodium sulphate ($Na_2So_4$) | 25.61 |
| Sodium chloride (Nacl) | 5.28 |
| Magnesium sulphate ($MgSo_4$) | 70.11 |

It is concluded from the analyses of the samples collected in October, 1933 that the surface deposit was composed at that time of approximately 21,000 tons of epsomite and 1,300 tons of mirabilite. According to the International Critical Tables, double salts of sodium and magnesium sulphates do not form at the prevaling temperatures at which those salts were probably precipitated.

Salts in black mud beneath the surface deposit in Brooklyn Lake.-Lying between the surface salt deposit and the sandy floor of the lake bed is a layer of black mud varying from 0 to 6 feet in thickness. Several measurements indicate that the black mud has an average thickness of 3 feet. Analyses of two samples of the mud layer are given in the following table:

Analyses of black mud samples from Brooklyn Lake
(Samples collected October 10th, 1933)

| Sample No. | Station No. | Insoluble residue | % $Na_2So_4 10 H_2O$ | % $MgSO_4 7 H_2O$ | % Combined water as $MgSo_4 H_2O$ |
|---|---|---|---|---|---|
| 11. A composite sample of the mud bed | 8 | 61.84 | 17.00 | 23.00 | 2.11 |
| 12. A sample of the upper six inches of the mud bed | 16 | 66.34 | 12.00 | 18.00 | 1.53 |
| Average | | 64.09 | 14.50 | 20.50 | 1.83 |

It is evident from the above analysis that a large amount of salt is contained in the mud layer. Computations of the amount of salt contained in the mud layer based upon (1) the average composition and (2) the average specific gravity is 1.8 and (3) that the layer of mud has an average thickness of 3 feet over 100 acres, follows:

| | Approximate number of short tons |
|---|---|
| Mirabilite ($Na_2SO_4 10\ H_2O$) | 100,000 |
| Epsomite ($MgSO_4 7\ H_2O$) | 150,000 |

Summary of the Brooklyn Lake Salt Deposits

| | Approximate tonnage of surface deposit | Approximate tonnage in black mud | Approximate total tonnage of salt |
|---|---|---|---|
| Mirabilite ($Na_2SO_4 10\ H_2O$) | 1,300 | 100,000 | 101,300 |
| Epsomite ($MgSo_4 7\ H_2O$) | 21,000 | 150,000 | 171,000 |

The above estimates are believed to be conservative.

What percentage of the salt contained in the black mud layer may be taken into solution when the lake is flooded is not known. It is believed that a considerable portion of the salt contained in the mud layer is disolved when the lake is extensively flooded.

A sample of the sandy floor of the lake bed was collected at station No. 8. The sandy layer lies directly below the black mud layer. Analysis No. 10 in table No. 1 was made on an average sample of the upper one foot of this sandy layer. It is of interest to note that this sample contained 12% mirabilite and 14% epsomite.

## PHILADELPHIA LAKE

This lake lies one half mile north of Brooklyn Lake in the SW¼ sec. 21 and the SE¼ sec. 20, T. 23 N., R. 76 W. The lake is very irregular in outline and covers an area of approximately 40 acres. When examined on November 1, 1933 and again in July, 1935, the lake was dry. A layer of soft black mud covered the surface. Thin irregular patches of sodium salts were scattered over the mud surface. These patches varied from 0 to 2 inches in thickness. No attempt was made to estimate the tonnage of the surface salt accumulation on this lake, owing to the limited amount. The analysis of a sample of crystalline salt from this lake (see analysis No. 9, table No. 1) yielded 75 % epsomite and 21% mirabilite. Ricketts[1] describes this lake as follows:

"The Philadelphia Lake has an area of about 40 acres and is very irregular in outline. Close to the shore the bottom is composed of black mud similar to that in the Brooklyn Lake. Further out there is a thin crust of magnesium sulphate over the mud. But in this lake the mud is found to rest upon a heavy

1. Ricketts, L. D., Annual Report of the Territorial Geologist, to the Governor of Wyoming, Jan., 1888, p. 54.

deposit of solid salt. Two pits sunk out in the lake showed in once case four, in another six and one half feet of this salt. A third pit sunk near the shore showed less than one foot. These few pits do not afford sufficient data for an estimation of the size of the deposit, but they do develop the fact that it is a large one. The following analysis will show the composition of this salt. The insoluble residue in this and other analyses means the residue insoluble in hot water:

| | |
|---|---|
| Insoluble residue ......... | 3.38 |
| Water .................... | 48.90 |
| Sulphur trioxide ......... | 31.33 |
| Magnesia ................. | 15.62 |
| Sodium Chloride .......... | 0.44 |
| Sodium Oxide ............. | 0.07 |
| | 99.74 |

An unsuccessful attempt was made to determine the position and character of this bed at the time the survey was made. The heavy mechanical equipment and labor necessary to explore this bed was not, however, available at the time. Further field studies will be necessary before the facts incident to the existence, character and composition of this bed are known.

The remaining small lakes of this group did not contain an appreciable amount of crystalline salts as surface incrustations.

LAKE COLLECTION OF SALTS

Oct. 10, 1933 & Nov. 1, 1933

| SAMPLE NO. | DESCRIPTION |
|---|---|
| 1. | Long Lake. Sample of Spring Water. |
| 2. | Long Lake. Salt sample, 100 W. of spring. |
| 3. | Brooklyn Lake. Surface sample. Station No. 4. |
| 4. | Brooklyn Lake. Surface sample. Station No. 16. |
| 5. | Lake No. I. Surface sample. |
| 6. | Lake No. II. Surface sample. |
| 7. | Lake No. III. S. E. of Rock River. Surface sample. |
| 8. | Lake No. IV. Surface sample. |
| 9. | Philadelphia Lake. Surface sample. |
| 10. | Brooklyn Lake. Sand 4' below surface. |
| 11. | Brooklyn Lake. Mud # 8. |
| 12. | Brooklyn Lake. Mud just under salt. |
| 13. | Philadelphia Lake. Mud sample. |

SALT SAMPLES FROM Mg So4 LAKES NEAR ROCK RIVER

| % | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Residue | 0 | 0 | 0 | 0 | 0 | .05 | .11 | .46 | 1.39 | 77.81 | 61.84 | 60.35 | 60.26 |
| Ca 0 | 0 | 0 | 0 | 0 | 0 | .00 | .00 | .00 | .00 | 2.81 | 5.28 | 5.50 | 6.94 |
| Mg 0 | 86 gm/l | 21.1 | 25.9 | 27.3 | 24.8 | 21.00 | 28.25 | 27.91 | 24.85 | 2.79 | 4.72 | 3.48 | 3.35 |
| $So_3$ | 188 gm/l | 53.9 | 52.7 | 54.6 | 54.4 | 52.85 | 55.07 | 55.77 | 51.98 | 9.88 | 19.41 | 16.12 | 17.48 |
| Cl | 82.1 gm/l | 1.0 | 1.2 | 1.0 | 0.8 | 1.80 | .76 | .34 | 1.28 | .48 | .86 | .96 | .60 |
| $Na_2O$ | 76 gm/l | 8.9 | 2.8 | 1.1 | 4.5 | 12.19 | 1.97 | 2.92 | 8.79 | 2.60 | 4.24 | 2.70 | 2.88 |
| Total | 432.1 gm/l | 85.2 | 82.6 | 84.0 | 84.6 | 87.89 | 86.16 | 87.40 | 88.29 | 96.37 | 96.35 | 95.11 | 91.51 |
| *** Comb. water as $MgSo_4H_2O$ | 38.4 gm/l | 9.5 | 11.6 | 12.2 | 11.2 | 9.36 | 12.60 | 12.46 | 11.08 | 1.25 | 2.11 | 1.55 | 1.50 |
| * Total plus combination water | 470.5 gm/l | 94.7 | 94.2 | 96.2 | 95.8 | 97.25 | 98.76 | 99.86 | 99.37 | 97.62 | 98.46 | 96.66 | 93.01 |
| % $MgSo_4 7 H_2O$ | 526 gm/l | 67.3 | 83.6 | 88.4 | 79.5 | 65. | 89. | 87. | 75. | 14. | 23. | 18. | 17. |
| % $Na_2So_4 10 H_2O$ | 395 gm/l | 24.2 | 7.7 | 3.0 | 12.3 | 28. | 5. | 8. | 21. | 12. | 17. | 12. | 13. |
| Total Solias | 482.5 gm/l | - | - | - | - | - | - | - | - | - | - | - | - |

Note: * is the total of *** and all above ***

# NATURALLY OCCURRING SODIUM SULPHATE

## MIRABILITE

The naturally occurring sodium salts, mirabilite (Glauber's Salt = hydrated sodium sulphate) and natron (hydrated sodium carbonate) and the magnesium salt epsomite (Epsom Salt = hydrated magnesium sulphate) occur in relative large quantities as saline lake deposits in numerous lake basins in Albany, Carbon and Natrona counties. These deposits were investigated by the Geological Survey of Wyoming in 1933 and 1934. Most of the deposits were mapped and extensive tests, both physical and chemical, were made to determine the character and tonnage of available salts in the Downey Lakes and the Rock Creek Lakes. The results of the studies of the Downey Lakes were published in 1934. A copy of the report accompanies this summary. The report on the Rock Creek Lakes has not been published. A copy of the report also accompanies this summary. For a number of years Glauber's Salts have been produced from the Pratt and Gill deposits in Natrona County and the Southwell deposit in Carbon County. Shipments from these deposits have ranged from 2000 tons to 6000 tons annually for several years. No estimates have been made by the Geological Survey of the probable tonnage in these deposits. Descriptions of these deposits are to be found in the Annual Report of the Territorial Geologist, January, 1888, by Louis D. Ricketts, Territorial Geologist, and in "Alkali Lakes and Deposits" by W. C. Knight and E. E. Slosson, Wyoming Experiment Station Bull. No. 49, 1901. All available information indicates that the tonnage in these deposits is large.

During the drought period of 1933-34, with the consequent evaporation of the brines which usually cover these deposits, the Geological Survey made a detailed study of Downey and Rock Creek Lakes. These studies included boring through the crystalline salt and the underlying mud layers. Samples were taken of the borings at intervals and chemical analyses were made of the samples. From the results of these investigations (see accompanying report for details) it was concluded that there were 8,514,000 cubic feet of crystalline salts in the north and middle Downey Lakes, exclusive of the salts in the underlying mud layer. From the chemical analyses of the collected samples it was concluded that there was present in these lakes 279,000 tons of mirabilite, 19,000 tons of epsomite, 7,000 tons of other salts and 22,000 tons of insoluble residue.

Natural sodium sulphates are (1937) being produced in California, Texas and Wyoming. Deposits are being developed in Utah and Washington. Natural sodium sulphates (salt cake and Glauber's Salt) used by producers in the United States in 1937 was 80,053 tons valued at $599,266. Saline lake deposits comprise a relatively small part of the total domestic production of sodium sulphate, most of which is recovered from chemical works. Imports (duty free) of crude sodium sulphate (salt cake) amounted to 220,176 tons and Glauber's Salt 1,425 tons in 1937. Approximately 70 per cent of imports of sodium sulphate is used by the Kraft paper industry of the south and enters Gulf ports. Most of the natural occurring sodium sulphate is produced from saline lake brines in California which also yield large amounts of sodium carbonates (soda ash) and boron minerals, chiefly sodium borate.

## TITANIFEROUS IRON

There are numerous dike-like occurrences of titaniferous magnetite in the pre-Cambrian complex of the Laramie Range. These occurrences, especially the one at Iron Mountain have attracted considerable attention. A bibliography of reports descriptive of these deposits is attached hereto.

The Iron Mountain occurrence lies in east-central Albany County, 9 miles west of Iron Mountain Station on the Colorado and Southern Railway. It is one of the largest occurrences of titaniferous magnetites in the United States. The main body of iron is an irregular dike-like mass which varies in width from 40 to 300 feet, and it is more than a mile in length. The greatest observed width is where Chugwater cuts through the mass. In several places the dike is cut by granite. Several lesser dike-like occurrences are associated with the main mass. Other similar occurrences are found in a belt which extends from Chugwater Creek northward to Sybille Creek. At the Shanton ranch in sec. 8 or 9, T. 18 N., R. 71 W. are several small dikes similar in character to the Iron Mountain deposits.

No attempt has been made to determine the possible tonnage of titaniferous iron in the various occurrences. If the occurrences are true dikes, rather than folded sills, it is expected that they would continue to great depth unless cut off by faults. They may even thicken somewhat in depth. It is concluded that there are many millions of tons of titaniferous iron in the main dike lying above the level of Chugwater Creek. Accurate estimates of the extent of the occurrences is impossible without resource to subsurface data which is wanting.

The titaniferous magnetite is a black granular, igneous rock intruded into anorthosite. Nine analyses cited by Singewald[1] show the metallic iron content varying from 45.49% to 54.48% and the titanium dioxide varying from 19.47 % to 23.49%. The average composition on the basis of the above analyses is 51.88% iron and 21.84% titanium dioxide. According to Singewald[2] "The titanium content is somewhat higher than the average for titaniferous magnetites. The average composition is equivalent to an ore composed of 49.80% magnetite and 41.5% ilmenite.

## COMMERCIAL POSSIBILITIES

Iron ores rich in titanium are practically unreducible at the temperature of blast or open hearth furnaces. Titaniferous iron ores have been successfully smelted in Sweden, England and the United States, but at prohibitive costs.

Ball[3] reports the "3,760 kilowatt hours were used on the average in smelting a ton of 2,000 pound of pig iron product, the total change averaging two of Wyoming iron to one of briquette of Pacific coast sand. During a run

1. Singewald, J. T. - The Titaniferous Iron Ores in the United States, U. S. Bureau of Mines, B ull. No. 64, 1913, p. 120.
2. Ibid
3. Ball, Sydney H. - Titaniferous Iron Ore of Iron Mountain, Wyoming, U. S. Geological Survey Bull. No. 315, 1907, p. 212.

of 2,583 pounds of iron, 205 pounds of graphite electrodes were consumed." Assuming a power cost of 4 mills per kilowatt hour, the electrical consumption on the above test would cost $15.04. Pig Iron is worth approximately $20 a ton.

Singewald[1] attempted a magnetic separation of samples from the Iron Mountain occurrence. The results of his experiments and conclusions are as follows:

POSSIBILITIES OF UTILIZATION

Five specimens of the ore were crushed and separated with a hand magnet. The first three were from Iron Mountain and the last two from Shanton ranch. The results follow:

Results of magnetic separation of Iron Mountain and Shanton ranch ore.

| | Un-screened ore | Ore through 50-mesh, over 100-mesh | | | Ore through screen finer than 100-mesh | |
|---|---|---|---|---|---|---|
| | | Magnetic | Nonmagnetic | Proportion through screen | Magnetic | Proportion through screen |
| | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. |
| Proportion | | 84.2 | 15.8 | 48.8 | 83.6 | 51.2 |
| Fe | 52.31 | 56.75 | 28.74 | | 56.75 | |
| $TiO_2$ | 21.75 | 18.30 | 40.12 | | 17.25 | |
| Proportion | | 77.7 | 22.3 | 46.3 | 76 | 55.7 |
| Fe | 54.48 | 60.76 | 32.61 | | 61.97 | |
| $TiO_2$ | 19.47 | 12.58 | 43.47 | | 10.32 | |
| Proportion | | 87.3 | 12.7 | 46.6 | 86.5 | 53.4 |
| Fe | 51.93 | 55.35 | 28.43 | | 55.44 | |
| $TiO_2$ | 21.85 | 20.03 | 34.33 | | 20.03 | |
| Proportion | | 84.7 | 15.3 | 48.0 | 82.2 | 52.0 |
| Fe | 51.50 | 55.05 | 31.83 | | 55.63 | |
| $TiO_2$ | 21.08 | 17.85 | 38.93 | | 17.85 | |
| Proportion | | 84.1 | 15.9 | 47.5 | 78.6 | 52.5 |
| Fe | 52.98 | 56.93 | 31.96 | | 57.30 | |
| $TiO_2$ | 19.98 | 17.22 | 34.58 | | 16.72 | |

Of these five samples the average Fe content is 52.64 per cent, and the average $TiO_2$ content, 20.83 per cent. Of the 50-100 mesh concentrate the average Fe content is 56.97 per cent, and the average $TiO_2$ content, 17.20 per cent. Of the concentrates finer than 100-mesh the average Fe content is 57.42 per cent, and the average $TiO_2$ content, 16.43 per cent. The average composition of the 50-100 mesh tailings is Fe 30.71 per cent, $TiO_2$ 38.29 per cent. This corresponds to a composition of the original ore of 52.56 per cent magnetite

1. Singewald, J. T. - The Titaniferous Iron Ores in the United States, U. S. Bureau of Mines. Bull. No. 64, 1913, p. 120.

and 39.58 per cent ilmenite; of the 50-100 mesh concentrates 62.05 per cent magnetite and 32.68 per cent ilmenite; of the concentrates that passed through a 100-mesh screen, 63.41 per cent magnetite and 31.22 per cent ilmenite; of the 50-100 mesh tailings, 72.75 per cent ilmenite and 5.40 per cent magnetite. It is again seen that there is little advantage in grinding finer than 50-mesh. This is what one could predict from the size of the ilmenite grains, as practically all are larger than the size passing through a 50-mesh screen, and the ilmenite inter growths in the magnetite are too minute to be separated by the 100-mesh crushing

The disappointing feature is the small amount of titanium removed. A careful study of the ore, however, reveals the cause of this. Polished sections of the five specimens of ore subjected to magnetic concentration were carefully measured, and it was found that ilmenite grains of separable size formed 15.3 per cent of the surface. If we calculate the titanium in the tailings in terms of ilmenite, we find the average by weight to be 12.1 per cent of the original ore. Allowing for the difference in specific gravity between magnetite and ilmenite, this is equivalent to 12.7 per cent of the original surface. In other words, 15.3 per cent of ilmenite was measured, and 12.7 per cent was separated, which is equivalent to a separation of 83 per cent of all ilmenite present in a separable condition. When the crude method of making the separation is taken into account, the result is all that could be expected.

It was shown above that 39.58 per cent of the original ore consisted of ilmenite, and that an equivalent of 12.1 per cent of ilmenite was removed. Consequently 27.48 per cent of ilmenite remained in the concentrates, which is equivalent to 69.4 per cent of the original ilmenite content of the ore. Hence the result of the separation tests was to separate 30.6 per cent of the titanium and to leave 69.4 per cent in the concentrates. It was further shown that by measurement 15.3 per cent of the ore was present in a separable condition. This was equivalent to 14.56 per cent by weight, or 36.8 per cent of the total ilmenite content of the ore; that is, only 36.8 per cent of the titanium of the ore is in a separable condition. The remaining 63.2 per cent of the titanium is so intimately intergrown and included in the magnetite as to make separation impossible. Even if a perfect separation of all ilmenite grains of separable size were obtained, there would still remain a concentrate with 13.2 per cent $TiO_2$ and 7.96 per cent Ti.

It is therefore apparent that it is impossible to make from this ore a concentrate low in titanium. However, the deposits are most attractive as to size and ease of mining.

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VERMICULITE

The vermiculites are a group of micaceous minerals which are being used for insulating purposes. The principal use is for house fill. The principal competitor of vermiculite is rock wool.

Vermiculite possesses the physical property of expanding (opening out accordion fashion) when heated. The value of vermiculite for insulating purposes is dependent upon the character and amount of expansion. They may expand from 3 to 30 times their original volume. Vermiculites from a single deposit may vary greatly in their capacity to expand. The expanded product may vary in weight from 3 to 15 pounds per cubic foot. For expanded vermiculite the standard volume ratio is 6 pounds per cubic foot. It is probable that the use of vermiculites which cannot meet this standard will increase. What per cent of the Wyoming vermiculites meet the standard volume ratio is not known. Expanded vermiculite from an occurrence south of Glenrock is reported to weigh from 10 to 12 pounds per cubic foot. The extreme irregularity of the vermiculite occurrences and the wide variation of the physical properties of the material within a given occurrence makes it extremely difficult, if not impossible, to determine the extent and character of the vermiculite in any given deposit in advance of exploration and tests of expanding quality.

Vermiculite deposits are found only in pre-Cambrian rock areas. The outlines of the pre-Cambrian areas have been mapped. Much additional field study will be necessary before detailed information as to the geology of these areas is definitely known. It is possible that additional occurrences of vermiculite remain to be discovered. Representatives of the Geological Survey have visited occurrences of vermiculite in the Encampment, Glenrock and Beaver Hill areas. A report on the varmiculite deposits occurring 10 miles south of Glenrock accompanies this summary. The geological conditions which prevail in the Glenrock area are comparable to the other known occurrence.

The following statement on the vermiculite industry is taken from the 1938 "Minerals Yearbook", pp. 1312-1314:

"Sales of vermiculite increased markedly in 1937 to 24,556 short tons valued at $235,164 compared with 16,933 tons valued at $185,787 (revised figures) in 1936. Virtually the entire output was cleaned and sized vermiculite shipped from western mines to calcining plants in various cities in the United States and to England, only small amounts being expanded or exfoliated by calcining at the mine. Sales of expanded vermiculite during the first half of 1937 exceeded those for all of 1936, and notwithstanding the decline that occurred later in the year business continued at a good rate until about November. Prices were unchanged. Most of the material continues to be used for house fill, but recent developments include a larger use in sponge rubber, in which the vermiculite is mixed with latex and some new applications in the way of burned clay refractories.

"The Zonolite Co. (5905 Second Blvd, Detroit, Mich.) and the Universal Insulation Co. (2601 West 107 St., Chicago, Ill.) both operating near Libby, Mont., were still the leading producers, although much of the increase in production came from Colorado where substantial developments occurred on both sides of the Continental Divide. The Vermiculite Co. of America (459 Harding St. NE., Minneapolis, Minn.) and the General Vermiculite Co. (Guthrie, Colo.) operated in the general vicinity of Canon City, Colo.; the latter company succeeded the Colorado Vermiculite Co., mentioned in Minerals Yearbook 1937. The United States Vermiculite Co. (915 Metropolitan Bank Bldg., Minneapolis, Minn.) acquired the property in Gunnison County, Colo., leased from the Ute Indians by the Associated Minerals Co. Wyoming production was restricted because the mill of the Mikolite Co. (1317 Union Ave., Kansas City, Mo.) burned in June and was not rebuilt and ready to resume operations until February 1938. Earle H. Paine, after doing considerable development work, was preparing to lease his property, also near Encampment, Wyo., to J. T. Gregory and associates (1560 Gaylord St., Denver, Colo.). No new shipments were reported from North Carolina, although North Carolina vermiculite was burned at various places from stock at processing plants.

"So long as the main use for vermiculite is as house fill, chiefly minus 3 plus 14-mesh, North Carolina material is at a disadvantage owing to the small yield of good, corklike pellets. This disadvantage is represented quantitatively by the difference in prices which, notwithstanding some freight advantage to certain important eastern consuming points, are $6 a ton f.o.b. North Carolina, compared with $11 to $15 f.o.b. Montana . Freight on raw material to the Atlantic seaboard from Libby, Mont., is around $13 a ton in carload lots (usually 43 tons), this making the delivered cost of unexpanded material $24 or more a ton, to which must be added at least $6 for expanding and bagging so that the total cost, exclusive of shrinkage and loss in finesworks out to at least $30 a ton at eastern calcining plants. Rock wool, the leading competitor, can be bought wholesale in Washington D. C., for $45, but this is the price for "commercial" grade; the granulated product sells for $53 to $60 a ton to dealers, while consumers pay 90 cents to $1.30 a bag. Bags nominally are equivalent to 4 cubic feet, and commercial wool runs 60 and granulated wool about 50 bags to the short ton. However, 4-cubic foot bags of vermiculite weigh only 24 or 25 pounds each, so run 80 to the ton. By selling these to dealers at 70 to 82 cents each, vermiculite manufacturers can get $56 to $65 a ton for the expanded product and still sell to consumers at about $1 a bag.

"For house insulation, according to one manufacturer, a 4-cubic foot standard bag of properly expanded vermiculite will cover 27 square feet 2 inches deep and reduce attic heat loss by 75 percent; a 3-inch layer stops 85 percent and a 4-inch layer 92 percent of the loss. One 32-day test by Professor Gordon B. Wilkesin laboratories of the Massachusetts Institute of Technology indicated that "mica pellets" were a much better insulator than rock wool from the standpoint of condensation. On the other hand, some official tests tend to show that under certain circumstances rock wool is the better insulator. Evidently there is need for better methods of testing porous materials f or heat conductivity, particularly under actual operating conditions. For mineral wool a volume factor of 10 pounds per cubic foot is generally recommended; but looser packing may give good results, and for nodulated glass wool packing as loose as 3 pounds per cubic foot may result in no appreciable settling and consequent lowering in efficiency. For expanded vermiculite the standard volume ratio is 6 pounds per cubic foot, but varieties that cannot meet this standard are likely to be used increasingly, although perhaps not at the same price per ton or even per bag.

"Vermiculite is typically an American product. Not only is Montana raw material being sent to London to be expanded there in a factory affiliated with the F. E. Schundler Co. (Joliet, Ill., and Long Island, City, N. Y.), but also substantial shipments of exfoliated vermiculite are being exported to Continental

Europe. Russian material has been exploited, and although it was not well-liked in the United States it is being used abroad, at least in the U.S.S.R. Recently the South African Department of Mines announced that samples of vermiculite from Palabora in the Leydsdorp area of northeastern Transvaal exfoliate satisfactorily and that samples from the Petersburg area, although not so good, may have commercial possibilities. Occurrences also were noted near Messina, north Transvaal."

# THE VERMICULITE DEPOSITS SOUTH OF GLENROCK, WYOMING

By

Page T. Jenkins

## Introduction:

The deposits described in this report are located from 7 miles to 10 miles south of Glenrock, Wyoming, in section 20, 29 and 33, T. 32 N., R. 75 W. and section 13, T. 32 N., R. 76 W. The writer spent 2½ days in October, 1938, in an examination of the deposits.

## General Geology:

The vermiculite is found in an elongated area about 4 or 5 miles long and 1 mile wide, trending in a NW - SE direction. The area is underlain by pre-Cambrian igneous and metamorphic rocks. From one quarter miles to two miles to the north of the area the Madison limestones, striking nearly east-west, crop out along the mountain front. The predominant pre-Cambrian rock types are a dark-colored metadiabase and a white to pinkish granite. Large irregular-shaped masses of serpentine and a few tabular masses of pyroxenite or amphibolite are exposed in the area. The serpentine and pyroxenite together with the metadiabase make up part of a pre-Cambrian roof pendant invaded by a granite batholith. The end stages of batholithic intrusion are represented by the intrusion of pegmatite dikes and veins which cut the granite, metadiabase , serpentine and probably the pyroxenite, though this latter relation was not found.

## Description of the deposits:

The Washakie Lode in Sec. 13, T. 32 N., R. 76 W., shows the largest mass of pure vermiculite opened up in the area. The vermiculite occupies an irregular-shaped pocket having a maximum width of 20 feet from which many smaller vermiculite lenses radiate out into light green, altered serpentine and light gray, impure talc schist. The vermiculite pocket is probably genetically related to a large pegmatite dike, which crops out a few hundred feet to the east. Irregular inclusions of disintegrated metadiabase and serpentine "horses" are found entirely surrounded by vermiculite. The contact between the vermiculite and serpentine is gradational and, in some cases, is marked by a thin band, about 1 inch thick, of white fibrous amphibole, probably actinolite. Prospect holes nearby show vermiculite bands alternating with and grading into mica schist bands which in turn, grade into unaltered metadiabase.

On the Stardust claims in Sec. 20, T. 32 N., R. 75 W., recent prospect holes show masses and lenses of vermiculite in altered serpentine, gold-colored vermiculite in bands and flakes scattered through impure talc schist, clusters of vermiculite plates embedded in large intergrown crystalline masses consisting of feldspar and quartz in a granite-pegmatite, and metadiabasic material grading into vermiculite. The relation of the vermiculite deposits to the pegmatite dikes and veins are best seen here. The country rock is, in most cases, a light green, altered serpentine. Smaller amounts of talc schist, chlorite schist and pyroxenite or amphibolite are found within or close to the larger serpentine masses. The serpentine also contains small amounts of chrysotile asbestos.

In the N. ½, Sec. 29, T. 32 N., R. 75 W., massive unaltered serpentine streaked with dark bands is exposed in pits dug in the top of a hill, locally called Serpentine Hill. No vermiculite was noted here. A few hundred feet to the southwest a large pegmatite dike strikes about S. 30° E. Associated with this and other pegmatite dikes are the vermiculite deposits of the Badger claims. Vermiculite in most of the prospect holes here grades through talc schists into metadiabase, although altered serpentine was found with vermiculite in some of the holes.

On the Beech claims in Sec. 33, T. 32 N., R. 75 W., a large tabular mass of vermiculite is associated with metadiabase and biotite. Apparently the biotite has been only partially converted to vermiculite as the material expands only slightly upon heating.

Mode of Origin:

The vermiculite was formed by alteration of serpentine and metadiabase under the influence of hot acqueons solutions derived from a granite-pegmatite magma. Some of the vermiculite was formed by the alteration of biotite which had previously crystallized from the pegmatite magma.

Development work:

The extreme spottiness and irregularity of the vermiculite deposits and the wide variation within and between deposits, of the vermiculite's physical properties (expansion and density of refined products) upon which its commercial value is dependent, makes it impossible to predict, in advance of exploration, the extent and character of the deposit. In one case, the expansion and density properties of the refined products of two bands of raw vermiculite in contact with each other, were markedly different. Two of the deposits are now being worked commercially on a small scale. Raw material from the Washakie Lode is mined, trucked to Glenrock and crushed to pass through a ¼-inch screen. The fines are screened out. The coarser material is burned in a small steel rotating kiln fired by natural gas and is sold and installed for house insulation in the immediate vicinity. Fines are burned and used for plaster aggregate. The whole process from mine to market is handled by two men. The material is reported to expand to a volume of 3 to 8 times the original volume. The weight of the finished product is about 10 to 12 lbs. per cubic foot. The other commercially-worked deposit is on the Stardust claims. Raw vermiculite is trucked to Casper and burned there. Some of this vermiculite is reported to expand up to 30 times the original volume and to weigh as little as 3 lbs. per cubic foot. However, the raw material from a single deposit may vary in expansion from 5 to 30 times original volume and the weight of the refined products may vary from 3 to 15 lbs. per cubic foot.