The Occurrences of Non-Metallic Minerals in Montana

Samuel T. Mitchell
THE OCCURRENCES OF
NON-METALLIC MINERALS
IN MONTANA

by
Samuel T. Mitchell

A Thesis
Submitted to the Department of Geology
in Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science in Geological Engineering

MONTANA SCHOOL OF MINES
BUTTE, MONTANA
June, 1951
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This thesis is essentially an abstract of the literature concerning occurrences in Montana of minerals with a non-metallic luster. The discussions give a general description of the occurrences of minerals as reported by the various references, but is not complete as less than 40 percent of the non-metallic minerals known to exist in Montana are discussed. Table II contains a partial list of non-metallic minerals which have been mentioned by various writers of geological articles concerning localities of this state.

In age, most of the minerals of either igneous or metamorphic origin seem to be associated with diastrophic events of Late Cretaceous or Tertiary times, while those minerals found in most of the ordinary sedimentary formations are often of the rock type and may be of any age since Cambrian times.

INTRODUCTION

Most of the minerals in Montana have been recognized and described by geologists of the United States Geological Survey and of the Montana...
Bureau of Mines and Geology, and also, by independent writers for geological magazines and books. The vast areal extent of the state coupled with its long geologic history of sedimentation, diastrophism, and vulcanism, has resulted in great diversity of minerals which are of interest from both economic and mineralologic points of view. No information is available of any publication in which a condensed but rather complete discussion of the location and mode of occurrence for non-metallic minerals in Montana has been made.

This thesis, prepared at the Montana School of Mines during the spring semester of 1951 as one of the requirements for the degree of bachelor of science in geological engineering, was intended to gather information relative to non-metallic minerals in as brief a form as practicable, with a non-metallic mineral being defined as one which has a non-metallic luster, or one which is utilized for some valuable inherent property rather than any particular metallic content.

In preparation of the thesis, all available publications relative to mineral occurrences in Montana were studied. Pertinent articles were listed in the bibliography, and the information concerning minerals was summarized. The original intent of the writer was to say something about every non-metallic mineral reported as occurring in the state; but the list was greater than anticipated, so that sufficient time for completion of this project was not available. The list of references for the minerals in Table II is not complete, being present only to verify the reported existence of these minerals in Montana.

All references have been grouped together in the bibliography.
The numbers at the end of each mineral description refer to the list number of the reference article in the bibliography. Because many of the following descriptions concerning each mineral are composites of several references, no attempt was made to include specific page numbers for each reference.
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AEGIRITE

This vanadiferous mineral is found in the Rainy Creek area about seven miles northeast of Libby, Lincoln County. An intrusive stock, chiefly pyroxenite with about ten percent apatite, cuts pre-Cambrian (Belt) formations, and is itself intersected by numerous quartz veins and syenite pegmatites. Aegirite is found near the contacts of the pegmatites as acicular crystals oriented nearly normal to the walls, or as a layer of needles, mostly less than a millimeter thick, lining the numerous zones of fracture, especially in the dikes. Spherulites up to an inch across maybe scattered rather thickly through the vein material.

W. H. Weed in describing the analcite-basalts on Band Box Mountain and other places in the Little Belt Mountains, Cascade County, states that "the second generation of pyroxene occurs as small slender prisms, having a colorless diopside core, surrounded by a deep-green mantle of aegirite."

Fibrous and prismatic aegirite has also been reported as a replacement mineral in the Bear Paw Mountains, Fergus County, where one of the primary rock-making minerals is nephelite, a common associate of aegirite. In all of the occurrences mentioned above, a nepheline-syenite has been the host rock.

References: (46), (76), (103), (141).
AGATES

Common, moss, and landscape agates are found along the river beds on the west side of the Yellowstone River, and more rarely on the gravel bars of the Missouri River. Also in the Yellowstone region, agates are often found on the mesa's and buttes many miles from the river. Specimens are picked up as rounded cobbles which are often covered with a chalk-like hard coating of silica, and the sizes range from pieces the size of a hazel nut to large 12-pound chunks. The supply is dependant upon erosion by winter ice and spring floods of an amygdaloidal lava containing agates at the river's headwaters.

Eight miles up the South Boulder Canyon from the Jefferson River, there is a series of andesite lava flows ("Oatmeal lava") which, if amygdaloidal, contain large quantities of agates.

References: (2), (24), (50).

ALABANDITE

This mineral has been recognized in material from the Helena-Jefferson Mine in the Wickes mining district. The site of the occurrence is about two miles south of Jefferson which is on the Butte-Helena highway. The specimens were noted in the New York vein on a contact of quartz monzonite and aplite, the vein being made up largely of rhodochrosite, rhodonite, and alabandite for a width of several feet.

Reference: (58).
ALABASTER

No details of a reported deposit of anhydrite or possible alabaster in the Little Snowy Mountains in Fergus and Golden Valley counties were given.

J. P. Rowe states that a deposit of anhydrite, 14 miles west of Wibaux in Dawson County, is essentially alabaster. The crystals are found in a "gumbo" clay beneath a volcanic rock which caps a butte. The anhydrite is thought by some to have been formed from gypsum by the heat of the overlying lava, but the so-called lava is probably "clinker" caused by the natural burning of thick coal beds.

References: (13), (113).

AMAZONSTONE

At the falls of Lost Creek, 3 miles north of Anaconda, Deer Lodge County, a small pegmatite, that intersects the Belt series, has a central unit, as much as 6 inches on edge, containing about 20 percent Amazonstone.

Reference: (54).

AMETHYSTS

This mineral has been reported as occurring in the drift on a mountain side near Argenta in Beaverhead County. Crystals from the interior of siliceous geodes are said to be as large as three inches in
length and one and one-half inches in width.

The Pohndorf Amethyst Pegmatite is about 2 miles northeast of the Toll Mountain picnic grounds in the southwestern part of Jefferson County. A lens-shaped pegmatite, 140 feet long by 55 feet wide, in quartz monzonite contains three rock types; of which one, a vesicular to vuggy aggregate of microcline and quartz, contains amethysts crystals perched on the sides and tops of tourmalinated quartz crystals. Colors range from dark-brownish purple to a bright lavender, and the quality is excellent though not of gem caliber.

References: (54), (80).

ANHYDRITE

Except for occurrences approaching alabaster, outcrops of anhydrite have not been described in the literature. Some anhydrite can be found around most deposits of gypsum of which there is a considerable amount in Montana. Anhydrite is reported in great thickness in the records of many oil-test wells, and at Hanover, Fergus County, the presence of this mineral has caused the abandonment of many parts of a gypsum mine.

At atmospheric pressure and temperature, and in the presence of moisture, gypsum and not anhydrite is the stable form of calcium sulfate. So in the zone of circulating ground water, any change is from anhydrite to gypsum. It is natural to expect that any large body which was originally anhydrite will now be found to have three vertical zones, namely an upper layer of gypsum, a gradational zone of gypsum and

-12-
anhydrite, and a bottom zone of anhydrite, in many cases it will be found that top side, bottom, and interior hydration may cause layers or zones of anhydrite to exist between zones of gypsum.

It has been said that the evaporation of a solution of calcium sulfate above a temperature of 66 degrees Centigrade will cause the precipitation of anhydrite, but the presence of impurities, particularly the sulfates and chlorides of magnesium and sodium, will lower this critical temperature to about 25 degrees Centigrade. This accounts for the relatively large amount of anhydrite in many gypsum deposits.

References: (87), (106).

**ASBESTOS**

Chrysotile asbestos, which is found near Cliff Lake in southern Madison County near the Idaho border, is associated with serpentine in a limestone close to a diabase contact. This type of asbestos appears to be secondary from chrysolite, amphibole, or pyroxene. Other occurrences of this mineral are those 16 miles northwest of West Yellowstone in Gallatin County; in the Madison Range east of Ennis in Madison County; and a third in the Beartooth Mountains, south of Red Lodge in Carbon County.

Anthophyllite asbestos occurs in an extensive deposit near Karst Kamp in Gallatin County about 17 miles south of the Gallatin Gateway. Although the natural state of this mineral is dense and hard, the fibers readily part into a soft fluffy mass. Silky fibers an inch or more in
length have been obtained from some of the pockets and lenses.

A small amount of anthophyllite asbestos has been shipped from the Rainy Creek District, northeast of Libby in Lincoln County, and about 2,000 tons from near Karst Kamp.

References: (10), (13), (104).

ASH, VOLCANIC

This material, which locally appears to be suitable for use as a building stone, occurs in most parts of the state. Good deposits that might be utilized for construction are said to be found in parts of Beaverhead, Gallatin, Rosebud, Missoula, and Ravalli Counties. Most of these beds are either of tertiary or cretaceous age.

BEAVERHEAD COUNTY:

Outcrops and quarries of volcanic ash, said to have come from the Yellowstone, or the Ruby Mountains, east of the district, are located in the Frying Pan district, about 8 miles northwest of Dillon and about 2½ miles from the Oregon Short Line Railroad. The bed which is about 1 mile long by ½ mile wide has a thickness of 40 to 60 feet.

BROADWATER, and JEFFERSON COUNTIES:

Several large deposits are found in Neocene Lake Beds.

DEER LODGE COUNTY:

Beds are found along Silver Bow Creek, and near Rocker. It is also said that an extensive deposit exists near the eastern end of the Lost

1This name is used in conformance to the titles found in most of the references, although the U. S. Bureau of Mines prefers the term Pumacite, in that no combustion is involved.
Creek Valley.

FERGUS COUNTY:

The occurrence in this county is directly east of those in Cascade County, or southeast of the same source, the Highwood Mountains. One prominent outcrop on Arrow Creek is also in the Colorado formation.

GALLATIN COUNTY:

The best exposures in the northern part of the county are the largest in the state. One pure deposit which was probably laid down in water has a thickness of 15 to 20 feet. Above this homogenous ash, there are several layers of impure beds, probably created by erosion and deposition, these latter varying in thickness from 100 to 1000 feet.

GRANITE COUNTY:

Unconsolidated thin beds are fairly common in Hell Gate Valley, while other beds of nearly pure ash, although coarse, are found at New Chicago, and along Dunkelburg Creek, also a cap of volcanic ash and clay is rather prominent, 2 or 3 miles up the river from Drummond, where it forms an outcrop on the left side of the highway for about a mile.

MADISON COUNTY:

The ash in this county is similar to that of Gallatin County. Along Blacktail Deer Creek in Madison and Beaverhead Counties, a deposit from 70 to 80 feet thick has been weathered into picturesque pillars and towers. A 6 to 12 inch bed of volcanic dust on Norwegian Creek in the Tobacco Root Mountains is so fine that most of it will pass through
a 100-mesh screen.

MEACHER COUNTY:

Rhyolitic tuffs and ash beds from the Castle Mountain area are abundant over the whole district, but especially around White Sulphurs, and all of the way down the Smith River Valley.

MISSOULA COUNTY:

Fossiliferous ash beds (contain plant leaves) which show distinct bedding and stratification are found north of Missoula at an elevation from 400 to 600 feet above the valley. One individual bed is known to have a thickness of 35 feet.

PARK COUNTY:

Erosion has left only minor remnants of beds which were apparently of the Neocene Lake type.

POWELL COUNTY:

The beds are impure and poor. Those below Helmville contain organic matter, clay, and a few diatoms.

RAVALLI COUNTY:

The best beds are in the Bitter Root Valley, with the largest being near Victor, near the foothills along the east side of the valley. Two different beds have been found, one with 8 feet of coarse compact ash, and the other with a few feet of very pure fine ash.
SILVER BOW COUNTY:

The ash deposits are of the lake bed type, and are compact but unconsolidated, being made of sand, gravel, rhyolitic tuff, and clay. The ash in the deposits north of Melrose is quite fine and has been cemented by a calcareous cement.

ROSEBUD COUNTY:

The description of the volcanic ash bed near Forsythe only stated that it had a thickness of about 3 feet.

References: (11), (52), (118).

BADDELEYITE

This rare mineral has been identified in specimens from the property of the Bozeman Corundum Company, 14 miles southwest of Bozeman. It occurs as minute crystals and rounded blebs, with a maximum size of about 3 millimeters, in both feldspar and corundum, but especially on the surface of corundum. It is an accessory mineral of gneissoid corundum-syenite and seems to be confined to rocks low in silica, which fact causes its formation rather than that of zircon.

References: (114), (150).

BARITE

Barite is found in many places in Eastern Montana in the Upper Cretaceous formations, but the best crystals are located just below a seam
of lignite above the Laramie clays. In Western Montana, the barite is found in other formations, and also as a gangue in ore veins.

An outcrop of several hundred feet in length with a width of 2 or 3 feet of pure barite is reported on the west bank of Pattee Creek, north of Mt. Miller, 2 miles southwest of Missoula, Missoula County.

A productive stratum has been traced for \( \frac{1}{2} \) of a mile in the Fox Hills formation at the head of Cabin Creek, 23 miles southeast of Ekalaka, Custer County, at this place, nodular barites, 5-10 centimeters long and 3-7 centimeters on the short axis have been reported.

Imperfect crystals, 6 to 8 cm. in length and 1 cm. thick, are found on Cedar Creek, 25 miles from its mouth, in Wibaux County. Another occurrence in Wibaux is said to be on the east bank of Beaver Creek, 3\( \frac{1}{2} \) miles south of the town of Wibaux. In this particular terrain, the best exposures are always found in rain-eroded ditches.

Other discoveries have been made, namely, crystals near Stanford in Judith Basin County, and a massive barite in the Ruby Mountains of Madison County, also, a bed of barite, three inches thick, occurs near the top of the Jefferson limestone in sec. 7, T. 2 S., R. 8 W. in the Melrose mining district, Silver Bow County. It is conspicuous because of its whiteness, and makes an easy horizon to trace.

A good example of barite occurring as gangue is that in the ore of the Hope, Midnight, Modoc, and other mines of the Philipsburg area in Granite County.

References: (13), (119), (121).
BENTONITE

Deposits of this mineral are rather widespread in Montana, but their generally low grade has precluded any substantial development.

In Treasure County, 6 miles north of Hysham is a deposit that is said to be 5 miles long with a width up to one mile, and a thickness varying from 10 to 30 feet.

An idea of the extent of a bed of bentonite in Montana may be derived from an occurrence in the Judith Basin where 5 to 30 feet of this material are found 550 feet above the base of the Colorado shale in the Colorado formation in which this bed of bentonite is a geologic marker for the region. From a good exposure on Arrow Creek, 6 miles north of Geyser, the beds extend eastward around the margin of a hill north of Merino to the upper part of the slopes of Stanford Buttes. It then appears on Skull Creek, 2 miles east of Stanford, and along the tracks of the Great Northern railroad, 3 miles east of Windham. The horizon is seen in cuts of the Milwaukee railroad northeast of Moore, and at the main highway crossing of Beaver Creek, 8 miles west of Lewistown. It is believed that this same formation is represented by the thin slabby sandstone with a silver-gray cast near Grass Range, 50 miles away, and in the Little Rockies, 75 miles away.

Some beds near Miles City, Montana, have been found to consist of 10 to 15 percent cristobalite, 10 to 15 percent quartz, and the rest is montmorillonite. The cristobalite has not been found to have any adverse effect on the use of the bentonite for drilling muds.
An occurrence known as the Kelly Deposit, is found on the Butte-Anaconda highway, 16 miles west of Butte. There is also a smaller body of this material, known as the Perry Deposit, about 10 miles west of Butte. Both are associated with the same geological formations, namely, the andesitic and rhyolitic flows of Cretaceous and Tertiary age.

In contrast to the previous deposits which seem to be associated with an origin involving volcanic ashes, a vein-like mass two to three feet in thickness is found on the property of the Lincoln Mining Company of Anaconda in the Dry Cottonwood Creek valley. Dry Cottonwood Creek enters the Deer Lodge River about half-way between Warm Springs and Race Track, and the bentonite is found 7 miles up this valley from the main highway. The origin could be due to the alteration of a vitrophyre dike, or from the alteration of a clay gouge created by large-scale faulting in igneous rocks, no sedimentary rocks being present. The granite present, which seems to be pertinent, is probably Late Cretaceous or Early Eocene.

References: (5), (13), (48), (77), (105).

BLACK SANDS

The occurrence of Black Sands is statewide, and studies have been made to determine if any valuable rare minerals were present in desirable quantities. Besides showing that there is a dearth of the valuable minerals, Columbium and Tantalum, the studies have shown a marked contrast between the mineral composition of samples from the plains region of the eastern part of the state and the mountainous area of the west.
In the west the bulk of Montana black sands comprises impersistent rock minerals as magnetite, hematite, ilmenite, chromite and garnet, and is augmented by less dense transparent minerals as zircon, monazite, barite, epidote, and rarely hornblende, pyroxene, tremolite, tourmaline, spodumene, and corundum. Some of the above are not abundant but are persistent. (The spodumene from Philipsburg is said to be the only occurrence of a mineral in Montana with Lithium).

The eastern deposits are characterized by different minerals that are associated with metamorphic rocks, namely, cyanite, staurolite, titanite, rutile, hornblende, andalusite, hypersthene, and sillimanite. The deep-seated metamorphic rocks of the east very obviously contrast with the relatively young rocks of the west.

Montana stream sands carry a larger percentage of dense persistent minerals than do average localities. It was suggested that prolonged chemical weathering with deep ground-water circulation, and a minor amount of erosion on dissected plateaux has allowed the minerals to remain, and they are only now being concentrated in placers.

References: (20), (143).
**BLACK SANDS**

Samples of Black Sands  
(Lbs./ton—except gold and platinum—dollars/ton).

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<th>Garnet</th>
<th>Olivene</th>
<th>Monazite</th>
<th>Zircon</th>
<th>Quartz</th>
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(Copied from reference No. 20).

None of this is platinum.
CALCITE
(Iceland Spar)

Calcite crystals of commercial quality are found near Greycliff, Montana in two vertical parallel veins in gneiss. These veins which are twelve miles southwest of Greycliff vary in width from 4 to 7 feet and strike northwest for several miles. A less important occurrence of calcite is found about one miler closer to Greycliff, while a third body of calcite is known 10 miles west of Greycliff, and 4 miles from Big Timber. A probable depth of 100 feet has been suggested for the veins.

Iceland spar has also traced from Upper Deer Creek in Sweet Grass County as far as Wilsall, in Park County.

References: (12), (13), (63), (94), (122).

CEMENT

At the present Montana has one cement plant in operation at Trident. If economic conditions should ever warrant more plants, there is an ample supply of materials available. A cement mixture is one that contains approximately 75 percent calcium carbonate, and 25 percent clay minerals, also included should be some magnesium carbonates and other impurities associated with limestone. Sometimes the ingredients occur naturally in the proper proportions and the material is then known as a "cement rock", but any mixture of limestone and clay which has a silica-alumina ratio between 4 to 1 and 3 to 1 can be utilized.

An example of a "cement rock" is a deposit 5 miles west and a little south of Havre. Here, beds of marl and shale in just the proper
proportions, have been metamorphised by an intrusion of monzonite porphyry, to make an ideal material for a cement plant. The beds which are 15 to 20 feet in thickness underlie an area of about 80 acres. The lack of fossils has prevented the determination of the age of the beds.

References: (4), (102).

CHALK

A narrow band of Niobrara chalk is said to outcrop in the foothills south of Livingston, Park County. It contains much clay, and frequently grades into shales with interbedded clayey sandstones. The east-west trending outcrop is exposed at Cinnabar Mountain, near Cokedale, and in the fronts along the Boulder River.

Reference: (145).

CHROMITE

The Stillwater County chromite deposits occur in southern Montana between Red Lodge and Livingston, in the Beartooth Mountains. Here a differentiated sheet or dike, known as the Stillwater Complex, is one-half to a mile in width and extends from Boulder Creek to Fish Creek, a distance of about 30 miles. Chromite which occurs on an horizon in the ultrabasic zone is found in harzburgite about 1000 to 1500 feet above the base of the complex. The chromite is commonly intergrown with silicates, of which bronzite is said to be the most usual, except on the Boulder River where an intergrowth of chromite and olivine prevails.
The ores form bands conforming to the banding of the surrounding rocks, but the bands may split and protrude into the surrounding rocks. The chrome zone may have a thickness of about 90 feet while individual deposits of chromite may be from a few inches to five and one-half feet in width.

Five areas have been partially developed in the region of the complex. They are Hellroaring Plateau, Line Creek Plateau, and the Silver Run Plateau, the latter with three exposures: Edsel, Four Chromes, and the Chrome Creek deposits. The Edsel Plateau is about 10 miles from Red Lodge, while the other two plateaux are about 20 miles.

On the western slope of the Tobacco Root Mountains, 3 miles south and 4 miles east of Sheridan, Madison County, are some lenticular masses or segregations of chromite in a series of diorite rocks. One deposit is known on Horse Creek while another is found near Iron Rod. Diorite dikes cut the gneiss composing the country rock to create lenses of chromite which sometimes have a width of five feet. The outcrops have been traced for about a mile. The grade is said to be from 21 to 35 percent Cr₂O₃.

References: (22), (61), (64), (126).

CINNABAR

It is said that near Boulder, Jefferson County, earthy cinnabar lines the fractures in chalcedony, a material which is found in fissures in a granitic rock, also minor amounts have been reported in sluice boxes.
A number of clay deposits of different geologic ages and origins occurs throughout Montana. Most are utilized only locally, primarily because of the lack of any outstanding qualities, and also because of the limited demand for ceramic products in this region.

There is in the eastern part of Cascade County an area of about 145 square miles of good clays. The eastern part of the region involved includes the plains region between the Little Belt and Highwood Mountains, while its western part lies in the Belt Creek Valley and in a small portion of the surrounding plains. Belt, a small coal-mining town, and Armington are located in the northwestern part of the clay deposit. The Kootenai formation which covers the surface of most of the area contains several horizons with commercial bodies of clay and shale. This formation, about 450 feet thick, is said to contain about 60 feet of desirable clay. The Anaconda Copper Mining Company has been conducting operations at Armington to secure clays for refractory purposes. In the past, use has also been made of clays occurring near Spion Kop on Williams Creek.

Near the top of the Kootenai, one-eighth of a mile west of the Great Falls smelter is a deposit of sandy clay or argillaceous shale which has been used for bricks and convertor liners. At Fields, three and one-half miles east of Great Falls, there is 42 feet of silicious
clay which has been used but is now abandoned because of a high-iron content. Other users of the Kootenai (Lower Cretaceous) clays have been the Great Falls Brick Company at Tracy and Sand Coulee, and the Lewistown Brick and Tile Company.

A clay bed of white material in the Fort Union formation of Tertiary age in the vicinity of Plentywood, Montana has been used locally for plaster and mortar but a buff color after burning spoils it for making white crockery, and the softening temperature during heating is too low for use as refractories. The known extent is said to be about 18 miles by 8 miles with a thickness of 4 to 8 feet.

A bed, 10 to 12 feet in thickness, of brick, tile or earthenware clay is found at a number of horizons in the Lance formation along an escarpment in the Ekalaka Hills in T. 1 N., R. 58 E. It burns to a gray color from a light green.

Pressed brick is manufactured by the Havre Brick Co. from a pit in the Judith River formation.

Bozeman lake beds (Tertiary) near Missoula, Montana provide the clay used by the Missoula Brick and Tile Company. Use is made of alluvial clays at Kalispell and Billings (Fromberg Brick Company).

In the past the Pioneer Brick and Fuel Company of Butte made use of a red to blue-gray shale from a pit in the Belt series of the pre-Cambrian formations, 8 miles east of Whitehall, Montana. In Deer Lodge, Montana, surface clay from a pit 1 mile southeast of town was used. Of present day operators, the Western Clay Manufacturing Company of Helena, Montana, is making very satisfactory products from a light blueish-gray clay from
Blossburg, between Helena and Elliston.

Thorough decomposition of a monzonite porphyry on the south slope of Mt. Miller in the New World Mining District provided material which after some beneficiation was used for a fire clay. Other local deposits are said to be suitable for bricks.

A potential clay source is the Fort Union formation of Tertiary age in eastern Montana. Similar horizons are successfully used in North Dakota, also, a small deposit of fire clay in Cretaceous rocks occurs in the Lost Creek canyon near Anaconda.

A deposit consisting primarily of the kaolin mineral dickite occurs in the South Moccasin Mountains of Fergus County, Montana. This white-firing clay is approximately three miles northeast of Hanover, Montana, in the SW_2 sec. 12, T. 16 N., 17 E. Occurring in the Heath formation of Mississipian age, this chalky-white, massive and blocky clay is overlain by a sandstone, and is supported beneath by a shale, both of this same geologic age. It has been suggested that hydrothermal alteration of a syenite sill created this clay deposit, several masses of syenite porphyry now being present in the locality. The kaolin deposit lies along a fault plane once suitable for the circulation of water, and it is believed that later applications of heat and pressure after alteration by hot water formed the present compact mass of kaolin. The volume of this valuable material is not known.

References: (8), (9), (23), (33), (69), (72), (78), (112).
COLUSITE

This mineral, named because of its discovery near the Colusa claim in Butte, has been found almost entirely within the "horsetail" area of an intensely altered quartz-monzonite zone. It has been noted only in the East-west or Anaconda system, and has not been found above the 1200 level.

References: (74), (88).

CORUNDUM

Deposits of this mineral have been described in Madison, Gallatin, and Beaverhead Counties, the only production being from the Elk Creek deposit, southwest of Bozeman. In Gallatin and Madison Counties, the corundum is found in thin lenticular layers of a biotite-sillimanite gneiss of the highly-metamorphosed Pony series (pre-Cambrian). S. E. Clabaugh believed the corundum because of its structure and composition was created in alumina-rich shale and sandstone beds by metamorphic processes. The largest known corundum-bearing body is found at Elk Creek where the Montana mine, the only producer of abrasive corundum in the western half of the United States, was operated for a short time at the turn of the century. The lense which is 800 feet long, 1 to 2 feet wide, and about 50 feet deep is said to now have a reserve of several thousand tons of 10 percent coruncum. The location, 23 miles south of Belgrade, is in secs. 22 and 23, T. 3 S., R. 3 E.

The Bozeman deposit is in the foothills of the Gallatin Range, about
3 miles west of the Gallatin River and 8 miles northwest of Gallatin Gateway. More specifically it is in sec. 31, T. 2 S., R. 4 E. of Gallatin County. The corundum is in pegmatite dikes in gneiss and has two zones parallel to the structure of the enclosing rocks. Of the 28 lenses which have been located, the longest is 100 to 200 feet, and nearly all are less than 1 foot in width. The overall corundum content is less than 0.1 percent.

The Bear Trap deposit in sec. 6, T. 4 S., R. 2 E. is generally similar to the other two. The older references describe considerable development at Anceny, 5 miles west of the Bozeman deposit, but investigators in 1943 were unable to find any trace of this deposit.

The Camp Creek corundum deposit which is in the NE$_{1}^{\frac{1}{4}}$ sec. 36, T. 8 S., R. 8 W., is in the Ruby Range southeast of Dillon, Beaverhead County. The gray corundum rock is found in an impure marble that contains various calcium-magnesium silicates. Most of the corundum crystals are concentrated in layers parallel to the foliation of the surrounding rocks and some of the layers are several inches thick with individual crystals having an average diameter of about $\frac{1}{4}$ of an inch. Possibly the original constituents of the Cherry Creek marbles were altered by regional metamorphism in pre-Beltian time to create the corundum and other minerals now associated with the deposit.

References: (6), (17), (55), (89), (107).
CRISTOBALITE

Identified by use of the X-ray powder method, cristobalite has been definitely determined as being a part of the constituents of bentonitic clays in the vicinity of Miles City. This mineral whose origin has not been determined has not been found in clays older than the cretaceous nor has it been found in volcanic ashes.

Reference: (48).

DESCLOCIZITES

W. F. Hillebrand in an 1889 article reports the occurrence of this mineral in the Mayflower Mine, Jefferson County, as a "lump of friable, uncrystallized material having a dull yellow to pale orange color, and consisting chiefly of vanadium, but carrying a large percentage of gangue". In this same deposit earthy vanadate was associated sometimes with a compact cerussite and galena in the process of alteration.

Reference: (59).

DIAMONDS

The authenticity of reported finds of these stones is doubtful, but the localities mentioned for discoveries in placers are in Grasshopper Gulch, and in Green Horn Gulch at Black Foot in Deer Lodge County. J. R. Mead has been quoted as stating diamonds were found at Ophir Gulch.

Reference: (80).
DIATOMACEOUS EARTH (DIATOMITE)

In the Townsend Valley of Broadwater County, diatomaceous earth occurs in layers interbedded with Oligocene clay and tuff, the deposit being indicative of an accumulation at the bottom of a pond. One outcrop is about a mile north of Beaver Creek, in a bluff facing the Missouri River (sec. 27, T. 9 N., R. 1 E.). Two one-foot beds are in evidence, and of these one is chalk white and quite pure.

Another place where diatomite is found is north of Greyson Creek near the east line of sec. 13, T. 6 N., R. 2 E., about five miles southeast of Townsend. Here a 10-foot, light-gray bed is thinly laminated like a shale. Lime and other impurities are mixed into the earth.

Reference: (93).

DOLOMITE

Most of the lower Paleozoic calcareous formations in Montana contain varying amounts of dolomite in their compositions, some being almost pure dolomite. The Pilgrim, Big Horn and Jefferson formations of southwestern Montana are excellent horizons in which to expect the occurrence of local deposits of nearly pure dolomite. The occurrences in the mentioned formations are massive with a sugary appearance but may be tough, firm, and compact. These general statements apply to other regions of the state where the nomenclature may be different, for example, numerous specimens of dolomite may be obtained in the Hasmark (Cambrian) formation.

References: (30), (106).
Most of the fluorite deposits in Montana are of replacement origin and are localized along poorly defined shear zones. Ordinarily the fluorite has a distinctive purple color but it may be found as colorless, tinted-green, or other colors, also, it normally has an octahedral cleavage but this may not be readily observable in grains of small size.

There are several deposits of fluorite in the Sweet Grass Hills in Liberty and Toole Counties, specifically along the irregular contact of Madison limestone and the alkalic syenite mass of Mount Royal in East Butte, the occurrences along Tootsie Creek being the most promising. The area most likely to become productive is in T. 36 N., R. 5 E., but minor bodies have been noted in T. 36 N., R. 4 E. The Tootsie Creek deposits, in secs. 19 and 20 of the first area given, are much larger than occurrences on Sage Creek, Halfbreed Creek, and Coral Creek. It is interesting to note that large deposits are limited to the East Butte of the Sweet Grass Hills.

The Spar Prospect, located in T. 17 N., R. 27 W., about 12 miles from Superior, Mineral County, was an extremely high-grade deposit of fluorite and was soon worked out. Strata of the Wallace or Newland formation of the Belt series was intruded by a dike which contained a lense of quartz with a body of fluorspar as an inclusion.

The Boeing Prospect, 3½ miles west of Austin, Lewis and Clark County, occurs where a felsitic dike cuts Madison limestone. This dike is said to be a biotite rhyolite which has been altered to montmorillonite.
The fluorite is found in irregular pockets or pipelike bodies, up to 2 feet by 6 feet, in the limestone. Because the fluor spar has been found at only one site in this district, it is possible a quartz monzonite stock, a short distance south of the prospect, may have been involved in the genesis. A very irregular, shattered, and mineralized zone containing fluorite is found on "weather vane" hill back of the Anaconda smelter in Deer Lodge County. The zone with a length of several hundred feet has numerous fissures and fractures which are filled with quartz and fluorite in an irregular pattern. The largest body is about 2 feet by 20 feet, but most are only a few inches to a few feet. Mining would be expensive, but high-grade specimens can be easily obtained in vugs. The age of the limestones is indefinitely given as Paleozoic.

A Silver Bow County fluorspar prospect is located about 6 miles west of Butte on Silver Bow Creek, the principal exploration being in sec. 13, T. 3 N., R. 9 W. (1/2 mile east of Silver Bow railroad station). A fault contact of andesite with quartz monzonite and aplite has created a zone where fluorite occurs in shoots, especially between the andesite and the Boulder Batholith. A zone, nearly 250 feet long and from 50 to 90 feet wide, is stated to contain bands of fluorspar ranging in widths from a few inches to 3 1/2 feet and with a length in the 10's of feet.

In the Ruby Gulch Mining District, Philips County, fluorite is common but the occurrences are sporadic. Its zone of occurrence is about three feet in width, and is always found in one of the major fault zones. It is most abundant above the 300-level but has been found in all depths of the mines. Ordinarily this fluorite forms a fine-grained
cementing materials for crushed porphyry fragments. This region is characterized by syenitic intrusive bodies cutting into limestone.

Replacements deposits of fluorite are found in T. 17 N., R. 19 E., in the Judith Mountains, northeast of Lewistown, Fergus County. Granitic and syenitic intrusive rocks and the Madison limestone are associated with the creation of the fluorite.

Lodes of fluorite are also found in the vicinity of Philipsburg, Granite County, especially in T. 8 N., R. 12 and 13 W. and T. 7 N., R. 13 W. The claims with this mineral are the Albion near the Deer Lodge Basin; the Banker along Boulder Creek near Princeton (said to have a 6 inch vein of high-grade CaF₂); the Mystery near the Boulder claim; and the Hope Mine. Fluorite is also a primary constituent of the alkaline rocks on Lost Creek, Granite County. Fluorite is also abundant in an association of metamorphosed shale of the Silver Hill formation (Cambrian) and a decomposed granitic rock along Mill Creek, Deer Lodge County, in the southeast part of the Philipsburg quadrangle in T. 4 N., R. 12 W.

Other localities in the state where this mineral has been observed are at Duck Creek Mountain in the Belt Mountains, 23 miles northeast of Townsend, Broadwater County; near Elkhorn, Jefferson County (T. 6 N., R. 3 W.); and in the Bell Boy and Bald Butte districts near Marysville, Lewis and Clark County. Specimens have been obtained at Potosi, Madison County, and also near the Mullan Pass, west of Skyline, in Lewis and Clark County.

References: (13), (27), (117), (137).
GARNETS

This mineral gave its name to the Garnet Mining District in Granite County, Montana. At this place a contact zone between limestone and granite contains many minerals of the contact type, especially garnets.

A similar origin is given for garnets in the Broadway Mine at the south end of the Mt. Tory Batholith where it contacts limestone near Bannack, Montana.

The placer miners on the upper Missouri found many garnets with the sapphires that were saved during their operations, also the Perry-Schroeder dredge which recently has been reworking some of these old gravel bars near Helena encountered and saved many garnets and sapphires.

An unusual rock occurs on the north side of Copper Mountain in the Tobacco Root Range, about 8 miles east of Sheridan. It is composed of 45 percent garnet, 40 percent emphaclte, 10 percent quartz, and 5 percent magnetite. This rock does not form an outcrop but weathers readily into reddish brown fragments and appears to be an eclogite. The garnets contained by the rock are generally less than one sixteenth of an inch in diameter.

References: (25), (115), (134), (149).

GOSLARITE

This zinc mineral has been found in some old workings on the 400-level of the "Gagnon" mine in Butte. It is associated with copper sulfate, and could be a decomposition product of cupriferous sphalerite.
Its normal occurrence is in tuffs curving downward from walls. The tuffs are sometimes nearly $3\frac{1}{2}$ inches in length.

Reference: (95).

**GRAPHITE**

The best known deposits of graphite are about 16 miles south of Dillon, Beaverhead County, on a ridge between Van Camp Creek and Timber Gulch, near the southwest end of the Ruby Range. A complex series of gneisses, schists, and dolomitic marbles (probably the Cherry Creek series underlain by the Pony series) was intersected during the Late Cretaceous or Tertiary times by many coarse to fine-grained granite-pegmatites and dark-colored igneous dikes of diabase, the result being the creation of graphite by the hot solutions and vapors usually associated with this type of igneous activity.

Three general types of occurrence for graphite are recognized in this district, namely as vein-like bodies or veinlets in the gneisses and pegmatites, as disseminations and irregular small masses in the pegmatites, and as disseminations in the metamorphic rocks. The veins or veinlets are essentially a roughly-parallel series of small pockets of graphite, which considered collectively make up an ore zone. Most of the pockets are only a few feet in length and depth, and a few may have a thickness of about six feet but the average is between 1 to 4 inches for these bodies which swell and pinch rapidly in a short distance. These veins which cut pegmatites and gneisses indiscriminately, in effect create a
honey-comb framework composed of graphite-filled fractures in a disseminated-graphite rock. An ore zone in this district is considered to be persistent to fairly great depths. The graphite disseminated in the pegmatites is coarser grained, and at irregular intervals masses or rosettes may appear. In the gneisses, fine-grained graphite is most abundant, the quality increasing in the area between two veins or in proximity to a vein. Essentially there is an intergrowth with quartz, feldspar, and mica, the latter disappearing locally so that graphite may become as much as one-third of the rock.

Although this district obviously had considerable graphite deposited in fissures and cavities, evidence is also abundant that replacement processes were very active and effective. One theory states that the carbon necessary for the formation of graphite may have been originally derived from the calcium carbonate in marble. The deep-seated exposure of marble to high temperatures in excess of its decomposition point would generate carbon monoxide. The oxidation of this gas to the dioxide form at a later stage would leave some carbon available for deposition as graphite.

Crystalline graphite is associated with talc at the Crescent Talc mine in Timber Gulch, 3 miles southwest of the deposits described above. Individual flakes are disseminated through the talc in sizes up to one-eighth of an inch across. As the graphite constitutes only one-half of one percent, no commercial value is now given to the graphite.

Graphite deposits occur in secs. 27 and 34, T. 12 S., R. 11 W., on a divide between Medicine Lodge Creek and Muddy Creek, 12 miles west of Dell, Beaverhead County. Here, a pre-Cambrian series of gneisses and
schists have been thrust against Madison (Mississipian) limestone by a late Cretaceous or Tertiary fault which had a displacement of about 4000 feet. In the large fault zone, graphite is found in the gouge, fault breccias, and in the crushed gneisses in both the main and subsidiary faults. It appears that pre-existing minerals were replaced by hot solutions or vapors escaping from great depths through the fault zone to produce the present graphite supply with a grade of about 12 percent.

Graphite is associated with a gold-bearing quartz vein at the Missouri-McKee mine northwest of Ennis or 10 miles west of McAllister in Madison County. The veins are believed to be of Cretaceous or Tertiary age.

References: (15), (104), (122), (136), (147).

GYPSUM

The vast deposits of gypsum in Montana have been arbitrarily divided by several writers into separate fields, commonly referred to as the northern, middle, and southern fields. The material in Cascade and Fergus Counties comprises the northern field, that in the vicinity of Limespur, Jefferson County is the middle field, and the huge gypsum bed in Carbon County represents the third field. One author considers the gypsum deposit at Libby, Montana, to be the northern field.

Gypsum in Montana occurs in two manners; first, as selenite crystals disseminated throughout the Bearpaw and Clagget shales of Cretaceous age. There is a great diversity of forms and sizes, and concentrations may be
found in the "bad land" country where erosion has removed the shales.
The second mode of occurrence is in the form of beds, and disintegrated
gypsum or gypsite deposits.

The age of the most important beds is believed to be Jurassic but
some are late Carboniferous and possible in part are Permian and Triassic.
In Central Fergus County, a domal uplift followed by erosion has exposed
Jurassic gypsum-bearing strata. The top bed has disintegrated to form a
7 to 11-foot layer of gypsite, followed by a layer of limestone with a
thickness of a few feet, and this in turn is followed by a bed of pure
white gypsum that can be easily mined because of its thickness of 15 to
32 feet. The best exposure is at Hanover on the north side of Big Snowy
Creek in the south Moccasin Mountains, 8 miles northwest of Lewistown.

Good high-grade beds of gypsum also occur at Heath, 8 miles south­
east of Lewistown. Here 13 to 14-foot outcrops are in evidence in the
SW 1/4 sec. 1, T. 14 N., R. 14 E., and in a railroad cut in NW 1/4 sec. 12.
The U. S. Gypsum Co. has a 300 acre lease in secs. 1 and 2, T. 14 N.,
R 19 E., in beds 5 to 10 feet thick, interbedded with limestone, limy
shales, and variegated clay shale.

The beds in Fergus County (in Ellis and Quadrant formations) go along
the north side of the Little Belt Mountains, around the Big Snowy Mount­
ains, and probably also around other domes than the one mentioned. Ex­
posures are on the East Fork of Spring Creek, near Irene, on the south
side of the Snowys, in the foothills southeast of Moore. On Alaska Bench
(east of the Snowys and near the N ranch), and northwest of Tyler.
Further to the south the beds become thin and impure.
In Cascade County, 3 to 6-foot beds are exposed near Milligan, Riceville, Goodman, and Kibbey. Near Milligan, the outcrops are in T. 15 N., R. 3 E., in the hills 4 miles north, on Freeman Creek near Longshire. These massive beds, several feet thick, are said to be in the Kibbey formation of the upper Carboniferous. At Riceville on the now abandoned Neihart branch of the Great Northern railroad, there is a 3 to 6-foot bed of upper Carboniferous age (otter formation). The deposit at Goodman has not been successful commercially, and it is said that the main bed has not been definitely determined. Kibbey which is 10 miles east of Riceville has a 13 to 15-foot bed at T. 16 N., R. 8 E. Another bed is found 12 miles east of Kibbey and 7 miles south of Geyser, on Tree Creek.

Big Horn County has a very large deposit in the Chugwater formation, about 20 miles from a railroad, where three beds, of 6, 60, and 50 feet each, occur in Red Valley, west of Lodge Grass Creek, in the Crow Indian Reservation at the north end of the Big Horn Mountains.

South of Billings, Montana, near the border of Wyoming, are three additional fine outcrops of gypsum. The smallest of the three is 8 miles southeast of Bridger where the gypsum is 10 to 12 feet thick. The second, 8 to 10 miles from the first, has a 15 to 20-foot thickness with an outcrop length of 1 to 2 miles, while the third and largest is found near Crockett on the railroad, 6 miles northeast of the first and 45 miles north of the second. From 20 feet at the southern edge of the outcrop, the thickness increases to a maximum of 50 feet during its known length of 3 miles. It is exceptionally pure.

This gypsum, south of Billings, is said to lie at or near the top of
the Chugwater formation. Of the thicker beds of this material, R. S. Knappen says that the upper 20 feet is a characteristically white granular gypsum. It has been mined at sec. 18, T. 7 S., R. 24 E., also a valuable reserve is said to underlie the Sundance formation in T. 7 S., R. 24 E.

Gypsum in Madison County is found in two beds in the vicinity of Lyons. Near sec. 10, T. 11 S., R. 3 E., which is between Cabin and Beaver Creeks, small tributaries of the Madison River, there are 10 feet of gypsum in the Dinwoody formation (below the "Red Beds" of the Chugwater formation and just over the Phosphoria formation). This bed is 10 miles east of Lyon, but the other deposit is about 12 miles west of Lyon, where it is in the NW¼ sec. 27, T. 10 S., R. 2 W., and is exposed along a wood road as a bed 10 to 20 feet in thickness. Located at the head of Trail Creek at the summit of the Gravelly Range (the southern extension of the Tobacco Root Mountains), it is thought to be in the Ellis formation above the "Red Beds".

The Jefferson Canyon gypsum deposit is in the northern tip of the Tobacco Root Mountains in the southeast corner of Jefferson County, and is 15 miles east of Whitehall. At the best this is a very small low grade deposit possibly of Devonian age, although one writer specifies a Jurassic (Morrison) age. The gypsum occurs as a bed or lense intercalated in the Jurassic (?) limestone. Circulating ground waters in the low grade material became gypsiferous solutions which redeposited calcium sulfate near or at the surface to create enriched zones. Most of these enriched deposits have been mined.
W. H. Weed mentions a place near Hunter's Hot Springs on the north bank of the Yellowstone River about 20 miles east of Livingston, where hot waters are depositing gypsum. Old fissures were said to be filled with a mass of gypsum and stilbite, and now make veins 1 to 5 feet in width. Later investigators were reported as being unable to find the site of this phenomenon.

References: (13), (38), (67), (70), (106), (109), (120), (132), (133).

HASTINGSITE

This mineral is found in notable amounts in a large laccolith forming the crest and west slope of a large anticline in the Crazy Mountains, Sweet Grass County. A number of sills and laccoliths which are interbedded with shales and sandstones of the Fort Union formation contain alkaline rocks, of which one, namely, theralite, is the host for hastingsite. Associated with aegirite, hastingsite occurs as an aggregate of subhedral grains which are distinguished from aegirite by their more perfect cleavage and characteristic pleochroism, also larger specimens may be found with well-developed prismatic and terminal planes.

The medium to coarse-grained, dark-colored theralite composed of biotite, augite, white feldspar, and nepheline contains enough olinene, often in nodules or elongated masses, to suggest either gravity settling or the straining out from the fluid magma by pressure. It has been suggested that the amphibole formed last of the mafic minerals and that these were followed by nepheline and feldspar. The lowered temperatures
accompanied by the increased concentrations of the alkalies caused alter-
ation of diopsidic augite to aegirite-augite, and then to hastingsite.

Reference: (146).

**HEDENBERGITE**

This mineral is found along a limestone-monzonite contact in the Silver Star mining district which is about 35 miles southeast of Butte. The contact is on the southern boundary of the Boulder batholith where it meets the Madison limestone of Mississipian age. The hedenbergite is found in the vicinity of the Broadway mine in an altered zone which has a deposit 350 feet long with the zonal width varying between 100 and 200 feet, or a surface outcrop of about 2800 square feet.

Reference: (138).

**HELVITE**

This rare mineral has been identified by optical and spectroscopic tests as occurring in the west drift of the 200-foot level of the Lexington mine in Butte. Its mode of occurrence was as sparse yellow grains as much as 2 millimeters in diameter, and as veinlets about one millimeters wide in the midst of a pink rhodochrosite and rhodonite specimen. The mine workings were inaccessible so that no determination of mineral associations could be made.

Reference: (62).
HEMATITE

A potential orebody is that of the "Running Wolf" hematite deposits in Cascade and Fergus Counties in Central Montana. Located on Running Wolf and Dry Wolf Creeks, 12½ miles southwest of Stanford (on Great Northern railroad), and about 54 miles southeast of Great Falls, these deposits are just within the northern border of the Little Belt Mountains. Formed by replacement of limestone, the ore is a compact gray or reddish-gray hematite which in places has just enough magnetite to be magnetic. The ore bodies range in width from 5 to 60 feet with an average of about 20. Practically no limonite, pyrite, or chalcopyrite are present.

Another hematite orebody is that on Sheep Creek in Meagher County, Montana. Here thin-bedded shales and arenaceous limestones surrounding the deposit have been tentatively assigned to the Algonkian Belt series. The detailed structure of the area is not known but apparently a westward trending anticline contains prominent steeply dipping fissure and breccia zones which had a structural control of ore deposition. The results from churn drilling indicated that solutions migrated outward along bedding planes from the fissures to cause ore deposition. Only two fissures in the region have been positively identified, and each has a width of 12 to 50 feet (average is 38.4) with a length of about 1300 feet. It has been shown that five horizons over a stratigraphic distance of 500 feet have been favorable for mineralization, with the result that bedded ores range from a few inches up to 105 feet in thickness, although the average is about 16.5 feet. The lateral extent of the mineralization is about 400
feet from the fissures. The ore is of three types: a hard compact hematite (49% Fe) with a minimum of limonite; a recemented breccia made up of fragments of hematite and limonite with limonite predominating (39% Fe—4% SiO₂); and a hard ore of cherty appearance, mostly limonite (46% Fe—21% SiO₂). Although the phosphorus and sulfur are said to be too high for use in blast furnaces; mining claims have been made on 400 acres in secs. 26 and 34 T. 12 N., R. 6 E.

Smaller bodies of hematite occur at several localities. Hematite (red iron ore) is found in the Cable Mine in Deer Lodge County. It is associated with magnetite in the Iron Mine on Elkhorn Peak in Jefferson County, and a lens of hematite, 2½ feet thick, occurs on a mountain ridge, east of Skunk Creek near Yogo, in a contact between limestone and a dark-colored, coarsely-granulated rock (shonkinité).

Hematite is also found at the west base of Jack Mountain in Jefferson County where the bright red ore forms a small butte rising above the general slope of the region. Another deposit of iron has been found at the Calvin Mine on Fox Mountain, west of Bernice (On Great Northern railroad between Butte and Helena), where it occurs in sintery or stalactitic botryoidal forms. It is not magnetic, but does have a brown streak of hematite.

Ferruginous sandstones were quarried on Warm Springs Creek in Meagher County for fluxing purposes but were abandoned as being too siliceous, also a low-grade hematite in the New World Mining District has been utilized as a flux, but for this type of use the importance of an iron deposit in Beaverhead County has been very much greater.
The Renova district, Madison County, has a bed of iron ore, chiefly hematite. This deposit is a short distance above the top of the Flathead quartzite and outcrops in an area of two or three square miles indicate that the bed ranges from 3 to 15 feet in thickness, and that it in 2 places contains a manganiferous streak from 1 to 4 feet thick. The iron ore is primarily of sedimentary origin but appears to have been enriched during the Tertiary.

Of interest is a deposit reported by Thomas E. Smith to exist in the region east of Billings, Montana, and south to the Wyoming border. He states that "along the railroad that parallels the East Fork of Arnells Creek from Forsyth to Colstrip, there is an area of iron-bearing beds of large tonnage, containing not less than 25 percent which could be exploited by stripping methods". Details on the mineral composition and association were lacking.

References: (29), (79), (90), (142), (144).

HUBNERITE

Because hubnerite has been found only to a limited extent in the several reported localities it is of not much importance. Quartz veins in the Potosi region near Pony are reported to carry hubnerite and its oxidation products. Highly quartzose veins vary from 1 foot to 6 feet in width contain small streaks of this tungsten mineral between 1 to 18 inches in thickness, although a width of 20 inches and grade of 4.5 percent tungstic acid was reported in one instance.
The Birdie mine which is 4 miles east of Butte contained chimney shoots that were 12 to 20 inches in width and from 6 to 10 feet in length along a 250-foot raise. It was also reported that a winze had been sunk on a body 3 to 5 feet wide with a length of 20 feet, also a few pieces of hubnerite have been found ½ mile north of the mine, and at a place 1½ miles to the east.

Specimens have been described from the 1000-foot level of the Gagnon mine in Butte, where the mineral is associated with sphalerite, bornite, and pyrite.

Another association for hubnerite is found at the Gold Queen group in Fergus County. The claims which are practically in the center of the North Moccasin Mountains lie in sec. 29, T. 18 N., R. 18 E. Here, the orebody occurs in a breccia dike (200 feet by 1500 feet) which is composed principally of fragments of intrusive rock with some quartzite and limestone. The hubnerite is congenital with the ore-bearing solutions as its relative abundance is a good indicator of the gold content of the ore, and although the hubnerite is scattered irregularly through the 12-foot orebody, it is most heavily concentrated along an indistinct line near the footwall.

Very small amounts of hubnerite occur as a primary mineral with quartz and sulfides in the Combination mine near Philipsburg, Montana, where it is also found with psuedomalachite. Concentrates of 20.1 at this mine assayed about one-third of a percent tungstic acid.

References: (34), (56), (96), (135).
JASPER

Mocha jasper stones, related to mocha agates, have been found in Dawson County near the town of Glendive. One mahogany variety has irregular streaks resembling the grain of wood while another type, composed of a dark-yellow jasper, contains turtle-back markings of gray chalcedony. Although the best specimens are found in the vicinity of Glendive, some have been picked up near Miles City and Billings. The mode of occurrence is similar to that of agates.

Reference: (50).

LAUMONTITE

This mineral of the zeolite group has been described from deposits near the Wolf Creek Station in Lewis and Clark County, Montana. It is said that there are several veins of massive laumontite in a distance of about five meters, and that some of the individual veins reach a thickness of about 0.6 of a meter. This mineral is ordinarily found as well-developed crystals and as an alteration products in cavities in basic rocks. No information was given about the wall rocks in the above occurrence.

Reference: (128).

LAZULITE

A mineral possessing the refractive indices and chemical reactions
of lazulite has been found as float at Hassel, Montana. This specimen was a somewhat altered volcanic breccia, injected with a blue coloring matter, the latter consisting of very irregularly distributed scales without any crystal form.

Reference: (84).

LEUCHTENBERGITE

The source of this material was in the Philipsburg district of Montana, namely, on the surface near Lost Creek, about one mile north of the Silver King Mine. Here the rocks which have undergone intense contact metamorphism contain forsterite, spinel and humite, also pure medium-grained marble grades into a greenish layer of fibrous appearance and silky luster, and it is to this layer that the crystals of leuchtenbergite are attached.

Reference: (129).

LIMESTONE

This rock is very abundant in Montana but is restricted to the mountainous, western part of the state. The plains region with the exception of local dome-like uplifts like the Judith and Snowy mountains is devoid of Paleozoic outcrops that contain good limestone beds similar to those in the mountains which occupy the western one-third of the state. Cretaceous, and other mesozoic, or tertiary beds contain only lenses or
concretions which are utilized only when better material from the west becomes too far away.

In the west, excellent limestone outcrops extend along the northern flanks of the mountains from Carbon County westward to the vicinity of Livingston in Park County, thence northward about the Little Belt, and Belt Ranges to the main range of the Rockies west of Great Falls. Between this irregular eastern limitation and the western boundary of the state, practically every mountain range consists of a core of gneiss or granite mantled with limestone, such rocks extending approximately to the Bitter Root Valley.

All of the Paleozoic formations contain limestone beds but the most sought after series is that of the Madison (Mississipian) where it outcrops near railroad facilities. This is proven by the fact that of the operating quarries in the state, four are obtaining rock from the Madison while the fifth is producing in the Meagher limestone of Cambrian age. The younger or overlying Jurassic limestones are often argillaceous, the Devonian limestones are impure, and the Cambrian limestones are thin-bedded with a lack of uniformity in composition.

The northwestern part of the state contains mostly Algonkian rocks of the Belt series in which the oolitic Newland limestone is a constant feature, but shaly and siliceous impurities are a major detraction. In the southwestern part of the state, good pre-Cambrian exposures of marble are known but the lack of immediate railroad facilities have left them undeveloped.

Several localities are important now, or have been in past, as a
source of limestone for use in the manufacture of lime or as a smelter flux. Cessation of operations has been due only to fluxuations of demand and not because of any scarcity of suitable material. The quarry at Elliston in Lewis and Clark County is the most important producer of lime in Montana, the upper Madison formation being its source of rock. Warren, Carbon County, is four miles southeast from the site of a quarry which provides lime rock for the sugar refineries at Billings, Sidney, and Hardin in Montana, and those at Sheridan, Worland, and Lovel in Wyoming. Again the upper beds of the Madison produce the desired limestone.

A quarry four miles west of Drummond, Granite County obtains limestone from the Upper Kootenai of Lower Jurassic age for use in sugar refineries in western Montana and eastern Washington, also for the smelter at Kellogg, Idaho.

A quarry at Browns, seven miles west of Anaconda, Deer Lodge County, is being operated, in the strata of the lower or middle part of the Madison formation, for the purpose of securing flux for the smelter of the Anaconda Copper Mining Company. In this same county, there was a small quarry with a kiln in Hoodoo Gulch on Lost Creek, where the calcium carbonate is very pure, but the railroad being ten miles distant made transportation costs too high.

Four main localities in the vicinity of Helena, Lewis and Clark County, were the sites of limestone quarries: (1) one-half a mile south of the city limits near the forks of Last Chance Gulch; (2) near Montana City (abandoned town) on Prickly Pear Creek; (3) one mile west of Montana City; and (4) two and one-half miles south of East Helena. The
Montana City quarries are of Madison age while the other two belong to the Cambrian, Pilgrim for the Helena quarry and Meagher for the East Helena pit.

A former quarry existed at Allbright on Belt Creek, 35 miles southeast of Great Falls, where the rock from the upper Madison was formerly used for smelter flux.

Formerly, two quarries existed in Jefferson County, namely, at Lime spur and Sappington. Both operated on rock from the Upper Madison formation to provide material for sugar refineries, but the bulk of the production from Lime spur was used in the smelters which once existed in Butte.

Trident, Gallatin County, is the location of a cement plant which maintains a quarry in the lower Madison (Lodge Pole). A small amount of lime has been manufactured in the past by the use of a rotary kiln.

Three miles south of Livingston, Park County, in a mountain pass made by the Yellowstone River, there are the remnant of four stone lime kilns which burnt lime rock from the upper Madison bluffs, just above them.

Fifteen miles south of Butte in the Highlands on the southern border of the Boulder Batholith, a small quarry, with kilns, was using marble which appears to be a roof pendant. Only secondary roads infiltrate this region.

In the vicinity of Divide on the Big Hole River, two localities were used in the past. The one at Maiden Rock produced flux for the smelter at Anaconda, and also provided rock for four local kilns, while the other in Limekiln Gulch near Dewey exclusively produced limerock for a
kiln operation. Both utilized material from the upper Madison in their operations.

References: (85), (102), (106), (141).

LIMONITE

This mineral is very widely scattered throughout the state in oxidized zones of veins and in gossans. Except for minor use as a smelter flux, its economic value is very small.

One deposit of limonite is found in the Flint Creek Range (Princeton District) of Granite County, about 18 miles by highway northeast of Philipsburg, in sec. 36, T. 8 N., R. 12 W. (or about 7 miles southeast of Maxville along Boulder Creek). Large masses of limonitic ore are found in Jefferson and Madison limestones as replacements, the chief gangue mineral being limestone. An estimated average thickness of 50 feet continues through adjoining claims for a distance of about 1800 feet. The bulk is said to be about 35,000 tons.

Another deposit is found on West Armell Creek in the Judith Mountains, where a considerable body of limonite occurs in conjunction with a porphyry contact. Although one exposure shows a thickness of 50 feet, the lateral limits have not been determined yet several thousand tons of limonite are present. A small deposit occurs on Upper Edwards Creek, also a limonite bed, 10 inches to 2 feet wide in limestone is found on the south slope of Crystal Creek Dome.

Limonite also occurs in conjunction with the Sheep Creek deposit.
described under hematite, and with a magnetite orebody at Elkhorn in Jefferson County, also see "pigments" for additional small deposits.

References: (79), (148).

LITHIUM

This element is a constituent of spring water found on the east bank of the Eastern Fork of the Boulder River, a tributary of the Yellowstone River. The location on the TA ranch near McCleod, Montana, is on the site of an outcrop of Lower Cretaceous and Jurassic rocks from beneath a covering of Upper Cretaceous shales and sandstones. The maximum output, which is during the month of July each year, is said to be about 45 gallons per minute and the content of lithium is about 0.81 parts per million.

Reference: (130).

LUDWIGITE

Occurring at Philipsburg, Montana, in conjunction with magnetite, ludwigite is found in metamorphosed limestone as small spherulites composed of radiating fibers of a very dark green or nearly black color.

Reference: (127).

MANGANESE

Mineral deposits containing manganese minerals are widely scattered
throughout the mining districts in western Montana. A partial list of districts containing enough manganese to warrant interest follows:

1. Butte, Silver Bow County  
2. Philipsburg, Granite County  
3. Castle Mountain, Meagher County  
4. Wigwam Creek, Madison County  
5. Cherry Creek,  
6. Dry Georgia,  
7. Renova,  
8. Varney,  
9. Melrose, Beaverhead County  
10. Wickes, Jefferson County  
11. Cave Gulch, Lewis and Clark County  
12. Bonita, Missoula County  
13. Anceny, Gallatin County  
14. Deer Lodge, Powell County  
15. Axes Canyon, Beaverhead County  
16. Neihart, Cascade County

The outer peripheral zone of the Butte district contains much zinc and manganese ore which in the oxidized zone consists of manganese oxides that contain varying amounts of silver and quartz. Below the oxidized zone, large quantities of rhodochrosite and rhodonite are found associated with quartz and sphalerite. One example, the Black Chief vein on the southwestern periphery of the Butte district, is cited as one of the world's largest and most-extensive of known rhodochrosite deposits.

At Philipsburg, the productive manganese area is practically restricted to the metamorphosed limestone adjoining a large batholith of grandodiorite about ½ mile east of town. Fissure veins of quartz had cut across shales and limestones to form channels for rhodochrosite solutions which then created irregular and tabular deposits by replacement. As amorphous manganese oxides constitute a large part of the ore in the oxidized zones which also contain considerable rhodochrosite, the oxides
of either pyrolusite, psilomelane, braunite, manganite, or wad are not considered to be primary in the silver veins, which are traceable for 3,500 feet with manganese occurring at irregular intervals. The estimated depths of occurrence for pyrolusite and rhodochrosite is about 700 and 1200 feet, respectively.

The Castle district has lodes that contain large amounts of a jaspery material carrying manganese, iron, lead and a few ounces of silver per ton. Analyses show the manganese runs from 6 to 13 percent.

The Wigwam Creek deposits are found at the western edge of Madison Valley, about 12 miles south of Ennis, in an area of about one square mile, where ore bodies are found in the hillsides as flat, lense-like, or pipe-like forms with a zoned or layered structure which has the richest ore in the center. Psilomelane forms the bulk of the ore, although manganite is common. As found, the psilomelane may be covered by manganite which is itself covered by wad, and all three may be coated by calcite. It appears that an underlying Upper-Cambrian limestone contains manganese (0.47% Mn and 1.28% Fe by test) as a disseminated black dust, and that this dust could have been leached and redeposited in cavities of limestone (also replacement was partially involved). The largest filled-cavity found was 50 feet long and 9 feet wide, with about one-half considered to be high-grade ore.

The Cherry Creek ore bodies have a history similar to that for the Wigwam Creek deposits which are about 12 miles to the north. The locality is just south of Cherry Creek and about 1 mile east of the Madison valley. Here the orebodies have developed along fissures or
joints with psilomelane being the chief mineral. The largest mineral pocket was about 3 feet by 50 feet. Additional claims have also been staked on Johnny Creek, 3 miles further south.

In Dry Georgia Gulch, east of Twin Bridges, a vein of manganese oxide is locally about 10 feet in thickness.

The Renova deposits are about 3 miles southwest of Renova on the Alder branch of the Northern Pacific railroad, the site being in the foothills at the eastern edge of the Jefferson Valley, near Gaylord. Being chiefly of the manganiferous iron ore type, the deposits have been used as a smelter flux. Orebodies range from 4 to 15 feet in thickness and contain manganese oxides in the form of streaks (sometimes as much as 4 1/2 feet thick). Although psilomelane is the predominate mineral, pyrolusite and wad are also found. It is said that an assay showing a content of 33 percent manganese would be a high value for this area. This particular occurrence seems indicative of an iron-bearing stratum that was enriched by the weathering of a land area down to the level of an old surface.

Varney deposits are near those of Wigwam and Cherry Creeks.

Melrose is in the vicinity of two deposits: one on Trapper Creek, 9 miles west of town, and the second about 4 miles west of town. At the first, a body of manganese oxide associated with a quartz vein has produced a few tons, while the second deposit is merely described as being a sedimentary body.

Two parallel veins of siliceous ferruginous manganese oxides occur 4 1/2 miles southwest of Wickes in a decomposed andesite. The ore is chiefly
psilomelane with some pyrolusite. The ore is spongy and porous and many of the voids are filled with ocher. The metallic content is reported to be 15-40% Mn, 13-20% Fe, 6-34% SiO₂, and about 2 oz. Ag/ton.

At Wickes, a different type of a deposit is found about 6 miles north of the railroad station near the head of a small gulch in a range of low mountains, a short distance east of the continental divide. Lying in a flat area several hundreds yards long in the bottom of the gulch is a horizontal bed of bog manganese and bog limonite, the latter being mostly ocher. It has been tested to a depth of 5 feet and for a distance of 50 feet beneath the over-lying 1½-foot covering of soil. Leaching of disseminated and vein minerals of manganese in neighboring granites and the ensuing precipitation of the dissolved Mn salts is considered to be the story of the deposit's origin.

One mile north of Bonita, Granite County on Cook's claim, pyrolusite and wad are found filling open spaces in a badly faulted and broken Paleozoic limestone. Samples run from 11 to 30 percent manganese, but by hand-sorting it has been possible to boost the grade to about 41-47 percent manganese for shipment.

A little high-grade manganese ore has been located about 3 miles northwest of Anceny, Gallatin County. The manganese is found as an oxide in a vein that cuts gneiss and schists.

Cooke City, Park County, is the locale for several veins that contain manganese values. Along with values of zinc, lead and silver, ore from the Irma Mine runs about 15 percent in manganese (as an impure rhodochrosite), also present in the ore is a small amount of manganese.
oxide, an iron-bearing manganocalcite, and a calcium-bearing manganosiderite.

At Neihart, the carbonate of manganese is the most abundant of the gangue minerals in the lead-silver-zinc ores. The reported range of values for the $\text{MnCO}_3$ is from 21 to 41 percent.

Discussions on manganese occurrences at Cave Gulch, Deer Lodge, and Axes Canyon, were not noted.

References: (21), (29), (39), (42), (45), (51), (90), (122).

MARBLES

Deposits containing true marble are found in several localities but are not being exploited commercially. This is caused by two important factors, namely, the lack of local demand and the excessive distances to eastern markets. Colors range from snowy white to blues and blacks, and some have a variegated or mottled effect with very pleasing designs.

A large deposit of variegated marble lays along the crest of a ridge near Townsend in Broadwater County. This deposit in the Meagher formation is dense and fine-grained, and is a black and gold, a plain black, or a black and white marble with veined or banded markings. Specimens from this deposit have taken a high polish.

A deposit in Nelson Gulch, southwest of Helena, Lewis and Clark County, has been described as containing seven distinct varieties of marble; namely, Creoles, Sinais, Egyptian blacks and creams, white statuary marble, Carrara marble, blue marble, and Georgia white marble.
Other sites containing marble of good quality are reported to be on Dempsey Creek in Powell County, north of Lothair in Hill County, near Dewey, Beaverhead County, and near Garnet in Granite County.

Where the upper Madison formation has been intruded by igneous bodies, the marble has been characteristically metamorphosed to marble, also the Cherry Creek series, southeast of Dillon, contains marble created by regional deformation, but development with the objective of securing large blocks has not been attempted.

Dimension stone for construction has been quarried at the Townsend site; from the Amsden formation in the Big Horn Mountains, south of Hardin, Big Horn County, and could be obtained from the Pilgrim and Madison formations if necessary.

References: (13), (31), (106).

MICA

In the Tobacco Root Mountains, mica is associated with pegmatites in the metamorphic terrain of the Cherry Creek series which consist of quartz-feldspar gneiss, quartz-mica schist, crystalline limestone, quartzite, and a hornblende-biotite schist. The composition of the pegmatites is made-up of microcline, quartz, plagioclase and muscovite, with minor amounts of black tourmaline and biotite, also a few crystals of green beryl have been found. Some of the pegmatites which are as large as 65 by 200 feet contain sheet mica which ranges in color from a ruby red to colorless, the latter being the most common.
The Big Chief Prospect, 5 miles northeast of Sheridan, is in the unsurveyed sec. 4 or 5, T. 4 S., R. 4 W., and contains sheets up to 4 by 6 inches but mostly produces books \( \frac{3}{4} \) to 3 inches in diameter. It is said that 90 percent of the production has been of No. 1 and 2 quality sheets. The Dulia Prospect on the East Fork of Granite Creek (between Virginia City and Sheridan) several miles above the White Swan Mine, has No. 3 quality books of muscovite. The Montana Mine near the east boundary of sec. 5, T. 5 S., R. 2 W., contains books of biotite (6 by 8 inches), and a small amount of sheet mica, but mostly, the books, in the mine and in adjacent pegmatites, are of \( \frac{1}{4} \) to \( \frac{1}{2} \) inch in size. It is twenty miles by road from Ennis to the northern part of sec. 6, T. 8 S., R. 1 W., where the location of the Rim Rock Prospect that contains books 2 inches in diameter of a red-ruby mica is found. The White Swan Mine of the White Swan Group is in two acres on Taylor grazing land in sec. 19, T. 5 S., R. 2 W., on the East Fork of Granite Creek. One-half to 5-inch books are said to run about 0.4 pounds per ton in this property. A study has shown that Vetter Prospect in S\( \frac{1}{2} \) sec. 6, T. 8 S., R. 11 W. (one-half a mile south of the Rim Rock prospect) is probably too small to yield any sheets of value.

Another mica deposit has been reported on the San Miguel group of claims near the town of Monarch, 49 miles southeast of Great Falls. This occurrence in the Little Belt Mountains is said to be in a bed about 4 feet thick.

Minor shipments of muscovite have also been made from the property
of the Zonolite Mining Company at Libby in Lincoln County.

References: (13), (131).

NARSARSUKITE

This yellow mineral is associated with quartz veins cutting a green syenite on the northwest finger of the main stock of East Butte, Sweet Grass Hills, Liberty County, in the center of sec. 24, T. 36 N., R. 4 E.

Reference: (147).

NITRATES

A nitrate deposit is found along the face of the cliffs of black limestone, on Camp Creek, 3 1/2 miles northeast of Melrose, Silver Bow County. This material of possibly organic origin of the cave type is low grade, requiring treatment of nearly 35 tons to obtain 1 ton of crude salts. It is said to be in rocks of Devonian age.

Gallatin County has reported several finds, especially in Tps. 8 and 9 S., R. 4 E., where the nitrates are found in the main valley and in some of its tributaries—for example, Canyon, Elkhorn, and Sage Creeks, the best being on the east side of the Gallatin river opposite the mouth of Cinnamon Creek. The Madison limestone formations contain most of occurrences, but on Sage Creek, the Phosphoria is the host. This nitrate is of the cave type, and contains common salt, glauber's salt, and others as impurities.

In Fergus County deposits of potassium nitrate were reported by
R. W. Petre of Baltimore, Maryland as "extending from the seams in a limestone escarpment in the Judith Mountains".

Large amounts of nitrates are indefinitely reported as occurring in the soils near Anaconda, Deer Lodge County, and near Victor, Ravalli County.

References: (13), (81), (110).

ONYX

An important deposit is reported in a vein which has been traced for \( \frac{1}{4} \) of mile in Madison County. No specific details concerning the location were mentioned, but it was stated that this cryptocrystalline quartz has a multitude of colors which form beautiful tapestry designs.

Reference: (2).

ONYX MARBLE

About 5 miles in a direct line north of Manhattan, Gallatin County, in the NW\( \frac{1}{4} \)SE\( \frac{1}{4} \) sec. 14, T. 2 N., R. 3 E., is the Manhattan Onyx deposit. The quarry is in the largest of several veins of calcite which cut the southwest tip of a fold belonging to a northeast trending syncline. The country rock is limestone of the Madison formation. Although the principal vein has length of \( 3/4 \)ths of a mile and a width about 65 feet, three sets of joints have limited the maximum size of blocks to a thickness of 2 or 3 feet.

A banded rock, locally known as "Montana onyx" is found on Sweet-
water Creek in sec. 9, T. 9 S., R. 5 W., about 20 miles southwest of Virginia City, Montana. Apparently lake-bed material had undergone silicification by the action of hot springs, over an area of one or two square miles to create this body of rock which has alternating bands of brown, buff, and gray colors composed of fine-grained sericite, clay, angular quartz grains, and partially altered flakes of biotite.

References: (32), (82).

PARICITE

Crystals of this mineral have been obtained near Pyrites, Ravalli County. Scattered in a fine-grained, loosely coherent, white material which consists essentially of silica, alumina, calcium, and a little alkali (the exact nature of this material is unknown but it appears to be a decomposed rhyolite or a trachite), the crystals are generally found as isolated minerals, but at times they may have grown over and partly or completely surrounded crystals of pyrite.

Reference: (99).

PEARCITE

This sulpharsenite of silver is represented by crystals in the Drumlummon Mine at Marysville in Lewis and Clark County. The mineral has also been noted in drusy form at the Big 7 mine at Neihart, Cascade County.

Reference: (98).
Phosphate rock is generally found in southwestern Montana at two principal horizons in the Phosphoria formation. One is near the base while the other is from 20 to 60 feet higher stratigraphically, near the middle of the formation. Of the two, the upper is the most extensive, being found over an area of about 25,000 square miles in southwestern Montana, southeastern Idaho, western Wyoming, and northeastern Utah. The principal bed is a black or gray, finely oolitic layer that is commonly 4 feet thick, containing in the most valuable fields a tricalcium phosphate content of more than 70 percent. From the rich areas the beds gradually become thinner and deteriorate toward the east.

Because of the effects of mountain building and erosion the occurrences of phosphate in Montana have been grouped into various fields or districts which facilitate their study and exploitation. A district which has little economic value at the present because of thinness and poor quality of the phosphate beds, is that of the Three Forks-Yellowstone Park area, the few deposits of fair thickness and quality being generally inaccessible. The best thicknesses (about 3 feet) are those of Indian Creek and Buck Creek where the material runs 59.52 percent and 52.44 percent tricalcium phosphate respectively, but most of the other exposures are less than two feet and where they are thicker a phosphatic shale is often a diluent. In most of Montana the lower bed is less than one foot in thickness.

The Elliston-Garrison field may be defined as the area between Avon
Valley on the east to Drummond on the west, and from the Clark Fork north to the summit of the Garnet Range or even a little beyond. The upper bed is about 4 feet thick and shows an analysis of 65 to 70 percent \( \text{Ca}_3\text{P}_2\text{O}_8 \). In the Melrose district, the Permian phosphate beds are commonly underlain by a series of light-gray cherty limestones and overlain by a massively-bedded chert constituting the Rex chert of the Phosphoria formation, all of the above members being compressed by later mountain building into a series of compressed and in part overturned folds. The greater part of the Melrose phosphate area is in the southern half of T. 2 S., R. 9 and 10 W., but three strips, half a mile to one mile wide, trend in a northwesterly direction into T. 1 S., R. 10 W. Of these three strips representing synclinal folds, one, the Big Hole syncline, has its northwestern part traversed by the Oregon Short Line Railroad for about three miles. The deposits here, being about 4 feet thick with a 65 to 70 percent tricalcium phosphate content, are very favorable for development.

The Philipsburg field may be considered approximately equivalent in area to that of the Flint Creek Range, or of that area lying between the Deer Lodge and Flint Creek valleys. As this field adjoins the Elliston-Garrison field which is just to the north, both combined can be considered as covering the northeastern part of Granite County and a small portion of Powell County.

In conjunction with the Melrose field, there is a McCarthy Mountain area which contains beds 2 to 6 feet in thickness and which run from 60 to 66 percent tricalcium phosphate.
Southeast of Dillon, there are characteristic outcrops of phosphate rock along the West Fork of Blacktail Deer Creek, which have been traced from T. 10 S. to the Lima Reservoir, a distance of 25 miles, along the east limb of an anticline that forms the Snowcrest Range. Occasional outcrops are also noted between Canyon Camp along the Ruby River (secs. 17 and 18, T. 9 S., R. 3 W.) to Little Basin Creek (sec. 7, T. 13 S., R. 6 W.) towards the south it is covered by tertiary rocks until it outcrops again in secs. 22 and 28, T. 13 S., R. 7 W., the total length being about 32 miles. The lower unit, 75 feet above the base of the Phosphoria, is from 4 to 6½ feet thick, while the upper unit 350 to 400 feet above the base has a thickness less than 3 feet.

References: (18), (66), (91), (111).

PIGMENTS

Natural pigments in Montana seem to be restricted to the oxidized iron minerals and in the literature have been divided into two types; namely, the red iron ores, and the brown iron ores.

Red iron ore (hematite) is rather restricted, having been found in the Cable Mine in Deer Lodge County, and associated with magnetite in an iron mine on Elkhorn Peak, Elkhorn District, in Jefferson County.

The brown iron ore (limonite) is more widely spread throughout the state than the red ore. Cascade and Meagher Counties have deposits in the Little Belt Mountain district. This material is also found at the Cable Mine, Deer Lodge County. Fergus County formerly had a small pro-
duction from the Judith Mountains, and had some prospecting performed at
Woodhurst Mountain and in the Little Belt Mountains. In Jefferson County,
this material is found at Wickes, and in the iron mine on Elkhorn Peak.
Phillips County has considerable limonite in the oxidized ores of the
gold districts near Landusky and Alabama.

Of potential commercial value as a pigment is an ocher or limonite
body which lies at the contact of limestone and diorite near a shale seam
in Madison County, about 3 miles south of Waterloo Station on the Northern
Pacific railroad branchline. The orebody which is 4 feet wide and
outcrops for several hundred feet is said to run 43 percent iron.

Reference: (144).

PYROPHYLLITE

A nearly vertical tabular body of this mineral which is similar to
talc in structure and appearance is found ½ mile northeast of Argenta
along Rattlesnake creek in a granitic igneous body from which it was
apparently formed by alteration of the original rock. Lacking definite
walls, it has approximate dimension of 200 to 400 feet across, and in it
bands of nearly pure pyrophyllite, 2 to 4 feet across alternate with
those of less pure material. The host rock of Cretaceous or Tertiary
age was apparently a small stock which cut argillites and quartzites of
the Belt series of pre-Cambrian age.

Reference: (104).
At Brown's Spur, 6 miles west of Anaconda, Powell County, there is a bed of quartzite which makes a very good silica brick because it has a low percentage of ingredients which will flux. The final product made from this material is a very refractory substance.

The Anaconda Copper Mining Company makes an excellent firebrick with a mixture of flint clay from Lost Creek, 4 miles east of Anaconda, and a plastic fire clay from Armington, Montana, the percentages being 40 and 60 percent, respectively. The Armington bed of slate-colored clay is 4 to 5 feet thick and occurs 26 feet above the Kootenai coal horizon in the Kootenai formation.

In the past refractory wares have been manufactured in Butte from another Lost Creek deposit near to the one belonging to the Anaconda Copper Mining Company.

A light-colored sandstone near Dillon, Montana, on the Oregon Short Line railroad has proven to be a failure when used for manufacturing bricks, but has a great value when used as a silica cement.

References: (49), (70).

The occurrence of Rubies in Montana has been very similar to the occurrence of Sapphires and other related minerals, especially where they have been found in the river sands along the upper Missouri River near Helena, Montana.
Rubies of a rich-red color have been found in the gravels of the upper waters of Rock Creek, Granite County, and in less amount in the gravels of Cottonwood Creek in Deer Lodge County. Of the specimens recovered only a very small percentage had any value as gems.

References: (1), (6), (41).

SANDSTONE

The extensive sandstone deposits available in Montana are chiefly east of the Rocky Mountains in formations of Cretaceous and Tertiary age. The best known sandstone is that of Yellowstone County near Columbus, but deposits also occur in Cascade, Chouteau, Gallatin, Beaverhead, Carbon, Custer, Fergus, and Sweet Grass Counties, also some good quartzites of Tertiary age are found in Beaverhead, and Missoula Counties.

Reference: (11).

SAPPHIRES

The deposit that has received the most publicity is that in the basin of Yogo Gulch, about 55 miles from Lewistown and 13 miles from Utica, in the foothills of the Little Belt Mountains. The sapphires occur as disseminated crystals in an almost vertical dike of monchiquite, 8 to 20 feet thick and of unknown depth. By using test pits the dike has been traced for six miles. The surface of the dike weathers easily to a soft clayey material beneath which are found three kinds of rock, a reddish rhyolite, a porphyry, and a dark-gray rock with a conchoidal
fracture resembling a diabase, that disintegrates easily. Most of the sapphires are found in the soft dark-gray rock. Neighboring dikes of almost similar composition have failed to produce any sapphires.

Sapphire corundum also occurs in dikes of mica-augite andesite at Ruby Bar near Eldorado Bar on the Missouri River, 12 miles northeast of Helena; also at French Bar nearly 12 miles east of Helena. It is possible that the decomposition and erosion of these and similar dikes which have not yet been found have contributed the sapphires and related minerals to the famous Missouri River bars; namely, the Emerald, Cheyenne, French, Spokane, Metropolitan, Ruby, Eldorado, Dana, and American bars. At some of the bars the mode of occurrence is in beds of gravel, 10 to 50 feet thick, which rest upon slate or granite, in bluffs that rise up to 130 feet above the river.

Another locality where sapphires have been found is in the area between Gold Creek and Myers Creek, affluents of Rock Creek in Granite County. This placer is 35 miles southwest of Philipsburg and 30 miles west of Anaconda. Other sites reported as having sapphires are near Norris, Madison County; on Cottonwood Creek, 10 miles east of Deer Lodge; and near Calumet, 12 or 14 miles from Salida.

References: (1), (6), (25), (37), (107), (108).

SCHEELITE

At Jardine, 5 miles northeast of Gardiner, in Bear Gulch (The Sheep-eater Mining District), scheelite occurs in mineralized shear zones of
folded pre-Cambrian schists, the zones being roughly parallel to the schistosity, to the original bedding, and to the slope of the mountain sides. The zones or veins are chiefly quartz with the scheelite in irregular bunches, pockets, or pipes. The widths vary from a few inches to a few feet, although one reaches a maximum of sixty feet with an average width of about twenty feet. The scheelite is massive and is a brown to a "honey colored" translucent variety.

A considerable amount of scheelite has been recovered by a dredge on Henderson Gulch, Granite County, during gold-mining operations.

References: (26), (56), (86).

SILLIMANITE

The deposits in the Ennis area of kyanite and sillimanite occur in the foothills of the eastern flanks of the Gravelly Range, 12.8 airline miles S. 13° W. of Ennis, Montana. Of the three groups of deposits in this region, the first is found in the northern part of sec. 6, T. 8 S., R. 1 W., and in the southern part of sec. 31, T. 7 S., R. 1 W. The second is in the west-central part of sec. 5, T. 8 S., R. 1 W., and the third is in the west-central part of sec. 31, T. 8 S., R. 1 W., at the forks of Cherry Creek.

This area is underlain by pre-Cambrian metamorphic rocks of the Cherry Creek series which consist of metamorphic sediments and a few bodies of metamorphosed dark-colored igneous rocks. The region has been invaded by several types of pegmatite, but kyanite is found most
abundantly in the unmetamorphosed quartzose pegmatites which occur in mica-garnet schists. Kyanite crystals are coarsely bladed with a maximum length of six inches, but the average length is about one inch. The sillimanite most commonly occurs as a replacement of kyanite in the form of small pods of white or gray fibers, but in the first group of deposits, it may occur in the form of three to six-inch lenses of roughly parallel, fine-grained sillimanite fibers. Although the belt of gneiss for group 1 can be traced for 4500 feet the kyanite is concentrated in aureoles around quartz-rich pegmatites where the grade maybe as much as 15 to 20 percent. The average though is estimated to be about 1 or 2 percent. The grade of the sillimanite is much less than that of the kyanite. Less definite information is available for the other occurrences of this region.

Three deposits of sillimanite are associated with corundum southwest of Bozeman in Gallatin and Madison Counties. The Bozeman deposit is 12 airline miles S. 70° W. of the town, in sec. 31, T. 2 S., R. 4 E. The Gallatin deposit lies 5 airline miles S. 35° W. of the Bozeman deposit while the Bear Trap deposit is found 9 airline miles S. 60° E. of Norris in sec. 6, T. 4 S., R. 2 E. The Bozeman deposit is believed to be underlain by the Cherry Creek series which have been intruded by a series of syenite sills ranging in thickness from a few inches to 3 or 4 feet in thickness and a length of 200 feet for some, though the majority are much shorter. The sillimanite may occur in the biotite-garnet gneiss or in the syenite sills where it is found with corundum. Locally the sillimanite, and also muscovite, may become very coarse, replacing all minerals
except corundum. In this case, the sillimanite runs about 60 percent but generally it is much less than corundum which is said to run from 0 to 10 percent.

The Gallatin deposit is the same as that described for "corundum". Again intrusion of granitized hornblend-biotite gneiss by syenite-pegmatites have created the dominant features. Locally, massive sillimanite occurs in pegmatites along their margins, elsewhere it may be in scattered masses in the pegmatites, or in sillimanite-rich stringers. Although in some instances sillimanite may make up 50 to 60 percent of the rock, operations of this deposit apparently would call for recovery of corundum as the principal material and with sillimanite as a by-product.

The Bear Trap deposit is generally similar to those above. Small amounts of material run from 55 to 60 percent sillimanite but it is said that iron-staining has reduced the value of the product.

Kyanite is reported in Norwegian Gulch, north of Norris in Madison County, and also as detrital material in the Missouri River bars near Helena. No details were given for the Norwegian Gulch deposit.

The Dillon Ultramafic Intrusive, 23 miles southwest of Dillon, features an occurrence of garnet-sillimanite gneiss which locally overlies that body. Sillimanite also occurs in quartz as aggregates of needles. Authors disagree as whether this occurrence is in the Cherry Creek or Pony series.

The Crystal Graphite deposit, 10 airline miles S. 40° E. of Dillon on the ridge between Camps Creek and Timber Gulch, is in a sequence of pre-Cambrian metamorphic rocks cut by graphite veins, one of which is a
sillimanite-bearing horizon. This dark gray rock, containing the sillimanite in an irregularly distributed pattern, also has minute seams and local patches up to one-inch across of sillimanite.

In the southwestern part of the Ruby Range, a deposit on the northside of Carter Creek, 9½ miles southeast of Dillon is comprised of felted aggregates of sillimanite needles which are scattered abundantly through a medium-grained biotite gneiss that has been intruded by many small unmetamorphosed sillimanite-bearing pegmatites.

Reported occurrences of sillimanite in Timber Gulch southeast of Dillon, and in the Miller Peak formation of the Missoula group in the Belt series seem to be so sparse as to be minor accessory minerals. Sillimanite and andalusite are rock forming minerals in the Jardine district, and also they are minor constituents of the aluminous and highly metamorphosed rocks (by an igneous contact) of the Pritchard formation of lower Beltian age on the west side of Mount Howe of the Anaconda Range. They also occur to a very minor extent in the Neihart quartzite which is beneath the Pritchard.

References: (29), (53).

STONE, BUILDING

This material which is very abundant in Montana has been utilized only to a very limited extent in Montana. Quarries are located in all parts of the state but the limited demand has rendered their operation extremely intermittent. Four general type of rocks are involved;
namely, limestone, sandstone, phyllite, and granite.

The sandstone quarries are the most numerous because this material is very widely spread, and small pits can be readily opened to satisfy the limited local demands. Beaverhead County has two favorable deposits of the quartzite type; one at Daily Spur, 15 miles southwest of Dillon on the Oregon Short Line railroad, and the other in the Rattlesnake or Reservoir region, 5 miles west of Dillon, this deposit being colored. The Laramie sandstone has been the source of material for three quarries in Carbon County, namely, at Red Lodge, Gebo, and Bridger, while the Cascade or Dakota formations have provided a light-brownish sandstone for quarries near Belt and Armington in Cascade County. The best sandstone quarry in Choteau County is four miles southwest of Havre. Custer County has a good fine-grained sandstone with a brown color but no demand for a product of this material exists. Quarries at Glendive, Dawson County; Forsyth, Rosebud County; Madison, Park, Teton, and Valley Counties supply only the local needs. Production in Fergus County is from the Dakota sandstone at a quarry 1½ miles from town, the bed being immediately above the Lewistown coal deposits.

Yellowstone County has the best known stone in the state at Columbus. In the Laramie formation there is a bed 10 to 20 feet thick of a sandstone which has a blueish color, a very fine grain, a high crushing power, and a very even structure. An unusually splendid rift and jointing makes any size block readily obtainable. Another sandstone quarry in this country has been operated at Billings but the blocks which can be successfully used for facings on buildings are not good for foundations.
In the past a limited amount of sandstone has been quarried near Livingston, Park County and Bridger, Gallatin County for local consumption. Missoula County is favored with vast quantities of quartzite around the northern edges of Missoula Valley, in Rattlesnake Creek, and in Pattee Canyon.

Phyllite has been used for construction purposes in Kalispell, Flathead County as a quarry of this siliceous slate occurs only 2 miles southwest of the city. There is also another occurrence of phyllite in Hell Gate Canyon, Missoula County.

Three counties have had operating granite quarries, namely, Jefferson County, Lewis and Clark County, and Ravalli County. Both of the Jefferson County quarries were in the vicinity of Butte, one at Elk Park, just northeast of the city on the Great Northern railroad, and one at Welch's Spur, 17 miles east of Butte or 1 1/2 miles from Welch's station on the Northern Pacific railroad. The quarry site in Ravalli County is in Blodgetts Canyon, a few miles northwest of Hamilton, while the best known quarry in Lewis and Clark County is 9 miles southwest of Helena near the former Rimini branch of the Northern Pacific railroad. This particular granite could not be polished very successfully but it had a good appearance when chipped.

References: (13), (123).
Montana's talc is of the replacement type and is found in rocks of two different geologic ages, although at the present only one is productive.

The replacement of dolomite in the Pilgrim formation (Cambrian age) created a vein-like deposit in an old limestone quarry, one-quarter of a mile south of the city limits of Helena, Montana. This was a high-grade, very desirable material, and was very soon exhausted.

More extensive deposits in a pre-Cambrian dolomitic limestone of the Cherry Creek group occur in a belt, 40 miles across, between the Madison River Valley to the Black Tail Deer Creek Valley near Dillon.

In the Ruby Range the principal deposit, the Smith-Dillon, is in Axes Canyon (sec. 23, T. 8 S., R. 8 W.) about 12 miles by road from Dillon. Occurring in a dolomitic limestone near a contact with a glassy quartzite, this talc body shows an elliptical plan with a length of 450 feet and a width of about 100 feet. Hand-sorting produces a massive white steatite that is used for talcum powder, while the mine-run material is used by the ceramic industry.

The other operating area of this district is found up Johnny Gulch, 20 miles south of Ennis and 4 miles from State Highway No. 191, on the east side of the Gravelly Range. Here, the largest area of marble containing talc is between Johnny Gulch and Cherry Creek, the dimensions of the body being about 5 miles in length and 1½ miles in width. In this mass the largest talc deposit is 2000 feet long and 800 feet wide.
Minor amounts of talc may be found anywhere in the marbles of the Cherry Creek series, but deposits worth further investigation are reported along the Sweetwater road (sec. 2, T. 8 S., R. 7 W.) about 7 miles from Dillon; along Carter Creek, 7 miles northeast from Axes Creek; along Timber Creek, 2½ miles southwest of Axes Creek; and in the vicinity of Virginia City along Granite and Idaho Creeks. The intimate association of talc and marble in Montana is said to be unique for these minerals.

In this region the action of hydrothermal solutions upon deep-seated magnesium bearing minerals has resulted in numerous vein-like talc bodies in marble rocks, most being ½-inch by 2 or 3 inches. Larger bodies like those described above, cease to be vein-like and are irregular in shape, but they may be roughly parallel to the bedding. Only the larger ones are being exploited to produce either cosmetic, ceramic or lava grades of talc.

References: (66), (104).

THULITE (PINK ZOIZITE)

Locally, thulite is an important and conspicuous constituent of the marble rocks which are associated with corundum on Camp Creek, southeast of Dillon in the Ruby Range. The color varies from a very pale pink to a deep rose, and the mineral occurs as irregular grains, small needles, and rarely as radial aggregates that may be two or three inches in diameter, phlogopite, and chlorite. Zoizite also has been reported from the vicinity of Philipsburg, Montana.

Reference: (55).
TIN

Although tin ores have been reported in the Meaderville section of Butte, most of the occurrence of this metal are as cassiterite or wood tin in the gravels of placer mines. Of interest is an 1888 report of C. F. Copes about a tin mine in the Ruby Range with large permanent veins which assay from 5 to 20 percent tin.

Cassiterite is reported in the stream gravels of the upper Bitter Root River, and of the Basin-Rimini area. In this latter region, wood-tin concentrated by gold miners during their placer mining operations in the alluvial gravel of a stream that heads in areas of rhyolite and quartz monzonite was of sufficient quantity to warrant making one small shipment of about one ton. In this area pebbles of wood-tin occur only in detrital deposits, 5 to 15 feet thick, which may mean they originated in small amounts during the cooling of the rhyolite rock. Tests made of the undisturbed gravels of the region have indicated only 0.02 pounds of tin per cubic yard.

References: (16), (19), (57).

TOPAZ

Gem topaz was reported from the West Kendall mine in the North Moccasin Mountains, north of Lewistown, Fergus County.

Reference: (36).
TOURMALINE

A dike of coarse pegmatite which is found 22 miles southeast of Butte and 16 miles from Silver Star, Jefferson County, near the edge of the Boulder Batholith contains inclusions of tourmaline in quartz crystals, the inclusions varying from delicate needles to those with a diameter of 5\(\frac{1}{2}\) millimeters. The pegmatite consists of black tourmaline, crystals of orthoclase, mica scales, and quartz crystals (colorless, smoky, and amethystine). The tourmalines are found in the colorless and smoky variety, none being present in the amethystine variety. Some of the smoky crystals are three feet in length with a diameter of eight inches, the whole being filled with acicular tourmaline.

Small specimens less than 3 millimeters in size are found in granite pegmatites in the Jardine area, and also among the contact rocks of Alpreston Gulch on Elkhorn Peak, Jefferson County.

References: (43), (73).

TRAVERTINE

The most important of the travertine deposits in Montana are in secs. 14, 15, and 22 to 24, T. 9 S., R. 8 E. near Gardiner, Montana, at the entrance to Yellowstone Park. The deposits are on a ridge which rises 600 to 800 feet above the town and then extends northwestward for several miles. The body of travertine varies in thickness from a few feet to more than 20 over an area of about 1,250 acres; but only 200 acres have been studied and mapped in detail and in these the reserves are estimated to
be more than 5,000,000 cubic yards. The material originated from hot springs and was laid down with a horizontally-banded structure which was consolidated into a compact mass. Irregular cavities and openings, along with various tints have made it a very attractive construction material.

Another occurrence of possible travertine is located in the Little Rockies, west of Landusky (probably in the SW1/4 sec. 18, T. 25 N., near the line between Rs. 23 and 24 E.). A large outcrop resembles aragonite but has the specific gravity of calcite. It may have been a spring deposit. It takes a good polish, but the lack of transportation and demand has prevented any development so that the extent is unknown.

There also is a deposit of travertine on the southeast side of the North Moccasin Mountains, in Fergus County.

Reference: (82).

**VANADINITE**

This mineral is said by A. N. Winchell to occur in the Rabbit, Radersburg, and Silver Star mining districts of the Dillon Quadrangle.

Reference: (148).

**VERMICULITE**

This mineral (a hydrated mica) occurs at several locations in Montana, the most important being northeast of Libby, Montana in the Rainy Creek Valley. Argillite and quartzite of the Algonkian Belt series were intruded by a stock, composed roughly of two-thirds
pyroxenite and one-third syenite, over an area of about six square miles. This created a deposit of vermiculite about 1800 feet wide and 3000 feet long with a depth of possibly 400 feet. Locally the grade may be 95 percent vermiculite but some cores of biotite may have an adverse effect on expansion. The material may have originated from biotite, phlogopite, and muscovite which were altered by the addition of variable amounts of water, or maybe solutions from a series of syenite dikes which are roughly parallel to the strike of the ore zone and which block off the ore in widths of 10 to 50 feet, may have altered the pyroxenite in whole or in part to form vermiculite. Of the 14 varieties of vermiculite listed by Dana, it is said that the Libby material most closely resembles jeffersite in physical properties. Of interest is the fact that a second series of dikes contains amphibole asbestos.

The vermiculite-bearing rock near Pony, Madison County, and in the region to the south occurs in pre-Cambrian biotite and hornblende schists. A zone of typical medium-grained schist at Pony is about \( \frac{1}{4} \) of a mile wide with layers of vermiculite several feet thick. The statement has been made that no igneous action was involved in the genesis of this deposit.

There is in the Bearpaw Mountains, 25 miles east of Box Elder, and 23 miles southwest of Havre, a deposit of vermiculite which occurs in dike-like concentrations that stand nearly vertical with widths varying from a few inches to nearly four feet. In these dikes, referred to as basic pegmatites, an altered rock (clay) segregates the vermiculite. The host rock for the dikes is a monzonite. Although the body of ore is be-
between 200 and 300 feet long, no material of good specifications is found.

Vermiculite is found on Gird Creek, 11 airline miles east of Hamilton, Ravalli County, in a deposit which is very similar to that at Libby, Montana. Pyroxenite has intruded the impure limestones and argillites of the Newland formation of the pre-Cambrian Belt series. There are also intrusive masses of syenite, and pegmatite dikes. The grade of this deposit is such that some beneficiation may be required for successful exploitation.

Undescribed occurrences of vermiculite are said to be found in schists south of Harrison, near Ennis; near Virginia City; and south of Dillon.

A micaeous material similar to vermiculite occurs in a dike on Mica Creek, a tributary of Squaw Creek which is 15 miles south of Bozeman and 3 miles east of U. S. Highway No. 191. The country rock, a pre-Cambrian gneiss and schist, contains several sills and dikes, one of the latter being a mica-bearing structure, 10 to 20 feet thick and 600 feet long, with a nearly vertical dip. Locally, a dark-green to black micaeous mineral, considerably altered, comprises almost all of the rock. It may be an altered biotite or a hydrobiotite. This material is flexible rather than elastic, and heat will cause it to expand only two or three times its original volume.

References: (3), (71), (104).
WITHERITE

This mineral was observed as a filling in cavities in the Altyn limestone of the Belt series in Glacier Park. The best exposures are along the gorge below Swift Current Falls in the lower beds of the Altyn limestone, immediately above the plane of the Lewis overthrust. The witherite appears in flat masses, 1 to 6 inches thick, parallel to the bedding; as lenses, 1 to 3 inches thick and 6 to 18 inches long; and as irregular lumps up to 2 feet in diameter. Replacement, if any is not believed to have taken place concurrently with the solution that made some of the cavities.

Reference: (35).

WULFENITE

Crystals up to $2\frac{1}{2}$ inches in length have been taken from the California Mine in the Castle Mountain district. Here, this mineral with its characteristic red color is said to occur in cavities in galena.

Wee-crystallized wulfenite of low grade (1 percent) is found near the summit of Little Baldy mountain near the crest of the Tobacco Root Range. The property is 11 miles east of Twin Bridges and contains a vein of porous and well-crystallized cerussite (50 percent Pb) impregnated with iron oxide and wulfenite. The foot and hanging walls are composed of black limestone.

Specimens have been secured in the region north and west of Garnet
in Granite County, and also in the area near Cooke City.

References: (60), (122).

ZIRCONS

These minerals have been found to only a very limited extent, reported occurrences being at Wisdom, Beaverhead County, and at Miles City, Custer County. A "black sand" test in Powell County in 1905 showed zircons to be present to the extent of eight pounds per ton.

References: (17), (54), (114).
CONCLUSIONS

This thesis is the beginning of a project which, if completed, would be very useful to mineralogists, petrologists, and others who may have use for a catalogue showing the various locations of non-metallic minerals in Montana. The serious collector of mineral specimens would not only receive great assistance, but maybe his incentive for description of mineral occurrences, not now found in the geological literature, would be stimulated.

A consolidated report of this type describing the various forms of occurrences and associations of non-metallic minerals could be of considerable value to prospectors, miners, and promoters. It might even widen the field of interest for many who are now primarily concerned only with metallic minerals.

Future production of most of the economic non-metallic minerals in Montana is dependent upon an intermittent local demand, or upon a stimulus and increased price for eastern markets by some factor such as a war-created scarcity. Most of the commercial minerals are of low grade so that low cost operations are necessary. This means that large amounts of capital for investment with an assured market are extremely advisable.

Because of the thoroughness of prospectors in the past, the discovery of new high-grade deposits, by the use of mineral-associations in known deposits, is considered unlikely.


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