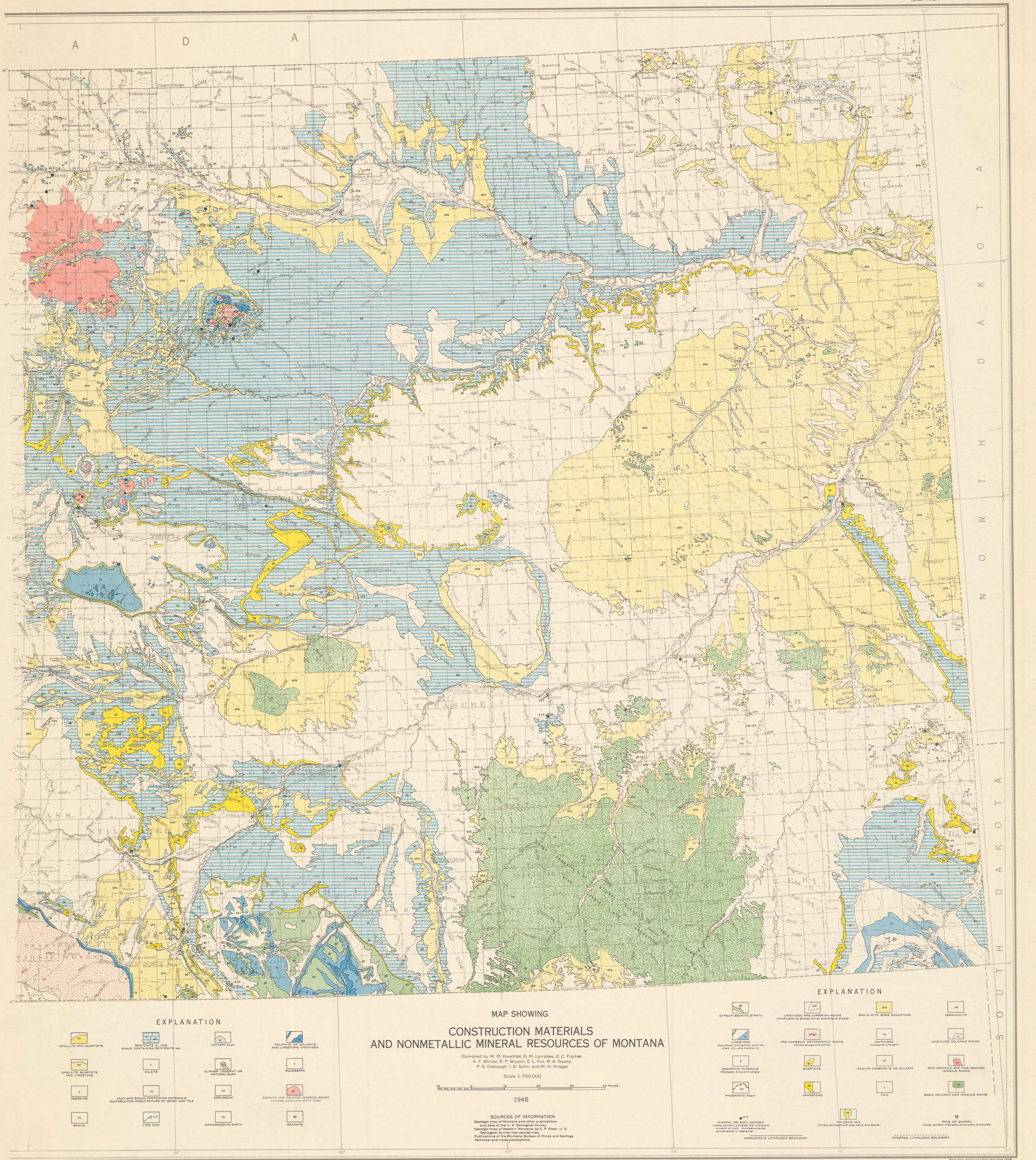
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PREPARED WITH THE COOPERATION OF
THE MONTANA STATE BUREAU OF MINES AND GEOLOGY



CONSTRUCTION MATERIALS AND NONMETALLIC MINERAL RESOURCES OF MONTANA

Construction materials and nonmetallic minerals other than fuels produced in Montana include clays, sand and gravel, dimension and crushed stone (sandstone, limestone, granite, basalt, and marble), bentonite, vermiculite, calcite for optical and general purposes, materials for Portland cement, volcanic ash or pumicite, and gem and industrial sapphires. Other miscellaneous mineral commodities such as agate, asbestos, and barite have been produced in small quantities from time to time.

During the five-year period, 1935-39, the average annual value of such materials and minerals produced in the State was about $4,400,000,[1] representing approximately 7 percent of the average annual value of all minerals produced. Sand and gravel accounted for about 45 percent of the total value of nonmetallic minerals and construction materials. During this same period, the value of all mineral production in Montana represented about 2.62 percent of the total United States production.

Deposits of materials which might be suitable for construction purposes and of nonmetallic minerals are discussed briefly in the following paragraphs, and the locations of mines and deposits are shown on this map. Sources of sand and gravel have been shown on a separate map (Missouri Basin Studies, No. 6). The data here presented and shown on both maps have been compiled from all readily available sources, including publications of the Montana Bureau of Mines and Geology and other state organizations, trade journals and technical publications, publications of the U. S. Bureau of Mines, and especially from the published and unpublished reports of the U. S. Geological Survey. The preliminary geologic map of Montana, published in 1944 by the U. S. Geological Survey, and a geologic map of western Montana now being compiled by C. P. Ross, U. S. Geological Survey, were the chief sources of data compiled on the distribution of the igneous rocks, limestones, sandstones, shales, and other rock types.

The map is neither complete nor wholly accurate, for the available source data are far from complete, and there has been inadequate time for checking the accuracy of published information, for carefully studying all references, and for the elimination of all errors that may have been made in the process of compilation. Information on construction materials is especially scarce, and a deposit shown as sandstone, for example, may be either hard, durable stone, or soft, friable sandstone interbedded with considerable shale.

AGATE

Agate occurs in more or less rounded nodules or broken fragments on the gravel bars and benches along the Yellowstone and Missouri Rivers, in an area the approximate center of which is Glendive. The original source from which the nodules were derived is probably a fine-grained igneous rock. The nodules range in weight from a few ounces to as much as 10 pounds. Many are of the moss-agate variety and are cut for jewelry in Billings, Livingston, Miles City, and Glendive.

Many of the deposits have been largely worked out and no production has been reported recently.

ASBESTOS

Amphibole asbestos has been prospected or mined in small quantities near Libby, Lincoln County, and south of Bozeman, Gallatin County. A deposit of chrysotile asbestos has been explored near Cliff Lake in southern Madison County. Some deposits have been reported in the Beartooth Mountains, Jefferson County, near Southern Cross in southwestern Granite County, and in Big Horn River Canyon, Big Horn County.

Very little asbestos has been produced from any of the deposits, some of which might yield a small production for local use.

BARITE

Barite occurs in Montana as residual deposits in Upper Cretaceous clays. One of the principal deposits occurs on Pattee Creek, 2 miles southwest of Missoula, Missoula County. There is no record of production from this deposit, but reserves may be moderate. Another is in the vicinity of Libby, Lincoln County. Deposits are also known at the head of Cabin Creek, Custer County; in Wibaux County; on Cedar Creek, Dawson County; on Rattlesnake Creek near Missoula, and in Beaverhead, Musselshell, Pondera, Madison, and Phillips Counties.

Very little barite has been produced, and the reserves are unknown.

BENTONITE

Bentonite, a clay composed chiefly of the mineral montmorillonite, is an alteration product of volcanic ash. It has been reported from widely scattered localities in Montana, but very little has been published concerning its physical and chemical properties, the extent of the beds, their variations in thickness, their attitudes, or the amount of overburden by which they are covered in different localities.

Bentonite is of two general types, commonly described as high swelling and non-swelling. High-swelling bentonite, if dried and placed in water, swells to many times (12-15) its dry volume and forms a gel-like mass; non-swelling bentonite swells only slightly, and slakes when wetted. Swelling bentonite contains soda as the exchangeable base, whereas non-swelling bentonite contains lime.

Some of the bentonite reported in Montana is of the high-swelling type, many beds of which occur interstratified with shale in the Mesozoic rocks that crop out in large areas in the plains of the central and eastern parts of the State. Bentonitic material, some of which may be non-swelling, occurs also in the Tertiary "lake beds" of intermontane valleys in the western part of the State and in the Paleocene rocks that are exposed extensively in the plains farther east. Bentonite associated with intrusive igneous rocks and volcanic flows is reported at a few localities in western Montana and is, at least in part, non-swelling. The areas of rock outcrops which appear most likely to contain workable deposits of bentonite are shown on the map.

Very little bentonite has been mined in Montana. The W. P. Enders Co. operated two bentonite plants at Warren, Carbon County. The source bentonite beds are probably in the Mowry shale (Upper Cretaceous). Seven miles northeast of Warm Springs, Deer Lodge County, a vein-like mass of bentonite 2 to 3 feet thick has yielded a small tonnage. In southeastern Carter County, the Belle Fourche formation (Upper Cretaceous), from which bentonite is mined at Belle Fourche, S. Dak., crops out in several townships near the Montana-Wyoming line. The Pierre shale (Upper Cretaceous), which also contains bentonite, crops out extensively in the same county.

The available information offers no basis for any tonnage estimate of minable reserves of bentonite in Montana, but the deposits are so widely distributed over the State, and are probably so large, that the extent of their future commercial development will depend chiefly upon an increasing demand for bentonite and the accessibility of the deposits as compared with that of deposits in other states. The physical and chemical properties of the Montana bentonites should be thoroughly investigated, for some of the clay should be suitable for use as grouting and waterproofing material, drilling mud, water softener, coagulent in purification and clarification of water supplies, detergent in laundering, and fuller's earth.

CALCITE

Deposits of vein calcite occur in two general areas in Park and Sweetgrass Counties, one north and the other east of Livingston. The veins occupy faults and other fractures in the Livingston formation (Upper Cretaceous and Paleocene) which in these areas consists of tuffaceous sandstone and siltstone with some shale.

The calcite has been deposited as a series of veins, which range from a few hundred to more than 2,000 feet in length.

Most of the calcite is opaque, coarse, white to brownish-orange, "bone" calcite which has been mined for chicken grits, and is not suitable for optical use. Calcite crystals occur in vugs or cavities commonly in the wider parts of the veins, and range in size from a fraction of an inch to 12 inches across. Although some optical calcite was produced, especially during the war years, most of the vug material is twinned, cleaved, milky, or otherwise unsuitable for optical use. Reserves of optical and other grades of calcite have not been estimated for the State as a whole.

BRICK AND TILE CLAY

Clay and shale suitable for the manufacture of brick and tile are known to occur in the Belt series (pre-Cambrian) near Whitehall; in the Kootenai formation (Lower Cretaceous) in the vicinity of Great Falls and Lewistown; in the Judith River formation (Upper Cretaceous) near Havre; in the Bozeman "lake beds" (Tertiary) at Missoula; and in Quarternary alluvium in many places, especially in parts of the Bitter Root, Clark Fork, and Flathead River valleys. The clay near Whitehall is of sufficiently high quality for use in ceramics and may be the material formerly used there in the manufacture of fire brick. This deposit may not be extensive.

The Kootenai formation is the most productive source of brick and tile clay at present, although it is known to contain usable deposits of such material only in the Great Falls and Lewistown areas. The variegated shales which are used in these areas attain a maximum thickness of 400 feet and have a wide lateral distribution. Although clay or shale of the Judith River formation has been used for pressed brick, it is said to shrink excessively in the firing process.

Blue, yellow, purple, and white clays in the Bozeman "lake beds" are worked at Missoula for manufacture of structural-clay products. Some of these clays, however, are too calcareous for this use.

Alluvial clays are of wide distribution and have been used in the manufacture of common brick in nearly every town. Most of this brick is made in small plants for local use. The alluvial clays are sandy in many places and occur with deposits of gravel, silt, and sand in the wide, intermontane valleys. The most extensive deposits and highest grade of alluvial clay are in the Bitter Root River valley, Clark Fork River valley from Plains to White Pine, and in the Flathead River valley, especially from Kalispell to Whitefish.

In 1944, 16,166 short tons of clay, classified as "miscellaneous clays, including slip clay and shale," was mined. This had a value of $10,508, placing Montana in fifteenth position among the clay-producing states.

Although the deposits of brick and tile clay in Montana are not as large as in some states, they are widespread and the reserves are practically inexhaustible.

FIRE CLAY

Fire clay is found in the Kootenai formation (Lower Cretaceous) near Armington, Cascade County; in undifferentiated Cretaceous beds on Lost Creek near Anaconda, Deer Lodge County; in an altered Tertiary intrusive rock on the southern slope of Miller Mountain in Park County; and in strata of unknown age near Whitehall, Jefferson County, Helena, Lewis and Clark County, (John Quirk mine), and Rimini, Lewis and Clark County.

The deposits of greatest known extent are those near Armington, and are mined by the Anaconda Copper Mining Co. along Armington Coulee, Sec. 31, T. 19 N., R. 7 E. They occur as lenses in a bed 4 feet 6 inches thick, 90 feet above the base of the Kootenai formation and 26 feet above a prominent coal bed. Near Spion Kop, sec. 3, T. 17 N., R. 8 E., a similar clay deposit has been prospected. These two clay lenses and others of probably small areal extent in the vicinity of Armington Coulee are thought to occur at approximately the same horizon. The probable line of outcrops of these beds is shown on the map.

Figures on production and consumption of fire clay in Montana are not available, but are known to be small. Reserves are probably not very large.

POTTERY CLAY

Pottery clay has been described near Plentywood, Sheridan County; northwest of Lewistown, Fergus County; near Blossburg, Powell County; at Thompson Falls, Sanders County; southwest of Missoula, Missoula County; and south of Grantsdale, Ravalli County.

The deposit of greatest known extent is that near Plentywood. The clay bed is a part of the Fort Union formation (Tertiary age); it is from 2 to 8 feet thick and covers an area of approximately 140 square miles. The clay is gray to white in color, has good plasticity and bonding power, high tensile strength, fuses at Seger cone 20, and is buff burning. It is similar to clays used for stoneware but its most promising use is in the manufacture of common and face brick.

Large deposits of pottery clay occur in the Rocky Mountain area where they were formed during Pleistocene time in most of the glacial lakes that filled the intermontane valleys. Nearly all of the pottery clay deposits are finely laminated, and some are interstratified with quartz sand. Such deposits are abundant throughout the western third of the State and are from 1 to 20 feet thick. The Missoula, Bitter Root, and Kalispell valleys, the valley between Thompson Falls and Plains, and many other similar valleys each contain at least one good clay deposit.

Good pottery clay also occurs in the Kootenai formation (Lower Cretaceous) about 8 miles northwest of Lewistown. This material is chalky, dense, brittle, and nonplastic.

No production of china clay or ball clay was reported in Montana in either 1943 or 1944. The reserve of pottery clay in the State is probably moderate.

CLINKER OR NATURAL SLAG

Many large deposits of clinker, formed where heat from burning coal has baked and fused the overlying shale, occur in eastern and southeastern Montana, and also nearby in Wyoming and North Dakota. Most of the clinker is in the Tongue River member of the Fort Union formation (Tertiary); minor amounts are associated with other formations. The clinker has been used locally for road metal and as a base for road metal, mainly in areas where gravel is lacking.

Evidence of the widespread distribution of clinker in southeastern Montana is contained in numerous reports on coal fields of the State. Belts of clinker commonly extend for miles along the outcrops of coal beds. The thickness of clinkered rock ordinarily is 10 to 25 feet but is several hundred feet in places; the clinker belts range in width from a few tens of feet to many hundreds of yards. Most of the clinker is overlain by only a thin mantle of soil.

ABRASIVE CORUNDUM, INDUSTRIAL SAPPHIRES, AND GEM SAPPHIRES

Corundum has numerous uses. Clear, transparent varieties of good color are used as gems, of which the best known are sapphires and rubies. Transparent to translucent corundum stones of poor color or small size are marketed as industrial sapphire for watch jewels and similar uses. Ordinary corundum, which is usually dull gray or blue, is used as an abrasive because of its toughness and hardness. Montana has yielded all of these varieties.

Deposits of abrasive corundum, in Gallatin and Madison Counties, were developed for mining during the war, but only a small quantity of the mineral was produced. Industrial sapphires and a few gem sapphires have been produced since 1891 from placer deposits along the Missouri River near Helena, on Rock Creek southwest of Philipsburg, and from stream gravels at a few other localities. Most of the industrial sapphires have been recovered as a byproduct of placer gold operations. The chief source of gem sapphires in the State is the deposit at the mouth of Yogo Gulch in Judith Basin County, where sapphires of excellent color occur in an igneous dike. The mine at Yogo Gulch, inactive since 1939, is owned by New Sapphire Mines Syndicate, an English company. This is the most important gem mine in the United States, but it probably cannot be operated profitably in competition with foreign and synthetic sapphire production unless the demand for natural sapphires is strong.

About 350 tons of abrasive corundum was produced from the abandoned Montana mine, Gallatin County, during the period of operation 1901-03. A few hundred tons of ore was mined during development work and testing in the years 1943-45, but there was no other production. Reserves of abrasive corundum in this area are estimated to be only a few thousand tons of ore containing about 10 percent corundum.

The production of industrial sapphire is valued at $20,000 to $50,000 per year, and the total production of gem and industrial sapphires in Montana between 1883 and 1943 is valued at more than $3,000,000. The production of industrial sapphires and occasional gems as byproducts of placer gold operations may be expected to continue in the future. Profitable production of sapphires alone is unlikely, although the reserves in stream gravels and in the dike rock at Yogo Gulch are probably large.

DIATOMITE

Diatomite, or diatomaceous earth, which is used as a filter, insulator, or filler, has been noted in the vicinity of Townsend, Broadwater County. One deposit, north of Greyson Creek, is about 10 feet thick; another, north of Beaver Creek, consists of two beds, each about 1 foot thick, which may have a greater areal extent than exposures indicate. Diatomite has also been reported along Flint Creek near New Chicago, Granite County. The diatomite deposits appear to have formed in fresh-water ponds during Oligocene time. No production has been reported in the State.

FLUORSPAR

Fluorspar deposits have been prospected or mined in a small way near Austin, Lewis and Clark County; near Silver Bow, Silver Bow County; in the Sweetgrass Hills, Liberty and Toole Counties; near Superior, Mineral County; and near Anaconda, Deer Lodge County. Fluorspar exposed incidental to other mining operations has been reported in the Little Rocky Mountains, Phillips County; Judith Mountains, Fergus County; Duck Creek Mountain, Broadwater County; near Elkhorn in Jefferson County; in the Marysville district, Lewis and Clark County; Philipsburg, Granite County; and in the shale of the Silver Hill formation and in decomposed granitic rocks on Mill Creek Deer Lodge County.

The deposits have received only cursory exploration. Little is known about the reserves; and in general fluorspar exposed in metal mines is either of such low grade or small amount that production from them is not expected unless the fluorite can be economically extracted as a byproduct.

GRAPHITE

The only graphite deposit from which production has been reported is about 15 miles southeast of Dillon, Beaverhead County. Other graphite deposits have been reported near Virginia City in the Tobacco Root Mountains, Madison County; near the Idaho line in southern Beaverhead County, and near Toston, Broadwater County.

Reserves are probably small, and the deposits are all so far from any consuming center that graphite mining in the State would probably be unprofitable.

GYPSUM

Large deposits of gypsum occur in formations of Mississippian, Triassic, and Jurassic age in south-central Montana. The Kibbey formation (Mississippian) contains thick beds of gypsum which are exposed near the road between Millegan and Lingshire, Cascade County; the Chugwater formation (Triassic) contains gypsum which is exposed in the Pryor Mountains, Bighorn County. This formation is reported to contain 60 feet of granular gypsum grading northward into a 3-foot, thinly-bedded limestone. The thickest, most widespread deposits of gypsum, however, occur in the Ellis formation (Jurassic) cropping out in Carbon, Cascade, and Fergus Counties; this is believed to be the only formation from which gypsum has been mined in the State. The mineral has long been mined from a 20-foot, pure white bed 1 mile south of Heath, Fergus County; at Hanover, Fergus County; at Goodman, Cascade County; and 8 miles south and east of Bridger, Carbon County. The gypsum is used for manufacturing stucco, wall plaster, and plaster of Paris.

PEGMATITES

In some states, pegmatites contain workable deposits of feldspar, mica, and lithium minerals, and although this may be true of the Montana pegmatites, only those which produced mica during the war have been studied recently. These are lense-shaped bodies, as much as 200 feet long and 65 feet wide, which occur in the Tobacco Root Mountains, Madison County.

None of the pegmatites examined could be profitably developed for mica at ordinary prices. Access is difficult, and deposits are far from trade centers. Whether the feldspar in the pegmatites is of marketable quality or occurs in economic quantities has not been determined. Large, well-developed feldspar districts in other states are nearer the important markets.

A few crystals of beryl are reported from the Big Chief mine. Small reserves of sheet mica of good quality occur on the Big Chief and White Swan properties. The Tobacco Root Mountains pegmatite district, although seeming not to warrant development, has never been thoroughly prospected. Since the presence of unexamined pegmatites is known, and the area is geologically favorable, it is believed that other workable deposits of pegmatite minerals might be found.

The total wartime production of trimmed sheet mica during 1943 and 1944 was less than 1,000 pounds.

PHOSPHATE

Phosphate rock is used mainly for conversion to superphosphate for fertilizer; some is also used in cattle feeds and in the chemical industry. By far the greatest phosphate reserve is in the sedimentary deposits of Montana, Idaho, Wyoming, and Utah. Exposures of phosphate rock occur sporadically across southwestern Montana from the vicinity of Yellowstone Park west and north to near Garrison and Elliston. This material occurs in the Phosphoria formation (Permian) of the northern Rocky Mountains. The rocks containing the phosphate deposits have been extensively folded and broken, and as a result, the phosphatic beds crop out in patches or in bands that stretch for many hundreds of miles across country. Although the richest and thickest of the phosphate deposits are in Idaho, Montana also has considerable quantities, and in the last few years has exceeded Idaho in total production.

Over 136,000 tons of phosphate rock was produced in Montana by three mining companies in 1944. Only one, the Montana Phosphate Products Co., of Trail, B. C., shipped notable amounts, and most of its product was sent to Trail. It operated mines near Anderson, Graveley, and Anaconda, and worked leases in Powell County. The International Minerals and Chemical Corp. mined phosphate rock near Douglas Creek in Granite County and operated a pilot plant near Sherryl for experimental purposes only, making no commercial shipments during 1944. Some phosphate rock was also mined near Maxville, but none was shipped.

A reserve of over 390,000,000 tons of phosphate rock was estimated by G. R. Mansfield for the whole State. The richest reserves are those in the general vicinity of Garrison, Maxville, and Philipsburg, but there are also deposits of potential value at many other places. The increased use of fertilizers on western soils, and the gradual depletion of eastern phosphate reserves will undoubtedly provide an increasing incentive for development of deposits in this region.

SODIUM AND POTASSIUM SALTS

Sodium and potassium salts are reported in lake beds southeast of Fort Benton, Chouteau County. Sodium sulphate, Glauber's salt, is said to occur 40 miles northwest of Great Falls, Teton County; and in the brines and lake bed of Lost Lake, Chouteau County.

None of these deposits has been exploited. The Fort Benton deposit has a reported reserve of 5,000,000 tons.

STONE

The various types of stone shown on the map are discussed briefly in the following paragraphs. A few limitations of a map of this type should be pointed out: The scale used limits the detail that can be shown, and the information given is based on inadequate reconnaissance mapping in many areas. Large areas of limestone, sandstone, or granite are shown, for example, where actually the bedrock is covered by shallow surficial deposits of sand, gravel, clay, or soil. A formation that is reported to be chiefly sandstone is shown on the map as sandstone even though it may contain beds of limestone, shale, and conglomerate.

Igneous and metamorphic rocks.—Granite, quartz monzonite, granodiorite, and some syenites have been grouped together on the map. Such rocks occur in the following counties: Beaverhead, Cascade, Chouteau, Gallatin, Granite, Jefferson, Judith Basin, Lewis and Clark, Madison, Missoula, Park, Ravalli, Silver Bow, and Sweet Grass. They may occur also in other counties of the western half of the State.

Some of these rocks are suitable for building stone and for crushed stone. Quarries have been operated in Lewis and Clark, Jefferson, and Silver Bow Counties.

The pre-Cambrian metamorphic rocks are chiefly gneiss and schist, but quartzite and marble also occur. Some ultrabasic intrusives have been included where not separately mapped. Materials suitable for crushed stone or riprap may occur in many of the areas underlain by these rocks.

Undivided pre-Cambrian rocks comprise the older igneous and metamorphic rocks which have not been separated into rock types. They may include granite, gneiss, schist, quartzite, slate, and marble, and some of them should be suitable for riprap and crushed stone.

The volcanic rocks, undivided, comprise the various kinds of volcanic rocks which have not been classified. They probably include acid and basic rocks, associated in places with pyroclastic material.

Acid volcanic and fine-grained igneous rocks include rhyolite and rocks of intermediate composition such as latite, quartz latite, and andesite. Some small areas of basic rocks, and quartz-diorite intrusives, may have been included. Some of these rocks are suitable for riprap and crushed stone.

Basic volcanic and fine-grained igneous rocks include shonkinite, diabase, and metabasalts. Although coarse-grained, some diorite and gabbro have been included. Many of these rocks have been used for riprap and crushed stone.

Limestone and dolomite.—Deposits of limestone and dolomite are plentiful in the State, and occur most commonly in the Paleozoic rocks of Cambrian, Ordovician, Devonian, Mississippian, and Pennsylvanian age. These strata are extensively exposed in the south-central and western parts of the State, and in a few localities in the eastern part. In northwestern Montana, the Paleozoic strata are approximately 4,800 feet thick. Except for about 400 feet of sandstone and shale in their basal part, they are made up chiefly of limestone, magnesian limestone and dolomite. The rocks of the Madison group (Mississippian), which range in thickness from about 800 feet to approximately 1,500 feet, generally consist of limestone containing very little magnesium. The Mission Canyon limestone, a persistent, massive unit in the upper part of that group, is in large part nearly pure limestone. Limestone also occurs interbedded with argillites in the pre-Cambrian rocks of western Montana, but much is highly argillaceous; this is true also of limestone of the Ellis formation (Jurassic) in central Montana and the Niobrara formation (Upper Cretaceous) in the southeastern corner of the State. Dolomite is especially common in the uppermost Cambrian rocks, outcrops of which are widely distributed in the south-central and western parts of the State, and in the Ordovician rocks exposed in the Bighorn Mountains and the Little Rocky Mountains.

The Madison limestone has been quarried for use as flux and for the manufacture of lime in Cascade, Gallatin, Park, Silver Bow, and Powell Counties, and pre-Cambrian limestones have been quarried for these uses at East Helena, Lewis and Clark County. Limestone of pre-Cambrian age, quarried at Helena, is used for building stone; limestone, probably pre-Cambrian, is also quarried at Kalispell, Flathead County. Building stone, probably the Madison limestone, is produced at Maiden Rock, Silver Bow County. Limestone is quarried 8 miles west of Sappington, Gallatin County, for use in sugar refining, and small quantities of the Madison have been quarried near two gold mines in the Little Rocky Mountains, Phillips County; this was used in the cyanide process. Dolomite has been quarried at Anaconda, Deer Lodge County.

Cement rock.—Limestone, probably the Madison limestone, has been used in manufacturing Portland cement at Trident and near Sappington, Gallatin County. In a plant at Hanover, Fergus County, cement is manufactured from Madison limestone mixed with shale from the Heath formation (Mississippian). Limestones and shale suitable for cement manufacture are reported to be enclosed in monzonite porphyry 6 miles south of Havre, Hill County. Cement rock is also reported to be present in the White River formation (Oligocene) in Carter County, though much of the calcareous rock in that County is too siliceous to be wholly satisfactory for this use. The Pierre shale of Carter County may contain material suitable for cement, but the calcareous beds of the Niobrara formation there exposed are described as too argillaceous, notwithstanding the use of Niobrara material for that purpose in Wyoming.

Marble.—Marble described as "remarkably pleasing and handsome," when polished, crops out on the mountain spur on the west side of the valley of the Missouri River opposite Townsend, Broadwater County. This marble, which occurs in several of the Paleozoic limestones, is evidently present in great quantity. Onyx marble, suitable for use as ornamental stone, has been quarried from a nearly vertical vein three-quarters of a mile long and 65 feet wide, 5 miles north of Manhattan, Gallatin County. This vein cuts the Madison and older Paleozoic limestones. Onyx that could be used for ornamental purposes occurs also in the Little Rocky Mountains, Phillips County; at Dempsey Creek, Powell County; and near Helena, Lewis and Clark County. Ornamental travertine is quarried near Gardiner, Park County.

Sandstone.—Sandstone is commonly exposed in areas underlain by Mesozoic and Tertiary rocks which are extensively exposed in the central and eastern parts of the State. Some sandstone occurs also in the pre-Cambrian and Paleozoic rocks of western and south-central Montana. The stone is particularly plentiful in the Kootenai formation (Lower Cretaceous), in the Eagle, Judith River, Fox Hills and Lennep formations (Upper Cretaceous), and in the Tongue River member of the Fort Union formation (Paleocene). Belts of outcropping sandstone of all these units are shown on the State map by the symbols "ss" and "shs," but it is noteworthy that sandstone, commonly soft, is present though less abundant in many areas not indicated as sandstone on the map, including the large areas of Upper Cretaceous shales shown by the symbol "sb" or left blank on the map. Some sandstone occurs in Tertiary "lake beds" in intermontane valleys of the Rocky Mountains; these "lake beds" are shown by the symbol "vo." Sandstone layers of the Kootenai and Eagle formations extend over large areas as well-indurated material suitable for building stone or riprap. The Virgelle sandstone member of the Eagle sandstone is a particularly massive cliff-forming unit that is commonly 100 feet or more thick. Beds of the Fox Hills sandstone, though persistent and comparable in thickness with those of the Eagle sandstone, are generally soft. The sandstones of the Judith River formation; of the Tongue River member of the Fort Union; and of the Tertiary "lake beds" are not continuous through great distances, are extremely variable in thickness, and are largely soft and friable. Nevertheless, they are used locally as building stone and probably include some material that could be used as riprap.

Sandstone is quarried in many parts of the State. It is used chiefly for building purposes, although a quarry 15 miles southwest of Dillon, Beaverhead County, has in addition produced sandstone for fluxing and for silica brick used in converter lining at the Washoe smelter at Anaconda. The sandstone of this quarry has been described as probably including material that would be suitable for use in manufacture of glass. The rock quarried probably forms part of the Tertiary "lake beds." Sandstone, possibly of the Fort Union formation, has been quarried within a few miles of Miles City, Custer County, for local use as building stone. A large quarry at Columbus, Stillwater County, has yielded building stone from a bed 10 to 20 feet thick in the Judith River or Lennep formations. The material from this quarry was used in construction of the State Capitol at Helena. The Columbus quarry has also produced some flagging and material for grindstones. The Virgelle sandstone member of the Eagle sandstone is quarried for building stone at Billings, Yellowstone County, and possibly is the unit containing the "thick, extensive ledges" of sandstone from which building stone has been quarried at Bridger, Carbon County, for shipment to Butte. Sandstone in the lower part of the Colorado shale is quarried for building stone at Great Falls, Cascade County, and building stone is also quarried from Upper Cretaceous beds of uncertain identity at Havre and Livingston. Sandstone of the Kootenai formation is quarried for building stone at Belt, Armington, and Great Falls, Cascade County; and at Lewistown, in Fergus County.

Quartzite.—Much quartzite interbedded with argillite occurs in pre-Cambrian rocks of the western part of the State. The Flathead quartzite (Middle Cambrian) of western and south-central Montana and of the Little Rocky Mountains, and the Quadrant quartzite (Pennsylvanian) of south-central Montana, are also potential sources of this rock. A few beds and lenses of quartzite occur in the Fort Union formation (Tertiary). The Quadrant quartzite follows the belts of phosphate rock shown on the map.

Much of the pre-Cambrian quartzite would be suitable for building purposes and riprap but is quarried with difficulty and has therefore been utilized to only a small extent. Some of the rock has been quarried near Dillon, Beaverhead County, for use in buildings at Dillon and Butte, and is described as having a beautiful deep red to pinkish color. Boulders of pre-Cambrian quartzite have been hauled from localities near Missoula, Missoula County, to be used in the foundations of houses in that city. The thin quartzite beds in the Fort Union formation of eastern Montana may be valuable locally as sources of riprap.

TALC

Data on the talc deposits of Montana are meager. However, a deposit near Ennis, Madison County, has been worked during the last few years for ceramic and lava grades of talc, and one deposit has been worked and another prospected near Dillon, Beaverhead County.

Production from these deposits has been small. No estimates of reserves have been made.

VERMICULITE

The most productive deposits of vermiculite in the United States are 7 miles northeast of Libby, Lincoln County. The vermiculite is a result of hydrothermal alteration of biotite, which is associated with a pyroxenite and syenite stock intruded into the Belt series. Other reported deposits are south of Havre, Hill County; on Gird Creek in the Sapphire Mountains, Ravalli County; and north of Pony, Madison County.

Between 1924 and 1943, the total reported production for the country was 253,695 short tons valued at $2,135,564. Most of this production was from the Libby area, where reserves are large.

VOLCANIC ASH

Volcanic ash, or pumicite, is an accumulation of angular, fine-grained, glassy particles having a chemical composition similar to rhyolite. Most of the ash in Montana is the result of early Tertiary volcanic activity and was deposited in the lakes which then occupied large parts of the wide intermontane valleys in the western part of the State. This water-laid ash is uniform in composition over wide areas. Much ash was deposited on the land surface, however, and later, with other material, was washed into the lakes. These deposits are impure and are usually much thicker than the ash that was originally deposited in water. Few deposits of ash that fell on the land surface have been preserved; the deposit along Checkerboard Creek, east of White Sulphur Springs, is one of these.

Most Tertiary ash is unconsolidated or poorly consolidated, but a deposit northwest of Dillon is sufficiently hard to be used as building stone. A poorly stratified deposit of porcelain-like ash occurs in the Benton shale of Upper Cretaceous age, south of the Highwood Mountains. This material breaks into small flat fragments. Ash is also said to occur in the Lebo shale member of the Fort Union formation (Tertiary age) in the eastern and southeastern parts of the State. The deposits in the Lebo, however, are probably thin.

No production of pumicite was reported for Montana in 1943 or 1944.

[1] Minerals Yearbooks, published by the U. S. Bureau of Mines, are the sources of most production data shown here.

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