South Dakota Geological and Natural History Survey

Freeman Ward, State Geologist

CIRCULAR 16

The Natural Resources of South Dakota

By
The Departments of Geology
of
The University of South Dakota
and
The South Dakota School of Mines

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EXPLANATION

The Survey issues two series of publications as follows:

BULLETINS.—Some subjects have been investigated a longer time, full data have been gathered, such preparatory or experimental work as was necessary has been entirely or nearly finished. In other words, the study of the subject is actually completed or so nearly so that the results can be relied on and published with a degree of confidence as to their value; and the treatment is full and thorough. In such a case the matter is published as a bulletin.

CIRCULARS.—But often during the progress of the work, enough information is at hand to be of value to those interested, yet not enough for a complete treatise. A part of a county or a part of a certain subject may be finished, perhaps, and publication waiting for the complete investigation of the whole county or the whole subject. There may be a demand for statistical matter, or lists of references, or current information, etc., which would hardly do for a formal bulletin. Such partial reports, summary reports, reports of progress, lists, or unit fragments of larger subjects, etc., are handled in circulars.

It is planned to publish the circulars frequently and the bulletins at longer intervals. With this arrangement much information will reach the public with a minimum of delay.

Inquiries may be addressed to the State Geologist, Vermillion, S. D.

INTRODUCTORY NOTE

Over twenty years ago the State Survey issued a bulletin (No. 3) on the Mineral Resources of South Dakota. This has served a useful purpose, the demand for it being so great that the edition was exhausted many years ago.

There is still a steady demand for data concerning the mineral resources of this state and there is need for a new bulletin, larger than No. 3 and bringing all information up to date.

To get the essential facts to the public with the least loss of time it has been thought best to issue a briefer circular instead of a more complete bulletin. The bulletin will appear some time in the future, as opportunity offers for its preparation.

In the very nature of the case each subject presented in this circular can be treated only in outline form. There is no room for discussions of geologic or economic conditions. It is also thought best to omit all citation of the literature. Those who are interested in any particular material or topic are urged to write in for additional data. Inquiries should be addressed to the State Geologist, at Vermillion, South Dakota.

This circular represents a joint effort and in this respect is similar to Bulletin No. 3. The departments of geology of the University of South Dakota and the South Dakota School of Mines have combined. Mr. J. P. Connolly of the School of Mines, at Rapid City, is responsible for the article on the Black Hills area. Mr. G. F. Moulton, Mr. E. P. Rothrock and the State Geologist, all from the University, at Vermillion, have contributed other articles. Reference to the Table of Contents will show the distribution of topics.

F. W.

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ARTESIAN WATER

FREEMAN WARD

The water resources of the State are various: lakes, in the eastern part; one navigable river; springs and mineral waters; artesian waters, etc. The water problem includes navigation, power, and water softening, as well as the usual matter of domestic supply. In this circular there will be room for only a brief presentation of the vital artesian water situation.

The Problem.—Probably 10,000 artesian wells have been drilled in the State, ranging in diameter from one and a half to eight inches. Many of them were dug years ago: new ones are being drilled every year. Individual wells have yielded ten to sixty gallons a minute very commonly; 200 to 800 gallons a minute was not unusual ten or fifteen years ago; while a maximum of 1,600 is reported.

The aggregate flow runs into a very large figure, and probably 90 per cent has been put to no useful purpose. In other words there has been a tremendous waste of valuable water for many years and the waste continues.

Fifteen years ago the query was put as to whether the supply of artesian water is inexhaustible: a theory was advanced that the supply was limited and that the use should be restricted. Today no theorizing is necessary. It is an established fact that the supply is notably diminished even in so short a period as ten years. Systematic record keeping and investigation have shown that wells that formerly were gushers are today flowing feebly, that many wells that used to flow have stopped flowing entirely, that the water level in pump wells have become lower and lower, that the limits of the artesian basin are continually being reduced. As one illustration of the lessening flow may be given the following: In 1922 there were two and a half times as many wells as in 1912, yet the total yield was only one fourth that of 1912. These facts are noted for all parts of this state and in North Dakota as well, which is in the same artesian basin. It may be further added that due allowance has been made for clogging, damaged casing and poor well construction.

The problem is easily understood. Suppose all the hydrants in a city water system were left wide open. The water in the supply tank or reservoir would gradually be drawn away till the pressure at the hydrant would be lowered. Many hydrants would not flow at all and finally only those in the lowest part of town would flow, since a few open hydrants could drain away the water as fast as it is pumped into the stand pipe or reservoir.

The present rate of wastage is so rapid that in a relatively short time (probably fifteen or twenty years) only the lowest parts

of the State will have any flowing wells. It is a serious situation and deserves the personal attention of all the citizens in the State.

The Remedy.—The obvious remedy is to stop the waste. Experiments and careful observation have shown that the flow from wells can be cut down a very great deal and still allow enough for necessary use and to prevent freezing. It has been found that if the flow is reduced to one gallon a minute, this will provide enough to water a hundred head of mixed stock, keep duck ponds and hog wallows supplied and prevent freezing at the well. The writer and others interested are not urging that the use of artesian water be restricted but that the large waste be stopped.

Even with the strict carrying out of the whole plan we can never hope to restore the original head,—that is past remedy. But the water can be conserved so that it will supply the State for many decades to come.

It is hoped that all well owners will make an effort to reduce the flow from their wells and that each citizen will express himself as in favor of the scientific investigation and legal action necessary for the saving of this valuable water supply.

THE BLACK HILLS

J. P. CONNOLLY

It is fitting that a review of the mineral resources of the Black Hills region should be made at this time. This year commemorates the fiftieth anniversary of the discovery of gold in the Black Hills, and although active mining operations did not begin until nearly two years later, the year of discovery, 1874, stands out as the beginning of one of the major industries of western South Dakota.

Following the close of the first quarter century of active mining in the Black Hills, a comprehensive review of the geology and mineral resources of the Hills region was made by Dr. C. C. O'Harra, of the State School of Mines, and published as a bulletin of the State School of Mines and of the State Geological Survey. The purpose of the present paper is to review briefly present conditions in the mining and quarry industries of the Black Hills. Therefore, descriptions of the geologic relationships of the various mineral occurrences are treated very briefly, and the reader who desires more detailed information of this character is referred to the earlier bulletins.

Production figures for 1923, given in the following pages, have been very kindly supplied by Mr. Otto Ellerman, State Mine Inspector.

Gold.—South Dakota stands well toward the top among the gold producing states of this country, each year vying with Nevada

for third place among the states of the Union. By far the largest part of South Dakota gold is produced from the Homestake Mine. From the standpoint of yearly and total production, and large scale of operations, continued over a long period of time, the Homestake ranks as one of the greatest gold mines in the world.

The Homestake Mine is situated at Lead, in the northern Black Hills. Viewed in a broad way the geological relationships are rather simple, although the details of the geology in the vicinity of Lead are quite complex. The rocks of the district, which enclose the Homestake ore body, are highly metamorphosed sediments of pre-Cambrian age. Their structure is not that of a simple monoclinal fold, as has been often held, but they are folded into a series of plunging anticlines and synclines. Into these complexly folded pre-Cambrian rocks have been injected two large dikes of Tertiary rhyolite, porphyry and many smaller intrusions.

According to the latest investigations, the ore bodies are the result of replacement of a certain highly calcareous and dolomitic bed in the pre-Cambrian series, as a result of which this bed has been altered to a mixture of cummingtonite (amphibole), chlorite, quartz, several gold-bearing sulphides, and finely divided free gold. According to the more generally accepted view, this mineralization took place in pre-Cambrian time, with some additional mineralization immediately following the igneous intrusions in Tertiary time. (Paige and earlier investigators.) Another view, recently expressed by Messrs. Wright and Hosted, geologists for the company, is that the entire mineralization took place in Tertiary time as a result of igneous intrusion. The ore bodies so far discovered are confined to the vicinity of the intrusives, and therefore, according to this view, new ore bodies should be sought near the contact between the altered calcareous bed and the Tertiary porphyry dikes. This illustrates nicely the manner in which an apparently purely scientific theory, namely, the age of the mineralization, may have a very important practical bearing.

The distribution of the gold in the ore is very irregular. It is most abundant in the ledge series, that is, in the altered carbonate rock, in which it averages about one fifth ounce a ton. Wright and Hosted give assay returns on two sample lines across the main ore body on the 1,000 foot level. These show variations in value from ten cents to thirty dollars a ton. The ore fed to the stamp mills averages $4 a ton.

The most interesting of the recent developments at the Homestake property is the practical completion of two very important programs of construction. These are remodeling and new installations at the Ellison shaft, and the building of the new South Mill. The remodeling at the Ellison shaft consists in altering the timbering to accommodate two seven-ton skips and cage, and to provide for separate pipe compartment and ladderway. The older arrange-

ment provided two cage compartments and a pipe and ladderway. In addition there have been installed underground crusher stations and loading pockets, a new steel headframe, and an electric hoist. At the time of writing, hoisting from the Ellison shaft had not yet begun.

The new South Mill was built to replace the old Homestake Mill, which has been abandoned because of subsidence due to mining in its vicinity. The new mill has been in operation for several months. It was built to handle 1,800 tons daily, but is so designed that additional units providing for increased capacity can be added as needed.

The value of the bullion produced at the Homestake Mine has run somewhere between five and seven millions of dollars a year for many years. The production in 1923 was $6,319,000. During 1922 dividends were paid at the rate of $3.50 a share, the total dividends paid amounting to $879,060. During 1923 dividends were $6.00 a share, amounting to $1,506,960. Total dividends paid by the company to the end of 1923 amounted to $45,310,684.

There is another type of gold ore, quite different from the Homestake type just described, that has been the source of important gold production in the Black Hills. Although at the present writing no ore of the second type is being produced, a brief description of the geological occurrence is worth while, because of the fact that one company, the Trojan Mining Company, suspended operations only a short time ago, and plans to resume operations in the near future.

This second type of gold ore is situated in the Bald Mountain and Ruby Basin districts, about five miles to the west and southwest of Lead. The rocks of this region consist of pre-Cambrian metamorphics at the bottom, overlain by about 500 feet of Cambrian sediments, quartzites, shales, and siliceous dolomites. All of these are intricately intruded by dikes, sills, and laccoliths of light colored porphyritic rocks of Tertiary age. The ores are replacement deposits in the siliceous dolomite beds, the ore bodies "making out" from fractures cutting through the rocks. These fractures cut the rocks in various directions, but most of them can be grouped into definite systems according to their direction. These fractures have served as channelways for the upward moving ore solutions, and as starting places for the replacement of the adjacent country rock. Ore has been mined at two horizons in the Cambrian formation; at the "lower contact," from a mineralized dolomitic bed just above the basal quartzite, and at the "upper contact," a similar mineralized dolomite nearly 500 feet higher stratigraphically. The ore in its original state is a hard, dense, bluish gray rock, called "blue ore" locally. Microscopic examination shows it to consist largely of secondary silica and much very finely divided pyrite. The exact manner of occurrence

of the gold in this ore has not been definitely determined. Some native gold has been observed, tellurides have been detected, but the major portion of the gold seems to be associated with the finely divided pyrite. This "blue ore" is very refractory: to date, no very satisfactory method of treating it to get a high recovery at a reasonable cost has been devised. If a satisfactory treatment is ever devised, many millions of tons of ore that is now left in the mines will be available, and will add greatly to the gold resources of the Black Hills.

Where the "blue ore" has been oxidized it has been changed into a rusty brown, hard, porous rock, consisting mostly of quartz, limonite, and the gold. This ore is not refractory, and the gold is recovered readily by fine grinding and cyaniding.

Many millions of dollars have been produced from these siliceous ores of the Bald Mountain and Ruby Basin districts, from the Golden Reward, Great Mogul, Trojan, and other mining companies. The Trojan Mining Company operated for a short time during 1923, producing $61,623 in bullion up to the time of closing down. This company announced plans for reopening in 1924.

There are many other smaller gold mining properties in the Black Hills. The State Inspector of Mines lists thirty-five mines that have produced gold, but of these only the two companies mentioned, the Homestake Mining Company and the Trojan Mining Company, are listed as regular producers. For details concerning the geological relations of the other deposits the reader is referred to the earlier bulletin by Dr. C. C. O'Harra.

The total gold production of the Black Hills from 1876 to 1923 inclusive is $243,062,293.

Silver.—An important amount of silver is produced each year from the Black Hills. At the present time the major part of the silver production cames from the recovery of silver in the gold ores of the Homestake and the Trojan properties. The ratio of gold to silver in the Homestake ore varies considerably, but averages about five to one. In the refractory, siliceous ores of the Bald Mountain and Ruby Basin districts the silver content is much higher, there being about five parts of silver to one of gold in the oxidized ore, and nearly three parts silver to one of gold in the blue ore.

In addition to the gold-silver ores mentioned in the preceding paragraph, there are some silver-lead ores in the Black Hills that have been responsible for important production in the past, and may again produce silver. The most important district is in the valley of Bear Butte Creek, near the town of Galena, about five miles to the southeast of Deadwood. The ores in this district are very similar in their geological occurrence to the blue siliceous ores of the Bald Mountain and Ruby Basin districts. They are

replacements in the Cambrian siliceous dolomites, along vertical fractures, and are found at three horizons. These are at the "lower contact," at or very near the base of the formation; at the "upper contact," about 300 feet above the Algonkian and near the top of the Cambrian series, and a less important horizon, about 100 feet above the Algonkian schists. There are some half dozen mines in the district, but only two, the Richmond-Sitting Bull and the New Silver Queen, are producing or doing any development work at the present time.

There are two other camps in the Black Hills that have produced silver-lead ore in the past, but are not being operated at the present time. These are the Carbonate Camp to the northwest of Deadwood, and the Spokane District in the southern Hills. In the Carbonate Camp the ores resemble those of the Galena District and the Bald Mountain District in their broader geological relations, but are in Carboniferous rocks instead of Cambrian. The mineralogy is somewhat different, as the ores are oxidized silver and lead minerals. In the Spokane District the ore deposits are well defined quartz veins in the pre-Cambrian rocks.

The total silver production in the Black Hills has amounted to $5,230,144 up to the end of 1922. During 1923 combined gold and silver production was valued at $6,453,084. Total gold and silver produced in the Black Hills to the end of 1923 amounts to $248,435.696.

Lead.—The lead that is produced in South Dakota comes from the silver-lead camps mentioned in the preceding paragraphs. The yearly production is small, never amounting to more than a few tons. During the period from 1906 to 1922 inclusive, the total production of lead from the Black Hills was about 360,000 pounds. Previous to 1906 published statistics do not segregate South Dakota's lead production from that of other states.

Tungsten.—During the years of the World War, when there was a very serious shortage of tungsten supplies and prices soared to heights hitherto undreamed of, South Dakota had an important share in the great and rapid production of that important metal. Two types of tungsten ore occur in the Black Hills. The first and most important type consists of replacement deposits in the Cambrian dolomite, associated with gold. The ore mineral is wolframite, and occurs as shells or rims around shoots of gold ore. The Homestake Mining Company, the Wasp No. 2, and the Bismark have been the chief producers of this type of ore. Ore of the second type occurs as quartz-wolframite veins in the pre-Cambrian rocks of the southern Black Hills.

During the years 1915 to 1918 inclusive, tungsten ores to the value of $1,106,740 were produced in the Black Hills. The Homestake Mining Company was responsible for about 80 per cent of that production. The sharp decline in price that followed

the war made it impossible for tungsten to be mined profitably in the Black Hills. In fact, there has been no tungsten produced in the United States since the close of 1920. On September 22, 1922, the law placing a tariff duty equivalent to $7.14 a short ton unit went into effect, and all imports of tungsten ceased immediately. This tariff may result in the reopening of many tungsten properties in the United States and be the means of reviving the industry in the Black Hills.

Tin.—Tin occurs in the Black Hills in considerable abundance in the form of cassiterite. It is a primary constituent of many of the pegmatite bodies, and less commonly is found in the quartz veins associated with the pegmatites. It is also found as stream or placer tin in the streams that drain the original tin-bearing rocks. Two districts in the Hills have produced some tin in the past, the Harney Peak region in Custer and Pennington counties, and the Nigger Hill District in the northwestern part of the Hills on the Wyoming-South Dakota line.

The United States is the greatest consumer of tin in the world. About 100,000 tons of tin are required annually to fill the needs of the industries of this country, but only about .1 of 1 per cent of the requirements are produced in this country. The development of an adequate domestic supply of this metal has long been a dream of many mining men, and for a time it was hoped that the Black Hills would supply that need. The presence of tin has been known in the Black Hills since 1883, and many attempts have been made to produce the metal. The dismal failure of the earlier attempts of the Harney Peak Tin Company is well known, and the memory of that fiasco has done more than anything else, perhaps, to retard the development of a tin industry in the Black Hills. At the present time interest is centered around Hill City in Pennington County, where the National Tin Corporation has been operating on four claims, the Mohawk No. 1 and No. 2, the Tin Boom, and the Cowboy. The ore is said to average 1 per cent to 1¾ per cent tin, but is quite spotty in its occurrence. At the present time it is unwise to hazard any guess as to the future of tin mining in the Black Hills.

Mica.—Most of the important mica deposits of the Black Hills are situated within a radius of ten miles of Custer, in Custer County, but other deposits occur in the vicinity of Keystone in Pennington County. The mica is all of the muscovite variety, and is of good grade. At one time production from this state was a very important factor in the total domestic production in the United States. During the years of greatest production,—from 1907 to 1911,—the output from five mines in the Hills was about one third of the total production in the United States. During that time a number of large mines were idle, and if all had been in operation, this state would have been the leading producer in

the country. By 1916 production from this state had dropped to about 10 per cent of the total for the country, and at the present time it is less than 1 per cent. The Westinghouse Electric and Manufacturing Company has been the largest producer of mica in the State, owning and operating four properties in the vicinity of Custer. This company consumed all the sheet mica they produced, and sold the scrap and trimmings to other companies for grinding. At the present time production is limited to comparatively small amounts of scrap mica, mostly from leased properties in the Keystone District. During 1923, 208 tons, valued at $4,160, were produced.

The tariff act of September 22, 1922, placed a graduated import duty on various grades of mica. Just what effect this is going to have on the mica industry, and especially on the industry in the Black Hills, is uncertain at the present time. There are still large quantities of good grade sheet mica in the Hills, and a vast supply of scrap mica, and under more favorable conditions than those of the present time a resumption of the industry may be looked for.

Lithia Minerals.—South Dakota is one of the chief sources of supply of lithia minerals in the United States. Three important lithium compounds occur in the pegmatites of the Keystone region, spodumene, amblygonite, and lepidolite. Two properties have been fairly regular producers. The Etta Mine, owned and operated by the Maywood Chemical Works, of Maywood, N. J., is the larger and more productive. Spodumene is the principal commercial product of this mine. The Bob Ingersoll, of Dennis Henault and Company, has produced some amblygonite, lepidolite, and small amounts of spodumene. Two other mines, the Hugo and Peerless, were formerly important producers of amblygonite.

Before 1918 South Dakota produced most of the lithia minerals of this country. In 1918 and 1919 California surpassed South Dakota, producing more than half of the total ouput of the country, mainly in the form of lepidolite. With the exception of spasmodic production in Maine and Massachusetts in one or two years, the whole output has come from California and South Dakota. Before 1917 the production of lithia minerals in South Dakota was small, 400 to 600 tons a year. In 1916 there were produced in the United States 619 short tons, valued at $12,035; in 1917, 2,062 short tons, valued at $49,912; 1918, 5,894 tons, with a value of $111,600; 1919, 6,287 tons with a value of $115,000; 1920, 11,696 short tons, valued at $173,002. Thus there has been a very steady and marked increase each year in the production of lithia minerals, until the 1920 production was nearly 19 times greater than that of 1916. This marked increase is due to the increased use of lithia in certain types of storage batteries, and of lithium salts and lepidolite in the manufacture of glass. During the past three years production of lithia minerals in the United States has decreased rather sharply, probably due to general business conditions. South Dakota production during 1923 amounted to 1,052 tons, valued at $39,125.

The Engineering and Mining Journal-Press for December 1, 1923, reports that Thomas A. Edison has purchased the Bull Con property in the Keystone District, not for the purpose of immediate operation, but to secure a reserve supply of lithia ore. One of the Edison companies had previously purchased the property adjacent to the Bull Con.

Arsenic.—The great demand and the high prices paid for arsenic during the past year or eighteen months have stimulated the search for arsenic deposits and the opening up of abandoned properties in various places in the United States. In the southern Black Hills in the Keystone District, some of the mines formerly operating on arsenical gold ores have been reopened, and are being worked now primarily for their arsenic content. The Keystone Arsenic Company has been organized and has done exploratory and development work on the Bullion, Ida Florence, and Bismark properties. At the present time their interest is centered chiefly on the Bullion, which they are developing rapidly. Ore is being mined at the same. The concentrating plant on the property has been remodeled, and the ore is concentrated on four Wilfley tables. For the present the concentrates are being shipped to Pueblo for the recovery of the arsenic and gold, but it is planned to erect a roasting plant in Keystone during the spring. The ore will then be roasted in Keystone, and the arsenic recovered as the oxide, and the calcines will be shipped to the smelter for the recovery of the gold.

Feldspar.—In the mining of the pegmatites for lithia minerals, mica, and some of the rare minerals, a great deal of feldspar must be handled, but it has been regarded as waste, and has gone over the dumps. Feldspar is a mineral in demand in various parts of the east for the manufacture of pottery, scouring soaps and washing powders, certain prepared roofing material, and for other purposes. Heretofore the freight rate on feldspar to eastern points has been so high as to prohibit shipping it out of the Hills. During the latter part of 1923, however, a much lower freight rate was obtained, and it is believed that Black Hills feldspar can now be put on the market at a profit. The Keystone Feldspar and Chemical Company has been formed to market the feldspar from such mines as the Etta, Peerless, Hugo, and Ingersoll. The company has announced that plans are prepared to erect a grinding plant in Keystone in order that ground feldspar may be marketed instead of the crude. During 1923 one hundred and fifty tons were shipped from the Black Hills, with a reported value of $3,000.

Gypsum.—Gypsum is a very abundant mineral in the Black Hills region. It occurs in association with the red Spearfish (Triassic) shales, in beds varying from a fraction of an inch up to thirty feet in thickness. There are also many small secondary veins of gypsum, formed by solution of the material in the beds through the action of the underground waters, and redeposited in cracks in the underlying rocks. At the surface in many places is a layer of highly gypsiferous clay, formed by weathering and partial decomposition of the underlying rock, known as gypsite. This, as well as the purer gypsum, is quarried, and made into plaster products. Two companies are mining gypsum in the Black Hills region and manufacturing plaster products, the United States Gypsum Company, with their mine and mill at Piedmont, and the Dakota Plaster Company, located at Black Hawk. Production during 1923 amounted to 9,621 tons, valued at $76,968.

Bentonite.—The name bentonite is given to a certain fine grained, clay-like material, very plastic and absorbent, characterized by an alkaline oxide and alkaline earth content of five to ten per cent. Because of its unusual character much experimental work has been done to determine possible uses for the material. The most important use at the present time is as a water softener. Quite recently a process has been patented to use bentonite in deinking print paper, in order that the paper pulp may be used again. Other uses for it are in soap manufacture, in the making of medical dressings, such as antiphlogistine, filler in paper and rubber goods, base for massage creams and other toilet preparations, clarifier of oils, and in the ceramic industry.

Bentonite occurs in commercial quantities and is being produced at two localities in the Black Hills. At Ardmore, South Dakota, the Pierre shales contain this material in beds varying in thickness from six inches to three feet. As it differs somewhat from the Wyoming bentonite, the name ardmorite has been applied to it. The beds are overlain by black soil, which is stripped off by steam shovel. The beds of ardmorite are then drilled, blasted, and the loosened material transported in trucks to the mills, where it is manufactured into a water-softener known to the trade as "Refinite." During 1923 the company at Ardmore produced this material to the value of $3,400. Near Belle Fourche bentonite closely resembling the Wyoming material is found in a three foot bed in the Graneros shale, about eight feet above the Mowry shale member. A company has been formed to produce this bentonite, and has announced plans for building a drying and grinding plant. Near the close of 1923 one hundred tons, valued at $600, were shipped to New Jersey for testing.

Quarry Products.—Building stone was quarried in the Black Hills for a number of years. The Dakota sandstone has been used rather extensively in construction work, supplied chiefly from

the quarries near Hot Springs and Odell. The beds are massive, easy to dress when freshly exposed, and readily accessible. The colors vary from white and buff to delicate pink. The Unkpapa sandstone has also been quarried for building purposes near Hot Springs and Buffalo Gap. The products of both of these formations have been used with satisfactory results in buildings in several of the cities in the Hills. These quarries are closed at the present time, however, and no production is reported from them for the year 1923.

The Minnekahta limestone is quarried at Pringle and shipped to sugar refineries, where it is used in the purifying and precipitation of sugar. During 1923, 13,500 tons, valued at $18,750, were quarried for this purpose.

Gravel and crushed rock are produced at several places in the Black Hills for use in road building and surfacing, and in the manufacture of concrete. The Northwestern Quarry Company is operating a quarry and crusher on the line of the Northwestern Railroad between Rapid City and Black Hawk; the Dark Canyon Quarry Company and the Black Hills Rock Products Company, with headquarters in Rapid City, are producing crushed rock for various purposes; the City of Lead produces crushed rock for road work and also disposes of part of its product to private buyers. In addition to these companies mentioned, various contractors on highway work in the Hills have been producing gravel and crushed rock for their own use. No figures are available for the amount of gravel and crushed stone produced during 1923.

Cement Material.—The very great abundance in the Black Hills of raw materials necessary in the manufacture of Portland cement has led to the establishment of the State cement plant at Rapid City. The plant is progressing rapidly toward completion at the date of writing, and it is expected that production will start during the summer. The materials to be used are the Minnekahta limestone and the Pierre shale. For complete descriptions of the plant, materials to be used, and the methods of manufacture, the reader is referred to the various articles in the April, 1924, number of the Black Hills Engineer.

Miscellaneous.—There are many other minerals in the Black Hills that should be listed among potential resources of the State, but are not being produced at the present time, either because present financial conditions will not permit their profitable production, or because commercial uses for them have not yet been fully developed. Columbite and tantalite occur in the pegmatites, and small amounts of this material have been shipped; beryl like-wise occurs in the pegmatites and there is a small demand for it. Seven tons, valued at $350, have been shipped during 1923. Small amounts of rose quartz are occasionally mined and shipped for

ornamental purposes. Pyrrhotite for smelting purposes, and small amounts of copper have been mined. Minerals containing uranium, bismuth, antimony, and other elements are known to occur in the Black Hills, but thus far have not been exploited commercially.

CEMENT MATERIALS*

FREEMAN WARD

The Niobrara chalk and the Pierre shale are widely distributed in the eastern part of the State. The two are exposed along the Missouri River from Yankton to above Chamberlain.

These two materials properly combined make an excellent grade of cement. And there is practically an unlimited supply. Large capacity plants could be established at any one of fifty places along the Missouri River. Secondary gypsum is a drawback locally, at least for large scale operation.

At Yankton a plant made a standard grade of cement for some fifteen years. In 1907 sixty men were employed and the capacity was 300 barrels a day. The annual output ranged from 35,000 barrels, valued at $70,000, to 140,000 barrels, valued at $280,000. This plant has not been in operation for several years.

CHALK

FREEMAN WARD

Uses.—Chalk rock has been used in this state for building stone, for making lime, and when mixed with shale, in the manufacture of cement.

Chalk may also be used, directly or indirectly, in the manufacture of whiting, paint, kalsomine, putty, rubber, leather, picture frame molding, gunpowder, oil cloth, roofing cement, and possibly other things. It is this second set of uses for which the English and French chalk has been imported.

Whiting is the basis of the manufacture of most of the other things listed and is made from chalk. It is of several grades. It may be merely the finely powdered chalk. The better grades receive additional treatment for the purpose of improving the texture, removing grit, etc., and have special trade names.

Occurrence.—The chalk rock is technically known as the Niobrara chalk and is of Cretaceous age. It rests upon the Benton group and is overlain by the Pierre shale. It outcrops extensively along the Missouri River from Yankton up to and beyond Chamberlain, being a prominent member of the bluffs bordering that

*Note.—Since the Black Hills area is covered in a single article, the topic here presented refers to material in other parts of the State.

stream. It is found as scattering outcrops east of the river, and also as a more or less continuous band nearly encircling the Black Hills to the west. It averages 150 feet in thickness.

Quality.—Specifications as to quality apparently have never been clearly defined. While the composition of the chalk is important, a chemical analysis alone will hardly be an adequate criterion of quality. Chemically the South Dakota chalk, while not quite as pure, is not vastly different from the foreign chalk.

But the physical qualities, color, texture, etc., seem to be more important in controlling the value and usefulness of the material. A few of these physical qualities may be told on inspection, but most of them cannot be determined without special equipment, or can be ascertained only by actual trial of the material in manufacture.

To this end a number of manufacturers were approached and were found willing to experiment with our material.

There is no doubt at all that a good grade of putty can be made from the South Dakota chalk. Putty made in the Survey laboratory has proven suitable for ordinary uses. Two manufacturers report that a satisfactory putty can be made. The color is darker than ordinary putty and this is the one drawback to a perfect article. The color of the chalk prevents its manufacture into white glazing putty, but (to quote from a manufacturer) "otherwise it possesses the same qualities as the whiting made from imported chalk." And since so much putty work is covered by paint this color need not prevent its very general use. Nor would the color interfere in the making of oil cloth, picture molding, and roofing cement, which articles require putty for their manufacture. Putty may be made from crude whiting (finely pulverized chalk). A better grade lighter in color can be made from the refined (treated) whiting. But none of it is white.

While the crude whiting seems to be unsuited for the manufacture of rubber because it is somewhat gritty, the refined (treated) whiting is quite suitable. It has no substances injurious to rubber and is so reported by two manufacturers. A prominent rubber company officer says, "I believe we could use this material in rubber goods without difficulty but that it would command a lower price than the ordinary whiting because of its appearance." The color again is objectionable, not because it in any way injures the quality or interferes with the particular manufacturing process involved, but because the trade is used to a particular color and has some prejudice against a different shade.

Refined whiting could be used in the manufacture of the darker tints of kalsomine, but its color would prevent its general acceptance by the trade.

No experiments were run to test the value of our chalk in the manufacture of leather or gunpowder.

In conclusion: It seems clear that the South Dakota chalk is a raw material suitable for the manufacture of both putty (and things made from putty) and rubber. But there is a color drawback which in competition may have to be met by a lower price.

CLAYS

FREEMAN WARD

Clays occur in greater quantity than any other resource in the State and yet only a small amount of investigation has been made of this material. In only a few cases has the exact quality of a given clay been determined.

Only a few pits have been operated. Common brick is the chief product, the annual output ranging from 3,000 to 10,000 M. Face brick, tile, etc., are but seldom made. Total value has ranged from $32,000 to $115,000 a year.

Cretaceous.—A very large proportion of the State is overlain by the Pierre shale. This is rather thoroughly covered by drift in the eastern half of the State. But it outcrops along nearly the whole length of the Missouri River and is the surface material in several thousand square miles of the western half of the State.

The Fox Hills, Lance and Ft. Union, in the northwestern part of the State, while not uniformly shaly like the Pierre, yet have many beds of shale that may be of commercial value. The Benton shale outcrops in the southeastern part of the State

None of the above shales (with one exception) have been systematically and thoroughly tested. Simple tests suggest that none of them can be used directly because of the high shrinkage, but will have to be mixed with sand or sandy shale before using. The Interior phase of the Pierre has been found usable with but slight modification: it would serve for common brick, face brick, drain tile or hollow blocks.

A pottery clay has been found in southwestern North Dakota. This suggests that a similar material may be found in the northwestern part of our own state.

Tertiary.—Much of the White River, which makes up most of the Badlands in the southwestern part of the State, consists of shale, sandy shale, or shaly sandstone. Thorough tests have been run on seven samples from this formation. For the most part they would require admixture with more sandy material, which is easily accessible. All would make a good grade of common brick.

Pleistocene.—The glacial deposits in the eastern part of the State have been used in the past for making brick. Loess from five different localities in the southeastern part of the State has been tested and proved to be suitable for the manufacture of common brick. One of these deposits could also be used for drain

tile. It was also found that not all the loess has the proper quality. One sample of till has been tested. If limestone pebbles can be gotten rid of this will make a good common brick.

Recent.—Some terrace and flood plain deposits have been used in the past for the manufacture of common brick. None of these deposits has been tested. No doubt more of this alluvial material would prove suitable for use in the clay industry.

COAL

FREEMAN WARD

Geographic Distribution.—Coal is found in the northwestern part of the State, chiefly in Harding and Perkins counties, but also in the western portions of Corson and Dewey counties and the northern parts of Ziebach and Meade counties. This field is an extension of the greater one adjoining in North Dakota. By far the greater part of these coal lands is too far from the railroad for profitable shipment.

In the eastern part of the State coal has been reported from wells and coal fragments are known to be in the glacial drift. Thus far no workable deposits have been discovered there. In Nebraska closely adjoining the southeastern part of South Dakota thin, non-workable beds of coal have been reported in the Benton and Dakota.

Geologic Occurrence.—The beds of coal occur in the Lance and Ft. Union formations, which are the upper members of the Cretaceous. There is but little of the Ft. Union in the State, and therefore the greater part of the coal is in the Lance and is associated with sandstone and shale.

Single beds range in thickness from a few inches to a maximum of fifteen feet. Beds three to six feet thick are commonly the case. Individual beds vary in thickness from place to place.

In extent the beds are lense-like. By no means do they occur over all the area of each county mentioned. Single beds, except for local erosion, may be several townships in area; more of them are smaller, being part of a section or several sections in extent. Approximately 400 square miles of the State are underlain by coal having a thickness of two feet ten inches or more.

Usually there is more than one bed in a locality and there may be as many as five or six separated by beds of shale and sandstone.

In general the beds are thinner and less abundant towards the southeastern part of the area; the thickest and most abundant coal is in Harding county.

Over much of the area the coal is near the surface, the overburden ranging from six to twenty feet.

Quality.—The coal is rated as lignite. Some of it is brown and of poor quality; but a larger part of the workable beds is a high-grade lignite, brownish black to black in color. Locally this coal is sub-bituminous in quality. The following anlayses are averages of nine widely distributed samples:

	Moisture	Volatile Matter	Fixed Carbon	Ash	B. T. U.
As Mined	37.3	25.5	27.1	10.1	6,051
Air Dried	13.4	35.2	37.1	13.8	8,486

The large amount of moisture causes considerable slacking on exposure to air, but most of the coal will keep very well in cellars and will stand shipment in closed cars.

Extended use has proven the value of this coal for cooking and general heating.

Production.—The greater part of the mining is purely a local matter. Some rancher will open up a mine to get coal for his own use, and will usually give his neighbors access to the coal. These local hauls may be as much as thirty miles, though usually less. This situation makes it difficult to get complete statistical material.

For this past year thirty-three mines have been reported. There are more than fifteen known to be producing and from which no report has been received. Probably there are some seventy-five additional mines or prospects which have been worked intermittently during the past ten years.

The thirty-three mines reporting have a total annual output of 44,610 tons valued at $131,300.

The price at the mine has averaged $2.50 a ton, on the track $3.25 a ton.

Total number of men working in these thirty-three mines is 95. The largest company operated three mines, using thirty men, and had an output of 25,000 tons per annum.

Most of the coal is mined by the strip pit method: a few mines use the drift method.

Five of the mines ship by railroad to the eastern part of the State. Coal has been successfully shipped to the southeastern part of the State, a railroad journey of nearly 400 miles.

Future.—While the coal field of South Dakota cannot be rated as large in comparison with most of the coal fields of the United States, yet its usefulness to the State at large may be greater than that allotted to it by some observers. The Federal Survey places the reserves in Perkins and Harding counties at 1,096,480,000 tons.

This estimate, in the opinion of the writer, should be materially raised. To this must be added the lesser amounts in the adjoining counties.

Until railroad facilities are better the coal will continue to be used in large part to meet the local fuel needs.

During the last several years the experimental work so ably carried on jointly by the United States Bureau of Mines and the University of North Dakota has demonstrated the fact that carbonizing and briquetting of lignite coal can be done successfully on a commercial scale and that the by-products, producer gas, tar, and ammonia, can be made as well. These processes can be applied also to the South Dakota coal, though their full development may need to wait on the further extension of adequate transportation.

GAS

G. F. MOULTON

Natural gas has been known and used in the State for thirty years or more. At the present time it is produced mainly in the north-central part of the State. One of the first important producing wells was drilled at Pierre, and is still in operation. Gas has since been found along the Missouri River from Pierre to Le Beau. It is also obtained in wells south of Ipswich and north of Redfield. A few smaller wells are located along the lower James River valley. A more definite location of these wells can be obtained from the map in Bulletin 10 of the State Geological Survey.

The statistics of the United States Geological Survey show that the gas production in South Dakota has been declining considerably during the three years ending in 1921. More recent data are not available. One explanation for the decrease in production might be that there was a smaller amount of drilling in the State during the war period. The decrease in artesian flow due to the generally lower pressure is probably also an important factor. The United States Geological Survey gives the following figures:

	1919	1920	1921
Rank of State as a gas producer..	17	16	17
Production (M. cubic feet)	32,600	20,000	9,700
Value where used	$16,900	$12,000	$4,000

In nearly all cases the gas seems to come from the shale. For that reason the production is generally small and cannot be depended on in more wells which might be drilled. On the other hand there is the usual advantage of long life.

The nearest gas production of considerable importance is in southeastern Montana on the Cedar Creek anticline. Here gas

has been produced in large amounts in the vicinity of Glendive and Baker. The total production near Baker is probably in excess of 5,000,000 cu. ft. a day at the present time. During the past year the Absoraka Oil and Development Company in a test south of Baker and only about a dozen miles from the South Dakota line, found gas enough for use in drilling. Since the Cedar Creek anticline has been found to be a place of gas production for about fifty miles along its length, it seems very probable that drilling on the Fox Hills dome in Harding County would also locate a gas field there, for it is a continuation of the main folding. In South Dakota, it would be necessary to drill from two to five hundred feet deeper than in Montana.

It should be observed that there is at least one essential difference between the conditions of gas production in central South Dakota and the conditions existing in the Fox Hills dome area. In the latter region gas is obtained from sandy zones. For this reason structural conditions are very important in determining the presence of gas, and geologic work should precede drilling there.

The lack of a large market in the western part of the State would prevent gas production there from becoming commercially important. The gas as found in Montana does not seem to contain any gasoline, and the only product which can be made and shipped is carbon black. Probably the same condition obtains in South Dakota.

MISCELLANEOUS

FREEMAN WARD

Concrete Blocks.—A small and variable industry, mostly of a very local character, has been the manufacture of concrete blocks. The average annual output during the past five years has been 20,000 cubic feet, valued at $12,000.

Lime.—During the last five years there have been two to four plants producing lime. The output has varied between 3,900 and 5,700 tons, ranging in value from $28,000 to $56,000.

Sand-Lime Brick.—This type of brick has been made in a few places in the State. The production has ranged from 1,200 to 4,000 M. annually, with a value between $13,000 and $32,000.

Volcanic Ash.—There has been no production of this material, although it occurs in the State in beds that could be worked.

OIL

G. F. MOULTON

Small traces of oil have been reported from several of the test wells of the State, but no marketable production has yet been obtained. Definite conclusions regarding the oil possibilities cannot be formed at the present time, because these various tests were: (1) either very near the Black Hills uplift on slight domes

(these also fail as oil producers near the Hills in Wyoming, where small fields are now being operated), (2) on no known structure, (3) or have not been carried deep enough to constitute a thorough test.

At the present time several test wells are being drilled. One of the most important of these is being drilled southwest of Isabel on a dome mapped by the State Geological Survey. Others are located at Blunt, northwest of Ft. Pierre, south of McIntosh, and near Lemmon. Drilling wells have been reported by the press near Interior, near Edgemont and east of Fairburn. The completion of these tests and a further investigation of the general geologic features of the State as outlined in Circular 14 will do much to help determine the chances of finding oil in South Dakota.

SANDS AND GRAVELS

E. P. ROTHROCK

Though sands and gravel deposits are to be found in all parts of the State, by far the greatest amount occurs east of the Missouri River. The workable deposits in this region are of glacial origin and are found in the bottoms of valleys, as terraces on valley walls, in isolated hills and ridges, and as great sheets or plains spread over the surface. As far as known, the sands and gravels west of the Missouri are stream deposits washed from the Black Hills and from the rocks underlying the region. They are found abundantly in some of the valleys in the Black Hills, scattered over the surface of the Badlands and of the region north of the Hills, and in the valleys and high terraces of the larger streams such as the White, Cheyenne, Moreau and Grand rivers.

It is not possible to give complete information on the amount, location, and value of the sand and gravels of the State because a complete list of the pits that have been and are now in operation could not be obtained, nor were production figures available for many of the pits which are known. Sufficient data are at hand, however, to warrant the general conclusions offered here.

The industry is carried on largely from small pits which are opened by the land owners when there happens to be a demand for sand or gravel in the vicinity. In most cases the pits are small and the sand and gravel is sold by the wagon load either to neighboring farmers, to nearby towns or to the county or state for road graveling. Some of these pits are quite large and well kept. In most cases, however, they are abandoned and allowed to fall in as soon as the particular work for which they were opened has been completed. Several counties have bought pits which they keep open for the maintenance of their roads.

The industry is carried on, on the largest scale, in the Big Sioux valley. Four companies are operating deposits on a large

scale here. Three of these, the American Sand and Gravel Company, the Zellers Concrete Materials Company, and the Kampeska Materials Company, are located in Watertown and operate deposits in Codington County. The fourth, the Sioux Falls Sand Company, has offices in Sioux Falls and is working a large deposit near that city.

The largest of these companies, the Sioux Falls Sand Company and the American Sand and Gravel Company, operate screening and washing plants and crushers. They are thus able to sell large quantities of very high grade, uniformly sized materials. The other two companies have screening but not washing plants on their properties. The larger pits opened for road graveling have grizzlies or similar screening devices used simply to remove boulders or very coarse gravels.

The most reliable figures for the total production are those published by the United States Geological Survey. These figures show that in the twelve years from 1910 to 1922, the total production of sand and gravel in South Dakota was 6,865,260 short tons.

The production in 1923, according to data collected by the State Geological and Natural History Survey, was 188,000 short tons. This figure represents only the reported production which came from a little more than half of the known pits of the State. It includes the big production of the Big Sioux valley. The pits from which reports were unobtainable are all doing a local business and their total production could not more than double the figures for the reported production. A fair estimate for the 1923 production, therefore, would not exceed 370,000 short tons.

The selling price of sands and gravels varies greatly in different localities. Prices are fixed by the owners of pits and are based on what is charged at some neighboring pit rather than on quality or accessibility of material. In some cases gravels are sold to the State or to a county by the acre instead of the load or cubic yard. Gravels sold in this way bring the lowest prices reported, sometimes as low as five cents a cubic yard, but in such cases pits are opened and maintained by the purchaser. Where sand or gravel is sold from pits maintained by the owner, the average price for unsorted gravel is 50 cents to $1 a cubic yard. The washed and screened materials produced in the Big Sioux valley are better standardized in price. In 1923 sand brought from 40 cents to $1.50 a ton, depending on the use for which it was graded. Washed and screened gravels sold for $1.20 to $2 a ton and unsorted gravels, 50 cents a ton. Figured on the more common basis, the sand from these pits sold for about 30 cents to $1.20 a cubic yard and gravels from 90 cents to $1.50 a cubic yard. It is of interest to note that these companies, producing on a large scale, can sell unsorted gravels at a

much lower rate than that charged at the smaller pits. The price of 50 cents a ton is equivalent to about 38 cents a cubic yard.

According to the figures of the United States Geological Survey, the total value of the sand and gravel produced in South Dakota in the twelve years from 1910 to 1922 was $1,626,760. This does not give the entire value of these resources but probably represents the largest part of it, because the greatest demand for these materials has been created by the graveling of roads, most of which has been done in relatively recent times. Using the average price of 75 cents a cubic yard or $1 a ton, the total value for the reported production for 1923 would be $188,000 and for the estimated production $370,000.

The following figures collected by the United States Geological Survey show the trend of the industry in the past ten years:

Total Sand and Gravel Produced in South Dakota from 1910 to 1922.

Year	Quantity short tons	Value
1910	849,000	$ 157,738
1911	92,757	41,286
1912	545,622	69,348
1913	1,068,833	89,306
1914	232,395	40,215
1915	256,270	45,717
1916	1,095,594	133,755
1917	885,957	489,577
1918	229,787	48,362
1919	648,939	231,390
1920	572,259	253,616
1921	185,639	136,152
1922	200,408	121,690

This table shows that while the sands and gravels are a profitable resource, their production has not become a stabilized industry. The minimum production, 92,757 tons, occurred in 1911, while the maximum, 1,095,594 tons, occurred in 1916. Between these extremes there is great variation with no apparent order. The cause of this fluctuation is probably the localized nature of most of the industry, and the total figures probably reflect the road building and construction programs in the State. In spite of the fluctuation, however, according to the above figures there is a production averaging about 500,000 tons a year, which means an industry worth about half that many dollars to the State.

The following table is a brief summary of the present status of the sand and gravel industry in South Dakota:

Total production in the last twelve years	6,865,260 short tons
1923 production (reported)	188,000 short tons
1923 production (estimated)	370,000 short tons
Total value in the last twelve years	$1,626,760
1923 value (reported)	188,000
1923 value (estimated)	370,000
Average price for washed sand per ton	$0.40 to $1.50
Average price for unsorted gravels per cubic yard	$0.50 to $0.75

STONE

G. F. MOULTON

Quartzite and granite are the two kinds of stone of principal importance in eastern South Dakota. Because of the small local demand and the competition at more distant markets, the production does not make up any important part of the output of the nation, but it is of considerable importance locally. In 1920, according to the reports of the United States Geological Survey, there were eight plants producing stone which amounted to 196,000 short tons and was worth $479,279. This was a considerable increase over the preceding year. More recent complete information is not now available, but reports on the operating conditions of some of the plants have been supplied by the quarry companies, whose kind cooperation has made this report possible.

Granite.—Monumental granite, which is probably of pre-Cambrian age, is exposed in northeastern South Dakota in the valley south of Big Stone Lake, and is quarried in the region between Milbank, South Dakota, and Ortonville, Minnesota. At the present time two quarries are in active operation. These are the Milbank Mahogany Granite Works, in southeastern Roberts County, and the Whetstone Granite Company, in northeastern Grant County. Both of these concerns produce granite of about the same character. Detailed information obtained from the Milbank Mahogany Granite Works follows.

This plant specializes in monumental stone and makes about 99 per cent of its product into blocks for that purpose. A very minor use is in cornerstones. The granite has been shipped to nearly every state in the union, but is most largely used locally. In the eight or nine years just past there has been a total production which sold for about $300,000. The output for 1923 was valued at $50,000.

Polished samples of the granite which were sent to the State University show a good surface which takes a high polish. The granite is coarsely crystalline and has a light to dark red-brown color which is well described by the trade name of "Mahogany."

The variations in color are not pronounced, so that the surface has a pleasing appearance. The process of quarrying and finishing is carried on by the same concern at the quarry, so that a complete unit of industry is represented in the plant.

The Whetsone Granite Company is probably working another portion of the same granite mass and has a smaller output of rock of about the same character. The uses of this product are the same as for the Mahogany granite.

Quartzite.—The Sioux quartzite is the most important commercial stone in South Dakota. It is pre-Cambrian in age and has an extensive area of outcrop in southwestern Minnesota, and in the Sioux Falls region, South Dakota, from which it extends westward about as far as Mitchell. The following companies operate quarries in South Dakota: the Wisconsin Granite Company, and the Dakota Granite Company, at Sioux Falls; the Simpson Quarry, the Minnehaha Stone Company, and the Wisconsin Granite Company, at Dell Rapids; the Spencer Stone Quarry, at Spencer; and Fred Michales, and E. L. Gregory at Alexandria.

The combined production of the Sioux Falls and Dell Rapids plants of the Wisconsin Granite Company for the year 1923 was 110,000 short tons of crushed stone. Much of this material was shipped to points ouside the State for use, and the market includes points as widely separated as central Texas, New York, and New Orleans. The stone is crushed and screened to size before being sold. The following sizes are marketed:

No. 2	2½ in. to 1¼ in.
No. 3	1¼ in. to ½ in.
No. 3½	1 in. to ¼ in.
No. 4	¼ in. to fine sand

Common uses of this rock are as follows: concrete material, road building material, stucco facings, refractory linings at steel mills, and in sewage disposal plants. A chemical analysis of the Dell Rapids product, which shows that the quartzite there contains only about ½ to 1 per cent of ferric oxide, suggests that this rock would be adapted to the manufacture of low grade glass. The physical properties of the quartzite were determined by the United States Department of Agriculture for the Wisconsin Granite Company, and show that the quartzite is one of the most durable stones known. Its properties are as follows: great hardness, high resistance to wear, absorbs only minute quantities of water, and has a crushing strength of more than 50,000 pounds per square inch.

The other principal producing concern in the quartzite business is the Dakota Granite Company, at Sioux Falls. This firm's output for 1923 amounted to 35,000 tons, valued at $54,000. Most of this stone was used for stucco and has been shipped as

widely as New York, California, and Canadian points. The character of material and the crushing and screening processes used are similar to those in the quarries of the Wisconsin Granite Company.

Other quartzite operations in the State are small, but have an output of similar material, which has mainly had a local use in road building. Several of these smaller plants were not operating during 1923.

Chalk is the only other stone of any considerable importance in the eastern part of the State. This material is described elsewhere in this circular.