

MISSOURI BUREAU OF GEOLOGY AND MINES

H. A. BUEHLER, Director and State Geologist, Rolla, Mo.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BUREAU OF GEOLOGY AND MINES

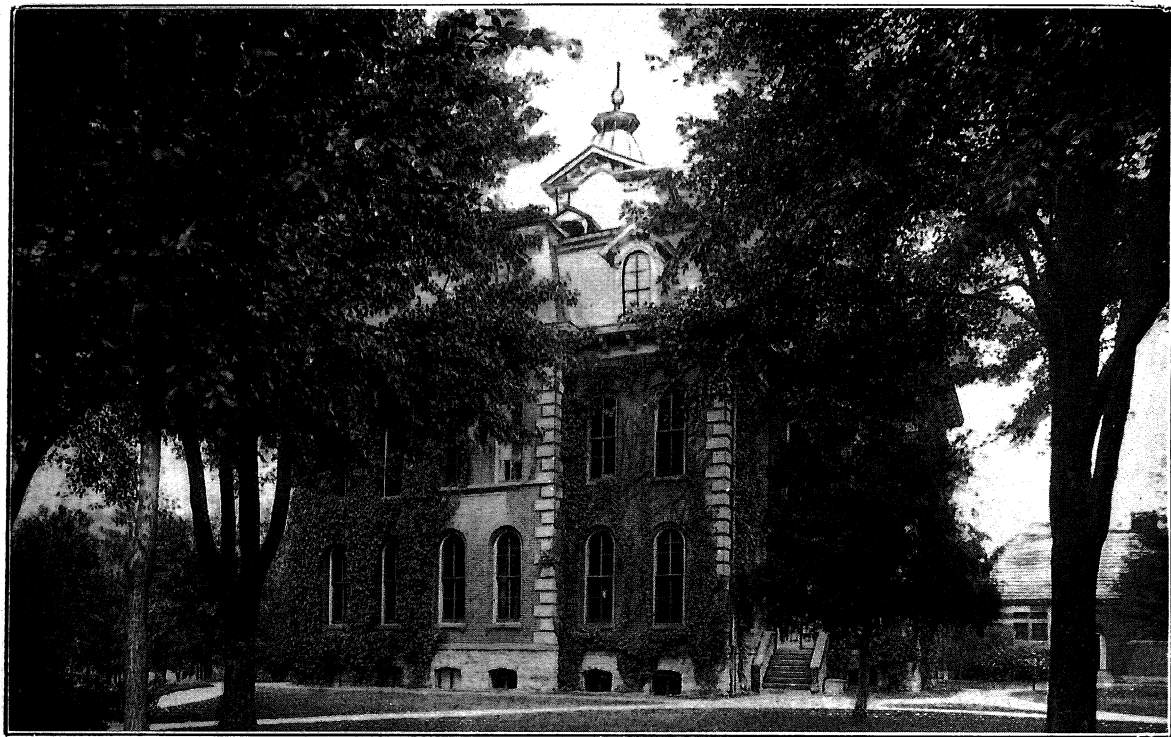
TO THE

Fiftieth General Assembly



1919

JEFFERSON CITY
THE HUGH STEPHENS CO.
PRINTERS



HEADQUARTERS MISSOURI BUREAU OF GEOLOGY AND MINES, ROLLA, MO.

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BOARD OF MANAGERS.

His Excellency, Frederick D. Gardner, Governor of Missouri, ex officio President of the Board, Jefferson City.

Hon. Elias S. Gatch, Vice-President, St. Louis.

Major Clark Craycroft, Secretary, Joplin.

Dr. E. M. Shepard, Springfield, Chairman of Publication Committee.

Hon. Philip N. Moore, St. Louis.

LETTER OF TRANSMITTAL.

To the President, Frederick D. Gardner, and the Honorable members of the Board of Managers of the Bureau of Geology and Mines:

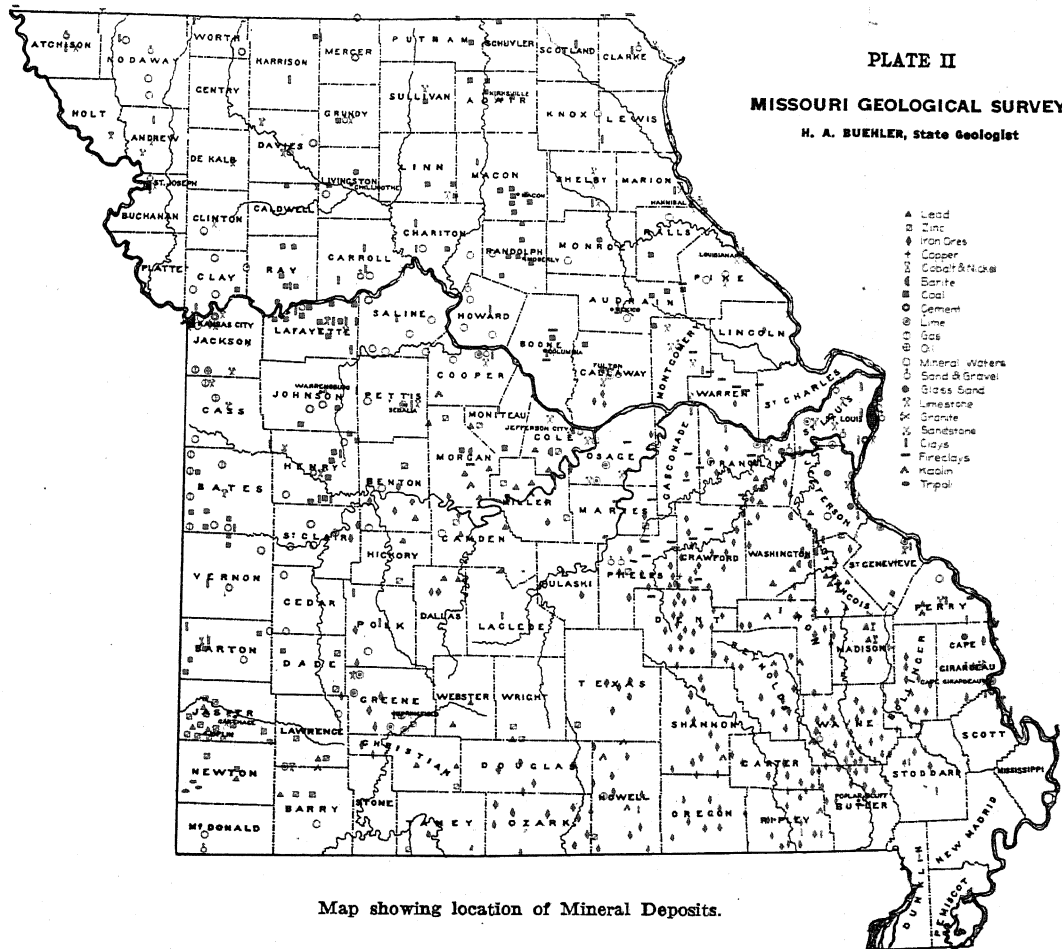
Gentlemen—I have the honor to submit herewith a report covering the work of the Bureau of Geology and Mines for the years 1917 and 1918.

The war has emphasized the basic importance of the mineral industries to the commercial welfare of the nation. With the acute need of ships for the transportation of troops, foreign imports were curtailed in many cases of minerals which under pre-war conditions were not produced in sufficient quantity to supply domestic demands. To meet the shortage vigorous measures were necessary and to assist in the problem the Government requested the cooperation of the State Geological Surveys in investigating and directing development. The phenomenal increase in production can be attributed, in many cases, to the efforts of these organizations and it indicates, in a striking way, the value of the investigations carried on by the State Bureaus.

The members of the Staff appreciate the interest which the members of the Board of Managers have manifested in the work as well as the hearty cooperation extended the Bureau by citizens in every part of the State.

Respectfully submitted,

H. A. BUEHLER,
State Geologist.



WORK OF THE BUREAU OF GEOLOGY AND MINES DURING 1917 AND 1918.

During the past biennial period the work of the Bureau of Geology and Mines has been directed chiefly to increasing production and encouraging development of those minerals and metals needed for war purposes. The lack of ships for imports, and the greatly increased consumption threw suddenly upon the mines of this country the imperative need for much greater output as well as the development of new mineral industries.

The importance of the mineral resources as a basis of the industrial welfare of the nation has been emphasized as never before, and vigorous future development will continue as a direct result of the present activities.

The great diversity and widespread distribution of the mineral deposits of Missouri is shown by the sketch map on the opposite page. The State contains a remarkable number of different minerals present in commercial deposits and there is scarcely a county that does not contain some type of deposit from which revenue is being obtained. During the past few years the value of the output of these different deposits has increased rapidly and consistently, and Missouri now stands as one of the leading mining states of the Union. New districts will be discovered and the present production by no means represents the maximum in any instance.

In the past twenty years the value of the minerals produced in Missouri has increased over 700 per cent, an average increase of more than 35 per cent a year. The extent of this increase during the past four years is well shown by the following figures:

1914.....	\$43,565,667
1915.....	59,821,032
1916.....	78,558,422
1917.....	91,139,525

War prices and demands have of course had considerable to do with the rapid strides made during the last year, but the 1917 production is remarkable in the face of a severe depression in the zinc market and congested transportation conditions.

The Missouri Bureau of Geology and Mines is the only state institution maintained for the purpose of assisting in the

development of our mineral resources and its activities have been an important factor in the growth of the various branches of the industry. It serves the mining industry in much the same manner that the Agricultural Bureau serves the farming industry and its work reaches all parts of the state. It is not the professional or experienced mining man alone who invests his time and capital in mining development. In fact the inexperienced layman is conspicuous in mining ventures of all kinds, so that the services of the Bureau are not at all restricted to one class of people. Neither are these services restricted to the mining districts for such problems as obtaining underground water supplies, road metals, sands suitable for various uses, brick and tile clays, cement and lime material, building stones and many others present themselves to any community. Also the services of the institution reach beyond the borders of the state, for people outside of Missouri are continually seeking opportunities to invest in our mineral resources and these people usually request and rely upon information given by the Bureau.

The work of the Survey is therefore largely directed to the giving of such service and the field investigations are designed to obtain the necessary facts upon which to guide prospecting and development.

STAFF OF THE SURVEY.

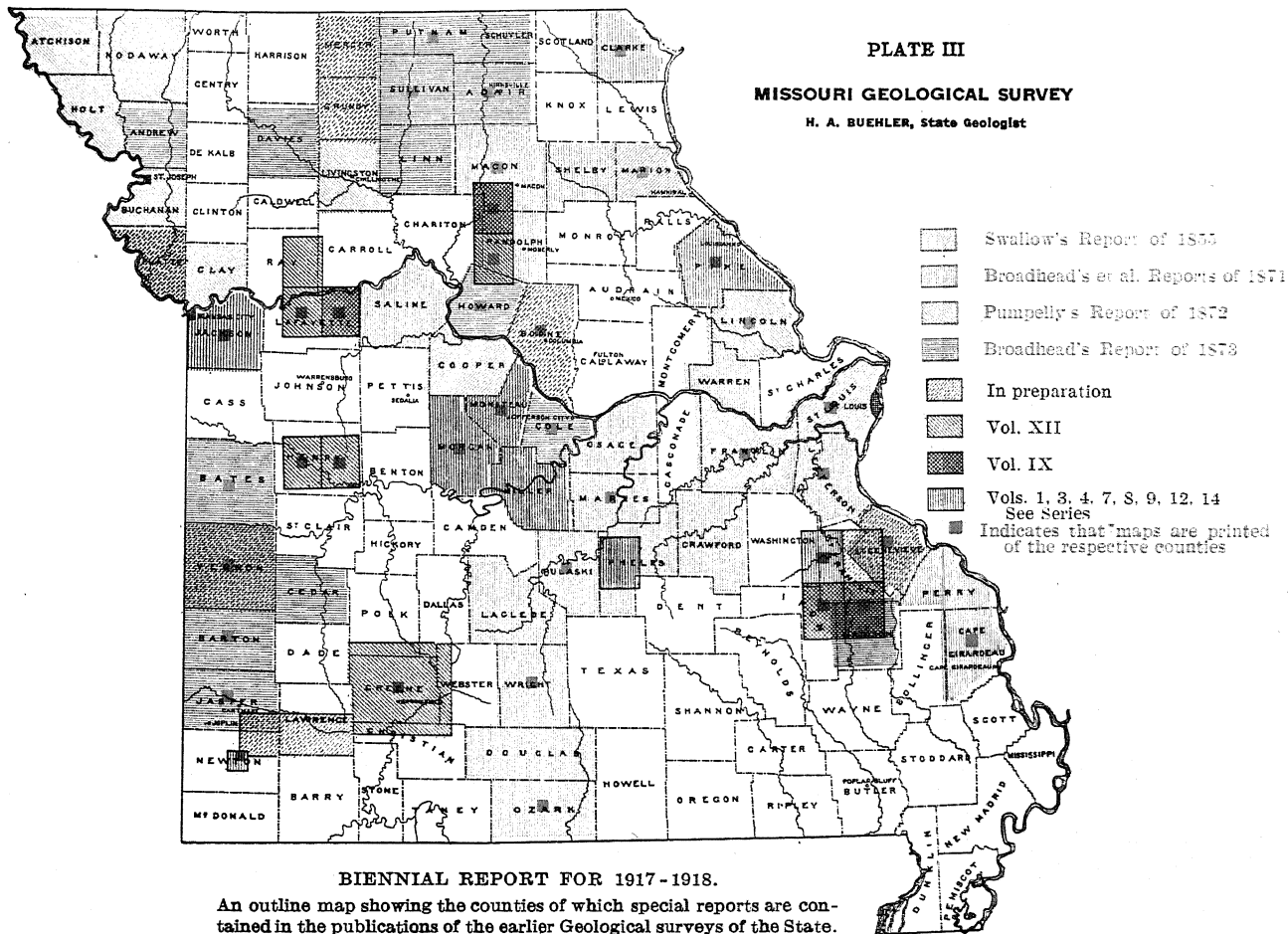
The staff of the Survey during the past biennial period has included the following members.

EXECUTIVE AND OFFICE FORCE.

H. A. Buehler, State Geologist.
 M. E. Wilson, Assistant State Geologist.
 A. L. Parker, Chief Clerk.
 W. E. Oyler, Chemist.
 Geo. L. Triefenbach, Draftsman.
 H. Ziesiness, Draftsman.

FIELD FORCE.

E. B. Branson, Geologist	Areal surveys.
J. S. Brown, Geologist	Oil investigations.
V. H. Hughes, Geologist	Economic surveys.
G. A. Muilenburg, Geologist	Oil investigations.
C. R. Schroyer, Geologist	Clay investigations.
W. A. Tarr, Geologist	Economic and Areal surveys.
Russell Gibson, Asst. Geologist	Pyrite investigations.
O. E. Markham, Asst. Geologist	Areal surveys.
G. A. Moore, Asst. Geologist	Areal surveys.
Wm. J. Nolte, Asst. Geologist	Oil investigations.
H. H. Armsby, Instrument man	Oil investigations.
L. E. Harlowe, Instrument man	Oil investigations.
C. O. Reinoehl, Instrument man	Oil investigations.



NATURE OF EMPLOYMENT OF STAFF DURING 1917 AND 1918.

The work of the Bureau is normally outlined and carried on under the supervision of the Director. However, during the war minerals crisis of 1918, Mr. H. A. Buehler, at the request of the Federal Bureau of Mines, and by the action of the Board of Directors of the Bureau, was temporarily loaned to the Bureau of Mines at Washington, and served there during the greater part of the year. During this period Mr. M. E. Wilson has served as Acting State Geologist.

Miss A. L. Parker has served unassisted during the entire period as Chief Clerk and Stenographer, and Mr. W. E. Oyler has, during the greater part of the time, had charge of the Chemical Laboratory. Mr. Geo. L. Triefenbach and H. Ziesiness served in turn as draftsman. All three of these men severed their connection with the institution upon being called into the service.

Under the supervision of Mr. M. E. Wilson, Mr. J. S. Brown, serving in the capacity of geologist, assisted by Mr. L. E. Harlowe, as instrument man, spent the entire field season of 1917 studying the oil situation in western Missouri. During the season, in addition to reconnoissance work, geologic structure maps of approximately 125 square miles of territory were made. The work covered portions of Cass, Jackson, Bates, Clay and Platte counties where conditions were considered favorable for testing for oil and gas, and one report on a part of the work has been published. During the season of 1918 this oil work was continued by two field parties with Mr. G. A. Muilenburg and W. J. Nolte as geologists, assisted by H. H. Armsby and C. O. Reinoehl as instrument men. The work this season consisted of less mapping and more reconnoissance work. Areas were covered in Mercer, Worth, Gentry, Clinton, Clay, Platte and Vernon counties, and minor investigations made in Barton, Bates, Cass and Lafayette counties. The results of this field work indicate the general nature of the structural features favoring the accumulation of oil or gas and the care with which each investigation should be made prior to drilling.

During the field season of 1917 and 1918, Mr. E. B. Branson and assistants continued field studies and mapping of the Devonian formations in central and eastern Missouri. The mapping has now been completed and a report is being prepared for

publication. Heretofore the Devonian series has not been differentiated nor accurately mapped.

Work on the manganese deposits of the southern part of the state was started in the latter part of 1918 by Mr. V. H. Hughes. The ores are usually low grade but during the war period the grade used by the blast furnaces was much lower than pre-war practice.

Mr. C. R. Schroyer was loaned to this Bureau from the Illinois State Geological Survey for the purpose of investigating the high grade fire clays of east central Missouri. The work is being undertaken at the request of Federal authorities interested in clays in connection with war uses. There is an acute shortage of high grade clays that were formerly imported in large quantities. Field work is at present under way and should be completed in the near future. The problem is a large one and includes a study of the high alumina clays which have only recently been discovered and which in some instances carry over 70 per cent alumina.

Mr. W. A. Tarr spent most of the summer of 1918 investigating the mineral deposits of the north central Ozarks. His work covered all or portions of Cole, Moniteau, Morgan, Miller, Maries, Osage, Gasconade and some special investigations were made in a few adjoining counties. The deposits which have especially attracted attention in this area are those of lead, zinc, barite, cannel coal, and clays. From time to time new discoveries are made, new development takes place and prospecting is almost continuously carried on. The possibility of using the cannel coal scattered in pockets over a portion of the district for the extraction of oil and its by-products, the finding of clays exceptionally high in alumina, the recent high price of barite, and a general revival of interest in the lead and zinc deposits have all tended to stimulate interest in the mining possibilities of this district.

Mr. Russel Gibson was employed through the field season of 1918 to investigate the "coal brass" or pyrite available from the coal mining districts of the state. The work was carried on in cooperation with the Federal Bureau of Mines.

COOPERATION.

Cordial cooperation has been continued throughout the period with the U. S. Geological Survey and the United States Bureau of Mines. The Bureau has for many years cooperated

with the United States Geological Survey in collecting the annual mineral statistics of the state, in the making of topographic maps, and at times when mutual benefits were to be derived, in jointly publishing reports. Cooperation in collecting the mineral statistics has been continued and one report published jointly but because of war conditions it has been necessary to temporarily discontinue topographic mapping during the biennial period.

OIL AND GAS.

The work on oil and gas during the past biennial period has been restricted to that part of the state underlain by the Pennsylvanian or "Coal Measures" rocks. Analogy to the Kansas oil fields, surface showings of oil, and the results of all previous prospect drilling in Missouri indicate that these rocks are the most likely to contain commercial deposits of oil or gas of any underlying the state. The Pennsylvanian rocks occur in the western and northern parts of Missouri over an area of approximately 25,000 square miles. They have been fully described in volume 13, second series, of the reports of this Bureau. The detailed structural features, however, which are required as a basis for intelligent prospecting for oil and gas have never been worked out and the mapping by the Bureau has been done in order to show the character of typical structures occurring in the region.

Jackson and Cass Counties.—A little more than two townships in southwest Jackson and northwest Cass county were mapped. Both oil and gas had been found in these townships and reconnoissance work suggested the presence of folding, which might form structural features worthy of further prospecting. The mapping revealed the presence of several well defined anticlines, one of which has never been tested. A well sunk on this structure as a result of the Survey work encountered gas under a pressure of 110 pounds, at a depth of about 400 feet. The prospecting of this anticline is to continue, and further drilling on the basis of the work done in this area has been planned. The report on this region has been published under the title of "The Oil and Gas Possibilities of the Belton Area."

Bates County.—The area mapped in Bates County covers the northwest township, including the town of Merwin. Gas wells have been used in this township for many years and showings of oil have been encountered in wells in the township and in adjacent areas. The mapping revealed the presence of folding,

less prominent than in the Belton Area but nevertheless of importance. Should further drilling be undertaken in this district, the location of several low anticlines are shown and new wells can be placed more intelligently and probably with better chances of success than those previously drilled. A blue print map of this district is available upon request.

Vernon County.—The area mapped in Vernon County covers a portion of the two northwest townships. In a number of wells in this part of the county small amounts of oil and gas have been found and the district has excited much interest relative to its oil and gas possibilities. The mapping shows the rocks to be folded, in some places sharply, with the result that several small but prominent anticlines have been formed. Drilling on one of these structures has already found a small flow of gas and a showing of oil. This map will form an excellent guide for future prospecting in the area and illustrates the type of structure probably occurring in the adjacent territory. The blue print map of the area is available.

Platte County.—The area mapped in Platte County lies shortly northwest of Parkville, and includes about ten square miles of territory. One of the most important groups of gas wells yet drilled in the state is contained within the area. The region was mapped with the hope of discovering the relation of the gas wells to the structural features and of outlining the most favorable areas for further prospecting. The result of the work shows the gas wells to be located upon a well defined terrace structure but the sand from which the gas is obtained is extremely erratic. The region is one difficult to prospect even on the strength of a structural map because of the non-persistent character of the gas bearing sands. The map is available upon request.

Clay County.—Considerable interest has been manifested in the southeast part of Clay County because of the presence shortly north of North Kansas City of a well from which small quantities of oil has been sold for a number of years. Leases have been taken in this area and the drilling of several wells planned. To determine the structural features of the district the territory surrounding the wells was mapped. The mapping revealed some very gentle folding though no prominent structures were found. Apparently, however, the well from which the oil is obtained is not located at the most favorable point

structurally. The map of this region is now ready for distribution and should serve as a useful guide for future drilling.

Clinton, Clay County.—The small town of Holt located on the Clinton-Clay County line, was at one time supplied with gas from 5 wells situated in or on the edge of the town. In two of the wells a showing of oil was reported. An area of about a township in extent was mapped surrounding the town. The rocks were found to dip gently to the northwest with some low folding. The map of this area is available upon request.

Gentry County.—A small area was mapped in southeast Gentry County in a locality where previous study had shown the rocks to have high dips. Some faulting was revealed as a result of this work and also some folding, but the structure so far as could be determined was not especially favorable for prospecting.

Mercer County.—A little more than a township was mapped in Mercer County, the area lying in the south central and southwest part between Princeton, Mill Grove and Modena. No showings of oil or gas have ever been found in this locality but good rock outcrops along Weldon River offer an excellent opportunity for obtaining the type of structure if any, present in this region. The rocks were found to dip generally in a southwest direction with several low folds trending northeast to southwest. However, no structure of exceptional importance was found. A map of the area surveyed will be available in the near future.

Worth County.—An anticline of considerable prominence has been described in southeast Worth County extending across the line into Gentry County. The village of Denver was supposed to have rested on this structure. Sometime was spent in mapping this locality, although the work progressed with great difficulty. Outcrops of rock were scarce, the country being covered with a thick mantle of glacial drift, and those outcrops which were found occupied almost a straight north and south line in the valley of Grand River. As a result of this work it appears that the report of an anticline in this locality was somewhat misleading, for so far as could be told the rocks everywhere dipped to the southwest. Aside from the areas mapped in detail, a very considerable part of west and northwest Missouri was scouted for the purpose of detecting any areas which gave promise of favorable oil structures. This work revealed the difficulty of attempting to do much detailed mapping in the northwest counties.

Northwest Missouri is covered with a heavy mantle of glacial drift, which over the greater part conceals the rock outcrops so necessary to this type of work.

As a result of the field work on oil and gas, it can be stated that the folding in the area underlain by the Pennsylvanian rocks has nearly everywhere been very gentle. Very low dips are the rule and prominent structural features involving marked dips or sharp folding are rare.

PYRITE FROM COAL DEPOSITS.

An impending acute shortage of sulphur bearing materials, due to the large increase in the manufacture of sulphuric acid during the war period, made it imperative that all possible sources of pyrite be investigated throughout the Eastern and Central portions of the United States. The Missouri Survey in cooperation with the Federal Bureau of Mines and the State Geological Surveys of the adjoining states in the Mississippi Valley, investigated the availability of pyrite, now a waste product of the coal mine, during the field season of 1918.

Pyrite is usually found associated with coal seams. To be recoverable it must occur as nodules or bands in the coal, and under normal conditions of mining it is usually thrown into the waste heap. Where separated and cleaned it can be utilized by acid manufacturers.

To be of commercial importance as a producer of pyrite, a mining district should be able to ship carload lots and for this reason usually the larger mining camps are the most favorable sources of supply.

The most important coal beds of Missouri in order of coal tonnage produced are the Bevier, Lexington, Weir-Pittsburg Lower, Mulberry, Cainesville, and Mulky. The Bevier is mined principally in Macon, Adair, Randolph, Platte, Callaway, Boone, and Johnson Counties; the Lexington principally in Lafayette, Ray, Clay, Putnam, and Schuyler counties; the Weir-Pittsburg Lower in Barton County; the Tebo in Henry, Linn, and Grundy; the Mulberry in Bates county; the Cainesville in Harrison county, and the Mulky in Audrain and Ralls counties.

The following table indicates the daily tonnage available from the various coal seams in the state on the present mining basis:

Coal Seam.	Daily tonnage.
Bevier.....	264
Tebo.....	56
Cainesville.....	16
Weir-Pittsburg Lower.....	12
Total.....	348

Smaller amounts are available from other seams which are not mined so extensively.

As obtained from the waste piles the pyrite has slate and coal attached and to be acceptable to pyrite burners it must be cleaned from a large part of the impurities. Where the mineral is recovered it is either cleaned by hand or by a crushing and washing plant whereby a high grade product is obtained.

It is estimated that at least 1,000,000 tons of this waste can be recovered annually from the coal mining sections of the United States.

MANGANESE.

For many years it has been known that manganese occurs quite widely distributed over the southern part of the state. Owing to the character of the deposits in general and to the prevailing low price of manganese ores, little attempt had been made to exploit the deposits. With the revival of the industry due to war needs a further examination of the deposits has been undertaken by the Bureau.

In 1881, some 2,000 tons of manganese ore was mined from the Cuthbertson Hill tract south of Arcadia, Iron county. This bank was reopened in 1916, but was soon closed down on account of the low grade of the ore. During the past year one carload of ore sorted from the dumps of several manganese prospects was shipped from Winona, Shannon county. During the same year, Mr. G. L. Barnes opened a deposit near Cornwall, Madison county.

Manganese in the form of oxides occurs in Missouri in four types of deposits. They are (1) deposits in porphyry, (2) deposits in residuum; (3) manganiferous iron ore, and (4) deposits in sedimentary rocks.

Deposits in Porphyry.—At a number of places in the porphyritic areas of Shannon, Carter, Reynolds and Iron counties, manganese in the form of a hard, black oxide occurs in local

concentrations in the porphyry. With one known exception, the deposits are vertical or nearly so, and are in consequence termed "veins" by the prospector. The several deposits examined in Shannon, Carter and Reynolds counties exhibit the same general characteristics. The mineralized zones vary from a few inches to a maximum of four feet in width. The ore body seemingly represents in part an impregnation and in part a replacement of the porphyry, all gradations from slightly impregnated country rock to pure ore being found within the mineralized zone. In places where the porphyry is closely jointed, the porphyry between joints has been quite completely replaced. Both the ore and the enclosing porphyry are extremely hard and so intimately associated as to require the removal of both porphyry and ore in mining operations, the ore seldom occurring in such manner as to part readily from the country rock.

On the Cuthbertson Hill tract, about four miles south of Arcadia in Iron county, a deposit of manganese ore has been worked by open cut. The ore body dips in a southwesterly direction at an angle of about 35 degrees. It is underlain by porphyry, more or less decomposed adjacent to the ore, and is overlain by what appears to be a fine grained arkose. The ore is impure, being admixed with porphyry.

The known deposits of manganese in porphyry occur at the following places:

NW. $\frac{1}{4}$, sec. 2, T. 28N., R. 3W.
W. $\frac{1}{4}$, SW. $\frac{1}{4}$, sec. 14, T. 28N., R. 3W.
SW. $\frac{1}{4}$ NE. $\frac{1}{4}$, sec. 36, T. 28N., R. 3W.
NE. $\frac{1}{4}$ NE. $\frac{1}{4}$, sec. 8, T. 28, R. 2W.
SE. $\frac{1}{4}$ NE. $\frac{1}{4}$, sec. 8, T. 28, R. 2W.
sec. 16, T. 33N., R. 2E.
SW. $\frac{1}{4}$ SW. $\frac{1}{4}$, sec. 18, T. 33N., R. 4E.

Deposits in Residuum.—These deposits consist of seams of manganese in residual clays, impregnated clays, surface-stained residual boulders, and chert breccias with matrix of manganese ore. Deposits of this character are widely distributed over the southern Ozark region, but at a few places only are the deposits of sufficient magnitude to invite close inspection. In sec. 36, T. 28N., R. 3W., (Shannon county) a hilltop embracing an area of several acres is thickly strewn with fragments and small boulders of manganese ore, intermingled with fragments of chert. The ore is highly siliceous, consisting of fragments of chert cemented together by oxide of manganese. A test pit shows the ore to extend six feet beneath the surface and to be

underlain by residual clay and chert. In sec. 25 to the northward there is a smaller deposit of similar ore.

North of Cornwall, in Madison county, a deposit of manganese ore has recently been reopened by Mr. G. L. Barnes. The deposit consists of fragments and boulders of manganese oxide, imbedded in residual clay. Considerable limonite carrying more or less manganese also occurs at this place. The deposit is reported to have been worked a number of years ago, the ore being used as flux at the Mine LaMotte furnace.

Manganiferous Iron Ore.—Limonite in a number of deposits in the southern part of the State is known to contain small percentages of manganese. Insofar as known, the ore does not contain sufficient manganese to command a premium because of its manganese content.

Iron ore carrying a comparatively high percentage of manganese has been mined and shipped from Buford Mountain in Iron county, (sec. 26, T. 35N., R. 3E.). The ore occurs in porphyry and is of that type known as specular iron ore. An average sample of the ore showed, upon analysis, 47.81 per cent iron, 8.54 per cent insoluble, 12.32 per cent manganese, and 0.044 per cent phosphorus.

Deposits in Sedimentary Rocks.—At a number of places, in the southern Ozark region, notably in Howell county, sandstone impregnated with oxide of manganese outcrops over considerable areas. The manganese content of the rock is much too low to comprise a possible source of manganese.

Several limestone horizons in the State are known to carry small percentages of manganese, which is apparently present in the form of manganese carbonate. None of these horizons can be considered as possible sources of manganese.

DIASPORE CLAY IN MISSOURI.

The presence of flint clay deposits in east central Missouri has been known for a good many years. The principal district in which they occur includes the counties bordering Missouri river in the north and south from St. Louis county as far west as Callaway and Osage. To the south Maries, Phelps and Crawford counties are also included.

Pockets of flint clay, in large number extend from Truesdale, Warren county past Montgomery City, to Fulton, Callaway county on the north. On the south they are even more

abundant from Jeffriesburg, Franklin county west to Belle, Maries county, and from Leasburg, Crawford county west to Rolla, Phelps county.

The opening of the first flint clay pits dates back nearly fifty years ago, almost with the beginning of railroad transportation in the district. Since this time there has been continuous but shifting and fluctuating activity and over 100 flint clay pits have been opened. Developments have formerly and still are confined to narrow zones bordering the railroads—zones whose outer limits are determined by the balance between cost of haulage and price obtained for the clay. At present no clay is hauled farther than five miles. The productive belts border the Wabash, St. Louis-San Francisco, and the Chicago, Rock Island and Pacific Railroads. The first two roads have long been transporters of flint clays, but the Chicago, Rock Island and Pacific did not enter the field until 1902, following its extension westward from Franklin county.

The flint fire clay has always been the principal type of clay produced in this district. This varies from a comparatively soft creamy white, nonplastic clay of an oily nature, to harsh hard, dull gray varieties, not unlike the mineral from which it receives its name. A light colored plastic clay—bond clay—is quite commonly associated with the flint clay. In some pits it is a decomposition product at the top of the deposits; in others it forms the major part of the deposit.

The most recently discovered and important associate of the flint clay is diaspore clay, an aluminum rich variety formerly discarded because of its sandy rough texture, and of the blistering and distortion it caused when fired. This type of clay has been found chiefly along the Chicago, Rock Island and Pacific Railroad from Gerald west to Belle, with one or two smaller lenses in pits near Hofflins on the St. Louis-San Francisco line. The presence of this rough type of clay has until recently been regarded as detrimental or worthless and today abandoned pits may be found where large bodies of it were left. The peculiar texture of the diaspore clay and its common association with the flint clay frequently as a core near the center of the deposit or as rounded boulders in the overlying weathered clay, aroused interest of Dr. W. S. Cox, of Cuba, Missouri, who had for several years been a producer of flint clay. Samples were sent by him to numerous firms for testing and valuation, and chemical analyses were obtained.

In texture diasporic clay ranges from a compact hard blue or gray flint clay with scattered flecks of white or bluish white and an occasional minute oolite through a true oolitic form, to a rough, porous ash colored mass not unlike the light colored varieties of bauxite. Red varieties of the clay, are also found. It had been discovered that where this type of clay was found there was an enrichment of alumina, depletion of silica, and frequently a very low lime and magnesia content. An analysis made on a sample of the clay by Mr. W. E. Oyler, Missouri Geological Survey, Rolla, Mo., showed the following results:

ANALYSIS OF DIASPORIC CLAY.

Moisture.....	.60 per cent
Loss on ignition.....	14.00 per cent
Silica (SiO_2).....	9.30 per cent
Alumina (Al_2O_3).....	73.73 per cent
Iron oxide (Fe_2O_3).....	.57 per cent
Soda (Na_2T).....	2.00 per cent
Potash (K_2O).....	.52 per cent
Total.....	100.72 per cent

The diasporic clay is therefore quite distinct from the flint clay both in texture and composition. It is apparently made up from particles and oolites of the mineral diaspor— $\text{AlO}(\text{OH})$ —containing 85 per cent aluminum and 15 per cent water, interbedded in more or less flint clay. This composition gives rise to the name “diasporic clay”, tentatively used here.

Edgar T. Wherry, of the Bureau of Chemistry, Washington, D. C., recognized the mineral in a sample sent from Rosebud as diaspor or diasporite¹ and later wrote² “The recognition of Diasporite, in comparatively large masses in association with clay suggests that this mineral may possibly prove to be of commercial value, either as an ore of aluminum or for the manufacture of abrasives.”

Dr. Cox has succeeded in introducing the diasporic clay into a broad field of usefulness, and it promises soon to assume an important place among aluminum ores; blended with clay it supplies the desired aluminum content in certain types of refractories; refined and bonded it is used as an abrasive under special trade names. Shipments in commercial quantities were begun about the first of this year (1918).

¹Amer. Mineralogist. Vol. 2, pp. 144-1917.

²Ibid Vol. 3, pp. 154-1918.

The deposits are large, often forming the cores of the flint clay pockets of the Rock Island district, and in a few of those along the Frisco. As developments are extended farther out new deposits are likely to be discovered and an ample supply is assured.

Diaspore clay is generally shipped under two trade names, "Ashy clay", the rougher, porous variety richest in aluminum, and "Massillon clay", a leaner variety with fewer and smaller oolites and of a more compact texture.

As investigation of this new clay and its associations is now being carried on by the Bureau.

THE SURVEY AS AN INFORMATION BUREAU.

One of the most important capacities in which the Survey serves the citizens of the state is as a Bureau of Information. Aside from reports and maps issued, an immense amount of data has been collected during the many years of work over the entire state, which has been classified and placed in the files of the institution. This data contains information concerning mineral deposits and geologic conditions in practically every county. It is available through correspondence and drawn upon to answer the thousands of requests for information yearly received. Companies and individuals outside the state are constantly in search of information covering our mineral resources. These parties are looking for some type of mineral deposits to develop and in many instances where outside concerns expect to enter the state for investment purposes, the Bureau is approached for information. The importance of this character of work cannot be over estimated.

The Bureau is also in constant receipt of minerals, ores, and rocks sent in from all parts of the state, with the request that their identity, value, and significance be reported upon. All such specimens are carefully examined and when necessary analyzed, and reports concerning them given.

CHEMICAL LABORATORY.

In connection with every problem undertaken by the Survey there is always more or less chemical work to be done. Besides this work, however, a great many laboratory determinations or

even complete analyses are necessary on the specimens submitted each year for identification or information as to value. This work in itself is practically sufficient to keep one chemist busy during the entire year.

The Survey does not enter the commercial field, and analyses, other than for problems being studied by the Bureau, are only made when specimens represent undeveloped deposits, or where communities have appealed for aid requiring chemical work.

During the past biennial period a complete series of analyses has been made of the various mineral waters found at Excelsior Springs and Eldorado Springs. This work was done at the request of the people interested in the exploitation of these waters in order that a standard, modern, set of analyses might be had upon which to base the therapeutic properties of the various waters.

During the summer of 1918 the demand for manganese has been abnormally great and numerous analyses have been made to show the character of the ore found in many of the deposits of the Ozark region.

Outcrops of asphaltic sandstone indicate the extensive occurrence of this rock in western Missouri. For many years the possibilities of its commercial use has been considered but there has been very little available data on the amount and quality of the bitumen contained. In connection with recent attempts to commercialize Vernon county deposits of this rock, laboratory tests have been conducted which allow a comparison with the asphaltic sandstones of Kentucky and Oklahoma now in use.

MUSEUM.

A large museum containing a complete set of the minerals, rocks, and a very large number of the fossils found in the state is maintained by the Bureau. This is not, however, maintained as an exhibit museum, but as a type collection for study purposes. In this respect it forms a valuable adjunct and is of great assistance to the members of the staff. Specimens are also loaned to citizens who desire to become acquainted with the character of certain minerals and ores and type sets have been furnished to a number of the public schools in the state. The collection is catalogued and systematically arranged in quarters given over entirely to the museum and new specimens are constantly being added.

In addition to the Museum at the Bureau's headquarters, an exhibit collection of several hundred specimens is kept at the State Fair in Sedalia, the Director of the Bureau being in charge of the Department of Mines and Forestry.

LIBRARY.

The Library of the Bureau is maintained through exchange with other home and foreign scientific institutions. Through this method practically complete sets of the publications of the U. S. Geological Survey, the Federal Bureau of Mines, the various State Geological Surveys, many of the foreign geological surveys, and nearly all of the scientific societies in the country are obtained. A number of technical magazines are also received through exchange.

RECONNOISSANCE WORK AND PERSONAL VISITS.

A great deal of reconnoissance work is done yearly over the state and on various problems. It is necessary that the Bureau keep in close touch with any new mineral development taking place in any part of the state. New mineral discoveries or the opening of deposits in a new territory is invariably followed by a demand for information and an investigation of the district by the survey. It is customary, therefore, to send a representative of the Bureau to localities where new discoveries or developments are reported, and if deemed advisable to make a brief reconnoissance report on the problem. Many such visits are made each year upon request and petition. The following list shows the character of these brief investigations or personal visits made during the past year:

Appleton City. St. Clair County.—Investigation of evidences of oil and gas and oil possibilities in the region.

Canton. Lewis County.—Investigation and advice concerning artesian well water supply.

Cedar City. Callaway County.—Investigation of glass sand deposits.

Columbia. Boone County.—Investigation of clay deposits.

Condray. Dent County.—Examination and advice concerning iron deposits.

Cornwall. Madison County.—Investigation of deposits of manganese.

Cuba. Crawford County.—Examination of a number of iron deposits.

Eldorado Springs. Cedar County.—Investigation of asphaltic sandstone deposits.

Fayette. Howard County.—Investigation of clay deposits.

Fenton. St. Louis County.—Investigation of peculiar geologic structure.

Gallatin. Daviess County.—Investigation of the oil possibilities over areas surrounding Gallatin.

Gore. Warren County.—Investigation of the clay deposits.

Independence. Jackson County.—Discussed oil and gas possibilities of the vicinity with citizens and advised concerning leasing and drilling.

Kirksville. Adair County.—Investigation and discussion of oil possibilities in northern Adair county.

Kansas City. Jackson County.—Discussion of coal mining possibilities with Kansas City officials.

Mokane. Callaway County. Investigation of clay deposits.

Nevada. Vernon County.—Investigation and reconnoissance mapping of portion of northwest Vernon county for oil and gas.

New Franklin. Howard County.—Visited and advised local parties concerning the drilling of a deep test for oil.

Oldfield. Christian County.—Investigation of lead and zinc deposits.

Perryville. Perry County.—Investigated district and advised concerning oil prospecting, also investigated lead and zinc prospects.

Pleasant Hill. Cass County.—Investigated area south of Pleasant Hill for oil and gas possibilities.

Pomona. Howell County.—Investigated iron deposits in the vicinity of Pomona.

Princeton. Mercer County.—Investigation and reconnoissance mapping of area around Princeton for oil and gas possibilities.

St. Charles. St. Charles County.—Investigation and advice concerning coal deposits.

St. Clair. Franklin County.—Investigation of lead, zinc and barite deposits.

St. James. Phelps County.—Investigation of iron deposits.

Savannah. Andrew County.—Examination of oil prospects in vicinity of Savannah.

Sedalia. Pettis County.—Investigation of clay deposits.

Versailles. Morgan County.—Investigation of mineral prospects.

Windsor. Henry County.—Investigation of evidences of oil around Windsor and Calhoun.

Warsaw. Benton County.—Investigated lead and barite deposits and advised concerning oil prospects.

Worland. Bates County.—Investigated and advised concerning coal stripping project.

TOPOGRAPHIC MAPPING.

The making of accurate surface or topographic maps is an important branch of the Survey work carried on in co-operation with the United States Geological Survey. These maps are being made in every state in the Union with the ultimate purpose of producing a complete map of the United States.

Under the terms of the cooperation the Federal Geological Survey furnishes trained topographers for the work from their organization, pays one-half of the field expenses and engraves the original plates at their own expense. By this method the maps are produced at the lowest possible cost and a cost of which the state assumes really less than one-half.

With the declaration of war, however, the army commandeered the services of the topographers in the Federal employ and it has not been possible to carry on cooperative work during the past biennial period. However, since the signing of the Armistice the Federal Survey is again in position to carry on the work and reestablish cooperative agreements.

At the present time about one-fifth of the state is covered by good topographic maps made on the scale of one inch to the mile. The original reconnoissance maps made in the eighties and early nineties were on a much smaller scale—two miles to the inch—are much less accurate and in no respect comparable to the present type of map. Including these older maps, however, a little less than one-half the state has been mapped topographically.

The following tables show the maps available and the accompanying sketch map indicates the area covered:

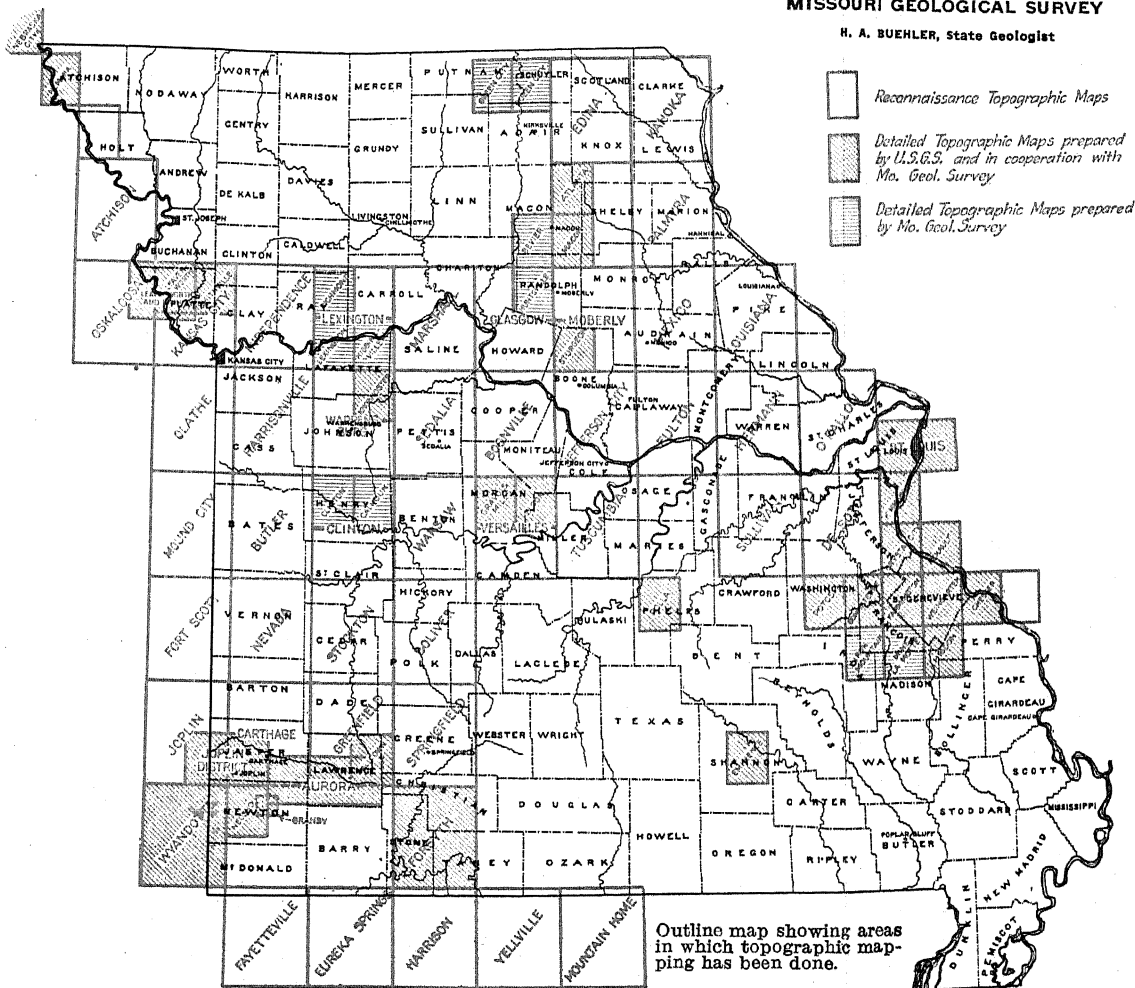
OLD RECONNOISSANCE TOPOGRAPHIC SHEETS; 30' QUADRANGLES;

Scale, 2 miles=1 inch.

Kahoka	Fulton	Marshall	Butler
Palmyra	Sullivan	Independence	Nevada
Mexico	Versailles	Harrisonville	Bolivar
Glasgow	Clinton	Sedalia	Greenfield
Lexington	Edina	Jefferson City	Stockton
Kansas City	Louisiana	Hermann	Springfield
Warrensburg	Moberly	DeSoto	Carthage
Boonville	Warsaw	Tuscumbia	O'Fallon

MISSOURI GEOLOGICAL SURVEY

H. A. BUEHLER, State Geologist



DETAILED TOPOGRAPHIC MAPS.

Chiefly 15' Quadrangles;—Scale, 1 inch=1 mile.

	Square miles.
Atlanta.....	229
Aurora.....	550
Bevier.....	230
Bonne Terre.....	236
Calhoun.....	234
Campbell Hill.....	40
Chester.....	158
Clinton.....	234
Crystal City.....	210
DeSoto.....	938
Edina.....	912
Eldon.....	234
Eminence.....	310
Farmington.....	326
Renault.....	50
Forsyth.....	957
Granby.....	15
Gravois Mills.....	234
Green City.....	228
Greenfield.....	19
Halltown.....	167
Higdon.....	236
Higginsville.....	232
Huntsville.....	231
Iron Mountain.....	236
Joplin.....	340
Kahoka.....	885
Kimmswick.....	175
Knobnoster.....	253
Leavenworth.....	160
Lexington.....	232
Macon.....	230
Mine La Motte.....	236
Nemaha.....	114
Neosho.....	239
O'Fallon.....	897
Palmyra.....	918
Platte County*.....	410
Potosi.....	236
Queen City.....	228
Richmond.....	231
Rolla.....	236
St. Louis.....	273
Smithville.....	231
Stotts City.....	19
Sturgeon.....	232
Sullivan.....	938
Weingarten.....	236
Wyandotte.....	75
Total.....	14,054

*Includes 300 square miles of the Leavenworth and Smithville sheets.

PUBLICATIONS.

THE GEOLOGY OF JACKSON COUNTY.

The report on the Geology of Jackson County by W. E. McCourt assisted by M. Albertson and J. W. Bennett was made ready for distribution during the summer of 1918. It consists of 158 pages of text dealing with all phases of the Geology of the county, 19 plates including 50 illustrations, 2 maps, and one plate of cross sections.

The text is divided into four chapters entitled Geography, Topography, Geology and Mineral Resources. There is also an appendix containing a large number of chemical analyses. Under Geography is given a resume of the history and settlement of the county with a brief discussion of its population and industries. Its transportation facilities are also taken up briefly and the important details of the climate are mentioned.

The present topography of the county has been developed chiefly by erosion of a series of interlayered limestones and shales dipping slightly to the northwest. In accordance with such development several prominent escarpments of limestone cross the area from southwest to northeast, forming a very conspicuous feature of its topography. Old abandoned river valleys, the presence of which record interesting changes in the courses of the major streams of the area occur in two different parts of the county. Under the chapter entitled Topography a description of these features is incorporated with that of the general discussion of the upland and valley areas, the drainage and altitudes and a special portion of the chapter, dealing entirely with the topography of Kansas City.

The indurated rocks exposed in the county belong entirely to the Pennsylvanian or "Coal Measures" series. They include the Cherokee, Henrietta, Pleasanton, Kansas City, and Lansing formations. With the exception of the Kansas City these formations are composed very predominately of shale with a few thin beds of limestone and a considerable amount of sandstone. Seams of coal are known to occur in the Cherokee, Henrietta, and Pleasanton, the only important beds, however, being confined to the Cherokee. The Kansas City formation is composed of a series of interlayered limestone and shale members, the whole being constituted of at least 50 per cent limestone. It

is the limestone members of this formation which are so conspicuously exposed over a large part of the county.

Overlaying the indurated rocks on the uplands of the county is a thin to thick mantle of fine yellow clay known as loess. This attains its maximum thickness adjacent to Missouri river and bluffs of it are conspicuous in Kansas City. Locally in Kansas City and in the region between Buckner and Sibley small deposits of glacial drift are found. Deposits of alluvium have been laid down over the stream bottoms but attain no great thickness except in the Missouri bottoms. Here borings have penetrated to depths of over 100 feet in places before reaching bed rock.

The mineral resources of Jackson county are entirely non-metallic. They include principally clay and shale, limestone, sand, gravel, oil, gas, coal, and water. Clay and shale suitable for the manufacture of brick, paving block, and drain tile occur so extensively as to form an inexhaustible supply. Limestone is extensively quarried at numerous points in the county chiefly for rubble and crushed rock. At Cement City both the limestone and shale are obtained for the manufacture of Portland cement. Missouri river and its tributaries afford an excellent source of sand and gravel suitable for commercial purposes, and an extensive sand and gravel industry has been developed in Kansas City.

Gas has been found in a large number of wells in the western part of the county and from some wells small quantities of oil have been obtained. The logs of many of these wells together with such data as are available concerning them have been included under the chapter on Mineral Resources. The occurrence of both oil and gas so far discovered are restricted to the Pleasanton, Henrietta, and Cherokee formations of the Pennsylvanian series and the productive sands occur at depths varying from 100 to about 700 feet, chiefly between 250 and 550 feet. Coal has not been mined in the county for many years though several beds including two which may be worked commercially are known to underlie the area.

The maps accompanying the report consist of a geologic map of Jackson County and a more detailed geologic map covering Kansas City.

OIL AND GAS POSSIBILITIES IN THE BELTON AREA.

The report on the oil and gas possibilities of the Belton Area by Malcolm E. Wilson includes a geologic structure map and description of the geology of an area which has long been considered as favorable for oil and gas prospecting. It covers approximately 71 square miles in Jackson and Cass counties and the area contains some of the most important discoveries of oil and gas yet found in the state. Two towns within the region, Belton and Martin City have for a number of years been partially or wholly supplied with natural gas from local wells and from a group of 5 shallow wells near Belton about 300 barrels of oil per month were produced in the past. Productive Kansas oil fields lie only about 30 miles to the southwest.

The Belton area is underlain by the Pennsylvanian formations to a depth of 650 to 870 feet or more. These rocks include the Cherokee shale, Henrietta and Pleasanton formations of the Lower Pennsylvanian and the Kansas City formation of the Upper Pennsylvanian. The beds have a gently regional dip to the northwest but this dip has been greatly interfered with by folding which has in places produced a reversal of the regional dip. There are in consequence several low, but well defined anticlines in the region which appear to be worthy of consideration for some initial testing or where this has been done, further testing. Previous to this report no structure map has ever been available to serve as a prospecting guide. As the anticlines afford the most favorable areas for testing, the map accompanying the report which outlines these structures should prove especially valuable in future exploration.

This report in a general way illustrates the character of the work which has been done by field parties working on oil and gas during the seasons of 1917-1918. Information similar to that contained in the Belton report is in hand though not yet in published form, for a number of other regions.

THE SAND AND GRAVEL RESOURCES OF MISSOURI.

A report on the "Sand and Gravel Resources of Missouri" by C. L. Dake, is now in the hands of the printer, and will be ready for distribution by the end of the year.

The report is divided into four chapters, as follows:—
(1) Nature, Origin, and Properties of Sand; (2) Method of Production and Market Conditions; (3) Uses of Sand and Gravel;

(4) Distribution of Sand and Gravel by Geological Formations and Districts. Accompanying the text are numerous tables of chemical and mechanical analyses of sand and gravel.

In Chapter 1 is given a brief outline of the principles of chemical and mechanical weathering that produce sand from solid rocks. This is followed by a discussion of the terminology used in classifying sands. This in turn is followed by a rather exhaustive discussion of the properties of sands, including color, cleanness, size of grain, form of grain; soundness of grain, specific gravity, voids, weight of sand, chemical composition, and refractoriness.

Chapter two outlines the methods employed in Missouri to secure sand, and includes detailed descriptions of loading and unloading devices, various types of dredges, crushing machinery and washing and screening outfits. This is followed by an analysis of state statistics of production by years, by sources, and by prices. The chapter closes with a discussion of the factors controlling prices, including a consideration of markets and competition from outside the state.

Chapter three presents a discussion of the various uses of sand and gravel, giving in considerable detail the essential properties for each.

Chapter four is devoted to a description of the various formations in the state capable of yielding sand or gravel and a description of plants producing therefrom.

The St. Peter sandstone which outcrops in a comparatively narrow belt from Cape Girardeau County on the south to Warren and Montgomery counties on the north, produces the white sand so extensively quarried for the manufacture of plate glass. It varies from 10 to 135 feet in thickness averaging from 50 to 80 feet, and is usually very white and free from impurities. The distribution of this formation is shown on a series of sketch maps which include all the counties in which this sandstone is found.

The Roubidoux has the widest distribution of any sandstone formation in the state and although not sufficiently pure to be utilized in the manufacture of high grade plate glass it can supply unlimited quantities of sand for other purposes and most of the streams of the Ozark region owe their extensive sand bars to the disintegration of this formation. To a lesser extent the Lamotte, Gunter, Thebes, Bailey, Beauvais, Vermicular, Phelps, Aux Vases, Renault, and Pennsylvanian sandstones have contributed to the commercial sand and gravel deposits of the state.

In the northern part of the state there are important glacial deposits from which sand and gravel are obtained for local use.

The report gives detailed descriptions of the various plants in operation.

MINERAL RESOURCES OF MISSOURI.

The Survey is so constantly in receipt of requests from both within and outside the state for information concerning Missouri's mineral resources and the extent to which they are developed that it has been considered advisable to issue a small descriptive pamphlet on the subject. This pamphlet entitled "Mineral Resources of Missouri" has proven popular beyond expectation. It condenses a large amount of information in a few pages, is well illustrated, contains a small map locating the principal mineral deposits and also a table of mineral statistics and a list of the available publications of the Bureau. This pamphlet serves admirably both to advertise and illustrate the various mineral industries and resources of the state and the large demand for it signifies that it is successfully serving its purpose.

UNPUBLISHED REPORTS.

The Bureau has several reports in preparation, a number of which are practically completed, including the Geology of Ste. Genevieve, Platte, Vernon, Mercer, and Grundy counties and the Underground Water Resources of Missouri.

During the past year it has been practically impossible to get engraving done except at an almost prohibitive cost and the publication of these reports has been delayed until more normal conditions return.

APPROPRIATION REQUESTED FOR 1919 AND 1920.

The sudden extraordinary demands thrown upon the mining industry, due to the urgent needs of the war emphasized the importance of a systematic knowledge of our mineral resources. This was especially true of the minerals and metals which were largely imported, and the domestic production of which did not equal domestic consumption. At the outbreak of hostilities foreign imports were cut off in order that ships might be made available for the transportation of troops, and it became necessary to increase the output of present mines, and vigorously develop many prospects and undeveloped regions. The United States did not produce sufficient manganese, chromite, pyrite, tungsten,

sulphur, zirconium, potash, high grade clays, graphite, arsenic, platinum, and many others minerals and metals. Recognizing the large fund of information concerning the undeveloped mineral resources already at hand in the various State Geological Surveys, the Government requested cooperation with the Federal Bureau of Mines, and Federal Geological Survey in the stimulation of the mineral industries, and the phenomenal increase in production which was soon attained can, in many instances, be directly traced to the cooperative efforts of these organizations. It is a striking illustration of the value of the work of the State Bureaus in having information at hand.

With the reconstruction period there will be a strong demand for increased production to supply the normal requirements of industries which were wholly, or in part diverted, to war purposes.

Missouri has a variety of commercial mineral deposits equaled by few of the states, and the increased importance of her mining industry is indicated by the value of the output, which in 1898 was only \$13,323,245, as compared with \$91,139,525 in 1917. Without exception each of the various mineral resources have increased in value, and with continued development the total production will continue to increase.

The Bureau of Geology and Mines has been an important factor in the past development; its reports and maps are in constant demand, and the Department continually receives requests for information covering deposits regarding which we do not now have complete reports. In order to be of the greatest service the information must be on file, and must be collected through actual field work and during the coming biennial period the Bureau plans on continuing its economic studies and geological mapping in various parts of the state.

TOPOGRAPHIC MAPPING.

In cooperation with the U. S. Geological Survey, the Bureau of Geology and Mines has been making accurate topographic maps during the past few years. The importance of these maps for war purposes is indicated by the fact that with the declaration of war, the War Department commandeered the topographic organization and concentrated the work along the Atlantic Coast for defense purposes. As a consequence, during the last biennial period it has not been possible to carry on the cooperative work, but with the signing of the armistice the organization

returns to its normal activities, and the work will be continued as in the past.

These maps are very accurate and of the greatest importance in drainage problems, road construction, land classification and every branch of engineering.

At present approximately one-fifth of the area of the state is covered by accurate maps. The work is done by actual field parties, the United States Geological Survey furnishing one-half the funds required. It also engraves the plates without cost to the State.

In order that the Bureau of Geology and Mines may continue and enlarge its work to meet the increased demands the Board of Managers earnestly request the following appropriation:

APPROPRIATION REQUESTED FOR 1919 AND 1920

Support fund requested—(For salaries, office expenses, traveling expenses, equipment, stationery, engraving and printing reports)	\$53,000
*Topographic mapping fund requested (For making topographic maps in co-operation with United States Geological Survey)	25,000
Total	\$78,000

*The United States Geological Survey will also appropriate \$25,000 for co-operation in this work, or they will spend a dollar for every dollar the State spends on it.

MINERAL RESOURCES OF MISSOURI.

PRODUCTION AND DEVELOPMENT FOR 1916 AND 1917.

The value of the mineral production for Missouri in 1917 reached a total of \$91,139,525, by far the largest ever recorded. As a whole the output of the various minerals did not increase over 1916 and both lead and zinc production, especially the latter, fell off during the year. However, the greatly increased demand for metals and minerals of all kinds caused prices to soar and many commodities commanded a higher price than ever before. This fact is largely responsible for the remarkable increase in production value over 1916, when the previous high record was established.

VALUE OF MINERAL PRODUCTION OF MISSOURI, 1914-1917.

Commodity.	1914.	1915.	1916.	1917.
Lead ore.....	\$11,143,104	\$14,579,361	\$24,172,965	\$34,038,976
Zinc.....	7,766,911	19,625,978	24,228,596	17,708,604
Coal.....	6,802,325	6,595,918	9,044,505	13,755,864
Clay products.....	6,074,284	5,428,403	7,634,559	10,328,374
Cement.....	4,495,744	4,007,697	6,333,567	8,248,007
Limestone.....	2,160,958	2,049,772	1,990,419	1,679,677
Marble.....	(d)	(d)	156,942	227,520
Mineral Paints.....	2,147,579	4,745,246	1,141,665	(c)
Sand and Gravel.....	1,020,903	675,684	877,634	1,101,745
Lime.....	686,051	573,442	956,300	1,519,266
Clay.....	463,703	641,040	988,884	1,386,338
Chats.....	340,616	346,378	433,456	214,007
Barytes.....	112,231	158,597	365,111	391,363
Copper.....	5,914	70,378	95,005	99,649
Mineral Waters.....	74,793	83,363	109,814	57,175
Tripoli.....	81,434	68,451	99,248	90,923
Iron Ore.....	75,696	99,853	116,484	134,906
Granite.....	77,971	85,624	80,390	58,241
Silver.....	33,826	29,232	85,178	50,747
Sandstone.....	3,588	10,104	14,991	6,862
Natural Gas.....	5,319	5,077	17,594	8,230
Pottery.....	2,944	3,166	(a)	(a)
Miscellaneous and concealed*.....	16,768	37,256	37,165	33,051
Total.....	\$43,585,667	\$59,821,032	\$78,558,422	\$91,139,525

*Includes such figures as are obtainable on Pyrite, Petroleum, Cobalt, Nickel, Pottery and Tungsten.

(a) Included in Miscellaneous.

(b) Incomplete record.

(c) Inasmuch as Mineral Paints are manufactured from raw materials listed elsewhere in these tables the 1917 production is not included. Had this been done, the value of the mineral production of the State would have totaled approximately \$100,000,000 in 1917.

(d) Included under limestone.

During the years 1916 and 1917 a considerable stimulus was given to the mineral industry in the state by the abnormally great demand for certain commodities followed in most cases by corresponding high prices. The years have been progressive ones in which the foundation for a greater production has been laid than is reflected in the latest statistical figures as yet available. Notable among new plants constructed or under way are two large iron furnaces, one owned by the Mid-Continent Iron Company, at Fremont, Carter county, and the other by the Missouri Iron and Steel Corporation at Brandsville, Howell county. The former was placed in blast in the late fall of 1918 and the latter is expected to be completed early in 1919. At Sherman, St. Louis county, the Meramec Portland Cement and Materials Company is erecting a large plant for the manufacture of Portland Cement, making the sixth large plant of this kind in the State. At New Florence, Montgomery county, a large clay plant has been built by the New Florence Fire Brick Company, at Wellsville, Audrain county, a similar plant is in process of erection by the Wellsville Fire Brick Company, and the Walsh Fire Clay Products Co. is putting up a large plant at Vandalia.

Especial activity developed through the period in the flint fire clay districts of Gasconade and Montgomery counties and many new pits were opened. A large number of old iron mines have been reopened or prospected for reopening and one new mine of importance, the Beulah mine, near Stanton, Franklin county, was developed. The opening of new mines for barite in Franklin county, pyrite in Wright and Franklin counties, zinc in Newton county, and coal in the northern and western part of the State constitute a part of the important mineral development during the period.

ASPHALTIC ROCK.

Asphaltic sandstone occurs in outcrop or close to the surface over wide areas in western Missouri. The occurrences lie chiefly in Barton, Vernon, Bates, Cass, Lafayette, Ray and Cedar counties with minor occurrences in adjoining counties and in Barry county. So far as our present knowledge goes, the principal deposits are those near Liberal, Barton county, Sheldon, Vernon county, and Higginsville, Lafayette county, though other occurrences may be just as important or even more so. The asphaltic sandstone beds all lie in Lower Pennsylvanian ("Coal Measures") strata, chiefly in the Cherokee shale but they are

also found in the Henrietta and Pleasanton formations and in the Warrensburg sandstone. The bitumen present is a residuum from crude petroleum originally contained in the beds, but which has become inspissated through evaporation or a natural distillation.

The asphaltic sandstone in general is composed of very fine to fine angular quartz grains loosely cemented together chiefly by the asphalt. It is in other words the typical fine grained, micaceous Pennsylvanian sandstone with an asphalt cement. The stone is brown to chocolate colored on a weathered surface and black on fresh fracture. It is commonly soft and friable though near Liberal, Barton county, the stone is quite hard and has been quarried for curbstone and flagging, being admirably suited for these uses. Near Sheldon, Vernon county, it has a maximum thickness of about 30 feet, while near Liberal, Barton county, wells have been reported to have penetrated as much as 50 feet of bituminous sandstone. Near Higginsville, Lafayette county, 15 to 20 feet of the material is exposed and borings have encountered asphaltic rock to depths of over 100 feet. In southwest Ray county, 15 feet of the material has been penetrated close to the surface. At very few localities is the thickness of the bituminous sandstone known. It is safe to say, however, that considerable areas are underlain by it close to the surface where the rock exceeds a thickness of 10 feet and probably 20 feet.

The amount of bitumen contained in the sandstone varies considerably in different beds in the same locality and between nearby points. A few tests made recently at this Bureau on the rock from Barry, Barton, and Vernon counties showed a bituminous content varying from 6.5 per cent to 8.2 per cent. Tests made on the Lafayette county bituminous sandstone have shown from 6 per cent to 8.5 per cent bitumen. After examining the deposits in Vernon county near Sheldon, Buckley stated that the bitumen in the stone frequently reached 12 to 15 per cent. The bituminous content of the rock is very deceptive and the amount of bitumen present is commonly overestimated. Judging from actual tests made on a number of samples which appear to be typical of the more highly bituminized stone, the amount of bitumen present will rarely exceed 10 per cent.

Relative to the nature of the bitumen, too little is now known. This is also variable from one locality to another depending largely upon the degree of inspissation and the nature

of the original oil. Two analyses of the bitumen from Vernon county have shown 11.5 and 9.6 per cent asphaltene and 80.3 and 81.1 per cent petroleue. The oil distilled from a sample of the sandstone from this same locality has a specific gravity of 0.915. As compared to Kentucky and Oklahoma asphaltic sandstones used for paving, the Missouri sandstone is quite similar in the amount of bitumen contained, but the average of the analyses cited by Snider for the Oklahoma bitumen show 21 to 28 per cent asphaltene, a higher per cent than in the Missouri bitumen. Relative to the use of the crushed natural rock for paving, therefore, the fact that the bitumen contained is chiefly a petroleum rather than an asphalt, must be borne in mind as an unfavorable factor.

The Missouri asphaltic sandstones have long attracted interest for their possible use as a natural paving material. In the last year they have been examined as a source of petroleum but at the present time this idea is believed not to be practical. Relative to the former use, however, recent experiments have shown that with proper treatment, the stone can be successfully used. Formerly, the stone had been looked upon with disfavor because of its failure to stand wear when used experimentally in Carthage and Springfield. In October, 1917, however, two blocks of pavement were laid in Higginsville, surfaced by a mixture in which the natural rock from the Higginsville deposit was used. In preparing the street a foundation of concrete was made and this covered by a two and one-half inch layer of asphalt prepared as follows:

PROPORTIONS OF INGREDIENTS USED IN HIGGINSVILLE PAVEMENT.

(Higginsville deposit).

Natural asphaltic sandstone.....	500 lbs.
Joplin chats.....	300 "
Sand.....	80 "
Limestone dust.....	60 "
Additional asphalt cement.....	60 "
	1,000 lbs.

The sandstone was pulverized and the whole mixed together at 300° F. and rolled down while hot. This forms a hard but resilient surface. So far it has successfully withstood traffic and extremes of temperature without showing much wear or cracking.

With this experiment in its favor it is believed that more

attention should be given the asphaltic sandstones of western Missouri, for paving. The deposits are well located for market and easily quarried.

Besides the asphaltic sandstones, asphaltic limestones occur in several western counties. Near Freeman and West Line, Cass county, the Bethany Falls limestone is in the upper beds partially saturated with asphalt and some of the stone has been quarried though not disposed of. It is reported that this stone contains about 6 to 11 per cent bitumen. The same beds are known to be asphaltic near Raytown, Jackson county. In southwest Missouri in parts of Barton, Cedar, Jasper, and other counties, the Burlington limestone of the Mississippian series is in places asphaltic. The source of the asphalt was probably in the overlying Pennsylvanian sandstones.

BARYTES.

TABLE OF PRODUCTION, 1907-1917.

Year.	Tons (short).	Value.	Average Per ton.
1907.....	44,039	\$162,459	\$3.69
1908.....	16,319	56,768	3.48
1909.....	34,815	119,818	3.44
1910.....	25,431	85,624	3.32
1911.....	21,500	81,380	3.79
1912.....	24,530	117,035	4.77
1913.....	31,131	117,638	3.75
1914.....	33,317	117,738	3.53
1915.....	39,113	158,597	4.05
1916.....	58,407	365,111	6.25
1917.....	59,046	391,363	6.62

The production of barytes in 1917 was the largest in the history of the state. There were 64,997 tons mined, of which 59,045 tons were sold for \$391,363, an average price of \$6.62 a ton. The remaining 5,951 tons of ore was carried over in stock. The price per ton was best yet recorded, exceeding the average of 1916 by 37 cents and that of any previous year by \$1.85. From 1902 to 1915 the average price of barytes varied from \$2.96 to \$4.77 a ton, averaging only \$3.56. However, in the past three years, the greatly increased use of the mineral has created a strong demand for it and in October, 1918, crude barytes delivered to the refining mills in St. Louis commanded \$9.80 a ton. It seems probable that the maximum price has not yet been reached.

The principal barytes producing states besides Missouri are Georgia, Tennessee and Kentucky, but none of these states produce the crude mineral which commands as high a price as the Missouri product. In 1917 Washington county, as formerly, was the principal barytes producer in the state, yielding over three-fourths of the amount mined. Other important producing counties were Jefferson, Morgan, Franklin, Cole, and Miller. Moniteau, Texas, and Benton counties have in the past produced barytes and are now known to contain workable deposits but no recorded mining was done in 1917. The following table shows the production by counties:

PRODUCTION OF BARYTES IN MISSOURI BY COUNTIES.

County.	Tonnage mined.	Tonnage sold.	
		Quantity.	Value.
Cole (a).....	1,210	1,110	\$6,630
Franklin.....	1,405	1,353	8,994
Jefferson (b).....	2,422	2,435	17,098
Miller (a).....	764	565	3,257
Morgan (a).....	1,997	1,957	10,638
St. Francois (b).....	1,394	1,394	7,949
Washington.....	46,394	40,821	274,414
UNDISTRIBUTED (c).....	9,411	9,411	62,383
Total.....	64,997	59,046	\$391,363

(a) Some barytes from Cole and Morgan counties included under Miller county.

(b) Some barytes from St. Francois county included under Jefferson county.

(c) Barytes reported by buyers, not reported elsewhere. Cannot be distributed by counties.

The workable deposits of barytes in Missouri occur principally in the residual clay overlying the Potosi, Gasconade, and Jefferson City formations. Mining is carried on chiefly through open shallow pits or runs which vary in depth generally from a few to 15 to 20 feet. Near St. Clair, Franklin county, however, one mine is operated through drifts run in from the hillside cross-cutting a segregation of the mineral 3 to 10 feet thick, heavily disseminated through the clay. The mineral is always segregated principally at the base of the residuum just above the bed rock and the clay in which it is embedded is red, tough and plastic, regardless of which formation it overlies. The individual deposits are usually small and scattered and the miners operate individually on a small scale. Many of the miners are farmers who dig "tiff" at such times as their work permits and the mineral is sold to local dealers who in turn ship it to

the refiners. Before reaching the refiner the crude barytes is not treated in any way except partially cleaned of the adhering clay. This is usually done in crude rockers or by rolling the boulders down a chute, after drying, which contains small openings through which the detached clay falls. Upon reaching the refiner the barytes is washed, ground fine, and bleached white, with sulfuric acid and shipped in this state to the consumers.

The present production of barytes in no manner represents the possibilities of the Missouri fields. In Franklin county alone, whose production of barite for 1917 was only 1,405 tons, extensive deposits of the mineral are known to occur near St. Clair, Morrellton, and Moselle. It is safe to say that these deposits are easily capable of producing many times the 1917 production, yearly.

Barytes is used chiefly in the manufacture of mixed paints, lithophone, and chemicals. To a lesser extent it is used in the manufacture of white rubber goods, asbestos, cement, artificial ivory, and in the preparation of fertilizers, boiler compounds, insecticides, and peroxide of hydrogen.

Buyers and Refiners of barytes in Missouri are:

Mineral Point Mining and Milling Co., Mineral Point, Mo.

Nulsen, Klein, and Krause, St. Louis.

J. C. Fink Mineral Co., St. Louis.

The following is a list of producers of crude barytes in 1917:

PRODUCERS OF CRUDE BARYTES, 1916 AND 1917.

Producer.	Location of Mine.
<i>Cole County.</i>	
Earnest Pearce.....	Centertown and Lohman
Thomas H. Belshe & Son.....	Eugene
W. T. Reavis & Sons.....	Eugene
S. M. Templeton.....	Eugene
George W. Sullens & Son.....	Henley
<i>Franklin County.</i>	
B. Duckworth.....	St. Clair
S. D. Bellew.....	St. Clair
Casey & Bellew.....	St. Clair
C. C. Rose & H. O. Hollow.....	St. Clair
Illmo Mining Company, produced in 1918.....	St. Clair
<i>Jefferson County.</i>	
H. C. Carter & Company.....	Halifax
Johnson Bros.....	Fletcher
Tom Pinell.....	Fletcher
A. E. Stocking.....	Fletcher
William E. Bernhardt.....	Vineland
T. L. Dapron.....	Vineland
O. E. Brooks.....	
<i>Miller County.</i>	
William Brazier.....	Tuscumbia
Oscar J. Gray.....	Tuscumbia
Kehr Brothers.....	Bagnell

PRODUCERS OF CRUDE BARYTES, 1916 AND 1917—Continued.

Producer.	Location of Mine.
<i>Moniteau County.</i>	
W. T. Reavis & Son.....	California
<i>Morgan County.</i>	
W. V. Bennett.....	Versailles
Stevenson & Merriott.....	Versailles
J. H. Phillips.....	Barnett
W. T. Reavis & Son.....	Gravois Mills
Earnest Pearce.....	Versailles
<i>St. Francois County.</i>	
L. E. Cole.....	Blackwell
L. E. Cole & Company.....	Blackwell
James Donald.....	Blackwell
Ode Engledon.....	Blackwell
McGready & Cole.....	Blackwell
<i>Washington County.</i>	
F. A. Clancy.....	Baryties
Stella Cummings.....	Baryties
L. L. Welsh.....	Baryties
John Degonia.....	Baryties
John C. Boyer.....	Blackwell
Thomas Madden.....	Blackwell
A. D. Polittle.....	Blackwell
Washington Land & Mining Company.....	Bliss
Aubuchon Mining Company.....	Cadet
L. E. Cole & Company.....	Cadet
Paul C. Boyer.....	Cadet
William Gatlett.....	Cadet
Nulsen, Klein & Krause Mfg. Company.....	Cadet
M. E. Rhodes.....	Cadet
White and Brothers.....	Cadet
P. H. Higginbotham.....	Fertile
E. A. Stocking & Son.....	Fletcher
C. C. Carlyon.....	Hopewell
Connoly and Thurman.....	Tiff
H. P. Lombard.....	Hopewell
Lenkart, Mixon & Shields.....	Hopewell
Mrs. Fannie L. Ahern.....	Mineral Point
Mrs. Agnes N. Boas.....	Mineral Point
Earl Chamberlain.....	Mineral Point
Clarence Dale.....	Mineral Point
C. G. Johnson.....	Mineral Point
Missouri Lincoln Trust Company.....	Mineral Point and Potosi
George B. H. Moore.....	Mineral Point
Joe Patashneiek.....	Mineral Point
Point Milling & Manufacturing Company.....	Mineral Point
J. E. Short.....	Mineral Point
John Wallace.....	Mineral Point
Henry Walton.....	Mineral Point
Mrs. M. J. Waugh.....	Mineral Point
E. P. Wells & Company.....	Mineral Point
Andrew White.....	Mineral Point
Ben White.....	Mineral Point
C. C. Rose & H. O. Hollow.....	Near Sullivan
Patrick Murphy.....	Old Mines
Bugg, Eversole & Towl.....	Potosi
A. H. Carr.....	Potosi
M. W. O'Hanlon.....	Potosi
A. Recar.....	Potosi
Mrs. S. L. Coleman.....	Racola
John H. Anderson.....	Richwoods
J. P. Rose.....	Richwoods
Samuel Boyer.....	Tiff
Bust Brothers.....	Tiff

PRODUCERS OF CRUDE BARYTES, 1916 AND 1917—Continued.

Producer.	Location of Mine.
<i>Washington County</i>	
U. S. Barytes Company.....	Tiff
J. D. Declue.....	Richwoods
Steve Kelso.....	Richwoods
John O. Long.....	Cadet
Johnson Brothers.....	Cadet
Casey & Bellew.....	

CEMENT.

The years 1916 and 1917 proved a busy period for the cement industry. The value of the production in Missouri in 1916 increased \$2,325,888 as compared with 1915, while the output in 1917 was valued at \$1,914,440 more than that of 1916. The number of barrels in stock at the end of 1917 was 403,424 against 307,538 barrels in 1916 and 861,717 barrels in 1915.

The following tabulation shows the number of barrels manufactured and sold, the total value, and the price per barrel in 1915, 1916, and 1917:

	1915.	1916.	1917.
Manufactured.....	4,646,771	5,178,021	5,882,240
Sold.....	4,628,484	5,732,001	5,800,988
Value.....	\$4,007,679	\$6,333,567	\$8,248,007
Price per barrel.....	0.866	1.105	1.435

The military importance of Portland cement is fully discussed in Bulletin 666s of the publications of the United States Geological Survey. In addition to the suggestions embodied therein regarding the usefulness of concrete, attention should be called to the fact that, because under war conditions structural steel is expensive, difficult to obtain; and greatly needed in many branches of war work, every effort should be made to substitute reinforced concrete for structural steel, wherever possible. Many buildings could as well be erected with far less steel by the use of reinforced concrete.

Missouri is abundantly supplied with limestones and shales suitable for use in the manufacture of Portland cement. The

widespread distribution of these materials is indicated by the scattered location of the plants utilizing them in the manufacture of cement. The following is a list of the plants operating in Missouri:

Firm name.	County.	Town.
Cape Girardeau Portland Cement Co.....	Cape Girardeau	Cape Girardeau
Union Sand and Materials Co.....	Jackson	Sugar Creek
Atlas Portland Cement Co.....	Ralls	Ilasco
Continental Portland Cement Co.....	St. Louis	Continental
Union Sand and Materials Co.....	St. Louis	Prospect Hill

In addition to the producing plants listed above, the Mera-mec Portland Cement and Materials Company has a plant in process of erection at Sherman, St. Louis county.

CLAYS AND CLAY PRODUCTS.

CLAYS MINED AND SOLD.

The value of clays mined and sold has been steadily increasing since 1914, the sales in 1917 being the highest ever recorded. As usual, fire clay continues to constitute over 90 per cent of the total.

The following table shows the quantity and value of clays marketed during the past four years:

CLAY MINED AND SOLD, 1914-1917.

	1914.		1915.		1916.		1917.	
	Quantity (short tons)	Value.	Quantity (short tons)	Value.	Quantity (short tons)	Value.	Quantity (short tons)	Value.
Kaolin.....	313	\$2,217	(a)	(a)	(a)	(a)	*573	\$3,992
Fire Clay.....	203,755	432,786	303,432	\$604,777	434,540	\$938,149	491,674	1,306,721
**Miscellaneous.....	5,114	28,700	4,953	36,263	3,963	48,575	5,020	75,625
Totals.....	209,181	\$463,703	308,385	\$641,040	438,503	\$986,724	496,694	\$1,386,338

(a) Included in miscellaneous.

* Total production for state not reported.

**Under "Miscellaneous" in the above table are included stoneware clay, brick clay, and clay for miscellaneous uses.

Missouri possesses a large variety of clays suitable for a variety of uses. The widespread occurrence of excellent brick and tile clay is attested by the active operation of 86 plants distributed over 35 counties of the State. Although an extensive stoneware industry flourished at one time in Missouri only a small

amount of clay for this use is now being produced. Kaolin suitable for chinaware is known to occur in Cape Girardeau, Bollinger, Perry, Ste. Genevieve, Madison, Iron, Miller and Morgan counties. In former years, large shipments of kaolin were made from Cape Girardeau and Bollinger counties; in recent years, the only sales reported were from Miller and Morgan counties, though it is known that kaolin is being produced in Bollinger county. Pettis county has recently become a producer of a pure white plastic clay of exceptional value and used in glass pot manufacture. The deposits are located shortly west of Sedalia.

Missouri produces large quantities of both plastic and non-plastic fire clays. In 1917 the production of plastic fire clay was 254,865 tons, valued at \$436,441, and of non-plastic fire clay was 179,675 tons, valued at \$501,708. The production of plastic fire clay continues to be derived chiefly from the famous Cheltenham seam in St. Louis City and St. Louis county. Smaller quantities are mined in Audrain and Callaway counties.

Non-plastic (flint) fire clays occur in the east-central portion of the State and are abundant in parts of Warren, Montgomery, Callaway, Franklin, Gasconade, Osage, Miller, Morgan, Phelps, Maries and Crawford counties. Their manner of occurrence is unique. The deposits are not confined to a particular geologic horizon or period, occurring in (or on) rocks of the Pennsylvanian Ordovician, Silurian and Mississippian ages. They do not occur as stratified beds, but as massive deposits filled crater-like depressions in the sandstone or limestone, similar in general configuration to the numerous sink holes of the Ozark region. The basins occupied by the flint clay vary from 50 to 350 feet in diameter, and from 15 to 50 feet in depth. To date over 100 of these deposits have been opened.

The flint clays usually have a remarkably pure chemical composition. The name "flint" clay is very appropriate, as regards physical appearance as it has a compact, dense, comparatively hard structure and breaks with a sharp, conchoidal fracture that resembles flint. When ground and mixed with water it usually has no more plasticity than so much sand, and in consequence cannot be molded alone.

A noteworthy discovery has recently been made in a number of the deposits being operated south of Missouri river. The discovery consists of considerable quantities of clay very high in alumina (up to 75 per cent or more) occurring associated with

the flint clay. The high alumina content is apparently due to numerous grains of diasporite and the name "diasporite" (or "diasporite") clay is suggested for the material. (See page 17.)

High alumina clay of this character has been found in deposits near Hofflins in Crawford county, Owensville, Rosebud and Canaan in Gasconade county, and Belle in Maries county.

PRODUCERS OF CLAY IN MISSOURI, 1916-1917.

Operator.	Type of clay mined.	Location.
<i>Audrain County.</i>		
Farber Clay & Mining Company.....	Plastic fire clay, brick clay....	Farber
Wellsville Firebrick Company.....	Plastic fire clay.....	Wellsville
A. P. Green Fire Brick Company.....	Plastic fire clay.....	Mexico
Alfred Elliott.....	Plastic fire clay.....	Wellsville
Walsh Fire Clay Products Company....	Plastic fire clay.....	Vandalia
Laclede-Christy Clay Products Company	Plastic fire clay.....	Vandalia
<i>Bollinger County.</i>		
Fred F. Bausch.....	Kaolin.....	Lutesville
American China Clay Company.....	Kaolin.....	Lutesville
William Berry and Son.....	Kaolin.....	Lutesville
Sampson Plastic Board Co.....	Kaolin.....	Lutesville
<i>Boone County.</i>		
Columbia Brick Company.....	Plastic brick clay.....	Columbia
<i>Callaway County.</i>		
Fulton Fire Brick Company.....	Plastic fire clay.....	Fulton
A. P. Green Fire Brick Company.....	Flint fire clay.....	Fulton
<i>Crawford County.</i>		
W. S. Cox.....	Flint fire clay, diasporite clay...	Hofflins
Watkins Mining Company.....	Flint fire clay.....	Hofflins
<i>Franklin County.</i>		
Julius Burton.....	Plastic and flint fire clay.....	Gerald
Casper H. Meyer.....	Flint fire clay.....	Gerald
J. H. Stoltz.....	Flint fire clay.....	Leslie
Jonsen and Nolan.....	Flint fire clay.....	Leslie
<i>Gasconade County.</i>		
Hollingsworth Bros.....	Flint fire clay and diasporite clay	Canaan
A. E. Graves.....	Flint fire clay and diasporite clay	Canaan
Howard and Cahill.....	Flint fire clay and diasporite clay	Canaan
Watkins Mining Company.....	Flint fire clay.....	Canaan
G. J. Snider.....	Flint fire clay.....	Canaan
J. P. Connell.....	Flint fire clay, plastic fire clay.	Owensville
L. A. Haynes.....	Flint fire clay and diasporite clay	Canaan
Cox & Sassman.....	Flint fire clay.....	Canaan
	Plastic fire clay.....	Owensville
	Diasporite clay.....	Rosebud
Chas. Decker.....	Flint fire clay.....	Canaan
John A. Skornia.....	Flint fire clay, brick clay.....	Owensville
Baur and Watkins.....	Flint fire clay and diasporite clay	Rosebud
Toelke & Hiedel.....	Flint fire clay, plastic fire clay, diasporite clay.....	Rosebud
Perry Garrison.....	Flint fire clay.....	Rosebud
William Offman.....	Flint fire clay.....	Owensville
Campbell & Lichte.....	Plastic fire clay, flint fire clay.	Bland
John Wehmeyer.....	Flint fire clay.....	Rosebud
<i>Henry County.</i>		
James W. Edwards.....	Stoneware clay.....	Calhoun
<i>Howard County.</i>		
Fayette Brick and Tile Company.....	Plastic fire clay.....	Fayette
<i>Johnson County.</i>		
Knobnoster Brick & Tile Company.....	Brick and tile clay.....	Knobnoster

PRODUCERS OF CLAY IN MISSOURI, 1916-1917—Continued.

Operator.	Type of clay mined.	Location.
<i>Maries County.</i>		
B. E. Rhidenhour.....	Flint clay and diaspore clay..	Belle
Heck Brothers.....	Flint clay and diaspore clay...	Belle
Missouri Fire Brick Company.....	Flint fire clay.....	Belle
Campbell and Lickte.....	Flint fire clay.....	Bland
L. E. Wallace.....	Flint fire clay.....	Belle
Thomas D. Alinheuser.....	Flint fire clay.....	Belle
<i>Miller County.</i>		
C. P. Tellman.....	Kaolin, fire clay.....	Marys Home
J. E. Moy.....	Kaolin.....	
<i>Montgomery County.</i>		
Ammann Mining and Manufacturing Company.....	Flint fire clay and plastic fire clay.....	Jonesburg
George Long.....	Flint fire clay.....	Montgomery City
New Florence Fire Brick Co.....	Flint fire clay.....	New Florence
Hydraulic Pressed Brick Company.....	Flint fire clay.....	New Florence
Chicago Fire Brick Company.....	Flint fire clay.....	High Hill
Supreme Fire Clay Company.....	Flint fire clay.....	High Hill
<i>Morgan County.</i>		
G. H. Hubbard.....	Kaolin.....	Stover
Versailles Fire Brick & Clay Manufac- turing Company.....	Flint fire clay.....	Versailles
<i>Osage County.</i>		
Bruce Ridenhour.....	Flint fire clay, diaspore clay...	Belle
<i>Pettis County.</i>		
Mueller-Dutton Company.....	Plastic fire clay.....	Sedalia
<i>St. Louis County.</i>		
Missouri Fire Brick Company.....	Plastic fire clay.....	Cheltenham-St. Louis
Laclede Christy Clay Company.....	Plastic fire clay.....	Cheltenham-St. Louis
Frederick E. Bausch.....	Plastic fire clay.....	Clayton
G. W. Gittins Clay Products Company...	Plastic fire clay.....	Clayton
Evans & Howard Fire Brick Company...	Plastic fire clay.....	Clayton
G. J. Berresheim.....	Plastic fire clay.....	Clayton
Johnson Fire Clay Company.....	Plastic fire clay.....	Clayton
J. P. Connell.....	Plastic fire clay.....	Glencoe
Albert Siems.....	Plastic fire clay.....	Oak Hill
Walsh Fire Clay Products.....	Plastic fire clay.....	St. Louis
St. Louis Vitrified & Fire Brick Company	Plastic fire clay, flint fire clay.	St. Louis
<i>St. Louis City.</i>		
J. W. Gannett.....	Plastic fire clay.....	St. Louis
Granview Fire Clay Mines.....	Plastic fire clay.....	St. Louis
Highlands Fire Clay Company.....	Plastic fire clay.....	St. Louis
Parker-Russel Mining and Manufacturing Company.....	Plastic fire clay.....	St. Louis
Thomas & Schaffey.....	Plastic fire clay.....	St. Louis
<i>Warren County.</i>		
Aluminum Flake Company.....	Flint fire clay.....	Truesdale
James Kelley.....	Flint fire clay.....	Truesdale
A. G. Hummel.....	Flint fire clay.....	Truesdale

CLAY PRODUCTS.

The production of clay products in 1917 exceeded that for any previous year by a wide margin. The value of these products for the year exclusively of pottery amounted to \$10,328,374, as compared to \$7,634,559 for 1916. The value of the fire brick

production alone was approximately \$5,000,000, this industry constituting almost 50 per cent of the total. Second in value to the fire brick was the manufacture of sewer pipe, the output of which sold for \$1,620,569, and third the manufacture of common brick to the extent of \$951,324 worth. Vitrified brick, front brick, architectural terra cotta, hollow building tile, enameled brick, drain tile, and roofing tile, follow in order with large outputs.

The following table indicates the type and value of the clay products for the years 1916 and 1917:

VALUE OF CLAY PRODUCTS FOR 1916-1917.

Product.	1916.	1917.
Fire brick.....	\$3,006,841	\$4,977,590
Common brick.....	896,201	951,324
Sewer pipe.....	1,308,977	1,620,569
Front brick.....	481,406	484,524
Vitrified brick, all uses.....	(a)	493,114
Architectural terra cotta.....	(a)	(a)
Drain tile.....	197,150	211,845
Fancy and ornamental brick.....	(a)	(a)
Miscellaneous.....	2,026,992	1,155,545
Totals.....	\$7,634,559	\$10,328,374

(a) Concealed under "Miscellaneous" which includes terra cotta, vitrified brick, enameled brick, tile, other than drain tile, silica brick and stove lining. Tables do not include pottery products.

St. Louis City and county still maintain a dominating position as the chief center of the fire brick industry in the state and constitute one of the leading centers of this industry in the United States. The output of fire brick from 8 manufacturing companies in this center amounted to \$2,152,905 in 1917. The clay mined and quarried for this immense output comes from a single bed called the Cheltenham, which occurs in extensive deposits at the base of the Pennsylvanian strata. The clay varies from less than a foot to about 12 feet in thickness, and is locally pure enough for glass pots. Audrain county follows as a second important fire brick producer with large plants at Mexico, Wellsville and Vandalia, and Callaway county third with a large plant at Fulton. Morgan and Montgomery counties contain important plants at Versailles in the former and New Florence in the latter. All of these plants are supplied with fire clays of Pennsylvanian age.

Sewer pipe, the manufacture of which comes second in importance to fire brick, is made principally in three counties, St. Louis, Henry and Jackson. Only minor productions come from other counties, and as with fire brick, St. Louis is by far the most important producing center. Deepwater is the principal clay working center of Henry county, and Kansas City of Jackson county.

Common brick and drain tile plants are more generally scattered over the state, common brick being made in 27 counties, and drain tile in 17 counties. These products are manufactured from alluvial, loessial or residual surface clays which occur in great abundance over much of the state.

The remaining industries are centered largely in St. Louis though important paving brick plants are located at several points in northern Missouri.

POTTERY.

Pottery manufacture in Missouri has in recent years not been a large industry. The output for the past two years consists of a relatively small amount of red earthenware made in St. Louis, and a still smaller amount of yellow stoneware made at Dexter, Stoddard county. The decline of pottery manufacturing in Missouri has, however, not been due to a lack of suitable clays, as there is an abundance of raw material throughout almost the entire state.

Following is a list of the clay products plants in the state:

PRODUCERS OF CLAY PRODUCTS, 1916-1917.

Operator.	Name of product.	Location of works.
<i>Audrain County.</i>		
A. P. Green Fire Brick Company.....	Fire brick.....	Mexico
Western Stove Lining Company.....	Stove Lining.....	Mexico
Walsh Fire Clay Products Company.....	Fire Brick.....	Vandalia
Wellsville Fire Brick Company.....	Fire brick.....	Wellsville
<i>Barton County.</i>		
Liberal Impervious Brick Company.....	Front brick.....	Liberal
Frank Rist & Son.....	Drain tile.....	Lamar
Universal Brick & Tile Company.....	Common brick.....	Oskaloosa
<i>Bates County.</i>		
W. S. Dickey Clay Manufacturing Company.....	Drain tile; fireproofing.....	Rich Hill
<i>Boone County.</i>		
Edwards Brick Company.....	Common brick; front brick; tile; fireproofing and fire brick.....	Columbia
<i>Buchanan County.</i>		
Herman Brick Company.....	Common brick; fireproofing.....	St. Joseph
St. Joseph Pressed Brick Company.....	Common brick; fireproofing.....	St. Joseph

PRODUCERS OF CLAY PRODUCTS, 1916-1917—Continued.

Operator.	Name of product.	Location of works.
<i>Butler County.</i>		
Popular Bluff Brick and Tile Company..	Common brick.....	Popular Bluff
<i>Callaway County.</i>		
Fulton Fire Brick Company.....	Fire brick.....	Fulton
<i>Cape Girardeau County.</i>		
Cape Girardeau Press Brick Company...	Common brick.....	Cape Girardeau
Kasten & Schmuke Press Brick Com- pany.....	Common brick.....	Jackson
<i>Carroll County.</i>		
Benjamin B. Glover.....	Common brick.....	Bogard
L. A. Harding.....	Common brick; drain tile.....	Carrollton
<i>Chariton County.</i>		
Brunswick Brick & Tile Company.....	Common brick; drain tile; fire- proofing.....	Brunswick
<i>Cole County.</i>		
Dawson Brick Yard.....	Common brick.....	Jefferson City
<i>Cooper County.</i>		
Boonville Brick Company.....	Common brick.....	Boonville
Missouri Reformatory.....	Common brick.....	Boonville
<i>Franklin County.</i>		
Washington Dry Pressed Brick Works...	Common brick.....	Washington
<i>Gasconade County.</i>		
Korff Brothers Brick Manufacturing Company.....	Common brick.....	Rosebud
<i>Henry County.</i>		
W. S. Dickey Clay Manufacturing Com- pany.....	Drain tile; sewer pipe; fireproofing silica brick; miscellaneous.....	Deepwater Morgan
<i>Howard County.</i>		
Fayette Brick & Tile Company.....	Common brick; drain tile; fire- proofing.....	Fayette
<i>Howell County.</i>		
W. B. Brown Brick Company.....	Common brick.....	West Plains
<i>Jackson County.</i>		
Hydraulic Press Brick Company.....	Front brick.....	Diamond
Builders Brick and Manufacturing Com- pany.....	Common brick.....	Kansas City
W. S. Dickey Clay Manufacturing Com- pany.....	Sewer pipe; fireproofing; miscel- laneous.....	Kansas City
Doarn Realty Company.....	Common brick.....	Kansas City
Lyle Rock Company.....	Common brick.....	Kansas City
<i>Jefferson County.</i>		
Pittsburgh Plate Glass Company.....	Miscellaneous.....	Crystal City
Festus Pressed Brick Company.....	Common brick.....	Festus
<i>Johnson County.</i>		
Knobnoster Brick, Tile, Light and Power Company.....	Common brick; front brick; fire brick.....	Knobnoster
<i>Lafayette County.</i>		
Alma Brick & Tile Company.....	Common brick.....	Alma
William Niemann.....	Common brick; drain tile.....	Corder
Higginsville Brick and Tile Company...	Common brick; drain tile.....	Higginsville
Lexington Triumph Press Brick Com- pany.....	Common brick.....	Lexington
<i>Lincoln County.</i>		
Winfield Tile & Brick Factory.....	Drain tile.....	Winfield
<i>Livingston County.</i>		
Shale Hill Brick & Tile Company.....	Common brick; drain tile; fire- proofing.....	Utica
<i>Mercer County.</i>		
American Ballast Company.....	Gumbo ballast.....	Princeton
<i>Montgomery County.</i>		
New Florence Fire Brick Company.....	Fire brick.....	New Florence

PRODUCERS OF CLAY PRODUCTS, 1916-1917—Continued.

Operator.	Name of product.	Location of works.
<i>Morgan County.</i>		
Versailles Fire Brick & Clay Company..	Fire brick.....	Versailles
<i>Nodaway County.</i>		
Nichols and Barber.....	Common brick; drain tile.....	Burlington Junction
Frank and Frost.....	Drain tile.....	Maryville
<i>Perry County.</i>		
John C. Popp.....	Common brick.....	Perryville
John E. Unterreiner.....	Common brick.....	Uniontown
<i>Pike County.</i>		
Philip Schurfeld.....	Common brick; drain tile; tile...	Louisiana
<i>Randolph County.</i>		
Moberly Paving Brick Company.....	Common brick; vitrified brick or block, sold for paving and other uses.....	Moberly
<i>St. Louis County.</i>		
Alton Brick Company.....	Common brick; front brick.....	Clayburn
Evans & Howard Fire Brick Company...	Fire brick.....	Clayton
St. Louis County Pressed Brick Company.....	Common brick; front brick.....	Clayton
Continental Brick Company.....	Common brick.....	Continental
William H. Harmann.....	Common brick.....	Eden
St. Louis Vitrified & Fire Brick Company	Fire brick.....	Maryland Heights
Consumer Brick and Quarry Company..	Common brick.....	St. Louis
Enterprise Brick Works Company.....	Common brick.....	St. Louis
Excelsior Press Brick Company.....	Common brick.....	St. Louis
Jacob Maes.....	Common brick.....	St. Louis
Walsh Fire Clay Products Company...	Fire brick.....	St. Louis
Missouri Pressed Brick & Imp. Company	Common brick.....	St. Louis
Mutual Press Brick Company.....	Common brick.....	Shrewsbury
Edgar Press Brick Company.....	Silica brick.....	So. St. Louis
American Press Brick Company.....	Common brick.....	Wellston
Missouri Fire Brick Company.....	Fire brick.....	Cheltenham
Blackmer & Post Pipe Company.....	Sewer pipe; fire brick.....	St. Louis
College Hill Pressed Brick Company...	Common brick.....	St. Louis
Evans and Howard Fire Brick Company.	Fire brick; sewer pipe; drain tile	St. Louis
Hydraulic Press Brick Company.....	Common brick; vitrified brick sold for paving or other uses; fancy brick; front brick; wall tile.....	St. Louis
Laclede Christy Clay Products Company	Drain tile; sewer pipe; fireproofing fire brick.....	St. Louis
Mitchell Clay Manufacturing Company.	Roofing tile.....	St. Louis
Parker-Russell Mining and Manufacturing Company.....	Fireproofing; fire brick, silica brick; miscellaneous.....	St. Louis
Progress Press Brick and Machine Company.....	Common brick; front brick; fancy or ornamental brick.....	St. Louis
St. Louis Terra Cotta Company.....	Architectural terra cotta.....	St. Louis
H. H. Schweer Brick Company.....	Common brick.....	St. Louis
Superior Press Brick Company.....	Common brick; front brick; fancy or ornamental.....	St. Louis
Winkle Terra Cotta Company.....	Architectural terra cotta.....	St. Louis
<i>Saline County.</i>		
H. Krumsick.....	Common brick; drain tile.....	Shackelford
<i>Scott County.</i>		
Post Brothers Tile Company.....	Drain tile.....	Commerce
Illmo Pressed Brick Company.....	Common brick.....	Illmo
<i>Stoddard County.</i>		
Chesley Clements Construction and Brick Manufacturing Company.....	Common brick; fire brick.....	Bloomfield

PRODUCERS OF CLAY PRODUCTS, 1916-1917—Continued.

Operator.	Name of product.	Location of works.
Dickman Brick and Tile Company.....	Common brick; drain tile; sewer pipe; fire brick.....	Dexter
Hunterville Tile Company..... Vernon County.	Drain tile.....	Hunterville
Norman Clay Tile Company.....	Drain tile; fireproofing.....	Nevada
H. Pohl.....	Common brick.....	Nevada
Deerfield Tile Company.....	Drain tile.....	Deerfield

PRODUCERS OF POTTERY, 1916-1917.

Operator.	Name of product.	Location of Works.
<i>St. Louis County.</i>		
Western Pottery Company.....	Red earthenware.....	St. Louis
Missouri Pottery and Supply Company.. Stoddard County.	Red earthenware.....	St. Louis
Evans Pottery Company.....	Stoneware.....	Dexter

COAL.

According to the figures of the United States Geological Survey in 1917 Missouri produced 5,670,459 tons of coal, valued at \$13,755,864. This is by far the largest production ever recorded for the state, and it exceeds the previous high value of 1916 by over \$4,500,000. The price per ton at the mines was also the highest recorded, ranging from \$2.00 in Boone, Chariton and Bates counties, to \$3.75 in Harrison, Grundy and Morgan counties. Throughout the state it averaged \$2.73.

This banner production came from 29 counties, one of which produced over a million tons, 6 over five hundred thousand tons and 10 over one hundred thousand tons. All of the principal coal producing counties showed a substantial increase in tonnage over 1916, this increase coming chiefly from greater production in the working mines and reopened old mines rather than from new mines. Barton county showed a notable increase, maintaining its lead as the first coal producing county and establishing the record for the first time of an annual production of over one million tons of coal for any county in the state. A very considerable part of the coal mined in this county comes from several limited areas where the coal is obtained by stripping. Giant steam shovels have enabled the profitable removal of as much as 40 feet of overburden to reach a bed of coal 2 to 3 feet in

thickness. The total stripping territory, however, is comparatively small and some of the individual areas are already exhausted. A decline in Barton county's coal production is naturally to be expected as the stripping fields are worked out though the county may continue to be the leading coal producer in the state for some time to come.

The chief production of the coal in Missouri comes from 8 beds. As in former years the largest tonnage for 1917 came from the Bevier bed, mined chiefly in Macon, Adair, Randolph, and Platte counties. The thickness of this bed varies from only about 22 inches in Platte county to from 3 to 5 feet in Macon county. This bed produces a little less than $\frac{1}{2}$ of the coal mined in the state. Second to the Bevier is the Lexington bed coal which is mined extensively in Lafayette and Ray counties. This bed is less than 30 inches in average thickness, but from it is produced about one-third of the coal mined in the state. The Lower-Weir-Pittsburg bed which is of third importance from the tonnage produced in the state, is mined chiefly in Barton county, though some coal is produced from this bed in Vernon county. This bed in Missouri varies from 24 to 36 inches thick and is mined very largely by stripping. Following these first three beds of importance come the Tebo, mined in Henry, Linn, and Grundy counties, the Mulberry, mined in Bates county, the Cainesville, mined in Harrison county and the Mulky, mined in Audrain and Ralls county. An important production is supplied from several other beds of meagre thickness and limited extent, from patches having considerable thickness and from pockets.

Cannel coal has been mined during the past two years in Cooper, Moniteau, Morgan, Callaway, and Cole counties. The production has been relatively small and has been used principally in the vicinity of the mines for domestic purposes. Some cannel coal, however, has been shipped from Morgan county.

The cannel coals of Missouri occur in pockets and are in all cases of limited lateral dimensions. It has been estimated that some pockets might contain as much as 500,000 tons of coal but that most of them contain considerably less than 100,000 tons. There are very few of these pockets which warrant the expenditures of very large sums of money in their development. Interest is still being maintained in these deposits because of the belief that valuable by-products might be obtained from the distillation of coal. It is true that cannel coal gives upon distillation a large amount of oil, tests made upon Missouri coals, show all the

way from 30 to 65 gallons to a ton of coal. It is also true that the oil might yield some valuable by-products but the primary consideration in erecting large plants to make these by-products is the source of supply. Most of the deposits are so small and scattered, and they would require such considerable expenditures in development that investigators have been extremely skeptical concerning projects based upon them as a source of supply.

The following tabulation illustrates the comparative tonnage of coal produced in Missouri during the past 4 years:

COAL PRODUCED IN MISSOURI.

County.	1914.	1915.	1916.	1917.
		(Net tons)		
Adair.....	256,397	280,187	436,413	693,084
Audrain.....	110,360	13,803	6,985	11,735
Barton.....	505,282	657,069	935,624	1,056,291
Bates.....	145,031	71,312	83,534	89,832
Boone.....	12,514	17,450	18,556	16,410
Callaway.....	39,555	64,136	61,814	60,881
Henry.....	224,894	183,311	171,933	110,557
Lafayette.....	703,029	799,297	907,116	961,739
Linn.....	108,626	97,242	108,338	128,512
Macon.....	765,365	666,245	795,631	924,667
Putnam.....	10,367	.....	8,519	21,651
Randolph.....	424,245	379,262	368,363	598,245
Ray.....	324,080	205,184	412,975	516,285
Vernon.....	43,165	75,377	81,844	.....
*Other counties.....	363,070	201,718	344,301	480,660
	3,935,980	3,811,593	4,742,146	5,670,549

*Includes Clay, Dade, Johnson, Platte, Ralls, Grundy, Harrison, Sullivan, and (for 1917) Vernon.

LIST OF PRINCIPAL COAL PRODUCERS IN MISSOURI.

	General Office.	Locations of Mines.
<i>Adair County.</i>		
Arctic Coal & Mining Company.....	Novinger.....	Novinger.
Big Creek Coal Company.....	Kirksville.....	Kirksville
Commercial Coal Company.....	Novinger.....	Novinger
Kansas City Midland Coal & Mining Company..	Novinger.....	Novinger
Star Coal Company.....	Kirksville.....	Kirksville
Union Coal Company.....	Novinger.....	Novinger
<i>Audrain County.</i>		
Eagle Coal Company.....	Vandalia.....	Vandalia
Martinsburg Coal and Mining Company.....	Martinsburg.....	Martinsburg
Standard Fuel Company.....	Vandalia.....	Vandalia
<i>Barton County.</i>		
Barton Ridge Coal Company.....	Pittsburg, Kansas..	Liberal
Carney-Cherokee Coal Company.....	Mulberry.....	Mulberry
Cherokee, Girard Coal Company.....	Mindenmines.....	Mindenmines
Clemens Coal Company.....	.....	Mindenmines
Elsworth-Klaner Coal Company.....	Mindenmines.....	Mindenmines
Domestic Fuel Company.....	Ardath.....	Ardath
O. S. Hubert Coal Company.....	Mindenmines.....	Mindenmines
Liberal Coal and Mining Company.....	Liberal.....	Liberal
Minden Coal Company.....	Joplin.....	Mindenmines

LIST OF PRINCIPAL COAL PRODUCERS IN MISSOURI—Continued.

County	General Office.	Locations of Mines.
<i>Barton County.</i>		
Mulberry Coal Company.....	Mulberry.....	Mulberry
Pittsburg and Midway Coal Mining Company....	.....	Midway
<i>Bates County.</i>		
Bates Coal Mining and Mercantile Company.....	Butler.....	Rich Hill
Collard & Scholer.....	Sprague.....	Sprague
Eureka Coal M. and M. Company.....	.....	Panama
Frankenfield Coal Mining Company.....	Rich Hill.....	Foster
Harrold Coal and Mining Company.....	Hume.....	Foster
Hickory Hill Coal Company.....	.....	Foster
Heckmore Mining Company.....	Rich Hill.....	Rich Hill
Ideal Coal and Mining Company.....	Hume.....	Hume
Jones Coal Company.....	Rich Hill.....	Rich Hill
Perry-McMahon Coal Company.....	Kansas City.....	Panama
Ritchie Coal Company.....	Rich Hill.....	Rich Hill
Sunshine Coal Company.....	Rich Hill.....	Rich Hill
<i>Boone County.</i>		
Boone County Coal Company.....	Columbia.....	Columbia
Columbia Coal and Mining Company.....	Columbia.....	Columbia
Robinson Cook.....	Columbia.....	Columbia
Davis and Watson C. and M. Company.....	Columbia.....	Columbia
<i>Callaway County.</i>		
Callaway County Coal Company.....	.....	Carrington
Fulton Fire Brick Company.....	Fulton.....	Fulton
Henry Gohring.....	Fulton.....	Fulton
Simmons Coal Company.....	Fulton.....	Fulton
<i>Chariton County.</i>		
W. C. Barcus.....	Prairie Hill.....	Prairie Hill
W. T. Beall.....	Prairie Hill.....	Prairie Hill
A. P. Hess.....	Prairie Hill.....	Prairie Hill
<i>Clay County.</i>		
Missouri City Coal and Mining Company.....	Missouri City.....	Missouri City
<i>Dade County.</i>		
O. Hickman.....	Golden City.....	Golden City
W. A. and R. A. Stout.....	Lockwood.....	Lockwood
<i>Harrison County.</i>		
Cainesville Coal Company.....	Cainesville.....	Cainesville
Melbourne Coal Company.....	Melbourne.....	Melbourne
<i>Henry County.</i>		
Bowen Coal Company.....	Windsor.....	Bowen
Carroll Coal Company.....	.....	Lewis
Crescent Coal Company.....	Yates.....	Yates
James England Coal Company.....	Deepwater.....	Deepwater
Hurst Coal Company.....	Deepwater.....	Deepwater
Home Coal Company.....	Deepwater.....	Deepwater
Parks Coal Company.....	Calhoun.....	Calhoun
Reliance Coal Company.....	Clinton.....	Brownington
Vincent-Embree Coal Company.....	.....	Lewis
<i>Johnson County.</i>		
Chilhowee Coal and Coke Company.....	Kansas City.....	Chilhowee
McGuire Brothers.....	Montserrat.....	Montserrat
<i>Lafayette County.</i>		
Edward Aull Coal Company.....	Lexington.....	Lexington
Boedeker Coal Company.....	Higginsville.....	Higginsville
Bonanza Coal Company.....	Higginsville.....	Higginsville
Canterbury Coal Company.....	Higginsville.....	Higginsville
Diamond Coal Company.....	Corder.....	Corder
Farmers Fuel Company.....	Kansas City.....	Higginsville
Imperial Coal Company.....	.....	Corder
J. J. Greer & Son.....	Lexington.....	Lexington
Laning-Harris Coal and Grain Company.....	Wellington.....	Wellington
McGrew Coal Company.....	Lexington.....	Myrick
Joseph Perry & Son.....	Lexington.....	Myrick

LIST OF PRINCIPAL COAL PRODUCERS IN MISSOURI—Continued.

County	General Office.	Locations of Mines.
<i>Lafayette County.</i>		
Plattensburg Coal Company.....	Lexington.....	Lexington
Waverly Coal Company.....	Waverly.....	Waverly
Wegener, M. P.....	Higginsville.....	Higginsville
Western Coal and Mining Company.....	St. Louis.....	Myrick
<i>Linn County.</i>		
Barr, Chas.....	Brookfield.....	Brookfield
Bucklin Coal Company.....	Bucklin.....	Brookfield
Collins & Fornkoff.....	Bucklin.....	Brookfield
Landreth Coal Company.....	Marceline.....	Marceline
Linn County Coal Mining and Land Company.....	Brookfield.....	Brookfield
Schaefer, John.....	Brookfield.....	Brookfield
I. B. Wine.....	Brookfield.....	Brookfield
<i>Macon County.</i>		
Central Coal and Coke Company.....	Kansas City.....	Keota, Ardmore, Bevier, Macon
Home Coal Company.....	Macon.....	Macon
Jones, John H.....	Bevier.....	Bevier
Northwestern Coal and Mining Company.....	Kansas City.....	Bevier
Smith, George E.....	Macon.....	Macon
<i>Ralls County.</i>		
Clark Coal Company.....	Perry.....	Perry
Ralls County Coal Company.....	Perry.....	Perry
<i>Randolph County.</i>		
Bradley Coal Company.....	Huntsville.....	Huntsville
A. Carson & Son.....	Huntsville.....	Huntsville
Crescent Coal Company.....	Yates.....	Yates
Harvey, B. P.....	Moberly.....	Moberly
Johnson & Jackson.....	Clifton Hill.....	Clifton Hill
Jacksonville Coal Company.....	Jacksonville.....	Jacksonville
W. E. Mitchell Coal & Mining Company.....	Huntsville.....	Huntsville
Northern Central Coal Company.....	Higbee.....	Huntsville
North Star Coal Company.....		Higbee
Rogers Coal Mining Company.....	Moberly.....	Moberly
McKiernan, W. H.....	Moberly.....	Moberly
Smith-Mariott.....	Moberly.....	Moberly
Stuck, W. H.....	Huntsville.....	Huntsville
Walton Coal Company.....	Higbee.....	Higbee
Werentze, J. W.....	Huntsville.....	Huntsville
<i>Ray County.</i>		
Belt Line Coal and Mining Company.....	Camden.....	Camden
Blair, Hugh.....		Rayville
Crawford, Wilson Coal Company.....	Richmond.....	Richmond
Conrow & Williams.....	Richmond.....	Richmond
Fowler Coal and Mining Company.....	Richmond.....	Richmond
Hubbel-Hamilton Coal Company.....	Richmond.....	Richmond
Mercantile Coal and Mining Company.....	Richmond.....	Richmond
Orrick Coal Company.....	Orrick.....	Orrick
Pickering Coal Company.....	Richmond.....	Richmond, Camden, Swanick
Ray County Coal Company.....	Kansas City.....	Richmond
Riverside Coal and Mining Company.....	Camden.....	Camden
Vibbard Coal Company.....	Vibbard.....	Vibbard
W. O. Ward Coal Company.....	Richmond.....	Richmond
<i>Schuyler County.</i>		
Moore Brothers.....	Coatesville.....	Coatesville
Providence Coal Company.....		Coatesville
<i>Vernon County.</i>		
Perry-McMahon Coal Company.....	Panama.....	Panama

COBALT AND NICKEL.

The sulphides of cobalt and nickel occur associated with the sulphides of lead, iron, and copper in certain parts of the disseminated lead region of southeastern Missouri. The chief deposits of commercial value occur near Fredericktown, in the southern part of the region. In the Flat River district, to the northwestward of the Fredericktown area, cobalt and nickel sulphides are occasionally recovered as a middlings product on the tables of the lead mills and shipped to smelters for refining.

The ore bodies in the vicinity of Fredericktown occur in the lower part of the Bonnetterre dolomite and in the underlying LaMotte sandstone. The ore consists of a mixture of lead, copper, cobalt, nickel and iron sulphides. The sulphides other than that of lead, occur in greatest quantity in the lower part of the workings, next to and in the sandstone, especially near the granite and porphyry.

The quantity of cobalt and nickel sulphides varies considerably in the different workings. The mines have generally been operated for lead, and nickel and cobalt have been produced as by-products, except from the mines operated by the North American Lead Company.

At Mine LaMotte, cobalt and nickel have been produced in small quantities for many years, even prior to 1857. According to Mr. J. M. McNeill, the chief source of the nickel and cobalt was the dressed galena, which usually carried from 0.2 to 0.3 per cent of these metals. Next in importance was a middlings product of the concentrating plant which usually carried 20 to 23 per cent lead, 0.5 to 1.0 per cent of copper and 2.5 to 3.5 per cent of cobalt and nickel. A larger percentage of copper was accompanied by a correspondingly larger percentage of cobalt and nickel. Besides these products of the mill, a small quantity of true cobalt-nickel ore was produced. In recent years, developments in the deeper workings have disclosed the presence of extensive deposits of copper-cobalt-nickel ore.

The chief source of cobalt and nickel in Missouri has been the mine of the North American Lead Company, adjoining Fredericktown. From 1900 to 1906 this property was operated as a lead mine. In exploiting the property large quantities of copper, nickel and cobalt sulphides were found associated with the lead sulphide. In 1906, the Company erected a smelter and refining works for the recovery of the lead, copper, cobalt, and

nickel content of the ores. The original plant, with a daily capacity of 100 tons, consisted of one blast furnace, two mechanical roasters, two hand rabbling furnaces, and electrolytic refining plant. Owing to the complexity of the ore, serious difficulties were encountered in both milling and smelting operations. In 1907, the Company succeeded in producing 2,731 pounds of cobalt oxide. In 1909, 83,394 pounds of cobalt oxide, 328,403 pounds of nickel, 8,314 tons of nickel and cobalt concentrates, 600 tons of copper, and 1,353 tons of lead concentrates were produced. At this time the ore body being worked is reported to have been 12 feet thick and to have carried 10% copper, 4 per cent nickel and cobalt, and 4 per cent lead. The company's affairs later became so involved that the property was sold at a forced sale in 1910 and remained idle until 1915, when the property was taken over by the Missouri Cobalt Company.

In addition to the properties described above, those of the Hudson Valley Lead Company, Madison Lead and Land Company and the Jackson Revelle Company, are said to carry similar nickel deposits. The Revelle property is located 8 miles south of Fredericktown, while the other two are four miles from Fredericktown.

COPPER.

In nearly all the deep mines of the southeastern disseminated lead district of Missouri, copper occurs in the ore in small quantity, though irregularly. It is only near Fredericktown, that the copper, cobalt, and nickel content of the ore has been the object of mining, yet a concentrate of these metals has been recovered as a middling product at several plants in other parts of the district. In 1916, 2,878 tons of copper concentrates were shipped from the Federal, Mine LaMotte and St. Louis mines. From the concentrates shipped, 368,000 pounds of copper were recovered. The production in 1917 was 635,013 pounds of metallic copper, valued at \$99,649. The output in 1917 was derived almost entirely from the disseminated lead mines although small quantities of ore were raised from the Racola mine in Washington county. Development of copper prospects has been carried on through the past year by Mr. H. B. Kerruish near Sullivan, Crawford county, and by Mr. Julian Pickles near Morrelton, Franklin county.

No production was reported in 1917 from the Missouri Copper Mountain mine in Franklin county, or the Cornwall and Swansea mines in Ste. Genevieve county. The Swansell

mine in reported, however, to have been in operation in 1916. The Racola mine in Washington county has been developed to the point of making shipments.

Attempts to mine copper have been made in Missouri since 1837 and at different times copper furnaces have been operated in Shannon, Ste. Genevieve, Jefferson, Franklin, and Crawford counties, while a matte carrying in addition cobalt and nickel has been steadily produced at Mine LaMotte in Madison county.

The Ste. Genevieve copper mines have been worked intermittently for many years. The principal deposit occurs as a bedded chert breccia in the lower part of the Jefferson City dolomite. Copper, in the form mainly of malachite and chalcopyrite, forms the cement of the breccia, the bed varies in thickness from 18 inches to 3 feet. The Missouri Southern Railway passes within three miles of the mines.

In Shannon county, copper occurs at a number of points and efforts have been made since 1837 to develop a copper industry. The best known prospects are the Slater, Jerktail, Sutton and Casey. At the first of the three, malachite and chalcopyrite occurs as the cement of the basal conglomerate overlying the pre-Cambrian porphyry. At the Casey the ore occurs as an impregnation of a horizontal shale bed. The deposit at each of the four places is bedded and may easily be prospected by drilling.

Both the Ste. Genevieve and Shannon county copper properties have been described in detail by H. Foster Bain and E. O. Ulrich in Bulletin 267 of the publications of the U. S. Geological Survey.

The following is a list of properties from which copper has been shipped in former years.

Name.	County.	Location.	Shipping Point.
Missouri Copper Mountain Mining Company.....	Crawford.....	Sec. 24, T. 40, N., R. 2W...	Sullivan
Mine LaMotte.....	Madison.....	Mine LaMotte.....	Mine LaMotte
North American.....	Madison.....	Fredericktown.....	Fredericktown
Cornwall.....	Ste. Genevieve	Sec. 15, T. 37 N., R. 8E....	Zell
Swansea.....	Ste. Genevieve	Sec. 21, T. 27, N., R. 8E....	Zell
Slater.....	Shannon.....	Sec. 36, T. 29, N., R. 4W...	Eminence
Jerktail.....	Shannon.....	Sec. 5, T. 29, N., R. 3W....	Eminence

FELDSPAR.

For a number of years there has been no production of feldspar in the state. The three deposits worked in the past are all located in Ste. Genevieve county and consist of irregular veins of potash feldspar, in the granite rock. The mineral is of good quality and was used very satisfactorily in the manufacture of pottery.

IRON.

PRODUCTION OF IRON IN MISSOURI, 1905-1917.

Year.	Total tons produced. (long)	Value.	Hematite (Red ore).	Limonite (Brown ore)
1905.....	113,012	\$161,878	78,746	*34,266
1906.....	80,910	158,109	39,105	41,805
1907.....	*111,768	*226,286	42,527	69,241
1908.....	98,414	218,182	77,400	21,014
1909.....	89,954	210,853	67,391	22,563
1910.....	78,341	168,697	55,832	22,509
1911.....	72,810	153,716	57,201	8,124
1912.....	42,120	9,996	39,721	3,756
1913.....	37,134	83,628	33,709	5,645
1914.....	37,554	75,696	32,054	5,500
1915.....	40,290	99,853	35,145	5,145
1916.....	34,914	116,484	27,568	7,346
1917.....	38,776	134,906	26,866	12,042

*Includes very small production from Iowa.

The production of iron ore in 1917 increased somewhat over the previous year and 38,776 tons valued at \$134,906 were mined. Of this amount 26,866 tons was hematite ore and 18,042 tons brown limonite ore, the average price per ton of each being \$3.98 and \$2.77, respectively. Some of the best quality of hematite especially that from Iron Mountain commanded a price much higher than the average. In 1916 a total of 34,914 long tons of ore was mined, having a value of 116,484 of which

27,568 tons was hematite and 7,346 tons brown limonite. The hematite ore mined during the two years came almost entirely from the Grover, Cherry Valley and Walker mines in Crawford county, the Hawkins and Kerr mines in Dent county, the Winkler mine in Phelps county, Iron Mountain in St. Francois county, and the Beulah mine in Franklin county. Except for the Iron Mountain production all of the hematite came from the filled sink deposits and a very large part of it from Cherry Valley. The brown ore came chiefly from the Carson and West Plains mining company's mines in Howell county, the Puxico mine in Stoddard county and other southern Missouri deposits of similar character. A small amount of brown ore was also produced in Dade and Iron counties.

There are now in Missouri three furnaces in operation; those of the Sligo Iron Works at Sligo, Dent county, the Mississippi Valley Iron Company at St. Louis, and the Mid-Continent Iron Company at Midco (near Fremont), Carter county. A fourth furnace at Brandsville, Howell county, is at present being erected by the Missouri Iron and Steel Corporation who expect to place the furnace in blast early in 1919. This furnace as well as the Mid-Continent Company's furnace will burn wood. The latter has installed a complete charcoal by-products plant. The Sligo Furnace has been continuously in operation for many years; the Mississippi Valley Iron Company's furnace was put in blast in 1916; and the Mid-Continent furnace late in 1918.

Due to the additional new furnaces and a somewhat better price for ore there is at present a stimulation in the iron industry of the state not reflected in the 1917 statistics. Pilot Knob is again being worked. Old sink deposits are being reopened and worked in Dent, Phelps, Crawford, and Franklin counties, and the new mine of the Beulah Mining Company, near Stanton, Franklin county, has become an important producer. This mine is practically the only undeveloped deposit of the filled sink type which has been opened in recent years and the deposit is reported to comprise an excellent body of ore. The effect of the new furnaces at Fremont and Brandsville will naturally be most pronounced in the brown ore districts of Howell, Ozark, Carter, Shannon, Reynolds, Wayne, and other adjacent south-east Missouri counties. Though a very large number of brown ore deposits occur in these counties mining in recent years has been almost restricted to the Carson and West Plains Mining Company's mine in Howell county and the Puxico mine in Stoddard, the latter being reopened in 1916. One of the greatest

drawbacks of this entire district in recent years has been the lack of more local furnace facilities and the stimulation which these bring to the industry so it is believed that a very greatly increased production of brown ore will follow the placing in blast of these two new furnaces.

Following are the list of producers of iron ore of 1916-1917:

Operator.	Name of Mine.	Kind of Ore.
<i>Carter County.</i>		
James J. Holland.....	Holland.....	Secondary limonite
<i>Crawford County.</i>		
Sligo Furnace Co.....	Cherry Valley...	Red and specular hematite
Sligo Furnace Co.....	Walker.....	Red and specular hematite
<i>Dade County.</i>		
W. C. Gettys.....	Gettys Bank...	Primary limonite
<i>Dent County.</i>		
Sligo Furnace Co.....	Grover.....	Red and specular hematite
John O. Greene.....	Hawkins.....	Red and specular hematite
Murray & Elayer.....	Kerr.....	Red and specular hematite
<i>Franklin County.</i>		
Beulah Mining Co.....	Stanton.....	Red and specular hematite
<i>Greene County.</i>		
R. E. Mansfield.....	.....	Primary limonite
<i>Howell County.</i>		
Kingsbury Mining Co.....	Carson.....	Secondary limonite
West Plains Mining Company.....	West Plains.....	Secondary limonite
<i>Iron County.</i>		
F. P. Wherry.....	Baird.....	Specular hematite
Big Muddy Coal and Iron Company.....	Pilot Knob.....	Specular hematite
<i>Phelps County.</i>		
L. L. Sankey.....	Winkler.....	Red and specular hematite
<i>Shannon County.</i>		
Mid-Continent Iron Company.....	No. 32.....	Secondary limonite
<i>St. Francois County.</i>		
Iron Mountain Mining and Smelting Company.....	Iron Mountain..	Specular Hematite
<i>Stoddard County.</i>		
Mississippi Valley Iron Company.....	Puxico.....	Primary limonite
<i>Wayne County.</i>		
Otto Grootzinger.....	H. K.....	Secondary limonite

*LEAD.

The value of the lead concentrates produced in Missouri during 1916-1917 was more than double the value of the production during any previous biennial period. The value of the concentrates produced in 1916 exceeded the value of the 1915 production by nearly \$10,000,000 and in turn the output in 1917 exceeded in value the production for 1916 by approximately the same amount. The 1917 increase in value of approximately 40 per cent was due entirely to a sharp increase in the price of lead, the production of concentrates for that year being 2,356 tons less than in 1916.

*Statistics on lead collected by the U. S. Geological Survey.

The total quantity of lead concentrates produced in Missouri in 1916 was 347,869 short tons, valued at \$24,172,965, as compared to an output of 312,567 tons, valued at \$14,579,361 in 1915. Of the production in 1916 of lead concentrates 307,025 tons, valued at \$20,729,737, was derived from southeastern and central Missouri. The average metal content of the concentrates was 65.66 per cent, as compared with 66.5 per cent in 1915. Shipments of lead concentrates from southwestern Missouri in 1916 were 40,844 tons, valued at \$3,452,228 as compared with 34,463 tons valued at \$1,805,782 in 1915. The lead carbonate concentrates amounted to 27 tons, valued at \$1,660, a decrease of 188 tons.

The total lead concentrates produced in 1917 was 345,513 tons, valued at \$34,038,976, 2,356 tons less than in 1916. The mines operating in the disseminated lead region of southeastern Missouri produced 306,071 tons, containing an average of 66.7 per cent lead, an increase of 1.04 per cent. This production was about 400 tons less than in 1916, but the value increased about \$9,300,000. The Joplin region reported the sale of 38,646 tons of galena concentrates and 394 tons carbonate in 1917, or about 1,800 tons less than in 1916.

The recoverable lead in southeastern and central Missouri concentrates in 1916 amounted to 201,632 tons, an increase of 17,726 tons. The output was equal to about 34 per cent of the primary lead smelted from domestic ores in the United States during the year. The quantity of recoverable lead from southwestern Missouri was 31,456 tons, valued at \$4,340,928, an increase of 4,922 tons. The average metal content of the galena concentrates was 77 per cent and the average price per ton was \$84.54, or \$32.02 more per ton than in 1915.

The quantity of recoverable lead in southeastern and central Missouri concentrates in 1917 amounted to 204,545 tons, valued at \$35,181,740, an increase of 2,913 tons. The quantity of recoverable lead from southwestern Missouri concentrates was 29,611 tons, valued at \$5,093,092, a decrease of 1,845 tons from 1916.

The following tables show the tonnage and value of lead concentrates during 1916 and 1917:

*PRODUCTION OF LEAD IN MISSOURI IN 1916-1917

District	Lead concentrates, 1916.				Lead concentrates, 1917.			
	Galena.		Carbonate		Galena.		Carbonate.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value	Quantity (short tons).	Value	Quantity (short tons.)	Value.
Southwestern Missouri—								
Alba-Neck City.....	318	\$24,795			389	\$39,593		
Ash Grove-Everton.....	67	5,025			8	800		
Aurora.....	106	7,516	3	\$102	229	21,337	25	\$1,189
Carthage.....	72	6,006			93	9,996		
Cave Springs.....	412	32,717			209	22,450		
Diamond.....	2	180				9		
Duenweg-Porto Rico.....	6,538	532,995			6,010	602,569	354	28,129
Fairview-Pioneer.....					5	500		
Granby.....	308	19,488			540	47,611		
Joplin.....	5,949	492,383	2	97	7,072	704,389	7	387
McDonell-Stark City.....	51	4,600			5	400		
Oronogo.....	3,062	259,150			2,331	228,801		
Sarcozie-Reeds.....	1	64						
Sherwood-Thoms Sta.....	615	52,692			271	27,761		
Spring City-Beef Br.....	340	27,492	22	1,461	387	42,113	3	107
Springfield.....	272	20,086			172	19,579		
Spurgeon-Seneca.....	240	18,866			138	13,287	5	275
Webb City-Carterville-Prosperity.....	22,231	1,930,295			20,650	2,143,772		
Wentworth.....					10	1,100		
Zincite-Klondike.....	139	9,618			77	6,522		
Christian county.....	94	6,600			49	5,233		
Ozark, Howell, Wright and Taney counties.....					1	72		
Totals.....	40,817	\$3,450,568	27	\$1,660	38,646	\$3,937,894	394	\$30,087
Central and Southeastern Missouri.....	307,025	20,720,737			306,473	30,070,995		
State totals.....	347,842	\$24,171,305	27	\$1,660	345,119	\$34,008,889	394	\$30,087

*This and following tables prepared by U. S. Geological Survey.

METAL CONTENT OF MISSOURI LEAD CONCENTRATES IN 1916-1917.

District.	1916.		1917.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
<i>Southwestern Missouri.</i>				
Alba-Neck City.....	236	\$32,568	306	\$52,632
Ash Grove—Everton.....	52	7,176	6	1,032
Aurora.....	81	11,178	191	32,852
Carthage.....	57	7,866	74	12,728
Cave Springs.....	317	43,746	165	28,380
Diamond.....	1	138		
Duenweg—Porto Rico.....	5,015	692,070	4,779	821,988
Fairview—Pioneer.....			4	688
Granby.....	228	31,464	387	66,564
Joplin.....	4,566	630,108	5,402	929,144
McDonell—Stark City.....	41	5,658	4	688
Orongo.....	2,401	331,338	1,760	302,720
Sarcoxie—Reeds.....	1	138		
Sherwood—Thom's Sta.....	496	68,448	216	37,152
Spring City—Beef Br.....	278	38,364	309	53,148
Springfield.....	221	30,498	137	23,564
Spurgeon—Seneca.....	187	25,806	106	18,232
Webb City—Carterville—Prosperity	17,100	2,359,800	15,659	2,693,348
Wentworth.....			8	1,376
Zincite—Klondike.....	106	14,628	59	10,148
Christian County.....	72	9,936	38	6,536
Ozark, Wright, Howell and Taney Counties.....			1	172
	31,456	\$4,340,928	29,611	\$5,093,092
Central & Southeastern Missouri...	201,632	27,825,216	204,545	35,181,740
State total.....	233,088	\$32,166,144	234,156	\$40,274,832

TENOR OF CRUDE LEAD ORE AND CONCENTRATES IN SOUTHWESTERN MISSOURI IN 1916 AND 1917.

	1916.	1917.
<i>Soft ground.</i>		
Total crude ore..... Short tons.....	4,711,700	3,447,850
Total lead concentrate in crude ore..... Percent.....	0.28	0.33
Lead content of crude ore..... Percent.....	0.22	0.25
Average lead content of galena concentrates..... Percent.....	78.0	76.1
Average lead content of carbonate concentrates..... Percent.....	55.5	62.2
<i>Average value per ton.</i>		
Galena concentrates.....	\$82.09	\$97.94
Carbonate concentrates.....	61.48	76.36
<i>Sheet ground.</i>		
Total crude ore..... Short tons.....	8,484,700	7,688,250
Total lead concentrates in crude ore..... Percent.....	0.33	0.36
Metal (lead) content of crude ore..... Percent.....	0.25	0.28
Average lead content of galena concentrates..... Percent.....	76.5	75.9
Average value per ton of galena concentrates.....	\$85.62	\$103.51

TENOR OF CRUDE LEAD ORE AND CONCENTRATES IN SOUTHEASTERN MISSOURI IN 1916 AND 1917.

		1916.	1917.
Total crude lead ore.....	Short tons.....	5,467,500	5,887,900
Galena concentrates in crude ore.....	Percent.....	5.60	5.03
Lead content in crude ore.....	Percent.....	3.68	3.47
Average lead content of galena concentrates.....	Percent.....	65.66	66.70
Average value per ton of galena concentrates.....		\$67.47	\$98.01

The increased market price of lead in 1916 and 1917 was an incentive for increased prospecting and mining activity in the old lead producing region of central Missouri. In the north-central district an increased interest was manifested in the shallow diggings. In Franklin county the old Northcumberland Mine was reopened and shipments are reported to have been made. Two or three other old mines in the Franklin county district were reported to be in the process of reopening in 1917.

LIME.

The production of lime has shown a marked increase during the past two years. The total output in 1916 was 199,260 tons, valued at \$956,300, an increase in value of \$382,858 compared with 1915. The production in 1917 was 234,936 tons, valued at \$1,519,266, an increase in value of \$562,966 over 1916.

The following table shows the output, value and disposition of lime burned during the past four years.

Disposal.	1916.		1917.	
	Quantity tons.	Value.	Quantity tons.	Value.
Building.....	55,846	\$289,415	59,986	\$388,147
Chemical works.....	16,050	82,874	68,051	402,101
Paper mills.....	8,897	37,336	14,576	77,381
Sugar factories.....	180	756		
Tanneries.....	5,279	23,927	6,085	31,996
Fertilizer.....	1,080	4,055	4,317	26,844
Dealers.....	67,028	329,172	63,537	498,634
Miscellaneous.....	44,900	188,765	18,382	94,163
Total.....	199,260	\$956,300	234,936	\$1,519,266
Hydrated.....	24,647	\$128,903	32,120	\$219,600

In 1916 Missouri ranked sixth among the states in the value of lime produced. The per capita consumption of lime was, however, only 0.02 ton. This low per capita consumption may be attributed to the fact that only about one-third of the State's population is concentrated in the larger cities, while the remaining two-thirds is scattered and in correspondingly less need of buildings that require lime in considerable quantities.

Missouri produces high calcium lime exclusively. The chief production is burned from stone obtained from the Burlington-Keokuk, Ste. Genevieve and Kimmswick formations. The Burlington-Keokuk and Ste. Genevieve burn to a pure white lime. The Kimmswick burns to a pure white lime, but slacks to a gray color, due to the presence of a small amount of manganese.

Of the 91 kilns in operation in 1916, 29 used coal, 32 used wood, 1 utilized producer gas, and 29 used wood and coal combined.

PRODUCERS OF LIME IN MISSOURI, 1916-1917.

Producers.	Location.
<i>Cape Girardeau County.</i>	
Cape Lime and Marble Company.....	Cape Girardeau
<i>Cooper County.</i>	
Lohse & Miller.....	Boonville
<i>Franklin County.</i>	
Henry Rohlfing.....	Gerald
Fred Riegel.....	Washington
<i>Greene County.</i>	
Ash Grove Lime & Portland Cement Company.....	Ash Grove and Gallaway*
Phenix Marble Company.....	Phenix
The Marble Head Lime Company.....	Springfield
<i>Jefferson County.</i>	
Glencoe Lime and Cement Company.....	Byers, Glen Park
<i>Lawrence County.</i>	
Peirce City Lime Company.....	Peirce City
<i>Marion County.</i>	
Hannibal Lime Company.....	Hannibal
<i>Miller County.</i>	
Spring Garden Marble Company.....	Near Eugene
<i>Osage County.</i>	
Anton Otto.....	Koeltztown
<i>Pike County.</i>	
Marble Head Lime Company.....	Louisiana
<i>Ralls County.</i>	
Star Lime Company.....	Oakwood
<i>St. Clair County.</i>	
Osceola White Lime Company.....	Osceola
<i>Ste. Genevieve County.</i>	
Arrow Head Manufacturing Company.....	Brickeys
*Peerless White Lime Company.....	Mosher
*Ste. Genevieve Lime and Quarry Company.....	Ste. Genevieve
Western Lime Works.....	Ste. Genevieve

PRODUCERS OF LIME IN MISSOURI, 1916-1917—Continued.

Producers.	Location.
<i>St. Louis County.</i>	
Arrow Head Manufacturing Company.....	St. Louis
*Glencoe Lime and Cement Company.....	Mincke, Glencoe
*Centaur Lime Company.....	Glencoe

*Produces also hydrated lime.

MANGANESE.

Missouri has not produced an important amount of manganese for many years, though one or two small shipments have recently been made from Shannon and Madison counties. The manganese deposits of the state are discussed on pages 15-17.

MINERAL PAINTS.

The value of mineral paints manufactured in Missouri has increased enormously during the past four years. The production of lead and zinc pigments alone in 1917 was 45,779 tons, valued at \$8,853,631 as contrasted to a total mineral paint production in 1914 valued at \$2,147,579.

Lead and zinc pigments constitute over 90 per cent of the total mineral paint production. The pigments produced are white lead, red lead, orange mineral, white and blue sublimed lead, litharge and lithophone. In addition to the lead and zinc products, considerable quantities of whiting and mineral primer are produced. The raw materials used in the manufacture of these products are derived chiefly from Missouri mines and quarries and are included in the figures covering the production of lead, zinc, barite and limestone. A small amount of the materials utilized is imported from other states.

In addition to the above, a pigment known as "formastat" is being produced from micaceous hematite mined six miles south of Doe Run, St. Francois county. By special treatment the product is given a gold, silver gray, or copper color.

MINERAL WATERS.

After attaining in 1916 the highest figure ever recorded, the value of mineral waters marketed suffered a severe slump in 1917. In the former year, \$109,814 was derived from the sale of mineral waters for medicinal and table uses, while in 1917 the sales totaled only \$57,175. The average price per gallon in

1916 was 8 cents, that in 1917 was about 13 cents. In addition to the sales recorded, a large amount of water was consumed by persons visiting many mineral springs in the State, from which water is not sold. It is impossible to obtain an estimate of the amount of water consumed in this way. Thirty-three springs were reported active during 1917.

The following table shows the value of mineral waters sold during the past four years.

VALUE OF MINERAL WATERS MARKETED, 1914-1917.

	1914.	1915.	1916.	1917.
Medicinal use.....	\$56,647	\$61,406	\$74,828	\$43,883
Table use.....	18,146	15,034	34,986	13,292
Total.....	\$74,793	\$76,440	\$109,814	\$57,175

"For more than a century Missouri's mineral waters have been exploited with profit to the citizens of the state. Prior to the year 1800 some of the saline springs were extensively used for the manufacture of salt and this industry thrived until about the year 1825. In 1823 the State of Missouri sunk a well 330 feet deep at Spalding, Ralls county, for the purpose of obtaining brine for the manufacture of salt. With the disappearance of this industry, however, attention was turned to the investigation of the medicinal properties of the many types of springs known to occur widely scattered over the State. The result has been a fluctuating industry, through which have risen a number of medicinal springs and medicinal spring resorts of wide reputation."

In addition to the numerous springs of mineral water, deep wells in many parts of the state have long been known for their yield of sulpho-saline waters. Water from the deep Belcher well in St. Louis has been sold for over 50 years and well waters of similar character at Louisiana, Hannibal and LaGrange have found their way to the market. Conditions favorable to securing water of this type by deep drilling obtain over a large part of the state.

The springs of Missouri from which waters are marketed at the present time may be classified under the following general heads:

- Chloride waters
- Carbonate waters
- Sulphate waters
- Sulphato-chloride waters.

Chloride waters.—The chief constituent of chloride waters is sodium chloride (salt). Minor constituents are chlorides, carbonates and sulphates of calcium and magnesium. The relative proportions of the various ingredients vary greatly in the

different springs. The most important springs and wells of this type in Missouri from which sales of water are reported comprise the following:

Name.	Town.	County.
Blue Lick Springs	Blue Lick.....	Saline
Belcher Artesian Well.....	St. Louis.....	St. Louis
Chouteau Springs.....	Near Boonville.....	Cooper
McAllister Springs.....	Houstonia.....	Saline
Excelsior Saline.....	Excelsior Springs.....	Clay
Salax Springs.....	Excelsior Springs.....	Clay
Sweet Springs.....	Sweet Springs.....	Saline

Carbonate waters.—The carbonates of sodium, calcium, magnesium and iron are the principal ingredients of the various carbonate waters. In some the carbonate of sodium predominates, in others the carbonates of calcium and magnesium constitute the principal mineral matter. In still others (chalybeate waters) the carbonate of iron, while not predominant, comprises a large percentage of the total solid content. No sales are reported from springs producing water in which sodium carbonate predominates. Gauged on the basis of water sold, the most important springs in Missouri in which the carbonates of calcium and magnesium are the principal constituents are the Cusenberry and Jackson Lithia springs at Mt. Washington, Jackson county. The most important chalybeate waters from the standpoint of wide usage and reputation are the Park Springs at Eldorado Springs, Cedar county, and the Siloam and Regent springs at Excelsior Springs, Clay county.

Sulphate waters.—The only springs of sulphate waters from which sales are reported are the B. B. and Fonzo at Bowling Green, Pike county. The chief mineral constituent is sulphate of magnesium, an analysis showing 475 grains per gallon. Calcium sulphate is present in the amount of 76 grains per gallon, and sodium sulphate 7 grains per gallon.

Sulphate-Chloride waters.—Waters of this type are marketed from the Sulpho-Saline and Salt Sulphur Wells at Excelsior Springs, Clay county. The principal constituents of the Excelsior Springs deep well waters is sodium chloride, with the sulphates of sodium, calcium and magnesium comprising a large percentage of the total mineral matter.

MINERAL SPRINGS REPORTING PRODUCTION IN 1916-1917.

Proprietor.	Name of spring.	Location.
<i>Carroll County.</i>		
Sam H. Minnis.....	Carrollton Mineral Well.....	Carrollton
<i>Cedar County.</i>		
E. M. Musick.....	Musick Mineral Well.....	Eldorado Springs
H. G. Bottom.....	Eldorado Spring water, Park Springs.....	Eldorado Springs
<i>Clay County.</i>		
Crystal Mineral Water Company..	Crystal Mineral.....	Excelsior Springs
Mrs. S. Callerman.....	Soda Saline Well.....	Excelsior Springs
Lithia No. 1 Water Company....	Lithia Number 1.....	Excelsior Springs
Excelsior Saline Water Company..	Excelsior Saline.....	Excelsior Springs
Natrona Soda Water Company...	Natrona Wells.....	Excelsior Springs
Arnold & Leonard.....	Peerless Wells.....	Excelsior Springs
Excelsior Springs Mineral Water and Bottling Company.....	Regent, Siloam, Sotarín, Sulfo-Saline.....	Excelsior Springs
Salax Water Company.....	Salax.....	Excelsior Springs
Salt-Sulfur Water Company.....	Salt-Sulfur Well.....	Excelsior Springs
<i>Cooper County.</i>		
E. A. Windsor.....	Chouteau Springs.....	Chouteau Springs
<i>Jackson County.</i>		
Cusenbary Mineral Water Company.....	Cusenbary.....	Mt. Washington
Jackson Lithia Spring Water Company.....	Jackson Lithia.....	Mt. Washington
Vaile Pure Water Company.....	Vaile.....	Independence
Independence Bottling Company..	White Spring.....	Independence
<i>Jefferson County.</i>		
Bokert Springs Mineral Water Company.....	Bokert Springs.....	Near DeSoto
<i>Lawrence County.</i>		
Paris Springs Bottling Company..	Chalybeate Springs.....	Paris Springs
<i>Lewis County.</i>		
LaGrange Prospecting Company..	LaGrange, Wyaconda.....	LaGrange
Silas Lake.....	Ponce De Leon Well.....	LaGrange
<i>Mercer County.</i>		
David Walker.....	Grand River Mineral.....	Mercer
J. S. Haymaker.....	Haymaker.....	Lineville
<i>Montgomery County.</i>		
G. W. Hendricks.....	Mineola.....	Mineola
<i>Nodaway County.</i>		
E. E. Corkin.....	Nek-Rok.....	Burlington Junction
<i>Pike County.</i>		
Bowling Green Mineral Springs Company.....	B. B. Fonzo, Kallanat, Ionian...	Bowling Green
Eagle Lodge.....	Eagle.....	Louisiana
Amos and Margaret Turner.....	Hornet.....	Bowling Green
B. Kubichk.....	Livertone.....	Bowling Green
<i>St. Louis County.</i>		
Belcher Water Bath and Hotel Company.....	Belcher Artesian Well.....	St. Louis City
P. F. Stepan.....	Old Orchard Mineral.....	Old Orchard
American Mineral Water Company.....	Windsor.....	Windsor Station
<i>Saline County.</i>		
F. W. York.....	Blue Lick Springs.....	Blue Lick
E. R. Blair.....	McAllister Springs.....	Near Houstonia
Missouri Mineral Water Company.....	Sweet Springs.....	Sweet Springs
<i>Sullivan County.</i>		
Milan Bottling Company.....	Milan Well.....	Milan

PETROLEUM AND NATURAL GAS.

PETROLEUM.

Although interest in the oil possibilities of Missouri during the past two years reached a maximum and a large number of tests were drilled there has been practically no successful development. During 1916 and 1917 approximately 50 test wells for oil were sunk in western, northwestern and north central Missouri, and in the following summer of 1918 a number of new test wells were added. Cass county leads with the largest number of tests drilled during this time; Jackson county follows with less than half as many. Several tests were sunk in each of Platte, Vernon Clay, Carroll, and Bates counties, and one or more holes sunk in Daviess, Livingston, Linn, Clinton, Putnam, and Howard. Of the total number drilled about 15 encountered showings of oil; these wells being located in Clay, Jackson, Cass, Bates and Vernon counties. None of these wells give promise of any substantial production, although it is claimed for several sunk in western Jackson county that two or three barrels of oil a day might be obtained.

The only production reported during the past two years came from wells previously drilled and was in the nature of small local sales at the well. The oil is used chiefly as a lubricant and for greasing farm implements.

Up to the present time important showings of oil in Missouri have been entirely restricted to the Pennsylvanian rocks and have been found in wells sunk in Clay, Jackson, Cass, Bates, Vernon, and Johnson counties. Less important showings have been found in Platte, Ray and Carroll counties. The oil has in all cases been encountered at relatively shallow depths ranging from less than 100 up to 525 feet. The oil bearing sands occur in the Cherokee shale, the Labette shale of the Henrietta formation, and the Pleasanton shale. The most promising sands have been found in the upper half of the Cherokee shale and in the lower part of the Pleasanton shale.

Brief mention is made in the following paragraphs of the situation to date in the few counties where previous drilling has revealed the presence of significant quantities of oil.

Clay County.—The most significant find of oil in this county at the present time is in the well owned by J. M. Evans, located in the hills just north of North Kansas City (Sw. $\frac{1}{2}$, Sec. 2,

Twp. 50 No., R. 33 W.). The well was drilled in 1908 to a depth of 324 feet. It started in the Winterset limestone and at the base penetrated 7 feet of oil bearing sand, which lies near the top of the Cherokee shale. It is reported that the pumping test showed a yield of about $2\frac{1}{2}$ barrels a day, though the well has never been pumped regularly for any length of time. Another well sunk close by is said to have been practically a duplicate of the Evans well, but a number of other wells sunk in southwest Clay county have shown no encouraging results. Mere showings of oil have been reported in wells at Smithville, Holt, and at a point 6 miles west of Kearney.

Jackson County.—Oil has been found in a number of wells in the western one-third of Jackson county. The wells are scattered all the way from Missouri river south to the county line. But the most important group so far drilled is located on the old Mastin Ranch in the west one-half, Sec. 36, Twp. 47N., R. 33W. Here, about 1909 eight wells were sunk to depths ranging from 350 to 500 feet, the wells starting about the base of the Chanute shale and finishing in the Cherokee shale. Between 350 and 400 feet, in the Cherokee shale about six feet of oil sand was encountered in all of the wells. At first several of the wells produced about three barrels per day each, but in 1909 five of the wells were put on the pump, each well yielding about two barrels a day. The production was a high grade lubricating oil which sold in 1912 for \$3.00 a barrel. The old Mastin Ranch wells have not been pumped for a number of years.

At a number of places in Kansas City wells have encountered oil at depths of 150 feet to 350 feet, chiefly in sands lying near the base of the Pleasanton shale. None of these wells have produced much oil individually. During the summer of 1917, a well sunk near the corner of 15th and Kensington penetrated 16 feet of oil sand lying practically at the base of the Pleasanton shale, at a depth of 205 feet. The well promised a small production of oil of good quality and is typical of a number of other wells drilled in the city.

In the vicinity of Martin City wells have encountered oil at depths of 250 to 450 feet, but none has been produced. Recently reports have been received that shortly northwest of Martin City several wells have encountered oil at comparatively shallow depths with some promise of a small production. The number of localities in the west third of Jackson county where showings or small quantities of oil have been found in wells,

are too numerous for individual mention. In most of the cases, however, the showings were too meagre to deserve any special recognition and there have been no other groups drilled comparably to the Mastin group.

Cass County.—Showings and small quantities of oil have been found at widely scattered localities in Cass county, but the only notable production has come from wells near Belton in the northwest corner. Near Belton a number of wells have found oil at depths of 250 to 450 feet, principally in sands contained in Cherokee shale. Notable among these wells have been the Rozier well, NE. $\frac{1}{4}$ Sec. 1, T. 46 N., R. 33 W., and the Goodbar well, in Sec. 2, T. 46 N., R. 33 W. From these wells in the past small quantities of oil were sold locally, though both wells have been idle for a number of years. The actual production of each well was very small. In 1917 several shallow wells were drilled about 6 miles northwest of Garden City, in the SW. $\frac{1}{4}$, Sec. 16, Twp. 44 N., R. 29 W. In one of the wells at the shallow depth of 97 feet and apparently in the Pleasanton shale a small quantity of oil was encountered. The oil was of surprisingly good quality, but the quantity entirely too small to be encouraging. Near East Lynn small showings of oil were obtained in shallow wells recently drilled and a number of wells near Harrisonville, Archie and Peculiar have found traces of oil at depths of less than 100 to about 300 feet, chiefly in the Pleasanton and Cherokee shale.

Bates County.—Commercial production of oil was reported in Bates county as early as 1886, but the production was extremely meagre and came from a single well near Merwin at which the oil was found at a depth of 220 feet in the upper part of the Cherokee shale. In 1890 a number of holes were drilled near Adrian in which oil was found in most of the wells at depths between 30 and 100 feet. Neither the quantity nor quality of this oil was worthy of much consideration and no production was ever recorded. At a number of other localities in the county, but especially in the northwest corner showings of oil have been found at relatively shallow depths in the Pennsylvanian formations, but in no case has the quantity found been of much commercial importance.

Vernon County.—The surface and shallow showings of oil in Vernon county have long attracted attention because of their abundance at widely scattered points. Principally, however, these showings are in the northwest part of the county and groups of shallow wells near Richards and Stotesbury have

encountered oil in the Cherokee shale at depths of 125 feet to 175 feet. The Stotesbury group, located just southeast of the town in Secs. 27, 28, T. 37N., R. 33W., was sunk in 1901, the wells encountering a little less than 30 feet of oil bearing sandstone at a depth of about 140 feet. No reliable test as to the production of these wells is available and only one of the group has been kept in repair. From this well oil is obtained by hand pump and sold locally. The wells near Richards were said to be of similar character to those near Stotesbury and the presence of this shallow oil bearing sand seems to be persistent over the northwest part of the county. Sandstones saturated with bitumen outcrop in many parts of the county especially the southeast part near Sheldon, and shallow dug wells sunk into these sands may partially fill with oil, or contain oil scums floating on the water. The county has no oil production though it has been thought by many that groups of shallow wells reaching the productive sandstone underlying the northwest part of the county might in some localities be of commercial importance.

Johnson County.—There has been considerable drilling for oil in the west part of this county around Holden and Kingsville, and small quantities of oil have been reported in several wells at shallow depths. In one well drilled shortly south of Kingsville, Sec. 7, Twp. 45N., R. 28W., oil was found at a depth of 110 feet in a sandstone apparently in the lower part of the Pleasanton shale. This oil was of excellent quality and very similar to that found northeast of Garden City, Cass county, but it was not found in any quantity.

Aside from the counties mentioned there has up to the present time been practically no important oil showings in the state. There is, of course, considerable territory still unprospected in the area underlain by the Pennsylvanian rocks. Much of this area will have to be drilled with very little geologic aid in view of the heavy glacial drift covering in the north part of the state, which conceals the rock outcrops and makes structural mapping an impossibility. Such work as has been done indicates that these rocks have been subjected to folding and that structures favorable to drilling do exist, though the folding is characteristically gentle and the structures are not pronounced. In the light of all the evidence and geologic study which may be drawn on, it appears that the Pennsylvanian formations are the most favorable for prospecting.

NATURAL GAS.

During 1916 and 1917 production was reported from 53 and 47 gas wells, respectively, the value of the gas sold being \$17,584 for 1916 and \$8,230 for 1917 according to report. The production during the two years, however, was in reality approximately the same, the discrepancy being due chiefly to the failure of the largest producer to report for the latter year. The number of wells reporting production has been slowly decreasing during the past few years and it is evident that new wells are not being drilled in as fast as the old wells give out. The maximum number of wells which have ever reported production during a single year is 66 as compared to 47 wells during 1917, though there has always been a considerable number of wells which have never reported.

The productive gas wells are located in the same counties in which the best showings of oil have been found and in counties adjoining these. The southernmost wells from which gas is being obtained are located shortly south of Minden, Barton county, on the Stephenson farm. Here three shallow wells have encountered gas in the Cherokee shale and one of them is being used to supply local farm buildings. To the north in Vernon county, one and possibly two wells of very shallow depths and located in the northwest part of the county are in use on farms. Bates county has always reported the largest number of wells. The wells are practically all in the western half of the county from north of Merwin south to Hume and east to Adrian, Butler and Rich Hill. At the present time the gas is almost entirely used for lighting and heating on farms, though for a number of years previous to 1914 wells in the vicinity of Sprague and Rich Hill very largely supplied the latter town.

In Cass county, which ranks third in the number of producing wells, the production is more generally scattered, although as in Bates county, largely confined to the western half. A number of wells are located around Belton, Cleveland, West Line, and Drexel and a few wells are found near Peculiar, Harrisonville, Eight Mile, and Garden City. At the present time the wells are practically all used for supplying farm houses and single residences. In the past the gas wells around Belton very largely supplied the town, but at present only a few residences are being heated and lighted from them.

Jackson county is second in the number of producing wells, the wells being very largely located in the western tier of town-

ships and all located, so far as known, in the western one-third of the county. A number of the wells are in Kansas City where the gas is used both for domestic lighting and heating and for manufacturing. At Martin City, in the southwest part of the county a group of five wells has been drilled, the strongest of which is reported to have had an initial flow of 1,500,000 cubic feet of gas daily. This group of wells is used for lighting and heating in Martin City at the present time.

Probably the most important group of gas wells in the state at the present time are the five wells located about four miles northwest of Parkville, Platte county, which supply this town with illuminating and heating gas. These wells are 400 to 595 feet deep and penetrate a gas sand lying in the upper part of the Cherokee shale. The two best wells are reported to have had a flow of gas of 1,000,000 cubic feet a day. One or two wells sunk in the town of Parkville have also penetrated gas sands of promise.

There are no productive gas wells reported in Clay county at the present time and only one well is known to be in use in Clinton county. This well is located on the R. A. Stockton farm about 4 miles east of Lathrop and used for lighting and heating on the farm. The gas was encountered at depths of 246 and 300 feet, apparently in the Pleasanton shale. It is the northernmost productive gas well in west Missouri, though it is said that small quantities of gas have been found in shallow depths in the northeast part of Clinton county around Cameron. The group of wells at Holt, where gas was encountered at a depth of about 125 feet is no longer in use.

The productive gas wells mentioned above located from Barton county on the south to Clinton county on the north all obtain gas from the various formations in the Lower Pennsylvanian. The principal gas sands are contained in the Cherokee shale, with those in the Pleasanton shale of second importance. The gas is encountered at depths most commonly of between 150 and 350 feet, though a number of wells reached the sands at depths of between 350 and 550 feet and the deepest important gas horizon reported is at 620 feet. Reported pressures range all the way from a few pounds up to $187\frac{1}{2}$ pounds per square inch, and the volume of gas obtainable ranges from a few thousand cubic feet to the ordinary shallow well in use on farms to as high as 1,520,000 cu. ft. reported in the Knoche well at Martin City, Jackson county. Most of the wells are short lived because

of water creeping into the sand and drowning out the gas. Some of the strongest wells, however, have been in use for over 15 years.

Aside from the area mentioned above which constitutes the most important gas producing territory in the Missouri, gas has been found in McDonald county in the southwest corner of the state and in St. Louis county. In McDonald county some wells at and near Noel and Anderson have a capacity of several thousand cubic feet of gas per day. The gas is obtained from a black shale 25 to 45 feet thick which lies just below the base of the Mississippian formations and is of Devonian age. This shale, called the Noel, is reached at depths of from only a few feet to 275 feet, depending upon the topographic position of the well. There is accordingly a great discrepancy in the depths of the various wells. While a small amount of gas may be produced from a considerable number of wells reaching this shale it is believed that no large production can be expected. In St. Louis county, in the City of St. Louis, several wells have encountered strong gas pressure in the Trenton limestone. The gas has been encountered at depths of 550 to 750 feet and pressures as high as 250 pounds to the square inch have been obtained. The wells are located on small anticlines which do not promise any extended field or lasting production. In fact, the best of the gas wells drilled between 1900 and 1906 have already given out.

PYRITE.

The production of pyrite during 1917 was disappointing in view of the anticipated developments and additional tonnage expected. Only two companies reported shipments for the year, the Empire Carbon Works, operating the Old Hobo mine in Crawford county, south of Bourbon, and the Commercial Acid Company, operating a mine near Anaconda, Franklin county. The latter mine, now known as the Kelsey, was on fire for over 9 months during the year, thus curtailing production to a comparatively small tonnage. Both deposits are of the filled sink type, the "sulfur ore" occurring in the sinks below the cap of red hematite.

Very little interest was taken in pyrite or marcasite mining in Missouri previous to 1911, though the presence of the mineral was known in a number of the iron sinks, notably Cherry Valley No. 2, the Leslie Mine, the Scotia mine, and the Buckland mine. Previous to this time the market value of the ore was relatively

low, local markets were not abundant and mining interests in the districts where the mineral occurred were centered on the production of iron ore. It was considered, in fact, only a misfortune to find "sulfur ore" in the iron sinks and when encountered the fact was not widely advertised. Previous to 1911 the development of the fertilizer industry in the Middle West was not such that an immense amount of sulfuric acid was needed for it, and it was due chiefly to the development of this industry that Missouri pyrites came into demand. No record of the pyrite mined or shipped previous to 1911 is available and though it is known that some ore was removed at one and probably two of the iron sinks, the amount was very small.

In 1911 the Rock Island Mining Company, operating the Leslie Mine in Franklin county reported the sale of pyrite for the first time though possibly some ore had been shipped previously from this mine. During the latter part of this year the Missouri Pyrite Company started operations at Vineland, Jefferson county, but this project apparently did not meet with success. In 1912 the Rock Island Mining Company again reported pyrite production but in 1913 the company reported that no ore was mined. However, by 1913 the Rolla Mining Company had opened the old Buckland iron pit 4 miles west of Rolla, Phelps county, and reported a considerable production for the year. The ore was shipped to the Commercial Acid Company in East St. Louis, Illinois. During the same year small shipments of coal pyrite (coal brass) were made from the Standard Coal and Mining Company's mine in Audrain county. The Rolla Mining Company continued to operate the Buckland mine through most of 1914 and 1915 till the ore body was mined out and the mine permanently abandoned. They were the only company reporting production in 1914. In 1915 the Beulah Mining Company entered the field with production from the Kelsey mine near Anaconda, Franklin county, and were the largest producers for this year, as well as for 1916. In 1916, however, the Empire Carbon Works reported production from their Old Hobo mine south of Bourbon, Crawford county, and owing to the closing of the Kelsey mine on account of fire for most of 1917, became the leading producer of pyrite for the last year. The companies mentioned have produced the principal part of the "sulfur ore" mined in Missouri but not all of it. At intervals some ore has been shipped from the Cherry Valley mines in Crawford county at least one car from Cornwall, Madison county, and develop-

ment work has been undertaken in Jefferson, Wright, and Howell counties from which sample shipments have been reported.

In 1917 interest was attracted to Madison county on account of what appeared to be promising occurrences of pyrite near Cornwall. Several of the largest companies producing fertilizer and acid entered the field and undertook an extensive drilling campaign; one shaft being sunk. In this region the ore bodies are entirely different from those in Crawford, Phelps, Franklin and adjacent counties where they occur in the filled sinks. Here they are flat lying bodies close to the surface or at shallow depths in the dolomite. The ore, however, was found so mixed with the dolomite that a milling process for separation would be necessary and this none of the companies seemed to be willing to undertake. This field has therefore, been at least temporarily almost abandoned, though probably some further exploration is warranted. The large bodies of pyritic ore in the mines at Fredericktown offer a most important source of supply for acid. At present it is reported that the Missouri Cobalt Company is shipping some of their pyritic ore to the Commercial Acid Company in East St. Louis where the sulfur is roasted off and the clinker returned to the Company's smelter where the cobalt, nickel and copper are extracted.

The pyritic ore from Howell county occurs in association with the brown iron ores and is found in meager quantity in the Carson and Kingsbury mine and in greater quantity in the Morrison Mine, near West Plains. A carload of sample ore has been shipped from the Morrison Mine (Sec. 12, T. 23N., R. 8W), but this covers the production of the field to date. The ore is of excellent quality.

In Wright county, near Norwood, Mr. R. L. Mook has drilled what is reported to be a large deposit occurring in the Jefferson City dolomite. No shipments have yet been reported from this property and it is said that the ore which runs from 18 to 26 per cent sulfur must be milled before shipping.

SAND AND GRAVEL.

The sand and gravel production in 1917 amounted to 2,274,072 short tons, valued at \$1,101,745, while in 1916 there were 3,643,205 short tons, valued at only \$877,634. The discrepancy of 1,369,133 less tons produced in 1917 over 1916, but valued at \$224,111 more, is notable. Statistics do not record

any previous year when the average price per ton was as high as in 1917, though the tonnage produced in this year was the smallest in the past ten years. The only increase in volume of production in 1917 over 1916 was in building sand and paving sand. These, however, are by volume the two most important items of production.

The following table indicates the amount and value of the output for the two years.

	1916.		1917.	
	Quantity short tons	Value.	Quantity short tons.	Value.
Building sand.....	766,534	\$224,863	1,018,719	\$449,596
Glass sand.....	(a)	(a)	153,970	162,838
Paving sand.....	(a)	(a)	(a)	(a)
Moulding and core sand.....	161,788	61,972	90,811	58,608
Engine sand.....	35,865	11,836	21,170	9,289
Grinding and cutting sand.....	138,141	66,438	(a)	(a)
Fire and furnace sand.....	(a)	(a)	(a)	(a)
Miscellaneous.....	1,175,970	261,797	329,267	209,459
Gravel.....	1,364,970	250,728	660,135	211,995
Total.....	3,643,205	\$877,634	2,274,072	\$1,101,745

(a) Figures concealed under "Miscellaneous" because of limited number of producers.

GLASS SAND.

The glass sand industry is one in which Missouri holds a high rank among the several producing states. The sand used for glass making comes exclusively from the St. Peter sandstone. This formation outcrops almost continuously from southern Cape Girardeau county north to Missouri river at Labadie, Franklin county, and on the north side of the river from southern St. Charles county west to Callaway. Isolated outcrops of importance occur in Lincoln county and smaller patches are found in Boone, Cooper, Pettis, and adjacent counties. Throughout the belt the St. Peter sandstone proper averages not far from 80 feet in thickness. Owing to an unconformity at its base, there are sudden variations within short distances, but these are usually of small magnitude.

The St. Peter is a remarkably pure quartz sand. Seventeen unwashed samples selected from fresh exposures gave an average analysis of 99.14 per cent silica and only 0.078 per cent iron oxide. The white portions of the formation are eminently suited for the manufacture of plate glass, the stained portions

for the manufacture of plain glass. Besides its use in the manufacture of glass, sand derived from the St. Peter formation is used as a core and moulding sand in steel work.

The principal quarrying centers are at Festus, Crystal City and Silica in Jefferson county, at and near Pacific in Franklin county, and at Klondike in St. Charles county.

MOULDING SAND.

The requisites of a good foundry sand are cohesiveness, refractoriness, porosity and permeability, suitable texture, and durability. Although no comprehensive investigation of the various sandstone and sand deposits of the state has been made, it is known that sand suitable for moulding purposes occurs in commercial quantities at a number of widely scattered points. The largest production of moulding sand at the present time is derived from the St. Peter sandstone. Sand from this source is used extensively as a core and ordinary moulding sand in steel work. St. Peter sand for moulding purposes has been shipped from Pacific, Herculaneum, and Silica.

In the vicinity of Corondolet Station in south St. Louis there occurs a very fine-grained, argillaceous sand which has an extensive use locally as a moulding sand. The sand occurs at the base of the loess deposits. At other places in St. Louis City and vicinity, moulder's sand is derived from the loess proper. Loess occurs in wide belts in Missouri bordering the Missouri and Mississippi rivers and there is reason to presume that a thorough investigation of these deposits will result in the discovery of large quantities of sand suitable for moulding purposes.

In previous years, moulding sand has been produced in Benton, Buchanan, Callaway, Crawford, Franklin, Jackson, Jefferson, Nodaway, Phelps, St. Charles, St. Louis, Greene, Jasper and several other counties.

BUILDING SAND AND GRAVEL.

The principal source of the sand and gravel production for building purposes are the alluvial deposits of Mississippi and Missouri rivers with several important tributaries. Active sand pumping plants are located at Canton, Hannibal, Louisiana St. Louis, Crystal City, and Cape Girardeau, on the Mississippi and Jefferson City, St. Joseph, Kansas City, Lexington, Glasgow, Boonville, and St. Charles on the Missouri.

The Meramec, Osage, Black and Elk rivers, all Ozark streams, furnish an excellent grade of sand and gravel to dredging plants at Valley Park, Sherman, Drake, Pacific, Osage City, Poplar Bluff, Mills Springs, and Noel. Dredging plants are also successfully operated at Festus on Joachim creek, Newburg and Arlington on Piney creek and in north Missouri near New London, on Salt River, and at Maitland and Skidmore on Nodaway river. Many smaller plants are operated elsewhere in the state and a few bank deposits are worked at Commerce, Pacific, Maryville, and Guilford.

The Ozark region is the original source of an inexhaustible supply of both sand and gravel through the disintegration of its surface rocks. The Jefferson City, Gasconade, and Potosi dolomites, which are exposed over so large a part of this region, are all composed to a notable extent of chert. Upon weathering and erosion the more resistant chert beds remain to be strewn over the surface, broken up and eventually washed into the stream beds where the process of rounding the small fragments is carried on by water action. This ever increasing and wide spread supply is only exploited at the most favorable points. The Robidoux sandstone formation, probably the most extensively exposed of any in the Ozark region, disintegrates to form a large part of the alluvial sands obtained in the area.

North of Missouri river, the Mississippian limestones, where exposed, furnish chert gravels, in a similar manner to the Ozark limestones and over the glaciated plains, the drift deposits in places yield an abundance of mixed pebble gravels. The Pennsylvanian sandstones, as well as the drift, also contributes to the supply of sands.

OTHER SANDS.

Under this heading are included grinding and polishing sand, furnace sand, engine sand, filter sand, sand for railroad ballast, etc. The chief production of sand for grinding and polishing purposes is at present derived from deposits in Cooper, Grundy, Howard, Jackson, Jasper, and Jefferson counties. The only furnace sand marketed in 1916 and 1917 was derived from the St. Peter sandstone at Pacific. During the same period, engine sand was produced in Cooper, Jackson, Marion, and Phelps county. Sand for railroad ballast has been produced in a number of counties in the state. The only counties reporting production during the past biennial period were Atchison, Franklin, Jasper, Marion, Osage, Phelps, and Wayne counties.

Sands suitable for the above purposes occur widely scattered over the state and will continue to be the source of considerable incomes to the communities exploiting the deposits.

LIST OF SAND AND GRAVEL PRODUCERS, 1916-1917.

Operator	Name of product.	Location.
<i>Atchison County.</i>		
Marvin A. Holliway.....	Building sand, gravel.....	Rockport
Jas. W. Whitman.....	Building sand; railroad ballast; gravel.....	Rockport
<i>Buchanan County.</i>		
Buchanan Sand Supply Co.....	Building sand.....	St. Joseph
Pioneer Sand Co.....	Building sand.....	St. Joseph
<i>Butler County.</i>		
Randles Sand and Gravel Co.....	Building sand; gravel.....	Poplar Bluff
Henry Turner Co.....	Building sand; gravel.....	Poplar Bluff
<i>Callaway County.</i>		
B. P. Beamer.....	Building sand; gravel.....	Fulton
E. S. Dunlap.....	Paving sand; gravel.....	Fulton
<i>Cape Girardeau County.</i>		
Morrison Ice and Fuel Co.....	Building sand.....	Cape Girardeau
<i>Carroll County.</i>		
P. L. Trotter.....	Building sand.....	Carrollton
W. B. Parkins.....	Building sand.....	Carrollton
<i>Clark County.</i>		
C. S. Sherwood.....	Building sand; gravel.....	Kahoka
<i>Cole County.</i>		
Jefferson City Sand & Gravel Co.....	Building sand; gravel.....	Jefferson City
Osage River Gravel Co.....	Gravel.....	Osage City
<i>Cooper County.</i>		
Charles Donnivant.....	Building sand.....	Boonville
Mo. River Sand & Gravel Co.....	Building sand; engine sand; paving sand; gravel.....	Boonville
<i>Crawford County.</i>		
John Dunlap.....	Moulding sand.....	Steelville
<i>Dallas County.</i>		
Tomlinson and Gillihan.....	Building sand.....	Buffalo
<i>Franklin County.</i>		
Moselle Sand & Gravel Co.....	Railroad ballast.....	Moselle
J. W. Glaser.....	Moulding sand; furnace sand....	Pacific
Valley Park Realty Company.....	Glass sand; building sand.....	Pacific
Tavern Rock Sand Co.....	Moulding sand.....	Pacific
The St. Louis Material and Supply Company.....	Building sand; railroad ballast...	
<i>Grundy County.</i>		
Mrs. S. M. Collier.....	Building sand.....	Trenton
S. S. Day.....	Building sand.....	Trenton
Chas. Fleming.....	Building sand.....	Trenton
<i>Holt County.</i>		
Mattox & Younger.....	Building sand.....	Maitland
A. Roach.....	Building sand.....	Maitland
<i>Howard County.</i>		
Glasgow Sand Co.....	Building sand.....	Glasgow
<i>Jackson County.</i>		
Osage River Gravel Co.....	Gravel.....	Kansas City
Stewart Peck Sand Co.....	Moulding sand; building sand; engine sand; paving sand.....	Kansas City
<i>Jasper County.</i>		
Independent Gravel Co.....	Grinding and polishing sand; gravel.....	Webb City
Webb City & Joplin Ballast Co.....	Railroad ballast; gravel.....	Webb City

LIST OF SAND AND GRAVEL PRODUCERS, 1916-1917.—Continued.

Operator.	Name of product.	Location.
<i>Jefferson County.</i>		
Pittsburg Plate Glass Co.	Glass sand; grinding and polishing sand	Crystal City
American Silica Sand & Mng. Co.	Moulding sand; glass sand	Herculaneum
Silica White Sand Co.	Moulding sand; grinding and polishing sand	Silica
<i>Lafayette County.</i>		
Lexington Triumph Press Brick Co. . .	Building sand	Lexington
<i>Marion County.</i>		
George W. Camery	Engine sand; railroad ballast; gravel	Hannibal
<i>Montgomery County.</i>		
J. E. Grennan	Miscellaneous sands; gravel	Montgomery City
<i>Nodaway County.</i>		
Henry Heitman	Gravel	Maryville
Jas. Nowland	Gravel	Nodaway River
<i>Osage County.</i>		
Chicago, Rock Island & Pac. Ry.	Railroad ballast	Argyle
<i>Perry County.</i>		
R. D. Killian	Gravel	Perryville
<i>Phelps County.</i>		
Gasconade Sand & Gravel Co.	Building sand; engine sand; railroad ballast; gravel sand	Arlington
J. H. Freeman Sand Co.	Building sand; engine sand; railroad ballast; sand	Newburg
<i>Pike County.</i>		
Louisiana Sand & Gravel Co.	Building sand; gravel	Louisiana
<i>St. Charles County.</i>		
Tavern Rock Sand Co.	Glass sand	Klondike
Theo. Pundman	Building sand	St. Charles
<i>St. Louis County.</i>		
Union Sand & Material Co.	Building sand; gravel	Drake
Tavern Rock Sand Co.	Glass sand; moulding sand	Pacific
Meramec Portland Cement Co.	Building sand; gravel	Sherman
Continental Portland Cement Co.	Gravel	Valley Park and St. Louis
<i>St. Louis City.</i>		
John W. Allen & Son	Moulding sand	St. Louis (Carondelet)
Meramec Portland Cement Co.	Moulding sand	St. Louis
Union Sand and Material Co.	Building sand	St. Louis
Missouri Portland Cement Co.	Building sand	St. Louis
<i>Scott County.</i>		
Joe Ellis	Building sand; gravel	Commerce
<i>Stoddard County.</i>		
City of Dexter	Gravel	Dexter
F. N. Norman	Building sand	Dexter
M. J. Williams	Gravel	Dexter
<i>Wayne County.</i>		
Missouri Pacific Ry. Co.	Railroad ballast; sand	Leeper
<i>Worth County.</i>		
J. C. Harris	Building sand	Sheridan

STONE.

The production of marble was the only item showing an increase in the stone industry in 1917, the value of all other kinds of stone produced showing a decrease as compared to

1916. Chats in particular suffered a decided set-back. A decrease in 1917 of nearly \$500,000 in the total value of all stone produced as compared to 1916 may be attributed chiefly to car and labor shortage and the curtailment of building operations.

The total value of all stone produced during the past four years is given in the following table:

	1914.	1915.	1916.	1917.
Chats.....	\$340,616	\$346,358	\$433,645	\$214,007
Granite.....	77,971	85,624	80,390	58,241
Limestone.....	2,160,958	2,049,772	1,990,419	1,679,677
Marble.....	(a)	(a)	156,942	227,520
Sandstone.....	3,588	10,104	14,991	6,862
Total.....	\$2,583,133	\$2,491,858	\$2,676,387	\$2,186,307

(a) Included in limestone.

LIMESTONE.

The value of limestone produced in Missouri decreased from \$1,990,419 in 1916 to \$1,679,677 in 1917. The product suffering the greatest decrease was that of dressed building stone, the value of which decreased from \$430,562 in 1916, to \$169,582 in 1917. This abnormal decrease is probably directly attributed to the completion of the State Capitol, large quantities of dressed stone from the quarries in southwestern Missouri being used in its construction. Stone produced for furnace flux, glass factories and agricultural purposes showed an appreciable increase.

The following tables show the value of the limestone produced according to uses in 1916 and 1917:

Purpose.	1916.	1917.
Building purposes, (rough).....	\$34,891	\$72,465
Building purposes, (dressed).....	430,562	169,582
Paving, curbing and flagging.....	2,748	2,325
Rubble.....	139,539	83,467
Riprap.....	367,484	266,829
Crushed, for road metal.....	235,625	198,419
Crushed, for railroad ballast.....	65,525	102,906
Crushed, for concrete.....	582,818	605,734
Furnace flux.....	49,227	71,148
Sugar factories.....	2,830	2,491
Glass factories.....	38,481	48,510
Agricultural purposes.....	6,063	8,631
Miscellaneous.....	34,626	47,170
Total.....	\$1,990,419	\$1,679,677

PRODUCERS OF LIMESTONE IN MISSOURI, 1916-1917.

Firm.	Type and uses of stone.	Quarry location.
<i>Andrew County.</i>		
Newall & Stuart.....	Riprap, concrete, railroad ballast..	Amazonia
Reinert Bros., Construction Com- pany.....	Riprap, railroad ballast.....	Savannah
Savannah Stone Company.....	Riprap, concrete, railroad ballast..	Shuster
<i>Barry County.</i>		
The Stone Materials Company.....	Railroad ballast, concrete, agricul- tural.....	Cassville
<i>Boone County.</i>		
J. M. Fellows.....	Rubble, concrete, agricultural.....	Columbia Rocheport
Spencer-Whitlow Company.....	Concrete, railroad ballast, road- making, rubble, riprap, septic filtertanks, agricultural.....	Columbia
Kansas City Bridge Company.....	Concrete.....	
U. S. Engineer Office.....	Riprap.....	
<i>Buchanan County.</i>		
Commercial Crushed Stone Company	Concrete.....	St. Joseph
Metropolitan Paving Company.....	Roadmaking, concrete.....	St. Joseph
<i>Caldwell County.</i>		
Breckinridge Stone Company.....	Concrete, riprap, rough building, agricultural.....	Breckinridge
<i>Callaway County.</i>		
United States Engineer Office.....	Riprap.....	Cedar City
Snow Flake Lime Works.....	Lime.....	Fulton
<i>Cape Girardeau County.</i>		
Edward Hely.....	Concrete, R. R. ballast, road making agricultural.....	Cape Girardeau
Cape Lime and Marble Co.....	Pigments.....	Cape Girardeau
Henry Taylor and Son.....	Roadmaking, agricultural concrete.	Jackson
The Arnold Stone Company.....	Riprap.....	Neely's Landing
Oscar F. Barrett.....	Riprap.....	Neely's Landing
Grand Tower Riprap Stone Com- pany.....	Riprap.....	Neely's Landing
Wash Miller.....	Concrete, agricultural.....	Oak Ridge
<i>Carroll County.</i>		
William G. Waltman & Son.....	Agricultural.....	Tina
<i>Cass County.</i>		
H. T. Smith.....	Rubble.....	Harrisonville
<i>Clark County.</i>		
L. W. Lewis Sons.....	Railroad ballast, riprap, concrete..	Dumas
<i>Clay County.</i>		
S. H. Atwood & Son.....	Concrete, riprap.....	South Liberty
Marshall Rust.....	Riprap.....	South Liberty
U. S. Engineers Office.....	Riprap.....	South Liberty
<i>Clinton County.</i>		
J. H. and J. O. Anderson.....	Riprap.....	Lathrop
James J. Attebury.....	Rough building, rubble.....	Plattsburg
Davis Mill Feed & Coal Company..	Roadmaking.....	Plattsburg
<i>Cole County.</i>		
Missouri State Penitentiary.....	Rough building, rubble, riprap, roadmaking, concrete.....	Jefferson City
Joseph Pope.....	Concrete.....	Cotton-rock
Lewis Wolf.....	Concrete.....	Cotton-rock
U. S. Engineers Office.....	Riprap.....	Osage City
<i>Cooper County.</i>		
J. J. Cole.....	Riprap.....	Blackwater
S. J. White & Company.....	Riprap.....	Blackwater
F. Stretz & Sons.....	Concrete, agricultural.....	Boonville
M. K. & T. Ry. Company.....	Railroad ballast, riprap.....	Sweeney

PRODUCERS OF LIMESTONE IN MISSOURI, 1916-1917—Continued.

Firm.	Type and uses of stone.	Quarry location.
<i>Daviess County.</i>		
Earnshaw Crushed Stone Co.	Concrete.	Gallatin
Knauer & Seiler Rock Company.	Concrete.	Gallatin
Union Township.	Roadmaking.	
Blankenship Brothers.	Riprap.	Pattonsburg
<i>Franklin County.</i>		
Glencoe Lime & Cement Company. .	Lime.	Port Royal
Fred & Joseph Buhr.	Rough building, roadmaking, riprap	Washington
U. S. Engineer's Office.	Riprap.	Berger
Henry Boumker.	Roadmaking.	
<i>Greene County.</i>		
Ash Grove & Portland Cement Com- pany.	Lime.	Ash Grove
Phenix Marble Company.	Dressed stone, marble concrete, curbing, flagging, rubble.	Phenix
Benton Stone & Crusher Co.	Concrete.	Springfield
Greene County.	Roadmaking.	Springfield
Horton Stone Company.	Roadmaking.	Springfield
Marble Head Lime Company.	Lime, roadmaking, railroad ballast.	Springfield
Springfield Traction Company.	Concrete.	Springfield
<i>Grundy County.</i>		
H. K. Hertzog.	Concrete, rough building.	Clinton
<i>Harrison County.</i>		
Bethany City Quarry.	Concret.	Bethany
<i>Holt County.</i>		
Curtis B. Whitmer.	Concrete.	Oregon
<i>Howard County.</i>		
U. S. Engineer's Office.	Riprap.	Glasgow-Lisbon
DeWitt & Shobe.	Riprap.	Glasgow
<i>Jackson County.</i>		
Davidson Construction Company. .	Roadmaking.	Grandview, Inde- pendence
W. M. Spencer.	Concrete, riprap, rubble, agricul- tural.	Independence
Belt Line Crusher Co.	Miscellaneous.	Dodson
Flanagan-Zeller Brick and Manu- facturing Company.	Rubble, roadmaking, agricultural. .	Kansas City
Halpin-Dwyer Construction Com- pany.	Concrete.	Kansas City
Kansas City Park Quarries.	Roadmaking, concrete.	Kansas City
Lyle Rock Company.	Rubble.	Kansas City
Masnian Construction Co.	Riprap, roadmaking.	Kansas City
J. J. Lyons.	Rubble.	Kansas City
McTernan - Halpin Construction Company.	Concrete.	Kansas City
Builders Brick and Mfg. Co.	Roadmaking.	Kansas City
Metropolitan Street Ry. Company. .	Concrete.	Kansas City
W. C. Mullen.	Rubble, riprap.	Kansas City
William R. Nelson Estate.	Rough building, roadmaking.	Kansas City
The Parker-Washington Company. .	Concrete.	Grain Valley
The Phelps Stone and Supply Com- pany.	Concrete.	Kansas City
M. F. Sullivan.	Rubble.	Kansas City
Swenson Construction Company.	Rubble, concrete.	Kansas City
Kansas City Board of Public Welfare	Rubble, concrete.	Leeds
Heiderstadt-Cope Stone Co.	Rough building, rubble, roadmaking concrete.	Kansas City
The Prince-Johnson Limestone Com- pany.	Concrete, agricultural.	Independence, Leeds, Kelso, Kansas City
Joseph O'Connor & Son.	Rubble, concrete.	Kansas City

PRODUCERS OF LIMESTONE IN MISSOURI, 1916-1917.—Continued.

Firm.	Type and uses of stone.	Quarry location.
<i>Jasper County.</i>		
Carthage Marble and Building Stone Company.....	Dressed building flagging, rubble, riprap and for sugar factories....	Carthage
Carthage Marble and White Lime Company.....	Dressed building, curbing rubble, and for sugar factories.....	Carthage
Carthage Superior Marble Company	Concrete, fluxing, glass factories, agricultural and miscellaneous...	Carthage
Consolidated Marble and Stone Company.....	Dressed building, flagging, rubble, riprap, glass factories, agricultural.	Carthage
John Gill & Son.....	Dressed building, rubble.....	Carthage
Spring River Stone Company.....	Dressed building, flagging.....	Carthage
<i>Jefferson County.</i>		
Peter McLoon & Company.....	Fluxing, glass factories, riprap....	Barnhart
<i>Lafayette County.</i>		
Diamond Coal Company.....	Concrete.....	Corder
Wegener Coal Company.....	Concrete.....	Higginsville
<i>Lawrence County.</i>		
Pierce City Lime Company.....	Railroad ballast.....	Pierce City
Phil L. Urbach.....	Concrete, agricultural.....	Marceline
<i>Lewis County.</i>		
C. F. Nagle.....	Riprap.....	Lagrange
<i>Lincoln County.</i>		
Crystal Carbonate Lime Company..	Fluxing, glass factories, riprap, railroad ballast, concrete, agricultural, miscellaneous.....	Elsberry
<i>Linn County.</i>		
Phil L. Urbach.....	Concrete.....	
<i>Marion County.</i>		
Hanes & Camery.....	Riprap.....	Hannibal
Hannibal Lime Company.....	Concrete, railroad ballast, road-making, riprap.....	White Bear
Houston-Blond Stone Company....	Riprap, roadmaking, concrete.....	Hannibal
<i>Mercer County.</i>		
J. L. Barnes.....	Concrete.....	
Elisha Hichman.....	Rough building, riprap, concrete, mill rock.....	Spickard
<i>Moniteau County.</i>		
S. J. White & Company.....	Riprap.....	Lupus
H. A. Mutter.....	Rough building, curbing, rubble...	
U. S. Engineer's Office.....	Riprap.....	
G. N. Davis.....	Rough building.....	Paris
Thos Trussell.....	Rough building.....	Paris
<i>Montgomery County.</i>		
W. B. Dixon.....	Concrete.....	
High Hill Ground Limestone Company.....	Agricultural.....	High Hill
U. S. Engineer's Office.....	Riprap.....	
<i>Newton County.</i>		
Cora L. Kirk.....	Rough building.....	Neosho
Neosho Special Road District.....	Roadmaking.....	Neosho
<i>Osage County.</i>		
Anton Otto.....	Rough building.....	Koeltztown
Fred Schimmle.....	Rough building, pressed building, flagging.....	Rich Fountain
U. S. Engineer's Office.....	Riprap.....	
<i>Pike County.</i>		
Marble Head Lime Company.....	Riprap, railroad ballast, road-making.....	Louisiana
Bowling Green City Qry.....	Roadmaking.....	Bowling Green
<i>Platte County.</i>		
Park College.....	Riprap, rough building, paving....	Parkville

PRODUCERS OF LIMESTONE IN MISSOURI, 1916-1917—Continued.

Firm.	Type and uses of stone.	Quarry loca
<i>Ray County.</i>		
Pea Ridge Stone Company.....	Concrete.....	Richmond
Badger Lumber Company.....	Concrete.....	Richmond
<i>St. Charles County.</i>		
E. H. Dierker & Son.....	Rough building, riprap, roadmaking	St. Charles
Rosedale Contracting and Supply Company.....	Rough building, riprap, roadmaking	St. Charles
Frank Toubler.....	Rough building, riprap, roadmaking	St. Peters
<i>Ste. Genevieve County.</i>		
Garron Quarry and Manufacturing Company.....	Riprap, fluxing.....	Brickeys
Morrison Valley Rock and Timber Company.....	Fluxing.....	Brickeys
Southeast Missouri Quarries Company.....	Rough building, riprap, fluxing....	Merrill
Peerless White Lime Company.....	Fluxing, sugar factories, glass factories.....	Mosher
Ste. Genevieve Lime and Quarry Company.....	Fluxing, sugar factories.....	Ste. Genevi
<i>St. Louis County.</i>		
George H. Koche.....	Rough building, road making.....	Fern Ridge
John C. Heins.....	Riprap, roadmaking.....	Florissant
Glencoe Lime & Cement Company..	Roadmaking, fluxing.....	Minche-Carlet, Glenc
Glen Oak Quarry Company.....	Riprap, roadmaking.....	Glendale
Charles Becher & Emil Gebhardt...	Roadmaking.....	Jefferson E racks
Henry R. Zadow.....	Riprap.....	Jefferson E racks
August Kassebeuam.....	Roadmaking.....	Mattese
Hermann W. Bussen.....	Riprap.....	Oakville
Winheim Brothers.....	Rough building, riprap, roadmaking, concrete.....	Oakville
Albert Bussen.....	Riprap, railroad ballast.....	Quarantine
James F. Rothwell.....	Rubble, riprap, roadmaking, miscellaneous.....	Vigus
Sinclair Quarry and Construction Company.....	Rubble, riprap, roadmaking, paint grinders.....	Vigus
Lamb Construction Company.....	Rough building, riprap.....	University
<i>St. Louis City.</i>		
Banbrick Brothers Construction Company.....	Rubble, roadmaking.....	St. Louis
Big Bend Quarry Company.....	Rubble, riprap, concrete, miscellaneous.....	Maplewood
Brockschnitt Quarry and Construction Company.....	Rubble, riprap, roadmaking.....	St. Louis
County Construction Company.....	Roadmaking.....	St. Louis
Eyermann Construction Company..	Rubble, roadmaking.....	St. Louis
Fehlig Construction Company.....	Concrete, rubble.....	St. Louis
Fruin-Banbrick Construction Company.....	Concrete, rubble, asphalt dust.....	St. Louis
Haller Brothers.....	Rough building, roadmaking.....	St. Louis
Hoffman Brothers Construction Company.....	Rough building, riprap, roadmaking, concrete.....	St. Louis
Heman Construction Company.....		St. Louis
Perkinson Brothers Construction Company.....	Roadmaking, rubble.....	St. Louis
Progress Press Brick and Machine Company.....	Rubble, roadmaking.....	St. Louis
Ruecking Construction Company...	Concrete.....	St. Louis
St. Louis Workhouse Quarry.....	Riprap, roadmaking.....	St. Louis
Tower Grove Quarry and Construction Company.....	Concrete, roadmaking.....	St. Louis
Union Quarry and Construction Company.....	Rubble, concrete.....	St. Louis

MARBLE.

During the past few years the marble production of Missouri has taken its place as one of the important industries of the state. Today marble is shipped from quarries in Greene and Jasper counties to many parts of the United States where it is used for monumental work, exterior, and interior decorations. The value of the production for 1917 was \$227,520, an increase of \$70,578 over the previous year. The greater part came from the quarries of the Phenix Stone Company, at Phenix, Greene county. During the past two years the Carthage Marble and Building Stone Company, the Carthage Quarry Company, the Consolidated Marble and Stone Company and the Spring River Stone Company, all operating quarries near Carthage in Jasper county, have been important producers.

The entire production is quarried from the Burlington formation of the Mississippian Series. The stone is durable, light gray to gray in color, medium to coarsely crystalline in texture and takes a beautiful polish. It polishes to soft gray tints and is excellently adapted to monumental work or interior decorating especially the latter use for which it is developing a wide popularity. No better example of the practical use and beauty of this marble for interior work can be found than in the State Capitol of Missouri, where it has been used exclusively.

SANDSTONE.

PRODUCTION OF SANDSTONE FOR 1907 TO 1917.

Year.	Value.
1889.....	\$155,557
1907.....	35,289
1908.....	17,954
1909.....	28,763
1910.....	39,398
1911.....	19,748
1912.....	15,004
1913.....	10,195
1914.....	3,588
1915.....	10,104
1916.....	14,991
1917.....	6,862

The production of sandstone in Missouri has been comparatively small and fluctuating during the past ten years, and with but one exception, the production in 1917 was the smallest in this entire period. In 1916 the value of the sandstone quarried

was \$14,996 while in 1917 it was only \$6,862. Missouri possesses an abundance of sandstone suitable for quarrying into both rough and dressed stone, and in the past it has been extensively quarried and used for building. Warrensburg, Johnson county, has always been the chief center of the sandstone quarrying industry with Miami Station, Carroll county, second in importance in recent years. In past years sandstone quarries were operated in Barton, Dade, Ste. Genevieve, Marion, Bates, St. Clair and Cape Girardeau counties but these have been practically abandoned for a number of years.

The cause of the decline in the Missouri sandstone industry during late years can be traced chiefly to two sources. (1) Sandstone has suffered because of its inadaptability for use in concrete, the use of which has greatly increased year by year for all structural purposes and (2) sandstone has lost its one time popularity as a building stone because of its inferior qualities of durability. Sandstone, unless quartzitic in character, tends to scale with exposure to the atmosphere, a character especially noticeable in the many older buildings in St. Louis. It seems improbable that the sandstone quarrying industry will ever again attain its former rank, at least that of the 80's and early 90's.

Following is a list of the sandstone producers in Missouri in 1916 and 1917:

Producer.	Use.	Location.
<i>Callaway County.</i>		
H. R. Miller.....	Miscellaneous.....	Fulton
Oscar L. Taylor.....	Rough building.....	Fulton
<i>Carroll County.</i>		
Carroll County Sandstone Co.....	Riprap.....	Carrollton
<i>Johnson County.</i>		
Benjamin Pickle.....	Rough and dressed building, rubble	Warrensburg

GRANITE.

The granite produced in 1916 was valued at \$80,390, a decrease of \$5,234 compared with the previous year. In 1917 a much greater decrease was recorded, the output for the year being valued at only \$58,241.

The principal purpose for which granite is quarried is for the manufacture of paving blocks. In 1916, the output of paving blocks amounted to 698,611, valued at \$37,094. The production in 1917 was 460,260, valued at \$26,538.

The chief quarries are located at Graniteville in Iron county

and at Syenite in St. Francois county. The granite area includes a large part of St. Francois, Madison and Iron counties, the rocks consisting chiefly of red granite and dark, fine grained porphyry. The granite can be produced in large blocks free from flaws, but the porphyry is usually so badly jointed as to render large blocks unavailable.

The names of the producers, and the purposes for which their products are used, are as follows:

PRODUCERS AND USES OF GRANITE, 1916-1917.

Name.	Location of quarry.	Purposes used for.
<i>Iron County.</i>		
Schneider Granite Co.	Graniteville.	Building, monumental, paving blocks, road metal.
Sheahan Granite Co.	Graniteville.	Monumental, paving blocks, riprap, road metal.
<i>Madison County.</i>		
Milne & Gordon.	Cornwall.	Concrete.
<i>St. Francois County.</i>		
Alexander Hanson.	Doe Run.	Paving blocks, curbing.
A. G. Asploff.	Syenite.	Paving blocks, rubble.
J. A. Legrand. ....	.....	Paving blocks.
Milne & Gordon.	Syenite.	Building (dressed).
Mo. Granite & Construction Co.	Knob Lick.	Concrete.
<i>Wayne County.</i>		
P. O'Keefe.	Kerrigan.	Paving blocks.

CHATS.

The mine tailings derived from the mining of lead and zinc ores in both southeast and southwest Missouri are called chats. The chats from the lead district of southeast Missouri are composed chiefly of dolomitic limestone; those from the zinc and lead districts of southwest Missouri may be divided into two classes: The chert (flint) chats from the sheet ground mines and the mixed limestone and chert chats from the shallow workings. During the past 8 years leading up to 1916 the use of chats for railroad ballast, road construction, and concrete work had been constantly growing and the shipments from 1909 to 1916 increased from 828,835 tons to 2,890,970 tons. In 1917, however, due chiefly to a combination of car and labor shortage, and probably to some extent to a decrease in concrete construction, the shipments of chats fell to 1,426,716 tons. Figuring on the basis of 15 cents per ton, the value of chats shipped for all purposes during 1917 is \$214,007.

By far the greater quantity of chats are shipped yearly

from the southwest district, and during the past 8 years the principal use of the material from both districts has been as railroad ballast. The amount used for commercial purposes has remained practically the same. Millions of tons of chats are produced each year, the disposal of which is a matter of considerable expense to the mining companies. It is hoped that this immense source of good road metal will become more widely used.

The following table shows the tonnage shipped from Missouri districts during the past 9 years, the values can be approximated by multiplying the tonnage by 15 cents:

PRODUCTION OF CHATS, 1909-1917.

	1909.	1910.	1911.	1912.	1913.
Railroad.....	355,901	1,009,533	865,011	1,911,705	1,231,005
Commercial.....	472,934	610,789	638,592	811,698	797,884
Totals.....	828,835	1,620,322	1,503,603	2,723,403	2,028,889

	1914.	1915.	1916.	1917.
Railroad.....	1,687,331	1,713,884	2,268,370	1,010,620
Commercial.....	583,440	595,307	622,600	416,096
Totals.....	2,270,771	2,309,191	2,890,970	1,426,716

SILVER.

The lead ore of southeastern Missouri carries a small amount of silver—the average content being about one troy ounce per ton of lead concentrates. Of the total quantity of lead concentrates produced each year, approximately 15 per cent is desilverized. In 1916, the recovery amounted to 129,450 fine ounces, an increase of 71,644 ounces compared with 1915. In 1917, the production amounted to 61,586 fine ounces, valued at \$50,747, a decrease of 67,864 ounces compared with 1916.

In 1916, a new source of silver was furnished by copper ore shipped from the Swansea mine in Ste. Genevieve county. The ore shipped is reported to have averaged 6.6 ounces of silver per ton. In the same year, the Einstein silver mine in Madison county was opened for the production of tungsten. (See "Tungsten", p. 97.) This mine was extensively worked in 1879 for

the silver content of the ore. Assays made at that time of 50 samples of sorted galena ore averaged about 46 ounces of silver per ton. Whether or not an attempt to recover the silver contained in the ore is being made during the present operations, is not known.

TRIPOLI.

The output of tripoli in 1916 was 8,570 tons, valued at \$92,248. The production in 1917 was 8,303 tons, valued at \$90,923, a decrease of 267 tons. The value of the annual production during the past eight years is indicated in the following table:

Year.	Amount.
1910.....	\$71,978
1911.....	72,701
1912.....	75,565
1913.....	83,995
1914.....	81,434
1915.....	68,451
1916.....	92,248
1917.....	90,923

General.—Technically, the material being marketed in the United States under the name of "tripoli" is not tripoli, that word being a misnomer. True tripoli, or tripolite, is composed chiefly of silica but represents the remains of aquatic plants known as diatoms. In commerce it is known as either diatomaceous earth or infusorial earth. The substance now being marketed under the name of tripoli, while also consisting chiefly of silica, has had a far different origin, it being a decomposition product of chert (flint). When the material was first put on the market in the eighties, it was thought to be a true tripoli or diatomaceous earth and in consequence was sold under that name. For many years thereafter even after its entirely different origin was established, the material was included with diatomaceous (infusorial) earth in the mineral statistics. In recent years, however, the tendency has been to restrict the use of the name "tripoli" to decomposed chert, while the real tripoli has been referred to under the name of diatomaceous or infusorial earth. It would therefore appear that usage has compelled the adoption of the name "tripoli" for all commercial substances consisting of decomposed chert and the name is so accepted in this discussion.

The confusion of names has often proven a serious handicap to the producers of tripoli. Owing to a difference in origin, a diatomaceous earth and a tripoli of the same chemical composition may possess vastly different physical properties. But prospective consumers will often condemn a tripoli without trial because an infusorial earth of the same chemical composition has failed to meet their requirements. In like manner, consumers often fail to recognize the fact that tripoli produced in different districts may vary greatly in physical properties and somewhat in chemical composition. The variation is due to the difference in character of the cherts from which the tripoli was derived and to the different conditions under which the tripoli was formed. Before the tripoli industry can enjoy the full measure of prosperity the prospective consumers must be brought to realize that there are different grades of tripoli just as there are different grades of coal, or iron ore, of crude petroleum, etc. The fact that tripoli produced in one district fails to meet the requirements for a certain use does not in any manner signify that tripoli produced in another district will likewise fail to give desired results.

SOUTHWEST MISSOURI DEPOSITS.

The southwest tripoli district is confined to Newton county. The principal quarries are located near Seneca and Racine, although deposits of tripoli are known to occur elsewhere in the county. Similar deposits to those being worked near Seneca and Racine are also worked in the adjacent portion of Oklahoma.

Occurrence and Origin.—The tripoli deposits occur in the upper part of the Boone formation, which consists of alternating limestones and cherts aggregating 350 feet in thickness. Most of the deposits exploited are on the tops of the hills. The bodies of tripoli range from 4 to 12 feet in thickness, and are overlain by chert, gravel, and red clay, such as are common in the region.

The commonly accepted theory of the origin of the tripoli is that it results from the decomposition of chert. Unaltered chert occurs in lenses or more commonly in "balls" through the body of the tripoli itself, locally in such quantity as to force abandonment of the quarry.

Physical Properties.—The tripoli is a light, even textured, minutely porous rock, crumbling easily to the touch in the "green state", but preserving its form very well when air dried. Its fracture is rough and uneven, showing no tendency to break

along definite lines. Owing to its extreme porosity the rock is highly absorbent. According to Hovey, the tripoli grains are very minute, the majority being not over 0.0004 inch in diameter.

Pure tripoli is snow-white in color. Iron stain causing delicate pink and red coloring is, however, quite common and often in the nature of banding.

When air dried the rock is sufficiently firm to withstand milling into cylindrical and tubular filter stones. Tripoli possessing similar properties is produced in no other part of the United States.

Chemical Composition.—The tripoli produced for commercial purposes seems quite uniform in chemical composition throughout the district, as indicated by the following three analyses of quarry samples:

	1.	2.	3.
Silica (SiO_2)	98.28	98.10	98.10
Alumina (Al_2O_3)	.17	.24	.24
Iron oxide (FeO — Fe_2O_3)	.53	.27	.27
Lime (CaO)	Trace	.18	.33
Potash (K_2O)	.17		
Soda (Na_2O)	.27	.23	.23
Loss on ignition	.50	1.16	1.17
	99.92	100.18	100.34

Uses.—Tripoli stone has a modern sale for blotter blocks and scouring bricks, but the important use is for filter purposes. Filter stones in sizes and shapes to suit the manufactures of filters are produced by the local mills. The size ranges from the ordinary house filter to single filters with a capacity of 400 gallons per hour, or batteries of such filters with any desired capacity. Tripoli stone used as a filtering medium will remove much of the matter mechanically suspended and incidentally much of the bacteria polluting the water, since the germs are largely attached to the suspended matter.

The rock ground to tripoli flour is used as an abrasive for general polishing, burnishing, and buffing. The flour is also used as an ingredient of various scouring soaps. Its use is suggested as an absorbent base in the manufacture of dynamite.

Operators.—In 1917 the following firms operated in Newton county:

Name.	Office.
American Tripoli Company.....	Seneca, Mo.
Seneca Tripoli Company.....	St. Louis, Mo.
W. G. & John Smith.....	Noesho, Mo., R. F. D. No. 4.
Wedron Silica Company.....	Ottawa, Ill.

SOUTHEAST MISSOURI DEPOSITS.

The formation in which extensive deposits of tripoli occur in southern Illinois outcrops at a number of places in the eastern edge of Perry county, in Cape Girardeau county, and in the southeastern part of the Ste. Genevieve county. Deposits of tripoli are known to occur at several places, in Perry and Cape Girardeau counties the better known deposits being those near Cape Girardeau, Seventy-Six and Wittenberg. South of the latter place, a low grade tripoli has been extensively quarried for railroad ballast, and a number of the other deposits near Cape Girardeau have been extensively worked in former years.

Occurrence and Origin.—The tripoli deposits occur in the Upper Oriskany (Devonian), which consists of a series of gray to yellow cherts aggregating 237 feet in thickness. The cherts are usually in thin layers, but in the lower part of the formation are sometimes three to five feet in thickness.

In places the cherts are thoroughly leached and decomposed, occurring as a fine, white tripoli.

Character.—In the Illinois district, three grades of the siliceous material are marketed under the names of silica or tripoli, novaculite, and ganister.

Silica (tripoli) represents completely decomposed chert. It is a snow white powder having a harsh, gritty feel. The silica is somewhat variable in chemical composition, silica content varying from 90 to 99 per cent.

Novaculite is harder and more impure than silica (tripoli). It apparently represents cherts which have not been as completely altered as those comprising the present silica beds.

Ganister is a white or cream-colored, crumbly, siliceous mass with a consistency not unlike corn meal. Pocket-like deposits of this material occur, in or on the lower Mississippian beds which immediately overlie the Oriskany.

Uses.—The Illinois silica is used as a filler for wood, for paints, for scouring soaps, toilet-powders, porcelain bodies, and glazes. Novaculite is at present used exclusively as a road

metal. The entire output of ganister is used in the manufacture of refractory brick and related products.

OTHER MISSOURI ABRASIVES.

Near Plattsburg, Clinton county, occurs a bed of ferruginous, argillaceous, arenaceous dolomite. The bed is one foot six inches thick and at the surface has a buff to yellowish color as a result of weathering. The fresh stone has a bluish gray color and is hard when quarried. The stone is being pulverized and marketed under the trade name of "Trimbleite." Its chief use is in the manufacture of tooth powder, polishing powder, and scouring soap.

TUNGSTEN.

The old Einstein Silver Mine, located nine miles west of Fredericktown, Madison county, was reopened in February, 1916, by the Madison Mining Corporation of New York, principally for the tungsten content of the ore.

The Einstein property was entered as mineral land in 1855 by Beaugholtz, who prospected for several years and finally sold his holdings to Knox and Einstein. Systematic prospecting was begun in 1877 and as a result a quartz vein was opened at a point about 100 feet above St. Francois River. An incline of 180 feet was put down on the vein and a tunnel was started from near river level, intersecting the vein about 200 feet from the portal. In 1879, the Einstein Silver Mining Company was formed and the work was vigorously pushed. A large masonry dam was built across St. Francois River to furnish power, a concentrating plant was installed, and a furnace to reduce the concentrates from the mill was built. Lead and silver values were saved. After producing 50 tons of lead and 3,000 ounces of silver, the property was shut down owing to litigation. The property remained idle until 1894, when an attempt to revive mining operations met with failure. In so far as known, no other attempt was made to reopen the mine until the Madison Mining Corporation started operations in 1916.

The Einstein mine is located near the southern end of the granite area which extends southward from Doe Run for a distance of about fifteen miles. The country rock is a coarse-grained, red granite which is cut by diabase dykes and veins of quartz. The former extend in a general north-south direction and are nearly vertical. The quartz veins trend in a general

east-west direction and a dip to the southeastward at an angle of about 63 degrees.

Three distinct veins of quarts have been opened up and developments started on four others. The veins vary from a few inches to five feet in width, the average width being about two feet. A depth of 550 feet has been reached on one of the veins and drifts have been started at various levels, the distance between levels being 75 feet.

This locality is unique in furnishing a number of minerals found nowhere else in the State. Tungsten, in the form of Hubernite, is scattered through the quartz from the size of a pin head to massive bunches weighing 100 pounds. Pyrite and a dark lithia mica (Zinnwaldite) usually appear where the Hubernite is bunched. At intervals the tungsten mineral occurs in the form of solid lenses varying from 3 to 15 inches thick and accompanied by a heavy clay gouge. An analysis of a sample of the pure tungsten mineral gave the following results:

Tungstic acid.....	76.50%
Oxide of manganese.....	18.33%
Oxide of iron.....	5.12%
	99.95%

The other metallic minerals occurring in the vein are galena and sphalerite (zinc blende). The galena is silver bearing, the ore before concentration containing approximately as many ounces of silver per ton as there is percentage of lead.

In the present operations, close hand-sorting methods are employed both underground and on the surface, the object being to obtain as much "high grade" as possible. The hand sorted product carried from 62% to 75% tungstic acid. The cobbings and regular run of milling ore are put through a concentrating plant. A sample of the mill concentrates show the following metallic content:

Tungstic acid.....	63.30%
Lead.....	5.73%
Zinc.....	3.87%

Mill concentrates are of two grades. First class concentrates contain 60% and over of tungstic acid.

The total production of tungsten ore to date is not available for publication. During one month of 1917 eleven tons of 60% product were marketed.

*ZINC.

The value of the zinc concentrates produced in 1916-1917 greatly exceeded the value of these concentrates produced during any previous biennial period. The unprecedented demands and the corresponding high prices of the metal stimulated mining activity to a degree previously unknown. The value of zinc concentrates for the two years was \$41,937,200 against \$27,392,889 for the preceding biennial period.

The year 1916 will long be remembered in the annals of zinc mining in Missouri. In that year the value of the output of zinc concentrates exceeded the value of the concentrates produced in the preceding high year of 1915 by nearly \$5,000,000 and was over three times the value of the production in 1914. The average values per ton of sphalerite (blende) concentrates for the years 1914, 1915, and 1916 were respectively \$38.74, \$76.24, and \$82.54. The increase in the value per ton was accompanied by a corresponding increase in tonnage, the output in 1916 being 277,176 tons, as compared to 241,111 tons in 1915 and 189,765 tons in 1914. Both the value and tonnage of carbonate and silicate ores increased in 1916 only slightly over the value and tonnage in 1915. In the former year, 26,894 tons of carbonate and silicate concentrates, valued at \$1,350,381 were produced; in 1915, 25,412 tons, valued at \$1,243,458 were marketed; in 1914 the output was 19,648 tons, valued at \$415,185.

The year 1917 witnessed a decided slump in both the value and output of zinc concentrates. The combined output of all concentrates decreased from 304,070 tons in 1916 to 262,574 tons in 1917. The value of the concentrates in the latter year was \$17,708,604, a decrease of \$6,519,992 from 1916. The average value per ton in 1917 of sphalerite concentrates was \$71.04; of silicate and carbonate concentrates \$40.50.

The slump in output began about the middle of the year 1917 and was directly resultant of a decrease in the price of spelter and an increase in the cost of mining operations. During the latter part of the year, the market and labor conditions were such as to make the mining of "sheet ground" and much of the "soft ground" in southwestern Missouri unprofitable. Many mines were shut down and the mills removed to the Oklahoma field. For several years, the "sheet ground" has been a dominant

*Statistics collected by the U. S. Geological Survey.

factor in the Joplin district, but owing to existing conditions it is probable that much of the "sheet ground" will not be mined again.

The total values of the recoverable metallic content of zinc concentrates produced in Missouri in 1916 was \$41,797,280, an increase of \$7,994,880 over 1915. The same for the year 1917 was \$27,115,272, a decrease of \$14,682,008 from 1916.

The quantity of crude ore mined from "soft ground" deposits in 1916 was 4,711,700 tons; that mined in 1917 was 3,--447,850 tons, a decrease of 1,263,850 tons. The total crude ore produced by "sheet ground" mined during 1916 and 1917 was respectively 8,484,700 tons and 7,688,250 tons. The percentage of concentrates in "soft ground" ore increased from 3.38 per cent in 1916 to 4.04 per cent in 1917. The percentage in "sheet ground" ore decreased from 2.11 per cent in 1917.

The following tables reflect very closely the conditions of the zinc industry during the past biennial period.

PRODUCTION OF ZINC IN MISSOURI IN 1916 AND 1917.

District.	1916.				1917.			
	Sphalerite.		Silicate and Carbonate.		Sphalerite.		Silicate and Carbonate.	
	Quantity. (short tons)	Value.	Quantity (short tons)	Value.	Quantity (short tons)	Value.	Quantity (short tons)	Value.
Southwestern Missouri:								
Alba—Neck City.....	14,227	\$1,132,591	102	\$4,077	9,001	\$607,099	474	\$17,486
Ash Grove—Everton.....			1,968	73,700			1,719	52,367
Aurora.....	3,194	239,595	4,895	207,215	3,123	209,749	4,717	176,102
Carl Junction.....	681	55,502			320	24,553		
Carthage.....	3,835	298,950	4	153	4,827	333,742	5	97
Cave Springs.....	2,595	225,062			1,603	123,661		
Diamond.....	306	25,132	256	11,327	798	62,930	98	4,731
Duenweg—Porto Rico.....	40,709	3,354,375	1,302	73,954	38,093	2,628,085	3,057	150,149
Fairview—Pioneer.....	35	2,600	111	6,069			50	1,850
Granby.....	6,924	662,695	9,310	573,689	6,126	413,491	15,828	656,561
Joplin.....	51,259	4,279,912	3,339	154,907	52,525	3,920,429	1,352	67,356
McDonell—Stark City.....	300	27,000	137	6,617			30	1,022
Oronogo.....	11,300	830,025			9,918	642,602		
Sarcoie—Reeds.....	4,856	329,467	130	5,300	1,542	109,212		
Sherwood—Thoms. Sta.....	4,721	310,287			1,465	102,641	65	2,850
Spring City—Beef Br.....	834	65,187	1,723	92,646	294	20,434	1,379	56,589
Springfield.....	2,005	156,169			1,583	118,478		
Spurgeon—Seneca.....	2,240	141,262	311	14,904	2,702	161,038	419	17,063
Stotts City.....	573	48,324			604	45,465		
Webb City—Carterville—Prosperity....	113,835	9,751,555			86,415	6,230,272		
Wentworth.....	4,991	348,217	960	39,000	6,250	380,088	293	10,894
Zincite—Klondike.....	7,278	573,128			4,154	300,321		
Christian County.....	100	6,000	734	29,827	52	2,578	520	20,289
Ozark, Wright, Taney and Howell Counties.....	13	780	582	14,867	7	417	507	12,424
Central and Southeastern Missouri....								
	276,811	\$22,863,815	25,864	\$1,308,252	231,402	\$16,437,285	30,693	\$1,247,830
	365	14,400	1,030	42,129	186	16,344	293	7,145
State total.....	277,176	\$22,878,215	26,894	\$1,350,381	231,588	\$16,453,629	30,986	\$1,254,975

METAL CONTENT OF MISSOURI ZINC CONCENTRATES IN 1916 AND 1917.

District.	1916.		1917.	
	Quantity (short tons)	Value.	Quantity (short tons)	Value.
Southwestern Missouri:				
Alba—Neck City.....	7,548	\$2,022,864	4,889	\$997,356
Ash Grove—Everton.....	645	172,860	571	116,484
Aurora.....	3,392	909,056	3,290	671,160
Carl Junction.....	373	99,964	173	35,292
Carthage.....	2,102	563,338	2,609	532,236
Cave Springs.....	1,391	372,786	844	172,176
Diamond.....	254	68,072	467	95,268
Duenweg—Porto Rico.....	22,079	5,917,172	21,181	4,320,024
Fairview—Pioneer.....	57	15,276	17	3,468
Granby.....	6,990	1,873,320	8,855	1,806,420
Joplin.....	28,363	7,601,284	28,568	5,827,872
McDonell—Stark City.....	206	55,208	11	2,244
Oronogo.....	5,952	1,595,136	5,313	1,083,852
Sarcxie—Reeds.....	2,717	728,156	869	177,276
Sherwood—Thoms Std.....	2,295	615,060	779	158,916
Spring City—Beef Br.....	1,040	278,720	649	132,396
Springfield.....	1,123	300,964	874	178,296
Spurgeon.....	1,247	334,196	1,522	310,488
Stotts City.....	135	84,420	337	68,748
Webb City—Carterville—Prosperity...	60,341	16,171,388	45,103	9,201,012
Wentworth.....	2,819	755,492	3,200	652,800
Zincite—Klondike.....	3,793	1,016,524	2,238	456,552
Christian County.....	303	81,204	214	43,656
Ozark—Wright—Taney & Howell Co...	182	48,776	157	32,028
	155,527	\$41,681,236	132,730	\$27,076,920
Central & Southeastern Missouri.....	433	116,044	188	38,352
State Total.....	155,960	\$41,797,280	132,918	\$27,115,272

TENOR OF CRUDE ZINC ORE AND CONCENTRATES IN SOUTHWESTERN MISSOURI IN 1916 AND 1917.

	1916.	1917.
<i>Soft Ground.</i>		
Total Crude Ore..... Short tons.....	4,711,700	3,447,850
Total Zinc Concentrates in Crude Ore..... Per cent.....	3.10	3.71
Zinc Content of Crude Ore..... Per cent.....	1.71	1.99
Average Zinc Content of Sphalerite Concentrates... Per cent.....	78.1	58.2
Average Zinc content of Silicates and Carbonates... Per cent.....	39.4	39.7
Average Value Per Ton:		
Sphalerite Concentrates.....	\$77.94	\$69.50
Silicates and Carbonates.....	\$50.21	\$40.50
<i>Sheet Ground.</i>		
Total Crude Ore..... Short tons.....	8,484,700	7,688,250
Total Zinc concentrates in Crude Ore..... Per cent.....	1.86	1.75
Zinc Content of Crude Ore..... Per cent.....	1.10	1.03
Average Zinc Content of Sphalerite Concentrates... Per cent.....	59.2	58.6
Average Value Per Ton Sphalerite Concentrates.....	\$86.02	\$72.16

*These tables prepared by the U. S. Geological Survey.

The high price of spelter obtaining during 1916 and the early part of 1917 was a stimulus for intensive operations in the productive areas and for more or less extensive prospecting throughout the southern Missouri region. Many mines which has long been idle were reopened and a number of new deposits were developed. The most noteworthy areas which have again or have for the first time made an appearance in the production columns are briefly discussed in the following paragraphs.

Fairview and Pioneer.—These districts in Barry county produced in 1916 and 1917 a small quantity of sphalerite and zinc silicate which was mined from shallow shafts and drifts. The concentrates were recovered by hand cobbing and hand jigging. Among the producers were the Pioneer Milling Company, J. M. Brewer and L. D. Freeman.

Stark City.—Two mines were in operation at Stark City, Newton county, during the biennial period of 1916-1917. These were the Stark City Mining Company and the Wild Rose Mining Company, both operating on the K. D. F. Mining Company's land. Both companies mined galena and silicate ores at the 76-foot level. The property was first developed in 1915 and the first shipments were made by the Stark City Mining Company in November of that year. A fair tonnage of concentrates was produced in 1916, but in 1917 only a small shipment was made.

McDowell.—Intermittent mining operations have been carried on at McDowell, Barry county, since the late eighties. In 1915 two productive mines were in operation. These were the Big Chance Company's lease on the Henderson and Stuckley land, and the C. D. Meyer's lease on the Hemphill land. In 1916, the old Springfield Fissure mine was reopened after being shut down for a number of years.

Galena, blende and silicate concentrates are produced at the McDowell mines. At the Big Chance mine zinc silicate concentrates were recovered by using a crusher and hand jigs. The Meyer's lease produced both lead and zinc concentrates from ore mined at the 65-foot level. The ore at the Springfield Fissure mine is in gumbo-runs, similar to those mined near Springfield, and the lead and zinc concentrates recovered at the old 200-ton mill were similar in grade.

Christian county.—There were a number of shippers of galena, sphalerite, and zinc silicate and carbonate in Christian county in 1916, and prospecting was active. The production

amounted to 94 tons of galena, 100 tons of sphalerite, and 734 tons of zinc carbonate and silicate. The total value of all concentrates shipped was about \$43,000. The sphalerite, most of the galena, and a considerable part of the zinc carbonate was shipped by the Ozark Mining Co. on the Bain land in sec. 36, T. 27N., R. 21W., where ore was mined at the 90 and 135 foot levels and milled at a 100-ton concentrating plant.

Another shipper of zinc carbonate was the Robertson Mining Co. in secs 29 and 30, T. 27N., R. 21W. Most of the ore shipped was hand-cobbed carbonate taken from shallow levels. Part of the ore was treated by means of hand jigs and a 150-ton mill was being constructed. Some drilling was done, and it is stated that a sphalerite ore body was struck at a depth of 90 feet which continues to the 180-foot level. The lessees on the Arnold land made the largest output of zinc carbonate concentrates. The Bray Mining Co. erected a 100-ton mill and did considerable development, though the ore mined was all taken from above the 40-foot level. The Bull Creek Mining Co. lease, also on the Arnold land, has a 60-ton mill which, owing to the scarcity of water, was not steadily operated in 1916. Koerner and Co. worked in an open cut on the Arnold land and shipped hand-cobbed concentrates. The Hobart Lee Tie Co. mined and shipped galena taken from shallow workings in sec. 11, T. 26N., R. 19W., and the Turkey Creek Mining Co. sank a shaft on the J. C. Bell land near Garrison. Some galena and sphalerite was shipped in 1916, but the work accomplished indicates a much larger production from these two mines.

The production of concentrates in 1917 dropped to 49 tons of galena, 52 tons of sphalerite, and 520 tons of silicate and carbonate. The total value of all concentrates shipped in that year was \$28,100.

Taney county.—Three mines were in partial operation during 1916 and 1917 in the Melva mining district of southwest Taney county. These were the King Solomon property in sec. 27, T. 22N., R. 21W., the Melva Mining and Milling Co., in sec. 26, T. 22N., R. 21W., and the Jose B. mine in sec. 35, T. 22N., R. 21W. The Jose B. is equipped with a gravity mill; Joplin-type mills have been installed on the other two properties. The plant of the Melva Milling and Mining Co. is reported to have been dismantled and removed in the summer of 1917.

These three mines are located on a fissure, locally known as the "Ten O'clock Run," which traverses, in a general north-

west-southeast direction, T's. 21 and 22 N., R's 20, 21 and 22 W. The area traversed by the fissure is underlain by dolomites belonging to the Jefferson City formation of the Lower Ordovician rocks. The fissure occurs at the crest of a sharp monocline, the limb of which dips to the southwestward at an average angle of 10 degrees. The dip continues for a distance of from 400 to 600 feet, after which the strata again abruptly resumes a horizontal position.

At the Melva Mining and Milling Co's. mine (formerly the Silver Moon) mining operations have disclosed a slightly brecciated zone averaging about seven feet in width. This zone is limited on the northeast by a sharp, clean-cut wall which varies but slightly from vertical. Sphalerite fills the cracks and crevices in the brecciated rock and in places occurs disseminated through the rock mass. The mineralized zone pinches and widens rather abruptly both laterally and vertically. The amount of brecciation decreases with depth and the richness of the ore suffers a corresponding decrease. At the 60-foot level the ore is reported to have averaged from 12 to 15 per cent in mineral content. At the bottom of the 151-foot shaft, the ore is reported to run less than two per cent.

The minerals mined consist of zinc silicate, zinc carbonate, sphalerite and small amounts of galena. The zinc minerals are quite intimately associated with the (dolomite) country rock and in consequence the ore must be pulverized before milling.

Mansfield.—After remaining dormant for many years, the Mansfield district was again the scene of much mining activity during the past biennial period, especially in the latter part of 1917. Leases were acquired on large blocks of acreage north and northwest of Mansfield, extensive drilling operations begun, considerable silicate and carbonate ore was mined from shallow shafts, and one or two deep shafts started. The work was being done chiefly by parties from Grand Island, Nebr., Kansas City, Mo., and Okmulgee, Okla.

The silicate and carbonate ores which were mined and shipped were extracted by means of numerous shallow shafts, or pits sunk to bed rock. The ore occurs in the residual clays resulting from the weathering of the Jefferson City dolomite, and is confined to straight narrow belts known as "runs." Several approximately parallel "runs" extending in a general north-south

direction have been developed. Two of them have been mined for a distance of about three-fourths mile.

As disclosed by deeper prospecting, the residual ores have resulted from the weathering of the upper portion of solution fissure deposits. The rock beds underlying the "runs" of residual ore are slightly brecciated, the crevices being filled with sphalerite. The resulting ore bodies are persistent for considerable distances, but are very irregular; the mineralized belt pinching and widening abruptly both laterally and vertically. The sphalerite is intimately associated with the country rock (dolomite) and the ore must be pulverized before milling to insure a commercial recovery.

Active operations were in progress in the Mansfield district during the early part of 1918. The old Red Bird mill which was in operation in former years was being overhauled preparatory to active milling. A number of drill holes were being put down and one or two deep shafts were in the course of sinking.

Ozark County.—The old Alice mine, located one fourth mile west of Wetherill, resumed operations in 1916. The ore produced is the carbonate of zinc. It occurs in the Jefferson City formation, which at this place is composed of fine grained, gray dolomite known as "cotton rock." The zinc mineral occurs as a replacement of partly decomposed dolomite, and as stringers and thin seams in the undecomposed rock. The ore is mined from a pit, or open cut, about 150 feet in diameter and 70 feet deep. The property is equipped with a 150-ton log washer. The washed product is hauled to West Plains, a distance of about 25 miles. Shipments from this mine were again suspended in November, 1917. Aside from the Alice mine, there is a small group of zinc carbonate mines to the north and south in the western edge of Howell county, containing considerable deposits of a fine grade of ore. Among them are the Rex, the G and J, and the Morning Star, from which quite an amount of ore has been shipped.

Zinc carbonate was also mined in 1916 from an open cut in sec. 36, T. 23N., R. 11W., about two miles north of the Alice mine.

Morgan County.—The Bluff Spring Mining Co. opened an old mine in sec. 12, T. 44N., R. 18W., near Tipton, and shipped some sphalerite concentrates recovered in a small 100-ton plant in 1916. The ore milled was hoisted through a 149-shaft and the average zinc assay of the sphalerite concentrates was more

than 62 per cent. The Pearce Mining Co. recovered both galena and sphalerite from levels between 30 and 80 feet at a mine in sec. 21, T. 42N., R. 18W. No concentrating plant was built and the sphalerite shipped was mine-run dirt having a zinc content of about 20 per cent.

LAWS GOVERNING THE BUREAU OF GEOLOGY AND MINES.

Sec. 6632. Bureau of geology and mines established.—There is hereby created and established a bureau of “geology and mines” for the State of Missouri, which shall be under the direction and in charge of a board of managers, which shall consist of the governor, who shall be *ex officio* president of the board, and four citizens from the state at large, who shall be appointed by the governor, by and with the consent of the senate, and shall hold their term of office four years.

Sec. 6633. State geologist—qualifications—how appointed—headquarters.—The board of managers are authorized, as soon as they are organized, to appoint one state geologist, who shall be a person of competent scientific and practical knowledge of the sciences of geology and mineralogy, and whose headquarters shall be located at the State School of Mines at Rolla, who shall be the director of the survey, and said state geologist may appoint such assistants and subordinate assistants and laborers as may be deemed necessary in order to make a thorough scientific, geological and mineralogical survey of the state.

Sec. 6634. Property to be kept at School of Mines at Rolla.—The board of managers of the bureau of geology and mines are hereby authorized and directed to transfer all instruments, books, charts, cabinet collections and other property of the State of Missouri now under control of said board to the State School of Mines at Rolla and to establish the headquarters of the geological survey at said State School of Mines.

Sec. 6635. Duty of state geologist and assistants.—It shall be the duty of the state geologist and his assistants, under the instructions and directions of the board of managers, to carry on, with as much expedition and dispatch as may be consistent with minuteness and accuracy, a thorough geological and mineralogical survey of the state already begun, with a view to determine the order, succession, arrangement, relative position, dip or inclination and comparative magnitude of the several strata or geological formations within this state, and to discover and examine all beds or deposits of mineral contents

and fossils, and to determine the various positions, formations, and arrangement of the many different ores, clays, rocks, coals, mineral oils, natural gas, mineral and artesian waters and other mineral substances as may be useful or valuable; also, to note carefully the character of the soils and their capacities for agricultural purposes, the growth of timber and other scientific matters that may be of practical importance and interest; and said geologists shall cause to be represented on the map of the state, by colors and other appropriate means, the various areas occupied by the different geological formations in the state, and to mark thereon the localities of the respective beds or deposits of the various mineral substances, and, on the completion of the survey, to complete a memoir of the geology and mineralogy of the state, comprising a complete account of the leading subjects and discoveries which have been embraced in the survey.

Sec. 6636. State geologist to inspect lands.—On the presentation of a petition to the state geologist signed by not less than fifty freeholders who reside in the neighborhood of lands situated in any county in this state which they may believe to contain or in which have been found valuable ore, clays, rocks, coals, mineral oils, or mineral matter, said petition being certified by the clerk of the county court in which the petitioners reside to contain the names of fifty freeholders residing within the neighborhoods of the lands, which lands shall be described in the petition according to government surveys, it shall be the duty of the state geologist in person or by assistants as soon as practicable to examine and inspect said lands and make report and map as to existence on said lands of valuable ores, clays, coals, mineral oils, or mineral matter found, and embody the same in his report now directed to be made by section 6635, Revised Statutes of Missouri, 1909.

Sec. 6637. Shall make maps, publish reports, etc.—It shall be the duty of the state geologist to make or cause to be made detailed maps and reports of counties or districts as fast as completed, which maps shall embrace all such geological, mineralogical and scientific details necessary to make complete reports of said districts or counties. The state geologist may also, from time to time, publish or cause to be published any reports of work completed, in the form of pamphlets or bulletins for general distribution.

Sec. 6638. Geologist to form a cabinet collection, etc.—It shall be the duty of the state geologist to collect full suits of

all materials, rocks, ores, fossils or other mineral substances of scientific or practical interest or utility as may be discovered, and that may be necessary to form a complete cabinet collection, to illustrate the various resources of the state, as may be necessary to assist in preparing the various reports of the survey.

Sec. 6639. Duty of assistants.—It shall be the duty of the said assistants to make full and complete examinations, assays and analyses of all such rocks, ores, soils or other substances as may be submitted to them by the state geologist for such purpose, and to furnish him with a detailed and complete account of the results so obtained.

Sec. 6640. Geologist may furnish items of information, etc.—The state geologist, from time to time, may furnish items of general information on new discoveries for publication in newspapers: *Provided*, the preparation of the manuscript and publication thereof does not interfere with the progress or add to the expense of the survey; he may also have authority to furnish cabinets for colleges or public museums, located within the State of Missouri, of minerals, rocks or fossils: *Provided*, said institutions shall pay the expense of preparing, labeling, transporting and putting up said collection, and also, further, that in the selection of said specimens the general state collection is not deprived of duplicates of the same, and that the state collection is not seriously injured.

Sec. 6641. Board to determine place for cabinet.—The board, with the state geologist, may determine the place for the state cabinet and headquarters of the survey.

Sec. 6642. Board to report to general assembly, etc.—It shall be the duty of the board of managers to report to each general assembly the progress and condition of the survey, an accurate account of money spent, and such reports of the state geologist and his assistants as have been completed, together with all such information as may be deemed necessary and useful.

Sec. 6643. Power of the board, etc.—The board shall have power to take possession of all property of former surveys, whether reports, maps, collections, instruments or other property belonging to the state, and all persons now in possession of the same shall deliver them up to the order of the president of the board of managers: *Provided*, that no cabinet or library already arranged shall be removed, but the state geologist and

his assistants shall have the power at any time to examine or study such collections in preparing their reports.

Sec. 6644. Board to make by-laws, etc.—The board may make such by-laws and regulations for the government and control of its meetings and labors of the state geologist and his assistants as may be deemed necessary.

Sec. 6645. Compensation of the board—salaries of geologists.—As full compensation for the members of the board of managers, they shall be allowed their necessary expenses while attending to the duties assigned them by this chapter. The board shall fix the salary of the state geologist, not to exceed three thousand dollars per annum, and his chief assistant, which shall not exceed one thousand eight hundred dollars per annum; for the principal assistant or paleontologist, if one is employed, not over one thousand eight hundred dollars.

Sec. 6646. State geologist may appoint other assistants, etc.—The state geologist may, with the approval of the board, appoint other necessary assistants, whose pay shall not exceed five dollars per day, and such other necessary laborers or assistants as may be necessary, who shall receive a fair compensation for their work. He shall also have power to negotiate for such chemical work, chemical apparatus and chemicals as may be necessary, and may, from time to time, with the approval of the board, have such work done. He may also, with the approval of the board, employ special assistants in paleontology, provided it be deemed necessary.

Sec. 6647. Accounts of salaries and expenses, how made.—All accounts of salaries and expenses shall be made under oath, and certified by the board, and filed with the auditor of the state.

Sec. 6648. Board to have general management of survey, etc.—The board of managers shall have the general management of the survey, and have full power to remove the state geologist and appoint his successor, when deemed necessary for the good of the work entrusted to him; and the state geologist shall have full control over his assistants, and have power to remove them when deemed necessary.

Sec. 6649. State geologist and assistants shall take oath of office, etc.—The board of managers, the state geologist and each of his principal assistants shall, before entering upon the discharge of their duties, take the usual oath of office to faithfully perform all the services required of them under this chapter, and

to abstain from all pecuniary speculations for themselves or others in the objects of their survey during its progress.

Sec. 6650. State auditor to draw warrant for salaries, expenses, etc.—The president of the board shall, from time to time, certify to the state auditor the sums of money required to pay the salaries of the state geologist and his assistants and the incidental expenses of the bureau; and on receiving such certificates, the auditor of the state shall draw his warrant on the treasurer of the state for the requisite amount in favor of the parties and persons entitled to receive the same, and shall charge the several sums so paid to the account of the proper appropriation.

PUBLICATIONS OF THE BUREAU OF GEOLOGY AND MINES.

The following is a complete list of the publications issued by the present Bureau of Geology and Mines and former Geological Surveys. The reports of the second series are given first, since most of these are still available for distribution. A majority of those listed under the headings of Former Surveys are exhausted. The volumes available are distributed free upon receipt of transportation charges.

By a recent postal ruling, books may be sent by parcel post, by knowing the weight of the volume given in this list the exact postage can therefore be determined at any post office. The Biennial Reports are sent at a uniform charge of 10 cents. All publications sent to foreign countries, go at the rate of two ounces for one cent.

The reports may be obtained upon application to H. A. Buehler, State Geologist, Rolla, Missouri.

Vol. No. 2nd series.	Weight. (ounces)
I. Geology of Miller County, by E. R. Buckley, A. F. Smith and S. H. Ball xiv + 207 pp., XVIII pls., including geologic map, 56 figs. 1913.....	33
Describes the topography, general geology, and mineral resources of Miller County, Mo.	
II. The Quarrying Industry of Missouri, by E. R. Buckley and H. A. Buehler, xv + 371 pp., LIX pls., including geologic map of Missouri. 1904.....	56
Discusses properties, geology, distribution and laboratory tests of Mis- souri granites, rhyolites, limestones and sandstones and describes the quarries from which they are obtained.	
III. The Geology of Moniteau County, by F. B. Van Horn, ix + 104 pp., XIII pls., including geologic map, 25 figs. 1905.....	24
Describes the topography, general geology and mineral resources of Moniteau County, Mo.	
IV. Geology of the Granby Area, by E. R. Buckley and H. A. Buehler, viii + 120 pp., XLII pls., including general geologic, topographic and outcrop map, 3 figs. 1906.....	34
Describes the general geology, occurrence of lead and zinc ores of the Granby Area in Newton County, Mo., and discusses the genesis of the ores of southwestern Missouri.	
V. Public Roads, their improvement and maintenance, by E. R. Buckley, xiii + 124 pp., XXX pls. 1907.....	29
Contains specifications for building roads, directions for their construc- tion, improvement and upkeep, a chapter on road materials, etc.	
VI. The Lime and Cement Resources of Missouri, by H. A. Buehler, xvi + 255 pp., XXXVI pls., including a geologic map of Missouri, showing location of lime and cement plants. 1907.....	45
Discusses properties, manufacture and production of lime and cement, the distribution of lime and cement resources by counties, including analyses and a chapter on the geological formations of Missouri and their composition.	

Vol. No. 2nd series.		Weight. (ounces)
VII.	The Geology of Morgan County, by C. F. Marbut, xiv + 97 pp., XIX pls., including a geologic map of Morgan County, 19 figs. 1908. Describes the topography, general geology and mineral resources of Morgan County, Mo.	25
VIII.	The Geology of Pike County, by R. R. Rowley, xiv + 122 pp., XX pls., 13 figs., geologic map of Pike County, 1908. Describes the topography, general geology, mineral resources and paleontology of Pike County, Mo.	27
IX.	Geology of the Disseminated Lead Deposits of St. Francois and Washington counties, by E. R. Buckley, 2 pts.; pt. 1. xvi + 259 pp., pls. I-XXXIX, 10 figs.; pt. 2 pls. XL-CXXI, including a general geologic map of south-eastern Missouri. 1909. Discusses location, history, production, physiography, general geological history, structure, mines, ores, genesis of the ores of southeastern Missouri, with a chapter on barite and galena in the potosi formation.	84
X.	The Iron Ores of Missouri, by G. W. Crane, xvi + 434 pp., XLVIII pls., 29 figs., and geologic map of Missouri showing the location of the iron deposits. 1912. Discusses the history, development, production, types and distribution of Missouri iron ores and general geology and physiography of the ore-bearing district.	6½
XI.	The Coal Deposits of Missouri, by Henry Hinds, xi + 503 pp., XXIII pls. 97 figs., and maps of the Clinton, Calhoun, Lexington, Bevier, Huntsville and Richmond quadrangles and geological map of Missouri, 1912. Describes briefly the Pennsylvanian series in Missouri and discusses in detail the mode of occurrence, coal industry, the distribution by counties, analysis, and tests of Missouri coal.	59
XII.	The Geology of the Rolla Quadrangle, by Wallace Lee, xii + 111 pp., X pls., 17 figs., topography and geologic maps of the Rolla quadrangle, 1913. Describes the topography, physiographic history, general geology and mineral resources of the Rolla quadrangle in Phelps and Dent counties, Mo.	23
XIII.	The Stratigraphy of the Pennsylvanian Series in Missouri, by Henry Hinds and F. C. Greene, with a chapter on Invertebrate paleontology by G. H. Girty, 500 + pp., XXXII pls., 5 figs.	
XIV.	The Geology of Jackson County, by W. E. McCourt assisted by M. Albertson and J. W. Bennett. 158 pp., XIX pls., including geologic maps and cross sections. Describes topography, general geology and mineral resources of county and includes brief discussion of history and settlement.	
XV.	The Sand and Gravel Resources of Missouri, by O. L. Dake. 250 pp., XLVII pls., including a large number of maps. Discusses nature and uses of sand and gravel, types found in Missouri and the Geology of Missouri sands and gravels. A large number of screen tests and analyses are contained in the report. The Oil and Gas Possibilities of the Belton Area, by Malcolm E. Wilson. Describes geology and geologic structure in southwest Jackson and Northwest Cass Counties. A pamphlet containing 39 pp., III pls., including geologic structure map.	

BIENNIAL REPORTS.

Postage.

Biennial Report of the State Geologist to the 42d General Assembly, by E. R. Buckley, 83 + 3 pp., VIII pls. 1903.	10c
Describes work of Bureau during years 1901 and 1902.	
Biennial Report of the State Geologist to the 43d General Assembly, by E. R. Buckley, 56 pp., III pls. 1905.	10c
Describes work of Bureau during years 1903 and 1904.	
Biennial Report of the State Geologist to the 44th General Assembly, by E. R. Buckley, 57 pp. 1907.	10c
Describes the work of Bureau during years 1905 and 1906.	
Biennial Report of the State Geologist to the 45th General Assembly, by H. A. Buehler, 59 pp., 1909.	10c
Describes work of Bureau during years 1907 and 1908.	

BIENNIAL REPORTS—Continued.

	Postage
Biennial Report of the State Geologist to the 46th General Assembly, by H. A. Buehler, 68 pp., VI pls. 1911.....	10c
Describes work of Bureau during years 1909 and 1910.	
Biennial Report of the State Geologist to the 47th General Assembly, by H. A. Buehler, 54 pp., IIIpls. 1913.....	10c
Describes work of Bureau during years 1911 and 1912.	
Biennial Report of the State Geologist to the 48th General Assembly, by H. A. Buehler, 62pp., IV pls. 1915.....	10c
Biennial Report of the State Geologist to the 49th General Assembly, by H. A. Buehler, 75 pp., Ipl. 1917.....	10c

MAPS.

Base Map of Missouri, compiled in cooperation with the United States Geological Survey. Shows elevations of towns. Unmounted.....	15c
Geological Map of Missouri, 1912.....	10c

FORMER SURVEYS. a

The following is a list of publications of this Bureau up to the publications of volume 13, 1st series. *Editions exhausted

- 1.* *Report of a Geological Reconnaissance* of that part of the State of Missouri adjacent to the Osage River, made to William H. Morell, chief engineer of the State, by order of the Board of Internal Improvement, by Henry King, M. D. Geologist. (Senate Journal, Appendix, 1st Session, 11th General Assembly, pages 506-535.) Jefferson City, 1840.
- aIn this list the publications of the Survey are arranged in the order in which they were transmitted for publication.
- 2* *First and Second Annual Reports* of the Geological Survey of Missouri, by G. C. Swallow, State Geologist, 448 pages, 17 plates, 18 sections, 26 figures and 5 maps, 8 vo. cloth. Jefferson City, December, 1855.
- 3.* *Third Report of Progress*, of the Geological Survey of Missouri, by G. C. Swallow, 3 pages, Jefferson City, December, 1856.
- 4.* *Fourth Report of Progress*, of the Geological Survey of Missouri, by G. C. Swallow, 8 pages. Jefferson City, December, 1858.
- 5.* *Fifth Report of Progress*, of the Geological Survey of Missouri, by G. C. Swallow, 13 pages. Jefferson City, December, 1860.
- 6.* *Geological Report of the Southwestern Branch of the Pacific Railroad, State of Missouri* by G. C. Swallow, xvii + 93 pp., 2 pls., fold map. St. Louis, 1859.
- 7.* *Annual Report of the State Geologist*, of the State of Missouri, by Albert D. Hager, 23 pages. Jefferson City, December, 1870.
- 8.* *Report of Geological Survey* of the State of Missouri, 1855-1871, by G. C. Broadhead, F. B. Meek and B. F. Shumard, 327 pages, 29 illustrations and 9 maps, 8vo. cloth. Jefferson City, March, 1873.
- 9.* *Preliminary Report on the Iron Ores and Coal Fields*, from the field work of 1872, by R. Pumpelly, A. Schmidt, G. C. Broadhead and W. B. Potter, 671 pages, 190 illustrations and an atlas with 14 large sheets, 8vo. cloth. Jefferson City, April, 1873.
- 10.* *Report of the Geological Survey* of the State of Missouri, including field work of 1873-1874, by G. C. Broadhead, 794 pages, 91 illustrations and an atlas of 15 sheets, 8vo. cloth. Jefferson City, August, 1874.
- 11.* *Industrial Report on Lead, Zinc and Iron*, together with notes on Shannon county and its copper deposits, by Chas. P. Williams, Ph. D., Acting State Geologist, 199 pages and 11 illustrations, 8vo. cloth. Jefferson City, December, 1876.
- 12.* *Bulletin No. 1*, by Arthur Winslow, G. E. Ladd, A. E. Woodward and G. Hambach, 85 pages and 2 sketch maps. Jefferson City, April, 1890.
- 13.* *Bulletin No. -*. A Bibliography of the Geology of Missouri, by F. A. Samson, 76 pages, 810 titles. Jefferson City, December, 1890.
- 14.* *Bulletin No. 2*. By G. E. Ladd and A. E. Woodward, 101 pages, 4 plates, 3 sections and 2 sketch maps. Jefferson City, December, 1890.
- 15.* *Biennial Report of the State Geologist*, Transmitted to the 36th General Assembly, Arthur Winslow, State Geologist, 53 pages, 2 diagrams. Jefferson City, January, 1891.
- 16.* *Bulletin No. 4*. A description of some Lower Carboniferous Crinoids from Missouri, by S. A. Miller, 40 pages and 5 plates. Jefferson City, February, 1891.
- 17.* *Bulletin No. 5*. By Erasmus Haworth and G. E. Ladd, 86 pages, 5 plates and 5 figures. Jefferson City, July, 1891.
- 18.* *A Preliminary Report on the Coal Deposits of Missouri*, by Arthur Winslow, 226 pages, 131 illustrations and 1 map, 8vo. cloth. Jefferson City, November, 1891.
- 19.* *Vol. II. A Report on the Iron Ores of Missouri*, by F. L. Nason, 366 pages, 8 plates, 62 illustrations and 1 map, 8vo. cloth. Jefferson City, December, 1892.

- 20.* *Vol. III. A Report on the Mineral Waters of Missouri*, by Paul Schweitzer, including notes of A. E. Woodward, 256 pages, 23 plates, 11 figures and 1 map, 8vo, cloth. Jefferson City, December, 1892.
- 21.* *Biennial Report of the State Geologist*, transmitted to the 37th General Assembly, Arthur Winslow, State Geologist, 37 pages, 3 diagrams. Jefferson City, January, 1893.
- 22.* *Vol. IV. Paleontology of Missouri (Part I)*, by C. R. Keyes, 271 pages, 32 plates and 9 figures, 8vo, cloth. Jefferson City, June, 1894.
- 23.* *Vol. V. Paleontology of Missouri (Part II)*, by C. R. Keyes, 266 pages, 24 plates and 2 figures, 8vo, cloth. Jefferson City, June, 1894.
- 24.* *Vol. VI. Lead and Zinc Deposits (Part I)*, by Arthur Winslow, 287 pages, 12 plates and 71 figures, 8vo, cloth. Jefferson City, July, 1894.
- 25.* *Vol. VII. Lead and Zinc Deposits (Part II)*, by Arthur Winslow, 383 pages, 29 plates and 268 figures, 8vo, cloth. Jefferson City, July, 1894.
- 26.* *Vol. VIII. Annual Report with Accompanying Papers*, by C. R. Keyes, 395 pages, 30 plates, 16 figures and 1 map, 8vo, cloth. Jefferson City, December, 1894.
- 27.* *Biennial Report of the State Geologist*, transmitted to the 38th General Assembly, C. R. Keyes, State Geologist, 60 pages. Jefferson City, January, 1895.
- 28.* *Vol. IX. Reports on Areal Geology (Sheets 1-4)*, by C. R. Keyes, A. Winslow, C. H. Gordon, Erasmus Haworth and F. L. Nason, 430 pages, 22 plates, 53 figures, 3 folio plates and 4 maps, 8vo, cloth. Jefferson City, April, 1896.
- 29.* *Vol. X. Surface Features of Missouri and Bibliography*, by C. R. Keyes, C. F. Marbut and J. E. Todd, 533 pages, 22 plates and 24 figures, 8vo, cloth. Jefferson City, June, 1896.
- 30.* *Vol. XI. Clay Deposits*, by H. A. Wheeler, E. M., 622 pages, 39 plates, 15 figures and 2 maps, 8vo, cloth. Jefferson City, November, 1896.
- 31.* *Biennial Report of the State Geologist*, transmitted to the 39th General Assembly, C. R. Keyes, State Geologist 63 pages, 7 plates and 2 figures. Jefferson City, December, 1896.
- 32.* *Vol. XII. Areal Geology (Sheets 5-10)*, E. M. Shepard, C. F. Marbut and G. C. Broadhead, edited by C. F. Marbut, 656 pages, 13 plates, 39 figures and 6 maps, 8vo, cloth. Jefferson City, December, 1898.
- 33.* *Biennial Report of the State Geologist*, transmitted to the 40th General Assembly, by John A. Gallaher, State Geologist, 68 pages. Jefferson City, December, 1898.
- 34.* *New Year Announcement of the Bureau of Geology and Mines*, by J. A. Gallaher, State Geologist, 27 pages. Jefferson City, January, 1900.
35. *Vol. XII. Preliminary Report on the Structural and Economic Geology of Missouri*, by John A. Gallaher, State Geologist, 260 pages, 65 plates, 9 sections and 6 figures, 8vo, cloth. Jefferson City, September, 1900. (Weight, 46 ounces.)
- 36.* *Biennial Report of the State Geologist*, transmitted to the 41st General Assembly, by Leo Gallaher, Act. State Geologist, 55 pages. Jefferson City, January, 1901.

FINANCIAL STATEMENT FOR 1917 AND 1918—SUPPORT FUND

1917.

H. A. Buehler.....	\$3,054.12	
M. E. Wilson.....	2,351.82	
Office expenses.....	1,368.34	
J. S. Brown.....	695.13	
A. L. Parker.....	610.00	
E. B. Branson.....	591.85	
Edwin Long.....	408.30	
G. B. Corless.....	386.72	
L. B. Harlowe.....	290.67	
W. E. Oyler.....	262.60	
Stuart St. Clair.....	231.52	
Mound City Engraving Company.....	197.31	
J. Barley.....	175.00	
Wm. J. Nolte.....	150.00	
W. E. Morse.....	150.00	
C. O. Reinoehl.....	120.00	
A. F. Smith.....	115.02	
L. R. Scheurer.....	108.02	
Clark Craycroft.....	52.90	
E. M. Shepard.....	51.93	
H. C. Cosgrove.....	54.00	
Total.....		\$11,425.25

FINANCIAL STATEMENT FOR 1917 AND 1918—SUPPORT FUND—Continued.

1918.		
H. A. Buehler	\$1,416.78	
M. E. Wilson	2,223.58	
Office expenses	1,869.98	
Hugh Stephens Printing Co.	3,575.67	
E. B. Branson	1,402.19	
A. L. Parker	770.00	
C. O. Reinoehl	1,095.56	
G. A. Mullenburg	757.16	
W. A. Tarr	821.23	
Russell Gibson	720.50	
W. J. Nolte	578.83	
W. E. Oyler	333.00	
Mound City Engraving Company	478.87	
H. H. Armsby	481.48	
V. H. Hughes	511.56	
C. R. Schroyer	532.23	
E. O. Markham	302.20	
G. P. Moore	171.59	
J. W. Barley	200.00	
C. L. Dake	150.00	
Edwin Long	470.10	
Empire Gas and Fuel Company (instruments)	131.00	
B. H. Rucker, (postage)	153.04	
E. M. Shepard	94.08	
Clark Craycroft	49.01	
F. C. Greene	62.04	
U. S. Paper Can and Tube Company	59.26	
P. N. Moore	10.40	
W. C. Morse	10.84	
E. S. Gatch	10.00	
Total		\$19,442.18

TOPOGRAPHIC FUND.

No expenditures during biennial period.

