MISSOURI BUREAU OF GEOLOGY AND MINES.

H. A. BUEHLER, Director and State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BUREAU OF GEOLOGY AND MINES

TO THE

Forty-Sixth General Assembly.

THE HUGH STEPHENS PRINTING COMPANY,
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BOARD OF MANAGERS.

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LETTER OF TRANSMITTAL.

To the President, Governor Herbert S. Hadley and the Honorable Members of the Board of Managers of the Bureau of Geology and Mines:

Gentlemen—I have the honor to submit a report on the work of the Bureau of Geology and Mines for the years 1909 and 1910.

It is my pleasure to acknowledge to the members of the Board my appreciation of the deep interest which they have manifested in the work, and also to acknowledge the hearty co-operation extended the survey by citizens, mining companies, real estate firms and the Bureau of Mines and Mine Inspection. Information, often of a confidential character, has been given us whenever requested and the entire staff has been received most cordially in all parts of the State.

Respectfully yours,
H. A. BUEHLER, State Geologist.

CHAPTER I.

WORK OF THE BUREAU OF GEOLOGY AND MINES DURING 1909 AND 1910

The work of the Bureau of Geology and Mines during the past biennial period has dealt chiefly with applied geology. Each of the investigations undertaken has had as its object the determination of those geologic factors which may have a bearing on the development of the mineral resources of the regions surveyed.

It is strictly the province of the geologist to study and describe the natural processes through which the various ores, clays, rocks, coal and other mineral resources have been formed into commercial deposits. These deposits are not accidental occurrences, but are invariably associated with certain geological features which, when explained, serve as the most valuable guides in mining and prospecting.

The activities of the Bureau touch almost every phase of the mining, clay working and quarrying industries and through its reports and correspondence it is actively engaged in pointing out the geologic features of economic value in each mining area. Each investigation has for its object either the development of one of our mineral resources, or the description of the geology and mineral resources of some particular area.

The value of the work increases in proportion to the completeness and detail with which it is executed. A study of a single iron mine is chiefly of local value; but a complete study of all the iron mines of the State results in a comparison of deposits and geologic conditions which increases the value of the work many times. One coal analysis is of value in indicating the heat units of a particular bed, but complete analyses covering the various mining districts, indicate the comparative value of the different beds mined within the State. The same is true of topographic surveys. The value of one topographic map is largely local, but a series of such maps covering a mining district or a river system affords data upon which State-wide problems may be based.

Because of this comparative importance of complete information covering any single series of deposits, or special areas, the

work of the Department is usually restricted to special investigations and county mapping, the rapidity with which the results become available depending entirely upon the appropriation received.

The following men have been employed permanently on the Bureau's Staff during the greater part of the past biennial period:

H. A. Buehler, State Geologist.
G. W. Crane, Geologist.
V. H. Hughes, Geologist.
F. C. Greene, Geologist.
John Bodman, Assistant Geologist.
Wallace Lee, Assistant Geologist.
A. X. Illinski, Chemist.

In addition to the above, a number of assistants have been employed for special investigations or for the summer field season. Mr. Henry Hinds has also been detailed by the United States Geological Survey for co-operative work in the Missouri coal fields.

Mr. J. B. Campbell, Clerk, and W. E. Morse, Janitor, have been employed at the office.

The topographic branch has been under the direct supervision of Mr. W. H. Herron, of the United States Geological Survey, Geographer for the Central district. Under his direction the Federal topographic and level parties have carried on the topographic mapping in the areas designated by the State Bureau.

CO-OPERATION.

During the past biennial period the Survey has enjoyed greater co-operation with the United States Geological Survey than ever before. Such co-operation is now carried on: (1) in the collection of mineral statistics; (2) in the collection of data covering deep drilling; (3) in the investigations covering the coals and Coal Measures; and (4) in topographic mapping.

Under the provisions of each agreement the Federal Bureau contributes one-half of the field expenses; making available for each co-operative investigation, double the fund allotted by the State. The State usually benefits also through obtaining trained men from the Federal Survey under whose supervision the work is carried out.

During the past biennial period the Federal Survey spent approximately $11,000 in such co-operative work in Missouri.

Since the establishment of the Federal Bureau of Mines a co-operative agreement has been entered into whereby that Bureau analyzes and tests all samples of coal collected by the State Survey.

GEOLOGIC INVESTIGATIONS.

During the past biennial period the Bureau has made a study of, and has in preparation reports on; (1) the coal deposits, (2) the iron ores, (3) lead and zinc deposits of the Aurora area, (4) the geology and structural materials of Jackson county, (5) the geology of Phelps county, and (6) ore deposits of the southern Ozark region (reconnaissance).

In conjunction with the investigations covering the coal deposits, work has also been carried on in northwest Missouri for the purpose of outlining those geologic features favorable for the occurrence of oil and gas.

COAL.

The Coal Measures underlie approximately 25,000 square miles of the northern and western portions of the State, including wholly or in large part 45 counties. In value, the output of the coal mines ranks next to the output of lead and of zinc.

Because of the great area underlain by these formations and the consequent possibilities of more extensive development as well as the general want of information concerning the position which the coal seams occupy in the Coal Measures formations, the Bureau is making a detailed study of the coal mining camps, and of the formations in which the various coal seams occur. The investigation is being carried on in co-operation with the United States Geological Survey, the cost of all field operations being shared equally by the two Departments. The complete results are available to both Surveys.

The work has been chiefly economic, and in general the following lines of investigation have been followed:

(1) A study of the stratigraphy of the Coal Measures:

(2) A study of the present mining camps.

(3) A study of the extent of our known productive veins and the possible location of new fields.

(4) A study of the fuel values of our minable coals.

(5) The determination of the depth to which the Coal Measures extend in each county.

A detailed study of the stratigraphy of the Coal Measures is essential to a proper knowledge of the occurrence of our coals. These formations have a total thickness of 2,000 feet, although the coal beds themselves comprises less than 25 feet or about 1-100 of the entire thickness. By a sufficiently detailed study, each of the

coal seams occurring in Missouri can be placed in the succession of formations and its relative position to the other coal seams be shown. Those portions of the formations in which coal does not occur can also be indicated and the approximate depth at which the productive Coal Measures may be encountered in each county can be determined.

In studying the present mining camps special attention has been given to the thickness and general nature of the various seams, while the occurrence of partings, faults, "horses" and clay seams, which materially affect mining operations, have also been observed. In each district the character of the floor and roof have been noted, and data collected on the entire succession of formations overlying the coal. This phase of the work has a direct bearing on the cost of mining and on the system which may be employed in extracting the coal. Where a strong roof is present, the long wall method of mining may be used. Through this method virtually all the coal may be taken from the ground, while under the room and pillar method from 25 to 50 per cent is left in stumps and pillars.

Through field observation and a study of drill records, the extent of the known seams is being determined and the areas in which unknown seams may occur are being outlined. In a number of instances seams have been found to occur over a large territory where mining is now restricted to a few isolated areas. Outcrop maps will be prepared to show the relation of the present mining area to the possible extent of the productive fields.

A systematic study of the fuel values of the various coal has been undertaken. In order that accurate and uniform samples might be obtained, samples that represent the average product of the mine, an assistant of this Department has visited the more important mines of the State and has taken samples from the working face; usually three separate samples were obtained from different portions of each mine. The necessary analytical work was done in the laboratory of the U. S. Geological Survey at Pittsburg, Pa., and later in the laboratory of the Bureau of Mines at the same place. Both the sampling and analyses have been carried out according to methods employed by the Federal Bureaus, assuring uniform results comparable with those of every bituminous coal field which has been sampled and tested by either the United States Geological Survey or Bureau of Mines.

The investigation of the Coal Measures is one of the most important and one of the most extensive researches undertaken by

the Bureau during the past biennial period. The results will bear directly upon an area comprising almost one-half of the entire State. Field work covering the area north of the Missouri river has now been completed, and during the coming season the area to the south will be studied. The results of the work will appear in a report devoted to the economic phases of our coal mining industry. A very brief summary of the work to date is given on page 26.

OIL AND GAS.

During the past few years the Department has received numerous requests for geologic data and maps indicating possible oil and gas fields in Missouri. The major part of the production of these fuels in the mid-Continental fields is obtained from the sandstones of the Coal Measures, where these formations have an arched or dome-like structure, due either to folding or inequalities in original sedimentation. It is near the crest of such folds or domes that the most productive wells are usually brought in.

The structure of the region underlain by the Coal Measures has not heretofore been worked out in detail, although the lower portion of these formations is composed of sandstones and shales having the proper stratigraphic relations for the formation of reservoirs. Because of the direct bearing of the structure on the location of the most favorable territory for drilling, observations on folding have been made in conjunction with the stratigraphic study of the Coal Measures. The final results will be embodied in a report showing the stratigraphy and structure of that portion of the State most favorable for the occurrence of oil and gas. This report will include records showing the formations encountered in deep drilling, which data are extremely valuable to drillers in indicating the character of the strata which are not exposed.

IRON ORES.

With the opening of Iron Mountain in 1844, Missouri became the important iron mining center of the country and for many years held first place as an iron producer. Although the annual output is, at the present time, less than 150,000 tons, the State contains extensive reserves of iron ore in the southeast and central Ozark region.

The ores include specular and red hematites and several types of limonite. They are associated with a majority of the Cambrian and pre-Cambrian formations of the Ozark region and occur under

a variety of geologic conditions, which materially affect, not only the character of the ore but also the methods of mining and the preparation for market.

During the past biennial period a study of these deposits has constituted one of the principal lines of investigation undertaken by this Bureau. The field work has been completed and the report will soon be available for distribution.

Special effort has been made in this work to show the geologic features which have been instrumental in the location of the ore bodies and in affecting the commercial grade of the ores. Through detailed studies of the developed properties, the characteristic occurrence and geologic relationship of each type has been described. By comparison, the observations on the developed properties may be utilized in a study of the undeveloped properties in the State, and through such comparison it is possible for the property owner, mining engineer, or investor to determine the type of ore, and the probable extent and grade of the deposit.

The report includes chapters covering: (1) a history of iron mining in Missouri; (2) the geology and topography of the iron bearing region; (3) types of Missouri iron ores; (4) geology of the brown hematites; (5) geology of the red hematites (sink deposits); (6) geology of the red and specular hematites associated with the granites; (7) detailed descriptions of individual deposits in each county; and (8) observations on commercial conditions.

In addition to a general geologic map showing the location of the various kinds of ores, thirteen county maps have been prepared showing the location of the known deposits in each.

LEAD AND ZINC.

The report on the disseminated lead deposits of St. Francois and Washington counties, which was completed by my predecessor during his administration, was published and became available for distribution during the early part of this biennial period. This report, of which Part I is manuscript and Part II illustrations and maps, discusses in detail the geology and ore deposits of the most important lead mining district of the State. The position of the ore bodies with reference to the various geological formations is given in the case of nearly every important mine in the district and every phase of ore concentration is shown. The dependence of concentration of the ore bodies on zones of faulting and jointing and other geological features is well illustrated. This report which

is the most complete of any yet published by this Bureau covering the lead deposits of the State, has created an active demand for work in the outlying districts of Madison, Franklin and Jefferson counties.

During this biennial period geologic mapping has been carried on intermittently on what is known as the Aurora sheet. This area, which comprises a part of Jasper and Lawrence counties, extends from three miles east of Carthage to the Christian county line and from north of Mt. Vernon to Monett, including the mining camps of Aurora, Sarcoxie, Reeds, Stotts City, and Wentworth. In all it embraces an area of approximately 550 square miles.

At present, mining in these camps is restricted to a comparatively small area, a majority of the intervening territory not having been prospected. The commercial ore bodies of this district have been shown to be closely related to certain geologic features. The present investigation will show these geologic features throughout the unprospected territory and will serve to indicate the most favorable areas for prospecting.

During the past biennial period a complete topographic map of this region has been made in co-operation with the U. S. Geological Survey and the geologic mapping is now more than two-thirds completed.

COUNTY REPORTS.

In addition to the investigations of special economic resources, such as iron ores, building stones, lime, cement, and lead and zinc, the Bureau has in preparation a series of county geological reports. Ultimately each county in the State should be mapped in detail and a report prepared descriptive of its geology and mineral resources. Such reports bring together in a single volume all the facts pertaining to our most important political unit—the county. In pursuance of this plan, the mapping of Jackson and a part of Phelps counties has been started during the past biennial period.

Jackson county—The rapid growth of Kansas City and its suburbs has created a strong demand for structural materials in the form of brick, terra cotta, building stone, lime and cement. Many of the shales, clays and limestones occurring in Jackson county are suitable for use in the manufacture of these materials, and in order that accurate knowledge concerning their distributions and serviceability may be had, a detailed study of the geologic formations underlying this county has been made during the past year.

The geologic mapping indicates accurately the distribution of the clays, shales and limestones. Samples of each have been collected and are now being tested in the laboratory. These tests include complete chemical analyses of the shales, clays and limestones, and burning and shrinkage tests of the shales and clays.

Within the limits of Kansas City, the work is being done on a map having a scale of 200 feet to the inch, the topographic base having been furnished by the Engineering Department of that City. Large scale work of this character is of special value to the Park Commissioners and Engineering Department, as the depths of the various limestones and shales at any point in the City can be computed from the map. The approximate cost of excavations for sewers and other purposes, and preliminary estimates on road building may be computed from this map without sinking test pits or doing extensive field work.

Phelps county—Geologic mapping in Phelps county, including the area embraced by the Rolla quadrangle, the topographic map of which was completed last year, has been started.

The results of geologic work undertaken by the St. Louis and San Francisco Railroad, for the purpose of outlining the most favorable points for drilling a number of deep holes to determine the occurrence of lead or zinc in the lower portion of the Gasconade formation, were given the Department. This work has shown an area of pronounced faulting south of Newburg and drilling is now in progress along this zone.

Using the results of the Railroad Company as a nucleus, mapping has been continued by the Bureau with the view of issuing a bulletin covering the stratigraphy and geologic structure of the Rolla quadrangle. This area is so situated as to be typical of a large part of the central Ozark region. An outline showing the faulted area south of Newburg and a brief descrtiption of the formations occurring in the immediate vicinity is given on page 55.

RECONNAISSANCE WORK.

Scattered throughout the Ozark region, outside of the developed areas, occur numerous prospects of lead, zinc, clay and iron. It has been impossible with the funds heretofore available to undertake detailed studies of these areas and this office has had little information regarding these deposits. During the past field season, Mr. V. H. Hughes has spent considerable time visiting reported prospects throughout the Ozarks in order to determine the more important areas for future work. This reconnaissance work

has shown a number of deposits which warrant more detailed investigation. On page 36 Mr. Hughes has described a number of the localities visited during the season.

CHEMICAL LABORATORY.

As a result of the field work done by the Staff, many samples are collected each year which require chemical analyses in order to determine their commercial value. The Bureau also received hundreds of samples from citizens of the State who desire to know their value. Many of these require careful analyses and the chemist of the Survey has devoted his time partly to analyzing such ores, clays, mineral waters, limestones, tripoli and glass sand. A number of these analyses are given in another part of this report. A greater part of the work, however, is directly connected with the systematic investigations being carried on by the Bureau, and the analyses will be included in the regular reports.

LIBRARY.

Through the medium of exchange with other Geological Surveys and scientific societies, the Bureau has collected a library of several thousand volumes. These volumes are devoted mainly to geology and mining and are of importance for reference in the work of the Department. Approximately 350 volumes have been added during the past two years.

As mentioned in the report of this Bureau to the 45th General Assembly, many of the reports of the scientific societies of American and Europe, as well as the technical journals, often consist of several parts and are received in an unbound condition. In order that these reports may be made of the greatest value, they should be bound and so indexed as to be available for ready reference. This could be done at a cost of approximately $1,000.

MUSEUM.

The Bureau has a geological museum of several thousand specimens consisting of samples of ores, rocks and fossils occurring in various geological formations of this State. These specimens are of great value to one desiring either a knowledge of the grade of ores mined in the State or a knowledge of the general nature and association of the various minerals and rocks. They are of special importance to the members of the Survey Staff as a means of comparison with ores from new or undeveloped localities.

During the past biennial period approximately 400 specimens have been added to the museum, including the most representative collection of Missouri iron ores ever brought together. These specimens include every variety of iron ore known to occur in Missouri and constitute an extremely valuable addition to the museum.

The Director of the Bureau has been placed in charge of the Department of Mining and Forestry at the State Fair and a representative collection of rocks and minerals has been placed on exhibit at Sedalia.

A portable collection of rocks, minerals and clays has been made up and has been exhibited at Springfield, Independence, Moberly, Joplin and St. Louis during the past year. This exhibit includes samples of all ores and stones being mined or quarried in Missouri and has an important educational value.

TOPOGRAPHY.

Topographic mapping during the past biennial period has been carried on in co-operation with the United States Geological Survey, which organization provides not only its trained men, but also pays one-half of the cost of field mapping. The plates from which the maps are printed are engraved at Washington without cost to the State, and electro-types from these plates are furnished to the Bureau without cost.

Under the terms of this agreement, the areas to be mapped are designated by the Board of Managers of this Bureau, while the actual field operations are under the direct supervision of the Director of the U. S. Geological Survey. The scale of work is agreed upon through a conference of representatives of both Departments, and depends upon the economic importance of the area and its surface relief. The mapping during the past biennial period was on a scale of one mile to the inch, with a twenty-foot contour interval.

As there is, at the present time, only a comparatively small portion of the State covered by accurate maps, the Board has placed this work in areas in which there is the most urgent need for geology and topography.

During the past biennial period the Rolla and Aurora sheets, covering an area of approximately 725 square miles, were completed. Field work covering the Green City and Queen City sheets located in Putnam and Schuyler counties is now under way. These sheets comprises an area of 550 square miles and include one of our most important coal mining areas. The Aurora special sheet in-

MISSOURI GEOLOGICAL SURVEY
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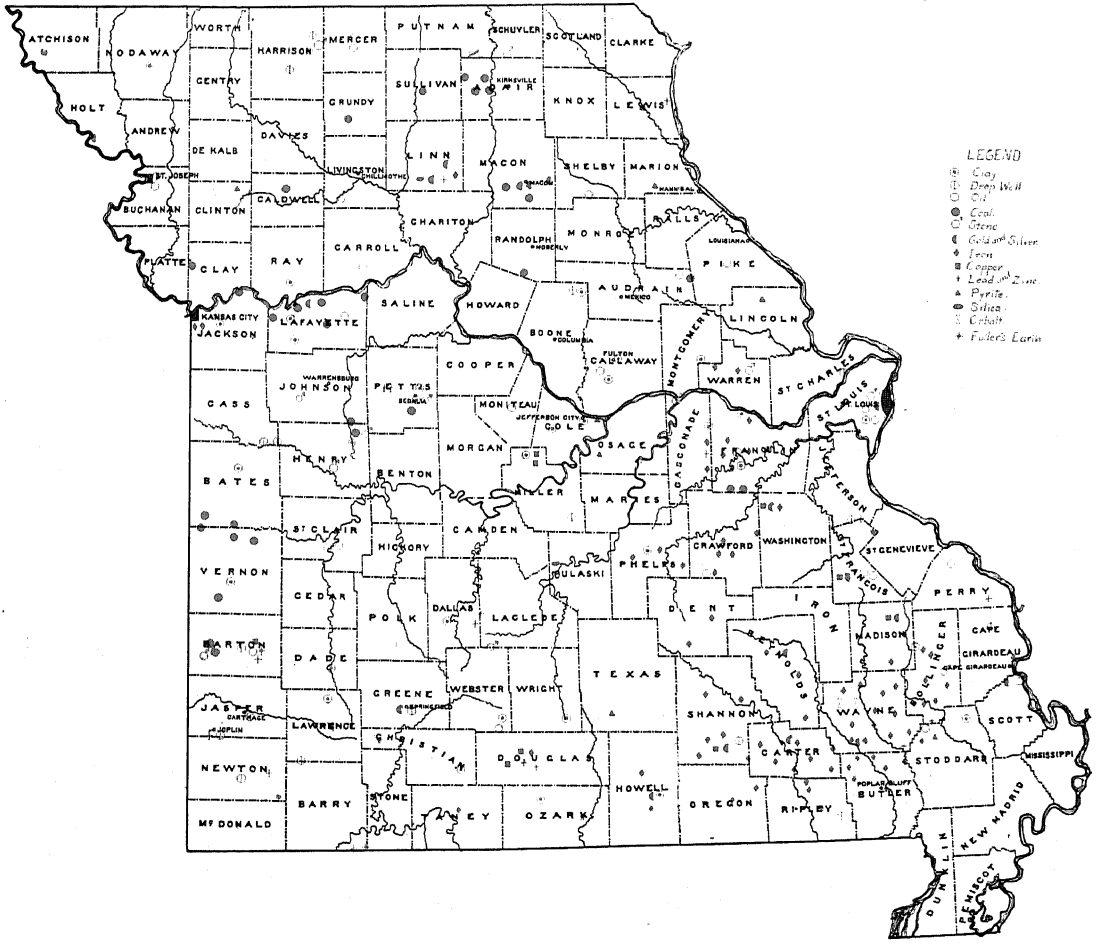
Outline map showing localities from which samples were received for analysis or test.



cludes the lead and zinc mining camps of Wentworth, Stotts City, Sarcoxie, Reeds and Aurora.

Traverse work has also been completed on the Bevier and Lexington quadrangles. The topographic maps of these areas were published by this Bureau prior to 1898 and the entire editions have long since been exhausted. The culture is being brought up to date before a new edition of these maps is published.

The total area completed during the past two years was 650 square miles, while the field work was partially done on 550 square miles and the culture brought up to date on 460 square miles. This work includes 150 miles of primary levels, 180 miles of secondary levels, 300 miles of primary traverse, and 3,240 miles of secondary traverse. Thirty-two bench marks were established.

There have been engraved and printed during this biennial period the Macon, Higdon, Weingarten and Leavenworth sheets.

INFORMATION BUREAU.

One of the principal objects of a Bureau of this character is that the citizens of the State and country may have the opportunity of obtaining reliable and unbiased information concerning the mineral resources of the State. The small land owner usually lacks the required funds to undertake extensive prospecting or development work without a reasonable assurance of success.

Therefore, the most important function of the Survey is to obtain, tabulate and furnish such information upon request from engineers, miners, investors, and land owners.

Inquiries are received covering every conceivable subject and in each instance the data at hand are given in as great detail as possible. In order that we may answer these requests fully, it is important that we have the data in the office. It frequently happens that this Bureau does not have the observations necessary to give the required information, in which case, we endeavor to send an assistant to the locality as soon as possible in order that an intelligent answer may be given to the inquiry.

Samples collected and submitted for test from undeveloped properties are received almost daily. The localities from which specimens were received and collected during the past biennial period is well shown on plate No. 1. This map indicates that the people are availing themselves of the services of this Bureau to a greater degree than formerly.

Prospective investors usually desire complete information cov-

ering one of our resources; as for example, lead or zinc, iron, clay, building stone, etc. In answer to such requests our reports are sent, where they will cover the inquiry. Requests are continually received for many of the reports published prior to 1900. These volumes are out of print and can now be obtained only through second-hand book stores.

There is a constantly increasing demand for these publications. The following table indicates the distribution of the reports and maps during the past biennial period:

	No.
Vol. 13	152
Vol. 12	5
Vol. 1	250
Vol. 2	272
Vol. 3	239
Vol. 4	344
Vol. 5	420
Vol. 6	594
Vol. 7	473
Vol. 8	462
Vol. 9	1134
Biennial report (45th)	1200
State Geological Map	900

At the present time the following reports are available for distribution and will be forwarded to any citizen upon receipt of transportation charges:

	Postage.
Preliminary report on Structural and Economic Geology, Vol. XIII, 1900, by John A. Gallaher	25c
Geology of Miller Co., Vol. I, 2nd series, E. R. Buckley, A. F. Smith and S. H. Ball	15c
The Quarrying Industry of Missouri, Vol. II, 2nd series, 1904, by E. R. Buckley and H. A. Buehler	40c
Biennial Report of the State Geologist to the 42nd General Assembly, by E. R. Buckley	10c
The Geology of Moniteau Co., Vol. III, 2nd series, 1905, by F. B. VanHorn	15c
Biennial Report of the State Geologist to the 43rd General Assembly, by E. R. Buckley.	10c
Geology of the Granby Area, Vol. IV, 2nd series, 1906, by E. R. Buckley and H. A. Buehler	20c
Biennial Report of the State Geologist to the 44th General Assembly, by E. R. Buckley.	10c
Public Roads, Vol. V, 2nd series, by E. R. Buckley	15c
Lime and Cement Resources of Missouri, Vol. VI, 2nd series, 1907, by H. A. Buehler	25c
Geology of Morgan Co., Vol. VII, 2nd series, 1908, C. F. Marbut	15c
Geology of Pike Co., Vol. VIII, 2nd series, 1909, by R. R. Rowley	15c
The Geology of the Disseminated Lead Deposits of St. Francois and Washington counties, Vol. IX, 2nd series, 1909, by E. R. Buckley	45c
Geological State Map	10c

CHAPTER II.

FUTURE WORK OF THE BUREAU.

As planned, at present, the geologic work of the Bureau during the coming biennial period will include a continuation of the following partly completed investigations: (1) a study of the coal deposits, (2) the mapping of areas favorable to the occurrence of lead and zinc, (3) a study of the structure of northwest Missouri showing areas most favorable for the prospecting for oil and gas, and (4) county mapping. Although these investigations are among the most urgent, there are others of equal importance that should be given early attention. The publication of data showing the extent of the known deposits of clay, barite, copper, tripoli, cobalt and nickel; the geological formations in which they occur and their location with respect to transportation and markets would not only outline the more favorable localities for prospecting and development, but would greatly assist in eliminating the continual waste of time and money spent in useless research in areas where there is little or no hope of success.

The following brief outline indicates a number of lines of investigation, covering which the survey has no publications available for distribution:

CLAY DEPOSITS.

Missouri is surpassed by few, if any, of the States in the variety and value of her clay deposits, although the extent and importance of the industries based upon their utilization is scantily appreciated by the citizens of the State. In fact, the extent of the undeveloped deposits is hardly comprehended and the possibilities of a more general development of the industries is largely unrecognized.

During 1896 this Department issued a report on the clay deposits, but the demand for this volume was so great that the edition was exhausted before 1900. The constant demand for this report and for information concerning deposits which were not at that time known makes it desirable that a revised edition be published at an early date.

The Coal Measures are composed largely of shales, many of which were not given special attention in the former report. Extensive and valuable deposits of fire clay also occur in the coal mines of the State. The large area over which these shales and fire clays are found as well as their adaptability for use in the manufacture of different clay products makes this an important part of the investigation leading to a revision of that report.

Deposits of kaolin occur not only in Cape Girardeau, Bollinger and adjoining counties but also in the central and southwestern Ozark region. These deposits should be studied in order that suitable methods of treatment may be outlined through which the sand and iron oxide occurring in many of the deposits may be eliminated.

Burning tests, chemical and rational analyses should be made of the clays from all deposits of commercial value. The extent to which there is a demand for this work is indicated by the number of analyses made during the past year in the laboratory of the Survey. A number of the results are given on page 64.

BARITE.

Approximately 50 per cent of the barite mined in the United States comes from Washington county, Missouri. This mineral has, however, rather a wide distribution throughout the south central portion of the State, where it occurs imbedded in the residual surface clays and in veins which frequently extend to considerable depth. It is usually associated with galena and is found chiefly in the geological formations of the Cambrian.

Barite is utilized extensively in the manufacture of white paints and in a number of other industries.

A report should be prepared showing the distribution, geologic association and commercial possibilities of this mineral, which is so little known outside of the immediate districts in which it is mined.

COBALT AND NICKEL.

During the past few years Missouri has been the chief producer, in the United States, of the semi-rare metals, cobalt and nickel; an extensive deposit of these ores having been developed near Fredericktown in Madison county. Similar deposits also occur on the Mine Lamotte tract but they have never been mined for these metals, which have only been recovered in small amounts as a by-product in the smelting of the lead ore with which they are associated.

In geologic position, the ore is apparently closely related to the granites and porphyries of the district, being found in the Bonneterre limestone and Lamotte sandstone near their contact with the igneous rocks. Geological conditions similar to those near Fredericktown occur over a large area in Madison county. Accurate geologic mapping would indicate the areas in which such contacts occur, and would serve as a most valuable guide to future development work.

SAND AND GRAVEL.

The St. Peters sandstone furnishes the pure white sand used in the manufacture of plate glass at the large factories located at Valley Park and Crystal City. This formation outcrops over a rather irregular area extending through several counties in the eastern portion of the State. It has been mapped in Franklin and Jefferson counties from Labadie on the Missouri river to Crystal City on the Mississippi river. This work should be extended to the south through Ste. Genevieve, Perry, and Cape Girardeau, and north through St. Charles, Warren and Montgomery counties, in which areas this formation is known to occur. In addition to a study of the glass sands, the deposits of building sand and gravel should be investigated. The output from these deposits has a value of about $1,000,000 annually.

TRIPOLI.

Extensive deposits of tripoli occur throughout the western portion of Newton county, Seneca being one of the most important centers of production in the United States. This material, which is a partially decomposed flint, is used extensively in the manufacture of filters and polishing powder.

Deposits having a similar chemical composition, which are locally known as "silica" occur in Ste. Genevieve, Perry and other counties of southeastern and central Missouri. The accurate locations of such deposits of tripoli would materially assist in their future development.

COPPER.

Ores of copper have been found throughout the Ozark region and have been mined and smelted intermittently near Sullivan, Eminence, Ste. Genevieve, and Fredericktown. They are frequently encountered with the iron ores of the central Ozark region

where with depth this ore appears to be quite persistent. Copper is also found to some extent in the disseminated lead district but no special endeavor is made to separate it.

These ores occur under different geological conditions and are associated with several geological formations. They have never been studied in detail by the State Survey, although a complete report would serve to indicate the various modes of occurrence and the possible future of the industry.

MINERAL PAINTS.

Ocherous iron ores, ground limestone, lead and zinc ores, ferruginous clays, and barite are all used in this State in the manufacture of mineral paints, the total output being valued at more than $1,500,000 annually.

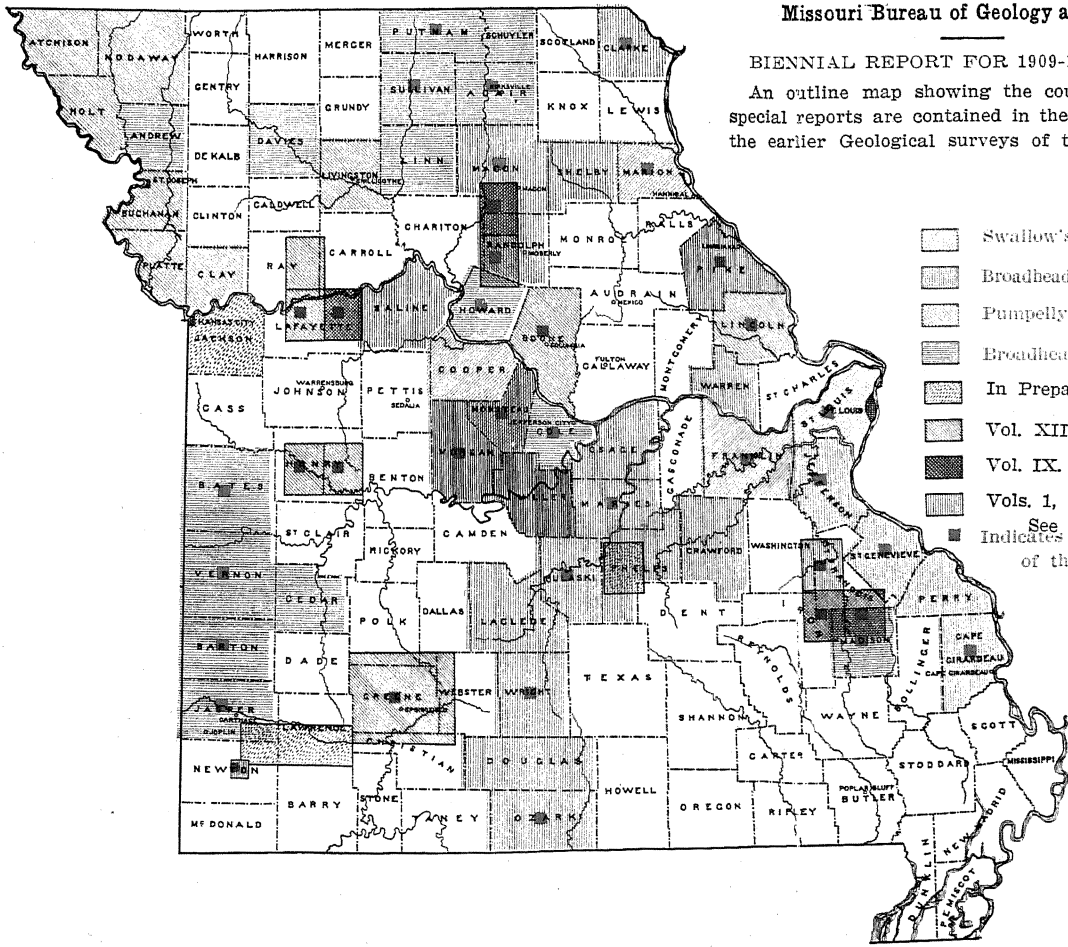
The chemical and physical characteristics requisite for each of these raw materials, their distribution and occurrence, the processes necessary in the preparation for market, and the demand for and uses of each of these pigments should be included in the text of a report covering these industries.

DEEP DRILLING.

In conjunction with the work on oil and gas and the investigation covering mineral waters, the Department should devote more attention to obtaining accurate records of deep well drilling. These records not only serve to show the nature of the geological formations penetrated, but provide a fund of information relative to the underground waters of the State; a factor of the greatest importance to every city and village. This information is now obtained only through correspondence. One assistant should be employed to visit each well being drilled and arrange to obtain cuttings, and samples of water, from which a complete record may be compiled.

COUNTY REPORTS.

As shown on the accompanying map, there are 53 counties of which there has been no detailed or reconnaissance reports published. At the present time, detailed reports covering Miller, Morgan, Moniteau, Pike and parts of Washington, St. Francois and Newton counties are available for distribution. Similar reports covering Greene, Lincoln, and parts of Henry, Lafayette, Ray, Randolph, Chariton, and Macon counties have been published but are now out of print. The reports covering the remaining counties



Missouri Bureau of Geology and Mines.

BIENNIAL REPORT FOR 1909-1910, Pl. II.

An outline map showing the counties of which special reports are contained in the publications of the earlier Geological surveys of the State.

- Swallow's Report of 1855.
- Broadhead's et al. Reports of 1871.
- Pumpelly's Report of 1872.
- Broadhead's Report of 1873.
- In Preparation.
- Vol. XII.
- Vol. IX.
- Vols. 1, 3, 4, 7, 8, 9.

See Series.

Indicates that maps are printed of the respective counties.

MISSOURI GEOLOGICAL SURVEY
H.A. BUEHLER, STATE GEOLOGIST.

Outline map showing areas in which topographic mapping has been done.

consist mainly of very brief descriptions of the geological formations and are the result of reconnaissance work done by the Geological Survey at an early date. They are not in sufficient detail to be of great economic value.

A detailed geological report should be made of every county in the State. The value of such areal reports lies in the fact that they assemble in one volume all the available data covering, not only, the geology and surface features but the occurrence and value of the deposits of ores, clay, stone, mineral waters, and other materials of economic value.

The Department has recently completed the field work in Jackson county and is mapping areas in Lawrence, Jasper and Phelps counties. Similar work should be undertaken in other parts of the State as rapidly as the appropriation will permit.

TOPOGRAPHY.

Accurate topographic maps are continually sought for by engineers, land owners, educators, and investors. The ordinary county or State map is usually compiled from office records which frequently do not correspond to actual locations in the field. As the State becomes more thickly settled and land lines are a matter of ever increasing importance, the demand for accurate maps is greatly increased.

The topographic maps made by this Department in co-operation with the United States Geological Survey are compiled from actual field surveys. Each forty acre tract is accurately surveyed, giving every cultural and natural feature of prominence. The importance of such maps cannot be over-estimated. They touch almost every phase of public and private interest, and are by far the most accurate maps published. The low price (five cents each) makes them available to every citizen.

The map opposite indicates the area of the State covered by detailed and reconnaissance maps. The latter were made some twenty years ago and are only intended to show the more prominent features of the country. The detailed maps are made with much greater accuracy.

Through co-operation with the United States Geological Survey the cost to the State of preparing these maps is about one-third of what it would be, were the State to undertake their preparation independently. Under the terms of this agreement, the Federal Government not only pays one-half of the actual field expenses and

one-half the cost of drafting, but also undertakes the engraving and printing without cost to the State.

While a number of States have made complete topographic maps covering their entire area and others have such surveys nearing completion, Missouri only began this work on a comparatively small scale four years ago. The importance of our water resources, mining interests, drainage projects, forestry problems, soil surveys, and other natural resources has created a strong demand for these maps and additional areas should be mapped as soon as possible. It is planned to extend this work near our important mining and commercial centers as rapidly as funds will permit.

APPROPRIATION NECESSARY.

On the foregoing pages a few of the important problems awaiting the attention of the Bureau are indicated. These problems do not include mention of the educational work of the Department, the preparation of mineral collections for High Schools and Colleges, the gathering of mineral statistics, nor the preparation of general reports covering the detailed study of many of our geological formations, which studies are very necessary in order to obtain the proper facts upon which to base deductions. Each of these subjects should be given more attention.

It is evident that with the appropriation heretofore available the majority of these problems can be given only passing consideration for many years to come. The rapidity with which complete results may be obtained will depend entirely upon the appropriations granted the Department. The results should be made available to each industry as soon as possible.

The service which the Bureau has already rendered the State in the rational development of our mineral industries cannot be estimated. That its reports are of material assistance is indicated by the continual demand for each of the volumes published. That the advice of the Bureau is valued is indicated by the almost daily requests for every kind of information.

As shown by statistics covering the output of our mineral resources, the total production of our mines, quarries and clay plants has increased from a value of $13,000,000 in 1898 to approximately $45,000,000 in 1908. This increase during the past decade has greatly increased the demands upon the Bureau, which is at present operating on almost the same appropriation received ten years

ago. During this time every mining, clay working and quarrying territory in the State has been greatly expanded.

In order that we may not only keep in touch with this development, but may precede it by pointing out those geologic features of especial importance in prospecting, the Department must materially enlarge its activities. It must place more assistants in the field if it is to be of the greatest help to the mining industries of the State.

We, therefore, earnestly recommend that the following appropriation be made for the work of this Department during the next biennial period:

Support	$40,000.00
Publications	5,000.00
Topography	20,000.00
Total	$65,000.00

THE PRINCIPAL COAL FIELDS OF NORTHERN MISSOURI.

BY HENRY HINDS.

Recognizing the importance to the country at large, as well as to the citizens of the State, of the coal deposits of Missouri, the Missouri Bureau of Geology and Mines, early in 1910, entered into negotiations with the U. S. Geological Survey at Washington for co-operation in making a systematic study of the coal fields of Missouri. It was arranged that the expense of this undertaking should be shared equally by the two organizations and the author was detailed by the Federal Survey to take charge of the field work, with F. C. Greene of the State Survey as assistant. Under an arrangement previously made between the State Geologist and the Technologic Branch of the U. S. Geological Survey, coal samples had been collected from the principal coal mining centers of the State and the chemical analyses and thermal determinations made of these samples are to be incorporated in the final report on the coal deposits.

During the field season of 1910, work was carried on in northwestern Missouri by F. C. Greene and in north-central, central and west-central Missouri by the Author. Mr. Greene's investigations were confined chiefly to that part of the State that contains rocks of the upper Pennsylvanian age. The writer visited the remainder of the potentially productive coal territory of northern Missouri, consisting of all or in part of the following counties: Harrison, Mercer, Putman, Schuyler, Scotland, Clark, Grundy, Sullivan, Adair, Lewis, Livingston, Linn, Macon, Shelby, Clay, Ray, Carroll, Chariton, Randolph, Monroe, Ralls, Lafayette, Saline, Howard, Boone, Audrain, Callaway, and Montgomery. Geological features were noted, available drill records obtained, and all active coal mines entered and examined. Efforts were made to determine the area underlain by each coal bed, the conditions affecting its commercial adaptability, and its geological relationships. The present article is merely a brief and incomplete abstract of the facts ascertained, full details being reserved for the final report that will be issued when the entire coal area of the State has been examined.

All coal found in northern Missouri forms part of the Pennsylvanian series of the Carboniferous system and this series embraces the youngest indurated rocks of the State. The Pennsyl-

vanian is classified on lithologic and economic grounds as consisting of an upper group called the Missouri and a lower group known as the Des Moines. The Missouri group is distinguished by an abundance of limestone and contains little coal of importance. The Des Moines group is now usually regarded by Missouri geologists as consisting of three divisions; viz, the Pleasanton shale above, the Henrietta limestone and shale next below, and the Cherokee shale at the base. The Pleasanton contains very little coal and, in northern Missouri, is a succession of sandstones and shales ranging in thickness from 100 to 150 feet. The Henrietta, which is from 50 to 90 feet thick, is rendered more or less distinct from the Pleasanton and Cherokee by the greater amount of limestone it contains. The Henrietta bears important, though thin, beds of coal, and these are extensively mined in Lafayette, Ray, Putnam, and other counties. Henrietta coals excel for domestic purposes and are comparatively free from iron pyrites, though always showing white scales of gypsum and calcite along the joint planes. They are all overlain by black fissile shale, known to miners as "slate," and this in turn by limestone caprocks. The roof of the coal is invariably strong and often ideally adaptable to the long-wall system of mining. Henrietta strata show marked persistency over wide areas. The Cherokee consists chiefly of shale, sandstone and clay, with a very little limestone and some important coal beds. The upper portion of this formation contains most of the coal now mined and the strata that are persistent in lateral extent; the lower portion contains basin deposits of considerable irregularity of thickness and lithological characters. Cherokee coal beds are best adapted to steaming purposes, are of all thicknesses up to six feet, and commonly have shale roofs of doubtful stability. The Cherokee lies unconformably upon the irregular upper surface of the Mississippian limestones and its thickness is variable.

The coal fields of chief commercial importance in northern Missouri are: Bevier, Lexington, Novinger, Mendota, Marceline, Vandalia, and Cainesville.

THE BEVIER FIELD.

This field is one of the most important in Missouri, containing as it does the Bevier coal, a bed of wide areal extent and fair thickness. In a broad sense, the workable portion of this bed is bounded on the east by the Wabash railroad from Macon City through Moberly and Centralia to Columbia, on the north by the Hannibal &

St. Joseph division of the Burlington system, on the west by the Middle Fork of the Chariton river, and on the south by an irregular line passing through Salisbury, Yates, Russel, Harrisburg and Columbia. An important tongue of the Bevier coal projects beyond Middle Fork into the northeastern corner of Chariton county, but is mined only at one place; viz, Fish Trap Ferry on the Chariton river. It is very probable that future prospecting will reveal workable outliers of the Bevier bed north and east of the boundaries named above. By no means all of the land within this territory is underlain by the Bevier bed; the coal has been cut out in the valleys of the main streams by pre-glacial drainage channels at numerous points, and by a channel of Pennsylvanian age in central Randolph county. These points will be brought out much more fully in the final report by means of maps and descriptive text.

The northern portion of this field, the Ardmore District in Macon county, is the most important, both because a greater quantity of coal is mined there than in any other single district in the State and because the coal is slightly thicker than farther south. The average thickness of the bed is 4 1-2 feet, though it is in places one or two feet above or below this average. A clay band averaging two inches in thickness splits the coal about one foot from its base. Locally this band becomes hard and arenaceous and thickens so as to become somewhat troublesome. At Lingo, where a detached area of the Bevier bed was formerly mined, this thickening of the clay band was especially notable. The roof of the Bevier bed in the Ardmore district is a sandy shale or a sandstone, changing abruptly from one to the other. The sandstone makes a firm roof, but has a tendency to cut down into the coal so as to make the thickness of the latter variable. The shale roof is of fair stability when proper precautions are taken.

One other bed, the Macon City coal, is of present economic importance on the eastern border of the Ardmore district. It lies from twelve to thirty feet above the Bevier and is about two feet thick. It is mined in and near Macon City, where it is of excellent quality and possesses a very strong roof. Other coal beds known to occur in this district will be described in the final report.

The Huntsville District of the Bevier field occupies the northwestern quarter of Randolph county west and north of the Wabash railroad, and the adjoining edge of Chariton county as far west as Salisbury. The coal of the Bevier bed is slightly thinner here than in the Ardmore district, averaging three and one-half to four feet, but is otherwise similar. Mining centers are Huntsville and Kim-

berly. Mining at Salisbury has not proved very profitable because of the thickening of the clay parting in the Bevier bed at that point. The Macon City coal is not mined within the limits of this district, though local trade is supplied from the same or a very similar bed at points near the M. K. & T. railroad between Moberly and Paris.

The Higbee District of the Bevier field lies in the south-central portion of Randolph county, west of the Wabash railroad, and the northeastern corner of Howard county. It is separated from the Huntsville district by a channel of late Pennsylvanian age in which the coal is replaced by sandstone and shale. The Bevier bed has been opened by shipping mines at and near Higbee, Yates, Elliott, Renick and Russel, and averages three and one-half feet in thickness with the usual thin clay band in its lower half. The roof is not quite so strong as in the northern districts, being an argillaceous shale that requires careful attention. The Macon City coal is mined at Renick, where it is eighteen inches thick and has an excellent roof of firm black shale overlain by a limestone cap-rock.

The Columbia District of the Bevier field is the continuation to the southeast of the Higbee district. The Bevier coal, averaging three to three and one-half feet in thickness, underlies the divides in the northwestern quarter of Boone county. Mining for local trade is prosecuted near Harrisburg, Rucker, and other points, and in a slightly more extensive manner near Columbia. Mining conditions are much the same as in the Higbee district, yet the Boone county area has not received the attention it merits. Improvement in railway facilities may mean more extensive mining of the coal. Another coal, about two feet thick and forty feet higher than the Bevier, underlies the higher lands of the district, while an eighteen-inch bed lies, at least locally, a short distance below the Bevier coal.

THE LEXINGTON FIELD.

The Lexington coal field equals the Bevier field in present importance, in spite of the fact that its only coal bed averages little more than twenty inches in thickness. This coal, the Lexington bed, is of excellent quality, as will be shown when analyses are published, can be mined very economically, and is located near large centers of fuel consumption. The roof of the coal is a strong limestone, in many localities separated from the coal by a thin stratum of black fissile shale ("slate") that can be conveniently taken down to make the requisite height along the face and used to build gob walls.

The Richmond District includes that portion of the Lexington field lying north of the Missouri river bottoms; viz, all of Ray county, except perhaps the northeastern corner, and at least the southeastern quarter of Clay county. The status of the Lexington coal bed in the remainder of Clay county and in Caldwell county will be discussed at a future date. In the greater part of the district the coal lies in two benches with limestone resting on the coal, thus:

	Ft.	In.
Limestone	5	..
Coal, pyritiferous (top coal)	0	5
Clay	0	2
Coal, clean (bottom coal)	1	7

This type of bed is found at and near Richmond, Vibbard, and Knoxville. In places, notably between Swanwick and Richmond and near Lakeview, the top bench is irregular or lacking and more rarely the upper portion of the bottom bench is absent. When traced from Richmond to Camden the top coal gradually disappears, its place being taken by black shale. At Camden, Fleming, Orrick, and Missouri City, the following is the average section:

	Ft.	In.
Limestone	7	..
Shale, black ("slate")	0	10
Coal	1	9

There is a vast amount of coal in the Richmond district still untouched.

The Higginsville District of the Lexington field includes all of Lafayette county except the eastern edge and the southeastern corner, where the country is topographically too low to contain the Lexington coal bed. In this southeastern corner, however, there is a lower coal called the Mulky bed, much like the Lexington bed in thickness and character; while at Waverly, in the northeast corner of the county, is a large basin of still lower coal that is four feet thick and has a roof of thick shale. The Lexington bed of the Higginsville district was cut out and replaced by sandstone and shale in an ancient channel several miles broad that lies between Lexington and Dover and extends thence southward to beyond Higginsville; and it has been removed more recently from the valleys of the major creeks. East of Lexington the coal is the same as at Richmond, being in two benches. At Dover the coal is as at Lakeview, in two benches but subject to rather abrupt and irregular thinnings. South and west of Lexing-

ton, where the most extensive mining is conducted, the coal bed is the same as at Camden, though the black shale between the coal and the limestone is a few inches thicker. West and south from Wellington and south from Lexington the thickness of coal decreases gradually, so that at Napoleon it is only seventeen inches and at Mayview only sixteen inches. Northwest and southwest of Odessa there is only from ten to sixteen inches of coal. Near Higginsville the coal is of the Camden type, but is only from fourteen to eighteen inches in thickness. The excellence of mining conditions, however, the superior quality of the coal, and the advantageous location of the town as regards shipping facilities have caused extensive mining to be prosecuted near it. Near Corder the thickness of the coal averages twenty-one inches, though somewhat decreased locally by "horsebacks." North and south of Corder there is a considerable area of coal land practically untouched.

THE NOVINGER FIELD.

The Novinger field is the third in importance in northern Missouri in point of present production. As now known, it embraces the northwestern quarter of Adair county, reaching its fullest development in the neighborhood of the Iowa & St. Louis railway between Youngstown and Connellsville, where the coal worked is reached by slopes and shafts. It is probable that future prospecting will reveal lucrative basins of coal between the Novinger and Bevier fields. The average section of the bed mined at Novinger and Connellsville is:

	Ft.	In.
Shale	..	..
Coal	2	2
Clay	..	0 ½
Coal	..	4
Clay	..	1
Coal	1	..
Total coal	3	½ ft.

This coal is excellent for steaming purposes, is very hard, and somewhat dirty at top and bottom. The shale roof requires rather careful attention. The long-wall method of mining is being introduced as an experiment: its success would mean that a great impetus would be given to mining in this and similar fields. East of Novinger, near Kirksville, the shale over the coal is replaced by a sandstone that has a very uneven under-surface, cutting down badly into the coal in rolls. Under Kirksville itself, the Novinger bed is so thin as to be unworkable. West of Novinger, at Danforth, a trou-

blesome "bench rock" splits the coal and thickens towards the west. At Stahl the Novinger bed is thirty inches thick, and a short distance west, at Dewey, it is still thinner. No systematic prospecting has been done between Dewey and Milan, the next point west at which coal is known to occur.

A coal bed that is from twenty-four to thirty inches thick lies about fifty-five feet below the Novinger bed, but no coal has yet been taken from it. The bed now mined at Stahl lies about ninety feet above the Novinger coal and will be mentioned under the next heading.

THE MENDOTA FIELD.

The Mendota field includes practically all of Putnam county, the northwestern corners of Schuyler and Adair counties, and the northeastern quarter of Sullivan county. There is a vast area of undeveloped coal land in this field, the value of which is scarcely realized. The coal present constitutes the southern extension of the bed termed the Mystic coal in reports of the Iowa Geological Survey, a bed that produces near Mystic, Centerville, Cincinnati and Seymour nearly one-fifth of Iowa's large coal output. In Missouri this bed is easily reached by drifts in the valleys of Blackbird, Shoal and Shuteye creeks, the lower part of Spring creek, and the Chariton river near the Iowa-Missouri line. Numerous small country mines are found in all these localities, but shipping mines are developed only near Mendota, Unionville, Stahl, and Coal City. The following average sections show the thickness of the coal and the nature of the overlying strata in the different districts:

AT MENDOTA AND UNIONVILLE.

	Ft.	In.
Limestone ("cap-rock")	1	6
Shale, drab ("clod")	..	7
Shale, black ("slate")	1	3
Coal	1	7
Clay parting ("mud-band")	..	2
Coal	..	11
Clay parting	..	1
Coal ("Dutchman")	..	1
Total coal	2 ft., 7 in	

AT STAHL.

	Ft.	In
Limestone ("cap-rock")	2	..
Shale, drab (clod")	1	..
Shale, black ("slate")	1	..
Coal	2	..
Clay ("mud-band")	..	2
Coal	..	10
Clay	..	0.½
Coal ("Dutchman")	..	1
Total coal	2 ft., 11 in.	

AT COAL CITY.

	Ft	In
Limestone ("cap-rock")	1	6
Shale, soft ("clod")	..	10
Shale, black ("slate")	1	..
Coal	1	8
Clay ("mud-band")	..	2
Coal	1	1
Clay	..	1
Coal ("Dutchman")	..	3
Total coal	3 ft.	

The coal is excellent for domestic purposes, being rather free from iron pyrites and coming from the mines with a very small percentage of slack and small coal. It is probable that workable basins in lower coal horizons also exist in this field in addition to those of the Novinger bed that are known to underlie the Mendota coal near Stahl. Details will be discussed in the final report.

THE MARCELINE FIELD.

The Marceline field occupies the southeastern portion of Linn county and the adjoining northern edge of Chariton county. Coal is mined rather extensively at Marceline and for local needs at Bucklin, Brookfield, and Rothville. At least three beds of coal are known to underlie this field, only one of which, the lowest and thickest, is utilized to any great extent, though one of the higher thin beds is mined a little near Rothville and Brookfield. A fourth bed, said to be thirty-two inches thick, is reported to lie about seventy feet below the lowest coal now worked. The bed worked is reached at Bucklin by a shaft 228 feet deep and at Marceline by three shafts respectively, 130, 190, and 212 feet deep. It is slightly irregular in thickness, being affected by "rolls" in the r[illegible] and the floor, and averages about twenty-nine inches of coal. It is rather dirty at Marceline and careful cleaning is rendered necessary by the presence of considerable iron pyrites ("sulphur"). The roof is a shale of fair strength. The field is commercially important because it is the only producer of coal along the line of the Atchison, Topeka & Santa Fe railway between Carrollton and Clark county.

VANDALIA FIELD.

The Vandalia field is perhaps better known for its fire clays than for its mineral fuel, yet there is immediately above these

clays a coal bed that is mined in rather a small way at and near Perry, Vandalia, Farber, Laddonia, Martinsburg, and Wellsville. This bed underlies the southwest corner of Ralls county, the extreme southeast corner of Monroe, the vicinity of Wellsville in Montgomery, and all of Audrain county east of a line drawn up the South Fork of Salt river to Mexico and thence southeasterly. Although several beds are known in this area, only one, known as the Vandalia bed, is considered workable. The Vandalia bed is of good quality locally, but contains numerous patches of poor coal where "slips" and "clay seams" are numerous. The roof over the bed is a hard, blue-back shale ("slate") that is lithified in places and bears ovoid concretionary boulders of impure limestone. The average measurement of the coal near Perry, where it is reached by drifts and shallow shafts is:

	In.
Coal	20
Clay	0.¾
Coal	5

In the remainder of the Vandalia field, where the coal is reached by shafts, the deepest of which is 110 feet, the bed worked averages:

	In.
Coal	20
Pyrite	0.¼
Coal	10

The product of this field is consumed largely within its own borders.

THE CAINESVILLE FIELD.

Recent discoveries at Cainesville, in Harrison county, have resulted in the sinking of a deep coal shaft by a strongly capitalized company and a large output may be expected in the near future. The bed that it is planned to work lies nearly 500 feet beneath the surface and is said to be four and one-half feet in thickness. Other somewhat thinner coal beds are also known to be present. This field will be visited in 1911 and described in detail. Drilling at neighboring points in Missouri and Iowa seems to indicate that the prospect of finding basins of valuable coal at considerable depth in this region is decidedly bright. It should be remembered, however, that these deep coal beds are well down in the Cherokee shales and are more likely to be in series of large basins lying at definite horizons than to be blanket beds extend-

ing uninterruptedly over a great expanse of territory. In other words, mining conditions are more apt to be like those encountered in Iowa, in Monroe, Polk, Mahaska and other counties than to be those of the Bevier and Lexington fields in Missouri.

OTHER COAL FIELDS.

Coal is known to be present in beds of moderate thickness at many localities in northern Missouri not already mentioned. Space does not permit of describing them in this brief abstract. The most important of these localities are Milan, Trenton, Melbourne and Fulton. Coal is also found in eastern Clark county and near Chillicothe, Sumner, Carrollton, Keytesville, Blackburn, Slater, Fayette and numerous other points, all of which will be described in the final report. In brief, it may be said that northern Missouri contains immense reserves of coal in beds of fourteen inches to six feet in thickness that are easily accessible. When compared with the amount left undisturbed, the amount of coal already taken out is almost infinitesimal; only near Lexington and Bevier has the depletion of easily available coal lands begun to make itself a problem. As will be more generally recognized in the future, nature has been generous with Missouri in storing great coal reserves, with all that means for commerce and manufacturing, within her borders.

RECONNAISSANCE WORK.

BY V. H. HUGHES.

During the past field season reconnaissance work was undertaken throughout the southern portion of the State in order that the Bureau might have information regarding prospects and mines located in those districts in which detailed geological work has not been done.

The following pages are devoted to a brief description of the more important areas visited and include a number of geologic features which, because of their bearing on the possible development of important mining areas, deserve future detailed work.

Among these, the fractured zone in Taney county, which was mapped for a distance of seventeen miles, shows an area in which lead and zinc ores have been found, but which has not been prospected sufficiently to determine its true value. The region of pronounced folding and faulting found in Crawford county, within which the Davis shale and possibly the top of the Bonne Terre dolomite is exposed, shows an area thought to be favorable for the occurrence of disseminated lead ore. This exposure of the Davis shale is approximately 30 miles west of the exposures in Washington county.

The examination of the known carbonate of zinc deposits occurring in those counties bordering the central portion of the Arkansas State-line indicates that the same geologic conditions exist over an extensive area and that systematic prospecting would develop additional commercial ore bodies.

DALLAS COUNTY.

This county is underlain chiefly by formations of the Cambrian series, which, due to the rough topography, are well exposed over a large part of the area. Those formations noted during this work belong to the Gasconade and Roubidoux, with an occasional outlier of Burlington limestone belonging to the Mississippian.

GASCONADE FORMATION.

This formation is composed of massive beds of cherty and non-cherty dolomite, which varies from a medium to a coarse grained, crystalline texture and usually has a whitish to grayish

blue color on a fresh fracture, while the weathered surface is a dark gray. The chert occurs as heavy beds and as nodules scattered throughout the formation. It is usually white or blue-white in color, although in several instances blue-black chert was observed. Southwest of the village of Wall Street massive beds of oolitic chert were observed near the top of the formation.

At Tunas in the north part of the county, a few beds of sandstone are exposed in the low bluffs occurring along Little Niangua river. These beds occur low down in the Gasconade and probably belong to the Gunter sandstone at the base of the formation. This is the lowest exposure, geologically, observed in the county.

ROUBIDOUX FORMATION.

The Roubidoux formation as recognized in the Ozark region consists of two dolomite and two sandstone members which aggregate 100 feet in thickness. Of these, the upper sandstone member is easily recognized in Dallas county. It underlies the high upland area and attains a thickness of 30 feet. On the undulating table land areas exposures of sandstone are of frequent occurrence along the smaller streams. This is especially true of the prairie area extending westward from Buffalo. In Sec. 34, T. 35, R. 20, where this sandstone has a thickness of 25 feet, it is fine grained, but so loosely cemented that a fresh fragment from the interior of the bed may be reduced to individual sand grains by crushing between the hands. It is white in color and apparently would make a good glass-sand. A pinnacle, known locally as "Lone Rock," situated on a high ridge one-half mile east of Tilden is an erosion outlier of this bed.

BURLINGTON FORMATION.

One or two outliers of the Burlington limestone occur in the western edge of the county. The limestone is blue-gray in color, coarsely crystalline in texture and contains some nodular chert. Residual chert from the Burlington formation is found in many parts of the county, but with the exception of comparatively small outliers the formation has been entirely eroded from this region.

MINING DEVELOPMENTS.

With two probable exceptions, all of the prospects visited in the county are located in the Gasconade formation. Much of the

"float" lead found in various localities throughout the county is undoubtedly residual from that formation.

The following prospects and mines have been worked within the past few years, but none of them are producing at the present time.

James Evans Prospect—This prospect is located in the N. E. ¼ N. E. ¼ Sec. 34, T. 35, R. 20. The forty is traversed from north to south by a small stream, along the east bank of which several shallow shafts have been sunk through residual clay and chert fragments to the solid rock. Large corroded crystals of galena were imbedded in this residual material.

Several thin seams of galena have been found filling joints in the solid dolomite exposed in the stream bed immediately below the workings. A section of the rocks in the immediate vicinity of the shafts shows in descending series:

4 ft. fine grained sandstone.
5 ft. fine, crystalline, cherty dolomite.
4 ft. fine grained dolomite.
4 ft. heavy bedded crystalline dolomite containing small lenses of decomposed chert.

These beds probably belong to the Roubidoux formation.

Henry Booth Shaft—This prospect is located on the south bank of a small branch in the N. W. ¼ S. W. ¼ Sec. 1, T. 35, R. 20. The shaft is 40 feet in depth, the upper 10 feet of which is entirely in residual clay and chert fragments carrying a considerable quantity of galena. The remaining 30 feet of the shaft was driven through solid dolomite, the upper 10 feet of which shows the effect of extensive leaching. The cavities resulting from this leaching process have been partially filled with calcite, together with small amounts of lead, zinc and iron sulphides. These beds do not apparently contain sufficient lead and zinc to warrant exploitation. The lower 20 feet encountered thinly bedded, finely crystalline dolomite which does not show solution effects. In this portion of the shaft the mineral is reported to have occurred filling occasional joint planes in the rock.

Considerable "float" lead has been found on the surface in the immediate vicinity of this shaft.

SMITH MINES.

These diggings, which consist of five shafts or test pits, are located in Sec. 35, T. 36 N., R. 20 W. The property has been abandoned for a number of years and the openings are now filled with detrital material. From the information obtained, three of

these shafts, the deepest of which was 100 feet, were sunk on an irregular opening, or solution fissure. This fissure has a general northeast-southwest strike and a maximum width of three feet. It was filled with residual, cherty clay carrying a considerable quantity of galena. Senator Henry Booth reports that 100,000 pounds of this ore were mined from these openings. Two shallow shafts or pits, which were sunk on either side of the fissure, encountered bedded rock at a depth of 14 feet. Some float galena was found in the residual clay overlying the solid rock.

SHAFT AT TUNAS.

This shaft, which has a depth of 85 feet, is located on the east bank of Tunas Fork near the west edge of town. It was sunk on a solution "fissure" or opening which has a general northeast-southwest strike and which varies from six to eighteen inches in width. This opening was filled with a very loosely cemented breccia consisting of finely broken chert, dolomite and sand. Throughout the depth of the shaft the breccia carried ores of both lead and zinc. The shaft was abandoned because of the inability of the operators to successfully cope with the water, which increased with depth.

Along Tunas Fork immediately west and north of the above shaft, bedded dolomite and sandstone form a low bluff line along the west side of the stream. These beds belong to the lower portion of the Gasconade formation and may include the Gunter sandstone horizon.

HILDEBRAND DIGGINGS.

These diggings are located 1-4 mile north of Tunas on the west bank of Tunas Fork. Here, the ground over an area 100 feet square has been thoroughly exploited by means of several shafts, the deepest of which was sunk to a depth of 100 feet.

Mining was restricted to a "pot hole" or "chimney" occurring in the lower Gasconade dolomite. This "chimney" was filled with residual clay and chert fragments carrying a considerable quantity of massive galena, one boulder of which is reported to have weighed 1,200 pounds. Several tons of this mineral were produced from these diggings. The area has been abandoned for several years.

HATFIELD DIGGINGS.

The Hatfield diggings are located along the base of a bluff on the south side of a small stream one mile north of Tunas. Three

shafts were opened at this place, the deepest of which was sunk a distance of 40 feet. This shaft followed a solution fissure varying from six to eighteen inches in width. The opening has a general north-south strike.

Similar conditions prevail here as at the Tunas shaft. Near the surface the material filling the crevice consisted of clay and chert fragments, while in the lower extremities of the shaft a breccia similar to that found in the Tunas shaft was encountered. The wall rock on either side consists of finely crystalline dolomite.

Pockets of galena occur scattered throughout the breccia, but no ores of zinc were found.

Small amounts of float lead have been picked up in the bed of the adjoining stream, and in the fields surrounding the shaft.

These shafts were sunk at the same horizon in the Gasconade formation as the one at Tunas. No work has been done here for several years.

RAMBO DIGGINGS.

This property, from which a large quantity of lead ore has been mined in the past, has been the most important producer in Dallas county. It is situated on the northern edge of a table-land area southwest of the village of Lead Mine. Mining has been confined to a large "chimney" which was discovered through the occurrence of a small amount of float galena, and not through any original surface features which might indicate such conditions.

The pit from which the ore was mined is roughly elliptical in shape, having a maximum diameter of 200 and a minimum diameter of 150 feet. The pit, which is now partially filled with detritus, is about 70 feet deep, although originally it was worked to a depth of 85 feet. From the bottom of the pit to within 12 feet of the top, massive beds of dolomite form a precipitous wall around nearly the entire circumference of the excavation. Originally, the faces of the dolomite wall were very irregular, the jutting ledges having been removed to facilitate mining operations. The dolomite is overlain with 12 feet of residual clay and chert. The pit was originally filled with similar cherty clay, in which was imbedded small and large masses of galena, which was easily cleaned by washing.

During the last few years that the mine was worked a cable tram and bucket system was used in hoisting the ore. When mining ceased at the 85-foot level, clay and fragments of chert composed the floor of the pit and it is quite probable that operations

could be carried to a considerable depth before encountering solid rock.

SIEGEL MINES.

This property is located near the north line of Sec. 35, T. 35 N., R. 19 W. Two shafts have been sunk, one to a depth of 185 feet, the other to a depth of 40 feet. Both shafts have been sunk on a solution crevice which varies from six to twelve inches in width, and has a general northeast-southwest strike. The crevice was filled with a dolomite breccia, carrying calcite and varying amounts of zinc sulphide. In places this breccia occurred firmly cemented, while at other points it was quite friable, consisting of small fragments of chert and sand-like crystals of dolomite which had their origin in the leaching of the side walls.

No galena was encountered in either shaft.

Throughout this and adjoining counties similar diggings indicate that a large part of the lead and zinc ores has been found in the residual clays, and in what are locally called "fissures," "chimneys," and "pot holes." The latter openings are the result of the solution of the limestone and frequently contain considerable mineral. Wherever the Gasconade limestone has been subject to such weathering processes, there is a possibility of the occurrence of similar dposits.

DOUGLAS COUNTY.

SHAFT NEAR GRANADA.

In a small valley one-half mile north of Granada a shaft has been sunk to a depth of 60 feet, at which level a considerable amount of drifting was done. The shaft and workings were driven through heavy bedded, crystalline dolomite of the Jefferson City formation. Near the surface the beds are dense, finely crystalline and contain considerable chert in the form of nodules and lenticular masses. At the bottom of the shaft and throughout the drifts the dolomite shows extensive leaching, which has resulted in the formation of numerous cavities. The cavities are partially filled with calcite, galena, jack and occasional small crystals of tetrahedrite (copper-iron sulphide). The property is not being worked at the present time.

MONAHAN DIGGINS.

This property, located about one mile northeast of Ava, has been prospected by means of several pits and open cuts in the sur-

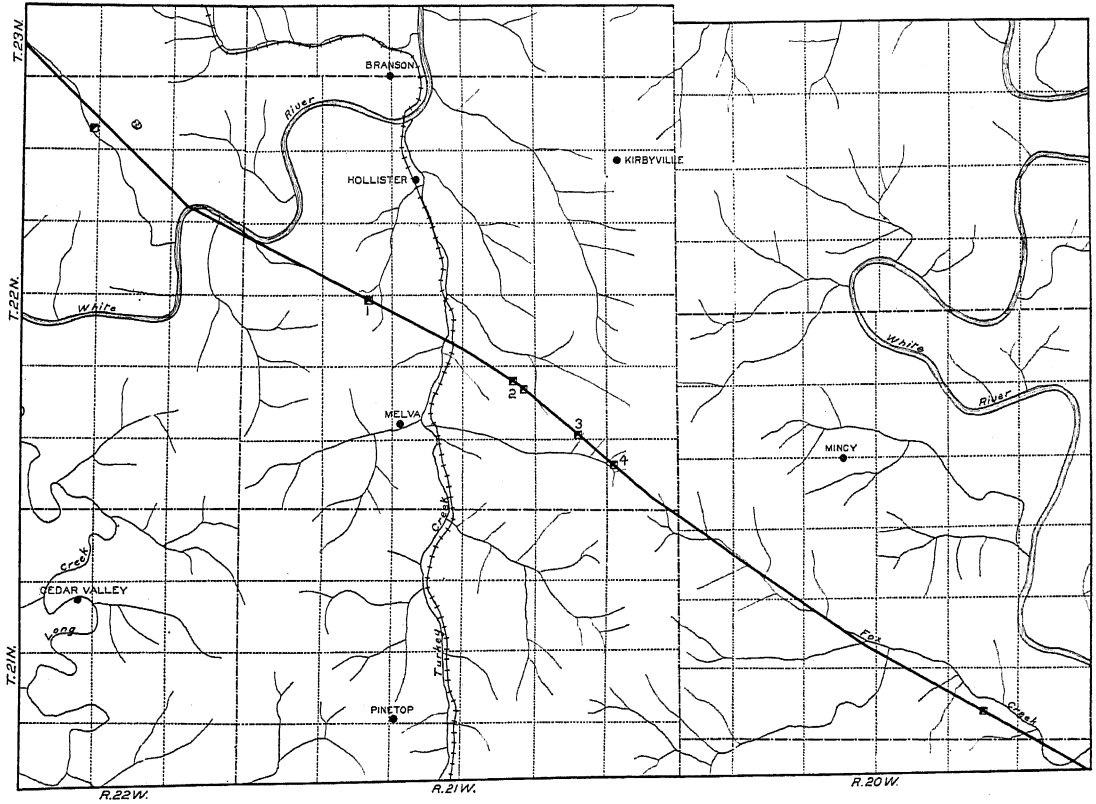
face ledges of the Jefferson City formation which occur in the area. None of the beds have been subjected to leaching, and the only trace of mineral encountered consisted of thin "knife-blades" of galena extending for a short distance along small joints. Owing to the lack of openings and to the density of the beds exposed, there is small likelihood of lead and zinc being encountered in commercial quantities.

BAKER PROSPECT.

The Baker prospect is located two miles south of the village of Drury in the southeastern portion of the county. Here, at the head of a deep, narrow ravine a drift was driven for a distance of 40 feet into a massive bed of crystalline dolomite. The rock has been subject to leaching and, at intervals in the drift, the resulting cavities were found to be partially filled with galena and jack. As indicated by the walls of the drift, however, a majority of these openings are apparently lined only with a thin coating of secondary dolomite, on which frequently occur small crystals of tetra-hedrite. Ten feet from the mouth, a shaft was sunk in the floor of the drift to a depth of 16 feet. Crystalline dolomite, showing the effects of leaching was encountered in this shaft from top to bottom and occasionally a local concentration of galena and jack was found to fill the cavities.

TANEY COUNTY.

The reconnaissance work in Taney county was restricted largely to an examination and tracing of a fractured zone traversing townships 21 and 22 N., in ranges 20, 21 and 22 W. This zone, which is known locally as the "Ten O'clock Run," is well defined, and, as shown on the accompanying map, has an average course striking S. 55° E. It crosses the Stone-Taney county line in Sec. 35, T. 23 N., R. 22 W., running approximately parallel to and on the northeast side of Fall creek until it reaches White river. At this point the fissure disappears in the river channel, which it follows for a little over one mile. It is seen again on the south side of White river in Sec. 18, T. 23 N., R. 21 W. and, striking in practically a straight line across Pine Mountain ridge, enters Arkansas with a course approximately parallel to the valleys of Fox and Bee creeks. This fissure has no apparent relation to the topography; crossing valleys and ridges indiscriminately, and at no place in its course through Taney county does it show evidence of dying out.



Outline map showing location of fractured zone in Taney County.

It has not as yet been traced westward from the Stone-Taney county line.

With the exception of the crest of Pine Mountain ridge, the area traversed by the fissure is underlain by the Jefferson City formation of the Cambrian series.

The Jefferson City is composed of fine grained, white to gray dolomite known as "cotton rock" and heavy massive beds of gray dolomite, which weather to an irregular surface. These beds are well exposed along the "bald knobs" where they usually terrace the hillsides. The Mississippian series underlies the crest of Pine Mountain ridge. Due to a heavy mantle of residual chert and soil, these formations are not well exposed. Where seen, they consist of coarsely crystalline fossiliferous limestone characteristic of the Boone formation.

The zone in which fracturing occurs has a width varying from 400 to 600 feet, within which the surface formation exhibits decided dips and considerable brecciation. The average dip is 10° S. 35° W., although at numerous points considerable variation from this average was noted. Instances of such variation occur on the northwest side of the White river valley where the strata dip 22°, and on the southeast slope of Pine Mountain ridge where locally they were observed to dip 30°.

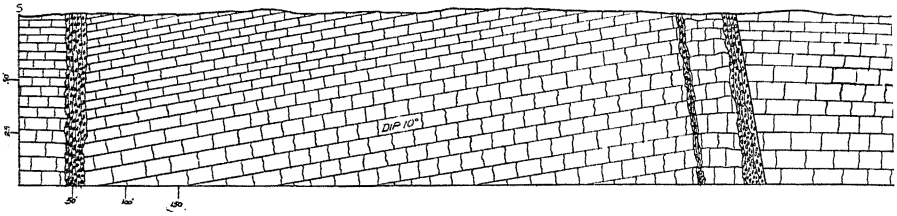
A section across this zone from north to south also shows a variation in the intensity of brecciation. This feature is illustrated in a cut along the St. Louis, Iron Mountain R. R. in Sec. 21, T. 22 N., R. 21 W., and at the Silver Moon mine in Sec. 26, R. 22 N., R. 21 W.

In the railroad cut there is exposed a broken zone having a width of 35 feet, within which the jointing has been so emphasized as to give the rocks a sheeted appearance and has virtually obliterated all evidence of bedding. To the south, this grades into a block of horizontally bedded dolomite having a width of 75 feet, beyond which occurs a narrow zone of brecciation having a width of three feet. From this point the strata dip 10° S. 35° W. towards a ravine, where they become covered with a mantle of residual materials. When next exposed, approximately 450 feet from the first broken zone, the formation is practically horizontal.

At the Silver Moon mine similar conditions occur. A shallow cut normal to the strike exposes two zones of brecciation separated by a block of little disturbed strata having a width of 35 feet. The northern most zone has a width of 15 feet, while the one to the south of the intervening block has a width of three feet. Beyond

the latter, the strata dip 10° S. 35° W. This dip continues for about 200 yards, at which point they abruptly resume their former horizontal position. This resumption of horizontal position is accompanied by a zone of brecciation which is exposed for a width of 10 feet. At this point, it is impossible to determine its exact width, due to a covering of residual materials.

The following cross-section illustrates the above relations:



Section of fractured zone near the Silver Moon shaft.

A number of shafts and test pits have been sunk at various points along this zone and some lead and zinc have been shipped from these prospects. The results of this development work indicate that the lead and zinc ores occur chiefly in the areas of most intense brecciation near the north wall. However, the southern zone described above has not been prospected and may carry ores of both lead and zinc.

At the Silver Moon mine, the shaft has been sunk to a depth of 64 feet, exposing a breccia having a width of 7 feet at the bottom of the shaft, at which point the south side of the shaft entered the unbroken rock or "Horse," as it is called locally. The north wall of the shaft is smooth and illustrates the clean break with which the fissured zone starts. This wall is reported to be coated with a layer of marcasite and pyrite having a thickness of one-fourth of an inch. This layer passes into an eight inch zone of breccia containing coarsely crystalline galena and jack; this, in turn, grades into a zone of about the same thickness in which the ores occur in small crystals. The remainder of this zone, having a width of 5 1-2 feet, becomes less brecciated towards the undisturbed rock and does not run as high in either lead or zinc. Stringers of calcite carrying some lead extend into the so-called "Horse." In this shaft, however, they do not carry sufficient mineral to pay for mining.

At the time this shaft was visited it was half full of water, making an examination impossible. The above succession was re-

ported by Mr. Anderson, who sunk the shaft. Each of these reported types of ore was seen upon the dump.

Similar conditions may be seen at a number of other prospects, although these have not been sunk to as great a depth as the Silver Moon shaft. The depth to which the mineral extends has not been determined at any point. In fact, in most instances, the mineral is reported to have increased with depth.

Oxidation has taken place in the upper part of the fissure, altering the zinc sulphide to the carbonate and corroding the galena slightly. The depth to which this oxidation has extended varies at different points. At the shaft of the Richardson prospect in the N. W. ¼ N. W. ¼ Sec. 20, T. 22 N., R. 21 W., the dump indicates that carbonate ore was encountered throughout the greater part of the entire depth, which was something over 60 feet, while at the Bennett and Leeper shaft the sulphides were noted within a few feet of the surface. Apparently oxidation has extended to an average depth of 20 feet, and in certain localities the fissure may be traced by this ore, which outcrops at the surface. This is true not only at the Richardson prospect but also at the King Solomon workings in the N. E. ¼ Sec. 27, T. 22 N., R. 21 W.

The carbonate ore has either a honey-combed porous texture, or is compact and granular; both types being of commercial grade.

Detailed mapping in this portion of Taney county will probably show additional structural features along which prospecting might be carried on with profit. At a number of points several miles distant from the above fractured zone, the formations show pronounced dipping. The structure, however, has not been worked out, nor detailed mapping undertaken.

The reconnaissance work has not shown the northwest end of the zone, which probably extends a considerable distance into Stone county.

OZARK, HOWELL AND OREGON COUNTIES.

A number of properties and prospects from which carbonate of zinc have been mined were examined in Ozark, Howell and Oregon counties, which border the Arkansas State line. The district included in the above country is apparently a northern extension of the Arkansas field, in which considerable carbonate of zinc is found and from which shipments have been made.

The ore occurs in those portions of the Jefferson City formation that have been subject to extensive leaching and decomposition. Each of the deposits examined is found in the cotton rocks

of the above formation where such decomposition has gone on.

Minable ore has been found at several widely separated points extending from the eastern portion of Ozark county to east of Alton in Oregon county. Systematic prospecting has not been carried on and as similar geologic conditions prevail throughout the entire area, there is every reason to believe that additional deposits of commercial value may be found.

The following brief descriptions indicate the characteristic occurrence of this ore:

ALICE MINE.

This mine, which is owned by the Empire Zinc Company, of Joplin, is located in T. 22 N., R. 11 W. one-fourth of a mile west of Wetherill, Ozark county. It consists of an irregular pit approximately 150 feet square by 40 feet deep.

The ore produced is the carbonate of zinc. It occurs in the Jefferson City formation, which at this point is composed chiefly of fine grained, gray dolomite known as cotton rock.

The opening shows the ore to occur in those portions of the formation which have been subject to leaching and decomposition. In these areas the cotton rock has been wholly or in part replaced by the ore; where replacement has not been complete the carbonate is found filling joints and following the bedding planes. Frequently, where the replacement is complete, the ore preserves the original structure of the dolomite. Two large circular "horses" of practically unaltered dolomite occur in the pit, which run too low in zinc to pay for mining, although some zinc carbonate occurs in fissures and along the bedding planes.

In the upper portion of the deposit and in the over-burden of clay, considerable limonite is found following roughly the original stratification planes. Below a depth of 20 feet it is found less frequently filling joints in the dolomite and decomposed materials.

Six development drifts have been driven from various points in the mine and three 20-foot test pits have been sunk beneath the present mining level. The drifts are reported to have passed through good ground, while the test pits show ore throughout their entire depth. This ore is said to be practically free from limonite. These drifts or test pits were not accessible when the property was visited.

The ore is classified as "gravel" or "coarse," the former constituting that portion which passes a one-inch grizzly. At the time

this mine was visited there were approximately 1800 tons of marketable ore on hand.

C. S. & R. ZINC MINES.

This mine is situated approximately in the center of Oregon county one mile northeast of Alton in the S. W. ¼ S. E. ¼ Sec. 27, and the N. W. ¼ N. E. ¼ Sec. 34, T. 24 N., R. 4 W. It consists of an oblong shaped pit, 160 by 100 feet in cross-section, and is approximately 20 feet deep.

The deposit occurs in the Jefferson City formation, which, at this point, is composed of characteristic cotton rocks containing an occasional thin bed of chert. The cotton rocks have been decomposed in many places to a soft greyish-yellow clay, under which circumstances the chert beds which remain unaltered have been distorted through settling. Veins of red joint clay are occasionally found in the partly or wholly decomposed cotton rock.

The carbonate of zinc mined from this property was first found in a narrow channel which followed the south and east walls of the above pit. This channel which had a width of from four inches to six feet, was mined before the rock to the north and west was taken out. Throughout this rock the ore occurred in thin plates filling small fissures and bedding planes, and in irregular channels where it had partially replaced the dolomite.

Aside from the zinc carbonate, hydrozincite is commonly found spotting the decomposed cotton rock. It is locally known as "oxide." Considerable limonite is associated with the ore occurring near the surface.

Development work at the mine consists of a 65-foot drift extending beyond the northeast face of the pit, three churn drill holes put down within 150 feet of the east side of the mine, and a test pit approximately 60 feet deep, also located to the east of the mine. Ore is reported to have been found, although neither the shaft nor drift were accessible.

This property has produced approximately 300 tons of carbonate ore which was reported to have run 39 per cent zinc. The ore was hauled 17 miles by wagon to Thayer, the nearest shipping point.

RAGAN ZINC PROSPECT.

This prospect is located one-half mile east of Thayer, Oregon county, in the N. E. ¼ N. W. ¼ Sec. 33, T. 22 N., R. 5 W.

Development work, consisting of several open cuts along the

hillslope and one comparatively deep shaft, shows considerable zinc carbonate filling joints and bedding planes, and replacing the cotton rock. The ore is intimately associated with a large amount of limonite, which makes it difficult to obtain a high grade product.

CRAWFORD COUNTY.

In addition to examining a number of deposits of iron ore, which will be described in the report covering that subject, the work, in Crawford county consisted chiefly of the examination and rapid geologic mapping of a complexly folded and faulted area occurring east of Wesco, in Secs. 16, 17, 18, 19, 20 and 21, T. 36, R. 4 W.

This area is of special economic interest, in that the formations exposed are the same as those occurring in the Southeast Disseminated Lead district of Madison, Washington and St. Francois counties. Until discovered this season by assistants of the Bureau, these formations were not known to occur at the surface in this region, the western most exposures heretofore mapped occurring in the southeastern part of Washington county over 25 miles to the east.

Through the elevation of these lower formations, the area is thought to present geologic features favorable for the occurrence of disseminated ore, and the following notes and maps have been prepared for the purpose of drawing attention to this possible economic development.

The detailed structure of the area has not been worked out and the accompanying sketch is only intended to show the approximate area underlain by the various formations exposed.

As is well known, the disseminated deposits of southeast Missouri occur chiefly in the Bonneterre dolomite where the overlying formations, consisting of the Davis shale and Doe Run, Derby and Potosi dolomites, have been largely removed by erosion. The productive areas have usually shown rich surface diggings, and the occurrence of such ore at what is thought to be the top of the Bonneterre formation in this area may be considered as evidence favoring the possible occurrence of deeper ores.

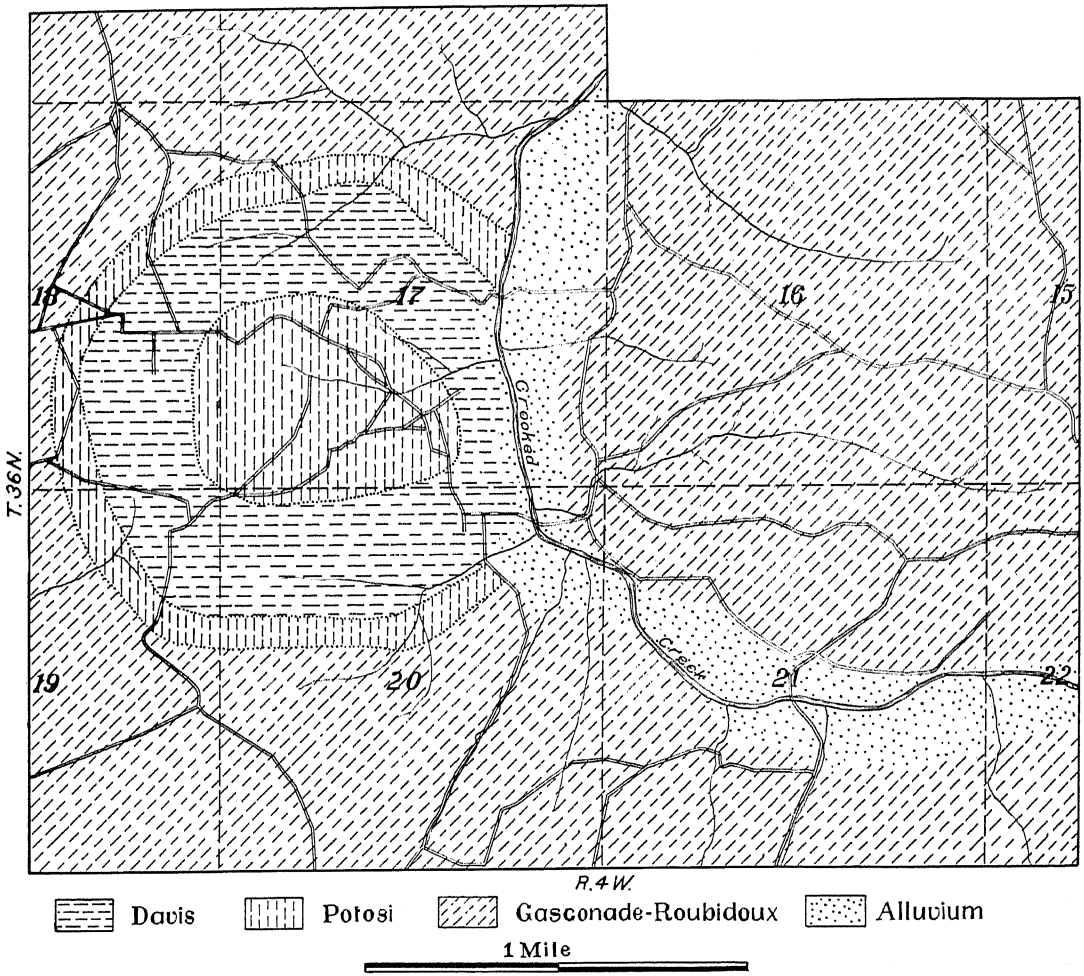
The following is a brief summary covering the formations observed in the area:

BONNETERRE FORMATION.

At the Metcalf diggings in N. W. ¼ Sec. 17, T. 36, R. 4, a heavy ledge of non-cherty crystalline dolomite is exposed for a short dis-

BIENNIAL REPORT
1909-1910. Pl. V.

Reconnaissance map, showing formations exposed in an area near Wesco, Crawford county.



tance in the bed of a small creek. A few feet above this outcrop, an old drift driven into the hillside exposed 3 to 4 feet of more thinly bedded chloritic dolomite, dipping sharply into the hill. These beds, which are considered as probable Bonneterre, are immediately overlain by a dark red clay free from chert and similar to that which characterizes the residual soil of the Bonneterre formation in southeastern Missouri. Still higher up the hillslope, numerous pits sunk to depths of from 10 to 12 feet encountered the Davis shale only.

Three hundred yards west of the above diggings a shallow shaft penetrated a small thickness of blue shale and very chloritic crystalline dolomite, both of which are similar to beds occurring near the base of the Davis formation, as exposed in the Disseminated Lead district, and it is probable that the Bonneterre dolomite lies but a few feet beneath the surface at this point.

DAVIS FORMATION.

As shown on the accompanying map, this formation entirely surrounds and is in turn probably entirely surrounded by an area in which exposures of Potosi dolomite and residual chert from the decomposition of this formation occur at the surface. Due to the occurrence of stream deposits along Crooked creek, outcrops of the enclosing belt of Potosi can not be seen along the east side.

The belt of Davis shale, which has a roughly circular outline, varies from 1,200 to 1,700 feet in width between the enclosing and enclosed areas of Potosi. Along the inner edge of this belt the strata exposed dip steeply towards the enclosed area of Potosi dolomite, while on the outer rim the beds have a similar dip towards the enclosing belt.

The formation consists of yellow, green and blue shales; thin intercolated beds of limestone; occasional rather heavy beds of dolomite; and several horizons of edgewise conglomerate, which are identical with those exposed in the southeastern lead district. The central boulder horizon, which forms so striking a datum plane in St. Francois county, was not noted in this area.

DERBY AND DOE RUN FORMATIONS.

These formations, which have a combined thickness of 80 feet in St. Francois county, were not recognized in this region, although an exposure of crystalline dolomite on Crooked creek in S. E. ¼

Sec. 17, T. 36, R. 4, and several outcrops in the outer belt of Potosi may belong to either of these formations. The outcrops observed are not of sufficient extent to warrant correlation.

POTOSI FORMATION.

As already mentioned, the Potosi formation is enclosed by, and in turn encloses, the area underlain by the Davis formation. The enclosed area is roughly circular in shape and has a diameter of approximately 3,300 feet; the enclosing or outer area forms a belt which has an average width of about 400 feet, except in N. E. ¼ Sec. 17, T. 36, R. 4, where it attains a width of 700 feet. Wherever observed, the beds are found to dip precipitously away from the area of Davis shale.

The formation, as recognized, consists of massive crystalline beds of dolomite containing irregular masses and seams of drusy quartz, which are so characteristic of this formation.

GASCONADE AND ROUBIDOUX FORMATIONS.

These are the surface formations over nearly the entire area of Crawford county, and, in this particular portion, completely surround the area in which the Davis and Potosi formations are exposed.

The Gasconade is composed of characteristic massive beds of crystalline, cherty dolomite, while the Roubidoux is made up of cherty dolomite and sandstone members.

CARBONIFEROUS.

Small outliers of the Carboniferous series occur in N. W. ¼ Sec. 20, S. W. ¼ Sec. 21, N. E. ¼ Sec. 16, and S. E. ¼ Sec. 20, T. 36 N., R. 4 W. They are composed chiefly of white sandstone, sandy shale, ferruginous clay-shale, flint fire clay, and coal. These deposits are evidently remnants of larger areas which at one time filled the depressions in the uneven surfaces of the underlying formations.

STRUCTURES.

Although the structures of the area were not studied in detail, sufficient information was obtained while traversing the area to account for the presence of the Davis formation approximately 700 feet above its normal position. Everywhere within the region of

Davis-Potosi exposures, the outcrops are characterized by steep dips, the beds often occupying a vertical position. The position of the outcrops and the direction of their dip show the area to be one of sharp folding accompanied by faulting, with folding as the predominant factor. In the enclosed area of Potosi, no dips were noted, bedding planes not being apparent at any point. In the enclosing belt of Davis exposure, the strata dip steeply towards the enclosed Potosi on the inner edge and towards the enclosing belt of Potosi on the outer edge. Wherever bedding planes were apparent in the outer belt of Potosi, the strata were found to dip steeply away from the area in which Davis shale outcrops. On the other hand, exposures of Gasconade and Roubidoux immediately surrounding the outer belt of Potosi are found to dip steeply towards the area in which the Davis-Potosi formations are exposed. And for some distance away from this area the formations have been subjected to much disturbance and the Roubidoux and upper Gasconade occur considerably below their normal elevation in Crawford county. For a distance of a mile or more from the outer exposures of the Potosi, abundant evidences of sharp anticlines and synclines accompanied by minor faulting are furnished by precipitously dipping ledges of both the Gasconade and Roubidoux.

Evidences of faulting occur along nearly the entire south side, at the northeastern corner, and for a short distance along the western border of the area of Potosi-Davis outcrop. In every case the line of faulting occurs between the outer belt of Potosi exposures and the surrounding area in which the Roubidoux and Gasconade formations outcrop.

Along the south line mentioned above, the break between the Potosi and Roubidoux-Gasconade may be traced by boulders of breccia consisting chiefly of broken fragments of drusy quartz. At the other two points, massive boulders of breccia consisting largely of broken chert fragments were noted between the outcrops of the Potosi and Roubidoux-Gasconade.

LEAD.

A considerable quantity of lead ore has been produced in the Metcalf diggings in N. W. ¼ Sec. 17, T. 36, R. 4, where it was found imbedded in the surface clays at the contact of the Bonneterre and Davis formations. These diggings comprise about one acre situated on the north slope of the hill. Within the area the ground has been quite thoroughly worked to a depth of 10 or 12 feet by means

of pits or shallow shafts sunk in close proximity to each other. The amount of lead produced is not known, but it is reported to have been quite large, considering the nature and extent of the mining operations. The citizens of the community state that one massive boulder of galena weighing several thousand pounds was found a few feet beneath the surface near the center of the area. The Bonneterre formation, which carries the disseminated lead deposits in southeast Missouri, forms the base of the hill.

FIRE CLAY.

Deposits of flint fire clay occurring east and southeast of Wesco have been worked intermittently for many years. Of these, the McGary, Scott and Taff clay banks have probably been operated most extensively. In the area mapped, fire clay in small amounts occurs in each of the above mentioned Carboniferous deposits. With a probable exception of the deposit in S. W. ¼ Sec. 21, T. 36, R. 4, where fire clay occurs associated with coal, the deposits are not of sufficient magnitude to warrant working.

The largest known deposit of fire clay occurring in the immediate vicinity of this area is the L. C. Taff bank, located one-half mile west of the outer belt of the Potosi exposures in the W. ½ Sec. 18. Here, the surface over an area about one-half mile square has been prospected to shallow depths by means of pits and drill holes, disclosing the presence of fire clay over practically the entire area. The depth to which the fire clay extends has not, however, been determined. The clay occurs on the crest and higher slopes of a ridge area and is situated in the western edge of the region which has undergone marked disturbance. Roubidoux sandstone comprises the most prominent surface formation, outcrops of which show the effect of folding. Clay has been shipped from this property at intervals for the past several years. The first pit worked is situated on the crest of the ridge and is 60 by 40 feet, with a maximum depth of 10 feet. The walls and floor of the pit show faces of gray flint fire clay overlain near the surface by a small thickness of sandy material. In the southwest corner occurs a small "horse" of sandstone. Recently, a new pit has been opened several hundred feet west of the above, and clay similar in character is being mined and shipped. The overburden at either pit, so far as has been disclosed, is nowhere over two feet in thickness.

On the north side of the ridge and nearly due north of the

above pits an excavation in the east bank of a small ravine shows a five-foot face of white very fine grained fire clay which is said to fulfill the requirements of the so-called china clays.

BARITE.

This mineral commonly known as "ball tiff" has been found in two places. On the east point of a low hill in Sec. 18, T. 36, R. 4, residual barite occurs in clay to a depth of two or three feet. Pits sunk to depths of six or eight feet at this place encountered shale of the Davis formation underlying the thin mantle of clay and barite. A shaft sunk on the south bank of a stream in S. ½ Sec. 17, T. 36, R. 4, disclosed a considerable amount of barite imbedded in clay which filled an opening on which the shaft was sunk.

COAL AND MINERAL WATERS.

Coal occurs associated with fire clay on the low point of a ridge where Mineral Springs Hollow enters the valley of Crooked creek. Here, a pit 15 by 18 feet sunk to a depth of 12 feet shows the following descending section:

0 to 3 feet of soil.
6 feet of bituminous coal of good quality.
4 to 6 ft. dark gray fire clay.

The coal dips at a moderate angle to the southward. The pocket is small, being restricted by surrounding formations and erosion valleys. Apparently no attempt has been made to work the deposit for local consumption.

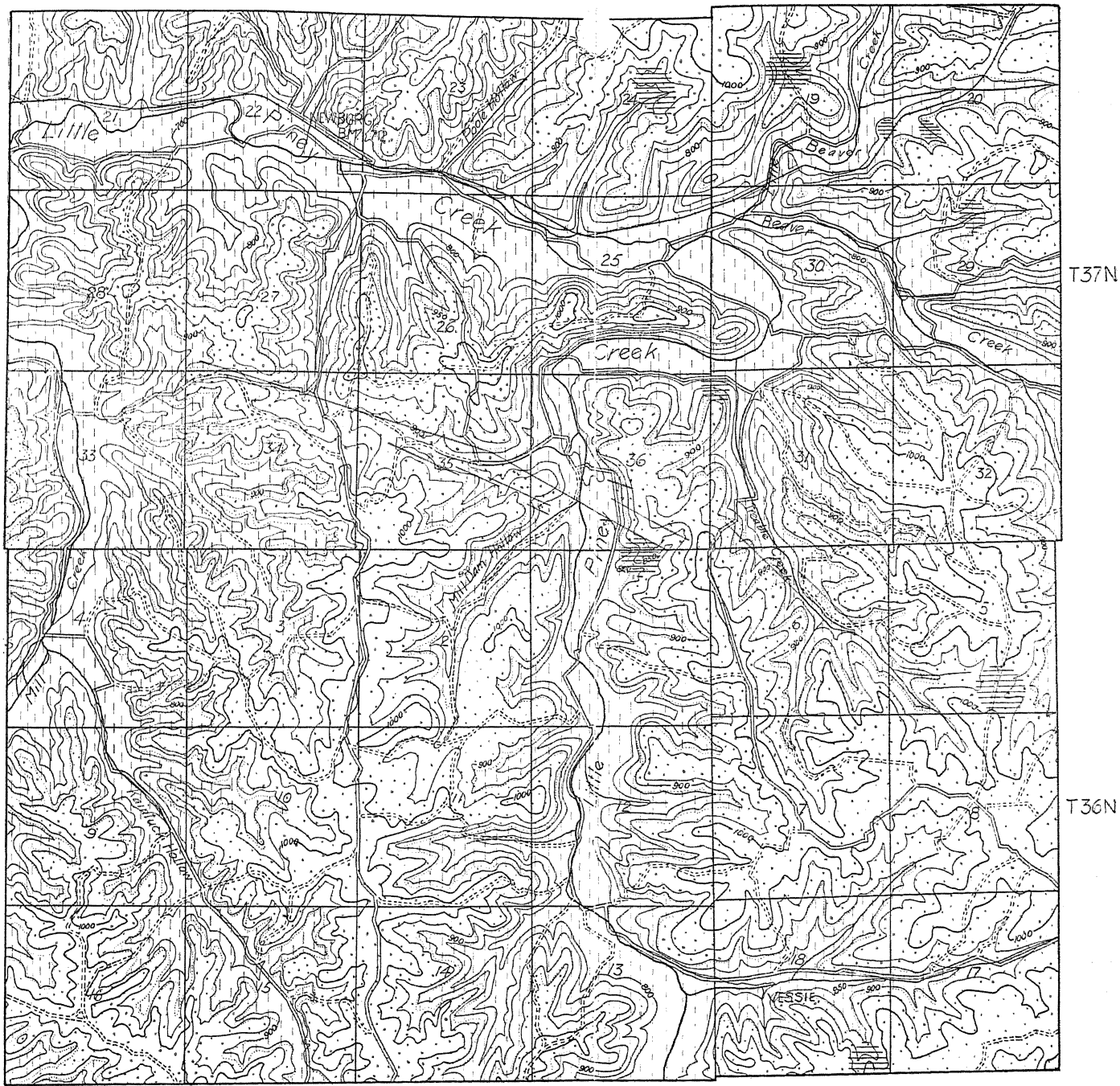
At the base of the hill immediately beneath the shaft a chalybeate spring issues from beneath a ledge of sandstone. The water of this spring was formerly utilized for medicinal purposes, and at one time a thriving village, located here, was maintained by the patients attracted by the medical properties of the water.

IRON.

Small amounts of both hematite and limonite have been found in different portions of the area. The hematite is confined entirely to the Carboniferous deposits where it occurs in small amounts associated with iron stained chert and ferruginous sandstone. In a Carboniferous deposit on the hillside in S. E. ¼ Sec. 20, T. 36, R. 4, occurred a small amount of specular hematite.

The limonite ore consists of altered sulphide showing excel-

lent pseudomorphs after marcasite. It is apparently confined to a certain horizon in the Potosi and wherever that portion of the formation has been eroded, small masses of the ore occur abundantly in a brownish red clay resulting from the decomposition of the dolomite. The best exposures of this ore occur in the head of the valley in S. E. ¼ Sec. 18, T. 36, R. 4, and near the head of a small ravine in W. ½ Sec. 17, T. 36, R. 4 W.



LEGEND

Faults · Roubidoux · Gasconade · Sinks · Contours

SCALE

Geologic Map of a portion of the Newburg Area; Phelps County.

NEWBURG DISTRICT.

BY WALLACE LEE.

Geological work in the Newburg district, which is shown on the accompanying map, was undertaken during the months of July and August, 1910, by the St. Louis & San Francisco R. R. to ascertain the most favorable localities in which to drill for lead. The results of this work have since been turned over to this Bureau and the mapping extended with the purpose of issuing a complete report covering the geology of the Rolla quadrangle situated in the western part of Phelps county. The area which has been examined is shown on the accompanying map. It includes 36 square miles in the vicinity of Newburg and occupies the central portion of the Rolla quadrangle. The following brief description of the general geology is published at this time in order that the results may be available in any future development work.

TOPOGRAPHY.

This is a hilly area, drained by Little Piney Creek and its tributaries. There is very little level land, the country being cut up with narrow and deep valleys. The valleys of Little Piney and its tributaries, Mill creek and Kaintuck Hollow have flat bottoms bordered in many places by steep bluffs. The maximum difference in elevation between river bottom and ridge is 314 feet at Newburg. At this place the Little Piney is 705 feet above sea level, while the ridge on the south side has an elevation of 1,019 feet. Approximately the same relative elevations are maintained in the southern part of the area, the Little Piney having a fall of about 10 feet to the mile.

GEOLOGY.

The Gasconade and Roubidoux, belonging to the Upper Cambrian series, are the only formations occurring in the area. Formerly the Pennsylvanian, Mississippian, Ordovician series and the Jefferson City formation of the Cambrian were probably represented. These, however, have been removed, leaving the surface, in many places, strewn with residual material largely derived from the Jefferson City, which was the next overlying formation.

GASCONADE FORMATION.

The Gasconade is the oldest formation in the area, and of this, only the upper 200 feet is exposed. In Miller and Morgan counties where detailed surveys have been made, the entire thickness of 250 to 300 feet is exposed, as well as a portion of the underlying Proctor dolomite.

The Gasconade is composed chiefly of beds of massive gray dolomite and chert, which occurs in the form of beds, 3 to 4 feet in thickness, nodules, and irregular sheets between the dolomite beds. The dolomite is ordinarily coarsely crystalline, although occasional beds from 2 to 4 feet in thickness have a dense finely crystalline texture. The chert beds are usually flat lenses, for which reason they are seldom of uniform thickness over any considerable area. One of these beds, however, is persistent over most of the area. This bed averages about 4 feet in thickness and occurs from 50 to 55 feet from the top of the formation. The upper portion of the bed, about one foot in thickness, is a dense mottled bluish chert containing occasional cavities. The remainder consists of layers of warped and broken, concentrically banded chert, between which are cavities, angular or crescent shaped, lined with quartz crystals and chalcedony. Occasionally these cavities are partly filled with galena and zinc blende, with which is associated some barite.

A few silicified fossils were found in weathered dolomite near the top of the formation, indicating that in part, at least, the chert is secondary.

The following is a typical section of the exposed portion of the Gasconade formation taken from the east side of Poole hollow, near the mouth, in the S. E. ¼ Sec. 23, T. 37, R. 9.

GASCONADE SERIES.

Ft.	
1	Dolomite, coarse grained.
3	Talus.
2	Dolomite, silicious.
1	Talus.
5	Dolomite.
7	Dolomite, pitted, cherty.
5	Dolomite, massive to platy, little chert.
6	Dolomite, pitted.
5	Dolomite, pitted and massive, some chert.
3	Talus.
2	Dolomite, pitted and massive.
4	Dolomite, compact, pitted, somewhat cherty.
1	Talus.
1	Dolomite, coarse grained.
1	Chert, white, dense.
1	Dolomite, cherty.

GASCONADE SERIES—Continued.

Ft.	
4	Dolomite, containing bands of chert about 1 ft. apart.
4	Chert, dense bluish with small cavities at the top; lower three feet banded and warped; contains crescent shaped cavities.
10	Dolomite, massive, thin beds of shattered blueblack chert.
6	Dolomite, very cherty. Chert mottled blue to gray.
2	Chert.
2	Talus.
12	Dolomite, massive, pitted.
8	Dolomite, massive, pitted, little chert.
3	Dolomite, breaks in small blocks.
4	Dolomite, fine, grained, massive.
2	Dolomite, contains chert in layers, increasing at the bottom.
4	Talus.
15	Dolomite, resembles cotton rock. Cherty.
4	Talus.
3	Dolomite, dense, fine grained, massive.

ROUBIDOUX FORMATION.

The Roubidoux formation, which immediately overlies the Gasconade and is conformable with it, consists of two sandstone and two cherty dolomite members. This formation, as well as the underlying Gasconade, dips gently to the north. On the south side of the area the elevation, as indicated by the contact, is 60 feet higher than on the north side.

The upper member of the Roubidoux east of this area is 30 feet thick and consists chiefly of thinly bedded cotton rock underlain by impure, densely crystalline, cherty, dolomite. In the area under consideration these beds occupy the tops of the ridges and are so covered with soil and residual chert that their thickness and general characteristics could not be determined.

Beneath this cherty dolomite is the upper sandstone member, which has a thickness of 25 feet. It is well exposed on most of the ridges, forming low cliffs which are sometimes taken advantage of in fencing the hilltop fields. It has a brownish red color, due to staining with iron oxide, and is comparatively coarse grained. The upper part is more massive, finer grained, and generally of a lighter color than the lower. The upper portion, especially, contains small fragments of chert, which are coarser near the top, giving it almost the appearance of a conglomerate. The upper part of this member is characterized by the presence through weathering of vertical, cylindrical, niche-like cavities one foot to two feet six inches in height, and about one foot in diameter with the base resting on the bedding plane, dividing the upper and lower parts. In places there occurs near the middle of this member a very fine

grained bed varying from 9 to 18 inches in thickness. Upon weathering this splits into very thin plates.

Ripple marks, shrinkage cracks and false bedding are common in this sandstone, especially in the lower portion.

Underneath this sandstone member occurs a horizon of cherty dolomite having a thickness of 35 feet. This member varies greatly in different parts of the area. The cherty layers grade into impure dolomite, and the dolomite often becomes sandy and silicious within short distances. Thin beds of sandstone are also of common occurrence. Certain beds bear a close resemblance to the dolomite of the Gasconade. This member of the Roubidoux weathers easily, for which reason exposures are not common.

Beneath this cherty dolomite is the lower sandstone member, which, while persistent, varies considerably both in thickness and texture. It is normally about 10 feet thick, friable and porous. Where it occurs along the lower hillsides and in the stream beds, it is seldom case hardened, but wherever it caps the lower ridges, removed from erosion, it is case hardened, like the upper sandstone member. When broken, it exhibits fine holes often partly filled with iron oxide, which gives the rock a speckled appearance. The color is similar to, but generally lighter than, the upper sandstone. Although sometimes massive, the beds are generally thin. Outcrops seldom occur except near the crests of the lower ridges and near the heads of steep sloped ravines.

While the normal thickness is ten feet, it is only three feet thick northwest of Newburg. At this place the beds are calcareous near the base and argillaceous near the top. Southwest of Kaintuck hollow in Sec. 16 it has a thickness of 20 feet. In the S. W. ¼ Sec. 32, T. 37, R. 8, and in the N. E. ¼ Sec. 17, T. 37, R. 9, the lower six inches is a conglomerate, while just southeast of the area mapped a bed of conglomerate occurs near the middle. False bedding, ripple marks and shrinkage cracks are common.

The grains of quartz sand of which both the upper and lower sandstone members are composed are clear and angular, and in some cases retain to a considerable extent their original crystalline form. Where exposed to the air and away from seepage, both sandstone members become case hardened and resist atmospheric weathering very effectively.

The following sections from the localities indicated, illustrate the changes in the character of the formation:

Ft.	In.	N. E. ¼ SEC. 17, T. 37, R. 9.
8		Dolomite, densely crystalline, fine grained.
9		Talus.
1		Chert, red, gnarled.
1		Talus
1		Chert, bluish to white.
22		Sandstone, massive, brown to reddish brown.
1		Talus.
4		Dolomite, platy, cherty, fine grained, dense.
3		Dolomite, coarse grained, pitted, resembles the Gasconade.
7		Dolomite, fine grained and crystalline, contains angular fragments and plates of chert, thinly bedded. Sandy at bottom.
2	6	Chert, massive to finely shattered, sometimes oolitic.
6		Dolomite, finely crystalline, thinly bedded, cherty.
1		Sandstone, compact, yellow, fine grained, contains minute cavities.
1		Dolomite, irregularly bedded, contains chert layers.
2		Chert, oolitic, color bluish.
5		Talus.
5	6	Sandstone, platy, thinly bedded, contains layers of chert between be ds.
	6	Sandstone conglomerate, chert fragments up to one inch in diameter.

On bluff, east side of Little Piney creek, center Sec. 36, T. 37, R. 9.

Ft.	In.	
25		Sandstone, massive, brown and reddish to white coarse grained at bottom to fine at top, cross bedding common
9		Talus.
15		Dolomite, gray, coarsely crystalline, contains small pockets of calcite, weathers to irregular surface and resembles Gasconade dolomite. Near base contains occasional thin flat layers of chert.
2		Talus.
1	3	Chert, mottled blue and white, contains bands of quartz grains and small angular geodes; weathers white.
3		Talus.
1	6	Dolomite, fine grained, contains much chert.
4		Talus.
6	6	Sandstone, white to red, medium to fine grained, massive to thinly bedded.
	6	Dolomite, gray, compact, hard, very sandy. Locally replaced by sandstone.
1		Sandstone, brown to yellowish brown, soft and medium grained.

JEFFERSON CITY FORMATION.

East of this area, the Jefferson City formation rests conformably upon the Roubidoux. At the base, it consists of hard, dense dolomite marked by a network of small cavities filled with finely divided silica, and at the top, of impure gray, fine grained dolomite known as cotton rock. Thin layers of flint occur in this formation. On the higher ridges of this area beneath the mantle of residual material, outliers of the Jefferson City formation may occur.

CAVE CONGLOMERATE.

Patches of sandstone conglomerate consisting of angular fragments of chert and pieces of quartzite with a matrix of sand are associated with most of the sinks in this area, the most notable occurrence being in the vicinity of the Treable creek fault. These

conglomerates have probably been formed in caves and solution channels, as evidenced by the unconsolidated sand containing fragments of chert and sandstone observed on the floor of the Gourd creek cave.

This formation is not usually found in place, although in the S. E. ¼ S. E. ¼ Sec. 31, T. 37, R. 8, it was observed filling a fissure in the Gasconade dolomite. This filled fissure has an average width of two feet and is exposed for a distance of 1,600 feet.

This conglomerate was noted in several localities where all other evidence of sinks or caves has been obliterated. The persistency with which it accompanies present caves and sinks would lead one to conclude that the presence of this material indicates the location of former openings of this character.

STRUCTURES.

The structural features of this district include caves, filled sinks and faulting.

CAVES—The caves occur in the Gasconade dolomites and have been formed by the solvent action of ground water. Near the mouth of Gourd creek there is a large cave having this origin. It is 100 feet wide and 12 feet high at the mouth, the principal chamber extending 185 feet into the hill. Back of this chamber is a tapering gallery several hundred feet long, from which issues a small stream. A bank of bat guano two to four feet thick covers about one-sixth of the area of the cave proper.

Smaller caves occur in the S. E. ¼ Sec. 9, T. 36, R. 9, at the mouth of Vessie branch, and in Poole hollow. In the N. E. ¼ Sec. 16, T. 36, R. 9, a cave has captured the drainage of one of the tributaries of Kaintuck hollow, the water passing through a tunnel 100 feet long and 6 feet high.

FILLED SINKS—Sinks resulting from the enlargement of caves and the falling in or settling of the overlying beds were formed during some previous period of erosion. Later, they were filled by deposits when the land was submerged. The material filling the sinks or caves was afterwards consolidated and more recently, as a result of erosion, the filled sinks have been brought to the surface. They occur not only at the heads of valleys but also on the ridges and uplands, their position apparently bearing no relation to the present surface or underground drainage. Wherever

exposed, the strata which once formed the roof of the cave may be seen dipping at various angles towards a common center.

FAULTING—A zone of normal faulting traverses the middle of the area, beginning in the S. W. ¼ Sec. 27, T. 37, R. 9, and extending southeast to Treable creek.

The principal fault has a maximum down-throw of 100 feet to the south. It begins in the S. W. ¼ Sec. 27, T. 37, R. 9, striking S. 60° E. After a slight bend, as shown on the map, it crosses Little Piney creek and dies out in the N. E. ¼ Sec. 1, T. 36, R. 9. At the first exposure in Sec. 27, and in the north-central part of Sec. 34, the upper Roubidoux sandstone having a displacement of 50 feet is exposed along the fault line. The sandstone at this place has a well developed system of joints striking with the fault and displaying irregular wavy seams of quartzite probably recementing the fractures in the sandstone.

At several places near the center of Sec. 35, the entire thickness of the upper sandstone is exposed south of the fault. The exposures form nearly vertical cliffs, and near the fault the surface is rough and brecciated. The fragments are chiefly angular quartzite with occasional pieces of chert. As a rule, the sandstone contains seams of quartzite, which form pencil-like ridges on the case hardened surface. These ridges cross each other at various angles, making a roughly rhomboidal network. Near the middle of the line between the northeast and southeast quarter sections nearly all of the Roubidoux below the top of the upper sandstone is exposed south of the fault. Along the fault near the top, the rock has been slickensided.

On the end of the ridge in the N. W. ¼ S. W. ¼ Sec. 36, and east of Little Piney creek, the faulting is recognized chiefly by the displacement, there being no conspicuous escarpments.

At the mouth of the ravine draining south between the northeast and northwest quarters of Sec. 35, T. 37, R. 9, the displacement is 60 feet. Approximately 1,200 feet south of the main fault in Sec. 35 there is a zone of distributive faulting, in which occur a number of parallel faults striking N. 58° E. These faults have a down-throw to the north, the displacement varying from 20 to 40 feet.

Faulting was here traced to the east as far as Mill Dam hollow and to the west as far as the central part of the S. W. ¼ Sec. 35. These faults are not persistent. In places they overlap each other, resembling step faulting, and here as well as farther to the west,

part of the displacement has been relieved by dip. The exposures are characterized by quartzite seams and jointing parallel to the strike.

Two small faults occur 500 feet apart on the bluff on the east side of Little Piney creek in the south-central part of Sec. 36. The area between these faults has been dropped about 20 feet. The escarpments are on the upthrow sides and are accompanied by the usual brecciation and quartzite seams. The faults dip toward each other at an angle of 20°. In the same section north and northeast from here, there are a number of faults of too little importance to be shown on the map.

On the southwest side of Treable creek, in the S. W. ¼ Sec. 31, there is a fault having a down-throw of 60 feet to the northeast and striking S. 55° E. From this place the fault can be followed about 1¼ miles to the N. E. ¼ Sec. 6, T. 36, R. 8, where it disappears beneath the delritus of the valley. There are no well defined escarpments, although the fault plane is clearly exposed near the mouths of the valleys and on the points of the ridges.

Indications of another fault are found on the east side of Treable creek, but the actual line of faulting was not determined. At the base of the ridge near the road in the S. W. ¼ N. E. ¼ Sec. 6, T. 36, R. 8, the contact of the lower sandstone with the Gasconade is 40 feet below its normal position. The fault line passes between this point and the top of the ridge immediately east, where the upper sandstone is found at the correct elevation.

IRON.

Iron ore is found associated with the filled sinks already described. From three of the sinks shown on the map, iron ore has been mined; these are, the Hudgeons bank, in Sec. 36, T. 37, R. 9, the Kelly No. 1, in Sec. 18, T. 36, R. 8, and the Buckland bank, in Sec. 20, T. 37, R. 8. The Moselle No. 10, in Sec. 20, T. 36, R. 8, is just outside of the area mapped. These deposits of iron ore were all opened forty years ago, and from them several thousand tons of ore were shipped.

The Moselle bank No. 10 is located on a small tributary of Gourd creek. The sink is apparently small. The ore is in part specular hematite and in part red hematite, ochre and limonite.

Kelly No. 1 bank is on the ridge north of Gourd creek. The ore is mainly red hematite, with which occurs some specular hematite.

The Buckland is a small deposit situated near the railroad. The ore consists of specular and red hematite.

It is possible that iron ore exists in other sinks in this area, and while it is recognized that filled sink structures do not always contain iron ore, they present the best localities in this district for prospecting.

LEAD AND ZINC.

Galena has been found in Phelps and adjoining counties for many years. The early settlers gathered it from the stream bottoms and smelted it into lead for bullets. A great many shallow test pits have been sunk in this area and in recent years prospecting has been carried on by sinking shafts and drilling. In a number of localities in the residual clay, near the contact of the Gasconade and Roubidoux formation, galena has been found in aggregates of crystals, commonly called "cog" ore. This is sometimes associated with barite and less often with zinc blende. These minerals originally occurred in the joints and solution cavities of the once overlying beds. The disintegration of these beds and the removal of the less stable minerals, has resulted in the concentration of the galena, barite and zinc blende in the residual clays. Lead also occurs in cracks and cavities in the chert beds of the Gasconade, particularly in those about 50 feet from the top of the formation. It appears to be more abundant where the beds are broken with numerous joints, especially near the surface. Zinc blende and galena also occurs in vugs and small solution cavities at some places in the dolomite beneath the brecciated chert.

The above brief outline of the geology of the Newburg district indicates the formations underlying the area, and those structures which may have been instrumental in directing the circulation of ground waters. The introduction of mineral bearing solutions in the lower portion of the Gasconade will depend largely upon the openings in the formation. Such avenues of circulation are probably afforded by the zones of faulting and deeper sinks and the area contiguous to such structures is considered the most favorable for deep prospecting.

The following companies have been engaged prospecting in the Newburg district during the past year.

The Little Piney Mining and Drilling Co.

J. B. Holman and Alexander Bros.

The Newburg Mining and Development Co.

CHEMICAL ANALYSES.

During the past biennial period the Department has received many specimens and samples requiring chemical tests or complete analyses to determine their commercial value. Samples collected by the members of the survey Staff have also been analyzed, the results being published in the reports of the Department.

The following include a number of complete analyses of clays, ores and mineral waters received from different localities. There are no special reports in preparation covering the areas from which they were obtained.

CLAYS.

(1)

Samples of drill cuttings taken from an undeveloped flint fire clay bank located just east of the Frisco railroad north of Rolla, Phelps county, on property owned by Mr. D. Cowen. This deposit is reported to have been drilled to a depth of 100 feet. The clay, as taken from a 30-foot shaft, carries considerable sand, and has a light, gray color.

		No. 1.	No. 2.
Moisture	(—105°)	0.65%	0.98%
Moisture	+105°)	11.49	12.27
Silica	SiO_2)	50.42	45.09
Iron Oxide	(Fe_2O_3)	0.73	0.87
Alumina	(Al_2O_3)	35.64	38.67
Lime	(CaO)	0.32	0.17
Magnesia	(MgO)	0.00	0.00
Total		99.25%	98.05%

Sample No. 1, 20 to 28 feet beneath surface.
Sample No. 2, 40 to 48 feet beneath surface.

(2)

Fire clay taken from near the bottom of the pit of the Fulton Fire Brick Company of Fulton, Mo.

Moisture	(—105°)	1.29
Moisture	(+105°)	9.71
Silica	(SiO_2)	55.32
Iron Oxide	(Fe_2O_3)	1.13
Alumina	(Al_2O_3)	30.26
Lime	(CaO)	0.20
Magnesia	(MgO)	trace
Titanium Oxide	(TiO_2)	1.52
Total		99.43

(3)

Samples of shale obtained from undeveloped outcrops occurring southwest of Nevada on land owned by J. P. Stephenson. The shale has been subject to weathering.

		No. 1.	No. 2.
Moisture	(—105°)	1.21	1.28
Moisture	(+105°)	8.31	4.56
Silica	(SiO_2)	54.02	75.16
Iron Oxide	(Fe_2O_3)	5.25	3.32
Alumina	(Al_2O_3)	26.59	13.29
Lime	(CaO)	0.47	0.24
Magnesia	(MgO)	trace	trace
Potash	(K_2O)	1.49	0.94
Soda	(Na_2O)	2.69	1.70
Total		100.03	100.49

No. 1 upper shale.

No. 2 lower shale separated from No. 1 by 5-inch seam of coal.

(4)

Sample of fire clay obtained from M. E. Pugh, Carrington, Mo.

Moisture	(—105°)	6.30
Moisture	(+105°)	6.11
Silica	(SiO_2)	61.31
Iron Oxide	(Fe_2O_3)	4.42
Alumina	(Al_2O_3)	19.68
Lime	(CaO)	0.40
Magnesia	(MgO)	1.85
Total		100.07

(5)

Sample of white kaolin from Perry county.

Moisture		14.00
Silica	(SiO_2)	44.99
Iron Oxide	(Fe_2O_3)	0.61
Alumina	(Al_2O_3)	40.19
Lime	(CaO)	none
Magnesia	(MgO)	none
Total		99.79

(6)

Samples of clay received from M. E. Pugh, Carrington, Mo.

		No. 1.	No. 2.
Moisture	(—105°)	6.30	0.73
Moisture	(+105°)	6.11	9.33
Silica	(SiO_2)	61.31	57.93
Iron Oxide	(Fe_2O_3)	4.42	2.69
Alumina	(Al_2O_3)	19.68	27.02
Lime	(CaO)	0.40	trace
Magnesia	(MgO)	1.85	0.87
Total		100.07	98.57

Sample No. 1 taken from bed of fire clay occurring underneath coal.

Sample No. 2 white fire clay from near Carrington.

(7)

White kaolin obtained from John Bartholomaeus at Warrenton, Mo.

Moisture	(—105°)	1.40
Moisture	(+105°)	12.29
Silica	(SiO_2)	43.42
Iron Oxide	(Fe_2O_3)	0.54
Alumina	(Al_2O_3)	39.65
Lime	(CaO)	none
Magnesia	(MgO)	0.85
Total		98.15

(8)

Surface clay submitted by the Centralia Development Co., Centralia, Mo. This clay is apparently of glacial origin.

Moisture	(+110°)	5.09
Silica	(SiO_2)	70.36
Iron Oxide	(Fe_2O_3)	3.27
Alumina	(Al_2O_3)	13.16
Lime	(CaO)	0.90
Magnesia	(MgO)	0.94
Alkalies		Undetermined
Total		93.72

(9)

Sample of white flint fireclay from near Wesco, Crawford Co.

Moisture	(at 105)	.57
Moisture	(+105)	4.23
Silica	(SiO_2)	78.25
Iron Oxide	(Fe_2O_3)	none
Alumina	(Al_2O_3)	14.88
Lime	(CaO)	trace
Magnesia	(MgO)	.696
Hf. residue		.39
Total		99.016

Partial analysis of fire clay obtained from Chadwick, Mo.

Silica	(SiO_2)	81.99
Iron Oxide	(Fe_2O_3)	11.35
Alumina	(Al_2O_3)	
Lime	(CaO)	none
Magnesia	(MgO)	0.35
Total		93.69

MINERAL WATERS.

(10)

Samples of water obtained from the R. D. Silver well, located two miles north of St. Peters in St. Charles county. The well has a strong artesian flow and is so cased that the water is obtained through two pipes from the upper and lower portions of the well.