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# GEOLOGY OF THE SOUTH HALF OF THE MERAMEC SPRING QUADRANGLE, MISSOURI

BY

HOWARD J. YORSTON

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A

THESIS

submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI

in partial fulfillment of the work required for the

Degree of

MASTER OF SCIENCE, GEOLOGY MAJOR

Rolla, Missouri

1954

84367

SCHOOL OF MINES ... ROLLA, MO.

Approved by - O R Grawe
Professor of Geology

## Acknowledgements

The author wishes to express his appreciation to Dr. O. R. Grawe, Chairman of the Department of Geology of the School of Mines and Metallurgy, University of Missouri, for his valuable assistance and guidance in the field work and in the preparation, critical review and correction of the manuscript. Dr. A. C. Spreng of the Department of Geology of the School of Mines and Metallurgy assisted in problems of paleontology. Dr. E. L. Clark, State Geologist, made available the maps, water well logs, geophysical data and unpublished manuscripts on file at the Missouri Division of Geological Survey and Water Resources. The writer is further indebted to the staff members of this organization for their aid, especially to Dr. Thomas Beveridge for contributing his time in discussing problems of stratigraphy and to Mr. Earl McCracken for the identification of questionable rock samples submitted to him. Finally the author wishes to thank the residents of this area who by their wholehearted, enthusiastic cooperation added immeasurably to the pleasure of undertaking this work.

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# INTRODUCTION

## Purpose and scope of report

This report is a continuation of the work initiated by Mueller (1)

(1) Mueller, H. E., Geology of the north half of the Meramec Spring Quadrangle: Missouri School of Mines and Metallurgy, Thesis, 1951, 124 pp.

in his mapping of the north half of the Meramec Spring Quadrangle. The completion of this work provides not only a geologic map of the whole quadrangle but also completes the mapping of the geology of a strip of quadrangles extending from Rolla to the Mississippi River. In addition to being a step closer to the goal of complete geologic coverage for the state, this work will be of value to those concerned with the prediction of depths of wells drilled in the search for water, which in view of the drought of the past year may become increasingly important in the near future.

The study is confined to the geology and associated features of this region. Additional data have been included where the author believes it to be of interest or to add to the general value of the report.

## Previous work

Very little work has been done in the south half of the quadrangle compared to that of the north portion. This is understandable in view of the interest in Meramec Spring and the more numerous and accessible rock exposures in the northern region.

Shumard (2) makes the first reference to the geology of this area

(2) Shumard, B. F., Reports on the Geological Survey of the State of Missouri, 1855-1871: Missouri Geological Survey, 1873, pp. 239, 249.

by describing a geologic section in sec. 17, T. 36 N., R. 7 W. and noting the presence of iron ore deposits in sec. 32, T. 36 N., R. 5 W. and in the NW 1/4, sec. 27, T. 36 N., R. 7 W. Schmidt[3] mentions or

(3) Schmidt, Adolf, The iron ores of Missouri, preliminary report on the iron ores and coal fields from the field work of 1872: Geological Survey of Missouri, 1873, pp. 133, 134, 153, 202, 203, 204, 207, 208.

briefly describes the Winkler, Smith (Nos. 1,2 &3), Benton Creek, Lamb, Clark (No. 2), Arnold and Blackwell Mines and the Cook, Craig, Hall, Seaton, Hyer and Cold Spring Banks. Nason[4] gives good descriptions

(4) Nason, F. L., A report on the iron ores of Missouri: Missouri Geological Survey, Vol. 2, 1892, pp. 116, 221, 226-229, 321.

of the Blair, Williams, African, Clark, Lamb, Smith, Stimson, Winkler Benton Creek Mines and the Hawkins Bank. Crane[5] describes, in

(5) Crane, G. W., The iron ores of Missouri: Missouri Bureau of Geology and Mines, ser. 2, Vol. X, 1912, pp. 204, 205, 223, 224, 226, 233, 289-292, 294, 296-298.

addition to the aforementioned, the Watkins, Brady, Burns, Clinton and Kelly (No. 3) iron deposits and mentions a reported occurrence of iron ore in the N 1/2, sec. 12, T. 35 N., R. 6 W. Fay and Martines[6]

(6) Fay, A. H., and Martines, C. E., Report on the Reed, Stimson and Kelly copper and iron banks of Phelps County, Missouri: Missouri School of Mines and Metallurgy, Thesis, 1902, pp. 5-10

give a detailed description of the Stimson Mine and a less detailed account of the Kelly (No. 3) Bank. The geologic descriptions in the majority of these old reports are inadequate, however, they are still of considerable value in that they contain the only available data on the underground workings in areas which no longer are accessible. Grawe (7) has redescribed the Kelly (No. 3), Cold Spring and Hawkins Banks

(7) Grawe, O. R., Pyrites deposits of Missouri: Missouri Geological Survey and Water Resources, ser. 2, Vol. XXX, 1945, pp. 258, 287, 302, 402, 415, 417, 430, 434.

and the Lamb, Stimson and Benton Creek Mines, giving the most complete accounts of their geology and mineralogy. Beckman and Hinchey (8)

(8) Beckman, H. C., and Hinchey, N. S., The large springs of Missouri: Missouri Geological Survey and Water Resources, ser. 2, Vol. XXIX, 1944, pp. 65, 88.

describe and give the statictics on two of the better known springs in the area, Brown Spring and Lake Spring.

C. L. Dake, other faculty members and students of the Geology Department of the Missouri School of Mines and Metallurgy have mapped isolated portions of the south half of the quadrangle. Dake's work consists, for the most part, of a reconnaissance survey along the main roads with a small amount of detailed mapping on parts of Dry Fork, and at the Kelly Bank and the area adjacent to Lecoma. Dake's survey was conducted for the purpose of preparing a generalized geological map of the state and the original maps are on file at the Missouri Division of Geological Survey and Water Resources. In addition, these files contain 29 logs of water wells drilled in the area and the field notes pertaining to geophysical surveys conducted primarily in the vicinity of iron banks. Gravimetric and magnetic reconnaissance surveys have also been made in this region as part of a statewide geoaccount of the Kelly (No. 3) Bank. The geologic descriptions in the majority of these old reports are inadequate, however, they are still of considerable value in that they contain the only available data on the underground workings in areas which no longer are accessible. Grawe[7] has redescribed the Kelly (No. 3), Cold Spring and Hawkins Banks

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## Present work

The major portion of the field work for the present report was conducted during the period August 1st to September 13th 1953. Detailed studies of problematical areas were undertaken during October, November and December.

## GEOGRAPHY

### Location and area

The south half of the Meramec Spring Quadrangle comprises an area of about 116 square miles, having a length of approximately 8.5 miles and a width of 13.7 miles. The major portion, consisting of 72 square miles, lies within Phelps County. A one and one-half mile strip on the east is in Crawford County and a two and one-half mile strip on the south is in Dent County. The half-quadrangle is bounded by parallels 37° 45' and 37° 52' 30" north latitude and by meridans 91° 30' and 91° 45' west longitude.

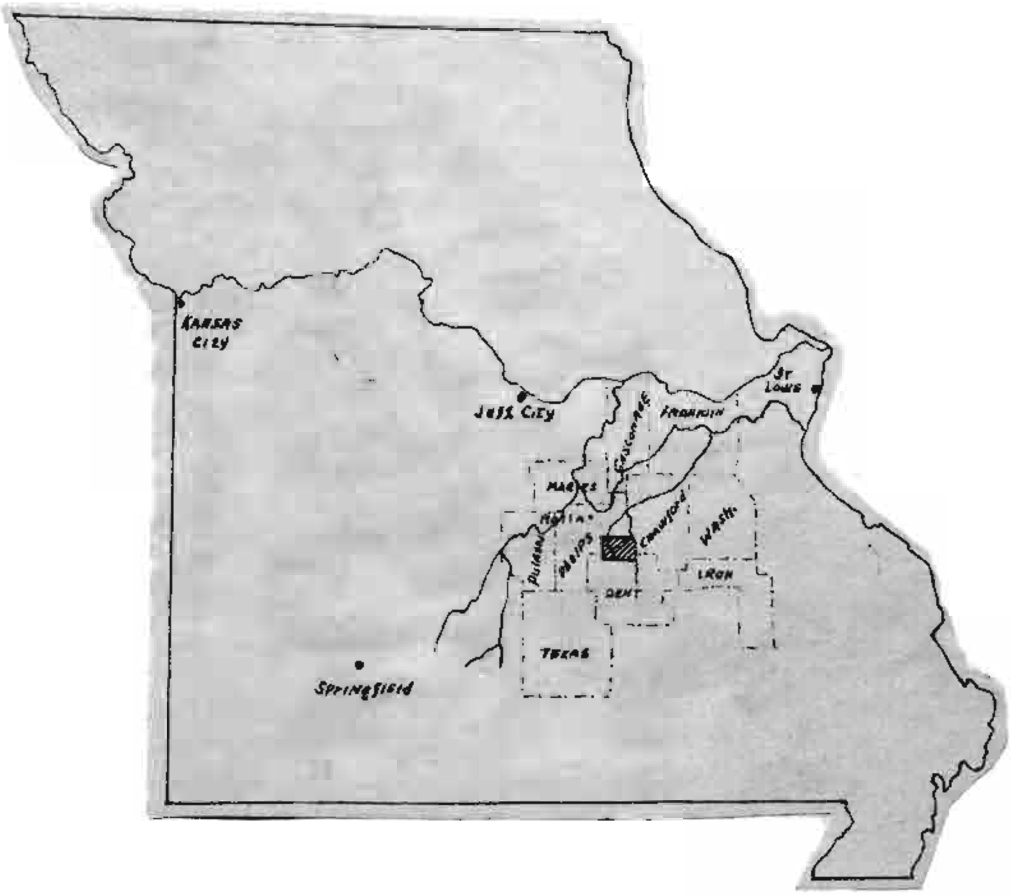


Fig. 1 Index map of region dealt with in this report.

### Early history and development

The early history and development of the area has been discussed by Schultz,(9) Goodspeed,(10) and in a publication of the Phelps County

Historical Society[11].

(9) Schultz, G., Early history of the northern Ozarks, Jefferson City, Missouri, Midland Printing Co., 1937. 192 pp.

(10) Goodspeed, History of Phelps County, Missouri. Reprint of material relating to Phelps County occuring on pages 623 to 688 and 974 to 1027 from History of Laclede, Camden, Dallas, Webster, Wright, Texas, Pulaski, Phelps and Dent Counties, Missouri. Chicago, Goodspeed Publishing Co., 1889. Reprinted at Missouri School of Mines and Metallurgy, Rolla, Missouri, February 1943, 79 pp.

(11) Phelps County Historical Society, The history of Missouri School of Mines and Metallurgy, Rolla, Missouri, Phelps County Historical Society, 1941, 1020 pp.

Artifacts, aboriginal house mounds, cave dwellings and skeletal remains have been found in the peripherial regions beyond the south half of the quadrangle. Fowke[12] describes these remains in Phelps,

(12) Fowke, Gerard, Cave explorations in the Ozark region of central Missouri: Smithsonian Institution Bureau of Ethnology Bulletin 76, 1922, pp. 41-42.

Fowke, Gerard, Aboriginal house mounds: Smithsonian Institution Bureau of Ethnology Bulletin 76, 1922, pp. 161-165.

Dent and other counties. Chapman[13] describes pre-historic remains

(13) Chapman, Carl H., Stone age men of Crawford County. Missouri Resources Museum Bulletin 16, p. 3.

found in Crawford County. To the author's knowledge, no remains other than artifacts in the form of arrow and tomahawk heads have been found in the south half of the Meramec Spring Quadrangle.

The Osage Indians were in the northern Ozarks when the first white explorers arrived in the latter part of the seventeenth century. These Indians clámed possession of all land between the Arkansas and Missouri

Rivers and maintained this claim until 1808, at which time it was ceded to the United States in return for an annual payment of $3,000.00. The Indians were permitted to continue living and hunting upon the ceded territory and did so until about the middle of the 19th century. The Delaware and Shawnee Indians entered the Ozark region in the latter part of the eighteenth century and settled along various rivers including the Meramec. The Shawnee are the best known of the early inhabitants of the Phelps County area. This tribe had a camp on the Meramec south of St. James and were instrumental in the establishment of the iron industry in the area. Continued encroachment by the white man, however, resulted in the western migration of these tribes and by 1836 the Indians had vacated this region.

The explorations of Joliet and Marquette along the Mississippi gave France a claim to the entire Mississippi Valley, aclaim which they retained until 1763. In this year the region was ceded to Spain, but the Spainards did not occupy the northern Ozarks until 1767. France regained control in 1800 but the Spainards remained as custodians until 1804 at which time the Louisiana Purchase brought the Mississippi Valley under the dominion of the United States.

The earliest white settlers in the northern Ozarks came from Tennessee, Kentucky and Virginia around 1820. These people were chiefly of Scotch-Irish-English decent. In the early 1830's German immigrants began entering the counties of Franklin and Gasconade. This immigration was the result of a book written by Gottfried Duden whose express purpose was to encourage German immigration to America. Duden purchased a farm in Warren County in 1824 and spent three years farming the land in order to gather detailed data for his book. He so praised Missouri that a short time after its publication, in Germany in 1829, the German immigration began. This early settlement of Germans in Missouri served as an inducement to later German immigrants to locate in Missouri.

The settlement history of Phelps County closely parallels that of the northern Ozarks except that few, if any, German families resided in the area prior to the Civil War. By 1880 there were more than 20 German families in the county.

The present inhabitants of the south half of the quadrangle are predominantly of Scotch-Irish-English descent. The second major group is of German extraction.

The early settlers were devoted almost entirely to agriculture which Goodspeed describes as, "a kind of easy-going agriculture." In 1826 the area entered upon the industrial age with the establishment of the Meramec Iron Works (14) at St. James. During the latter part of

(14) Mueller, H. E., op. cit., 1951. This report contains an excellent, brief account of the history and development of the Meramec Iron Works. A more detailed treatment is given in Van Nostrand's Thesis listed in the bibliography.

the eighteen hundreds and early nineteen hundreds iron ore mining and timbering were important industries. Mining and timbering declined shortly after the turn of the century and agriculture again assumed the role of the chief industry. Cattle grazing has become increasingly important in the past few years and if the present trend continues the major portion of the region will be devoted to it in the future. The most popular breed at present seems to be the Black Angus and the author has seen excellent herds of this stock during his field work.

## Culture

There has been little community development in this area. Most of those communities which survived the decline of the mining and timbering industries were stunted in future growth by the advent of good roads which permitted rapid travel to the larger towns of Rolla, St. James and Salem. At present, in the area, only Lecoma and Hobson are of sufficient size to warrant a status approaching that of a town. Small communities consisting of several houses, a school and a church are found at convienent points throughout the area, but for the most part the population is dispersed in isolated dwellings.

The region is served by several excellent state and county primary roads and a large number of fairly good secondary roads. State Highway No. 72, running parallel to Dry Fork is the only surfaced road in the area. State Highway O, along the western boundary; State Highway No. 68, in the eastern zone, and a network of roads in Dent County are excellent gravelled roads capable of carrying heavy traffic under all weather conditions. The major drawback to these roads is the use of low-water bridges which are impassable during times of high water, however, the infrequency of such conditions fully warrants their use. The Shuman Ridge Road along the eastern boundary of Range 7 is improperly classified on the topographic map of the quadrangle. Recent improvements have made this road comparable to the better roads mentioned above. Further, the road net in Dent County has been extended subsequent to the revision of the map and is not completely shown.

Many of the dirt roads shown on the map are no longer passable throughout all or part of their length. The visiting motorist is cautioned against entry upon these abandoned roads before making local inquiry. This is particularly important where the roads cross major streams since in almost all cases the fords have been washed out and crossing is impossible. Turn-arounds are not always available at these sites and backing up a steep, loosely gravelled or sanded road is attended with considerable difficulty.

A small loop of track of the St. Louis and San Francisco Railroad cuts across the extreme southeast corner of the quadrangle. Formerly a spur of this track extended northwest to Clinton and then northward paralleling State Highway No. 68. Service on this spur was discontinued following the decline of the mining and timbering operations in the area and the track was removed in the early 1930's. St. James now serves as the railroad center for the area.

A private landing strip is located in the center of sec. 3, T. 35 N., R. 7 W. The strip is unsurfaced and capable of handling only light airplanes.

## Climate

The climate of the region is temperate and continental. The summers are hot with maximum temperatures of 105 degrees F. and an average of about 75 degrees F. The winters are completely unpredictable, severe cold periods with temperatures as low as - 20 degrees F. are followed by unusually mild spells having temperatures as high as 70 degrees F. The annual mean temperature is 55.5 degrees F.

The annual mean precipatation is 41.81 inches.[15] The distribution

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(15) Mueller, H. E., ibid. p. 22.

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is not uniform, late summers are usually extremely dry giving rise at times to drought conditions, the winter months are generally accompanied by moderate moisture whereas late spring usually is characterized by heavy rainfall.

## PHYSIOGRAPHY

### Regional setting and geologic history

The Meramec Spring Quadrangle is located in the northcentral part of the Salem Plateau sub-province of the Ozark Plateau. Figure 2 (16) shows the location with respect to the major and minor

(16) Beckman, H. C. and Hinchey, N. S., op. cit. P. 20

physiographic features. The Salem Plateau is used here in the same


**Fig. 2. Major Physiographic Provinces of Missouri**

senso as it was defined by Fenneman, (17) i.e., as that portion of the

(17) Fenneman, N. M., Physiography of the eastern United States, New York, McGraw Hill, 1938, p. 647.

Ozark Plateau underlain by Ordovician or older beds excluding the St. Francois Mountains. The Springfield Plateau is genetically the same as the Salem but differs stratigraphically in that it is underlain by beds of Mississippian age.

The geologic history of the Ozarks (18) is one of repeated uplift

(18) Fenneman, N. M., ibid. p. 659-662.

and peneplanation. After several of these cycles the region was domed during the Appalachian Revolution and as far as is known it has been a land mass ever since. It has been base-leveled and uplifted on several more recent occasions. One such uplift gave rise to the development of broad valleys and wide meandering streams in Late Pliocene. A subsequent uplift, marking the beginning of the Quaternary, initiated gorge cutting in these valleys which has continued to the present time. Glaciation, which modified the topography of Northern Missouri in Pleistocene time, did not extend into the Ozark region and had no direct effect upon the topography. The present topography is the result of continued normal erosion throughout all of Quaternary time.

## Topography and Drainage

The topography of the southern half of the quadrangle is gradational, ranging from relatively undissected uplands in the northwest across moderately dissected hills in the center to deeply entrenched uplands in the east. The highest point in the area is Blue Knob (center, sec. 36, T. 36, R. 6 W.) with an altitude of 1296 feet. The lowest point, with an altitude of 840 feet, is in the valley of Benton Creek in the extreme northeast corner of the area. The maximum relief is 456 feet.

The drainage is dendritic. The major streams, Dry Fork, Norman Creek and Benton Creek, flow northward and ultimately empty into the Meramec River in the north half of the quadrangle.

The valley of Dry Fork is the largest and shows the best development of the three streams. The flood plain varies in width from 0.0 miles in sec. 2, T. 36 N., R. 7 W. to a maximum of 0.9 miles in sec. 35, T. 36 N., R. 7 W. The thickness of the alluvium varies from 0 to 20 feet with an average of about 15 feet throughout most of the valley. Well developed, incised meanders indicate rejuvination of the stream and corroborate the statements, relative to the development of wide meandering streams and subsequent uplift, made in the preceeding section. A cut through meander is found in north central, sec. 7, T. 35 N., R. 6 W. The previous course of the river was southward around the isolated hill whereas the present course circumvents the hill on the north side. A second but much smaller meander is found on the valley floor in the NW 1/4, sec. 35, T. 36 N., R. 7 W. Throughout most of its course natural levees have been developed on Dry Fork. These are approximately 10 feet high and are located from 30 to 50 feet from the stream channel.

The region drained by the Dry Fork is underlain predominantly by the Roubidoux sandstone. The major exception to this is the area in the northwest which is underlain by the Jefferson City formation.

Norman Creek drains the central portion of the region which is also underlain by the Roubidoux formation. The stream can best be described as a small scale replica of Dry Fork even to the remarkable similarity in the direction of course. Both streams are intermittent. This intermittency is due to the high porosity and permeability of the Robidoux formation which reduces the run-off and permits seepage of the water into solution channels in the underlying Gasconade dolomite. Along Dry Fork some of this sub-surface drainage is returned through Brown, Lake and several other springs, along the course, but the quantity of water derived in this manner is normally insufficient to saturate the floor of so large a valley.

Benton Creek is the only perennial water course in the region. The low resistance to erosion of the Gasconade dolomite which underlies most of the area accounts for the mature dissection of the terrain drained by this creek. This also provides a steep gradient for the tributary streams and permits a high percentage of run-off. The walls and heads of the valleys are in both the Roubidoux and the Gasconade formations and are characterized by steep incisions which further increases the ruggedness of the topography.

## Caves

Two caves occur in the area. One is 1/4 mile east of the intersection of the Shuman Ridge Road and the east-west road crossing the north portion of sec. 7, T. 36 N., R. 6 W. The second is located 1/4 mile on a bearing of S. 20' W. from the Central School in SE 1/4, SE 1/4, sec. 16, T. 36 N., R. 7 W. Both caves are of the same type in that collapse of the roof has formed a sink through which entrance into the underground chambers may be gained. The Central School cave reportedly has been explored but no data are available as to the nature of its chambers or its extent. The second cave has not, as far as is known, been explored. These caves differ from the majority of caves in the Ozark region in that they are in the Robidoux formation whereas all others are in the Gasconade. The author was informed that a cave exists in the bluff on the north bank of Dry Fork in the NE 1/4, sec. 2, T. 36 N., R. 7 W. however, it could not be located. Several small caves were found in the Roubidoux formation along Dry Fork. These have been formed by the solution of dolomite beds interstratified the quantity of water derived in this manner is normally insufficient to saturate the floor of so large a valley.

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## Springs

In the area under consideration the springs are neither large nor of particular interest. The majority are located along the bluffs of Dry Fork where the exposure of water bearing strata produces a continuous dripping of water into pools formed in the stream bed. Although the quantity of discharge is small, these pools provide a valuable source of water for stock during the dry season in late summer.

Two of the larger springs feeding Dry Fork are Lake and Brown Springs both located in the northern part of Dent County. Lake Spring is situated approximately 100 feet west of the highway bridge over Hyers Branch in the SE 1/4, sec. 3, T. 35 N., R 7 W. A rock walled pool has been built at the spring site to collect the water before it empties into Hyers Branch. The flow [19] on May 12, 1936 was 14,400 gallons per day. At the time of the present author's visit in late August the discharge was considerably less. Brown Spring is the largest spring in the area. It is located in sec. 17, T. 35 N., R. 6 W. on the east bank of Dry Fork. The water issues from the base of a bluff, flows in a westerly direction and empties directly into Dry Fork. The flow [20] on May 18, 1936, was 90,500 gallons per day. The

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(19) Beckman, H. C. and Hinchey, N. S., op. cit., p. 88.

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(20) Beckman, H. C. and Hinchey, N. S., ibid. p. 65.

discharge from this spring was also very low at the time the writer inspected it.

Two other comparitively large springs, not mentioned by Beckman and Hinchey, are located in the same general area. One is in the NW 1/4, sec. 3, T. 35 N., R. 7 W. and the other in the NE 1/4, sec. 34, T. 36 N., R. 7 W. Both springs are in a meadow above Dry Fork and the water emerges from an exposed rock ledge.

The two springs mentioned above and the small springs along Dry Fork are in the basal part of the Roubidoux formation whereas Brown Spring and Lake Spring are in the Gasconade formation approximately 60 feet below the Gasconade-Roubidoux contact.

## Scenic attractions

Although there are no specific scenic attractions in this area the visitor who is willing to travel the back roads or little used trails will find a simple, rustic beauty equal to that anywhere in the Ozarks. The true beauty of the region can best be viewed from the high bluffs overlooking the valleys. Fortunately one of these scenic overlooks is readily accessable from the Cook Station Road where it crosses Benton Creek in sec. 5, T. 36 N., R. 5 W. Standing on the bluff above the creek one can look over the beautiful valley and well imagine the Utopia it represented to the early settler seeking his new home.

## Wildlife

Mueller[(21)] reports that the present wildlife of this area includes,

(21) Mueller, H. E., op. cit. p. 31

among the fur-bearing animals, deer, squirrel, beaver, fox, rabbit, oppossum, skunk, mole and gopher. To this list the author will add racoon which he has seen on two occassions. The smaller animals are most frequently seen along the flood plains at least during the dry summer months. The writer did not see any deer but did see signs of them such as tracks in corn fields and beds in the rocky regions.

The quail and dove are the common game birds and of these the quail predominates. They are most frequently encountered in the fields adjacent to the flood plains of the major streams.

Snakes reported to inhabit the region include copperheads, rattlesnakes, cottonmouths, water moccasin (non-poisonous), blacksnakes, whipsnakes, garter snakes, racers, hoopsnake, milksnake and puffadder. From the authors experience the blacksnake is most common. The copperhead is reportedly common, however, only two were met during the field work. The cottonmouth is quite rare and the rattlesnake almost unheard of.

The perrenial nature of Benton Creek makes it the only suitable stream for game fish in the area. The only fish seen in the stream were suckers, however, it is quite likely that the fish common to the Meramec River, to the north, work their way up Benton Creek especially when the water level is high.

Hunting in the region is completely restricted to the local residents. A large part of the area is devoted to a game preserve and most of the farms are limited game preserves established by cooperation between the farmers and the State Conservation Commission.

# DESCRIPTIVE GEOLOGY

## Stratigraphy

General. --- The rocks in this area consist primarily of dolomites and sandstones of topmost Cambrian and Lower Ordovician age. They are underlain by approximately 1400 feet of strata which separates them from the pre-Cambrian granites and porphyries which constitute the principal basement rocks of the Ozark Dome.

The sequence of Cambrian formations, with their approximate thickness which underlie this area is as follows: the Lamotte formation (0 - 300 feet), the Bonneterre formation (200 - 350 feet), the Davis formation (170 feet), the Derby-Doe Run formation (100 - 250 feet), the Potosi formation (300 feet) and the Eminence formation (250 feet).

Bridge (22) and Dake (23) give excellent summaries of both the

(22) Bridge, J., Geology of the Eminence and Cardareva Quadrangles: Missouri Bureau of Geology and Mines, ser. 2, Vol. XXIV, 1930 pp. 55-97.

(23) Dake, C. L., The geology of the Potosi and Edgehill Quadrangles: Missouri Bureau of Geology and Mines, ser. 2, Vol. XXIII, 1930 pp. 26-135.

pre-Cambrian igneous and Cambrian sedimentary rocks in adjacent areas.

## CAMBRIAN SYSTEM

### Eminence formation

The Eminence formation of Upper Cambrian age is the oldest rock unit exposed in the south half of the Meramec Spring Quadrangle.

Name and history. --- The beds presently assigned to the Eminence formation formerly were included in the Third Magnesium Limestone by early geologists. Nason (24) in 1892 introduced the term Gasconade to

(24) Nason, F. L., op. cit., pp. 114-115.

apply to the limestone beds underlying the Roubidoux formation. However, his failure to define the base of the Gasconade resulted in the establishment of a stratigraphic unit which contained a series of beds now differentiated into six formations ranging from the Bonneterre through the Gasconade. In 1901, Nason (25) redefined the Gasconade by

(25) Nason, F. L., On the presence of a limestone conglomerate in the lead region of St. Francois County, Missouri: American Journal of Science, ser. 4, Vol. 11, 1901, p. 396.

establishing as its base that of the present Potosi formation and thus included those formations which presently are known as the Potosi, Eminence and Gasconade. In 1908, Buckley, (26) established the

(26) Buckley, E. R., Geology of the disseminated lead deposits of St. Francois and Washington Counties: Missouri Bureau of Geology and Mines, ser. 2, Vol. IX, 1908, p. 51.

boundaries of the Potosi formation and indicated the stratigraphic position of the Eminence. Ulrich, (27) in 1911, gave the first des-

(27) Ulrich, E. O., Revision of the Paleozoic Systems: Bull. Geol. Soc. America, Vol. 22, 1911, pp. 630, 631.

cription of the Eminence formation.

Distribution. --- The only known exposure of the Eminence formation in this area occurs along the bluff on the east bank of Benton Creek in the north central part of sec. 5, T. 36 N., R. 5 W. The width of the outcrop is too small to permit accurate representation and it is exaggerated slightly on the areal geologic map.

Thickness. --- The maximum exposed thickness in the south half of the quadrangle is 15 feet but from a study of the formation in other areas the thickness, while variable, is known to be as much as 250 feet.

Lithologic character. --- In general the Eminence formation consists of light-gray, medium-grained, massively-bedded, cherty dolomites. The pinnacle weathering pattern, controlled by intersecting joints and massive bedding, distinguishes the Eminence quite readily from other formations. Another somewhat distinctive feature is the "sandy" texture of some of the beds which results from the loose aggregation of coarse dolomite crystals.

Chert occurs abundantly as beds and irregular lenses in the formation. It differs from the cherts of the lower Gasconade in that it is more weathered and has a rusty, porous appearance.

Sandstones are rare in the formation but it is not too uncommon to find disseminated sand grains within some of the dolomite beds. An insoluble residue of the Eminence dolomites in this area contained very fine angular quartz grains.

Aside from the massive structure, the exposure on Benton Creek does not exhibit the characteristic Eminence structural features. In fact the lowermost Gasconade beds of this area show more of these features, such as the pinnacle weathering outline and "sandy" texture, than do the exposed Eminence Beds. The massiveness of the formation is, however, very distinctive especially when compared with the rather uniform, medium bedding of the Gasconade.

Lithologically, the Eminence in this region consists almost entirely of light-gray, fine-grained, dense argillaceous dolomite. The uppermost bed weathers to dark gray, roughly pitted massive blocks whereas the two lower beds display fairly well defined, bedding planes spaced one to two inches apart. Vugs filled with clear calcite crystals are more common in this group of Eminence beds than in any other rocks examined in the quadrangle. Chert is noticeably absent.

Composite section measured on the east bank of Benton Creek in the SE 1/4, SE 1/4, NW 1/4, sec. 5, T. 36 N., R. 5 W.

| Ordovician System<br>Gasconade formation | Thickness<br>Feet | <br>Inches |
|---|---|---|
| 23. Covered by residual cherts. Large amount of light to dark gray, to angular, porous, chert conglomerate containing sub-rounded chert pebbles 1/8 to 1/4 inches long. A second type of chert is reddish-pink with brecciated appearance. A third type is light-gray with elongate cavities 1/4 X 1 1/2 inches, similar to that in lower Robidoux but less dense. | 32 | 6 |
| 22. Dolomite, lead-gray on weathered surface, light pinkish-gray to dark-tan on fresh surface; medium-to coarsely-crystalline thin-bedded (1 inch) visible on weathered surface only. Weathers with pitted surface and blocky pattern forming steps 4 to 5 inches high. | 24 | 0 |
| 21. Covered zone; chiefly dolomite similar to bed no. 20; also light gray to buff, fine-grained dolomite. | 14 | 2 1/2 |

| | | |
|---|---|---|
| 20. Dolomite, lead-gray on weathered surface, pinkish-gray on fresh surface; medium-grained, euhedral crystals; finely bedded (1/4 to 3/4 inches), bedding visible on weathered surface only, elongate vugs along bedding planes. Weathers with pitted surface and in an irregular pattern. | 4 | 0 |
| 19. Dolomite, light-gray on weathered surface, light-gray crystals with rust-brown residue filling interstices on fresh surface; medium-grained, euhedral crystals; fine-to medium-bedded (1/2 to 2 1/2 inches); porous; on weathered surface resembles sandstone. | 0 | 7 |
| 18. Covered. Float in upper zone is characteristic Gasconade dolomite, lead-gray on weathered surface, light-gray on fresh surface with dark-tan bands along bedding planes; medium-grained, euhedral crystals, sandy texture; fine-bedded (1/2 inch). Weathers with pronounced pitted surface and in blocky outline. | 17 | 6 |
| 17. Dolomite, light tan, fine-grained, contains large amount of brecciated, glassy to translucent chert. | 0 | 8 |
| 16. Dolomite, similar to bed no. 14 but finer grained and thin bedded with vugs aligned along bedding planes. | 1 | 0 |
| 15. Covered. | 2 | 1 |
| 14. Dolomite, light gray with tan stain; medium-grained, euhedral crystals; massive, less dense than lower beds; sandy texture on fresh surface but not on weathered; well defined joint dipping 85 degrees, S. 50 degrees E. | 1 | 6 |
| 13. Covered by pink, fractured cherts and dolomite and by many limonites pseudomorphs. | 11 | 0 |
| 12. Dolomite, light-to medium-gray on weathered surface, pink to tan on fresh surface; medium-grained, euhedral crystals; fine-to medium-bedded with lenticular vugs along planes; weathered surface has sandy appearance. | 1 | 6 - 10 |

| | | |
|---|---|---|
| 11. Covered by chert, dolomite and limonite pseudomorphs. | 3 | 6 |
| 10. Dolomite, medium-to dark-gray on weathered surface, medium-gray on fresh; medium-grained, subhedral crystals; finely bedded with thin vugs along planes; weathered surface has slight sandy texture. | 2 | 1 |
| 9. Dolomite, light-gray with pinkish tint on fresh surface, dark, dull-gray on weathered surface; medium-grained; thin-bedded (2 inches). Weathers to a rough pitted surface with a pinnacle outline. | 11 | 6 |
| Gunter member | | |
| 8. Dolomite, light-to medium-gray on fresh surface, tan to brown on weathered surface, medium-grained, loosely consolidated, sandy texture on weathered surface; thin-bedded (1/4 to 1 inch); contains rounded, frosted, fine sized sand grains which concentrate on weathered face. | 0 | 4 1/2 |
| 7. Dolomite, light-gray on fresh surface, dull-gray on weathered surface; fine-grained; thin-bedded (1/4 to 2 inches), slightly crinkly; contains rounded, frosted, fine-grained sand; blue-green shale partings and vugs filled with calcite crystals. | 1 | 2 |
| 6. Dolomite, light-gray on fresh surface, dull-gray on weathered; fine-grained; medium-bedded (2 inches); contains rounded, frosted, fine-grained sand. | 0 | 4 |
| 5. Dolomite, light-gray on fresh surface, dull light-gray on weathered surface; fine-grained; thin-bedded (1/4 to 1/2 inch); very sandy, contains blue-green shale partings. | 2 | 8 |
| Total Gunter Member | 4 | 6 |
| Total Gasconade | 132 | 0 |
| Contact--- Elevation 849 feet | | |

Cambrian System
Eminence formation

| | | |
|---|---|---|
| 4. Dolomite, light-gray with green and brown stain on fresh surface, dark, dull-gray on weathered surface; fine-grained; very massive. Weathers with pimply surface and blocky outline. | 6 | 2 |
| 3. Dolomite, pinkish-gray on fresh surface, dull-gray on weathered; medium-grained; thin-bedded (2 inches). Weathers tabular. | 0 | 10 |
| 2. Dolomite, medium-gray on fresh surface, dull-gray with pinkish-tint on weathered surface; medium-grained; thin-bedded (1-2 1/2 inches); weathered surface shows trace of bedding planes and tendency of individual beds to protrude in a tabular fashion. | 5 | 4 |
| 1. Covered by alluvium. | 3 | 1 |
| Total Eminence | 15 | 4 |

Water level of Benton Creek --- Elevation 834 feet.

Stratigraphic relations. --- In the Benton Creek section the Gasconade-Eminence contact is sufficiently sharp to permit its definite location at the interface of the massive Eminence dolomite and the overlying, thin-bedded, sandy dolomite of the Gunter Member. The dolomites of the Eminence and Gunter are very similar so that if it were not for the abrupt introduction of rounded, frosted sand grains in the Gunter no particular lithologic distinction could be made between the two beds. Therefore, from the evidence found in this region the contact between the Gasconade and Eminence formations is conformable.

Throughout the Ozark region the Gasconade-Eminence contact is considered unconformable, and is often marked by the basal sandstone or conglomerate of the Gunter. Dake (28) and Bridge (29) discuss this

(28) Dake, C. L. op. cit., 122, 128-129.

(29) Bridge, J., op. cit., p. 90-91.

conglomerate and other criteria pointing to the unconformable nature of the contact between the two formations.

Paleontology. --- No fossils have been found in the Eminence outcrop exposed in this area. At other localities the cherts of the formation are reportedly quite fossiliferous with trilobites and gastropods constituting the important forms. The Cambrian Correlation Chart (30) contains a fairly complete listing of the Eminence fauna.

(30) Howell, B. F., et. al., Correlation of the Cambrian formations of North America: Bull. Geol. Soc. Amer., Vol. 55, 1944, pp. 993-1004.

Age and correlation. --- The Eminence formation is assigned to the upper part of the Trempealeauman Stage of the Upper Cambrian Series.

The Eminence has been correlated (31) with parts of many formations throughout the United States and Canada on the basis of fauna.

(31) Howell, B. F., et. al., ibid., pp. 993-1004.

Massive dolomite of the Eminence formation along Benton Creek in the SE¼, NW¼, sec. 5, T. 36 N., R. 5 W.

## ORDOVICIAN SYSTEM

### Van Buren Formation

The beds which now constitute the Van Buren formation of some geologists were originally considered as part of the Gasconade formation by Marbut.(32) Ulrich referred them to Upper Eminence after

(32) Marbut, C. F., The geology of Morgan County: Missouri Bureau of Geology and Mines, ser. 2, Vol. VII, 1908, pp. 19, 26.

locating a faunal break which he believed made their location within the Gasconade formation untenable. Dake,(33) however, found a pronounced

(33) Dake, C. L., op. cit., p. 136

unconformity between these beds and the underlying Eminence (Ulrich's Lower Eminence). Ulrich continued to insist that the beds could definitely be separated from the Gasconade formation on the basis of fauna and considered the presence of the lower physical and upper faunal unconformities sufficient evidence to establish a new formation. In 1923 he suggested the name Van Buren. The name was accepted by the Missouri Bureau of Geology and Mines in 1929 and first appeared in print in McQueen's(34) report in 1930. Since that time geologists have

(34) McQueen, H. S., Insoluble residues as a guide to stratigraphic studies: Missouri Bureau of Geology and Mines 56th Biennial Report, 1931, P. 118. (Published in March 1930).

variously accepted and rejected the Van Buren as a formation. The most recent Ordovician correlation chart(35) treats the Van Buren as a

(35) Twenhofel, W. H., et. al., Correlation of the Ordovician formations of North America: Geol. Soc. Am. Bull., Vol. 65, 1954, pp. 247-298.

member of the Gasconade formation.

According to Bridge,[36] a silicious oolite bed, 4 to 8 inches

(36) Bridge, J., op. cit., p. 99.

thick forms a boundary between Van Buren and Gasconade fauna and also a tentative contact zone of the two formations.

The author located an oolitic chert bed overlain by a thin, coarse-textured dolomite which in turn was overlain by "cotton rock," at the base of the bluff and 200 feet north of the transit station marker located in the SW 1/4, sec. 29, T. 36 N., R. 5 W. This sequence compares favorably with that given by Bridge[37] at his ten-

(37) Bridge, J., ibid. pp. 83, 112.

tative boundary. However, this is the only exposure of these beds found in the mapped area and at no other site was it possible to establish a Van Buren-Gasconade contact. In view of the inability to differentiate between the two formations, the Van Buren was not mapped as a separate unit but was treated as the lower part of the Gasconade. This decision has little effect upon the appearance of the geologic map since the Van Buren, if mapped separately, would appear as a thin strip along the valley of Benton Creek in the northeastern part of the area.

The term Gasconade is used in this report to apply to all beds between the Eminence and Roubidoux formations.

## Gasconade formation

Name and History. —— Nason [38] first used the name Gasconade

(38) Nason, F. L., op. cit. pp. 114-115.

with reference to the series of limestone beds which underlie the Roubidoux formation. Ball and Smith [39] established the base of the

(39) Ball, Sydney H. and Smith, A. F., The Geology of Miller County: Missouri Bureau of Geology and Mines, ser. 2, Vol. 1, 1903 p. 40.

Gasconade at the top of Gunter sandstone. The limits thus established, from the top of the Gunter to the base of the Roubidoux, corresponded to the upper part of the Third Magnesium Limestone of Swallow, [40] who made the first reference to the presence of this

(40) Swallow, G. C., The first and second annual reports: Geological Survey of Missouri Reports, 1885, p. 126.

formation. In 1908 Marbut [41] added the Gunter sandstone to the

(41) Marbut, C. F., op. cit., pp. 19,26.

Gasconade and placed the lower contact between the Proctor (Upper Eminence) formation and the Gunter sandstone. The separation of the Van Buren from the Gasconade formation has been discussed in the preceeding section.

Distribution. —— The Gasconade formation outcrops in the valley of Dry Fork and Norman Creeks and caps the hills in the eastern and southeastern parts of the area. It is exceeded in areal extent, in this region, only by the Roubidoux formation.

Thickness. —— The total thickness of the Gasconade formation can be estimated in the northeastern part of the half-quadrangle where the entire formation is exposed over a distance of approximately one and one-half miles. An exact measurement of the thickness cannot be obtained in this area because of the undulating nature of the beds and the necessity of locating the Roubidoux-Gasconade contact on the basis of float.

At Benton Creek in sec. 5, T. 36 N., R. 5 W., the Gasconade-Eminence contact is at an elevation of 849 feet. One and one-half miles to the west the Roubidoux-Gasconade contact has been established at 1070 feet. Discounting the dip of the formation, this would give a thickness of 221 feet. An accurate correction cannot be made for the dip since it is not uniform, however, the dolomite beds exposed along the Cook Station Road in the small valley in the SW 1/4, sec. 5, T. 36 N., R. 5 W., occur at approximately the same elevation as corresponding beds in the valley of Benton Creek which indicates that the dip is not appreciable over this half-mile distance.

None of the logged water wells drilled in the south half of the quadrangle penetrate the Eminence formation. Mueller (42) reports that,

(42) Mueller, H. E., op. cit. p. 40.

in the north half of the quadrangle, three wells pass through the entire Gasconade indicating thicknesses from 230 to 290 feet for the formation. He cautions, however, that all wells were drilled in areas showing structural effects of solution.

Hendrix (43) reports an average thickness of 190 to 200 feet for

(43) Hendrix, H. E., The geology of the Steelville Quadrangle: State of Missouri, Department of Business and Administration, Division of Geological Survey and Water Resources. Unpublished manuscript. p. 52.

the Gasconade in the Steelville Quadrangle. Dake (44) states that at

(44) Dake, C. L., op. cit., pp. 153-154.

Scotia, Wesco and Steelville in Crawford County, the thickness of the Gasconade in exposed sections is not over 180 feet and possibly as low as 150 feet.

Lee (45) indicates a thickness of 350 feet for the Gasconade

(45) Lee, Wallace, The geology of the Rolla Quadrangle: Missouri Bureau of Geology and Mines, ser. 2, Vol. XII, 1913, p. 12.

formation in the vicinity of Newburg in the Rolla Quadrangle.

It is evident that there is a general thining of the formation across the southern-half of the Meramec Spring Quadrangle from approximately 300 feet in the west to 200 feet in the east. The variation in thickness, however, is not uniform and it would be impossible to predict the thickness at any given locality because at numerous points throughout this area solution has removed a portion of the Upper Gasconade dolomite resulting in a thining of the formation.

Lithologic Character. —— Dolomite. —— The Gasconade formation consists primarily of light-gray, fine- to coarse-crystalline, thin- to massive-bedded, cherty dolomite.

Coarse crystallinity is characteristic of the Gasconade dolomite especially in the lower part. In the upper part medium-to coarse-grain is quite common, however, ther is no tendency toward a gradation and beds of varying coarseness are irregularly distributed. Very fine crystalline dolomite is rare, having been found in only one bed which is recorded in the section measured at Norman Creek in sec. 5, T. 36 N., R. 6 W. This dolomite is slightly coarser than the "cotton rock" of the Roubidoux and Jefferson City formations but otherwise highly resembles it.

Bedding in the dolomite is, as a general rule, well developed, however, in most cases it can be detected only on the weathered surfaces where differential weathering accentuates the bedding planes. Beds of less than an inch in thickness are not uncommon but are generally obscured by a much thicker blocky development of the weathered rock. The blocky or tabular pattern of the weathered dolomite has resulted from differential weathering along preferred bedding planes and joints and is best observed in areas where the formation caps the hills. Good examples are found along the Cook Station Road in the SE 1/4, sec. 6, T. 36 N., R. 5 W. and along the bluffs on Benton Creek. Where the Gasconade is overlain by the Roubidoux formation the dolomite tends to weather in steep, flat-faced bluffs.

An excellent exposure of this type of weathering is located at the Morrison (46) Ford across Dry Fork in sec. 11, T. 36 N., R. 7 W.

(46) The name, Morrison Ford, appears on the topographic map, however, the local inhabitants insist that the correct name is the Morris Ford.

An interesting type of dolomite is found in the lower beds which upon cursory examination is likely to be mistaken for a sandstone. The grains are coarse, euhedral, and almost completely seperated from neighboring crystals. On the weathered surface the grains protrude in much the same manner as sand grains in a sandstone, Dake (47)

(47) Dake, C. L., op. cit., p.123.

has stated that this phenomenon is found only in the Eminence and Bonneterre formations. Hendrix (48) mentions the sandstone-like

(48) Hendrix, H. E., op. cit., p. 54.

texture of the lower dolomites in his description of the Gasconade.

It is of further interest that associated with these dolomites is a dolomoldic chert that appears to have formed by a deposition of silica around the dolomite crystals which have been subsequently dissolved leaving a perfect mold within the chert.

Chert is commonly found in and interstratified with the dolomite. In the lower beds lenticular nodules and thin lenses of dense, white chalcedonic chert occur, whereas in the upper beds irregularly shaped chert particles tend to predominate.

A dark gray color, rough pitted surface and blocky outline characterizes the weathered Gasconade dolomites. They may be distinguished from the Eminence dolomites by their blocky rather than pinnacle type weathering pattern and by their less craggy appearance, and from the Roubidoux and Jefferson City dolomites by their darker color and blocky pattern. Mueller (49) mentions a similarity between

(49) Mueller, H. E., op. cit., p. 41.

the weathered Gasconade, pitted dolomites and the Quarry ledge of the Jefferson City in that both become dark and roughly pitted upon the weathering. The pitting of the two beds is similar but the

Gasconade dolomite is generally darker on the weathered surface than any of the Quarry ledge specimens the author has examined. On the fresh surface, some of the upper Gasconade dolomites are quite similar in granularity, color, yellowish-tan weathering residue streaks, and fetid odor to the "stinkstone" dolomites of the Jefferson City.

Shales and sandstones. --- Shales and sandstones are very rare in the Gasconade formation. Blue-green shale partings have been found at several horizons, however, except for those in the Gunter sand member and those associated with an upper sandstone lens, they are present only locally. Where continuous, as in the two cases mentioned, these shales constitute valuable markers although their use in the field is restricted because they appear only in fresh cuts or in well cuttings.

The Gunter sandstone constitutes the only distinctive sandstone within the Gasconade formation. Bridge (50) has recorded an average

(50) Bridge, J., Op. cit., p. 100.

thickness of 15 feet in the Eminence Quadrangle and states that moving westward it grades from a complete sandstone into thin-bedded sandstones with intercalated dolomite beds. Dake (51) reports that the

(51) Dake, C. L., op. cit., p. 139.

Gunter is absent or very thin throughout Crawford County.

In the Meramec Springs area, the Gunter sandstone is represented by a thin, sandy, dolomite at its only point of exposure in sec. 5, T. 36 N., R. 5 W. The lithology of this outcrop has been described in the preceding section.

A thin dolomitic sandstone bed was located approximately 50 feet below the Roubidoux-Gasconade contact in the SW 1/4, SW 1/4, NW 1/4, sec. 5, T. 36 N., R. 6 W. The bed is 3/4 inch thick and is associated with blue-green shale lenses and partings. It is quite likely that this bed correlates with those found by Dake [52] and

(52) Dake, C. L., op. cit., p. 154.

Mueller [53] in the north half of the Meramec Spring Quadrangle. The

(53) Mueller, H. E., op. cit., p. 43.

bed mentioned by Mueller is located 9 feet above the Richland Chert Zone and those by Dake approximately 35 feet below the Roubidoux formation, hence there is apparently a close relationship between these beds as shown by their similar location in the section.

Chert. --- The Gasconade contains a large amount of chert which is most conspicuous as float on the hillsides and in the stream beds of areas underlain by the formation. In addition to float, chert occurs as massive cryptozoan reefs, bedded members, thin lentils and stringers, and nodules within and interbedded with the dolomite.

The major chert mass is found generally about 50 feet below the Roubidoux-Gasconade contact and is sometimes referred to as the Richland chert zone. The zone consists of massive, dense, white, oolitic chert, which produces a large amount of the white, blocky, chert float characteristic of the Gasconade; and a cryptozoan reef chert which forms the upper part of the zone. This reef has been located in widely separated areas throughout the Ozarks and is an excellent marker. In this area the massive chert zone is exposed along the northwest wall of the valley of West Fork in the

SE 1/4, SE 1/4, sec. 13, T. 36 N., R. 6 W. About 20 feet above the valley floor the massive cryptozoan reef can be found, however, it is not continuous in outcrop. Another exposure of this reef is located in the stream bed immediately east of the State Highway 68 Bridge over the northernmost creek in sec. 2, T. 35 N., R. 6 W. At this site the Gasconade-Roubidoux contact is approximately 20 feet above the reef which is less than normal. Very likely this abnormally small thickness of the Upper Gasconade (beds above the massive chert zone) has resulted from solution of the upper Gasconade dolomites and subsequent let down of the overlying Roubidoux formation.

Dense, white, bedded, porcelaneous cherts are found also at various horizons in the Gasconade. The best developed chert of this type was located 20 to 30 feet below the massive reef, described above, at the level of the valley floor on the southeast bank of West Fork in the SE 1/4, SE 1/4, sec. 13, T. 36 N., R. 6 W. This chert contains a large number of broad, low spired gastropods which from sections the author has identified as Ophileta sp.

There are several varieties of chert float in the Gasconade formation, some of which can be related to the massive or bedded cherts whereas others can not be traced to any in situ chert member. In the lower part of the formation a very distinctive dolomoldic chert was found above the Eminence-Gasconade contact, at the intersection of the Cook Station Road and Benton Creek in sec. 5, T. 36 N., R. 7 W. This chert is grey, in color, has a massive, dense structure, except for the presence of a large number of pores having the almost perfect outline of dolomite crystals, and exhibts a fairly coarse, rosette-type quartz druse . The dolomoldic chert zone is apparently continuous, having been reported by Grohskopf and McCracken (54) as

Section measured at the hill on the east side of Benton Creek in the SE 1/4, SW 1/4, NW 1/4, sec. 29, T. 36 N., R. 5 W.

| Ordovician System<br>Roubidoux formation | Thickness<br>Feet | <br>Inches |
|---|---|---|
| Top of hill. Elevation —— 1115 feet | | |
| 13. Chert, gray, massive, brecciated. | 2 | 6 |
| 12. Covered. Chert float similar to above. | 3 | 6 |
| 11. Covered. Large blocks of sandstone and chert; chert, pink to gray, dense, porcellaneous, banded about cavities filled with coarse druse. Sand contains chert fragments and silica oolites. | 19 | 7 |
| 10. Sandstone, brown to tan, sub-rounded, frosted, friable, iron oxide stained, few weathered chert fragments, few gray, silica oolites; on weathered surface sand grains stand out in relief. Weathers slabby. | 3 | 0 |
| Total Roubidoux | 28 | 7 |
| Contact —— Elevation 1086 feet | | |
| Gasconade formation | | |
| 9. Covered. Rust-brown to dark-gray, weathered chert and blocks of sandstone from above. | 45 | 9 |
| 8. Dolomite, lead-gray on weathered surface, medium-gray on fresh surface with a brown, clayey residue between grains; fine-to medium-grained, few weathered chert fragments. Weathers blocky (blocks 18 to 24 inches thick). Toward top grain becomes coarser and weathering more intense resulting in a pagoda-like pattern. | 11 | 6 |
| 7. Chert, dirty-gray on weathered surface, white to brown on fresh surface, in places oolitic, shows banding about elongate cavities which are paralled to the bed. | | 9 |

Section measured at the bluff on the north bank of Norman Creek in the SW 1/4, SW 1/4, NW 1/4, sec. 5, T. 36 N., R. 6 W.

| Ordovician System<br>Roubidoux formation | Thickness<br>Feet | <br>Inches |
|---|---|---|
| Top of hill — Elevation 1034 Feet | | |
| 22. Cover to top of hill. | 30 | 9 |
| 21. Sandstone, brownish-tan to-white; fine-grained, sub-rounded, frosted; thin-bedded (1/8 to 1/4 inch); case hardened surface, otherwise friable. Weathers to thin projecting slabs. Dip 10 degrees south. | 22 | 4 |
| 20. Sandstone, similar to bed No. 21 but more massive. Weathers blocky with flat face. | 2 | 6 |
| 19. Covered. Sandstone and chert float. | 33 | 6 |
| Total Roubidoux | 86 | 7 |
| Contact —— Elevation 947 feet 11 inches | | |
| Gasconade formation | | |
| 18. Dolomite, light-gray on weathered surface, light-cream gray on fresh surface, with few brown, weathered spots; medium-grained, thin-bedded (1/8 to 1/4 inch), numerous thin cavities along bedding planes otherwise has a very dense texture. | 4 | 8 |
| 17. Dolomite, similar to No. 16 but finer grained, more poorly bedded, intensly weathered with many large vugs 3 to 5 inches long. | 3 | 8 |
| 16. Dolomite, brownish-gray on weathered surface, light cream-gray on fresh surface with brownish stain in cavities; medium- to coarse-grained; thin-to medium-bedded. Weathers to thin blocks. | 2 | 2 |
| 15. Dolomite, brownish-gray on weathered surface, light-gray with brown,clayey streaks on fresh surface, very similar to bed No. 13 but massive. | | 10 |
| 14. Covered. | 2 | 1 |

| | | | |
|---|---|---|---|
| 13. | Dolomite, gray, coarse-grained, thin- to medium-bedded, linear cavities along bedding planes, few brown, weathered clayey spots. | 5 | 10 |
| 12. | Dolomite, brownish-gray on weathered surface, light-gray on fresh surface; medium-grained; some cavities. Contains bluish-gray chalcedonic chert. | | 5 |
| 11. | Dolomite, gray on weathered surface, buff- to cream-gray on fresh surface; medium-grained; thin-bedded, (1/4 inch). Weathers to pitted surface. | | 11 |
| 10. | Dolomite, gray to tan on weathered surface, light-gray and clean on fresh surface; thin-to medium-bedded (1 to 2 1/2 inches); has a ropy texture but does not exhibit pitting. Contains few disseminated sand grains. | 1 | 3 |
| 9. | Dolomite, dull-gray on weathered surface, light-gray on fresh surface with a large number of green particles and brown, clayey weathered zones; medium-grained, thin- to medium-bedded. Weathers with pitted surface. | 3 | 11 |
| 8. | Dolomite, similar to bed No. 7 but with more cavities, medium-grained, no visible bedding planes but weathers slabby (1 to 3 inches). Practically a gradation from the underlying bed. | | 11 |
| 7. | Dolomite, cream-gray on fresh surface; very fine-grained; thin-bedded (1/8 to 1/4 inches) weathers flat faced with blocky pattern (2 to 5 inches) | 1 | |
| 6. | Dolomite, medium-gray, coarse-grained, thin-bedded (1/4 to 3/4 inches). Weathers tabular. At base has blue-green shale partings. | | 3 |
| 5. | Dolomite, light-gray on fresh surface with numerous brown-coated very fine solution cavities; coarse-grained, finely bedded (1/4 inch). Weathers in blocky pattern with flat face. | | 7 |

| | | |
|---|---|---|
| 4. Dolomite, coarse-grained, thin-bedded (1/4 to 3/4 inches). Upper part contains blue-green shale lenses having a maximum length of 5 inches. Also contains a 3/4 inch bed of sandy dolomite. The sandy bed is localized, sand is white, fine-grained and sub-rounded. | | 7-11 |
| 3. Dolomite, light cream-gray on fresh surface with few brown streaks, coarse-grained, thin-bedded (1/4 inch), contains fine cavities and weathers to pitted surface. | 1 | 2 |
| 2. Dolomite, light-gray on fresh surface, medium-grained, fine, wavy bedding. Upper part contains platy beds separated by blue-green shale partings. | 1 | 1 |
| 1. Dolomite, light-gray on fresh surface with brown weathered zones, coarse-grained, massive, small solution cavities. Weathers to pitted surface. | 1 | 8 |
| Total Gasconade | 33 | 1 |

Stream bed of Norman Creek --- Elevation 915 feet.

Weathering. --- The rough pitted, step-like development of the Gasconade dolomite is generally well developed along moderately steep bluffs and best developed toward the base of the bluff where the break in slope occurs. Below the break, where active erosion by streams is taking place, the dolomite is flat-faced and of less pitted character. In areas of rolling hills or gentle slopes dolomite outcrops are not found but the hillsides are profusely covered with chert. The high incidence of chert residuum in the soil seriously detracts from its productivity and restricts farming operations to the alluvium covered valley floors.

Topographic expression. --- Areas underlain by the Gasconade formation are highly dissected with narrow valleys and fairly steep, talus covered hillsides. Where capped by the resistant overlying Roubidoux sandstones, the Difference in the rate and nature of weathering produces deeply incised valley heads which are quite distinctive. The sum of these features produces a topography so different from the Roubidoux that a reasonably accurate contact can be drawn on the basis of topography alone.

Stratigraphic relations. --- The Gasconade-Eminence contact, as previously mentioned, is conformable in this area.

The physical evidence for a break between the Gasconade and Roubidoux formations is extremely scant. The presence of a sandstone-chert conglomerate in the basal Roubidoux is sometimes pointed to as evidence of an unconformity but similar conglomerates are common throughout the Roubidoux and chert pebbles are frequently found in the dolomite of the upper Gasconade. The contact in this area appears to be conformable. In other areas, for example, in the Appalachian Mountains, a section several hundred feet thick separates the Roubidoux and Gasconade equivalent formations. Further, this intervening unit contains the Tribes-Hill-Stonehenge fauna which has never been reported in Missouri.

Paleontology. ––– The Gasconade fauna of this area has been described by Bridge (57) who divided the formation into four zones,

(57) Bridge, J., ibid., p. 115.

the Euomphalopis zone in the lower portion, the Ozarkina zone in approximately the middle part, the distinctive Cryptozoon ozarkensis zone and the upper Helicotoma zone. In each case the zone is named after the fossil most abundantly found in it. This zonation was not apparent in the area studied, however, no specific search was made for fossils in the section.

A detailed account of the brachiopod and cephalapod fauna found in the Gasconade is contained in papers by Ulrich and Cooper (58)

(58) Ulrich, E. O., and Cooper, A. G., Ozarkian and Canadian brachiopoda: Geological Society of America Special Papers No. 13, 1938, 322 pp.

and Ulrich et. al. (59)

(59) Ulrich, E. O., Foerste, A. F., Miller, A. K., and Furnish, W.M., Ozarkian and Canadian cephalapoda: Geological Society of America Special Papers No. 37, 1942, 157 pp.

A large amount of the Gasconade chert contains fossils in the form of internal and external molds and casts. However, both the are common throughout the Roubidoux and chert pebbles are frequently found in the dolomite of the upper Gasconade. The contact in this area appears to be conformable. In other areas, for example, in the Appalachian Mountains, a section several hundred feet thick separates the Roubidoux and Gasconade equivalent formations. Further, this intervening unit contains the Tribes-Hill-Stonehenge fauna which has never been reported in Missouri.

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A large amount of the Gasconade chert contains fossils in the form of internal and external molds and casts. However, both the matrix and fossils are composed of the same material and the fossils are visible only where differential solution has removed the matrix but left the fossil form intact. When exposed on the surface the fossils stand out in relief and are readily noticed but generally lack the structural details necessary for positive identification. The best fossil preservation has been found within weathered, tripolitic chert masses. Preservation of this type of chert is brought about by the formation of a very fine quartz druse contemporaneous with the differential solution at the interface of fossil and matrix. As the cavity is enlarged the very fine druse gives way to a coarser but still finer grained quartz druse. A subdued outline of the fossil appears on the crystalline face of the druse and is normally of little value in identification. If, however, the outer or coarse band is chipped away, a perfectly preserved specimen may be obtained on the inner layer of very fine druse. Chert float exhibiting this type of preservation can usually be identified by its tan color, smooth, rounded, finely porous surface and unusual lightness.

Fossils were obtained in place at two localities and from two different beds. The previously described Cryptozoan reef close to the Gasconade-Roubidoux contact, in sec. 2, T. 35 N., R. 6 W., yielded one specimen of Finkelnburgia sp. and a very poorly preserved, unidentifiable specimen of an orthoceraconic type cephalopod. The bedded chert in the valley of West Fork in sec. 13, T. 36 N., R. 6 W. contains a large number of gastropods of the genus Ophileta.

In the chert float the most common fossils were found to be gastropods similar to Ophileta and Euomphalopsis.

By far the most interesting and certainly the most prolific faunal assemblage was obtained from a block of tripolitic chert float found in the valley of Benton Creek in the vicinity of the transit station marker in sec. 29, T. 36 N., R. 5 W. This block measured approximately 7 inches by 4 inches by 12 inches and contained hundreds of well preserved fossils. A preliminary study of this specimen revealed the presence of several species of Ophileta, Ozarkina sp., Hystricurus sp., several species of Finkelnburgia very similar to F. bellatula and F. missouriensis, two species of unidentified, high spired gastropods, and one species of an orthoceraconic type cephalopod. The trilobite referred to the genus Hystricurus is similar to Hystricurus missouriensis but differs in size and in the shape of the glabella. It is about 1/2 the size of the H. missouriensis holotype. The glabella is very high, ovate in outline and slopes equally in both posterior and anterior directions. Several cranidia and pygidia have been found and since all the cranidia belong to the same species it seems reasonable to assume that the pygidia also belongs to that species.

Age and correlation. --- The Gasconade represents the oldest formation of the Canadian series. In the classification proposed by Ulrich it constituted the highest or youngest formation of the Ozarkian system.

The formation is continuous throughout the Ozark region and has been reported in outcrop and well cuttings in numerous localities. A recently published correlation chart (60) by the Ordovician Subcommittee of the Committee on Stratigraphy, of the National Research Council, gives the correlative formations throughout the United

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(60) Twenhofel, W. H., et. al., Correlation of the Ordovician formations of North America; Geol. Soc. Am. Bull., vol. 65, 1954, pp. 247-298.

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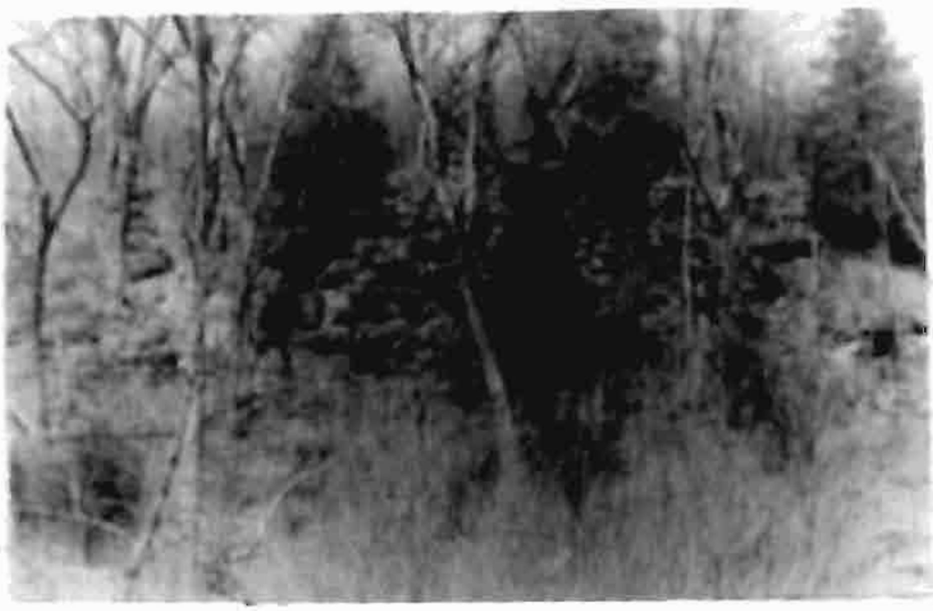
States, Canada, Newfoundland and Greenland.



Typical outcrop of Gasconade dolomite on the bluff above Byers Branch in the [illegible], [illegible], sec. 3, T. 35 N., R. 7 W.

**Fig. 1. Massive cryptozoan chert reef in the Gasconade formation. Creek bed east of State Highway No. 68 in the northcentral part of sec. 2, T. 35 N., R. 6 W.**

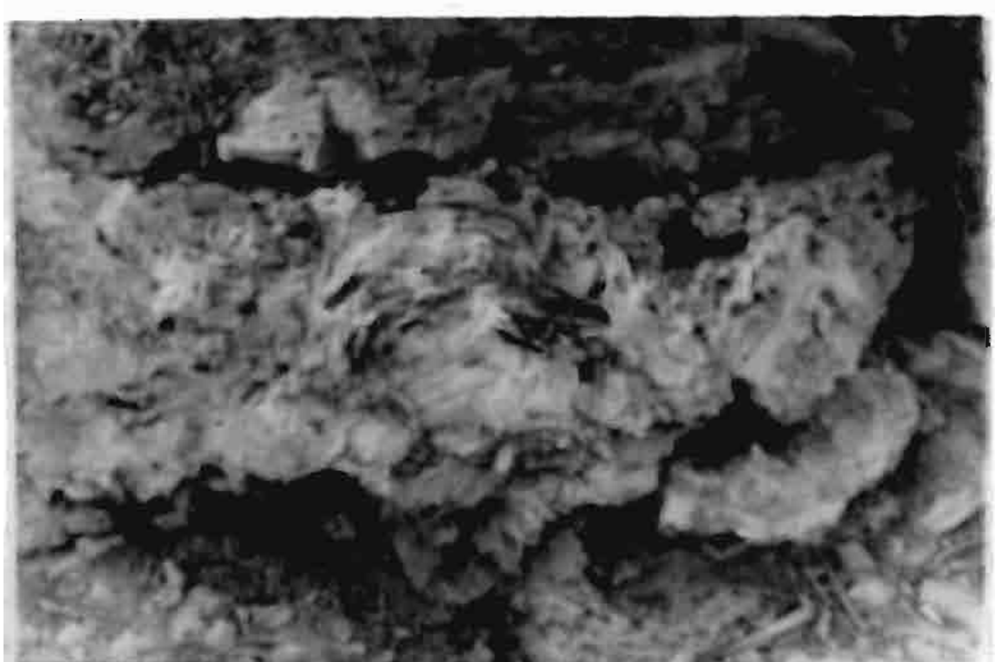


**Fig. 2. Near view of cryptozoan chert shown in fig. 1.**

Roubidoux formation

Name and history. —— The sandstone and dolomite beds now referred to the Roubidoux formation formerly constituted the Second Sandstone of Swallow, Shumard and other early geologists. Nason[61]

(61) Nason, F. L., op. cit., p. 115.

introduced the name Roubidoux to be applied to the beds then known as the First and Second Sandstones which he believed were equivalents. This interpretation later proved to be incorrect when the true relationship between the Roubidoux and the First or St. Peter Sandstone was established. Winslow[62] used the name Roubidoux in referring to what

(62) Winslow, Arthur, Lead and zinc deposits: Missouri Geological Survey, Vol. VI, 1894, p. 331.

is now called the St. Peter Sandstone and coined the name Moreau for the present Roubidoux formation. Ball and Smith[63] introduced the

(63) Ball, S. H., and Smith A. F., op. cit., pp. 50-51.

name St. Elizabeth to designate the beds between the Gasconade and Jefferson City formations. The name Roubidoux was reintroduced by Bain and Ulrich,[64] who at the same time defined the formation as it is

(64) Bain, H. F., and Ulrich, E. D., The copper deposits of Missouri: U. S. G. S. Bulletin 267, 1908, p. 12.

presently accepted.

Distribution. —— The Roubidoux formation underlies more than 2/3 of the total area in the south half of the Meramec Spring Quadrangle. It has been removed from the valleys of the larger streams particularly along Benton Creek in the east and along the southern extent of Dry

Fork. In the northwestern part of the area it is overlain by the Jefferson City formation.

Thickness. --- The thickness of the Roubidoux formation can be determined from surface outcrops and well log data in the northwestern part of the area where it is capped by the overlying Jefferson City formation. It should be pointed out, however, that any thickness determined for the Roubidoux will invariably be an approximation, since, in most cases, neither the upper nor lower contacts can be established with absolute certainty in the field, and in cases where the thickness is obtained from drilled wells there is the possibility that a hidden sink structure has been penetrated which may account for a considerable differance between the measured and true thicknesses. Further, where composite sections are measured over fairly large distances the erratic nature of the dip will prohibit the application of an accurate dip correction.

In this part of the Ozark region the Roubidoux is reported to range from about 115 to 150 feet in thickness. Lee [65] gives the

(65) Lee, W., op. cit., p. 21.

thickness in the Rolla Quadrangle as ranging from 115 to 150 feet; Mueller [66] reports a thickness of 115 to 130 feet in the north half

(66) Mueller, H. E., op. cit. p. 56.

of the Meramec Spring Quadrangle and Hendrix [67] has found a thickness

(67) Hendrix, H. E., op. cit., p. 68.

of 120 to 150 feet of Roubidoux where the formation is exposed and overlain by Roubidoux residium, in the Steelville Quadrangle. Thus the original thickness of the formation is known to have exceeded 150 feet in that area.

In the south half of the Meramec Spring Quadrangle the thickness of the Roubidoux formation, as far as can be determined, ranges from 105 feet to 142 feet. The minimum figure was obtained from a well drilled in sec. 18, T. 36 N., R. 7 W. which passed through the formation. The maximum figure was obtained from the Roubidoux exposed in sections 10 and 11, T. 36 N., R. 7 W. and includes a correction for the regional dip. Another well drilled in sec. 31, T. 36 N., R. 7 W., approximately 3 miles south of the well mentioned above, passed through 135 feet of the Roubidoux. In view of the reported thickening of the formation toward the sough by both Lee and Mueller, the 105 feet thickness is apparently to small and may be accounted for by thinning due to solution or structure, or to the relief on the pre-Roubidoux surface. If the rate of thickening established by Mueller is assumed to be constant then a thickness of approximately 160 feet may be inferred for the original Roubidoux in the southernmost part of the Meramec Spring Quadrangle, however, since part of the formation has been removed from here this figure cannot be confirmed.

Lithologic character. --- In the sough half of the Meramec Spring Quadrangle the Roubidoux formation consists largely of sandstone with interbedded dolomite and chert. The quantitative relationship of the rock types shows considerable variation across the area. In the western and northwestern portions, the sandstone and dolomite occur in almost equal amounts. Toward the south and east the dolomite content diminishes and the sandstone becomes the predominant constituent. The chert varies in both form and quantity across the half quadrangle. In the western area the chert is, for the most part, disseminated in or associated with the dolomite whereas in the central and eastern portions it occurs in beds up to 6 feet thick and is commonly interstratified with sandstone. This may be due to a replacement of the dolomite by chert or to the segregation of disseminated silica upon solution of the dolomite.

The Roubidoux outcrops in the bluffs along Dry Fork follow to some degree the general pattern of the Roubidoux described by Lee (68)

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(68) Lee, W., op. cit., p. 22-30.

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in the Rolla Quadrangle. A still better correlation is obtained if the covered beds of the Dry Fork outcrops are assumed to be dolomites. Farther to the east, the outcrops along Norman Creek show very little dolomite and even if the zones now mantled with cover are considered to represent dolomite beds a correlation cannot be shown with the section in the Rolla Quadrangle. High magnetic anomalies have led to the suggestion that a submarine ridge once existed in this area which would account for the difference in the section.

Sandstones. —— In general, the sandstones of the Roubidoux formation are dull, reddish-brown on the weathered surface and light-gray to tan on the fresh surface. The grain size ranges from fine to coarse, however, the majority of grains are of medium size. The grains are commonly rounded but show extensive secondary overgrowth which produces well developed crystal faces. Bedding ranges from almost fissile to massive beds approximately 5 feet thick. The sand is quite friable on fresh surfaces, however, exposed faces and blocks in the float are frequently case-hardened which provides an effective armor against weathering. Cream colored, spherical or discoidal oolites are common in the sandstone as are chert fragments which range from sand grain to pebble size. The chert fragments are both rounded and angular and generally appear to be quite weathered. Many of the sandstone beds are slightly calcareous and in the lower part of the formation dolomitic sandstones are found. Orthoquartzites formed by the cementation of sand grains with chert and vitreous silica are quite common, however, they appear to be local features and cannot be traced for any distance laterally.

An interesting relationship between the sandstone and dolomite beds can be seen in the outcrop at the base of the bluff on the northeast bank of Norman Creek in the east central part of sec. 18, T. 36 N., R. 6 W. The lowermost bed consists of a thin, very friable sand which appears to have been cemented at one time. Immediately overlying this bed is a very sandy dolomite, the sand of which is identical to that in the underlying bed. The appearance of these beds suggest the possibility that the lower pure sand bed was formed by the post depositional solution of dolomite from a sandy dolomite such as the uppermost bed. A behavior similar to this has been noted before in the Gunter sand member of the Gasconade formation, in which the weathered surface of sandy dolomites shows an accumulation of sand grains and appears as sandstone. A similar origin has been suggested for some of the Jefferson City sandstone beds.

The Roubidoux sandstones are generally iron-stained and some beds show an accumulation of iron oxide in the form of small projecting nodules. Manganese oxide also commonly causes staining of the sandstone.

The most prominent sandstone bed in the Roubidoux occurs in the upperpart of the formation. This bed is the equivalent of the 3rd sandstone member of Lee. It frequently is found capping the central part of the half quadrangle and is the prominent bluff former where the Roubidoux section is exposed. This bed ranges from 30 to 40 feet in thickness and is located approximately 50 feet above the base of the formation. In the lower part it is commonly brown to reddish-brown but lightens to tan, light-gray or white in the upper parts. Grain size varies from very fine to fine and the grains invariably show crystal faces as the result of secondary overgrowth. The bedding is medium to coarse except in the center to upper part where very fine bedding produces thin laminae which protrude from the weathered face. Cross-bedding and ripple marks are well exhibited by this member.

The uppermost bed of the Roubidoux formation consists of a white, very clean, fine-to medium-grained sandstone. This bed averages two to three feet in thickness and is sufficiently wide spread in this area to be used in establishing the contact between the Jefferson City and Roubidoux formations.

Cross-bedding, ripple-marks and casts of mud-cracks are common features in the sandstones of the Roubidoux formation. The ripple-marks are generally small having crests from 3 to 4 inches apart and in this area only current type ripple-marks were seen. Dake[(69)]

(69) Dake, C. L., op. cit., p. 164.

reports that both current and oscillation types are found in the Roubidoux. An interesting structure resembling giant, ripple-marks occurs in upper sandstone beds on the bluff on the west bank of Dry Fork in the NE 1/4, sec. 16, T. 36 N., R. 7 W. The crests of these "ripple marks" are about 30 feet apart and the amplitude amounts to several feet. Actual measurements could not be made because the bluff at this site is inaccessible.

Casts of mud cracks are commonly seen in the sandstone float. The trace of these casts produces a mosaic of imperfect polygonal forms ranging from 1 to 5 inches in diameter.

Dolomites. —— Two types of dolomite occur in the Roubidoux formation. The lower dolomite is very similar to that of the underlying Gasconade formation. It is light-gray in color, fine-to medium grained, thin-to medium-bedded and weathers to a dull, dark gray pitted surface. Disseminated sand grains are common, however, the quantity of sand in any bed shows considerable lateral variation. Thin chert beds are frequently interstratified with the dolomite. Good exposures of the lower Roubidoux dolomite are found at the base of the bluffs along Dry Fork.

The dolomite of the upper Roubidoux is rarely exposed. When it does outcrop its similarity to the "cotton rock" of the lower beds of the Jefferson City formation, requires that other criteria must be utilized in order to distinguish between the two formations. The term "cotton rock" is used to define a white to buff, very fine-grained, argillaceous dolomite. The name in no way implies a resemblance of the dolomite to cotton. From a descriptive viewpoint the term is a misnomer, however, it is widely used in the literature and generally accepted. The "cotton rock" is medium-bedded and generally interstratified with chert beds of the same thickness. Exposures of this rock occur in the intermittent stream crossing State Highway No. 72

in sec. , T. 36 N., R. 7 W. Another outcrop which is believed to be Roubidoux but may be lower Jefferson City appears along the bank of the northeast trending intermittent stream in the vicinity of the east-west road in the SE 1/4, SE 1/4, SE 1/4, sec. 19, T. 36 N., R. 7 W. This site is of interest in that Roubidoux sandstone outcrops along the road whereas in the stream bed on both sides of the road medium-bedded "cotton rock" interstratified with chert is found with its base at a lower elevation than the top of the sandstone. Beds definitely identified as Jefferson City outcrop along the road 23 feet above the stream bed. The dip on these beds is to the northeast, east of the stream bed and to the northwest, west of the stream bed, indicating a folded structure possibly the plunge of a small north-south anticline. The anomalous relationship of the sandstone to the "cotton rock" beds may be explained by the deposition of the dolomite over an east-west trending sand bar or similar structure, which was later folded along a north-south axis. The sand bar structure was suggested by Dr. O. R. Grawe and is believed to be a more acceptable explanation than one involving the intersection of two folds.

Cherts. --- Chert occurs in the Roubidoux formation as massive and thin beds, nodules, cryptozoa, float and disseminated fragments in the sandstone.

The bedded cherts are found in both the lower and upper parts of the formation. The lower cherts, exposed in outcrops along Norman Creek and in the eastern part of the area, are white to light-gray on the fresh surface, dense, porcellaneous, frequently oolitic and break with a smooth or conchoidal fracture. They can usually be distinguished from Gasconade cherts which they resemble, by the presence of sand grains disseminated through the chert or serving as centers for siliceous, cherty oolites. Also the Roubidoux chert contains a much coarser quartz druse than that normally found in the Gasconade chert. The float produced by the lower Roubidoux chert is similar to that found below the massive chert zone of the Gasconade.

A chert mass located on the west side of the north-south road in the SE 1/4, SE 1/4, SE 1/4, sec. 24, T. 36 N., R. 6 W., is of some interest in that lithologically it appears to be Gasconade however, stratigraphically it must be referred to the Roubidoux formation. This mass is very dense, china white and completely free of fossils, oolites or sand grains. Sand grains were found in fragments in the vicinity however, it could not be established beyond doubt that these fragments were derived from the chert mass. This chert occurs in a region underlain by Roubidoux sandstone and since no evidence of faulting could be found, no basis existed for assigning it to any but the Roubidoux formation.

In the upper dolomites thin beds of white, slightly chalky chert occur which except for the white color resemble the surrounding "cotton rock." At places streamers extend out from these beds and engulf blocks of the dolomite. The chert also occurs as nodules within the dolomite.

The cryptozoan cherts of the Roubidoux have been found in this area only in the float. The fragments show a much finer development of the laminae and a more uniform appearance than does the cryptozoan cherts of the Gasconade. When found <u>in situ</u>, in stream beds, they are reported to have a ropy, concentric structure and pot-holed upper surface.

A chert mass which in general appearance resembles the cryptozoan structure was found in the intermittent stream bed, 300 feet east of the north-south road in the SW 1/4, SW 1/4, NW 1/4, sec. 3, T. 36 N., R. 7 W. This chert is translucent in part, bluish-gray in color, has a concentric structure and weathers pot-holed on the upper surface. A similar type chert has been described by Cullison (70) as being

(70) Cullison, J. S., The stratigraphy of some Lower Ordovician formations of the Ozark Uplift: Missouri School of Mines and Metallurgy Bulletin, Techincal Series, Vol. XV, No. 2, 1944, p. 15.

characteristic of the upper Cotter formation. Chert float having similar characteristics has been seen in the stream beds throughout the area and may have been derived from these masses. It differs from the typical cryptozoan structure in that it shows a more uniform layering or banding and does not exhibit the curved sets of laminae separated by columns.

Many types of chert float are found in areas underlain by the Roubidoux formation. White to cream, dense, oolitic blocks of chert are derived from the lower part of the formation, especially in the eastern part of the area.

Dark, dull-red chert breccia, consisting of large angular chert fragments is commonly found. The mosaic appearance of this breccia suggests that it has been formed by the fracturing of a chert mass rather than by the agglomeration of individual chert particles.

Dense, white, porcellaneous chert containing lenticular, thin, separated bands of bluish-gray, banded chert and airfoil shaped slots seen in the float derived from the Roubidoux formation. These slots generally are coated with a quartz druse and are believed by some workers to be voids left by the solution of dolomite pebbles originally contained within the chert. A similar type texture is found in Eminence cherts and some specimens have been reported to still retain the dolomite pebbles. A thin section was made of a Roubidoux specimen of this type chert, however, no evidence of dolomite was found.

Chert within the sandstone occurs as rounded, flattened pebbles and small irregularly shaped particles. The latter do not form conglomerates in that they appear to have been introduced after the deposition of the sand.

A "sandstone" composed entirely of samll chert fragments was located below the major sandstone bed on the north bank of Dry Fork in the NW 1/4, NW 1/4, sec. 1, T. 36 N., R. 7 W. The chert grains are rounded and of uniform size. The deposit may be primary in origin or it may have resulted from the concentration of chert particles imbedded in a dolomite which has undergone solution.

The two most useful Roubidoux cherts for determining location within the section are what may be called a "spongy" or "lacy" chert and a very distinctive dark-red, oolitic chert. The first mention has been found throughout the area and always in the upper part of the formation. On the weathered surface it is white to light-gray with a slight pink tint and consists of a fine network of connecting veins which outline numerous pores that are coated with a very fine quartz druse. The fine veins, pores and druse gives the chert a delicate external appearance.

The dark-red, ollitic chert is found in the uppermost part of the Roubidoux and has been used in the field as a guide in establishing the contact between the Jefferson City and Roubidoux formations. It has been found in the western part of the area in the vicinity of Jefferson City outcrops and as residuum on the highest uplands in the central and eastern regions. This chert is characterized by a dark-red matrix cementing medium-sized cream colored oolites, the centers of which contain sand grains. It is not to be confused with a somewhat similar oolitic chert which occurs in the lower Jefferson City formation. The Jefferson City chert is brick-red in color and contains large brown to cream colored oolites, the centers of which are hollow or contain a brown clayey residue.

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Section measured along a north-south line from the base of bluff on the north bank of Dry Fork to the top of the hill in the SW 1/4, sec. 14, T. 36 N., R. 7 W.

| Ordovician System<br>Roubidoux formation | Thickness<br>Feet | <br>Inches |
|---|---|---|
| 22. Covered. Chert, sandstone boulders and quartzite | 12 | 0 |
| 21. Sandstone, grayish-brown on weathered surface, brownish-tan on fresh surface. Fine-to medium-grained, grains sub-rounded with secondary overgrowth; massive. Contains smooth rounded chert pebbles and few oolites. | 11 | 0 |
| 20. Covered. | 10 | 8 |
| 19. Sandstone, weathers brownish-gray. Tan to brown on fresh surface. Very fine-to fine-grained, grains sub-rounded to rounded, frosted. Coarsely bedded. Weathers blocky. | 6 | 0 |
| 18. Sandstone, very similar to bed No. 19 but is thin bedded (1/4 to 1/2 inch) and weathers with thin projecting slabs. | 5 | 0 |
| 17. Sandstone, very similar to bed No. 19, weathers flat faced and tabular, forms a prominent ledge. Surface is case-hardened and has a greasy appearance. Shows good gross-bedding. | 29 | 0 |
| 16. Dolomite, grayish-brown, coarsely crystalline, argillaceous. Contains sand grains. Weathers to a black rough surface. | 1 | 0 |
| 15. Sandstone, dusty-brown color on weathered and fresh surface. Fine-grained, grains rounded and frosted, massive; very friable. Contains small, rounded chert fragments. | | 5 |
| 14. Sandstone, white to cream on fresh surface, fine-grained. Contains zones of tripolitic chert cement. Weathers irregular. | | 8 |
| 13. Sandstone, grayish-brown on weathered surface. Fresh surface is white with brown to reddish-brown patches. Fine-grained, massive, very well cemented, almost quartzitic. Weathers irregular. | 4 | 7 |

| | | | |
|---|---|---|---|
| 12. | Sandstone, brown to tan; fine-grained. Grains are sub-rounded. Friable. | | 8 |
| 11. | Covered. | 13 | 0 |
| 10. | Dolomite, light gray, very sandy, medium-grained crystalline. Sand very fine- to medium-grained, sub-rounded and frosted. Weathers to a smooth, rounded surface upon which only the sand grains are seen. | 1 | 4 |
| 9. | Sandstone, very similar to bed No. 8 but finer grained. Contains bands of sandy dolomite. Dolomite light-gray with fine- to medium grained sand. | 1 | 8 |
| 8. | Sandstone, light-to medium-tan; sub-rounded, slightly frosted grains; friable and porous. Thin bedded. Weathers dull-gray with a rounded face. | 4 | |
| | Total Roubidoux | 101 | 0 |

Contact. —— Elevation 958

Gasconade formation

| | | | |
|---|---|---|---|
| 7. | Dolomite, light-gray on fresh surface, coarsely crystalline, medium bedded (seen only on the weathered surface). Weathers dark gray with small pits parallel to the bedding planes. | 4 | 6 |
| 6. | Dolomite, light-gray with brown stain on fresh surface, medium crystalline, medium-bedded. Weathers tabular. | | 4 |
| 5. | Dolomite, typical Gasconade dolomite, light-gray on fresh surface, coarsely crystalline. Weathers to a rough, pitted surface. | 1 | 8 |
| 4. | Dolomite, light-gray, fine-grained. Contains many small solution cavities and calcite crystals. Weathers to a rounded, vuggy surface, vugs from 1 to 7 inches long. | 1 | 2 |
| 3. | Dolomite, light-gray; medium to coarsely crystalline. Contains light gray to white porcellaneous, dense chert. Weathers step-like. | 2 | 2 |
| 2. | Chert, white, porcellaneous, banded, dense. | 0 | 6 |

| | | |
|---|---|---|
| 1. Covered by talus and alluvium. | 17 | 8 |
| Total Gasconade. | 28 | 0 |

Bed of Dry Fork —— Elevation 930 feet.

Section measured along an east-west line from the base of the bluff on the west bank of Dry Fork to State Highway No. 72 in the NE 1/4, sec. 16, T. 36 N., R. 7 W.

| Ordovician System<br>Jefferson City formation | Thickness<br>Feet | <br>Inches |
|---|---|---|
| 18. Dolomite, weathers to light-gray. Fresh surface light-gray with dull tan residue streaks; fine-grained; has fetid odor when broken. Weathers with a slightly pitted surface. | 2 | 6 |
| 17. Covered. | 30 | 6 |
| Total Jefferson City | 33 | 0 |
| Contact. --- Elevation 1034 feet. | | |
| Roubidoux formation | | |
| 16. Sandstone, weathers light-gray. Fresh surface white; fine-to medium-grained, grains sub-rounded with secondary overgrowth; well consolidated. Contains small white chert grains and dull white, medium-grained oolites. | 2 | 0 |
| 15. Sandstone, medium-gray on weathered surface, reddish-brown on fresh surface, medium-grained, grains sub-rounded with secondary overgrowth. Contains a large number of medium sized chert grains and oolites. Upper weathered surface consists of a chert conglomerate with chert pebbles approximately 3/4 inch in length. | 5 | 9 |
| 14. Covered. Chert and sandstone float. One type of chert has a "spongy" appearance, is light-pinkish-gray and contains a large number of small pores lined with a very fine druse; a second type is white, dense, porcellaneous and has a brecciated appearance. Sandstone is tan on fresh surface, gray on weathered; medium-grained. Contains a large number of coarse chert grains and pebbles. Also contains coarse-grained cream-colored oolites. | 39 | 6 |
| 13. Sandstone, lead-gray on weathered surface, reddish-brown on fresh surface; fine-to medium-grained, predominantly fine-grained. Grains coated with iron oxide. Thin-bedded but weathers to slabs 2 to 5 inches thick. Manganese oxide stain along some of the bedding | | |

| | | | |
|---|---|---|---|
| | planes. Contains small chert grains. | 11 | 6 |
| 12. | Sandstone, tan on fresh, wet surface, dark-brown to gray on weathered surface; fine-to medium-grained, predominantly medium-grained. Coarsens toward the top, grains sub-rounded with secondary overgrowth; thin-to massive-bedding. Weathers with rounded face. | 9 | 0 |
| 11. | Sandstone, light brownish-gray on weathered surface, white with rust-brown stain on fresh surface; fine-grained, grains sub-rounded with secondary overgrowth; thin to massive bedding. Contains very few small, discoidal, cream oolite. Surface is case-hardened and contains small lenticular vugs parallel to the bedding. Ripple marks well developed. Fifty inches above the base is a 6 to 8 inch zone containing very thin undulating beds. A similar zone 10 inches thick occurs 88 inches above the base. | 23 | 8 |
| 10. | Sandstone, reddish-violet stain on wet, weathered surface. Wet, fresh surface is light-gray. Thin-bedded. Beds separated by blue-green shale partings. Sand grains cememted by leached, rotted chert. | 1 | 8 |
| 9. | Sandstone, fine-grained, slightly calcareous, medium-bedded. Grains cemented by chert forming a pseudoquartzitic mass (appears to be quartzite but grains do not break). | 1 | 1 |
| 8. | Sandstone, wet, weathered surface dark-gray. Wet, fresh surface light-to medium-gray; medium-grained, grains sub-rounded with secondary overgrowth. Contains very small cream colored chert particles. | 2 | 2 |
| 7. | Covered. | 6 | 6 |
| 6. | Sandstone, dirty-gray on weathered surface, brownish-tan on fresh, wet surface; medium-grained. Grains sub-rounded and frosted. Medium-to coarse-bedding. Toward the upper part color becomes more reddish and quartzite lenses occur parallel to the bedding. | 5 | 1 |
| 5. | Dolomite, dull-gray on weathered surface, pinkish-gray on fresh surface; fine crystalline; argillaceous, slightly sandy. Contains calcite crystals in vugs and fractures. Laterally becomes more sandy and is replaced by chert. | | 4 |

| | | |
|---|---|---|
| 4. Chert, bluish-gray, sandy, oolitic chalcedonic. Contains small cavities lined with fine druse. Laterally grades into a white sandy chert and finally into overlying bed. | | 2 |
| 3. Dolomite, dull-gray on weathered surface. Light-gray on fresh, wet surface. Medium crystalline; thin-bedded. Contains fine- to medium-grained, sub-rounded sand grains. Upwards grades into a gine-grained pinkish dolomite with diminishing sand grains. | 2 | 2 |
| 2. Sandstone, weathered surface light-to medium-gray. Fresh surface white; fine-to medium-grained. Grains sub-rounded with secondary overgrowths; very cherty. Locally becomes a sandy chert, chert is white, dense and tripolitic. Upward grades into a sandstone containing coarse chert grains and some creamy oolites. Uppermost part is quartzitic. | 1 | 10 |
| 1. Sandstone, medium light-gray on weathered surface. Brown on fresh, wet surface. Medium-grained, grains sub-rounded with secondary overgrowth. Thin-to medium-bedding. Well consolidated. Weathers step-like. Exhibits well developed ripple marks. | 2 | 1 |
| Total Roubidoux | 114 | 7 |

Water level. —— Elevation 920 feet.

Weathering. —— The dolomite beds of the Roubidoux formation weather rapidly and their location on bluff exposures is sometimes marked by distinct indentations. As the weathering proceeds back from the face of the bluff the undercut sandstone beds above, collapse and produce a talus which covers the indented zones. Because of this phase of the weathering, the dolomite beds are exposed only where the steepness of the bluff prevents the accumulation of talus. The weathering of the dolomite also produces a large quantity of chert.

The Roubidoux sandstone is for the most part poorly consolidated and should be expected to disintegrate readily. However, almost all exposed sandstones, whether in place or as float, develop a case-hardened surface which effectively limits further disintergration. At places the silicification produces an orthoquartzite.

Areas underlain by the Roubidoux formation are mantled by a soil cover consisting essentially of sand and small chert fragments. The hillsides and stream valleys are littered with blocks of dark reddish-brown, case-hardened sandstone and blocks and fragments of the cherts previously described.

Topographic expression. —— The characteristic topography of the Roubidoux formation is one of gently rolling uplands in which the topographic rolls follow the general pattern of the structural rolls of the beds. Hills are smoothly rounded and the sides slope gently. As the lower part of the formation becomes exposed the underlying Gasconade with its readily soluble dolomite beds exerts a dominant influence upon the topography. The valleys become more steeply entrenched, the stream gradients increase and the overall topographic expression assumes a transitional appearance between the rugged, maturely dissected Gasconade topography and the moderately dissected topography of the Roubidoux formation.

Since the sandstone members of the Roubidoux formation show such a different weathering habit from that of the Roubidoux, Gasconade and Jefferson City dolomites, the possibility of locating structures by topographic expression was considered. A study was made of the topography associated with known faulted regions in the Rolla and Meramec Spring Quadrangles, however, the results were inconclusive. In the case of the Newburg fault zone,[71] in the Rolla Quadrangle, where the displacement amounts to as much as 100 feet, the topography fails to reveal any perceptible divergence from that of uniformly weathered homogeneous beds. The value of the stream patterns in detecting folds is discussed in a later section.

(71) Lee, W., op. cit., p. 77-80.

Stratigraphic relations. --- The only good exposure of the Roubidoux-Gasconade contact in this area was found along the east bank of Dry Fork in the SE 1/4, SW 1/4, sec. 14, T. 36 N., R. 7 W. The contact at this site is sharp in that well recognized Gasconade dolomite is overlain by the basal Roubidoux sandstone. Immediately above the basal sandstone is a second sandstone which contains bands of sandy dolomite. This in turn is overlain by a sandy dolomite which on the weathered surface appears as a loosely consolidated sandstone. This sequence suggests the possibility that the basal Roubidoux was formerly a sandy dolomite and that solution has removed the dolomitic material, leaving a fairly pure sandstone.

In other parts of the area the contact is covered and its location must be inferred. For mapping purposes float was used to establish the contact in most areas and this should be kept in mind when considering the accuracy of the work. Some workers have established the contact by reference to a marker bed such as the massive chert zone generally accepted as being 50 to 60 feet below the Roubidoux-Gasconade contact. However, in this area, especially in the eastern part, the location of this bed with respect to the contact was found to vary from 15 to 60 feet and for this reason it was considered unwise to use this criterion arbitrarily except where absolutely necessary.

The author has not found any valid evidence for an unconformal relationship between the Roubidoux and Gasconade in the south half of the Meramec Spring Quadrangle. The evidence for an unconformity between these formations in other areas has been previously discussed in the section dealing with the Gasconade formation.

The Jefferson City-Roubidoux contact appears to be completely conformable in this area. In establishing the contact, for the purpose of mapping, several criteria were used. The contact was placed 5 feet above the uppermost, white, clean, dense, fine-grained sandstone of the Roubidoux; 25 feet above the dark-red, silica oolite with sand grain centers; 10 feet below the thin blue-green shale partings and lenses interbedded with Jefferson City "cotton rock;" 20 feet below the brick-red,non-sand oolite of the Jefferson City and 25 feet below the "stinkstone" dolomites of the Jefferson City formation. In practice the contact was established on the basis of the sum of the lithologies rather than on any individual bed.

Paleontology. —— The Roubidoux formation contains very few fossils in this area. During the field work the author collected 3 specimens of Lecanospira, a genus of gastropod indicative of but not restricted to the Roubidoux, and a poorly preserved orthoceraconic type cephalapod. Only one of the Lecanospira specimens was found in place and that in the Roubidoux outcrop in the stream bed at its intersection with the north-south road in the NW 1/4, NW 1/4, sec. 33, T. 36 N., R. 7 W. The other two specimens were found in float that is unquestionably Roubidoux. Cryptozoa considerably different from those found in the Gasconade have also been seen in the Roubidoux.

The most complete and recent discussion of the Roubidoux fauna is given by Heller.[72] He has divided the formation into three faunal

(72) Heller, R. L., Stratigraphy and paleontology of the Roubidoux formation of Missouri: University of Missouri, Thesis, 1950, p. 40.

zones and lists or describes the species found in each zone.

Age and correlation. --- The Roubidoux formation is lower Canadian (Ordovician) in age.

It has been correlated with other formations on the basis of stratigraphic position, lithology and fauna. The typical Roubidoux fauna has been reported in many beds throughout North America and Northern Europe. The correlation with other North American formations is given in the correlation chart prepared by the Ordovician Sub-committee of the Committee on Stratigraphy of the National Research Council.[73]

(73) Twenhofel, W. H., et. al., op. cit., pp. 247-298.

Cryptozoan-like chert structure in the Roubidoux formation located in the creek bed in the $NW\frac{1}{4}$, $SW\frac{1}{4}$, $NW\frac{1}{4}$, sec. 3, T. 36 N., R. 7 W.

Fig. 1. Well developed joints in the Roubidoux sandstone on County Highway Y in the NW¼, SE¼, sec. 32, T. 37 N., R. 6 W.

Fig. 2. Thin-bedded sandstones of the Roubidoux formation. Creek at State Highway No. 72 in the northcentral part of sec. 16, T. 36 N., R. 7 W.

## Jefferson City formation

Name and History. —— The Jefferson City formation, originally called the Second Magnesium Limestone, was named by Winslow (74) and

(74) Winslow, Arthur, op. cit., p. 331.

defined as those beds between the Moreau (Roubidoux) and Saccharoidal (St. Peter) sandstones. Ulrich (75) revised this definition by

(75) Ulrich, E. O., in Bassler, R. S., Bibliographic Index of American, Ordovician and Silurian Fossils: Bull. U. S. Nat. Mus., No. 92, Vol. 2, 1915, Pl. 2.

restricting the term Jefferson City to the lower beds and forming two new formations, the Cotter and Powell, from the former Upper Jefferson City beds. A later revision was made by Cullison, (76) who introduced

(76) Cullison, J. S., The stratigraphy of some Lower Ordovician formations of the Ozark Uplift: Missouri School of Mines and Metallurgy Bulletin, Technical Series, Vol. XV, No. 2, 1944, p. 15.

the Rich Fountain formation which includes some upper Roubidoux beds and the restricted Jefferson City of Ulrich. He also separated beds from the lower Cotter and formed the Theodosia formation. The two formations were placed in the Jefferson City Group.

At present the Jefferson City (restricted), Cotter and Powell formations are generally accepted but the Rich Fountain and Theodosia are not.

In this work, the author has followed the practice of Mueller and uses the name Jefferson City in an unrestricted sense. No attempt has been made to separate the Cotter formation.

Distribution. —— The Jefferson City formation underlies an area of approximately 14 square miles in the northwestern part of the half quadrangle and appears as an outlier associated with a fault in sections 24 and 25, T. 36 N., R. 7 W., and sections 19 and 30, T. 36 N., R. 6 W. Other small patches of the formation and residual material derived from it occur in sink structures and on the tops of hills at scattered points throughout the area.

Thickness. —— The maximum thickness of the Jefferson City is found in the SW 1/4, sec. 18, T. 36 N., R. 7 W., where a well has penetrated 260 feet of the formation. This figure compares favorably with the maximum thickness found by Mueller[77] in the north half of

(77) Mueller, H. E., op. cit., p. 71.

the Meramec Spring Quadrangle and by Lee[78] in the Rolla, Quadrangle.

(78) Lee, W., op. cit., p. 35.

Lithologic character. —— The Jefferson City formation consists of dolomites, cherts and sandstones. In this area only the dolomites and cherts appear in outcrop whereas the sandstone is found in the float. Although the thickness of the formation is great only the lower beds have been found exposed. The best exposures are found in two quarries. Natural outcrops are found in drainage ditches along the major highways, on some of the hillsides, and in parts of the small intermittent streams which drain in the area.

Dolomites. —— The lower Jefferson City dolomites which outcrop in this area are of three general types: "cotton rock," Quarry ledge type dolomite and the so-called "stinkstone."

The Jefferson City "cotton rock" is identical to that found in the Roubidoux formation. It is white to buff in color, very fine-grained and argillaceous. The weathered surface differs from fresh material in having a powdery appearance and generally shows a duller, darker color. Small crystals of pyrite have been found in the rock which may be significant. It has been noticed that limonite pseudomorphs are most commonly found in areas underlain by "cotton rock" and slightly coarser-grained dolomites in both the Gasconade and Jefferson City formations. Bedding is fine-to medium with beds from 2 1/2 to 3 inches being very common. Associated with the typical "cotton rock" is a slightly coarser dolomite which otherwise highly resembles it. Blue-green shale partings and lenses are common along the bedding planes of these rocks. In the section studied in the NW 1/2, sec., 30, T. 36 N., R. 6 W., the blue-green shale lenses attain 3/4 inches in thickness and contain very thin beds of a white cherty sandstone. A very white, fossiliferous, tripolitic chert has been found with these same beds.

The Quarry ledge dolomite is prominently exposed in the Rolla Quadrangle and the north half of the Meramec Spring Quadrangle. In the south-half, however, it has been found only in the quarry on State Highway No. 72 in the SW 1/4, sec. 9, T. 36 N., R. 7 W. and in the quarry in the SE 1/4, SE 1/4, SE 1/4, sec. 19, T. 36 N., R. 7 W. This dolomite is almost identical to the "cotton rock" except that it is massively bedded and contains segregations of silica which produces a pitting on the weathered surface.

The "stinkstone" dolomites are the most distinctive, wide spread Jefferson City beds found in this area. On the weathered surface these beds are medium-to dark-gray and markedly pitted. On the fresh surface they are light-to medium-gray with tan residue stain, medium-grained and thin-to medium-bedded. The name "stinkstone" refers to the odoriferous character of the rock when freshly broken.

Sandstones. —— Sandstone has been found as float in the stream beds draining the northwestern part of the area, along the major highways and as residuim on the hill tops. For the most part these sandstones cannot be distinguished from those in the upper part of the Roubidoux formation. They are white to light-gray except where stained by iron oxide, fine-grained and generally friable. An interesting type of sandstone float, which has been found at several localities, occurs in roughly cylindrical form approximately 2 1/2 inches in diameter. The rock is very dense and composed of fine-grained, colorless sand. The grains are sub-angular on the fresh surface but sub-rounded to rounded on the iron oxide-stained, weathered surface. A quartzite equivalent of this same rock has also been found.

Grawe and Cullison (79) give a detailed account of the Jefferson City sandstones in this general area.

(79) Grawe, O. R., and Cullison, J. S., A study of sandstone members of the Jefferson City and Cotter formations at Rolla, Missouri: Journal of Geology, Vol. XXXIX, No. 4, 1931, pp. 305-330.

Cherts. —— Thin beds of white chert are commonly found interstratified with the lower "cotton rock" and fine-grained dolomites.

The most distinctive Jefferson City chert float is a grayish-blue chalcedonic type chert which is prevalent in the beds of streams draining areas underlain by the formation. This chert has been found as nodules, blocks, and cryptozoan colonies. Although, it has not been observed in place, chert nodules of a darker gray color and fine granular appearance have been found in the fine-grained dolomites. Care must be used in establishing contacts on the basis of this float since it has been traced at least 60 feet below the Jefferson City-Roubidoux contact.

Cryptozoan cherts are common in the Jefferson City float. They occur as dense, white cherts and as grayish-blue, chalcedonic cherts. On the fresh surface they show a very delicate structure of very closely spaced (1/20 inch) laminae, which are slightly curved upward and do not exceed 1/2 inch in length. These cherts weather to an irregular surface of continuous, touching laminae approximately 1/8 inch thick.

Oolitic cherts are frequently found but are not as common as in the Roubidoux and Gasconade formations. The oolites differ from those found in the Roubidoux by the lack of sand grains in the center, however, this is not sufficient criteria to distinguish between oolitic cherts of the two formations since all Roubidoux oolites do not exhibit this feature.

Small boulders of tripoli are common in the Jefferson City residuim. These boulders are dark rust-brown on the weathered surface and cream with iron stain on the fresh surface. They are characterized by their extreme lightness. It is believed that the tripoli results from the weathering of dolomite containing disseminated silica.

Section measured from the valley floor to the intersection of the 1100 foot contour and Shuman Ridge Road, along a north-south line, in the NW 1/4, sec. 30, T. 36 N., R. 6 W.

| Ordovician System<br>Jefferson City formation | Thickness<br>Feet | <br>Inches |
|---|---|---|
| 22. Covered. | 11 | 0 |
| 21. Dolomite, medium-gray on weathered surface. Light-gray with light-brown residue spots and clay coated openings on fresh surface; fine-grained; argillaceous. Weathers with pitted surface. Has fetid odor when broken. "Stinkstone." | 8 | 0 |
| 20. Dolomite, similar to bed No. 21 except slightly lighter in color. | 0 | 10 |
| 19. Covered. | 3 | 6 |
| 18. Similar to bed no. 21. | 3 | 0 |
| 17. Dolomite, dark-gray on weathered surface. Light-gray on fresh surface. Coarse-grained, argillaceous. Weathers to a rough but not pitted surface. | 1 | 0 |
| 16. Dolomite, typical "stinkstone." | 0 | 1 |
| 15. Covered. | 4 | 6 |
| 14. Dolomite, similar to typical "stinkstone" but lighter in color and less odoriferous. | 0 | 8 |
| 13. Covered. | 3 | 0 |
| 12. Dolomite, buff on weathered surface. White to buff on fresh surface. Very fine-grained, thin to medium bedded. "Cotton rock." | 1 | 0 |
| 11. Chert, white, tripolitic. | 0 | 2 |
| 10. Dolomite, intermediate between "stinkstone" and "cotton rock." | 2 | 0 |
| 9. Dolomite, typical pitted "stinkstone." | 5 | 0 |
| 8. Dolomite, "cotton rock" with slight fetid odor. Weathers to a pitted surface. | 2 | 0 |

| | | | |
|---|---|---|---|
| 7. | Shale, blue-green, fissile. Contains thin seams of cherty sandstone. Sand is fine-grained, sub-rounded and frosted. Chert is white and powdery. | 0 | 5 |
| 6. | Dolomite, gray colored, medium-grained, dense. Has bluish tint on weathered surface. Lower 2 inches weathered to a white, argillaceous, rough-surfaced bed. | 5- | 2 |
| 5. | Covered. | 2 | 6 |
| 4. | Dolomite, buff to light-gray; fine-grained; argillaceous. Appears very similar to "cotton rock." | 0 | 5 |
| 3. | Chert, bluish-gray, dense, transluscent. | 0 | 2 |
| 2. | Dolomite, light-gray, fine-grained. Weathers slabby. In general similar to "cotton rock." | | |
| 1. | Covered to valley floor. | 1 | |
| | Total Jefferson City | 55 | 6 |

Weathering. --- The Jefferson City formation weathers to gentle slopes and tends to weather along rather than cut through individual beds. For this reason it is far more common to find the top of a bed protruding through the cover than it is to find bluff exposures. The residual material covers the outcrops so that exposures are found only where it is removed naturally as long drainage channels or artificially as in the ditches along highways.

Two types of soil are found in areas underlain by the Jefferson City formation. Near the Jefferson City-Roubidoux contact the soil is commonly deep reddish-brown. Farther up in the formation the soil assumes a light-brown color. It has been noticed, however, that where the undersoil has been exposed in the digging of ponds it has distinct reddish color and possibly the light-brown color mentioned above is due to the surface leaching of the reddish-brown material.

Topographic expression. --- The Jefferson City formation in the area underlies slightly dissected uplands which exhibit a very gentle topography. The major relief is found about the fringes of the formation slightly above the contact with the underlying Roubidoux. Mueller [80] correlates this break in slope with the occurrence of the

(80) Mueller, H. E., op. cit., p. 79.

Quarry ledge, however, outcrops were not available in the area to verify this.

Stratigraphic relations. --- The conformable nature of the Roubidoux-Jefferson City contact has been discussed in the preceeding section.

Aside from the Quaternary alluvium, Pennsylvanian deposits preserved in sink structures and residual Mississippian cherts, no formation younger than the Jefferson City has been found in this area. However, in the Rolla Quadrangle a Devonian outlier resting unconformably upon the Jefferson City has been described by Bridge and Charles.(81) They believe it to be part of the Grand Tower formation

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(81) Bridge, Josiah and Charles, H. E., A Devonian outlier near the crest of the Ozark Uplift: Journal of Geology, Vol. XXX, No. 6, 1922, pp. 450-458.

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of Onondaga age. Thus any sediments older than Grand Tower and younger than Jefferson City that may have been deposited in this area were removed prior to Grand Tower time.

Paleontology. --- Fossils are scarce in the Jefferson City formation, in this area. They have been found only in the chert float and other residual material. A chert boulder, believed to be Jefferson City, located on the east side of State Highway No. 72 in the SE 1/4, SE 1/4, sec. 21, T. 36 N., R. 7 W., contained two trilobite cranidia of an unidentified genus. A poorly preserved coiled cephalapod; two imprints of sponges, believed to be Archaeosyphia,(82) and two

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(82) Cullison, J. S., op. cit., p. 48, Pl. XXIV.

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unidentified gastropods were obtained from residual material in the quarry on the west side of State Highway No. 72 in the SW 1/4, SW 1/4, sec. 9, T. 36 N., R. 7 W. White, fossiliferous, mealy chert associated with the lower "cotton rock" beds exposed along the east side of the road in the SW 1/4, SW 1/4, sec. 19, T. 36 N., R. 6 W., contained several specimens of low-spired gastropods. Similar material containing two specimens of orthoceraconic cephalapods was found in the

Winkler Mine. Both specimens were poorly preserved and it was necessary to prepare sections in order to identify them as cephalapods. Chert float showing a cryptozoan structure similar to that found in the Roubidoux formation is fairly common in the Jefferson City.

A thorough treatment of the Jefferson City fauna is given by Cullison.[83]

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(83) Cullison, J. S., ibid. pp. 47-90, Pl. XXIV to XXXV.

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Age and correlation. —— The Jefferson City formation is upper Canadian, (Ordovician) age and has been correlated with many formations throughout North America. The most recent and complete correlation is given in the correlation chart of the National Research Council.[84]

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(84) Twenhofel, W. H., et. al., op. cit., pp. 247-298.

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Fig. 1. Small sink structure in the Jefferson City formation, located in the quarry on the east side of State Highway No. 72 in the SW¼, sec. 9, T. 36 N., R. 7 W.

Fig. 2. Thin, slabby bedding of the lower Jefferson City dolomite. The outcrop is located in the same quarry as the sink structure shown above.

## MISSISSIPPIAN SYSTEM

Residual cherts of Mississippian age have been reported throughout the Ozark region. In this area one boulder of Mississippian material was located along the Shuman Ridge Road in the SE 1/4, SE 1/4, sec. 24, T. 36 N., R. 7 W. The rock consists of a very fossiliferous, sandy, oolitic chert. The weathered surface is dusty-grayish-brown in color and contains very fine pits due to the removal of oolites. On the fresh surface the chert is light-gray with a slight brown tint and has a very porous structure. Crinoids, brachiopods and gastropods are abundant in the specimen. Chert similar to this has been found in adjacent areas and has been referred to the Lower Burlington. Bridge[85] has described the Mississippian material found in this general region and has correlated it with formations ranging from basal Osagean to Lower Meramecian.

(85) Bridge, Josiah, A study of the residual Mississippian of Phelps County (central Ozark region), Missouri: Journal of Geology, Vol. XXV, No. 6, 1917, pp. 558-575.

PENNSYLVANIAN SYSTEM

Deposits of Pennsylvanian age have been reported in the north half of the Meramec Spring Quadrangle and in the northeastern part of the Rolla Quadrangle. These deposits consist of sandstone, clay and chert. Of the three only the clay is sufficiently distinctive to definitely identify Pennsylvanian material in the field. These clays are purple, green, yellow and white in color and are associated with light colored, fine-to medium-grained, massive sandstones. In this area clays of this type have been found at two localities. Prospect holes dug in the NW 1/4, NW 1/4, sec. 3, T. 35 N., R. 6 W., have penetrated beds of tripolitic and oolitic chert interstratified with purple and white clay. The surrounding area is underlain by lower Roubidoux, hence a sink structure is definitely indicated. The extent of this structure and the Pennsylvanian clay deposit is unknown. A second outcrop of clay which is believed to be Pennsylvanian in age is located in a drain at the northeast edge of Hawkins Bank in sec. 11, T. 35 N., R. 6 W.

The Pennsylvanian sandstones in other areas have been compared to the Roubidoux in order to establish criteria by means of which they may be differentiated. Only in the larger features do the two sandstones differ measureably. The Pennsylvian sandstones are massive and do not exhibit the ripple marks, sun cracks or cross-bedding which are common in the well bedded Roubidoux sandstones. Grain size, shape of grains and heavy mineral content (86) are too similar in the two

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(86) Cordry, C. D., Heavy minerals in the Roubidoux and other sandstones of the Ozark Region, Missouri: Journal of Paleontology, Vol. III, No. 1, 1929, p. 84.

sandstones to be used to distinguish between them.

The clays and basal chert conglomerates found in and adjacent to the Meramec Spring Quadrangle have been correlated with Pennsylvanian formations in other parts of Missouri by McQueen.(87)

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(87) McQueen, H. S., Fire clay districts of east central Missouri: Missouri Geological Survey and Water Resources, ser. 2, Vol. XXVIII, 1943, p. 124.

## QAUTERNARY SYSTEM

### Residuum

Throughout most of the area, the upland regions and gentle slopes are covered with a thick layer of residuum. The thickness of this cover varies and can best be determined by reference to the logs of drilled wells. The maximum thickness recorded on the well logs of this area is 40 feet.

It is possible that some of the material which constitutes the residual layer is not residuum in the true sense of the word but is actually a gravel that was carried and deposited by streams which traversed the area prior to uplift.

### Alluvium

The flood plains and lower parts of the major stream valleys are covered with a thick deposit of alluvial material, consisting of boulders, gravel, pebbles, sand and silt. As would be expected, the most common coarse material is chert. The major part of these deposits exposed along the present stream channels consist of the fine-grained material. Along the northeast bank of Dry Fork at Morrison Ford in sec. 11, T. 36 N., R. 7 W., there is a thick bed of alluvial material which at a distance is strikingly similar to loess. Closer examination reveals it to be a massive bed of poorly consolidated silt and fine sand grains.

### Conglomerate

Along the west bank of Dry Fork in the NE 1/4, SW 1/4, sec. 25, T. 36 N., R. 7 W., a poorly consolidated conglomerate, consisting of coarse sand and large, rounded chert pebbles, juts out from the bank and bed of the stream. This conglomerate does not fit any part of the known section and is therefore believed to be of recent origin.

# STRUCTURE

## Regional

The regional dip in this area is 30 feet per mile, north 34 degrees west. Superimposed upon this homocline are low, broad regional folds and small, sharp local folds caused by differential solution. The structure is further complicated by the ever present sink structures which produce strong dips and small faults of local extent.

## Folds

Two sets of folds occur in the area. The axis of one set trends N. 70 degrees E. and the axis of the other is in a general north-south direction. The folding is not sufficiently prominent to be readily seen in the field except along State Highway No. 72 where road cuts periodically expose the folded nature of the beds. The direction of the axis of the east-west folds is indicated by the alternating appearance and disappearance of the Gasconade formation along Dry Fork and Norman Creeks. Wherever the streams cut the crests of the folds, the older Gasconade formation is exposed.

The north-south folds can be detected only by the construction of a cross-section of the area. From the section it is seen that the beds in the northwestern part of the area are essentially flat lying. To the east a small, sharp fold occurs in the vicinity of Shuman Ridge. Folding in this area had been previously indicated by high magnetic anomalies which suggested the presence of a pre-Paleozoic ridge.

To the east of Norman Creek a broad, upward trend of the beds begins and extends eastward beyond the limits of the quadrangle. It is this broad fold which accounts for the extensive exposure of the Gasconade formation in the eastern part of the region.

In the extreme northeastern part of the area, the intersection of east-west and north-south folds brings the Eminence formation to the surface. The outcrop of Eminence is on the south flank of a high magnetic anomaly (88) the crest of which is approximately 2 1/2 miles

(88) Grohskopf, J. C. and Reinoehl, C. O., Magnetic surveys: Missouri Bureau of Geology and Mines, 57th Biennial Report, 1933, appendix IV.

to the north. The general inference is that a ridge or some other type of protuberance has produced an upwarp of the beds in the area and has brought the basement prophyries closer to the surface.

### Geophysical indication of structure

There is a good correlation between the magnetic highs throughout the area and the regional structure. The major magnetic anomaly lies in a general north south direction along Shuman Ridge, which is slightly west of the central part of the half quadrangle. The positive magnetic intensity is greatest approximately 2 miles west of Seaton, and approximately 8 miles to the north. In the vicinity of the south crest of the anomaly the beds show a general upward trend toward the south. Approximately 1 mile north of the crest is the major fault in the area. The structure section shows that Shuman Ridge occupies the crest of a small but well defined north-south fold which continues beyond the north limit of the half quadrangle. Another magnetic high occurs in the northeastern part of the area. The peak of intensity is found approximately 2 1/2 miles north of the north boundary of the area and on the eastern edge of the Meramec Spring quadrangle. The exposure of the Eminence formation in the north central part of sec. 7, T. 36 N., R. 5 W. occurs on the south flank of this high and, as previously mentioned, occupies the crest of two intersecting folds.

In general it can be said that high magnetic intensities are associated with an upward folding of the beds in this area.

## Faults

The majority of faults in the south half of the Meramec Spring quadrangle are found within the numerous sink structures. Faulting in these structures commonly involves a collapse of insoluble sandstone beds following the removal by solution of the underlying supporting dolomite. The faults in most cases are probably of a pivot type and are somewhat circular in strike. The fault plane generally is seen along only part of the wall of the sink structure and is marked by slickensides, silicification and chert breccia.

A small fault which may be connected with a sink structure occurs in the Lennox Branch east of State Highway No. 72. Approximately 1/2 mile east of the highway bridge the stream is diverted to the north by a low bluff exposure of the massive member of the Roubidoux sandstone. The beds of this exposure are sharply folded. Immediately to the south of the fold and at the base of the bluff an outcrop of Roubidoux dolomite occurs above its normal place in the section. The fault plane cannot be located definitely, however, it is believed to lie along the bed of Lennox Branch to the south west. The relationship of the beds throughout the valley indicates that the block to the north has dropped a vertical distance of approximately 15 feet. The writer was unable to trace the fault beyond this general locality.

The major fault that occurs in this area trends northwestward across sec. 30, T. 36 N., R. 6 W, and sections 24 and 25, T. 36 N.,

R. 7 W. Outcrops are not sufficiently numerous to properly delineate this fault. Its existence is readily apparent from the stream bed approximately 300 feet west of the house, located in the SW 1/4, SE 1/4, SE 1/4, sec. 24, T. 36 N., R. 7 W. At this site the Jefferson City formation outcrops at an elevation considerably lower than the surrounding hills which are capped by the Roubidoux sandstone. To the northwest the Jefferson City beds continue to outcrop for a short distance and then disappear under a thick residual cover. Southeast of the house mentioned above, Jefferson City "cotton rock" is found along the northwall of the small valley in the north central part of section 30, T. 36 N., R. 6 W. whereas along the south wall only Roubidoux residuum can be found. In the eastern part of this valley, Roubidoux sandstone outcrops appear abruptly and no further evidence of faulting can be found. Along the road to the north of the fault are outcrops of Jefferson City dolomite, a sandstone which cannot with certainty be assigned to either the Jefferson City or Roubidoux formation and Roubidoux, Jefferson City and Mississippian float. An outcrop of "cotton rock" which is either Roubidoux or Jefferson City occurs in the drain in the NE 1/4, sec. 24, T. 36 N., R. 7 W. and is the only guide in inferring the formational contacts in the area northeast of the fault.

## Joints

Many of the sandstone, dolomite and chert beds show well developed joint patterns. The average strike of the major joint system is N. 20 degrees E. and that of the minor S. 60 degrees E. The dip of the plane is generally about 80 degrees to the east for the major joint and to the northeast for the minor.

There is a fairly close correlation between the direction of jointing and the direction of flow of the majority of tributary streams. Also the marked similarity in the course pattern of both Dry Fork and Norman Creeks indicates that there has been some degree of structural control and it is possible that at least part of the stream beds follow along joint planes.

Sink structures

Sink structures, common in this part of the Ozarks, result from the differential solution of underlying strata and the downwarp or collapse of the unsupported overlying beds. If the structure forms at depth little or no evidence of its existance appears at the surface until erosion removes the overlying material and exposes some diagnostic feature. If, however surface beds are affected, either a gentle bowl shaped depression results from downwarp of the beds or a steep walled, irregular cavity forms as a result of the collapse of the beds. Surface drainage is then diverted into the depression, in one case forming a lake or pond whereas in the other underground channels provides a sub-surface drainage.

Examples of recently formed sink structures having topographic expression are found east of the farm house in the NW 1/4, SW 1/4, sec. 2, T. 35 N., R. 6 W.; approximately 1/4 mile west of the Hale School located in the northcentral part of sec. 9, T. 36 N., R. 6 W.; approximately 1/4 mile south 20 degrees west of the Central School located in the NE 1/4, NE 1/4, NE 1/4, sec. 21, T. 36 N., R. 7 W and at numerous other localities throughout the half quadrangle.

Sink structures which formed in the geologic past are of considerable economic importance in the Ozark Region since in these structures are found the only known deposits of clay, hematite iron and iron sulfide. Those which contain clays of Pennsylvanian age are believed to have been surface features at the time the clay was deposited whereas those which contain the iron minerals were below the zone of oxidation at the time the iron was emplaced, as the iron sulfide, and have been exposed to the surface only recently. Since these ancient sink structures have been filled their present appearance at the surface is not marked by a topographic depression and special criteria must be applied in order to recognize them in the field.

In some cases the rimrock, a fring of uncollapsed sandstone about the periphery of the structure, can be located at least in part. When found it may be used to delineate the extent of the structure. Generally, however, the rimrock is completely covered with residuum or exposed in such a small amount thatit is of value only in indicating the presence of a sink structure.

Sharply dipping sandstone beds are also indicative of the presence of sink structures. The beds dip gently about the periphery of the sink structure but increase to almost vertical dips toward the center. An excellent example of sharply dipping beds is found along the east-west road in the vicinity of Seaton in the central part of the half quadrangle. These beds show abrupt changes in the angle and direction of dip in distances of less than 50 feet and represent a series of small sink structures which continue eastward to the Bronson Mine area. Another well exposed series of erratically dipping beds is located along State Highway O in sec. 17, T. 35 N., R. 7 W.

Outliers are commonly associated with sink structures. Thus the outcrop of very fine-grained Jefferson City dolomite on the east side of State Highway No. 72 in the NE 1/4, SW 1/4, SE 1/4, sec. 21, T. 36 N., R. 7 W. surrounded by Roubidoux sandstone discloses the presence of a sink structure. Similar occurrences of Jefferson City and Pennsylvanian are found throughout the Meramec Spring Quadrangle.

On the geologic map the standard symbol is used to indicate the presence of sink structures. The size of the symbol is in a general way related to the size of the structure, however, the outline of the symbol does not represent the true outline of the structure.

# ECONOMIC GEOLOGY

## Agricultural lime

Both the Gasconade and Jefferson City dolomites are quarried on a small scale for the production of "agricultural lime." The use of dolomite for this purpose has a twofold advantage over limestone in that magnesium is beneficial to the soil and dolomite, being less soluble than limestone, is effective for a longer period of time. The presently operating quarries are located in the SW 1/4, SW 1/4, sec. 9 T. 36 N., R. 7 W.; SE 1/4, SE 1/4, sec. 19, T. 36 N., R. 7 W. and on the Hide-a-way Ranch in the south central part of sec. 11, T. 36 N., R. 7 W. Abandoned quarries are located on the west bluff overlooking Peters Branch in the NW 1/4, SW 1/4, sec. 35, T. 36 N., R. 7 W. and in the SW 1/4, SW 1/4, sec. 19, T. 36 N., R. 6 W.

## Clay

Commercial deposits of Pennsylvanian clays have been found in adjacent areas but in the south half of the Meramec Spring Quadrangle only two poor shows of clay have been noted. These occur in Hawkins Bank and in the NW 1/4, NW 1/4, sec. 3, T. 35 N., R. 6 W. There still may be some undiscovered sink structures which may contain clays.

## Copper

Copper carbonate has been reported in the Kelly No. 3 and Stimson Mines in this area. The most complete report on these deposits is given by Fay and Martinez.(89) Copper ore reportedly has been ship-

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(89) Fay, A. H. and Martinez, C. E., Report on the Reed, Stimson and Kelly copper and iron banks of Phelps County, Missouri: Missouri School of Mines and Metallurgy, Thesis, 1902, pp. 5,6,7,10.

ped from both mines but the tenor of the ore is believed to have been too low so that commercial production never was attained.

## Iron

Limonite pseudomorphic after pyrite is found as boulders in the residuum of the three major formations exposed in this area but is most common in the lower part of the Gasconade and Jefferson City formations. These boulders are rust-to dark-brown in color, have a dull, varnish-like luster and are readily distinguished by their high specific gravity. An accumulation of economic significance is lacking in the south half of the Meramec Spring Quadrnagle.

Hematite in the form of dull earthy masses, red paint ore, and dense blue specularite occurs in may of the sink structures throughout the region. Many of these deposits were of commercial importance. In other areas similar deposits have been found underlain by pyrite and marcasite and Grawe (90) attributes the hematite to the oxidation

(90) Grawe, O. R., Pyrites deposits of Missouri: Missouri Geological Survey and Water Resources, ser. 2, Vol. XXX, 1945, p. 108.

of these iron sulfides.

The following compilation contains the name and location of all mines and banks which previously have been described or named, together with a statement concerning the present condition of those mines visited by the author. Mines and prospects are indicated on the geologic map by the quarry symbol.

African Mine — SW 1/4, SE 1/4, sec. 22, T. 36 N., R. 6 W.

Benton Creek Mine — SE 1/4, SW 1/4, sec. 32, T. 36 N., R. 5 W.

Dupuy and Ballinger (91) report that the mine may be reached via

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(91) Dupuy, L. W. and Ballinger, H. J., Filled sink iron deposits in Crawford, Dent, Franklin and Texas Counties, Missouri, United States Department of Interior, Bureau of Mines Report on Investigations No. 4452, May 1949, pp. 7-11.

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the road from Bangert, however, the author found this road very difficult for a passenger car and approached the mine on foot from the north. The area bout the mine is overgrown but the face of the stripped area is clear and one of the shafts was found intact.

Blair Mine -- SE 1/4, sec. 9, T. 35 N., R. 6 W.

Blue Mountain Mine -- NW 1/4, NE 1/4, SW 1/4, sec. 31, T. 36 N., R. 5 W.

Burns Mine -- sec. 23, T. 36 N., R. 6 W.

Brady Mine -- SE 1/4 sec. 27, T. 36 N., R. 6 W.

This mine is readily acessible from the road crossing the section. It is completely overgrown.

Bronson Mine -- NE 1/4, SW 1/4, sec. 26, T. 36 N., R. 6 W.

There are several pits and prospect holes in this immediate vicinity which probably formed part of this mine. State Highway No. 68 passes directly over the site of the former shafts to the underground workings according to the local residents. All of the open pits are overgrown.

Clark Mine -- NE 1/4, NW 1/4, NE 1/4, sec. 23, T. 36 N., R. 6 W.

Clinton Mine -- SE 1/4, NW 1/4, NW 1/4, sec. 26, T. 36 N., R. 6 W.

The Clinton mine is immediately west of State Highway No. 68. The area surrounding the pit is slightly overgrown but the pit itself is clear.

Cold Spring Mine -- N 1/2, SW 1/4, SE 1/4, sec. 29, T. 36 N., R. 7 W.

Coppage Bank -- SE 1/4, NW 1/4, sec. 6, T. 35 N., R. 6 W.

This bank could not be located at its reported location, however, the thick growth in the area may have covered the site of the former workings.

Hall Bank -- NW 1/4, sec. 5, T. 36 N., R. 6 W.

Hawkins Bank -- SE 1/4, NW 1/4, sec. 11, T. 35 N., R. 6 W.

Hawkins bank is easily reached from State Highway No. 68.

The area is overgrown but the pit is relatively clean. A small prospect pit on the south edge of the workings has been reworked and is now serving as a water pond.

Hyer Mine — sec. 26, T. 36 N., R. 7 W.

Kelly No. 3 Bank — SE 1/4, NE 1/4, SW 1/4, sec. 6, T. 36 N., R. 6 W.

The ford across Norman Creek no longer exists in this area, thus Kelly Bank can be approached by car only from the west. The face of the bank is very clean however, the surrounding region is covered with a thick growth.

Lamb J. Bank No. 1 — NW 1/4, sec. 35, T. 36 N., R. 6 W.

The Lamb Bank No. 1 is located 0.4 miles along the dirt road from its intersection with State Highway No. 68 at the Gronson Mine. The area is thoroughly overgrown and the pit is filled with water.

Lamb Mine — N 1/2, SE 1/4, sec. 34, T. 36 N., R. 6 W.

Nine Sixteen Bank — SE 1/4, SW 1/4, sec. 9, T. 35 N., R. 6 E.

Parry Prospect — SW 1/4, SW 1/4, sec. 3, T. 36 N., R. 6 W.

Perkins Prospect — SW 1/4, SE 1/4, NW 1/4, sec. 1, T. 36 N., R. 6 W.

Seaton Mine — N 1/2, sec. 30, T. 36 N., R. 6 W.

Smith Mine — S 1/2, SW 1/4, sec. 27, T. 36 N., R. 6 W.

A pit which may have been part of this mine lies a short distance south of the east-west road through this section. The pit is overgrown and cannot be approached by car.

Stimson Mine — NE 1/4, SE 1/4, sec. 10, T. 36 N., R. 6 W.

Watkins Mine — NW 1/4, NE 1/4, sec. 12, T. 35 N., R. 7 W.

Winkler Mine — SW 1/4, SE 1/4, sec. 14, T. 36 N., R. 6 W.

There are three pits in this general area. The main pit is located several hundred feet east of the 1180 bench mark on State Highway No. 68. A second pit is located 1/8 mile to the northwest and may be approached by the road which intersects the highway from the east approximately 1/4 mile to the north of the bench mark. A third pit is located approximately 1/4 mile to the north of the second. The area about all pits is overgrown and the second pit is filled with water.

Williams Mine — N 1/2, sec. 16, T. 35 N., R. 6 W.

Publications giving descriptions of the majority of the mines are listed on pages 2 and 3 of this report.

## Sand and Gravel

Thick deposits of clean sand are found in both Dry Fork and Norman Creeks throughout most of their courses in this area. Much of this material is satisfactory for use in concrete with little or no further treatment. Chert gravel is also found in the above mentioned creeks but larger and cleaner deposits are located in the bed of Benton Creek. The gravel is satisfactory for use as a road material but would be generally unsatisfactory for use as a concrete aggregate because a large part of the chert is badly weathered and iron stained.

## Water Resources

Ponds. –– The growth of the cattle industry and the shortage of water in recent years has brought about the increase in the number of ponds being constructed in this area. The soil, alethough sandy in most places, contains sufficient clay to form an impervious seal and permits satisfactory storage of the water. Ponds provide the only source of water for cattle during the summer months on many farms.

Artificial lake. –– A dam very recently has been constructed across Peters Branch immediately west of State Highway No. 72 in the SE 1/4, sec. 34, T. 36 N., R. 7 W. A lake is now being formed at the site by the entrapment of water which issues from a perennial spring located along the branch in the NW 1/4, sec. 3, T. 36 N., R. 7 W.

Springs. –– The perennial springs in the south half of the Meramec Spring Quadrangle are located in the valley and along the tributaries of both Dry Fork and Benton Creeks. The springs are contained in both the Roubidoux and Gasconade formations and although the total output is approximately equal for the two in this area, the larger individual springs are located within the Gasconade. The rate of flow is directly related, not only to stratigraphic position, but also the geographical location. From south to north the springs steadily decrease in capacity from 90,500 gallons per day for the Brown Spring (92) (sec. 17, T. 35 N., R. 6 W) to very slight seeps from

(92) Beckman, H. C. and Hinchey, N. S., The large springs of Missouri: Missouri Geological Survey and Water Resources, ser. 2, Vol. XXIX, 1944, p. 65.

the bluff east of the Spring Hill School (NW 1/4, sec. 11, T. 36 N., R. 7 W.). This indicates that the major catchment area lies to the south with additional water being derived from the east and west.

The water obtained from springs although small is nonetheless important since it does provide a constant source of water throughout the year.

Streams. -- Benton Creek is the only perennial stream in the area. The major portion of the water is obtained from springs, the largest of which is located just east of the eastern boundary of the Meramec Spring Quadrangle in sec. 9, T. 36 N., R. 5 E. The second largest is located in the bed of Benton Creek in the SW 1/4, sec. 29, T. 36 N., R. 5 W. and the smallest along West Fork in the SE 1/4, sec. 13, T. 36 N., R. 6 W.

The perennial nature of Benton Creek is due not only to the large output of the springs feeding it but also to the lack of thick sand deposits. Such deposits inhibit the surface flow of water in the valleys like Dry Fork.

## Wells

Water has been obtained from wells drilled in the Jefferson City, Roubidoux and Gasconade formations in this area. There is no record of wells in the Eminence formation, however, it is certain that some of the unlogged wells bottom in this formation. Unfortunately, very few of the wells have been logged and the data are insufficient to make a critical analysis of the water-bearing potential of the various formations. However, from the information available it has been found that for the type of well drilled in the area, the average output from the Jefferson City formation is about 3 g.p.m. with a range from 2 1/2 to 6 g.p.m. from the Roubidoux formation about 5 g.p.m. with a range from 2 1/2 to 6 g.p.m. and from the Gasconade formation about 8 g.p.m. with a range from 1 to 15 g.p.m. These figures are based upon the data from 4, 3 and 9 wells respectively and for this reason should not be considered in any way representative. Of the formations mentioned the Gasconade provides the largest and most dependable supply of water for household consumption or small scale industrial use. For a large supply of water, to satisfy the needs of a city of large industry, it would be necessary to drill to the Potosi formation which is the most prolific aquifer in the region. This would require drilling to a depth of approximately 500 feet below the Roubidoux-Gasconade contact.

Essential data regarding the water well logs are contained in Appendix I to this report.

GEOLOGIC HISTORY

The oldest rock exposed in Missouri and presumably present in the south half of the Meramec Spring Quadrangle indicate that the earliest event in the geologic history of this area was the extrusion of rhyolite and volcanic ash in pre-Cambrian time. In later pre-Cambrian time the rhyolite was intruded by granite, granite porphyry, basic dikes and quartz veins. These rocks were deeply eroded by streams which produced a rough, rugged topography by Upper Cambrian time.

During the upper Cambiran the area was invaded by a sea which reworked the thick accumulations of residual material and produced basal conglomerates in parts of the Ozarks. Over the conglomerate a great thickness of sand, the Lamotte formation, was deposited. At the end of Lamotte time the sedimentary environment gradually changed and several hundred feet of limestone, the Bonneterre formations, was deposited. Muds where then introduced which gave rise to a dolomite-shale sequence, the Davis formation, which includes the most extensive shale deposits in the Cambrian System of the Ozark Region. The source of these shales is unknown but since they decrease in the vicinity of the porphyry peaks, it is evident that they were carried in and were not derived from the Ozark area. The quantity of mud in the sea gradually decreased and the argillaceous, calcareous rocks of the Derby-Doerun formation were deposited. After the deposition of the Derby-Doerun the area emerged and in parts of the Ozark Region a large part of the sedimentary cover was removed. Deep well logs in the north half of the Meramec Spring Quadrangle and in surrounding areas indicates that more than half of the original thickness of the Derby-Doerun formation was removed during this period of erosion.

When the seas again advanced a thick accumulation of carbonate rocks was laid down with little change in the depositional environment throughout Potosi and Eminence time.

The evidence available in the south half of the Meramec Spring quadrangle suggests that little, if any, interruption in sedimentation took place at the end of Eminence time. Here the boundary between the Cambrian and Ordovician is marked by the presence of a sandy dolomite which can hardly be considered indicative of a long period of emergence and erosion. Elsewhere, however, the unconformity between the Eminence and Gasconade formations is profound.

The region was then inundated by the Gasconade seas which lapped against the highest peaks on the Ozark Dome and covered the region with a thick layer of calcareous sediments. There seems to be little difference between this and the earlier Potosi and Eminence seas. The sea was essentially clear containing little argillaceous material and the temperature was sufficiently moderate to support a prolific algal growth through at least part of the time. At the end of Gasconade time, as suggested by faunal studies, the seas again may have withdrawn from the land, but the physical evidence for such a break at this time is about as meager as that indicating a break between the Eminence and Gasconade formations in this area.

The Roubidoux sea which flooded the area was at first little different from the preceding Gasconade sea. The rocks of the two formations near the contact are quite similar except for the presence of sandy dolomite beds in the lower part of the Roubidoux. However, in later Roubidoux time large quantities of sand was carried into the area from an unknown source and gave rise to the massive sandstone beds which characterize the Roubidoux formation. The presence of cross-bedding, ripple marks and mud cracks indicate that during part of the time the seas were shallow and at times the land mass was above water. Toward the end of Roubidoux time the sand no longer was being deposited but clays were being carried in which gave rise to the argillaceous dolomites in the upper part of the formation. Aside from a thin sandstone bed separating them there is a continuation of these dolomites into the Jefferson City formation which indicates little or no post-Roubidoux emergence. A faunal break, however, does signify that a period of non-deposition occurred between the two formations.

The Jefferson City sea differed slightly from those which formerly covered the area. At times the water contained a considerable quantity of clay which produced the "cotton rock" type dolomites and periodically sands were carried into the region.

Formations of younger Ordovician age are unknown in the area and it cannot be stated with certainty whether they were deposited and removed or never deposited. The presence of Middle and Upper Ordovician beds in other parts of the state would indicate that at least some of these sediments were laid down in the area and subsequently removed.

Silurian rocks have not been found in this region, however, they too may have been present at one time but removed by erosion.

The presence of a Devonian outlier resting upon Jefferson City beds in the Rolla Quadrangle indicates that Devonian seas covered this part of the Ozark region at least part of the time. It also tends to indicate that formations younger than the Jefferson City and older than Devonian existed at one time since considerably more of the Jefferson City formation would have been eroded if it had been exposed during 2/3 of Ordovician and all of Silurian time. The total quantity of Devonian deposited is unknown since all but this one outlier of Grand Tower age had been removed prior to the encroachment of the Mississippian seas upon the area.

The residual Mississippian found in this area gives no evidence as to its former stratigraphic relations. In the Rolla Quadrangle the most extensive Mississippian deposit rests upon the Jefferson City formation. From this and other deposits it is known that at least the Fern Glen, Burlington, Keokuk and Lower Warsaw seas spread over this area. Almost all of the Mississippian sediments were removed by an uplift that occurred during later Mississippian or early Pennsylvanian time.

At some time between the deposition of the Jefferson City formation and the Pennsylvanian sediments the area was tilted toward the northwest. The result of this tilting was to remove all of the Jefferson City and part of the Roubidoux from the area so that the Pennsylvanian Cherokee deposits were laid directly upon the two formations. It has been pointed out that the presence of clay and coal seams in the Pennsylvanian indicates that the region was sufficiently near sea level to permit the formation of swamps. The Pennsylvanian period of deposition ended with an uplift which with succeeding uplifts has made the Ozark Region a positive area to the present time.

Following the doming of the Ozark during the Appalacian Revolution which marked the end of Paleozoic time, several cycles of uplift and base leveling have occurred. The number of these cycles is unknown but evidence for the two latest may be seen in the physiographic appearance of the region. In the northwestern part of the half quadrangle the slightly eroded uplands underlain by the Jefferson City formation represent a former pene plane which is believed to have developed at the end of Pliocene time. Uplift occurred, probably at the beginning of the Pleistocene, which produced a second base level approximately 100 feet below the former peneplanes. Uplift again occurred which rejuvinated the streams and produced the incised meanders that appear along the present courses of Dry Fork. Dr. O. R. Grawe has suggested that removal of the glacial ice sheet from the northern part of the state was responsible for this second uplift.

# CONCLUSIONS AND SUMMARY

1. A geologic map of the south half of the Meramec Spring Quadrangle has been prepared.

2. The geology and geography of the area has been described.

3. A more detailed study of the major fault in the area is necessary in order to properly determine its extent.

WATER WELL AND PROSPECT HOLE LOGS

| No. G. S. Well Log # | Location ¼/ ¼/ ¼/T(N),R(W),Sec. | Owner | Depth of Formational Contacts (in Ft.) | Total Depth (in Ft.) | Elevation of Collar (in Ft.) | Production (in g. p.m.) | Sample Analyst |
|---|---|---|---|---|---|---|---|
| 217 | NE/SE/NW/ 35-6-18 | Hobson & Co. | Or/Og --- 65 | 165 | 1125 | 6 (abandoned) | E. McCracken |
| 2205 | 36-6-6 | Chas. Shuman | All Or | 94 | unk. | Prospect hole | E. McCracken |
| 2206 | SE/NE/SW 36-6-6 | Chas. Shuman | All Or | 75 | unk. | Prospect hole | E. McCracken |
| 3947 | SW/SE/SE 35-7-3 | Joe Bowles | All Og | 157 | 1008 | unk. | E. McCracken |
| 4177 | NW/SE/NE 36-6-10 | Parry Property | All Or | 37 | unk. | unk. | E. McCracken |
| 4178 | NW/SE/NE 36-6-10 | Parry Property | All Or | 37 | unk. | Prospect hole | E. McCracken |
| 4179 | SW/SW/SW 36-6-3 | Parry Property | All Or | 36 | unk. | Prospect hole | E. McCracken |
| 4218 | NE/NE/NE 36-6-27 | Erdmann Property | Or/Og --- 130 | 210 | 1197 | unk. | E. McCracken |
| 4416 | SW/SW/NE 35-7-1 | Taylor Lenox Jr. | All Og | 129 | 1010 | unk. | E. McCracken |
| 4417 | NE/SW/SW 35-7-1 | Taylor Lenox Jr. | All Og | 165 | 1035 | 4 | E. McCracken |
| 5295 | SW/SW/SW 36-7-18 | Ollie Koch | Ojc/Or -- unk.<br>Or/Og -- 365 | 432 | 1230 | 10 | E. McCracken |
| 5393 | SE/SE/SE/SW 35-7-17 | R.W. Gibson | Or/Og -- 50 | 140 | 1131 | 5 | E. McCracken |
| 6013 | SW/SW/NW 36-7-7 | Jantz Property | All Ojc | 12[illegible] | 117[illegible] | 7 | E. McCracken |
| 6258 | NE/SE/SW 36-5-32 | Benton Creek Mine | All Or | 130 | unk. | Prospect hole | E. McCracken |
| 7896 | NW/NW/NW/NW 36-7-20 | Rhenolds Property | All Ojc | 96 | 1156 | 1½ | J. G. Grohskopf |
| 7597 | SE/SE/SE/SE 36-7-7 | Hugh McWhorter | All Ojc | 120 | 1167 | 1½ | J. G. Grohskopf |
| 7919 | Center/SW/SE 36-7-11 | Chester Green | Or/Og -- 50 | 122 | 987 | 5 | J. G. Grohskopf |
| 7933 | Center/SE/NE 36-6-34 | Ed Lamb | All Or | 70 | 1100 | Prospect hole | J. G. Grohskopf |
| 8005 | NE/SW/SE 36-7-10(?) | J. E. Simily | Ojc/Or -- 50 | 135 | 1063(?) | 6 | J. G. Grohskopf |
| 8045 | SE/SE/NW/SE 36-7-11 | E. Coffmann | Or/Og -- 40 | 217 | 986 | 8 | J. G. Grohskopf |
| 8061 | NE/SW/SE 36-7-31 | Louis Schmiske | Ojc/Or -- 40<br>Or/Og -- 175 | 211 | 1189 | 1 | J. G. Grohskopf |
| 8132 | NE/SE/SW 36-5-32 | Benton Creek Mine | Or/Og -- 145(?) | 191 | 1206 | Prospect hole | J. G. Grohskopf |
| 8133 | NE/SE/SW 36-5-32 | Benton Creek Mine | Or/Og -- 143 | 192½ | 1183 | Prospect hole | J. G. Grohskopf |
| 8134 | NE/SE/SW 36-5-32 | Benton Creek Mine | Or/Og -- 125(?) | 190 | 1203 | Prospect hole | J. G. Grohskopf |
| 8190 | SW/SW/SW 36-6-3 | G. O. Parry | All Or | 81 | unk. | Prospect hole | J. G. Grohskopf |
| 8209 | NE/SE/SW 36-5-32 | Benton Creek Mine | All Or | 120 | 1200 | Prospect hole | J. G. Grohskopf |
| 8218 | NE/SE/SW 36-5-32 | Benton Creek Mine | Or/Og -- 130(?) | 195 | 1210 | Prospect hole | J. G. Grohskopf |
| 8292 | NE/SE/SW 36-5-32 | Benton Creek Mine | Or/Og -- 130 | 195 | 1184 | Prospect hole | J. G. Grohskopf |
| 8302 | SW/NE/SW 35-6-18 | John Howard | Or/Og -- 100 | 200 | 1142 | 10 | J. G. Grohskopf |
| 8859 | SE/SE/SE 36-6-3 | W. Parry | Or/Og -- 100 | 246 | 1057 | unk. | R. S. Watson |
| 9569 | NW/NW/SW/SW 36-6-10 | Ira Parry Sr. | Or/Og -- 120 | 354 | 1060 | unk. | E. McCracken |
| 10287 | SW/SE/SE/SE 36-7-21 | Melvin Gahr | Or/Og -- 65 | 150 | 987 | 4 | R. P. McNeal |
| 10289 | NE/NW/SE 35-6-2 | E. H. Snodgrass | Or/Og -- 70-90 | 223 | 1123 | 15 | E. McCracken |
| 10408 | SW/NW/NW 36-7-6 | Max Colvin | All Ojc | 112 | 1207 | 2½ | R. P. McNeal |
| 10492 | NE/NE/NE 35-7-9 | Jack Sturgeon | Or/Og -- 105 | 240 | 1059 | unk. | E. McCracken |
| 11356 | NW/NW/SW/SW 36-7-15 | James E. Wilson | All Or | 123 | 1014 | 2½ | G. Shearrow |
| 11694 | Center/SW 36-7-11 | L. M. Watts | Or/Og -- 50 | 198 | 980 | 15 | S. F. Marinkovic |

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# VITA

Howard Joseph Yorston was born in New York City on November 27, 1923. He graduated from St. Jean Baptist Grammar School in 1937 and Haaren High School in 1941. During the period January 1942-December 1946 he served in the Army Air Forces. He entered the Missouri School of Mines and Metallurgy in February 1948. In August 1950 he was recalled to active military duty for a period of two years. He resumed his studies at the School of Mines and Metallurgy in September 1952 and received the Degree of Bachelor of Science, Geology Major in August of the following year. He entered the graduate school of the Missouri School of Mines and Metallurgy the following September as a condidate for the degree of Master of Science, Geology Major to be conferred in May 1954.

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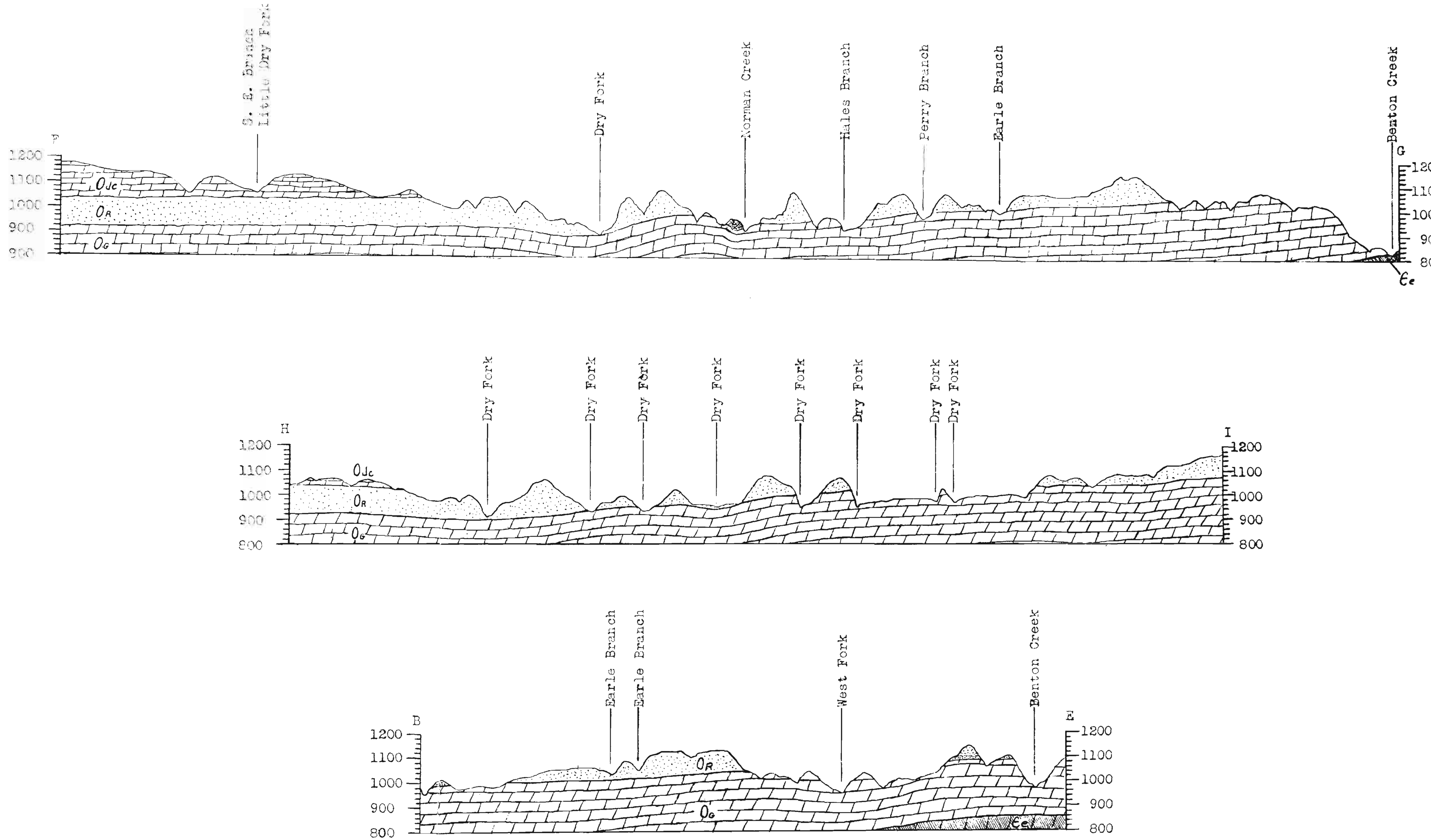
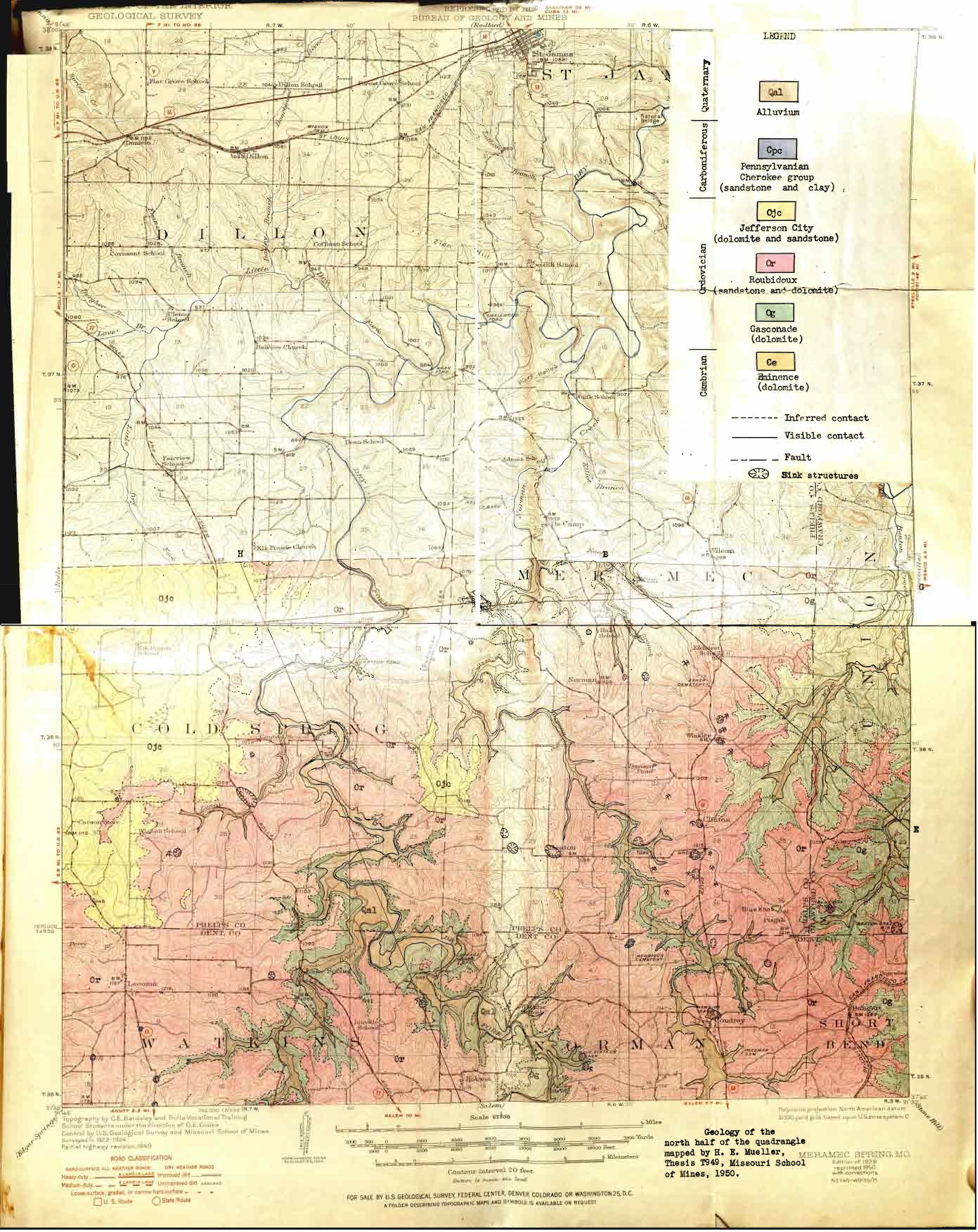



Fig. 3

Structure sections to accompany geologic map

Horizontal scale 1/62500
Vertical exaggeration 13




Geology of the north half of the quadrangle mapped by H. E. Mueller, Thesis T949, Missouri School of Mines, 1950.