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# Geology of the Berryman area, Washington County, Missouri

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# GEOLOGY OF THE BERRYMAN AREA
# WASHINGTON COUNTY, MISSOURI

BY

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THESIS

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Approved by O. R. Grawe
Professor of Geology

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This thesis is the result of work done under the joint cooperation of the Geology Department of the School of Mines and Metallurgy, University of Missouri, and the Missouri Geological Survey and Water Resources. The work was done under the supervision of Dr. O. R. Grawe, Chairman of the Geology Department, and Dr. E. L. Clark, State Geologist. Their guidance and consideration of the various problems was a large factor in the accomplishment of this project. Dr. Clark has given freely of the information and facilities of the Missouri Geological Survey and Water Resources. The manuscript was read critically by Dr. Grawe, who suggested changes which have made the presentation more effective. Dr. G. A. Muilenburg spent a day in the field and has given many helpful suggestions to the writer. John Grohskopf furnished valuable information concerning the stratigraphy of this region. Many courtesies were extended the writer by the inhabitants of the area during the course of the field work. The writer wishes to express his gratitude for the combination of efforts that has made this work possible.

# CONTENTS

# CONTENTS

Page

LIST OF ILLUSTRATIONS

Fig. Page

# LIST OF PLATES

# INTRODUCTION

Purpose and scope-- This investigation was initiated by the Missouri Geological Survey and Water Resources and is submitted in partial fulfillment of the requirements for the degree of Master of Science in Geology at the School of Mines and Metallurgy, University of Missouri, Rolla, Missouri.

The area discussed in this thesis was selected because of recent exploration for lead within this region and because of the need for more detailed information of the structure and geologic history of the area. The work constitutes part of a program of geologic mapping by the Missouri Geological Survey and Water Resources to complete the mapping of a strip of quadrangles extending across the Ozark Uplift from Rolla eastward to the Mississippi River.

Previous work-- The earliest geologic reference to this area was made by Schoolcraft(1). His observations were restricted to

(1) Schoolcraft, Henry R. Journal of a tour into the interior of Missouri and Arkansaw performed in the years 1818 and 1819. London, Sir Richard Phillips, 1821. pp. 4-6.

the presence of sandstone, quartz, and flinty jasper on the elevated ridges. Winslow(2) referred to early mining in the area, described

(2) Winslow, Arthur. Lead and zinc deposits. Missouri Geological Survey. Reports, Vol. 7, part 2, 1894. pp. 683-685.

the workings, stating that the shafts were sunk in a magnesian limestone. In the summer of 1924, Dake(3) ran a road traverse

(3) Dake, C. L. Unpublished maps and field notes.

along Missouri Highway No. 8. In 1926, Bridge[4] did reconnaissance

(4) Bridge, Josiah. Unpublished map.

geology along the Palmer fault which crosses the mid-portion of the area in an east-west direction. The most recent work, by Mihm and Kidwell[5], consisted of geologic mapping of approximately four

(5) Mihm, George, and Kidwell, A. L. Unpublished maps and notes.

square miles in the vicinity of the Palmer fault offset.

Present work-- The present field work was accomplished during the months of June, July, August, and September of 1947. The entire time was devoted to the work.

# GEOGRAPHY AND PHYSIOGRAPHY

Location and size of area-- The area covered by this report is in that portion of the Berryman quadrangle which lies in Washington County, Missouri. The area is bounded on the north by Missouri Highway No. 8, on the east by meridian 91°00' west longitude, on the south by parallel 37°45' north latitude, and on the west by the western boundary of Washington County. Approximately 62 square miles were mapped geologically.

Figure 1. Geographical location of the Berryman area.

Scenic attractions-- The area was included in the Clark National Forest in order to preserve its natural beauty. Its high bluffs and sinuous valleys afford views seldom excelled. The scenic attractions have caused numerous public resorts and privately owned summer homes to be built in order that the sportsman and the vacationer may hunt the game-filled forest and fish the clear fast streams. Many caves occur in the area, but none has yet been found of sufficient size to be commercialized. Many springs feed the streams and also provide a major source of water supply and refrigeration for the rural homes.

Figure 2. Berryman, Missouri. A typical community. Sec. 13, T.37 N., R.2 W.

Population— The area is sparsely populated and most of the people live in the tillable valleys. Several of the inhabitants are direct descendants of the early settlers, and many of the original homesteads still are in possession of the homesteading families. The majority of the early settlers migrated into this region from the Virginias, Kentucky, and Tennessee. A typical community consists of a few homes and a combination store, post-office, and filling station.

Figure 3. One of the many small sawmills in this area. Sec. 30, T.37 N., R.1 W.

Industry-- Agriculture is the principal industry. Large blocks of Government owned land are used freely as open range. This encourages the raising of cattle which, in turn, promotes the raising of hay and grain. Recently the forest attracted the timber industry and many small sawmills have been erected.

Figure 4. A prospect hole for shallow lead ore. NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 5, T.36 N., R.1 W.

Since 1725, the date of original lead discovery in Washington County[6], mining has been an integral part of the life of the

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(6) Buckley, E. R. Geology of the disseminated lead deposits of St. Francois and Washington Counties. Missouri Bureau of Geology and Mines. Reports, ser. 2, Vol. 9, part 1, 1908. p. 2.

farmer. Attempts are constantly being made by these people to locate and develop commercial ore bodies. Many shallow diggings, often dug by an individual, are found scattered throughout the area. Farmers engage in this type of work especially during the winter months, when work on the farm is slack.

Towns-- The closest towns of appreciable size are Steelville, the seat of Crawford County, approximately 16 miles to the west, and Potosi, the seat of Washington County, nearly 20 miles to the east. Steelville is a community of about 1000 inhabitants. Potosi has a population of about 2000.

Figure 5. Missouri Highway No. 8; the major transportation artery.

Transportation-- The area is not traversed by a single railroad, but is served by State Highway No. 8 along the north border of the area. It is the connecting road between Steelville and Potosi and carries all the traffic through the area. Access to the farms is largely by county roads and by numerous forest trails of the United States Forest Service. Only two county roads are maintained; one running south to Palmer, the other running south Courtois and thence east to Quaker. Many of the forest trails can be travelled only during periods of dry weather owing to the lack of maintenance and bridges.

Figure 6. A road serving the back country. NW $\frac{1}{4}$ sec. 30, T.37 N., R.1 W.

Climate-- The climate in this area, although generally considered mild, is variable seasonally. A mean annual temperature of 55° is the result of a winter average around 30° and a summer average about 80°[7]. The summers are characteristically hot and dry and the

(7) Dake, C. L. Geology of the Potosi and Edgehill quadrangles. Missouri Bureau of Geology and Mines. Reports, ser. 2, Vol. 23, 1930. p. 17.

winters mild.

The mean annual precipitation, according to Beckman[8], is 42

(8) Beckman, H. C. Water resources of Missouri 1857-1926. Missouri Bureau of Geology and Mines. Reports, ser. 2, Vol. 20, 1927. pl. 3.

inches. The early spring months and the fall months are periods of heaviest rainfall. The late summer and early autumn months are frequently dry.

Topography-- The area lies within the highly dissected eastern portion of the Ozark Plateau. The upland level lies chiefly between an altitude of 1100 and 1200 feet, however, there are numerous hills rising above this altitude.

The lowest point in the area is near the junction of Courtois and Lost Creeks at an altitude of about 750 feet. The highest point, about 1310 feet above sea level, is the Eminence knob in the SE ¼ section 1, T.35 N., R.2 W. The average local relief is about 200 feet. The largest local relief, about 250 feet, occurs in the south half of section 32, T.37 N., R.1 W., along Courtois Creek downstream from the mouth of Hazel Creek.

Topographically, the region is in medium maturity and it is thoroughly dissected with a typical dendritic drainage pattern. Although the topography of the area shows little relation to the structure, in a few places the drainage does seem to be structurally controlled. The most obvious control is by the fault which strikes northwest in the Courtois and Hazel Creeks valleys.

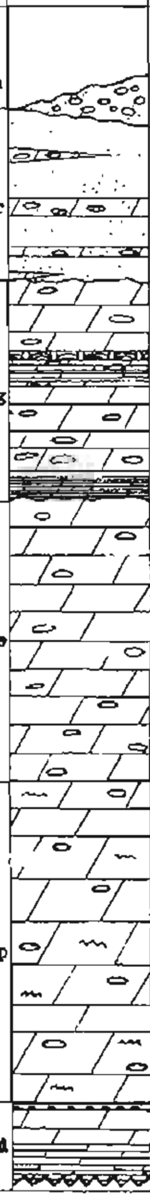
The area is within the drainage basin of the Meramec River and is drained by the Courtois, Lost, Little Lost, Hazel, Cub, and Indian Creeks. All of the drainage is toward the north into Courtois Creek, which flows out of the extreme northwest corner of the area. The main tributaries are Johns Creek, Trace Creek, and several unnamed all weather branches. All the major streams and tributaries have small flood plains, while the minor valleys are typically V-shaped.

One feature of valley development worthy of note is the result of stream piracy. In the SE $\frac{1}{4}$ NW $\frac{1}{4}$ section 4, T.35 N., R.1 W., a wind gap has been formed as the result of stream piracy on Rocky Fork Creek. A low swale at the base of the east valley slope (Fig. 7) marks the former position of the stream bed. This swale merges into the low portion of the wind gap. Rocky Fork Creek formerly flowed through this old water course northward into Cub Creek. A small branch flowing in a northwesterly direction into Cub Creek was able to encroach upon Rocky Fork Creek, provide a lower stream bed, and thereby capture the drainage of Rocky Fork Creek. As a consequence, Rocky Fork Creek now follows the drainage course of this former small branch. During the normal course of erosion and development the stream bed has become lower and a small flood plain has developed along the new course. The present flood plain lies below the lowest part of the wind gap.

Figure 7. Wind gap near the mouth of Rocky Fork Creek. Looking north. SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 4, T.35 N., R.1 W.

Plate 1

| ERA | PERIOD | FORMATION | SYMBOL | COLUMNAR SECTION | THICKNESS (in feet) | CHARACTER OF ROCKS |
|---|---|---|---|---|---|---|
| CENOZOIC | RECENT | Alluvium | Qa | | 0-30 | Clay, sand, gravel, boulders. |
| | | Unconformity | | | | |
| PALEOZOIC | ORDOVICIAN | Roubidoux | Or | | 120+ | Sandstone, iron-stained, cross-bedded, ripple-marked. Dolomite, buff, arenaceous. Chert, sandy, oolitic. |
| | | Unconformity | | | | |
| | | Gasconade | Og | | 150-220 | Dolomite, gray, coarsely crystalline, cherty. Chert, cryptozoonic, oolitic, dense, tripolitic. Shale, green; at base of formation. |
| | | Unconformity | | | | |
| | CAMBRIAN | Eminence | Ce | | 180-220 | Dolomite, light gray, coarsely crystalline, massive, cherty. Chert, gray, oolitic; weathers to rusty porous masses. |
| | | Potosi | Cp | | 230-280* | Dolomite, brown, medium crystalline, massive, cherty, drusy, bituminous odor. Druse, chalcedonic banded. |
| | | Derby-Doerun | Cd | | 50+* | Dolomite, light gray, fine to medium crystalline, druse-lined vugs; no chert. |



* Deep well drilling in this area shows a maximum of 340 feet of Potosi and 110 feet of Derby-Doerun.

GENERALIZED SECTION OF THE BERRYMAN AREA

Scale 1" = 100'

# DESCRIPTIVE GEOLOGY

## STRATIGRAPHY

### Introduction

The formations in this area are of Cambrian and Ordovician age. The Cambrian (restricted), Ozarkian, and Canadian systems as defined by Ulrich also are represented.

## PALEOZOIC SEDIMENTARY ROCKS

### CAMBRIAN SYSTEM

#### Derby-Doerun formation

The stratigraphically lowest and therefore the oldest strata exposed in the area are assigned to the Derby-Doerun formation. Although these names originally were applied to separate formations by Buckley[9], restricted areal distribution and limited vertical

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(9) Buckley, E. R. op. cit. pp. 44-49.

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extent precludes any effort to separate these formations in this area. It is for this reason that the term Derby-Doerun is used.

Buckley described the Derby as a "...fine-grained, crystalline, slightly calcareous dolomite..." having alternate soft porous beds and dense, hard and brittle beds. He described the Doerun as a thin-bedded, chiefly argillaceous dolomite.

Probably the most extensive and intensive study of these formations since Buckley, was made by Dake[10], who found, in the

(10) Dake, C. L. op. cit. 228 pp.

Potosi quadrangle, a series of beds of "...coarsely crystalline light brown to gray non-drusy dolomites...". No description of equivalent beds had been made from the type section and Dake was reluctant to include them in the Derby-Doerun formation, thereby establishing a series of massive beds at the top of the formation, but he included these beds in the Derby-Doerun in his field mapping. These beds reach a maximum thickness of 30 feet, which is nearly one-third of the thickness of the combined Derby and Doerun formations.

The beds mapped as Derby-Doerun by Dake in the Potosi quadrangle continue along Cub and Courtois Creeks in the Berryman quadrangle. The relationship of thse beds to one another is clearly shown south of the Berryman quadrangle, along the road to Goodwater. Here the massive beds overlie a thin-bedded zone which, in turn, overlies rock which is believed to belong to the Davis formation. The massive beds lie immediately below the Potosi. This series of massive beds, aggregating 30 feet in thickness, as assigned to the Derby-Doerun formation in order to be consistent with the mapping of Dake in the adjacent Potosi quadrangle.

Grawe[11], however, has expressed the opinion that the inclusion

(11) Grawe, O. R. Personal communication.

of the Derby and Doerun formations in the stratigraphic section is unfortunate. "...They are not important enough to map as separate units, they are conformable with each other, their present use is not in conformity with the original definitions laid down by Buckley, and their identification in the field from the Potosi above and the Davis below is difficult...". Grawe holds "...that these formations may not be represented in the area at all and that the massive granular dolomites here recognized as the top of the Derby-Doerun might better be included in the Potosi, while the thin-bedded argillaceous dolomites at the base of the Derby-Doerun might better be included in the Davis...".

History-- The Derby-Doerun formation as recognized today was formerly included in the St. Joseph of Winslow. Keyes later placed this rock in the Fredericktown and it was still later put in the Potosi by Nason. Ulrich defined the formation as part of the Elvins. Buckley first described the formation and split it into two formations assigning the names Derby, from the Derby mine, to the older strata, and Doerun, from the Doerun Lead Company, to the younger strata.

Areal distribution-- The areal extent of the Derby-Doerun is very limited; the formation is exposed only in the southern part of the area as a thin belt along Courtois and Cub Creeks. A Derby-Doerun inlier outcrops along Courtois Creek from about the north line of section 5, T.35 N., R.1 W., to near the center of the west line of section 8, T.35 N., R.1 W. In sections 2, 3, and 4, T.35 N., R.1 W., along Cub Creek a belt of Derby-Doerun is exposed. The formation disappears below the surface just before reaching the west line of section 4, T.35 N., R.1 W. The maximum thickness of 60 feet is exposed at the north end of the bridge which crosses Cub Creek in the NE ¼ section 3, T.35 N., R.1 W. Because the entire formation is not exposed, its total thickness is undetermined in the mapped area. As a result of a study of cuttings from deep well drilling in the vicinity of Palmer, section 14, T.36 N., R.1 W., north of these exposures, the subsurface laboratory of the Missouri Geological Survey and Water Resources has reported a maximum thickness of 110 feet for this formation.

Lithologic character-- The Derby-Doerun in this area can be divided into two zones; an upper massive zone of approximately 30 feet, and an underlying, only partially exposed, thin-bedded zone of undetermined thickness. The upper massive zone is a gray to buff, fine-grained to coarsely crystalline, non-cherty dolomite. The thin-bedded zone consists of gray to dark gray, or slightly bluish gray, medium to coarsely crystalline, non-cherty dolomite.

The presence of green shale is indicative of this formation. Dake(12) reports that in the Potosi and Edgehill quadrangles, where approximately 95 square miles of Potosi formation outcrop, green shale never has been seen in the Potosi formation.

The Derby-Doerun is distinguished from the overlying Potosi by

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(12) Dake, C. L. op. cit. p. 113.

Figure 8. Thin-bedded zone of the Derby-Doerun exposed along the Cub Creek stream channel in the SW $\frac{1}{4}$ NE$\frac{1}{4}$ sec. 3, T.35 N., R.1 W.

the small quantity and character of the druse, the contrasting light color, the crystalline appearance, and the lack of the characteristic Potosi odor. Where exposed to stream action the Derby-Doerun becomes much darker in color. Under these conditions, separation of this formation from the overlying Potosi may be difficult, but the distinction can be made on the basis of the quantity and character of the druse, the crystalline appearance, and the lack of the characteristic Potosi odor.

Chert is absent from this formation although druse is present in variable quantities.

Variations in the amount of druse can be observed by a comparison of exposures. In the NE $\frac{1}{4}$ SE$\frac{1}{4}$ section 2, T.35 N., R.1 W., along the road up Cub Creek, the Derby-Doerun carries small amounts of druse. In the SE $\frac{1}{4}$ NW $\frac{1}{4}$ section 2, T.35 N., R.1 W., along the

Figure 9. Highly drusy Derby-Doerun. SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 2, T.35 N., R.1 W.

road just east of Antioch church, the Derby-Doerun exhibits abundant druse just above the road level. The druse at this locality is confined to a bed of massive dolomite about 4 feet thick. There is a notable difference in the manner of occurrence of this druse as contrasted to the manner of occurrence in the Potosi. Where the druse in the Potosi commonly forms a curtain-like drape over the outcrop, the druse at this locality lies horizontally in thin bands along stratification planes. This may be observed best by comparing Figure 9 with Figure 13. This drusy horizon is not widespread even over an area as small as that mapped and it is believed such an occurrence is a local phenomenon. This exposure was first identified as Potosi, but the presence of typical Derby-Doerun extending for 30 feet above, and the thin-bedded zone exposed in the stream below served to place this exposure in the lower portion of the massive zone. The druse in the Derby-Doerun, seemingly, is confined to the massive zone and is commonly found as a lining in the cavities and vugs of this rock.

Figure 10. Partial view of the section measured across the Derby-Doerun and Potosi contact. NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 2, T.35 N., R.1 W.

The following section measured along the road up Cub Creek in the NE $\frac{1}{4}$ SE $\frac{1}{4}$ section 2, T.35 N., R.1 W., shows the contact of the Derby-Doerun and the Potosi formations.

Top of hill. Altitude 1110 feet.

Potosi formation

| | |
|---|---|
| Dolomite, massive, dark brown, medium crystalline, drusy, odoriferous. Residual soil deep red with abundance of druse fragments. Smooth to rough and pitted ledge and pinnacle outcrops along the hill slope with ledge outcrop at the base. | 148 feet |

Derby-Doerun formation

| | |
|---|---|
| Dolomite, thin-bedded, fine-grained, light to dark gray, contains dendrites. Weathers into steps and exhibits closely spaced wavy lines on weathered surface. | 3 feet |
| Green shale, residual clay, and calcite zone, undulating, mealy. | 1 foot |
| Dolomite, massive, light gray to buff, medium to coarsely crystalline. Blocky appearance in bluffs and smooth pinnacles on slopes. | 16 feet |

Road level. Altitude 942 feet.

There is a definite break in the lithology of the rock in the section given above between the dark colored, drusy, dolomite and the fine-grained, light to dark gray, dendritic, dolomite. Also there is a break in lithology between the fine-grained, light to dark gray, dendritic, dolomite and the massive, medium to coarsely crystalline, light gray to buff, dolomite lying below the shale, clay, and calcite zone. The fine-grained, dendritic rock is variable in character and shows characteristics similar to either the overlying Potosi or the underlying Derby-Doerun.

Although it would be easy to place the contact at the shale, clay, and calcite zone, especially in light of the postulated unconformity between the Derby-Doerun and the Potosi formations, the writer believes that this is a solution zone. Green shale seams are present in the overlying thin-bedded strata and are confined to the bedding planes of that strata. In the shale, clay, and calcite zone a green shale is completely surrounded by residual clay. The residual clay probably was carried into the solution zone, filling the space formed by the solution of the dolomite. The overlying Potosi is known to be a good aquifer and its open, cavernous character is repeatedly encountered in drilling. Such a rock admits a considerable quantity of ground water which upon reaching the massive zone of the Derby-Doerun, spreads laterally along stratification planes searching for fissures allowing downward movement. This lateral movement results in intensive solution along the planes of lateral movement. Fissures admitting downward movement of the ground water need not penetrate the entire massive zone, but probably allow downward circulation to a point where the fissures disappear. At this point lateral movement again takes place along stratification planes and gives rise to several horizons in the massive zone along which an intensive solution has taken place. Such solution zones are seen at various horizons in the massive zone and the reasoning given above may explain why the shale, clay, and calcite zone of the above section is not persistent.

This zone might be interpreted as an unconformity lacking a basal conglomerate because of the lack of resistant material in the underlying rock, but in the limited exposures which exist in the area the shale, clay, and calcite zone is not consistently present and cannot be traced from outcrop to outcrop. It was decided to draw the contact for the area mapped on the top of the fine-grained, thin-bedded strata since they can be identified in nearly all localities where the contact is mapped. The possibility of the shale, clay, and calcite zone representing an unconformity may be worthy of consideration in regional work on this contact.

Derby-Doerun residual material is characterized by a buff soil, but, unless float boulders of dolomite which can be assigned to this formation are found, identification by the residuum may be impossible. The abundant residual material from the Potosi formation floats and creeps into the Derby-Doerun residuum masking the contact and making the identification of the Derby-Doerun residuum difficult.

The cedar "glades" reported by Dake[13] as being characteristic

(13) Ibid. p. 104.

of the Derby-Doerun are present along Cub Creek and can be viewed from the bridge across Cub Creek in the NE $\frac{1}{4}$ section 3, T.35 N., R.1 W. Cedars are abundant on the lower portion of the valley slopes, but disappear up slope as the Potosi formation is approached.

Figure 11. Stylolites in the massive zone of the Derby-Doerun.
SE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 3, T.35 N., R.1 W.

Stylolites are abundant in the massive zone of the Derby-Doerun. They are very closely spaced and are exposed as longitudinal sections of the individual stylolites. The exposed area may be 1 to 2 inches horizontally and 12 to 16 inches vertically, or may be 12 to 16 inches horizontally and 2 to 3 inches vertically. The striations are either vertical or slightly inclined to the vertical and both positions occur on a single exposed surface. Some of the stylolites are curved through an angle of perhaps 25 degrees. Individual stylolites terminate abruptly with minute offset against an overlapping set. This type of succession may be repeated several times accounting for the relatively large vertical extent of the exposed stylolitic surfaces. The offset is so small that it is seen only upon close examination and on some exposures weathering has obliterated the offset entirely. Stylolites were not found in the thin-bedded zone of the Derby-Doerun or in the overlying Potosi.

Weathering-- The Derby-Doerun typically develops smooth sparingly pitted pinnacles. This type of exposure is ideally developed on the point just west of Kelly Hollow near the center of section 3, T.35 N., R.1 W., and again on the point east of Rocky Fork Creek in the SE $\frac{1}{4}$ NW $\frac{1}{4}$ section 4, T.35 N., R.1 W. The formation of these pinnacles is controlled by the joint system which has been noted in numerous exposures of the Derby-Doerun. Where conditions are not conducive to the formation of pinnacled outcrops, the massive zone weathers into blocky bluffs or ledges, and the thin-bedded zone weathers to gentle slopes. In only one locality has the thin-bedded zone been seen in vertical relief.

Figure 12. Derby-Doerun pinnacle outcrop. SE ¼ NW ¼ sec. 4, T.35 N., R.1 W. Also see Figure 7.

Topographic expression— The distribution of the Derby-Doerun formation within the mapped area is too limited to control topography. The thin belt forms both low bluffs and gentle slopes. The bluffs are capped with Potosi.

Stratigraphic relations-- Within the confines of this area the Derby-Doerun appears to be conformable with the Potosi. In the adjacent Potosi quadrangle, Dake(14) found the base of the Potosi

(14) Dake, C. L. op. cit. p. 104.

to be rather irregular with the Derby-Doerun present only locally, indicating an unconformity between the two formations. Elsewhere he found the Potosi resting directly on Davis and even upon Bonneterre, which led him to believe that the unconformity was an important one. Such evidence does not exist in this area.

Figure 13. Close view of the Derby-Doerun and Potosi contact. NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 2, T.35 N., R.1 W.

Paleontology-- No fossils were found in the Derby-Doerun of this area and very few are reported from this formation.

Correlation-- Ulrich placed the Derby-Doerun formation at the top of his Cambrian (restricted) system. On the Kansas Geological Society Correlation Chart[15] the Derby-Doerun is correlated with

(15) Correlation chart prepared for the Kansas Geological Society Fifth Annual Field Conference by Anthony Folger. August 1931.

the St. Lawrence member of the Trempealeau formation of Iowa and Wisconsin and, although absent in Texas, it occupies a position between the Wilberns and Ellenburger formations. Bridge[16] places

(16) Bridge, Josiah. The correlation of the upper Cambrian sections of Missouri and Texas with the section in the Upper Mississippi Valley. U.S. Geological Survey. Professional Paper 186-L. 1936. pp. 233-237.

the Derby-Doerun as equivalent to the upper part of the Wilberns formation of Texas and as equivalent to the Bad Axe member of the Franconia formation of the Upper Mississippi Valley.

Potosi formation

The term Potosi is applied to those rocks lying between the Derby-Doerun below and the Eminence above. It is restricted to a cherty, drusy, dark colored, massive, dolomite having a characteristic odor. This restriction is based on an interpretation of previous descriptions of the formation. Originally the formation was named from the town of Potosi, Missouri, where it is characterized by the development of quartz druse or "mineral blossom", as it is known in southeastern Missouri.

History-- Winslow[17] first used the name Potosi for all

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

strata lying between his St. Joseph limestone and the Crystal City sandstone. From his text it can be assumed that the St. Joseph limestone included the present day Bonneterre, Davis, and possibly the Derby-Doerun. It is uncertain if the base of his Potosi was at the base of the Potosi as now defined or at the base of the Derby-Doerun. Bain and Ulrich[18] applied the term, Potosi group, to the

(18) Bain, H. F., and Ulrich, E. O. The copper deposits of Missouri. U. S. Geological Survey. Bulletin 267. 1905. p. 26.

rocks lying between the Elvins (Davis and Derby-Doerun) below and the St. Peter (Crystal City) sandstone above. Buckley[19] limited

(19) Buckley, E. R. op. cit. p. 51

the formation to the drusy, cherty dolomite when he defined the Derby and the Doerun formations and restricted the use of the term Potosi to the strata between the Doerun and the Eminence.

Areal distribution-- The Potosi formation in this area is restricted almost entirely to the southern half of the area. Only small areas of Potosi are exposed north of the Palmer fault. On the high ridges it is capped with Eminence or Eminence residuum. In many places it is pure conjecture whether the Eminence is in place or is represented only by a residual blanket over the Potosi. The area underlain directly by Potosi is approximately 19 square miles or comprises about 30 percent of the total area.

Thickness-- At the south line of section 8, T.35 N., R.1 W., the Derby-Doerun is present at an altitude of 960 feet and the Eminence is at 1150 feet. This gives an apparent thickness of 190 feet for the Potosi. However, a dip of about 2 degrees westward, causing the Derby-Doerun to disappear below the surface in that direction, adds an additional 90 feet to the thickness. This makes a total thickness of 280 feet for the Potosi at this locality. In the south half of section 34, T.36 N., R.1 W., at the north line of section 3, T.35 N., R.1 W., the Potosi apparently is 180 feet thick. The regional dip, which is approximately 1 degree, adds another 50 feet to the total thickness, making a total thickness of 230 feet. This is the smallest observed thickness for the Potosi in the area.

Lithologic character-- The Potosi is a very massive, brown, cherty and drusy, odoriferous, medium crystalline dolomite. Gradations from these characteristics have been noted, the rock grading into a light brown, non-drusy, and scarcely odoriferous dolomite. The Potosi is consistently a massive formation in which the bedding planes are several feet apart, if they can be observed at all. The odor of the Potosi is one of the formation's most outstanding characteristics. This odor has been described as fetid, but, to the writer, this odor would seem to be described better as bituminous. This odor is most readily detected when the rock is freshly broken and becomes faint or disappears entirely within a few minutes after fracture. Bridge[20] and Dake[21] attributed the odor and

(20) Bridge, Josiah. Geology of the Eminence and Cardareva quadrangles. Missouri Bureau of Geology and Mines. Reports, ser. 2, Vol. 24, 1930. p. 70.

(21) Dake, C. L. op. cit. p. 112.

the brown color of the dolomite to the presence of decomposed hydrocarbons or organic matter.

The color of this rock is markedly affected by weathering. The color may vary from dark brown to light tan, but a definite brown color is predominant. In the NW $\frac{1}{4}$ SE $\frac{1}{4}$ section 8, T.35 N., R.1 W., along the road to Goodwater, a shear zone involves the Potosi dolomite. The characteristic dark color and odor of the formation are noticeably absent in the actual shear zone. Here

Figure 14. Drusy Potosi bluff showing the even fracture and joint system. NE corner sec. 5, T.35 N., R.1 W.

the color approaches a light gray and the odor becomes earthy. Similar effects have been noted at numerous localities by Dr. G. A. Muilenburg[22] both in the Potosi and the Bonneterre formations.

(22) Muilenburg, G. A. Oral communication.

The conditions surrounding these observations indicate that such bleaching can be attributed to oxidation by ground water.

Figure 15. Shear zone in the Potosi. NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 8, T.35 N., R.1 W.

Many springs issuing from the Potosi show a thin film of oil on the surface of the water. This material is here called oil without the benefit of chemical analysis; the only test made was to break the film and watch the reaction. Because the film immediately reformed over the surface when broken, it was assumed to be an oil film rather than a film due to iron oxides. The presence of this film is believed to be substantiating evidence for the assumption by Bridge and Dake that the odor and color of the formation are due to decomposed hydrocarbons or organic matter.

The Potosi normally varies from a fine-to medium-grained crystalline dolomite. Locally it may have an earthy texture, although this is seen only in places where the formation has been subjected to intensive solution.

The most distinctive criterion for the identification of the Potosi is the presence of a characteristic druse. This has been used to identify the formation during the mapping of the area. The Potosi druse is characterized by a mass of quartz crystals formed on finely banded, convex, chalcedonic surfaces. The druse has been described by Buckley(23) and others, but it is described more fully by Dake(24).

(23) Buckley, E. R. op. cit. p. 53.

(24) Dake, C. L. op. cit. pp. 113-115.

A white chert with dolomolds(25) occurs at numerous localities on Potosi residual surfaces. Frequently the chert fragments are bordered on one edge by a zone of alternate bands of clear and milky quartz which is surmounted by quartz crystals. The dolomolds disappear at the edge of the fine banding. White dolomoldic chert is found throughout the Potosi, but a chert having unusually large dolomolds occurs about 25 feet below the top of the formation as

(25) This term is used synonymously with the term dolocast as defined by McQueen.

mapped in this area. These dolomolds may be 0.5 millimeter on edge in contrast to the usual size of 0.1 to 0.3 millimeter. The writer did not observe this chert in place, but it was so persistently present at this stratigraphic horizon that it was used as indicative of this horizon.

A similar type of chert was found in cuttings from deep well drilling in the Palmer area. This chert proved to be so consistent that it is used by the subsurface laboratory of the Missouri Geological Survey and Water Resources as one of the bases for correlations[26].

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(26) McCracken, Earl. Oral communication.

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Weathering— The weathered surfaces of the Potosi dolomite may vary from smooth to rough and pitted. The development of joints is conducive to the formation of pinnacles on weathering slopes. These pinnacles are more rough and pitted on the surface than those of the Derby-Doerun. Where the Potosi outcrops in low bluffs and ledges the surface is rough and pitted except on comparatively recent bluff surfaces where it may show a smooth blocky appearance (Fig. 14). On ledge outcrops it is common to find a lace like curtain of druse draping the surface (Fig. 13).

Residual soils of the formation are packed with fragments of druse. This, coupled with the deep red color, is almost an infallible criterion for the recognition of Potosi residuum. Because of the resistance of the druse to weathering, it is common to find typical Potosi residuum covering the underlying Derby-Doerun. This

Figure 16. Residual soil of the Potosi. SE $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 6, T.35 N., R.1 W.

may lead to considerable error in mapping the base of the Potosi formation if it be attempted on the basis of float alone.

Topographic expression— Rather steep slopes and bluffs characterize the area of Potosi outcrops. The rockiness of the slopes prohibit their cultivation. The dividing ridges are narrow and the ravine heads are rather abrupt.

Stratigraphic relations-- In this area the relation with the underlying Derby-Doerun appears to be conformable, although regional evidence has been cited for an important unconformity. Exposures of

Figure 17. Potosi ridge with steep rocky slopes. Running essentially north in the east half of sec. 5, T.35 N., R.1 W.

the Potosi-Eminence contact are extremely rare. Dake[27] considered

(27) Dake, C. L. op. cit. p. 116.

the Potosi to be conformable with the Eminence above, and no evidence has been observed which would indicate other than a conformable relationship in the area covered by this thesis.

The specific determination of the contact of the Potosi and the Eminence formations is practically impossible. Dake[28] assigns

(28) Ibid. pp. 116-117.

an interval of perhaps 40 feet to a transitional phase, and this transitional phase he has mapped with the Potosi formation. The precise location of the contact will vary for any given area, depending upon the type of outcrops available and the whim of the observer. Because the exposures at the critical horizon are very meager, and because much of the mapping has been done on float and residuum, the writer mapped the top of the Potosi as that horizon where the banded chalcedonic druse material is present in consistently appreciable quantities. The transitional phase has, therefore, been included in the Eminence formation and the altitude of the contact along the eastern edge of the map will be fairly consistent at about 40 to 50 feet lower than the contact as mapped by Dake in the Potosi quadrangle to the east.

Paleontology-- The writer did not collect fossils from this formation and the fauna reported by others consists of not more than a dozen fossils.

Correlation-- The Potosi is considered to be Upper Cambrian in age. It is the basal formation of the Ozarkian system of Ulrich. Because of the absence of faunal evidence, it is necessary to correlate this formation on the basis of stratigraphic position. The Potosi has been correlated with the Potosi of Alabama(29),

(29) Ulrich, E. O. Revision of the Paleozoic systems. Geological Society of America. Bulletin. Vol. 22, 1911. pl. 27.

with the Royer and Fort Sill of the Arbuckle group of Oklahoma, and with the Madison of Iowa and Wisconsin[30]. According to

(30) Correlation chart. op. cit.

Bridge[31], the Potosi is equivalent to the lower portion of the

(31) Bridge, Josiah. op. cit. pp. 233-237.

Ellenburger of Texas and to the St. Lawrence member of the Trempealeau formation of the Upper Mississippi Valley.

Eminence formation

The term Eminence is applied to those rocks lying between the Potosi formation below and the Gasconade formation above. The lower portion of the Eminence formation, as mapped in this area, includes a recognized transition zone of approximately 50 feet which, apparently, is a gradational phase from characteristic Eminence into characteristic Potosi.

History-- The first description of the Eminence was published by Ulrich[32] in 1911. The formation had previously been assigned

(32) Ulrich, E. O. op. cit. pp. 630-631.

to the Gasconade by Nason[33], which included the great series of

(33) Nason, F. L. Report on iron ores. Missouri Geological Survey. Reports, Vol. 2, 1892. Chapter 5.

limestone beds, interstratified with thin beds of sandstone, underlying the Roubidoux sandstone. Winslow[34], in 1894, included the

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

present Eminence in the Potosi member of the St. Francois limestone, which included all the rocks from the Lamotte sandstone to the St. Peter sandstone. In 1901 Nason[35] defined the base of the Potosi

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

Nason, F. L. The geologic relations and age of the St. Joseph and Potosi limestone of St. Francois County, Missouri. American Journal of Science. Ser. 4, Vol. 12, 1901. pp. 358-361.

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formation which then included the present Eminence, Potosi, Derby-Doerun, and most of the Davis. Bain and Ulrich[36], in 1905,

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(36) Bain, H. F., and Ulrich, E. O. op. cit. p. 12.

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included everything between the Davis and the Roubidoux in the Gasconade limestone. This included the Eminence as recognized today. As defined by Ulrich[37], the Eminence overlies the Potosi

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(37) Ulrich, E. O. op. cit. pp. 630-631.

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formation and lies immediately below the Gasconade or Proctor, where present.

The Proctor was not identified in this area and is believed to be absent. Therefore, the Eminence formation is overlain by the Gasconade formation in this area.

Areal distribution— The Eminence formation is the cap rock of the ridges in the southern part of the area. In the vicinity of the Palmer fault it is the surface rock and forms bluffs along the streams. The areal extent of this formation is exceeded only by that of the Potosi. The Eminence is exposed over approximately 15 square miles.

Thickness-- At no locality is the top and the bottom of the Eminence exposed in one section. Because this formation is practically one lithologic unit, an estimation of thickness from separate exposures is difficult. In the south half of section 32, T.37 N., R.1 W., a bluff with a sheer rise of over 100 feet is capped by another 100 feet of covered slope. This entire section has been mapped as Eminence, indicating a thickness of more than 200 feet for the total thickness of the formation. In section 14, T.37 N., R.2 W., just northwest of the northwest corner of the mapped area, the formation appears to be 220 feet thick.

Lithologic character-- The Eminence formation is a massive, cherty, light gray, crystalline dolomite. Although massive, this formation usually is definitely bedded, the bedding being much better defined than that in the Potosi formation.

Well defined bedding planes may show an undulating surface, the individual beds varying in thickness from 6 inches to several feet. The thinner phases of this formation are not numerous in their exposure which may be due either to their not being developed, or to the fact that such exposures tend to weather into gentle slopes and are hidden by residual material. At several places where extensive solution takes place the formation, where otherwise massive, tends to become thin-bedded. Wet weather seeps will transform a massive bed into a series of steps with well defined planes of parting.

With the exception of its basal portion, the formation is rather consistently light gray and frequently bright gray. Variations from this may be observed locally with gradations to dark gray and sometimes to a greenish tint. At such localities a little search has shown the light gray coarsely crystalline rock to be predominant.

This rock is almost wholly coarsely crystalline, although local zones of finer grained rock have been seen. These zones are not persistent or widespread as far as the writer has been able to determine. The Eminence is more coarsely crystalline than either the Potosi or the Gasconade formations. Although exceptions have been found, generally the Eminence, on fresh surfaces, tends to give a bright, rough fracture surface with the break passing through the crystals of dolomite. In contrast, the Gasconade has a dull rough fracture surface with a tendency to break around the crystals of dolomite causing them to stand out in relief. This is not so pronounced when comparing the Eminence to the upper portion of the Gasconade formation as it more nearly approaches the characteristics of the Eminence.

The Eminence contains numerous small vugs which are lined with dolomite crystals, and less commonly, with quartz crystals. This feature is ever present in this area.

The character of the Eminence formation is shown by the following section measured in the NE $\frac{1}{4}$ section 24, T.37 N., R.2 W., 0.2 mile south of the north line of section 24 and 0.3 mile west of the east line of section 24, at the point where Courtois Creek bends away from the bluff. This section was measured in a northeast direction to the knoll marked by the closed 900 foot contour line on the topographic map.

Top of knoll. Altitude 910 feet.

| | |
|---|---|
| Covered slope. Abundant chert in the residuum. Chert is drusy, rusty and porous, white and gray, smooth, dead white, and dolomoidic. | 25 feet |
| Dolomite, light gray, coarsely crystalline, massive; weathers to dead white; gray chert; disposition toward thin bedding along water seeps. | 12 feet |
| Dolomite, light gray, coarsely crystalline, gray chert; altered dolomite pebbles in dolomite matrix gives conglomeratic appearance. Pebbles vary in size from that of sand to $\frac{1}{2}$ inch long by $\frac{1}{4}$ inch thick and have a flattened oval form. Pebbles weather into relief. | 1 foot |
| Dolomite, light gray, coarsely crystalline, massive; white and gray chert; irregular cavities bordered by a thin dead white chert band and lined with clear quartz crystals. Gives rock a diagnostic appearance. | 4 feet |
| Dolomite, light gray, coarsely crystalline, massive; dull white when weathered; gray chert. | 10 feet |
| Dolomite, light gray, coarsely crystalline, massive; interspersed with ramifying quartz seams; quartz weathers into relief. | 5 feet |
| Dolomite, light gray, coarsely crystalline, massive. | 5 feet |
| Dolomite, light gray, coarsely crystalline, massive; small vugs and cavities; weathered surface dull gray; dolomite rhombs weather out giving surface a sandy appearance. | 10 feet |
| Dolomite, light gray, coarsely crystalline, massive; small vugs and cavities lined with dolomite crystals; gray chert as stringers and, more rarely, nodules; 6 inches to 18 inches zone parallel to bedding having rock fractured into small rhombic blocks 1 inch to 3 inches on edge; this zone undercuts massive rock. | 41 feet |
| Covered slope. Talus of dolomite blocks with some chert. | 23 feet |

Water level. Altitude 774 feet.

One of the most valuable aids in the field identification of the Eminence formation is the type of residual chert the formation develops on weathering. The absence of large amounts of chert in the unweathered formation leads to the conclusion that the abundant chert on residual surfaces is formed during the process of weathering.

Figure 18. Large chert mass on Eminence residual surface. SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 1, T.35 N., R.2 W.

Residual surfaces of this formation at first glance show an abundance of rusty, dull, worn looking chert. Well up in the formation residual masses of this chert are frequently found with dimensions of several feet. Such masses are less frequent in the lower portion of the formation, seldom exceeding 12 inches across. The larger fragments are included in a more abundant matrix of reddish residual clay and smaller fragments which usually are less than 2 inches across. Fresh surfaces of the chert vary from almost black to white; often these colors form well defined bands. The weathered chert commonly is highly stained brown or reddish brown by limonite which may form a coating over the entire surface, may completely permeate the rock so that broken surfaces show the stain throughout, or may form streaks through the rock. This chert has a brecciated appearance. As the chert masses decrease in size they become more porous and open, showing a much more pronounced rusty, rotten appearance.

Chert masses are rarely seen on fresh exposures. The chert is present as nodules and as small irregular segregations which weather into relief. These segregations do not penetrate the dolomite to any great extent.

In the basal portion of the formation, the horizon previously referred to as the transition from the Eminence into the Potosi, a typical type of chert is developed and, with experience, can be identified in the residuum as belonging to this horizon. It consists of red, rusty, open and porous masses having a mealy or rotten appearance. When broken open it is seen to consist of irregular connecting chert bands forming the walls of a network of openings. The fresh chert usually is gray, although occasionally it is finely banded, gray to cloudy white. In shape these masses greatly resemble the shape of many of the masses of Potosi druse and the origin of the two may be somewhat similar. The surfaces of the chert bands do not have quartz crystals formed on them as does the Potosi druse. Since the characteristics of Potosi druse are not developed in this material it has been assigned to the basal portion of the Eminence and included in that formation in mapping the area.

Dark gray or very dark reddish brown chert has been noted in Eminence residuum in masses up to 12 inches in diameter. Along the road to Courtois in the SW corner of section 6, T.35 N., R.1 W., at an altitude of 1240 feet, an abundance of this type of chert is present. Also very similar chert was seen near the top of the Eminence in the center of the NW $\frac{1}{4}$ section 9, T.36 N., R.1 W. Although a dark chert has been noted in the lower portion of the Gasconade which may be confused with this Eminence material, the Gasconade chert never has been seen in large masses.

In the SW corner of section 9, T.36 N., R.1 W., a ledge of gray chert is exposed very near the top of the Eminence formation. This is one of the few localities where chert is found so well developed. The shape of this chert somewhat resembles that of the basal chert except that the walls of the openings of the higher chert are much thicker and it is not so highly weathered or so rotten in appearance as the lower chert. The cavities are relatively clean and usually the iron stain is confined to the external surface of the rock.

Weathering-- The Eminence weathers to dull dark or bluish gray surfaces. On fresher surfaces, such as bluff faces, it frequently is more nearly grayish buff. Bluffs of Eminence show a rough blocky surface which is due to the tendency of this rock to break out into blocks with relatively smooth surfaces. Where not exposed in bluffs the Eminence tends to outcrop in low ledges and frequently in pinnacles. The ledges are rough and pitted and take on a dull gray color. The pinnacles are rough, pitted, and show the same coloration as the ledges. The Eminence pinnacles are much rougher and more pitted than those of the Potosi, although the lower beds of the Eminence weather with a smoother surface, more nearly like the beds of the Potosi.

Eminence residual soil has a definite red color but it is not as dark a red as that of the Potosi soil. Small chert fragments are profuse in this residuum.

Topographic expression-- In the southern part of the area the Eminence formation caps the ridges forming the divides. In general, Eminence slopes are more gentle than those underlain by the Potosi and, like those of the Potosi, they are rocky and unsuited to agriculture. In the vicinity of the Palmer fault, the Eminence forms the bluffs along the streams. These are very steep and as much as 100 feet high. Where not exposed in bluffs the formation tends to form low ledges.

Stratigraphic relations-- The Eminence immediately overlies the Potosi formation and is immediately overlain by the Gasconade formation. The relations with the underlying Potosi have been discussed in connection with the Potosi. The overlying Gasconade is considered to be unconformable with the Eminence. This unconformity has been recognized largely through the work of Dake[38],

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(38) Dake, C. L. op. cit. 228 pp.

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who showed that the Gasconade overlaps all lower formations down to, and including, the Bonneterre. Although Dake did not see the Gasconade on the pre-Cambrian, he cites evidence that this relationship exists. The contact between the Eminence and the Gasconade formations is used to mark the systemic break between the Cambrian and Ordovician systems. The Eminence, therefore, is the uppermost Cambrian formation in this area, while the Gasconade is the lowest Ordovician formation. The best evidence for the systemic break lies in the faunal record. The physical evidence in the mapped area is not pronounced.

Paleontology-- No effort has been made by the writer to collect fossils from the Eminence formation. It is locally very fossiliferous and where fossils were found they were used solely to verify other field criteria.

Correlation-- The Eminence is correlated by Bridge[39] with

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(39) Bridge, Josiah. op. cit. pp. 233-237.

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the Ellenburger of Texas (in part) and with the Madison, Jordan, and Lodi members of the Trempealeau formation of the Upper Mississippi Valley. According to the Kansas Geological Society Fifth Annual Field Conference correlation chart the Eminence is equivalent to the Signal Mountain formation of Oklahoma.

# ORDOVICIAN SYSTEM

## Gasconade formation

The term Gasconade is applied to those rocks lying immediately below the Roubidoux and over the Eminence. This is the oldest formation of the Ordovician system in Missouri. The term, Gasconade, is used in this report as Dake[40] used it in mapping the formation

(40) Dake, C. L. op. cit. 228 pp.

in the Potosi and Edgehill quadrangles. It includes both the Van Buren formation and the Gasconade formation as mapped and described by Bridge[41].

(41) Bridge, Josiah. op. cit. 228 pp.

It was deemed best to include the Gunter member and the Van Buren and Gasconade formations in one formation, the Gasconade, as was done from 1903 to 1930. The top of the Van Buren formation could not be accurately defined. The siliceous oolite bed used by Bridge[42] has not been noted in this area, and the criteria used

(42) Ibid. p. 99.

by Hendricks[43] could not be established consistently.

(43) Hendricks, Herbert. Geology of the Macks Creek quadrangle. Thesis, University of Iowa, Iowa City, Iowa.

History-- The term Gasconade was proposed first by Nason[44]

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

to include a great limestone series underlying the Roubidoux. This defined the top of the formation but the base was not delimited. As a result, the term subsequently was applied to various sections from the Roubidoux to the Davis formation. Ball and Smith[45] were

(45) Ball, S. H., and Smith, A. F. The geology of Miller County. Missouri Bureau of Geology and Mines. Reports, ser. 2, Vol. 1, 1903. p. 40.

the first to define the base of the formation. They write, "...The Gasconade limestone conformably overlies the Gunter sandstone...". This definition of the formation was later followed by Marbut, although he modified the designation to include the Gunter sandstone in the basal portion of the Gasconade. Buckley accepted Marbut's classification and the definition of the term held until 1930 when a new formation, the Van Buren, was described by Bridge[46]. He

(46) Bridge, Josiah. op. cit. pp. 98-108.

split off the lower portion of the Gasconade and included the Gunter as a basal member of his Van Buren formation. At that time extensive subsurface study by McQueen indicated that the Van Buren and the Gasconade might be separated over wide areas. After several more years of subsurface study, other members of the Missouri Geological Survey and Water Resources have found that the exact contact between the Van Buren and the Gasconade is indeterminable. It now seems more feasible to return to the earlier definition of the Gasconade and include the Gunter member and the Van Buren formation in it.

Areal distribution-- The Gasconade formation is not present south of the Palmer fault. In the area of the offset, west of the Berryman fault, the Gasconade forms the hills and valleys with the Eminence present as a thin belt in the lower valleys. The Gasconade is the cap formation in the area between Courtois and Hazel Creeks just north of the Palmer fault. It is exposed over approximately 6 square miles.

Thickness-- The exposed thickness of this formation is variable. There seems to be more of the formation present west of the Berryman fault than east of this fault in the Shirley Syncline[47]. In sections 19 and 20, T.37 N., R.1 W., the maximum

(47) Dake, C. L. op. cit. p. 178.

thickness between the Eminence and the Roubidoux is 150 feet. In sections 6, 7, 8, 17, and 18, T.36 N., R.1 W., considerably more Gasconade is present. Judging from the interval between the Eminence and the height at which undoubted Gasconade float material is found, with due allowance for dip, the Gasconade must not be less than 220 feet thick.

The extent of the area studied is too limited to give much positive evidence to explain this variation in thickness. At least three possible explanations merit consideration. They are: 1) thinning of the formation by solution, probably in some measure dependent upon the position in the Shirley Syncline, 2) thinning of the formation by overlap onto pre-Cambrian rock, and 3) possible non-deposition controlled by post-Eminence pre-Gasconade movement on the Berryman fault.

The first possibility is least likely as an interval of 50-55 feet is observed between a prominent cryptozoon ledge and the Roubidoux. Bridge[48] reports 70 feet for this interval in the

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(48) Bridge, Josiah. op. cit. p. 111.

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vicinity of Eminence, Missouri. Thus, a maximum of 20 feet can be accounted for as due to thinning by solution unless the solution takes place below the cryptozoon ledge. This is not considered likely.

The second possibility is believed to be the most probable. Nearly 3 miles to the north of this area a group of pre-Cambrian knobs are exposed with Gasconade in juxtaposition, the top of the Gasconade being at an altitude of approximately 1200 feet. Along the northern border of the mapped area the top of the Gasconade is at an altitude of 900 feet. This difference in altitude is attributed to the effect of initial dip. A variation in thickness of 70 feet occurs between localities nearly 2 miles apart, a thinning of 35 feet per mile. Where the initial dip is in excess of 100 feet to the mile, a contemporary thinning by overlap of 35 feet to the mile is quite possible.

The third possibility has been insufficiently investigated, owing to the limited extent of the area studied. Dake[49] developed evidence

(49) Dake, C. L. op. cit. pp. 121-122.

for post-Eminence pre-Gasconade faulting in this region, and post-Eminence pre-Gasconade movement is entirely possible along the Berryman fault.

Lithologic character— The Gasconade formation is a fine to coarsely crystalline, massive to thin-bedded, cherty dolomite. It varies from a bright gray, usually confined to the upper portion of the formation, to a dull gray in the lower portion.

Bedding is well defined and causes the formation to outcrop in steps and bedded ledges. This is in contrast to the Eminence which forms blocky bluffs and massive ledges. Parts of the Gasconade greatly resemble the Eminence formation but the two usually can be distinguished by the character of the bedding shown on the outcrop. Thin-bedded zones occur throughout the Gasconade but these zones are more persistent at the base of the formation and below a prominent cryptozoon ledge than above this ledge, where the formation is much more massive.

Chert--Chert of the Gasconade is diagnostic. It is sometimes possible to identify zones in the formation by the type of chert in the residuum.

Sporadically drusy chert masses from 4 to 15 inches across, gray-white to dark gray, often banded, are abundant in the residuum

Figure 19. Massive upper portion of the Gasconade. SE $\frac{1}{4}$ NE $\frac{1}{4}$, sec. 21, T.37 N., R. 1 W.

derived from the upper portion of the formation. Cryptozoon structure is frequent in this chert.

Chert blocks of comparatively large dimensions which exhibit good cryptozoon structure are derived from the cryptozoon ledge, a chert bed, about 50 to 55 feet below the top of the formation, containing an abundance of cryptozoons. This material sometimes can be traced laterally for considerable distances.

The portion of the Gasconade below the cryptozoon ledge gives rise to a residuum containing numerous small angular fragments of dense, white, oolitic, and porcelaneous chert. This chert is so abundant on outcrops that it gives a light color, almost a "snowy" appearance, to the slopes.

Figure 20. Close view of the cryptozoon ledge in the Gasconade. On the north side of Highway No. 8, SW $\frac{1}{4}$ NW $\frac{1}{4}$, sec. 22, T.37 N., R.1 W.

The basal portion of the formation contains a white, mealy, tripolitic chert. Quartz druse is present in the basal portion of the formation but it differs from that in the upper portion of the formation in that it may be found in the dolomite itself as well as coating chert.

A rusty, porous chert, similar to that so typical of the Eminence, is developed sparingly on Gasconade surfaces. This chert may be found in the basal portion of the formation and less frequently it may be found in the upper portion. Although it may be impossible to distinguish these types individually, the material with which each type is associated will serve to locate them in their proper places in the section.

Figure 21. Druse in the lower portion of the Gasconade. Along Highway No. 8 about 50 yards west of Lost Creek Inn, in NE $\frac{1}{4}$ NW $\frac{1}{4}$, sec. 20, T.37 N., R.1 W.

Several distinct differences have been noted between the druse of the Gasconade and the druse of the Potosi. Gasconade druse is commonly dark gray, sometimes having a violet tint. This druse does not have the banded character so well developed in the Potosi formation, and the quartz crystals are not as large as those of some Potosi druse. Instead of the quartz druse being common, as it is in the Potosi, the Gasconade druse forms a thin coating on chert and dolomite. The writer has been able to distinguish the druse of each formation without great difficulty.

Chert is present in the formation in thick beds, as much as 4 feet thick; in thin beds, 1 inch to 3 inches thick; in seams along bedding planes; and as nodules disseminated throughout the rock. Nodules may be confined to particular beds.

From studies of acid insoluble residues, the subsurface laboratory of the Missouri Geological Survey and Water Resources has identified a basal zone which they term the Gunter member. It is characterized by green shale partings and a small amount of sand. The insoluble residue of cuttings from wells in this area seldom exceeds ten percent of the total rock.

Weathering— Steep cherty slopes with protruding ledges or low bluffs are characteristic of surfaces underlain by the Gasconade. The rock commonly is rough and pitted, almost cavernous, and upon weathering becomes dark gray except on fresh surfaces where it is grayish buff. The surface coloration of the rock seems to be a function of the time the surface has been exposed.

The cryptozoon ledge protrudes as a ledge or is broken into blocks of cryptozoonic chert that are readily identified.

Topographic expression-- Gasconade areas are highly dissected and characterized by steep rocky slopes. Like the Potosi and the Eminence, the Gasconade surfaces are not suited to cultivation because of their rocky character. Narrow, steep-sided valleys with abrupt heads are characteristic of the formation in this area.

Stratigraphic relations-- The Gasconade is unconformable on the Eminence and is overlain unconformably by the Roubidoux. The latter is the most apparent physical break in the entire Berryman section. A conglomerate consisting of chert pebbles in a sandstone matrix has been found near the upper contact in several places. The pebbles are sub-angular to rounded indicating that they probably were subjected to transportation before being incorporated in the basal Roubidoux. Above the contact, as observed in this area, is a well sorted, clean white sandstone which rests upon massive dolomite. This contact was used by Ulrich to mark the boundary between his Ozarkian and Canadian systems.

Paleontology-- The fossils taken from this formation have been used to verify other field criteria. No attempt was made to add to the faunal record of this formation, but typical genera are Ophileta, Sinuopea, Rhachopea, Euomphalopsis, and Cameroceras.

Correlation-- The Gasconade is correlated by Ulrich and Cooper(50) with the Oneota formation of the Upper Mississippi Valley

(50) Ulrich, E. O., and Cooper, G. A. Ozarkian and Canadian Brachiopoda. Geological Society of America Special Paper 13. August 22, 1938. pl. 58.

and with the Chepultepec of Alabama. Bridge(51) concurs in this

(51) Bridge, Josiah, op. cit. pp. 233-237.

correlation.

Roubidoux formation

The Roubidoux is the youngest consolidated formation exposed in the Berryman area. The term is applied to a group of rocks, principally sandstone, which overlies the Gasconade dolomite.

History-- The term Roubidoux was proposed first by Nason[52]

(52) Nason, F. L. op. cit. p. 114.

to apply "...to the rock...overspreading the Ozark region from Cabool to Gasconade City and from Salem to Doniphan.". It was defined as equivalent to the Second Sandstone of earlier geologists. The term subsequently was confused by Winslow who applied it to beds above the Jefferson City equivalent to the St. Peter[53], and

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

was ignored completely by Van Horn[54] and by Ball and Smith[55], who

(54) Van Horn, F. B. Geology of Moniteau County. Missouri Bureau of Geology and Mines. Reports, ser. 2, Vol. 3, p. 21. 1905.

(55) Ball, S. H., and Smith, A. F. op. cit. 207 pp.

used the term St. Elizabeth. Bain and Ulrich[56], in 1905, used the

(56) Bain, H. F., and Ulrich, E. O. op. cit. p. 12 and p. 18.

term as Nason defined it, and Marbut[57] followed in this definition

(57) Marbut, C. F. The geology of Morgan County. Missouri Bureau of Geology and Mines. Reports, ser. 2, Vol. 7, 1907. p. 33.

thus establishing the term.

Areal distribution-- The Roubidoux is present in isolated patches west of the Berryman fault. North of the Palmer fault it forms the cap rock of the upland area and dips below valley level along the northeast border of the mapped area. It is exposed over approximately 6 square miles.

Thickness-- The thickness cannot be determined in this area as the top of the formation has been eroded. Topographic relief developed entirely within the Roubidoux is sufficient to indicate that the thickness probably is not less than 175 feet. The thickness of this formation has been reported to increase toward the south. In the Rolla quadrangle, Lee[58] reported a thickness of

(58) Lee, Wallace. The geology of the Rolla quadrangle. Missouri Bureau of Geology and Mines. Reports, ser. 2, Vol. 12, 1913. p. 21.

115 to 150 feet.

Lithologic character-- The Roubidoux in this area is a white, fine- to coarse-grained, clean sandstone. On exposures, the sand grains always show evidence of secondary enlargement, exhibiting well defined crystal faces surrounding, or partially surrounding, rounded sand grains.

Cross-bedding, a conspicuous feature, is exposed excellently on the south side of Little Lost Creek, in the NE $\frac{1}{4}$ section 26, T.37 N., R.1 W., in a bluff of massive sandstone nearly 30 feet high.

Ripple marks in the formation have been reported many times and numerous specimens have been collected from areas over the

State, but they were not seen in situ in the area mapped for this thesis.

The extent of the dolomite in this formation has not been accurately determined in this area. Roubidoux dolomite has been seen in only one locality. All other exposures identified as Roubidoux are entirely sandstone; some exposures are 30 to 40 feet thick. If an appreciable quantity of dolomite is present in the Roubidoux in this area, it is covered by residuum. Because continuous exposures through the formation are not available, it cannot be said that dolomite beds are absent from the formation, but the exposed portions of the formation lead the writer to believe that dolomite beds are not so prevalent in the Roubidoux in this area as has been reported in other parts of the State, particularly

Figure 22. Massive Roubidoux being quarried for local use as building stone. SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 20, T.37 N., R.1 W.

those north of the Berryman area.

White, gray, yellow or cream, and nearly black chert is common in the Roubidoux residuum. The chert may be dense, brittle, or porous. Chert containing abundant cryptozoon structure is common.

The sandy texture of the Roubidoux soil is conducive to the growth of the pine and much of the timber cut in the area comes from surfaces underlain by the Roubidoux.

Weathering-- Weathered surfaces of the Roubidoux are almost always case-hardened. These surfaces are often quartzitic and both the case-hardened and quartzitic character is most pronounced on float blocks of the sandstone. The surfaces are reddish brown due to an iron oxide stain. This stain is the result of oxidation of iron-bearing interstitial water which is fed to the surface by capillary action.

Topographic expression-- North of the Palmer fault, the Roubidoux forms the cap rock on the ridges and probably is responsible for the steep slopes of the valley heads in the underlying Gasconade. Roubidoux sandstone forms a rim around the abrupt and steep-sided valley heads in the Gasconade, and gives them an open U or semi-circular plan. Valleys in the Roubidoux are steep-sided with the slopes broken intermittently by massive ledges of sandstone.

Stratigraphic relations-- The relation of the Roubidoux to the underlying Gasconade can be observed best along Lost Creek from the east edge of the map to section 20, T.37 N., R.1 W. In the

SE $\frac{1}{4}$ NE $\frac{1}{4}$ section 20, T.37 N., R.1 W., in Machell Hollow, the Gasconade-Roubidoux contact is gradational. A sandstone passes into a thin-bedded sandy dolomite interbedded with thin sand beds. This succession passes into a non-sandy, massive dolomite. The actual contact most often is covered. The sandstone commonly outcrops in ledges 5 to 6 feet above the massive Gasconade dolomite with a covered interval occurring between the exposures. A chert pebble conglomerate occurs near the contact. The pebbles show evidence of wear, indicating a period of erosion between the Gasconade and Roubidoux deposition. The chert pebbles in the conglomerate often are altered to tripoli.

Figure 23. Typical field relationship of Roubidoux and Gasconade outcrops. SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 21, T.37 N., R.1 W.

Paleontology-- Fossils were not collected from the Roubidoux. Bridge[59] reported a diagnostic fauna characterized by *Lecanospira*.

(59) Bridge, Josiah. op. cit. p. 124.

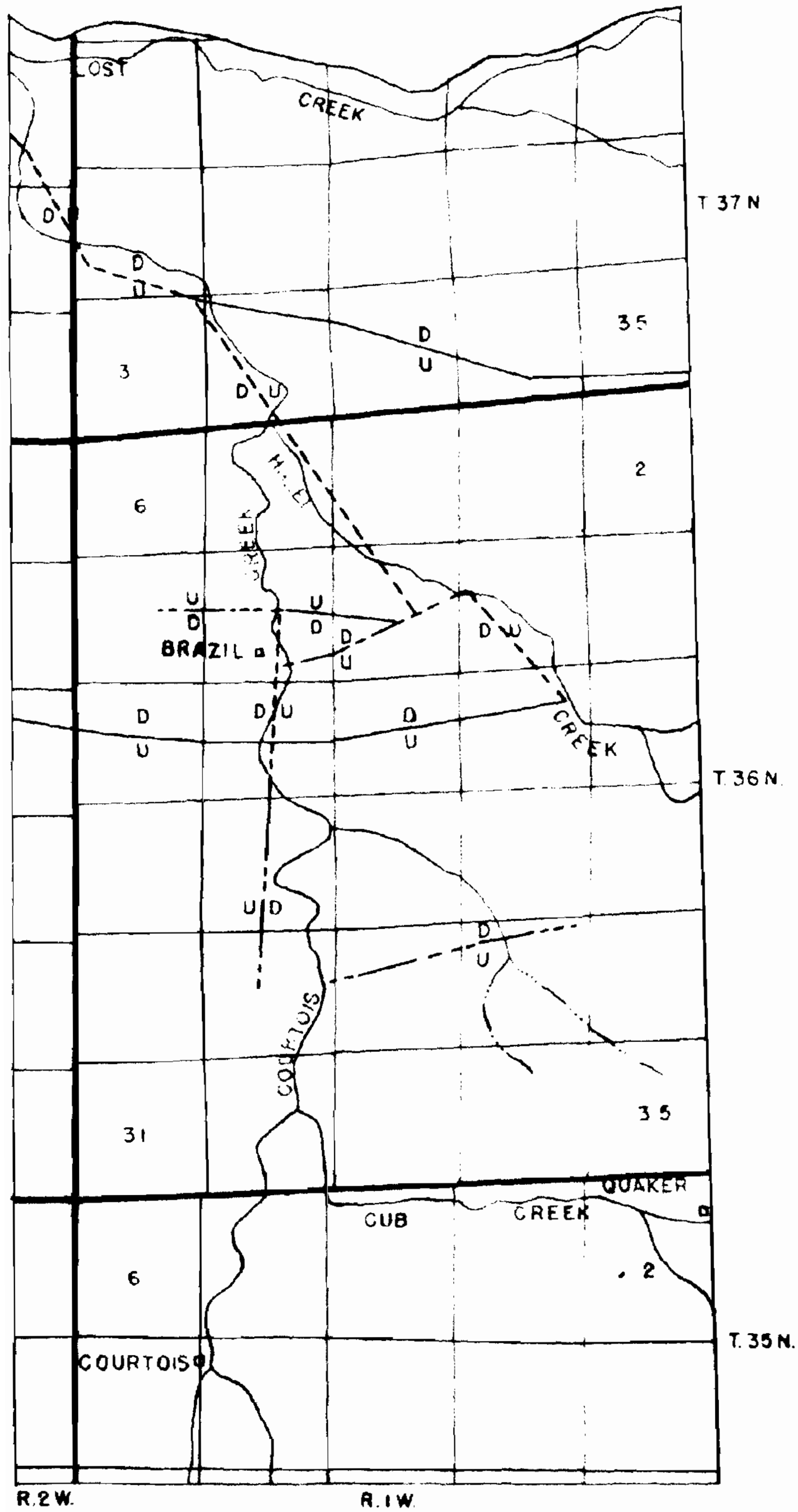
Correlation-- The Roubidoux is correlated with the New Richmond formation of Iowa[60] and is designated as Middle Canadian

(60) Correlation chart. op. cit.

in Oklahoma by Ulrich and Cooper[61].

(61) Ulrich, E. O., and Cooper, G. A. op. cit. pl. 58.

FAULT SYSTEM IN THE BERRYMAN AREA




Scale $\frac{1}{93284}$

# STRUCTURE

The Berryman area is northwest of the St. Francois mountain region and is situated on the northwest flank of the Ozark Uplift. As in most of the other parts of the State the strata are nearly horizontal. In the southeastern part of the area a local anticlinal structure has brought the Derby-Doerun to the surface in the valleys of Courtois and Cub Creeks, although the dip is less than 1 degree. The anticlinal structure gives rise to the extensive outcrop of Potosi dolomite in the southern part of the area.

Two major faults, the Palmer and the Berryman, constitute the main structural features. The Palmer fault appears in two parts, a northern portion which enters the quadrangle at the eastern edge near the south line of section 35, T.37 N., R.1 W., and follows an irregular course in a westerly direction through sections 34, 33, 32, 31, and 30, T.37 N., R.1 W., and a southern portion which enters the area from the west near the center of section 13, T.36 N., R.2 W., and strikes nearly east through sections 18, 17, 16, and 15, T.36 N., R.1 W. The northern portion of the Palmer fault is a continuation of the fault traced by Dake(62) in the

(62) Dake, C. L. op. cit. p. 181.

adjacent Potosi quadrangle and was named by him from the town of Palmer in that quadrangle. The name also was applied to the southern portion. The term is continued in this report as the northern and southern portions are correlative on the basis of strength and magnitude; the vertical displacement is approximately 300 feet, which is nearly 100 feet greater than the vertical displacement along the other faults. Each portion can be traced for several miles in either direction from this area and the strike of each portion is nearly the same, with minor variations. This further suggests their correlation.

The Berryman fault is named from the town of Berryman, Missouri, the fault being exposed west of this community. It is present in the Berryman area in the Courtois and Hazel Creeks valleys, but it is not exposed. Its existence is proved by the difference in altitude, which cannot be accounted for by dip, of stratigraphic markers on either side of the Courtois and Hazel Creeks valleys. A minor fault can be traced into Hazel Creek valley from the vicinity of Brazil, in section 8, T.36 N., R.1 W., but it does not extend across the valley. This indicates that the fault terminates at the Berryman fault in the stream valley. The Berryman fault was traced beyond the northwest corner of the mapped portion of the quadrangle and is exposed best along Highway No. 8 west of Courtois Creek in the SW $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$ section 14, T.37 N., R.2 W. At this locality the Eminence is in juxtaposition to the Roubidoux with a small patch of steeply dipping Gasconade exposed in the fault zone. Although detail mapping has not been carried northward more than 3 miles beyond the Berryman area, the evidence suggests that the Berryman fault may prove to be a continuation of the Leasburg fault which has been mapped in T.38 N., R.3 W. To the south, in section 14, T.36 N., R.1 W., the Berryman fault apparently passes into a monoclinal fold as direct evidence for its persistence could not be found southeast of this locality, although there is a difference of 40 feet in the altitude of a stratigraphic marker across the Hazel Creek valley.

Other faults occur and seem to be associated with the movement along the Palmer and Berryman faults. These minor faults are unnamed and their control of structure is local.

The faults in this area are high angle faults and exist as a zone of faulting rather than as a single plane. The exposures of the faults are most often recognized as a zone of disturbance, as much as 100 yards wide, with different formations on either side of the disturbed zone.

The fault pattern (Plate 2) consists of two intersecting faults, each showing offset. The northern portion of the Palmer fault is offset from the southern portion by the Berryman fault. Two conditions normally causing offset do not seem capable of explaining the offset of the Palmer fault. If an existing fault is later faulted by a second fault the trace of the first fault on the upthrown side will migrate along the dip of the fault plane as erosion brings the downthrown and upthrown sides to the same level, thus, producing offset. A casual observation clearly shows that the offset of the Palmer fault cannot be due to the migration down dip along the fault plane because the trace of the fault is not appreciably changed in crossing a valley of nearly 300 feet relief, indicating that the fault plane is nearly vertical. To explain the offset by the migration down dip along the fault plane would demand that the fault plane of the northern portion be dipping less than 1 degree from the horizontal, a condition which does not exist. Horizontal movement may result in offset, but horizontal movement which necessitates compressive forces has not been recognized as extensive in the Ozark region. More study than this limited area is needed to determine the role of compression in these fault movements.

Another hypothesis seems necessary to explain the offset of the Palmer fault. The evidence upon which this hypothesis is based is reviewed in the following paragraphs.

Deep well drilling in the vicinity of Palmer, in section 14, T.36 N., R.1 W., defines a buried pre-Cambrian ridge running essentially north through sections 6, 7, 8, and 17, T.36 N., R.1 E. The State Magnetic Map(63) depicts this pre-Cambrian ridge by high positive anomalies and indicates that a pre-Cambrian spur turns westward entering the Berryman area in the vicinity of Quaker, in section 2, T.35 N., R.1 W., and continues almost to Courtois, in section 7, T.35 N., R.1 W. The Derby-Doerun inliers along Courtois and Cub Creeks seem to be due to a structure determined by this pre-Cambrian spur. The Palmer fault lies within the area embraced by the west trending south spur and the north trending ridge of the buried pre-Cambrian mass. It is

(63) Magnetic Map of Missouri. 1943.

notable that the Palmer fault is offset along the nose of the buried ridge.

The northern portion of the Palmer fault terminates at the Berryman fault in the SW $\frac{1}{4}$ section 30, T.37 N., R.1 W. Vertical displacement on the Palmer fault just east of the Berryman fault is approximately 300 feet. This strongly suggests that the Berryman fault was pre-existent to the Palmer fault as the Palmer fault would not be expected to die out so abruptly with such a large vertical displacement. If the northern portion of the Palmer fault did die out, it would be expected to pass into a fold. The absence of a fold as an extension of the fault substantiates the idea that the Berryman fault existed at the time of movement along the Palmer fault.

The buried pre-Cambrian ridge and the Berryman fault probably have been largely responsible for the offset on the Palmer fault. By being pre-existent, the Berryman fault furnished a plane of weakness along which the forces responsible for the Palmer fault were resolved where buttressed by the buried pre-Cambrian ridge to the east. To the north, where the pre-Cambrian ridge terminates, the buttressing effect diminished and allowed the Palmer fault to continue eastward passing along the nose of the buried ridge.

A large region lying south and east of the Berryman quadrangle, including the rock in the southern half of the Berryman area, was differentially moved up at least once, probably repeatedly. This is the movement to which the faulting may be attributed. From the Derby-Doerun inliers along Courtois and Cub Creeks, in T. 35 N., R.1 W., there is a gentle dip northward to the south portion of the Palmer fault. The Derby-Doerun inliers are present at an altitude equal to that of the Potosi-Eminence contact at the Palmer fault. As the Potosi formation is nearly 300 feet thick, this places the Derby-Doerun about 300 feet higher in T.35 N., R.1 W., than it is likely to be at the Palmer fault.

It is probable that these structures extend into the underlying pre-Cambrian basement. A maximum vertical displacement of more than 300 feet along the Palmer fault in this area and of more than 400 feet in section 14, T.36 N., R.2 W., to the west can scarcely be accounted for as occurring entirely within a sedimentary series with an aggregate thickness of only about 1250 feet. The maximum vertical displacement along the Palmer fault is almost one-third of the total thickness of the sediments present. Movement may have occurred along pre-existing planes of movement in the pre-Cambrian basement, but evidence for this was not observed.

The part of the northern portion of the Palmer fault which strikes south of east from SW $\frac{1}{4}$ SW $\frac{1}{4}$ section 30, T.37 N., R.1 W., furnishes the key to the relationship between the Palmer and Berryman faults. The vertical displacement along the northern portion of the Palmer fault is approximately 300 feet and the upthrown side is toward the south. The vertical displacement along the Berryman fault is about 200 feet and the upthrown side is to the east. The vertical displacement along that part designated above is about 100 feet with the south side the upthrown side. This displacement is the result of movement along the Berryman fault which made the north side upthrown with about 200 feet of vertical displacement, and later movement along the Palmer fault which dropped the north side nearly 300 feet. Therefore, this part of the north portion of the Palmer fault was subjected to the movement along both the Berryman fault and the Palmer fault, and the present vertical displacement is the result of partial compensation of the Palmer fault movement to the extent of the previous vertical displacement along the Berryman fault.

The age of the faulting cannot be determined more accurately than to date it as post Roubidoux. The same is true for the relative age of the two major faults. The age of both can probably be referred to the same orogeny, although movement along the Berryman fault probably occurred prior to the movement along the Palmer fault. Thus, the age difference of the two faults is the age difference of two stages of the same orogeny.

A large anticlinal structure lies immediately south of the Berryman area causing the Davis formation to rise to the surface along Courtois Creek. In going from north to south, the formations exposed grow progressively older, Potosi, Derby-Doerun, Davis; they then grow progressively younger, Davis, Derby-Doerun, Potosi, so that the Potosi formation is again the oldest rock exposed before reaching Goodwater, 3 miles to the south of the Berryman area.

The conditions which brought about the structure in the Berryman area may be summarized. Differential movement caused the rock to the south and east to be uplifted. Stresses exceeded the elastic limit of the rock and ruptures occurred; they are expressed in the fault pattern. The Berryman fault is considered to have formed first with the Palmer fault movement later. The Palmer fault was offset to the north due to a line of weakness afforded by the Berryman fault and a buttressing effect of the buried pre-Cambrian ridge. The associated faults are probably a result of the same movement. This movement cannot be dated more accurately than as being post Roubidoux and may well have recurred at various times throughout geologic time.

The block lying east of the Berryman fault and north of the Palmer fault has been subjected to a series of disturbances. Its original attitude was the result of conditions of initial deposition with an intitial dip in excess of 100 feet per mile from the pre-Cambrian knob now exposed 3 miles north of this area in section 2, T.37 N., R.1 W. Movement along the Berryman fault raised the western portion of this block bringing the Eminence formation to the present surface. At a later time movement along the Palmer fault dropped the southern part of the block nearly twice the vertical distance it had been raised by the Berryman movement. Thus, the present attitude of this block is the result of initial dip toward the southwest, the Berryman fault movement raising the western edge, and the Palmer movement dropping the southern portion.

The stylolites in the Derby-Doerun inliers (see p. 23) are unique to this portion of Missouri. It is interesting to note that they are associated with a structural condition which may not be often repeated. Their presence here, and their absence in surrounding localities, may be connected to an increase in pressure during times of differential uplift by forces transmitted through the underlying pre-Cambrian ridge, the pressure increase acting to increase the activity of solution.

A structure map has not been attempted as there are only two datum planes definite enough to permit their use. One is the Derby-Doerun-Potosi contact which is so limited in extent as to be of little value in making a structure map. The other is the Eminence-Gasconade contact, which is confined to that block lying north of the Palmer fault and east of the Berryman fault, and also is too limited in extent for structural control. This area is so small that a structure map would be of little consequence. The Potosi-Eminence contact is not satisfactory as a structural datum. It often cannot be determined within less than 50 feet, the contact being drawn largely on druse development which may not be consistent in stratigraphic position. The Gasconade-Roubidoux contact should be used with caution because the Gasconade is subject to extensive solution, the Roubidoux is frequently found in solution sinks, the sandstone is resistant and the Roubidoux tends to float and creep down slopes masking the contact with the underlying Gasconade in many places.

# GEOLOGIC HISTORY

The geologic history of this small area must be considered in conjunction with what is known about the larger Ozark area of which it is a part. The earliest period of geologic history recorded by rocks exposed at the surface is the Upper Cambrian. The Derby-Doerun formation was deposited in a sea which was clearing from the influx of mud which was brought in during the preceding Davis time, and slightly argillaceous limestones were deposited. Evidence outside of the mapped area indicates that the region probably emerged and was eroded before the invasion of the Potosi seas, but there is no evidence to indicate that this took place in the Berryman area. If there was emergence and erosion in this area at the close of Derby-Doerun time, the submergence giving rise to Potosi deposition must have rapidly reached conditions causing the deposition of limestone, as cuttings from wells penetrating the Potosi show a notable deficiency of sand or shale. The conditions of deposition during Potosi time remained stable through Eminence time and a great thickness of limestone was deposited. Eminence deposition was brought to a close by emergence with erosion which marked the close of the Cambrian period.

The succeeding Ordovician period began with the invasion of the area by the Gasconade seas. Limestones again were deposited. The abundance of a supposed lime secreting algae, Cryptozoon, indicates the Gasconade seas were conducive, at times, to the growth of marine life. This may indicate a warm and probably shallow sea which received considerable sunlight. The Cryptozoon ledge must have formed during a period when these conditions prevailed. A period of emergence and erosion must have followed Gasconade deposition and it is expressed by the conglomerate found at the base of the Roubidoux. If the Gasconade at the time of this erosion possessed the capacity to produce chert on weathered surfaces that it exhibits today, the erosion period between the Gasconade and the Roubidoux must have been of short duration as the amount of chert represented by the conglomerate is small. Roubidoux seas were subject to intermittent influxes of sand, probably from some distant source. Another interpretation of the alternate beds of dolomite and sand found in the Roubidoux formation could be that a repeated shallowing of the seas during Roubidoux time gave rise to conditions favoring the deposition of sand.

No record of geologic time later than the Roubidoux is exposed in the Berryman area. Considerable movement must have taken place at some time following the Roubidoux, and, as a result, the southern part of the area was differentially moved up with the formation of the various faults.

Peneplanation is evident in surrounding areas with perhaps two separate peneplanes, both following Pennsylvanian time, followed by rejuvenation causing the streams to entrench themselves. It is probable that this series of events also applies to the Berryman area, but the record of their existence has been obliterated through erosion.

# ECONOMIC GEOLOGY

The Berryman area contains small deposits of lead, barite, gravel, sandstone, and large quantities of dolomite. None of these is extensively developed and there is very little production at the present time.

The lead mineral galena (PbS) was produced from a few shallow workings. Actual production figures are unavailable, but the amount removed must have been very small judging from the size of the prospects. The alignment of the old prospect holes and the plan of the abandoned underground workings indicate that the galena was associated with joints and fissures in the rock. The Fredericktown Lead Company of Fredericktown, Missouri, was engaged in exploratory work among some of the old prospects while the field work for this thesis was being carried on, but the company abandoned its prospecting before the field work was completed in September, 1947. This company encountered only a small quantity of lead ore. Groups of abandoned prospects are located in the SE $\frac{1}{4}$ SE $\frac{1}{4}$ section 28, T.36 N., R.1 W., in the north half of the NE $\frac{1}{4}$ section 5, T.36 N., R.1 W., in the SW $\frac{1}{4}$ section 31, T.37 N., R.1 W., and isolated prospect holes may be found throughout the area. The prospects are preserved today as partially filled pits and shafts surrounded by the excavated material. A few shallow shafts still are open except for the debris that has collected in their bottoms.

Barite or tiff is confined to sections 14 and 15, T.36 N., R.1 W., which constitutes part of the Palmer barite district[64].

(64) Dake, C. L. op. cit. p. 198.

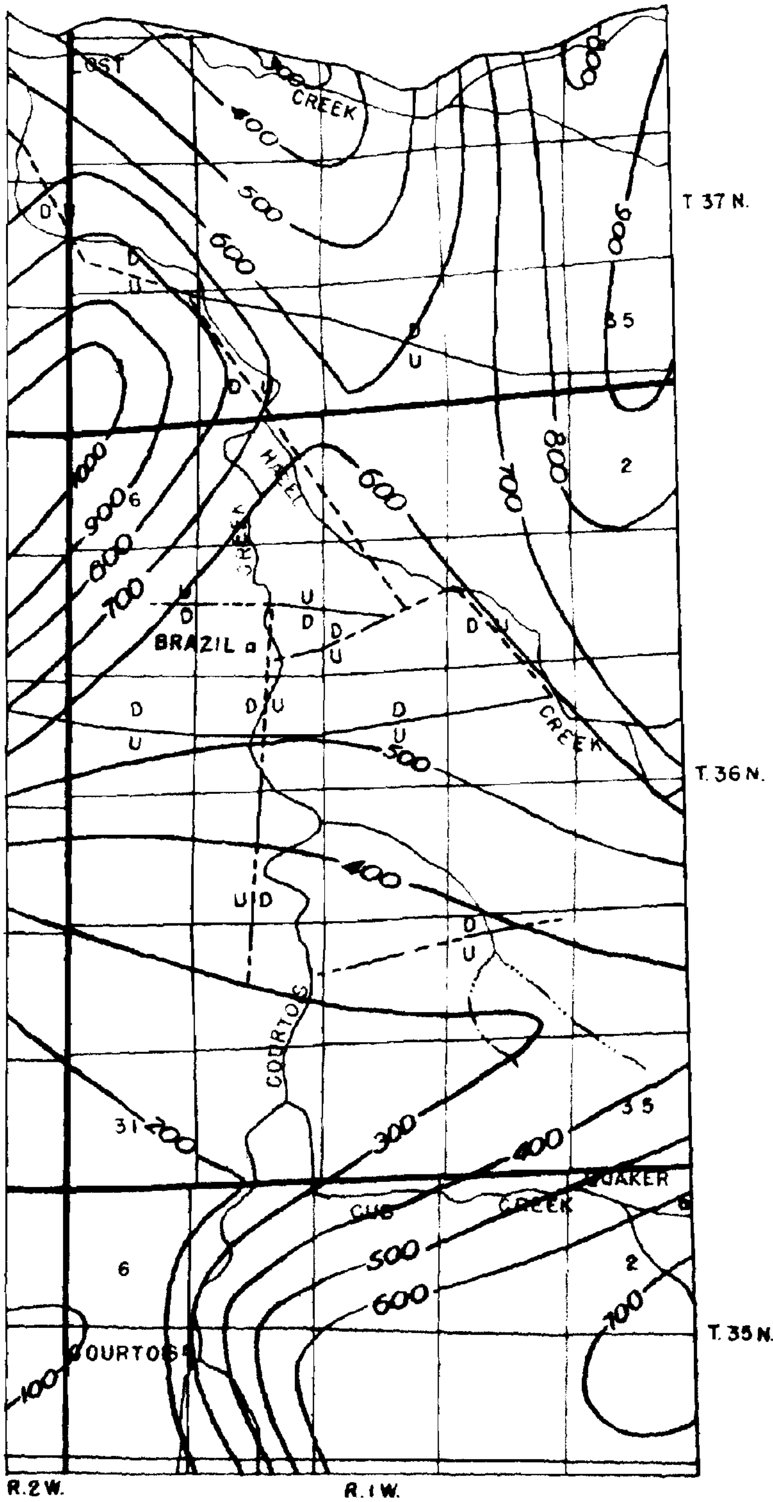
It occurs near the Potosi-Eminence contact in the residual clay formed by the weathering of these formations. The barite occurs in sizes varying from large masses weighing 35 to 50 pounds to small fragments. The deposits are shallow and the diggings in this area are seldom more than 10 feet deep. The distribution of the diggings is erratic, indicating that the barite occurs in pockets or streaks. The work in this area is intermittent and production figures are not available.

Gravel deposits, consisting of chert and druse fragments, border the streams. It has been used for building and for road construction and maintenance. The deposits are not large and are only of local significance because of more favorable locations of other extensive deposits elsewhere.

Sandstone is used as a building stone by the local people of this area. A small quarry near the base of the Roubidoux formation is located in the SE $\frac{1}{4}$ SE $\frac{1}{4}$ section 20, T.37 N., R.1 W., along the road to Palmer.

The bulk of the surface rock exposed in the Berryman area is dolomite which is not used commercially at the present time. This dolomite probably will be high in silica which may preclude its use for industrial purposes. If in the future a need is developed for a dolomite of this type, there is an abundance of it in the Berryman area.

FAULT SYSTEM IN THE BERRYMAN AREA
with lines of equal magnetic anomaly
in the vertical field superimposed




Scale $\frac{1}{93284}$

Contour interval 100 gammas

From Magnetic Map of Missouri. 1943.

# MAGNETIC ANOMALIES

The relationship of lines of equal anomaly in the vertical magnetic field of the earth to the structure of the Berryman area is shown on Plate 3. The buried pre-Cambrian spur is reflected by high intensities in T. 35 N., R.1 W., where values rise eastward from 100 gammas in section 1 and 2, T.35 N., R.2 W., to 700 gammas in sections 2 and 11, T.35 N., R.1 W. A gradient of increasing magnetic anomaly occurs northward to the vicinity of Brazil, in section 8, T.37 N., R.1 W. A positive anomaly of more than 1000 gammas lies in section 30, 31, and 32, T.37 N., R.1 W., in sections 5, 6, and 7, T.36 N., R.1 W., in sections 25 and 36, T.37 N., R.2 W., and in sections 1 and 12, T.36 N., R.2 W. These are north of the south portion of the Palmer fault and west of the Berryman fault. The contour lines representing this anomaly are flattened where they approach the Berryman fault. A corresponding negative anomaly appears in sections 19, 20, 21, 28, 29, and 30, T.37 N., R.1 W. The increase in gamma value in the northeast portion of the area does not seem to be a reflection of known structure.

# CONCLUSIONS AND SUMMARY

By virtue of this study several interesting and important facts have been added to the general knowledge of the geology of the Berryman area, Washington County, Missouri.

1. An areal geologic map of the Berryman area has been prepared.
2. The intersecting Palmer and Berryman faults have been mapped.
3. The cause of the large scale offset of the Palmer fault has been determined.
4. The relationship of the Palmer and Berryman faults has been investigated.
5. The structure of the area has been described.
6. The stratigraphic relations of the formations exposed in the Berryman area have been determined.

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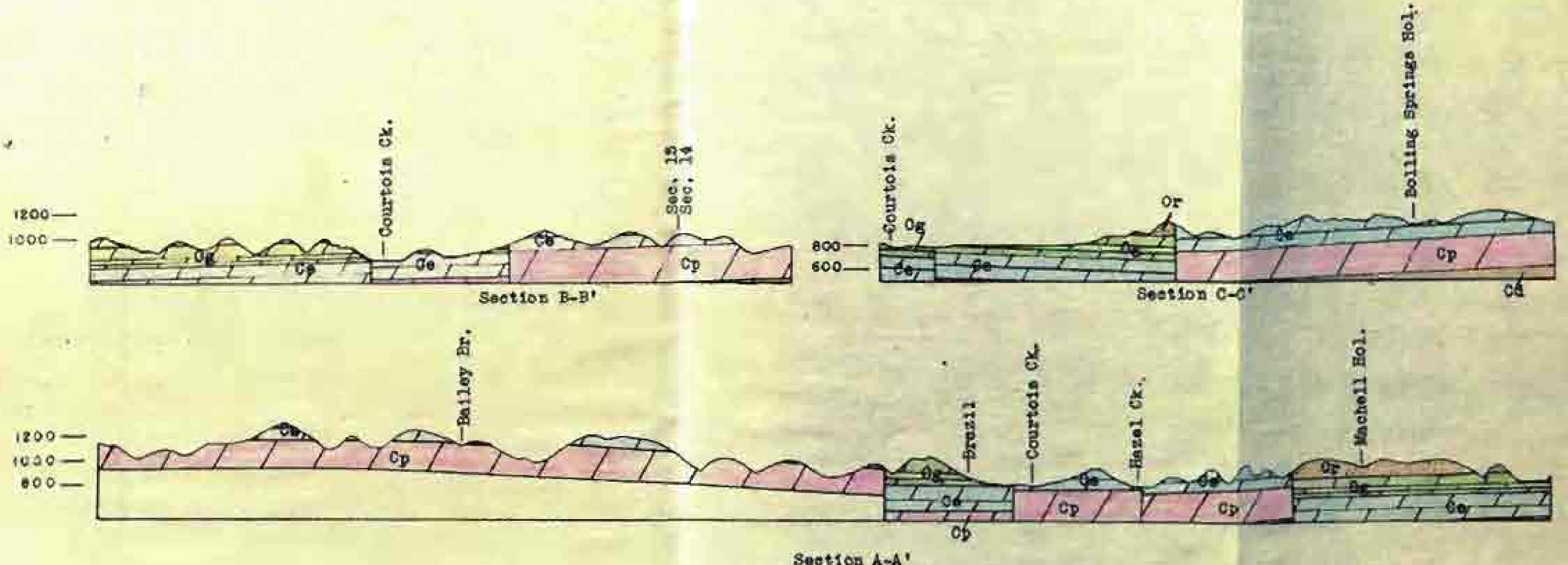
# VITA

Jack A. James was born at Yale, Oklahoma on the 24th day of January, 1919. He entered Drury College, Springfield, Missouri, in the fall of 1936 and was graduated from that institution in the spring of 1940 with the degree, Bachelor of Arts, Geology Major.

He was engaged as a chemist for the Atlas Powder Company of Wilmington, Delaware, for nearly four years. From March, 1944 until December, 1946 he was a member of the Armed Forces, serving with the Army of the United States. Upon separation from the Army he joined the Officers Reserve Corps with the rank of 1st Lieutenant.

He entered the School of Mines and Metallurgy, University of Missouri, Rolla, Missouri, in February, 1947 and became a candidate for the Degree of Master of Science, Geology Major.

During his enrollment in the School of Mines and Metallurgy, he was employed on a part time basis by the Missouri Geological Survey and Water Resources.




STRUCTURE SECTIONS

Horizontal Scale $\frac{1}{62500}$

To accompany Areal Geology Map


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
STATE OF MISSOURI
GEOLOGICAL SURVEY AND WATER RESOURCES
EDWARD L. CLARK, STATE GEOLOGIST
MISSOURI
BERRYMAN QUADRANGLE
15-MINUTE SERIES
J O H N S O N
C O U R T O I S
W A L T O N
O S A G E
Berryman
AREAL GEOLOGY
Plate 5
EXPLANATION
SEDIMENTARY ROCKS
Recent
QUATERNARY
Qa
Alluvium (stream deposits)
ORDOVICIAN
Or
Roubidoux sandstone
Og
Gasconade dolomite
CAMBRIAN
Ce
Eminence dolomite
Cp
Potosi dolomite
Cd
Derby-Doerun dolomite
Fault

The United States Geological Survey is making a series of standard topographic maps to cover the United States. This work has been in progress since 1882, and the published maps cover more than 47 percent of the country, exclusive of outlying possessions.

The maps are published on sheets that measure about $16\frac{1}{2}$ by 20 inches. Under the general plan adopted the country is divided into quadrangles bounded by parallels of latitude and meridians of longitude. These quadrangles are mapped on different scales, the scale selected for each map being that which is best adapted to general use in the development of the country, and consequently, though the standard maps are of nearly uniform size, the areas that they represent are of different sizes. On the lower margin of each map are printed graphic scales showing distances in feet, meters, miles, and kilometers. In addition, the scale of the map is shown by a fraction expressing a fixed ratio between linear measurements on the map and corresponding distances on the ground. For example, the scale $\frac{1}{62,500}$ means that 1 unit on the map (such as 1 inch, 1 foot, or 1 meter) represents 62,500 of the same units on the earth's surface.

Although some areas are surveyed and some maps are compiled and published on special scales for special purposes, the standard topographic surveys and the resulting maps have for many years been of three types, differentiated as follows:

1. Surveys of areas in which there are problems of great public importance—relating, for example, to mineral development, irrigation, or reclamation of swamp areas—are made with sufficient detail to be used in the publication of maps on a scale of $\frac{1}{31,680}$ (1 inch = one-half mile) or $\frac{1}{24,000}$ (1 inch = 2,000 feet), with a contour interval of 1 to 100 feet, according to the relief of the particular area mapped.

2. Surveys of areas in which there are problems of average public importance, such as most of the basin of the Mississippi and its tributaries, are made with sufficient detail to be used in the publication of maps on a scale of $\frac{1}{62,500}$ (1 inch = nearly 1 mile), with a contour interval of 10 to 100 feet.

3. Surveys of areas in which the problems are of minor public importance, such as much of the mountain or desert region of Arizona or New Mexico, and the high mountain area of the northwest, are made with sufficient detail to be used in the publication of maps on a scale of $\frac{1}{125,000}$ (1 inch = nearly 2 miles) or $\frac{1}{250,000}$ (1 inch = nearly 4 miles), with a contour interval of 20 to 250 feet.

The aerial camera is now being used in mapping. From the information recorded on the photographs, planimetric maps, which show only drainage and culture, have been made for some areas in the United States. By the use of stereoscopic plotting apparatus, aerial photographs are utilized also in the making of the regular topographic maps, which show relief as well as drainage and culture.

A topographic survey of Alaska has been in progress since 1898, and nearly 44 percent of its area has now been mapped. About 15 percent of the Territory has been covered by maps on a scale of $\frac{1}{500,000}$ (1 inch = nearly 8 miles). For most of the remainder of the area surveyed the maps published are on a scale of $\frac{1}{250,000}$ (1 inch = nearly 4 miles). For some areas of particular economic importance, covering about 4,300 square miles, the maps published are on a scale of $\frac{1}{62,500}$ (1 inch = nearly 1 mile) or larger. In addition to the area covered by topographic maps, about 11,300 square miles of southeastern Alaska has been covered by planimetric maps on scales of $\frac{1}{250,000}$ and $\frac{1}{62,500}$.

The Hawaiian Islands have been surveyed, and the resulting maps are published on a scale of $\frac{1}{62,500}$.

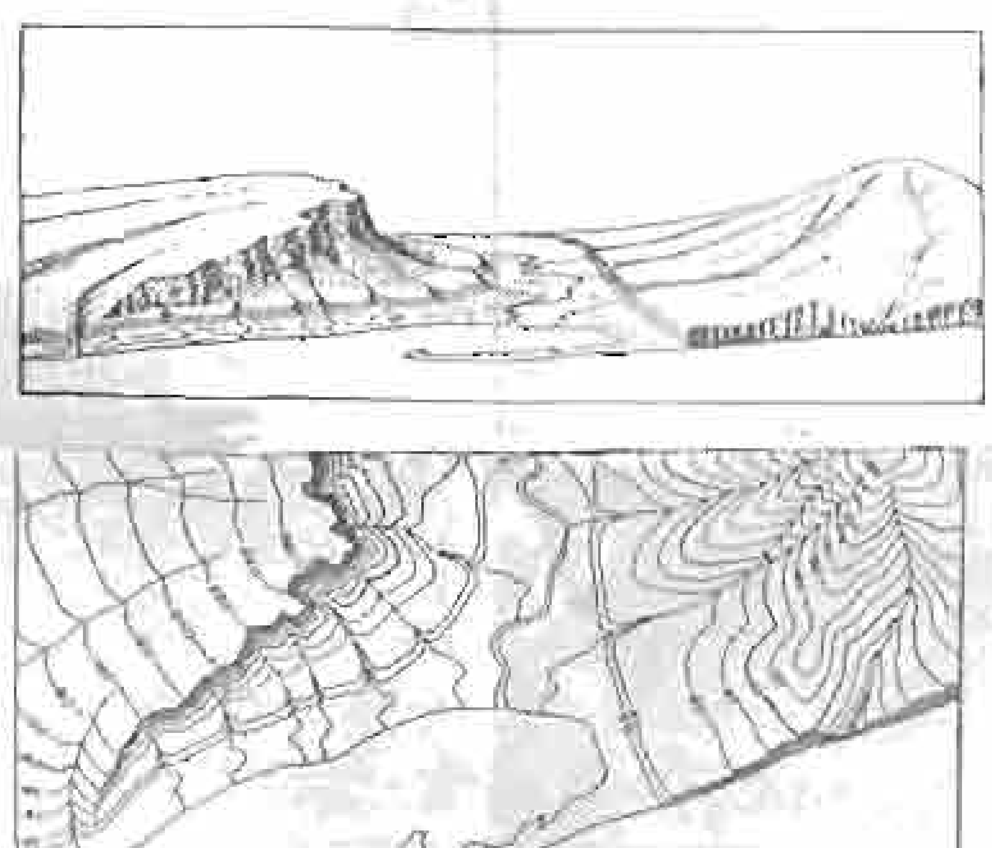
A survey of Puerto Rico is now in progress. The scale of the published maps is $\frac{1}{30,000}$.

The features shown on topographic maps may be arranged in three groups—(1) water, including seas, lakes, rivers, canals, swamps, and other bodies of water; (2) relief, including mountains, hills, valleys, and other features of the land surface; (3) culture (works of man), such as towns, cities, roads, railroads, and boundaries. The symbols used to represent these features are shown and explained below. Variations appear on some earlier maps, and additional features are represented on some special maps.

All the water features are represented in blue, the smaller streams and canals by single blue lines and the larger streams by double lines. The larger streams, lakes, and the sea are accentuated by blue water lining or blue tint. Intermittent streams—those whose beds are dry for a large part of the year—are shown by lines of blue dots and dashes.

Relief is shown by contour lines in brown, which on a few maps are supplemented by shading showing the effect of light thrown from the northwest across the area represented, for the purpose of giving the appearance of relief and thus aiding in the interpretation of the contour lines. A contour line represents an imaginary line on the ground (a contour) every part of which is at the same altitude above sea level. Such a line could be drawn at any altitude, but in practice only the contours at certain regular intervals of altitude are shown. The datum or zero of altitude of the Geological Survey maps is mean sea level. The 20-foot contour would be the shore line if the sea should rise 20 feet above mean sea level. Contour lines show the shape of the hills, mountains, and valleys, as well as their altitude. Successive contour lines that are far apart on the map indicate a gentle slope, lines that are close together indicate a steep slope, and lines that run together indicate a cliff.

The manner in which contour lines express altitude, form, and grade is shown in the figure below.



The sketch represents a river valley that lies between two hills. In the foreground is the sea, with a bay that is partly enclosed by a hooked sand bar. On each side of the valley is a terrace into which small streams have cut narrow gullies. The hill on the right has a rounded summit and gently sloping spurs separated by ravines. The spurs are truncated at their lower ends by a sea cliff. The hill at the left terminates abruptly at the valley in a steep scarp, from which it slopes gradually away and forms an inclined tableland that is traversed by a few shallow gullies. On the map each of these features is represented, directly beneath its position in the sketch, by contour lines.

The contour interval, or the vertical distance in feet between one contour and the next, is stated at the bottom of each map. This interval differs according to the topography of the area mapped: in a flat country it may be as small as 1 foot; in a mountainous region it may be as great as 250 feet. In order that the contours may be read more easily certain contour lines, every fourth or fifth, are made heavier than the others and are accompanied by figures showing altitude. The heights of many points—such as road intersections, summits, surfaces of lakes, and benchmarks—are also given on the map in figures, which show altitudes to the nearest foot only. More precise figures for the altitudes of benchmarks are given in the Geological Survey's bulletins on spirit leveling. The geodetic coordinates of triangulation and transit-traverse stations are also published in bulletins.

Lettering and the works of man are shown in black. Boundaries, such as those of a State, county, city, land grant, township, or reservation, are shown by continuous or broken lines of different kinds and weights. Public roads suitable for motor travel the greater part of the year are shown by solid double lines; poor public roads and private roads by dashed double lines; trails by dashed single lines. Additional public road classification if available is shown by red overprint.

Each quadrangle is designated by the name of a city, town, or prominent natural feature within it, and on the margins of the map are printed the names of adjoining quadrangles of which maps have been published. More than 4,100 quadrangles in the United States have been surveyed, and maps of them similar to the one on the other side of this sheet have been published.

Geologic maps of some of the areas shown on the topographic maps have been published in the form of folios. Each folio includes maps showing the topography, geology, underground structure, and mineral deposits of the area mapped, and several pages of descriptive text. The text explains the maps and describes the topographic and geologic features of the country and its mineral products. Two hundred twenty-five folios have been published.

Index maps of each State and of Alaska and Hawaii showing the areas covered by topographic maps and geologic folios published by the United States Geological Survey may be obtained free. Copies of the standard topographic maps may be obtained for 10 cents each; some special maps are sold at different prices. A discount of 40 percent is allowed on an order amounting to $5 or more at the retail price. The discount is allowed on an order for maps alone, either of one kind or in any assortment, or for maps together with geologic folios. The geologic folios are sold for 25 cents or more each, the price depending on the size of the folio. A circular describing the folios will be sent on request.

Applications for maps or folios should be accompanied by cash, draft, or money order (not postage stamps) and should be addressed to

THE DIRECTOR,
*United States Geological Survey,*
*Washington, D. C.*

November 1937.

## STANDARD SYMBOLS