GUIDEBOOK

TO A FILLED-SINK STRUCTURE
AND CIRCLE DEPOSITS (BARITE)
IN SOUTHERN COLE COUNTY,
MISSOURI

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FIELD TRIP FRIDAY AFTERNOON

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STOP 1 - FILLED-SINK STRUCTURE

INTRODUCTION

Our first stop enables us to see an excellent exposure of a "filled-sink structure". In addition, a "filled-cave" (?) can be seen at this same location. Closely related to these features are circle deposits which will be seen at the next stop. The occurrence of these features is restricted to the northern and western flanks of the Ozark dome. Filling material includes clay, shale, sandstone, coal, hematite, pyrites, galena, sphalerite, barite and dolomite.

GEOLOGY

Stop #1 is approximately six miles south of Jefferson City on Highway 54 south, Cole County. The inverted cone shape of the structure is best exposed on the east side of the expressway. Surrounding dolomites of the Jefferson City Formation dip toward the center of the structure with evidence of faulting along the margin. The fault planes also appear to dip inward toward the center of the structure.

Fill material of the structure is dominated by sandstone with lesser amounts of shale and minor amounts of clay. Slickensides within the clay gouge can be observed. The core of the deposit is a monomineralic quartz sandstone, fine to medium grained, frosted in part, with fair sorting. The shale associated with the deposit is gray-green in color and occurs between the sandstone core and the country rock. Blocks of Jefferson City dolomite are incorporated in the fill.

The age of materials in the structure and others like it is thought to be Pennsylvanian. The sand, however, at this particular stop looks much like that of the St. Peter Sandstone.

J Harlan Bretz in his 1950 publication entitled Origins of the filled-sink structures and circle deposits of Missouri lists what he feels are the major identifying features of "filled-sink structures". He lists the following characteristics belonging exclusively to them:

1. Strata of the closely adjacent country rock dip centripetally toward and into the cavity.

2. Debris from these in-dipping wall strata has been recognized, deep in the fill, as discontinuous units from wall to wall.

3. Where the calcareous country rock is capped with sandstone, the in-dip has produced low hogback ridges, the rim rock, striking peripherally about the fill.
4. Steeply inclined in-dipping sandstone strata descend across the edges of subjacent dolomite or limestone strata.

5. A selvage or gouge of residual clay-with-cherts separates the fill from the wall. Where rim rock descends into the fill, this selvage lies between it and the wall rock.

6. Slickolites in calcareous rock and slickensides in sandstone occur both at contact of fill and wall, and in rotated masses in the fill.

7. Sandstone rim rock is brecciated and sheared.

8. The fill material has bowl-shaped synclinal structures, in which are
   a. brecciation and faulting,
   b. shearing and slickensiding,
   c. corrugation and complex minor folding of layers, even drag folds,
   d. thickening and thinning of strata, even boudinage,
   e. stylolitic penetration of coal and chert into limestone and dolomite,
   f. replacement of fill material with pyrites in the iron-bearing sinks,
   g. quartz veins and geodes and siliceous cementation of breccias.

Some of these features are present at Stop #1 while others are more general and relate to "filled-sink structures" as a group.

The "filled cave" (?) which appears on the north end of the east cut contains brecciated blocks of carbonate in a ground mass of black carbonaceous shale. The absence of in-dipping wall rock is particularly noteworthy.
STOP 2 - GOLLER MINES

INTRODUCTION

Stop 2 will be a visit to the site of three abandoned barite circle deposits. Called the Goller mines, they occur within a quarter-mile radius in SE ¼ sec. 28, T. 42 N., R. 13 W. in Cole County, Missouri -- about 2 ½ miles east of Eugene and 20 miles southwest of Jefferson City. (See accompanying route map on back cover.) They are examples of mineralized solution-collapse structures commonly referred to as circle deposits because of their circular outlines. We are indebted to Mr. George A. Propst, of Brazil, Missouri, owner of the mines property, for permission to visit the area.

GEOLOGY AND ORE DEPOSITS

The Goller mines are among the more than 250 barite, lead and zinc occurrences known in the Central Mineral district of Missouri (figure 1). Twelve or 13 counties are generally included. The district is localized by a domal structure on the northern flank of the Ozark uplift, informally termed the Central Missouri high by Kisvarsanyi (1974). The occurrences are considered to be part of the stratiform, Mississippi Valley-type mineralization of the Ozarks. Deposits are localized in fissures and fractures, breccia zones, and solution channels, as well as in "circles". Residual ore accumulations, formed from surface weathering of one or another of the types of deposits listed above, have probably been the dominant source of past mine production.

Significant barite, lead and zinc mineralization is known to occur in Ordovician, Mississippian and Pennsylvanian rocks of the Central district. Most of the primary occurrences are open space fillings, but a group of the largest barite deposits, located in the Lupus area in Moniteau County, were replacement deposits in the Mississippian Burlington Limestone. Pennsylvanian outliers preserved in depressions in the Ordovician bedrock surface often contain abnormally thick coal seams. Both the coal beds and associated shales sometimes contain appreciable amounts of sphalerite, marcasite and galena, as exemplified at the Simpson mine west of High Point in southern Moniteau County. A fractured Pennsylvanian sandstone at Vista, St. Clair County, is mineralized by coarsely crystalline, clear barite.

However, some of the mined-out circle deposits in Ordovician rocks are the most visible and interesting for study. They have also been the major barite producers in recent years. They can range in diameter from 30 or 40
Figure 1. Location of the Central Mineral District.
feet up to nearly 300 feet, and some of the larger ones have been mined to depths exceeding 50 feet. The Steenberg mine, located a mile north of the Goller mines, is thought to have been the largest of this type of deposit. It probably yielded between 25,000 and 30,000 tons of barite concentrates. The walls of the circle deposits are nearly vertical and the dolomite strata are often smooth-faced and competent-looking. When the pits were pumped out, it was common to see tabular masses of barite plastered to the walls, relics of the rich mineralization that occurs in the peripheral zone. A possible sequence of events in the development of a circle deposit is given in figure 2. This interpretation conforms in most respects to the views of Mather (1947, p. 6) and Bretz (1950, p. 823-826). However, Mather (1946, p. 48-49) thought that circles might be transitional to filled sinks. Bretz contends that the latter preceded circle formations. He considers that the red tallow clay found in most circles is evidence of their formation in a post-Pennsylvanian erosion cycle.

The Goller mines circle deposits were formed in the lower part of the Jefferson City Dolomite. The three pits are now filled with water, but when mining was in progress in 1969-1970, much of the structure and mineralization was exposed. Fortunately, many of the characteristics can be seen in the mine dumps. At the Goller no. 1, the pit at the bottom of the hill and east of the mine road, there is "Quarry Ledge" lithology exposed at the level of the drive-in. A well log from the nearby Steenberg mine had a 20-foot thickness of this unit and the base was about 50 feet above the top of Roubidoux Formation sandstones. That would place the bottom of the mineralized ground in the circle at about the Ojc/Or contact as shown in figure 2.

MINERALOGY

The remarks in this section are taken from Leach and Wharton (1973) and are based on research by Leach (1973). The mineralogy of the deposits in the Central Mineral district is relatively simple, with barite, galena, sphalerite, pyrite, marcasite, chalcopyrite and calcite being the most abundant. Galena is usually more prevalent near the outer walls of circle deposits, and often exhibits automorphic contacts against sphalerite and is therefore believed to have been deposited before barite and much of the sphalerite. In the district as a whole, galena and sphalerite are more common in vein deposits than in the circles.

The most common form of barite is the white, translucent variety occurring as fine-grained, massive, or platy aggregates cementing brecciated fragments and filling open spaces in fractured rock. Transparent barite is also found as crystals that may reach up to 1 1/2 feet in length. In doubly polished sections, the only apparent difference between the 2 types is the
Figure 2. Development of a Circle Deposit.
Scale 1" = 100
extremely large number of small fluid inclusions in the white barite. Some samples of white barite contain up to 15-20 volume percent of fluid.

The general sequence of deposition was pyrite and marcasite, galena, sphalerite, barite, and calcite. Chalcopyrite was deposited throughout the sequence. However, the complete sequence of deposition is not present in most deposits. There was practically no galena and sphalerite in the Steenbergen mine, and very little galena in Goller no. 1. Barite, galena and pyrite-marcasite are abundant in the Goller mine dumps; sphalerite is present here and there, often as leached crystals; malachite and azurite, presumably after chalcopyrite, are fairly common.

MINING HISTORY

District Summary

The writer assisted Dr. Frank G. Snyder in a study of the mineral deposits in the Central district between 1968 and 1972. Wharton (1973) reported on mine production, compiled as part of the investigation. Lead mining reached its peak in the district during the 1870's, and there was renewed mining activity for both lead and zinc between 1900 and 1913. Production was suspended for all purposes by 1950. The deposits were small and the total recorded production was only about 15,800 tons of lead and 3,540 tons of zinc.

The first account of barite mining and processing in Missouri was made by Broadhead (1874). He described a barite grinding plant in operation along the Osage River near Henley, Cole County, in 1869 and perhaps dating back to 1866. The plant location was only 3 or 4 miles east of the Goller mines. However, no production records were kept for the district until 1910. Output has been almost continuous since then, with record tonnages of barite concentrates (over 34,000 tons per year) shipped in 1937 and 1940, most of it from the Lupus area in Moniteau County. About 30 mines and washers were in operation at the time in 8 of the 11 counties in the district. Beginning in 1955, barite production declined to a few hundred tons a year by two or three small operators. Mining was rejuvenated in 1969 when Circle Mines, Inc., began operations at some previously-mined deposits in Miller and Cole Counties. These included the Goller no. 1 and 2 mines. Over 5,000 tons of barite per year were shipped in 1969 and 1970 before the new company went bankrupt. Total barite production recorded for the district through 1972 was nearly 331,000 tons; about 3 percent of Missouri's total output to date. Cole, Moniteau and Morgan Counties were the ranking producers in the Central district, in that order. In recent years, the barite ore concentrates have been of chemical-grade quality and have been sold for use in paint manufac-

-7-
Goller Mines

The Goller no. 2 mine (south end of mine road), called Smith's or Old Circle Diggings, was first mined for lead in 1840, according to Broadhead (1874, p. 332-334). He reported that at least 700 tons of galena had been produced from the deposit by a wide shaft 70 feet deep. Barite was present but no mention was made of it being recovered at this time. Notches for setting timbers along the circle wall are still plainly visible on the north side of the pit. Goller no. 3, northernmost of the deposits, was called the Sand Diggings. It also had a long history of lead production, mostly from the residual clay capping and from clay-filled fissures. Broadhead reported that four shafts at this deposit yielded 15 tons of galena in 1869.

The three Goller deposits were subsequently mined for barite by open pit methods, probably in the 1940's. Circle Mines pumped out and test-drilled the 3 flooded pits in 1968-1969, and proceeded to reactivate the Goller no. 1 and no. 2 mines. The Goller no. 3 pit supplied water for the company's washer and jig plant at the mine site. Circle Mines shipped about 7,700 short tons of high-grade barite concentrates and about 25 tons of galena from these operations. The old Steenbergen mine, about a mile north in NW\textsubscript{4} sec. 27, was being readied for mining at the time Circle Mines shut down operations in September, 1970.

TIME AND ORIGIN OF MINERALIZATION

Mather (1947, p. 12-14) gives evidence for low-temperature hydrothermal solutions of magmatic origin as the source of the barite, lead and zinc mineralization in the Central district, and considered it to be post-Lower Pennsylvanian in age. Most of his supporting evidence would apply equally well to the currently popular theory of brines charged with barite and metal chlorides migrating up-dip from deep sedimentary basins.

Muienberg (1957, p. 3-4) notes that the physiographic development in the Ozark region related to post-Pennsylvanian uplift resulted in barite being deposited "in whatever rocks were at the surface where the mineralizing solutions were concentrated". This accounts for the wide-ranging ages of the barite host rocks (Cambrian-Ordovician-Mississippian-Pennsylvanian) in a northward direction from the axis of the Ozark uplift. The source of the barite is not explained, but Dr. Muienberg was known to favor a supergene, meteoric origin. Snyder in personal communications favored the deep basins as the probable source of the mineralizing solutions. Wagner (1973, p. 229), writing about the Washington County district, contends that the barium, sulfur and metals were transported by warm saline brines of undetermined origin, which later mixed with shallow, cool meteoric fluids before deposi-
ton in the Potosi and Eminence formations. Faults and fractures were considered to have produced an open plumbing system in the host rocks. He supports a time span from late Pennsylvanian to late Tertiary for the time of mineralization.

Fluid inclusion studies by Leach (1973) indicate that the mineralizing solutions were much warmer (80° to 110° C) and more saline (>22 weight percent of salts) in sphalerite from the Central district than in barite (≤400°C and from 4 to 10 weight percent salts). He concludes that there were probably two distinct periods of mineralization that may have been unrelated. He notes that the earlier lead-zinc episode may have had a common origin with the formation of the Bonmeterre deposits of Southeast Missouri and with the Tri-State and Northern Arkansas ore deposits. The later barite episode in central Missouri was possibly linked with the Washington County mineralization. Shaly sediments in the Ouachita geosyncline are cited by Leach (1973, p. 139) as a plausible source of the lead-zinc mineralization in the Ozarks. Barium may have been derived from alkali feldspars in the Cambrian Lamotte Sandstone or in the Precambrian basement rocks (Leach, 1973, p. 158).
SELECTED REFERENCES


Bryant, F. C., 1913, The baryte industry of Cole County, Missouri: Eng. and Min. Jour., v. 95, no. 6, p. 317-318.


