Fluorspar Deposits in Western Kentucky

Part 2

Central part of the Commodore fault system Crittenden County

Mineral Ridge area, Livingston and Crittenden Counties

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FLUORSPAR DEPOSITS IN WESTERN KENTUCKY

CENTRAL PART OF THE COMMODORE FAULT SYSTEM, CRITTENDEN COUNTY

By Robert D. Trace

ABSTRACT

The central part of the Commodore fault system is in the western Kentucky fluorspar district, in Crittenden County, about 6 miles northwest of Marion. It has yielded from 30,000 to 40,000 tons of crude fluorspar and nearly 20,000 tons of zinc ore.

Limestones, sandstones, and shales of the Meramec, Chester, and Pottsville groups of Carboniferous age crop out as relatively flat-lying beds, except near faults. The rocks are transected by high-angle normal faults. The main faulted zone is the Commodore fault system, which displaces the beds from 1,500 to 2,000 feet.

The principal vein minerals are fluorite, calcite, smithsonite, sphalerite, and galena. Fluorite and smithsonite are the chief ore minerals, occurring as lenses along the faults.

The mines have been worked since 1892, but most of the workings are caved or filled with water.

INTRODUCTION

The central part of the Commodore fault system is in the northwestern part of Crittenden County, about 6 miles northwest of Marion and 1 or 2 miles northeast of Sheridan (fig. 2). The area can be reached from Marion by going 4 miles southwest on U. S. Highway 60, 3 miles northwest on Route 297 and northeast on a dirt road about a mile to the Bebout property. This dirt road approximately parallels the fault system (pl. 5). During extremely rainy seasons, parts of the dirt road are impassable.

According to Weller (1927, p. 100) the Commodore fault system is approximately 13 miles long, trends generally from N. 20° E. to N. 25° E., and extends southwest from near the Ohio River almost to the Crittenden-Livingston County line. In the area studied, however,

296349—54——2

the general trend of the fault system is about N. 30° E. This report deals only with the central part of the fault system, from the Bebout and Lafayette properties on the south to and including most of the Jenkins property on the north (pl. 5). The mapped area is rectangular, about 9,500 feet by 1,500 feet, elongate northeastward, and covers approximately half a square mile.

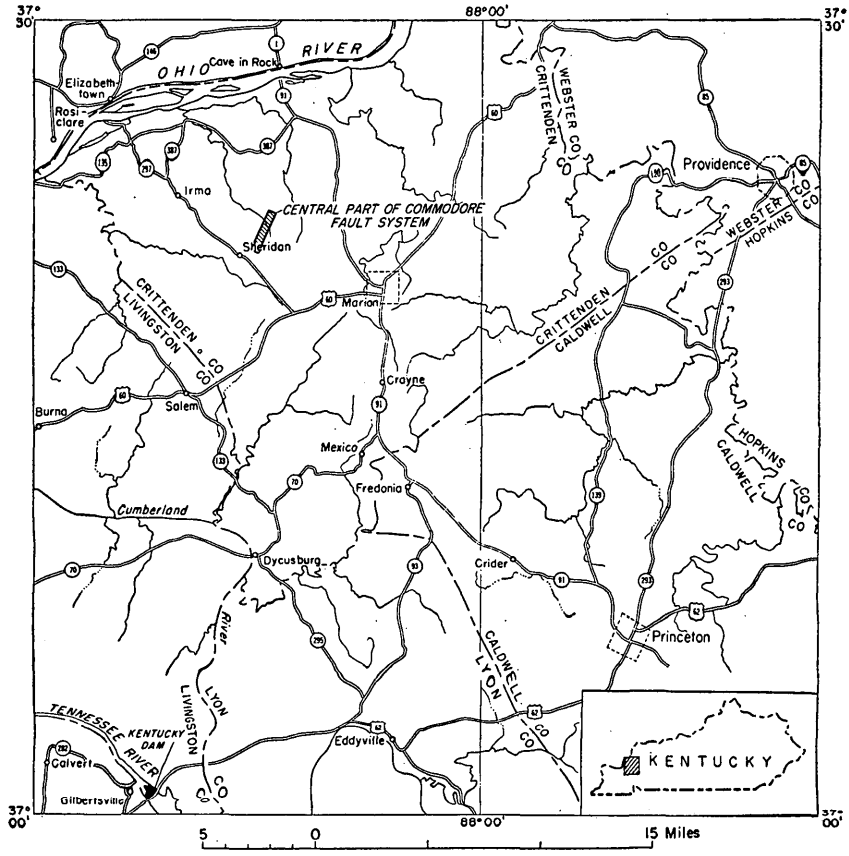

FIGURE 2.—Index map of western Kentucky, showing location of the central part of the Commodore fault system, Crittenden County, Ky.

The mines and prospects are in rolling hills of the Shawnee section of the Interior Low Plateaus (Fenneman, 1938, p. 434–440). Dense brush and a moderate growth of trees are common along the fault system, which is bordered in part by cleared farm land. Altitudes in the mapped area range from 415 feet above sea level north of Glendale School to 560 feet near the Riggs shaft. Caney Fork, flowing northwest toward the Ohio River, drains the area.

According to Fohs (1907, p. 214) the first prospecting or mining along the central part of the Commodore fault system was done in

1892 at the Commodore mine. In 1905 Ulrich and Smith (1905, pl. 8) mentioned Franks prospect, and although the location is slightly different from that given by Fohs, it is probably on the Commodore property.

Fohs (1907, p. 38) states that the Glendale and Leona mines started work in 1901 and 1904, respectively, and Ulrich and Smith (1905, pl. 8) show the location of the Glendale and Terry prospects on an illustration. The names Glendale, Leona, and Terry probably refer to deposits on the Hickory Cane property.

Currier (1923, p. 106) describes mining operations on the K. K. property in 1920, and A. H. Reed, Sr., stated that mining was done on this property in 1916.

The first published mention of the Pasco property was by Jillson (1921, p. 172–175) in 1921; A. H. Reed, Sr., told the writer that the Pasco property was in operation at an earlier date. Jillson refers to the Glendale (Hickory Cane) and K. K. properties as being active, and the Commodore and Pasco properties as being inactive.

The Sullenger property is briefly mentioned by Currier (1923, p. 107). No mention of the Lafayette, Jenkins, and Bebout properties was found in the literature.

In October 1942 none of the mines or prospects in this area was being worked. Two shafts had been sunk in September 1942 on the north end of the Commodore property. The south end of the Hickory Cane property was worked from November 1941 to March 1942, and for a short period during 1944 and 1945. During late 1943, a lessee carried out a diamond-drilling program on the Jenkins property, but no mining was done. The Pasco and K. K. properties were operated for brief intervals during 1943 and 1945. A lessee sank the Riggs shaft on the Bebout property during 1945.

The earliest geologic report that deals with the Commodore area is by Ulrich and Smith (1905 pl. 8). Both the geology and ore deposits were mapped and described. Currier (1923, p. 106) briefly described the fluorspar deposits of the Commodore area and presented some data on the structure and igneous rocks.

The most detailed description of the geology of the Commodore area is by Weller (1927) and Weller and Sutton (1951). The writer has followed Weller's overall conception of the geology of the Commodore area, but has shown some differences by using a larger mapping scale.

As part of the wartime program of the U. S. Geological Survey for the investigation of strategic and critical minerals, field study of the central part of the Commodore fault system was started in October 1942 and continued intermittently until June 1945. Field work was under the general supervision of James Steele Williams and R. E. Van Alstine. H. J. Klepser, W. R. Thurston, G. C. Hardin, Jr.,

R. W. Lemke and D. A. Warner of the U. S. Geological Survey were associated with the writer in the field work. The major part of the field work consisted of studying the structure and stratigraphy from surface evidence, as only a few underground workings were accessible and they were in the zone of gravel spar. Brief underground studies were made at the Pasco and K. K. No. 2 shafts by the writer and at the Yandell shaft by D. A. Warner. The other shafts and pits were inaccessible because they were flooded or caved. Some underground data were obtained from three holes (diamond-drill holes 4, 5, and 6) drilled by the U. S. Bureau of Mines during the summer of 1945 (Starnes and Hickman, 1946). The writer also has incorporated into this report information based upon holes drilled by the Ozark-Mahoning Co. in 1947; the locations of the holes are not shown on the geologic map.

Because of the inaccessibility of most of the mine workings, the writer found that unpublished maps, drill logs, and reports of A. H. Reed, Sr., mining engineer of Marion, Ky., were of considerable assistance. Published and unpublished maps of Stuart Weller also have been of great value. Mine operators cooperated by permitting examination of accessible workings and volunteering information about past mining operations.

GEOLOGY

The geology and cross sections of the area are shown on plate 6. The accuracy of the interpretations on the geologic maps and cross sections probably varies considerably depending upon the proximity of surface outcrops, accessible underground workings, or diamond-drill holes.

SEDIMENTARY ROCKS

The sedimentary rocks of the fluorspar district of western Kentucky, described briefly in Chapter A by Williams and Duncan, consist of limestones, sandstones, and shales of the Meramec, Chester, and Pottsville groups of Carboniferous age. The Warsaw and Spergen limestones underlying these formations may have been penetrated in diamond-drill hole 1 (pl. 6, cross section *C–C′*). These two Mississippian formations consist of light to dark limestones (Weller, 1927, p. 10); the Spergen is oölitic in places. Typical cherty St. Louis limestone is present on the footwall of the Commodore fault system. The Ste. Genevieve limestone was penetrated in diamond-drill holes 7 and 8 (secs. *G–G′* and *H–H′*), but the absence of detailed drill logs precludes a more detailed description. The Rosiclare sandstone member has not been found in the central Commodore area.

The Renault limestone is believed to have been cut in several of the drill holes. The Cypress and Bethel sandstones and possibly the

Paint Creek shale were cut in some of the drill holes, and also are exposed on the surface. These formations are mapped as a unit, however, because of insufficient data regarding the Paint Creek shale. The Golconda limestone is exposed at a few places along the Commodore fault system but has not been found underground, either in a mine working or in a drill hole. Beds that probably represent the lower part of the Hardinsburg sandstone crop out at the Hickory Cane property and also on the south end of the Lafayette property.

The Palestine sandstone probably was cut by diamond-drill hole 7 (pl. 6, sec. *G–G'*). The sequence of Kinkaid limestone, Degonia sandstone, and Clore limestone is shown as one unit on the geologic map (pl. 6). In some of the cross sections of plate 6, this unit is divided into the three formations. Their combined thickness locally totals as much as 280 feet (sec. *H–H'*). The Degonia sandstone contains shale as well as sandstone.

The Caseyville sandstone of Pennsylvanian age is the youngest formation exposed in the Commodore area. As shown on plate 6, it may be as much as 200 feet thick. The scarcity of outcrops that permit accurate dip measurements precludes a more definite statement about the thickness of this formation.

For the purpose of describing the evidence for the geologic interpretations as shown on plate 6, the area is divided into three parts: the footwall side of the Commodore fault, the area between the Commodore and Glendale faults, and the hanging-wall side of the Commodore fault system.

On the footwall side of the Commodore fault the rocks are mapped as St. Louis limestone. Outcrops are poor, as the St. Louis limestone weathers readily to a cherty red soil. A few pits have been sunk along the footwall side, and the dumps from these pits contain fragments of St. Louis limestone. As boulders of oölite that resemble the Ste. Genevieve limestone were found locally, the lower part of the Ste. Genevieve limestone may crop out locally along the footwall side of the Commodore fault. However, the St. Louis limestone also contains some oölites, hence the oölitic texture is not completely diagnostic of the Ste. Genevieve limestone. Conversely, the Ste. Genevieve limestone may contain some chert, which generally is typical of the St. Louis limestone.

In December 1947 the Ozark-Mahoning Co. started a diamond-drilling program on the north end of the Commodore property. The writer examined the core from 4 drill holes, 3 from the footwall and 1 from the hanging wall of the fault. The footwall holes, drilled in the vicinity of the New No. 1 Commodore shaft, undoubtedly started in St. Louis limestone, which is a dark-gray fine- to medium-grained limestone with intercalated beds of dark-gray shaly limestone. Beds

of dark-gray oölitic limestone, however, were cut about 200 feet below the surface; these beds may be assigned to the Spergen limestone.

It is difficult to identify the formations between the Commodore and Glendale faults because of the scarcity of outcrops. Where major faults are close together as here, the intervening rocks are complexly fractured. The geology can be interpreted accurately only after many underground workings or cores of drill holes have been studied.

Sandstone crops out in most of the central block south of the Yandell shaft; its identification as Cypress or Bethel sandstone is based upon the information obtained from cores of diamond drill holes 3, 4, 5, and 6 and from study of the underground workings at the K. K. shafts. Typical Golconda limestone is exposed in a prospect pit about 100 feet northwest of diamond-drill hole 3. In that part of the central block north of the Yandell shaft, the identification of the Golconda limestone and Hardinsburg sandstone is based upon data from diamond-drill holes 7 and 8, and upon unpublished underground maps by A. H. Reed, Sr., of the Rock shaft of the Hickory Cane property. From the distribution of the outcrops, the contact of the Golconda limestone and Hardinsburg sandstone is from 500 to 600 feet north of the drill site for diamond-drill hole 6. Farther north the rocks excavated from three shafts that were caved in 1945 suggest that the Golconda was cut.

The Caseyville sandstone and the sequence of Kinkaid limestone, Degonia sandstone, and Clore limestone crop out on the hanging wall of the Commodore fault. In the area south of fault 54 the contact between the Caseyville sandstone and the Kinkaid limestone cannot be located on the surface. The Riggs shaft starts in Caseyville sandstone and crosses the contact with the Kinkaid limestone at a depth of 40 feet. The contact strikes northeasterly and dips 35° SE. From the Riggs shaft northeast to near diamond-drill holes 5 and 6, the trace of the contact at the surface is mapped on the basis of the strike and dip of the contact in the Riggs shaft. The dips of the strata along the fault system are known to change, however, and therefore this trend cannot be extended accurately for any great distance. The Kinkaid limestone is adjacent to the Glendale fault in the vicinity of diamond-drill hole 3. The nearest outcrop of Caseyville sandstone is at the dirt road, 250 feet east of the Glendale fault, and in other places as far east as Caney Fork. A narrow strip of Kinkaid limestone is inferred just northeast of diamond-drill hole 6 (pl. 6), although the limestone does not crop out. A few feet west of the Rock shaft, a steep sandstone cliff, 6–10 feet high, which ends abruptly against overburden on the west, is believed to be the eastern boundary of the strip of Kinkaid limestone. Since the surface trace of the Glendale fault is probably farther west, the area between the projected trace of the

fault and the sandstone cliff is thought to be weathered Kinkaid limestone.

North of fault 54 the contact of the Caseyville sandstone and Kinkaid limestone is offset to the east. This contact is exposed along an abandoned road (pl. 6., coordinates 38,000 N., 21,000 E.). Caseyville sandstone crops out also in the road near the top of the hill, about 300 feet east of the New No. 2 Commodore shaft. The lack of exposed bedrock below the hilltop suggests that weathered Kinkaid limestone may underlie this remnant of Caseyville sandstone. The nearly identical altitudes of these two places on or near the contacts of the two formations indicate that the strata are approximately horizonal. No direct measurement of the dip of the strata could be obtained.

The Ozark-Mahoning Co. in December 1947 drilled a hole in the hanging wall under the New No. 2 Commodore shaft, and penetrated shale, limestone, and sandstone of the Kinkaid, Degonia, Clore, and Palestine formations.

It is difficult to completely correlate the geology as mapped by the writer with that mapped by Ulrich (1905, pl. 8). Ulrich's map shows 2 faults that diverge northeastward from the old LaRue mine, the east branch passing near the Glendale School. The eastern fault, called the Glendale by Ulrich, is identical with the Commodore fault system. The west branch, called the LaRue fault by Ulrich, lies west of the area mapped by the writer. Ulrich shows the Mansfield (Caseyville) sandstone on the hanging wall and his Birdsville formation (upper Chester) on the footwall of the Glendale fault, and St. Louis limestone on the footwall of his LaRue fault. Weller and the writer, however, found St. Louis limestone on the footwall of the Commodore (Ulrich's Glendale) fault system.

IGNEOUS ROCKS

Although not exposed at the surface, dark colored igneous rock is known to be present in the northern part of the area. Ulrich and Smith (1905, p. 103) report that a sill was cut in a prospect shaft near Glendale Church (school). Weller (1927, p. 88–89) noted a dike of peridotite at Glendale (school). An unpublished mine map of the area near the Rock shaft shows several peridotite dikes and sills. Currier (1923, p. 21–33) noted that lamprophyre dikes and sills are common in the fluorspar district but does not describe any in the central Commodore area.

No surface exposures of igneous rocks were seen by the writer. The location of the dike, shown on the map about 100 feet east of the Rock shaft (pl. 6), is based on the log of diamond-drill hole 7. Specimens of dark igneous rocks were found on the dumps near the Rock

shaft and also the New No. 2 Commodore shaft. The Ozark-Mahoning Co. drilled a hole in December 1947 under the New No. 2 Commodore shaft and cut about 8 feet of lamprophyre at a vertical depth of 150 feet. The lamprophyre is dark-gray with a medium-grained sugary texture. Irregular plates and small books of brown mica are abundant. A thin section of the lamprophyre shows that it is highly altered. The texture is holocrystalline with scattered, large metasomes of calcite in a medium-grained groundmass that consists dominantly of calcite, biotite ($N\beta$ and $N\gamma$ between 1.61 and 1.62), and chlorite. Leucoxene, pyrite, magnetite(?), and ilmenite(?) are common. Apatite in rods and prismatic crystals is an accessory mineral. Anhedral crystals of plagioclase feldspar and quartz are sparse.

STRUCTURE

The central part of the Commodore area is broken by several high-angle faults that presumably are normal. The strata are generally flat lying, although along the hanging wall of the Commodore fault system south of fault 54, they dip as much as 40° SE. The strata between the Commodore and Glendale faults also vary in dip. Crossbedding locally is common in the sandstones, and where the outcrop is small the crossbedding may be misinterpreted as the true bedding.

The outstanding structure in the mapped area is the Commodore fault system which includes the Commodore and Glendale faults. Other known faults are Weller's fault 54 (1927, p. 104, 113) and a fault associated with a dike near the Rock shaft. Additional faults undoubtedly occur in the mapped area, particularly between the Commodore and Glendale faults.

COMMODORE FAULT SYSTEM

The Commodore fault system strikes northeast and dips steeply southeast. The total displacement is between 1,500 and 2,000 feet, the northwest side being upthrown. Except for the extreme north and south parts, the fault system is divisible into two subparallel major faults, the Commodore fault on the northwest side, and the Glendale fault on the southeast side. Where the two faults are close together, the included fault block is commonly so broken and fractured that it is not possible to distinguish the intervening formations. The St. Louis limestone is at the surface northwest of the fault system; the Kinkaid limestone is on the southeast side. The Cypress sandstone, Paint Creek shale, and Bethel sandstone sequence, Golconda limestone, and the Hardinsburg sandstone crop out within the fault block.

The Glendale fault probably branches from the Commodore fault near the north edge of the Lafayette property, and can be traced at

least as far north as the vicinity of the Rock shaft. On the Commodore property, the best evidence for the continuation of the Glendale fault was found in diamond-drill hole 8. Nearly 400 feet of limestone and shale with a few very thin sandstone layers were cut. As the hole probably started in the Kinkaid limestone, such a thick sequence of limestone and shale is not to be expected in a typical section here. Calcite veins at a depth of 230 feet in the drill hole suggest a fault, presumably the Glendale fault. Mineralized rock, considered to be evidence of the Commodore fault, was cut near the bottom of the drill hole. Farther north the Glendale fault probably joins the Commodore fault.

OTHER FAULTS

In his regional study, Weller (1927, p. 104, 113) mapped fault 54 as passing just north of Glendale School. At this locality, the writer found the following evidences for the fault: the offset of the contact of the Caseyville sandstone and the Kinkaid limestone, and a few slickensided sandstone boulders on the hillslope north of Glendale School. The strata are downthrown 25-50 feet on the south side of fault 54.

A fault along a dike of lamprophyre is believed te be present on the Hickory Cane property near the Rock shaft. Such a fault has been inferred from the stratigraphy as given in a generalized log of diamond-drill hole 7. The fault strikes N. 20° W., presumably similar in direction to that of several dikes in the vicinity, as shown on an unpublished mine map of the Rock shaft. The displacement is probably less than 40 feet (pl. 6, cross section *G-G'*).

FLUORSPAR DEPOSITS

The fluorspar and zinc mines along the central part of the Commodore fault system, Crittenden County, Ky., have been worked intermittently since 1892. Approximately 30,000–40,000 tons of fluorspar, 20,000 tons of zinc ore, and a small tonnage of lead ore have been produced.

GENERAL FEATURES

Fluorite, calcite, sphalerite, smithsonite, and galena are the most abundant minerals in the area. Small quantities of pyrite and quartz are present. The fluorite is purple and fine- to medium-grained in veinlets, but is brown massive and coarse-grained in veins and gravel spar. The calcite is white to medium brown, generally coarse-grained, and commonly occurs as veinlets in the limestone and as large massive veins. Quartz locally lines vugs and forms veinlets of fine-grained material. The silica content of the fluorspar veins is generally low,

296349—54——3

and most of the silica that is mined with the fluorspar is from the sandstone country rock.

Sphalerite typically occurs as red to brown fine disseminated grains in the limestone, fluorite, and calcite. In a few places the disseminated sphalerite becomes so concentrated that it appears to be massive. Smithsonite, the principal zinc mineral of the central Commodore area, generally is in gray irregular-shaped porous masses associated with partly weathered limestone. Presumably it formed by the alteration of sphalerite. Fine-grained disseminated galena is associated with the sphalerite and fluorite in places, and also with the fluorite alone. Small disseminated crystals and very small veinlets of pyrite were noted locally in the vein material and in the adjacent sandstones.

Most of the minable fluorspar deposits in the area are of the gravel-spar type, concentrated by the weathering of country rock and veins. With the possible exception of part of the fluorspar body at the Commodore mine, none of the veins in unweathered bedrock have been of minable size. The gravel-spar deposits consist of coarse-grained, generally brown fragments of fluorite in a matrix of clay, mud, and a few remnants of limestone and vein calcite. In places narrow veins of fluorite have been preserved in the zone of gravel spar.

Within the area studied, the mineral deposits are localized along the Commodore fault system, and no deposits are known along the other faults.

Four main fluorspar or zinc deposits have been mined in the central Commodore area: the K. K. fluorspar body near the K. K. No. 1 shaft, the K. K. zinc and fluorspar body near the K. K. No. 3 shaft, the Hickory Cane zinc body near the Rock shaft, and the Commodore zinc and fluorspar body near the Old Main Commodore shaft.

Data on the size and grade of these ore deposits were obtained mostly from unpublished maps and reports of A. H. Reed, Sr. The dimensions of the stopes (pl. 5) were used to approximate the size of the ore bodies, as no other information was available.

The K. K. fluorspar body, mined from the No. 1 shaft, was about 85 feet long, 75 feet deep, and from less than an inch to 12 feet wide. It is reported to have averaged 75 percent calcium fluoride and 10 percent silica.

The K. K. zinc and fluorspar body, mined from the No. 3 shaft, is reported to have been 180 feet long, 40 feet deep, and 4–5 feet wide. No data on the grade of the ore are available.

The Hickory Cane zinc body was approximately 400 feet long and more than 100 feet deep. Estimates of the average widths and grades of the ore, which was mostly carbonate, are not available.

The Commodore ore body was chiefly fluorspar from the surface to a depth of 125 feet and zinc ore from 125 to 200 feet. It was approxi-

mately 175 feet long. The zinc ore is reported to have been 8–10 feet wide, but the width of the fluorspar is unknown to the writer.

The wall rocks of the known ore bodies of fluorspar and zinc are as follows: The K. K. fluorspar body, on the Glendale fault, lies between a footwall of Cypress or Bethel sandstone and a hanging-wall sequence of Kinkaid limestone, Degonia sandstone, and Clore limestone. The K. K. zinc and fluorspar body, on the Commodore fault, is between the Bethel(?) sandstone and the St. Louis limestone. The wall rocks of the Hickory Cane zinc body near the Rock shaft probably are the Kinkaid, Degonia, Clore, Golconda(?), Cypress, Bethel, and St. Louis formations. The Commodore fluorspar body is probably between the St. Louis limestone on the footwall and the Cypress sandstone and possibly the Golconda limestone on the hanging wall.

McFarlan (1943, p. 391–395) briefly summarizes various theories that have been proposed for the origin of the fluorspar deposits of western Kentucky. The deposits generally are considered to be hydrothermal, the ore-bearing solutions presumably originating from some underlying large intrusive mass of igneous rock, as yet not found. Weller and Grogan (1945, p. 398–402) have found fragments of weathered granite in Pope County, Ill. It is not known whether the granite fragments were derived from some now unexposed intrusive body or whether they are of glacial origin.

No conclusions about the primary origin of the fluorspar bodies can be drawn from studies along the central part of the Commodore fault system, because the underground workings seen at the Pasco and K. K. No. 2 shafts, and probably those of most of the other deposits, are in deposits of gravel spar.

DESCRIPTIONS OF MINES AND PROSPECTS

BEBOUT

Only the north end of the Bebout property (pls. 5 and 6) is included in the mapped area. There are two shafts on the property, the Bebout and the Riggs. The Bebout shaft is caved and inaccessible, but is reported to be 50 feet deep; at a depth of 40 feet in the shaft, a short crosscut was driven northwestward to the Commodore fault to a fluorspar and galena vein. In 1944, a lessee sank the Riggs shaft to a depth of at least 90 feet, but no vein was found to that depth. The shaft first passed through about 40 feet of Caseyville sandstone and then 50 feet of Kinkaid limestone. The beds strike approximately S. 30° W., and dips 35°–40° SE.

LAFAYETTE

Only the northern part of the Lafayette property (pls. 5 and 6) was mapped. Two shafts have been sunk, the Reed shaft and the Lead shaft; both were inaccessible in 1945.

The Reed shaft was sunk about 50 feet, entirely in overburden derived from weathered St. Louis limestone. A crosscut was driven in the overburden for a distance of about 265 feet southeast to a lead vein, which is probably along the Commodore fault. From the intersection of the crosscut with the lead vein, a raise to the surface and a winze were excavated for a combined total depth of 100 feet. This combined raise and winze is known as the Lead shaft. A drift is reported to have been driven from the bottom of the shaft, following the lead vein. The dump near the Lead shaft contains pieces of galena a few inches in diameter and some pieces of limestone with small grains of disseminated galena.

PASCO

The Pasco property (pls. 5 and 6) was first prospected during World War I. A small tonnage of fluorspar probably was shipped during the prospecting operations. The mine openings on the property are the Pasco shaft, said to be 100 feet deep, and several shallow prospect shafts and pits. Lessees worked the 66-foot level of the Pasco shaft for a short period during the fall of 1943. A brief study of this level was made by the writer, but poor ventilation prevented a more detailed examination. The Pasco shaft starts in the hanging wall of the Commodore fault and cuts the fault at a depth of about 60 feet. The fracture zone contains gravel spar, which consists of clay, gouge, and fragments of fluorite. A short crosscut on the 66-foot level also cuts the Commodore fault. Drifts extend southwest and northeast of the shaft at the 66-foot level. Only about 40 feet of the southwest drift was accessible in 1943. A long crosscut from the bottom of the shaft is reported to cut both the Commodore and Glendale faults, but no mining was done.

K. K.

The first mention in literature of the K. K. property (pls. 5 and 6) is by Currier (1923, p. 106) who discussed the mining operations in 1920. Fluorspar was produced from this property during the period 1916–1919 and also during the middle 1930's. From 25,000 to 35,000 tons of fluorspar, containing an average of 75 percent of calcium fluoride and 10 percent of silica, and about 2,000 tons of zinc carbonate were mined during these times. Most of the fluorspar came from the southern part of the property, and the zinc ore came from the northern part. Lessees mined about 800 tons of fluorspar from the No. 2 shaft from 1940 through 1943.

The No. 2 shaft, which cuts the Glendale fault, was the only one on the property that was accessible to the writer (fig. 3 and pls. 5 and 6, cross section *A–A'*). It is 130 feet deep, with crosscuts and drifts at depths of 100 and 130 feet. An 18-foot winze was sunk on the vein from the 100-foot level, and a short drift was driven southwestward at

the bottom. The fluorspar zone consisted chiefly of gravel spar, red clay, and gouge, with a few veins of coarse-grained brown fluorite. The zone containing fluorspar ranged in width from 2 to 8 feet. In 1944 an exploratory crosscut from the 130-foot level was driven westward in Bethel(?) sandstone, and is reported to have cut the Commodore fault. No minable deposits were found.

Most of the fluorspar production from the property was from the No. 1 shaft (pls. 5 and 6), which is 185 feet deep, with crosscuts and drifts at depths of 110, 150, and 185 feet. Bodies of gravel spar were cut on

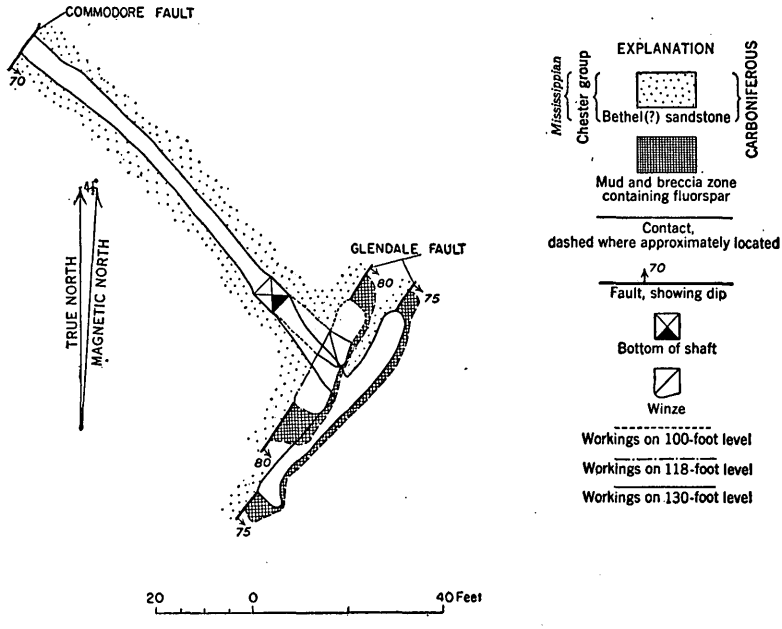

FIGURE 3.—Map of underground workings at the K. K. No. 2 shaft, Commodore fault system, Crittenden County, Ky.

all three levels and ranged in width from less than an inch to 12 feet, 4 feet being average. Mining was abandoned at the shaft because of caving.

Shafts Nos. 3 and 4 are 150 and 90 feet deep, respectively, with levels at the bottom of each; they are connected on the 90-foot level (pl. 5). Zinc carbonate (smithsonite) was the most abundant vein material found, and was reported to be as much as 4 or 5 feet wide in the No. 3 shaft. The Dover shaft (pl. 6) was sunk in 1941 or early 1942, to a depth of 24 feet in Cypress(?) sandstone. There are many other shallow caved shafts and pits on the K. K. property, but no information concerning them is available.

Four diamond-drill holes have been put down on the K. K. property, three of them in 1929 and a fourth by the U. S. Bureau of Mines in 1945. Diamond-drill hole 1 (pl. 6, cross section *C–C'*), 930 feet deep, was started in St. Louis limestone and remained in limestone to the bottom. The hole was drilled southeastward from the footwall side of the Commodore fault at an angle of 67°. A study of the core indicates that the hole did not cut the southeastward-dipping Commodore fault, but apparently was parallel with it.

Diamond-drill hole 2, cross section *C–C'*, 880 feet deep was drilled from the same location and in the same direction as diamond-drill hole 1 but at an angle of 52½°. This hole cut scattered veinlets of fluorspar, zinc minerals, and lead minerals from a depth of 400 feet to the bottom. The great length of core containing small quantities of ore minerals suggests that the drill hole intersected the fault zone at a small angle.

Diamond-drill hole 3, cross section *B–B'*, was started from the hanging wall of the Glendale fault at an angle of 45°. Based on a generalized log of this hole the writer believes that the hole cut Kinkaid limestone for 80 feet, crossed the Glendale fault at a barren section, and continued to the bottom, 138 feet, in Bethel(?) sandstone.

Diamond-drill hole 4 (Starnes and Hickman, 1946, p. 44), shown in cross section *D–D'*, was drilled northwestward from the hanging wall of the Glendale fault to a depth of 272 feet at an angle of 50°. No commercial fluorspar or zinc ore bodies were found.

SULLENGER

Although Currier (1923, p. 107) briefly mentioned the Sullenger property, no other historical data are available. The east boundary of the Sullenger property with the Hickory Cane property was in dispute in 1945. Two shafts, the Null shaft and the Maddox shaft, were sunk in 1941, 1944, and 1945 by lessees, who obtained leases from the owners of the Sullenger property. The maps (pls. 5 and 6) accompanying this report suggest that these shafts are on the Hickory Cane property and they are therefore described below under the section on that property. It should be emphasized, however, that the property lines could not be located accurately because of the vagueness of the descriptions of the original property surveys and the lack of property-line markers. Therefore the maps should not be taken as evidence for the relative position of the shafts and property lines.

Mine openings that are definitely on the Sullenger property (pl. 6) consist of several caved, shallow prospect pits. A small tonnage of gravel spar was mined. The mine waste left on the surface is mostly weathered limestone with abundant chert, calcite, veinlets of fluorite, and a few small grains of sphalerite and galena.

HICKORY CANE

Mining probably started about 1901 on the Hickory Cane property (pls. 5 and 6), and both fluorspar and zinc ore have been produced. Most of the 7,000–8,000 tons of zinc carbonate was mined from the northern part of the property in 1924 and 1925. Workings on the property consist of several shafts and prospect pits, the deepest being the Rock shaft, 240 feet. The mine workings in the northern part of the property are the oldest and most numerous. Recently various mine operators have worked in the southern part of the property. During 1941, 1942, 1944, and 1945, small quantities of fluorspar were mined from the Yandell shaft, the Null shaft, and the Maddox shaft.

The Rock shaft has levels at depths of 25, 60, 120, 155, 160, 200, and 240 feet. Considerable stoping was done, particularly between the 60- and 160-foot levels. According to Reed, smithsonite, sphalerite, and galena are present in the workings of the Rock shaft and the smithsonite extends to a depth of 160 feet. From 160 feet to 240 feet and adjacent to the footwall of the Glendale fault, galena is reported to occur in a zone 4–5 feet wide. Toward the hanging wall, brecciated calcite, 12–15 feet wide, is reported to contain disseminated sphalerite and galena. This brecciated zone is said to contain 25–30 percent of sphalerite and 3–4 percent of galena. It is reported that on the 240-foot level the ore contained up to 15 percent of sphalerite and as much as 1 percent of galena.

There are many other shafts, all inaccessible, west of the Rock shaft. Some of these old shafts may be as much as 155 feet deep. The most abundant vein mineral on the shaft dumps is smithsonite. Some sphalerite with subordinate galena and fluorite also is present.

From November 1941 to March 1942, about 215 tons of gravel spar was produced from the 35-foot level of the Maddox shaft. Later, the shaft was sunk to a depth of 60 feet and a crosscut was made to the vein (fig. 4). A vertical raise was cut to the surface in 1945 and called the Yandell shaft (Starnes and Hickman, 1946, p. 43). The drift on the 60-foot level is along the Commodore fault, with Bethel(?) sandstone on the hanging wall and St. Louis limestone on the footwall. The fault zone contains mud, gouge, calcite, fragments and veins of fluorspar, and disseminated sphalerite and galena. Fluorite is the most abundant of the vein minerals.

The Null shaft was sunk in 1944 to a depth of 55 feet. Dispute as to the location of the Sullenger-Hickory Cane property line stopped operations.

Three diamond-drill holes (pl. 6) were completed on the Hickory Cane property. About 1929, diamond-drill hole 7 was put down 335 feet at an angle of 60°. The writer's stratigraphic interpretation of a

generalized log of this hole is shown in plate 6, cross section *G–G′*. The fault zone of the Commodore fault system contained calcite with disseminated sphalerite and galena, and included an 18-inch vein of massive sphalerite. The other two drill holes were put down by the U. S. Bureau of Mines in 1945 (Starnes and Hickman, 1946, p. 43) in the southern part of the property. The first of them, diamond-drill hole 5 (cross section *E–E′*), is 300 feet long, and was drilled northwestward at an angle of 50°; the second hole, diamond-drill hole 6 (cross-section *F–F′*), is 360 feet long and was drilled also northward at

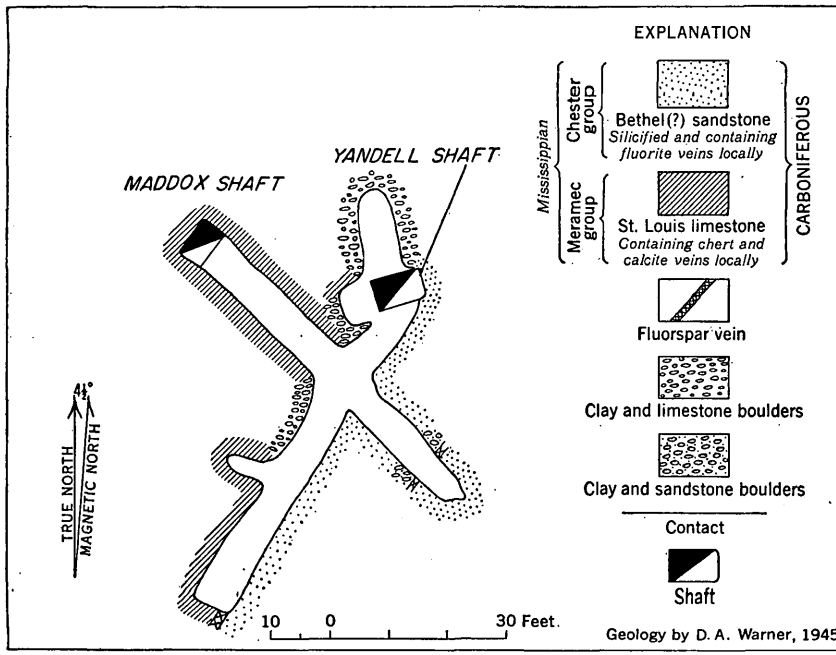

FIGURE 4.—Map of 60-foot level of Yandell shaft, Commodore fault, Crittenden County, Ky.

an angle of 50°. No minable fluorspar or zinc ore bodies were indicated by diamond-drill holes 5 and 6.

COMMODORE

Mining in the central Commodore area started on the Commodore property (pl. 6) in 1892. The Original Shaft is reported to be the first shaft sunk. The first major mining operation was undertaken during the period 1905–1909, and about 10,000 tons of zinc ore was mined from the Old Main Shaft. Formerly a mill on the property concentrated the ore. During World War I, a large quantity of fluorspar was mined from the upper levels of the Old Main shaft. Exploration

work was done on the property in 1942, when lessees sank the New No. 1 and New No. 2 shafts to depths of 100 and 114 feet, respectively, and drove short drifts from the bottoms of these shafts.

None of the workings were accessible when the area was mapped by the writer. Currier (1923, p. 106–107) describes the Old Main shaft and workings, and states that the shaft is 300 feet deep. According to an unpublished mine map made by A. H. Reed, Sr., the Old Main shaft is 240 feet deep, with levels at depths of 100 and 200 feet. The dump material in the area near the Old Main shaft is composed chiefly of limestone with large quantities of light-brown and white coarse grained calcite. Pieces of purple and brown fluorite with disseminated sphalerite and galena are common.

In the New No. 1 shaft, a former lessee reports 2½–4 feet of fluorspar and sphalerite. The vein in the drift assayed 35–66 percent of calcium fluoride, 6–10 percent of zinc, 3–27 percent of calcium carbonate, 14–31 percent of silica, and traces of lead. In the New No. 2 shaft, a former lessee reports that 8 feet of calcite and fluorite with traces of sphalerite are present.

Two diamond-drill holes have been put down on the Commodore property. One hole, whose location is unknown, is said to have cut the workings near the Old Main shaft. The other, diamond-drill hole 8 (pl. 6, cross section *H–H′*) was drilled northwestward for 436 feet at an angle of 60°. Several small veinlets of fluorite were reported to have been cut.

JENKINS

A small quantity of fluorspar has been produced from the Jenkins property. Two shafts, the Perryman and the Jenkins, and a few prospect pits have been sunk on the property. Neither shaft is accessible, but according to local reports, the Perryman shaft is 97 feet deep and the Jenkins shaft is 50 feet deep. A fluorspar vein 2–4 feet thick is reported to have been found in the bottom of each shaft. Waste piles near the shafts consist chiefly of limestone breccia and calcite with a few veinlets of purple fluorite and a trace of sphalerite.

Three diamond-drill holes (pl. 6, cross section I–I′) were put down by a lessee in 1943. Diamond-drill holes 9 and 10 were drilled northwestward at angles of 45° and 60° and for lengths of 149 and 147 feet, respectively. Diamond-drill hole 11 was started at an angle of 60° but was abandoned because of poor core recovery. Although the Commodore fault system was definitely cut in diamond-drill hole 9 and possibly 10, no core was obtained that indicated deposits of minable fluorspar or zinc ore.

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INDEX