Mineral Ridge area Livingston and Crittenden Counties

By ROBERT D. TRACE

FLUORSPAR DEPOSITS IN WESTERN KENTUCKY

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[Plates 7 and 8 are in pocket]

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MINERAL RIDGE AREA, LIVINGSTON AND CRITTENDEN COUNTIES

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ABSTRACT

The Mineral Ridge area, in the southwestern part of the Kentucky-Illinois fluorspar field, is broken by a complex northeastward-trending system of steeply dipping normal faults. Mining activity started in the Mineral Ridge area in about 1870. More than 25,000 tons of fluorspar and small quantities of zinc and lead have been produced, most coming from the Mineral Ridge No. 1 property, in the northeastern part of the mapped area. The other properties have produced only small quantities of ore.

The ore deposits are localized along faults that displace relatively flat-lying shales, sandstones, and limestones of the Chester and Meramec groups of Carboniferous age. Stratigraphic displacements range from a few feet to about 700 feet. Detailed geologic mapping of the surface and data from underground workings and diamond drilling have revealed 34 faults. Only a few of these faults contain economic deposits of fluorspar.

The most abundant vein minerals are calcite and fluorite, with subordinate quantities of sphalerite, galena, smithsonite, quartz, marcasite, and pyrite. Fluorspar bodies are of two types—gravel-spar deposits and vein deposits. The gravel-spar deposits are generally composed of high-grade fluorspar; the vein deposits are composed of calcite and fluorite. The sphalerite and galena generally are associated with the fluorite.

The localization of the vein deposits within the faults is believed to have depended primarily upon the availability of space for deposition. Replacement of the wall rock or vein minerals by mineralizing solutions has been slight.

INTRODUCTION

The Mineral Ridge fluorspar area is about 3½ miles southeast of Salem, Ky., in the eastern part of Livingston County and the southwestern part of Crittenden County (fig. 5). The area can be reached from Salem by going about 4 miles southeast on a graded gravel road that branches from U. S. Highway 60 at the eastern edge of Salem. The nearest railway terminal is at Marion, about 14 miles northeast of the area.

More than 25,000 tons of fluorspar and small quantities of zinc and lead have been mined in the area since about 1870. Most of the fluorspar, lead, and zinc came from the Mineral Ridge No. 1 property; other productive mines include the Riley, the Goering, the Billy Owl, and the Green Mines.

The area mapped and studied is rectangular, about 12,000 feet by 1,350 feet, and elongate to the northeast. Locally, the name Mineral

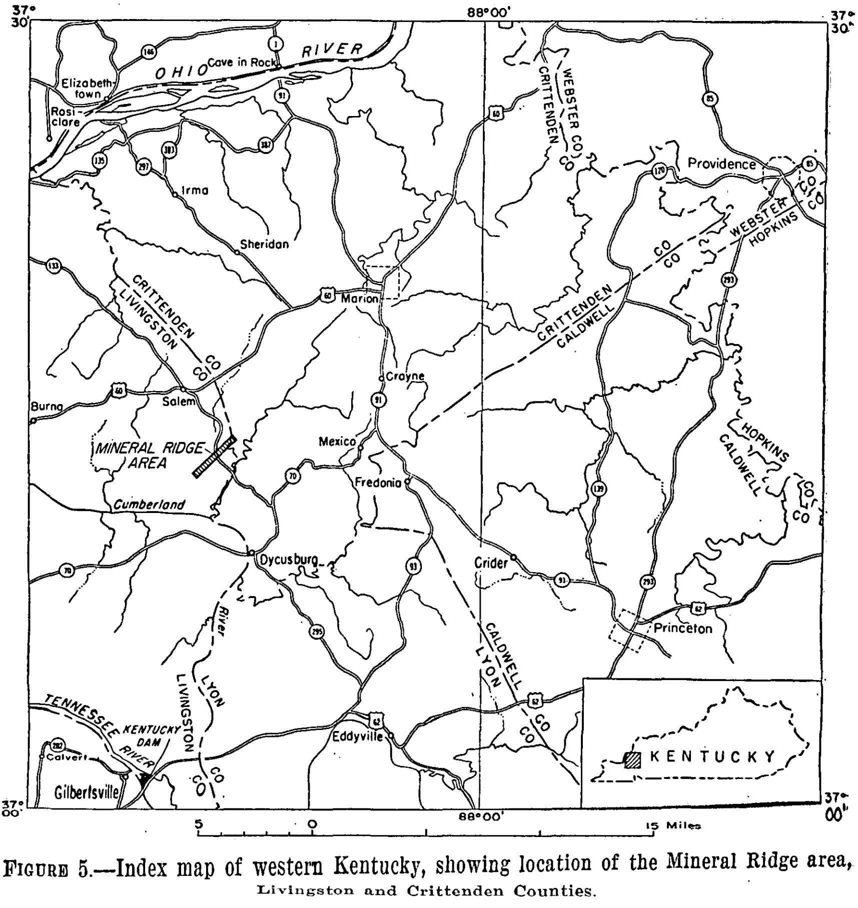


FIGURE 5.—Index map of western Kentucky, showing location of the Mineral Ridge area, Livingston and Crittenden Counties.

Ridge refers to the northeastern part of the Mineral Ridge No. 1 property, but in this report the name Mineral Ridge is applied to the entire mapped area. Mining has been done at various places along both sides of a narrow wooded northeast-trending ridge. Altitudes range from 330 feet to 490 feet above mean sea level.

The first mention of mining in the Mineral Ridge area was by Norwood (1876, p. 465–469) who described pits belonging to Tisdal, Henry Woods, and Robert Woods. From Norwood's map and description, these three shafts are probably on the Goering (formerly Woods) property.

Ulrich and Smith (1905, p. 195, 196) mention the Henry Woods and Hodge prospects, and the Riley mine. The Hodge prospect also is probably on the Goering property.

Fohs (1907) referred briefly to the Riley (p. 38, 222), Martin (p. 228), Woods (p. 230), and Tisdale (p. 230) prospects. Hoeing (1913) mentioned the Goering (Woods) and the Wallace (Pierce) properties. Currier (1923, p. 127, 128) described briefly a few prospects in the northeastern part of the mapped area. Sutton (Weller and Sutton, 1940; 1951) in 1929 mapped the geology of the Eddyville quadrangle, which includes the Mineral Ridge area.

In August of 1942 the U. S. Bureau of Mines examined the Mineral Ridge No. 1 property and in 1945 explored parts of the Woods fault and adjacent fractures by diamond drilling (Muir, 1947).

As part of the U. S. Geological Survey's program for the investigation of strategic and critical minerals, field study of the Mineral Ridge area was started in November 1942 and continued intermittently until March 1948. Field work was under the general supervision of James Steele Williams and R. E. Van Alstine. The geology of the area south of the road from Salem to Dycusburg was mapped mostly by R. T. Russell, with modifications and additions by the writer. Several other members of the U. S. Geological Survey, including H. J. Klepser, G. C. Hardin, Jr., W. R. Thurston, and D. A. Warner, have collaborated with Russell and the writer. The final responsibility for the work, however, is the writer's.

A. H. Reed, Sr., mining engineer of Marion, Ky., contributed data on inaccessible workings and historical information. The Ozark-Mahoning Co. furnished mine maps of the 215- and 300-foot levels of the John Pace shaft, drill-hole locations and logs of the Riley and Goering drill holes, and several property maps. The writer is particularly indebted to E. A. Brecke, engineer and geologist of the Ozark-Mahoning Co., for information about the area.

A system of coordinates was established in order to facilitate location of points in the Kentucky fluorspar district. The U. S. Geological Survey bench mark set in the concrete sidewalk about 40 feet west of the southwest corner of Grassham's garage at the corner of North Hayden and West Broadway Streets in Salem, Ky., was chosen as the zero point, and coordinate lines were extended from this point. (See coordinates on pl. 7.)

GEOLOGY

GENERAL FEATURES

The surface geology of the area northeast of the Salem-Dycusburg road is better known than that of the area to the southwest (pl. 7).

The northeastern part of the area has many drill holes and accessible mine workings. In contrast, the southwestern area has one diamond-drill hole and few accessible underground workings. Drill-hole data show that parts of the Mineral Ridge area are complexly faulted, and many structural interpretations are possible because of the difficulty in identifying the relatively small slivers of the formations in the faulted area.

The bed rocks exposed in the area are sandstone, limestone, and shale of the Meramec and Chester groups of Carboniferous age. No igneous rocks are exposed or have been reported. The sedimentary rocks are approximately horizontal except near faults, where beds have been dragged to various angles by movement along the fault planes. The complexly faulted area is bounded by two northeast-trending normal faults, the Clay Lick fault on the northwest, and the Woods fault on the southeast. The intervening faults have been given numbers arbitrarily by the writer for purposes of description (pl. 7). The stratigraphic displacement along the faults ranges from a few feet to at least 700 feet.

The relationship of topography to lithology and structure is clearly shown in the Mineral Ridge area. The northeast-trending ridge is a fault block of sandstone of the Chester group flanked by limestones of the Meramec group. Within the complexly faulted area the relationship is shown on a smaller scale by several "quartzite reefs," a local term for small ridges of silicified sandstone commonly present along faults in the area.

The thickness of overburden in the area generally varies with the type of underlying bedrock. Ordinarily the overburden above limestone averages about 20 feet in thickness, but may be as much as 70 feet. The overburden above sandstone, however, is very thin, usually ranging from 2 to 5 feet thick.

SEDIMENTARY ROCKS

The recognition of the formations in this complexly faulted area is a very difficult task. Because of few surface outcrops, most of the stratigraphic information is based upon drill-hole information. A drill may penetrate only a small part or sliver of a formation between faults. As a result, unless the lithology is particularly distinctive, the formation cannot be identified positively. Fossils were of little value in distinguishing formations, as most of the data came from drill holes. *Platycrinus penicillus* specimens confirmed the identification of the Ste. Genevieve limestone, and some species of *Lithostrotion* confirmed the identification of a few outcrops of St. Louis limestone. The formations exposed in the mapped area and their character and thickness are summarized in figure 6.

Age	Group	Formation and member	Thickness (feet)	Lithology
QUAT.		Alluvium	0 - 40	Silt, sand, and gravel; unconsolidated
CARBONIFEROUS	Chester group	Glen Dean limestone	25 +	Limestone, medium-gray, medium-grained; lower part of formation
CARBONIFEROUS	Chester group	Hardinsburg sandstone	125 ±	Sandstone, light-gray, fine-grained, with a few thin fissile gray shale beds
CARBONIFEROUS	Chester group	Golconda formation	100 +	Limestone, light- to dark-gray, fine- to medium-grained, with interbedded calcareous medium-gray shale. Upper shale beds are 0.5 to 1 foot thick and as much as 12 feet thick in lower part of formation
CARBONIFEROUS	Chester group	Cypress sandstone	125 - 225	Sandstone, light-gray, fine-grained, with a few shaly partings; 6- to 8-foot shale bed near top Shale, black and gray, commonly massive; or thin beds of intercalated shale and sandstone Sandstone, light-gray, fine-grained, with a few thin shale beds
CARBONIFEROUS	Chester group	Paint Creek shale		Limestone, medium- to dark-gray, fine- to medium-grained, commonly with shaly partings; green and black shale beds 1 - 10 feet thick; locally medium-gray fine-grained oölitic limestone beds about 2 feet thick; 5- to 10-foot bed of shale commonly at upper contact; locally 2-foot calcareous sandstone bed is present in the middle and near the top of the formation
CARBONIFEROUS	Chester group	Bethel sandstone		
CARBONIFEROUS	Chester group	Renault formation	75 - 100	
CARBONIFEROUS	Meramec group; Ste. Genevieve limestone	Levias limestone member	0 - 25	Limestone, light- to medium-gray, generally oölitic
CARBONIFEROUS	Meramec group; Ste. Genevieve limestone	Rosiclare sandstone member	0 - 15	Limestone, light-gray, fine-grained, sandy, or light greenish-gray sandstone
CARBONIFEROUS	Meramec group; Ste. Genevieve limestone	Fredonia limestone member	200+	Limestone, light- to medium-gray, fine- to coarse-grained, generally oölitic; in places contains shaly limestone beds and thin beds of green shale
CARBONIFEROUS	Meramec group	St. Louis limestone	300 +	Limestone, medium-gray, fine-grained, commonly with irregular-shaped dark-blue chert nodules 1 - 2 inches thick; locally is oölitic; may contain shaly partings; bottom not exposed

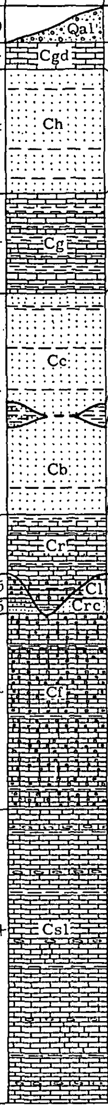


FIGURE 6.—Section of formations exposed in the Mineral Ridge area, Livingston and Crittenden Counties, Ky.

The St. Louis limestone of the Meramec group is the oldest exposed formation. Most of the area southeast of the Woods fault is underlain by St. Louis limestone. This area (pl. 7), however, is labelled undifferentiated St. Louis and Ste. Genevieve limestone, as some Ste. Genevieve limestone is known to be present on the footwall of the Woods fault in the vicinity of the John Pace shaft and also in places to the southwest. Residual chert of the St. Louis limestone also is found at the same and even higher altitudes. Faulting and associated drag folding probably occurred in the limestone footwall of the Woods fault, but because of the depth of overburden and lack of drill holes and mine workings, the faults could not be found.

The Ste. Genevieve limestone, also of the Meramec group, is present along the footwall of the Clay Lick fault, and also locally within the complexly faulted area. The formation is distinguished mainly on lithology. The bottom of the formation is placed at the lowermost bed of coarse-grained white oölitic limestone. The upper contact with the overlying Renault formation of the Chester group is drawn where the limestone becomes argillaceous. Commonly a shale bed is present in the lowermost part of the Renault. Some oölitic limestone may occur near the base of the Renault formation, but it is uncommon, and if present, the texture is noticeably finer grained than that of the Ste. Genevieve limestone. In some of the drill cores the Ste. Genevieve limestone has been differentiated into the Fredonia limestone, Rosiclare sandstone, and Levias limestone members (pl. 7).

The Chester group consists of alternating beds of limestone, sandstone, and shale. The sandstone formations are similar in many respects and it is difficult to differentiate among them unless an overlying or underlying formation is exposed also.

The Renault formation is composed of limestone and shale, typical of the formation elsewhere in the fluorspar field. Disseminated pyrite was noted locally. Individual grains or cubic crystals of pyrite average 0.1 millimeter in diameter but are as large as 0.8 millimeter; a few clusters of grains may be as large as 4 millimeters in diameter. A shale bed as much as 10 feet thick occurs locally in the uppermost part of the formation.

The Bethel, Paint Creek, and Cypress formations are dominantly sandstone with subordinate shale. These three formations were not differentiated in mapping. The Paint Creek shale could not be identified in most of the drill holes and probably is absent in places. The upper contact of the Cypress sandstone with the overlying Golconda formation in most places is gradational. The gradational zone, composed of thin beds of sandstone and limestone, is about 5 feet thick. Sandy shale, 6–8 feet thick, also occurs commonly at the top of the Cypress sandstone.

The Golconda formation is characterized in the Mineral Ridge area by thin interbedded shale and argillaceous limestone beds. The contact of the Golconda with the overlying Hardinsburg sandstone generally is sharp.

The Hardinsburg sandstone does not crop out and only a part of what is believed to be Hardinsburg sandstone was penetrated by a drill. It is primarily a sandstone, with a few thin shale beds.

The overlying Glen Dean limestone, the youngest Chester formation found in the Mineral Ridge area, may be exposed in one small area on the southwestern part of the Mineral Ridge No. 1 property.

Irregular to roughly spherical chert pebbles are found on the dump near a small pit on the Wallace property at coordinates 16,050 S. and 10,420 E. The pebbles are light gray, commonly brown stained and range in diameter from less than half an inch to 3 inches, averaging about half an inch. As this gravel was not found elsewhere in the Mineral Ridge area, and the area over which it crops out could not be traced, it is not mapped separately. Gravel similar to that on the Wallace property was reported to the writer by Sutton (oral communication) as the Tuscaloosa formation of Cretaceous age. Roberts described this formation in 1931.

Quaternary alluvial deposits of unconsolidated sand, silt, and gravel are found along Puckett Springs Branch (pl. 7).

STRUCTURE

The fault pattern of the mapped area (pl. 7) is complex, and surface information is inadequate to map the details. In the northeast part of the area, drilling and underground workings have furnished sufficient data for mapping a complex network of faults. South of the Salem-Dycusburg road, however, most of the fault pattern has been determined primarily from outcrops.

The best surface indications of faulting are fault breccia, evidences of mineralization, and the presence on the waste pile from shallow pits or shafts of rock belonging to stratigraphically widely separated formations. The relationship of topography to faulting has already been mentioned. In the Mineral Ridge area, this criterion, on a large as well as small scale, is of great value. Widely separated beds cropping out within a small area also indicate the presence of faults.

The rocks of the area are broken by two main normal high-angle faults, the Clay Lick fault (Weller's No. 74) and the Woods fault (Weller's No. 75). These faults are farthest apart (nearly 1,100 feet) in the central part of the area (pl. 7). The faults converge both to the northeast and southwest. Southwest of the Salem-Dycusburg road, the faults generally are about 500 feet apart, although at the extreme southwest end of the mapped area they are only about 100 feet apart. The two main faults range in dip from 70° toward each other to vertical. The downthrown grabenlike block between the bounding faults is broken by numerous normal faults; many fractures probably exist that are not shown on the map.

The amount of displacement along both the Clay Lick and Woods faults varies considerably. Between these bounding faults, cross faults have allowed some blocks to drop down more than others. The common displacement along the main faults is 300–400 feet, although a displacement of as much as 700 feet is known (pl. 7, section *N–N′*), bringing the Hardinsburg sandstone and Glen Dean limestone next to the St. Louis or Ste. Genevieve limestones. The displacement along cross faults is ordinarily less.

Dragged beds along most of the faults suggest that the movement was essentially vertical. Brecciation of beds is common along the faults. Most of the dislocation took place before mineralization, although the sheeted condition of the fluorspar veins probably suggests some postmineralization movement.

Where seen, the footwalls of the faults are not as brecciated as are the hanging walls. The footwall edges of the fault zones are commonly sharp and well defined, whereas the boundaries between the fault zone and the rock of the hanging wall are gradational and the hanging walls are cut by a series of en échelon faults. Seams of clayey fault gouge, generally a few inches wide, are abundant along the faults, particularly near the hanging wall. Commonly these seams of fault gouge are parallel to the fault and are interspersed between veins of fluorspar and calcite.

The age relationships of the faults could not be determined in detail. Mostly they are essentially contemporaneous, although some of the cross faults are probably a little younger than the northeast-trending main faults.

The fault pattern of the area has been mapped by Norwood (1876), Ulrich and Smith (1905), Weller (1926) and Sutton (Weller and Sutton, 1951). Norwood showed a single fault, the Excelsior, through the Mineral Ridge area. Ulrich first advanced the conception of two major faults, the "Marion" fault on the northwest and the Woods faults on the southeast, with intervening minor faults. Later work by Weller has shown that Ulrich's Marion fault is actually two different faults, and Weller has used the name Marion to describe a fault outside the mapped area. Therefore the name is discarded for the Mineral Ridge area and Weller's term "Clay Lick fault" is used here. The name "Woods fault" is retained for the southeast-bounding fault.

Previous mapping was done on scales of roughly 1 inch to 2 miles (Ulrich, 1905) and 1 inch to 1 mile (Weller and Sutton, 1951), on which it was impracticable to show the detail shown herein. The overall structural pattern, however, is but slightly changed from the older work. The mapping scales used formerly forced the previous workers to show the two major faults essentially as straight lines. Large scale mapping has suggested that the faults are curved in places.

Many details of the 34 faults are omitted from the following discussion inasmuch as the information is presented graphically (pl. 7).

The Clay Lick fault is the fault farthest northwest in the mapped area. This fault generally cannot be located definitely and is mapped mostly from topographic evidence. The Martin mine (pl. 7) is the only working along this fault.

The Wood fault, on the other hand, has been traced by extensive workings and many diamond-drill cores. Most of the ore produced in the area has come from this fault.

Fault 1 is a hypothetical fault, whose presence is suggested by the juxtaposition of the Cypress and Golconda formations near the bottom of the hill slope, with a massive-bedded sandstone, believed to be Cypress, on top of the hill. No outcrop of the fault was noted.

Fault 2 is a long fault, subparallel with the Clay Lick and Woods faults, and probably formed contemporaneously with them. Fault 17 (pl. 7) may be a continuation of this fault, but offset by fault 15. Fault 2 was traced along most of its extent by surface workings and diamond drilling. It is probably the second most productive fault in the area.

As most of the faults are nearly vertical normal faults, fault 3 is unusual in two respects: first, underground workings from the John Pace shaft show that above the 215-foot level it dips about 63° NW. (section *D–D′*), and second, recurrent movement along it that accompanied nearby younger faulting was of the reverse type (section *C–C′*).

Fault 4 is hypothetical, based on stratigraphic evidence shown in cores of diamond-drill holes (sections *C–C′* and *D–D′*).

Fault 5 was located by underground diamond drilling from the 215-foot level of the John Pace shaft. The 300-foot level on the northeast end curves as though to follow fault 5, rather than the Woods fault (fig. 6).

Fault 6, cut by several diamond-drill holes, nearly parallels fault 2 throughout its length. Fault 16 may be part of fault 6 offset by fault 15.

Fault 7 is hypothetical, based upon stratigraphic data from cores of Goering diamond-drill holes 6 and 7 and U. S. Bureau of Mines diamond-drill holes 95 and 96 (sections *I–I′* and *J–J′*). The topographic relief in the vicinity also is suggestive of the presence of this fault.

Fault 8 is hypothetical, presumably trending northeast, based upon stratigraphic evidence obtained from drilling cores (section *J–J′*).

Faults 9, 10, and 11 were found in diamond-drill holes and in the 75-foot level of the Mahoning-Goering shaft (sections *D–D′*, *F–F′*, and *G–G′*). The trends of faults 9 and 11 arbitrarily are plotted the same as that of fault 10. No surface evidence was found for these faults, probably because the walls of the faults are deeply weathered limestone.

The presence of fault 12 is based upon stratigraphic discrepancies (sections *J–J′* and *K–K′*) and topographic evidence.

Fault 13 was cut in diamond-drill holes (sections *K–K′* and *L–L′*).

Fault 14 is a small fracture entirely in sandstone where the drill penetrated it. No mineralized rock was found along it, and its trend is uncertain to the author.

The mapping of fault 15 is based mostly on evidence from diamond-drill cores (sections *M–M′*, *N–N′*, and *O–O′*). Silicified sandstone cropping out up hill from the junction of faults 15 and 16 is confirmatory evidence.

Faults 16 and 17 may be offset continuations of faults 6 and 2, respectively. Their presence is shown in diamond-drill cores.

Faults 18 and 19 were noted in diamond-drill cores. The projection of these faults to the surface is hypothetical because their dip is unknown.

The location of fault 20 is based upon topographic evidence, but the presence of this fault is indicated by sandstone, probably Bethel, cropping out near Ste. Genevieve limestone. Fault breccia and vein calcite were noted in two small pits along the fault.

Fault 21 is inferred from the offset of the Clay Lick fault, and also from the presence of silicified sandstone along the Salem-Dycusburg road and steeply dipping sandstone beds near the junction of that road with the mine road.

Faults 22 and 23 are entirely within sandstone at the surface. They were traced by exposures of silicified sandstone.

Fault 24 was inferred and traced from the distribution of float of silicified sandstone along the hill slope.

The presence of faults 25 and 26 is indicated by sandstone cropping out close to limestone and shale of the Renault formation.

Fault 27 is inferred from steeply dipping beds of sandstone and sandstone cropping out near the Lloyd shaft, which was sunk in Ste. Genevieve limestone.

The presence of fault 28 is suggested by the juxtaposition of Cypress or Bethel sandstone against Ste. Genevieve and St. Louis limestones.

Underground workings from the Green shaft are on fault 29 (fig. 7). The fault pattern in this area is not clearly understood. Fault 29 dips northwest in the Green shaft. The cross cut in the footwall at a depth of 77 feet is in cherty limestone boulders, presumably residual from the St. Louis limestone. At the top of a shallow shaft about 100 feet east of the Green shaft (pl. 7), however, sandstone is exposed. Possibly a fault joins fault 29 before reaching the surface; or perhaps a cross fault is subparallel to the road east of the Green shaft. The first interpretation is more probable.

Faults 30 and 31 are cross faults based upon types of waste rock taken from the various pits and shallow shafts.

The presence of fault 32 is based upon evidences of mineralization and fault breccia taken from a shallow shaft and a pit on the side of the hill slope.

FLUORSPAR DEPOSITS

GENERAL FEATURES

More than 25,000 tons of fluorspar has been produced from the mines and prospects of the Mineral Ridge area. In addition, small quantities of sphalerite, smithsonite, and galena, associated with the fluorspar, have been mined.

The fluorspar came from gravel spar and vein deposits, which are localized along parts of the faults of the area. Most of the ore has come from the vicinity of the John Pace shaft, where levels as deep as 300 feet have been worked.

MINERALOGY

The chief minerals in the fluorspar deposits are calcite and fluorite, with subordinate quantities of quartz, sphalerite, galena, smithsonite, marcasite, and pyrite.

The most abundant vein mineral is milky white to gray massive calcite ($CaCO_3$). Calcite veinlets are also scattered abundantly through the country rock near the fluorspar veins. The boundaries of the calcite veins and veinlets with the country rock are generally sharp, although gradational contacts occur in places. The massive calcite in the veins ordinarily is fractured only slightly. Studies of thin sections, however, show that the calcite is twinned almost invariably.

Fluorite (CaF_2) is the next most abundant vein mineral. It is brown, clear, or light purple. The brown or clear variety occurs where the vein is wide and is composed chiefly of fluorite; the purple variety is common where the fluorite is in small veinlets or aggregates of veinlets. Nearly all of the fluorite is coarse grained. Massive fluorite generally shows a sheeted structure, with bands about half an inch wide; it breaks readily along these bands.

Sphalerite (ZnS) is a common associate of fluorite. It is bright reddish-brown and occurs in small grains or aggregates of grains, either as veinlets or as scattered disseminations. The sphalerite is associated with the fluorite, and only subordinately with the calcite.

Galena (PbS) is common in the veins and, like sphalerite, is generally associated with the fluorite. Its distribution is much more erratic than that of the sphalerite. The galena ordinarily occurs in tiny imperfect cubes but locally in cubes as large as 1 inch on an edge.

Fine-grained quartz is commonly, although not abundantly, associated with the vein deposits. In thin section, the vein quartz is seen to be a felted or matted mass of small prismatic quartz crystals averaging 0.02 millimeter in length, similar to that described by Currier (1937, p. 384, 385). Locally part of the felted aggregate is composed of a mosaic of strained tiny quartz grains less than 0.001 millimeter in diameter. Fragments of sandstone also are found in the veins. In some samples probably derived from sandstone, the quartz grains are roughly equidimensional, 0.3 millimeter in diameter, and have a granoblastic texture. Parts of this type of siliceous material also are crushed and have a fine-grained cataclastic groundmass with clusters of the equidimensional quartz grains still present, typical of a mortar texture. Some of the rock containing equidimensional-grained quartz has an interstitial filling and coating of a carbonate mineral. Green chlorite, brown tourmaline, and biotite are locally present, suggesting a clastic origin of the siliceous material. A few tiny grains of twinned plagioclase feldspar were seen.

Tiny anhedral grains and cubic crystals of brassy pyrite are common in the fluorspar veins.

Marcasite occurs in a cavity cutting across the vein on the 300-foot level from the John Pace shaft (pl. 8). The cavity strikes northeast, parallel to the drift, and dips 15°–25° SE. The opening ranges in width from 1 to 2 feet; on both walls marcasite forms botryoidal masses with radii of about 2 inches. In polished section, the marcasite is seen to have wavy concentric growth rings. Each growth layer consists of strongly anisotropic blades of marcasite, radiating outward from the center of the mass.

THE VEINS AND ORE BODIES

The veins are commonly a mixture of calcite and fluorite, although either may occur to the exclusion of the other. The veins range in width from less than an inch to 40 feet; vein widths of about 4 feet are most common. In places the veins consist of sheeted coarse-grained brown or clear fluorite, but more commonly calcite is dominant, with small fluorite veins crosscutting the calcite. Sphalerite and galena are widely distributed through the veins, generally associated with the fluorite. Sphalerite locally may constitute as much as 6 percent and galena 2 percent of the vein material.

The contacts of the veins with the country rock are commonly sharp along the footwalls, but along the hanging walls the contacts between the veins and country rock are generally irregular and are marked by series of short en échelon fractures.

Very little information is available on the size of the ore bodies. Most of the mined deposits were residual deposits of fluorite formed by the weathering of the country rocks and gangue minerals near the surface and commonly termed gravel spar; data about them are scarce. Gravel-spar deposits were rarely more than 100 feet deep, 100–200 feet long, and 3–5 feet wide. In the workings of the John Pace shaft and other adjacent caved shafts, the ore body consisting of combined gravel spar and vein material is about 300 feet long, ranges in width from a few inches to 40 feet; it has been mined from the surface to the 300-foot level. Much of the vein is calcite at its wider places.

The grade of the mined fluorspar varied widely. The gravel-spar deposits were high grade, generally containing 60–85 percent of calcium fluoride. About 12,000 tons of ore was mined in 1946–47 from the vein deposit in the John Pace shaft; the ore averaged 45 percent of calcium fluoride, about 3 percent of zinc sulfide, and 1 percent of lead sulfide. Smithsonite is reported to have been mined in the weathered zone from a few shallow pits and trenches along the faults.

ORIGIN AND LOCALIZATION OF VEIN DEPOSITS

The relationships of the crosscutting minerals of the vein deposits indicate that quartz and calcite were the first minerals to be deposited. The vein quartz, found as the felted aggregates of prismatic crystals previously described, occurs sporadically as irregular remnants within the veins. Quartz may be the earliest vein mineral, but the evidence is insufficient to prove this conclusively. After a period of fracturing, fluorite filled the fractures and possibly replaced the calcite slightly. Fluorite replaced the country rock on a small scale, but evidence for large-scale replacement is lacking. The occurrence of sphalerite and galena in fractures in the fluorite suggests that the sulfides were the latest minerals to be deposited.

In the Mineral Ridge area few data are available on the localization of the vein deposits within the faults. Study of the workings from the John Pace shaft and the writer's general experience elsewhere in the Kentucky district, however, suggest that the most important factor was availability of space, both for penetration of the solutions and deposition of the calcium carbonate and fluorine. The source of the fluorine, although not definitely known, is assumed to have been magmatic. The calcite, at least in part, however, was probably derived from the country rock limestones.

In the John Pace shaft, the widest part of the vein occurs at the junction of the Woods fault and fault 5. The widening of veins at the junction of faults is common elsewhere in the district.

The control that stratigraphy exercised on localization of the ore is illustrated in a raise from the northeastern part of the 215-foot level of the John Pace shaft. According to the operator, a fluorspar vein between the Renault formation and the St. Louis limestone, was cut off abruptly at the contact of the Renault formation with the overlying Bethel sandstone (pl. 7, section *D–D′*). A shale bed about 3 feet thick at the top of the Renault formation probably had some influence in controlling the deposition of the vein minerals.

The influence of shale is illustrated also in the northeast face of the 215-foot level of the John Pace shaft (pl. 8). The vein pinches out against shale of the Renault formation. On the other hand, in a stope above the 215-foot level at the junction of the Woods fault and fault 5, a bed of shale about 5 feet thick stands nearly vertical on the hanging wall near the widest part of the vein.

DESCRIPTION OF MINES AND PROSPECTS

RILEY

The Riley mine was first described by Ulrich and Smith (1905, p. 195–197). The shaft they described was sunk in 1904 to a depth of 75 feet; it is caved now, and a slumped area is the only evidence remaining (pl. 7). A jig mill was built on the property in 1903 but dismantled in 1907. According to local reports, little effort was made to mine fluorspar. Since 1907, several shallow shafts and prospect pits were dug along the Woods fault, and small amounts of fluorspar were mined. Currier (1923, p. 127) reported that the property was in operation in 1920.

Fohs (1907, p. 276) referred to the Riley mine and stated that a 2-inch vein of wad was present in the old original shaft. This report was not verified by the writer.

The Ozark-Mahoning Co. drilled 9 holes on the property in 1946. Hole 4 cut about 6 feet of material containing an average of 35 percent of calcium fluoride and small quantities of zinc and lead. Most of the other holes cut barren fault zones (pl. 7, sections *A–A′* and *B–B′*). Fluorspar on dumps from pits along the Woods fault contains typical fluorspar vein material with small quantities of sphalerite and galena.

MINERAL RIDGE NO. 1

The first definite mention of mining on the Mineral Ridge No. 1 property was made by Currier (1923, p. 128), who briefly described the prospect of the Farris Fluorspar Co. The old Woods prospects

(Norwood, 1876, p. 465–469), however (mentioned below under a description of the Goering property), possibly may be on the Mineral Ridge No. 1 property.

Muir (1947, p. 3–4) described the general history of development on the property up to the time of the work by the Ozark-Mahoning Co. in 1945. Muir also described the results of a U. S. Bureau of Mines diamond-drilling program in 1945 on the property.

The Mineral Ridge No. 1 property has produced most of the ore mined from the Mineral Ridge area. Nearly all of this ore has come from the northeastern part of the property. Production data before 1937 are not available. Between 1937 and 1941, however, about 3,500 tons of fluorspar was mined. In 1944, Mr. Diffie of Tulsa, Okla., leased the property and put down 2 diamond-drill holes (pl. 7). The Ozark-Mahoning Co. from 1945 to 1947 produced about 12,000 tons of ore containing an average of 45 percent of calcium fluoride, 3 percent of zinc sulfide, 1 percent of lead sulfide, 30 percent of calcium carbonate, and 20 percent of silica. The mine was subleased to the Alco Lead Co. in November 1947.

Shafts and pits have been dug at various sites on the property, particularly near the northeast end. Little information is available about the work southwest of the John Pace shaft, with the exception of a 40-foot shaft sunk in 1947 about 20 feet southeast of U. S. Bureau of Mines diamond-drill hole 105. The shaft went through limestone boulders and a few veinlets of calcite and fluorite, but no ore deposits were found (pl. 7, sec. *O–O′*).

The Luther Pace and Old shafts were inaccessible at the time of the field work, but A. H. Reed, Sr. (oral communication), states that the Luther Pace shaft was sunk 60 feet, and a short crosscut was made at a depth of 25 feet; about 8 inches of fluorspar was cut. The upper 30 feet of the shaft was sunk in Cypress sandstone and the lower 30 feet in shale and shaly limestone, probably belonging to the Paint Creek shale. The Old shaft (now caved) was 185 feet deep with levels at depths of 100, 150, and 185 feet. Most of the ore from the entire Mineral Ridge area before 1945 was made from these workings. A considerable quantity of the ore probably was gravel spar.

The John Pace shaft (pl. 8) was sunk to a depth of 130 feet in 1941, after the Old shaft had caved. A crosscut was driven to the vein, which consisted of a wide zone of calcite and limestone breccia with scattered fluorite veinlets. Bethel or Cypress sandstone is present at the northwest end of the crosscut, and St. Louis limestone is present to the southeast on the footwall.

In 1945, the Ozark-Mahoning Co. sank the John Pace shaft to a depth of 215 feet and sank a winze from that level to a depth of 300 feet (pl. 8). Most of the 12,000 tons of ore shipped from the property from 1945 to 1947 by the Ozark-Mahoning Co. came from these levels. The country rock in the crosscut on the 215-foot level and the footwall of the Woods fault along the southeast side of the drift is St. Louis limestone. In the southwestern part of the workings, the Renault formation and Bethel sandstone are present on the hanging wall. To the northeast, the Renault formation is exposed on the hanging-wall side, as a result of cross faulting. The zone of widest mineralized rock and vein material is near the junction of the Woods fault and fault 5.

On the 300-foot level, the footwall of the Woods fault is St. Louis limestone and the hanging wall is the Renault formation.

GOERING

The original prospects in the Mineral Ridge areas mentioned by Norwood (1876, p. 19–21) were the Henry and Robert Woods shafts, probably on the Goering property. The Hodge prospect mentioned by Ulrich and Smith (1905, p. 195) is possibly on this property also. Currier (1923, p. 127–128) mentioned shallow workings of the Giant Mining Co.

Few production data are available for the Goering property. In 1917, about 125 tons of fluorspar was mined. Lessees probably have mined a total of a few hundred tons of fluorspar at various intervals.

Operations on this property generally have been in the western part near the Wallace property and in the central part. Most of the mining has been on a small scale, as the shafts are 50 feet or less in depth.

The Ozark-Mahoning Co. drilled 8 diamond-drill holes (pl. 7) late in 1946. In 1947, the Mahoning-Goering shaft was sunk to a depth of 75 feet (section *F–F′*), and some fluorspar was mined from a level at that depth. Later the shaft was sunk to a depth of 125 feet, but little mining was done.

WALLACE

The Wallace (Pierce) property was not operating during the time of the writer's field work, and information about it is meagre. Most of the work on the property was done in the northeast corner, near the Goering and Mineral Ridge No. 1 properties.

The first mention of the property probably was by Ulrich and Smith (1905, p. 195), who referred to it as the Henry Hodge prospect. The writer is uncertain whether Ulrich and Smith were referring to the workings on the Wallace property or on the Goering property.

Hoeing (1913, p. 65) noted that zinc carbonate was being mined in 1913 from the A. J. Pierce property.

Small-scale mining operations were conducted during World War I, according to local reports, and shortly afterwards according to Currier (1923, p. 127, 128).

OPENCUT NORTHEAST OF JOHN PACE SHAFT
Mineral Ridge No. 1 property. View looking northeast along Woods fault, 1944.

The last mining operation on the property was about 1930 when the Wallace Fluorspar Co. sank a shaft to a depth of 130 feet near the Goering property line. Considerable gravel spar and some galena are reported to have been found. This shaft could not be identified in the field by the writer.

MARTIN

Ulrich and Smith (1905, pl. 8) show the location of the Tom Martin prospect on their geologic map. Fohs (1907, p. 228) mentioned that the Martin prospects were operated by C. and A. T. Pope in 1904 and that J. A. Clark had started prospecting on the property in 1902.

Since 1904 small-scale mining operations have been conducted at intermittent intervals and small quantities of gravel spar have been mined. The shafts were probably no more than 50 feet deep.

KELLY

No large-scale mining has taken place on the Kelly property or on other properties southwest of the Salem-Dycusburg road. Gravel spar and some smithsonite and galena have been mined from several shallow shafts and pits on the Kelly property. Few historical or geologic data are available for this property.

No records are available of production from the Kelly property. According to A. H. Reed, Sr., Mr. Kelly Spradling mined a little fluorspar during World War I. In 1944 Mr. Ray Jennings sank a shaft to a depth of 100 feet (pl. 7). The U. S. Bureau of Mines put down one diamond-drill hole in 1945 (Muir, 1947, p. 6, 9).

BILLY OWL

The first work on the Billy Owl property known to the writer was done in 1935 and 1936 when the Pugh No. 1, Pugh No. 2, and Billy Owl shafts were operated. The depths of these shafts are 30, 60, and 125 feet, respectively.

No production data are available for the Billy Owl property. A small quantity of gravel spar with a little galena has been produced from the various shallow pits and shafts.

When James Steele Williams of the Geological Survey visited the Billy Owl shaft in November 1942, the shaft was about 125 feet deep with short crosscuts and drifts at depths of 72 and 115 feet. On both levels low-grade purple and honey-yellow fluorite with a little galena occurs in a matrix of clay and calcite boulders.

GRASSHAM NO. 3

Very little prospecting has been done on the Grassham No. 3 property. The Lloyd shaft was sunk during World War II to a depth of 30 feet in Ste. Genevieve limestone. The waste dump at the shaft contains white calcite with small streaks of purple and colorless fluorite and traces of galena and sphalerite.

GREEN

According to local reports, some gravel spar was mined in 1919 from the trench in the western part of the Green property (pl. 7).

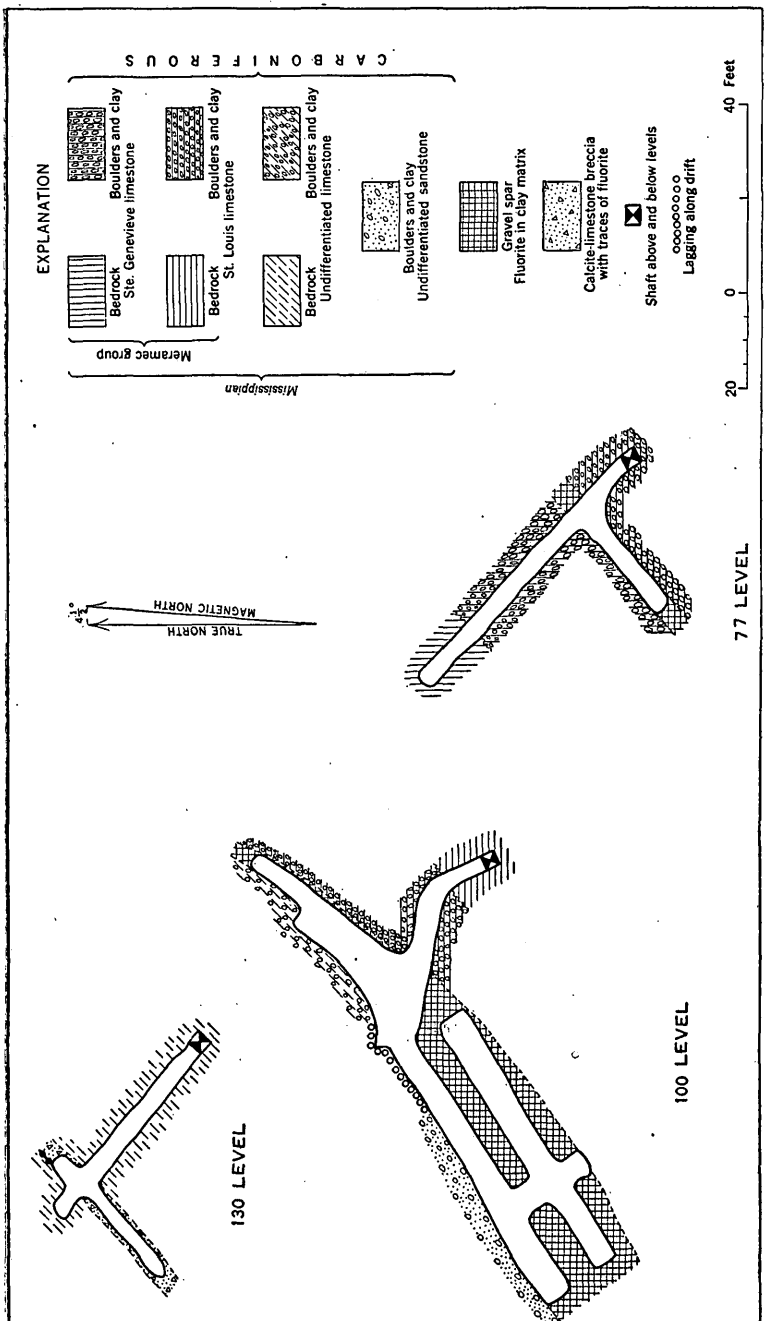
The Green mine (fig. 7) was started about 1929 by a Mr. C. E. Townsend. About 400 tons of fluorspar was mined between 1929 and 1936 from the upper level and shaft. In 1940, Mr. C. N. Pugh of Sturgis, Ky., sank the shaft to a depth of 130 feet and drove crosscuts and drifts at depths of 100 and 130 feet.

The 77-foot and 100-foot levels were driven in gravel spar that ranged from 4 to 20 feet in width. High-grade gravel spar about 2 feet wide was seen by Russell in the faces on the 77-foot level. Two zones of gravel spar, each about 4 feet wide, were found on the 100-foot level. The 130-foot level is below the weathered zone; the vein is solid and is composed of a calcite-limestone fault breccia with traces of fluorite. The Green mine is a typical example of a low-grade vein deposit that was concentrated by weathering to a high-grade, although small, deposit of gravel spar.

RYAN

According to Messrs. Robert and Richard Reed of Paducah, Ky., about 30 tons of high-grade gravel spar was taken in the fall of 1942 from a 30-foot shaft (now filled) on the Ryan property just south of the Reed shaft (pl. 7).

Because of bad ground the 30-foot shaft was abandoned, and the Reed shaft was sunk to a depth of 86 feet. Crosscuts were driven in four directions at a depth of 60 feet, but no fluorspar was found.



From pace and compass survey, 77 level by R. D. Trace September 1943, 100 and 130 level by R. T. Russell, May 1945

FIGURE 7.—Map of underground levels of the Green Mine, Mineral Ridge area, Livingston County, Ky.

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