Fluorspar Deposits in Western Kentucky

Part 1

A. Introduction

By JAMES STEELE WILLIAMS *and* HELEN DUNCAN

B. Babb fault system, Crittenden and Livingston Counties

By GEORGE C. HARDIN, Jr.

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FLUORSPAR DEPOSITS IN WESTERN KENTUCKY

INTRODUCTION

By James Steele Williams and Helen Duncan

The need for fluorspar in the manufacture of open-hearth steel, hydrofluoric acid, aluminum, certain insecticides, refrigerants and air-conditioning compounds, welding rods, 100-octane gasoline, and many other products necessary to the prosecution of World War II resulted in unprecedented demands for this commodity. To help increase production to meet these demands, the War Production Board in 1942 asked the United States Geological Survey to plan a comprehensive study of the fluorspar deposits in the United States. This study has been carried on in many parts of the country in cooperation with geologists and engineers of State and Federal agencies and with local producers.

Before planning a specific program for field work, the senior author accompanied by L. W. Currier, also of the Geological Survey, visited the Kentucky-Illinois fluorspar field in June 1942. As a result of this visit, a confidential report prepared for war agencies recommended that detailed geological studies be made of certain mineralized areas in the region. The accompanying reports describe most of the fluorspar areas studied in western Kentucky.

For many years prior to World War II more than 90 percent of the total fluorspar output of the United States came from the Kentucky-Illinois field, which contains by far the most important deposits of this commodity in the country. The field includes about 700 square miles in southeastern Illinois and western Kentucky. The principal mineralized areas are in Crittenden, Caldwell, and Livingston Counties in Kentucky and in Hardin County, across the Ohio River in Illinois. The largest towns in the region are Rosiclare, Elizabethtown, and Cave in Rock, all situated along the Ohio River in Illinois, and Marion and Salem in Kentucky. Transportation of fluorspar is by barge from towns located along the Ohio River, by truck, and by railroad. Marion, Ky., and Rosiclare, Ill., are on branch lines of the Illinois Central Railroad, but Elizabethtown, Cave in Rock, and Salem are not served by railroads. Illinois State Route 34 connects the Illinois part of the field with U. S. Highway 45 and U. S. Highway 60 crosses the Kentucky part. Ferries operating at Cave in Rock and Elizabethtown provide means of crossing the Ohio River in this area. Marion, which is the center of the fluorspar industry in Kentucky, is about 11 miles by highway from the Ohio River and 25 miles by rail from Princeton, Ky.

Topographically the region is characterized by rolling hills, wide valleys, and moderate relief. In general the higher hills are capped by sandstones and the broad valleys are underlain by limestones or shales. Altitudes range from 300 feet to a little more than 800 feet above sea level. The Ohio River is the principal waterway. The Kentucky part of the field is drained by the Tennessee and Cumberland Rivers and smaller streams tributary to them, and by other streams that flow directly into the Ohio River.

The rocks in the region are largely of sedimentary origin; but dikes, sills, and irregularly shaped bodies of intrusive rocks are present. These igneous bodies are mainly lamprophyres or mica peridotites. The sedimentary rocks are chiefly limestones, sandstones, and shales of late Paleozoic age. The St. Louis limestone of the Meramec group is the oldest formation of Mississippian age that the writers found exposed at the surface, but A. H. Sutton (Weller and Sutton, 1951) has reported that the Spergen limestone crops out north of Princeton. Older rocks, however, are penetrated in some of the deeper mines in Kentucky and Illinois. The St. Louis limestone is overlain by the Ste. Genevieve limestone, the youngest formation of the Meramec group, above which is a sequence of alternating limestones, sandstones, and shales of the Chester group, also of Mississippian age. In places these are overlain by the Caseyville sandstone of Pennsylvanian age. Cretaceous and Tertiary formations are known in the southern edge of the Kentucky part of the field, and isolated remnants of these younger formations are found elsewhere in the area. Quaternary deposits of residual, alluvial, and eolian origin occur in the stream valleys and locally on the hill tops and slopes. The accompanying stratigraphic section gives the general lithologic character and thickness of the Paleozoic formations exposed in the Kentucky part of the field.

Structurally the Kentucky-Illinois fluorspar field consists of two eroded anticlinal uplifts that have been intruded by dikes and other igneous bodies and broken by many faults. The center of the northern uplift is in Hardin County, Ill. The location of the center of the southern uplift is not definitely known, but it is thought to be along the Tennessee River, west of Paducah. Most of the larger faults in the Kentucky part of the field are high-angle normal faults that trend northeastward. Stratigraphic displacements along these faults range from a few inches to almost 2,000 feet, displacements of 300 to

800 feet being common. These faults are cut or joined by cross faults and other fractures and by oblique faults that are in the main shorter and have less displacement than the principal faults; however, a few of the northwestward-trending faults and especially the eastward-trending faults, are long and have large displacements. A few prominent faults are of the low-angle type, and some small reverse faults may be present. Except near the faults, along which deformation is rather marked locally, the sedimentary rocks are nearly horizontal.

Generalized section of Carboniferous formations exposed in the western Kentucky fluorspar district

[With field collaboration of J. Marvin Weller and A. H. Sutton]

Age	Group	Formation and member	Character	Thickness (feet)
Pennsylvanian.	Pottsville.	Caseyville sandstone.	Mainly sandstones with some sandy shales and clay shales; sandstones are conglomeratic in some places; a thin bed of coal occurs locally.	60-400
Mississippian.	Chester group.	Kinkaid limestone.	Alternating limestone and shale beds of variable lithology; limestones typically dense, light- to medium-gray, thin-bedded, nonargillaceous but with shale partings; shales commonly gray to black, but red and olive-green layers rather characteristic of formation in western part of area; sandstone beds in lower part, and one or more persistent layers of milky-gray to blue-gray chert 1 to 5 feet or more thick occur near base of formation, especially in Livingston County; large boulders of chert are characteristic of weathered rock.	[1] 0-200
		Degonia sandstone.	Yellow to brown thin-bedded flaggy cross-bedded ripple-marked sandstone; carbonaceous in some places; thins eastward.	10-30
		Clore limestone.	Gray thin-bedded shaly limestone interbedded with argillaceous and calcareous shales.	30-60
		Palestine sandstone.	Light-gray thin-bedded to massive medium-grained sandstone, olive-tan to grayish in surface exposures.	40-80
		Menard limestone.	Dark-gray, dark olive-tan, and black fine-grained to sublithographic, commonly argillaceous limestones interbedded with thin zones of very dark gray fissile shale and clayey shale; some beds of dense limestone contain large crystals of dark-brown calcite.	80-140
		Waltersburg sandstone.	Medium-gray fine-grained shaly thin sandstone beds and very dark gray shales, mostly in lower part; sandstones are massive in some places; sandstones characteristically weather to thin rectangular blocks; some coaly streaks in shales.	20-60
		Vienna limestone.	Upper part mainly dark-gray fissile shale and dark-gray calcareous clayey shale, which weathers tan to light yellow; lower part, dark-gray fine-grained limestone and medium-gray crystalline limestone; some 1- to 2-inch beds and nodules of dark-blue chert; formation generally weathers to mass of clay filled with leached soft, spongy chert fragments 1 inch or more in diameter.	20-40
		Tar Springs sandstone.	Light- to medium-gray fine-grained shaly sandstone, dark-gray shale, and shale with thin sandstone lenses; may contain thin coal beds.	100-200

See footnotes at end of table.

Generalized section of Carboniferous formations exposed in the western Kentucky fluorspar district—Continued

Age	Group	Formation and member	Character	Thickness (feet)
Mississippian.	Chester group.	Glen Dean limestone.	Light- to medium-gray medium-grained to coarsely crystalline, commonly crinoidal limestone with relatively thin medium-gray shale beds; many beds coarsely oölitic; very fossiliferous; may contain 4- to 5-foot bed of sandy shale and sandstone near middle.	40–90
		Hardinsburg sandstone.	Light-gray fine- to medium-grained massive sandstone with dark shale member in middle; rare greenish shale beds; in some places a thin basal conglomerate; some thin beds of limestone; slabby at most exposures.	20–140
		Golconda formation.	Dark-gray to black fissile shale and calcareous clayey shale, which weathers tan or brown, with thin dark-gray shaly limestone beds and nodules; limestone beds weather to flags and are very fossiliferous at most places; locally contains sandy shale and sandstone near middle.	30–170
		Cypress sandstone.	Light-gray to greenish-gray fine- to medium-grained massive sandstone, calcareous in some places; dark shale member in middle or near base of formation; conglomeratic beds near base in some places; beds become thinner southeastward; weathers slabby at some localities.	25–125
		Paint Creek shale.	Dark-gray slightly sandy shale with thin beds of impure nodular limestone and sandstone in western and northern parts of area; limestone beds become predominant toward southeast.	¼–100
		Bethel sandstone.	Light-gray medium-grained massive sandstone, weathering light brown to light gray; some flaggy beds and thin blue-gray clay shales; conglomeratic sandstone at base in some places.	25–125
		Renault formation.	Medium- to dark-gray medium- to coarse-grained crystalline limestone, shaly limestone, and dark greenish-gray or, locally, red commonly calcareous shales; some oölitic zones; many limestone beds contain very small crinoid stems and other small fossils.	20–100
	Meramec group.	Ste. Genevieve limestone. Levias limestone member (Lower Ohara limestone member of some reports).	White to light- or medium-gray oölitic limestone; contains pink calcite crystals at many localities; a few beds are nonoölitic, but many are 95 percent oölites.	[2] 0–50
		Ste. Genevieve limestone. Rosiclare sandstone member.	Greenish-gray to olive fine-grained commonly calcareous or shaly, slabby or massive sandstone, weathering olive-brown to buff; in places contains small lenses of black clay; member is lenticular and gradational into limestones in some localities.	[2] 0–20
		Ste. Genevieve limestone. Fredonia limestone member.	Mainly white to light-gray and brown-gray oölitic limestone commonly cross bedded and stylolitic; many beds composed entirely of oölites; some beds containing few oölites are medium crystalline; others, especially in the lower part, are dense to lithographic dark-gray or ivory-colored and nonoölitic; some chert nodules; member contains some very thin zones of green shale and, in places, lenses of sandy limestone or limy sandstone (Sub-Rosiclare? sandstone); member weathers to red soil.	180–200
		St. Louis limestone.	Medium-gray to nearly black fine-grained to lithographic limestone and dolomite; contains abundant blue-gray and some tan to ivory-colored chert nodules; some oölitic beds and a very few thin beds of white to light-gray calcareous sandstone; many stylolites; some limestone beds are brownish gray and medium crystalline; formation weathers to deep brownish-red chert-covered soil.	[3] 350–400

[1] Entirely removed in some places by pre-Pottsville erosion.
[2] Entirely removed in some places by pre-Chester erosion.
[3] Entire thickness not exposed.

The fluorspar deposits of the Kentucky-Illinois field may be divided into three types: vein deposits, bedding-replacement deposits, and residual or gravel-spar deposits. The principal fluorspar bodies in the important Cave in Rock area, Illinois, are of the bedding-replacement type, whereas most of those mined in the Rosiclare area, Illinois, and in Kentucky are vein deposits. A few bedding-replacement deposits are associated with some of the veins in Kentucky. The residual or gravel-spar deposits originated from the weathering of veins and locally form workable bodies of fluorspar above noncommercial veins.

Most of the large vein deposits are in the principal northeastward- or eastward-trending faults, but in places the largest deposits are in cross or oblique faults or other fractures. Some of the vein deposits are generally thought to be fissure fillings with very little replacement of the wall rock; others are generally thought to have resulted from a relatively large amount of wall-rock replacement. In some deposits the fluorspar cements breccia fragments.

The fluorspar bodies of the veins are lenses in a broad sense but are irregular in shape and variable in size. Some pinch out abruptly both laterally and vertically, some have considerable length but little vertical extent, some are much greater in vertical than in horizontal dimension, and some are about as long as deep. The position and size of the fluorspar bodies are influenced by structural and stratigraphic factors.

Calcite is the most abundant mineral of the veins. With it are commonly associated fluorite, sphalerite, galena, and quartz. Barite is common in a few veins but is very rare in most. Other associated minerals are marcasite, pyrite, chalcopyrite, greenockite, malachite, smithsonite, gypsum, and limonite. Ankerite, cerussite, pyromorphite, anglesite, celestite, sulfur, hydrozincite, and calamine have also been reported. Bitumen is present, especially with fluorite, in some of the veins. No generalizations are as yet warranted concerning the vertical or lateral distribution of galena, sphalerite, fluorite, or calcite, either within the veins or with respect to the whole field. Theories for the origin and localization of the fluorspar and the paragenesis of the minerals have been discussed by several authors (p. 6), some of whom have held that the Kentucky-Illinois deposits belong to the mesothermal class. Evidence gathered in connection with the studies of the various fault systems to be described suggests that the deposits are more likely epithermal or telethermal.

The quality of the fluorspar varies greatly in the Kentucky-Illinois field, even within deposits along a single fault system. In general the silica content is low. Sphalerite and galena occur in minor amounts in most deposits, but either mineral may form an ore body or an important percentage of the ore in certain parts of fluorspar deposits that are elsewhere relatively free from these minerals. In some places the fluorspar has been so high grade that it has been mined and shipped, with only a small amount of hand sorting, as acid-grade fluorspar. It thus contained 98 percent or more of calcium fluoride and not more than 1 percent of silica. The fluorspar now being mined averages about 45 percent of calcium fluoride, but material containing as little as 35 or perhaps even 30 percent has been commercially minable under especially favorable conditions.

In the reports of this series, the term fluorspar is used for a mineral aggregate or mass containing enough fluorite to meet the qualifications of ore or potential ore, even at a future date. Fluorite, the essential constituent of fluorspar, is a mineral having specific properties and a definite chemical composition—calcium fluoride (CaF_2). In its most limited definition, the word ore is restricted to minerals that are mined for their metallic content; but for want of a more appropriate term, it is commonly applied to many nonmetallic minerals.

The following chapters of this bulletin deal with fluorspar deposits along one or more fault systems or with fluorspar deposits grouped according to other criteria. The mapped areas are restricted fairly closely to the immediate vicinity of the faults and mineralized areas.

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