Geology and Mining of Gypsum in Southwestern Indiana[1]

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Introduction

Gypsum in southwestern Indiana was first noted by Logan (3), who described a layer of selenite a few inches thick in the vicinity of Huron, Lawrence County. Many hundreds of oil and gas wells were subsequently drilled in southwestern Indiana, but not until about 30 years later were relatively thick beds of gypsum and anhydrite recognized in the lower part of the St. Louis Limestone (Meramec, Mississippian).

Intense exploration for commercial quantities of gypsum began in 1951. McGregor (4) later delineated the approximate limits of the evaporite deposits. By late 1955 the National Gypsum Co. and the U. S. Gypsum Co. had established mines and fabricating plants and were shipping gypsum products from the Shoals (Martin County) area. In 1958 the Pennsylvania Railroad Co. discovered a potentially commercial deposit in T. 9 N., R. 5 W., Owen County, and in 1964 the Indiana Geological Survey discovered another potentially commercial deposit in sec. 10, T. 7, N., R. 4 W., Greene County. The deposits in Owen and Greene Counties have not been developed.

Stratigraphy

Gypsum and anhydrite have been observed in well cuttings from a broad band that extends northwestward from Perry and Harrison Counties to Vigo and Clay Counties and then southwestward along the Indiana-Illinois border (Fig. 1). Evaporites are found in the lower part of the St. Louis Limestone and are associated with carbonate rocks that are characteristically less cherty than the upper part of the St. Louis. The lower St. Louis Limestone ranges from less than 100 feet thick at the outcrop to more than 270 feet thick in the extreme southwest corner of the State. The strata dip approximately 35 feet per mile to the southwest but do not increase regulary in thickness from northeast to southwest as might be expected in this part of the Illinois Basin. A northward-trending belt of lower St. Louis rocks, about 150 to 200 feet thick, separates a belt of slightly thicker rocks in Martin, Daviess, Dubois, and Perry counties from the major part of the basin. The known commercial deposits of gypsum appear to be coincident with small embayments along the eastern flank of the belt of greater sedimentation (Fig. 1).

The lower part of the St. Louis Limestone in the evaporite area is largely composed of brown carbonaceous limestones alternating with gypsum and anhydrite. Black, gray, red, and green shales are found near the top of the unit. Dolomite is present as continuous tan to brown fine-grained strata; dolomite also is found in lenses associated with minor structural highs. Traces of chlorides are found within the

1. Submitted with approval of the State Geologist, Dept. of Natural Resources, Geological Survey, Bloomington, Indiana.

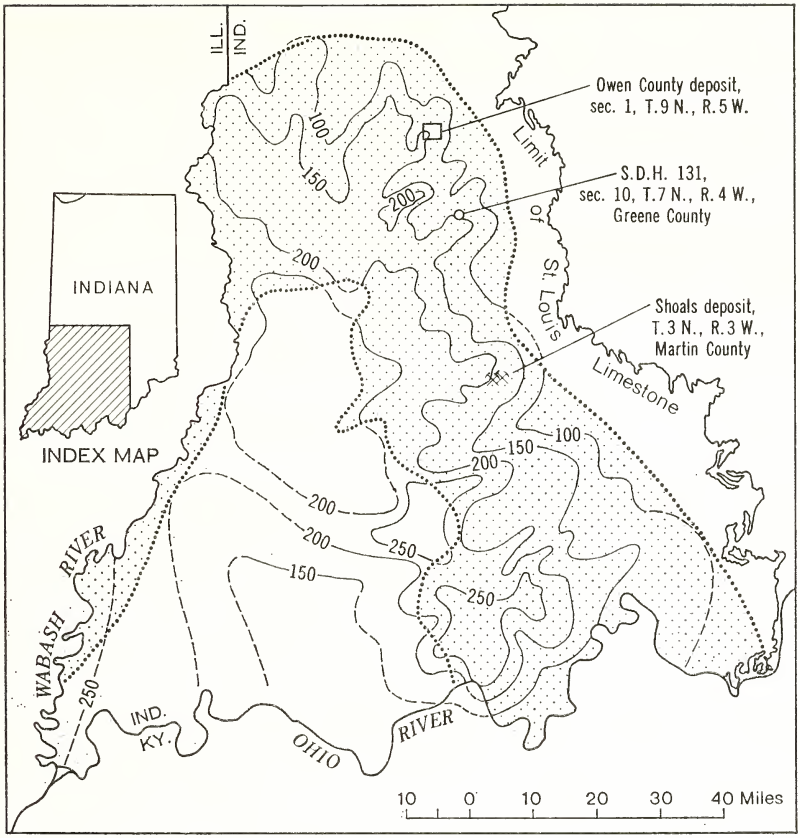

Figure 1. Map of southwestern Indiana showing thickness of lower part of St. Louis Limestone and approximate distribution of evaporites.

evaporites, and fluorite crystals are present in vuggy carbonate rock above and below the evaporite unit.

In the western part of the Shoals deposit a bed of shale, 1½ to 2 feet thick, lies near the top of the main gypsum bed. X-ray analyses indicate that the shale is largely composed of quartz, illite, chlorite, and dolomite.

The evaporites are present in four or fewer beds, none of which is known to exceed 16 feet in thickness. Most of the gypsum is gray to white and is largely crystallized in the tabular selenite form. Some pink to brown selenite is present near the top of the unit. Secondary gypsum that has recrystallized in near-vertical fractures and along bedding planes is mostly of the fibrous "satin spar" variety. This secondary material is white to transparent and in places contains inclusions of shale or carbonate rock that have been displaced from the surrounding material. Blue-gray anhydrite is present in lateral and vertical continuity with the gypsum. Inclusions of dolomite are common within the anhydrite, and conversely, anhydrite veins and crystals are commonly

found in the dolomite. Bundy (1) stated that much of the anhydrite was recrystallized from older anhydrite or gypsum.

The St. Louis Limestone is exposed at the surface a few miles east of the present major evaporite beds, but only traces of nodular gypsum have been noted in the outcrop area. Breccia within the section suggests that the gypsum, if formerly present, was probably leached by ground water. In Illinois, Saxby and Lamar (6) also recorded the presence of breccia and the absence of gypsum in the outcrop.

Depositional Environment

It is generally accepted that a restricted environment in which normal marine circulation has been modified by a sill or barrier is required for the deposition of gypsum. The mechanics of developing such an environment may be multiple and are not fully understood with respect to the evaporites of southwestern Indiana. McGregor (4) postulated that epeirogenic movements periodically caused sills to form within the basin. Pinsak (5) suggested that sills were caused by differential compaction in the strata overlying Silurian reefs.

Some structural relief does exist on the underlying Salem Limestone, but the relief may not be due to compaction over Silurian reefs. Certainly, the configuration of the evaporite distribution is not well enough known to allow definite conclusions to be drawn about the true depositional environment. Topographic barriers separating shallow lagoons or estuaries from the sea could produce features similar to those resulting from compaction. Calcareous mudbars having some subaerial or underwater relief at the top of the Salem Limestone (5) support such an interpretation.

Commercial Deposits

The Shoals deposit is mostly in T. 3 N., R. 3 W., Martin County. The National Gypsum Co. has opened an inclined shaft in the SW¼ sec. 21, and the U. S. Gypsum Co. has opened a vertical shaft in the NW¼ sec. 23. The main ore body at Shoals has a maximum known thickness of about 16 feet. Commercial-grade gypsum is present over several square miles at depths ranging from about 350 feet in the east to more than 500 feet below the surface in the west end of the deposit. The deposit averages approximately 75 to 95 percent gypsum, and the remainder is limestone, dolomite, shale, and anhydrite. Recent tests indicate that waste ore containing 67 percent gypsum can be upgraded to 80 percent purity with a recovery of approximately 82 percent of the gypsum (2). Hydration of the evaporites appears to be more complete on the east (updip) side of the deposit where ground water is abundant in fractures and in the porous overlying strata.

The Pennsylvania Railroad Co. and the Compton Development Corp. have drilled more than 30 core holes in secs. 1, 2, 11, and 12, T. 9 N., R. 5 W., and secs. 6 and 7, T. 9 N., R. 4 W., Owen County. The ore body in this area has a maximum thickness of about 15 feet and lies at a minimum depth of 400 feet below the surface. Analyses of the main ore body from 13 locations indicate an average grade of 84 to 86 percent gypsum; the remaining 14 to 16 percent is carbonate rock

and anhydrite. The evaporites contain traces of chlorides (.067 to .014 percent) throughout the area. Gypsum in the main bed grades laterally to anhydrite toward the south and west. Abrupt termination of the main gypsum bed on the east and northeast is probably due to leaching by ground water (Fig. 2).

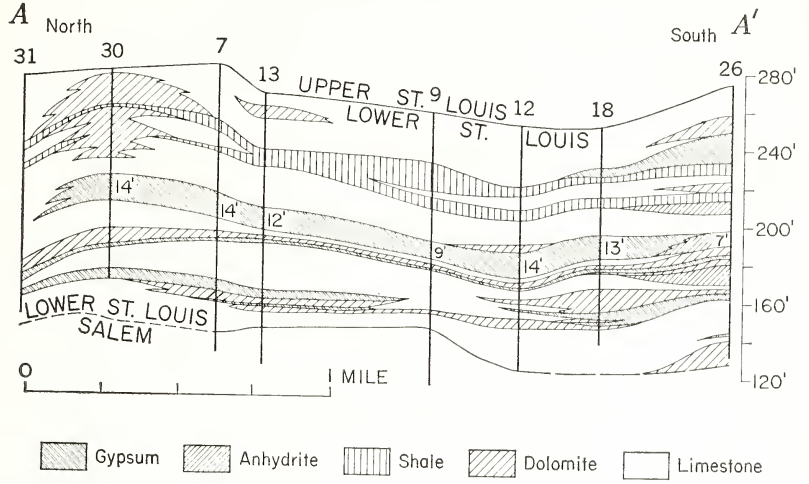

Figure 2. North-south cross section of lower part of St. Louis Limestone, Owen County, Indiana.

Because of the apparent correlation between slightly greater sedimentation and commercial gypsum concentrations along the eastern flank of the basin, the Indiana Geological Survey drilled Survey Drill Hole 131 in the NW¼ NW¼ sec. 10, T. 7 N., R. 4 W., Greene County. The lower part of the St. Louis Limestone contains three evaporite zones in this area. In Survey Drill Hole 131 the first evaporite bed, at 277 feet depth (248 feet above sea level), consists of 13 feet of gypsum, anhydrite, and shale; the upper 8 feet of this unit averages 75.5 percent $CaSO_4.2H_2O$. The second evaporite bed, at 314 feet depth, consists of 11.3 feet of gypsum and anhydrite. The third bed, at 363 feet depth, consists of 12.6 feet of gypsum and shale (averaging 80 percent $CaSO_4.2H_2O$).

Mining

The National Gypsum Co. uses an inclined shaft 25 feet wide, 12 feet high, and 2,052 feet long to exploit the evaporite deposit at Shoals. Underground facilities include a maintenance and truck service shop, spare parts, explosive storage depots, and a mine superintendent's office. A power substation with three 250kva transformers is maintained near the shaft, and three 100 kva skid-mounted transformers are used near the working face. Recovery of the rock is by the room-and-pillar method with 40-foot-wide rooms, 20- by 30-foot pillars, and 25-foot crosscuts. The face is drilled with two Joy CD-42 double-boom 1¾-inch drills. Ammonium nitrate and electric caps are used to blast the ore. A 9½-foot pull produces about 350 to 400 tons per shot. The ore is

loaded by three Michigan front-end loaders and transported to the primary crusher by two 20-ton and two 10-ton side-dump tractor trailers. The primary Allis-Chalmers 30- by 60-inch roll crusher reduces about 250 tons of ore per hour to minus 12-inch size. The ore is carried to the surface at 278 fpm by a 30-inch conveyor belt and is reduced to about 1-inch diameter by a hammer mill. Two Raymond roller mills grind the ore until about 90 percent passes 100 mesh at a rate of 30 tph. The gypsum then enters the manufacturing processes to become wallboard and plaster. Twenty-four types of wallboard, 10 types of plaster, and raw gypsum and anhydrite (for cement) are produced at the plant. Approximately 200 people are employed at the plant; about 21 of these are employed underground.

The U. S. Gypsum Co. uses a 430-foot vertical shaft at its mine in sec. 23, T. 3 N., R. 3 W., Martin County. Recovery of the rock is by the room-and-pillar method with 25-foot rooms and 30-foot pillars. Three Joy CD-42 double-boom 1¾-inch drills are used to develop a 7-foot pull. Ammonium nitrate and blasting caps are used to obtain about 170 tons of ore per shot. Three Joy BU-11 conveyor-loaders load two LeTourneau trailers of 10 tons capacity and three Wagner telescoping trucks of 15 tons capacity; these trucks transport the ore to the primary crusher. A single-roll 30- by 48-inch 200-tph McClanahan and Stone crusher near the shaft reduces the ore to minus 6 inches. After primary reduction the ore is carried to the surface in 100 cu. ft. (5 ton) capacity skips, which discharge into hoppers for secondary crushing. A double-roll McClanahan and Stone crusher reduces the ore to minus 3 inches and a 3-foot Traylor gyratory crusher reduces the ore to about 1 inch before final grinding. Three Raymond (60-inch bullring) roller mills grind the ore to about 95 percent passing 100 mesh. More than a hundred wallboard and plaster products are manufactured at the plant. Raw gypsum is also marketed for portland cement, agricultural uses, and the glass industry. Approximately 200 people are employed above ground and 25 are employed in the mine.

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