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THE GEOLOGY OF A PORTION OF THE HUTCHINSON SALT MEMBER OF THE WELLINGTON FORMATION IN THE MINE OF THE CAREY SALT COMPANY, LYONS, KANSAS

T. F. Lomenick

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Abstract

An investigation of rock conditions in the Lyons Mine of The Carey Salt Company revealed that the first 115 to 135 in. of the salt section below the floor in the westernmost portions of Entries 7 and 9 contains between 20 and 40% shale. A second shaly zone, approximately 40 to 50 in. thick, is present generally from about 220 to 235 in. below the floor. Four separate shaly zones, each a few inches in thickness, occur in the first 250 in. of salt rock above the mine roof.

Introduction

One of the most promising geologic environments for the disposal of large quantities of high-level radioactive waste is subterranean rock salt deposits.[1] For the past few years laboratory and field tests have been conducted at ORNL and in the Carey Salt Mine, Hutchinson, Kansas, to determine the suitabiiity of salt mines for the disposal of liquid and solid radioactive waste; however, more field data on such things as the behavior of salt when heated and subjected to radiation, as well as information on the handling of radioactive materials in a mine, is needed before an operational disposal project in bedded salt can be designed. It is hoped that much of this information can be obtained by a proposed experiment which involves the strategic placement of canned fuel elements in the Lyons Mine of The Carey Salt Company, Lyons, Kansas. The location of the experimental plot within the mine is governed to a large part by the quantity of shale that is interbedded with the salt. Thus an investigation of rock conditions above and below a part of the mine floor was made. The results of this investigation are discussed in this report.

General

The Lyons Mine of The Carey Salt Company is located in Rice County, Kansas, near the city of Lyons. The mine was opened in 1890 and closed in 1948. During this period approximately 100 acres was mined out. The salt was mined by the room-and-pillar method, with salt extraction varying from between 70 to 75% in older parts of the mine to about 60% in the more recent workings. The floor of the mine lies a little over 1000 ft below the land surface, which is about 1700 ft above sea level.

Regional Geology

The Hutchinson salt member of the Wellington formation underlies central and southcentral Kansas and extends southward into Oklahoma (See Fig. 1.). The member is an integral part of the gently westward-dipping Permian-Pennsylvanian sedimentary rocks that underlie much of Kansas and crop out in the eastern one-third of the state. The salt is not present along this outcrop, probably because it has been dissolved by ground and surface water; however, it is present down the dip to the west. The eastern edge of the salt body lies approximately 400 ft below the land surface, but near its western edge in Kansas the Hutchinson is found at a depth of about 2000 ft. Thicknesses of the unit range up to as much as 700 ft in Kansas. In general, the Hutchinson consists of a complex mixture of salt, anhydrite, and shale, with salt being the predominant fraction throughout most of its extent in Kansas.[2]

It is generally agreed that large salt beds such as the Hutchinson were formed as a result of the evaporation of sea water. During the Permian period a relict sea covered a large part of what is now the state of Kansas. The sea was partially cut off from the ocean to the southwest by an uplift of mountains across present-day southwestern Oklahoma.[3] As water vaporized in the evaporation basin, it was replaced by the lateral flow of sea water through the inlet to the southwest. When the brine became saturated, salts were deposited. Periodic inflows of clay and silt to the basin from streams draining the surrounding land masses resulted in the deposition of shale beds in the sequence. As the evaporites and associated sediments were deposited, the basin underwent intermittent downwarping. This allowed a relatively thick sequence of evaporites to be

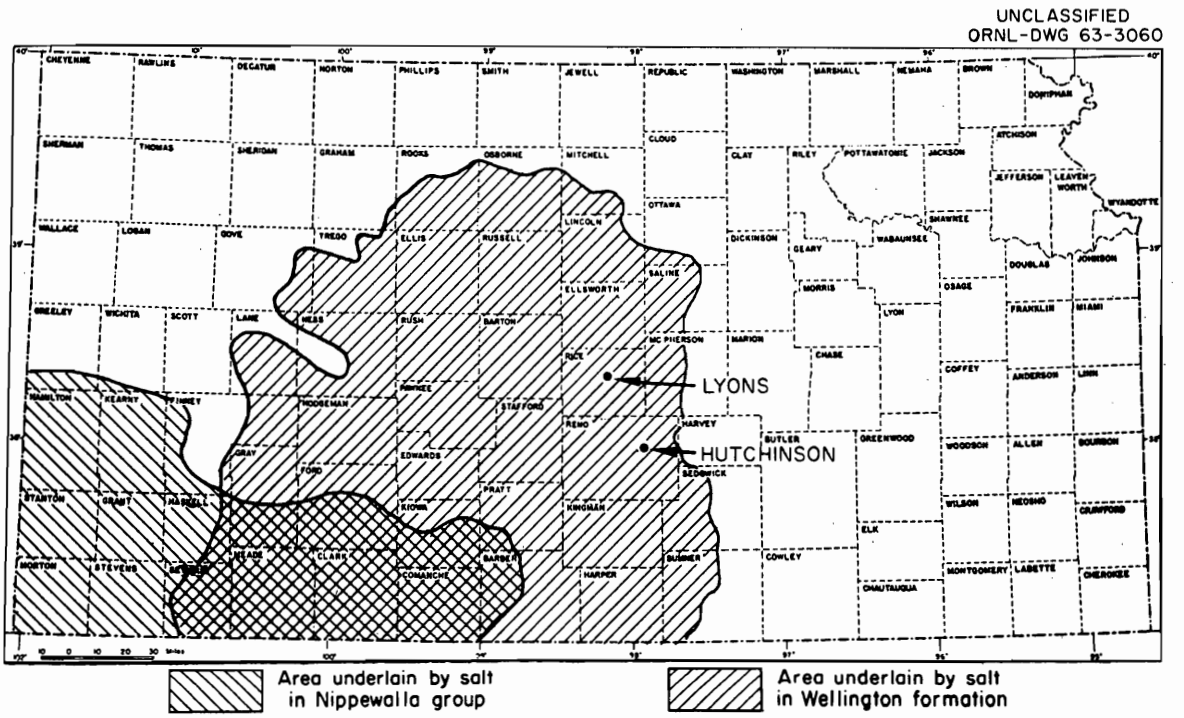

Fig. 1. Area Underlain by Deposits of Rock Salt and Salt Manufacturing Plants in Kansas (After Jewett, J. M., State Geological Survey of Kansas, Bulletin 41, Part 3, p 150, 1942).

deposited in a comparatively shallow basin. The Mediterranean Sea is an example of a modern evaporation basin. Here more water is removed through evaporation than is added by the sum of rainfall and runoff from the surrounding land. A net water inflow from the Atlantic Ocean through the Straights of Gibraltar compensates for the volume deficit in the Mediterranean.

Geology in the Lyons Mine

At the Lyons Mine, the Hutchinson salt member consists of about 300 ft of nearly flat-lying beds of salt, shale, and anhydrite, with salt comprising about 60% of the sequence. The mine is operated in the lower part of the member. Within the mined unit, 1- to 6-in. layers of relatively pure sodium chloride are separated by clay and shale laminae that are usually less than 1 mm in thickness. These laminae constitute the major impurity in the salt and are characteristic of most bedded salt deposits. Shale beds, several inches in thickness and separated by about 15 to 18 ft of salt, lie above and below the mined unit and thus limit the vertical extent of mining. The mine floor was usually cut within a few inches of the underlying shale bed, while the roof is normally several feet below the overlying shale bed. The least contaminated salt, and thus the source of most of the production in the mine, lies in a 9-ft-thick section that extends from the top of the shale below the floor upwards to a thin shale parting, approximately 1/16 in. thick. Another prominent shale parting lies about 3 1/2 ft above the 9-ft roof. In some parts of the mine, this section was also mined. However, the additional excavation has resulted in a weak roof that buckles and fractures and frequently

allows a 3-ft section of overlying impure or "dirty" salt, 12 1/2 to 15 1/2 ft above the mine-floor that extends to a relatively thick shale bed above the mined area, to fall.

At the time of this investigation, the general location of the canned-fuel experiment was to be in the extreme southwest end of Entry 9 in the mine (See Fig. 2.). It was felt that due to the nature of the experiment it would be more convenient to place the fuel elements in an excavated portion of the present floor of the mine. An alternate plan specified that the tests be conducted in an unused part of the salt section from which salt was mined. This would require the excavation of a considerable amount of salt that lies in the section above the present roof of the mine and, of course, would increase the cost of the operations. It was therefore necessary to define in detail the rock conditions that exist below the floor and above the roof of the mine prior to the selection of the actual test site.

Two 2-in.-diam 30-ft deep core holes were drilled in the floor of the mine in Entry 9 (See Fig. 2.), while two cores approximately 20 ft in length were obtained from the roof of the mine at the same locations. These cores, along with the log of a hole drilled previously in Entry 7 (ref 4), were used to construct a geologic cross section of a portion of the salt section from the northwest end of Entry 7 to the southwest end of Entry 9 (See Fig. 3.).

Considerable quantities of shale and some anhydrite are included in the salt section from the floor down to a depth of about 115 in. in Entry 9 and to a depth of approximately 135 in. in Entry 7 of the mine. The shale, which is noncalcareous and greenish gray to black in color, commonly occurs in beds 1 in. to as much as 16 in. thick that usually contain a few

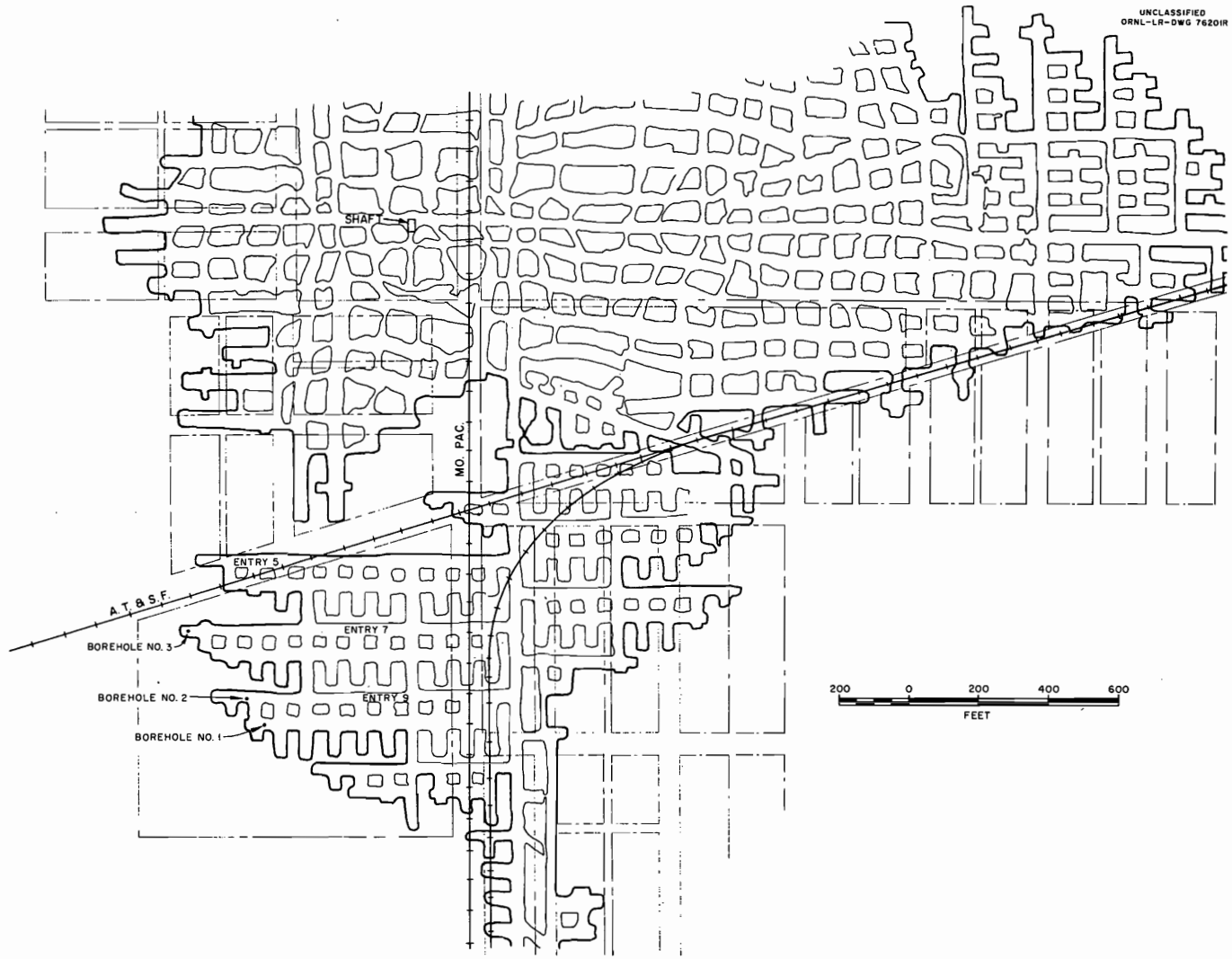

Fig. 2. Map of a Part of Mine of the Carey Salt Company Lyons, Kansas Showing Areas Excavated and Location of Salt Core Holes.

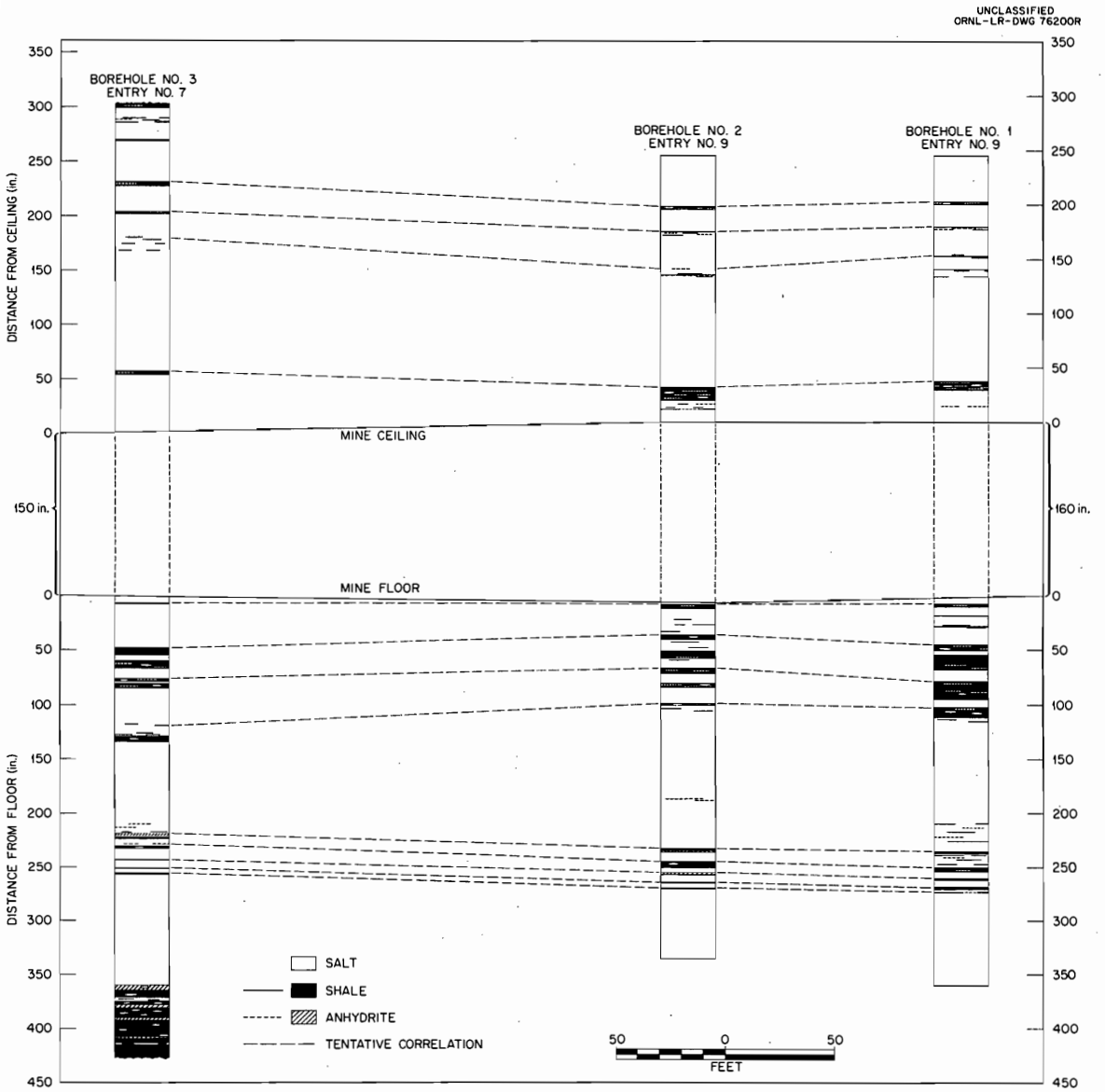

Fig. 3. Generalized Geologic Cross Section of a Portion of the Hutchinson Salt Member of the Wellington Formation in the Mine of the Carey Salt Company, Lyons, Kansas.

crystals of clear-to-orange halite and some stringers of fine-grained anhydrite. As seen in Fig. 3, these beds thicken and thin considerably over relatively short distances. Frequently, the beds grade, both laterally and vertically, into salt that contains many pods and irregularly shaped lenses of shale. This unit of the section is underlain by about 80 to 125 in. of relatively pure salt. The salt consists essentially of medium to coarsely crystalline, clear to brownish halite that contains disseminated blebs and inclusions of dark-colored clay that in places gives the salt a dark smoky appearance.

A second zone of interbedded salt, shale, and anhydrite, about 40 to 50 in. thick, lies beneath the relatively pure salt sequence. The shale and anhydrite is similar to that described higher in the section, but the shale beds are thinner, and a larger amount of anhydrite in the form of lenses is present. For the remaining part of the section in Entry 9, which was cored to a depth of about 360 in. below the mine floor, the cores show a relatively pure salt sequence like that described above. In Entry 7, the salt is interrupted by thick shale and anhydrite beds at a depth of about 360 in. It is likely that the same thick shale and anhydrite unit would have been intercepted in Entry 9 had the drilling proceeded a few feet deeper.

The ceiling of the mine, up to about 250 in., consists of a relatively pure salt sequence that is interrupted by four separate shale zones. These shales, like those below the mine floor, are greenish gray to black in color and frequently contain lenses and crystals of clear-to-orange halite along with stringers and lenses of anhydrite. The thickest of the shale beds lies at a minimum distance of about 20 in. above the present roof of the mine. The bed was observed to be about 12 in. thick in Borehole 2,

Entry 9, but it had thinned to about 3 in. in the core from Entry 7 of the mine. The other shale zones, as shown in Fig. 3, lie between about 130 and 230 in. above the roof. The salt from the ceiling cores is composed mainly of medium-to-coarse grained, clear-to-brownish halite crystals that contain in places many blebs and irregularly shaped masses of clay that gives the material a smoky appearance. In addition, from about 70 in. above the mine roof to the end of the cored section, the salt contains many scattered blebs of an orange-to-red-colored microcrystalline mineral that has been tentatively identified as polyhalite.

Conclusions

The salt unit that has been mined in the Lyons Mine consists of relatively pure salt that contains minor inclusions of clay and shale. The first 115 to 135 in. of the section below the floor in the westernmost portion of Entries 7 and 9 contains between 20 and 40% shale. The shale is present in beds that vary greatly in thickness over relatively short distances and may grade vertically and laterally into zones of salt that contain many pods and irregularly shaped lenses of shale and anhydrite. A second shaly zone, approximately 40 to 50 in. thick, is present generally from about 220 to 235 in. below the floor. Four separate shaly zones occur in the first 250 in. of section above the mine roof. The thickest shale bed lies at a minimum distance of about 20 in. above the ceiling of the mine, while the other less prominent zones of shale lie between about 130 and 230 in. above the roof. These zones are usually only a few inches thick and contain, in addition to shale, lenses and stringers of anhydrite and salt.

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