

1.0 INTRODUCTION

Koch Hydrocarbon LP (Koch) owns and operates an underground liquid hydrocarbon storage facility near Hutchinson, Kansas, that includes more than 70 solution-mined caverns. In support of the operation of the Hutchinson facility, Koch elected to perform a geomechanical study. The study was performed to determine (1) the compliance with generally accepted guidelines for liquid hydrocarbons in similar geologic settings and (2) the acceptable operating pressures and existing factor of safety for liquid hydrocarbon storage at the Koch facility.

A key component of this study was the drilling of a dedicated test well. The test well, named Hutchinson Test Well No. 1HF, was drilled to recover rock core for laboratory testing and to obtain additional detailed information on the lithology and properties of the rock surrounding the existing caverns.

Coring began in Hutchinson Test Well No. 1HF in the nonsalt units overlying the Hutchinson salt. This was done to collect core samples of the salt and nonsalt units that form the roof of the existing caverns. The test hole was subsequently drilled through the salt section and terminated in the nonsalt units below. This report describes the coring activities for Hutchinson Test Well No. 1HF and includes a description of the lithology of the core.

Field activities and the core are described in Chapter 2.0, and Chapter 3.0 summarizes the lithology of the core recorded in the field. Cited references are listed in Chapter 4.0. Appendix A is the lithologic description of the core. Appendix B contains a photographic log of the core, and Appendix C contains the field logs of the core. The Schlumberger geophysical logs are provided in Appendices D, E, F, and G.

2.0 FIELD OPERATIONS

All activities completed at the field site are in accordance with the following RESPEC procedures or as modified to meet specific conditions encountered:

- **Test Procedure TP-01**, RSI Standard Procedure for *Sample Acquisition, Storage, and Shipping, Rev. 3*.
- **Test Procedure TP-09**, RSI Standard Procedure for *Logging and Preserving Rock Core at a Field Site, Rev. 1*.

2.1 GENERAL OPERATIONS DESCRIPTION

Core tools were under the direction of Mike L'Orange of Dynatec Drilling, Inc. Pratt Well Services provided site support as needed. The coring assembly was nominally 5 feet in length with an outside diameter of 6 inches. The coring assembly was a double tube with the inner tube rotating on a bearing assembly to minimize damage to the core while drilling. The resulting core was nominally 4 inches in diameter.

The inner core barrel was retrieved through the core rod via a cable that attached onto the inner barrel by means of a stinger assembly. After pulling the inner barrel out of the hole, the inner barrel was laid down on the catwalk. Core was removed from the inner barrel by holding the core barrel at an angle and rapping on the barrel with a hammer. The extracted core was placed directly into wooden core boxes capable of holding one 5-foot-long piece of core.

The core was moved off the catwalk and away from the drill rig, temporarily placed on the ground, and subsequently moved to a heated trailer located on the site for logging. The core was then wiped clean, the pieces reassembled, and two different-colored parallel lines (red on the right and yellow on the left when viewed from the bottom of the core) were scribed on the core to maintain orientation of the pieces. A lithologic description of the core was recorded, depths (relative to ground level) were marked on the core, and photographs of the core were taken. Upon completion of these tasks, the core was placed on polyvinyl chloride (PVC) splints to facilitate handling and to protect the core, enclosed in plastic sleeves, replaced in the core boxes, and lids were nailed onto the core boxes. The core was padded and constrained in the core boxes using foam sheeting.

Prior to shipment, the core was moved to a heated warehouse to prevent freezing. After the completion of field activities, the core boxes were loaded on a heated truck for shipment to the RESPEC offices in Rapid City, South Dakota.

2.2 WELL ACTIVITIES

The well was spudded on January 18, 2002, and drilling proceeded to a depth of 159.5 feet at a diameter of 14 3/4 inches. Conductor pipe (10 3/4-inch-diameter) was set to a depth of 154.4 feet and fully cemented by circulation on January 19, 2002. Pratt Well Services drilled this section of the hole. Pratt rigged down on January 20, 2002.

Dynatec Drilling began rigging up over the precollared hole on January 21, 2002, and began drilling out cement on January 22, 2002. Drilling continued to 270 feet using a 9 7/8-inch-diameter bit. On January 23, 2002, 260.6 feet of 7-inch-diameter casing was set in the hole and cement circulated. It should be noted that regulatory issues dictated the two, closely placed sets of casing. Using a 6 1/4-inch-diameter bit, cement was drilled out and an additional 40 feet of new hole was drilled on January 24, 2002.

Coring activities began late January 24, 2002, when the core point (the top of the first core run) was reached at a depth of 310 feet below ground level. The final core run, Run 118, was recovered on January 27, with the depth of the well at 894 feet. When coring activities were complete, Schlumberger performed a suite of geophysical logs during the afternoon of January 27. These logs are included as appendices to this report. Fracture gradient tests were then performed upon completion of the geophysical logging; these tests were concluded in the early morning of January 28, 2002.

3.0 LITHOLOGIC DESCRIPTION

3.1 GENERAL

The cored section of the well was within the Permian Wellington Formation as described by Walters [1976]. The cored interval includes members of the Sumner Group: Wellington Shale, Hutchinson Salt, and Wellington Shale-Anhydrite. The rotary section of the hole likely penetrated the Nippewalla Group, Ninnescah Shale, and the uppermost part of the Wellington Shale. All these formations are primarily shales similar in character to the Wellington Shale. In fact, the Ninnescah Shale is typically identified only by a transition in the rock color from gray (Wellington Shale) to red (Ninnescah Shale). A detailed description of the core is provided in Appendix A.

The shales encountered by the borehole were quite brittle causing the core to experience numerous fractures during handling. However, core recovery was near 100 percent. Overall, the core was recovered in excellent condition with very little dissolution of the salt.

3.2 WELLINGTON SHALE

From the core point at 310 feet (all depths are given as feet below ground level) to a depth of about 514 feet, the rock consists primarily of shale with minor amounts of anhydrite and very minor dolomite. The anhydrite occurs as lamina and thin beds with frequent nodules. Lamina, in this report, is defined as layers less than 1 centimeter thick; beds are thicker than 1 centimeter. The shale is primarily gray to dark gray and occasionally red. The anhydrite is light gray in color.

Numerous fractures are present throughout the shale. The fractures are commonly subvertical and often filled with gypsum and red anhydrite that is a polymorph after gypsum (i.e., a material with anhydrite mineralogy and a gypsum crystalline structure). The core also contains subhorizontal fractures. These fractures tended to be very narrow and tight with mineralization occurring only as a coating on the fracture surfaces.

3.3 HUTCHINSON SALT MEMBER

The Hutchinson Salt at Hutchinson occurs from a depth of about 514 feet to a depth of about 859 feet. The salt sequence is comprised of alternating beds of shale, salt, and anhydrite. Of this 345-foot-thick salt sequence, a cumulative 245 feet of the interval (71 percent) is salt, 82 feet (24 percent) is shale, and 18 feet (5 percent) is anhydrite.

The salt crystals are generally clear to smoky in color with clay occurring as inclusions and on the crystal interfaces giving the intact core a generally clear to smoky to black color, dark gray being the most typical. Some salt beds are "dirty" containing significant amount of shale. The salt is generally coarse with crystal sizes generally ranging from 0.25 to 1 inch, but crystal size occurrences of 3 to 4 inches were observed in the core. The salt is cohesive and typically well bonded to the shale interbeds. Figure 3-1 shows a stratigraphic column through the Hutchinson Salt at Hutchinson.

3.4 WELLINGTON SHALE-ANHYDRITE

Shale and anhydrite were encountered from 859 feet to the bottom of the cored interval at 894 feet. The shale is typically dark gray with minor anhydrite- and salt-filled fractures. The anhydrite is light gray to white and containing gray shale laminations and masses giving the anhydrite a mottled appearance in part.

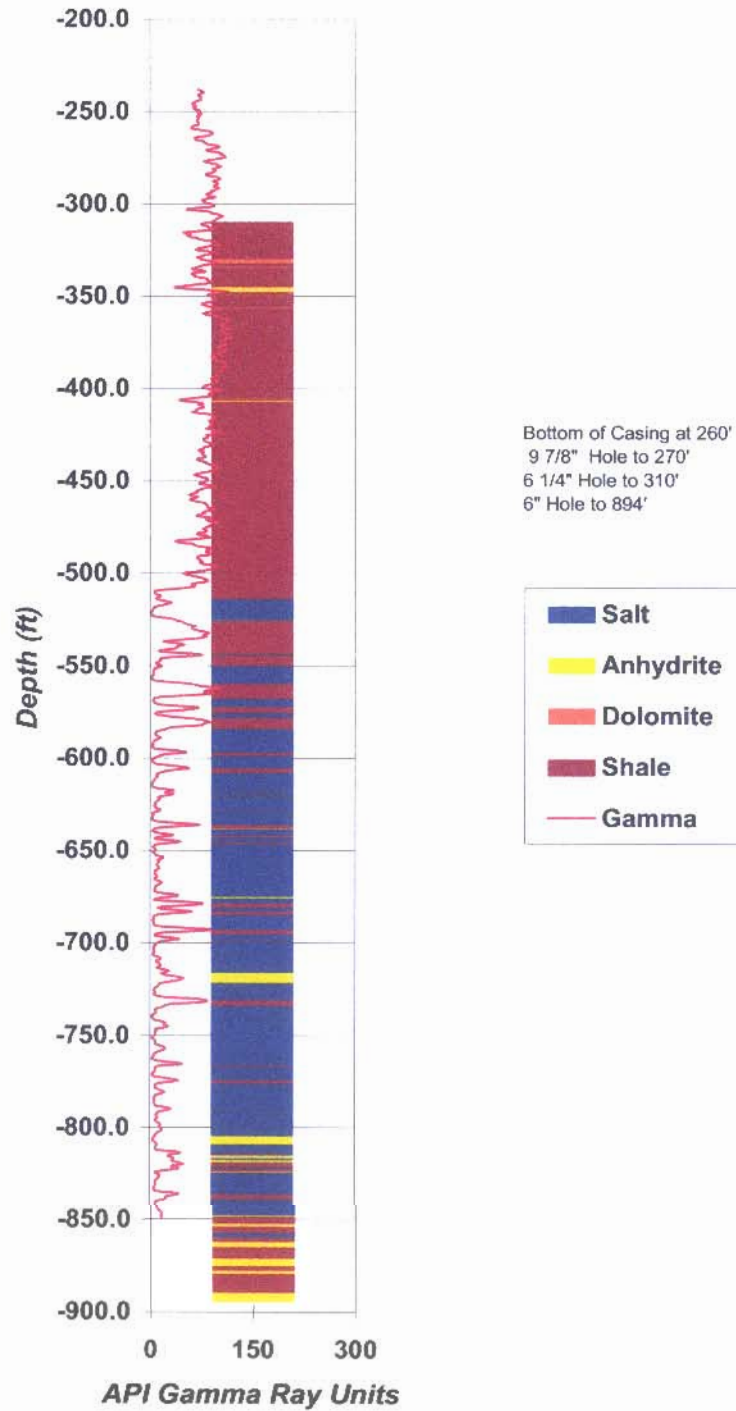


Figure 3-1. Stratigraphic Column and Gamma Ray Trace Through the Cored Section of Hutchinson Test Well No. 1HF.

4.0 REFERENCES

Walters, R. F., 1976. "Land Subsidence in Central Kansas Associated With Rock Salt Dissolution," *Proceedings, Solution Mining Research Institute, Inc.*, June.

**DESCRIPTION OF CORE RECOVERED FROM
KOCH-HUTCHINSON TEST WELL NO. 1HF
HUTCHINSON, KANSAS**

Topical Report RSI-1648

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