Salt Solution Mining by Pittsburgh Plate Glass Company at Natrium, W. Va.

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ABSTRACT

This is a general description of successful commercial operations by Pittsburgh Plate Glass Company in solution mining underground ultra-deep halite in the late Silurian Salina deposit by means of wells at Natrium, West Virginia. Starting with the area's geology, well history is traced from the initial well drilling in 1942. Included are details of well construction, field design and development, well operation and well maintenance of the Company's 6800 feet deep Natrium brine wells.

INTRODUCTION

Pittsburgh Plate Glass Company is in business to make a profit. The Company is anxious to accomplish all phases of the business, including brine production, in a safe and efficient manner taking into consideration long-term values and with the minimum capitalization, administration, operation, maintenance, transportation and sales expenses.

At its Natrium, West Virginia, plant site, located on the Ohio River between Wheeling and Parkersburg, the Company manufactures chlorine and caustic soda as well as related products. Sodium chloride is the fundamental raw material for this manufacturing process.

It is essential that sodium chloride for such chemical plant use be economically available. Mechanical mining of halite at this location is precluded by the excessive expense involved in deep operations. Likewise, shipment of salt to Natrium was economically unattractive. The Company's chemical processing operations require a water solution of sodium chloride, commonly referred to as brine. If salt is received in solid form, it must be converted to brine in dissolving apparatus. A considerable economic advantage is attained in raw material costs if brine can be produced from wells at or near the plant site, thus reducing mining and handling expense and eliminating dissolving problems.

The expected existence of underground halite in this area was one primary factor in the selection of this site. The name selected for this site was "Natrium," the modern Latin word for sodium and the source of the chemical symbol Na for sodium. Sodium chloride brine has been successfully produced from ultra-deep wells in the area of the plant by solution mining the underground natural halite deposit.

The purpose of this presentation is to sketch the experience in solution mining of halite at Natrium, West Virginia. The unusually great depth to the salt at this location has magnified the costs of solution mining and has contributed to well problems. As a result of greater depth, all costs have been necessarily greater -- new drilling, expense for tubing and casing, logging costs, pumping costs during operation, stronger and heavier tools for maintenance, and so on.

GEOLOGY AND HISTORY

Natural halite occurs underground in the Salina Basin, located in northeastern United States. This is a formation of late Silurian age. In its present condition, the salt or halite member dips downward in a southeastward direction. Natrium is located within the southern portion of the Salina Basin (1) (2) (3) (4).[1] At this geographic location in the deep section of the Basin, the top of the halite formation is encountered about 6700 feet below the ground surface. The average thickness from top to bottom of the salt is about 115 feet.

Natrium's first well was drilled in 1942. At that time, Salina salt was predicted to exist beneath Natrium but its existence there had not been definitely proved. The Company's early wells established the existence of Salina salt beneath Natrium. The geology of these wells has been described by Martens (1). The local stratigraphic column has been illustrated and described in West Virginia Geological Survey Maps (5).

The Company's wells at Natrium (6) represented the first artificial brine production in West Virginia. At the time of initial drilling and for many years thereafter, these were the deepest wells in commercial operation for production of artificial brine. Initial operation of the first wells took place in early 1943; operation was continued for over nineteen years. It is worth noting that the first well installed is still producing. Figure 1 is an illustration showing steel derricks over two of the Company's wells.

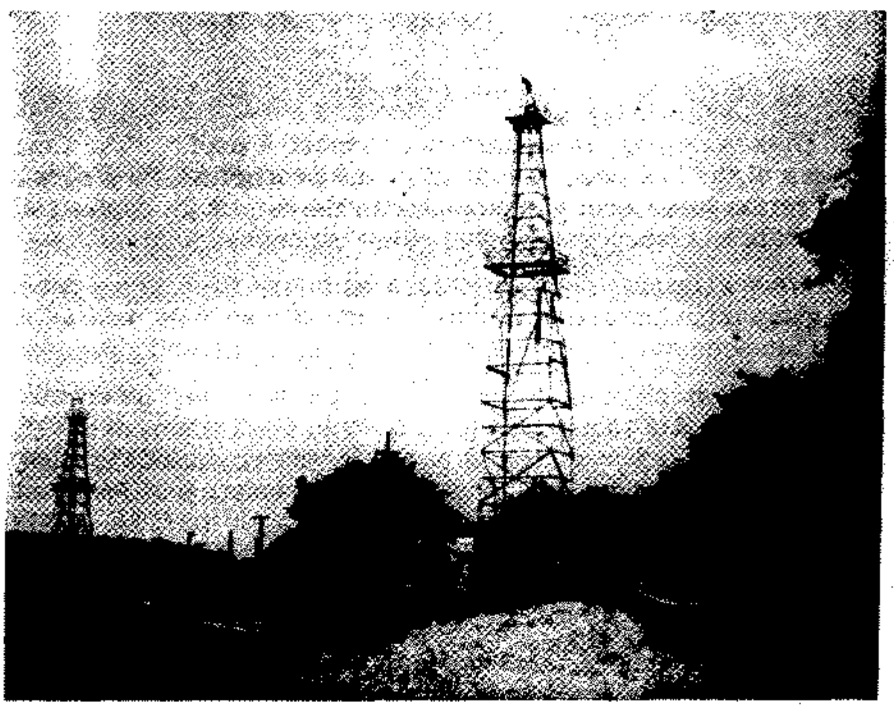

Figure 1. Steel Derricks Over Two of the Company's Wells.

WELL CONSTRUCTION

Well drilling experience has been gained at Natrium with rotary-mud drilling and with cable-tool drilling equipment. Some wells have been drilled top-to-bottom with rotary using mud and others have been drilled top-to-bottom with cable tools. All bore hole diameters have been at

[1]Numbers in parentheses designate "References" listed at the end of the paper.

least 10 inches. Figure 2 is a photograph of a cable-tool spudding machine at work drilling one of the Company's wells.

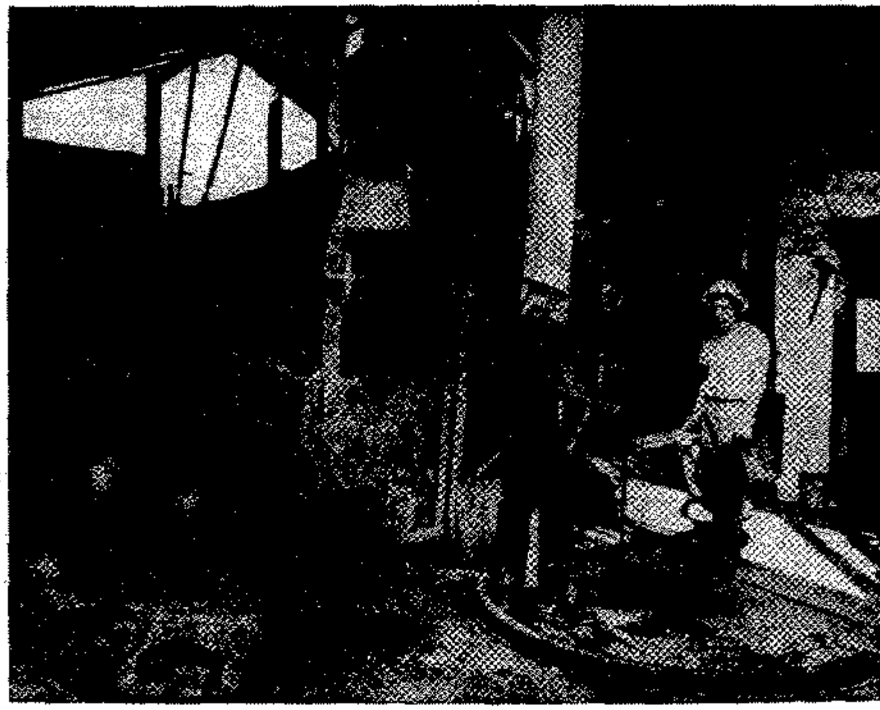

Figure 2. Cable-Tool Spudder Drilling One of the Company's Wells.

Casing programs near the surface of the Natrium wells have been varied to suit underground conditions and the method of drilling. Each well has received a string of 8 5/8 inch O. D. seamless steel production casing. In addition, each well has been equipped with a string of 4 1/2 inch O. D. galvanized seamless steel production tubing. In certain instances, Securaloy casing and tubing were installed near the bottom of a well to enable easier redrilling.

We have employed many of the usual oil and gas well techniques for drilling, logging, cementing and completing these wells.

FIELD DESIGN AND DEVELOPMENT

For the original plant facility, there were four wells. These were drilled in the main plant area. Additional wells were drilled at later intervals. The original four wells and No. 5 Well have become interconnected by natural dissolving. The wells following No. 5 were so positioned that they were fairly distant from the main cavity.

WELL OPERATION

In the operation of the wells, dissolving water is injected to the halite zone; the halite is dissolved and the resulting brine is brought to the surface. For prevention of corrosion of steel equipment, a water for dissolving is desired which has a pH slightly above 7. Such water used for injection is ground water produced from wells 80 feet deep in Ohio River Valley alluvial sand and gravel deposits. The temperature range of dissolving water is from 60° F. to 100° F.

The Company employs high pressure centrifugal boiler feed type pumps to supply injection water at a pressure of 900 to 1000 psig. These pumps are located at central points and their discharge is piped to the well locations.

The wells operate with "top" injection of cavity water and "bottom" withdrawal of brine from the cavity through the tubing. During a well's initial operation, it operates singly because its cavity is independent. Later, after interconnection of well cavities, a group can be operated with injection to certain wells and production from certain wells. Producing wells in the common cavity are equipped with submersible motors and pumps for brine production.

A tank capacity of two million gallons storage for raw brine is provided in the plant to level out fluctuations in supply and demand. Supply fluctuations can occur as a result of repairs to cavity water pumps or repairs to pipelines carrying water or brine. Demand fluctuations can occur as a result of changing plant output or as a result of consumption equipment being out of service for repairs or improvements.

WELL MAINTENANCE

Maintenance of well equipment has been necessary as a result of earth formation movements and because of chemical action on well piping. The great majority of well maintenance has been accomplished using Company labor. Trials through 1948 using cable tools and standard rigs for maintenance were not completely successful. This was attributed to difficulty working in a fluid-filled hole and inability to successfully control tools at the bottom of the hole.

The Company owns a rotary drilling rig rated for 7500 feet depth and driven by natural gas engines. The equipment includes 4 1/2 inch drill pipe, a power slush pump and other items. This rig has been used when necessary for down-hole well maintenance. The rig is portable and can be easily moved between wells. Figure 3 is a photograph showing components of the Company's rotary rig.

Figure 3. Components of the Company's Rotary Rig.

Well maintenance using this rotary equipment is accomplished using men on the Company's payroll who have been trained at Natrium to operate the rotary rig. Formerly, when this rig was the only rotary in this territory, delivery of spare parts and drilling material required much time and we were forced to warehouse many items. Presently, with the influx of rotary contractors to the Appalachian area, the local supply stores have been more able and cooperative in procuring supplies for this rig.

An example of pipe damage that required well maintenance is shown in the photograph in Figure 4. This shows a section of Securaloy tubing which had been installed in a well and which had been punctured presumably as a result of earth movements near the bottom of the well. It was necessary to remove the tubing, locate and replace the damaged section and reinstall the tubing string in the well.

Figure 4. Damage to Securaloy Well Tubing.

Under extreme conditions of earth movements, isolated situations have been encountered where damage occurred to casing which prevented economical drilling-out. To solve this problem, rotary tools were used to install a permanent whipstock -- a wedge-shaped device -- in the casing just above the point of damage; the whipstock then served to deflect drilling tools allowing them to cut through the casing and continue to the well bottom.

IMPROVEMENTS AND FUTURE

Some bench-scale salt dissolving work has been done and has been helpful in evaluating characteristics of the dissolving process. Figure 5 shows a sectioned salt block during the course of a cavity dissolving test and Figure 6 portrays the block following the test.

The Company keeps in touch with new technology on wells and drilling which could have application to brine wells. Very attractive from the standpoint of economics is the method of rotary drilling which uses air instead of liquid for circulation. Advances in well logging techniques are being watched to determine if they will advantageously provide desired information on present or

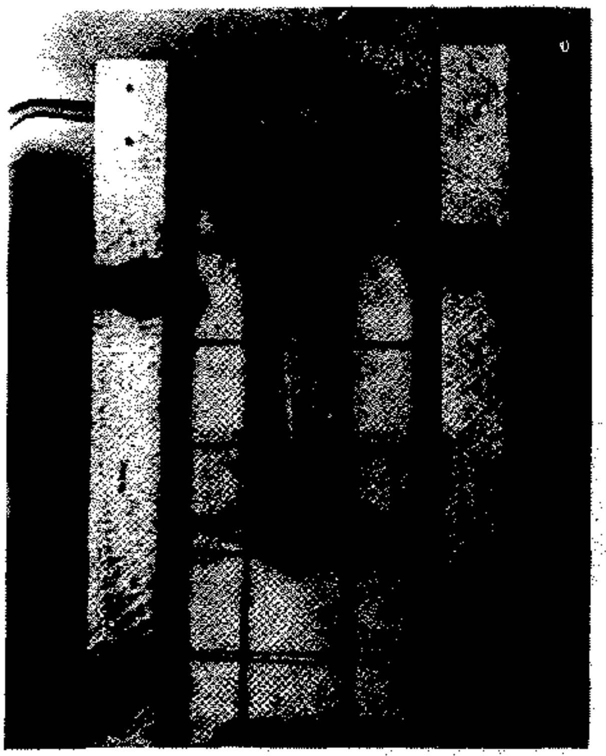

Figure 5. Sectioned Salt Block During Dissolving Test.

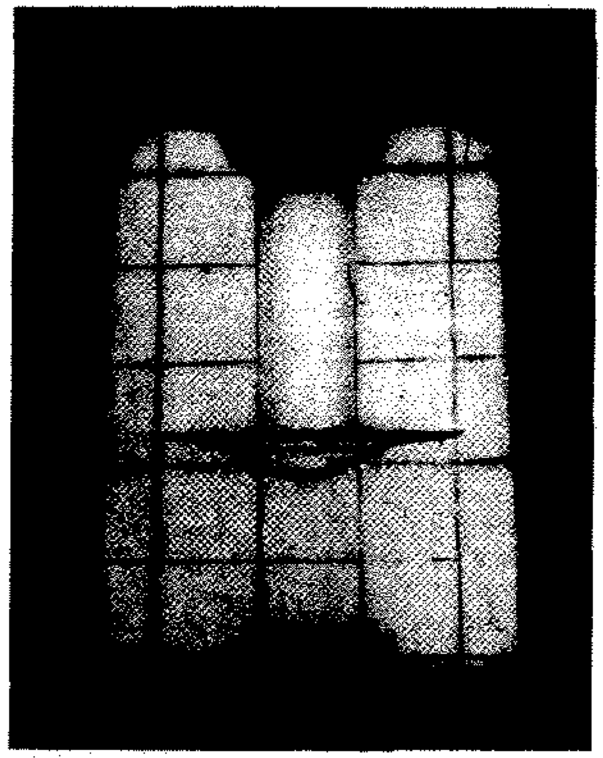

Figure 6. Sectioned Salt Block After Dissolving Test.

being watched to determine if they will advantageously provide desired information on present or future brine wells.

New methods of well design, development and operation will be tried if economic studies indicate that cost savings can be achieved by their use.

REFERENCES

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