SUMMARY REPORT ON SALT DISSOLUTION REVIEW MEETING

March 29-30, 1977

Submitted by Ad Hoc Committee:

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June 23, 1977

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**UNION
CARBIDE**

OFFICE OF WASTE ISOLATION
OAK RIDGE, TENNESSEE

*prepared for the U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
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June 23, 1977

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Re: Report of Ad Hoc Committee
Salt Dissolution Review Meeting
March 29-30, 1977
Austin, Texas

CONCLUSION

It is the unanimous conclusion of the Ad Hoc Committee that attended the OWI-sponsored Salt Dissolution Review Meeting that radioactive waste can be stored in salt at underground repository sites sufficiently removed from natural and/or man-made dissolution areas so that the waste will not be liberated during its hazardous period at projected rates of future salt dissolution. To ensure long-term isolation of radioactive waste in salt formations, the committee here makes specific recommendations for needed research concerning A) General Principles, B) Basinal or Regional Studies, and C) Site-Specific Studies, each stated in sequence of priority. Of highest priority overall is preparation of a document that will summarize, in the form of a critically annotated bibliography, the data that are already available on salt dissolution.

INTRODUCTION

The Salt Dissolution Review Meeting was held in Austin, Texas, on March 29-30, 1977. It was organized and hosted by A. Saberian & Associates under sponsorship of the Office of Waste Isolation, Union Carbide Corporation, Nuclear Division. The meeting focused the attention of the 45 attendees, all of whom are interested in natural or man-made dissolution of salt, on the question of radioactive-waste storage.

Members of the Ad Hoc Committee feel that the review meeting was successful. The meeting fostered open and productive discussion of current research on salt dissolution, and it produced many positive recommendations for future research in this field.

First, we wish to make some general statements that summarize the major topics of discussion that recurred during the meeting, and then we wish to present our recommendations for future studies.

GENERAL STATEMENTS

Rock salt (halite, NaCl) is a highly soluble rock, and thus circulating ground water represents one of the major threats to containment of radioactive wastes stored underground in salt beds or salt domes. However, salt beds of Permian and older age have survived intact and undissolved beneath overlying sediments in thousands of square miles in most parts of such major basins as the Permian, Michigan, Appalachian, and Paradox. These salts have survived for more than 200 million years, a time span 1,000 times longer than the hazardous period during which the long-lived transuranium elements, such as plutonium, must be isolated from the biosphere.

For salt dissolution to occur, there are four requirements that must be met: 1) a supply of water unsaturated with respect to NaCl, 2) a deposit of salt against which or through which the water flows, 3) an outlet that will accept the resultant brine, and 4) energy (such as a hydrostatic head) to cause flow of water through the system. And when all four conditions are met, salt dissolution and brine transport can be quite rapid, in terms of geologic time.

Although we realize that a thorough search will be carried out to identify and plug all boreholes and shafts in the vicinity of a proposed storage site, we feel that attention must be paid to the possible effects of salt dissolution around an improperly plugged borehole or around an unplugged borehole that may have escaped detection. Thus, a number of our recommendations center on the impact such boreholes might have on a storage site.

Salt dissolution is a natural phenomenon in some basins where the four necessary requirements are met. It usually occurs at shallow depth (less than 800 feet below the land surface), and the resultant NaCl brine forms a saline-ground-water plume that may locally emerge at the earth's surface as a brine spring or salt plain. Natural dissolution of salt in many geologic basins is cyclic; that is, periods of dissolution wax and wane according to tectonic, climatic, erosional, and ground-water changes. In some areas, unraveling the geologic history of a basin has enabled episodes of dissolution to be dated, whereas in other areas the periods of dissolution are uncertain.

Whether dissolution results from natural causes or man-made boreholes, it appears that the resultant collapse, subsidence, and fracturing of overlying rock may cause a greater vertical permeability that would favor more salt dissolution, if the four requirements listed previously are all met.

Our recommendations for future research in salt dissolution fall into three broad categories: A) research on the general principles of salt dissolution that will find application in any salt basin, B) basinal or regional studies that are needed once it is thought a specific basin may contain sites suitable for waste storage, and C) site-specific studies needed to qualify a particular storage facility. The recommendations in each category are stated in their order of priority.

RECOMMENDATIONS

A. General Principles

1. The first concern is preparation of a summary document in the form of a critically annotated bibliography that will gather and assess the data that are already available on salt dissolution. These data exist, for example, in reports submitted to OWI-ERDA-AEC, in reports published by the federal and state governments and by geological and engineering societies, and in reports prepared by industry. The summary document should provide a review of field studies, laboratory studies, and other pertinent reports, and it should contain a complete list of reports together with an abstract and evaluation of each report. Preparation of this document might be an early assignment for one of the Geologic Project Management firms that will work on the Nuclear Waste Terminal Storage program.

2. There appears to be evidence that salt dissolution can produce a self-perpetuating cycle: dissolution causes cavern development and then land subsidence, with the resultant disrupted rock having a greater vertical permeability that allows increased water percolation and additional salt dissolution. Studies of this process can be carried out experimentally and in the field near man-made cavities, breccia pipes, and dissolution fronts.

3. Studies need to be made of the long-term effect and rate of outward migration of dissolution caverns around abandoned boreholes that connect an upper and a lower aquifer through a salt layer. Subsidence around a borehole can produce cracks in the ground above the cavity and thus enhance access of water from overlying aquifers.

4. A study should be undertaken of the performance of commercial brine-well systems to determine whether the various insoluble constituents associated with halite will plug abandoned boreholes or will lower the flow rate and thus restrict salt dissolution around abandoned boreholes. Field study should be complemented by theoretical and experimental laboratory studies.

5. Theoretical and experimental studies need to be done of salt dissolution by diffusion (such as on an abandoned borehole that allows communication between an aquifer and an underlying salt formation). Studies should include the effects of collapse of overlying beds.

6. Modification of the existing cavity-leaching numerical models (in particular, the ones used by industry) should be undertaken to simulate and forecast dissolution in salt-borehole-aquifer systems.

7. An investigation of the mechanisms for natural dissolution of salt at isolated sites surrounded by areas of undissolved salt far from a dissolution front needs to be undertaken. For example, do such features as San Simon Sink and breccia pipes result from salt dissolution associated with faults, from proximity to overlying or underlying aquifers, or from other mechanisms?

8. An investigation needs to be initiated of the hydrologic conditions that might exist in salt domes or bedded salt through a study of operating and abandoned salt mines. This study should determine whether water, oil, or natural gas seeps or leaks are present. Further studies should then focus on the origin and dynamics of such seeps or leaks.

9. We are concerned about the possible ingress of water from near-surface fracturing caused by subsidence that may occur above a repository after partial backfilling of the mine with salt or other material. Study of the type and percentage of backfilling as related to possible development of these features that may be similar to breccia pipes is important in evaluating future salt dissolution.

10. In a similar light, we are concerned about possible salt-dissolution problems stemming from a permeable fracture zone that may exist around any large-diameter access shaft that was blasted or drilled.

11. Methods for determining how long water has been in the subsurface should be developed. Tritium and carbon-14 have been used for dating water less than about 30,000 to 40,000 years old, but other techniques are needed to date older water. Such age data will help provide information on directions and velocities of ground-water flow near prospective waste-storage sites, rates of salt dissolution, and advance of salt-dissolution fronts.

12. Studies on the effect of formation temperature on salt dissolution should be initiated. The heat generated by the waste should be considered as well as the effect of natural thermal gradients on the leaching pattern of cavities.

B. Basinal or Regional Studies

1. The first step in evaluating salt dissolution in a particular basin that might be used for waste storage is to make a comprehensive study of the geohydrology of the entire region or basin. This study should (for example) relate the shallow aquifers overlying the salt to the artesian systems, evaluate bedrock aquifers above and below salt beds (or above and alongside of salt domes), determine whether there are interconnections, identify recharge and discharge sites, and determine if salt is being dissolved and, if so, whether it is being dissolved by recent meteoric water or by deeper artesian water migrating updip. Once the geohydrologic framework is established, mathematical modeling should improve understanding of flow directions, flow rates, recharge and discharge sites, and present-day or future sites for dissolution of salt.

2. We feel that enough studies have been made in the major bedded-salt basins to conclude 1) that dissolution is currently going on at shallow depths, generally ranging from 200 to 800 feet below the land surface, and 2) that dissolution fronts commonly are migrating laterally in gently dipping salt beds at the slow rate of about 2 to 5 miles per million years. However, upon selection of a specific basin for detailed study, it will be necessary to fully evaluate regional and local depths at which dissolution is occurring and rates at which any dissolution front is migrating.

3. Breccia pipes in candidate basins need to be studied, because they represent possible local conduits for ground water to enter or leave a salt bed. Such studies of breccia pipes should determine their distribution, origin, time of development, relation to salt beds, associated jointing and fracturing, and potential to act as conduits for water.

4. Owing to the advanced status of consideration of southeastern New Mexico for a possible storage facility, we feel that San Simon Sink in particular should receive immediate and detailed study. Studies here should include geophysical, coring, and geohydrological investigations to establish the relationship of this feature to salt deposits of the region.

5. Of importance would be the study of elements and/or isotopes present in various waters and soluble rock units in the basin in order to "fingerprint" the source of NaCl in brines and thus better understand regional and local dissolution features and paths of brine migration. In addition to tracer elements, certain ratios (such as Na/Cl, Cl/Mg, and Ca+Mg/SO₄) have been used locally to differentiate sources of brines.

6. Also pertinent would be the study of climatic conditions of the recent past (late Pliocene, Pleistocene, and Holocene), especially in relation to the recent history of salt dissolution in the basin. The salt-dissolution response to past climatic variations should help in predicting future dissolution under assumed climatic conditions.

7. Another investigation of importance would be determination of the ages of recent tectonic movement and/or salt flowage in relation to the recent history of salt dissolution and brine migration.

C. Site-Specific Studies

1. The recommendations and practices of Part B should be instituted on a local scale for detailed evaluation of the integrity of a site.

2. Special studies of a specific salt dome that might be selected should include the potential for movement of water along the flanks of the dome, in the cap rock, and in the sediments above the dome.

3. Geophysical and remote-sensing studies are needed in the vicinity of a proposed storage facility to evaluate the geologic setting more fully. These studies might point to an undetected area or zone of salt dissolution or might indicate a feature that would influence groundwater flow near the repository.

4. Another needed investigation would locate possible brine- or air-filled cavities in the salt bed at or near a proposed storage facility. Application of previous research on thermomigration of such fluid inclusions to the study of the proposed site is warranted.

This report is respectfully submitted by members of the Ad Hoc Committee:

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SALT DISSOLUTION REVIEW MEETING

MARCH 29-30, 1977, HILTON INN, AUSTIN, TX

Tom B. Piper, Chairman

PROGRAM

Tuesday March 29

Highland Room

8:00 am Welcome - ASA (Dr. A. Saberian)
 8:02 am Introduction - OWI (Dr. G. D. Brunton)
 8:30 am - USGS (Dr. Charlie Jones)
 1) Salt Dissolution in Southeastern New Mexico
 2) San Simon Sink
 10:00 am Coffee
 10:15 am Salt Dissolution in Oil and Gas Test Holes in
 Kansas - Walters Drilling Co. (Dr. R. F. Walters)
 11:15 am Test Drilling to Investigate Subsidence in Bedded
 Salt - BASF Wyandotte Corp. (Mr. David J. Dowhan)
 12:15 pm Lunch

Emerald/Sapphire Room

2:00 pm Geohydrologic Studies of Gulf Coast Interior Salt
 Domes - LSU (Prof. C. G. Smith)
 3:00 pm Coffee
 3:15 pm Growth and Shape of a Salt Cavity -- Computer Model
 and Calibration from Detroit Mine Experiment - IIT
 Research Institute (Dr. Richard H. Snow)
 4:15 pm Samples of salt dissolution breccia in the Delaware
 Basin - U of New Mexico (Dr. Roger Anderson)

Wednesday March 30

Emerald/Sapphire Room

9:00 am Investigation of Salt Transport in Vertical Boreholes
 and Brine Invasion into Fresh Water Aquifer - U of Texas
 (Dr. R. M. Knapp , Dr. A. L. Podio)
 10:00 am Coffee
 10:15 am Dissolution of Salt on the East Side of the Permian
 Basin in Texas and Oklahoma - U of Oklahoma (Dr. Ken
 Johnson)
 11:15 am In-Situ Experiment - OWI (Dr. G. D. Brunton)
 PM Ad-Hoc Committee - Dr. Ken Johnson, Chairman

LIST OF ATTENDEES

SALT DISSOLUTION REVIEW MEETING

MARCH 29-30, 1977

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