Y/OWI/TM-18/4

MASTER

SUMMARY OF GEOLOGIC REVIEW GROUP MEETING
November 17-18, 1977

Issued January 6, 1978

John C. Frye, Chairman
James H. Crawford
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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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FOREWORD

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The Department of Energy's (DOE) principal programmatic effort for ultimate and final disposal of high-level radioactive waste generated from commercial nuclear power reactors is named the National Waste Terminal Storage (NWTs) Program. That portion of the NWTs Program, which is currently assigned to the Office of Waste Isolation under DOE's Oak Ridge Operations Office, is primarily concerned with locating and constructing a waste repository in a suitable salt formation. As part of its continuing activities, the Office of Waste Isolation established the Geologic Review Group and arranged for the following people to serve on it:

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The objectives of the Geologic Review Group are:

1. To study and critically review the long-term geologic stability of rock units considered for geologic disposal of nuclear waste.
2. To study and critically review all geologic study plans and activities of the NWTs Program leading to site selection and development of facilities that will safely dispose of commercial radioactive waste that must be delivered to federal repositories for terminal storage.

Presentations of various aspects of the NWTs Program were given to the Geologic Review Group on January 28-29, March 17-18, May 26-27, July 21-22, September 14-15, and November 17-18, 1977. Where appropriate and possible, reports 1, 2, and 3 covering these meetings were published. This document reports on the meeting held on November 17-18, 1977. The agenda for the meeting is shown in the Appendix.

A. INTRODUCTORY STATEMENT

The Geologic Review Group (GRG) met at the Marriott Hotel in New Orleans November 17 and 18, 1977. On November 17 the GRG was briefed by the several contractors on the progress of work in Louisiana, Texas, and Mississippi; by the U.S. Geological Survey; by Law Engineering Testing Company, which, as Geologic Project Manager, is performing the functions of analysis, synthesis, and final recommendation of a site in the Gulf Coast salt dome region; and by personnel of the Office of Waste Isolation (OWI). On November 18 the GRG discussed the data presented and prepared a report.

The GRG also learned of the impending dissolution of OWI. The GRG urges that the role of nationwide coordination and overall supervision, originally assigned to OWI, be carried out in the future as it has been up to the present, by one organization that is fully competent and that is cognizant of the many scientific and technical problems involved with high-level-waste management.

The GRG recommends strongly that the announced schedule for the selection of at least one repository site be maintained and that the announced program of selection of multiple sites in differing geologic environments be continued as expeditiously as possible. Although all geologic media are not equally attractive, the GRG is of the opinion that the data developed to date have not eliminated the possibility of constructing a satisfactory repository in any of the media now under investigation.

B. GULF COAST SALT DOME PROJECT

B.1 Organization of Work Program

After reviewing the organization of the work program for the Gulf Coast Salt Dome Study, the GRG concludes that the organizational structure established by OWI for the allocation of operational functions and responsibilities is effective, reasonable, and compatible with the schedule for site selection.

Presentations by each of the participating organizations demonstrated a competence for, and a grasp of, their assigned responsibilities. This indicates that OWI has effectively communicated the details of the organizational purpose and has made a satisfactory choice of participants.

The GRG is aware of the impending replacement of OWI by one or more organizations to provide overall management for both exploratory and technical-operational phases in site selection and repository construction. The GRG considers that the place of this management function in the work program organization is crucial and urges that there be no temporal gap in the transfer of management duties. Otherwise, the entire program would like falter for lack of unifying leadership, and the schedule would be jeopardized. It should also be pointed out that further fragmentation of this central coordinating function would lead to serious damage to the program and to unacceptable delays.

One recommendation that seems urgent as a result of the presentations is the establishment of uniform criteria for salt dome acceptability to guide the work in each salt dome region. Such uniform criteria are essential if the studies carried out under the several technical contractors operating in each state are to be compatible and amenable to comprehensive evaluation.

During discussions of programmatic obstacles, several participants noted that long delays are often associated with final approval of contracts and environmental impact assessments. These delays make rational planning of the work very difficult and threaten an already rigorous schedule. Because the site-selection schedule is an important ingredient in achieving the national goal of an acceptable radioactive waste disposal program, the GRG recommends that the Department of Energy (DOE) aid in expediting the work by giving prompt attention to all requests for direction and approval.

B.2 Hydrologic Aspects

Hydrologic investigations are necessary for the evaluation of potential repository sites in salt domes in order to (a) determine the short-term environmental effects of construction and operation of a repository, (b) predict the long-term hazards of radioactive waste storage at specific sites, and (c) plan the construction and operation of a given repository. All hydrologic work should be focused clearly on these objectives, and a maximum return of useful information should be sought for a given investment of money. Proposals for test drilling at distances probably no greater than 20 miles from a potential repository site should be reviewed very carefully. The GRG is concerned that such drilling may not only fail to yield relevant information but may also needlessly increase the public's apprehension about the possibility of long-distance transport of radionuclides.

The GRG is aware of the large amount of test drilling that will be needed to define the hydrogeology of a potential repository site. A reasonably detailed picture of water salinity in the vicinity of salt domes must be obtained from past test holes, petroleum exploration wells, and numerous test

holes yet to be drilled. Salinity distributions together with other hydrogeologic data will allow estimates of the rates of salt dissolution; thus the drilling program is a critical part of the evaluation of the long-term integrity of the waste repository. Present and anticipated delays in receiving funding, obtaining various permits, and completing contracts for the work are slowing the progress of hydrologic evaluations of sites. Since announced schedules reflect serious objectives, DOE should expedite these matters at once.

Plans to collect important data from the drill holes penetrating any portion of the caprock and from those drilled in the domes appear to be well formulated. Nevertheless, special consideration should be given to the problem of hole abandonment when the caprock and salt plug have been penetrated. If the salt dome that is being explored is to become a repository site, normal plugging techniques will not be acceptable for these holes. Also, all possible cores, cuttings, water samples, and logs should be taken to obtain duplicate samples of cuttings and water samples and have them properly preserved for possible future studies.

The manner of presentation of hydrologic data requires great care. The use of prominent arrows on maps to show movement of ground water from potential repository sites to distant well fields can serve no constructive purpose and can be particularly misleading to the public for the following reasons:

1. The flow field is three-dimensional, and any water even briefly in contact with the outer surface of the salt will become a brine that is denser than potable water. Therefore, its trajectory will not follow that of the potable water in an aquifer.

2. Even the most elaborate mathematical mode cannot accurately predict the trajectories of water from a point source for more than a few miles in complex sedimentary aquifers similar to those near the salt domes. Heterogeneity and anisotropy can be extremely important in governing flow directions, to test-drill the aquifers over areas of several hundred square miles, with a spacing of one mile or less, in order to obtain the data for existing models would be prohibitively expensive. Even if this information could be obtained, hydraulic head distributions thousands of years into the future cannot be anticipated.
3. A time scale is normally not given with the water-level maps showing supposed water trajectories. The rate of radionuclide movement is much slower than that of ground water because of sorption and ion exchange, and generally will be measured in hundreds, or even thousands, of years per mile. Absolutely no danger would exist to the present-day population or to their immediate descendants from radionuclides transported several miles by ground water from a repository in a salt dome.
4. Finally, radionuclides are to be completely isolated in the salt and are not part of the ground-water transport system. If any predictable avenue of escape of radionuclides into the ground water exists in a given salt dome,

the repository simply will not be constructed in that dome.

An imaginary trajectory from a salt dome to a well field incorrectly implies that the repository itself is part of the ground-water transport system when, in fact, the non-permeable boundary of the salt domes does not contribute any water to the ground-water flow system.

B.3 Tectonic Stability

Consideration of tectonic stability should address two principal questions: (1) Could movement of the salt mass containing radioactive waste bring this waste into contact with the biosphere during the period of desired isolation? (2) Could tectonic processes alter the characteristics of the salt dome and its environs so as to permit transfer of radionuclides to the biosphere by ground-water movement?

The first question involves assessment of existing movements and evaluation of the probability of inducing movement, or accelerating existing movements, through modification of the natural environment by development of a repository and emplacement of waste in the salt. For a repository excavated at a depth of, say 1000 m, upward movement of the order of 1 mm per year would be necessary to bring the waste to the surface in, say, one million years. Hence, to ascertain whether existing movements could effect such a transfer requires only that the measuring instrument be sensitive enough to detect a few tenths of a millimeter of movement per year. Instrumentation more elaborate or more sophisticated than is required to detect this amount of movement would seem unwarranted.

The possibility of induced or accelerated movement can best be evaluated by closely coupling work on theoretical modeling with experimental study of the mechanical properties of salt, along with measurement of possible in situ stresses. If the time-dependent behavior of salt is known reasonably well, modeling can be undertaken to evaluate the amount and rate of movement that might be induced by (a) relief of load related excavation, (b) changes in flow characteristics of the salt caused by increased temperature, (c) stresses related to excavation or thermal loading, and (d) in situ stresses. Work currently in progress to evaluate the mechanical properties of salt (e.g., Sandia, RE/SPEC) and to perform geomechanical modeling (LSU) appears adequate and should be continued. Some thought should perhaps be given to in situ stress measurements if the preliminary results of the modeling suggest that possible in situ stresses could have a significant effect on salt mobility during the time frame of concern.

The second principal question - namely, that of possible influences of tectonic processes on the hydrogeologic regime in the salt dome environment - appears not to have received adequate attention. This question also involves two important aspects: (1) the possibility of such processes altering the hydraulic transport characteristics of the salt and of the immediately surrounding rocks and (2) possible changes in the ground-water flow regime which could affect dissolution rates or the flow of ground water into or through the salt dome. Again, the problems can perhaps best be addressed by closely coupling work on mechanical properties and mass characteristics with appropriate theoretical modeling. Observations related to seepages, "blowouts", fissures, shear zones, and similar features need to be followed to achieve a better understanding of the processes responsible for these

features and of the implications with respect to ground-water transport. Work of this sort appears to be in a very preliminary state and needs additional emphasis.

B.4 Characteristics of Medium

The GRG considers that existing and planned investigations of the characteristics of salt, caprock, and adjacent rocks are adequate for determining the suitability of dome salt as a repository medium. Investigators are aware of problems that rock characteristics may pose and have planned studies that will provide answers in a reasonable time frame. Some of the major problems are the following:

1. Petrography and structural relations of salt and caprock.
Impurities in the salt are very minor and should be no handicap to the development of a repository. Caprock is principally anhydrite, with minor amounts of quartz, carbonates, pyrite, and other minerals. The contact between caprock and salt is generally sharp; it is tight in some places but serves as a pathway for water movement in other places. However, the amount of water moving along the contact appears to be generally too small to threaten the integrity of a repository in the salt.
2. Water flow and seepage within a salt dome. Water has been encountered in some salt-dome mines in the form of flow along fissures and as slow seepages. Such water could be a threat to a waste repository and will have to be avoided in developing a repository site. In many occurrences the source of

the water is uncertain. In some mines the water is evidently ground water or surface water that enters the mine along fissures opened by the mining operations. It may be that all the water encountered in mines has such a source, but this conclusion requires demonstration. Studies are under way to trace the source of the water by means of structural studies of the salt, analysis of the water, and attempts to date the water. The GRG recommends that these studies be emphasized because moving water in a salt dome would obviously jeopardize the integrity of a repository.

3. Blowouts. Blasting during mining operations occasionally produces "blowouts" - forcible ejections of salt from parts of the roof or wall, leaving cavities of up to a few meters in diameter and 30 m long. Such phenomena have been recognized for a long time, but their mechanism is still not understood. The blowouts are generally not observed when taking place because they occur only during blasting, and the evidence of their occurrence is simply the open cavity and a pile of ejected salt fragments. There is some evidence that blowouts result from release of pockets of trapped gas, probably methane or carbon dioxide; there is also

evidence that the salt may have been under stress, since the material released by a blowout crackles when placed in water. Reports of blowouts suggest that they are limited to certain zones in the salt, generally zones in which streaking of dark material indicates that the salt may have been sheared and may contain a little organic material. In some mines, no blowouts have occurred. Blowouts would probably not jeopardize the integrity of a repository if it is developed on a single level but might be troublesome if wastes are placed in salt at several levels. The GRG recommends continued study of blowouts to determine their origin, if possible, and to characterize the kinds of zones in which they occur so that these zones may be avoided in developing a repository.

4. Shearing and complex folding of the salt within a dome. This occurrence is evidenced by the streaking of minor dark impurities through the salt. However, no actual planes of fault movement are detectable because breaks in the salt are self-healing. Open fissures in the salt may be produced by water movement along cracks produced by mining operations but would not persist in a dome under natural conditions. Detailed study of structures in the salt is not justified except for the

location and characterization of zones in which blowouts are to be expected. Production of open fissures during excavation of a repository is not to be expected as long as the repository site is more than a few hundred meters below the surface.

B.5 General Geologic Considerations

The erosional and climatic history of the most recent half of Quaternary time (i.e., approximately the last 10^6 years) should be understood as an indication of the reasonable expectable events that might affect the repository site during the next 10^4 to 10^5 years. Massive quantities of data exist regarding the erosional history of the Gulf Coast salt dome region under investigation, and new original research is not needed. However, these data have not been synthesized in such a way as to clearly determine the implications for the safe operation of a potential repository in a salt dome.

Available data concerning the maximum depth of incision of channels into pre-Quaternary rocks during episodes of maximum sea-level lowering should be reviewed. Such erosional valleys have subsequently been filled in response to rising sea levels and have been defined on the basis of extensive drilling and geophysical data. Since the sea-level fluctuations are synchronous with episodes of continental glaciation, they serve an added role as paleoclimatic indicators. Such data are essential in regard to the possible erosional breaching of the dome that might be selected and the possible modifications of the hydrologic system in the vicinity of such a dome.

It is possible to predict (and thus avoid) the location of future deep stream incision, if such were to occur, from a study of the pattern of the present drainage system; however, future changes in the hydrologic regime caused by such erosional events could be much more extensive than they were in the past.

The surficial Quaternary deposits can be used as an index to geologic history of the last 10^6 years. In places where radiometric age determinations of such deposits can be obtained, such new data will be useful, particularly in estimating rates of possible upward movement of salt domes. However, long-range correlation studies of the many terrace surfaces would have little value to the specific objectives of the project.

The general geology of the region under study is so well known that further widespread stratigraphic studies are not relevant to the program. The relationships of each of the domes to be investigated to the regional geology is of particular importance.

B.6 Program Assessment

The GRG wishes to commend OWI for planning the program on the Gulf Coast salt domes and for assembling the competent group of contractors that are engaged in the project. On the basis of data presented to the group, the GRG is confident that the necessary work can be done on schedule (assuming no undue delays in contract approvals) and that a site can be recommended by the target date. However, a possible danger exists in the proliferation of time-consuming data collection of questionable relevance, which could make it impossible to meet the target date.

C. GENERAL COMMENTS

As originally constituted, the GRG was charged with the task of review and advice on a projected national program designed to carry on exploration for six areas in which sites for high-level radioactive waste repositories might be located. The program was intended to localize the investigations within each of the six areas, with the ultimate objective of design and development of six repositories, over a period of years, constructed in several different geologic media. Furthermore, at the outset of the program, the objective was the safe containment of solidified reprocessed wastes from the nuclear power industry. The GRG continues to regard the original objectives as highly important to the future welfare of the United States.

During the past year, the objectives of the program have been altered by a partial redefinition of the waste materials to include unreprocessed spent fuel elements; and definitions of the period of preliminary decay of radionuclides and the period of required retrievability of waste have become uncertain. Moreover, the system created to serve a unified planning and supervising function on a national basis has been fragmented; so assurance can no longer be given of uniformity in exploration procedures, uniformity in quality control and design criteria, and maintenance of the original time schedule.

The GRG is concerned about these seeming disruptions in a program so essential to the nation and recommends that highest priority be given to the coordination of the separate, and sometimes overlapping and competitive, segments of the geologic disposal effort as it now exists.

REFERENCES

1. Frye, John C.; Crawford, James H.; Davis, Stanley N.; Donath, Fred A.; Gloyna, Earnest F.; and Krauskopf, Konrad B.; "Summary of Geologic Review Group Meeting January 20-21, 1977," Office of Waste Isolation, Union Carbide Corporation, Nuclear Division, Y/OWI/TM-18/1 (Mar. 7, 1977).
2. Frye, John C.; Crawford, James H.; Davis, Stanley N.; Donath, Fred A.; Gloyna, Earnest F.; and Krauskopf, Konrad B.; "Summary of Geologic Review Group Meetings March 17-18 and May 26-27, 1977," Office of Waste Isolation, Union Carbide Corporation, Nuclear Division, Y/OWI/TM-18/2 (July 18, 1977).
3. Frye, John C.; Crawford, James H.; Davis, Stanley N.; Donath, Fred A.; Gloyna, Earnest F.; and Krauskopf, Konrad B.; "Summary of Geologic Review Group Meetings July 21-22, 1977," Office of Waste Isolation, Union Carbide Corporation, Nuclear Division, Y/OWI/TM-18/3 (Aug. 31, 1977).

APPENDIX
GEOLOGIC REVIEW GROUP MEETING
AGENDA
November 17, 1977

<u>Topic</u>	<u>Speaker</u>	<u>Time</u>
WELCOME	C. D. Zerby, OWI	8:30
INTRODUCTION	R. B. Laughon, OWI	8:35
LOUISIANA		
LSU Studies: Geomechanics	R. L. Thoms, LSU	8:45
Quaternary Studies	C. R. Kolb, LSU	
Geohydrology	C. G. Smith, LSU	
Regional Geology	R. E. Wilcox, LSU	
Borehole Project	M. F. Hawkins, LSU	
USGS Hydrology Studies	G. N. Ryals, USGS-BR	11:00
TEXAS		
USGS Hydrology Studies	J. E. Carr, USGS-H	11:30
LUNCH		12:00
TEXAS (continued)		
TBEG Proposed Work	E. G. Wermund, TBEG	1:30
MISSISSIPPI		
USGS Hydrology Studies	C. A. Spiers, USGS	2:00
OVERALL GULF COAST PROJECT	J. G. LaBastie, Law Engr.	2:30
AVERY ISLAND IN-SITU EXPERIMENT	P. D. Fairchild, OWI	3:30
GENERAL DISCUSSION		4:00
ADJOURNMENT		5:00

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