

**SUMMARY COMMENTS AND GEOLOGIC EVALUATION:
THE STATE'S REVIEW OF DEPARTMENT OF ENERGY
DOCUMENTATION ON THE PROPOSED
HIGH LEVEL NUCLEAR WASTE REPOSITORY PROGRAM**

Prepared By:

**Thomas N. Tetting, Engineering Geologist
Department of Natural Resources
Division, Oil, Gas & Mining**

EXECUTIVE SUMMARY CONTENTS

1. Introduction
2. Geologic Structure and Seismicity
3. Geochemical Concerns and Salt Dissolution Features
4. Exploration Considerations and the Experimental Shaft Concerns
5. Summary
6. Attached State Consultant's Reviews

INTRODUCTION

This report is a compilation of review concerns and criticism of the documentation provided by the Department of Energy (DOE) with regard to geologic factors relating to the proposed siting of a high level nuclear waste repository at the Gibson Dome in Southeast Utah. This document summarizes the review carried out by the Division of Oil, Gas and Mining (DOGM) as well as several University and private consultants. Material has been referenced accordingly and represents almost four years of DOGM's association with the project. It should be mentioned that this is a summary document and as such may only represent some of the more important concerns facing the project. By no means are all comments or questions which have been raised over the years and which have not yet been addressed by DOE proposed to be included.

It is hoped that by this presentation further investigations of DOE will proceed to satisfy areas of concern which may then allow adequate Environmental Assessments (EAs) to be prepared for the Lavender and Davis Canyon sites. Until that time it is unequivocally stated that the present efforts of DOE to study the sites at Gibson Dome are entirely unsatisfactory to the level which would allow comprehensive EAs to be written. Five sections follow which bring this point to light.

GEOLOGIC STRUCTURE AND SEISMICITY

Geologic considerations presented by the State through the review and evaluation of DOE's prolific document library are extremely important for further consideration of Davis or Lavender Canyons for nomination to site characterization studies. It is essential that the structural and stratigraphic aspects of the regional geologic setting be investigated to evaluate the impacts which are expected if further studies are implemented. Once considered, these ideas will then aid an investigative team to properly assess the likelihood that Davis or Lavender Canyons are suitable sites to further consider for site characterization studies. DOE must address the data inadequacies outlined by the State in order to complete comprehensible EAs for the sites. DOE's efforts to date should be considered incomplete to this extent.

Nowhere is the level of data inadequacy more noticeable or more critical than in the assumptions used to satisfy the non-standardized favorable or unfavorable conditions in the 10CFR 960 Guidelines. In many cases unknown quantities or information have been dismissed as insignificant. It is the State's position that regardless of the guidelines, many geologic issues must be reassessed before preliminary findings are made and suitable information exists to write EAs.

A more in-depth presentation of data inadequacies which fit into the category of structural geology are offered below to summarize the present situation.

I. High levels of seismicity are evident on the Colorado Plateau contrary to DOE's presentation in draft working papers for the EAs. These high levels are sporadic so that by averaging the limited statistics gathered over the short time period, an overall low level assessment has been made. This evaluation is drawn from studies and monitoring conducted by Woodward Clyde Consultants.¹ "Unusual" activity for the geologic setting has also been determined to have occurred within the last six years around Capitol Reef National Park², only 60 to 70 miles from Gibson Dome. Earthquakes of a magnitude M_L 6 1/2 to 7 are reported. The level of seismicity may be attributable to stress concentrations in a heterogeneous crustal setting caused by an eastward transgression of the Basin and Range-Colorado Plateau transition zone. This in turn may be a sign that reactivation of pre-existing zones of weakness is occurring, i.e. faults with little or no apparent surficial expression (other than the Waterpocket Fold monocline itself) are becoming active.

The cause for concern on this issue is further substantiated by other hypotheses which utilize the idea of pre-existing zones of structural weakness. These are termed lineaments. Both the Colorado and Olympia-Wichita lineaments represent certain identified surficial expressions of possible older (Paleozoic-PreCambrian) zones of weakness. It is less than reassuring that both lineaments cross each other at nearly right angles in the Paradox Basin. These theories pervade the scientific literature and are not only presented by Wong³ but by Baars and Stevenson⁴ and others.

¹ Wong, I.G.; 1984, p. 11; Seismicity of the Paradox Basin and the Colorado Plateau Interior; ONWI-492; 131p.

² Wong, I.G.; 1984, p. 64; Seismicity of the Paradox Basin and the Colorado Plateau Interior; ONWI-492; 131p.

³ Wong, I.G.; 1984, p. 80; Seismicity of the Paradox Basin and the Colorado Plateau Interior; ONWI-492; 131p.

⁴ Baars, D.L. and Stevenson, G.M.; 1981; "Tectonic Evolution of the Paradox Basin, Utah and Colorado"; Rocky Mountain Association of Geologists; Geology of the Paradox Basin.

Further credibility for the idea of older structural and reoccurring influence within the geologic setting is also described by Weimer⁵ in his presentation of fault block structure patterns in SW Colorado. All of the work on the subject gives credence to the issue that DOE should further investigate the subject.

II. Regardless of proffered hypotheses, the geologic setting may include sites of intense fracturing which may or may not be expressed at the surface by features such as joints and fractures. Quantitative data has not been discussed by the DOE which would characterize a routine effort in examination of surficial joint and fracture analyses. Bruhn⁶ has advised that such an undertaking would be particularly applicable to the Gibson Dome area and essential to preliminary studies. Certainly a conservative approach to a proposal such as siting a high level nuclear waste repository would not disregard the effects of these potential sources of problems until further investigations were carried out.

III. Mine-induced seismicity documentation and investigation as reported by Wong⁷ for coal mining in the Book Cliffs and activity in the Cane Creek Potash Mine, needs to be presented and discussed further in the EAs. Again, quantitative results of measurements have not been reported. A serious problem may be presented by this feature as a "geologic hazard" during shaft construction and operational phases. Furthermore, the possibility also exists that fractures may be induced in surrounding strata during excavation which could promote potential radionuclide migration pathways away from the site area. Estimates of the radius of possible effects from the source range up to several kilometers. Chan⁸ also reports (citing ONWI-290) seismic effects in the Paradox basin caused by coal mining in the Book Cliffs, 110 miles away.

⁵ Weimer, R.J.; 1980; Recurrent Movement on Basement Faults, A Tectonic Style For Colorado and Adjacent Areas; Colorado Geology; Rocky Mountain Association of Geologists.

⁶ Bruhn, R.L.; 1984; Review of Structure and Tectonics Section for Davis and Lavender Canyons; EA Working Papers; Prepared for the Utah Office of Planning and Budget; Document attached.

⁷ Wong, I.G.; 1984; p. 117-118; Seismicity of the Paradox Basin and the Colorado Plateau Interior; ONWI-492; 131 p.

⁸ Chan, M.A.; 1984; Review of High Level Nuclear Waste Issues at the Lavender and Davis Canyon Sites; Prepared for the Utah Office of Planning and Budget; Document attached.

IV. Finally, concerns developed by Huntoon⁹ regarding an alternate hypothesis for recent seismic and faulting activity associated with the Needles fault zone (Grabens region) should be investigated in light of this departure from older, more accepted theories. This type of approach to understanding motion in the surrounding geologic setting contributes to the complexity of the geologic system and underscores the state's position that DOE has not studied the area sufficiently.

V. "Facies changes are not well understood or documented within the geologic setting. Rapid facies changes in interbeds of the Paradox Formation may effect and control fluid movement and dissolution."¹⁰

In summary then, the five previous parts of this section represent areas of a basic lack of investigation and have been overlooked or played down because of their inherent difficulty of resolvability and time-consuming nature. They nevertheless represent unanswered questions which should have been investigated prior to EA development and still need to be addressed.

⁹ Huntoon, P.W.; 1982; The Meander Anticline, Canyonlands, Utah: An Unloading Structure Resulting from Horizontal Gliding on Salt; Geological Society of America Bulletin; V. 93; p 941-950.

¹⁰ Chan, M.A.; 1984; Review of High Level Nuclear Waste Issues at the Lavender and Davis Canyon Sites; Prepared for the Utah Office of Planning and Budget; Document attached.

GEOCHEMICAL CONCERNS AND SALT DISSOLUTION FEATURES

A major tenet in DOE's efforts to portray an adequate geochemical assessment of the Davis-Lavender Canyons region of the Paradox basin is the hasty manner in which only a limited amount of information was assembled. Again, as in other sections addressing the 10CFR960 guidelines, inferences are drawn illogically or if presented logically are usually supported by the lack of data rather than by the presence of it. The two parts of this section presented below provide a summary of major concerns which will require additional investigation or treatment prior to EA completion.

I. Primarily, the greatest concern which falls into the geochemical category is the subject of salt dissolution. Containment characteristics of salt cycle 6 could be seriously compromised by the host rock. The levels of present salt dissolution or potentially related impacts have not been sufficiently documented. The dissolution process in the region is not as homogeneous or uniform nor as complete as depicted by the DOE.

The two canyon sites under study are surrounded by potentially active sites of current salt dissolution and may in turn be effected. Lockhart Basin (12 miles north), and Beef Basin (13 miles southwest) are the most recognized and probably the oldest stages of salt dissolution evolution. The Needles fault zone (11 miles west), may be a relatively intermediate aspect of salt dissolution phenomena (regardless of Huntoon's explanation)¹ and the Shay/Bridger Jack/Salt Creek graben system (approximately 5 miles southeast), an even newer stage of salt dissolution. Hite and Lohman² state in reference to activity in Paradox Basin salt structures, "Collapse of the crests of the salt anticlines occurred in two stages apparently widely separated in time. The first stage followed perhaps rather closely the late Cretaceous folding. The second stage followed epeirogenic uplift of the entire Colorado Plateau in the middle and late Tertiary and this stage is still continuing." Dissolution within synclines, adjacent to the domed salt structures (or anticlines) of the region is a feature common to the Paradox basin and may be characteristic of associated collapse features. Further investigation into the relationship between Gibson Dome and the surrounding features is essential for this reason alone.

¹ Huntoon, P.W.; 1982, The Meander Anticline, Canyonlands, Utah: An Unloading Structure Resulting from Horizontal Gliding on Salt; Geological Society of America Bulletin; V. 93; P. 941-950.

² Hite, R.J. and Lohman, S.W.; 1973; P. 41; Geologic Appraisal of Paradox Basin Salt Deposits for Waste Emplacement; Open File Report, USGS-4339-6; 75 p.

Faulting may have and could continue to play an integral part in the initiation of the effects of salt dissolution. The presence of faults beneath Davis Canyon and in Lockhart Basin may be correlative to this account. Claims by Hite and Lohman³ that the Gibson Dome is "characterized by relatively simple disharmonic folding and minor faulting" need to be substantiated by DOE if indeed, the faulting is minor.

Another area in which more investigation is needed is that of the formation of the breccia pipes found in Lockhart Basin. Relationship to the salt dissolution phenomena or groundwater history of the area should be studied.

In addition, saline brines are present in both the overlying Honaker Trail Formation and in the underlying Leadville Limestone. Geochemical examination of the brines has not disproved an origin from dissolution of the salt⁴ and further study is needed.

Two other factors causing concern are the presence of a karstic topography at the top of the Mississippian limestone (the existence of which has not been disproven in the Gibson Dome area) and subsurface northwest trending faults offsetting Mississippian and lower Paradox rocks. Both create genuine concerns about salt dissolution potential and possible solution pathways which DOE has not adequately addressed. The combination of these features and their variability, including a spectrum of intraformational contacts between the Leadville and Molas Formations, creates the sense that there is a more complicated set of relationships having potentially negative consequences on the issue than has been acknowledged by DOE.

Finally, localized and overpressured zones of high permeability might be present which could give rise to local dissolution and subsidence within the Paradox or other formations.

It is apparent that more detailed work needs to be done to determine what localized effects may be occurring in the site areas. Existing data and evaluations which have been presented by DOE are inadequate to have reached the conclusions regarding the dissolution potential at the sites. Modeling of dissolution is complicated and may be

³ Hite, R.J. and Lohman, S.W.; 1973; Geologic Appraisal of Paradox Basin Salt Deposits for Waste Emplacement; Open File Report, USGS-4339-6; 75p

⁴ Parry, W.T. and Morrison, S.J.; 1984; Review and Analysis of High Level Nuclear Waste Issues: Review of the Statutory EA for the Davis Canyon Site; Paradox Basin, San Juan County; Geochemistry; Prepared for the Utah Office of Planning and Budget; Document attached.

unpredictable because of irregularities and self perpetuation effects of dissolution fronts.⁵ Regardless, a more detailed approach needs to be taken. Additional subsurface investigations into all stages of salt dissolution sites in proximity to the proposed locations, as well as development of geophysical survey lines in both canyons are necessary before favorable or unfavorable conditions in the guidelines can be assessed.

II. Determination of the geochemical suitability of the sites as investigated needs to address the salt dissolution question further and must also satisfy questions regarding pressure, temperature, and host rock mineralogy in the repository, as well as radionuclide transport behavior. Although a more specific treatment of the review of these points can be found in the attached document by Parry and Morrison⁶, it is pertinent to include the fact that much relevant information has not been assessed from available sources or has been ignored. Transport and retardation mechanisms need to be evaluated, clay mineralogical transformations need to be presented, and literature summarized. Modeling of transport mechanisms is overly simplified and completely unsuitable for acknowledged site variables. The interaction of these geochemical variables will effect the longevity of engineered barriers and the release of radionuclides to the accessible environment. As presented to date, the information assembled by DOE fails to provide even a basis for evaluation of the sites let alone a choice between them to select a candidate site for further characterization studies.

⁵ Chan, M.A.; 1984; Review of High Level Nuclear Waste Issues at the Lavender and Davis Canyon Sites; Prepared for the Utah Office of Planning and Budget; Document attached.

⁶ Parry, W. T. and Morrison, S.J.; 1984; Review and Analysis of High Level Nuclear Waste Issues: Review of the Statutory EA for the Davis Canyon Site; Paradox Basin, San Juan County; Geochemistry. Prepared for the Utah Office of Planning and Budget; Document attached

EXPLORATION CONSIDERATIONS AND THE EXPERIMENTAL SHAFT CONCERNS

The application of deductive reasoning to the development of a project of this magnitude appears nowhere any more openly and misconceived than in the area of DOE's exploratory investigation. The extrapolation of data from the single GD-1 well site for modeling of the Gibson Dome region is a questionable process at best.

Bruhn¹ has described a possible geologic scenario which could be present and affect the repository sites. It is one of many and would not show up from the present level of exploration. It represents those which must be considered, however, if a conservative approach to the project is to be maintained. The potential for large lateral variations in fracture orientation and intensity exists across the region, particularly as they may reflect changes in stress fields in various strata through time. It cannot be described from the limited well site data. Effects from these stress patterns will need to be considered during project planning stages. Concerns such as this simply reinforce the opening statement of this section. Other concerns described below further establish this point.

I. Evaluation of joint set and fracture mapping as well as aerial photo interpretation may yield more relative insight into the nature of regional stress patterns. Previous work conducted by DOE has been cursory and quantitative data is lacking from presentations. "Minimally incised drainages" on a NE trend around the site areas may indicate geomorphologically that patterns have evolved exhibiting some secondary stress influences which ought to merit further investigation. Examination of the results of many of DOE's mapping projects has not yet been possible because of their late preparation, e.g. isopach maps of formations.²

¹ Bruhn, R.L.; 1984; Review of Structure and Tectonics Section; EA Working Papers for the Davis and Lavender Canyons; Prepared for the Utah Office of Planning and Budget; Document attached.

² Zeisloft, J.; 1984; Review of the EA of Lavendar and Davis Canyon Sites, San Juan County, Utah; Prepared for the Utah Office of Planning and Budget; Document attached.

II. Correlation of drill cuttings and samples from existing wells with geophysical logs has not been described and is appropriate to the current level of investigations.³

III. Chan, in her report to the state,⁴ mentions several diagenetic concerns including porosity, dolomitization and intergranular cementation which could have significant effects on hydrological modeling. These subjects are poorly treated in DOE reports essentially because of the overall lack of drill hole data. The sparse sampling conducted so far has led to gross assumptions of stratigraphic and structural homogeneity.

IV. Chapman and Willet⁵ raise excellent questions regarding secondary permeability and in general, the dependability of presented information pertaining to salt cycle 6 as obtained from hydraulic tests at GD-1. The case they present is justified because detailed information is as yet unsubstantiated by other well site examinations.

V. Concerns over the extent of mineral and hydrocarbon resources in the area, as well as public interaction over mining claims create another area which DOE needs to discuss in greater detail including: potential conflicts between DOE sponsored exploration and private assessment work, e.g. at the proposed GD-2 site; compensatory strategies; presentation of the level of current or active oil and gas exploration in the Paradox basin and possible impacts of the project on it and; a more accurate site specific estimate of hydrocarbon potential for Gibson Dome.

³ Zeisloft, J., 1984; Review of the EA of Lavender and Davis Canyon Sites, San Juan County, Utah; Prepared for the Utah Office of Planning and Budget; Document attached.

⁴ Chan, M.A.; 1984; Review of High Level Nuclear Waste Issues at the Lavendar and Davis Canyon Sites, Utah; Utah Office of Planning and Budget documentation attached.

⁵ Chapman, D.S. and Willet, D.; 1984, Review of Geohydrology Sections of E.A. of the Davis Canyon Site; Prepared for the Utah Office of Planning and Budget; Document attached.

VI. The environmental impacts and associated reclamation responsibilities of proposed DOE exploration studies have been minimized if discussed at all. Conflicting information has been given in the working papers for the EA's with regard to the duration of individual borehole and exploration studies. Descriptions of access for seismic surveys, where portrayed as difficult, do not indicate what exact actions will be needed to implement the study nor describe the level of difficulty implied.

Mapping of access roads to exploration sites including the exploratory shaft, has been avoided due to the extensive addition of impacted acreage added onto the existing unrealistic totals presented by DOE.

The most unconscionable aspect of the proposals so far is the lack of regard for reclamation. No reference has been made to the poor level of revegetation success achieved at the GD-1 site, which is the only example of DOE rehabilitation in the area. The long term impacts to a multitude of proposed sites throughout the Gibson Dome and associated regions have received low levels of concern. If DOE has not already mentally chosen the Gibson Dome site for further site characterization studies, then reclamation concern should be further elaborated.

VII. Additional investigation is sorely needed on the concept of the experimental shaft design. Following the July 1983 publication of the ONWI-390 Technical Report, the State contracted an engineering firm, Ford, Bacon and Davis, to comment on the proposals offered in both that report and in the ONWI-455 document. The consultant's report, released in January, 1984 was based upon the single shaft concept. Therefore the most important issue facing the State in this section may be whether or not the single shaft concept is still considered. Since this is planned as an underground mining venture it may be necessary that at least two means of separate access and exit are required for ventilation and safety precautions. Detailed and published plans addressing this point are lacking altogether. Regardless of the concept, the series of comments and questions raised by the F.B. and D. report are still relevant and largely unanswered. It is the state's position that prior to site characterization studies, detailed plans addressing subjects raised in the report still need to be designed and reviewed. The general summary of major concerns with the shaft design proposal are given below.

1. Many items and assumptions regarding shaft design need to be confirmed by an exploratory borehole(s) prior to site selection. Time tables presented so far are obsolete. Testing criteria are sketchy. Extrapolation of geologic information from GD-1 alone is completely unacceptable.

2. Proposed drilling methods have not been entirely demonstrated as feasible. Proven technology has not yet been established for a project of this magnitude.

3. Shaft sealing designs and the maintenance of dry repository conditions has not been assured to eliminate the possibility of ground water contamination of the salt bed after repository operations cease. Details are lacking.

4. Geologic surface deposit characterization studies need to be presented due to the effects upon borehole and shaft placement, stability of the shaft headframe and hoisting facilities, spoils, wastewater holding facilities, access road design, runoff considerations and soil storage designs.

5. Earthquake design standards appear to be loosely adhered to in terms of magnitude and distance considerations.

6. Salt disposal considerations are lacking definition. Plans involving use of the existing disposal area at the Cane Creek Potash Mine are unacceptable as this mine has not received final permitting and approval from the Utah Division of Oil, Gas and Mining and already presents salt impact problems for the Colorado River.

7. Designed storage areas for such materials as well casing, liners, salt, and cuttings (fluids) are inadequately sized and will in effect drastically increase the number of acres impacted. This may in turn effect results of other studies such as on visual impacts.

8. Shaft liner designs are subject to variability and need to be substantiated. Concerns over long term integrity of grout-salt seals and corrosion of steel materials are relevant. Effective-life estimates of materials need to be proven.

9. All levels of reclamation of the site need to be examined and addressed, particularly in light of state requirements.

It is easy to see from the number and level of the previous concerns that the attitude of investigation which has been applied to the Gibson Dome site has been a cursory one and continues to perpetuate the well founded fears of the state that incomplete EAs for the sites will be written.

SUMMARY

In summation, the information submitted in the previous report has attempted to outline and detail to some extent, the outstanding problems and concerns facing the geological investigation into establishing a basis for evaluating the Gibson Dome site as a potential candidate for further site characterization studies. There are other detailed geologic remarks addressing associated issues such as geologic hazards, host rock characteristics and alternate sites developed by the Utah Geological and Mineral Survey (UGMS).

It can clearly be seen from the present position that a vast quantity of investigative work still needs to be performed prior to DOE completing an adequate E.A. and using it to compare proposed sites nationwide in order to choose three for further site characterization. It is anticipated that the comments contained herein will help provide adequate justification to encourage this end.

Documents attached:

1. Bruhn, R.L.; Review of Structure and Tectonics Section, Draft E.A. for the Davis and Lavender Canyons.
2. Chan, M.A.; Review of High Level Nuclear Waste Issues at the Lavender and Davis Canyon Sites, Utah.
3. Chapman, D.S. and Willet, S.D.; Review of Geohydrology Sections of E.A. of the Davis Canyon Site.
4. Parry, W.T. and Morrison, S.J.; Review and Analysis of High Level Nuclear Waste Issues: Review of the Statutory E.A. for the Davis Canyon Site Geochemistry, Paradox Basin, San Juan County, Utah
5. Zeisloft, Jon; Review of the E.A. of Lavender and Davis Canyon Sites, San Juan County, Utah.