GL01332

pmw

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

EARTH SCIENCE LABORATORY
420 CHIPETA WAY, SUITE 120
SALT LAKE CITY, UTAH 84108
TELEPHONE 801-581-5283

October 27, 1983

Organizing Committee
25th U.S. Symposium on Rock Mechanics
c/o Prof. C. H. Dowding
Dept. of Civil Engineering
Northwestern University
Evanston, IL 60201

Dear Dr. Dowding:

I recently received a copy of the 25th Symposium on Rock Mechanics - Call for Papers from Dr. W. R. Judd. He noted that the "Waste Isolation" session would consist of invited papers only, so the abstract which I submit seems most appropriate for the Geophysical Exploration session.

I have served as the exploration geophysicist member of the Battelle-ONWI Geologic Review Group and the DOE-Hanford BWIP Geologic Overview Committee since 1979, and as a peer reviewer for the Nevada NWTS exploration program in 1979 and 1981. I have developed many thoughts regarding the role of geophysics in the National High Level Waste Isolation Program which I would like to share with symposium attendees. An abstract of my proposed presentation, "Exploration Geophysics in the National Nuclear Waste Isolation Program", is enclosed for reviewers' consideration.

Sincerely,

Howard P. Ross

Howard P. Ross
Section Head, Geophysics

HPR/jp

enclosure

EXPLORATION GEOPHYSICS IN THE NATIONAL NUCLEAR WASTE ISOLATION PROGRAM

by

Howard P. Ross
Earth Science Laboratory
University of Utah Research Institute

Introduction

Deep geologic disposal is currently favored as the optimum means for safely isolating the nation's high level nuclear waste (HLW) from the accessible environment. The Department of Energy (DOE) has been charged with responsibility for implementing a program of identifying favorable rock types and selecting favorable geologic environments and specific sites suitable for geologic containment in a subsurface repository. Several years of intensive multidisciplinary study have led to the conclusion that bedded salt, dome salt, volcanic tuff, basalt and granitic rocks are potentially favorable host rock types. Geologic, geophysical, geochemical, hydrologic, engineering and other studies have been carried out on regional and area scales and several specific sites with dimensions of five to 20 kilometers have been identified as potentially favorable. Detailed site characterization is currently in progress.

Geophysical methods have played an important role in regional, area, and site exploration to date, and will be important in detailed site characterization, site comparison, and repository performance monitoring activities. Geophysical techniques are most appropriate for several reasons. The geophysical technology has been highly developed for, and very successful in, the exploration and development of petroleum and mineral resources, and in characterizing the subsurface prior to engineering projects (dam, highway, and nuclear reactor sites). Geophysical survey techniques can provide substantial information regarding stratigraphy, rock type, the occurrence of faults, fractures, and other discontinuities, and aspects of the geohydrology of both large and small areas on a cost-effective basis. Geophysics can characterize the subsurface geometries and in situ physical properties in a manner which facilitates site-to-site comparisons. A particular requirement of the HLW repository exploration program is the need for a minimum of borehole penetrations of the repository host rock (regardless of cost) in order to maximize the integrity of the repository. Geophysical methods directly respond to several physical properties important for engineering studies and ultimate containment; these include density, fluid content, acoustic impedance, clay and zeolite content, homogeneity.

Although the geophysical methods are well suited to regional, area and site exploration, we must be aware of the limitations of these methods. We recognize inherent limitations in spatial and physical property resolution, natural and instrumental noise, signal-to-noise measurement problems, and interpretational ambiguities, to name a few. It is important to integrate geologic information and borehole data in order to maximize the information content of the geophysical surveys.

Figure 1 illustrates the locations where area characterization studies have been carried out within the United States. Granitic (or more accurately igneous crystalline) rocks occur in the northeastern, southeastern and northcentral states and have only been evaluated in a regional sense to date. The salt program has focused on the interior salt dome basins of the southeast, and on bedded salt occurrence in the Paradox Basin (Utah) and the Permian Basin (Texas). Layered basalts are the potential repository host at the Hanford site in the Columbia River Plateau. Volcanic tuffs have been selected as the most favorable rock types at the Nevada Test Site.

Table 1 summarizes the seven sites which are being studied in detail, and indicates the geologic environment and types of geophysics used to date, either for area or site characterization.

Gravity data have played an important role in the initial discovery and subsequent first order size delineation, of the Gulf Coast salt domes. The domes typically exhibit a small positive density contrast with respect to poorly consolidated near surface (0-3000 feet) sediments, and an increasingly negative density contrast for the remainder of the vertical column of the dome, which often exceeds 10,000 feet. The dominant long wavelength low led to the discovery of many of the domes in earlier days of petroleum exploration. The initial estimates of salt dome size (horizontal section) based on gravity data are generally subject to substantial revision following completion of reflection seismic surveys. Gravity data have been used to interpret regional and local structure at the Pasco Basin, Yucca Mountain, and Gibson Dome, perhaps being more important at Yucca Mountain and Gibson Dome. Aeromagnetic survey data have been used in a similar manner, with the highest information content resulting from volcanic rocks at the Yucca Mountain area.

Reflection seismic data have the capability of the greatest spatial resolution of the geophysical methods and have established more precise geometries and depths for the salt domes, and the delineation of some caprock structures. Seismic surveys have delineated sedimentary and basement structures in the Paradox and Permian Basins and placed some limits on the extent of peripherial dissolution activity. Extensive seismic surveys at the Nevada Test Site and at the Pasco Basin have contributed rather little through initial interpretation stages.

Seismicity has been evaluated on a regional scale for all prospective sites. The possibility of active tectonism is relatively higher for the Pasco Basin, Yucca Mountain and Gibson Dome sites and microearthquake networks have already been established to monitor a much lower level of seismicity in these areas. Similar surveys will be carried out at the remaining sites.

Available well logs have been studied to determine stratigraphy, depths and unit thicknesses in area characterization studies. Exhaustive suites of logs have been obtained in wells drilled within the DOE NWTS program. The log suite typically includes mud, temperature, caliper, neutron, density, acoustic, resistivity, self-potential, gamma ray and many special purpose logs. The integrated interpretation of these logs provides much physical property information and determines the details of packer placement and other aspects of the hydrologic tests.

The electrical methods have a major role to play in the nuclear waste disposal program and the state-of-the-art of these methods may be less familiar to this audience. The physical property of primary interest is electrical resistivity and it may be determined through a variety of time domain or frequency domain electromagnetic (EM) or direct contact methods. Several methods have been used at the Hanford site, Paradox Basin, Nevada Test Site and in the Permian Basin to search for conductive fault zones, brine pockets and dissolution areas, and other lithologic changes. One specialized resistivity array, the dipole-dipole array, has been used extensively by mining, geothermal, and petroleum companies to simultaneously provide high resolution sounding and profiling information. The method is routinely used to explore for mineralization or alteration effects (clay minerals, zeolites, finely disseminated pyrite or carbonaceous matter) by simultaneously measuring induced polarization and electrical resistivity. The depths of search are typically 500 to 4000 feet, which encompasses the range of probable repository depths. Figure 2 illustrates one such data profile from the Nevada Test Site. This method, especially when supplemented by the IP measurement may be an important tool for searching for brine pockets and establishing homogeneity of potential repository sites.

The magnetotelluric (MT) method holds some promise of providing deep (two to 40 km) resistivity and structural information. The data are often ambiguous to interpret and geometries may be poorly resolved, but MT offers one alternative in areas of basalt or volcanic tuff where reflection seismic data may be of little value. A controlled artificial source version of MT (CSAMT) can provide fairly high spatial resolution to repository depths.

Several specialized techniques will be employed in site characterization to maximize spatial resolution and in situ physical property mapping. Most important are: high resolution 3-D seismic surveys; hole-to-surface and hole-to-hole electrical resisitivity; and borehole gravity. High resolution airborne magnetic and electromagnetic surveys should play an important role in the granitic rock program.

TABLE 1. GEOPHYSICS EMPLOYED IN AREA OR SITE CHARACTERIZATION

SITE	GEOLOGY	GEOPHYSICS						
		GRAV	MAG	REFL. SEIS.	PASS. SEIS.	ELEC. RES.	MT	WL
Pasco Basin, WA	Columbia River Plateau Basalts	X	X	X	X	X	X	X
Yucca Mtn., NV	Tertiary volcanic tuffs	X	X	X	X	X	X	X
Gibson Dome, UT	Paradox Basin bedded salt	X	X	X	X	X	-	X
Deaf Smith Co., TX	Permian Basin bedded salt	m	-	X	m	X	-	X
Richton Dome, MI	Inland salt dome	X	-	X	m	-	-	X
Cypress Creek, MI	Inland salt dome	X	-	X	m	-	-	X
Vacherie Dome, LA	Inland salt dome	X	-	X	m	m	-	X

GRAV = Gravity
MAG = Magnetic
WL = Well logging
MT = Magnetotelluric

REFL. SEIS. = Reflection seismic
PASS. SEIS. = Passive seismic
ELEC. RES. = Electrical resistivity

X = major effort
m = minor effort

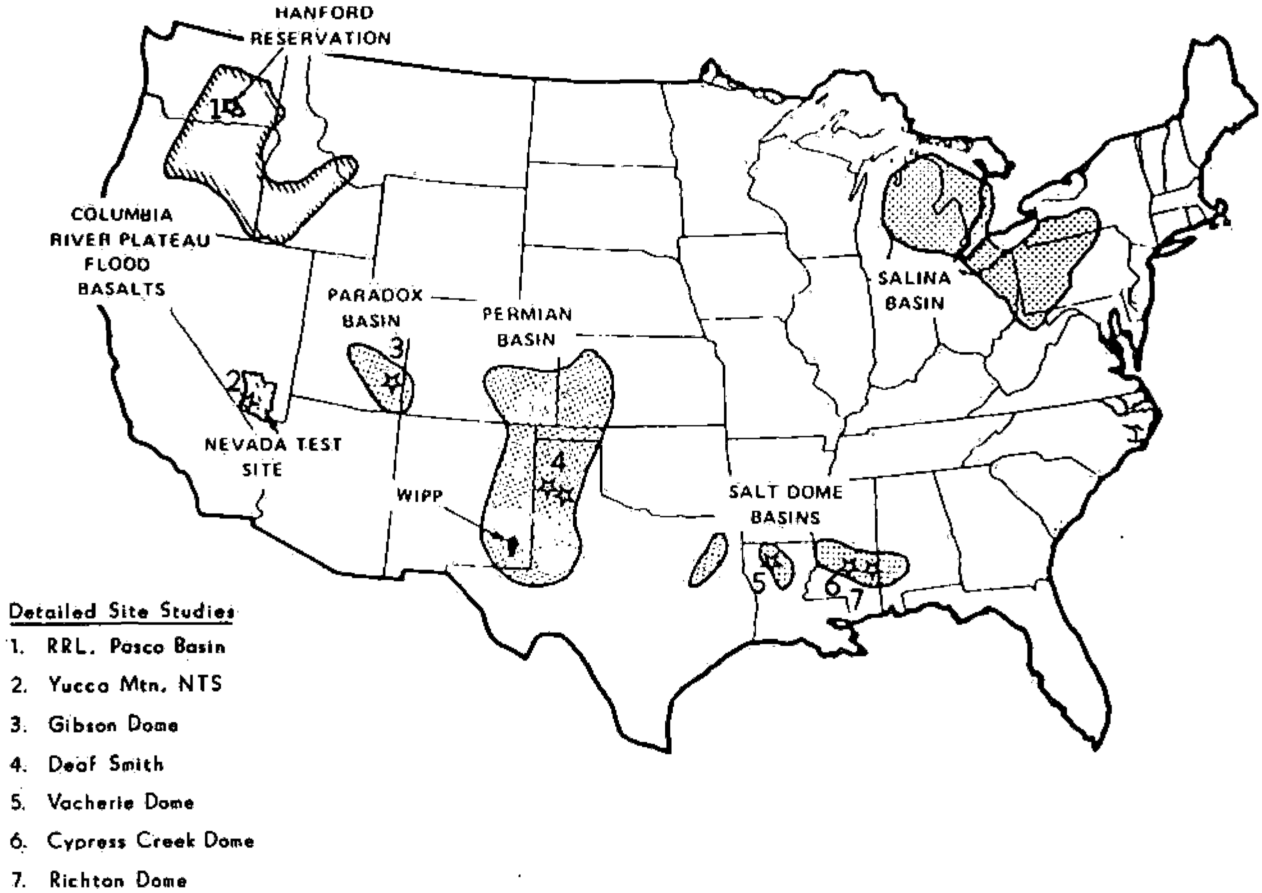
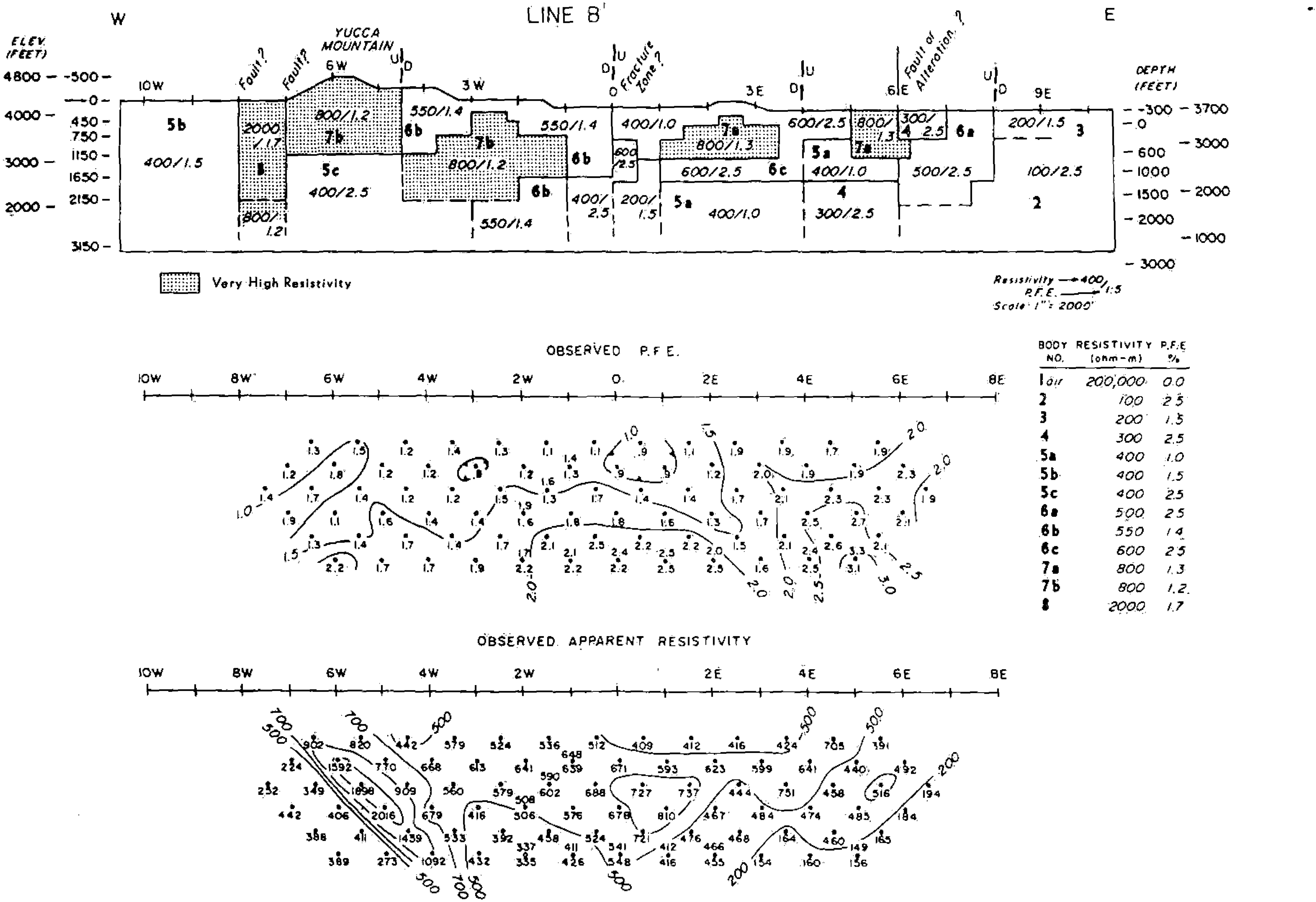


Figure 1. Regional study areas and sites of detailed geophysical exploration in the national high level waste program.



BODY NO.	RESISTIVITY (ohm-m)	P.F.E. %
1 air	200,000	0.0
2	100	2.5
3	200	1.5
4	300	2.5
5a	400	1.0
5b	400	1.5
5c	400	2.5
6a	500	2.5
6b	550	1.4
6c	600	2.5
7a	800	1.3
7b	800	1.2
8	2000	1.7

Figure 2. Dipole-dipole electrical resistivity and induced polarization results, Line B' across Yucca Mountain, Nevada Test Site. (Electrode separation is 1000 feet).