PROPOSAL FOR A GEOSCIENTIFIC INVESTIGATION AT THE IDAHO NATIONAL ENGINEERING LABORATORY

SUBMITTED TO

EG&G IDAHO, INC.
IDAHO FALLS, IDAHO
83415

IN RESPONSE TO

TKP-132-83

Earth Science Laboratory

University of Utah Research Institute
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NOVEMBER 11, 1983

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Request for Proposal TKP-132-83

by

Earth Science Laboratory Division
University of Utah Research Institute
420 Chipeta Way
Salt Lake City, Utah 84108
801-581-5283

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1.0 Summary

The geotechnical investigation proposed herein will seek to identify geologic faults in the Idaho National Engineering Laboratory (INEL) site, which could be important in a site characterization study of a New Production Reactor (NPR) on the eastern Snake River Plain (ESRP). The two major geologic hazards anticipated in this portion of the ESRP are earthquakes and volcanic activity. It is possible that the Arco and Howe faults extend onto the Plain, and that a major boundary fault may terminate the northern edge of the Plain. The most reliable evidence for extension of these faults onto INEL is the Holocene geologic record (Allen, 1975); examination of this record is the task of this proposal. Volcanic activity must also be assessed to identify recency, recurrence, location, and volume type of eruptions that have occurred on the ESRP.

The Earth Science Laboratory proposes a phased program of geological and geophysical investigations, emphasizing integration of multiple data sets, to answer the geologic questions posed by the RFP and meet contractor requirements in a timely fashion. Literature review will be followed by evaluation of remote images and aerial photographs. Linear features identified will be confirmed through field investigations, including geologic mapping, trenching and radiometric dating, which will establish the existance or non-existence of fault zones and history of their activity. Gravity and aeromagnetic geophysical methods will aid in identification and interpretation of fault zones. Reliance is placed upon proven geological and geophysical methods for this study, as there is no time to test and develop new or unproven techniques.

Earth Science Laboratory professionals assigned to this project are well experienced in identification of buried geologic structures and the geological and geophysical characteristics of volcanic environments.

2.0 Introduction

The Earth Science Laboratory/University of Utah Research Institute (ESL/UURI) proposes to conduct a multi-disciplined geotechnical investigation of the eastern Snake River Plain within and adjacent to the Idaho National Engineering Laboratory (INEL; Figure 3.2), in order to assess the probability that existing and planned facilities on the site will suffer future tectonic or volcanic damage. The proposed study is particularly critical in view of the profound fault rupture, with up to 10 feet of normal displacement, associated with the recent Challis (Idaho) earthquake, the epicenter of which was located only about 50 miles northwest of INEL.

As requested, this proposal addresses four separate but closely related tasks. Task 4 requires an overall evaluation of the volcano-tectonic hazard potential on the INEL. Literature study for Task 4 thus will be directly applicable to the first three tasks, which involve the search for specific major fault zones disrupting or concealed beneath the relatively flat-lying Quaternary volcanics and sediments of the eastern Snake River Plain. Surface expressions of these fault zones, if present, are likely to be very subtle, so our approach will involve not only careful surface evaluation, but also characterization of buried discontinuities using diverse geophysical techniques. These and other methods we belive to be most useful for fault zone detection and delineation are outlined in Section 3.0.

3.0 Discussion of Applicable Methods for the Delineation of Buried Faults

The delineation of a buried fault or fault zone is a difficult exercise both from the standpoint of thickness of cover over the fault and from the standpoint of lateral and vertical variations in the character of the fault and the heterogeneous nature of the rocks which are cut by the fault (e.g., California Division of Mines and Geology, 1983). Because of this complexity we propose a strategy for the investigation of faults which involves an integrated effort between geologists and geophysicists employing a variety of geoscientific methods. In addition, because of the tight schedule required for the proposed work, it will be necessary to employ the same strategy for Tasks 1, 2 and 3. The techniques that we propose using are sequenced from the regional and general, to more specific, with later techniques being planned on the basis of the knowledge derived from earlier portions of the project. For instance, the selection of which geophysical methods to use depends upon the geology, and in particular, upon the configuration of the subsurface units and their physical property contrasts. Inherent ambiguities in interpretation and other limitations in any geophysical method dictate the use of multiple methods to help establish the probability of a given geologic interpretation. The strategy we propose using for Tasks 1, 2 and 3 is shown in Figure 3.1. The methods shown in Figure 3.1 are discussed below.

3.1 Literature Review

The first step in our investigations will be a thorough literature review. This will encompass published and open-file data from federal, state and local researchers, conversations with selected professionals active in the ESRP, and optimum use of geoscientific data already compiled for site

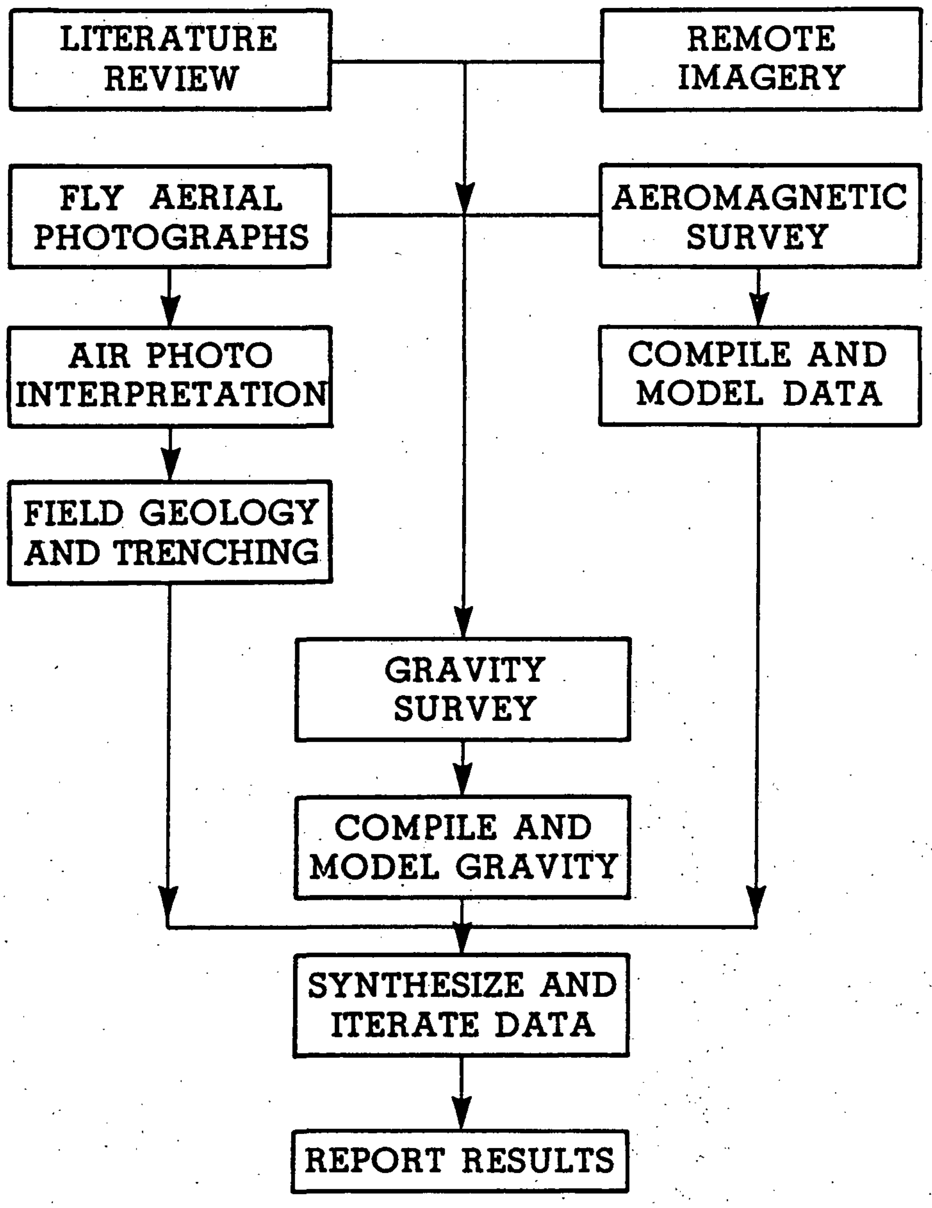

Figure 3.1. Strategy for the proposed investigation at the Idaho National Engineering Laboratory.

suitability studies of existing facilities at INEL. The extensive library facilities at the University of Utah will be available for our use in identifying and acquiring articles and maps. Literature applicable to all tasks will be compiled at the same time, to maximize efficiency of time.

Historical seismicity records for southern Idaho area will be reviewed, and maps and sections of hypocenters will be compiled where appropriate. The Intermountain Seismic Monitoring Network, which covers the entire state of Idaho, is operated by Dr. Robert Smith of the University of Utah, Department of Geology and Geophysics. Digital data files for the southern and central Idaho will be searched and data on seismicity will be compiled, including hypocenter depth, location, magnitude and time of occurrence. These data will then be interpreted to help delineate active fault zones and regional stress patterns (which relate to Tasks 1 through 4).

Earth Science Laboratory professionals are broadly familiar with siting requirements for nuclear facilities and therefore assume the existence of some form of detailed microearthquake data base for the immediate INEL area. We propose to undertake an evaluation of these data in response to Tasks 1 through 4. Should no detailed microearthquake data base be available for the INEL site, we propose to evaluate the present regional network to determine the minimum magnitude of events which could be detected at INEL and the hypocenter location errors for local events. If these parameters are not acceptable for an adequate tectonic hazard evaluation we would propose the immediate emplacement of a multistation (6 to 10 seismographs) microearthquake network at costs additional to those presently proposed.

3.2 Remote Sensing

Readily available Landsat and ERTS imagery can be of potential use in the delineation of buried fault zones, particularly when portions of these zones are traceable on the surface, as is the case with the Arco and Howe faults. This type of imagery is able to provide the big picture and allow known fault zones and linear features to be considered in their regional context. With such large scale imagery the relationship between fault systems outside the Snake River Plain (SRP) and volcanic vents within the SRP may become apparent.

3.3 Air Photo Interpretation

Color air photos at a scale of approximately 1:24,000 are extremely useful for mapping lithologic units and structural aspects (faults and fractures) of large areas. For the project, we propose that the area shown on Figure 3.2 be photographed with 1:24,000 scale color stereo photos. Mapping on these photos can be done quickly and efficiently, will be the basis for planning geologic field work, and may assist in planning subsequent geophysical surveys. Specifically, in the INEL site and vicinity, it may help trace the probable continuations of the Arco and Howe faults from their exposures north of the SRP into the INEL site. Color air photos can also be used to detect any features that may indicate the presence of a northern boundary fault to the ESRP or that may indicate that the northern boundary is a monoclinal hinge such as is seen along the southern boundary of the ESRP. Low sun-angle photography is often highly successful in identifying young fault traces. Selected areas of this study will be photographed using this technique. In addition, the evaluation of volcano-tectonic hazards for the INEL site will require identification of areas of past volcanic activity and

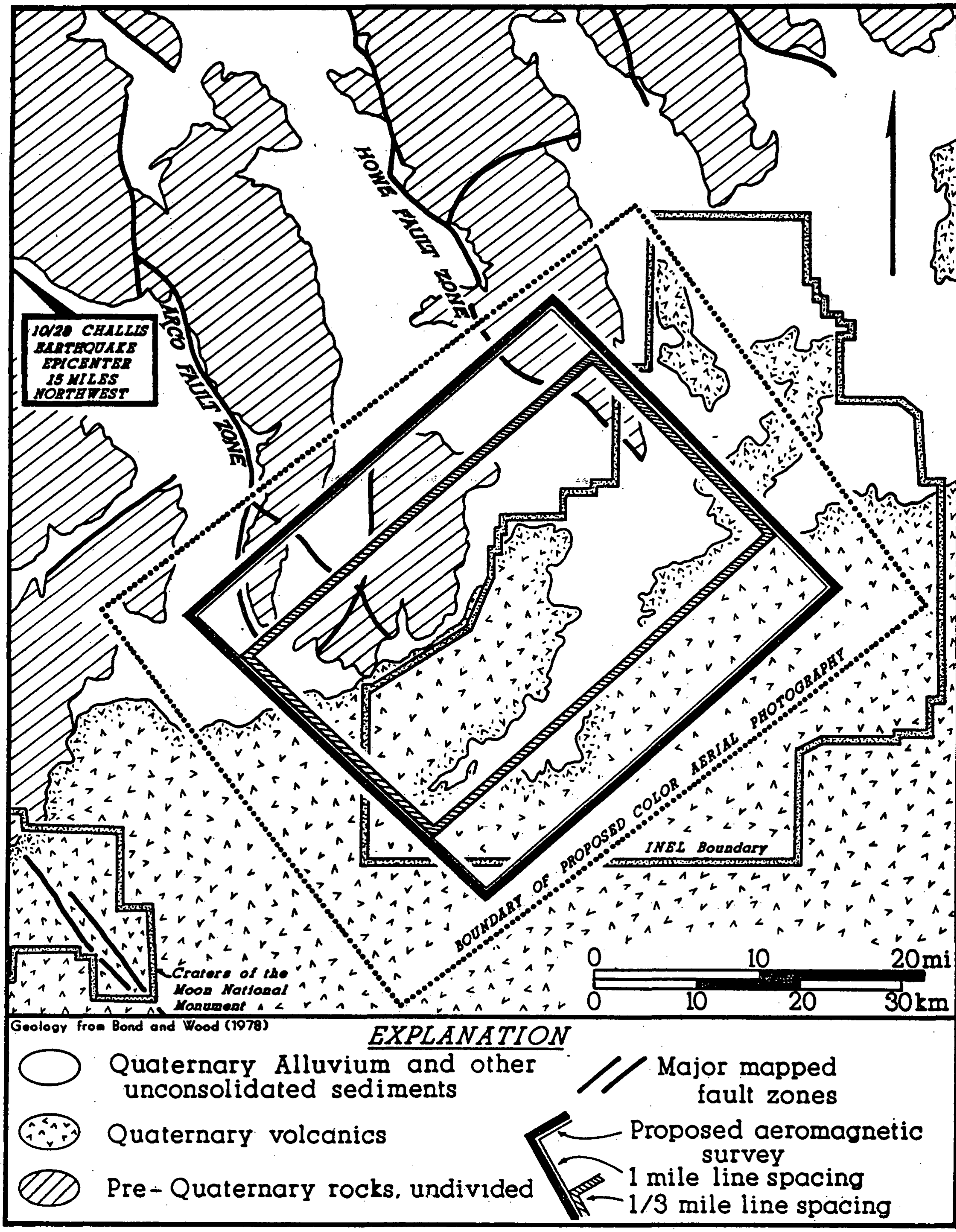

Figure 3.2. Index and generalized geologic map showing location of proposed aerial photography and aeromagnetic surveys.

recent faulting. This can be done most effectively through the use of aerial photography. Existing photogeologic interpretations (LaPoint, 1977) will be reviewed for content prior to acquiring new photos.

3.4 Field Geology and Trenching

Once structures and relevant volcanic features have been identified on the aerial photographs, field checking will be necessary to confirm the character of the features and provide for the collection of lithologic samples to be analyzed by petrographic and geochronologic techniques. This also provides an opportunity for the geologist to describe the fault zones in detail. A detailed analysis is necessary to understand the recency of offset, the magnitude of offset, the direction of offset (strike-slip or dip-slip), and perhaps evaluate the frequency of recurrence of movement along the fault zone. In areas of poor exposure of young features, it is often possible to gain a great deal of information by trenching across possible faults along with careful documentation of material exposed in the excavation.

3.5 Radiometric Dating

The timing of volcanic and tectonic events is of paramount importance for the evaluation of structural and volcanic hazards in the INEL site, and can supplement other geologic studies. Statistically, both faulting and volcanic activity are episodic events separated by periods of quiescence. In order to evaluate the future danger due to these geologic phenomena, it is necessary to define quantitatively the most recent movement on particular faults and the dating of and timing among past events. Potassium-argon dating of volcanic materials will allow the timing among volcanic events to be identified, and in cases where similar rocks of different ages are juxtaposed by faults, dating can help resolve the location and nature of the fault. Young movement along faults can be dated by the radiometric carbon techniques, if appropriate materials are available.

3.6 Gravity Method

The gravity method is used for delineation of faults and is often successful in mapping the position and vertical displacement of basin and range type faults. A substantial density contrast (0.27 g/cc) can be expected between the Paleozoic bedrock in the Lost River and Lemhi Ranges (2.67 g/cc), and the bulk density for Snake River Plain basalts (2.4 g/cc). These density contrasts result in gravity highs associated with range blocks that either crop out or are buried, as opposed to the lows associated with thicker basalt flows. An inspection of Snake River Plains regional data (Mabey et al., 1974) confirms this expression.

Phase I of the proposed gravity study will be to assemble existing gravity data for an area of approximately 100 by 100 miles centered about the INEL site. The ESL/UURI has the Dept. of Defense (DOD) computer data tape for more than 400,000 gravity stations in the western United States. These data would be plotted at regional and detailed scales, and integrated with other available data to form a preliminary interpretation.

Phase II of the gravity study would provide for up to 20 detailed profiles, totaling 250 new stations, specifically sited to define the Howe, Arco, and Boundary faults and their possible extensions into the ESRP. Precise elevation and position surveying would be carried out for these new stations in order to reduce the gravity data with the precision necessary. The data would be corrected for topographic effects to result in terrain corrected bouguer gravity values. ESL has the software necessary to do these tasks.

The combined regional and detailed gravity data would be interpreted using three-dimensional and two and one-half dimensional (finite strike length) gravity modeling programs available at ESL (see Table 6.2, Geophysical Computer Programs). Results of the modeling would be integrated with geological information and other geophysical interpretations to arrive at a final interpretation.

3.7 Magnetic Method

Aeromagnetic data are also used in both a regional and detailed sense to address buried fault locations in mineral, geothermal and petroleum exploration. The range of magnetic susceptibility and remanent magnetization contrasts for rocks of interest to this proposal spans several orders of magnitude. Inspection of the aeromagnetic map of Idaho (U.S. Geological Survey, 1978) indicates the probable magnetic expression of some of the faults of interest, beneath basalt cover. These data, however, are limited in density and spatial resolution, and should be used only for regional scale interpretation and for the design of a specific detailed survey.

We propose a detailed low-level (200 meters or 600 feet above mean terrain) aeromagnetic survey with flight lines oriented approximately N50°E to cross the known Howe and Arco fault traces and their possible extensions onto the ESRP at approximately right angles. The proposed survey layout is shown as Figure 3.2. The flight line spacing would be approximately 400 m (1310 ft) across the bedrock and western INEL area, but would increase to 800 m to the east, where the structures in question are thought to be deeper and hence of lower spacial frequency (information) content. An additional 10 flight lines are oriented perpendicular to the N50°E grid to serve as leveling lines for the data, and to provide the best delineation of the suspected boundary fault.

Computer programs are available at ESL/UURI for three-dimensional and two and one-half dimensional (finite length two-dimensional bodies) numerical modeling of magnetic data (see Table 6.2). The use of the numerical modeling will refine the delineation of the faults and help to quantify dips and depths. Iterative interpretation using preliminary solutions for gravity and magnetic data will also improve the accuracy of the interpretation.

3.8 Other Methods

Several other geophysical methods are often used for fault delineation and these have been considered and rejected as less cost effective for the INEL study. Seismic reflection data are often the highest resolution geophysical method for subsurface fault detection, but are quite expensive ($5,000 to $10,000 per line mile) and often completely ineffective in volcanic or basalt flow terrains. The choice of this method for fault detection at the INEL site would commit essentially the entire amount of available funds to a single high-risk method.

Detailed electrical resistivity surveys could also address the buried fault problem at INEL, but unknown resistivity contrasts between bedrock and basalts, and the loss of resolution at moderate depths cause us to favor gravity, magnetic, and passive seismic methods for this program. Should it become apparent that electrical resistivity surveys would be highly effective, some reduction of gravity or magnetic efforts could be made to offset the cost of no more than six dipole-dipole resistivity lines sited to cross the probable structural trends.

We have also considered and rejected a number of geochemical techniques for the delineation of buried fault zones. Trace element and mercury geochemical techniques require the existence of circulating fluids and gases from those fluids. There is no evidence for these processes at the INEL site. Gas geochemistry is useful for delineating fault zones in many instances (Nielson, 1978), but the processes involved are capricious and results cannot be interpreted without a great deal of ambiguity.

We believe that the multi-method approach proposed here best addresses Tasks 1 through 3. We further recognize that the October 28, 1983, 6.9 magnitude earthquake centered near Borah Peak and the ensuing after shock sequence represent an important data set which must be studied. This event gives additional importance to Task 3, presence of a major boundary fault, which may act to decouple the tectonic stress regime at the INEL site from the active Arco Fault.

4.0 Proposed Statement of Work

4.1 Task 1 - A Preliminary investigation to determine the existence or nonexistence of an extension of the Howe fault into the Eastern Snake River Plain.

The scarp of the Howe fault has been described in the vicinity of the town of Howe by Malde (1971). The scarp cuts alluvial fan material and is more than 40 feet high in places. Trenching has exposed evidence of numerous periods of movement on the fault. As exposed in the trench, the fault dips 64° and the movement is all apparently normal.

Our investigation of the Howe fault will begin with tracing the fault on high-altitude imagery. Since the fault is well exposed along the western flank of the Lemhi Range (Bond, 1978), the high altitude imagery will allow the characterization of the fault geometry where it is well exposed. The Howe fault must be considered to be a series of branching and converging fault segments rather than a single fault, and the imagery will define average distance between branching segments, changes in strike and width of the zone so that this information can be used in our interpretation of any extensions of the fault into the ESRP. Faults seldom display simple geometries, and the extrapolation of a zone which contains numerous branches and reentrants will be much different from one which has fewer of these features. The high-altitude imagery can then be used to identify possible features which may be due to the continuation of the fault into the ESRP.

The southern exposures of the Howe fault and areas of its possible continuation into the ESRP and the INEL site will be photographed on 1:24,000 scale stereo aerial photographs and low sun-angle photographs. These photos will be used by geologists with experience in volcanic rocks and structural geology to produce an initial map showing the distribution of lithologic units and faults and fracture zones. Using these photos, areas can be identified for field checking to confirm or deny the existence of faults. If clear evidence of the continuation of the Howe fault zone, or any other faults, is found, trenching will be undertaken to expose the fault for detailed mapping and sample collection. If warranted by the exposures and lithologies present, samples will be collected for radiometric age dating. This may allow determination of the timing of the last movement of the fault.

An aeromagnetic survey will be flown with principal flight direction perpendicular to suspected faults with suitable tie-lines to produce a detailed survey. Detailed gravity profiles will be completed which cross the suspected fault trend at nearly right angles and tie in with the regional gravity data base. A quantitative interpretation of gravity and magnetic data will be completed using existing computer modeling programs. The approach is summarized in Figure 3.1.

4.2 Task 2 - A preliminary investigation to determine the existence or nonexistence of an extension of the Arco fault onto the Eastern Snake River Plain.

The Arco fault is well exposed along the western flank of the Lost River Range north of Arco. The latest scarp associated with this fault is about 25 feet high. As exposed in a trench (Malde, 1978) offset is normal along a narrow fault zone which dips steeply to the west. This study also demonstrates that multiple events have occurred along the fault zone.

It is proposed that our investigation of the Arco fault will proceed in the same manner as was outlined for the Howe fault. This approach is outlined in Fig. 3.1.

4.3 Task 3 - A preliminary investigation to determine the existence or nonexistence of a major boundary fault along or near the northwest edge of the ESRP.

Sparlin et al. (1982) have concluded that the northwestern edge of the ESRP in the vicinity of the INEL site is bounded by a fault with greater than 4 km of offset. This is different from the southeastern boundary of the ESRP, which is thought to be a monoclinal flexure with only minor associated faulting. The presence or absence of a boundary fault and the character and magnitude of the fault, if present, will have an influence on the projection of the Howe and Arco faults into the ESRP. Therefore this portion (Task 3) of the investigation will be the first to be undertaken.

Our procedure for investigating the presence or absence of a boundary fault will be similar to that outlined for Tasks 1 and 2, including a detailed gravity survey and the aeromagnetic survey (Fig. 3.1).

4.4 Task 4 - An investigation and evaluation of the potential for volcano-tectonic hazards on the INEL.

Through the Tertiary and into Recent time the Snake River Plain has been the site of extensive faulting and volcanic activity. This past activity is primary evidence that additional faulting and eruptions of volcanic material may occur at any time in the SRP in general and on the INEL site in particular. Other authors (Kuntz, 1978) have dealt with the potential hazards which may be experienced at various facilities on the INEL site. Additional data exist in the literature which can be interpreted in terms of both the conditions which may be experienced during a volcanic eruption and the probability of an eruption which may affect the INEL site. Although basaltic eruptions are expected, the possibility of other types of activity, such as identified in the ESRP by Prostka and Embree (1978), and through the drilling of INEL-1, will be evaluated.

The prediction of volcanic activity is an inexact science at best. It relies in establishing a history of previous eruptions, paying attention to the time of repose between eruptions, the character of the eruptive events and the spacial distribution of the eruptions. Numerous studies have been completed on the geochronology of the SRP (e.g. Armstrong et al., 1975, 1980) and data from these can be applied to the interpretation of the timing of the volcanic events. New data from this study will allow refinement of statistical models applicable to forcasting recurrence intervals of volcanic events.

4.5 Task 5 - Reporting

A final report which will present our data and interpretation will be prepared for this project. A draft copy of the report will be submitted to EG&G, Idaho for their review and comments prior to the submission of the final report.

5.0 Proposed Scientific Team

5.1 Summary of Qualifications

A highly qualified scientific team is proposed for this project. Dr. Dennis L. Nielson, Section Manager of the geology group at ESL, will serve as project manager. Dr. Duncan Foley and Mr. Bruce Sibbett will serve as geologists on the project, and Dr. Howard P. Ross and Mr. Claron Mackelprang will be the geophysicists assigned to the project. The qualifications of these people for this project are summarized below, and their detailed resumes can be found in Section 12.0.

Dr. Dennis L. Nielson is presently Section Head, Geology for ESL/UURI. He has extensive experience in the geology of volcanic terrains, and for a number of years has taught a course through the Yellowstone Institute, which deals with volcanic processes. His principal interest in the past five years has been the evaluation of structural controls of fluid flow in active hydrothermal systems. Much of this work has involved mapping of structures and projecting their continuation into unexposed areas. In addition to his scientific capabilities, Dr. Nielson brings a strong management background to the project. He has served as project manager and principal investigator for a number of projects at ESL including DOE's Industry Coupled Program and Geothermal Exploration and Assessment Technology Program. As project manager for this study, Dr. Nielson will be responsible for both the technical quality of the work performed and ensuring that the work is completed on time and within budget.

Dr. Duncan Foley studied volcanic terrains of western Nevada for his dissertation, and has mapped volcanic rocks for the U.S. Geological Survey. These studies included extensive interpretation of aerial photographs, detailed ground investigations for fault identification, and radiometric dating of volcanic rocks. He has mapped geology adjacent to the Snake River Plain in Idaho, and is familiar with the greater Snake River Plain-Yellowstone volcanic province through work in Yellowstone. He is familiar with geologic hazard forecasting through thesis work and teaching at Ohio State University, and participated as geologist on a team investigating environmental conditions and geologic hazards at Utah geothermal areas.

Mr. Bruce S. Sibbett is a geologist with ESL. He has extensive experience in mapping within volcanic terrains throughout the western U.S. He recently completed mapping on Ascension Island, a volcanic island in the South Atlantic Ocean. Mr. Sibbett is particularly skilled in the interpretation of morphological and structural features in volcanic terrains. He has extensive experience in the interpretation of tectonic and volcanic features on aerial photographs.

Dr. Howard P. Ross is currently Section Head, Geophysics for ESL/UURI. He holds a Ph.D. degree in geophysics and has had 20 years of experience in the application of gravity magnetic, electrical, and seismic techniques to exploration problems and research in mining, geothermal, petroleum, and engineering work. His present position includes a broad range of program management, survey design and supervision, and interpretation activities for DOE, DOD and private clients in the mining, geothermal, petroleum and engineering industries. Dr. Ross has also served as a consultant to geothermal and mining firms and to the Department of Energy and its contractors for nuclear waste isolation activities. Dr. Ross has been a member of the Battelle ONWI Geologic Review Group since 1979, a member of the Basalt Waste Isolation Program (BWIP) Geology Overview Committee since 1979, and a member of the Geological Studies Peer Review Group, Nevada Test Site--NWTS Program, at the 1979 and 1981 Peer Review meetings. Through this involvement Dr. Ross is perhaps the most informed geophysicist in the U.S. regarding the HLW program, who is not employed within the NWTS program.

Mr. Claron E. Mackelprang is a geophysicist with over 20 years of varied experience in mineral and geothermal exploration. Mr. Mackelprang has extensive experience in the gravity, magnetic, electrical resistivity/IP and electromagnetic methods. He has completed numerous numerical model interpretations for these methods, and for magnetotelluric data, and has completed one microearthquake survey.

5.2 Experience in Locating Buried Structures

The location of buried structures is of paramount importance in a number of investigations where the staff proposed for this project has extensive experience. In both the mining and geothermal industry, buried structures are often the targets of exploration activities. All of the members of our proposed scientific team have had experience in the exploration for these types of targets. ESL geophysicists have several years experience specifically directed toward delineating buried faults in conjunction with Basin and Range porphyry copper exploration program. A recent geothermal steam discovery near Cove Fort, Utah resulted from an integrated geological and geophysical (gravity, magnetic, resistivity) interpretation by ESL scientists. This discovery well intersected a buried fault zone which serves as a conduit for high-temperature fluids.

Dr. Nielson and Mr. Sibbett have proposed geologic models for structural controls of the Roosevelt Hot Springs geothermal system based on their studies of fault and fracture zones in the adjacent Mineral Mountains of Utah. They have published these findings in numerous reports. They have also developed subsurface models for numerous geothermal and mineral systems throughout the western U.S. Dr. Foley has identified subsurface structures during investigations of volcanic terrains, and is presently involved in deep drilling in Texas. Mr. Mackelprang has extensive experience in locating subsurface structures for both mineral and geothermal industries.

5.3 Experience in Siting and Licensing Nuclear Power Plants

The staff of ESL has no experience in the siting or licensing of nuclear power plants. However, Dr. Howard Ross has been active as a member of peer review panels for all of the nation's high level radioactive waste disposal geologic exploration programs. These include:

Geology Review Group - ONWI - Battelle - Salt Program, 1979 - present

Geology Peer Review Group - DOE - Nevada Test Site - 1979, 1981

Geology Overview Committee - Rockwell Hanford, Basalt Waste Isolation 1979 - present

Through this participation Dr. Ross has worked with various teams of national and local experts in hydrology, geochemistry, geology and geophysics in addressing geologic and environmental problems resulting from hazardous waste isolation. His duties have been expanded in the National Program to provide expert geophysical consultation to Battelle for specific work in the salt programs in Utah, Texas, Mississippi, Louisiana and for early stage planning and review of the granitic rocks program in the North Central, Northeastern and Southeastern United States. Dr. Foley has performed an outside reviewer for ONWI geological site characterization in the Paradox Basin, Utah.

ESL/UURI has completed detailed model interpretations of induced polarization and electrical resistivity data for the USGS in support of the nuclear waste disposal program at the Nevada Test Site. This work has been instrumental in delineating faults and potential resource conflicts.

6.0 Qualifications of Earth Science Laboratory/University of Utah Research Institute

6.1 General Statement about ESL and UURI

The University of Utah Research Institute (UURI) is a self-supporting corporation organized in December, 1972 under the Utah Non-Profit Corporation Association Act. Under its charter the Institute is separate in its operations and receives no financial support from either the University of Utah or the State of Utah. The charter includes provisions for UURI to conduct both public and proprietary scientific work for governmental agencies, academic institutions, private industry, and individuals. In this work UURI has a close technical association with the University and is able to draw upon the talents of faculty and students. When such activities are proprietary UURI may be taxed on income as determined by IRS codes.

The Earth Science Laboratory (ESL) is a division of the University of Utah Research Institute (UURI) which provides consulting and contracting services in a broad range of scientific areas that includes field programs, data interpretation, research and technique development, geochemical analytical services, custom computer software, development of electronic instrumentation, and training seminars and workshops. ESL emphasizes the integration of scientific disciplines and techniques in solving problems in the earth sciences. An optimum, cost-effective combination of techniques from the fields of geology, geochemistry, geophysics, and hydrology can be applied by in-house experts to solve specific problems.

The ESL professional staff is broad and diversified in education and experience (see Table 6.1). Even though the main portion of a given project

Table 6.1
EARTH SCIENCE LABORATORY
PROFESSIONAL STAFF*

Geologists			6
	Ph.D.	2	
	M.S.	1	
	B.S.	3	
Geochemists			4
	Ph.D.	1	
	M.S.	2	
	B.S.	1	
Geophysicists			9
	Ph.D.	5	
	M.S.	3	
	B.S.	1	
Computer Scientists			1
	B.S.	1	
Electronics Engineers			2
	B.S.	2	
		Total	22

* This professional staff is supported by 2 business administrators, 8 technicians, 3 secretaries, and 3 draftspeople.

may be done by a few scientists, the expertise of this entire staff can be made available as required, and personnel assigned to a project are free to draw upon the talents of other personnel at ESL.

The ESL staff has experience mainly along three different lines: 1) applied scientific work, 2) research, and 3) program management. The following paragraphs describe some of our more significant project work.

6.2 Summary of Staff Expertise and Facilities

6.2.1 Geology

Geologic investigations provide essential data for successful completion of a wide variety of earth science projects. The ESL staff has a broad background in design and management of geologic work as well as in application of individual geologic techniques such as field mapping, structural and stratigraphic studies, mineralogy, petrology, and lithologic logging of drill chips and core. ESL's project management experience includes a full spectrum of services from project design and execution to supervision of drilling and evaluation of results. ESL is experienced in formulation of exploration models, regional geologic interpretation, detailed stratigraphic and structural analysis, and development and testing of techniques for specific applications.

6.2.2 Geochemistry

Geochemistry has, during the last decade, become an increasingly essential component of earth science investigations. ESL's broad practical experience and proven exploration and research capabilities allow us to offer services ranging from routine analysis of geologic materials to design, execution and management of fully integrated geochemical exploration programs and from application of existing geochemical techniques to development of new techniques. ESL has made significant contributions to development and application of new geochemical techniques for a wide variety of applications.

A geochemical laboratory designed especially for geothermal and mineral studies has been operational since 1977. The laboratory is equipped with an ARL Inductively Coupled Plasma Spectrometer (ICP), capable of analyzing 37 elements simultaneously, an IL Atomic Absorption Spectrophotometer, a Jerome Gold Film Mercury Detector, an Orion Specific Ion Meter and electrodes, an X-ray diffraction instrument and complete sample preparation facilities. In addition, an electron microprobe, a scanning electron microscope, and K-Ar and fission track age dating are also available. Interactive computer programs available on ESL's PRIME 400 computer allow statistical treatment and provide geochemical plots of the analytical data.

6.2.3 Geophysics

Application of geophysical techniques greatly enhances ESL's ability to investigate the subsurface. The staff has broad competence and experience in survey design and management and in integrated geological interpretation of geophysical data for a wide variety of resources. ESL has a suite of user-interactive computer programs that operate on the PRIME 400 computer to facilitate quantitative modeling and interpretation (Table 6.2). ESL's research scientists have pioneered in the development of new interpretation techniques for geophysical data and the implementation of these techniques on the computer in a highly cost-effective way. ESL can help the client to develop their in-house computer-based interpretation capabilities and can

TABLE 6.2

ESL/UURI GEOPHYSICAL SOFTWARE
(PRIME 400 SYSTEM)

GM3D	Three-dimensional gravity and magnetic prism modeling program
GRAV2D	Two- and 1/2-dimensional gravity modeling and inversion program
MAG2D	Two- and 1/2-dimensional magnetic modeling and inversion program
TMAG3D	Talwani prism three-dimensional magnetic modeling program
TERRAIN	Gravity terrain correction program
IP2D	Two-dimensional IP and resistivity modeling program
IPINV	Two-dimensional IP and resistivity forward and inverse modeling program
MT2D	Two-dimensional MT and line source (CSAMT) modeling program
MT3D	Three-dimensional MT and line source (CSAMT) modeling program
SLUMB	One-dimensional Schlumberger array modeling and inversion program
SPXCPL	Two-dimensional modeling program of self-potential effects from cross-coupled fluid and heat flow
WELLOG	Geophysical well log data base management and plotting program
CROSS PLOT	Performs cross-plots of well log data values
HYPOINVERSE	Earthquake hypocenter location program
HYPOELLIPSE	Calculates error ellipse for hypocenter locations
JHD	Joint hypocenter determinations, large numbers of events
EQPLOT	Plots earthquake hypocenter locations, map form
CROSSSECTION	Plots earthquake hypocenter locations in cross-section

provide training of personnel in operation of available programs.

6.2.4 Electronics Engineering

High-quality field data are vital for today's earth scientists. ESL's electronics engineers provide broad competence and experience in instruments for electrical geophysical surveys. The latest hardware and software are available for custom application. The Electronics Laboratory is well equipped for development of microprocessor-integrated geophysical instrumentation. Test, design, and prototype construction facilities are state-of-the-art.

6.2.5 Computer Operations

ESL's computer center offers a broad range of computer services. The group specializes in development and implementation of user-interactive software for display, analysis and interpretation of geological, geochemical and geophysical data. The software can be used either at a client's facility or on a time-sharing basis on ESL's computer via the telephone. Table 6.2 lists the software that is currently operating on ESL's computer.

Computer facilities consist of a PRIME 400 minicomputer system with a link to the University of Utah's UNIVAC 1100/60 computer. The system includes a PRIME 400 CPU with time-sharing capability and virtual memory, 1256 K bytes of main memory, 460 M bytes of disk storage, a 9-track magnetic type drive, a 36-inch Zeta pen plotter, a Statos electrostatic plotter, two line printers, 2 Tektronix 4014 graphics terminals with digitizing tablets, a DECwriter terminal, 7 CRT terminals, and two Texas Instruments Silent 700 terminals. Three dial-in phone lines are available to users, one at 300 baud and two at 1200 baud data transmission rates. The system is specifically oriented to scientific and engineering computation and to handling and interpreting geoscience data.

6.2.6 Sample Library

The Sample Library provides open-file accessibility and archival storage for field and drill samples as well as reference to analyses done on the samples. We provide proprietary storage for confidential samples as well as storage of samples that are accessible by the public. At present the Library contains over 105,000 meters of drill chip samples and 2,100 meters of core from 171 shallow thermal gradient holes and deep holes, mainly in geothermal areas. Samples from the INEL deep geothermal well are stored in this Library and could be used in this study if it is deemed advisable. Samples may be studied at our facility by clients in order to compare their own drill results with samples from other geothermal areas. Complete sample preparation facilities are available and are used to prepare samples for storage and for routine or special chemical or physical analyses. Density and magnetic susceptibility measurements can be done at our facility.

6.2.7 Document Library

ESL has an extensive document library that is available for use by clients. We have issues of all the important geothermal journals and many other earth science journals as well. Xerox and microfiche copies of many published articles are available. At present the library contains about 12,000 titles.

In addition, ESL has exchange privileges with the complete library facilities of the University of Utah campus where 2,000,000 titles are available.

6.2.8 Office Facilities

The main offices of the Earth Science Laboratory are located in Research Park, on the east side of the Salt Lake Valley, adjacent to the University of Utah. There are over 4,600 square meters of laboratory and office space in two buildings. Located here are the geochemical laboratory, the electronics laboratory, the computer center and our extensive document library as well as offices. The Sample Library occupies 450 square meters in a small building in suburban Salt Lake City and is accessible to the main offices in a 10-minute drive. The campus of the University of Utah, where the Department of Geology and Geophysics is located, is a 5-minute drive from ESL's main facilities.

6.2.9 Management

The Earth Science Laboratory operates under a matrix management system where a principal investigator is able to draw on members of the geology, geochemistry, geophysics, computer or electrical engineering groups to form a scientific team most qualified to handle a specific project. The principal investigator is then responsible for management and technical guidance of the working group. The principal investigator is responsible to the Associate Director/Technology and the Associate Director/Administration for the technical and financial portions of the contract respectively.

7.0 Proposed Schedule of Work

Figure 7.1 shows the proposed schedule of work for this project. In order to deliver a draft report to EG&G, Idaho on the March 15, 1984 deadline, a number of factors will have to be realized.

1. The awarded contract will have to be in place by 1 December.
2. There will have to be no delays in the awards of subcontracts for aeromagnetic and aerial photography surveys.
3. The weather in the project area will have to be suitable for the completion of the work.

If the above qualifications are realized, we anticipate that a draft report will be delivered to EG&G, Idaho by 15 March, 1984.

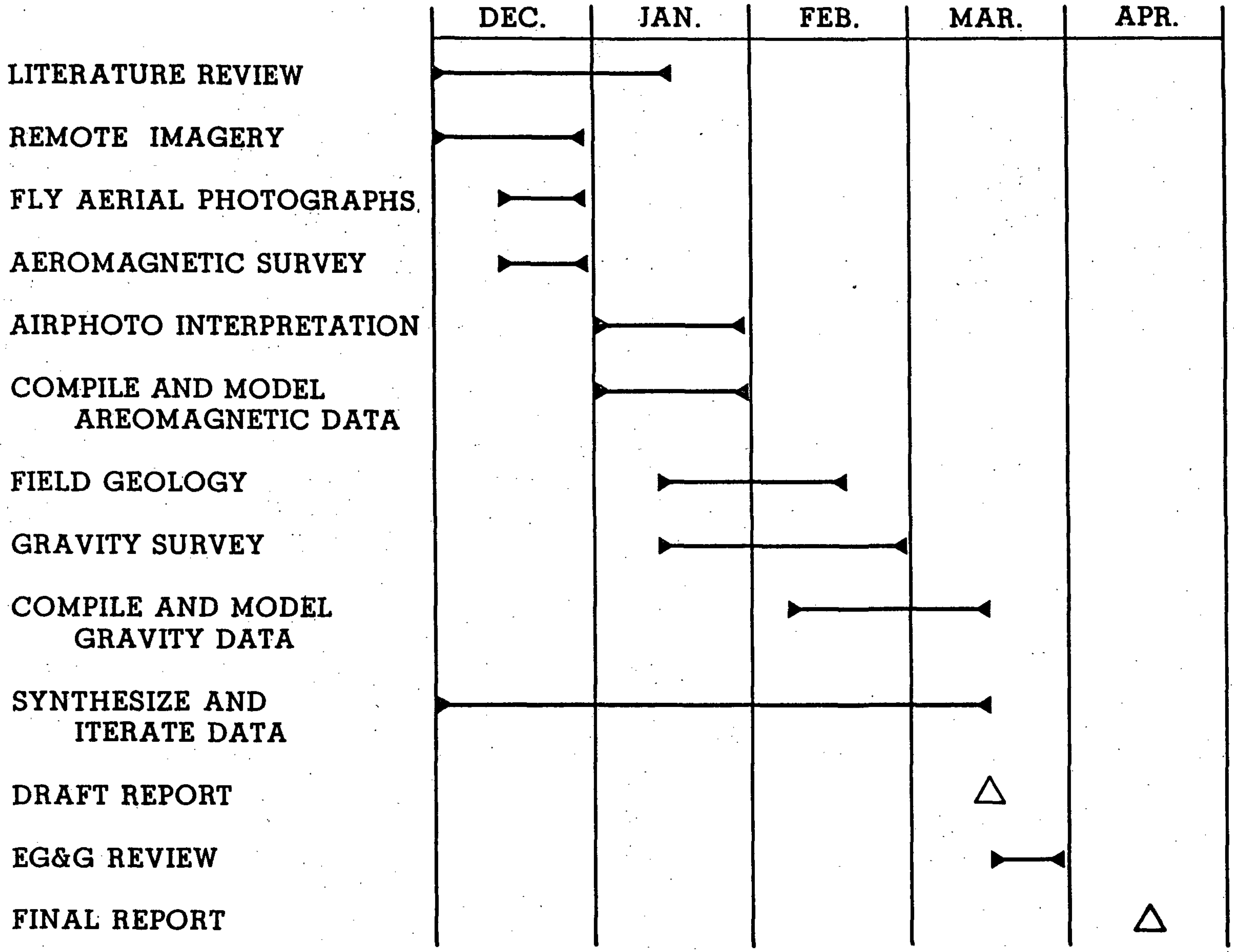

Figure 7.1. Proposed project schedule.

8.0 Proposed Management

For this project, ESL/UURI has assembled a working group composed of experienced geologists and geophysicists (Fig. 8.1). The project will be managed by Dr. Dennis Nielson, who will be responsible for the overall schedule and quality of the project. Dr. Nielson will in turn be responsible to Dr. Phillip M. Wright, Associate Director/Technology, for the successful completion of this project. Dr. Wright's resume is included in Section 12 of this proposal. Dr. Howard Ross will be responsible for the completion and quality control of the geophysical work. He will be assisted by Mr. Claron Mackelprang. Dr. Duncan Foley and Mr. Bruce Sibbett will be responsible for the completion of the geologic work.

FIGURE 8.1
PROJECT MANAGEMENT

Dr. Phillip M. Wright
Associate Director/Technology

Dr. Dennis L. Nielson
Principal Investigator

Geophysics
Dr. Howard P. Ross
Mr. Claron E. Mackelprang

Geology
Dr. Duncan Foley
Mr. Bruce S. Sibbett

9.0 Evaluation of Potential Conflicts of Interest

The Earth Science Laboratory, University of Utah Research Institute (ESL/UURI) is not engaged in any work which would constitute a conflict of interest with this proposal. The ESL/UURI is a prime contractor for geothermal exploration, research and development activities to the U.S. Department of Energy-Division of Geothermal Energy, and to the U.S. Department of Defense-Air Force for geothermal exploration. Other past clients of ESL include the United Nations, USAID, and various geothermal, mining and petroleum companies. None of the work would appear to present a conflict of interest with the proposed work.

ESL/UURI has an established working relationship with EG&G, Idaho on geothermal programs funded by the Idaho Operation Office of the Department of Energy. However, there are no contractual relationships between EG&G, Idaho and ESL/UURI.

10.0 Proposed Budget

The proposed budget for this project is shown on the following pages. Since we have applied the same methodologies for Tasks 1, 2 and 3 and there are many overlaps between these tasks and Task 4, it is difficult to breakout a budget for individual tasks. On a percentage basis, the distribution of the total costs would be as follows.

Task 1	25%
Task 2	25%
Task 3	35%
Task 4	15%

BUDGET

A.	Salaries and Wages:		$ 51,480
	1. Senior Personnel		
	D. Foley — 3.0 mo.		
	C. E. Mackelprang — 3.0 mo.		
	D. L. Nielson — 1.5 mo.		
	H. P. Ross — 3.0 mo.		
	B. S. Sibbett — 3.0 mo.		
	P. M. Wright — .25 mo.		
	2. Other Personnel		
	Staff Analyst — .5 mo.		
	Draftsperson — 1.0 mo.		
	Secretary — 1.0 mo.		
	Technician — 2.0 mo.		
B.	Employee Benefits:		$ 21,107
	1. 41% of Salaries and Wages		
C.	Total Salaries, Wages and Employee Benefits:		$ 72,587
D.	Travel:		
	1. Vehicle Travel - 4,000 miles @ $.30/mile	$ 1,200	
	2. Per Diem - 60 man days @ $21/day	1,260	
	3. Lodging - 60 man days @ $40/day	2,400	
	4. Two trips from S.L.C. to Idaho Falls @ $370/each	$ 740	
	TOTAL TRAVEL		$ 5,600
E.	Supplies:		$ 1,400
F.	Computer Costs:		$ 8,000
G.	Reporting and Publication Costs:		$ 1,000
H.	Equipment Rental:		
	1. Gravimeter	$ 2,000	
	2. Electronic Survey System	3,000	
	TOTAL EQUIPMENT RENTAL		$ 5,000

I.	Other Costs:		
	1. K-Ar dates - 10 @ $300/each	$ 3,000	
	2. ^{14}C dates - 10 @ $200/each	2,000	
	3. Trenching (Backhoe Services)	5,000	
	TOTAL OTHER COSTS		$ 10,000
J.	Subcontracts:		
	1. Aeromagnetic Survey	$40,000	
	2. Aerial Survey	15,000	
	TOTAL SUBCONTRACTS		$ 55,000
K.	Total Direct Costs:		$158,587
L.	Indirect Costs:		$ 48,842
	1. 43% of "K" less $45,000		
M.	General and Administrative:		$ 15,334
	1. 13.5% of "K" less $45,000		
N.	Total Direct, Indirect Cost and G&A:		$222,763
O.	Management Allowance:		$ 12,252
	1. 5.5% of "N"		
P.	Total Project Costs:		$235,015

11.0 References

Allen, C. R., 1975, Geological Criteria for Evaluating Seismicity: Geol. Soc. Amer. Bull., v. 86, p. 1041-1057.

Armstrong, R. L., Harakal, J. E., and Neill, W. M., 1980, K-Ar dating of Snake River Plain volcanic rocks - new results: Isochron/West, n. 27, p. 5-10.

Armstrong, R. L., Leeman, W. P. and Malde, H. E., 1975, K-Ar dating, Quaternary and Neogene volcanic rocks of the Snake River Plain, Idaho: Am. Jour. Science, v. 275, p. 225-251.

Bond, J. G. and Wood, C. H., 1978, Geologic map of Idaho: Idaho Dept. of Lands, Bureau of Mines and Geology.

California Division of Mines and Geology, 1983, Guidelines for evaluating the hazard of surface fault rupture: California Geology, vol. 36, no. 11, p. 249-251.

Kuntz, M. A., 1978, Geology of the Arco-Big Southern Butte area, eastern Snake River Plain, and potential volcanic hazards to the Radioactive Waste Management Complex, and other waste storage and reactor facilities at the Idaho National Engineering Laboratory, Idaho: U. S. Geol. Survey Open File Report 78-691, 70 p.

LaPoint, P. J. I., 1977, Preliminary photogeologic map of the eastern Snake River Plain, Idaho: U.S. Geol. Survey MIscellaneous Field Studies Map MF-850.

Mabey, D. R., 1978, Regional gravity and magnetic anomalies in the Eastern Snake River Plain, Idaho; Jour. Research U.S. Geol. Survey, v. 6, no. 5, p. 553-562.

Mabey, D., Peterson, D. L., and Wilson, C. W., 1974, Preliminary gravity map of south Idaho; USGS Open File Report 74-78.

Malde, H. E., 1971, Geologic investigation of faulting near the National Reactor Testing Station, Idaho: U. S. Goel. Survey Open File Report, 167 p.

Nielson, D. L., 1978, Radon emanometry in geothermal exploration, theory and an example from Roosevelt Hot Springs, KGRA, Utah: Univ. of Utah Research Institute, Earth Science Lab. Rept. No. 14, 31 p.

Prostka, H. J., and Embree, G. F., 1978, Geology and geothermal resource sof the Rexburg Area, eastern Idaho: U. S. Geol. Surv. Open-File Report 78-1009, 14 p.

Scott, W. E., 1981, Surficial geologic map of the Eastern Snake River Plain and adjacent areas 111°-115° W., Idaho and Wyoming: U.S. Geol. Survey Open File Report 81-507.

Sparlin, M. A., Braile, L. W., and Smith, R. B., 1982, Crustal structure of the eastern Snake River Plain determined from Ray Trace modeling of seismic refraction data: Jour. Geophys. Res. v. 87, p. 2619-2633.

U.S. Geological Survey, 1978, Aeromagnetic map of Idaho: USGS Geophysical Investigations Map GP-919 (scale 1:500,000).

12.0 Resumes of Personnel

Dr. D. L. Nielson
Dr. D. Foley
Mr. B. S. Sibbett
Dr. H. P. Ross
Mr. C. E. Mackelprang
Dr. P. M. Wright

RESUME

Dennis L. Nielson

POSITION: Section Manager - Geology, Earth Science Laboratory, University of Utah Research Institute, Salt Lake City, Utah

EDUCATION: B.A., Geology, 1970, Beloit College, Beloit, Wisconsin
M.A., Geology, 1972, Dartmouth College, Hanover, New Hampshire
Ph.D., Geology, 1974, Dartmouth College, Hanover, New Hampshire

SHORT COURSES: Volcanic Rocks and Their Vent Areas, University of Nevada, Réno, 1977
Engineering Management by Objectives for Improving Productivity, University of Utah, 1978
Geothermal and Hydrothermal Systems, Yellowstone Institute, 1978
Economics of Minerals and Energy Projects, AIME, 1981

SOCIETY AFFILIATIONS: American Geophysical Union
Geological Society of America
Geothermal Resources Council
Society of Economic Geologists
Utah Geological Association

HONORS AND AWARDS: Haven Science Prize, Beloit College (1970)
NDEA Title IV Fellowship - Dartmouth College (1971-1974)
American Men and Women of Science
President, Basin and Range Section, Geothermal Resources Council (1979)

PROFESSIONAL EXPERIENCE:

7/80-present — Section Manager - Geology. Earth Science Laboratory, University of Utah Research Institute. Responsible for overall technical quality of geologic work and management of the geologic staff.

7/79-present — Geologist/Project Manager, Earth Science Laboratory, University of Utah Research Institute. Project manager for the following programs under Department of Energy contracts: Geothermal Exploration and Assessment Technology Program, Industry Coupled Program, M-X/Renewable Energy Systems Program. Responsible for coordinating technical work at Roosevelt Hot Springs KGRA, Utah; and Beowawe; Tuscarora; Colado; McCoy; Soda Lake-Stillwater KGRAs, NV. Formulation and technical review of procurements, contract monitoring , and program design. Also manager of numerous proprietary geothermal exploration programs. Participated in a program to assess the state-of-the-art and recommend needed research in an industry sponsored program in solution mining and hydrometallurgy. Have participated in numerous

DOE advisory committees including those concerned with the Baca Geothermal Demonstration Power Plant, Deep Continental Scientific Drilling Program, and the Hot Dry Rock Project.

1979-present — Instructor, Yellowstone Institute, for a course on Calderas and Hydrothermal Systems which concentrates on the formation of calderas, ash-flow tuff stratigraphy, and the geology of hydrothermal systems in the caldera environment.

4/78-7/79 — Geologist, Earth Science Laboratory, University of Utah Research Institute. Develop case studies for geothermal resource areas in western U.S. Responsibilities include supervision of geologic programs, geologic mapping, synthesis and publication of exploration data, and formation of exploration criteria.

6/74-4/78 — Staff Geologist, The Anaconda, Co., Salt Lake City, Utah. Uranium exploration in frontier project areas in the United States. Responsible for generating and supervising projects through the initial drilling stages. Experience in Precambrian plutonic and metasedimentary environments and Tertiary volcanic and sedimentary environments. Activities included detailed mapping, quadrangle mapping, regional reconnaissance, interpreting geophysical and geochemical data, supervising rotary and diamond drilling, and land acquisition through leasing and claim staking.

1971 summer — Field Geologist, Great Lakes Exploration Co. (subsidiary of Bear Creek Mining Co.). Reconnaissance mapping in the Precambrian Shield of the Upper Peninsula of Michigan and northern Wisconsin. The mapping was designed to locate areas having potential for massive sulfide deposits.

1970 summer — Field Geologist, Great Lakes Exploration Co. (subsidiary of Bear Creek Mining Co.). Quadrangle mapping and geochemical surveys of water wells and soils in conjunction with a massive sulfide exploration program in northern Wisconsin.

1968 fall — Field Assistant, Bear Creek Mining Co. Base metal exploration in the Upper Peninsula of Michigan and northern Wisconsin. Duties included drafting, supervising diamond drilling, and assisting with field mapping.

PUBLICATIONS:

PAPERS AND TECHNICAL REPORTS

Nielson, D. L., 1973, Silica diffusion at Ascutney Mountain, Vermont: Contributions to Mineralogy and Petrology, v. 40, p. 141-148.

Nielson, D. L., Clark, R. G., Lyons, J. B., Englund, E. J., and Borns, D. J., 1976, Gravity models and mode of emplacement of the New Hampshire Plutonic Series, <u>in</u> Lyons, P. C., and Brownlow, A. H. (eds.) Studies in New England Geology: Geological Society of America Memoir 146, 301-318.

Nielson, D. L., Sibbett, B. S., McKinney, D. B., Hulen, J. B., Moore, J. N., and Samberg, S. M., 1978, Geology of Roosevelt Hot Springs KGRA, Beaver County, Utah: University of Utah Research Institute, Earth Science Laboratory, Rept. No. 12, 121 p.

Nielson, D. L., 1978, Radon in geothermal exploration, theory and an example from Roosevelt Hot Springs KGRA, Utah: University of Utah Research Institute, Earth Science Laboratory, Rept. No. 14, 31 p.

Nielson, D. L., and Moore, J. N., 1979, The exploration significance of low-angle faults in the Roosevelt Hot Springs and Cove Fort-Sulphurdale Geothermal Systems, Utah: Geothermal Resources Council Transactions, v. 3, p.503-506.

Nielson, D. L. (ed.) 1979, Program Review: Geothermal Exploration and Assessment Technology Program including a report of the Reservoir Engineering Technical Advisory Group: University of Utah Research Institute, Earth Science Laboratory, Rept. No. 29, 128 p.

Foley, D., Nielson, D. L., and Nichols, C. R., 1980, Geothermal systems of the Yellowstone Caldera: Geothermal Resources Council Field Trip No. 1, 69 p.

Glenn, W. E., Hulen, J. B., and Nielson, D. L., 1980, A comprehensive study of LASL Well C/T-2 Roosevelt Hot Springs KGRA, Utah and application to geothermal well logging: Los Alamos Scientific Laboratory, Rept. LA-8686-MS, 175 p.

Nielson, D. L. (ed.) 1980, Geothermal Systems in Central Utah: Geothermal Resources Council Guidebook to Field Trip No. 7, 54 p.

Nielson, D. L., 1980, Summary of the geology of the Roosevelt Hot Springs Geothermal System, Utah: in Nielson, D. L. (ed.), Geothermal Systems in Central Utah, Geothermal Resources Council Guidebook to Field Trip No. 7, p.25-29.

Nielson, D. L., Moore, J. N., and Forrest, R. J., 1980, Road log to geothermal systems in central Utah: in Nielson, D. L. (ed.), Geothermal Systems in Central Utah, Geothermal Resources Guidebook to Field Trip No. 7, p.44-54.

Sibbett, B. S., and Nielson, D. L., 1980, Geology of the central Mineral Mountains, Beaver County, Utah: University of Utah Research Institute, Earth Science Laboratory, Rept. No. 33, 42 p.

Ward, S. H., Ross, H. P., and Nielson, D. L., 1981, Exploration strategy for high-temperature hydrothermal systems in the Basin and Range Province: Am. Assoc. Petroleum Geologists Bull., 65/1 p.86-102. Reprinted in Energy Minerals, AAPG reprint Series No. 25, p. 232-248.

Nielson, D. L., 1981, The bedrock geology of the Hillsboro quadrangle, New Hampshire: N. H. Dept. of Resources and Economic Development Bull. No. 8, 76 p.

Ross, H. P., Nielson, D. L., and Moore, J. N., 1982, Roosevelt Hot Springs geothermal system, Utah-Case Study: Am. Assoc. Petroleum Geologists Bull., v. 66, no. 7, p. 879-902.

Nielson, D. L., (ed.), 1982, Overthrust belt of Utah: Utah Geological Association Publication 10, 335 p.

Hulen, J. B. and Nielson, D. L., 1982, Stratigraphic permeability in the Baca geothermal system, Redondo Creek area, Valles Caldera, New Mexico: Geothermal Resources Council Transactions, v. 6, p. 27-30.

Evans, S. H. and Nielson, D. L., 1982, Thermal and tectonic history of the Mineral Mountains intrusive complex: Geothermal Resources Council Transactions, v. 6, p. 15-18.

Foley, D., Nielson, D. L., and Nichols, C. R., 1982, Road Logs: West Yellowstone to Canyon Junction, Canyon Junction to Mud Volcano - Sulphur Cauldron Area, Canyon Junction to Tower Junction, Tower Junction to Mammoth Hot Springs, Mammoth Hot Springs to Norris Junction, Madison Junction to Old Faithful, in Reid, S. G. and Foote, D. J. (eds.) Geology of Yellowstone Park Area: Wyoming Geological Association Guidebook.

Hulen, J. B. and Nielson, D. L., 1983, Stratigraphy of the Bandelier Tuff and characterization of high-level clay alteration in borehole B-20, Redondo Creek area, Valles Caldera, New Mexico: Geothermal Resources Council Transaction, v. 7, p. 163-168.

ABSTRACTS

Nielson, D. L., 1973, Contact metamorphism and molecular diffusion at Ascutney Mountain, Vermont: Geological Society of America, Abstracts with Programs, Northeastern Section, p.203.

Nielson, D. L., Lyons, J. B., and Clark, R. G., 1973, Gravity and structural interpretations of the mode of emplacement of the New Hampshire Plutonic Series: Geological Society of America, Abstracts with Programs 1973 Annual Meetings, p.750.

Nielson, D. L., Sibbett, B. S., and McKinney, D. B., 1979, Geology and structural control of the geothermal system at Roosevelt Hot Springs KGRA, Beaver County, Utah (abs.): American Association of Petroleum Geologists Bull., v. 63/5, p.836.

Ward, S. H., Chapman, D. S., Evans, S. H., Nielson, D. L., Wannamaker, P. E., and Wilson, W. R., 1979, Roosevelt Hot Springs Geothermal System: Geologic and geophysical models: IAVCEI Abstracts and timetables, IUGG XVII General Assembly, Canberra, Australia.

Nielson, D. L, 1980, Geology of low- and intermediate-temperature hydrothermal systems: National Conference on Renewable Energy Technologies, Proceedings, Honolulu, p.8-3 to 8-4.

Sibbett, B. S., and Nielson, D. L.,1980, The Mineral Mountains intrusive complex, Utah: Geological Society of America, Abstracts with Programs, Rocky Mountain Section, v. 12, No. 6, p.305.

Ward, S. H., Ross, H. P., and Nielson, D. L., 1980, Strategy of exploration for high temperature hydrothermal systems in the Basin and Range Province (abs.): Am. Assoc. Petroleum Geologists Bull., v. 64/5, p.799.

Ross, H. P., Nielson, D. L., and Glenn, W. E., et al., 1981, Roosevelt Hot Springs, Utah geothermal resource-integrated case study (abs.): Am. Assoc. Petroleum Geolgists Bull., v. 65/5, p. 982.

RESUME

Duncan Foley

BIRTHPLACE AND DATE: Appleton, Wisconsin, December 17, 1947

POSITION: Geologist, Project Manager, Earth Science Laboratory, University of Utah Research Institute, Salt Lake City, Utah

EDUCATION:

B.A., Geology,	1971,	Antioch College, Yellow Springs, Ohio
M.Sc., Geology,	1973,	Ohio State University; emphasis on environmental geology
Ph.D., Geology,	1978,	Ohio State University; emphasis on volcanic geology

PROFESSIONAL AFFILIATIONS:

1982, American Association of Petroleum Geologists
1980, Utah Geological Association
1979, American Geophysical Union
1978, Geothermal Resources Council
1976, Society of Sigma-Xi
1972, Geological Society of America

PROFESSIONAL EXPERIENCE:

6/79-present Geologist, Project Manager, Earth Science Laboratory, University of Utah Research Institute, Salt Lake City, Utah. Project Manager for programs of low- and moderate-temperature geothermal resource assessment in western and Great Plains states, including coordination with two U. S. Geological Survey resource assessment efforts, evaluation of geothermal resources at federal facilities, transfer of resource assessment technology to private sector explorationists, production of geothermal resources maps for western states, and evaluation of geothermal resources in proposed wilderness areas. Participated in project to estimate national geothermal market potential. Ongoing study of central Idaho geothermal systems.

1979-present Instructor, Yellowstone Institute, for "Calderas and Hydrothermal Systems," a week long lecture and field course that emphasizes interpretation of ash-flow tuff stratigraphy, caldera evolution, and the geological nature of hydrothermal systems in calderas; taught in Yellowstone National Park.

1/78-6/79 Associate Geologist, Earth Science Laboratory. Assisted in management of U. S. Department of Energy funded program of low-temperature geothermal resource assessment in western U. S. Environmental geologist for overview of southern Utah Known Geothermal Resource Areas.

9/73-1/78 Teaching Associate, Department of Geology and Mineralogy, Ohio State University. Environmental geology, historical geology, introductory geology, oceanography, field methods, and for three summers at central Utah field camp. Taught "Geology and the Environment." Also held research position in K-Ar Isotope

Geochronology Lab.

7/73-8/73	Dr. Wayne A. Pettyjohn, Ohio State University. Water sampling and observing detailed reclamation progress for ground control for remote sensing of strip-mined lands.
6/72-9/72	Field Assistant, Dr. James W. Collinson, Ohio State University, N.S.F. Grant. Regional Upper Paleozoic stratigraphy of east-central Nevada.
6/71-9/71 and 9/72	Field Assistant, U.S. Geological Survey, Western Mineral Resources Branch, Menlo Park, California. Geologic mapping near Goldfield, Nevada, with emphasis on volcanic stratigraphy.
9/69-12/69	Assistant Community Manager, Community Government, Antioch College, Yellow Springs, Ohio. Management of diverse student programs, involving financial, personnel, and extensive college and community contact.
4/69-8/69	Physical Science Aide, U.S. Geological Survey, Pacific Mineral Resources Branch, Menlo Park, California. Mineral separations lab; geochemical sampling of alteration assemblages and detailed geologic mine mapping in Goldfield and Silver Peak, Nevada.
9/66-12/66	Assistant, Geology Department, Field Museum of Natural History, Chicago, Illinois. Fossil Invertebrates; curating trilobite collection.

PROFESSIONAL ACTIVITIES:

Presented talks on geologic parameters of geothermal energy to American Association for the Advancement of Science (1980), Industrial Development Research Council (1980), National Rural Electric Cooperative Association (1980), National Water Well Association (1979), U.S. Department of Energy Contractors (1978, 1979, 1980), Intermountain Institute of Food Technologists (1982), and Snake River Section of American Institute of Mining Engineers (twice in 1982).

Coleader of Geothermal Systems of the Yellowstone Caldera fieldtrip, Geothermal Resources Council (1980); leader of Wyoming Geological Association field trip to hydrothermal systems of northern Yellowstone National Park (1982).

President, Basin and Range Section, Geothermal Resources Council (1980-82).

Secretary, Utah Geological Association (1981-1982)

Courses and workshops attended: Geothermal energy in the Cascades (1981); Geochemical fundamentals for geothermal exploration and reservoir evaluation (1980); Fission-track age dating (1979), "Direct Utilization of Geothermal Energy: Development of Four Educational Reports" (1979), Geothermal Geology of Yellowstone (1978); Volcanic rocks and their vent areas (1978); Direct utilization of geothermal energy (1978).

PUBLICATIONS:

"Environmental geology and land-use planning on the Big Darby Creek, Ohio, watershed," Foley, D., unpub. M.Sc. thesis, Ohio State University (1973).

"Geology and Land-Use Planning on the Big Darby Creek, Ohio, Watershed," Foley,D. and McKenzie, G. D., Geol. Soc. of Am., Abstracts with Programs, 6, No. 6, 508 (1974).

"The geology of the Stonewall Mountain Volcanic Center, Nye County, Nevada," unpub. Ph.D. dissertation, Ohio State Univ., 139 p. (1978).

"Geology of the Stonewall Mountain Volcanic Center, Nye County, Nevada," Foley, D. and Sutter, J. F., Geol. Soc. of Am., Abstracts with Programs, 10, No. 3, 105 (1978).

"The Essence of Urban Environmental Geology," McKenzie, G. D., Utgard, R. O., Foley, D. and McKenzie, D. I., Journal of Geological Education, 26, 32-37 (1978).

"Geology in the Urban Environment," Utgard, R. O., McKenzie, G. D. and Foley, D., eds., Burgess Pub. Co., Minneapolis, Minn., 355 p., (1978).

"Western States Cooperative Direct Heat Geothermal Program of DOE," Wright, P. M., Foley, D., Nichols, C. R. and Grim, P. J., Geothermal Resources Council, 2, Section 2, 739-741 (1978).

"Geology Effects," Environmental Overview Report on Utah Geothermal Resource Areas, Foley, D., in White, K. L., Hill, A. C. and Ursenbach, W. O., eds., Lawrence Livermore Lab UCRL-13955, 1, 6.1-6.13 (1978).

"State Coupled Resource Assessment Program - An Update," Foley, D., Wright, P. M., Struhsacker, D. W., Nichols, C. R., Mink, L. L., Brophy, G. P., Grim, P. J. and Berry, G. Geothermal Resources Council Transactions, 3, 217-219 (1979).

"Nature and Distribution of Geothermal Energy," Muffler, L. J. P., Costain, J. K., Foley, D., Sammel, E. A. and Youngquist, W., Direct Utilization of Geothermal Energy: A Technical Handbook, D. H., Anderson and J. W. Lund, eds., Geothermal Resources Council Special Report No. 7, 1-1 to 1-15 (1979).

"The State Coupled Program - A New Emphasis," Foley, D., Brophy, G. P., Mink, L. L. and Blackett, R. E., Geothermal Resources Council Transactions, 4, 779-781 (1980).

"Geothermal Exploration Program Hill Air Force Base, Davis and Weber Counties, Utah," Glenn, W. E., Chapman, D. S., Foley, D., Capuano, R. M., Cole, D., Sibbett, B. S, Ward, S. H., University of Utah Research Institute, Earth Science Laboratory, Rept. 34, 77 p. (1980).

"Exploration Strategies for Regional Assessment of Hydrothermal Resources," Ward, S. H., Foley, D., Moore, J. N., Nielson, D. L., Ross, H. P., Wright, P. J., in Witherspoon, P., Bresee, J., eds., in preparation.

"Low-temperature Geothermal Resources in the Central and Eastern United

States," Sorey, M. L., Reed, M. J., Foley, D., Renner, J. L., in Reed, M. J., ed., Assessment of low-temperature geothermal resources of the United States-1981: U. S. Geological Survey Circular, in press (1983).

"Hydrothermal Systems of Central Utah - A Regional Perspective," (abs.), Foley, D., in, Britt, T. L., ed., Program and abstracts for the Utah Geological Association 1982 symposium on the overthrust belt of Utah; Utah Geological Assoc. Pub. 11, p. 18.

"Road logs: West Yellowstone to Canyon Junction, Canyon Junction to Mud Volcano - Sulphur Cauldron Area, Canyon Junction to Tower Junction to Mammoth Hot springs, Mammoth Hot Springs to Norris Junction, Madison Junction to Old Faithful", Foley, D., Nielson, D. L., Nichols, C. R., in Reid, S. G., Foote, D. J., Geology of Yellowstone Park Area: Wyoming Geological Association 33rd Annual Field Conference Guidebook, pgs. 343-352, 356-363 (1982).

"Road Log, Field Trip #3 Emphasizing Geothermal Phenomena," Foley, D., in Goolsby, J. E., ed., Field Trip Road Logs: Wyoming Geological Association 33rd Annual Field Conference, p. 22-24, (1982).

"Tables of Co-located Geothermal Sites and BLM Wilderness Study Areas," Foley, D., Dorscher, M., Earth Science Lab Open File Report 107, DOE/ID/12079-88, 166 p., (1982).

"Hydrothermal systems of the Wood River District, Idaho," Foley, D., Zeisloft, Jr., Blackett, R. E., Geol. Soc. of Am., Abstracts with Programs, in press (1983).

RESUME

Bruce S. Sibbett

BIRTHPLACE AND DATE: Soda Springs, Idaho, July 29, 1945

POSITION: Geologist, Earth Science Laboratory, University of Utah Research Institute, Salt Lake City, Utah

EDUCATION: B.S., Geology, 1972, Brigham Young University, Provo, Utah.
M.S., Geology, 1976, University of Idaho, Moscow, Idaho

PROFESSIONAL AFFILIATIONS: Utah Geological Association, Geological Society of America.

PROFESSIONAL EXPERIENCE:

April 1978-present — Geologist with the Earth Science Laboratory, University of Utah Research Institute. Assisted with the geologic mapping of Roosevelt Hot Springs, KGRA, Utah and with the writing of the subsequent report. Logged well cuttings from deep geothermal wells at Soda Lake, Stillwater, Dixie Valley and Humboldt House KGRAs, Nevada. Assisted with the mapping of the central Mineral Mountains, Utah and wrote report on the geology. Mapped the Colado and Tuscarora, Nevada geothermal areas. Available drill cuttings from both of these areas were logged and the information integrated with surface geology for the resulting reports. Involved with the case study and well site selection at Wendel Hot Springs, California. Mapped the geology of several geothermal prospects in Nevada and Utah on ESL consulting contracts.

1976-1978 — Exploration Geologist with Lucky McUranium Corporation (renamed Pathfinder Uranium Exploration). Supervised drilling programs on roll-front uranium properties in Wyoming, designed and carried out a geochemical sampling and reconnaissance exploration program in the Blackhills and the Williston Basin. Also examined uranium property submittals.

1975-1976 — Graduate assistantship doing library research for the U.S. Bureau of Mines mineral resources inventory system, environment and reserves estimates of metallic mineral deposits in southern Africa.

1972-1974 — Mineral examiner with the Bureau of Land Management in Arizona and New Mexico. Technical examination and report on mineral patent applications, mining claim validity determinations, environmental impact statement, sand and gravel sales, mineral resource inventory, preparation of contract stipulations and

	bonding requirements. A course in mineral deposit evaluation and sampling techniques.
1970-1972 (part-time)	Geologic field assistant with Burlington Northern Inc. for two summers and a spring. Geochemical exploration and staking claims in western Montana. Worked with bedded copper, porphyry molybdenum and lead-silver veins.
1966-1968	Two years in the U.S. Army, Vietnam; honorable discharge.

PUBLICATIONS:

"Geology of Roosevelt Hot Springs KGRA, Beaver County, Utah," Nielson, D. L., Sibbett, B. S., McKinney, D. B., Hulen, J. B., Moore, J. N. and Samberg, S. M., University of Utah Research Institute, Earth Science Laboratory, Report No. 12, DOE/DGE Contract EG-78-C-07-1701, Salt Lake City, 121 (1978).

"Geology and Structural Control of the Geothermal System at Roosevelt Hot Springs KGRA, Beaver County, Utah," Nielson, D. L., Sibbett, B. S. and McKinney, D. B., American Association Petroleum Geologists Bull., 63/5, 836 (1979).

"Geology of the Soda Lake Geothermal Area," University of Utah Research Institute, Earth Science Laboratory Report No. 24, DOE/DGE Contract EG-78-07-C-1701, Salt Lake City, 14 (1979).

"Geology of the Central Mineral Mountains, Beaver County, Utah," Sibbett, B. S. and Nielson, D. L., University of Utah Research Institute, Earth Science Laboratory Report, No. 33, DOE/DGE Contract 78-28392.b.5 (1980).

"The Mineral Mountains Intrusive Complex, Utah," Sibbett, B. S. and Nielson, D. L., Geological Society of America Abstracts with Programs, Rocky Mountain Section, 12, No. 6, 305 (1980).

"Geology of the Colado Geothermal Area, Pershing County, Nevada," Sibbett, B. S. and Bullett, M. J., University of Utah Research Institute, Earth Science Laboratory, Report No. 38, 34 (1980).

"Geothermal Exploration Program Hill Air Force Base, Davis and Weber County, Utah," Glenn, W. E., Chapman, D. S., Foley, D., Capuano, R. M., Cole, D., Sibbett, B. S. and Ward, S. H., University of Utah Research Institute, Earth Science Laboratory, Report No. 34, 77 (1980).

"Interpretation of Drill Cuttings from Geothermal Wells," Hulen, J. B. and Sibbett, B. S., Introduction to Geothermal Log Interpretation, Geothermal Resources Council Tech. Training Course No. 7, April 22-23, Reno, Nevada (1981).

"Interpretation of Drill Cuttings from Geothermal Wells," Hulen, J. B. and Sibbett, B. S., University of Utah Research Institute, Earth Science Laboratory, Open File Report (1981).

"Geochemistry of Selected Rock Samples, Colado Geothermal Area, Nevada," Christensen, O. D., Sibbett, B. S. and Bullett, M. J., University of Utah Research Institute, Earth Science Laboratory, Report No. 50, 17 (1981).

"Geology of the Northeast Part of the Loon Creek Mining District, Custer County, Idaho," Sibbett, B. S., University of Idaho Master Thesis (1976).

"Interpretation of a Telluric-Magnetotelluric Survey at the Tuscarora Geothermal Exploration Unit, Elko County Nevada," (Abst.) Mackelprang, C. E., Lange, A. L., Sibbett, B. S., and Pilkington, H. D., Geophysics, v. 47, no. 4, p. 421 (1982).

"Geology of the Tuscarora Geothermal Prospect, Elko County, Nevada," Sibbett, B. S., Geol. Soc. Amer. Bull., v. 93, p. 1264-1272 (1982).

"Geology of MacFarlane's Spring Thermal Area, Nevada", Sibbett, B. S., Zeisloft, J., and Bowers, R. L., Geothermal Resource Council, Transactions, v. 6, p. 47-50 (1982).

"Geothermal Potential of Ascension Island, South Atlantic, Phase I - Preliminary Examination", Nielson, D. L., and Sibbett, B. S., Earth Science Lab. Tech. Rept. Prepared for U. S. Air Force, 79 p. (1982).

"Lithology and Well Study of Campbell "E-2", Geothermal Test Well, Humboldt House Geothermal Prospect, Pershing County, Nevada," Sibbett, B. S. and Glenn, W. E., University of Utah Research Institute, Earth Science Laboratory, No. 53, 17 p. (1981).

"Lithologic Interpretation of the De Braga #2 and Richard Weishaupt #1 Geothermal Wells, Stillwater Project, Churchill County, Nevada," Sibbett, B. S. and Blackett, R. E., University of Utah Research Institute, Earth Science Laboratory, Report No. 70, 10 p. (1982).

RESUME

Howard P. Ross

BIRTHPLACE AND DATE: Stockbridge, Massachusetts, October 26, 1935

POSITION: Senior Geophysicist/Project Manager, and Manager of Geophysical Group, Earth Science Laboratory, University of Utah Research Institute, Salt Lake City, Utah

EDUCATION: B.A., Geology, 1957, University of New Hampshire
M.Sc., Geophysics, 1963, Pennsylvania State University
Ph.D., Geophysics, 1965, Pennsylvania State University

Short Course, Modern Methods of Seismic Data Processing, GeoQuest International, Inc., October, 1979

PROFESSIONAL AFFILIATIONS: Society of Exploration Geophysicists
American Geophysical Union
European Assn. Exploration Geophysicists
American Assn. Petroleum Geologists
Utah Geological Association

PROFESSIONAL EXPERIENCE:

1/80-present Consultant in Exploration Geophysics. Clients include:
Thermal Power Co., San Francisco, CA
Exxon Minerals Co., Tucson, AZ
Dept. of Energy/Nevada Operations, Las Vegas, NV
Kennecott Exploration, Inc., Casper, WY

8/77-present Section Head, Geophysics; Senior Geophysicist and Project Manager, Earth Science Laboratory, University of Utah Research Institute, Salt Lake City, Utah. Principal investigator for geophysical survey planning, supervision, and interpretation contracts. Coordinate, interpret, and evaluate geophysical surveys and geologic data to form technical case histories of geothermal exploration/reservoir assessment studies. Provide management assistance and technical evaluation as necessary to Department of Energy. Supervise and conduct geophysical interpretations for industry clients, U.S.G.S., and UN contracts.

9/79-present Consultant, Office of Nuclear Waste Isolation (ONWI), Battelle Memorial Institute, Columbus, Ohio. Member of the Geologic Review Group for site characterization studies of the national nuclear waste storage program.

9/79-present Consultant, DOE/Richland, Washington and Rockwell Hanford Operations. Member Geologic Overview Committee for Basalt Waste Isolation Project.

1969-1977 Senior Geophysicist, Bear Creek Mining Company/Kennecott Exploration, Inc., Geophysics Division, Salt Lake City, Utah.

Designed, supervised, conducted and interpreted geophysical field surveys in search of porphyry copper and other mineralization-induced polarization, magnetic, and gravity methods. Developed interpretation programs for magnetic data, and magnetic properties studies. Supervised contract aeromagnetic surveys and the geologic interpretation of these data. Presented seminars on the use and interpretation of geophysical data. In-company consultant on remote sensing (SLR and other imagery programs). Group Leader, Interdisciplinary Research Program for skarn research, September 1971 - March 1972. Field experience and interpretative work in New Mexico, Arizona, Nevada, Wisconsin, Minnesota, Montana, Utah and Tennessee.

1967-1969 Senior Research Geophysicist, Kennecott Exploration, Inc., Geophysics Division R&D, Salt Lake City, Utah. Conducted research in aeromagnetic interpretation, field rock magnetization studies. Developed first generation computer programs for magnetic interpretation schemes. Programmed electromagnetic coupling problem for IP studies. In-company consultant for remote sensing programs. Detailed and reconnaissance aeromagnetic interpretation. Supervised interpretation of deep-sea magnetic data (manganese nodule research).

1965-1967 Research General Physical Scientist, Air Force Cambridge Research Laboratories, Lunar-Planetary Research Branch, Bedford, Massachusetts. Organized and conducted laboratory reflection spectroscopy experiments and telescopic observations of the moon in the 0.2 to 3.0 micron (UV-VIS-IR) region of the spectrum. Pursued theoretical studies of the moon and planets. Developed instrumentation and monitored contracts for their fabrication. Programmed in Fortran IV for the reduction of spectroscopic data, signal-to-noise studies, mathematical models of geologic processes. NASA co-investigator Apollo Application Program (pre ERTS).

1961-1965 Graduate Research Assistant, The Pennsylvania State University, Mineral Conservation Section, University Park, Pennsylvania. Planned, executed and interpreted geophysical field surveys conducted each summer to determine if diabase or massive magnetite gives rise to various magnetic anomalies.

1958-1961 Computer and Acting Chief Computer, United Geophysical Corporation, Pasadena, California. Computer for reflection seismic crew engaged in oil and gas exploration; interpreted and processed seismic records; also organized office work, drafting, accounting.

PUBLICATIONS:

"In Situ Determination of the Remanent Magnetic Vector of Two-Dimensional Tabular Bodies," Ross, H. P. and Lavin, P. M., Geophysics, 31, No. 5, 949-962 (1966).

"A Bidirectional Reflectance Accessory for Spectroscopic Measurements," Hunt, G. R. and Ross, H. P., Applied Optics, 6, No. 10, 1687-1690 (1967).

"A Simplified Mathematical Model for Lunar Crater Erosion," Jour. Geophysical Research, 73, No. 4, 1343-1354 (1968).

"A Statistical Analysis of the Reflectance of Igneous Rocks from 0.2 to 2.65 Microns," Ross, H. P., Adler, J. E. M. and Hunt, G. R., Icarus, 11, 46-54 (1969).

"Recognition of the Geologic Framework of Porphyry Copper Deposits on ERTS-1 Imagery," Allan, J. W., Andrews, R. K., Ross, H. P. and Wilson, J. C., Kennecott Expl. Inc., Final Report to NASA, September (1975).

"Interpretation of Resistivity and Induced Polarization Profiles, Calico Hills and Yucca Mountain Areas, Nevada Test Site," Ross, H. P. and Lundbeck, J., University of Utah Research Institute, Earth Science Laboratory, Rept. No. 8, to the U.S. Geological Survey, September (1978).

"Numerical Modeling and Interpretation of Dipole-Dipole Resistivity Data, Lakes District, Ethiopia," Ross, H. P., Smith, Christian and Atwood, J. W., University of Utah Research Institute, Earth Science Laboratory, Rept. No. 15, to the United Nations, December (1978).

"Numerical Modeling and Interpretation of Dipole-Dipole Resistivity Data, Olkaria Field, Kenya," Ross, H. P., Smith, Christian, Glenn, W. E., Atwood, J. W. and Whipple, R. W., University of Utah Research Institute, Earth Science Laboratory, Rept. No. 16, to the United Nations, February (1979).

"Geothermal Well Drilling Estimates Based on Past Well Costs," Chappell, R. N., Prestwich, S. J., Miller, L. G. and Ross, H. P., Geothermal Resources Council Transaction, September, 3, 99-102 (1979).

"Interpretation of Resistivity and Induced Polarization Profiles With Severe Topographic Effects, Yucca Mountain Area, Nevada Test Site," Smith, Christian and Ross, H. P., University of Utah Research Institute, Earth Science Laboratory, Rept. No. 21, to the U.S. Geologic Survey, October (1979).

"Numerical Modeling and Interpretation of Dipole-Dipole Resistivity and IP Profiles, Cove Fort-Sulphurdale KGRA, Utah, Ross, H. P., UURI/ESL Report, DOE/DGE Contract No. DE-AC07-78ET28392 (1979).

"A Summary of the Geology and Geophysics of the San Emidio KGRA, Washoe County, Nevada, Mackelprang, C. E., Moore, J. N., and Ross, H. P., Geothermal Resources Council Trans., v. 4, p. 221-224 (1980).

"Review of Well Logging in the Basin and Range Known Geothermal Resource Areas, Glenn, W. E., Ross, H. P., and Atwood, J. W., paper SPE 9496, 55th annual meeting, SPE/AIME, Dallas, 16 p. (1980).

"A Strategy of Exploration for High Temperature Hydrothermal Systems in the Basin and Range Province, Ward, S. H., Ross, H. P., and Nielson, D. L., Bull. AAPG, v. 65, no. 1 (1981).

"Interpreted Resistivity and IP section, Line W1, Wahomonie Area, Nevada Test Site, Nevada", Smith, C., Ross, H. P., and Edquist, R., U.S.G.S. Open-File Report 81-1350, 8 p. (1981).

"Exploration Strategies for Regional Assessment of Hydrothermal Resources", Ward, S. H., Foley, D., Moore, J. N., Nielson, D. L., Ross, H. P., and Wright, P. M.: in Geothermal Energy Technology, J. C. Bresee and P. A. Witherspoon, eds. (1982, in press).

"The Cove Fort-Sulphurdale KGRA-A Geologic and Geophysical Case Study", Ross, H. P., Moore, J. N., Christensen, O. D., UURI/ESL Report No. 90, 32 p. (1982).

"Roosevelt Hot Springs Geothermal System, Utah-Case Study", Ross, H. P., Nielson, D. L., and Moore, J. N., AAPG Bull., v. 66, n. 7, p. 879-902 (1982).

"Interpretation of Resistivity and Induced Polarization Profiles with Severe Topographic Effects, Yucca Mountain area, Nevada Test Site," Smith, C., and Ross, H. P.: with introduction by D. B. Hoover, U.S.G.S. Open-File Report 82-182, 19 p. (1982).

"Review of Well Logging in the Basin and Range Known Geothermal Resource Areas", Glenn, W. E., Ross, H. P., and Atwood, J. W., Jour. Petroleum Tech., May, p. 1104-1118 (1982).

"A Study of Well Logs from Cove Fort-Sulphurdale KGRA, Millard and Beaver Counties, Utah", Glenn, W. E., and Ross, H. P., UURI/ESL Report No. ESL-75, 39 p. (1982).

PATENT:

"A Bidirectional Reflection Attachment for a Double Beam Spectrophotometer," Hunt, G. R. and Ross, H. P., submitted October 1966, U.S. Patent No. 3,506,365.

ABSTRACTS AND PRESENTATIONS:

"The Roosevelt Hot Springs, Utah Geothermal Resource - An Integrated Case Study," Ross, H. P., Nielson, D. L., Glenn, W. E., Moore, J. N., Smith, Christian and Christensen, O. D., 66th Annual AAPG Meeting, San Francisco, June (1981).

"Reflection Seismic Surveys for Basin and Range Geothermal Areas - An Assessment," Ross, H. P., Glenn, W. E. and Swift, C. M., Jr., 66th Annual AAPG Meeting, San Francisco, June (1981).

"The Cove Fort-Sulphurdale KGRA - A Geological and Geophysical Case Study (abs.)," Ross, H. P., Moore, J. N. and Glenn, W. E., Geophysics, 46, No. 3 (1981).

"An Examination of 2-D Earth Model Resolution With the Dipole-Dipole Resistivity Method (abs.)," Smith, Christian, Glenn, W. E., Tripp, A. C. and Ross, H. P., Geophysics, 46, No. 3 (1981).

"A Strategy of Exploration for High Temperature Hydrothermal Systems in the Basin and Range Province," Ward, S. H., Ross, H. P. and Nielson, D. L., 65th Annual AAPG meeting, Denver, June (1981).

"Review of Well Logging in the Basin and Range Known Geothermal Resource Areas," Glenn, W. E., Ross, H. P. and Atwood, J. W., Paper SPE 9496, 55th Annual Meeting, SPE/AIME, Dallas, 16 p. (1980).

"Dipole-Dipole Resistivity Survey of a Portion of the Coso Hot Springs, KGRA, Inyo County, California", Fox, R. C., Ross, H. P., and Wright, P. M., (abs) Geophysics, v. 44, no. 3, p. 405 (1979).

"Aeromagnetics in Porphyry Copper Exploration," GSA Penrose Conference on Geologic Interpretation of Magnetic Data (unpublished), Reston, Virginia, April (1974).

"An Integrated Magnetic Study of Intrusive and Altered Sedimentary Rock of the Santa Rita, New Mexico Porphyry Copper Deposit," Trans. AIME, Dallas, February (1974).

RESUME

Claron E. Mackelprang

POSITION: Geophysicist, Earth Science Laboratory, University of Utah Research Institute, Salt Lake City, Utah

EDUCATION: Completed selected graduate level courses,
B.Sc., Physical Geology, 1963, Utah State University
Assoc. Sc., 1959, Civil Engineerng, College of Southern Utah

PROFESSIONAL AFFILIATIONS: Member of Society of Exploration Geophysicists

PROFESSIONAL EXPERIENCE:

10/79-present Geophysicist, Earth Science Laboratory, University of Utah Research Institute, Salt Lake City. Utah. Coordinate, interpret and evaluate geophysical survey data to form technical case histories of geothermal exploration/reservoir assessment studies. Provide geophysical expertise and assistance to private industry and state agencies working with DOE/DGE Industry Coupled Program. Provide geophysical expertise to private industry as member of a consulting team evaluating geophysical data for occurrences of oil, mineral deposits and geothermal fluids.

1977-1979 Geophysicist, Bear Creek Mining Company. Responsible for supervision and coordination of geophysical personnel, survey design, implementation and data interpretation from the application of geophysical techniques supporting geologic exploration staff, resulting in major contribution to discovery of blind copper deposit. Designed, implemented and compiled, and interpreted aeromagnetic surveys utilizing small, in-house aeromagnetic system. Conducted rock and soil geochemical surveys with emphasis on precious metal environments of Mexico and western U.S. resulting in delineation of prospective zones. Compiled land status maps from courthouse records identifying mineral and surface ownership. Performed public relations work with property owners obtaining trespass permission for geophysical crews. Prepared final interpretations of geophysical survey data submitting reports to District Exploration managers.

1964-1977 Assistant Geophysicist, Bear Creek Mining Company/Kennecott Exploration Inc. Applied extensive knowledge of geophysical techniques to prophyry copper and molybdenum, massive sulphide, base metal, phosphate and sulphur exploration in domestic and foreign environments. Responsible for geophysical survey design, field crew supervision, data acquisition, and data interpretation utilizing advanced computer techniques, maintenance of gravity data library. Conducted and supervised ground EM, magnetic and induced polarization surveys in Haiti, utilizing local, inexperienced labor resulting in delineation of volcanogenic massive sulfide mineralization. Supervised gravity, ground magnetic and induced polarization crews, conducted aeromagnetic surveys including data acquisition and interpretation in Alaska, Washington, Idaho, Montana, Nevada, Utah, New Mexico, Colorado, Arizona, Texas, Tennessee, Wisconsin and Minnesota. Developed programs to process gravity, altimeter, transit annd stadia data on Hewlett-Packard 9830 system; devised procedures for processing geophysical field data on hand-held programmable calculators enabling gross data interpretation while still in the field.

1962, 1963 summers	Geological Field Assistant, Bear Creek Mining Company. Aided senior geologist in geochemical sampling and field mapping of selected areas within San Juan Mountains of Colorado, also in Utah and New Mexico.

AWARDS:

Recipient of Best Paper Award, Site-specific Exploration Session, Geothermal Resource Council Annual Meeting, 1980.

PAPERS:

"A Summary of the Geology and Geophysics of the San Emidio KGRA, Washoe County Nevada", GRC, 1980.

"Interpretation of a Telluric-Magnetotelluric Survey at the Tuscarora Geothermal Exploration Unit, Elko County, Nevada", SEG, 1981.

PUBLICATIONS:

Interpretation of the Dipole-Dipole Electrical Resistivity Survey, Tuscarora Geothermal Area, Elko County, Nevada, ESL Rept. #72, February 1982.

Two-Dimensional modeling Results of Telluric-Magnetotelluric Data from the Tuscarora Area, Elko County, Nevada, ESL Rept. #63, January 1982.

Interpretation of a Dipole-Dipole Electrical Resistivity Survey, Colado Geothermal Area, Pershing County, nevada. ESL Rept. #41, Sept. 1980.

Numerous properietary reports for Bear Creek Mining Company/Kennecott Exploration Inc. regarding interpretation of geophysical data.

RESUME

Phillip M. Wright

BIRTHPLACE AND DATE: Park City, Utah, March 14, 1938

POSITION: Associate Director for Technology, Earth Science Laboratory Division, University of Utah Research Institute, Salt Lake City, Utah

EDUCATION: B.S. (High Honors), Geological Engineering, 1960, University of Utah, Salt Lake City, Utah
Ph.D., Geophysics, 1966, University of Utah, Salt Lake City, Utah,
Title of Ph.D. Thesis: Heat Flow and Geothermal Gradients in Utah

SHORT COURSES: Motivation and Management: Practical Management Associates, Salt Lake City, Utah, 1969 and 1973.

Engineering and Management: University of California at Los Angeles, 1971.

Mineral Deposits and Mineral Exploration: University of Nevada at Reno, 1973.

Geostatistics in the Mining Industry: Colorado School of Mines Alumni Association, Tucson Arizona, 1976.

Geothermal Resources and the Institutional Maze: Geothermal Resources Council, 1979.

SOCIETY AFFILIATIONS: American Geophysical Union
Society of Exploration Geophysicists
Society of Economic Geologists
Geothermal Resources Council
Utah Geological Association

HONORS AND AWARDS: United Park City Mines Scholarship, 1956-1960
United States Steel Foundation Fellowship, 1961-1963
National Science Foundation Regular Graduate Fellowship, 1964-1966

Elected to: Tau Beta Pi, 1960
Phi Kappa Phi, 1960
Phi Beta Kappa, 1960
Sigma Xi, 1965

PROFESSIONAL EXPERIENCE:

9/82-12/82 Taught course GG521, Gravity and Magnetic Methods of Exploration, a graduate-level course at the Department of Geology and Geophysics, University of Utah.

9/78-present Associate Director for Technology, Earth Science Laboratory Division, University of Utah Research Institute. Report to

Director of the Earth Science Laboratory. Assume about half of Director's functions during academic year. Coordinate, review and ensure quality of all scientific and engineering work performed at ESL. Responsible for technical work on budgets of about $3 million per year. Portion of work involves geothermal research and management assistance programs on behalf of the U.S. Department of Energy. Geothermal work encompasses entire U.S. Have also worked at the Ahuachapan geothermal field in El Salvador. Another portion of work involves minerals exploration projects, services and research. Project Manager for Solution Mining and Hydrometallurgy project at UURI, supported by industry and designed to improve solution mining technology.

5/77-9/78 Senior Geophysicist/Project Manager, Earth Science Laboratory Division, University of Utah Research Institute. Responsible for assembling a multidisclipinary, high-quality earth science staff and installation of appropriate laboratory facilities. Reviewed work of less senior geophysicists on numerous geothermally related projects. Participated in planning for all ESL projects. Project Manager for State Coupled Geothermal Resource Assessment Program under contract to U. S. Department of Energy.

1969-5/77 Chief, Geophysics Division - U.S. Operations, Kennecott Exploration, Inc., Salt Lake City, Utah. Reported to Director, Exploration Services and to Vice-President, Exploration. Responsible for budgets up to $800,000 per year. Supervised professional geophysical staff, field geophysical crews and contract geophysical services. Interacted with worldwide exploration offices to provide geophysical input to exploration programs. Designed, supervised and interpreted broad range of geophysical surveys. Generated exploration targets. Project manager on reconnaissance induced polarization project in Western U.S. and Canada which led to discovery of a new, major covered porphyry copper sulfide system. Managed projects in seismic research, field and office interpretation of large aeromagnetic data base, and others. Field experience and interpretative work in Arizona, New Mexico, Nevada, Utah, Montana, Washington, Wisconsin, Minnesota, Colorado, British Colombia, South Africa and Botswana.

1966-1969 Senior Geophysicist, Kennecott Exploration Services, Salt Lake City, Utah. Reported to Chief Geophysicist. Responsible for exploration geophysical programs in Arizona, Nevada and Utah. Worked closely with geologists in Bear Creek Mining Co., a Kennecott subsidiary. Designed, supervised and interpreted geophysical surveys. Generated targets.

1956-1966 Undergraduate and Graduate Student, University of Utah, Salt Lake City, Utah.

1956-1966 (part-time) United Park City Mines Company, Park City, Utah. Worked as underground miner. Later worked with Chief Engineer and Chief Geologist as assistant. Experienced in all types surface and

	underground survey work, geologic mapping and interpretation. Directed underground long-hole drilling program which aided in discovery of new lead-zinc mineralization. Ore reserve calculations.
1961 (summer)	The Anaconda Company, Salt Lake City, Utah. Worked as assistant geologist on a beryllium prospect near Ely, Nevada. Underground geologic mapping sampling. Ore reserve calculations.
1957 (summer)	Bush and Gudgell, Engineers, Salt Lake City, Utah. Member of survey crew.

PUBLICATIONS:

"Heat Flow and Precision Temperature Measurements in Boreholes," Costain, J. K. and Wright, P. M., Soc. Prof. Well Log Anal. Annu. Logging Symp., Trans. No. 10, J1 (1969).

"Heat Flow at Spor Mountain, Jordan Valley, Bingham, and LaSal, Utah," Costain, J. K. and Wright, P. M., J. Geophys. Res., 78, No. 35, 8637 (1973).

"Annual Review of Geophysics," Mining Engineering, 25, No. 2 (1973).

"Frontiers of Mining Geophysics," Ward, S. H., Campbell, R. E., Corbett, J. D., Hohmann, G. W., Moss, C. K. and Wright, P. M., Geophysics, 41, No. 2 (1977).

"Western States Cooperative Direct Heat Geothermal Program of DOE," Wright, P. M., Foley, D., Nichols, C. R., Grim, P. J. and Swanson, Jim, Geoth. Resources Council, Trans., 2, Sec. 1, 739 (1978).

"Nature, Occurrence and Utilization of Geothermal Energy," Commercialization of Geothermal Resources, Geoth. Resources Council, 1 (1978).

"Nature and Occurrence of Geothermal Resources," Commercial Uses of Geothermal Heat, Geoth. Resources Council Spec. Report No. 9, 123-134 (1980).

"State Coupled Resource Assessment Program - An Update," Foley, Duncan, Wright, P. M., Struhsacker, D. W., Nichols, C. R., Mink, L. L., Brophy, G. P., Grim, P. J. and Berry, George, Geothermal Resources Council, Transactions, vol. 3, 1979.

"Gravity and Magnetic Methods in Mineral Exploration," Seventy-Fifth Anniversary Volume, Economic Geology, Society of Economic Geologists, 1981.

"Seismic Methods in Mineral Exploration," Seventy-Fifth Anniversary Volume, Economic Geology, Society of Economic Geologists, 1981.

MAJOR ORAL PRESENTATIONS:

Determining Variations in the Thickness of Recent Cover with Gravity: to AIME Annual Meeting, New York, New York, 1968.

Educating Tomorrow's Earth Scientist for Industry: to Southwest Section, AIME, Las Vegas, Nevada, 1972.

Integration of Geophysical Data into Mining Exploration Programs: to Society of Economic Geologists Annual Meeting, New York, New York, 1975.

Mining Geophysics: taught a one-day mining geophysics course as part of a course entitled "A Total Concept of the Mining Industry", a summer course taught by the Colorado School of Mines, each year 1970-1976.

Dipole-dipole Resistivity of a Portion of the Coso Hot Springs KGRA, Inyo County, California: to Society of Exploration Geophysicists 48th Annual Meeting, San Francisco, California, 1978.

Use of Geophysics in Geothermal Exploration: A short course sponsored by CEL and the United Nations in El Salvador, C.A. for delegates from Central and South American in June 1979.

Geothermal Geophysics: to National Conference on Renewable Energy Technologies, Honolulu, Hawaii, 1980.

Nature and Occurrence of Geothermal Resources: to Geothermal Resources Council Symposium on Commercial Uses of Geothermal Heat, Boise, Idaho, 1980.

Nature and Occurrence of Geothermal Resources in the United States: to the First Sino/US Geothermal Resources Conference, Tianjin, People's Republic of China, 1981.

Geochemistry in Geothermal Exploration: to the First Sino/US Geothermal Resources Conference, Tianjin, People's Republic of China, 1981.