

CAPABILITIES

Earth Science Laboratory

University of Utah Research Institute

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University of Utah Research Institute
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CAPABILITIES
EARTH SCIENCE LABORATORY
UNIVERSITY OF UTAH RESEARCH INSTITUTE

General Statement

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 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.

The Earth Science Laboratory (ESL) of the University of Utah Research Institute (UURI) provides consulting and contracting services for research and applications of research in a broad range of geoscience topic areas. 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 1). Even though the main portion of a given project 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

Table 1
EARTH SCIENCE LABORATORY
PROFESSIONAL STAFF*

Geologists			4
	Ph.D.	2	
	M.S.	1	
	B.S.	1	
Geochemists			4
	Ph.D.	1	
	M.S.	2	
	B.S.	1	
Geophysicists			4
	Ph.D.	4	
Electronics Engineers			1
	B.S.	1	
		Total	<u>13</u>
Consulting reservoir engineers	Ph.D.	2	
Consulting geophysicist	Ph.D.	1	
Consulting geochemists	Ph.D.	4	
Consulting isotope geochemist	Ph.D.	1	

* This professional staff is supported by 2 business administrators, 3 technicians, 2 secretaries, 1 draftsperson, and 3-6 University students.

following paragraphs describe some of our more significant project work.

Geothermal Energy

ESL scientists have acquired extensive field experience in more than 15 high-temperature geothermal systems in the western U.S. and have helped the U.S. Department of Energy (DOE) to manage several major geothermal programs on which DOE has spent over \$50 million in the past five years (see Table 2). As part of this work, we have performed geological, geochemical, geophysical and hydrological studies of a regional and site-specific nature for high-, intermediate-, and low-temperature geothermal resources.

ESL has also provided geothermal exploration and evaluation services to industry clients with geothermal properties in Utah, Nevada and California, to the Department of Defense (DOD) at several U.S. military installations and to the United Nations at several foreign sites. This work has included detailed geologic mapping, geophysical surveys and interpretation and geochemical analyses and their interpretation.

Subsurface Fluid Flow/Fluid-Rock Interaction

The Earth Science Laboratory professional staff, in conjunction with consultants Dr. David Cole, Dr. Donald Langmuir and Dr. Denis Norton, has extensive experience in identifying and modeling subsurface fluid flow paths, fluid mixing, and calculation of fluid-mineral equilibrium relationships. These techniques are used successfully in predicting the possibility of pollution resulting from solid waste disposal, acid mine-water drainage, solution mining and other industrial related contamination and in predicting fluid-reservoir rock interaction in geothermal systems.

Table 2
REPRESENTATIVE GEOTHERMAL PROGRAM MANAGEMENT
(for U. S. Department of Energy)

1. Industry Coupled Program. Assist DOE in management of national program of cooperation in geothermal exploration between DOE and industry. Management assistance role consisted of helping to write procurement solicitations, helping to evaluate proposals from industry to DOE and helping to monitor contracts between industry and DOE. Also responsible for the acquisition of new geological, geochemical and geophysical data from 14 geothermal areas in the western U.S. to supplement industry data. Published interpretations of new data along with data originally collected by the geothermal industry in reports and case studies. Total DOE expenditures on program have been \$16 million.
2. State Coupled Program. Coordinate DOE programs in western U.S. wherein teams of geologists under separate contract to DOE worked in each state to assess low- and moderate-temperature (<150°C) geothermal resources. Management role includes formulating policy and procedures for program, communicating program goals to state teams, conducting workshops for bringing state teams together, evaluating proposals from state teams to DOE, and monitoring project progress. This program will ultimately result in publication of detailed geothermal resource maps for about 25 states in the western U.S. where most of the geothermal resources occur. Total DOE expenditures on program have been \$26 million during the past 7 years.
3. Exploration Technology Development Program. Manage national program for the development of new technology for exploration and evaluation of geothermal resources. ESL's management role consists of assisting DOE in issuing solicitations and evaluating proposals and evaluating quality of work performed by other contractors. In addition, ESL plays a major role in this program by performing in-house research and technology development. Total DOE expenditures on program have been \$6 million during the past 5 years. Program will continue after FY 1982.
4. Technology Transfer Program. Provide geological, geochemical and geophysical consulting services to potential new users of geothermal energy in the western U.S. Coordinate engineering and economic aspects of projects with other DOE contractors. Provide speakers for professional and general audience seminars. Total DOE expenditures on program were \$1 million. Program phased out at the end of 1982.
5. User Coupled Confirmation Drilling Program. Designed and implemented new DOE program for cost sharing by DOE of drilling for low- and intermediate-temperature geothermal resources (<150°C). Currently manage the geoscience aspects of program nationally for DOE. Total program expenditures by DOE were \$4 million over the past 3 years. Program will phase out in 1984.

6. Department of Defense Geothermal Exploration. Manage two large projects for geothermal exploration at Lackland Air Force Base and Ascension Island, South Atlantic Ocean. Each project includes detailed geological, geochemical and geophysical studies to site drill tests, supervision of drilling and evaluation of results.
7. Geothermal Sample Library. Manage national library where drill chip and core samples from geothermal wells drilled with DOE and other funding are studied and curated. Library currently contains nearly 80,000 m of drill chip samples and 2100 m of core from 171 geothermal wells.

In-Situ Leaching and Solution Mining Research

ESL has conducted an in-depth evaluation of the state of the art in in-situ leaching and solution mining on behalf of 6 large mining companies, the National Science Foundation and the U.S. Bureau of Mines. This study was aimed specifically at identifying the research problems of highest priority in developing new technologies for in-situ leaching and solution mining.

Drilling

Members of the geologic staff have extensive experience in well-site geology and in planning and supervising drilling operations. This includes deep, large diameter rotary holes in addition to shallow rotary holes and diamond core drilling.

Proper logging of drill cuttings in all types of rocks and unconsolidated materials, involving hundreds of thousands of feet of drill hole, have been handled by the staff. Accurate, clean, and orderly acquisition, curation, and labeling of drill-derived materials should be a normal part of a drilling operation. In addition, ESL has made systematic studies of geochemical contaminants introduced into samples by the drilling process. This is an important prerequisite to studies of subsurface geochemistry.

Soil Geochemistry

ESL has conducted extensive research work and numerous surveys to determine gas and trace element concentrations in soils resulting from the activity of hot subsurface water in geothermal systems and for mineral exploration. We have successfully developed exploration techniques for a number of resource types.

Minerals

Our minerals exploration, evaluation and development experience is broad in topic and is both regional and site-specific in area. ESL geoscientists have worked in sedimentary, intrusive, skarn, and metamorphic environments on disseminated and massive sulfide deposits of base metals, and on precious metals, uranium, iron, coal, diamonds and petroleum. Our professionals have worked in most of the major mineral provinces of the United States and in Australia, Botswana, Brazil, Canada, Cyprus, Haiti, Mexico, South Africa, and Zambia.

Environmental and Waste Hazards Studies

The Earth Science Laboratory/UURI has participated in a Phase II study to determine the magnitude and extent of environmental contamination at Hill Air Force Base as part of the Department of Defense Installation Restoration Program. This program included an extended records search, geophysical surveys, soil coring, drilling of hydrologic test holes, chemical analysis of soil and fluid samples and the recommendation of remedial actions.

Nuclear Waste Disposal

Dr. Howard Ross, ESL/UURI, 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.

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.

Research

ESL's research experience includes development and implementation of new geological, geochemical and geophysical techniques for geothermal and mineral resources (Table 3). Specialities are: structural and stratigraphic controls of fluid flow, trace element geochemistry, fluid geochemistry, mineralogy, fluid/mineral equilibrium models, advanced interpretation techniques for electrical, gravity and magnetic data, physical properties studies, and development and implementation of computer algorithms.

Workshops and Conferences

ESL has had a great deal of experience in presenting technical workshops, shortcourses and conferences. These are tailored specifically to the needs of the client. Recent examples of such presentations include:

Geology of Geothermal Systems. Yellowstone Park shortcourse programs.

Application of geothermal, geology, geochemistry and geophysics in gold exploration.

Geophysical Exploration Workshops

Table 3
MAJOR GEOTHERMAL RESEARCH AND INSTRUMENTATION DEVELOPMENT

Research Accomplishments	Where Applied
<p>1. <u>Trace Element Geochemistry.</u> Developed new techniques for geothermal exploration and resource evaluation, for siting of drill holes and for gathering data during drilling of holes using trace element geochemistry of surface samples and of drill chips and cores. Conducted major research studies at The Geysers, CA and Roosevelt Hot Springs, Utah. Applied techniques at several other areas. These techniques are currently in use by major geothermal companies in the U.S. Published 7 reports.</p>	<p>The Geysers, CA Roosevelt Hot Springs, UT Cove Fort/Sulphurdale, UT Colado, NV Beowawe, NV McCoy, NV</p>
<p>2. <u>Mercury Geochemistry.</u> Documented relationships between temperature distribution underground and occurrence of mercury in drill chip samples. Showed that mercury geochemistry can be used to site drill holes, guide drilling and locate fluid entries in drill holes. Published 2 reports.</p>	<p>The Geysers, CA Roosevelt Hot Springs, UT Beowawe, NV Colado, NV McCoy, NV</p>
<p>3. <u>Resistivity Data Interpretation.</u> Developed new highly sophisticated programs using two-dimensional and three-dimensional models for interpretation of resistivity and induced polarization geophysical data. Complete mathematical formulation had never been done before. Published 6 reports.</p>	<p>Roosevelt Hot Springs, UT Cove Fort/Sulphurdale, UT Beowawe, NV Colado, NV Tuscarora, NV McCoy, NV Lakes District, Ethiopia Olkaria District, Kenya</p>
<p>4. <u>Magnetotelluric Data Interpretation.</u> Developed new and unique computer programs using two-dimensional and three-dimensional models for interpretation of magnetotelluric geophysical data. Mathematical formulation had never been done before. Published 3 reports.</p>	<p>Roosevelt Hot Springs, UT Tuscarora, NV</p>
<p>5. <u>Self Potential Data Interpretation.</u> Developed new and unique methods for interpretation of self potential data. Reports in press.</p>	<p>Roosevelt Hot Springs, UT</p>

6. Resistivity and Induced Polarization Instrumentation. Developed a new, state-of-the-art, four-channel field receiver for resistivity and induced polarization data collection. Features are light weight, field programmable computer control, phase and amplitude measurement. Field tested in Colorado.

7. Magnetotelluric Instrumentation. Developed a new and unique field system for acquisition of magnetotelluric geophysical data. Features are computer control with digital magnetic recording of data. Uses SQUID magnetometers. For research purposes -- this field system will not be marketed in its present configuration. Roosevelt Hot Springs, UT

The Self Potential Method as applied to geothermal exploration
Application of Geophysical Methods to Minerals Exploration
Electrical Methods in Oil and Gas Exploration
DOE Geothermal Direct Heat Program. State Coupled Geothermal
Resource Assessment Technical Conferences.

Military Bases

ESL has performed geoscience studies on the following military bases:

China Lake Naval Air Station, California

Hill Air Force Base, Utah

Williams Air Force Base, Arizona

Ascension Auxilliary Airfield, Ascension Island, South Atlantic

Adak Naval Air Station, Alaska

Lackland Air Force Base, Texas

Clients from Private Industry

Table 4 contains a list of domestic industrial clients we have served from 4/1/80 to the present and Table 5 contains a similar list of foreign clients.

Summary of Staff Expertise and Facilities

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

Table 4
PRIVATE INDUSTRY CONTRACTS
4/80-7/84
DOMESTIC

- GEOPHYSICS

Anaconda Copper Company	Hunt Energy Corporation
CH ₂ M Hill, Inc.	JCW, Inc.
Energy Fuels Nuclear, Inc.	Rocky Mountain Energy
Florida Exploration Company	Umont Mining Co.

- SOLUTION MINING

Amax, Inc.	Duval Corporation
Amoco Minerals Company	Kennecott Copper Corporation
Anaconda Copper Company	Phelps Dodge Corporation

- GEOCHEMISTRY

American Microsystems, Inc.	Native Plants
Aminoil, USA	Nevin Sadlier-Brown Goodbrand, Ltd.
Amoco Minerals Company	Nu-Energy Resources, Inc.
Anderson & Kelly, Inc.	Occidental Geothermal, Inc.
Berkeley Group, Inc.	Occidental Minerals Corporation
Chevron Oil Fields Research Co.	Occidental Resources Corporation
Chevron Resources	Phillips Petroleum Co.
Coleman National Fish Hatchery	Rocky Mtn. Center for Occupational and Environmental Health
EarthFax Engineering, Inc.	Silver King Mines
Ecology & Environment, Inc.	Sohio Alaska Petroleum Co.
EG&G Idaho, Inc.	Sohio Petroleum Co.
Gertsch, Juncal & Associates	Supron Energy Corporation
Getty Oil Company	Technical Research Associates
Grace Geothermal Corporation	Terra Tek Core Services
GRI Corporation	Terra Tek Research
Hunt Energy Corp.	Trans-Pacific Geothermal
Indian Valley Hospital District	Union Oil Company of California
Kennecott Minerals Company	United States Steel Corporation
MAPCO	Utah Biomedical Test Laboratories
Morrison-Knudsen Co., Inc.	

- GEOLOGY

California Energy	Morrison-Knudsen
CH ₂ M Hill	Nielson Geoconsultants
Evans & Sutherland	Occidental Geothermal, Inc.
Grace Geothermal	Philippine Geothermal
GRI Operator	Phillips Geothermal
Homestake Mining Company	Radian Corp.
Hunt Energy Corporation	Rocky Mountain Corrosion Control
Hunt Geothermal	Terra Tek
Kennecott Minerals Company	Trans-Pacific Geothermal
Marek Tokarz	Union Geothermal
Montgomery Engineering	Utah Biomedical Test Laboratories

Table 5
PRIVATE INDUSTRY CONTRACTS
4/80-7/84
FOREIGN

- ⊙ GEOPHYSICS
C.R.A. Exploration Pty. Limited, Australia
Premier Geophysics, Inc., Canada
- ⊙ GEOCHEMISTRY
Nevin/Sadlier-Brown/Goodbrand Ltd., Canada
- ⊙ COMPUTER
C.R.A. Exploration Pty. Limited, Australia
British Petroleum of Canada, Canada

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. Dr. Dennis L. Nielson is manager of the geologic group. His resume is included with this document.

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. Dr. J. N. Moore is manager of the geochemistry group and Ms. Ruth Kroneman is manager of ESL's analytical

facilities. Their resumes are included.

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. 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 provide training of personnel in operation of available programs. Dr. Howard P. Ross is manager of the geophysics group. His resume is included.

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. Mr. Dale Green manages the electronics engineering group. His resume is included.

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.

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 tape 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.

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 80,000 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 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.

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 on the University of Utah campus where 2,000,000 titles are available.

Office Facilities

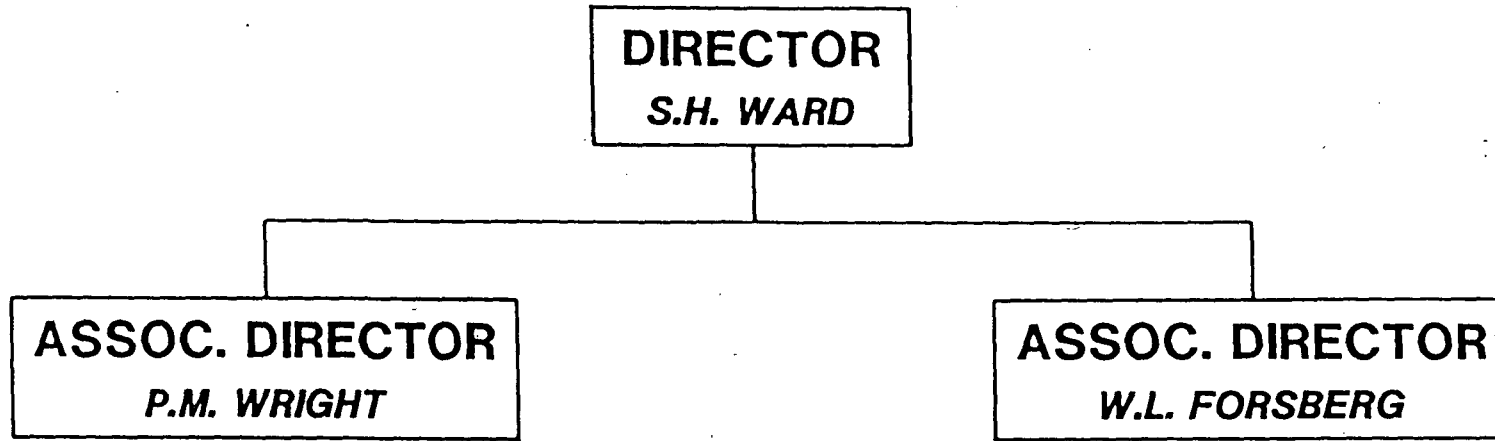
The main offices of the Earth Science Laboratory are located in Research Park, on the east side of the Salt Lake Valley, adjacent to the University of Utah. There are over 11,000 square feet of laboratory and office space in two buildings. Located here are the geochemical laboratory, the electronics laboratory, the computer center and our extensive document library as well as offices. The Sample Library occupies 4000 square feet 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 but a 5-minute drive from ESL's main facilities.

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. The organization structure of ESL is shown in Figure 1. Dr. Stanley H. Ward is the Director and Dr. Phillip M. Wright is Associate Director/Technology for ESL. Their resumes are included.

ESL ADMINISTRATIVE MANAGEMENT



- GEOCHEMISTRY
- GEOLOGY
- GEOPHYSICS
- COMPUTER OPERATIONS
- ELECTRONICS

- CONTRACT NEGOTIATIONS & COMPLIANCE
- FACILITIES
- FISCAL MANAGEMENT
- MARKETING
- PERSONNEL & PURCHASING



Resumes of Key Personnel

RESUME

Dale J. Green

POSITION: Senior Electronics Engineer, Earth Science Laboratory, University of Utah Research Institute

EDUCATION: B.S., Electrical Engineering, 1956, University of Utah.
Graduate Work, Electrical Engineering, 1961, University of Utah.
Graduate Work, Geophysics, 1964, University of Utah.

SOCIETY AFFILIATIONS: SEG, Inst. of Electrical and Electronics Engineers.

PROFESSIONAL EXPERIENCE;

- 1977-present Senior Electronics Engineer, Earth Science Laboratory, University of Utah. Design and program microprocessor-based geophysical instruments including: phase-measuring induced-polarization and electromagnetic receiver; controlled-source and natural field magnetotelluric system; temperature gradient measuring system. Supervise one engineer and one technician.
- 1966-1977 Senior Electronics Engineer, Kennecott Exploration, Inc., Geophysics-R&D Division, Salt Lake City, Utah. Designed geophysical prospecting and borehole logging equipment. Designs included Induced Polarization (IP) receivers (one model measured Percent Frequency effect (PFE) and four models measured phase). The last phase receiver employed a computer for data processing and computation of voltage and resistivity; various small IP transmitters; a dual-channel audio magnetotelluric (AMT) receiver; an interface and formatter for a 7-track tape recorder; electromagnetic (EM) transmitters and receivers; and IP, nuclear, temperature and velocity modules for borehole logging. During the past two years, microprocessors have been studied for their use in all the above types of instrumentation. Directly supervised four to six technicians. Have travelled extensively stateside and overseas training geophysical crews.
- 1957-1966 Senior Project Engineer, Sperry Utah Company. Design of servomechanisms for radar antennas and the guidance system of the Sergeant guided missile.
- 1963-1965 Teaching and Lab Assistant, Geophysics Department, University of Utah, Salt Lake City. Wrote computer programs, designed and maintained equipment for department.
- 1961-1962 Research Assistant, Chemistry Department, University of Utah, Salt Lake City. Designed instrumentation for mass spectrometer.

June 1956-
October 1956

Engineer, Autonetics Company, Downey, California. Designed equipment for automatic testing of Navaho missile.

1954-1956

Lab Assistant, Electrical Engineering Department, University of Utah, Salt Lake City, Utah. Repaired and maintained lab equipment for EE Department.

1955

Assistant Engineer, Naval Air Development Center, Johnsville, PA. Designed equipment for distance measuring equipment.

1949-1952

Aircraft Electrician, U. S. Air Force. Maintained aircraft electrical system.

RESUME

Ruth L. Kroneman

POSITION: Research Chemist, Earth Science Laboratory, University of Utah
Research Institute

EDUCATION: 1954, Western Montana College of Education, Dillon, Montana
B.A., Chemistry, 1956, Carleton College, Northfield, Minnesota

PROFESSIONAL EXPERIENCE:

- 1978-present Analytical Chemist, Earth Science Laboratory, University of Utah
Research Institute. Set up, operation and maintenance of
Applied Research Laboratories' inductively coupled plasma
quantameter (ICP). Development of procedures for analysis of
rock, water, brines and mineral concentrate samples by ICP and
other methods. Supervision for analytical lab and sample prep
facilities.
- 1976-1978 Research Chemist, Stauffer Chemical Company of Wyoming.
Nonroutine analytical problems including soda ash impurities,
ore analysis, mineral identification and water analysis.
Upgraded the routine procedures used in the quality control lab
and developed procedures for improved impurity monitoring.
Identifying and solving chemistry related problems of soda ash
production. Set up sampling and analysis procedures to meet EPA
drinking water standards.
- 1975-1976 Lab Manager, Georesearch Laboratories, Inc. Geochemical and
assay analysis. Preparation and well as analysis, hiring,
training, supervision of personnel and technique development.
- 1966-1975 Geochemist, Kennecott Exploration, Inc. Analysis of rock, soil
and water samples including classical techniques as well as
instrumental methods. Procedure development was frequently
required, particularly for trace metals by atomic absorption
spectrophotometry. Hired, trained and supervised laboratory
personnel. Major projects; analysis of brine and sediment
samples from the Red Sea, the analysis of ocean water for
synergistic toxic metals, and the analysis of sediments and pore
water from the manganese nodule areas of the Pacific Ocean.
These projects all required technique development to overcome
problems of limited sample size and interference from sodium
chloride.
- 1964-1966 Research Chemist, Research Institute, Inc. Research on chemical
effects of radiation. Development and operation of a pilot
plant for metallurgical research.
- 1956-1957 Junior Chemist, Ames Laboratory. Analysis of various materials
for major and trace constituents, some procedure development.

RESUME

Joseph N. Moore

DATE OF BIRTH: January 21, 1948

POSITION: Geologist/Project Manager and Section Manager of Geochemical Group, Earth Science Laboratory, University of Utah Research Institute, Salt Lake City, Utah

EDUCATION: B.S., Geology, 1969, City College of New York
M.S., Geology, 1972, Pennsylvania State University
Ph.D., Geology, 1975, Pennsylvania State University

SOCIETY AFFILIATIONS: Geological Society of America
Geothermal Resources Council

HONORS AND AWARDS: 1971, Sigma Xi Grant
1971, Paul D. Krynine Fund Award
1972, Sir William Logan Medallion
1973, Phi Kappa Phi Honor Society
1978, American Men and Women in Science

PROFESSIONAL EXPERIENCE:

- 1979-present Section Manager, the Geochemistry group, Earth Science Laboratory. Responsibilities include management of ESL geochemical programs and analytical facilities as well as the development of new geochemical techniques for use in geothermal exploration.
- 1977-1979 Geologist, Earth Science Laboratory. Conduct and supervise geologic programs in known geothermal resource areas of the Basin and Range.
- 1975-1977 Staff geologist, Uranium Division/The Anaconda Co. Primary responsibilities included developing an exploration program in volcanic terrains for hydrothermal uranium deposits and detailed and reconnaissance mapping in the Basin and Range.
- 1972-1975 Graduate Teaching Assistant, Pennsylvania State University. Duties included preparation of laboratories and laboratory lectures for basic physical geology and mineralogy courses.
- 1970-1972 Graduate Research Assistant, Pennsylvania State University. Research involved a comparison of igneous and impact breccias.
- 1971 summer Geologist, Johns-Manville Ltd. Detailed mapping in the Stillwater Complex, Montana.
- 1968-1969 summers Geologic Field Assistant, U.S.G.S., Dr. Nicholas Ratcliffe, party chief. Assist in detailed bedrock mapping of Taconic geology in southwestern Massachusetts.

1968 Part-Time Laboratory Assistant; Lamont Geological Observatory, Paleomagnetism Section, Dr. Neil Opdyke, supervisor. Duties included cutting, preparation, and magnetic analysis of deep sea drill cores.

PUBLICATIONS:

"Northeast Breccia Pipes and Dikes," Moore, J. N. and Gold, D. P., International Geologic Congress (24th Session) Guidebook, Monterey Hills: Diatremes, Kimberlites, Lamprophyres, and Intrusive Breccias West of Montreal (1972).

"Mixed-Volatile Equilibria in Calcareous Rocks from the Alta Aureole, Utah," Moore, J. N. and Kerrick, D. M., Am. Jour. Sci., 276, 502-524 (1976).

"Geology of Roosevelt Hot Springs KGRA Beaver Co., Utah," Nielson, D. L., Sibbett, B. S., McKinney, D. B., Hulén, J. B., Moore J. N. and Samberg, S. M., University of Utah Research Institute, Earth Science Laboratory Report (ID0/78-1701.b.1.1.3), 120 p. (1978).

"Geology of the Cove Fort-Sulphurdale KGRA," Moore, J. N. and Samberg S. M., Bibliographic Annotations and Petrographic Descriptions by B. Sibbett, University of Utah Research Institute, Earth Science Laboratory (ID0/78-1701.b.1.1.5), 44 p. (1979).

"Geology Map of the San Emidio Geothermal Area," University of Utah Research Institute, Earth Science Laboratory (EG-78-C-07-1701) 8 p. (1979).

"Geology, Geochemistry, and Geophysics of the Roosevelt Hot Springs KGRA, Utah," Basic Geology for the Exploration of Geothermal Systems, GRC Technical Training Course #5, 24 p. (1980).

Geochemistry of solids in geothermal systems, Moore, J. N., National Conference on renewable energy resources technologies, Honolulu, 1980.

"Trace Element Geochemical Zoning in the Roosevelt Hot Springs Thermal Area, Utah," Christensen, O. C., Moore, J. N. and Capuano, R. M., Geothermal Resources Council Trans., 4, 149-152 (1980).

"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 Transaction, 4, 221-224 (1980).

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

"Hg and As soil geochemistry as a technique for mapping permeable structure over a hot-water geothermal system", Capuano, R. M., and Moore, J. N., [abs.] Geol. Society America, Rocky Mt. Section 12, no. 5, 269 (1980).

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"Geochemical Indicators of a High-Temperature Geothermal System" [abs.], Moore, J. N., Capuano, R. M., and Christensen, O. D., 9th International Geochemical Exploration Symposium, Saskatoon, Canada, May 12-14 (1982).

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"The Cove Fort-Sulphurdale KGRA - A Geological and Geophysical Case Study" Ross, H. P., Moore, J. N. and Christensen, O. D., ESL Report 90, 29 p. (1982).

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"Geologic map of the McCoy geothermal prospect, Adams, M. C., Moore, J. N., and Struhsacker, E., ESL Report 111 (DOE/ID/12019-92), (1982).

"Trace Element Distribution in an Active Hydrothermal System, Roosevelt Hot Springs Thermal Area, Utah," Christensen, O. D., Capuano, R., Moore, J. N., J. Volcanology and Geothermal Research, v. 16, p. 99-129 (1983).

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"Preliminary geothermal assessment of the Tuttapani thermal area, Madhya Pradesh, India: Geothermal Resources Council Transactions, in press.

"Geochemistry of the Meager Creek geothermal field, Moore, J. N., Adams, M. C., and Stauder, J. J., British Columbia Geothermal Resources Council, in press.

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, Reno, 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. Principal investigator for the geothermal exploration of Ascension Island, South Atlantic Ocean, under contract to U.S. Department of Energy and U.S. Air Force. 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, in 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.
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- 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.
- Nielson, D. L., and Hulen, J. B., 1983, Geologic model of the Baca geothermal reservoir, Valles caldera, New Mexico: Proceedings Ninth Workshop on Geothermal Reservoir Engineering, Stanford University, p. 145-150.

ABSTRACTS

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- 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.
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- 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.
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- Nielson, D. L., and Hulen, J. B., Results of deep drilling in the Valles caldera, New Mexico (abstract): Invited paper, International Symposium on Continental Drilling, Tarrytown, N.Y.

WORK IN PROGRESS

Papers in Press

- Aleinikoff, J. N., Nielson, D. L., Hedge, C. E. and Evans, S. H.,
Geochronology of Precambrian and Tertiary rocks in the Mineral Mountains,
south-central Utah: U. S. Geol. Survey Professional Paper.
- Morris, H. T., Sibbett, B. S., Nielson, D. L., and Steven, T. A., Geologic map
of the Bradshaw and Lincoln Mining Districts, Beaver County, Utah: U. S.
Geol. Survey Mineral Investigation Series Map.
- Ward, S. H., Foley, D., Moore, J. N., Nielson, D. L., Ross, H. P. and Wright,
P. M., An exploration strategy for regional assessment of hydrothermal
resources, in Bresse, J. C. and Witherspoon, P. A., Geothermal Energy
Technology.
- Nielson, D. L., and Hulen, J. B., Internal geology and evolution of the
Redondo Dome, Valles caldera, New Mexico: Jour. Geophys. Research
Special volume on calderas and associated igneous rocks.

Papers in Preparation

- Nielson, D. L., Evans, S. H. and Sibbett, B. S., Magmatic, structural, and
hydrothermal evolution of the Mineral Mountains intrusive complex, Utah.
- Zandt, G., and Nielson, D. L., Active seismicity at Roosevelt Hot Springs
geothermal area, Utah.

CONTRACTS

Principal Investigator

"A Comprehensive study of samples from Well 9-1 in the Roosevelt Hot Springs, Utah geothermal area and applications to geothermal well logging", Los Alamos National Laboratory, 2/15/79 to 5/14/80, \$36,313.

"Geologic mapping of intrusive igneous rocks in the southern Mineral Mountains, Utah", U. S. Geological Survey, 10/1/80 to 12/31/80, \$4,990.

"Public release of geoscientific data from the Baca Geothermal Demonstration Power Plant Project", U. S. Dept. of Energy, 8/15/82 to 12/30/82, \$4,690.

"Seismic and structural studies of the Roosevelt Hot Springs system, Utah", U. S. Dept. of Energy, 10/1/82 to 9/31/83, \$73,280.

"Evaluation of reservoir controls at the Baca geothermal system, New Mexico", U. S. Dept. of Energy, 10/1/82 to 9/31/83, \$74,900.

"Geothermal exploration of Ascension Island", U.S. Department of Energy, 10/1/82-8/30/83, \$961,125.

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.
- 9/79-1983 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 Trans.*, 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. Geological 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, Wahomomie 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. (1984, 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).

"Aeromagnetic map of Ascension Island, South Atlantic Ocean", Ross, H. P., Nielson, D. L., and Green, D. J., UURI/ESL Report, in prep. (1984).

"Electrical resistivity studies, Ascension Island, South Atlantic Ocean," Ross, H. P., Green, D. J., Sibbett, B. S., and Nielson, D. L., UURI/ESL Report, in prep. (1984).

"Interpretation of a detailed aeromagnetic study, Ascension Island, South Atlantic Ocean", Ross, H. P., and Nielson, D. L., UURI/ESL Report, in prep. (1984).

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 (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).

"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).

"Aeromagnetism 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

Stanley H. Ward

BIRTHPLACE AND DATE: Vancouver, B.C., Canada, January 16, 1923

POSITION: Professor, Department of Geology and Geophysics, College of Mines and Mineral Industries, University of Utah, Salt Lake City, Utah
Director, University of Utah Research Institute, Earth Science Laboratory, Salt Lake City, Utah

EDUCATION: 1940, John Oliver High School, Vancouver, Canada
B.A.Sc., Engineering Physics, 1949, University of Toronto, Toronto, Ontario, Canada
M.A., Geophysics, 1950, University of Toronto
Ph.D., Geophysics, 1952, University of Toronto

SOCIETY AFFILIATIONS: Fellow, Royal Astronomical Society
Fellow, Institute of Electrical and Electronic Engineers
Fellow, Geological Society of America
Member, Society of Exploration Geophysicists
Member, Geothermal Resources Council

Member, European Association of Exploration Geophysicists
Member, Canadian Institute of Mining and Metallurgy
Member, American Geophysical Union
Member, International Union of Geodesy and Geophysics
Member, Society of Sigma Xi
Member, Professional Engineers of the Province of Ontario
Member, Australian Society of Exploration Geophysicists

PROFESSIONAL EXPERIENCE:

4/78-present Director, Earth Science Laboratory, University of Utah Research Institute. Responsible for the management of research activities of a professional staff of 29 and a support staff of 30. Responsible for administration of funds totalling \$10,000,000.

7/73-6/80 Director, University of Utah Seismograph Stations. Responsible for the management of research activities of a professional staff of 6 and a support staff of 8. Responsible for administration of funds totalling \$132,000.

7/70-6/80 Professor, Department of Geology and Geophysics, University of Utah. Research and teaching concerned with electromagnetic exploration with the objectives including the search for minerals, oil and gas, and geothermal energy, deep probing of the earth's crust, and study of the lunar interior.

1959-1970 University of California, Berkeley, Professor of Geophysical

Engineering. Research and teaching concerned with electro-magnetic exploration with the objectives including the search for minerals and oil, deep probing of the earth's crust, study of the earth's magnetosphere, and study of the lunar interior.

1958-present Consulting Geophysical Engineer. Consults to mining, petroleum, geothermal, aerospace and instrument companies and to governmental agencies; designs, supervises, and interprets data from exploration campaigns; originates, invents, advises regarding hardware and software utilized in mining exploration, petroleum exploration, and geothermal exploration; primarily concerned with electromagnetic exploration; consults on special government problems; clients have included:

Phelps Dodge Corporation
Kennecott Copper Corp.
Noranda Mines Ltd. - Canada
Placer Development Ltd. - Canada
Brenda Mines Ltd. - Canada
Craigmont Mines Ltd. - Canada
Endako Mines Ltd. - Canada
Scurry Rainbow Oil Co. - Canada
Pure Oil Company
Amax Exploration, Inc.
Commonwealth Scientific and Industrial Research Organization,
Australia
Colonial Sugar Refining Co., Australia
Sinclair Oil and Gas Co.
United States Steel Corp.
Varian Associates
The Bunker Hill Co.
Peerless Gas and Oil Co.
The U.S. Dept. of Justice
Cyprus Mines Corp.
Morrison-Knudson Co., Inc.
The National Aeronautics and Space Administration
Westinghouse Electric Corp.
Universidade Federal Do Bahia Instituto de Geosciencias E
Instituto de Fisico-Brazil
Engenheiros Consultores Associados, S.A. - Brazil
Exxon Corporate Research Laboratory, Newark
Atlantic Richfield Co., Dallas
Greatland Exploration Ltd., Anchorage
McPhar Instrument Corporation, Toronto
Exxon Production Research Laboratory, Houston
Quintana Minerals Corp. Houston
General Electric Corporate Laboratory, Schnectady
CRA Exploration Pty. Ltd., Melbourne
Royal Dutch Shell, Amsterdam
Houston Oil and Gas Corporation, Denver
SERU Nucleaire (Canada) Limitee, Montreal, Canada
Getty Oil Co., Salt Lake City
Anglo American of South Africa, Johannesburg
BP Minerals, Vancouver

1953-1958 Managing Director and Chief Geophysicist, Nucom Ltd. (subsidiary of American Metal Climax Inc.). Supervised geophysical aspects of exploration program involving as many as 275 men; supervised operation of three helicopter-borne electromagnetic prospecting units; supervised gravity, magnetic, electromagnetic surveys; prepared budgets of \$500,000 yearly for research and operations; interpreted data from mining geophysical surveys; collaborated in design of airborne, ground and drill hole prospecting systems; prepared reports on surveys and papers for publication in scientific and professional journals.

1949-1953 Managing Director and Chief Geophysicist, McPhar Geophysics Ltd. Directed operations and research of geophysical contracting firm; interpreted data from mining geophysical surveys; supervised staff of forty engineers, technicians, clerical staff; prepared cost estimates for surveys; collaborated in design of airborne, ground and drill hole electromagnetic prospecting systems; prepared reports on surveys and papers for publication in scientific and professional journals.

PUBLICATIONS AND REPORTS:

113 Publications
31 Abstracts
14 Contract Reports

Mainly in geophysical exploration and exploration strategies for minerals and geothermal energy.

RESUME

Phillip M. Wright

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

POSITION: Technical Vice President, 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:

5/84-present Technical Vice President, University of Utah Research
Institute. Responsible for administering and directing
technical work performed by UURI and for development and
maintenance of technical and scientific capabilities within
UURI.

- 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.
- 9/78-5/84 Associate Director for Technology, Earth Science Laboratory Division, University of Utah Research Institute. Reported to Director of the Earth Science Laboratory. Assumed about half of Director's functions during academic year. Coordinated, reviewed and ensured 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 involved geothermal research and management assistance programs on behalf of the U.S. Department of Energy. Geothermal work encompassed entire U.S. Also worked at the Ahuachapan geothermal field in El Salvador. Another portion of work involved 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 multidisciplinary, 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 Columbia, 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 Gudgeon, 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.

"Uses of Geochemistry with Injection-Backflow Testing in Geothermal Reservoir Studies", Wright, P. M., Capuano, R. M., Adams, M. C. and Moore, J. N., Geothermal Resources Council, Transactions, vol. 7, 1984 (in press).

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.