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GEOLOGY AND GEOPHYSICS**

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1 Sept. 1977

Retrospective Case Studies

Task Descriptions

Task 1. Phase Zero Study

Objectives: to define objectives, tasks and milestones of this project and to assign priorities.

Background: ERDA-DGE's overall goal is to facilitate discovery, assessment and development of 3,000-4,000 MWe of geothermally generated power in the United States by 1985. The basic task is to reduce technological and economic risk factors, financial burden, institutional problems and other problems to such a level that industrial development of geothermal energy will be fostered. DGE functions as the lead agency for the Federal Geothermal Program.

This project, Retrospective Case Studies (RCS) operates directly under DGE's Resource Exploration and Assessment program. The overall objectives of this project are:

1. To improve the general and specific level of understanding of geothermal systems, and
2. To improve tools and technology for geothermal exploration and assessment.

These two goals will be accomplished by completing tasks 1-10 specified herein and by completing independent, goal-oriented technique development.

Tasks: Specific project tasks defined by this Phase Zero Study are listed below.

Task 2. Establish Internal Management Scheme

Objective: to design and provide project management which a) establishes a project working group, b) ensures that project tasks are completed and that project objectives are achieved within the required time frame, and c) establishes a formal oral and written reporting procedure.

Background: The current management structure of the Earth Science Laboratory, University of Utah Research Institute (ESL) is shown in Figure 1. Line management of RCS will conform to this structure.

The project management structure of RCS is specified in Figure 2. The main project working group will be ESL staff and managers. Talent will be drawn from the Department of Geology and Geophysics of the University of Utah at the discretion of the PI.

Tasks: Specific management tasks, in addition to those listed in more detail elsewhere, include:

- 2.1 Establish and pursue a number of strategies for obtaining retrospective case history data from industry.
- 2.2 Provide verification, review, interpretation and publication of data generated by RCS.
- 2.3 Identify voids in RCS and in DGE's geothermal energy program and make written recommendations and/or proposals for independent research to DGE.

Task 3. Establish Information Documentation Scheme

Objectives: to provide processing, cataloging, cross referencing, open file accessing, and archival storage of data, documents, books, and maps generated under RCS.

Background: A central library facility is needed where ESL users and outside users from industry, government, private interest groups, and other institutions can easily obtain and study reference material related to discovery, assessment, and utilization of geothermal resources. Our intention is to establish and make available such a facility in our office. This library will house not only data generated through contracts awarded by DGE, but it will also house background technical information specified in Task 4 and geothermal information compiled under other projects.

Tasks:

- 3.1 Establish drawer and shelf library files with cross referenced card catalogues and data, and flat or hanging files for maps and large format information.
- 3.2 Set up microfiche and microfilm files with readers and printers.
- 3.3 Establish information control and check-out procedures.
- 3.4 Establish open-file library facilities for non-RCS project staff users.
 - a) Set up separate open-file card catalogues to protect proprietary information.
 - b) Establish copying mechanisms and costs for non-RCS users.
- 3.5 Microfilm or microfiche and file one-of-a-kind documents, data, and maps.

Task 4. Assemble Background Technical Information and Worldwide Case History

Reference Base

Objective: to create a comprehensive, easily useable reference base for comparison with data generated by this project and for future use.

Background: This information reference base will be important for

comparison and interpretation of data generated by this project and will form an important part of the open-file library facilities specified under Task 3. Material to be assembled include (at minimum):

- (1) A comprehensive reference base on geothermal resources in the following topic areas:
 - a) occurrences, especially in the U.S.
 - b) exploration for geothermal resources,
 - c) assessment of geothermal resources.
- (2) A general, less comprehensive, reference base in at least the following topic areas:
 - a) utilization of geothermal resources,
 - b) current geothermal projects, agencies, people,
 - c) energy resources in general (nature, occurrences, economics),
 - d) disseminated mineral deposits (paleogeothermal systems),
 - e) volcanology,
 - f) geopressed geothermal resources,
 - g) problems and techniques of drilling in geothermal environments.

Tasks:

- 4.1 Obtain geothermal and other pertinent bibliographies through purchase or search of computer-based bibliographies such as GEOREF, ENERGY LINE, NTIS.
- 4.2 Select desired information from bibliographies.
- 4.3 Assemble and file selected literature by copying from journals, purchase of texts, purchase of microfiche.
- 4.4 Assemble and file data, maps and reports generated by RCS.
- 4.5 Obtain and file copies of geothermal reports from other laboratories, institutions, government agencies, and companies.

- 4.6 Subscribe to pertinent journals.
- 4.7 Solicit and file previously unpublished information from government agencies, laboratories and companies.
- 4.8 Solicit and file information from foreign countries which have active geothermal projects.
- 4.9 Compile information on people working in geothermal energy, affiliations, projects, companies, research labs, academic institutions, government agencies, contractors, and consultants.

Task 5. Establish Core and Cuttings Sample Library

Objectives: 1) to provide cataloging, open file accessing, and archival storage of core and cuttings samples from geothermal holes drilled with DGE funding under this and other projects and 2) to provide sample abstracting, compositing, washing, and preparation.

Background: Samples of core and cuttings which result from DGE-funded geothermal drilling and from other sources are a valuable resource for future examination, comparison and research. A central storage facility, open for use by industry, government agencies, academic institutions and others is desirable in promoting geothermal discovery, assessment and utilization research. Non-returnable samples would be provided, at DGE's discretion, for research at other laboratories.

Tasks:

- 5.1 Establish a core and cuttings sample library.
- 5.2 Equip the sample library with sample washing and preparation equipment and with a binocular microscope.
- 5.3 Establish an open-file capability for sample examination and rules for outside users to obtain non-returnable samples.

5.4 Create abstracts of samples for easy examination and for exchange with other sample storage facilities.

5.5 Create sample composites of selected holes for analysis.

Task 6. Convert Information Control to In-House Computer Retrieval Format

Objectives: 1) to store location data on material housed in our files and in our core/cuttings library for easy access and card catalogue updating, and 2) to provide key-word search capability for information in our files.

Background: Because of the comprehensive nature of our proposed geothermal files, a computer-based retrieval capability is desirable. This will provide an economic and versatile way to quickly locate information, to locate core and cuttings samples, to update card catalogues, and to provide key-word search of in-house information.

Tasks:

- 6.1 Write a computer program to store and access information on file location of specific documents, data, maps, and core and cuttings samples.
- 6.2 Write or otherwise obtain a key-word search program to search documents, data or maps in our files for specific information desired by topic, area or data type. Enter key words as specified on other computer bibliographies such as GEOREF.
- 6.3 Provide search/retrieval of above computer files as a service to non-RCS users at cost.

Task 7. Develop Standard Interpretation Procedures

Objective: to develop and document a framework for interpreting each type of data obtained through RCS.

Background: Data generated by this project will fall into one of three broad classes: exploration, assessment, or utilization. Certain types of data will fall under one or more of these classes as shown below:

Exploration and assessment: geological, geophysical and geochemical.

Assessment and utilization: drilling techniques, reservoir engineering, and surface plant engineering.

Specific data expected to be generated by this project include:

1. Geological: mapping, photogeology, aerial photography, structure, volcanic and sedimentary stratigraphy, geochronology, paleomagnetic, petrologic, hydrologic.
2. Geophysical: resistivity, induced polarization, self potential, electromagnetic, magnetotelluric, gravity, magnetic, precise leveling earthquake monitoring, ground noise, reflection seismic, refraction seismic, fan shooting, thermal gradient/heat flow, thermal infrared imagery, and well logs of various kinds.
3. Geochemical: surface and drill hole alteration, trace element geochemistry, soil and rock geochemistry and mineralization, water chemistry, stable isotope geochemistry of rock and fluids, gas geochemistry of fluids, geothermometry.
4. Drilling techniques: drilling plans, drilling histories, coring techniques, chip sampling techniques, mud logs, temperature logs, blow-out prevention techniques, casing techniques, completion techniques, abandonment techniques.
5. Reservoir engineering: well production test data; well head and down-hole temperature and pressure (static and/or flowing); drawdown; well interference; reinjection data; numerical modelling of flow in well bore and/or reservoir; interpretation of reservoir

parameters such as porosity, permeability, temperature, pressure, recharge.

6. Surface plant engineering: separator design, separator design, reinjection well design, pipeline design, fluid and steam sampler design, generation plant design.

Each of the above specific data types have a) technical, b) environmental impact, and c) cost components.

Each type of data to be interpreted and published under this project will have both quantitative and qualitative aspects. Much of the geophysical, well log, reservoir engineering and surface plant engineering data will be amenable to quantitative interpretation using numerical and/or standard engineering techniques. The remainder of the data will necessarily be interpreted in more qualitative fashion. The expertise currently available and anticipated in ESL and in the Department of Geology and Geophysics will enable interpretation of all types of geological, geochemical, geophysical and drilling techniques data, and of some engineering data. If data outside our expertise is generated by this project we will coordinate with DGE personnel, in order to have the data interpreted by laboratories, contractors or other groups.

Tasks: In developing standard interpretation procedures, the general strategy and tasks will be:

- 7.1 Assemble technical information (primarily), and environmental and cost information (secondarily) on exploration, assessment and utilization of geothermal resources worldwide (Tasks 3 and 4).
- 7.2 Evaluate the applicability of each technique in each case study to exploration, assessment and/or utilization of geothermal resources.

Compile and document geologic models for geothermal systems.

Documentation will be in the form of internal technical memoranda, with subsequent publication as an ESL report for selected subjects.

This task will be initiated before actual submitted data are received, and will be ongoing throughout the project. The ultimate results of this task will be better understanding of geothermal systems and better specification of exploration, assessment and utilization strategies.

- 7.3 Acquire and/or write numerical modeling programs as needed to interpret expected data.
- 7.4 Develop integrated approaches to utilization of more than one type of earth science data to provide converging lines of evidence for exploration and assessment of geothermal systems.
- 7.5 Identify gaps in the current knowledge base and document these with recommendations in writing to DGE.

Numerical modeling of geophysical and well log data is within our current expertise, and will form an important part of the interpretation we expect to provide. Table 1 shows numerical modeling programs available or planned for use in this project.

Task 8. Develop and Pursue Strategies for Obtaining Data from Industry.

Objective: to obtain data from industry for interpretation and publication.

Background: It is the practice of many companies and utilities who have obtained information and data on geothermal resources at their own expense to keep such information and data proprietary. In some cases this practice is one important method of ensuring competitive advantage. In other cases the information could be released with no harm to the

company if there were some reason for doing so. Whereas some companies are relatively free with information and data as a matter of policy, others are not.

That dissemination of this now proprietary information would contribute to a better public understanding of geothermal resources is obvious. This task is aimed at developing and pursuing a number of strategies for gaining access to as much of the current, rapidly expanding industrial data base as possible without harming industry. The information and data would then be brought up to a state-of-the-art standard of interpretation and would be published.

Any proposed strategy for attaining the objective of this task must recognize that the company which owns the data must derive some benefit from giving it up to the public. Strategies then can be structured around various methods of benefiting a company. Hopefully enough viable strategies can be devised that a successful appeal can be made to a variety of companies on a variety of data. Strategies explored to date include:

Tasks:

- 8.1 Provide technical geoscience expertise to a company in return for data.
- 8.2 Provide technical writing and report preparation with appropriate credit given to the company whose data are published.
- 8.3 Offer remuneration for data through an RFP.
- 8.4 Offer financial participation in exploration consortia.
- 8.5 Offer partial financial funding for an academic or government scientist to work within a company on a problem of the company's choice.

Task 9. Effect Standard Interpretation Procedure

Objective: to bring data generated by this project up to a common and state-of-the-art level of interpretation prior to publication of case histories.

Background: Not all of the data generated by this project are expected to be fully interpreted and ready for publication in a form useable to those who have no in-house interpretation capability.

Tasks:

- 9.1 Assess validity of interpretation (if any) obtained with data.
- 9.2 Interpret data using standard procedures developed in Task 7.
- 9.3 Compare data and interpretation of 9.2 to world-wide reference base assembled under Task 6.

Task 10. Write and Distribute Case Histories

Objective: to disseminate technical literature on exploration, assessment and/or utilization of geothermal resources.

Tasks:

- 10.1 Reinterpret, rewrite, edit and distribute reports on data obtained from industry. Reports will include copies of data and any discussion or text as submitted by industry along with our appended interpretation and discussions. The reports will be issued under our cover either to DGE or to a distribution list specified by DGE. Copies of raw data and maps will be available from our facility (after release from confidentiality by the submitting company) for the cost of reproduction.

Figure 1. Earth Science Laboratory - University of Utah Research Institute

MANAGEMENT STRUCTURE

1. Executive Committee
 - a) Composed of project managers
 - b) Formulates ESL policy (with Director)
 - c) Monitors work progress with attention to high technical quality, attainment of project objectives.
2. Associate Director
 - a) Responsive to decisions of Executive Committee
 - b) Responsible for personnel, facilities management.

Figure 2

RCS PROJECT MANAGEMENT STRUCTURE

===== formal reporting, first priority -- periodic and technical reports

----- formal reporting, second priority -- day-to-day letters, memos
phone conversations, first
priority reporting at need.

Table 1

GEOPHYSICAL AND WELL LOG DATA INTERPRETATION

Data Type	Numerical Modeling Capability	Availability
Gravity	1. 2-D Talwani profile inversion 2. 3-D Talwani or prism	short term now
Magnetic/Aeromagnetic	1. 2 1/2-D Shuey profile 2. 3-D Talwani or prism 3. 2-, 3-D Power spectra, filtering continuation 4. Curie-point geotherm depth	now now intermediate term to be evaluated
Galvanic resistivity/IP	1. 2-D, any array 2. 3-D, any array 3. Down-hole electrodes in vicinity of 3-D body.	now short term now
MMT, AMT, T/MT	1. 1-D 2. 2-D 3. 3-D	short term short term long term (new work)
EM (controlled source)	1. 2-D 2. 3-D	long term (new work) long term (new work)
Seismic	1. multiple dipping interface refraction 2. multiple dipping interface reflection 3. seismic noise analysis 4. microearthquake hypocenter	long term long term to be evaluated now
Heat flow and conductive cooling	1. 2-D heat flow, isotherms 2. 3-D heat flow, isotherms	now long term
Well logs	1. Normal Resistivity 2. IP 3. Micrologs	short term long term long term