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PRELIMINARY DRAFT

Program Plan

Geothermal Exploration and Assessment Technology

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INTRODUCTION

This document represents an update of the Geothermal Exploration and Assessment Technology Program Plan. It is based on a document published in 1978 (U. of Utah, Dept. Geology and Geophysics, 1978) and draws heavily from that work. The purpose of this program is to provide assistance to the Nation's industrial community by helping to remove technical and associated economic barriers which inhibit the discovery and assessment of geothermal resources. As discussed in a later section of this document, this will aid efforts to bring geothermal electric power production and direct heat applications on line by increasing the success rates of exploration programs and by encouraging participation in exploration programs. Increased exploration and increased success rates are required if the DOE goals for electric power generation and direct heat utilization are to be met. A secondary goal of this program is to identify and implement basic and applied research which will improve exploration success in the mid- and far-term (i.e., 2000 to 2020).

Near-term problems, and strategies to solve those problems, are generally better defined than are mid- or far-term problems. Near-term work encompassed by this Program Plan deals mainly with development of new technology for exploration and assessment within known areas of surficially-expressed high-temperature convective hydrothermal systems, whereas mid- and far-term work deals mainly with development of technology to discover new resources which usually lack significant surface manifestation and whose discovery is vital to the Nation's mid- and far-term energy needs. Part of this Program

Plan deals with continued elucidation of exploration and assessoant problems over the next few years so that effective methods will be available for all stages in the national geothermal program.

Federal involvement in providing such assistance is detailed in Public Law 93-410, the Geothermal Energy Research, Development, and Demonstration Act of 1974, and in ERDA-86, the Definition report for the Geothermal Energy Research, Development and Demonstration Program, published by ERDA in October, 1975, in response to P.O. 93-410.

The Program in Geothermal Exploration and Assessment Technology is an industry-driven program. The plan is based on a substantial review, conducted in concert with industry, the USGS, and academia, of the technical and associated economic barriers to commercial hydrothermal development which currently face industry (Ward, 1978; Goldstein, Norris and Wilt, 1978; Nielson, 1980). Continued input from the industrial community through several standing Technical Review Committees will ensure meaningful program input, review, and update and will ensure consideration of exploration and assessment problems associated with development of low- to high-temperature convective hydrothermal resources and of geopressured, hot dry rock, magma, radiogenic, and normal geothermal gradient resources, if required. Current emphasis is on high-temperature convective hydrothermal resources.

The Geothermal Exploration and Assessment Technology Program complements the following DOE/DGE research programs dealing with other aspects of geothermal development:

- Reservoir Engineering

-Well Log Interpretation

-Well Log Instrumentation

-Drilling and Completions

-Subsidence

-Induced Seismicity

Strong ties and cooperation have been established with DOE's Industry Coupled Program, State Coupled Program, and User Assistance Program. In addition this Program is closely related to the U. S. Geological Survey's Geothermal Research Program that has objectives dealing with characterizations of various kinds of geothermal systems, regional and national assessments of geothermal resources, and evaluation and development of scientific concepts for identifying and describing these resources. A careful coordination with all of these programs will be maintained to ensure that no undesirable overlap occurs.

Benefit/cost studies have been made for the elements in this Program Plan. These studies indicate that as much as 50% of the total $20 million needed to prove the existence of a 200 MWe convective hydrothermal reservoir could be saved through improvement in exploration and assessment technology (Ward, 1978). Considered in light of the more than 200 high-temperature hydrothermal systems that are expected to be explored by industry in the United States by the year 2000, the accrued benefits will be approximately 40 times the estimated program costs (Dhillon, et al., 1978). This program will also provide significant benefits to exploration for and assessment of moderate- and low-temperature hydrothermal systems as well as to the other resource types.

TECHNICAL BARRIERS TO DISCOVERY AND ASSESSMENT OF GEOTHERMAL ENERGY

Technical, economic and institutional barriers strongly inhibit commercialization of geothermal energy in the United States. This fact was formally recognized by the Congress with the passage of Public Law 93-410. P.O. 93-410 and ERDA-86 both list goals and objectives to be accomplished in order to assist industry to develop geothermal energy. That industry needs this assistance is amply demonstrated in such documents as Ward (1978), Dhillon et al. (1978), and Nielson (1980).

Ward (1978) emphasized that the industry has not found efficient means for exploring for geothermal resources. This is clearly demonstrated by the variety of geoscience methods currently being used in the northern Basin and Range (Ward et al., in press). Dhillon et al. (1978) concluded from discussions with industry representatives that improved interpretation techniques were required if increased exploration success is to be realized. They also emphasized that the success of such a program as the Geothermal Exploration and Assessment Technology Program could be quantified by the increase in success ratios of geothermal wells. Nielson (1980) compared the success ratios of wells drilled by the geothermal industry with those drilled by the petroleum industry, and that comparison is shown in Table I. The poor track record of the geothermal industry is evident. Nielson (1980) pointed out that improved success ratios would increase the amount of geothermal resources found per exploration dollar expended, and would also increase the amount of geothermal exploration by making the return on investment more competitive with other resource types.

In order to address the basic goal of the Geothermal exploration and Assessment Technology Program and aid in removing the technical and associated economic barriers to the discovery and assessment of geothermal resources, the following barriers have been defined and are summarized in Table 2.

1. Conceptual and predictive models of geothermal systems are unreliable.

The geoscience methods used by the exploration geologist locate the structural controls and products of geothermal systems such as hydrothermal alteration and high heat flow. In general these methods do not define the geothermal system itself. Thus, as emphasized by Ward et al. (in press) it is necessary to have a conceptual model of the geothermal system to apply the proper exploration methods. This fact is also emphasized by an evaluation of the effectiveness of different exploration methods in different geothermal environments (Dhillon et al., 1978). When physical and chemical property values are assigned to the components of such models, they can be used to predict the expected surface, surface-to-borehole, and borehole-to-borehole response of the geological, geophysical, geochemical, and hydrological techniques which research geoscientists are trying to refine. Improvements in exploration tools could be developed much more rapidly if reliable reservoir models existed because these models, coupled with suitable numerical or analog analyses, could more quickly sort the many questions for potential technique improvement and thus allow the geoscientist to concentrate on the most fruitful means of attack.

Table 2: Summary of technical barriers to discovery and assessment of geothermal resources.

1. Conceptual and prediction models of geothermal systems are unreliable.
2. Regional- and district-scale exploration techniques are inadequate.
3. Drill site selection techniques need improvement and development.
4. Assessment methods need refinement and technology development.
5. Technology transfer needs stimulating.

2. Regional- and district-scale exploration techniques are inadequate.

The geothermal industry is presently drilling the best geothermal prospects in the U.S., i.e., systems easily found because of surface manifestations such as hot springs and fumaroles. However, there are large regions within the U.S. which do not show these manifestations but which may contain hidden geothermal resources. Efficient methods must be devised to assess the potential of these areas. The elimination of this barrier will result in the discovery of new geothermal districts. Within known districts it is probable that many buried resources remain undiscovered also. It is in these areas that the industry is presently turning its attention and where wildcat wells have the highest chance of success. As indicated in Table I, however, the success ratios for wildcat wells are quite low.

3. Drill site selection techniques need improvement and development.

The evidence for poor drill site selection techniques is demonstrated in Table I. Even in geothermal resource areas, step out drilling in 1978 (Smith et al., 1979) resulted in only one producing well out of seven drilled. It is difficult to determine, comprehensively, the strengths and weaknesses of available exploration techniques for the following reasons: the resource could be situated in a variety of geological structures and rock types; too few usable reservoirs have been found to provide sites for test and evaluation of improved techniques and instrumentation; and the technology currently in use or potentially available is complex. There is a need to be able to correlate the data of various exploration and assessment techniques with the reservoir characteristics determined by deep drilling to improve the

TABLE 1
Comparison of geothermal and oil and gas wells drilled
in U. S. 1975-1978 (Nielson, 1980)

Year	Total Geothermal Wells Drilled	Total Geothermal Wells Producers	Total Geothermal Wells Success Ratio	Success Ratio Total Oil & Gas	Geothermal Wildcat Wells Drilled	Geothermal Wildcat Wells Producers	Geothermal Wildcat Wells Success Ratio	Success Ratio Oil & Gas Expl.
1975	46	37	.80	.644	6	1	.166	.233
1976	52	39	.75	.657	21	2-3	.95-.143	.265
1977	52	25	.38	.673	15	0	0	.270
1978	58	30	.52	.654	13	2	.154	.253

Data from: Dhillon et al., 1978; Smith and Matlick, 1976; Smith et al., 1977, 1978, 1979; and DOE/EIA, 1978.

TABLE 3
SUMMARY OF RECOMMENDATIONS OF TECHNICAL REVIEW COMMITTEES OF
THE GEOTHERMAL EXPLORATION AND ASSESSMENT TECHNOLOGY PROGRAM

COMMITTEE	RECOMMENDATIONS	PRIORITY	FUNDING	DURATION
STRUCTURE, STRATIGRAPHY, AND IGNEOUS PROCESSES	1. Surface Geology -detailed geologic mapping -aerial photography	1	225K/yr	5 yrs
	2. K-Ar Dating --to refine models of relationship of magma systems & geoth. systems.	2	75K/yr	5 yrs
	3. Subsurface Studies Structural	3	40K/yr	
	Gravity (3 surveys/yr)		105K/yr	5 yrs
	4. Rock Properties	4	30K/yr	
	5. Igneous Studies Models of magma system evolution - chemistry.	5	155K/yr	3-5 yrs
EXPLORATION ARCHITECTURE	1. Refinement of MT		250K/yr	
	2. Groundwater effects on thermal measurements		100K/yr	
	3. Regional fluid geochem		100K/yr	
	4. Regional gas geochem		100K/yr	
	5. K-Ar dating - regional		100K/yr	
	6. Joint collection and inversion of data.		50K/yr	

COMMITTEE	RECOMMENDATIONS	PRIORITY	FUNDING	DURATION
ELECTRICAL METHODS	1. EM modeling & inversion	1		
	a) cost-effective 2D & 3D modeling programs		300K/yr	3 yrs
	b) alternate inversion schemes		100K/yr	3 yrs
	2. Controlled source EM field studies	2	100K/yr	2 yrs
	3. Rock Properties	3	200K/yr	3 yrs
	4. Regional MT map	1	50K/yr	2 yrs
	5. Calibration sites & procedures	2	60K/yr	1 yr
	6. MT Workshop	3	20K/yr	
	7. Testing of following (no budget recommendation provided): -Induced Polarization -Magnetometric Resistivity -Long array MT -Singular coincident loop TPEM.			
WATER/ROCK INTERACTION	1. Mineralogy, geochemistry, + petrology in geothermal reservoirs.		600K/yr	2 yrs
	2. Workshop on water/rock in geothermics		25K/yr	
	3. Rock + fluid properties		200K/yr	2 yrs
	4. Geothermometers		175K/yr	2 yrs
	5. Obtain core			

COMMITTEE	RECOMMENDATIONS	PRIORITY	FUNDING	DURATION
THERMAL METHODS	1. Bottom hole T during drilling			
	2. Relations between thermal conductivity and physical parameters		60K/yr	3 yrs
	3. Effects of groundwater flow on thermal measurements		100K/yr	5 yrs
	4. "Free hole" Program		1000K/yr	5+ yrs
	5. Shallow & intermediate depth drilling		1500K/yr	
	6. Deep hole T transmission system.		100K/yr	3 yrs
SEISMIC METHODS	1. Data compilation and dissemination	1	100K/yr	
	2. Rock properties	2	75K/yr	2
	3. Research in processing & interpretation	3	75K/yr	2
	4. Seismic @ Valles Caldera	4	200K 100K	1st year 2nd year
	5. Clear Lake Survey	5	125K 25K	1st year 2nd year
	6. Microseismic noise @ Beowawe	6	30K 15K	1st year 2nd year
	7. Microearthquake	7	50K 50K	1st year 2nd year
	8. Basic research on microearthquake processing & interpretation	8	70K/yr	4 yrs

interpretation of surface and near-surface measurements. The current lack of a reliable exploration technology and the necessity for deep drilling make geothermal exploration a costly, high-risk undertaking.

4. Assessment techniques need refinement and technology development.

At the present time there is no reliable way to determine extent, depth, temperature, nature of fluid, or productivity of a potential geothermal resource -- without a number of deep drill holes which actually sample the reservoir. Yet deep drilling costs, especially in the reservoir rocks themselves, are very high. Accordingly, there would be a large cost benefit to geothermal development if less expensive surface and/or shallow drilling techniques could be used to make reservoir predictions or to extend substantially the data derived from fewer boreholes.

A number of the geoscience methods offer promise. Geochemical and isotopic thermometry show promise of reliable remote prediction of reservoir temperatures, but these techniques are still being developed. Electrical geophysical methods are potentially capable of detecting hot saline fluids in porous rocks and thus showing the current extent and depth of a reservoir, but unambiguous data interpretation has not been achieved. Other methods offer hope to solve parts of the the total problem.

5. Technology transfer needs stimulating.

Because the purpose of the federal involvement in geothermal development is the fostering of a viable geothermal industry, it is particularly important that new technologies are quickly and effectively transferred to industry for its use. The conventional techniques of technical reports and workshops are appropriate but inadequate. New means of making technology transfer both timely and effective need to be found.

BENEFIT OF IMPROVED EXPLORATION SUCCESS

Under the present tax structure an investment in a geothermal resource will not generate a return (ROI) until the field begins to generate revenue. Therefore, exploration companies have a need to reduce the required risk capital and reduce the time required to develop a given resource. Capital requirements can be reduced by streamlining the exploration stage leading to well siting. It is the aim of the Geothermal Exploration and Assessment Technology Program to not only make the exploration stage more efficient in terms of cost, but also to increase the reliability of the methods such that the success rate of wells is increased. The result will be an increased sucess rate of wells at a decreased cost of exploration required to site those wells.

Ward (1978) shows a cost estimate of industry's expenditures for discovery and assessment of a 200 MWe hydrothermal field. He estimated that the development cost of such a field is about $200 million and about $20 million is the cost required to prove the field. Thus 10 per cent of the total cost represents the risk capital required to interest major investors in supporting the project.

Ward et al. (in press) have presented an exploration architecture for hydrothermal systems in the Basin and Range which estimates that the exploration costs up to the deep testing of a geothermal target amount to approximately $350,000. Expenditures such as this are only warranted for high-temperature systems which are capable of generating electricity with presently available technology. It was esimated in the 1978 Program Plan that these front-end costs, exclusive of drilling, could be reduced by approximately 50% and the drilling success ratio could be increased. Dhillon et al. (1978) have estimated that a 29% increase in the success ratio can result in a savings of $287 million to $526 million (equivalent 1978 dollars) in the 1978-2000 time frame.

The most expensive stage in a geothermal exploration project is the drilling of production test holes. Geothermal well drilling costs have been discussed by Chappell et al. (1979). They have shown that costs have been escalating over the past decade at a rate which is higher than the average national inflation rate. They have also shown that average drilling costs increase exponentially as a function of depth. Figure 1 is duplicated from their paper and gives an idea of well costs as a function of depth. The FY 1979 budget for the Exploration and Assessment Technology Program was approximately $2,300,000. Examination of Figure 1 shows that $2.3 million is the approximate cost of one 9000 foot geothermal well. Total budget for FY 1980 is $__________ which is equivalent to one ______ foot geothermal well. Thus current expenditures are minimal, and by resulting in only one additional successful deep well, the entire yearly budget can be justified.

The above discussion emphasizes the high-temperature geothermal systems which are presently being explored for electric applications. Very little data on exploration for direct heat resources presently exists. Of course, drilling costs will be the same for the lower temperature resources. However, the lower value of individual resources will require low-cost, very efficient

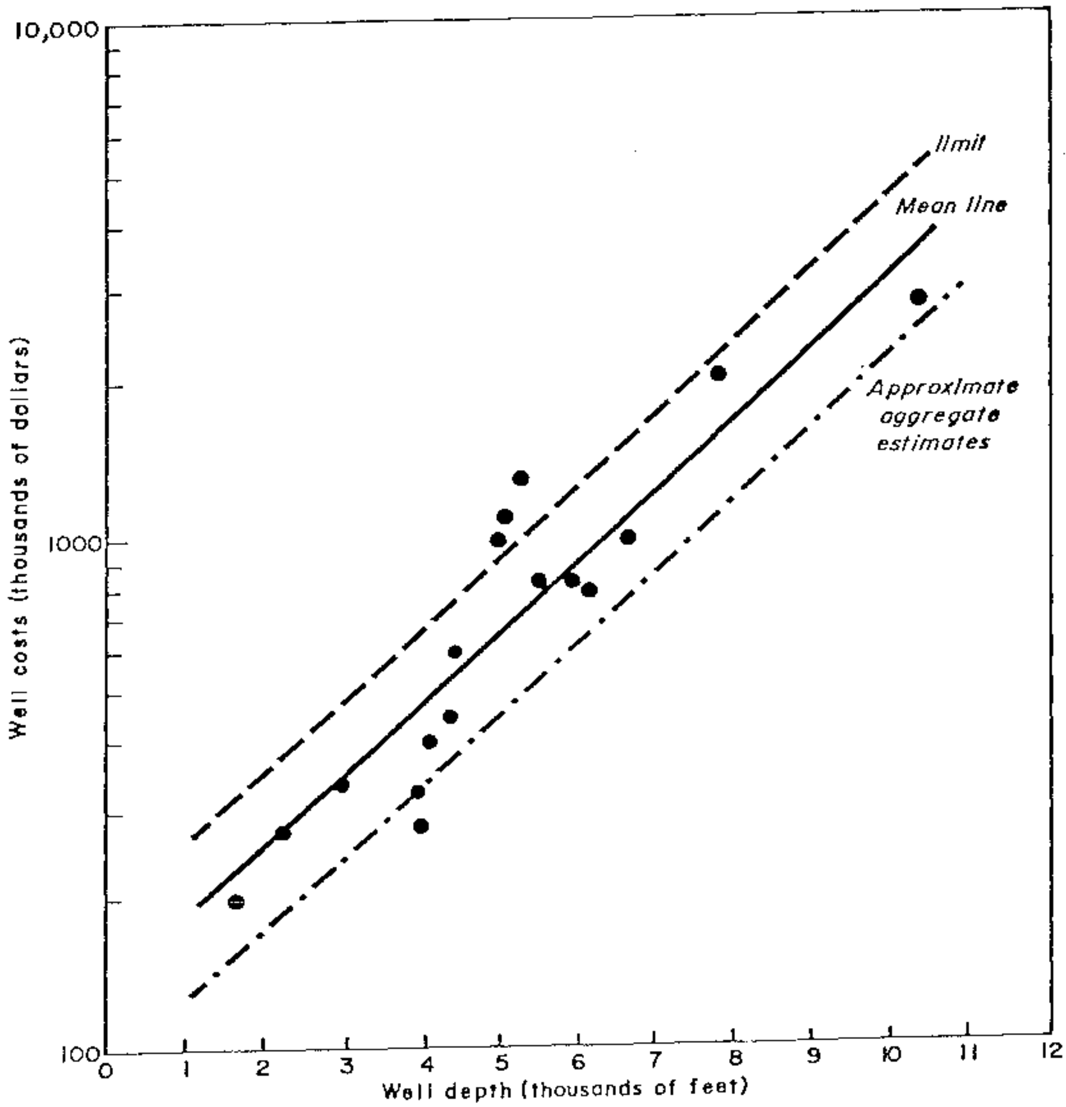


Figure 1: Wells costs vs. depth.
(Chappell et al., 1979).

exploration prior to the siting of a test well. The resources themselves are probably going to be as difficult to find as the high-temperature systems. During FY 1980, the Geothermal Exploration and Assessment Technology Program will provide a significant component in the development of exploration case studies and the formulation of exploration architectures for low- to intermediate-temperature geothermal systems. Rising energy costs have stimulated broad interest in the direct heat applications and it is the charter of the Division of Geothermal Energy to encourage the development of these resources. We do not at the present time have sufficient data to give a quantitative benefit analysis of the Geothermal Exploration and Assessment Technology Program in lower temperature environments; however, high exploration costs and lack of models of the geothermal systems could easily dampen the enthusiasm which currently exists for their development.

TECHNICAL PLAN

GEOTHERMAL EXPLORATION AND ASSESSMENT TECHNOLOGY PROGRAM

Technical Review Committee Approach to Task Definition

In order to initiate this DOE program and define specific needs of the geothermal exploration industry, seven consortia of geothermal experts were convened during late 1977 and early 1978 to define technical problems facing the industry. The reports of these consortia were reviewed by managers from industry, and the resultant recommendations were used to formulate FY 1979 DOE procurements and to define technology development programs at the Earth Science Laboratory/University of Utah Research Institute, the Department of Geology and Geophysics/University of Utah, and the Lawrence Berkeley Laboratory. The reports of the seven consortia along with the review by industry managers are documented by Ward (1978). A DOE program plan for the Geothermal Exploration and Assessment Technolgy Program is based on this document (Univ. of Utah, Dept. Geol. and Geophys., 1978).

The technical review committees of the Geothermal Exploration and Assessment Technology Program are made up of experts from industry as well as academic and research institutions. There are currently six committees which cover these areas: Water/Rock Interaction; Structure, Stratigraphy, and Igneous Processes; Exploration Architecture; Electrical Methods; Seismic Methods; and Thermal Methods. These committees meet to define the state-of-the-art in geothermal exploration and to recommend exploration technology development. Figure 2 illustrates the role of these committees in defining the specific tasks of the Geothermal Exploration and Assessment

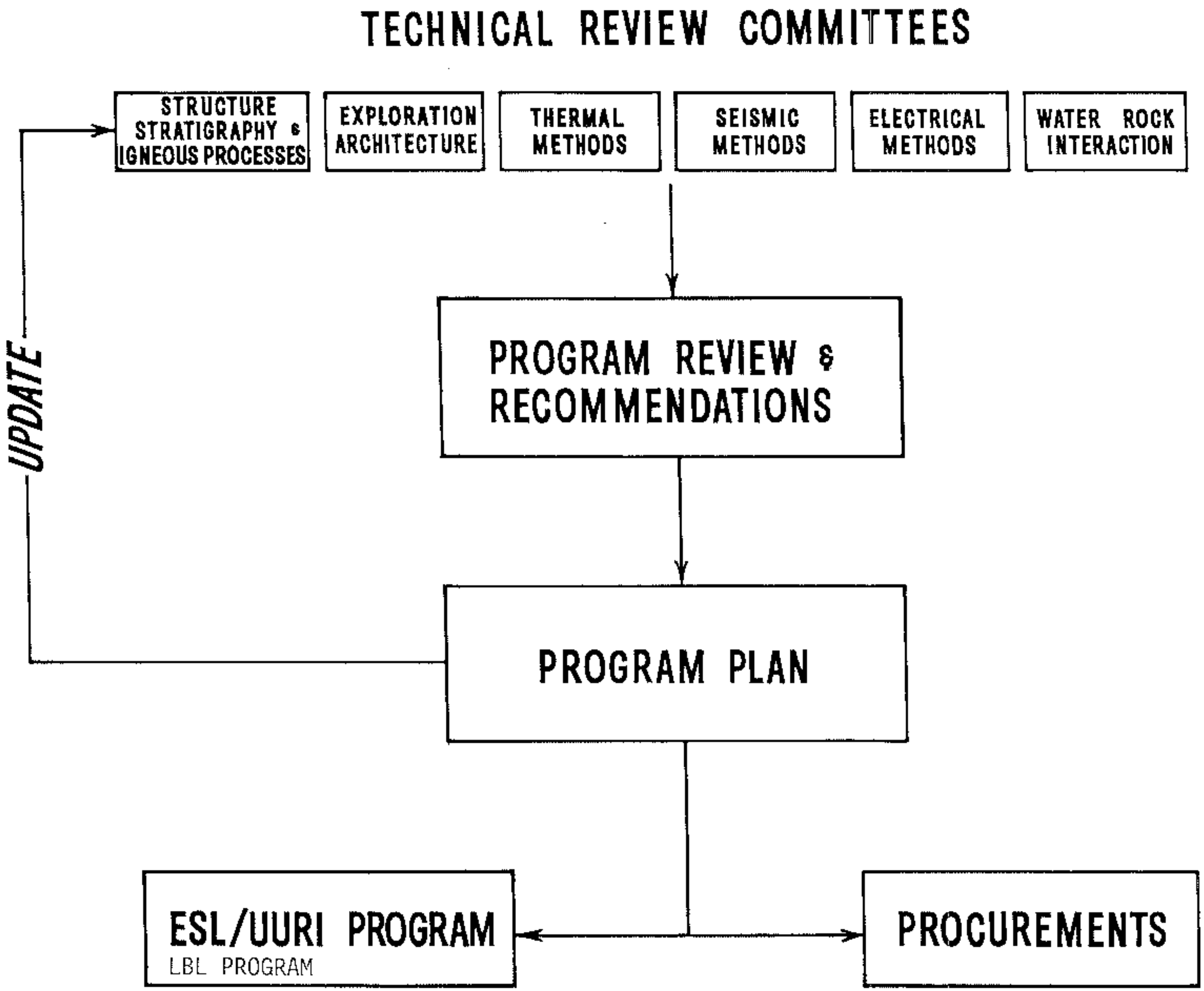

TECHNICAL REVIEW COMMITTEES
STRUCTURE STRATIGRAPHY & IGNEOUS PROCESSES
EXPLORATION ARCHITECTURE
THERMAL METHODS
SEISMIC METHODS
ELECTRICAL METHODS
WATER ROCK INTERACTION
UPDATE
PROGRAM REVIEW & RECOMMENDATIONS
PROGRAM PLAN
ESL/UURI PROGRAM
LBL PROGRAM
PROCUREMENTS

FIGURE 2

technology Program. The reports of the individual committees are contained in Nielson (1980), and their recommendations are summarized in Table 3.

4.2 Task Descriptions--Earth Science Lab/UURI and UU/GG

The Earth Science Laboratory/University of Utah Research Institute and the Dept. of Geology and Geophysics/ University of Utah are involved in a number of continuing studies aimed at reducing the importance of the barriers which were defined in Table 2. These studies are derived from recommendations of the technical review committees and might be generalized as follows.

Integrated geological, geochemical, and geophysical studies are underway to develop conceptual models of geothermal systems. Up to this time, these studies have concentrated on the high-temperature systems, specifically Roosevelt Hot Springs, Utah. However, new efforts are underway to develop similar models for low- to moderate-temperature geothermal resources. From the knowledge generated by the above work, exploration strategies for the low- to moderate-temperature resources will be developed.

Studies of trace elements and stable isotopes are contributing to the above system models and are being specifically directed toward prediction of approach to fluid entries in geothermal test wells. Empirical relationships have been established and work is presently underway to quantify the methods.

Studies of the application of electrical geophysical techniques to the exploration for geothermal resources is an additional ongoing program. This work involves the testing of resistivity, induced polarization, magneto-telluric, audio-magnetotelluric, and electromagnetic systems in geothermal areas. In additon, two- and three-dimensional modeling routines are being developed and tested.

4.3 Lawrence Berkeley Laboratory Task Descriptions

4.4 Procurements for FY 1980

Procurements for FY 1980 are in the preliminary evaluation stages. Following the recommendations of the Technical Review Committees and in light of the limited amount of funding available, the following topics will be addressed:

1. Identify, describe, and interpret the characteristic signatures of water/rock interactions and their systematic variations in recording fluid flow and thermal history in active hydrothermal systems.

2. Improve and develop geothermometers.

3. Establish the basis of empirical relationships between thermal conductivity and physical parameters derived from standard geophysical well logs.

4. Establish standards for calibration and testing of electrical methods.

5. Evaluate microearthquake surveys as an exploration method for geothermal systems.

4.5 Relationship of Tasks to Barriers

The relationships of the above defined tasks to the barriers summarized in Table 2 are shown in Table 4. As shown, each barrier is addressed by a number of different tasks.

Table 4: Relationships of tasks to barriers which inhibit the exploration and assessment of geothermal resources.

MANAGEMENT PLAN

GEOTHERMAL EXPLORATION AND ASSESSMENT TECHNOLOGY PROGRAM

Figure 3 portrays the management structure for the Program in Geothermal Exploration and Assessment Technology. Figure 4 portrays the flow of information and the coordinating structure vis-a-vis other related programs. Every effort will be made a) to design minimum but essential overlap with other related programs, and b) to support interface efforts concerned with resource types other than hydrothermal.

5.1 DOE/DGE

The Manager, Exploration Technology, acting with the concurrence of the Program Manager, Geothermal Technology Development and with the concurrence of the Director, Division of Geothermal Energy (DOE/DGE) will provide overall programmatic guidance for the definition, planning, direction, and control of the Program in Exploration Technology. DOE/DGE will also provide overall financial guidance to the DOE-supported participants in the program, including subprogram-level guidance to the Geothermal Program at the Idaho Operations Office. The Manager for Exploration Technology will be responsible for coordinating this program with national geothermal program elements contained within DOE, as illustrated in Figure 4, and with the USGS and other agencies participating in the national geothermal program.

5.2 DOE Idaho Operations Office

The Office of Geothermal Energy, Idaho Operations Office, will provide program administration including planning assistance, financial management,

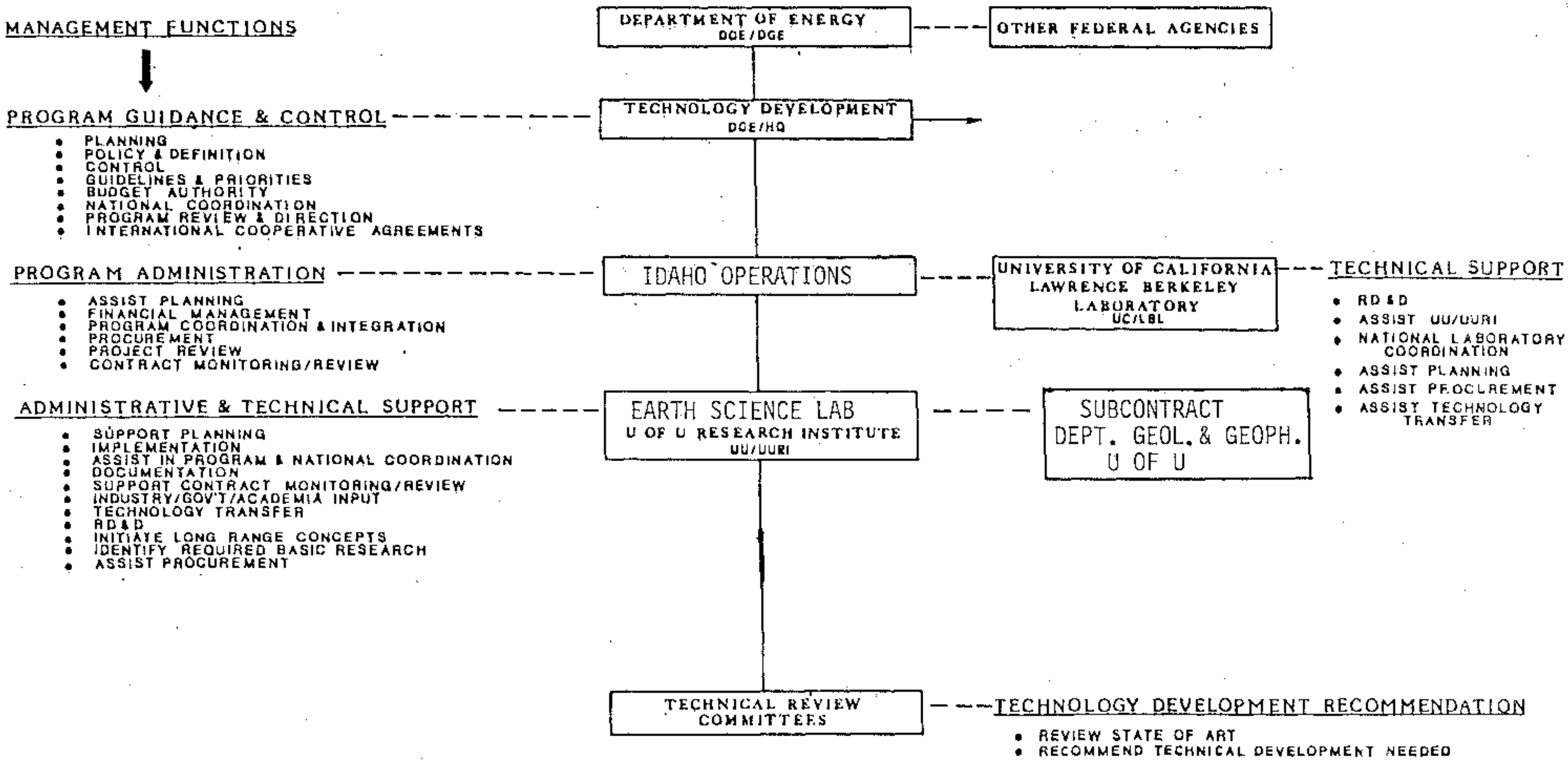
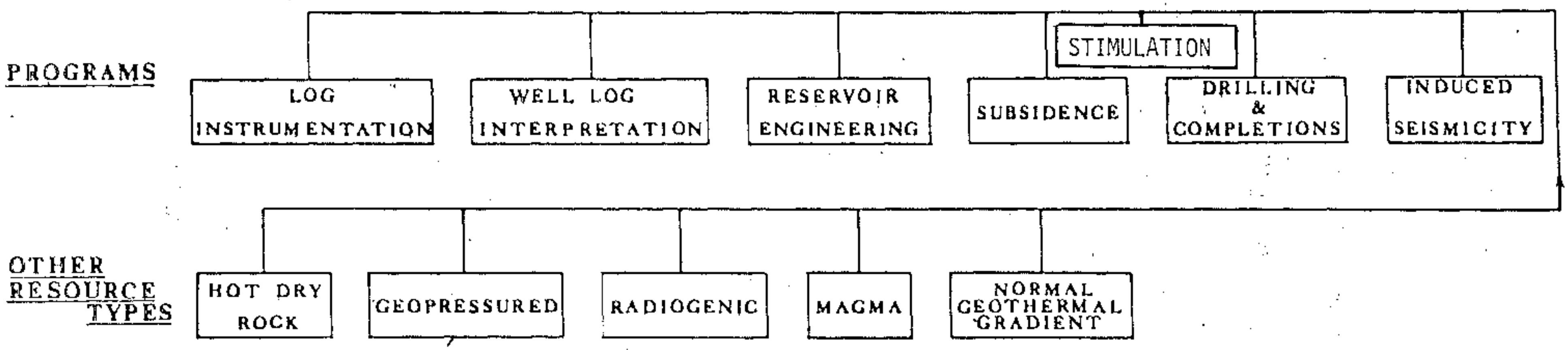

MANAGEMENT FUNCTIONS
PROGRAM GUIDANCE & CONTROL
PLANNING
POLICY & DEFINITION
CONTROL
GUIDELINES & PRIORITIES
BUDGET AUTHORITY
NATIONAL COORDINATION
PROGRAM REVIEW & DIRECTION
INTERNATIONAL COOPERATIVE AGREEMENTS
PROGRAM ADMINISTRATION
ASSIST PLANNING
FINANCIAL MANAGEMENT
PROGRAM COORDINATION & INTEGRATION
PROCUREMENT
PROJECT REVIEW
CONTRACT MONITORING/REVIEW
ADMINISTRATIVE & TECHNICAL SUPPORT
SUPPORT PLANNING
IMPLEMENTATION
ASSIST IN PROGRAM & NATIONAL COORDINATION
DOCUMENTATION
SUPPORT CONTRACT MONITORING/REVIEW
INDUSTRY/GOV'T/ACADEMIA INPUT
TECHNOLOGY TRANSFER
RD&D
INITIATE LONG RANGE CONCEPTS
IDENTIFY REQUIRED BASIC RESEARCH
ASSIST PROCUREMENT
DEPARTMENT OF ENERGY
DOE/DOE
OTHER FEDERAL AGENCIES
TECHNOLOGY DEVELOPMENT
DOE/HQ
IDAHO OPERATIONS
UNIVERSITY OF CALIFORNIA
LAWRENCE BERKELEY
LABORATORY
UC/LBL
TECHNICAL SUPPORT
RD&D
ASSIST UU/UURI
NATIONAL LABORATORY COORDINATION
ASSIST PLANNING
ASSIST PROCUREMENT
ASSIST TECHNOLOGY TRANSFER
EARTH SCIENCE LAB
U OF U RESEARCH INSTITUTE
UU/UURI
SUBCONTRACT
DEPT. GEOL. & GEOPH.
U OF U
TECHNICAL REVIEW
COMMITTEES
TECHNOLOGY DEVELOPMENT RECOMMENDATION
REVIEW STATE OF ART
RECOMMEND TECHNICAL DEVELOPMENT NEEDED

FIGURE 3

FIGURE 4


PROGRAMS
LOG INSTRUMENTATION
WELL LOG INTERPRETATION
RESERVOIR ENGINEERING
STIMULATION
SUBSIDENCE
DRILLING & COMPLETIONS
INDUCED SEISMICITY
OTHER RESOURCE TYPES
HOT DRY ROCK
GEOPRESSURED
RADIOGENIC
MAGMA
NORMAL GEOTHERMAL GRADIENT

program coordination and integration, procurement, project review, contract monitoring/review and procurement activities.

5.3 <u>Earth Science Lab/University of Utah Research Institute (ESL/UURI)</u>

ESL/UURI will provide administrative and technical support for exploration and assessment technology. In detail, ESL/UURI will be reponsible for: planning support; program implementation; assisting in program and national coordination; program documentation; supporting contract monitoring and review; obtaining and collating industry, government and academic inputs; assuring technology transfer; conducting RD & D; initiating the development of long-range conceptual models of geothermal resource types; and identifying items requiring applied and basic research in support of the program.

5.4 <u>University of California/Lawrence Berkeley Laboratory (UC/LBL)</u>

The UC/LBL activities may include assistance with program planning, procurement, technology transfer, coordination of the efforts of related programs at UC/LBL and at other national laboratories, and conducting RD & D.

5.5 <u>Relationship to Other Programs</u>

It will be the responsibility of DOE/DGE to ensure coordination of this program with USGS geothermal programs. DOE/DGE also will ensure coordination with regional and generic programs in hydrothermal and other resource types as shown in Figure 4.