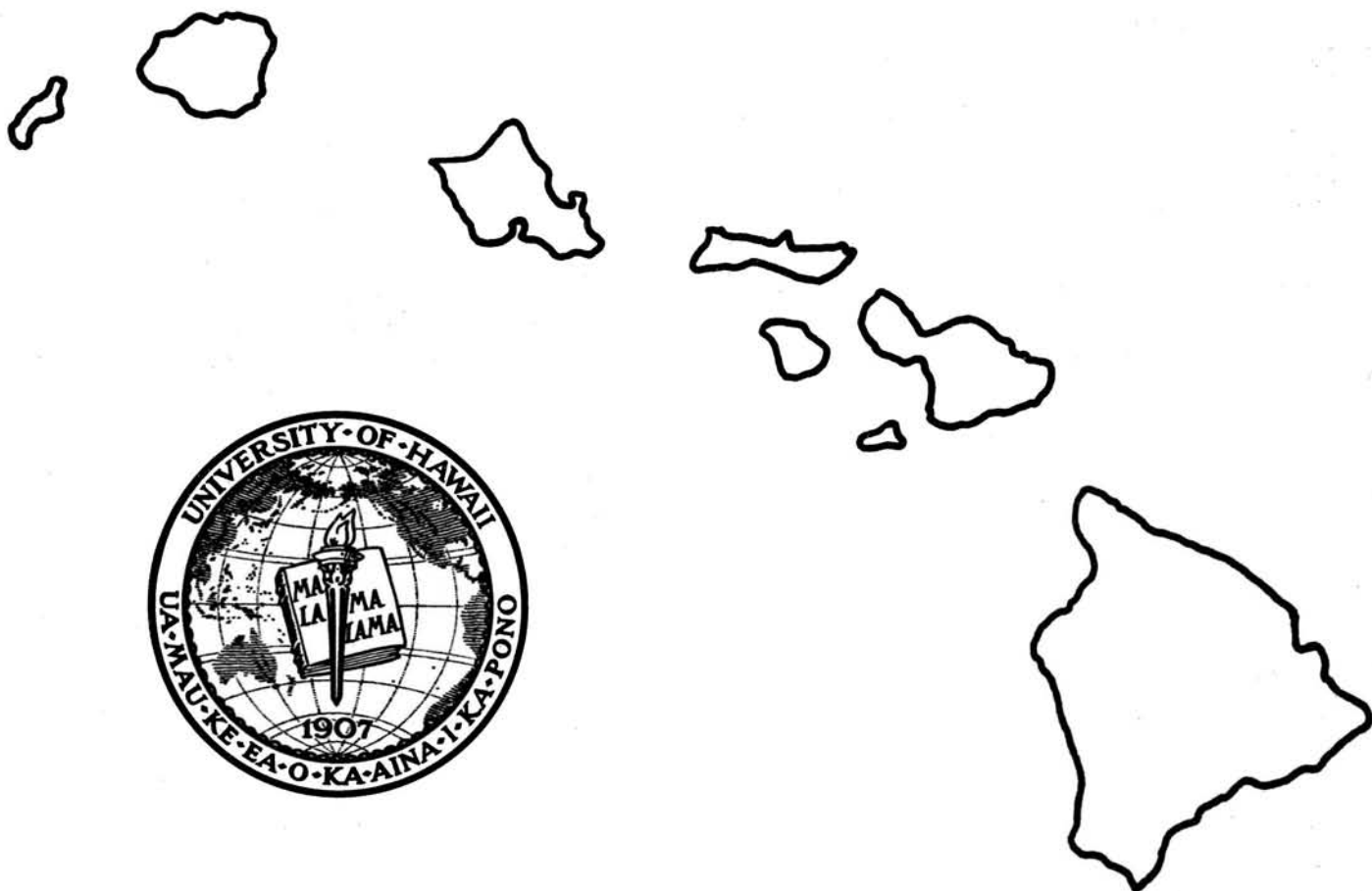


THE HAWAII GEOTHERMAL PROJECT

QUARTERLY PROGRESS REPORT NO. 2

September 1 Through November 30, 1973



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SUPPORT FOR PROJECT PROVIDED BY:

National Science Foundation
State of Hawaii
County of Hawaii

University of Hawaii
Holmes Hall 240 - 2540 Dole Street
Honolulu, Hawaii 96822

There have been three presentations made during this quarter by the Project Director on behalf of the HGP, as follows:

- World Affairs Forum of Hawaii -- Club 15 October 15 Talk delivered on "Technology's Response to the Energy Crisis"
- Natural Energy Group of Honolulu October 24 Talk on the general aspects of natural energy
- U.S.-Italy Conference on Geothermal Energy at the University of Pisa, Italy November 6 General discussion of the HGP

The following trips have been made by the Project Director during the second-quarter period on behalf of the HGP.

- September 17 Trip to Hilo, Hawaii to conduct one-day tour of geothermal sites for AEC-Los Alamos representatives, Duffield and Smith.
- October 2-4 Conferred with NSF in Washington, D.C. on a variety of research programs, with particular emphasis on energy -- both geothermal and ocean thermal. Visited offices of Hawaii's congressional delegates.
- November 5-10 U.S.-Italy Conference, Pisa, Italy. Attended as one of eight U.S. participants to this NSF-sponsored conference. Gave a presentation on the HGP, Phase I, and presented paper by Dr. Ping Cheng on Modeling Hawaiian Geothermal Resources. Toured geothermal fields throughout central Italy. (Funding for this trip came directly from NSF, not through the HGP budget.)
- November 17-20 Attended by invitation the NSF-RANN Symposium on National Energy Issues, Washington, D.C., and conferred with HGP Program Manager for NSF.
- November 21 Visited AEC-Los Alamos Scientific Laboratory, New Mexico to confer on their hot-rock geothermal program, and discussed status of joint magma properties study with Sandia staff.

The major activity contemplated during the third quarter, in addition to assisting in the enactment of appropriate legislation for the development of geothermal power in Hawaii, is to plan strategy for the continuation of the HGP through the remainder of Phase I and into Phase II -- in light of the additional input provided by the energy crisis. The recommended program should be reasonably well defined by February 8, 1974 to provide the National Liaison Board (which includes Ritchie Coryell, NSF Program Manager) the opportunity to react to the plan. However, the HGP should not limit its outlook to a program based exclusively on NSF grants, but should establish its continuing role in relation to the State requirements and potential support, as well as to the total

federal funding picture. The overriding objective of the HGP should continue to be a balanced program for removing all potential roadblocks -- exploratory, technological, environmental, regulatory, socioeconomic -- which could limit the development of geothermal power in Hawaii. The ultimate goal of this project is to bring geothermal technology and related software to the point that private and/or public capital can proceed with the generation and distribution of geothermal power in Hawaii.

Brief progress reports from the three Program Directors follow.



John W. Shupe
Project Director

HAWAII GEOTHERMAL PROJECT

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SUMMARY OF THE MEETING OF THE HAWAII ADVISORY COMMITTEE OF THE H. G. P.

3:00 P.M. Wednesday, October 31, 1973

Members Present: Bacon Miwa
 Ellis Peterson
 Grabbe for Mark Sadamoto for Kimura
 Hughes Williams
 Marland Woollard
 McKaughan

HGP Staff: Abbott Sharma
 Kamins Shupe
 Klein Yuen

Following introductions and opening comments by Shupe on the general objectives of the Advisory Committee, a briefing was presented by the HGP staff on the overall research program, as well as a progress report on Phase I.

Abbott reported on the infrared measurements for determining surface heat. Flight paths were flown along the eastern Puna rift of Kilauea, the southwest rifts of both Kilauea and Mauna Loa, the northwest rift of Hualalai, and the south Kohala area. In addition to the anticipated hot spots along the Puna rift, an interesting anomaly was noted on the southwest rift of Mauna Loa near South Point.

Klein described the electromagnetic and the electrical resistivity studies. Keller's reconnaissance surveys indicated possible geothermal anomalies in three spots along the Puna rift. Current and subsequent tests by Klein's group will investigate these anomalies at greater depth and, in addition, will obtain data near the South Point hot spot, along the great crack in the southwest Kilauea rift zone, and between Kohala and Hualalai. Refinement of the electrical resistivity equipment will permit penetration and data acquisition of up to two miles.

Yuen gave a summary of the two programs developed to supplement the geophysical surveys. Both a mathematical and physical model have been established to study well test analyses and behavior of the Ghyben-Herzberg fresh water lens under simulated production conditions. Study has also been initiated on procedure for extracting energy from hot brine.

Kamins listed the progress to date on the environmental-socioeconomic program, with major emphasis on legal and regulatory aspects. He and his staff have met with representatives from the State Departments of the Attorney General, Land and Natural Resources, Regulatory Agencies, the County of Hawaii, and the geothermal officer of the State of California to develop alternatives for developing a definition for geothermal resources, and to establish regulations for utilization of the resource. One alternative that is being given serious consideration is to identify geothermal energy as a mineral, which would automatically establish ownership as residing with the State. Lively discussion ensued on the pros and cons of this alternative.

A brief discussion was held regarding the format of subsequent meetings. It was the general consensus of those in attendance that an earlier meeting time in the afternoon would allow for a greater period of discussion. It was also the consensus of the Committee that since a number of the key items on the agenda had not been covered, it would be desirable to hold an adjourned meeting in early December.

GEOPHYSICS PROGRAM

Task 2.1: Photogeologic Surveys Task Investigator: Dr. Agatin T. Abbott

Study of the black and white prints obtained during the infrared scanning survey described in the first quarterly report is continuing. Areas of special interest and those that appear favorable for more intensive investigation have been selected for reproduction in color by the Digicolor process. The colored photographs and subsets of the thermal spectrum will provide more definitive answers on the surface temperatures. The colored imagery which will include 17 line miles of flying should be delivered from the processor in about ten days.

It is expected that study of the colored prints will help considerably in making the choice of drill sites.

Task 2.4: Electromagnetic Induction Surveys Task Investigators: Douglas Klein and Robert Harvey (Report by: Dr. A.S. Furumoto)

Most of the time has been spent at the home Institute in improving field instrumentation. The critical part is the switching mechanism for the field generator.

Sandia Corporation will test an air drop rock penetrating device on the Island of Hawaii during December 1973. The task leaders are participating in this experiment as this device has capabilities of being used as ground electrodes in the electromagnetic surveys.

Task 2.5: Microearthquake Surveys Task Investigator: Dr. A. S. Furumoto

The telemetry equipment are being assembled. No field testing has been done for telemetry.

A ground noise survey system was used in connection with the East Papua Crustal Survey held in Papua, New Guinea during November 1973. The system proved to be very effective for long distance seismic refraction surveys as well. Techniques for compactness and portability were learned from the Australian scientists who ran the Papua Survey.


Augustine S. Furumoto

ENGINEERING PROGRAM

Task 3.1: Well Test Analysis

Work is continuing on determining the availability of hardware and software required for the prediction of geothermal well performance. Although the methods of well test analysis used with petroleum and gas industries cannot be applied without change to geothermal systems, it is expected that the principles of petroleum reservoir engineering for single-phase liquid flow can be modified and used for hot water geothermal reservoirs.

A literature survey on physical modelling is nearing completion, and design work has been begun for a physical model of geothermal reservoirs potentially available on Hawaii. A dimensional analysis study is in progress to help determine the parameters of significance, the media to be used, and the scale factors.

Task 3.2: Ghyben-Herzberg Lens Dynamics

During the last quarterly period the finite difference equation solution has been derived for the problem of free convection in a coastal aquifer with geothermal heating from below. A computer program has been written for the numerical solution of the set of non-linear algebraic equations by an iterative method.

The problem of pumping and recharging in a porous medium under isothermal conditions has been studied extensively but the problem of pumping and recharging in a geothermal reservoir has not been discussed in the literature. This problem now has been properly formulated and methods are being investigated for obtaining solutions.

Task 3.6.1: Heat Exchanger and Binary-Fluid Cycle Design

During the past quarter computer programs to study the effects of variations of system parameters were written and tested. A Rankine cycle with superheat and heat input from a high temperature brine was the main focus of the research efforts.

Work was continued on the design of heat exchangers suitable for use with hot brine. A vertical configuration is being considered first because of the availability of suitable heat transfer equations for design purposes.

Task 3.6.2: Optimal Hot Brine Plant Design

Work is continuing on the study and comparison of different cycles which can be used with a geothermal reservoir. While some general information can be obtained, specific design data can be generated only after the parameters of the geothermal reservoir have been determined.



Paul C. Yuen

ENVIRONMENTAL-SOCIOECONOMIC-LEGAL PROGRAM

Work continued during the quarter on Task 4.3 -- Legal Aspects, and Task 4.6 -- Economic Aspects of Geothermal Development. No funds have yet been budgeted for the third task in this portion of the project, which is to investigate the environmental aspects of geothermal development in Hawaii.

Legal Aspects

During the quarter, the research staff worked with representatives of the agencies of the State of Hawaii most directly concerned with the establishment of a legal regime for geothermal resource development; namely, the Departments of the Attorney General, Planning and Economic Development, Land and Natural Resources, and Regulatory Agencies. It was agreed that the existing state laws leave in doubt the definition and ownership of geothermal resources, and that such legal ambiguity would discourage investment in and development of the resource, since the absence of controlling law there would probably be prolonged litigation to settle the matter in the courts. Similarly, it would enhance development to place Hawaii government regulation of geothermal resource use in some designated agency -- a state agency, since in Hawaii economic regulation is centralized in the state government.

Following meetings with these representatives, there was unanimous agreement among the agencies concerned that the regulatory function should be placed within the Department of Land and Natural Resources, which already has oversight responsibility with respect to water and minerals. Consequently, the Department has drafted a bill to explicitly add geothermal to the natural resources under its jurisdiction and to define geothermal resources so as to make the ownership clear. The bill has been submitted to the Office of the Governor for possible inclusion in the administrative legislative program for the 1974 Hawaii State Legislature, which convenes in January.

A preliminary report, intended to serve as background for legislators and others concerned with the question of establishing a legal setting for geothermal development in Hawaii, was prepared by Robert Kamins, Donald Kornreich, and George Sheets. The report utilizes comparative data on geothermal laws gathered from a survey of legal practices in the twelve Western states other than Hawaii.

During the quarter, David N. Anderson, Geothermal Officer for the State of California, visited the project as consultant concerning regulation of geothermal prospecting and production. He is helping the project to prepare a model set of regulations based on the experience of California, but fitted to the conditions of Hawaii. The regulations would carry the bulk of the legal constraints to be applied to geothermal development in this

state, since there seems to be agreement on the proposition that the statutory provisions should be general, leaving the regulatory agency authority to specify such details as bonding requirements, drilling fees, permits, inspection of wells, etc.

Economic Aspects

A survey of the rapidly growing, but still unsynthesized, literature on geothermal economics was undertaken by Richard Peterson, Nabil El-Ramly and Robert Kamins. From this material, data on the costs of geothermal exploration and production in various producing areas are being collected to ascertain, among other things, the effects of economies of scale on geothermal production costs.

Gathering data on the electric industry of Hawaii continued. Much uncertainty as to the short- and long-term supply conditions of the industry has, of course, been injected by the national fuel shortage and consequent rise in oil prices to the utility companies. The oil shortage adds to the comparative advantage of geothermal power, but also adds to the complication of economic analysis.

Econometric models of the State of Hawaii were examined to ascertain their applicability to the projection of geothermal development in this state. The provisional conclusion is that it is not feasible to make projections of impacts on the economy of the County of Hawaii alone. Investigation of statewide models continues.



Robert M. Kamins