UNIVERSITY OF UTAH RESEARCH INSTITUTE
UURI
EARTH SCIENCE LABORATORY
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108—1295
TELEPHONE 801-524-3422

# MEMORANDUM

To: Kenneth J. Taylor, DOE/ID

From: Howard P. Ross, UURI

Date: April 19, 1991

Subject:: Status and Problems, State Cooperative Program Grants

The final report has been received from the Desert Research Institute, University of Nevada System. The report incorporates all the revisions we requested and looks good. This grant can be closed out any time.

Dr. W. Gosnold (U. North Dakota) and Dr. Henry Heasler (U. Wyoming) have been prompted to complete their overdue final reports and submit them as soon as possible. The U. of Wyoming report should be in by month's end, but the timing for the North Dakota report is not known. The long overdue South Dakota Geothermal Resource Map is again on a back burner until the final report is finished.

I called Don Thomas, University of Hawaii P.I., on April 16 to remind him of his June 20 grant termination date. Dr. Thomas says he is far from the point where he can write up the final reptort. It appears that he has had his technician collecting published information regarding silica in North American geothermal systems, but has done little else on Task 4.7. which we inserted in the contract modification last September. Don claims to have been very busy with the Hawaii SOH program and other things. Don understands that Marshall Reed has transferred $50,000 to DOE/ID which is intended for future support for him. Don hopes to receive this soon, so he can use it to travel to the mainland with his technician to obtain fluid samples from Cerro Prieto and other geothermal systems. His present intent is to await new funding before completing the final report. He says he won't be able to finish the report by June 20. He says he is not getting any salary money from the grant.

I talked to Marshall about this conversation and he confirmed that $50,000 was at DOE/ID, intended for Thomas. Marshall would rather see a 5-yr contract or grant so he can provide continued support for Thomas' studies. He says Thomas should submit a new brief proposal with SOW tasks. Alternatively if the new money could he added to the present grant this might be o.k.

I believe Dr. Thomas should complete his grant and report, including a chapter on applicability of silica treatment to North American systems based on literature data. This would of course be a

preliminary study based on little data, but would allow completion of the grant. Please determine if the grant must be finished without new funds, and how new funds can be directed to Thomas. Let's discuss this.

I called Roman Motyka, Alaska-DGGS on April 17. Roman suffered a bad knee injury (ACL) this winter (skiing), and with other problems is again behind schedule for completing his resource compilation, report, and map. Roman received from DOE/ID a copy of his January 2, 1991 letter which requested a grant extension to June 30, 1991. The copy was stamped M003, so I presume it was approved. After his injury he asked his accounting to request from DOE (March 18) another extension to January 31, 1992. Is this in progress? It seems unlikely he could possibly finish by June 30 and the DGGS will want to bill for final printing costs (a 4-color map). I know he needs more time, but I'm worried about getting the deliverables if this goes on until 1992. The state has little interest in geothermal energy at present.

Lastly, I am behind in my own quarterly SCP report, and need to review invoice information with you. Let's discuss these items when you have a chance.

M E M O R A N D U M

TO: Scott D. Applonie, Contract Specialist
DOE/ID

FROM: Howard Ross, UURI

SUBJECT: Outstanding deliverable, previous grant, North Dakota Mining and Mineral Resources Research Institute, Inst. No. DE-FG07-85ID12606

1) Background information on grant is appended

2) Suggested partial text for letter follows:

It has come to my attention that one deliverable from a previous grant to NDMMRRI, University of North Dakota, Grant No. DE-FG07-85ID12606, remains outstanding. The final report "Geothermal Resource Assessment of South Dakota" was submitted by Dr. William D. Gosnold, Jr. Principal Investigator, on August 24, 1987 with the understanding the the Geothermal Resource Map of South Dakota, scale 1:1,000,000, would follow. This map has never been received by DOE. We understand from discussions with Dr. Howard Ross, University of Utah Research Institute (UURI) that new data from the present grant has been incorporated into the map and that the map is now in draft form but has not yet been submitted for review by UURI and DOE.

I encourage you to expedite the completion, review and submittal of this long overdue deliverable. Although the previous grant has been formally closed out and final payment made, failure to complete the deliverable requirements may be viewed as an evaluation factor in the consideration of future DOE grants.

3) As I noted in our telephone conversation, Dr. Gosnold has prepared and presented numerous good papers on the work he completed for DOE, and has supported the DOE geothermal program in discussions with his congressmen and others. He is however, habitually late in the completion of his deliverables. It might be best to talk to Gosnold first, or his Contracts Office, rather than going up too high in the organization (i.e. V.P. Research).

4) Please call me if I can provide additional information. My FTS number is 588-3444.

(1-81)

# NOTICE OF FINANCIAL ASSISTANCE AWARD

*(See Instructions on Reverse)*

Rec 1/91

Under the authority of Public Law 93-410 and subject to legislation, regulations and policies applicable to *(cite legislative program title):*
Geothermal Research, Development, and Demonstration Act of 1977

1. PROJECT TITLE
Geothermal Resource Assessment Research

2. INSTRUMENT TYPE
[X] GRANT [ ] COOPERATIVE AGREEMENT

4. INSTRUMENT NO.
DE-FG07-85ID12606

5. AMENDMENT NO.
M004

3. RECIPIENT *(Name, address, zip code, area code and telephone no.)*
University of North Dakota, Mining & Mineral Resource Research Institute, P.O.Box 8103 University Station, Grand Forks, ND 58202

6. BUDGET PERIOD
FROM: 12/30/86 THRU: 7/1/87

7. PROJECT PERIOD
FROM: 8/9/85 THRU: 7/1/87

10. TYPE OF AWARD
[ ] NEW [ ] CONTINUATION [ ] RENEWAL
[X] REVISION [ ] SUPPLEMENT

9. RECIPIENT PROJECT DIRECTOR *(Name and telephone No.)*
Dr. William D. Gosnold (701) 777-2631

RECIPIENT BUSINESS OFFICER *(Name and telephone No.)*
Susan Hoffman (701) 777-4141

12. ADMINISTERED FOR DOE BY *(Name, address, zip code, telephone No.)*
R. Jeffrey Hoyles (208) 526-0790
U.S. Department of Energy
Idaho Operations Office
785 DOE Place, Idaho Falls, ID 83402

11. DOE PROJECT OFFICER *(Name, address, zip code, telephone No.)*
Peggy Brookshier (208) 526-1403
U.S. DOE, Idaho Operations Office
785 DOE Place, Idaho Falls, ID 83402

13. RECIPIENT TYPE
[ ] STATE GOV'T [ ] INDIAN TRIBAL GOV'T [ ] HOSPITAL [ ] FOR PROFIT ORGANIZATION [ ] INDIVIDUAL
[ ] LOCAL GOV'T [X] INSTITUTION OF HIGHER EDUCATION [ ] OTHER NONPROFIT ORGANIZATION [ ] C [ ] P [ ] SP [ ] OTHER *(Specify)*

14. ACCOUNTING AND APPROPRIATIONS DATA

| a. Appropriation Symbol | b. B & R Number | c. FT/AFP/OC | d. CFA Number |
|---|---|---|---|
| | | | |

15. EMPLOYER I.D. NUMBER/SSN

16. BUDGET AND FUNDING INFORMATION

| a. CURRENT BUDGET PERIOD INFORMATION | | b. CUMULATIVE DOE OBLIGATIONS | |
|---|---|---|---|
| 1) DOE Funds Obligated This Action | $ -0- | (1) This Budget Period *[Total of lines a.(1) and a.(3)]* | $ -0- |
| 2) DOE Funds Authorized for Carry Over | $ 9,263.60 | (2) Prior Budget Periods | $ 47,000 |
| 3) DOE Funds Previously Obligated in this Budget Period | $ -0- | | |
| 4) DOE Share of Total Approved Budget | $ 9,263.60 | (3) Project Period to Date *[Total of lines b. (1) and b. (2)]* | $ 47,000 |
| 5) Recipient Share of Total Approved Budget | $ -0- | | |
| 6) Total Approved Budget | $ 47,000 | | |

17. TOTAL ESTIMATED COST OF PROJECT $ _____
*(This is the current estimated cost of the project. It is not a promise to award nor an authorization to expend funds in this amount.)*

18. AWARD/AGREEMENT TERMS AND CONDITIONS
This award/agreement consists of this form plus the following:
a. Special terms and conditions (if grant) or schedule, general provisions, special provisions (if cooperative agreement)
b. Applicable program regulations *(specify)* _____ *(Date)* _____
c. DOE Assistance Regulations, 10 CFR Part 600, as amended, Subparts A and [ ] B (Grants) or [ ] C (Cooperative Agreements).
d. Application/proposal dated 2/4/87, [ ] as submitted [X] with changes as negotiated

19. REMARKS
This modification revises the budget categories with no increase in obligated funds. Revision attached.

20. EVIDENCE OF RECIPIENT ACCEPTANCE
*(Signature of Authorized Recipient Official)* *(Date)*
*(Name)*
*(Title)*

21. AWARDED BY
R. Jeffrey Hoyles 6/26/87
*(Signature)* *(Date)*
R. Jeffrey Hoyles
*(Name)*
Contracting Officer
*(Title)*

(7-81)

# NOTICE OF FINANCIAL ASSISTANCE AWARD

*(See Instructions on Reverse)*

Under the authority of Public Law 93-410 and subject to legislation, regulations and policies applicable to *(cite legislative program title)*:

1. PROJECT TITLE
Geothermal Resource Assessment Research

2. INSTRUMENT TYPE
☒ GRANT ☐ COOPERATIVE AGREEMENT

4. INSTRUMENT NO.
DE-FG07-85ID12606

5. AMENDMENT NO.
Orig.

3. RECIPIENT *(Name, address, zip code, area code and telephone no.)*
University of North Dakota, Mining & Mineral Resource Research Institute, P.O. Box 8103, University Station, Grand Forks, SD 58202

6. BUDGET PERIOD
FROM: 8/9/85 THRU: 8/9/86

7. PROJECT PERIOD
FROM: 8/9/85 THRU: 8/9/86

8. RECIPIENT PROJECT DIRECTOR *(Name and telephone No.)*
Dr. William D. Gosnold (701)777-2631

10. TYPE OF AWARD
☒ NEW ☐ CONTINUATION ☐ RENEWAL
☐ REVISION ☐ SUPPLEMENT

9. RECIPIENT BUSINESS OFFICER *(Name and telephone No.)*
Sue Hoffman (701)777-4151

12. ADMINISTERED FOR DOE BY *(Name, address, zip code, telephone No.)*
Ronald A. King (208)526-1912
U. S. Department of Energy
Idaho Operations Office
550 Second Street
Idaho Falls, ID 83401

11. DOE PROJECT OFFICER *(Name, address, zip code, telephone No.)*
Peggy A. Brookshier (208)526-1403
U.S.DOE, Idaho Operations Office
550 Second Street, Idaho Falls, ID 83401

13. RECIPIENT TYPE
☐ STATE GOV'T ☐ INDIAN TRIBAL GOV'T ☐ HOSPITAL ☐ FOR PROFIT ORGANIZATION ☐ INDIVIDUAL
☐ LOCAL GOV'T ☒ INSTITUTION OF HIGHER EDUCATION ☐ OTHER NONPROFIT ORGANIZATION ☐ C ☐ P ☐ SP ☐ OTHER *(Specify)*

14. ACCOUNTING AND APPROPRIATIONS DATA

| a. Appropriation Symbol | b. B & R Number | c. FT/AFP/OC | d. CFA Number |
|---|---|---|---|
| 89X0224.91 | AM1510000 | ID-54-91/4/0 | |

15. EMPLOYER I.D. NUMBER/SSN

16. BUDGET AND FUNDING INFORMATION

| a. CURRENT BUDGET PERIOD INFORMATION | | b. CUMULATIVE DOE OBLIGATIONS | |
|---|---|---|---|
| (1) DOE Funds Obligated This Action | $ 47,000 | (1) This Budget Period *[Total of lines a.(1) and a.(3)]* | $ 47,000 |
| (2) DOE Funds Authorized for Carry Over | $ -0- | (2) Prior Budget Periods | $ -0- |
| (3) DOE Funds Previously Obligated in this Budget Period | $ -0- | | |
| (4) DOE Share of Total Approved Budget | $ 47,000 | (3) Project Period to Date *[Total of lines b. (1) and b. (2)]* | $ 47,000 |
| (5) Recipient Share of Total Approved Budget | $ -0- | | |
| (6) Total Approved Budget | $ 47,000 | | |

17. TOTAL ESTIMATED COST OF PROJECT $ _____

*(This is the current estimated cost of the project. It is not a promise to award nor an authorization to expend funds in this amount.)*

18. AWARD/AGREEMENT TERMS AND CONDITIONS

This award/agreement consists of this form plus the following:

a. Special terms and conditions (if grant) or schedule, general provisions, special provisions (if cooperative agreement)

b. Applicable program regulations *(specify)* _____ *(Date)* _____

c. DOE Assistance Regulations, 10 CFR Part 600, as amended, Subparts A and ☐ B (Grants) or ☐ C (Cooperative Agreements).

d. Application/proposal dated Undated, ☐ as submitted ☒ with changes as negotiated

19. REMARKS

This Grant consists of this NFAA, Part I-Budget Plan, Part II Conditions, Part III-Statement of Work, and Part IV-Special Terms and Conditions. The DOE Financial Assistance Rules (10 CFR Part 600), OMB Circular A-110, and OMB Circular A-21, are incorporated by reference and attached hereto.

20. EVIDENCE OF RECIPIENT ACCEPTANCE

Alex Kotch 8/21/85
*(Signature of Authorized Recipient Official)* *(Date)*

Alex Kotch
*(Name)*
DIRECTOR - OFFICE OF RESEARCH AND PROGRAM DEVELOPMENT
*(Title)*

21. AWARDED BY

[signature] 9/9/85
*(Signature)* *(Date)*

William C. Drake
*(Name)*
Contracting Officer
*(Title)*

## STATEMENT OF WORK

The Grantee shall conduct a summary assessment of low and moderate temperature geothermal resources in South Dakota.

The tasks to be conducted in the geothermal resource assessment of South Dakota are:

TASK 1 - Obtain a network of heat flow data in South Dakota. Specific elements of this task are:

a. Measure geothermal gradients in all available wells and drill holes, and

b. Determine thermal conductivities of the formations in the measured wells.

TASK 2 - Obtain sufficient stratigraphic data to produce structure contour maps of all significant lithologic units within the study area. Significant lithologic units are those having properties and/or stratigraphic position which may influence the temperature of a geothermal aquifer.

TASK 3 - Measure temperature gradients in deep wells that penetrate the geothermal aquifers, to calibrate the heat flow and thermal conductivity grids used in downward projection of temperature fields.

TASK 4 - Synthesize previously published data to produce temperature contour maps on the geothermal aquifers, i.e., Dakota (Cretaceous), Madison (Mississippian), Duperow (Devonian), and Red River (Ordovician).

TASK 5 - Prepare geothermal resource map of South Dakota using the format similar to other maps produced under the State Coupled Program (but at a scale of 1:1,000,000). Submit a draft copy of the map to DOE and appropriate DOE-designated reviewers prior to publication.

TASK 6 - Prepare a text that will accompany the geothermal resource map, which will be written in a style that may be readily understood by non-geologists. The text will include a description of geothermal resources in South Dakota, temperature contour maps for each geothermal aquifer, appropriate definitions, discussions of possible geothermal applications, and a list of current geothermal applications in South Dakota.

TASK 7 - The Final Report to the Department of Energy will include the geothermal resource map, the accompanying text, and a report describing the research project, methodology, and data gathered.

TASK 8 - Provide overall project management and complete and report on tasks in a timely manner. Management reports shall be provided as defined by the attached DOE Form EIA-459A - Reporting Requirements Checklist. The required reports are also summarized as follows:

| | | |
|---|---|---|
| 1. | Form DOE-538 Notice of Energy RD&D | 30 days after award of grant |
| 2. | Quarterly Management Summary Report | 15 days after calendar quarter end |
| 3. | Project Status ~~Project~~ | 15 days after calendar quarter end |
| 4. | Final Report (Draft) | Due 45 days prior to updated completion date |
| 5. | Final Report | Due on updated completion date |
| 6. | Financial Status Report - OMB Form 269 | Due annually and upon completion |

The deliverables resulting from the tasks outlined above which will be delivered to DOE are summarized as follows:

M E M O R A N D U M

TO: Ken Taylor, DOE/ID

FROM: Howard Ross, UURI

SUBJECT: Reminder - Hawaii DBED Grant Termination Date

DATE: May 30, 1991

Just a reminder that the Hawaii- DBED grant termination date is presently scheduled for June 20, 1991. No draft final report has yet been received and in my April 16 telephone conversation with Don Thomas, it sounded as if he did not intend to complete the study and reporting requirements at this time without additional funding.

I wonder if you and contracts have decided to award a no cost time extension or to award new funds to this grant. I will be in my office on May 31 but leave for a meeting Saturday June 1. I will be attending a meeting of the Long Valley Science Panel at the Sheraton Old Town, Albuquerque, June 2- June 6. The hotel phone number is (505)-843-6300 should you need to reach me there.

D O E GEOTHERMAL TECHNOLOGY DIVISION

PROGRAM REVIEW - APRIL 1990

# STATE COOPERATIVE RESERVOIR ANALYSIS PROGRAM

## Introduction

The State Cooperative Reservoir Analysis Program (SCP) was established by DOE in the late-1970's as the State Coupled Program to assess low- and moderate-temperature geothermal resources in the United States. The early efforts of the program were national in scope and focused on statewide resource assessment, resulting in the publication and distribution of a series of state geothermal resource maps. More recent work has expaned upon earlier resource assessment activities and has included detailed reservoir analysis and generic studies.

As a result of a 1987 DOE/ID solicitation, eleven grants and were signed with state-designated agencies to conduct geothermal research. One additional grant was signed later to provide support for an unsolcited research proposal. The grant participants and a brief description of the status of the projects follows.

## Current Projects

The University of Alaska, Geophysical Institute, is completing a geological and geochemical study of the Geyser Bight resource, Umnak Island. Results to date indicate that a zoned plutonic rock unit 9.5 (Ma) is the probable reresvoir rock, and volcanic rocks range in age from 75,000 to 534,000 years. A previously unreported fumarole field, 4 km south of Geyser Bight valley, was discovered during this study.

The State of Alaska, Division of Geological and Geophysical Surveys, has completed a fluid chemistry study of the Geyser Bight area in support of the Geyser Bight geologic study. Fluid chemistry analyses indicate spring waters are derived from two separate reservoirs. Estimated reservoir temperatures, uncorrected for some dilution, are 221-228 C and 225-235 C. Much work remains to be done on the Aleutian Island - Alaska Penisula geothermal resource map.

The State of Hawaii, Department of Business and Economic Development, is studying methods of controlling silica deposition from geothrmal fluids of the Hawaii East Rift Zone. Mixing of 60% condensate and 40% brine, and treatment with weak acids both show great promise in retarding silica precipitation. The high surface area of precipitated silica may have some commercial value. Completion of the study has been delayed by shutdown of

the HGP-A well, the only source of fluids for the study.

The State of Idaho, Department of Water Resources, is completing a geochemical study of the Wood River geothermal systems and monitoring of the Banbury-Twin Falls reservoirs. The Berkeley Group, Inc., a subcontractor to ID-DWR, completed a detailed review of all existing data on the Boise geothermal aquifer. BGI used the most reliable data to constrain numerical simulations of present and future reservoir behavior under various development scenarios. All studies will be completed in FY90.

The Desert Research Institute, University of Nevada, has completed a 13 month hydrologic monitoring program at the Moana geothermal system. These and other geologic data are being used to complete a quantitative evaluation and numerical model of the Moana resource. The results and the numerical model will be made available to regulatory agencies and developers to coordinate future development of the resource.

The Division of Earth Sciences, University of Nevada, has just completed a study of the genesis of geothermal fluids of the Great Basin. The study has determined a late Pleistocene age (40,000 - 10,000 years BP) for the fluids which indicates a paleo-recharge scheme. Range-bordering faults probably provide conduits for recharge of the deep geothermal systems. Pleistocene lakes probably contributed to recharge in western Nevada.

New Mexico Research and Development Institute is using a subcontractor, New Mexico State University, in a study to evaluate the use of time-integrated radon soil-gas surveys for geothermal resource assessment in the southern Rio Grande Rift. One drill hole which tests a radon anomaly in the Rincon survey area has recorded a temperature of 65 C at a depth of 90 meters. This study has advanced the radon soil-gas technique and yielded several target areas for moderate-temperature geothermal fluids.

The State of North Dakota, Mining and Mineral Resources Research Institute, is cooperating with the Geological Surveys of North Dakota and South Dakota in a comprehensive geothermal resource assessment. Five heat flow holes have been drilled and logged in the South Dakota heat flow anomaly. Five more heat flow holes will be drilled this spring, three in South Dakota and two in North Dakota. New studies suggest the stratabound geothermal resource may be twice as large as previously reported.

The State of Oregon, Department of Geology and Mineral Industries, is drilling a deep scientific and heat flow hole at Santiam Pass on the crest of the Oregon Cascades. The projected depth of Santiam Pass 77-24 is 3000 feet. This project is jointly funded by DOE and Oxbow Geothermal Corporation. This hole was drilled to 460 feet and cased in November prior to shutdown for winter.

The State of Utah, Geological and Mineral Survey, has completed a multidisciplinary study of the Newcastle resource which currently provides space heating for three large greenhouses, a church, and several residences. Geological, geophysical, and geochemical studies have characterized this hidden resource in detail, and have determined a reservoir temperature in excess of 130 C, with an anomalous heat loss of 12.4 MW. The study suggests new approaches for the discovery of other hidden Basin and Range geothermal systems.

The State of Washington, Department of Natural Resources, drilled eight 152 m temperature gradient holes to better define the Southern Washington Cascade Range heat flow anomaly. Two holes did not penetrate the effects of cold surface waters, but four holes had temperature gradients of 50 to 58 degrees C/km. A related study integrated K-Ar age dates, geochemistry and volcanic stratigraphy of the Indian Haven Quaternary volcanic field to evaluate volcanic production rates.

The University of Wyoming, Department of Geology and Geophysics, continues work on an improved three-dimensional modeling scheme for solving the combined heat conduction and forced convection equations for determining subsurface temperatures. A model will be developed for one of the Bighorn Basin hydrothermal systems.

Present Status

Technical work has been completed for five grants and final deliverables have been received from the Washington and Utah teams. Most teams have been granted no cost time extensions; three grants will continue into FY91.

Program Evaluation

A review of interim and final results so far indicates this phase of the State Cooperative Program has been extremely productive in terms of new resource information (Washington Cascades; Newcastle, Utah; Rio Grande Rift), reservoir monitoring and evaluation, and in addressing production problems (Hawaii silica studies). Two studies were presented at the 1989 GRC conference (Great Basin geothermal fluids, and Newcastle case study) and several other studies will be presented at the 1990 and 1991 GRC conferences. A number of other quality technical reports and presentations will result from projects now in progress.

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

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TELEPHONE 801-524-3422

M E M O R A N D U M

TO: Kenneth Taylor

FROM: Howard Ross

DATE: March 9, 1989

SUBJECT: Brief summary of FY-88 SCP grants

**University of Alaska-Geophysical Institute - Dr. Donald L. Turner and Dr. Christopher Nye**

The University of Alaska-Geophysical Institute is conducting a geologic and geochemical study of the Geyser Bight geothermal resource, the hottest (180-264°C) and most extensive area of thermal springs in Alaska, in cooperation with the AK-DGGS. Although the resource is located on a remote uninhabited Aleutian Island, the geological data and K-Ar age dating are expected to contribute to our knowledge of volcanic island arc systems in general.

**Alaska - Division of Geological and Geophysical Surveys - Dr. Roman J. Motyka**

The state of Alaska-DGGS in cooperation with the University of Alaska-Geophysical Institute is completing a fluid chemistry investigation and geological mapping of the Geyser Bight KGRA. A second task requires the preparation of a 1:1,000,000 scale technical geothermal energy resource map for the Aleutian Island - Alaska Peninsula region, and compilation and evaluation of all available geochemical data on geothermal fluids for this region.

**Hawaii - Department of Business and Economic Development - Dr. Donald Thomas**

The state of Hawaii is studying methods of controlling silica deposition from geothermal fluids of the Hawaii East Rift Zone. Principal components of the study include: silica polymerization studies; low temperature (<100°C) brine treatment; design of a pilot scale treatment system; characterization of treated fluids; and characterization/economic evaluation of

precipated silica.

**Idaho - Department of Water Resources - Ms. Leah V. Street**

The Idaho - DWR is continuing monitoring of the Banbury - Twin Falls resource and studying geothermal resource potential of the Cassia Mountains to the south. Continued monitoring of the Boise geothermal aquifer, and numerical modeling of this system by a consultant constitute a separate work task. A third project involves a study of the geochemistry of the Wood River geothermal systems and evaluation of the fluoride content of the thermal fluids.

**University of Nevada System - Desert Research Institute - Dr. Elizabeth Jacobson**

The Desert Research Institute (DRI) is conducting detailed hydrologic monitoring of the Moana geothermal system, in support of a quantitative evaluation and numerical modeling of this resource. Uncoordinated development of this moderate-temperature resource is rapidly expanding and the long-term productivity of the Moana system may be threatened. This study should provide a solid data base and quantitative model for state regulatory agencies and developers using the resource.

**University of Nevada - Las Vegas - Division of Earth Sciences - Dr. Thomas Flynn**

This study integrates fluid geochemistry, stable light isotope data, glacial ice data and archaeological information to study the genesis of geothermal fluids in the Great Basin. Substantial new chemistry data is being obtained for several moderate-, and high-temperature resources in Nevada. A contemporary fluid recharge model and the paleo recharge model will be developed as part of this study.

**New Mexico Research and Development Institute - Dr. Larry Icerman**

NMRDI is conducting an evaluation of time-integrated radon soil-gas surveys in the southern Rio Grande Rift. Radon gas concentrations will be determined as a function of depth and caliche development and surveys will be completed over the Radium Springs geothermal area. Surveys will then be completed in the Tortugas Mountain and Rincon areas as preliminary geothermal resource evaluation.

**North Dakota Mining and Mineral Resources Research Institute (MMRRRI) - Dr. William Gosnold**

The North Dakota MMRRI brings together the North Dakota and South Dakota Geological Surveys and UND staff for a comprehensive geothermal resource assessment of these two states. Five new heat flow holes will be drilled in each state, and temperature, hydrologic, and stratigraphic data will be integrated with

existing data to evaluate the production potential for geothermal aquifers in these states.

**Utah Geological and Mineral Survey - Mr. Robert E. Blackett**

The Utah Geological and Mineral Survey (UGMS) is conducting a geothermal resource assessment at the New Castle geothermal area in cooperation with the University of Utah Department of Geology and Geophysics. This study includes detailed mapping in bedrock and Quaternary deposits, a soil mercury geochemical survey, fluid geochemistry, gravity surveys, and temperature monitoring in twelve shallow (<60 feet) gradient holes. A conceptual model will be developed which may be applicable to other blind Basin and Range hydrothermal systems.

**Washington Department of Natural Resources - Mr. Michael Korosec**

The State of Washington - DNR has drilled eight 150 m temperature gradient holes to improve the delineation of the Southern Washington Cascade Range heat flow high. These data, coupled with K-Ar age dating and geochemical analyses will be used to refine time-space-volume models for Cascade volcanism and to evaluate geothermal potential of the region.

**University of Wyoming - Department Geology and Geophysics - Dr. Henry P. Heasler**

Dr. Heasler is working with two University of Wyoming mathematicians to develop improved three-dimensional computational schemes for solving the combined heat conduction and forced convection equations for determining subsurface temperatures. A model will be developed for either the Cody or Thermopolis hydrothermal system in the Bighorn Basin, Wyoming. The computational techniques will be applicable to a large number of mixed convective - conductive geothermal resources.

12/02/88

# FY-88 ANNUAL REPORT

## HYDROTHERMAL RESEARCH

## STATE COOPERATIVE RESERVOIR ANALYSIS PROGRAM

### I.0 Introduction

The State Cooperative Reservoir Analysis Program (SCP) was established by DOE in 1977, as the State Coupled Program to assess low-and moderate-temperature geothermal resources in the U. S. The early efforts of the SCP were national in scope. Geoscientific investigations were made in all states, with the more intensive activity focusing on states with either known existing geothermal resources or a large user potential. These studies provided extensive input to the USGS computer file GEOTHERM and demonstrated that most moderate-and high-temperature geothermal resources are found in the western portion of the country, with scattered low-temperature resources also found in the great plains and Atlantic coast region. These and subsequent studies have led to the publication and distribution of a series of state geothermal resource maps. More recent work has expanded upon earlier resource assessment activities and included detailed reservoir analysis and generic studies.

Research activities within the SCP are carried out by a state agency or group given the responsibility for geothermal resource evaluation within that particular state. Past participants have included state geologic surveys, water resource departments, and university geoscience departments within the western United States. SCP programs are initiated by the Division of Geothermal Technology and are administered by the Idaho Falls Operations Office. UURI provides technical and administrative support to DOE/DGT and DOE/ID, and technical geoscience support to various state teams.

### II. Fiscal Year Accomplishments

#### Pre-1988 Grants

Eight grants established by DOE from 1984 to 1986 continued to be active in FY88. Technical studies were completed by six state teams during FY88 although some deliverables remained outstanding at year's end. A brief summary of these projects follows.

#### Alaska - Division of Geological and Geophysical Surveys

Final interpretation and reporting of the geochemical and petrographic study of the Mt. Spurr volcano geothermal resource area was completed. Although the area is somewhat remote a geothermal resource potential is indicated, and some state lands have been leased. A "Alaska Geothermal Bibliography" was also completed and made available to the public as a deliverable.

University of Arizona - Department of Geoscience

This grant provides for the completion of 40 K/Ar age dates of young geologic samples in support of State Cooperative Program teams and other DOE funded hydrothermal research. Thirty samples were submitted during FY88 which will conclude the work under this grant. Age dates of samples submitted during FY88 support geologic studies and the evaluation of geothermal resource potential in the Oregon and Washington Cascade Range, and studies of the Los Azufres, Mexico and Ascension Island geothermal systems.

Idaho - Department of Water Resources

Idaho-DWR and USGS studies of the Twin Falls County geothermal areas were completed, but the USGS report is still pending. These studies document the geologic controls for the Banbury Hot Springs and Twin Falls geothermal systems, and provide base line data for reservoir management as development of these systems continues. A subcontract study by Boise State University documents declining heads within the Boise geothermal aquifer and provides base line data for future reservoir management.

Montana - College of Mineral Science and Technology

This grant supported detailed gravity and CSAMT studies of the Ennis Hot Springs area, Montana as two MS theses. State-of-the-art geophysical studies were completed which defined the probable resource area.

New Mexico Research and Development Institute

A final report was submitted by NMRDI which provides a major study of the geologic controls for the geothermal resources of southwestern New Mexico. Other reports describe hydrologic studies of the Animas Valley geothermal resource and drilling projects at the Las Cruces geothermal resource and in the Urogrande area.

North Dakota - Mining and Mineral Resources Research Institute

The technical studies completed under this grant in FY87 defined a large area in southern South Dakota where seven accessible aquifers carry temperatures of 30 to 120 degrees C. Work continued in FY88 on the 1:1,000,000 scale Geothermal Resource Map of South Dakota.

Oregon Department of Geology and Mineral Industries

DOGAMI completed detailed geologic mapping projects and a plan for future geothermal research and deep drilling in the Oregon Cascades. Technical studies of the industry drill hole, UTGH-1, and final reporting for this grant neared completion.

Southern Methodist University

Dr. David Blackwell completed his compilation of heat flow data for the Decade of North American Geology geothermal map, and a compilation of heat flow data for the entire United States. Final heat flow measurements for Cascade industry holes were also completed and reported to DOE.

An impressive amount of geothermal resource assessment and research is documented by the deliverables of these SCP team members. Numerous technical reports have been published by the individual state teams, in professional journals, and as reports to DOE. SCP principal investigators presented their results at annual meetings of the Geothermal Resources Council, the Geological Society of America, and the American Geophysical Union.

## 1987 SCP GEOTHERMAL SOLICITATION

A new Program Research and Development (PRDA) for State Geothermal Research and Development was issued by the DOE-Idaho Operations Office in April 1987. This PRDA provided funding of approximately $1,200,000 for cost shared state-oriented research and development of geothermal energy. The final evaluation of competitive proposals was completed early in FY88 and 11 new grants were awarded between January and September.

A broad range of research, generic studies, and resource assessment is represented by these grants. Regional resource assessments are being carried out in North and South Dakota, Washington, Alaska, and Nevada. Specific geothermal systems are the subject of detailed studies in Alaska, Hawaii, Idaho, Wyoming, Nevada, Utah and New Mexico. Geochemical research and data collection is a major component of studies in Hawaii, Nevada, Idaho and New Mexico. Advanced numerical modeling of combined heat flow and fluid flow is underway at the University of Wyoming and the University of North Dakota.

Technical studies were well underway for all but a few grants at the end of FY88. The term of these grants varies between 12 and 24 months, and contract modifications and time extensions are to be expected. Excellent progress and interesting new data are already reported by the Alaska, North Dakota, Utah, and Washington state teams.

## III. Management

### 1. Organization

### 2. Interfaces/Contacts

The primary interfaces within the State Cooperative Projet are the various state teams and their Principal Investigators. A listing of the teams and PI s active in FY88 follows:

Alaska-Division of Geological and Geophysical Surveys
Dr. Roman Motyka
University of Alaska-Geophysical Institute
Dr. Donald Turner
University of Arizona- Dept. of Geosciences: Dr. Paul Damon
Hawaii- Dept. of Business and Economic Development
Dr. Donald Thomas
Idaho- Division of Water Resources: Ms. Leah Street
Montana College of Mineral Science and Technology
Dr. William Sill, Dr. Charles Wideman
University of Nevada- Desert Research Institute
Dr. Elizabeth Jacobson
University of Nevada- Division of Earth Sciences
Mr. Thomas Flynn
New Mexico Research and Development Institute
Dr. Larry Icerman
University of North Dakota- Mining and Mineral Res. Inst.
Dr. William Gosnold
Oregon Department of Geology and Mineral Industries
Dr. George Priest
Utah Geological and Mineral Survey: Mr. Robert Blackett
Washington- Department of Natural Resources:
Mr. Michael Korosec
University of Wyoming- Department of Geology and Geophysics
Dr. Henry Heasler

3. Meetings/Reviews

No specific meetings were organized for the SCP teams as a group. DOE/ID convened a meeting of it's Technical Review Committee for a final ranking of proposals at Idaho Falls on November 9, 1987. The review of a Idaho-DWR subcontractor report on the Boise geothermal aquifer, and plans for a well test of this geothermal system were the subjects of several meetigs involving ID-DWR, DOE/ID, UURI, EG&G, USGS, and City of Boise representatives throughout FY88. The reservoir test was later cancelled. Several state team members gave presentations at the GRC, GSA, and AGU annual meetings.

4. Issues

Several issues arose during FY88, most of which have been resolved. Funding available for the new solicitation was substantially less than the total amount requested by worthy proposals. To fund as many of the hihger rated projects as possible DOE negotiated SOW's for only the most important tasks. Unfortunately not all proposals in the competitive range could be funded. An unsolicited proposal by the State of Oregon (DOGAMI) was judged to have technical merit but only limited funds were available to fund it. The identification of a specific drilling site along the axis of the Cascades, and environmental studies of the project impact must be completed before this grant can be funded. DOE faced polotical pressure and the potential for

lawsuits because of the sensitive nature of a report describing declines of the Boise geothermal aquifer, and because of plans to conduct a critically needed well test of this aquifer. The wording of the report was modified and DOE withdrew plans for the Idaho-DWR aquifer test.

IV. Budget

V. End of Year Status

With the successful completion of essentially all the pre-FY88 SDP grants, the current status derives from progress on the 11 new grants. The Washington-DNR thermal gradient drilling has been completed, with six of eight holes recording temperature gradients of about 50 deg C/km. The field work at Geyser Bight, AK KGRA was completed and a great increase in the knowledge of this high-temperature system will be forthcomming. The Utah (UGMS) Newcastle data gathering nears completion, and a significant case study of this "blind" Basin and Range system will result. Most other studies are less advanced due to the lengthy funding process. Several of these studies address the possible overdevelopment and depletion of reservoirs currently used for district space heating; all the funded projects have technical and economic merit.

The major problem facing the State Cooperative Program is that of funding. Congress did not add new funds for FY89 so new projects cannot be funded and supplemental funding for the present projects is essentially zero. This may mean the end of several state teams and the resulting loss of geothermal expertise within these states- a serious problem for many states with undeveloped resource potential or for states with declining geothermal reservoirs because of unregulated production.

VI. Future Plans

The present grants will continue for another six to 24 months, with some possibility of contract modification and no cost time extension. Many of the studies will be reported in national technical journals and presented at professional meetings such as the GRC, GSA, and AGU. Without new funding by Congress the program will be phased out by the end of FY90. Another open solicitation for state-oriented, cost-shared research is the best way to identify the most important projects to fund.

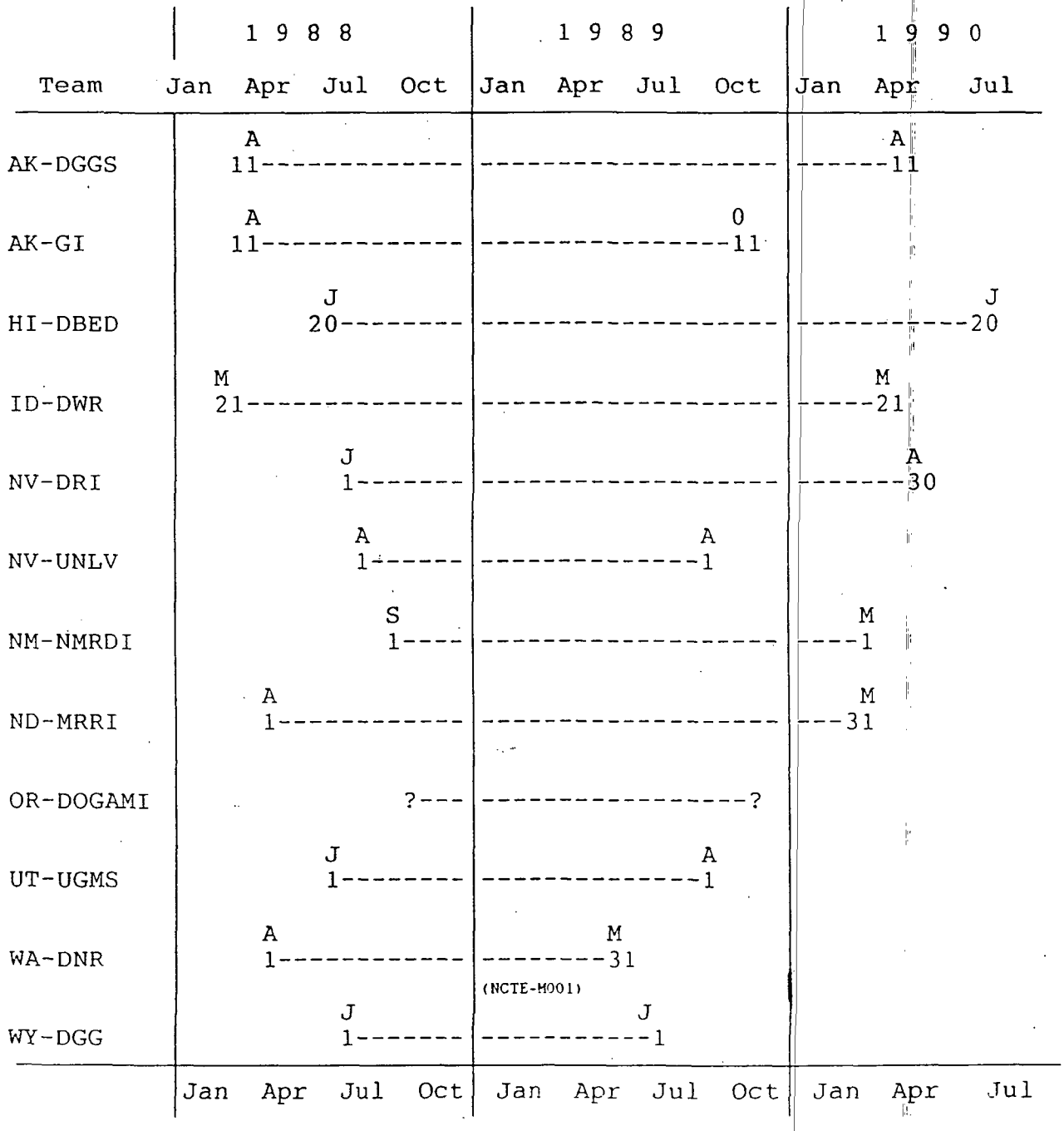
# 1988-89 State Team Info:

| Team | Principal Investigator | Telephone | |
|---|---|---|---|
| Univ-Alaska-Geophys Inst. | Dr. Donald L. Turner | (904) 474-7198 | L. |
| Alaska - DGGS | Dr. Roman Motyka | (907) 465-2520 | |
| Hawaii - Dept. Bus. Econ. Dev. | Dr. Donald Thomas | (808) 948-6482 | MH |
| Idaho - Dept. Water Res. | Ms. Leah Street | (208) 734-3578 | LI |
| U. Nevada - L.V. Desert Res. Inst. | Dr. Elizabeth Jacobson | (702) 673-7373 | LF |
| U. Nevada - L.V. Div. Earth Sciences | Mr. Thomas Flynn | (702) 784-6151 | MK |
| New Mexico - NMRDI | Dr. Larry Icerman | (505) 827-5886 | add't MR |
| U. North Dakota | Dr. Wil Gosnold | (701) 777-2631 | K.H. |
| Oregon - DOGAMI | Dr. George Priest | (503) 229-5580 | not yet |
| Utah - UGMS | Mr. Robert Blackett | (801) 581-6831 | M K |
| Washington - DNR | Mr. Michael Korosec | (206) 459-6372 | L.T |
| U. Wyoming - D.G.G. | Dr. Henry Heasler | (307) 766-3278 | M.K |

STATE TEAM SCHEDULES

1988 GRANTS

Short Form Summary, 1 May 1989



WSEO



STATEMENT OF WORK

## 1.0 INTRODUCTION

The FY-1987 Continuing Resolution Bill, PL 99-591, includes funding to be used specifically to assist states with significant resources to continue programs relating to resource assessment, development or technical assistance and related activities. The Washington State Energy Office (WSEO), in response to PRDA No. DE-PR07-87ID12662, will complete and verify the computer program GEODIM that is intended for use in the design and optimization of geothermal systems connected to district heating or other major geothermal direct utilization facilities.

## 2.0 SCOPE

The scope of the work to be performed by the Washington State Energy Office includes the analysis, completion, and field verification of the computer program GEODIM. The tasks that are included are as follows:

| TASK | ACTIVITY |
|---|---|
| 1 | Evaluate and analyze the partially completed GEODIM computer program. |
| 2 | Modify the GEODIM computer program. |
| 3 | Field test, verify and finalize the GEODIM computer program. |
| 4 | Complete and publish documentation. |

## 3.0 APPLICABLE DOCUMENTS

The work described herein is abstracted from a proposal titled "Development and Field Testing of Geothermal Optimization Computer Model GEODIM" dated June 18, 1987, as revised on September 15, 1987, submitted to the U.S. Department of Energy, Idaho Operations Office, in response to PRDA No. DE-PR07-87ID12662.

## 4.0 TECHNICAL TASKS

TASK 1. Evaluate and Analyze the Partially Completed GEODIM Computer Program

1.1 Conduct a complete evaluation of the completed portion of the GEODIM computer program. This will be performed by WSEO's geothermal and computer departments.

1.2 Perform an analysis of the rationale developed by the University of Lund for completion of the program and an evaluation as to what modifications, if any, are required to meet the needs of the wide variety of geothermal projects that the program must be designed to meet. This portion of the work will be under the direction of WSEO, but will include review and input from the Oregon Institute of Technology, the Oregon Department of Energy, the Idaho Department of Water Resources, and the University of Lund.

1.3 Determine, together with the University of Lund, input and output parameters that are critical to meet the needs as determined under Task 1.2.

TASK 2 Modify the GEODIM Computer Program

Modify the completed part of the program as needed. Design and develop logic and/or code for the uncompleted portion of the program. This work will be carried out at the University of Lund, Department of Engineering Geology through a contract arrangement with WSEO. WSEO will establish computer linkage with the University of Lund in order to facilitate review and direction of work in progress.

TASK 3 Field Test, Verify and Finalize the GEODIM Computer Program

3.1 Field test and calibrate the program against the reference system, which is the 50 $MW_{th}$ Lund geothermal system. Make any necessary corrections to the program. This task will be performed by the Department of Engineering Geology, University of Lund.

3.2 Field test the program on selected operating U.S. geothermal systems. Systems selected for field testing include: Yakima and Walla Walla, Washington; Boise, Idaho; and Klamath Falls, Oregon. Additional sites will be selected if needed. WSEO will direct the field test but with assistance and cooperation of the Oregon Institute of Technology, the Oregon Department of Energy, and the Idaho Department of Water Resources. The gathering and preparation of field test data will be done by subcontractors to be selected by WSEO.

3.3 Prepare detailed recommendations to the operators of the tested systems. This will include a description of the status of the system and suggestion for optimization. This work will be completed by WSEO.

3.4 Upon completion of the field tests, the program will be revised to correct the errors in code or program features found to be unsatisfactory. Any modifications to the program will be conducted by the University of Lund. After completion of any modifications, the test system will be rerun by WSEO.

TASK 4 Complete and Publish Documentation

4.1 Complete work on the GEODIM User Manual, source code, and program documentation. These work elements will be completed by the University of Lund.

4.2 Publish the user manual and make the program and user manual available to all interested parties. WSEO will prepare the final manuscript and printing will be done by the Washington State Department of Printing. WSEO will advertise the availability of the program in a number of national publications and will present the results of the work at local, regional, and national meetings.

5.0 REPORTS, DATA AND OTHER DELIVERABLES

Reports will be due as indicated in Part V - Reporting Requirements. Additional deliverables required by this grant are as follows:

DELIVERABLES

5.1 Completed GEODIM Computer Program.

5.2 GEODIM computer program user manual including program documentation and an annotated source code.

5.3 Analyses and recommendations for operating district heating systems at Walla Walla and Yakima, WA; Boise, ID; and Klamath Falls, OR.

6.0 SPECIAL CONSIDERATIONS

None.

wp/Thorne
1213

## REPORT DISTRIBUTION LIST

Grant No. DE-PR07-88ID12739

| Report/Plan | Form No. | Frequency | No. of Copies | Address |
|---|---|---|---|---|
| Federal Assistance Management Summary Report | EIA-459E | Q | 1,1,1,1,1 | a,b,c,d,e |
| Notice of Energy RD&D | DOE 538 | O | 1,1 | a,f |
| Technical Progress Report | N/A | Q | 1,1,1,1 | a,b,d,e |
| Topical Report | N/A | A | 1,4,1,1 | a,b,d,e |
| Final Technical Report | N/A | F | 1,4,1,1 | a,b,d,e |
| Financial Status Report | SF-269 | F | 1,1,1 | a,b,c |

## LIST OF ADDRESSEES

a. U.S. Department of Energy
785 DOE Place
Idaho Falls, ID 83402
Attn: Trudy A. Thorne

b. Same as above
Attn: Kenneth J. Taylor

c. Same as above
Attn: Earl Jones

d. U.S. Department of Energy
Forrestal Bldg., CE-342
1000 Independence Ave, SW
Washington, DC 20585
Attn: Marshall Reed

e. EG&G Idaho, Inc.
P.O. Box 1625
Idaho Falls, ID 83415
Attn: Ben Lunis, WCB E-3

f. U.S. Department of Energy
Technical Information Center
P.O. Box 62
Oak Ridge, TN 37830

U.S. DEPARTMENT OF ENERGY Grant Number: DE-PR07-88ID1273

# FEDERAL ASSISTANCE REPORTING CHECKLIST

FORM EIA 459A (10-90)

FORM APPROVED OMB NO 1900-0127

| 1. Identification Number: DE-PR07-88ID12739 | 2. Program/Project Title: Geothermal Research & Development Asst. |
|---|---|

3. Recipient: Washington State Energy Office

| 4. Reporting Requirements: | Frequency | No. of Copies | Addressees |
|---|---|---|---|
| **PROGRAM/PROJECT MANAGEMENT REPORTING** | | | |
| ☐ Federal Assistance Milestone Plan | | | |
| ☐ Federal Assistance Budget Information Form | | | |
| ☒ Federal Assistance Management Summary Report | Q | 1,1,1,1,1 | a,b,c,d,e |
| ☐ Federal Assistance Program/Project Status Report | | | |
| ☒ Financial Status Report, OMB Form 269 | F | 1,1,1 | a,b,c |
| **TECHNICAL INFORMATION REPORTING** | | | |
| ☒ Notice of Energy RD&D | O | 1,1 | a,f |
| ☒ Technical Progress Report | Q | 1,1,1,1 | a,b,d,e |
| ☒ Topical Report | A | 1,4*,1,1 | a,b*,d,e |
| ☒ Final Technical Report | F | 1,4*,1,1 | a,b*,d,e |

FREQUENCY CODES AND DUE DATES:

A - As Necessary; within 5 calendar days after events
F - Final; 90 calendar days after the performance of the effort ends.
Q - Quarterly; within 30 days after end of calendar quarter or portion thereof.
O - One time after project starts; within 30 days after award.
X - Required with proposals or with the application or with significant planning changes.
Y - Yearly; 30 days after the end of program year. (Financial Status Reports 90 days).
S - Semiannually; within 30 days after end of program fiscal half year.

5. Special Instructions:

*3 copies plus a camera-ready copy

| 6. Prepared by: (Signature and Date) | 7. Reviewed by: (Signature and Date) |
|---|---|
| Kim 10/4/91 22-88 | Judy Thorne 4/19/88 |

# TECHNICAL PROPOSAL

# AND

# REQUEST FOR INCREMENTAL FUNDING: FY-91

## TECHNICAL AND ADMINISTRATIVE SUPPORT

## STATE COOPERATIVE RESERVOIR ANALYSIS PROGRAM

submitted to

DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE
785 DOE PLACE
IDAHO FALLS, ID 83402

by

University of Utah Research Institute
Earth Science Laboratory
391 Chipeta Way, Suite C
Salt Lake City, UT 84108-1295

September 12, 1990

Howard P. Ross
Principal Investigator
Earth Science Laboratory
University of Utah
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Wilford L. Forsberg
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Phillip M. Wright
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# STATEMENT OF WORK

# STATE COOPERATIVE RESERVOIR ANALYSIS PROGRAM

## 1.0 Introduction

The State Cooperative Reservoir Analysis Program (SCP) was established by DOE in the late-1970's, as the State Coupled Program to assess low- and moderate-temperature geothermal resources in the United States. Since the inception of this program, UURI has provided technical program monitoring, coordination, and administrative support to DOE for the SCP, and has provided technical support to state teams especially in the areas of geochemistry and geophysics.

As a result of a 1987 solicitation, the DOE/ID Program Research and Development Announcement (PRDA) for State Geothermal Research and Development-PRDA No. DE-PR07-87ID12662, ten grants and one cooperative agreement were signed with state-designated agencies to conduct geothermal research. One additional grant with the Oregon Department of Geology and Mineral Resources (DOGAMI) has since been signed which calls for incremental, phased funding. Nine grants remain active as of September 12, 1990. Two grants are scheduled for completion on September 30,1990 but draft final reports have not yet been received and reviewed, and additional no cost time extensions (NCTE) may be required. Recent NCTE's and contract modifications now in progress provide for six grants to be completed between October 1, 1990 and June 20, 1991. The DOGAMI grant extends to October 15, 1992.

## 2.0 Scope

UURI will continue to provide technical and administrative support to DOE/ID and DOE/HQ for the continuation of the State Cooperative Program for FY-91. Anticipated activities include progress monitoring, review of state-team expenditures, critical review of state-team technical reports and technical assistance in geology, geochemistry, and geophysics to the state teams. The critical review of final technical reports is an important effort during the concluding phase of this program.

## 3.0 Applicable Documents

Applicable documents are reports submitted on geoscience research and technical assistance conducted under DOE Contract No. DOE-AC07-85ID12489 and from DOE Contract No. DE-AC07-90ID12929, and DOE/ID Program Research and Development Announcement (PRDA) for State Geothermal Research and Development-PRDA No. DE-PR07-87ID12662.

## 4.0 Technical Tasks

The following technical tasks will be completed in support of State Cooperative Program activities under the requested FY-91 Incremental Funding.

4.1 Continue monitoring of and technical assistance for 9 SCP grants. At least 4 grants are expected to continue after January 1, 1991. Prepare a report which summarizes the results of the 11 SCP grants, and present the report at an appropriate DOE or GRC meeting. Provide support for the OIT Geo-Heat Center inventory of hydrothermal potential (T>120 °F) collocated with cities in 14 western states.

4.2 Provide continuing technical assistance (geophysical, geochemical) to state teams as follow up to resource definition studies initiated under the 1987 PRDA, and collaborate with state team scientists in reporting and/or presenting technical results. Field studies are currently planned in support of the Utah and New Mexico state teams.

4.3 Provide geologic, geochemical, physical property, laboratory, age dating, and other support for the DOGAMI Santiam Pass drill hole. UURI has reserved approximately $6000 of FY-90 Technical Assistance funds for this purpose.

4.4 Evaluate possible future initiatives for the State Cooperative Program. Identify high priority states and suggest projects of interest to DOE.

5.0 Reports, Data, and Deliverables

Prepare appropriate reports and deliverables based on the above tasks, including monthly progress reports, weekly news items, and technical reports as appropriate.

6.0 Special Considerations

None.

7.0 Requested Funding

The funding requested for this project for FY-91 is $50,500.

The requested funding provides partial support for Howard P. Ross, Project Manager, and other UURI scientists as required for review and advice. The above funding will also provide for travel to the 1991 Geothermal Resources Council (Sparks, NV), to DOE/Idaho, and for field work in support of state teams as may be required.

Proceedings - DOE Geothermal PR VIII San Francisco CA. April 17-20, 1990

# HYDROTHERMAL ENERGY - AN IMPORTANT PART OF AMERICA'S ENERGY STRATEGY

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Salt Lake City, UT

## ABSTRACT

The U.S. Dept. of Energy (DOE) established a Geothermal Energy Program in the mid-1970's as one response to America's need to develop alternative energy sources. One element within the Geothermal Program is Hydrothermal Energy, which includes Industrialization, Reservoir Technology, and Conversion Technology as separate tasks. The successes which have resulted from this program, combined with anticipated future progress, will increase the role of geothermal energy as a contributor to our nation's future energy needs. Geothermal energy has become an important component of the U.S. National Energy Strategy.

## INTRODUCTION

During the 1970's America became increasingly concerned about its' dependence on imported fossil fuel energy. As a result, a national commitment was made to evaluate and develop alternative energy resources. Among the many alternative energy resources being considered was geothermal energy. There were, and are, several characteristics about the geothermal energy resource which make it advantageous over other resources. It's abundance in the United States and the fact that it's development poses a minimum hazard to the environment are among the many advantages. However, there were many unknowns concerning this resource. Recognizing this, the United States Department of Energy (USDOE) established a Geothermal Program which continues today.

Because of the various forms in which the Geothermal resource takes, the USDOE's Geothermal Program consists of four categories: Hydrothermal, Geopressured, Hot Dry Rock and Magma. This paper describes the Hydrothermal energy research category and indicates the status for some of its' current projects.

The hydrothermal resource consist of large reservoirs of heated fluid. The temperatures and chemical composition of the reservoir fluids vary which in turn varies the way they are utilized. Low-and moderate-temperature resources, (10 to 150 C) are used primarily in direct heat applications such as heat pumps, aquaculture, and space heating. High temperature resources, (¶150 C) are more commonly used for power generation.

There are many challenges to utilizing the high temperature hydrothermal resource. These challenges include locating and quantifying the resource, drilling into the resource, handling the brines, solving power plant development and maintenance problems, and injecting the brines. The goal of the Hydrothermal Program is to provide solutions to challenges such as these and ultimately to reduce the life-cycle cost of electricity produced from the hydrothermal resource to 3 - 7 cents / kWh by 1997.

Because of the wide range of utilization and the accompanying challenges, the Hydrothermal Program has been divided into four tasks. These tasks are Industrialization, Reservoir Technology, Hard Rock Penetration and Conversion Technology. DOE-HQ located in Washington D.C. provides the program management for all of these tasks. The project management for all tasks with the exception of the Hard Rock Penetration task, is provided by DOE-ID located in Idaho Falls, ID. This paper will only discuss those tasks managed by DOE-ID. The fiscal year 1990 budget levels for these tasks are shown in Table 1.

| Task | Funding, ($K) |
|---|---|
| Reservoir Technology | 2,100 |
| Energy Conversion | 1,500 |
| Industrialization | 350 |

TABLE 1 - FY-1990 funding for tasks in the Hydrothermal Program

Each task consists of several projects, which are being carried out by various government labs, universities and contractors. A description and status of the three tasks and their respective projects follows.

## INDUSTRIALIZATION

The goal of the industrialization task is to promote the use of Geothermal Energy throughout the nation and the world. The industrialization task is broken up into two projects. These projects are State Cooperative Grants and Direct Heat Participation & Support.

### State Cooperative Grants

The State Coupled Grants project consists of 12 cost shared grants to various groups to study aspects of geothermal energy that are not being studied by private industry, but which have the potential for results that will be applicable to industry. One additional grant funded by the Reservoir Technology task supporting deep scientific drilling the Cascades is also reported here. Figure 1 indicates those states with a participating state team(s) and the study areas involved. The total funding for the grants in this project is $1,524,996. The grant participants and a brief description of their projects follow.

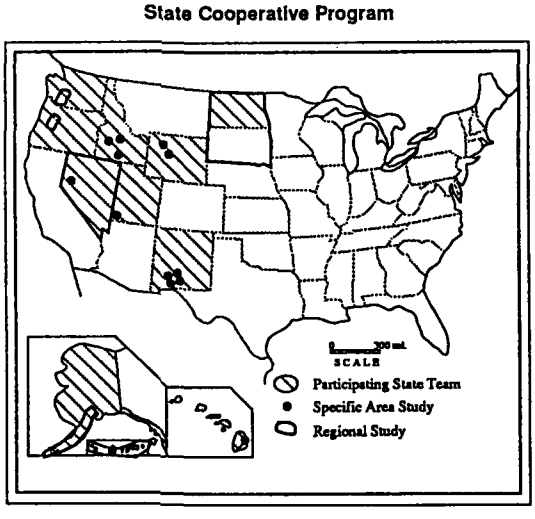


Figure 1. Participating state teams and study areas, State Cooperative Program

The University of Alaska, Geophysical Institute is performing a geologic and geochemical study of the Geyser Bight geothermal resource, Umnak Island. Results to date indicate that a zoned plutonic rock unit 9.5 (Ma) is the probable reservoir rock, and volcanic rocks range in age from 75,000 to 534,000 years. A previously unreported fumarole field, 4 km south of Geyser Bight valley, was discovered during this study.

The state of Alaska, Division of Geological and Geophysical Surveys, has completed a fluid chemistry study of the Geyser Bight area in support of the Geyser Bight geologic study. Fluid chemistry analyses indicate spring waters are derived from two separate reservoirs. Estimate reservoir temperatures, uncorrected for some dilution, are 221-228 C and 225-235 C. Much work remains to be done on the Aleutian Island - Alaska Peninsula geothermal resource map.

The state of Hawaii, Department of Business and Economic Development, is studying methods to control silica deposition from geothermal fluids of the Hawaii East Rift Zone. Mixing of 60% condensate and 40% brine, and treatment with weak acids both show great promise in retarding silica precipitation. The high surface area of precipitated silica may have some commercial value. Completion of the study has been delayed by shutdown of the HGP-A well, the only source of fluids for the study.

The state of Idaho, Department of Water Resources is completing a geochemical study of the Wood River geothermal systems and monitoring of the Banbury-Twin Falls reservoirs. The Berkeley Group, Inc., a subcontractor to ID-DWR, completed a detailed review of all existing data to constrain numerical simulations of present and future reservoir behavior under various development scenarios. All studies will be completed in 1990.

The Desert Research Institute, University of Nevada has completed a 13 month hydrologic monitoring program at the Moana geothermal system. These and other geologic data are being used to complete a quantitative evaluation and numerical model of the Moana resource. The results and the numerical model will be made available to regulatory agencies and developers to coordinate future development of the resource.

The University of Nevada Las Vegas, Division of Earth Sciences has completed a study of the genesis of geothermal fluids of the Great Basin. The study has determined a late Pleistocene age (40,000 - 10,000 years BP) for the fluids which indicates a paleo-recharge scheme. Range-bordering faults probably provide conduits for recharge of the deep geothermal systems. Pleistocene lakes probably contributed to recharge in western Nevada.

The New Mexico Research and Development Institute is using a subcontractor, New Mexico State University, in a study to evaluate the use of time-integrated radon soil-gas surveys for geothermal resource assessment in the southern Rio Grande Rift. One drill hole which tests a radon anomaly in the Rincon survey area has recorded a temperature of 65 C at depth of 90 meters. This study has advanced the radon

soil-gas technique and yielded several target areas for moderate-temperature geothermal fluids.

The state of North Dakota, Mining and Mineral Research Institute, is cooperating with the Geological Surveys of North Dakota and South Dakota in a comprehensive geothermal resource assessment. Five heat flow holes have been drilled and logged in the South Dakota heat flow anomaly. Five more heat flow holes will be drilled this spring, three in South Dakota and two in North Dakota. New studies suggest the stratabound geothermal resource may be twice as large as previously reported.

The State of Oregon, Department of Geology and Mineral Industries, is drilling a deep scientific and heat flow hole at Santiam Pass on the crest of the Oregon Cascades. The projected depth of Santiam Pass 77-24 is 3000 feet. This project is jointly funded by DOE and Oxbow Geothermal Corporation. This hole was drilled to 460 feet and cased in November prior to shutdown for winter.

The state of Utah, Geological and Mineral Survey, has completed a multidisciplinary study of the Newcastle resource which currently provides space heating for three large greenhouses, a church, and several residences. Geological, geophysical, and geochemical studies have characterized this hidden resource in detail, and have determined a reservoir temperature in excess of 130C, with an anomalous heat loss of 12.4 MW. The study suggests new approaches for the discovery of other hidden Basin and Range geothermal systems.

The state of Washington, Department of Natural Resources drilled eight 152 meter temperature gradient holes to better define the southern Washington Cascade Range heat flow data. Two holes did not penetrate the effects of cold surface waters, but four holes had temperature gradients of 50 to 58 degrees C/km. A related study integrated K-Ar age dates, geochemistry and volcanic stratigraphy of the Indian Haven Quaternary volcanic to evaluate volcanic production rates.

The state of Washington, State Energy Office is finalizing a computer program (GEODIM) which optimizes the design of wells, pipes, pumps and heat transfer systems.

The University of Wyoming, Department of Geology and Geophysics is developing an improved three-dimensional computational scheme for solving the combined heat conduction and forced convection equations for determining subsurface temperatures. A model will be developed for one of the Bighorn Basin hydrothermal systems.

A review of the interim and final results so far indicates that the current state team grants have been extremely productive in terms of developing new resource information (Washington Cascades; Newcastle, Utah; Rio Grande Rift), reservoir monitoring and evaluation data, and in addressing production problems (Hawaii silica studies).

Information and reports pertaining to these projects can be obtained by contacting Dr. Howard Ross at the University of Utah Research Institute. The majority of these grants will be completed by December, 1990. If additional funding becomes available for this project, it will be continued with new grants being issued.

Direct Heat Participation & Support

The Direct Heat Participation and Support project is made up of activities which have been or are taking place under two grants. The two grantees are the Oregon Institute of Technology and the National Geothermal Association.

The grant with the Oregon Institute of Technology, (OIT) is to perform research and development assistance in areas of geothermal direct-use development, and moderate temperature (90 - 150 C) wellhead electric generating systems. Direct-use development assistance ranges from answering technical questions and consultations on methods, equipment and applications to providing technical and engineering economic feasibility studies. Applications areas include space and district heating, geothermal heat pumps, greenhousing, aquaculture, and industrial processing.

Recipients of technical assistance include individual home and business owners, district heating systems operations and maintenances personnel, and consulting engineers. Work consists of consultation during initial design phases of projects, trouble shooting and failure analysis, and recommendation for corrections.

The Geo-Heat Center also provides information services in the forms of: a quarterly Bulletin (2000 subscribers), special technical papers and presentations, Geothermal Direct Use Engineering and Design Guidebook, published feasibility studies, a geothermal library, computer programs to aid in design, and tours of geothermal facilities.

Current research activities include: (1) ascertaining optimum exploration and assessment strategies for hydrothermal and geopressured resources collocated with cities and potential greenhouses and aquaculture sites; (2) investigation into the use of uninsulated piping for geothermal district heating systems; and (3) reservoir/well interaction research involving the downhole heat exchanger.

Anyone interested in the technical assistance or information pertaining to this work should contact Paul Lienau, OIT.

The grant with the National Geothermal Association is intended to promote U.S. geothermal technology world wide. A number of the projects taking place in this grant have had significant cost share from state governments and industry. To date, the grant has resulted in a number of accomplishments. Among them are: (1) conferences between foreign geothermal developers and U.S. power plant companies to allow foreign developers to see first hand the services which exist in the U.S.; (2) giving the World Bank a briefing on geothermal energy; (3) developing a report titled "A National Strategy for the Export of U.S. Geothermal Technology"; and (4) sending a team of U.S. geothermal developers to the Magati Soda Company located in Kenya and to Central America to assess the U.S. geothermal industries opportunities.

Activities currently underway include the development of world wide power plant data base and a Geysers Monograph.

The work done under this grant has been extremely productive in helping U.S. geothermal industries assess their opportunities world wide. A report has been developed for each project which has taken place under this grant. These reports can be obtained by contacting Dave Anderson, National Geothermal Association.

## RESERVOIR TECHNOLOGY

The goal for the Reservoir Technology task is to improve the technology for geothermal energy resource utilization by developing and testing analytical and interpretive methods to more effectively locate, develop and utilize hydrothermal resources. By obtaining this goal, it is thought that:

> Industry will be enabled to maximize energy recovery from a resource through more realistic predictions of reservoir performance.
>
> The adverse thermal and chemical effects of injection on geothermal reservoirs will be reduced.
>
> New techniques will be developed to identify fractures in geothermal reservoirs and to locate geothermal reservoirs.

The task is broken into five projects: Reservoir Analysis, Exploration Technology, Brine Injection, Geothermal Technology Organization, and Geysers Related Research.

### *Reservoir Analysis*

The Reservoir Analysis project is intended to provide analytical and interpretive tools for determining reservoir characteristics and reservoir performance with greater certainty. The objectives for the project are to improve production well siting and decrease the uncertainty associated with long-term reservoir decline. Several activities are currently taking place in this project.

The Lawrence Berkeley Laboratory (LBL) and the University of Utah Research Institute (UURI) are developing new geophysical equipment and field testing its' use for monitoring fluid flow in reservoirs. LBL continues the testing of vertical seismic profiling and microseismic monitoring for detection and mapping of fractures in geothermal systems. Finally, LBL and UURI are developing and verifying computer modeling methods to evaluate the use of borehole geophysical techniques for locating fractures and permeable zones in geothermal systems.

Stanford University, the Idaho National Engineering Laboratory (INEL) and LBL are analyzing field data from individual production well tests and interference tests. They will refine computer modeling techniques for identifying reservoir processes and evaluating their impact on the response of hydrothermal systems to development. In addition, UURI, LBL and INEL are interpreting field data and attempting a synthesis of knowledge about reservoir processes.

Stanford and LBL are continuing their efforts to develop theoretical and computer models to predict reservoir performance from combined well testing and production history. They are using laboratory physical models to develop techniques for simulating the response of geothermal systems to different reservoir management programs and evaluating the usefulness of these techniques for estimating the generating capacity and longevity of these systems.

### Brine Injection Technology

The Brine Injection Technology project addresses industry needs for effective and environmentally acceptable injection systems which reduce adverse impacts on geothermal reservoirs. The objective for this project is to decrease the uncertainty associated with injecting brines into producing reservoirs. The project is focusing on three specific areas: fluid migration, fluid-rock chemical interactions, and injection well placement.

UURI is evaluating potential geothermal tracers in laboratory experiments which simulate natural geothermal systems. They are developing, with industry, field operations techniques for tracer injection, sampling, and interpretation to track the transport of injected fluid. INEL and Stanford are applying computer modeling techniques to the tracer return field data for the determination of reservoir physical properties and fluid interactions in the reservoir. UURI, Stanford, LBL and INEL are

participating in a field test with Oxbow Geothermal Company in the Dixie Valley system to verify tracer usefulness and to develop interpretative methods to analyze tracer results.

LBL and UURI are performing theoretical studies of geophysical techniques to determine if injection of spent geothermal fluids can generate signals which can be detected at the surface with existing geophysical equipment. They will design equipment capable of detecting the theoretically determined signals if existing equipment is found to be unsuitable.

INEL is continuing to develop computer models with the capability to analyze and predict the flow of injected fluids through reservoirs. INEL researchers are investigating the potential for coupling the fluid flow computer model with models of chemical interactions between rocks and the injected fluid. The INEL fluid flow model FRACSL is available for simulation of injection into commercial geothermal systems.

Exploration Technology - The Exploration Technology project is designed to develop techniques to locate and characterize geothermal resources. The objectives for this project are to increase the success ratio of wildcat wells and to devise better methods of discovering hidden geothermal systems. The following work is currently being done in this project.

UURI is collecting and analyzing existing data from geothermal exploration projects and is integrating it with geological, geophysical and geochemical data from field and laboratory investigations to develop conceptual models for exploration of geothermal systems. UURI is also utilizing this data to prepare case studies of resource exploration for the industry.

UURI and LBL are performing numerical analysis to determine theoretical geophysical responses from fluid filled fractures and are designing and conducting field tests of surface geophysical techniques to verify the responses expected. They are investigating the use of new interpretation methods for locating fractured hydrothermal systems. They are concentrating on electromagnetic and passive seismic methods of exploration and will combine the observed geophysical data with laboratory measurement of physical properties and existing geologic data to provide exploration plans for regions like the Cascades volcanic province for which the data sets are available.

Geothermal Technology Organization

The Geothermal Technology Organization (GTO) has been formed by the DOE and Industry to sponsor geothermal technological development. The geothermal industry works with the DOE through a cooperative research agreement between the DOE Idaho Operations Office and the GTO. The DOE is represented in the GTO by the INEL.

Research selected for funding by GTO has a high likelihood of yielding near term benefits.

Geysers Related Research

At the last Geothermal Technology Division annual review meeting, several operators asked for research directed toward the problems at The Geysers geothermal field. After discussions with operators and researchers, a number of proposals were compiled to study various aspects of The Geysers reservoir. Several of the proposals were selected for initial funding under the Reservoir Technology Program because of industry interest and the immediate need for the research. The remaining proposals are still under consideration for funding. Industry cost sharing will be an integral part of the support for these remaining projects.

The research projects will be conducted by various laboratories and universities. A strong management team has been designated to coordinate the research projects and to facilitate communication between researchers and industry. Dr. John E. Mock, Division Director, has designated Lawrence Berkeley Laboratory as the "Lead Laboratory" for the The Geysers Research, and he asked Dr. Marcelo Lippmann to act as coordinator and to provide the geothermal operators with a point of contact for joint projects in The Geysers. Mr. Joel Renner, coordinator for the Geothermal Technology Organization, will provide additional contact for the research projects cost-shared with industry. Federal management for the research is provided by Mrs. Peggy Brookshier at the Idaho Operations Office, and by Mr. Marshall Reed in DOE Headquarters.

Initial funding has been provided for research activities relating to geochemistry. Mike Simonson and Don Palmer at the Oak Ridge National Laboratory will begin a thermodynamic investigation of hydrogen chloride in steam to determine the thermodynamic parameters. Mike Adams at the University of Utah Research Institute will initiate the development of vapor phase tracers to track injected fluid through the reservoir. Al Truesdell at the U.S. Geological Survey will continue his investigation of chemical indicators that show the changing conditions in The Geysers reservoir. Ray Solbau of Lawrence Berkeley Laboratory will modify the LBL downhole sampler for vapor collection in the reservoir.

Two geophysical research projects have received initial funding. Ernie Majer of Lawrence Berkeley Laboratory will conduct microearthquake studies at The Geysers to determine the stress system around injection wells. Jay Zucca of Lawrence Livermore National Laboratory will continue the seismic attenuation study to locate steam in undrilled areas.

Several projects dealing with reservoir engineering and modeling received initial funding. Hank Ramey and Frank Miller at Stanford University will renew their investigation of water adsorption in porous rocks to determine the initial saturation of The Geysers. Roland Horne also of Stanford University will work with the data collected by the operators to analyze previous tracer tests conducted in the field. "Bo" Bodvarsson at Lawrence Berkeley Laboratory will continue to develop a general data base that will be available to operators and researchers and will develop a model to evaluate injection. Karsten Pruess also at Lawrence Berkeley Laboratory will provide new documentation of geothermal modules for the numerical model MULKOM that will be available to industry.

One of the geological studies received initial funding. Joe Moore of University of Utah Research Institute will conduct fluid inclusion studies of Geysers rocks to determine fluid compositions and temperatures of trapping.

## ENERGY CONVERSION

The goal for the Energy Conversion Task is to develop concepts which will allow better utilization of Geothermal energy at a reduced cost. The task is broken into three projects: Heat Cycle Research, Materials Development and Advanced Brine Chemistry.

### Heat Cycle Research

Several recent studies have indicated that geothermal developers are very concerned with power plant technology. In particular, developers have expressed an interest in binary plant technology and cooling systems. The Heat Cycle Research Project is primarily concerned with advancing binary power plant technology. The main objectives for the project are as follows:

- Increase net geothermal fluid effectiveness of binary plants by incorporating concepts which reduce cycle irreversibilities and increase availability.
- Increase net geothermal fluid effectiveness of binary plants through the utilization of supersaturated vapor expansions in the turbine.
- Reduce heat rejection system cooling water make-up requirements for geothermal power plants, while retaining performance comparable with conventional wet cooling.

The Heat Cycle project is carried out by the Idaho National Engineering Laboratory, (INEL). The project utilizes a Heat Cycle Research Facility to generate experimental power plant data. This facility is a small (60 kW) power plant located at the B C McCabe Binary Power Plant in California's Imperial Valley. Data received from this facility is analyzed by the INEL.

During the 1980's a number of concepts were developed to increase the overall efficiency of geothermal power plants. Three of these concepts included using an optimized mixed hydrocarbon working fluid, countercurrent flow paths in heat exchangers and integral phase changes in the condenser. These concepts have been tested at the Heat Cycle Research Facility over the past 6 years. These tests have confirmed that, relative the Heber Binary Power Plant, a 20% improvement in brine utilization can be realized by applying the concepts. This improvement results in a 12 to 18% in reduction in cost of electricity. Currently, the final field tests are being completed and the data summarizing the tests is being organized for formal reporting.

The Heat Cycle Research Facility is preparing for the supersaturated turbine expansion tests which can provide an additional 8% improvement in geofluid effectiveness to begin in 1991. In the expansion, the working fluid vapor passes through the "two-phase" region as it is expanded in the turbine. Although these expansions can be shown theoretically to improve the geofluid effectiveness, they are not totally utilized because of concern relative to liquid condensate formation and the potential for damage to the turbine blades. The INEL has developed a 2-D nozzle which will be used to determine the limits regarding supersaturated turbine expansion and condensate formation.

In addition to the activities taking place at the Heat Cycle Research Facility, work is also being done to evaluate more advanced cycles and to test materials which may result in heat exchanger scale reduction. For more information on the work taking place in this project contact Mr. Greg Mines or Dr. Carl Bliem, both of EG&G Idaho.

### Materials Development

Geothermal brines are often extremely difficult to work with. High temperatures and corrosiveness make the selection of materials to use for drilling a well, producing a well, and operating a geothermal power plant very difficult. The objective for the Material Development project is to reduce the costs associated with lost circulation; develop well cementing materials which have a lifetime of 30 years at 400 - 600 C; develop corrosion resistant, low fouling heat exchangers; and development of elastomers which can be used in the drilling applications. This project is currently broken into four activities described below. All these activities are being conducted out of Brookhaven National Laboratory, (BNL).

Chemical systems for lost circulation control are currently being developed at BNL in a collaborative effort with Sandia National Laboratory's Hard Rock Penetration Task. Efforts at BNL consist of developing chemical systems which are tested at the Sandia National Laboratory. At this time both the formula for the lost circulation material and the pumpability have been established.

The development of advanced high-temperature cements is being conducted in three phases. First, light weight cements are being tested in low CO2 containing brines. The testing was completed in 1989. Second, ceramic-like cements which can be used for well completions at temperatures up to 500 C are being developed. Third, CO2-resistant high-temperature cements are being developed.

A thermally conductive polymer concrete coating has been developed at BNL. This coating is being tested in a heat exchanger apparatus which was built and will be tested by the Idaho National Engineering Laboratory in Hawaii. The results of this experiment will be analyzed and reported in a collaborative effort by both laboratories.

Advanced elastomers for downhole drill motors are currently being developed. These elastomers are being optimized for sealing applications and for use as a stator in a downhole drill motor. To date the work has been focused on developing and doing laboratory tests. If these tests are successful, the elastomers will be fabricated and field tested.

This project has resulted in a large amount of interaction between BNL and industry. Individuals interested in this work should contact Larry Kukacka, BNL

Advanced Brine Chemistry

Handling and disposing of geothermal brine can be difficult because of the brine chemistry. Brine scaling results in handling difficulties. Brine chemical content often results in disposal problems which arise for environmental reasons. The advanced brine chemistry project is attempting to reduce these obstacles. The project consists of two activities: modeling and waste disposal.

The modeling activities are taking place at the University of California at San Diego, (UCSD). The objective for this activity is to reduce the costs associated with scale deposition on production well casing and power plant equipment. UCSD is carrying out research involving aqueous chemical models for geothermal process design. The University has developed a variable temperature model which predicts calcium carbonate, calcium sulfate, and amorphous silica scale formation as a function of brine composition and partial pressure of $CO_2$.

The model has a temperature range of 0 to 250 degrees C. Current modeling activities are focusing on the addition of gas model parameters, such as hydrogen sulfide and methane solubility. Individuals interested in this model should contact John Weare, Univ. of California at San Diego.

The waste disposal activities are taking place at Brookhaven National Laboratory, (BNL). The objective for this activity is to reduce costs of surface disposal of sludge from geothermal brines. In cooperation with industry, BNL is developing low-cost biochemical processes to concentrate or solubilize toxic materials from geothermal brine residues. A number of bioreactor designs have been constructed. Studies dealing with the optimization of sludge concentration and the use of thermophilic and thermo-adapted microorganisms are in progress. Furthermore, experiments using calcium and flat-bed bioreactors with different sludge loading and mixing times are being conducted to study subsequent bioreactor designs capable of accommodating larger volumes (0 - 350 gallons). People interested in more information on this work should contact Gene Premuzic, BNL.

## CONCLUSION

It is evident that in the Hydrothermal program, a significant amount of work is being done on a large range of subjects. This work is being done to solve the problems which may inhibit industry from fully developing hydrothermal resources. In order for this work to be effective, industry must provide the government with input regarding their specific concerns. While this input is ongoing in many of the projects, more industry input and involvement is always needed.

With continued research in the Hydrothermal program, ultimate objective of reducing the cost of electricity produced from the hydrothermal resource will be achieved. As this takes place, it will be a positive step in our country's search for alternate energy sources. More importantly, it will allow our nation to reduce its' need for foreign energy products.

## ACKNOWLEDGMENT

I wish to thank Joel Renner, Idaho National Engineering Laboratory for providing information on the Reservoir Technology section; Larry Kukachka, Brookhaven National Laboratory for providing information on the Geothermal Materials project, Paul Lienau, Oregon Institute of Technology for providing information on their Industrialization project, and Gladys Hooper, U.S. Dept. of Energy for providing information on the Advanced Brine Chemistry project.

## REFERENCES

U.S. Dept. of Energy, Washington, D.C., April 14, 1988, "Programmatic Objectives of the Geothermal Technology Division", Volume II- Appendices.

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Idaho National Engineering Laboratory, August 1988, "Annual Operating Plan for Geothermal Reservoir Technology Research".

U.S. Dept. of Energy, August 1988, "Annual Operating Plan for the Energy Conversion Task".

# HYDROTHERMAL ENERGY - AN IMPORTANT PART OF AMERICA'S ENERGY STRATEGY

**Kenneth J. Taylor**
**U.S. Department of Energy**
**Idaho National Engineering Laboratory**

**Marshall Reed**
**U.S. Department of Energy**
**Washington, D.C.**

**Howard Ross**
**University of Utah Research Institute**
**Salt Lake City, Utah**

As a response to America's need for Alternate Energy Sources, the U.S. Department of Energy has a Geothermal Program. Within this program is the Hydrothermal category. Currently, a wide range of tasks are being addressed as part of the Hydrothermal Program. The tasks include Industrialization, Reservoir Technology, and Conversion Technology. The successes already made in this program combined with upcoming successes will increase the likelihood of geothermal energy becoming a contributor to our nations future energy needs and thus become an important component in the U.S. National Energy Strategy.

M E M O R A N D U M

TO: Paul Lienau, OIT

FROM: Howard Ross, UURI

DATE: March 9, 1993

SUBJECT: Approximate Funding Levels, State Cooperative Program, FY-77 to FY-90

Here are my best estimates of funding levels, including contract modifications, for DOE State Cooperative Program for several (distinct) periods since the program began. The listed amounts do not include any UURI or OIT funding. Please call me if you need additional information.

Period FY-77 thru FY-82
DOE $14,132. K States $1,690. K Total $15,822. K
In addition: Southern Methodist Univ DOE $498.4 K

Period FY-84
DOE $800.2 K States $132.6 K Total $932.8 K

Period FY-85 to FY-86
DOE $1,036. K States $0. K
In addition: Southern Methodist Univ. DOE $115.8 K
Washington State Energy Off. DOE $50.0 K

Period FY-88 to FY-89
DOE $1,268.6 K States $320. K (est)
In addition: Oregon-DOGAMI DOE $200. K Oxbow Pwr $100. K
Washington State Energy Office DOE $51.4 K

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Orig.

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DOE STATE-COUPLED PROGRAM
LOW TEMPERATURE GEOTHERMAL RESOURCE ASSESSMENT
CONTRACT $ x 1000 [AS OF 10/1/82]

| PARTICIPATING STATE | FUNDING | | |
|---|---|---|---|
| | DOE | STATE | TOTAL |
| ALASKA | $ 1,199 | $ 462 | $ 1,661 |
| ARIZONA | 1,069 | -- | 1,069 |
| CALIFORNIA | 543 | 45 | 588 |
| COLORADO | 897 | -- | 897 |
| HAWAII | 350 | 150 | 500 |
| IDAHO | ~~1,012~~ 1,017 | -- | ~~1,012~~ 1,017 |
| KANSAS | 374 | 28 | 402 |
| MASSACHUSETTS | 65 | -- | 65 |
| MONTANA | 760 | 108 | 868 |
| NEBRASKA | 496 | 43 | 539 |
| NEVADA | 755 | -- | 755 |
| NEW MEXICO | 872 | 232 | 1,104 |
| NORTH DAKOTA | 288 | 59 | 347 |
| OKLAHOMA | 244 | 69 | 313 |
| OREGON | 1,818 | 113 | 1,931 |
| TEXAS | 1,203 | 50 | 1,253 |
| UTAH | 798 | 72 | 870 |
| WASHINGTON | 795 | 212 | 1,007 |
| WYOMING | 589 | 47 | 636 |
| TOTALS | $14,~~127~~ 14,132 | $ 1,690 | ~~$15,017~~ 15,822 |
| TEXAS (SMU) | + 498.4 | — | |

# STATE COOP GRANTS HPR 3/8/93

thru FY82

| | 1 DOE | 2 DOE | 3 DOE | 4 State | 5 DOE | 6 State | 7 | 8 | Totals 9 DOE | Totals State |
|---|---|---|---|---|---|---|---|---|---|---|
| Alaska 1 | 3/17/78 #1 75,070 | mods #1 115,000 | 3/17/79 #2 652.3K | #2 32,923 | #3 357.9 | #3 430K | thru 1/15/83 | | 1,200,200 | 462,923 |
| Arizona 2 | 312,515 | Mods #1 756,604 | | | | | | | 1,069,119 | — |
| Colorado 3 | 154,130 | mods 743,291 | | | | | | | 897,421 | — |
| Idaho 4 | orig+mods → 1,017,304 | | | | | | | | 1,017,304 | — |
| Kansas 5 | 164,009 (?) | state 22,301 | | | | | | incomplete | 374.-K 164,009 | 28.-K 22,301 |
| Mass - Amherst 6 | 65,422 | — | | | | | | | 65,422 | — |
| Montana 7 | 760,245 | state 107,926 | | | | | | | 760,245 | 107,926 |
| Nebraska 8 | 496,415 | state 43,000 | | | | | | | 496,415 | 43,000 |
| New Mexico 9 | 871,680 | state 231,850 | | | | | | | 871,680 | 231,850 |
| North Dakota 10 | 288,266 | 49,452 | | | | | | | 288,266 | 49,452 |
| Oklahoma 11 | 243,981 | st. 68,875 | | | | | | | 243,981 | 68,875 |
| Oregon 12 | #1 852,735 | st. #1 80,999 | #2 965,522 | #2 32,285 | | | | | 1,818,257 | 113,284 |
| TX-[illegible] | 1,033,837 | — | | | | | | | 1,033,837 | — |
| Texas - SMU | 498,392 | | | | | | | | [498,392] | |
| Utah 15 | 798,304 | 72,461 | | | | | | | 798,304 | 72,461 |
| Washington 16 | 794,748 | 212,492 | | | | | | | 794,748 | 212,492 |
| Wyoming 17 | 588,984 | 47,199 | | | | | | | 588,984 | 47,199 |
| California 18 | 220,533 7/79 → | | | | | | | | 543 K | 45 K |
| Nevada 19 | → | | | | | | | | 755 K | — |
| Hawaii 20 | → | | | | | | | | 350 K | 150 K |
| Texas - Tech | 170,000 | state 50,000 | | | | | | | 170,000 | 50,000 |
| 22 | | | | | | | | | | |
| State 23 | | | | | | | | TH 15,822 K | 14,132.-K | 1,690 K |
| 24 | | | | | | | | | | |
| 25 | | | | | | | | | | |
| 26 | | | | | | | | | | |
| 27 | | | | | | | | | | |
| 28 | | | | | | | | | | |
| 29 | | | | | | | | | | |
| 30 | | | | | | | | | | |
| 31 | | | | | | | | | | |

excludes OIT

# STATE TEAM CONTRACTS
# FY-84-85

| | | | FY-84 | | | FY-88 GRANTS | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 Compl | 3 DOE # | 4 State | 5 | 6 | 7 | 8 | 9 DOE | State |
| Alaska 1 | DGGS | 8/13/85 | 27,875 | 0 | | Alaska | DNR | 1980 1991 | 72,000 | |
| Alaska 2 | GI, UAK | 5/31/86 | 117,000 | 0 | | Alaska | GI | | 55,593 | |
| Idaho 3 | DWR | 8/17/85 | 98,579 | 0 | | HI | BED | | 87,173 | |
| Montana 4 | MCMST | 12/11/85 | 93,421 | 0 | | ID | DWR | | 154,088 | |
| New Mexico 5 | NMERDI | 3/7/86 | 90,000 | 0 | | UNV- | DRI | | 140,639 | |
| Oregon 6 | DOGAMI | 6/25/86 | 150,000 | 110,000 | | UNV- | DES | | 157,114 | |
| Utah 7 | UGMS | 9/26/85 | 83,000 | 0 | | NM | NMRDI | | 129,267 | |
| Washington 8 | DNR | 2/28/86 | 117,679 | 22,609 | | ND | MMRI | | 194,814 | |
| WY 9 | U WY | — | — | 0 | | | | | | |
| Washington 10 | SEO | 9/21/85 | 22,653 | 0 | | UT | UGMS | | 61,641 | |
| Oregon 11 | OIT | 6/30/85 | 316,875 | 0 | | WA | DNR | | 170,776 | |
| 12 | | | | | | WY | U WY | | 45,511 | |
| 13 | | | 800,207 | 132,609 | HI | | | TH 1,585,770 | 1,268,616 | 320K |
| 14 | | | | | | OR | DOGAMI | Santiam Pass | 200,000 | Oxbow 100K |
| 15 | FY 85 & →88 | | | | | WA | SEO | | 51,435 | |
| Alaska 16 | GI, UAK | 7/8/86 | 120 K | | | | | | | |
| Alaska 17 | DGGS | | 40 K | | | | | | | |
| Idaho 18 | DWR | 8/29/88 | 158,579 | | | | | | | |
| S.D. 19 | | | — | | | | | | | |
| Utah 20 | UGMS | 11/30/86 | 40 | | | | | | | |
| MT 21 | | 6/31/88 | 93,421 | | | | | | | |
| New Mexico 22 | NMERDI | 6/15/88 | 109,970 | | | | | | | |
| ND 23 | NDMMRI | 6/1/88 | 47 | | | | | | | |
| WY 24 | U WY | 9/18/87 | 17,595 | | | | | | | |
| OR 25 | OR WRD | | 20 | | | | | | | |
| OR 26 | DOGAMI | 10/31/88 | 359,357 | | | | | | | |
| 27 | | | 1,005,922 | | | | | | | |
| Ariz 28 | UA Geoch | 1/31/89 | 30 | | | | | | | |
| Texas 29 | SMU-HF | 5/31/88 | 115,790 | | | | | | | |
| Wash 30 | WSEO | | 50 | | | | | | | |
| FL 31 | U. FL ark | 7/20/87 | 2,158 | | | | | | | |

ESL-87001
DOE/ID/12489-13

Please return to Howard

Oct. 1987

# STATE COOPERATIVE

# RESERVOIR ANALYSIS PROGRAM

## ANNUAL SUMMARY

## FISCAL YEAR 1987

by

Howard P. Ross
October 1987
Earth Science Laboratory
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CONTENTS



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## INTRODUCTION

Eleven State Cooperative Program (SCP) grants were active at the beginning of the 1987 fiscal year. The grants were originally established through non-competitive procurement processes in 1984, and several grants had since been modified to include supplemental funding, extended contract periods, and revisions in the statement of work. A year-end summary of activities and deliverables for these grants is presented in this report.

## GRANTS COMPLETED IN 1987

### University of Alaska Geophysical Institute

The Geophysical Institute, under the direction of Dr. Donald L. Turner and Dr. Eugene M. Wescott, Principal Investigators, completed a series of geological and geophysical studies relating to the geothermal resource potential of the Mt. Spurr area, Alaska. The Mt. Spurr volcano is a composite Quaternary cone located on the west side of Cook Inlet about 80 miles west of Anchorage, and approximately 40 miles from the Beluga electrical transmission line. A major ash and steam eruption from Crater Peak in July, 1953, and the presence of fumaroles indicate the potential for a high-temperature geothermal resource. The statement of work called for mercury, helium, self-potential, resistivity and CSAMT surveys of the more accessible south and southeast flanks, radar and gravity surveys of the central ice field and age dating of selected rock units. The integrated interpretation of these and other geologic data was to result in the development of a geothermal resource model of the area. A separately funded but cooperative effort by the Alaska Division of Geologic and Geophysical Surveys was undertaken simultaneously to provide geologic mapping and in-depth petrologic studies of major rock types.

Adverse weather conditions during the field season and high helicopter transportation costs complicated the field program. Some of the geophysical data (radar, electrical resistivity and CSAMT) were not as definitive as had been hoped. The study did yield a substantial amount of new information regarding the geothermal potential of the Mt. Spurr Area.

Geologic mapping indicated that the present summit depression was produced by a Mt. St. Helens type sector collapse, rather than by a caldera collapse. Geophysical surveys indicated that snow and ice depth exceeds 500 m in the deepest parts of the basin. Previously unreported fumaroles and hot springs were identified on Mt. Spurr and Crater Peak. Coincident mercury and helium anomalies and low-resistivity CSAMT anomalies were identified south of Mt. Spurr, suggesting geothermal systems at depths estimated to be 2000 feet. Release of the data to open file has contributed to State of Alaska geothermal lease sales in the Mt. Spurr area. Drs. Turner and Wescott note that any future

geothermal development in the Mt. Spurr area must be cognizant of a strong volcanic hazard present in the area.

A final report was submitted in December, 1986 in fulfillment of the Grant deliverable requirements. The report was submitted without prior review by DOE in draft form, and was found to be weak in fulfilling the statement of work requirements. Funding limitations precluded a revision of the final report.

Deliverables

"Geothermal Energy Resource Investigations at Mt. Spurr, Alaska", D. L. Turner and E. M. Wescott, eds., University of Alaska Geophysical Institute report UAGR-308, 78 p., December 1986.

## Utah Geological and Mineral Survey

Mr. Archy Smith and Mr. Raymond Kerns, Principal Investigators, directed the second phase (Mod. M001) study under a 1984 grant to the UGMS. Under this modification, Karin Budding completed a low-temperature geothermal assessment in the Washington County (including St. George) area of Southwestern Utah.

This study began with a detailed literature search and data compilation and then developed a preliminary geologic model to explain warm spring and well occurrences. A field program of well and spring temperature measurements, geochemical sampling and analyses, and geologic studies acquired new data. The integration of new data led to a substantial improvement in the geothermal database and the development of new models for the thermal water occurrences.

The highest water temperature recorded in the St. George basin was 42 degrees C at Pah Tempe Hot Springs. Several other occurrences of springs and wells above 20 degrees C were recorded. The majority of Na-K-Ca calculated reservoir temperatures ranged from 30 to 50 degrees C. The final report for this grant was received in good form in December 1986.

Deliverable

"Low-Temperature Geothermal Assessment of the Santa Clara and Virgin River Valleys, Washington County, Utah" by Karin E. Budding and Steven N. Summer; UGMS Special Studies 67, 34 p., 1986.

## Washington - Department of Natural Resources

New studies in Washington geothermal resource assessment were initiated in 1984 through a modification to an existing contract. Dr. J. Eric Schuster was named as the Principal Investigator for this contract, and Michael Korosec acted as Program Coordinator and Geologist. Principal tasks in the statement of work included the drilling and temperature logging

of shallow gradient holes, mercury surveys, geologic mapping and sampling of thermal and mineral springs.

Preliminary reporting was completed in 1986 but this contract remained open because of the late completion of geologic maps. These maps were completed in 1987 and received by DOE/ID in May, and the contract has since been closed out.

Deliverables

"The 1985 Geothermal Gradient Drilling Project for the State of Washington", Barnett, Brent; Washington DNR O. F. Rept. No. 86-2, 34 p., 1986.

"Geologic Map of the Hood River Quadrangle, Washington and Oregon", Korosec, Michael A.; WDGER O.F. Rept. No. 87-6, 41 p., 1987.

"Geologic Map of the Mount Adams Quadrangle, Washington" Korosec, Michael A.; WDGER O.F. Rept. No. 87-5, 39 p., 1987.

University of Wyoming, Department of Geology

Dr. Henry Heasler was the Principal Investigator for a 1985 grant to complete a geothermal resource assessment and numerical modeling of the thermal regime in the Jackson Hole Area of northwestern Wyoming. Field work in the Jackson Hole area was completed in the fall quarter, 1986 and the completed final report was delivered to DOE/ID in April, 1987.

Dr. Heasler combined analytic thermal models for intrusions and finite-difference thermal models of the steady-state heat conduction and convection equation with available well and hot spring information to assess the origin and distribution of thermal waters in the Jackson Hole area. The study concluded that deep circulation of groundwaters in the Paleozoic section and convection along the Teton fault system best explain the observed warm temperatures. The possibility of high-temperature heat sources in the study area is unlikely. Modeled temperatures in the deeply buried Paleozoic section ranged from 220 degrees C to 100 degrees C.

Deliverables

"Geothermal Modeling of Jackson Hole, Teton County, Wyoming"; Heasler, H. P., U. Wyoming - Dept. Geol. and Geophysics final report to DOE, 35 p., 1987.

University of Florida - Department of Geology

Through a UURI Purchase Order agreement with the University of Florida, the results of new heat flow studies in Arkansas and Missouri have been made available to DOE and to the national

geothermal resource map. Purchase of a final report and tabulated data helps to offset personal expenses incurred by Dr. Douglas Smith and his graduate students during field trips and for subsequent thermal conductivity determinations and heat flow calculations. A final report was received by DOE in August.

During this study, approximately 70 boreholes in northern Arkansas were sought and located, but only six proved suitable for accurate temperature logging. Three additional boreholes in Missouri were successfully logged to complete the study and terms of the Purchase Order Agreement.

Although the new heat flow values were all low and not encouraging for the presence of geothermal resources, they are significant in several respects. They represent the first heat flow measurements for the Ozark Plateau and depict the Ozarks as an anomolously low heat flow province. The borehole logged at Green Forest, Arkansas is the deepest hole used for heat flow measurements in Arkansas, and the borehole logged at Atlas, Missouri, is the deepest hole logged for heat flow purposes in Missouri.

Deliverable

"Heat Flow in Arkansas", Douglas L. Smith; Univ. Florida Dept. of Geol. Final Report to UURI; 37 p., July, 1987.

## GRANTS CONTINUING IN 1988

Eight research grants established during 1984 and subsequently modified continue to be active into fiscal year 1988. A brief narrative review and update of these grants follows. A short-form task, status and financial summary for these grants is appended as an updated quarterly report summary.

### Alaska-Division of Geological and Geophysical Surveys

The continuing work under the DGGS grant is the final interpretation and reporting of geothermal energy investigations for the area of Mt. Spurr volcano. The studies include petrographic, microprobe and geochemical studies. A no-cost time extension until December 31, 1987 has been requested to allow Dr. Christopher Nye time to correct an algorithm used to reduce mineral chemistry data and reinterpret his data.

Deliverables

"Alaska Geothermal Bibliography", S. A. Liss, R. J. Motyka, and C. J. Nye: Alaska DGGS Final Rept. to DOE, 258 p., 1987.

University of Arizona - Department of Geosciences

This grant, established in February 1986, provides for the completion of up to 40 K/Ar age dates on young geologic samples in support of researchers funded under other DOE geothermal programs. The age dates are completed under the direction of Dr. Paul Damon, Principal Investigator. To date 10 samples have been submitted and dated as indicated in the Deliverables below; two samples from Oregon (George Priest); two samples from Cerro Prieto (Marshall Reed); six samples from Ascension Island (Dennis Nielson).

A no-cost time extension will probably be required to continue the dating service through 1988 when several new SCP grants may wish to utilize the service.

Deliverables

Two age dates, Cerro Prieto, Mexico, to Marshall Reed (DOE/DGT). Two age dates, Cascade Volcanics, to George Priest (DOGAMI). Six age dates, Ascension Island, to Dennis Nielson (UURI).

Idaho-Department of Water Resources

Leah Street, Principal Investigator, has completed field studies and report writing for the Banbury Hot Springs and Twin Falls study areas, but final report preparation and printing remain to be completed. The Boise geothermal system study by Dr. Charles Waag has been completed and the much-discussed final report is undergoing revision.

Although both final reports are expected soon, a no-cost time extension may still be required. Results of the geothermal study of Twin Falls County, Idaho were recently presented at a GRC Poster Session.

Montana College of Mineral Science and Technology

This grant supported detailed gravity and CSAMT studies at the Ennis Hot Springs area, Montana as two MS thesis. The Principal Investigators of the grant are Dr. Charles Widman and Dr. William Sill. Draft reports for both studies have been reviewed and revisions are being made for the final reports. A no-cost time extension until December 31, 1987 has been requested to allow completion of these reports.

New Mexico Research and Development Institute

A major modification to the statement of work for this grant provides for the substitution of a limited resource assessment study near Orogrande and for much of the Animas Valley hydrologic study. Dr. Larry Icerman, Principal Investigator, reports that preliminary hydrologic studies in the Animas Valley and the geothermal resource assessment for South-central New Mexico are

largely completed. The project (as revised) is on schedule. Final reports are due by December 31, 1987.

North Dakota - Mining and Mineral Resources Research Institute

This grant provided for a geothermal resource assessment of South Dakota, and the preparation of a geothermal resource map of the state at a scale of 1:1,000,000. Dr. Wil Gosnold, Jr., is the Principal Investigator for the grant. The final technical report has been delivered to DOE and accepted, and the contract has been closed out. Delivery of the Geothermal Resource Map of South Dakota is expected soon.

Dr. Gosnold's study concluded that seven accessible geothermal aquifers in South Dakota contain an accessible resource base of about 11,207 x $10^{18}$J. Geothermal fluid temperatures range from about 30 degrees C in the Cambrian Deadwood Formation to about 120 degrees C in the Cretaceous Newcastle Sandstone. Approximately 10,000 $km^2$ of the resource area is characterized by anomalously high hea- flow values exceeding 100 $mWm^{-2}$.

Deliverable

"Geothermal Resource Assessment - South Dakota", William D. Gosnold, Jr., NDMMRRI Bull. No. 87-07-MMRRI-01, 37 p., 1987.

Oregon Department of Geology and Mineral Industries

Amendments to this DOGAMI grant provide for completion of a feasibility study to develop a plan for further research and scientific drilling in the Cascade Mountains, for detailed geologic mapping and for geologic studies in support of the jointly funded Industry-DOE drill hole CGTH-1. Dr. George Priest, Principal Investigator, submitted final reports for the Scientific Drilling Plan, and geologic mapping studies in August. The scientific plan for drilling in the Cascade Range is a well written, comprehensive document.

Detailed mapping, lithologic studies and geothermal interpretations relating to the CGTH-1 drill site remain to be completed before the grant termination date of October 31, 1988.

Deliverables

Black, G. L., et al., 1987, Geologic map of the Crescent Mountain Area, Linn County, Oregon; DOGAMI Map Series, GMS-47.

Blackwell, D. D., Black, G. L. and Priest, G. R., 1986, Geothermal-gradient data for Oregon (1982-1984); DOGAMI O. F. Rept. 0-86-2, 107 p.

Priest, G. R., Woller, N. M., Blackwell, D. D., and Gannett, M. W., 1987, Geothermal exploration in Oregon, 1986; Oregon Geology, v. 49, no. 6, p. 67-73.

Priest, G. R., et al., 1987, Geologic Map of the Breitenbush River Area, Linn and Marion Counties, Oregon; DOGAMI Map Series, GMS-46.

Priest, G. R. et al., 1987, Investigation of the thermal regime and geologic history of the Cascade volcanic arc: first phase of a program for scientific drilling in the Cascade Range; DOGAMI O. F. Rept. 0-86-3, 120 p.

Taylor, E. M., 1987, Field geology of the Northwest quarter of the Broken Top 15' Quadrangle, Deschutes County, Oregon; DOGAMI Special Paper 21, 20 p.

Southern Methodist University

Dr. David Blackwell, Principal Investigator, was funded through a FY 86 grant to compile existing heat-flow data for the United States. This grant also calls for a compilation of existing data on temperatures in regional aquifers and other appropriate geothermal data, and the publication of results as a national geothermal map. Contract modifications added tasks to conduct thermal gradient measurements on Cascade drill holes and to determine heat-flow values for these sites.

The national heat-flow map has been submitted to NOAA for printing and final measurements on Cascade holes were made during the last quarter. A no-cost time extension may be required to extend the present (expired) grant termination date.

Dr. Blackwell has made several presentations on the national heat-flow map at the AGU, GRC and GSA meetings. Presentations have also been made regarding the geothermal data from the deep Cascade drill holes.

## 1987 SOLICITATION

A new Program Research and Development (PRDA) for State Geothermal Research and Development - PRDA No. DE-PRO7-87ID12662 was issued by DOE - Idaho Operations Office on April 1, 1987. This PRDA provided funding of approximately $1,200,000 for cost-shared, state-oriented research and development on those aspects of geothermal energy not currently being studied by private industry, but which had the potential for the development of geothermal resources. The DOE cost share would not exceed $200,000 per award, and the state or state-designated organization must cost share a minimum of 10% of the gross amount proposed.

The PRDA schedule called for a proposal closing date of September 30, 1987. A preliminary determination of the

competitive range of proposals was completed in August but complexities with individual proposals and the procurement process has delayed awards until sometime after October 1, 1987. Ten or more grants may be established through this solicitation before the end of the year.

The University of Utah Research Institute (UURI) continues to provide assistance to DOE in the procurement process and in technical monitoring of existing contracts.

## SUMMARY AND CONCLUSION

The State Cooperative Program continued at a relatively low level during 1987 as four existing grants were concluded and deliverables received from the state teams. An additional short-term study, conducted under a UURI Purchase Order, was also completed. In addition, the North Dakota team has submitted its final report but has yet to submit an accompanying state resource map. Draft final reports have been received and reviewed for two of the seven remaining contracts, Idaho and Montana, as these grants near conclusion. Only two of the present SCP contracts, Oregon-DOGAMI, and Arizona (K/Ar dating) should continue well into calender year 1988. The 1987 PRDA may result in 10 or more new grants for state supported geothermal research and resource assessment.

The State Cooperative Program has been very productive in 1987 and reflects the investment of prior years government funding and substantial effort by the state teams. Presentations by Drs. Blackwell, Gosnold, and Priest, and by Leah Street at the GRC, the AGU and the GSA have called attention to this program and aided in distributing the technical results before the national technical community. Good solid technical results have been presented in state survey publications by the Alaska, Utah, Washington and Oregon teams. Studies of the Twin Falls and Boise geothermal system in Idaho have illustrated the need and provide the background data for careful reservoir management practices. Drs. Heasler (Wyoming) and Gosnold (North Dakota) are using state-of-the art numerical techniques in the evaluation of geothermal resources. The geothermal resource assessment of South Dakota has given encouragement for a much wider development of these resources in that state.

A retrospective look at the deliverables and presentations funded by the State Cooperative Program suggests that this program must be among the most cost-effective, productive, and visible of all DOE programs .

Howard

# FY 1990 ANNUAL REPORT

# STATE COOPERATIVE RESERVOIR ANALYSIS PROGRAM

## 1.0 FISCAL YEAR ACCOMPLISHMENTS

### 1.1 Work Performed

A new Program Research and Development (PRDA) for State Geothermal Research and Development was issued by the DOE-Idaho Operations Office in April 1987. This PRDA provided funding of approximately $1,200,000 for cost-shared state-oriented research and development of geothermal energy. The final evaluation of competitive proposals was completed early in FY 88 and 11 new grants were awarded between January and September, 1988.

A broad range of research, generic studies, and resource assessment is represented by these grants. Regional resource assessments are being carried out in North and South Dakota, Washington, Alaska, and Nevada. Specific geothermal systems and generic research are the subject of detailed studies in Alaska, Hawaii, Idaho, Wyoming, Nevada, Utah, and New Mexico. Geochemical research and data collection is a major component of studies in Hawaii, Nevada, Idaho, and New Mexico. Advanced numerical modeling of combined heat flow and fluid flow is underway at the University of Wyoming and the University of North Dakota.

### 1.2 Accomplishments

Technical studies and field work were completed for seven of the SCP grants, and neared completion for the remaining four grants. Contract modifications have extended the period of performance for all eleven grants. Several significant accomplishments can be identified by the state teams during FY 1990. Dr. Donald Thomas, (University of Hawaii state team) reports successful results in acid treatment of high silica brines from the Hawaiian East Rift Zone. These results show potential for keeping the silica in solution and minimizing production and environmental problems associated with production of thermal fluids. Mr. Thomas Flynn (University of Nevada-Division of Earth Sciences) and his team members completed a significant study which casts new light on the origin of geothermal fluids in the Great Basin. In New Mexico, Jim Witcher has discovered a previously unknown low- to moderate-temperature geothermal system in the Rincon area using soil-gas radon techniques followed up with shallow thermal gradient drilling. Robert Blackett and his team at the Utah Geological and Mineral Survey have identified the controlling features and properties of the hidden Newcastle geothermal system. Other accomplishments may be inferred from the bibliography of reports and deliverables, Section 8.0.

### 1.3 Milestones/Deliverables

The state team grants call for project schedules and deliverables individually negotiated with DOE-ID. Each grant requires delivery of draft final reports to DOE and UURI 45 days prior to the project completion date to allow for critical review and revisions. All grants have been extended by contract modifications or no cost time extensions. Figure 1 illustrates the project period and completed projects for the eleven grants, and for a separately funded grant to the State of Oregon (DOGAMI). Deliverables are reports and publications as listed in Section 8.0.

(ADD STATE TEAM SCHEDULES FROM SEPTEMBER QUARTERLY)

## 1.4 Budget/Labor Expended

(PMW will fill this in)

## 1.5 Variances From Plans

All research projects have required more time than the investigators originally anticipated. Many studies are being conducted in a university environment in which the investigators must respond to other unanticipated demands on their time. Contract modifications have been required for three grants. A modification to the North Dakota grant shifts some of the thermal gradient drilling scheduled for North Dakota to sites in South Dakota. The University of Nevada-Desert Research Institute grant has been modified to recognize limitations in the existing data base and the accuracy of final computer models of the Moana geothermal system. The study of treatment of high-silica brines in the East Rift Zone of Hawaii has been broadened to include similar brines from North American geothermal systems.

## 1.6 Status

The estimated percent completion for the eleven SCP grants is indicated below. Two additional grants have been completed since the end of FY 1990, and draft final reports have been submitted for review by two additional state teams.

| State Cooperative Program Team | Status |
|---|---|
| Alaska-Div. Geological & Geophysical Surveys | 75 % |
| Univ. Alaska- Geophysical Institute | 95 % |
| Hawaii-Dept. Business,Economic Dev., & Tourism | 75 % |
| Idaho-Div. Water Resources | 95 % |
| Univ. Nevada- Desert Research Institute | 85 % |
| Univ. Nevada-Division Earth Sciences | 100 % |
| New Mexico- Research and Development Institute | 95 % |
| Univ. North Dakota- Dept. Geology & Geol. Engr. | 90 % |
| Utah-Utah Geological and Mineral Survey | 100 % |
| Washington- Department Natural Resources | 100 % |
| Univ. Wyoming-Dept. Geology & Geophysics | 90 % |

# 2.0 MANAGEMENT

## 2.1 Interfaces and Contacts

The primary interfaces within the State Cooperative Project are the various state teams and their Principal Investigators.
UURI provides progress monitoring and technical review services to DOE, and geoscience, technical, and contract administration assistance to the state teams.

A listing of the teams and PI's active in FY90 follows:

Alaska-Division of Geological and Geophysical Surveys
Dr. Roman Motyka

University of Alaska-Geophysical Institute
Dr. Christopher Nye

Hawaii-Dept. of Business, Economic Development, & Tourism
Dr. Donald Thomas

Idaho-Division of Water Resources
Mr. Paul Castelin

University of Nevada-Desert Research Institute
Dr. Elizabeth Jacobson

University of Nevada-Division of Earth Sciences
Mr. Thomas Flynn

New Mexico Research and Development Institute
Mr. Patrick Rodriguez (Administrative)

University of North Dakota-Mining and Mineral Res. Inst.
Dr. William Gosnold

Oregon Department of Geology and Mineral Industries
Dr. George Priest

Utah Geological and Mineral Survey
Mr. Robert Blackett

Washington-Department of Natural Resources
Mr. Michael Korosec

University of Wyoming-Department of Geology & Geophysics
Dr. Henry Heasler

Additional contacts important to the State Cooperative Project were:

Southwest Technology Development Inst-New Mexico State Univ.
Dr. Rudi Schoenmackers, Director
Mr. Jim Witcher, Technical P.I., NM SCP team

Utah Geological and Mineral Survey
Dr. Lee Allison, Director
Mr. Michael Shubat, Geologist

United States Geological Survey-Idaho
Mr. William Young

## 2.2 Meetings/Reviews

No specific meetings were organized for the SCP teams as a group. UURI hosted a meeting in Salt Lake City on December 7, 8, 1989 for a discussion of radon methods in geothermal exploration. The meeting was attended by members of the New Mexico and Utah SCP teams, and by UURI. Utah-UGMS and UURI personnel participated in a Utah Geothermal Energy Symposium organized by UURI, the UGMS and the Utah Energy Office and held in Salt Lake City on October 24, 1989. The Utah Geological and Mineral Survey (UGMS) conducted a field review of the Newcastle geothermal study on site on June 12 and 13, 1989. About 20 scientists, engineers and prospective developers attended the review. Idaho-Division of Water Resources hosted a review of the Boise geothermal aquifer numerical model study at the Boise Geothermal Reservoir Users Group, February 6 in Boise.

The Hawaii, Nevada-Division of Earth Sciences, New Mexico, North Dakota, and UURI SCP teams contributed to the 1990 International Geothermal Energy Symposium in Hawaii, and the Utah and Wyoming SCP teams gave presentations at GSA and AAPG meetings in Jackson and Denver, Colorado, respectively.

## 2.3 Issues and Resolution

Groups opposed to geothermal energy development in Hawaii conducted several protests in the name of environmental concerns, and protested DOE funded research in the Hawaii East Rift Zone. A grant to the State of Hawaii to study the chemistry and treatment of high-temperature, high-silica brines was modified to include research on similar brines in North American geothermal systems and on site work in Hawaii was discontinued. No cost time extensions have been taken by several state teams to respond to issues raised in reviews of draft final reports and to offset other delays and problems encountered during their studies.

# 3.0 REPORTS AND PAPERS


Baker, S. J., and Castelin, P. M., 1990, Geothermal resource analysis in Twin Falls County, Idaho, Part II: Idaho-DWR Water Information Bull. No. 30, Pt. 16, 36 p.

Berkeley Group Inc., 1990, Boise geothermal aquifer study: BGI Final rep. for Idaho-DWR Contract #DWR-89-03-46-102-54, Oakland CA, 158 p.

Blackett, R. E., Shubat, M. A., Chapman, D. S., Forster, C. B., Schlinger, C. M, and Bishop, C. E., 1990, The Newcastle geothermal system, Iron County, Utah: Utah Geol. and Min. Survey final rep. to DOE, 84 p.

Blackett, R. E., 1990, A hydrologic model of the Newcastle geothermal system, Southwestern Utah; Abs. 1990 Rocky Mountain Sec. Mtg., AAPG, Denver, Sept. 18.

Flynn, T. and Buchanan, P. K., 1990, Geothermal fluid genesis in the Great Basin: Univ. Nevada-Div. Earth Sciences Final rep. to DOE, DOE\ID\12784, 154 p.

Gosnold, W. D. Jr., LeFever, R. D., Chu, M., Crashell, J. J., and Brekke, J., 1990, Stratabound geothermal resources in the Northeastern Great Plains; Geothermal Resource Council Trans, v. 14, p. 675-682.

Heasler, H.P., 1990, Geothermal modeling of Jackson Hole, Northwestern Wyoming: Abstracts with Programs, 43rd Annual Mtg., Rocky Mountain Section, GSA, Jackson, WY, v. 22, n.6, p.14.

Korosec, M. A., 1989, New K-Ar age dates, geochemistry, and stratigraphic data for the Indian Heaven Quaternary volcanic field, South Cascade Range, Washington: Washington Div. of Geology and Earth Resources, Open File rep. 89-3, 42 p.

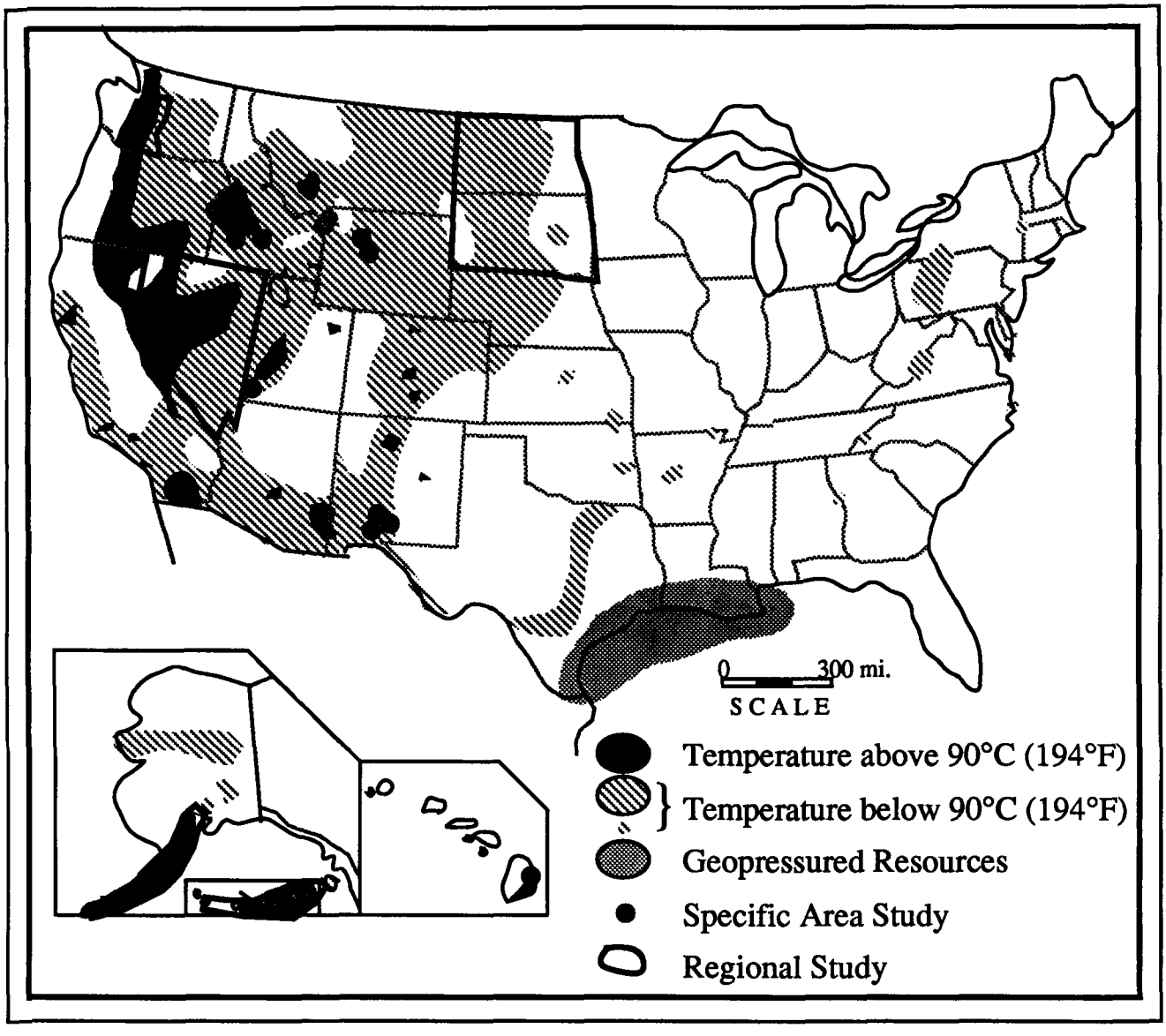
Ross, H. P., Blackett, R. E., Shubat, M. N., and Mackelprang, C. E., 1990, Delineation of fluid upflow and outflow plume with electrical resistivity and self-potential data- Newcastle geothermal area, UT; Geothermal Resource Council Trans., v.14, p. 1405-1412.

Street, L. V., 1990, Geothermal resource analysis in the Big Wood River valley, Blaine County, Idaho: Idaho-DWR Water Information Bull. No. 30, Pt. 17, 26 p.

Taylor, K. J., Reed, M., and Ross, H. P., 1990, Hydrothermal energy-An important part of America's energy strategy, in Proceedings, U.S. Dept. of Energy Geothermal Program Review VIII, San Francisco, April 18-20, p.19-26.

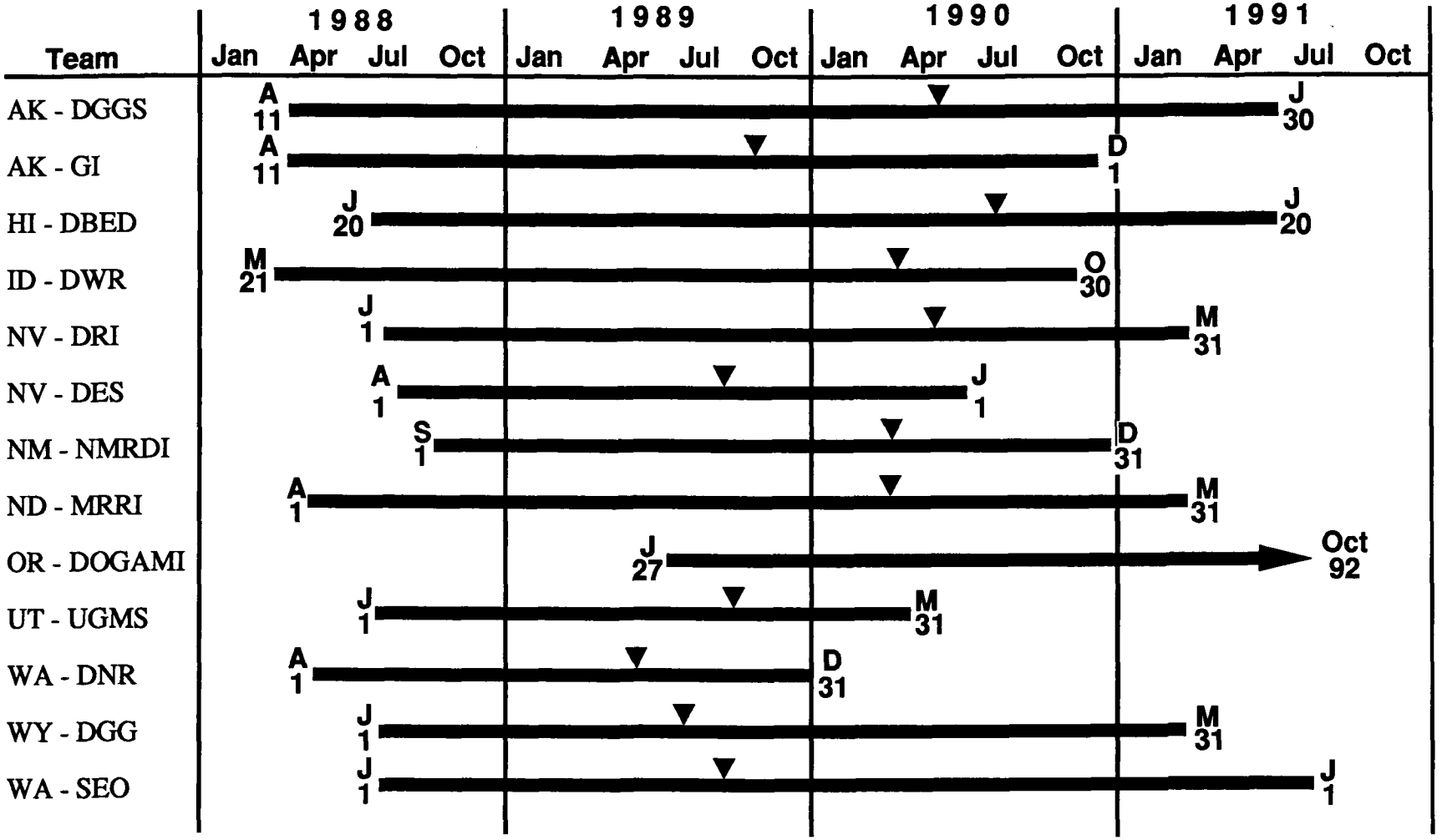
Thomas, D. M., 1990, The history and significance of the Hawaii geothermal project:Geothermal Resources Council Trans., v.14, p. 809-814.

# 1988 State Cooperative Program

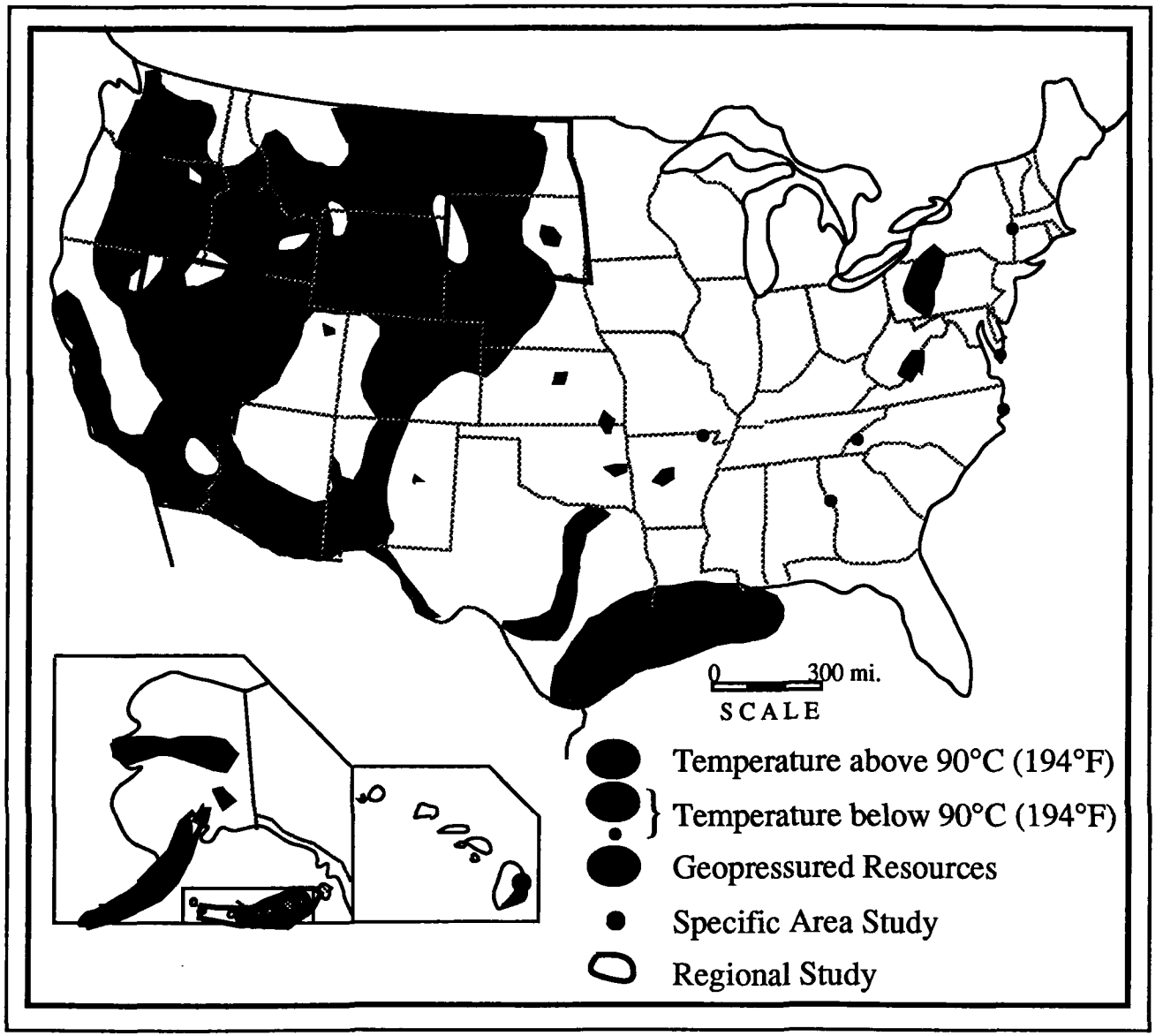



Rob —
from Nov-Dec
1990

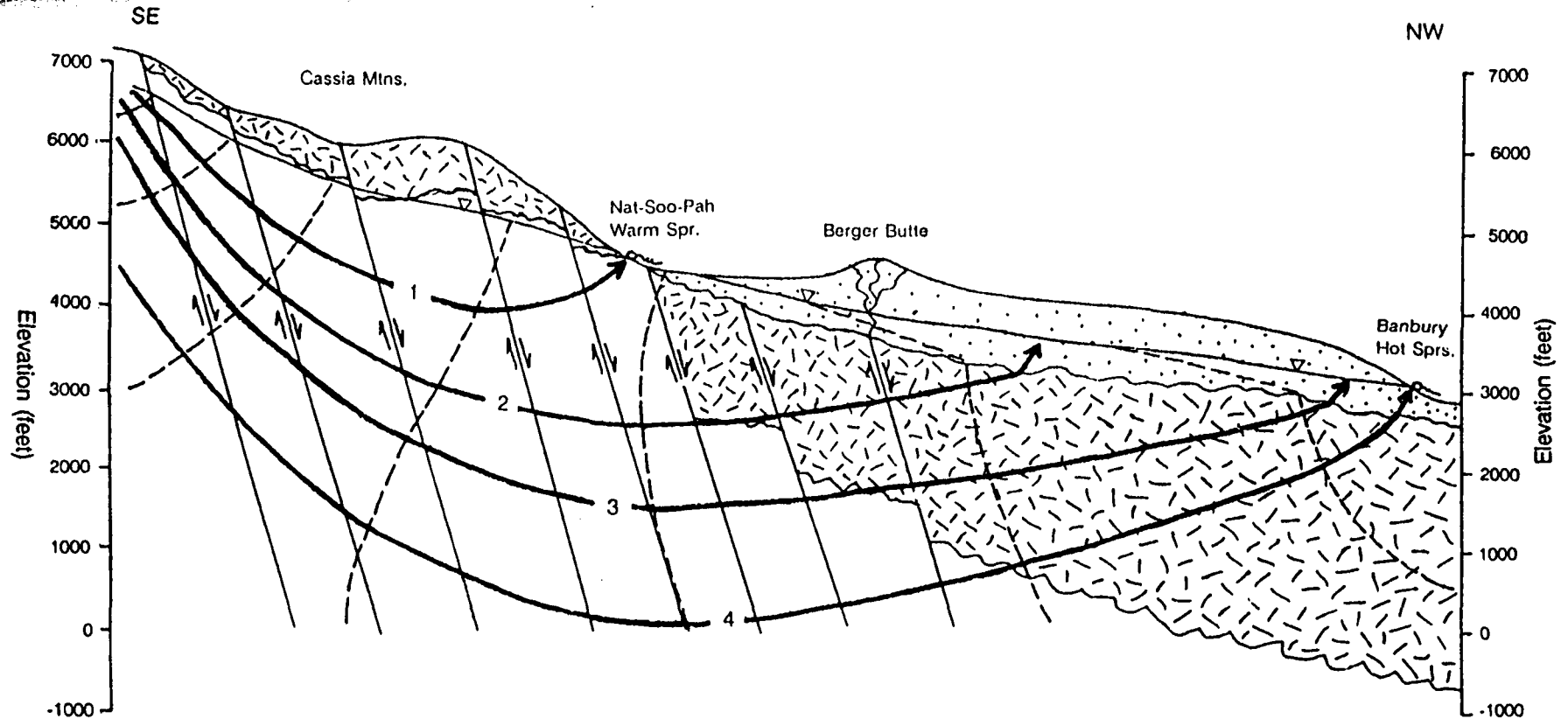
# State Team Schedules - 1988 Grants



# 1988 State Cooperative Program




For DOE Program Review, Washington, DC, May 17 1989 -for Marshall Reed.




HORIZONTAL SCALE 1: 365,000

VERTICAL EXAGGERATION X15

EXPLANTION

GEOLOGIC FEATURES

- Quaternary-Tertiary Basalts
- Tertiary Idavada Volcanics
- Paleozoic Sedimentary Rocks

HYDROLOGIC FEATURES

- ▽ Potentiometric Surface
- ---- Equipotential Line (contour interval = 500 ft)
- → Flow Line

Figure 12. CONCEPTUAL HYDROGEOLOGIC PROFILE OF GEOTHERMAL SYSTEM

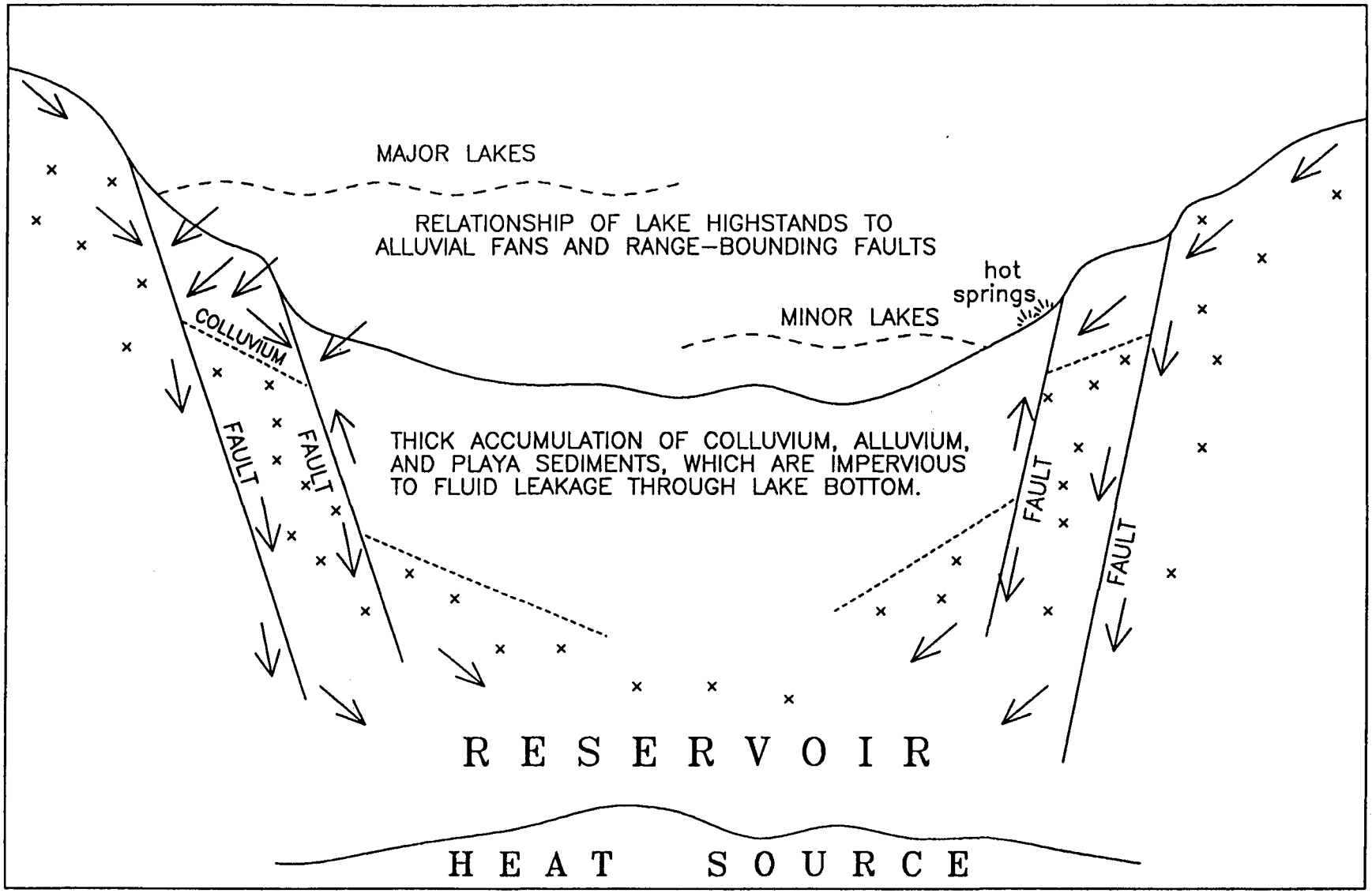



Figure 8.5: New conceptual model of geothermal recharge involving high-angle Basin and Range style faulting, range run-off, and fluid contribution from large pluvial lakes that saturated the alluvial fans above faults. See text for discussion of recharge/discharge flowpaths.

D O E GEOTHERMAL TECHNOLOGY DIVISION

STATUS REPORT - DECEMBER 1990

# STATE COOPERATIVE PROGRAM

## Introduction

The State Cooperative Reservoir Analysis Program (SCP) was established by DOE in the late 1970's as the State Coupled Program to assess low- and moderate-temperature geothermal resources in the United States. The early efforts of the program were national in scope and focused on statewide resource assessment, resulting in the publication and distribution of a series of state geothermal resource maps. More recent work has included detailed reservoir analysis and generic studies.

As a result of a 1987 DOE/ID solicitation, eleven grants were signed with state-designated agencies to conduct geothermal research. One additional grant was signed later to provide support for an unsolicited research proposal. The grant participants and a brief description of the status of the projects follows.

## Completed Projects

The University of Alaska, Geophysical Institute, has completed a geological and geochemical study of the Geyser Bight geothermal resource, Umnak Island. Results of this study indicate that a zoned plutonic rock unit (9.5 Ma) is the probable reservoir rock, and volcanic rocks range in age from 75,000 to 534,000 years. A previously unreported fumarole field, 4 km south of Geyser Bight valley, was discovered during this study and has been mapped and described in detail. Heat for the geothermal system is derived from the Mt. Recheshnoi volcanic system.

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The Division of Earth Sciences, University of Nevada-Las Vegas, has completed a study of the genesis of geothermal fluids of the Great Basin. The study has determined a late Pleistocene age (40,000 - 10,000 years BP) for the fluids which indicates a paleorecharge scheme. Range-bordering faults probably provide conduits for recharge of the deep geothermal systems. Pleistocene lakes probably contributed to recharge in western Nevada.

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The State of Washington, Department of Natural Resources, drilled eight 152 m temperature gradient holes to better define the Southern Washington Cascade Range heat flow anomaly. Two holes did not penetrate the effects of cold surface waters, but four holes had temperature gradients of 50 to 58 degrees C/km. A related study integrated K-Ar age dates, geochemistry and volcanic stratigraphy of the Indian Haven Quaternary volcanic field to evaluate volcanic production rates.

Current Projects

The State of Alaska, Division of Geological and Geophysical Surveys, has completed a fluid chemistry study of the Geyser Bight area in support of the Geyser Bight geological study. Fluid chemistry analyses indicate that spring waters are derived from two intermediate level hydrothermal reservoirs with minimum temperatures of 165 and 200 degrees C, and a probable deeper reservoir with a minimum temperature of 265 C. Work continues on a second task, the compilation of the Aleutian Island - Alaskan Peninsula geothermal resource map.

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The Desert Research Institute, University of Nevada, has completed a 13 month hydrologic monitoring program at the Moana geothermal system. These and other geologic data are being used to complete a quantitative evaluation and numerical model of the Moana resource. The study results and the numerical model will be made available to regulatory agencies and developers to coordinate future development of the resource.

New Mexico Research and Development Institute is using a subcontractor, New Mexico State University, in a study to evaluate the use of time-integrated radon soil-gas surveys for geothermal resource assessment in the southern Rio Grande Rift. One drill hole which tests a radon anomaly in the Rincon survey area has recorded a temperature of 85 C at a depth of 90 meters. This study has advanced the radon soil-gas technique and yielded several target areas for moderate-temperature geothermal fluids in the Rincon and Radium Springs areas. Self-potential surveys conducted by NMSU and UURI scientists have further defined the more promising target areas.

The University of North Dakota is cooperating with the Geological Surveys of North and South Dakota in a comprehensive geothermal resource assessment of these states. Eight heat flow holes have been drilled and logged in the South Dakota heat flow anomaly, and two more test hydrologic anomalies in North Dakota. New studies suggest that the stratabound geothermal resource may be twice as large as previously reported.

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The University of Wyoming, Department of Geology and Geophysics, continues work on an improved three-dimensional modeling scheme for solving the combined heat conduction and forced convection equations for determining subsurface temperatures. A model will be developed for either the Cody or Thermopolis hydrothermal systems.

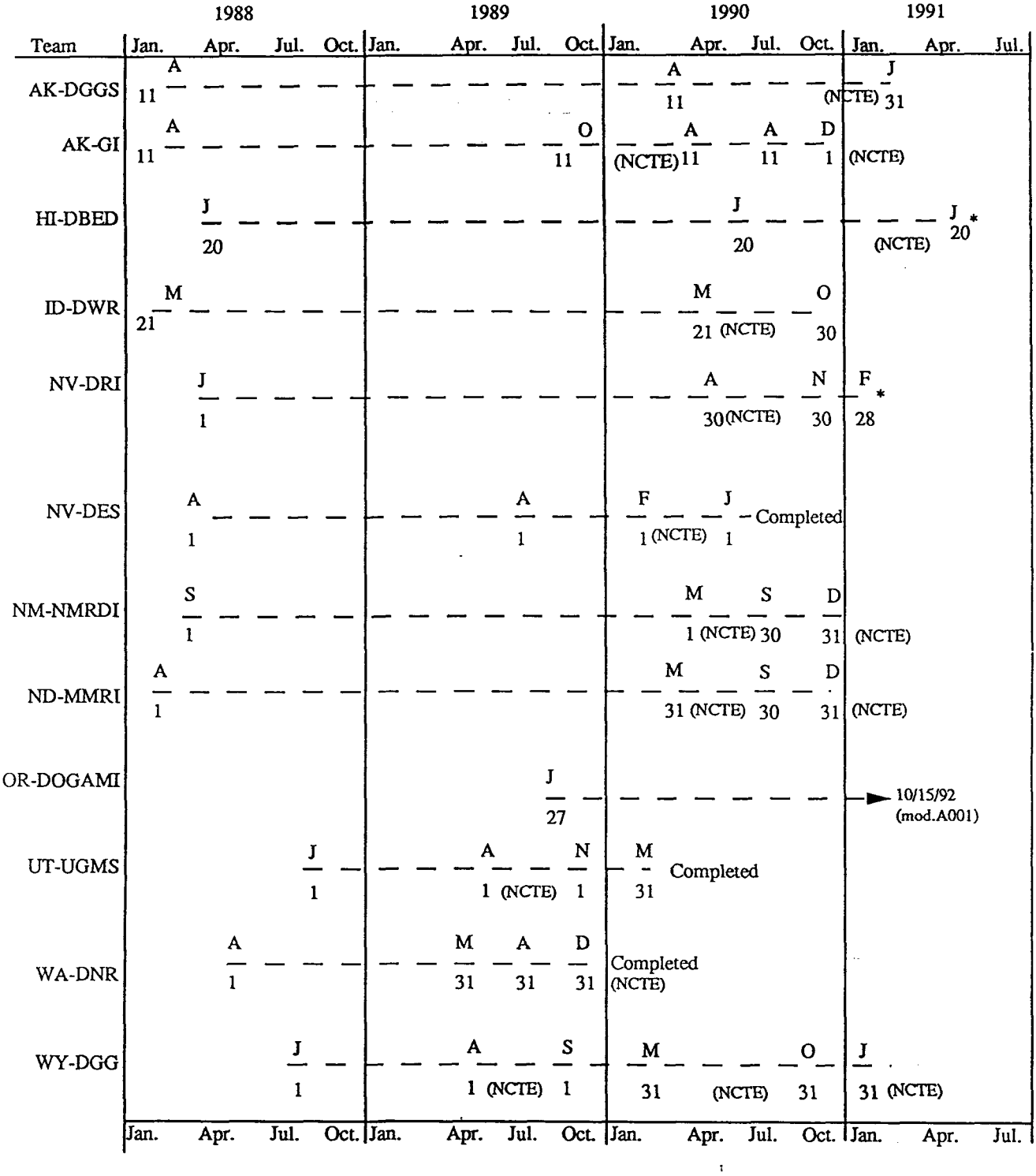
Present Status

Final deliverables have been received for five grants and all technical work has been completed for three others. All teams have received no cost time extensions. Only the Oregon-DOGAMI grant will continue beyond FY91.

Program Evaluation

A review of interim and final results so far indicates this phase of the State Cooperative Program has been extremely productive in terms of new resource information (Washington Cascades; Newcastle, Utah: Rio Grande Rift), reservoir monitoring and evaluation, and in addressing production problems (Hawaii silica studies). Four studies have been presented at the 1989 and 1990 GRC conferences, and these and several other studies will be presented at other conferences. A number of quality technical reports and presentations will result from projects described above.

# STATE TEAM SCHEDULES
## 1988 GRANTS
## Short Form Summary, 1 October 1990




* Contract modification in progress, September 1990

SCPR93.rpt

# STATE COOPERATIVE PROGRAM PUBLICATIONS

## 1 October 1988 - 30 September 1989


Barnett, B., 1989, Geothermal drilling by the State of Washington in 1988: Washington Geologic Newsletter, v. 17, p. 33-34.

Barnett, D. B., and Korosec, M. A., 1989, Results of the 1988 geothermal gradient test drilling project for the State of Washington: Washington Division of Geology and Earth Resources, Open-File Report 89-2, 36 p.

Blackwell, D. D., and Baker, S. L., 1988, Thermal analysis of the Breitenbush geothermal system: Geothermal Resources Council Transactions, v. 12 p. 221-227.

Gosnold, W. D., 1988, Analysis of heat flow and groundwater flow in the South Dakota geothermal anomaly: Geothermal Resources Council Transactions, v. 12, p. 221-227.

Lewis, R. E., and Young, H. W., 1989, The hydrothermal system in central Twin Falls County, Idaho: U. S. Geological Survey Water Resources Investigations Report 88-4152, 45 p.

Priest, G. R., Black, G. L., and Woller, N. M., 1988, Geologic map, McKenzie Bridge quadrangle, Lane County, Oregon: Oregon Department of Geology and Mineral Industries, GMS-48, 1:62,500.

Wescott, E. M., Turner, D. L., Nye, C. J., Motyka, R. J., and Moore, P., 1988, Exploration for geothermal energy resources at Mt. Spurr, Alaska, Geothermal Resources Council Transactions, v. 12, p. 203-210.

Witcher, J. C., 1989, Geothermal resources of southwestern New Mexico and southeastern Arizona: New Mexico Geological Society Guidebook, 39th Field Conference, SW New Mexico, p. 191-198.


## 1 October 1989-31 December 1989


Blackett, R. E., Shubat, M. E., Chapman, D. S., Forster, C. B., and Schlinger, C. M., 1989, An assessment of geothermal resources at Newcastle, Utah: Geothermal Resources Council Transactions, v. 13, p. 109-116.

Buchanan, P. K., 1989, Recharge of geothermal fluids in the Great Basin: Geothermal Resources Council Transactions, v. 13, p.117-123.

Korosec, M. A., 1989, New K-Ar age dates, geochemistry, and stratigraphic data for the Indian Heaven Quaternary volcanic field, South Cascade Range, Washington: Washington Division of Geology and Earth Resources Open-File Report 89-2, 36p.

# D O E GEOTHERMAL TECHNOLOGY DIVISION

## STATUS REPORT - DECEMBER 1990

## STATE COOPERATIVE PROGRAM

### Introduction

The State Cooperative Reservoir Analysis Program (SCP) was established by DOE in the late 1970's as the State Coupled Program to assess low- and moderate-temperature geothermal resources in the United States. The early efforts of the program were national in scope and focused on statewide resource assessment, resulting in the publication and distribution of a series of state geothermal resource maps. More recent work has included detailed reservoir analysis and generic studies.

As a result of a 1987 DOE/ID solicitation, eleven grants were signed with state-designated agencies to conduct geothermal research. One additional grant was signed later to provide support for an unsolicited research proposal. The grant participants and a brief description of the status of the projects follows.

### Completed Projects

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# STATE COOPERATIVE RESERVOIR ANALYSIS PROGRAM

## 1.0 Introduction

The State Cooperative Reservoir Analysis Program (SCP) was established by DOE in 1977, as the State Coupled Program to assess low-and moderate-temperature geothermal resources in the U. S. The early efforts of the SCP were national in scope. Geoscientific investigations were made in all states, with the more intensive activity focusing on states with either known existing geothermal resources or a large user potential. These studies provided extensive input to the USGS computer file GEOTHERM and demonstrated that most moderate-and high-temperature geothermal resources are found in the western portion of the country, with scattered low-temperature resources also found in the great plains and Atlantic coast region. These and subsequent studies have led to the publication and distribution of a series of state geothermal resource maps. More recent work has expanded upon earlier resource assessment activities and included detailed reservoir analysis and generic studies.

Research activities within the SCP are carried out by a state agency or group given the responsibility for geothermal resource evaluation within that particular state. Past participants have included state geologic surveys, water resource departments, and university geoscience departments within the western United States. SCP programs are initiated by the Division of Geothermal Technology and are administered by the Idaho Falls Operations Office. UURI provides technical and administrative support to DOE/DGT and DOE/ID, and technical geoscience support to various state teams.

## 2.0 Research Objectives

The primary objective of the State program is to provide updated evaluations and assessments of the low- and moderate-temperature geothermal resources in the United States. Data generated by the program is very useful to potential developers of geothermal resources and to state agencies responsible for the management of geothermal resources.

## 3.0 Annual Research Objectives and Progress

### PRE-1988 AWARDS

Three grants established by DOE from 1984 to 1986 continued to be active in FY89. Technical studies were completed by these state teams during FY89 although one deliverable remained outstanding at year's end. A brief summary of these projects follows.

#### University of Arizona - Department of Geoscience

This grant provides for the completion of 40 K/Ar age dates of young geologic samples in support of State Cooperative Program teams and other DOE funded hydrothermal research. Ten samples were submitted during FY89 which concluded the work under this grant. Age dates of samples submitted during FY89 supported geologic studies and the evaluation of geothermal resource potential in the Oregon and Washington Cascade Range.

#### Idaho - Department of Water Resources

Idaho-DWR and USGS studies of the Twin Falls County geothermal areas were completed in FY88, but the USGS report was completed in FY89. These studies document the geologic controls for the Banbury Hot Springs and Twin Falls geothermal systems, and provide base line data for reservoir management as development of these systems continues.

North Dakota - Mining and Mineral Resources Research Institute

The technical studies completed under this grant in FY87 defined a large area in southern South Dakota where seven accessible aquifers carry temperatures of 30 to 120 degrees C. Work continued in FY89 on the 1:1,000,000 scale Geothermal Resource Map of South Dakota. The map awaits printing, which is complicated due to multiple colored overlay patterns.

Oregon Department of Geology and Mineral Industries

DOGAMI completed technical studies of the industry drill hole, CTGH-1, and final reporting for this grant during FY89.

## 1987 SCP GEOTHERMAL SOLICITATION

A new Program Research and Development (PRDA) for State Geothermal Research and Development was issued by the DOE-Idaho Operations Office in April 1987. This PRDA provided funding of approximately $1,200,000 for cost shared state-oriented research and development of geothermal energy. The final evaluation of competitive proposals was completed early in FY88 and 11 new grants were awarded between January and September, 1988.

A broad range of research, generic studies, and resource assessment is represented by these grants. Regional resource assessments are being carried out in North and South Dakota, Washington, Alaska, and Nevada. Specific geothermal systems are the subject of detailed studies in Alaska, Hawaii, Idaho, Wyoming, Nevada, Utah and New Mexico. Geochemical research and data collection is a major component of studies in Hawaii, Nevada, Idaho and New Mexico. Advanced numerical modeling of combined heat flow and fluid flow is underway at the University of Wyoming and the University of North Dakota.

Technical studies and field work neared completion for eight of the SCP grants, although contract modifications have extended the period of performance for six grants. Additional no-cost-time extensions (NCTEs) can be expected.

Significant new subsurface temperature data were acquired by the Washington-Department of Natural Resources SCP team (eight drill holes to 152 m) and the North Dakota team. A major contract modification to the North Dakota grant changed the drilling program to eight holes to investigate the sources of high heat flow in South Dakota, and two holes to investigate hydrologic disturbances along the Billings Nose, Williston Basin, in North Dakota.

Geothermal resource investigations of the Newcastle, Utah and Geyser Bight, Alaska geothermal systems have been completed and the data are in final interpretation and reporting stages. Reservoir monitoring and numerical modeling studies are underway for the Moana, NV and Boise and Twin Falls-Banbury, Idaho geothermal reservoirs. These three reservoirs are nearing full development and the reservoir data are necessary to aid in reservoir management of these systems. A silica geochemistry and brine treatment study by the Hawaii state team has been interrupted by environmental problems requiring well installation workover; completion of this important project will significantly delayed.

One new grant was awarded in FY89, to the Oregon-DOGAMI state team. This grant provided for well siting and environmental studies (Phase I) and then drilling, with matching industry funds, a deep temperature gradient scientific hole along the axis of Cascade volcanism, in the Santiam Pass area. Phase I studies were completed in July and Phase II funding was awarded in October following review of all environmental studies. A drill site was prepared and the hole drilled to 460 feet before abandoning the site for winter. The scientific studies associated with this

drill hole will prolong the grant period to October 1992.

## 4.0 Problems and Solutions

Several problems arose during FY89, and these have been satisfactorily resolved by contract modifications. One major problem was the resignation of three principal investigators from the institutions receiving the grants. Dr. Larry Icerman left the New Mexico NMRDI team and was replaced by Patrick Rodriquez. Dr. Elizabeth Jacobson replaced Dr. Michael Campana as University of Nevada-Las Vegas, Desert Research Institute principal investigator. Paul Castelin, Senior Hydrogeologist with the Idaho Department of Water Resources, replaced Leah Street as principal investigator. We regret the loss of these long term geothermal supporters from the State Cooperative Program but look forward to new friendships with their replacements.

Several K-Ar age dates initially reported to Michael Korosec, WA-DNR by the University of Arizona were in error due to calibration errors by a graduate student. Some of the revised age dates which appeared to be instrumentally correct disagreed with volcanic stratigraphy observed by WA-DNR, further illustrating problems with the K-Ar method for low K, low Ar rock samples.

A substantial extension of the grant period for the Hawaii study will be required, as noted earlier, but the study will be completed in its entirety. The Oregon DOGAMI Santiam Pass scientific study will continue well into 1992, presenting some problems in contract monitoring, reporting and accounting.

## 5.0 Reports

Blackett, R. E., Shubat, M. A., Chapman, D. S., Forster, C. B., and Schlinger, C. M., 1989, An assessment of geothermal resources at Newcastle, Utah, Geothermal Resources Council Trans., v. 13, p. 109-116.

Buchanan, P. K., 1989, Recharge of geothermal fluids in the Great Basin, Geothermal Resources Council Trans., v. 13, p. 117-123.

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Korosec, M. A., and Barnett, D. B., 1989, Geothermal resource exploration target defined by Division drilling projects: Washington Division of Geology and Earth Resources, Washington Geologic Newsletter, v. 17, no. 3, pp. 12-14 (reports DOE funded work).

Ross, H. P., 1989, State Cooperative Reservoir Analysis Program, Quarterly Report; Sept. 30 - Dec. 31, ESL-89007-PR, 14 p.

Ross, H. P., 1989, State Cooperative Reservoir Analysis Program, Quarterly Report; April 1 - June 30, ESL-89040-PR, 14 p.

Ross, H. P., 1989, State Cooperative Reservoir Analysis Program, Quarterly Report; Jan. 1 - Mar. 31, ESL-89024-PR, 14 p.

Ross, H. P., 1989, State Cooperative Reservoir Analysis Program, Quarterly Report; July 1 - Sept. 30, ESL-89049-PR, 14 p.

## 6.0 Major Achievements

University of Arizona — Age dates in support of DOE Geothermal Studies. 10 K-Ar age dates, young volcanic rocks.
4 dates, Oregon Cascades
6 dates, Washington Cascades (some unreliable)

Idaho-Department of Water Resources — Compilation of all available well information for Boise geothermal aquifer by subcontractor, Berkeley Group, Inc., and development of interim numerical model.

North Dakota - Mining and Mineral Research Institute — Completion of 5 temperature gradient drilling in South Dakota.

Utah - Utah Geologic and Mineral Survey — Completion of data gathering at Newcastle geothermal area, including a radon survey at no cost to DOE. Presentation of results at GRC.

Nevada - UN-LV Division of Earth Sciences — Presentation of stable light isotope and radiocarbon age data for Great Basin geothermal fluids at the GRC.

Washington - Department of Natural Resources — Complete analysis of eight temperature gradient holes and volcanic stratigraphy study.

## 7.0 Interfaces and Contacts

The primary interfaces within the State Cooperative Project are the various state teams and their Principal Investigators. A listing of the teams and PI's active in FY89 follows:

Alaska-Division of Geological and Geophysical Surveys
Dr. Roman Motyka
University of Alaska-Geophysical Institute
Dr. Donald Turner, Dr. Christopher Nye
University of Arizona- Dept. of Geosciences: Dr. Paul Damon
Hawaii- Dept. of Business and Economic Development
Dr. Donald Thomas
Idaho- Division of Water Resources: Ms. Leah Street (replaced by) Mr. Paul Castelin
University of Nevada- Desert Research Institute
Dr. Elizabeth Jacobson
University of Nevada- Division of Earth Sciences
Mr. Thomas Flynn
New Mexico Research and Development Institute
Dr. Larry Icerman (replaced by) Patrick Rodriquez
University of North Dakota- Mining and Mineral Res. Inst.
Dr. William Gosnold
Oregon Department of Geology and Mineral Industries
Dr. George Priest
Utah Geological and Mineral Survey: Mr. Robert Blackett
Washington- Department of Natural Resources:
Mr. Michael Korosec
University of Wyoming- Department of Geology and Geophysics
Dr. Henry Heasler

## 8.0 Meetings and Reviews

No specific meetings were organized for the SCP teams as a group. Drs. Larry Icerman, Wil Gosnold, and Henry Heasler gave presentations at the DOE Geothermal Reservoir Technology Program Technical Management Reviews in May. The Utah (UGMS) and Nevada (UN-LV-DES) teams presented papers at the annual GRC meeting in Santa Rosa in October. Howard Ross, UURI P.I. for the SCP, represented DOE at the meetings of the Boise Geothermal Reservoir Users Group at Boise in January and April.

## 9.0 End of Year Status

At the end of FY89 seven of the 12 SCP grants had been extended or were in the process of receiving NCTEs. Two other grant periods will likely have to be extended. The Washington-Dept. Natural Resources team has completed one final report, and a second final report should be completed in the first quarter, FY90. This will be the first grant ready for close out. Final deliverables for three other grants are expected during the second quarter, FY90. The Hawaii and Oregon grants will continue into FY91 and FY92 respectively.

Monitoring results and computer models for the Boise and Moana reservoirs are expected to provide important information necessary for proper management of these systems. Temperature gradient studies in Washington, North Dakota and South Dakota are expected to contribute to future exploration efforts and geothermal energy utilization.

Leah Street and Larry Icerman, long term supporters of the DOE geothermal programs, are no longer involved in the State Cooperative Program.

## 10.0 Future Plans

Without new funding the State Cooperative Program will be largely phased out in FY90. Two of the state resource maps published in the early 1980's, Utah and Idaho, are out-of-print but often requested. Other state resource maps are quite out-of-date and would benefit from revision and reprinting. In addition new generic, exploration, and development activities could be undertaken by state teams to further the utilization of geothermal energy. Few states will maintain a geothermal expertise without federal funding.

# COOPERATIVE AGREEMENT BETWEEN THE U.S. DEPARTMENT OF ENERGY AND THE COMISION FEDERAL DE ELECTRICIDAD DE MEXICO

## 1.0 Project Description

In 1986, The U.S. Department of Energy signed an agreement with the Comision Federal de Electricidad (CFE) of Mexico to conduct cooperative research on geothermal systems in Mexico. Los Azufres, located in central Mexico, was selected for detailed study by U.S. and Mexican investigators because of its similarity to the Cascades and the extensive amount of subsurface data that had already been collected. Since the agreement was signed, U.S. investigators from UURI, LBL, Stanford, and the USGS have worked closely with Mexican scientists on geologic, geochemical, geophysical, and reservoir engineering problems.

The extensive amount of subsurface data available on Los Azufres has provided an excellent opportunity to evaluate the characteristics of a geothermal system in a complex volcanic setting and to publish the results. Because of the similarities between Los Azufres and the volcanic hosted geothermal systems of the Cascades, these data should prove very useful in the development of exploration strategies for systems within the U.S.

## 2.0 Research Objectives

During the past several years, UURI has been actively involved in several different projects that were jointly defined by the U.S. and Mexican investigators. The overall objective of this work has been to test exploration and reservoir mapping techniques in complex volcanic environments. The goals of the studies being conducted by UURI and CFE researchers are to:

1) Test the application of fluid inclusion data to the development of conceptual hydrologic models of geothermal systems;

2) Evaluate the use of whole rock geochemistry (with emphasis on rare-earth element distributions) to develop detailed stratigraphic correlations and structural relationships in altered aphyric volcanic deposits; and

3) Evaluate the structural setting of volcanic-hosted geothermal systems through geophysical and remote sensing techniques including aeromagnetic and electrical geophysical surveys, and satellite imagery.

## 3.0 Annual Research Objectives and Progress

Task 1. Complete fluid inclusion studies of selected geothermal wells.

Progress: Fluid inclusion studies of six wells were completed. The results of these studies were integrated with the results of previous studies by IIE to characterize the salinities, gas contents and temperatures of the reservoir fluids from the northern portion of the field.

The data demonstrate that the upper portions of the reservoir can be divided into three roughly concentric zones. The innermost zone is located above the upwelling center and is characterized by inclusions with relatively low $CO_2$ contents. This portion of the reservoir contains abundant fumaroles and zones of acid alteration indicative of a high gas flux.

Homogenization temperatures of the inclusions from this zone follow the boiling point to depth curve for pure water.

These zones are differentiated from each other on the basis of the temperature-depth relationships displayed by the fluid inclusions. Fluid inclusions from the upper 600 m of the intermediate zone lie close to the boiling point for pure water. In contrast, fluid inclusions from the outermost zone appear to define a conductive gradient to depths of 1000 m.

Fluid inclusions from the outer two zones have relatively high $CO_2$ contents that locally exceed 3.7 weight percent $CO_2$. These gas- rich inclusions form a cap over the geothermal system that is thickest in the outermost zone. Comparison of the homogenization temperatures with boiling point to depth curves for appropriate $CO_2$ contents indicates that the pressures were greater than hydrostatic during formation of the inclusions. The higher pressures could have resulted from the low permeabilities in the shallow reservoir rocks.

Task 2. Complete chemical analyses of rock samples from selected wells.

Progress: Eighty-six flows and tuffaceous deposits of the Mil Cumbres andesites from five wells were chemically analyzed in order to establish the stratigraphy of the upper 2500 m of the reservoir at Los Azufres. Nine major chemical groups, ranging from basaltic andesite through andesite and dacite were distinguished on the basis of their major element chemistries. Although most of the chemical groups are repeated at irregular intervals throughout the volcanic section, a few have limited lateral and vertical distributions. These observations suggest that several different eruptive centers were active during emplacement of the Mil Cumbres andesites.

Although the majority of the individual flow packets have limited distributions, systematic variations in their chemistries, particularly with respect to La, Ce, MgO, $TiO_2$,and $P_2O_5$, have allowed us to group them into four volcanic sequences which can be correlated across the field. The uppermost sequence (sequence I) is found only in the eastern half of the field. This sequence consists entirely of andesite flows with intermediate $SiO_2$ contents. Volcanic sequences II and III consist dominantly of andesite although minor dacite and basaltic andesites are also present. The oldest sequence encountered in the drill holes is composed mainly of basaltic andesite with minor interbedded andesite.

Flows of the Mil Cumbres andesites have been disrupted by east-trending faults that control much of the present surficial alteration. A northeastward thickening of volcanic sequence II suggests that some of these faults were active during deposition of the andesite flows. The greatest offsets are found at the base of this sequence.

Task 3. Conduct and interpret two aeromagnetic surveys of the Los Azufres geothermal system to determine the effectiveness of specialized aeromagnetic surveys for determining structural controls and alteration areas in geothermal resources related to fractured volcanic systems.

Progress: The compilation of high- and low-level surveys flown in FY88 was completed in FY89. UURI completed an interpretation of the data which emphasized the use of numerical models in identifying magnetic source geometries and fault and fracture delineation. Numerous linear magnetic trends were identified from the detailed data, at least 18 of which correlate with mapped faults and other probable structures. Several mapped faults could be extended on the basis of the magnetic data, and more than 12 previously unmapped structures were interpreted from these data. A large area of low magnetic relief closely corresponds to mapped surface alteration in the central portions of the geothermal area. Several areas of reversed polarity volcanic units were

also identified. The high altitude survey identified major west and west-northwest trending structures which may be important to the localization of the geothermal system.

Interpretations by CFE focused on digital processing for noise reduction, upward continuation, and two-dimensional modeling.

Task 4. Evaluate the structural setting of volcanic-hosted geothermal systems using satellite imagery.

Progress: Several stages of digital image-processing were completed on a Landsat 5 image of the Los Azufres geothermal area and its surroundings. Thematic Mapper (TM) imagery contains seven bands of digital information and various combinations of TM bands can be displayed on the three primary-color channels of the color monitor. The image made by displaying TM band 7 on the red channel, TM band 4 on the green channel, and TM band 2 on the blue channel was judged best for structural information and for definitive signatures in hydrothermally altered areas. Numerous structures were mapped as lineations on this (7,4,2) image. Areas of hydrothermal alteration were also interpreted.

## 4.0 Reports

The results of the work described in Section 3.0 and presented at the Proceedings: Symposium in the Field of Geothermal Energy, held in San Diego on April 4-5, 1989. The following papers were published in the proceedings volume:

M. M. Lemieux, J. N. Moore, E. Gonzales P., G. Izquierdo, and R. Huitron E.: Chemistry of Los Azufres reservoir fluids: data from fluid inclusions, p. 29-36.

A. Razo M., R. Huitron E., and J. N. Moore: Geologia del campo geotermico de Los Azufres, Mich., p. 7-17.

A. Razo M., R. Huitron E., J. N. Moore, A. C. Tripp and M. M. Lemieux: Stratigraphy of the Los Azufres geothermal reservoir, p. 17-28.

H. P. Ross, P. M. Wright, A. Razo M., Geraldo H. Garcia E., J. Francisco Arellano G., J. Jesus Arredondo F. and J. Luis Guerrero G., 1989, Aeromagnetic studies, Los Azufres geothermal area, Michoacan, p. 55-62.

A. Razo M., G. H. Garcia E., J. Francisco Arellano G., J. Luis Guerrero G., H. Lira Herrera, H. P. Ross and P. M. Wright, 1989, Levantamiento Aeromagnético del Campo Geotérmico de Los Azufres, Mich. Vuelo Bajo, p. 63-72.

P. M. Wright, H. Lira H., and D. R. Ramsey, 1989, Interpretation of Landsat Thematic Mapper satellite imagery at Los Azufres geothermal field, Michoacan, Mexico, p. 73-76.

H. Lira Herrera, 1989, Sensores Remotos, p. 77-80.

## 5.0 Major Achievements

Task 1: Secondary bicarbonate-rich reservoirs are believed to be present over many geothermal systems associated with young volcanism. However, there are no detailed studies describing the chemical and thermal structure of these reservoirs. Thus, our fluid inclusion studies represent an important step in developing a better understanding of the occurrence and characteristics of these shallow reservoirs.

Task 2: Our chemical studies have demonstrated that chemical analyses (particularly major and rare earth element contents) can be used to define the stratigraphic relationships in complex, high-temperature geothermal reservoirs. Lateral discontinuities in the chemical units were used at Los Azufres to locate and characterize major structural discontinuities within the system.

Task 3: Detailed and regional aeromagnetic surveys at Los Azufres mapped many known faults and delineated several other structures some of which appear to be important for the localization of the geothermal system. The large area of surface alteration is also recognized in the detailed magnetic survey. Specialized aeromagnetic surveys may contribute substantial geologic information for other volcanic-hosted geothermal systems, such as in the U.S. Cascade Range.

Task 4: Digital image-processing of TM data revealed numerous structures previously identified as faults, and additional geologic structures at Los Azufres. In addition, two color processed TM band combinations were identified which show promise for the mapping of hydrothermal alteration in volcanic rocks.

## 6.0 Interfaces and Contacts

We have maintained close contact with CFE at all levels.
The primary contact with CFE is Ing. Antonio Razo, Chief of the
Department of Exploration, Geothermal Projects. Cooperating CFE scientists are:

Ing. Antonio Razo, Chief, Department of Exploration
Hector Lira - Geologist
Rogillio Huitron - Geologist
Geraldo Garcia - Geophysicist

In addition, we have worked closely with Dr. David Nieva, who is responsible for all geothermal studies conducted by the Instituto de Electricidad Investigaciones (IIE).

## 7.0 Meetings and Reviews

A symposium on the joint investigations conducted under the U.S. DOE-CFE agreement was held in San Diego on April 4-5, 1989. This meeting was open to the public. Papers presented at the meeting are compiled in a Proceedings volume (NTIS publication CONF-8904129).

## 8.0 Future Plans

DOE and CFE have agreed to extend the program for Cooperative Research. Research projects at Los Humeros and La Primivera, Mexico have been jointly proposed by CFE and U.S. investigators. These studies will be initiated if funding becomes available.

UAKI Ann Rept to DOE 1/10/89

# FY-88 SCP PROGRAM

SCP Reports

Stratigraphy, petrology, and geochemistry of the Spurr Volcanic Complex, Eastern Aleutian Arc, Alaska, 1987, Nye, C. J. with appendix by R. J. Motyka; U. Alaska Geophys. Inst. Report UAG-R-311, 135 p. (December)

Geochemistry, isotopic composition, and origin of fluids emanating from mud volcanoes in the Copper River Basin, Alaska, 1988, Motyka, R. J., Poreda, R. J., and Jeffrey, A. W. A., submitted to Geochimica et Cosmochimica Acta - (September; partial DOE-SCP support).

U. S. Geothermal Database and Oregon Cascade Thermal Studies, 1988, Blackwell, D. D., Steele, J. L., and Carter, L.; Southern Methodist Univ. - Geothermal Laboratory Final Rept. to DOE; DOE/ID/12623-1, 90 p., May.

Three-dimensional gravity modeling techniques with application to the Ennis Geothermal Area, 1987, Semmens, D., Montana College of Mineral Science and Technology - Dept. Phys. and Geophys. Engr. final Rept. to DOE, Pt.I, 182 p., December.

A controlled source audiomagnetotelluric investigation of the Ennis Hot Springs Geothermal Area, Ennis, Montana, 1988, Emilsson, G. R., Montana College of Mineral Science and Technology - Dept. Phys. and Geophys. Engr. Final Rept. to DOE, Pt.II, 97 p., June.

New Mexico Statewide Geothermal Energy Program, 1988, Icerman, L. and Parker, S. K., eds., New Mexico Research and Development Institute Final Rept. to DOE, Grant DE-FG07-84ID12546, 210 p., April.

Evaluation of the Boise Geothermal System, 1987, Waag, C. J., and Wood, S. H., Boise State Univ. Dept. Geol. & Geophys. Final Rept. to Idaho DWR, 154 p., December.

Geothermal Resource Analysis in Twin Falls County, Idaho, 1987, Street, L. V., and Detar, R. E., Idaho - Dept. Water Resources Final Rept. to DOE, IDWR Water Information Bull. No. 30, Pt.15, 46 p., Grant DE-FG07-84ID12549, December.

Geologic Map of the Crescent Mountain Area, Linn County Oregon, 1987, Black, G. L., et al., Oregon-DOGAMI GMS-47.

Geologic Map of the McKenzie Bridge Quadrangle, Lane County, Oregon, 1988, Priest, G. R., et al., Oregon-DOGAMI GMS-48.

Geothermal Research, Oregon Cascades, 1988, Priest, G. R., and Black, G. L., Oregon-DOGAMI Final Rept. to DOE, Grant DE-84ID12526, 15 p.

Geology and geothermal resources of the Breitenbush-Austin Hot Springs Area, Clackamas and Marion Counties, Oregon, 1988, Oregon - DOGAMI Open File Rept. 0-88-5, 91 p.

## SCP MAJOR ACHIEVEMENTS

Univ. Arizona - Age Dates in support of DOE Geothermal Studies. 16 K/AR age dates, young volcanic rocks.

9 dates, Oregon Cascades
1 date, Ascension Island
6 dates, Los Azufres, Mexico

Idaho - Dept of Water Resources - ID - DWR concluded studies of the Boise and Twin Falls - Banbury aquifer systems which clearly document decline of the geothermal aquifers under continued development. These studies provide valuable baseline data and a basis for further studies and reservoir management.

Montana - CMST State-of-the-art gravity and CSAMT studies of the Ennis Hot Springs area were completed. These studies define the limits of this warm water resource area.

New Mexico RDI - The NMRDI report presents previously unpublished hydrologic and thermal data for the Lightning Dock geothermal area in south-western New Mexico, and the results of a 1,176 foot deep exploratory well near the Jarilla Fault Zone near Orogrande, New Mexico.

Oregon-DOGAMI - Completed geologic mapping projects in the area of the CTGH-1 drillhole and the Breitenbush and McKenzie Bridge area. A technical study of the CTGH-1 drillhole was completed and distributed.

Southern Methodist University - Dr. David Blackwell completed his compilation of heat flow data for the Decade of North American Geology geothermal map and has submitted the map to GSA for publication. Final heat flow measurements for Cascade industry holes were completed and reported to DOE.

The 1987 SCP PRDA Solicitation was completed and 11 new grants, totaling approximately $1,200,000 were issued to state teams for geothermal studies. A broad range of site specific and regional assessment projects are included in these grants. Work on the new projects is well underway.

The Alaska-DGGS and GI study of Geyser Bight has already developed substantial new information on this high temperature geothermal system. The Washington - DNR thermal gradient drilling program of eight 500 foot holes is underway in the southern Washington Cascades, and the Utah-UGMS study at Newcastle has already developed substantial thermal gradient and near surface temperature data.

H. Ross

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

EARTH SCIENCE LABORATORY
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108—1295
TELEPHONE 801-524-3422

MEMO TO: ESL SCIENTIFIC STAFF

FROM: MIKE WRIGHT

SUBJECT: ANNUAL REPORT

DATE: November 14, 1988

Beginning this year, DOE is requiring an annual report on all of their research projects. Separate reports will be assembled for the major research programs, namely Hydrothermal Research, Hot Dry Rock Research, Geopressured Research, and Magma Research. The Hydrothermal Research report will be compiled by Joel Renner and Sam Aoki in Idaho Falls. We are being asked to send our contribution to Idaho Falls by 6 Dec 88. The attachment to this memo gives the outline of the report along with an explanation of what is to be discussed under each heading. The following outline shows which sections of the report for which we will be need to provide input to Idaho.

State Coop?

| | |
|---|---|
| Executive Summary | no |
| I. Introduction | no |
| 1. Background | no |
| a. Need/Justification | no |
| b. History of research | no |
| c. Mandates | no |
| 2. Objectives | no |
| a. Logical basis | no |
| b. Hierarchy | no |
| 3. Work Breakdown Structure | no |
| II. Fiscal Year Accomplishments | |
| 1. Category X | |
| a. Task X.1 | no |
| (1). Project X.1.1 | yes |
| (2). Project X.1.2 | yes |
| b. Task X.2 | |
| III. Management | no |
| 1. Organization | no |

| | | |
|---|---|---|
| 2. | Interfaces/Contacts | yes |
| 3. | Meetings/Reviews | yes |
| 4. | Issues | yes |
| IV. | Budget | yes |
| V. | End of Year Status | yes |
| VI. | Future Plans | yes |

I suggest that the easiest way to handle this task is to divide it up for writing and let me compile our response to Idaho. The projects we need to write up and the person(s) responsible for each one are listed below. The first listed name is the person responsible for compilation of the report to give to me.

| | |
|---|---|
| Baca Research | Jeff Hulen and Dennis Nielson |
| Coso Research | Joe Moore, Jeff Hulen and Dennis Nielson |
| Dipmeter Research | Lee Allison and Dennis Nielson |
| Injection Research - Tracer Development | Mike Adams |
| Heber Research | Joe Moore |
| Borehole Research | John Stodt |
| Mexico Research | |
| Geology and Chemistry | Joe Moore |
| Aeromagnetic Survey | Howard Ross |
| Remote Sensing | Mike Wright |
| State Coupled Program | Howard Ross |
| Caldera Research | |
| Rock Properties | Al Tripp |
| Technical Assistance in Cascades | Mike Wright |
| Cascades Reservoir Characterization | Dennis Nielson |
| Long Valley MT Survey | Phil Wannamaker |

Would each of you please give me written text on disk for each of the categories (except "Budget") marked "yes" in the table above, following the information given in the attachment to guide you in topics to be discussed under each project? Submissions should be concise and should emphasize accomplishment and conclusions. I will be able to put in the budget information, so you don't need to worry about that. I will get our response together and transmit it to ID

via electronic mail. Our due date is Tuesday, 6 December, so I need your input first thing Monday morning, 5 December.

ANNUAL PROGRESS REPORT ANNOTATED OUTLINE

Executive Summary

I. Introduction

[This should consist of summary material to inform the reader of the rationale for the research program. The Introduction will vary little from year to year.]

1. Background

a. Need/Justification

[Present the technical basis of the program. Identify the issues being addressed and why they are important. Size of resource is an acceptable starting point, but the issues limiting the resource should also be discussed.]

b. History of research

[Briefly discuss the work that has gone before, including not only that done under the current research program but any other research that contributed directly to solving major problems. Cite significant accomplishments in chronological order. Indicate budget history for DOE-sponsored portions of program.]

c. Mandates

[Identify any special mandates, both legal and administrative, under which the program functions. As necessary, quote relevant portions of public laws, NEPP, etc.]

2. Objectives

a. Logical basis

[Discuss the need for program objectives as guides to the direction of the research effort and markers of progress. Address how the objectives satisfy needs and will resolve issues.]

b. Hierarchy

[Present the 3-level hierarchy of objectives that apply to the research category (i.e., hydrothermal, geopressure, hot dry rock, and magma) as given in the GTD's objectives document. Discuss how the objectives in the research category relate/interact with each other; identify interdependencies among objectives at the same level. Specify the major technical issues each level 3 objective is intended to resolve.]

3. Work Breakdown Structure

[Give the WBS for the research category. Specify the objectives that apply to each element of the structure down to the activity level. Provide a summary description of each element. (Note: Only cover those elements to which the annual report applies.)]

II. Fiscal Year Accomplishments

[This section presents the detailed discussion of progress made during the reported fiscal year. As necessary, accomplishments from previous years may be used to introduce current progress, but they should be noted as such. The WBS at the activity level is used as the framework for discussion.]

1. Category X

[Give a brief, general discussion of work performed relative to the resource category; indicate the extent to which progress toward the highest level objective was made. If possible, support discussion with analysis from economic model.]

a. Task X.1

[Present an overview of task, work performed, and progress toward the second level objectives that relate to the task. Show relationship of progress to achieving highest level objective; as above, use model analysis if appropriate.]

(1). Project X.1.1

[Describe the project, including the activities that comprise the project. Identify the objectives which apply at the project level; also state the annual objectives used to guide work for each activity. Discuss progress toward objectives, comparing actual versus planned as given in the Annual Operating Plan; list milestones and discuss their status; identify any problems encountered and solutions tried. Highlight major achievements, and explain their significance. Provide a list of technical reports issued during the year.]

(2). Project X.1.2

[Give same types of information requested for Project X.1.1 for all remaining projects of Task X.1.]

b. Task X.2

[Repeat instructions for Task X.1 for all remaining tasks.]

III. Management

[This section contains information pertinent to the administration of the program; it answers the questions who, what, and when?]

1. Organization

[Give the structure of the management organization, explaining lines of authority; identify line management personnel.]

2. Interfaces/Contacts

[Specify interfaces for cooperation/coordination with other organizations outside the program (e.g., USGS, state agencies, BLM, EPA, UNOCAL, Chevron, DOE/OBES). Identify contact persons at those organizations.]

3. Meetings/Reviews

[List meetings held during the year, including management reviews, seminars, workshops, etc, funded wholly or in part by the program. Include subjects/issues addressed at meetings and results/decisions.]

4. Issues

[Identify key management issues that arose during the year and steps taken to resolve them. Indicate any issues which remain unresolved along with potential effect on program.]

IV. Budget

[Present the available budget (BA) and expenditures (BO) for a five-year segment of the program (i.e., from reporting year minus three to reporting year plus one) highlighting the reporting year. Provide a breakdown to the activity level with totals at the project and task levels. Tabular format is preferred with narrative as necessary to explain special circumstances or problem areas during the year.]

V. End of Year Status

[Summarize Section II, giving the status of the research effort at close of year with particular emphasis on achieving objectives. Highlight significant accomplishments, milestones attained and missed, and problems encountered.]

VI. Future Plans

[Briefly address research plans for the future especially next fiscal year. Potential new initiatives may be included provided they are linked to attaining program objectives.]

ESL-88046-PR
DOE/ID/12489-38

# STATE COOPERATIVE

# RESERVOIR ANALYSIS PROGRAM

# QUARTERLY REPORT

July 1 - September 30, 1988

November 4, 1988

by

Howard P. Ross

Earth Science Laboratory
University of Utah Research Institute

## INTRODUCTION

This report presents a brief description of State Cooperative Reservoir Analysis Program (SCP) activities by State Teams and by the Department of Energy during the quarter ending September 30, 1988. Significant events which occurred during October are noted to bring the status current to a reporting date of November 1. Project budgets are updated to November 1, 1988.

## PRE-1988 GRANTS

### University of Arizona - Department of Geosciences

Fourteen K/Ar dates remain to be completed under this grant. Four dates will be completed in support of George Priest's existing grant for mapping in the Oregon Cascades. The remaining 10 dates have been allocated to the new (1988) Washington DNR grant for work in the Washington Cascades. These dates should be completed and the grant closed out before the end of 1988.

### Idaho - Department of Water Resources

Final report deliverables have been received from the Idaho - DWR and from one subcontractor, Boise State University (Dr. C. Waag). Closeout of this grant has been delayed because of the late delivery of a subcontractor's (USGS) report. The report has been available to ID-DWR and to DOE in draft form for several months. The report now awaits printing. Another no cost time extension will be required for formal closeout of this grant.

### Oregon - Department of Geology and Mineral Industries

Final report deliverables were received October 31. These included: a geologic map of the McKenzie Bridge quadrangle; a geologic map of the Breitenbush - Austin Hot Springs area; the CTGH-1 data, analysis and well study; and a final technical report summarizing all work completed under this grant.

### North Dakota - Mining and Minerals Resource Research Institute

This grant was closed out in 1987 following delivery of the principal deliverable, a final technical report. An important part of this report, the "Geothermal Resources Map of South Dakota" has not yet been delivered to DOE, but is expected shortly. Dr. Wil Gosnold, P. I. is reminded periodically of the overdue deliverable and reports substantial progress after a very busy academic year. Dr. Gosnold continues to be one of the most productive scientists funded by the DOE SCP and provides good exposure for the results of this program.

## 1988 GRANTS

Negotiations were completed and agreements signed for the New Mexico - NMRDI grant. Contract activities continue for one grant resulting from an unsolicited proposal (Oregon - DOGAMI).

Most state teams already report progress on compilations, contracting, sampling, analyses, and mapping activities related to the 1988 grants. A substantial portion of the field programs have been completed by four SCP teams: the University of Alaska - Geophysical Institute; Alaska - Division of Geological and Geophysical Surveys; the Utah Geological and Mineral Survey; and the Washington - Department of Natural Resources. Some future contract modifications have already been identified, but no major problems with these grants have been identified to date.

## COMMENTS

The deliverables resulting from the pre-1988 grants included several high quality studies which are significant contributions to the geothermal resource database or basic geology of the states involved. The studies funded by the 1988 grants include diverse topics such as: sophisticated algorithm development, monitoring and numerical modeling of hydrothermal systems, some of which may be in danger of overdevelopment; geothermal fluid genesis; geochemical studies; and basic drilling and temperature gradient studies. We look forward to the technical data and interpretations which will result from these studies.

STATE TEAM SCHEDULES

PRE-1988 GRANTS

Short Form Summary, 1 November, 1988

| | 1988 | | | | | | 1989 |
|---|---|---|---|---|---|---|---|
| Team | Jul | Aug | Sept | Oct | Nov | Dec | Jan |
| Az-K/Ar | ---------- | | (NCTE) | ---------- | | | -----31 |
| ID-DWR | --------29---------- | | | | | | |
| | F m8 (NCTE needed) | | | | | | |
| ND-MMRRI | - - - - - - - - - - - - - - - - - - | | | | | | |
| | (map due - grant | | | closed out) | | | |
| OR-DOGAMMI | Q---------- | | | -Q---31 | | | |
| | | | | F(rec) | | | |

Q: Quarterly Report
F: Final Report
m: Grant Mod. No.
NCTE: No Cost Time Ext.

## STATE TEAM STATUS - PRE 1988 GRANTS

1. Arizona - K/Ar Dating  Grant Number DE-FG07-86ID12622

Financial:

| | |
|---|---|
| Total Funding Authorized | $29,999 |
| Invoices Through 11/1/88: | $19,250 |
| Total Funds Remaining | $10,749 |

Project Period: 1-31-89

| Deliverables: | Date Received |
|---|---|
| 1. 2 samples, Cerro Prieto -Moore/Reed | 4/2/87 |
| 2. 2 samples, OR Cascades- DOGAMI-Priest | 9/16/87 |
| 3. 6 samples, Ascension- UURI- Nielson | 9/16/87 |
| 4. 4 samples, OR Cascades- DOGAMI- Priest | 2/4/88 |
| 5. 6 samples, Los Azufres- Moore/Reed | 4/4/88 |
| 6. 5 samples, OR Cascades- DOGAMI- Priest | 4/18/88 |
| 7. 1 sample, Ascension- UURI- Nielson | 5/4/88 |

Current Issues:
14 samples remain to be completed; Washington State (DNR) has been allocated 10 dates for the 1988 grant. DOGAMI has been allocated the remaining four samples for their old grant. This will complete the Arizona K/Ar dating grant.

2. Idaho Dept. Water Resources  Grant Number DE-FG07-84ID12549

Financial:

| | |
|---|---|
| Total Funding Authorized: | $158,579 |
| Invoices Through 11/1/88: | $125,000 |
| Total Funds Remaining: | $ 33,579 |

Project Period: 8-29-88 (NCTE required to 12/31/88)

| Deliverables: | Date Received |
|---|---|
| 1. "Geothermal Resource Analysis in Twin Falls County, Idaho": IDWR Final Report | 1/11/88 |
| 2. "Evaluation of the Boise Geothermal System": Boise State Univ. Final Report | 1/11/88 |
| 3. "The Hydrothermal System in Central Twin Falls County, Idaho": USGS Final Report (as a subcontractor to IDWR) | Overdue |

Current Issues:
USGS report has completed Geologic Names review and is now awaiting printing. A delivery date to IDWR is still uncertain. One more NCTE will be required.

3. Montana-MCMS&T Grant Number DE-FG07-84ID12525

Financial:
Total Funding Authorized: $93,421
Invoices Through 9/1/88: $93,421
Total Funds Remaining: $ 0

Project Period: 6-31-88

| Deliverables: | Date Received |
|---|---|
| 1. Final Report, Geophysical Research on Geothermal Resources in Montana | |
| 1a) "Three Dimensional Gravity Modeling Techniques with Application to the Ennis Geothermal Area" by D. Semmens | 12/23/87 |
| 1b) "A Controlled Source Audiomagnetotelluric Investigation of the Ennis Hot Springs Geothermal Area, Ennis, Montana" by G. R. Emilsson | 7/5/88 |

Current Issues:

All deliverables received and Grant closed out.

4. New Mexico-NMRDI Grant Number DE-FG07-84ID12546

Financial:
Total Funding Authorized: $109,970
Invoices Through 11/1/88: $109,970
Total Funds Remaining: $ 0

Project Period: 6-15-88

| Deliverables: | Date Received |
|---|---|
| 1. Final Report | |
| 1a) South-central New Mexico study (NMSU) | 6/9/88 |
| 1b) Animas Valley (Lightning Dock Geothermal) | 6/9/88 |
| 1c) Orgrande geothermal resource assessment (Lightning Dock Geothermal) | 6/9/88 |

Current Issues:

All deliverables received and Grant can be closed out. Final invoice received by DOE/ID 10/18/88. Approved for final payment on 11/03/88.

5. Oregon-DOGAMI Grant Number DE-FG07-84ID12526

Financial:
Total Funding Authorized: $359,357
Invoices Through 11/1/88: $330,874
Total Funds Remaining: $ 28,483

Project Period: 10-31-88

| Deliverables: | | Date Received |
|---|---|---|
| Original Grant | | |
| Task 1.1 | Geologic Map, Breitenbush River Area (1:62,500; GMS-46, 1987) | 8/7/87 |
| | Geologic Map, Crescent Mountain Area (1:62,500; GMS-47, 1987) | 8/7/87 |
| | Geologic Map, NW/4 of Broken Top 15' (1:24,000; Spec. Paper 21) | 8/7/87 |
| Task 1.2 | Temperature Data Collection Geothermal-Gradient Data for Oregon (1982-1984); Open File Rep. 0-86-2 | 8/7/87 |
| Task 1.3 | Project Management and Reporting | Quarterly |
| Mod. M-001 | | |
| Task 1.1 | Feasibility Study/Scientific Plan for Research (Open File Rep. 0-86-3) | 8/7/87 |
| Task 1.2 | Geologic Map, McKenzie Bridge 15' Quad., with data, interp., description. | 10/31/88 |
| Task 1.3 | Project Management and Reporting | Quarterly |
| Mod. A-002 | | |
| Task I. | Geologic map, approx. 15 sq. mi. centered on CTG drill site, Sec.28,T8S,R8E, E/2 Breitenbush 15'topo quad. | 10/31/88 |
| Task II. | Raw data and analyses, well core, CTG drill hole. (archival storage at UURI) | 10/31/88 |
| Task III. | CTG well study: comprehensive report with geologic and geothermal implications and geologic models. | 10/31/88 |
| Tasks 1, I, II, III. | Final Technical Report | 10/31/88 |

Current Issues: All work completed and deliverable received. DOGAMI is awaiting final billings by subcontractors before submitted final invoice (expected by 11/30/88). The Grant can be closed out after final payment.

6. Southern Methodist Univ. Grant Number DE-FG07-84ID12623

Financial:

| | |
|---|---|
| Total Funding Authorized: | $115,790 |
| Invoices Through 9/1/88: | $115,790 |
| Total Funds Remaining: | $ 0 |

Project Period: 5-31-88

| Deliverables: | Date Received |
|---|---|
| 1. Annual Data Report (GRC Trans., v.11) | 3/14/88 |
| 2. Final Tech. Report on Cascades heat flow studies and the Heat Flow Map of North America "U.S. Geothermal Database and Oregon Cascade Thermal Studies", by D.D. Blackwell, J. L. Steele, L. Carter. | 7/1/88 |

Current Issues:
All deliverables received and Grant closed out. Additional funding provided by a EG&G Purchase Order to further update the heat flow database.

7. North Dakota-NDMMRI Grant Number DE-FG07-84ID12606

Financial:

| | |
|---|---|
| Total Funding Authorized: | $47,000 |
| Invoices Through 6/1/88: | $47,000 |
| Total Funds Remaining: | $ 0 |

Project Period: Closed Out

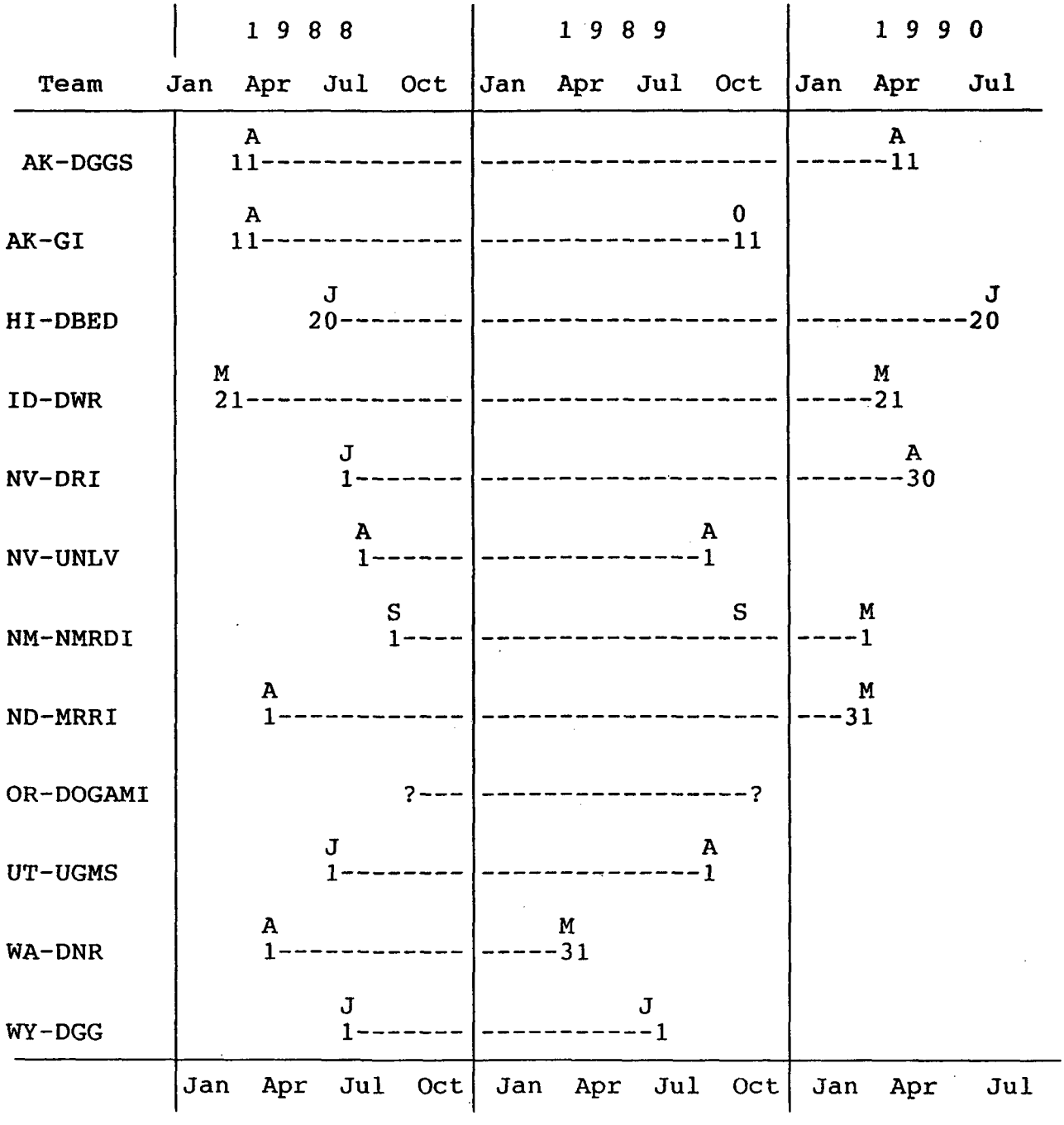
| Deliverables: | Date Received |
|---|---|
| 1. Task 5. Geothermal resource map of South Dakota (scale 1:1,000,000) | overdue |
| 2. Task 7. Final report, "Geothermal Resource Assessment of South Dakota", by W. D. Gosnold, Jr. | 8/28/87 |

Current Issues: Dr. Gosnold continues to work on the final map, which is nearing completion. No date has been set for printing and delivery.

STATE TEAM SCHEDULES

1988 GRANTS

Short Form Summary, 1 September 1988



## STATE TEAM STATUS - 1988 GRANTS

1. Alaska - Dept. of Natural Resources — Grant Number DE-FG07-88ID12744

Financial:
Total Funding Authorized: $72,000
Invoices Through: 11/1/88 $ 0
Total Funds Remaining: $72,000

Project Period: 4-11-90 (24 months)

Deliverables: Date Received
1. Contributions to GI-UAK geologic map of Geyser Creek Valley area (Task 4.1.1)
2. Report on fluid geochemistry, Geyser Bight KGRA (Task 4.1.2)
3. Contributions to GI-UAK final report on Geyser Bight KGRA study (Task 4.1.3)
4. Geothermal resource map of Aleutian Islands-Alaska Peninsula Region (Task 4.2.1)
5. Tables of fluid geochemistry (Task 4.2.2)
6. Descriptive circular to accompany Geothermal Resource Map (Task 4.2.3)

Current Issues:
Compilations underway and field work at Geyser Bight area, Umnak Island, is completed.

2. Univ. of Alaska - Geophysical Institute — Grant Number DE-FG07-88ID127 42

Financial:
Total Funding Authorized: $55,593
Invoices Through: 11/1/88: $31,607
Total Funds Remaining: $23,986

Project Period: 10-11-89 (18 months)

Deliverables: Date Received
1. Geologic map of Geyser Creek Valley area at 1:25,000 scale (Task 4.1.1)
2. Management, logistical, technical support for Alaska DGGS fluid chemistry study
3. Final report on Geyser Bight geothermal area study (Task 4.1.3)

Current Issues:
Invoices #1-4 received. Field work at Geyser Bight area

has been completed. Principal Investigator Don Turner will be on leave much of time November - February 1988 and Dr. Christopher Nye will cover for him. Field operations cost more than expected.

3. Hawaii-Dept. Business and Economic Development — Grant Number DE-FG07-88ID12741

Financial:
Total Funding Authorized: $ 87,173
Invoices Through: 11/1/88: $ 0
Total Funds Remaining: $ 87,173

Project Period: 6-20-90 (24 months)

Deliverables: Date Received

1. Final technical report which describes in detail the following studies:
   a. Silica polymerization studies
   b. Low-temperature brine treatment
   c. Fabrication of pilot scale treatment system
   d. Fluid characterization
   e. Preliminary design of pilot scale system
   f. By-product characterization.

Current Issues:
Subcontract between HI-DBED and Univ. of Hawaii is just now being signed. No progress yet on technical work.

4. Idaho - Dept. of Water Resources — Coop. Agreement No. DE-FC07-88ID12748

Financial:
Total Funding Authorized: $154,088
Invoices Through: 11/1/88: $ 15,127
Total Funds Remaining: $138,961

Project Period: 3-21-90 (24 months)

Deliverables: Date Received

1. Final technical report, all new studies, Twin Falls County Geothermal Systems (Task 1.0)
2. Final technical report, Boise geothermal aquifer study, to include all new monitoring results, Consultant's report, and IDWR summary and interpretation (Task 2.0)
3. Final technical report, geochemical studies of Wood River geothermal systems (Task 3.0)

Current Issues:

All field studies underway. IDWR RFP for consultant reservoir engineer should go out in November after numerous delays.

5. Desert Research Institute
University of Nevada System

Grant Number
DE-FG07-88ID12757

Financial:

Total Funding Authorized: $140,639
Invoices Through: 11/1/88: $ 0
Total Funds Remaining: $140,639

Project Period: 4/30/90 (22 months)

Deliverables: Date Received

1. Final technical report for the Moana system studies, including monitoring results, interpretation, models (Tasks 4.1-4.5)
2. User's manual for reservoir model, and any new software developed in project (Task 4.5)

Current Issues:

Field work and planning for monitoring studies are underway. Communication has been established with LBL reservoir engineering group. Dr. Elizabeth Jacobson approved by DOE/ID as temporary Project Director (8-1-88 to 6-30-89).

6. Division of Earth Sciences
Univ. of Nevada-Las Vegas

Grant Number
DE-FG07-88ID12784

Financial:

Total Funding Authorized: $157,114
Invoices Through: 11/1/88: $ 0
Total Funds Remaining: $157,114

Project Period: 8/1/89 (12 months)

Deliverables: Date Received

1. Final technical report which describes:
   a. Fluid chemistry study, Great Basin
   b. Geothermal reservoir rock data
   c. Glacial ice study
   d. Archaeological isotope/age date study
   e. Data base summary
   f. Description of sampling and analyses
   g. Great Basin fluid genesis model
2. Technical data base submitted to GEOTHERM

Current Issues:
Data compilation underway. Renegotiating agreements for sampling geothermal fluid with industry groups.

7. New Mexico Research and Development Inst. Grant Number DE-FG07-88ID12794

Financial:
Total Funding Authorized: $129,267
Invoices Through: 11/1/88: $ 0
Total Funds Remaining: $129,267

Project Period: 3-01-90 (18 months)

Deliverables: Date Received
1. Final technical report describing soil-depth radon gas surveys; Tortugas Mountain survey; Radium Springs survey; Rincon survey; final evaluation and interpretations.

Current Issues:
Contract signed on September 2. Subcontract with New Mexico State University has been executed. Field work now underway.

8. North Dakota Mining and Mineral Res. Inst. Grant Number DE-FG07-88ID12736

Financial:
Total Funding Authorized $194,814
Invoices Through: 11/1/88 $ 41,357
Total Funds Remaining: $153,457

Project Period: 3-31-90 (24 months)

Deliverables: Date Received:
1. Detailed final technical report including all new data, maps, tables (Tasks 4.1-4.8)
2. Presentations of results at state and national meetings (Task 4.9)

Current Issues;
New wells for heat flow have been identified, and drilling is underway by South Dakota Geological Survey.

9. State of Oregon Grant Number
Dept. of Geology and Mineral Industries

Financial:
Total Funding Authorized $ 0
Invoices Through 11/1/88 $ 0
Total Funds Remaining $ 0

Project Period:

Deliverables: Date Received
Current Issues:
Unsolicited proposal from DOGAMI. Contract not yet signed.

10. Utah Geological and Mineral Survey — Grant Number DE-FG07-88ID12756

| | | |
|---|---|---|
| Financial: | Total Funding Authorized: | $61,641 |
| | Invoices Through: 11/1/88 | $ 0 |
| | Total Funds Remaining: | $61,641 |

Project Period: 8-1-89 (14 months)

Deliverables: Date Received
1. Final technical report, which will include all new geological, geochemical, and geological data (Tasks 4.1-4.9)
2. Geological map of the Newcastle geothermal area (scale 1:24,000) (Tasks 4.2, 4.3)

Current Issues: Project well underway.

11. State of Washington, Dept. of Natural Resources — Grant Number DE-FG07-88ID12740

| | | |
|---|---|---|
| Financial: | Total Funding Authorized: | $170,776 |
| | Invoices Through: 11/1/88 | $ 10,592 |
| | Total Funds Remaining: | $160,184 |

Project Period: 3-31-89 (12 months)

Deliverables: Date Received
1. Final technical report for drilling project and heat flow results (Task 4.1)
2. Final technical report, volcanology study, models of Cascade volcanism (Task 4.2)

Current Issues:
BLM requirements for blow out preventers on 1000 ft. gradient holes, and competition for drilling contractors resulted in higher per foot drilling costs, reduced depths, rotary instead of core, and other changes to program. Eight holes will be drilled to 500 ft. deep. Contract modification is required.

12. State of Washington — Grant Number
State Energy Office

Financial: Total Funding Authorized: $ 51,435

********** Monitoring/Reporting by Ben Lunis, EG&G ********

13. University of Wyoming — Grant Number
Dept. Geology and Geophysics — DE-FG07-88ID17382

Financial:
Total Funding Authorized: $ 45,511
*Invoices Through:* 11/1/88: $ 22,000
Total Funds Remaining: $ 23,511

Project Period: 7-1-89 (12 months)

Deliverables: — Date Received

1. Final technical report describing:
   a. Computer algorithms developed
   b. New temperature data from the Cody or Thermopolis hydrothermal system
   c. Finite-difference model for system studied
   d. Numerical methods and test results

Current Issues:

Mathematics has been largely developed. Now programming algorithms so complex 3-D models can be run on PC's. Delayed due to computer change over.

ANREPT, SCP

# FY-88 ANNUAL REPORT

# HYDROTHERMAL RESEARCH

# STATE COOPERATIVE RESERVOIR ANALYSIS PROGRAM

## I.O Introduction

The State Cooperative Reservoir Analysis Program (SCP) was established by DOE in 1977, as the State Coupled Program to assess low-and moderate-temperature geothermal resources in the U. S. The early efforts of the SCP were national in scope. Geoscientific investigations were made in all states, with the more intensive activity focusing on states with either known existing geothermal resources or a large user potential. These studies provided extensive input to the USGS computer file GEOTHERM and demonstrated that most moderate-and high-temperature geothermal resources are found in the western portion of the country, with scattered low-temperature resources also found in the great plains and Atlantic coast region. These and subsequent studies have led to the publication and distribution of a series of state geothermal resource maps. More recent work has expanded upon earlier resource assessment activities and included detailed reservoir analysis and generic studies.

Research activities within the SCP are carried out by a state agency or group given the responsibility for geothermal resource evaluation within that particular state. Past participants have included state geologic surveys, water resource departments, and university geoscience departments within the western United States. SCP programs are initiated by the Division of Geothermal Technology and are administered by the Idaho Falls Operations Office. UURI provides technical and administrative support to DOE/DGT and DOE/ID, and technical geoscience support to various state teams.

## II. Fiscal Year Accomplishments

### Pre-1988 Grants

Eight grants established by DOE from 1984 to 1986 continued to be active in FY88. Technical studies were completed by six state teams during FY88 although some deliverables remained outstanding at year's end. A brief summary of these projects follows.

### Alaska - Division of Geological and Geophysical Surveys

Final interpretation and reporting of the geochemical and petrographic study of the Mt. Spurr volcano geothermal resource area was completed. Although the area is somewhat remote a geothermal resource potential is indicated, and some state lands have been leased. A "Alaska Geothermal Bibliography" was also completed and made available to the public as a deliverable.

University of Arizona - Department of Geoscience

This grant provides for the completion of 40 K/Ar age dates of young geologic samples in support of State Cooperative Program teams and other DOE funded hydrothermal research. Thirty samples were submitted during FY88 which will conclude the work under this grant. Age dates of samples submitted during FY88 support geologic studies and the evaluation of geothermal resource potential in the Oregon and Washington Cascade Range, and studies of the Los Azufres, Mexico and Ascension Island geothermal systems.

Idaho - Department of Water Resources

Idaho-DWR and USGS studies of the Twin Falls County geothermal areas were completed, but the USGS report is still pending. These studies document the geologic controls for the Banbury Hot Springs and Twin Falls geothermal systems, and provide base line data for reservoir management as development of these systems continues. A subcontract study by Boise State University documents declining heads within the Boise geothermal aquifer and provides base line data for future reservoir management.

Montana - College of Mineral Science and Technology

This grant supported detailed gravity and CSAMT studies of the Ennis Hot Springs area, Montana as two MS theses. State-of-the-art geophysical studies were completed which defined the probable resource area.

New Mexico Research and Development Institute

A final report was submitted by NMRDI which provides a major study of the geologic controls for the geothermal resources of southwestern New Mexico. Other reports describe hydrologic studies of the Animas Valley geothermal resource and drilling projects at the Las Cruces geothermal resource and in the Orogrande area.

North Dakota - Mining and Mineral Resources Research Institute

The technical studies completed under this grant in FY87 defined a large area in southern South Dakota where seven accessible aquifers carry temperatures of 30 to 120 degrees C. Work continued in FY88 on the 1:1,000,000 scale Geothermal Resource Map of South Dakota.

Oregon Department of Geology and Mineral Industries

DOGAMI completed detailed geologic mapping projects and a plan for future geothermal research and deep drilling in the Oregon Cascades. Technical studies of the industry drill hole, CTGH-1, and final reporting for this grant neared completion.

Southern Methodist University

Dr. David Blackwell completed his compilation of heat flow data for the Decade of North American Geology geothermal map, and a compilation of heat flow data for the entire United States. Final heat flow measurements for Cascade industry holes were also completed and reported to DOE.

An impressive amount of geothermal resource assessment and research is documented by the deliverables of these SCP team members. Numerous technical reports have been published by the individual state teams, in professional journals, and as reports to DOE. SCP principal investigators presented their results at annual meetings of the Geothermal Resources Council, the Geological Society of America, and the American Geophysical Union.

## 1987 SCP GEOTHERMAL SOLICITATION

A new Program Research and Development (PRDA) for State Geothermal Research and Development was issued by the DOE-Idaho Operations Office in April 1987. This PRDA provided funding of approximately $1,200,000 for cost shared state-oriented research and development of geothermal energy. The final evaluation of competitive proposals was completed early in FY88 and 11 new grants were awarded between January and September.

A broad range of research, generic studies, and resource assessment is represented by these grants. Regional resource assessments are being carried out in North and South Dakota, Washington, Alaska, and Nevada. Specific geothermal systems are the subject of detailed studies in Alaska, Hawaii, Idaho, Wyoming, Nevada, Utah and New Mexico. Geochemical research and data collection is a major component of studies in Hawaii, Nevada, Idaho and New Mexico. Advanced numerical modeling of combined heat flow and fluid flow is underway at the University of Wyoming and the University of North Dakota.

Technical studies were well underway for all but a few grants at the end of FY88. The term of these grants varies between 12 and 24 months, and contract modifications and time extensions are to be expected. Excellent progress and interesting new data are already reported by the Alaska, North Dakota, Utah, and Washington state teams.

## III. Management

### 1. Organization

### 2. Interfaces/Contacts

The primary interfaces within the State Cooperative Projet are the various state teams and their Principal Investigators. A listing of the teams and PI's active in FY88 follows:

Alaska-Division of Geological and Geophysical Surveys
Dr. Roman Motyka
University of Alaska-Geophysical Institute
Dr. Donald Turner
University of Arizona- Dept. of Geosciences: Dr. Paul Damon
Hawaii- Dept. of Business and Economic Development
Dr. Donald Thomas
Idaho- Division of Water Resources: Ms. Leah Street
Montana College of Mineral Science and Technology
Dr. William Sill, Dr. Charles Wideman
University of Nevada- Desert Research Institute
Dr. Elizabeth Jacobson
University of Nevada- Division of Earth Sciences
Mr. Thomas Flynn
New Mexico Research and Development Institute
Dr. Larry Icerman
University of North Dakota- Mining and Mineral Res. Inst.
Dr. William Gosnold
Oregon Department of Geology and Mineral Industries
Dr. George Priest
Utah Geological and Mineral Survey: Mr. Robert Blackett
Washington- Department of Natural Resources:
Mr. Michael Korosec
University of Wyoming- Department of Geology and Geophysics
Dr. Henry Heasler

3. Meetings/Reviews

No specific meetings were organized for the SCP teams as a group. DOE/ID convened a meeting of it's Technical Review Committee for a final ranking of proposals at Idaho Falls on November 9, 1987. The review of a Idaho-DWR subcontractor report on the Boise geothermal aquifer, and plans for a well test of this geothermal system were the subjects of several meetigs involving ID-DWR, DOE/ID, UURI, EG&G, USGS, and City of Boise representatives throughout FY88. The reservoir test was later cancelled. Several state team members gave presentations at the GRC, GSA, and AGU annual meetings.

4. Issues

Several issues arose during FY88, most of which have been resolved. Funding available for the new solicitation was substantially less than the total amount requested by worthy proposals. To fund as many of the hihger rated projects as possible DOE negotiated SOW's for only the most important tasks. Unfortunately not all proposals in the competitive range could be funded. An unsolicited proposal by the State of Oregon (DOGAMI) was judged to have technical merit but only limited funds were available to fund it. The identification of a specific drilling site along the axis of the Cascades, and environmental studies of the project impact must be completed before this grant can be funded. DOE faced polotical pressure and the potential for

lawsuits because of the sensitive nature of a report describing declines of the Boise geothermal aquifer, and because of plans to conduct a critically needed well test of this aquifer. The wording of the report was modified and DOE withdrew plans for the Idaho-DWR aquifer test.

IV. Budget

V. End of Year Status

With the successful completion of essentially all the pre-FY88 SCP grants, the current status derives from progress on the 11 new grants. The Washington-DNR thermal gradient drilling has been completed, with six of eight holes recording temperature gradients of about 50 deg C/km. The field work at Geyser Bight, AK KGRA was completed and a great increase in the knowledge of this high-temperature system will be forthcomming. The Utah (UGMS) Newcastle data gathering nears completion, and a significant case study of this "blind" Basin and Range system will result. Most other studies are less advanced due to the lengthy funding process. Several of these studies address the possible overdevelopment and depletion of reservoirs currently used for district space heating; all the funded projects have technical and economic merit.

The major problem facing the State Cooperative Program is that of funding. Congress did not add new funds for FY89 so new projects cannot be funded and supplemental funding for the present projects is essentially zero. This may mean the end of several state teams and the resulting loss of geothermal expertise within these states- a serious problem for many states with undeveloped resource potential or for states with declining geothermal reservoirs because of unregulated production.

VI. Future Plans

The present grants will continue for another six to 24 months, with some possibility of contract modification and no cost time extension. Many of the studies will be reported in national technical journals and presented at professional meetings such as the GRC, GSA, and AGU. Without new funding by Congress the program will be phased out by the end of FY90. Another open solicitation for state-oriented, cost-shared research is the best way to identify the most important projects to fund.

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# STATE COOPERATIVE
# RESERVOIR ANALYSIS PROGRAM
# QUARTERLY REPORT

January 1 - March 31, 1988

April 1 - June 30, 1988

September 1, 1988

by

Howard P. Ross

Earth Science Laboratory
University of Utah Research Institute

## INTRODUCTION

This report presents a brief description of State Cooperative Reservoir Analysis Program (SCP) activivties by State Teams and by the Department of Energy during the two quarters ending March 31 and June 31, 1988.

The status of State Team activities and grants has been in a constant state of flux during this period, with the conclusion of several grants, and the negotiation and awarding of grants for several new studies. The status of both old and new grants is indicated separately on summary sheets which make up the bulk of this report. These sheets are updated to September 1, 1988, with some of the new grants still unsigned.

## PRE-1988 GRANTS

Final report deliverables were received during the first quarter from the Alaska - Division of Geological and Geophysical Surveys, and from the Idaho - Department of Water Resources. In the second quarter final deliverables were received from Montana - MCMS&T; New Mexico - NMRDI; and Southern Methodist University. These grants have since been closed out by DOE-ID with the exception of the Idaho - DWR grant. The status of active grants is discussed below.

### University of Arizona - Department of Geosciences

Fourteen K/Ar dates remain to be completed under this grant. Four dates will be completed in support of George Priest's existing grant for mapping in the Oregon Cascades. The remaining 10 dates have been allocated to the new (1988) Washington DNR grant for work in the Washington Cascades. These dates should be completed and the grant closed out before the end of 1988.

### Idaho - Department of Water Resources

Final report deliverables have been received from the Idaho - DWR and from one subcontractor, Boise State University (Dr. C. Waag). Closeout of this grant has been delayed because of the late delivery of a subcontractor's (USGS) report. The report has been available to ID-DWR and to DOE in draft form for several months. The report appears to have completed the lengthy review process and now awaits final editing and printing. Another no cost time extension will be required for formal closeout of this grant.

### Oregon - Deparment of Geology and Mineral Industries

Several major deliverables, including quadrangle geologic maps and a science plan for Cascade studies, have previously been completed and delivered under this grant. Work appears to be on schedule for completion of the remaining deliverables by the revised contract closeout date of 10-31-88.

North Dakota - Mining and Minerals Resource Research Institute

This grant was closed out in 1987 following delivery of the principal deliverable, a final technical report. An important part of this report, the "Geothermal Resources Map of South Dakota" has not yet been delivered to DOE, but is expected shortly. Dr. Wil Gosnold, P. I. is reminded periodically of the overdue deliverable and reports substantial progress after a very busy academic year. Dr. Gosnold continues to be one of the most productive scientists funded by the DOE SCP and provides good exposure for the results of this program.

## 1988 GRANTS

Negotiations were completed and agreements signed for ten grants and one cooperative agreement during the first two quarters of 1988 as a result of the 1987 DOE-ID SCP solicitation. One additional grant (New Mexico - NMRDI)awaits final signing. Contract activities continue for one grant resulting from an unsolicited proposal (Oregon - DOGAMI). It is uncertain if funds are available to support the last proposal in the competitive range of the 1987 solicitation.

Most state teams already report progress on compilations, contracting, sampling, analyses, and mapping activities related to the 1988 grants. Some future contract modifications have already been identified, but no major problems with these grants have been identified to date.

## COMMENTS

The deliverables resulting from the pre-1988 grants included several high quality studies which are significant contributions to the geothermal resource database or basic geology of the states involved. The studies funded by the 1988 grants include diverse topics such as: sophisticated algorithm development, monitoring and numerical modeling of hydrothermal systems, some of which may be in danger of overdevelopment; geothermal fluid genesis; geochemical studies; and basic drilling and temperature gradient studies. We look forward to the technical data and interpretations which will result from these studies.

STATE TEAM SCHEDULES

PRE-1988 GRANTS

Short Form Summary, 1 September 1988

| | 1988 | | | | | | 1989 |
|---|---|---|---|---|---|---|---|
| Team | Jul | Aug | Sept | Oct | Nov | Dec | Jan |
| Az-K/Ar | ---------- | | (NCTE) | ---------- | | | -----31 |
| ID-DWR | --------29 | | F m8 (NCTE needed) | | | | |
| ND-MMRRI | - - - - - - | | (map due - grant | losed out) | | | |
| OR-DOGAMMI | Q---------- | | | -Q---31 | | | |

Q: Quarterly Report m: Grant Mod. No.
F: Final Report NCTE: No Cost Time Ext.

## STATE TEAM STATUS - PRE 1988 GRANTS

1. Arizona - K/Ar Dating  Grant Number DE-FG07-86ID12622

Financial:

| | |
|---|---|
| Total Funding Authorized | $29,999 |
| Invoices Through 9/1/88: | $19,250 |
| Total Funds Remaining | $10,749 |

Project Period: 1-31-89

| Deliverables: | Date Received |
|---|---|
| 1. 2 samples, Cerro Prieto -Moore/Reed | 4/2/87 |
| 2. 2 samples, OR Cascades- DOGAMI-Priest | 9/16/87 |
| 3. 6 samples, Ascension- UURI- Nielson | 9/16/87 |
| 4. 4 samples, OR Cascades- DOGAMI- Priest | 2/4/88 |
| 5. 6 samples, Los Azufres- Moore/Reed | 4/4/88 |
| 6. 5 samples, OR Cascades- DOGAMI- Priest | 4/18/88 |
| 7. 1 sample, Ascension- UURI- Nielson | 5/4/88 |

Current Issues:
14 samples remain to be completed; Washington State (DNR) has been allocated 10 dates for the 1988 grant. DOGAMI has been allocated the remaining four samples for their old grant. This will complete the Arizona K/Ar dating grant.

2. Idaho Dept. Water Resources  Grant Number DE-FG07-84ID12549

Financial:

| | |
|---|---|
| Total Funding Authorized: | $158,579 |
| Invoices Through 9/1/88: | $125,000# |
| Total Funds Remaining: | $ 33,579# |

Project Period: 8-29-88

| Deliverables: | Date Received |
|---|---|
| 1. "Geothermal Resource Analysis in Twin Falls County, Idaho": IDWR Final Report | 1/11/88 |
| 2. "Evaluation of the Boise Geothermal System": Boise State Univ. Final Report | 1/11/88 |
| 3. "The Hydrothermal System in Central Twin Falls County, Idaho": USGS Final Report (as a subcontractor to IDWR) | Overdue |

Current Issues:
USGS report has completed Geologic Names review and is in final editing. It has been assigned a high priority for printing, but delivery date to IDWR is still uncertain. One more NCTE may be required.

# $ figures may not be current with DOE/ID.

3. *Montana-MCMS&T* Grant Number DE-FG07-84ID12525

Financial: Total Funding Authorized: $93,421
Invoices Through 9/1/88: $93,421
Total Funds Remaining: $ 0

Project Period: 6-31-88

| Deliverables: | Date Received |
|---|---|
| 1. Final Report, Geophysical Research on Geothermal Resources in Montana | |
| 1a) "Three Dimensional Gravity Modeling Techniques with Application to the Ennis Geothermal Area" by D. Semmens | 12/23/87 |
| 1b) "A Controlled Source Ausiomagnetotelluric Investigation of the Ennis Hot Springs Geothermal Area, Ennis, Montana" by G. R. Emilsson | 7/5/88 |

Current Issues:

All deliverables received and Grant closed out.

4. New Mexico-NMRDI Grant Number DE-FG07-84ID12546

Financial: Total Funding Authorized: $109,970
Invoices Through 9/1/88: $109,970
Total Funds Remaining: $ 0

Project Period: 6-15-88

| Deliverables: | Date Received |
|---|---|
| 1. Final Report | |
| 1a) South-central New Mexico study (NMSU) | 6/9/88 |
| 1b) Animas Valley (Lightning Dock Geothermal) | 6/9/88 |
| 1c) Orgrande geothermal resource assessment (Lightning Dock Geothermal) | 6/9/88 |

Current Issues:

All deliverables received and Grant closed out.

5. Oregon-DOGAMI Grant Number DE-FG07-84ID12526

Financial: Total Funding Authorized: $359,357
Invoices Through 6/1/88: $279,066#
Total Funds Remaining: $ 80,291#

Project Period: 10-31-88

| Deliverables: | | Date Received |
|---|---|---|
| Original Grant | | |
| Task 1.1 | Geologic Map, Breitenbush River Area (1:62,500; GMS-46, 1987) | 8/7/87 |
| | Geologic Map, Crescent Mountain Area (1:62,500; GMS-47, 1987) | 8/7/87 |
| | Geologic Map, NW/4 of Broken Top 15' (1:24,000; Spec. Paper 21) | 8/7/87 |
| Task 1.2 | Temperature Data Collection | 8/7/87 |
| | Geothermal-Geradient Data for Oregon (1982-1984); Open File Rep. 0-86-2 | |
| Task 1.3 | Project Management and Reporting | Quarterly |
| Mod. M-001 | | |
| Task 1.1 | Feasibility Study/Scientific Plan for Research (Open File Rep. 0-86-3) | 8/7/87 |
| Task 1.2 | Geologic Map, McKenzie Bridge 15' Quad., with data, interp., description. | |
| Task 1.3 | Project Management and Reporting | Quarterly |
| Mod. A-002 | | |
| Task I. | Geologic map, approx. 15 sq. mi. centered on CTG drill site, Sec.28,T8S,R8E, E/2 Breitenbush 15'topo quad. | |
| Task II. | Raw data and analyses, well core, CTG drill hole. (archival storage at UURI) | |
| Task III. | CTG well study: comprehensive report with geologic and geothermal implications and geologic models. | |

Current Issues: Appears to be on schedule with revised contract close date of 10/31/88.

# $ figures probably not current with DOE/ID

6. Southern Methodist Univ. Grant Number DE-FG07-84ID12623

Financial:

| | |
|---|---|
| Total Funding Authorized: | $115,790 |
| Invoices Through 9/1/88: | $115,790 |
| Total Funds Remaining: | $ 0 |

Project Period: 5-31-88

| Deliverables: | Date Received |
|---|---|
| 1. Annual Data Report (GRC Trans., v.11) | 3/14/88 |
| 2. Final Tech. Report on Cascades heat flow studies and the Heat Flow Map of North America "U.S. Geothermal Database and Oregon Cascade Thermal Studies", by D.D. Blackwell, J. L. Steele, L. Carter. | 7/1/88 |

Current Issues:
All deliverables received and Grant closed out. Additional funding provided by a EG&G Purchase Order to further update the heat flow database.

7. North Dakota-NDMMRI Grant Number DE-FG07-84ID12606

Financial:

| | |
|---|---|
| Total Funding Authorized: | $47,000 |
| Invoices Through 6/1/88: | $47,000 |
| Total Funds Remaining: | $ 0 |

Project Period: Closed Out

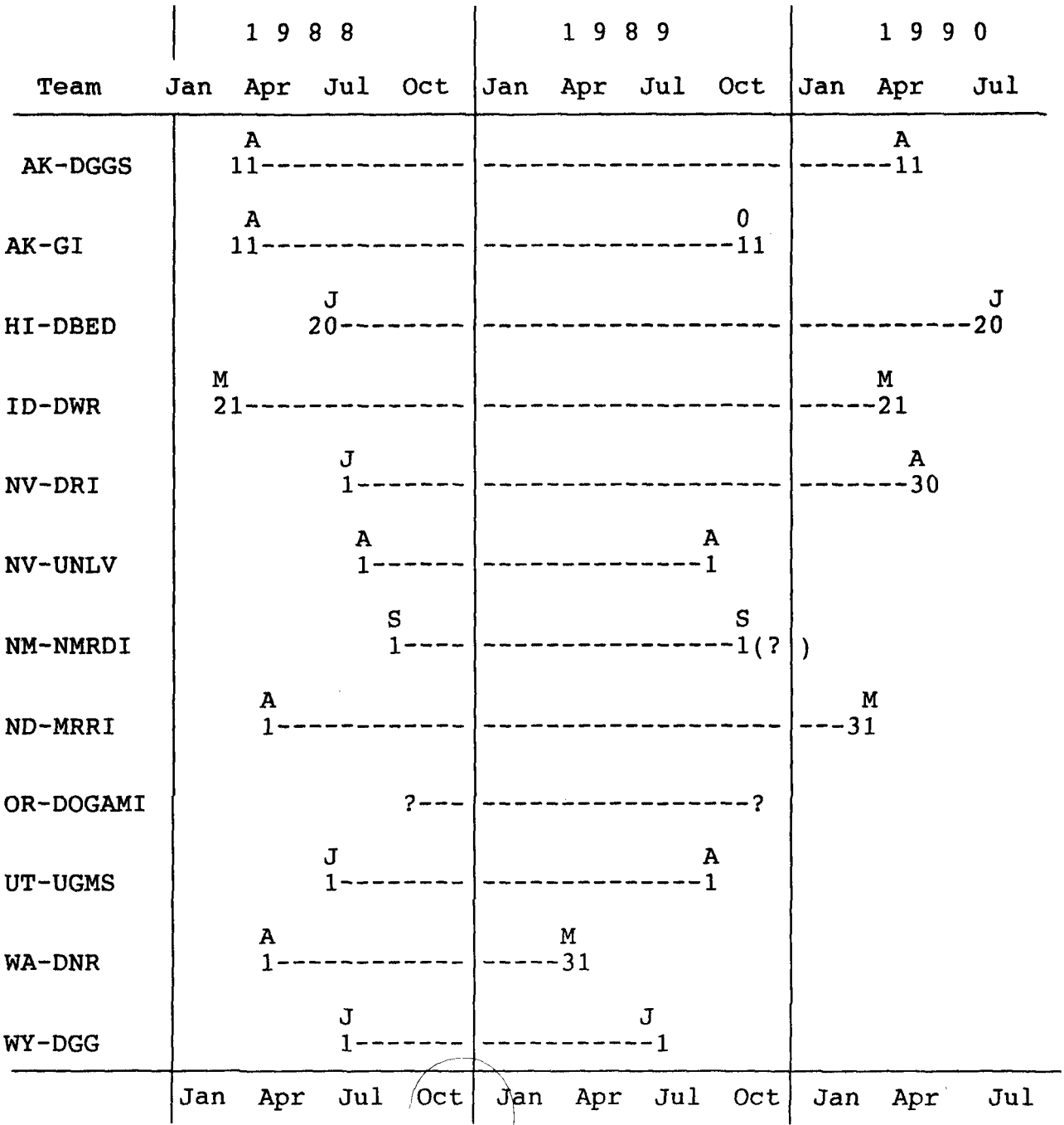
| Deliverables: | Date Received |
|---|---|
| 1. Task 5. Geothermal resource map of South Dakota (scale 1:1,000,000) | overdue |
| 2. Task 7. Final report,"Geothermal Resource Assessment of South Dakota", by W. D. Gosnold, Jr. | 8/28/87 |

Current Issues: Dr. Gosnold continues to work on the final map, which is nearing completion. No date has been set for printing and delivery.

STATE TEAM SCHEDULES

1988 GRANTS

Short Form Summary, 1 September 1988



## STATE TEAM STATUS - 1988 GRANTS

1. Alaska - Dept. of Natural Resources — Grant Number DE-FG07-88ID12744

Financial:
Total Funding Authorized: $72,000
Invoices Through: 9/1/88 $ 0
Total Funds Remaining: $72,000

Project Period: 4-11-90 (24 months)

Deliverables: Date Received
1. Contributions to GI-UAK geologic map of Geyser Creek Valley area (Task 4.1.1)
2. Report on fluid geochemistry, Geyser Bight KGRA (Task 4.1.2)
3. Contributions to GI-UAK final report on Geyser Bight KGRA study (Task 4.1.3)
4. Geothermal resource map of Aleutian Islands-Alaska Peninsula Region (Task 4.2.1)
5. Tables of fluid geochemistry (Task 4.2.2)
6. Descriptive circular to accompany Geothermal Resource Map (Task 4.2.3)

Current Issues:
Compilations and field work underway.

2. Univ. of Alaska - Geophysical Institute — Grant Number DE-FG07-88ID127 42

Financial:
Total Funding Authorized: $55,593
Invoices Through: 9/1/88: $ 0
Total Funds Remaining: $55,593

Project Period: 10-11-89 (18 months)

Deliverables: Date Received
1. Geologic map of Geyser Creek Valley area at 1:25,000 scale (Task 4.1.1)
2. Management, logistical, technical support for Alaska DGGS fluid chemistry study
3. Final report on Geyser Bight geothermal area study (Task 4.1.3)

Current Issues:
Field work underway.

3. Hawaii-Dept. Business and Economic Development — Grant Number DE-FG07-88ID12741

Financial:
Total Funding Authorized: $ 87,173
Invoices Through: 9/1/88: $ 0
Total Funds Remaining: $ 87,173

Project Period: 6-20-90 (24 months)

Deliverables: Date Received

1. Final technical report which describes in detail the following studies:
   a. Silica polymerization studies
   b. Low-temperature brine treatment
   c. Fabrication of pilot scale treatment system
   d. Fluid characterization
   e. Preliminary design of pilot scale system
   f. By-product characterization.

Current Issues:
Studies underway.

4. Idaho - Dept. of Water Resources — Coop. Agreement No. DE-FC07-88ID12748

Financial:
Total Funding Authorized: $154,088
Invoices Through: 9/1/88: $ 0
Total Funds Remaining: $154,088

Project Period: 3-21-90 (24 months)

Deliverables: Date Received

1. Final technical report, all new studies, Twin Falls County Geothermal Systems (Task 1.0)
2. Final technical report, Boise geothermal aquifer study, to include all new monitoring results, Consultant's report, and IDWR summary and interpretation (Task 2.0)
3. Final technical report, geochemical studies of Wood River geothermal systems (Task 3.0)

Current Issues:
All field studies underway. IDWR RFP for consultant reservoir engineer go will out in September. Contract modification in SOW (Task 2) will be submitted soon.

5. Desert Research Institute
University of Nevada System

Grant Number
DE-FG07-88ID12757

Financial:

| | |
|---|---|
| Total Funding Authorized: | $140,639 |
| Invoices Through: 9/1/88: | $ 0 |
| Total Funds Remaining: | $140,639 |

Project Period: 4/30/90 (22 months)

Deliverables: Date Received

1. Final technical report for the Moana system studies, including monitoring results, interpretation, models (Tasks 4.1-4.5)
2. User's manual for reservoir model, and any new software developed in project (Task 4.5)

Current Issues:

Project just beginning. Communication has been established with LBL reservoir engineering group. Dr. Elizabeth Jacobson approved by DOE/ID as temporary Project Director (8-1-88 to 6-30-89).

6. Division of Earth Sciences
Univ. of Nevada-Las Vegas

Grant Number
DE-FG07-88ID12784

Financial:

| | |
|---|---|
| Total Funding Authorized: | $157,114 |
| Invoices Through: 9/1/88: | $ 0 |
| Total Funds Remaining: | $157,114 |

Project Period: 8/1/89 (12 months)

Deliverables: Date Received

1. Final technical report which describes:
   a. Fluid chemistry study, Great Basin
   b. Geothermal reservoir rock data
   c. Glacial ice study
   d. Archaelogical isotope/age date study
   e. Data base summary
   f. Description of sampling and analyses
   g. Great Basin fluid genesis model
2. Technical data base submitted to GEOTHERM

Current Issues:

Studies underway.

7. New Mexico Research and Development Inst. Grant Number

Financial:
Total Funding Authorized: $129,267
Invoices Through: 9/1/88: $ 0
Total Funds Remaining: $129,267

Project Period: (not yet determined)

Deliverables: Date Received
1. Final technical report describing soil-depth radon gas surveys; Tortugas Mountain survey; Radium Springs survey; Rincon survey; final evaluation and interpretations.

Current Issues:
Contract should be signed by September 1. Copies not yet available.

8. North Dakota Mining and Mineral Res. Inst. Grant Number DE-FG07-88ID12736

Financial:
Total Funding Authorized $194,814
Invoices Through: 9/1/88 $ 0
Total Funds Remaining: $194.814

Project Period: 3-31-90 (24 months)

Deliverables: Date Received:
1. Detailed final technical report including all new data, maps, tables (Tasks 4.1-4.8)
2. Presentations of results at state and national meetings (Task 4.9)

Current Issues;
New wells for heat flow have been identified, and drilling is underway by South Dakota Geological Survey.

9. State of Oregon Grant Number
Dept. of Geology and Mineral Industries

Financial:
Total Funding Authorized $
Invoices Through 9/1/88 $
Total Funds Remaining $

Project Period:

Deliverables: Date Received

Current Issues:

Unsolicited proposal from DOGAMI. Contract not yet signed.

10. Utah Geological and Mineral Survey — Grant Number DE-FG07-88ID12756

| Financial: | | |
|---|---|---|
| | Total Funding Authorized: | $61,641 |
| | Invoices Through: 9/1/88 | $ 0 |
| | Total Funds Remaining: | $61,641 |

Project Period: 8-1-89 (14 months)

Deliverables: Date Received

1. Final technical report, which will include all new geological, geochemical, and geo-ogical data (Tasks 4.1-4.9)
2. Geological map of the Newcastle geothermal area (scale 1:24,000) (Tasks 4.2, 4.3)

Current Issues: Project well underway.

11. State of Washington Dept. of Natural Resources — Grant Number DE-FG07-88ID12740

| Financial: | | |
|---|---|---|
| | Total Funding Authorized: | $170,776 |
| | Invoices Through: 9/1/88 | $ 0 |
| | Total Funds Remaining: | $170,776 |

Project Period: 3-31-89 (12 months)

Deliverables: Date Received

1. Final technical report for drilling project and heat flow results (Task 4.1)
2. Final technical report, volcanology study, models of Cascade volcanism (Task 4.2)

Current Issues:

BLM requirements for blow out preventers on 1000 ft. gradient holes, and competition for drilling contractors may result in higher per foot drilling costs, reduced depths, rotary instead of core, and other changes to program.

12. State of Washington
State Energy Office

Grant Number

Financial: Total Funding Authorized: $ 51,435

********** Monitoring/Reporting by Ben Lunis, EG&G ********

13. University of Wyoming
Dept. Geology and Geophysics

Grant Number
DE-FG07-88ID17382

Financial:

| | |
|---|---|
| Total Funding Authorized: | $ 45,511 |
| Invoices Through: 9/1/88: | $ 0 |
| Total Funds Remaining: | $ 45,511 |

Project Period: 7-1-89 (12 months)

Deliverables: Date Received

1. Final technical report describing:
   a. Copmuter algorithms developed
   b. New temperature data from the Cody or Thermopolis hydrothermal system
   c. Finite-differenece model for system studied
   d. Numerical methods and test results

Current Issues:
Contract signed 7-1-88, project now underway.

DOE REPORT REQUIREMENTS

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

EARTH SCIENCE LABORATORY
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108—1295
TELEPHONE 801-524-3422

# MEMORANDUM

**TO:** UURI Staff

**FROM:** W. L. Forsberg

**SUBJECT:** Manuscripts - Required Statements

**DATE:** March 13, 1990

Attached is a copy of the sample statements for acknowledgement, disclaimer, and copyright transfer that need to be reviewed and the appropriate action taken as manuscripts are being prepared for publication. Most contracts and grants have some type of reference to these statements.

Please see me if you have any questions about the statements.

Acknowledgement and disclaimer statements must be used within technical manuscripts (including extended abstracts) produced under Federal contracts and grants (and non-Federal manuscripts where appropriate). Each contract or grant should be reviewed for specific required statements. The following are example acknowledgement and disclaimer statements:

## ACKNOWLEDGEMENT

> This work was supported, in whole or in part, by the U.S. Department of Energy, Contract NO. DE-AC07-85ID12489. Such support does not constitute an endorsement by the U.S. Department of Energy of the views expressed in this publication.

The following disclaimer should appear on the inside front cover or on the title page of each report prepared under Federal sponsorship:

## DISCLAIMER

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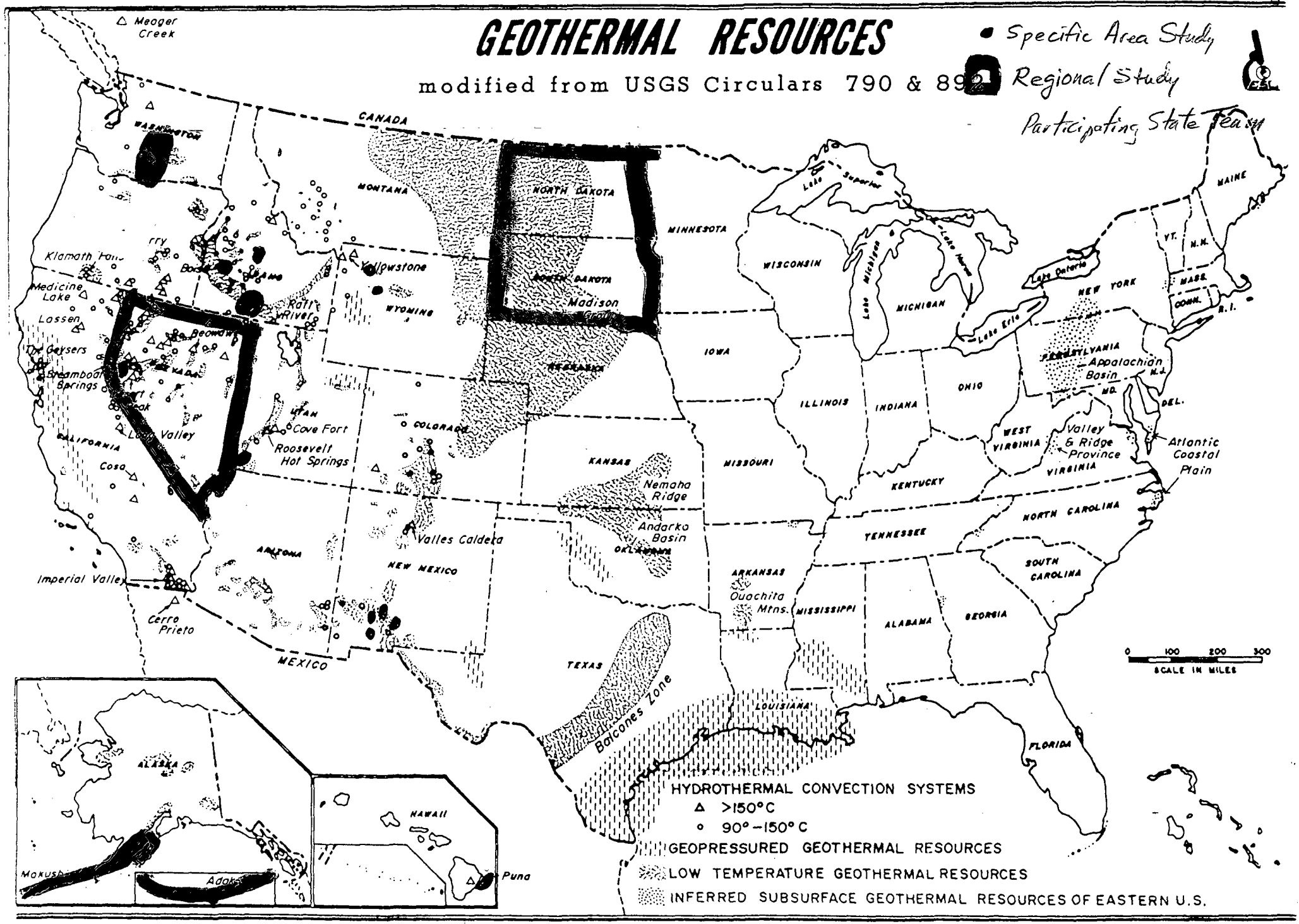
When manuscripts that are sponsored by a Federal agency are submitted to a copyright publication, and the publisher asks the author to complete a copyright transfer form before final acceptance, the author must include a statement on the copyright transfer form similar to the following example:

> The submitted manuscript has been authored by a contractor of the U. S. Government under Contract No. DE-AC07-85ID12489. Accordingly, the U.S. Government retains a non-exclusive, royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for U.S. Government purposes.

1988 State Cooperative Prog.




Geo/RM-003

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

EARTH SCIENCE LABORATORY
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108—1295
TELEPHONE 801-524-3422

M E M O R A N D U M

TO: Kenneth Taylor

FROM: Howard Ross

DATE: March 9, 1989

SUBJECT: Brief summary of FY-88 SCP grants

**University of Alaska-Geophysical Institute - Dr. Donald L. Turner and Dr. Christopher Nye**

The University of Alaska-Geophysical Institute is conducting a geologic and geochemical study of the Geyser Bight geothermal resource, the hottest (180-264°C) and most extensive area of thermal springs in Alaska, in cooperation with the AK-DGGS. Although the resource is located on a remote uninhabited Aleutian Island, the geological data and K-Ar age dating are expected to contribute to our knowledge of volcanic island arc systems in general.

**Alaska - Division of Geological and Geophysical Surveys - Dr. Roman J. Motyka**

The state of Alaska-DGGS in cooperation with the University of Alaska-Geophysical Institute is completing a fluid chemistry investigation and geological mapping of the Geyser Bight KGRA. A second task requires the preparation of a 1:1,000,000 scale technical geothermal energy resource map for the Aleutian Island - Alaska Peninsula region, and compilation and evaluation of all available geochemical data on geothermal fluids for this region.

**Hawaii - Department of Business and Economic Development - Dr. Donald Thomas**

The state of Hawaii is studying methods of controlling silica deposition from geothermal fluids of the Hawaii East Rift Zone. Principal components of the study include: silica polymerization studies; low temperature (<100°C) brine treatment; design of a pilot scale treatment system; characterization of treated fluids; and characterization/economic evaluation of

precipated silica.

**Idaho - Department of Water Resources - Ms. Leah V. Street**

The Idaho - DWR is continuing monitoring of the Banbury - Twin Falls resource and studying geothermal resource potential of the Cassia Mountains to the south. Continued monitoring of the Boise geothermal aquifer, and numerical modeling of this system by a consultant constitute a separate work task. A third project involves a study of the geochemistry of the Wood River geothermal systems and evaluation of the fluoride content of the thermal fluids.

**University of Nevada System - Desert Research Institute - Dr. Elizabeth Jacobson**

The Desert Research Institute (DRI) is conducting detailed hydrologic monitoring of the Moana geothermal system, in support of a quantitative evaluation and numerical modeling of this resource. Uncoordinated development of this moderate-temperature resource is rapidly expanding and the long-term productivity of the Moana system may be threatened. This study should provide a solid data base and quantitative model for state regulatory agencies and developers using the resource.

**University of Nevada - Las Vegas - Division of Earth Sciences - Dr. Thomas Flynn**

This study integrates fluid geochemistry, stable light isotope data, glacial ice data and archaeological information to study the genesis of geothermal fluids in the Great Basin. Substantial new chemistry data is being obtained for several moderate-, and high-temperature resources in Nevada. A contemporary fluid recharge model and the paleo recharge model will be developed as part of this study.

**New Mexico Research and Development Institute - Dr. Larry Icerman**

NMRDI is conducting an evaluation of time-integrated radon soil-gas surveys in the southern Rio Grande Rift. Radon gas concentrations will be determined as a function of depth and caliche development and surveys will be completed over the Radium Springs geothermal area. Surveys will then be completed in the Tortugas Mountain and Rincon areas as preliminary geothermal resource evaluation.

**North Dakota Mining and Mineral Resources Research Institute (MMRRRI) - Dr. William Gosnold**

The North Dakota MMRRI brings together the North Dakota and South Dakota Geological Surveys and UND staff for a comprehensive geothermal resource assessment of these two states. Five new heat flow holes will be drilled in each state, and temperature, hydrologic, and stratigraphic data will be integrated with

existing data to evaluate the production potential for geothermal aquifers in these states.

**Utah Geological and Mineral Survey - Mr. Robert E. Blackett**

The Utah Geological and Mineral Survey (UGMS) is conducting a geothermal resource assessment at the New Castle geothermal area in cooperation with the University of Utah Department of Geology and Geophysics. This study includes detailed mapping in bedrock and Quaternary deposits, a soil mercury geochemical survey, fluid geochemistry, gravity surveys, and temperature monitoring in twelve shallow (<60 feet) gradient holes. A conceptual model will be developed which may be applicable to other blind Basin and Range hydrothermal systems.

**Washington Department of Natural Resources - Mr. Michael Korosec**

The State of Washington - DNR has drilled eight 150 m temperature gradient holes to improve the delineation of the Southern Washington Cascade Range heat flow high. These data, coupled with K-Ar age dating and geochemical analyses will be used to refine time-space-volume models for Cascade volcanism and to evaluate geothermal potential of the region.

**University of Wyoming - Department Geology and Geophysics - Dr. Henry P. Heasler**

Dr. Heasler is working with two University of Wyoming mathematicians to develop improved three-dimensional computational schemes for solving the combined heat conduction and forced convection equations for determining subsurface temperatures. A model will be developed for either the Cody or Thermopolis hydrothermal system in the Bighorn Basin, Wyoming. The computational techniques will be applicable to a large number of mixed convective - conductive geothermal resources.

# TECHNICAL PROPOSAL

## TECHNICAL AND ADMINISTRATIVE SUPPORT

## STATE COOPERATIVE RESERVOIR ANALYSIS PROGRAM

submitted to

DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE
785 DOE PLACE
IDAHO FALLS, IDAHO 83402

by

University of Utah Research Institute
Earth Science Laboratory
391 Chipeta Way, Suite C
Salt Lake City, UT 84108-1295

December 14, 1988

Howard P. Ross
Principal Investigator
Earth Science Laboratory
University of Utah
Research Institute

Wilford L. Forsberg
Treasurer
University of Utah
Research Institute

Phillip M. Wright
Technical Vice President
University of Utah
Research Institute

STATEMENT OF WORK

STATE COOPERATIVE RESERVOIR ANALYSIS PROGRAM

## 1.0 Introduction

The State Cooperative Reservoir Analysis Program (SCP) was established by DOE in the mid-1970's, as the State Coupled Program to assess low-and moderate-temperature geothermal resources in the U.S. The early efforts of the State Coupled Program were national in scope. Geoscientific investigations were made in all states, with the more intensive activity focusing on states with either known existing geothermal resources or a large user potential. These studies provided extensive input to the USGS computer file GEOTHERM and demonstrated that most moderate-and high-temperature geothermal resources are found in the western portion of the country, with low-temperature resources also found in the great plains and Atlantic coast region. These and subsequent studies have led to the publication and distribution of a series of state geothermal resource maps. More recent work has expanded upon earlier resource assessment activities and included detailed reservoir analysis and generic studies.

Since the conception of the program, UURI has provided technical program monitoring, coordination, and administrative support to DOE for the SCP, and has provided technical support to state teams. UURI has also provided technical and administrative support to DOE/ID and DOE/HQ during the establishment of new grants, including the 1987 PRDA solicitation. This solicitation resulted in ten new Grants and one Cooperative Agreement which were signed with state teams during FY88.

## 2.0 Scope

UURI will provide technical and administrative support to DOE/ID and DOE/HQ in the continuation of the State Cooperative Program. Thirteen contracts with State teams are active as of December 1, 1988 and other grants may be issued in FY89. Anticipated activities include assistance to DOE in the solicitation process, progress monitoring, review of state team expenditures, critical review of state team technical reports and technical assistance (geological, geochemical, geophysical) to the state teams.

## 3.0 Applicable Documents

Reports submitted on geoscience research and technical assistance conducted under DOE Contract No. DE-AC07-85ID12489. DOE/ID Program Research and Development Announcement (PRDA) for State Geothermal Research and Development-PRDA No. DE-PRO7-87ID12662.

## 4.0 Technical Tasks

### Task 4.1 Progress Monitoring

Monitor the technical progress of state teams on all tasks funded through the State Cooperative Program. Accomplish such monitoring through telephone conversations, written communications, and at on-site visits or meetings as may be required. Provide DOE/ID and DOE/HQ with regular updates and evaluations of state team progress.

### Task 4.2 Technical Support

Provide geoscience technical support to state teams through conducting studies that support state team efforts or contribute to state team results. Provide geological, geochemical and geophysical consultation and services as appropriate and within available UURI funding. Provide critical technical report reviews.

## 5.0 Reports, Data and Deliverables

Prepare appropriate reports and deliverables based on the above tasks, including monthly progress reports, a year-end progress report, and technical reports as appropriate.

## 6.0 Special Considerations

None.

## 7.0 Proposed Budget

The proposed budget for this project is $96,978.

| | | HOURS | AMOUNT |
|---|---|---|---|
| A. | SALARIES AND WAGES: | | |
| 1. | Salaries - Professional | | $32,067 |
| | M. C. Adams | 32 | |
| | M. L. Allison | 16 | |
| | J. N. Moore | 32 | |
| | H. P. Ross | 1080 | |
| 2. | Salaries - Support | | $ 3,142 |
| | Draftsperson | 173 | |
| | Secretary #1 | 173 | |
| | Total Salaries & Wages | | $35,209 |
| B. | EMPLOYEE BENEFITS | | |
| 1. | 0.367 of A.1 & A.2 | | $12,922 |

| | | | |
|---|---|---|---|
| C. | TRAVEL: | | |
| | 1. Trips to DOE/ID from SLC, UT (4) | $1,312 | |
| | 2. Trip to Boise, ID from SLC, UT | 370 | |
| | 3. Trip to GRC Meeting (Santa Rosa, CA) | 900 | |
| | 4. Trip to San Francisco, CA | 500 | |
| | 5. Trip to SLC, UT from Tacoma, WA | 600 | |
| | Total | | $3,682 |
| D. | SUPPLIES: | | |
| | 1. Drafting Supplies | $ 200 | |
| | 2. Office Supplies | 100 | |
| | Total | | 300 |
| E. | CONSULTANTS: | | |
| | 1. D. Foley - 3 days @ $200/day | | 600 |
| F. | REPRODUCTIONS: | | |
| | 1. Printing and Binding | | 100 |
| G. | OTHER COSTS: | | |
| | 1. Geochemical Analyses | | 1,100 |
| H. | TOTAL A THRU G: | | $ 53,913 |
| I. | INDIRECT COSTS: | | |
| | 1. 0.486 of H | | $ 26,202 |
| J. | G. & A. COSTS: | | |
| | 1. 0.219 of H | | $ 11,807 |
| K. | TOTAL H THRU J: | | $ 91,922 |
| L. | FEE: | | |
| | 1. 0.055 of K | | $ 5,056 |
| M. | TOTAL PROJECT COSTS: | | $ 96,978 |

~~Leo~~ Pratsch
Marshall

# 1988-89 State Team Info:

| Team | Principal Investigator | Telephone | |
|---|---|---|---|
| Univ-Alaska-Geophys Inst. | Dr. Donald L. Turner | (907) 474-7198 | L.P. |
| Alaska - DGGS | Dr. Roman Motyka | (907) 465-2520 | L.P. |
| Hawaii - Dept. Bus. Econ. Dev. | Dr. Donald Thomas | (808) 948-6482 | MR |
| Idaho - Dept. Water Res. | Ms. Leah Street | (208) 734-3578 | L.P. |
| U. Nevada - L.V. Desert Res. Inst. | Dr. Elizabeth Jacobson | (702) 673-7373 | LP |
| U. Nevada - L.V. Div. Earth Sciences | Mr. Thomas Flynn | (702) 784-6151 | MR |
| New Mexico - NMRDI | Dr. Larry Icerman | (505) 827-5886 | add'l MR |
| U. North Dakota | Dr. Wil Gosnold | (701) 777-2631 | L.P. |
| Oregon - DOGAMI | Dr. George Priest | (503) 229-5580 | not yet |
| Utah - UGMS | Mr. Robert Blackett | (801) 581-6831 | M.R. |
| Washington - DNR | Mr. Michael Korosec | (206) 459-6372 | L.P. |
| U. Wyoming - D.G.G. | Dr. Henry Heasler | (307) 766-3278 | M.R. |

Low Profile

# 1988-89 State Team Info:

| Team | Principal Investigator | Telephone | |
|---|---|---|---|
| Univ-Alaska-Geophys Inst. | Dr. Donald L. Turner | (904) 474-7198 | L |
| Alaska - DGGS | Dr. Roman Motyka | (907) 465-2520 | L |
| Hawaii - Dept. Bus. Econ. Dev. | Dr. Donald Thomas | (808) 948-6482 | M |
| Idaho - Dept. Water Res. | Ms. Leah Street | (208) 734-3578 | L |
| U. Nevada - L.V. Desert Res. Inst. | Dr. Elizabeth Jacobson | (702) 673-7373 | L |
| U. Nevada - L.V. Div. Earth Sciences | Mr. Thomas Flynn | (702) 784-6151 | M |
| New Mexico - NMRDI | Dr. Larry Icerman | (505) 827-5886 | M |
| U. North Dakota | Dr. Wil Gosnold | (701) 777-~~5460~~ 2631 | L |
| Oregon - DOGAMI | Dr. George Priest | (503) 229-5580 | not yet |
| Utah - UGMS | Mr. Robert Blackett | (801) 581-6831 | M |
| Washington - DNR | Mr. Michael Korosec | (206) 459-6372 | L |
| U. Wyoming - D.G.G. | Dr. Henry Heasler | (307) 766-3278 | M |

# SCP - 1988 Grants

SCP88.001

| Grantee | Inst. | Inst. No. | Proj. Period | DOE Signed |
|---|---|---|---|---|
| Idaho - Dept. Water Resources | CA | DE-FC07-88ID12748 | 3/21/88 - 3/21/90 24mo | 3/21/88 |
| NorthDakota - M & MR Inst. | G | DE-FG07-88ID12736 | 4/1/88 - 3/31/90 24mo | 3/30/88 |
| Wyoming, - Univ., Dept G & G | G | DE-FG07-88ID12738 | 7/1/88 - 7/1/89 12mo | 6/14/88 |
| Washington, State Economic Of | G | ~EG&G ~ Call Bern | | |
| Washington, Dept. Natural Res | G | DE-FG07-88ID12740 | 4/1/88 - 3/31/89 12mo | 3/31/88 |
| Univ. Alaska, Geophys. Inst. | G | DE-FG07-88ID12742 | 4/11/88 - 10/11/89 18mo | 4/8/88 |
| Alaska, Dept. Natural Resources | G | DE-FG07-88ID12744 | 4/11/88 - 4/11/90 24mo | 4/8/88 |
| Hawaii, Dept. Bus. & Econ. Dev | G | DE-FG07-88ID12741 | 6/20/88 - 6/20/90 24mo | 6/14/88 |
| Utah Geological & Mineral Sv | G | DE-FG07-88ID12756 | 6/1/88 - 8/1/89 14mo | 5/4/88 |
| Desert Res. Inst.-UN-LV<br>Michael E. Campana (702) 673-7392 | G | DE-FG07-88ID12757 #140,639 | 7/1/88 - 4/30/90 22mo | 5/26/88 |
| Univ. Nevada-L.V.- DES | | | | |
| New Mexico - NMRDI | | | | |
| California Energy Commission | | Left hanging | | |
| Oregon - DOGAMI | | | | |

United States Government | Department of Energy

# memorandum

Idaho Operations Office

DATE: August 11, 1988

SUBJECT: Status of PRDA DE-PR07-87ID12662

TO: Lew Pratsch
Marshall Reed
DOE-HQ, Forrestal Bldg., CE-342

Attached for your information is a document describing the current status of the State Team Geothermal Research and Development PRDA. As you will see from this document, the majority of grants have gone out.

If there are any questions concerning this issue, please contact me.

Ken J. Taylor
Project Manager
Advanced Technology Division

Attachment

cc: Ben Lunis, EG&G Idaho, Inc.
Howard Ross, UURI

STATE TEAM GEOTHERMAL RESEARCH AND DEVELOPMENT
PRDA #DE-PR07-87ID12662

In FY86 and FY87, $1.2M was received for a state teams PRDA. In FY88, $150k was added to the $1.2M to give a total of $1.35M. The competitive solicitation was initiated in FY87 so that the state team money could be obligated to various institutions.

At this time, 9 grants have been put in place and 3 are pending. This is described below.

| | |
|---|---|
| Grants in Place: | |
| North Dakota | $194,814 |
| Washington State Energy Office | $51,435 |
| Utah Geological and Mineral Survey | $61,641 |
| Washington Department of Natural Resources | $170,776 |
| University of Alaska/State of Alaska | $127,593 |
| Idaho Department of Water Resources | $154,088 |
| University of Wyoming | $45,511 |
| State of Hawaii | $87,173 |
| Desert Reasearch Institute | $140,639 |
| Grants Pending (Funding Levles Estimated): | |
| University of Nevada, Las Vegas | ~~$162,059~~ 157,114 |
| New Mixico R&D Institute (Rio Grande) | ~~$129~~,267 126,267 |
| California Energy Commission (Wilbur) | $55,721 |
| Total Sum of All Grants: | $1,380,717 |

The University of Nevada at Las Vegas and the New Mexico R&D Institute will both have their grants in place by the beginning of September, 1988. At that point, it will be determined whether or not to fund the California Energy commission.

CONTACTS

| | | |
|---|---|---|
| Howard Ross, UURI | Support | 8-588-3444 |
| Ben Lunis, EG&G Idaho | Support | 8-583-1458 |
| Ken Taylor, DOE-ID | Project Manager | 8-583-9063 |
| Marshall Reed, DOE-HQ | Project Manager | 8-896-8076 |
| Lew Pratsch, DOE-HQ | Project Manager | 9-896-1512 |

# U. S.

# DEPARTMENT OF ENERGY

# DIVISION OF GEOTHERMAL ENERGY

# STATE COUPLED PROGRAM


SC/MW-001

# STATE COUPLED PROGRAM

## A GOAL-ORIENTED PROGRAM TO COLLECT AND PUBLISH REGIONAL AND AREAL GEOTHERMAL DATA

- TO ENCOURAGE DEVELOPMENT BY PROSPECTIVE USERS

- TO ASSIST USGS IN RESOURCE INVENTORY (Circular 790 Update)

SC/MW-020

# COMPANION PROGRAMS

- COMMERCIALIZATION PLANNING
- USER COUPLED DRILLING
- PONs AND PRDAs
- USER ASSISTANCE
- USGS REGIONAL ASSESSMENT

# MAJOR BARRIERS TO COMMERCIALIZATION

- Lack of defined resources
- Lack of an established industry
- Limited technical and economic data
- Policy and regulatory confusion
- Environmental impact uncertainties

# STATE COUPLED PROGRAM

## PURPOSE

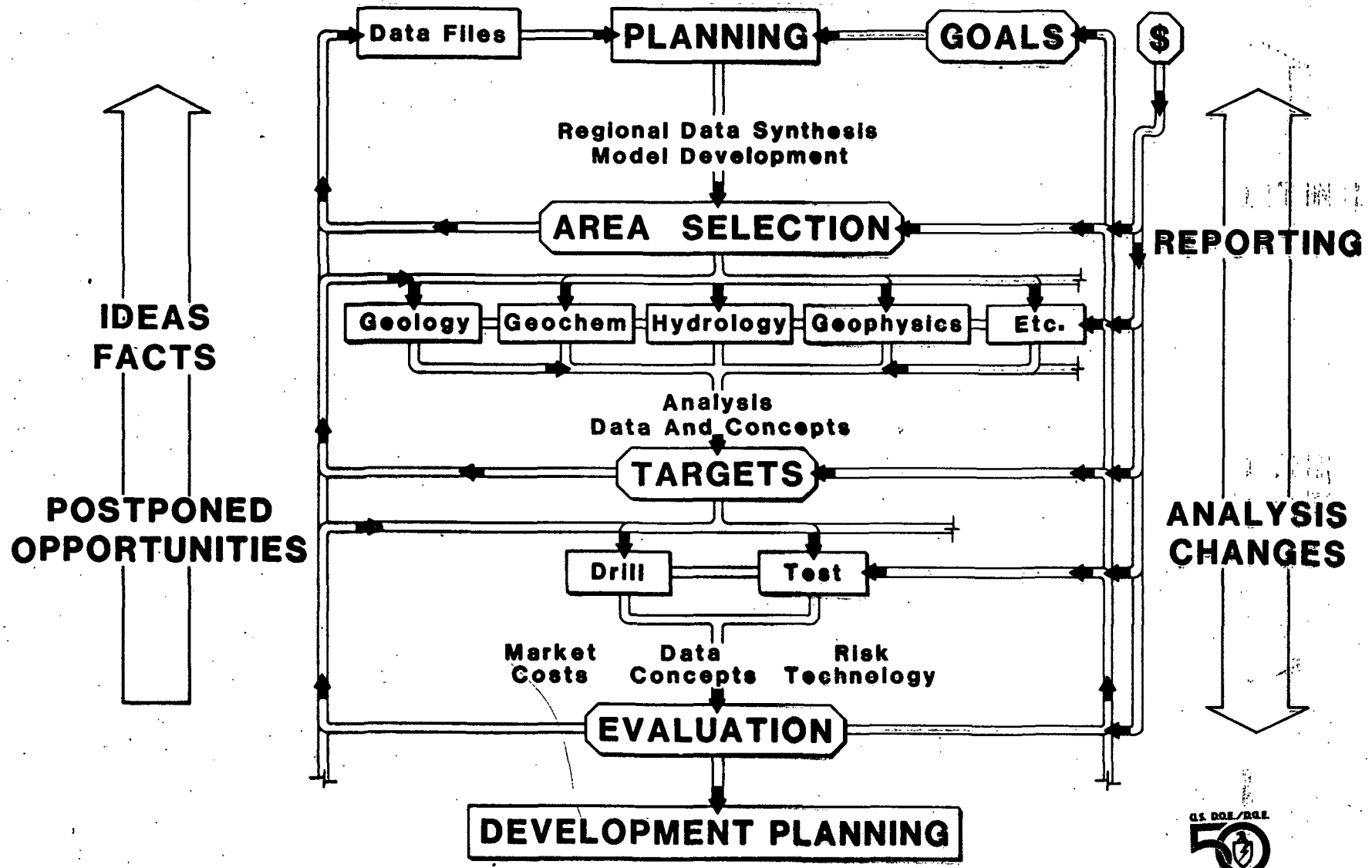
- TO COLLECT AND PUBLISH REGIONAL AND AREAL GEOTHERMAL RESOURCE DATA

## JUSTIFICATION

- TO FACILITATE SELECTION OF HIGH-QUALITY SITES FOR FURTHER EXPLORATION BY USERS AND DEVELOPERS

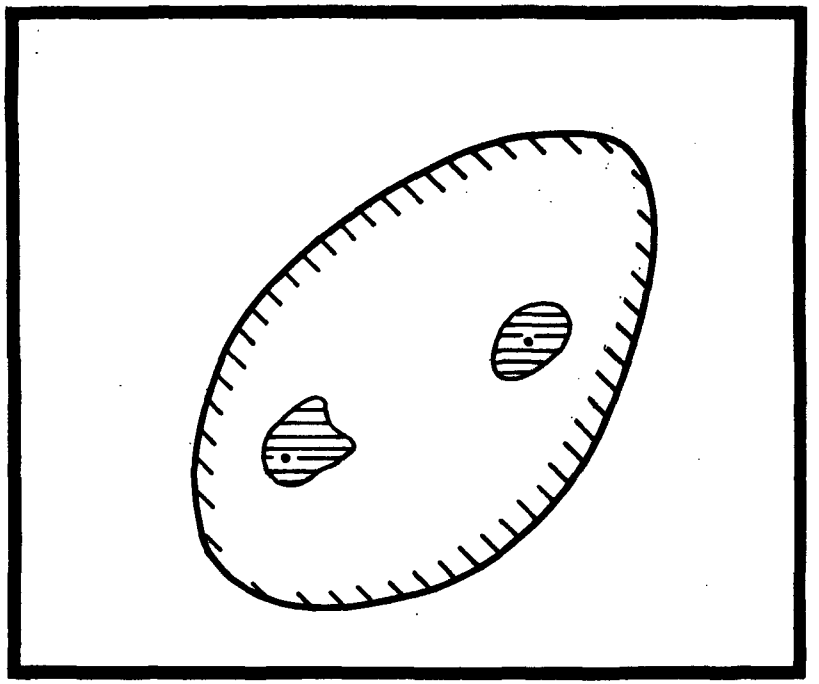
SC/MW-019

# EXPLORATION




SC/MW-022

# EXPLORATION STAGES



STATEWIDE INVENTORY

REGIONAL RECONNAISSANCE

AREA EXPLORATION

SITE SPECIFIC ANALYSES

SC/MW-029

# DIRECT VS INDIRECT DETECTION

DIRECT METHOD - TEMPERATURE MEASUREMENT
SPRINGS AND DRILL HOLES

INDIRECT METHODS - HEAT FLOW STUDIES
- GRADIENT EXTRAPOLATION
- CHEMICAL GEOTHERMOMETRY
- GEOLOGIC MAPPING
- GEOPHYSICAL SURVEYS
- GEOCHEMICAL SURVEYS
- HYDROLOGIC STUDIES

# GEOTHERMAL MODEL DEVELOPMENT

PURPOSE – TO DEVELOP AND TEST NEW GEOTHERMAL TARGET MODELS

METHODS – GEOLOGICAL AND HYDROLOGICAL REASONING, DRILL TESTING

PRODUCTS – PROVEN TARGET CONCEPTS

EXAMPLE – MODEL FOR EAST COAST GEOTHERMAL RESOURCES DEVELOPED AT VPI

# REPORTS

## NEEDS OF PROSPECTIVE USERS ARE PARAMOUNT

- **RESOURCE DESCRIPTION**

  **LOCATION, TEMPERATURE, DEPTH,**

  **WATER QUALITY, PRODUCTIVITY**

- **GEOLOGIC CHARACTERIZATION**
- **DISCOVERY POTENTIAL**
- **SOURCES OF FURTHER INFORMATION**
- **SUPPORTING SCIENTIFIC DATA**

## PERIODIC REPORTS ALSO REQUIRED BY DOE

U.S. DOE/DOE

50

STATE COUPLED PROGRAMS

# EXPLORATION STAGES

- STATEWIDE INVENTORY
- RECONNAISSANCE 1,000–
  LARGE REGIONS 10,000 Sq. mi.
- AREA EXPLORATION 100–
  SELECTED AREAS 1,000 Sq. mi.

STATE COUPLED PROGRAM

- SITE EXPLORATION less than
  SELECTED SITES 10 Sq. mi.
- TEST AND PRODUCTION
  WELL DRILLING

USER COUPLED DRILLING PROGRAM


SC/MW-028

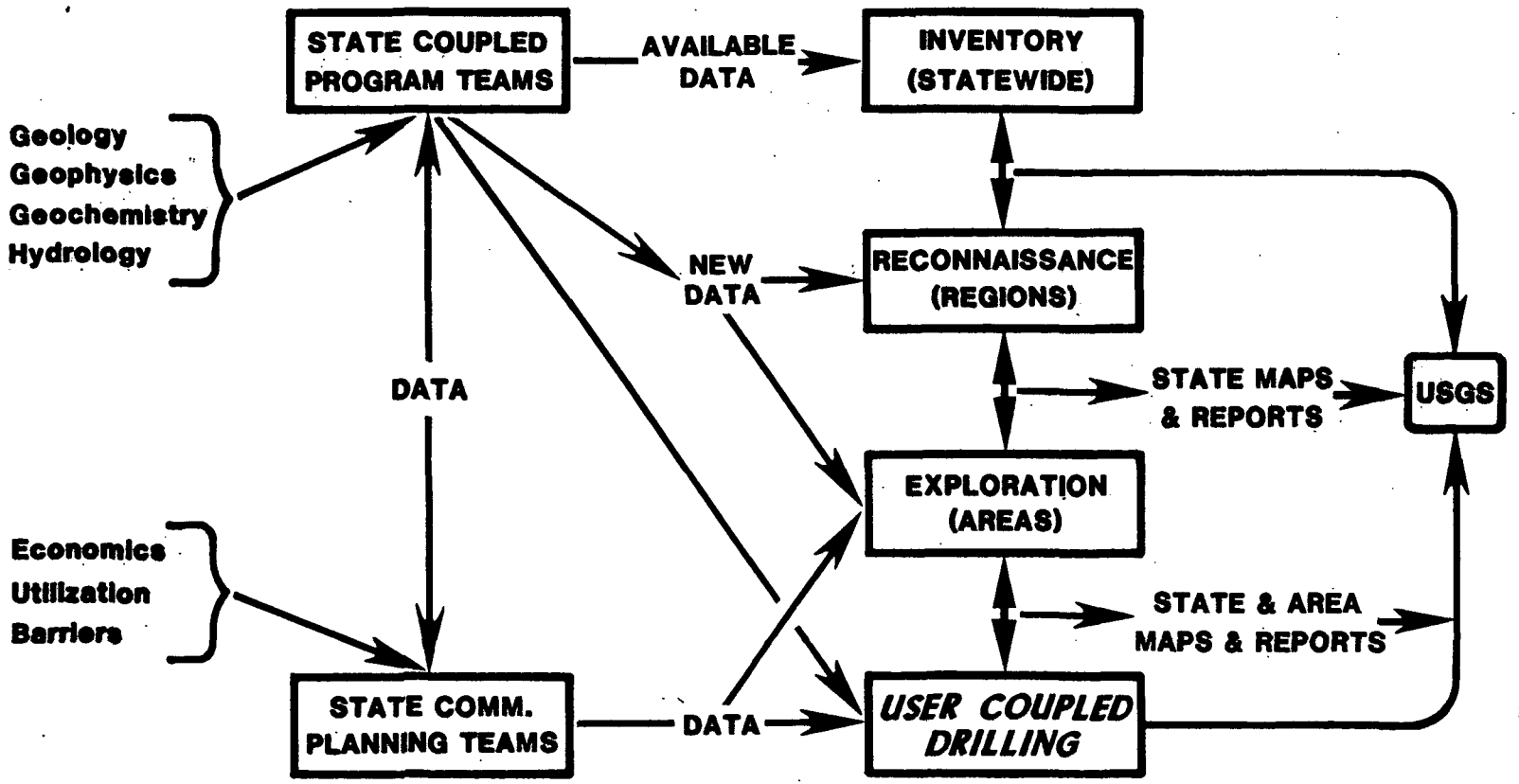
# PROPOSALS

## (TAILORED TO EACH STATE'S NEEDS)

SUGGESTED % EFFORT

| | YEAR 1 | YEAR 2 | YEAR 3 | OUT-YEARS |
|---|---|---|---|---|
| STATEWIDE INVENTORY | 30 | 10 | 5 | 5 |
| REGIONAL RECONNAISSANCE | 25 | 25 | 10 | 5 |
| AREA EXPLORATION AND MODEL DEVELOPMENT | 5 | 15 | 20 | 25 |
| MAP PRODUCTION | 10 | 10 | 10 | 5 |
| REPORTING | 5 | 5 | 10 | 5 |
| USER ASSISTANCE | 5 | 10 | 25 | 35 |
| USGS INTERFACE | 10 | 10 | 5 | 5 |
| COMMERCIALIZATION PLANNING SUPPORT | 5 | 10 | 10 | 10 |
| DOE REQUESTS FOR DATA | 5 | 5 | 5 | 5 |

# STATE COUPLED PROGRAM




U.S. DOE/DOE
50
STATE COUPLED PROGRAM

# PROGRAM DEVELOPMENT MATRIX

| Barriers → / Program Elements | Lack of Defined Resources | Lack of an Established Industry | Limited Technical Data | Policy and Regulatory Confusion | Environmental Impact Uncertainties |
|---|---|---|---|---|---|
| • Reservoir Confirmation | XX | XX | XX | X | X |
| • Market Development | | XX | X | | |
| • State Planning and Development | X | XX | X | XX | X |
| • Technology Demonstrations | | XX | XX | X | X |
| • Environmental Assessment | | X | X | XX | XX |
| • Policy and Regulatory Issues Assessment | | X | X | XX | X |
| • Progress Monitoring | X | X | X | X | X |

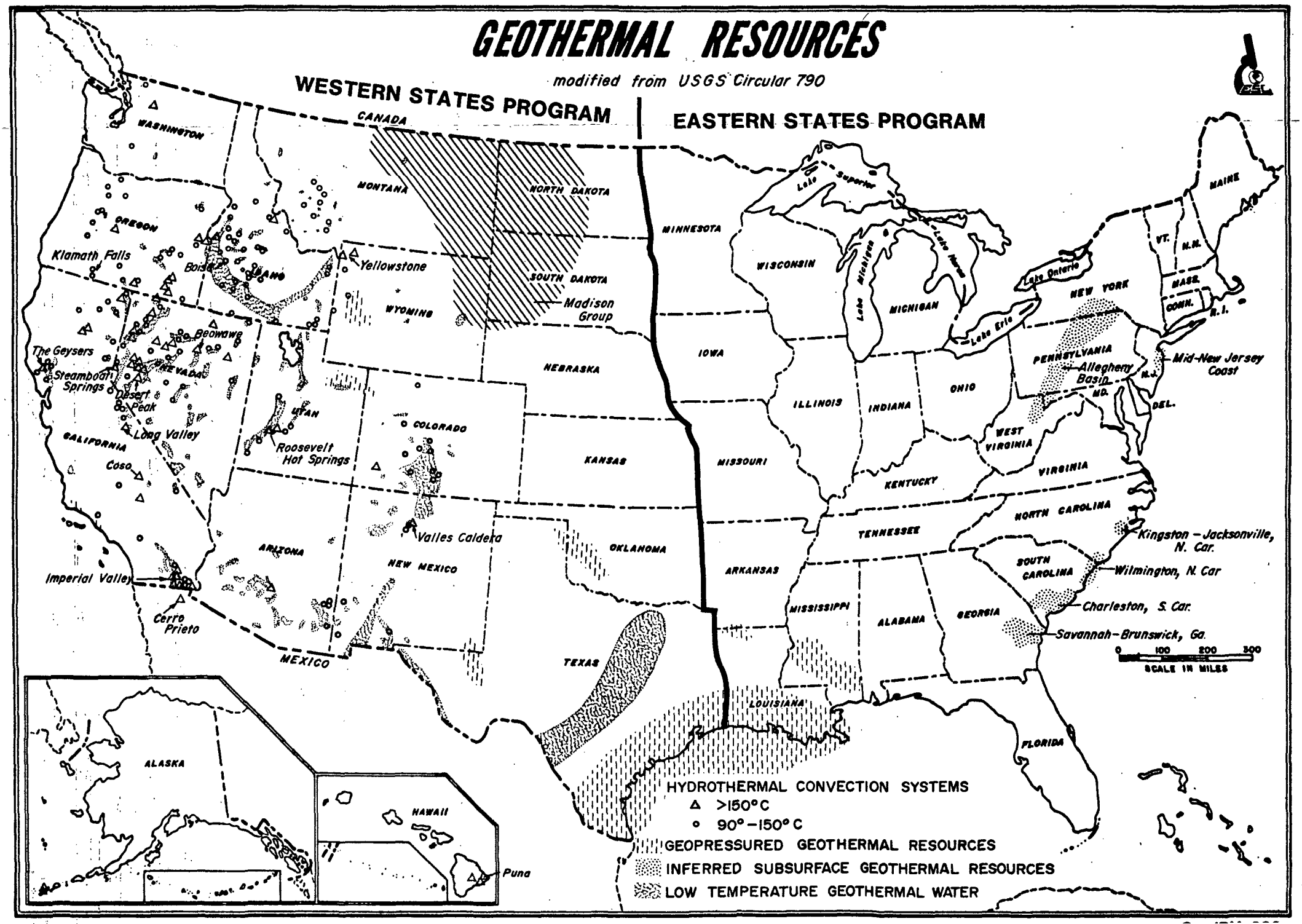
**XX** Primary Impact **X** Secondary Impact

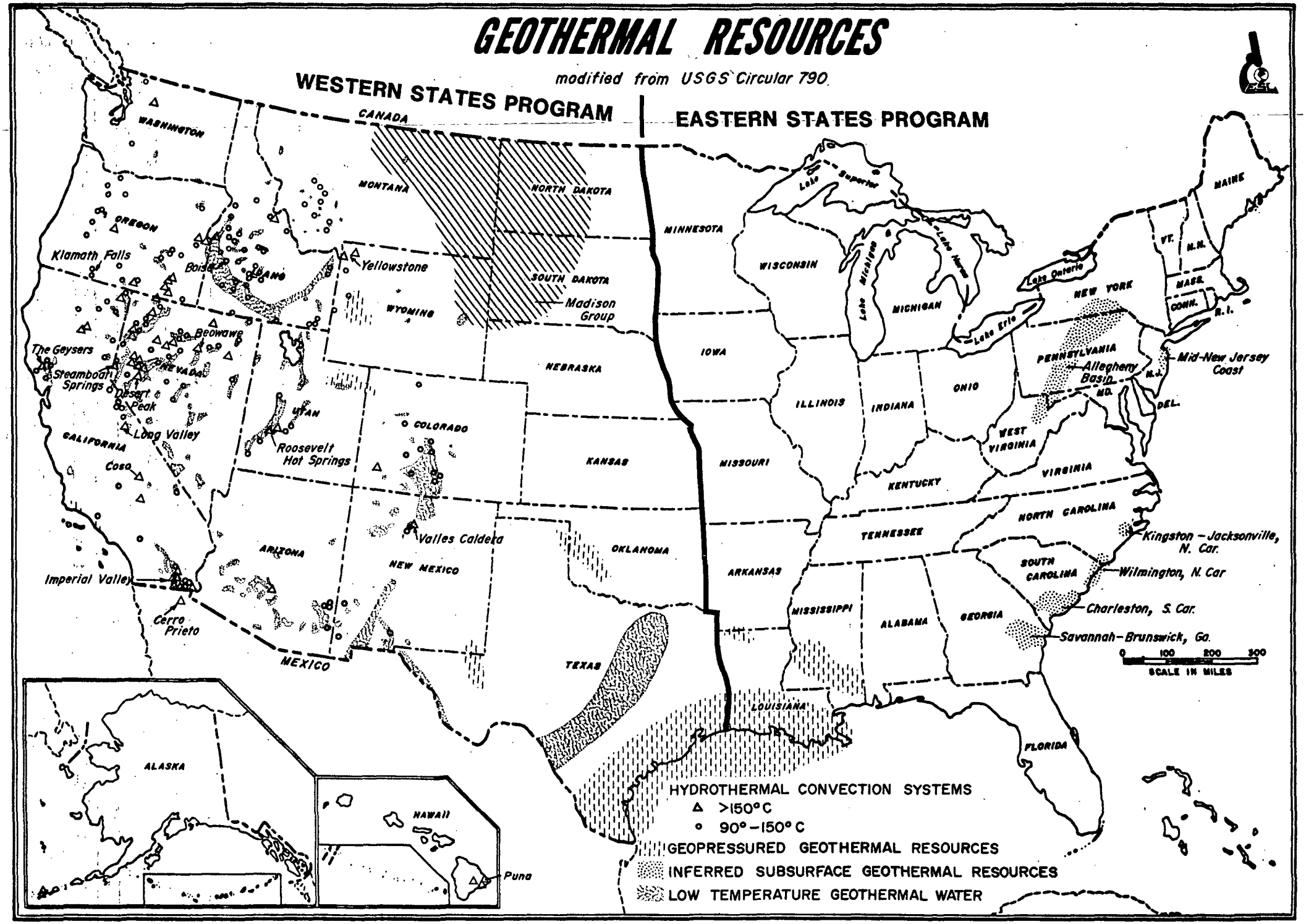
U.S. DOE/RUT 50 STATE COUPLED PROGRAM

SC/MW-015

# GEOTHERMAL RESOURCES

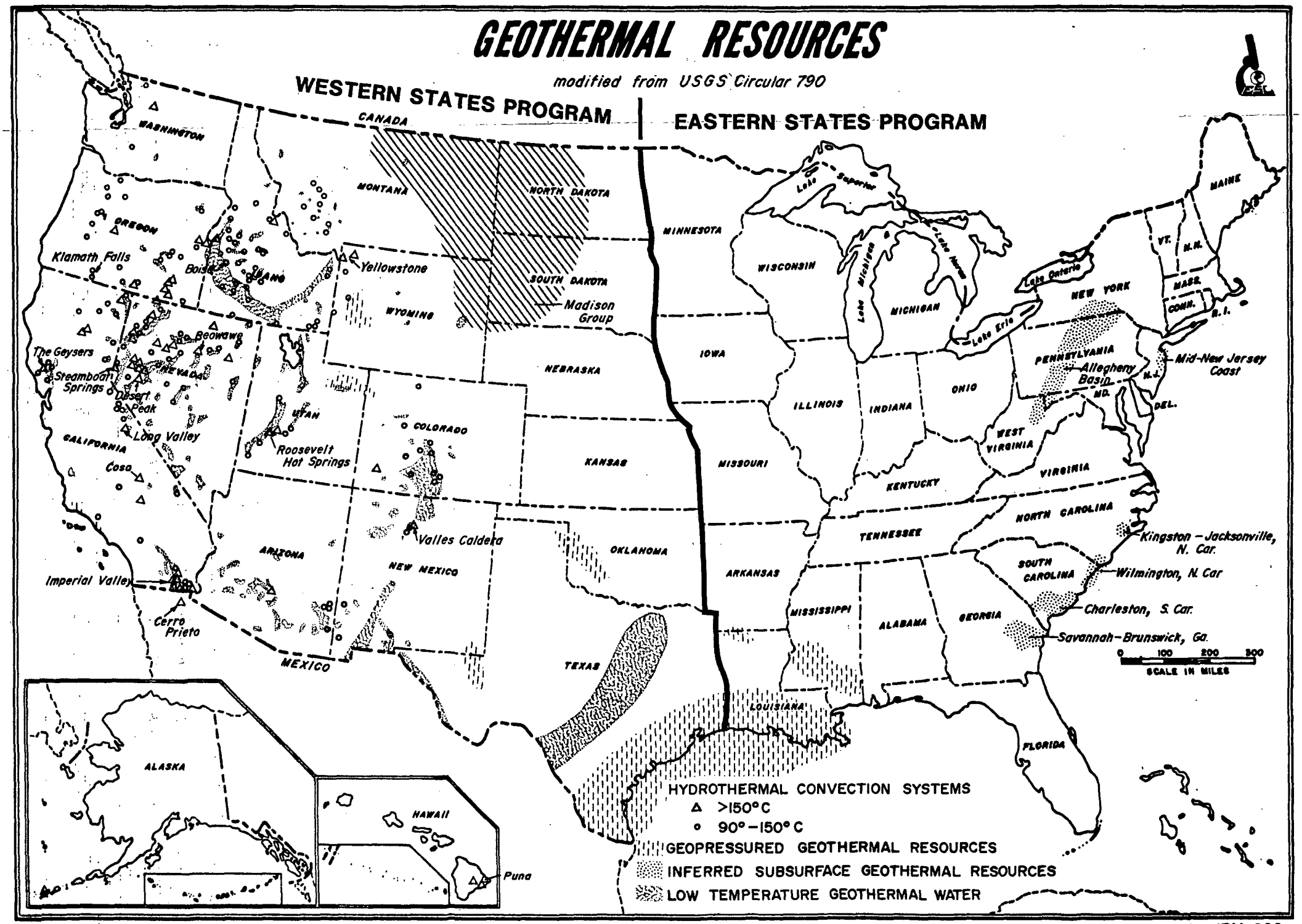
*modified from USGS Circular 790*

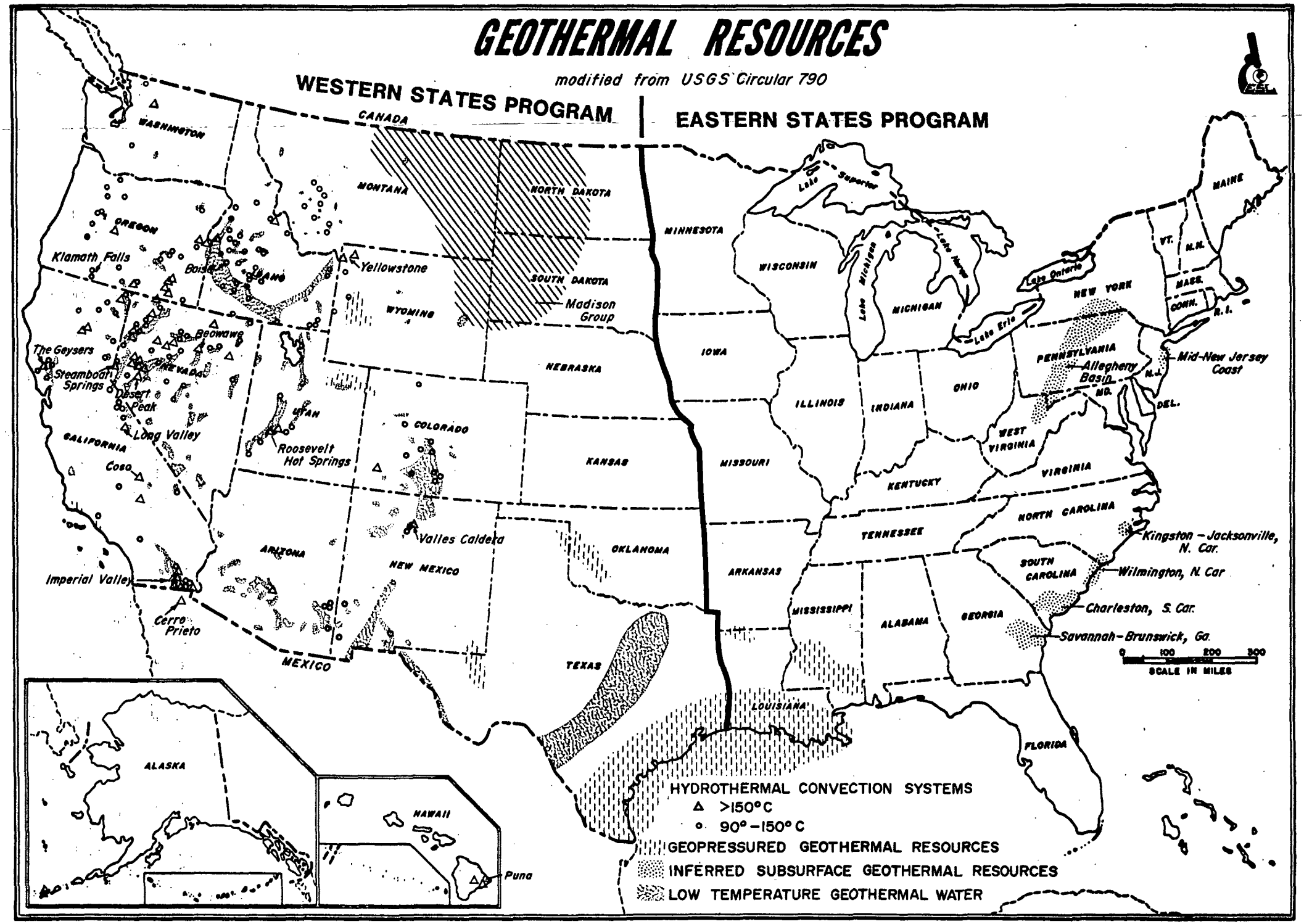



GEOTHERMAL RESOURCES
modified from USGS Circular 790
WESTERN STATES PROGRAM
EASTERN STATES PROGRAM
CANADA
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
COLORADO
UTAH
ARIZONA
NEW MEXICO
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VT.
N.H.
MASS.
CONN.
R.I.
N.J.
MD.
DEL.
Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario
Klamath Falls
Boise
Yellowstone
Madison Group
Beowawe
The Geysers
Steamboat Springs
Desert Peak
Long Valley
Coso
Roosevelt Hot Springs
Valles Caldera
Imperial Valley
Cerro Prieto
MEXICO
Allegheny Basin
Mid-New Jersey Coast
Kingston – Jacksonville, N. Car.
Wilmington, N. Car
Charleston, S. Car.
Savannah – Brunswick, Ga.
0 100 200 300
SCALE IN MILES
ALASKA
HAWAII
Puna
HYDROTHERMAL CONVECTION SYSTEMS
△ >150°C
○ 90°–150°C
GEOPRESSURED GEOTHERMAL RESOURCES
INFERRED SUBSURFACE GEOTHERMAL RESOURCES
LOW TEMPERATURE GEOTHERMAL WATER

# GEOTHERMAL RESOURCES

*modified from USGS Circular 790*




GEOTHERMAL RESOURCES
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Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario
Klamath Falls
Boise
Yellowstone
Madison Group
The Geysers
Beowawe
Steamboat Springs
Desert Peak
Long Valley
Roosevelt Hot Springs
Coso
Imperial Valley
Cerro Prieto
Valles Caldera
Allegheny Basin
Mid-New Jersey Coast
Kingston – Jacksonville, N. Car.
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Charleston, S. Car.
Savannah – Brunswick, Ga.
0 100 200 300
SCALE IN MILES
ALASKA
HAWAII
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HYDROTHERMAL CONVECTION SYSTEMS
△ >150°C
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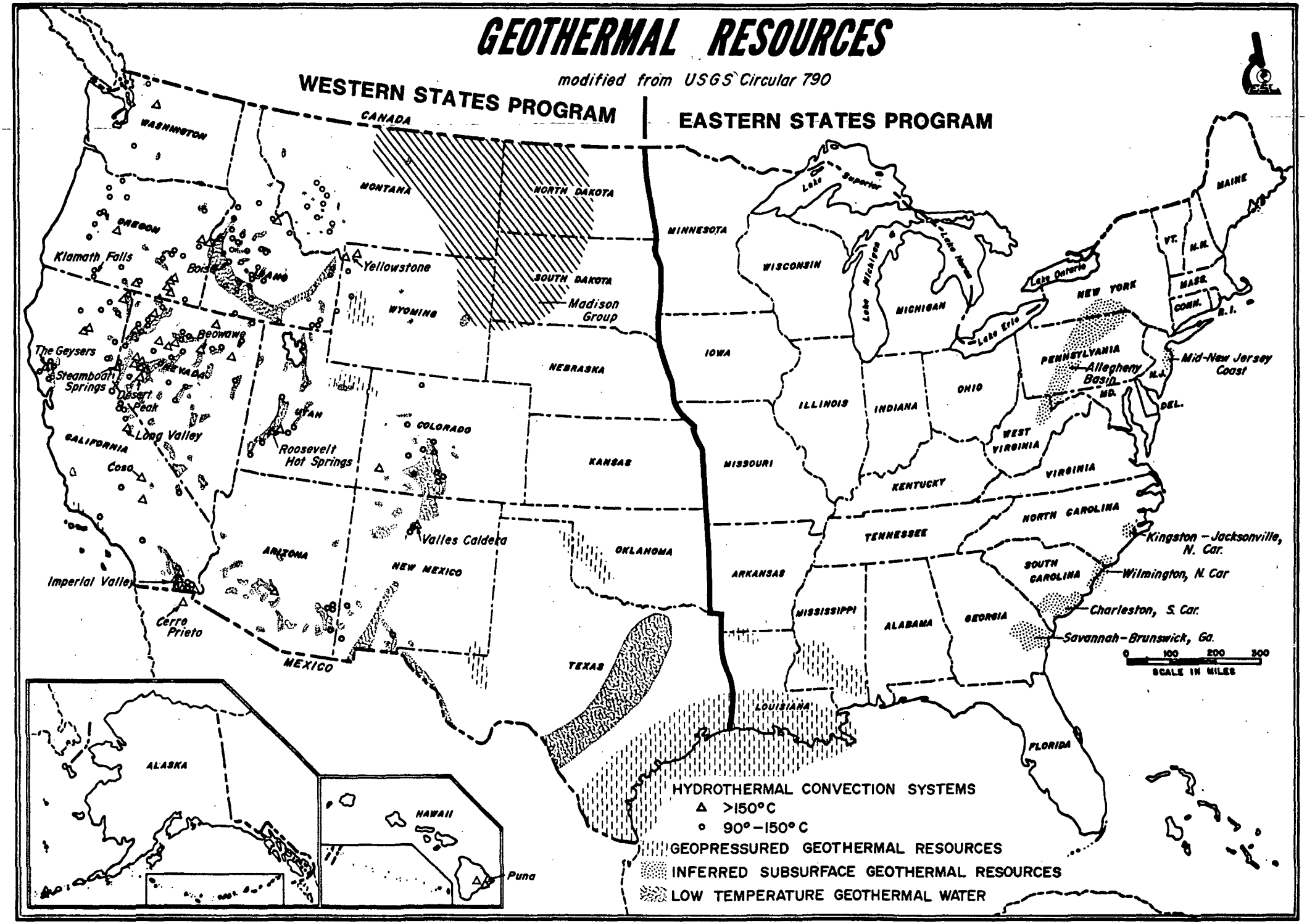
GEOPRESSURED GEOTHERMAL RESOURCES
INFERRED SUBSURFACE GEOTHERMAL RESOURCES
LOW TEMPERATURE GEOTHERMAL WATER

# GEOTHERMAL RESOURCES

*modified from USGS Circular 790*

## WESTERN STATES PROGRAM | EASTERN STATES PROGRAM



ESL-89007-PR
DOE/ID/12489-46

# STATE COOPERATIVE
# RESERVOIR ANALYSIS PROGRAM
# QUARTERLY REPORT

September 30 - December 31, 1988

January 31, 1989

by

Howard P. Ross

Earth Science Laboratory
University of Utah Research Institute

## INTRODUCTION

This report presents a brief description of State Cooperative Reservoir Analysis Program (SCP) activities by State Teams and by the Department of Energy during the quarter ending December 31, 1988. Significant events which occurred during January are noted to bring the status current to a reporting date of February 1, 1989. Project budgets are updated to February 1, 1988.

## PRE-1988 GRANTS

### University of Arizona - Department of Geosciences

Ten K/Ar dates remain to be completed under this grant. Four dates will be completed in support of George Priest's existing grant for mapping in the Oregon Cascades. The remaining 6 dates have been allocated to the new (1988) Washington DNR grant for work in the Washington Cascades. These dates should be completed and the grant closed out before the end of February 1989. A no cost time extension may be required.

### Idaho - Department of Water Resources

Final report deliverables have been received from the Idaho - DWR and from one subcontractor, Boise State University (Dr. C. Waag). Closeout of this grant has been delayed because of the late delivery of a subcontractor's (USGS) report. The report has been available to ID-DWR and to DOE in draft form for several months. The report still awaits printing. Another no cost time extension will be required for formal closeout of this grant.

### Oregon - Department of Geology and Mineral Industries

Final report deliverables were received October 31. These included: a geologic map of the McKenzie Bridge quadrangle; a geologic map of the Breitenbush - Austin Hot Springs area; the CTGH-1 data, analysis and well study; and a final technical report summarizing all work completed under this grant. Closeout of the grant awaits final invoicing by DOGAMI.

### North Dakota - Mining and Minerals Resource Research Institute

This grant was closed out in 1987 following delivery of the principal deliverable, a final technical report. An important part of this report, the "Geothermal Resources Map of South Dakota" has not yet been delivered to DOE, but is expected shortly. Dr. Wil Gosnold, P. I. is reminded periodically of the overdue deliverable and reports substantial progress after a very busy academic year. Dr. Gosnold continues to be one of the most productive scientists funded by the DOE SCP and provides good exposure for the results of this program.

## 1988 GRANTS

Contract activities continued for one grant resulting from an unsolicited proposal (Oregon - DOGAMI).

Most state teams already report progress on compilations, contracting, sampling, analyses, and mapping activities related to the 1988 grants. A substantial portion of the field programs have been completed by four SCP teams: the University of Alaska - Geophysical Institute; Alaska - Division of Geological and Geophysical Surveys; the Utah Geological and Mineral Survey; and the Washington - Department of Natural Resources. Some future contract modifications have already been identified, but no major problems with these grants have been identified to date.

## COMMENTS

The deliverables resulting from the pre-1988 grants included several high quality studies which are significant contributions to the geothermal resource database or basic geology of the states involved. The studies funded by the 1988 grants include diverse topics such as: sophisticated algorithm development, monitoring and numerical modeling of hydrothermal systems, some of which may be in danger of overdevelopment; geothermal fluid genesis; geochemical studies; and basic drilling and temperature gradient studies. We look forward to the technical data and interpretations which will result from these studies.

STATE TEAM SCHEDULES

PRE-1988 GRANTS

Short Form Summary, 1 November, 1988

| | 1988 | | | | | | 1989 | | |
|---|---|---|---|---|---|---|---|---|---|
| Team | Jul | Aug | Sept | Oct | Nov | Dec | Jan | Feb | Mar |
| Az-K/Ar | ---------- | | (NCTE) | ---------- | | | -----31 | | |
| ID-DWR | --------29---------- | | | | | | ---------- | | |
| | F m8 (NCTE needed) | | | | | | | | |
| ND-MMRRI | - - - - - - - - - - | | | - - - - - - - - - - | | | - - - - - - - - - | | |
| | (map due - grant | | | closed out) | | | | | |
| OR-DOGAMMI | Q---------- | | | -Q---31--------- | | | ---------- | | |
| | | | | F(rec) | | | | | |

Q: Quarterly Report m: Grant Mod. No.
F: Final Report NCTE: No Cost Time Ext.

## STATE TEAM STATUS - PRE 1988 GRANTS

1. Arizona - K/Ar Dating  Grant Number DE-FG07-86ID12622

Financial:

| | |
|---|---|
| Total Funding Authorized | $29,999 |
| Invoices Through 1/31/89: | $22,250 |
| Total Funds Remaining | $ 7,749 |

Project Period: 1-31-89

| Deliverables: | Date Received |
|---|---|
| 1. 2 samples, Cerro Prieto -Moore/Reed | 4/2/87 |
| 2. 2 samples, OR Cascades- DOGAMI-Priest | 9/16/87 |
| 3. 6 samples, Ascension- UURI- Nielson | 9/16/87 |
| 4. 4 samples, OR Cascades- DOGAMI- Priest | 2/4/88 |
| 5. 6 samples, Los Azufres- Moore/Reed | 4/4/88 |
| 6. 5 samples, OR Cascades- DOGAMI- Priest | 4/18/88 |
| 7. 1 sample, Ascension- UURI- Nielson | 5/4/88 |
| 8. 4 Samples, WA Cascades - WA-DNR-Korosec | 12/31/88 |

Current Issues:
14 samples remain to be completed; Washington State (DNR) has been allocated 10 dates for the 1988 grant, 4 of which have been completed. DOGAMI has been allocated the remaining four samples for their old grant. This will complete the Arizona K/Ar dating grant.

2. Idaho Dept. Water Resources  Grant Number DE-FG07-84ID12549

Financial:

| | |
|---|---|
| Total Funding Authorized: | $158,579 |
| Invoices Through 1/31/89: | $125,000 |
| Total Funds Remaining: | $ 33,579 |

Project Period: 8-29-88 (NCTE required to 3/31/89)

| Deliverables: | Date Received |
|---|---|
| 1. "Geothermal Resource Analysis in Twin Falls County, Idaho": IDWR Final Report | 1/11/88 |
| 2. "Evaluation of the Boise Geothermal System": Boise State Univ. Final Report | 1/11/88 |
| 3. "The Hydrothermal System in Central Twin Falls County, Idaho": USGS Final Report (as a subcontractor to IDWR) | Overdue |

Current Issues:
USGS report is still awaiting printing. A delivery date to IDWR is still uncertain. One more NCTE will be required.

3. Montana-MCMS&T Grant Number DE-FG07-84ID12525

Financial: Total Funding Authorized: $93,421
Invoices Through 9/1/88: $93,421
Total Funds Remaining: $ 0

Project Period: 6-31-88

| Deliverables: | Date Received |
|---|---|
| 1. Final Report, Geophysical Research on Geothermal Resources in Montana | |
| 1a) "Three Dimensional Gravity Modeling Techniques with Application to the Ennis Geothermal Area" by D. Semmens | 12/23/87 |
| 1b) "A Controlled Source Audiomagnetotelluric Investigation of the Ennis Hot Springs Geothermal Area, Ennis, Montana" by G. R. Emilsson | 7/5/88 |

Current Issues:

All deliverables received and Grant closed out.

4. New Mexico-NMRDI Grant Number DE-FG07-84ID12546

Financial: Total Funding Authorized: $109,970
Invoices Through 11/1/88: $109,970
Total Funds Remaining: $ 0

Project Period: 6-15-88

| Deliverables: | Date Received |
|---|---|
| 1. Final Report | |
| 1a) South-central New Mexico study (NMSU) | 6/9/88 |
| 1b) Animas Valley (Lightning Dock Geothermal) | 6/9/88 |
| 1c) Orgrande geothermal resource assessment (Lightning Dock Geothermal) | 6/9/88 |

Current Issues:

All deliverables received and Grant can be closed out. Final invoice received by DOE/ID 10/18/88. Approved for final payment on 11/03/88.

5. Oregon-DOGAMI Grant Number DE-FG07-84ID12526

Financial: Total Funding Authorized: $359,357
Invoices Through 1/31/89: $354,709
Total Funds Remaining: $ 4,648

Project Period: 10-31-88

| Deliverables: | | Date Received |
|---|---|---|
| Original Grant | | |
| Task 1.1 | Geologic Map, Breitenbush River Area (1:62,500; GMS-46, 1987) | 8/7/87 |
| | Geologic Map, Crescent Mountain Area (1:62,500; GMS-47, 1987) | 8/7/87 |
| | Geologic Map, NW/4 of Broken Top 15' (1:24,000; Spec. Paper 21) | 8/7/87 |
| Task 1.2 | Temperature Data Collection Geothermal-Gradient Data for Oregon (1982-1984); Open File Rep. 0-86-2 | 8/7/87 |
| Task 1.3 | Project Management and Reporting | Quarterly |
| Mod. M-001 | | |
| Task 1.1 | Feasibility Study/Scientific Plan for Research (Open File Rep. 0-86-3) | 8/7/87 |
| Task 1.2 | Geologic Map, McKenzie Bridge 15' Quad., with data, interp., description. | 10/31/88 |
| Task 1.3 | Project Management and Reporting | Quarterly |
| Mod. A-002 | | |
| Task I. | Geologic map, approx. 15 sq. mi. centered on CTG drill site, Sec.28,T8S,R8E, E/2 Breitenbush 15'topo quad. | 10/31/88 |
| Task II. | Raw data and analyses, well core, CTG drill hole. (archival storage at UURI) | 10/31/88 |
| Task III. | CTG well study: comprehensive report with geologic and geothermal implications and geologic models. | 10/31/88 |
| Tasks 1, I, II, III. | Final Technical Report | 10/31/88 |

Current Issues: All work completed and deliverable received. DOGAMI is awaiting final billings by subcontractors before submitted final invoice (expected by 2/28/89). The Grant can be closed out after final payment.

6. Southern Methodist Univ. Grant Number DE-FG07-84ID12623

Financial:

| | |
|---|---|
| Total Funding Authorized: | $115,790 |
| Invoices Through 9/1/88: | $115,790 |
| Total Funds Remaining: | $ 0 |

Project Period: 5-31-88

| Deliverables: | Date Received |
|---|---|
| 1. Annual Data Report (GRC Trans., v.11) | 3/14/88 |
| 2. Final Tech. Report on Cascades heat flow studies and the Heat Flow Map of North America "U.S. Geothermal Database and Oregon Cascade Thermal Studies", by D.D. Blackwell, J. L. Steele, L. Carter. | 7/1/88 |

Current Issues:
All deliverables received and Grant closed out. Additional funding provided by a EG&G Purchase Order to further update the heat flow database.

7. North Dakota-NDMMRI Grant Number DE-FG07-84ID12606

Financial:

| | |
|---|---|
| Total Funding Authorized: | $47,000 |
| Invoices Through 6/1/88: | $47,000 |
| Total Funds Remaining: | $ 0 |

Project Period: Closed Out

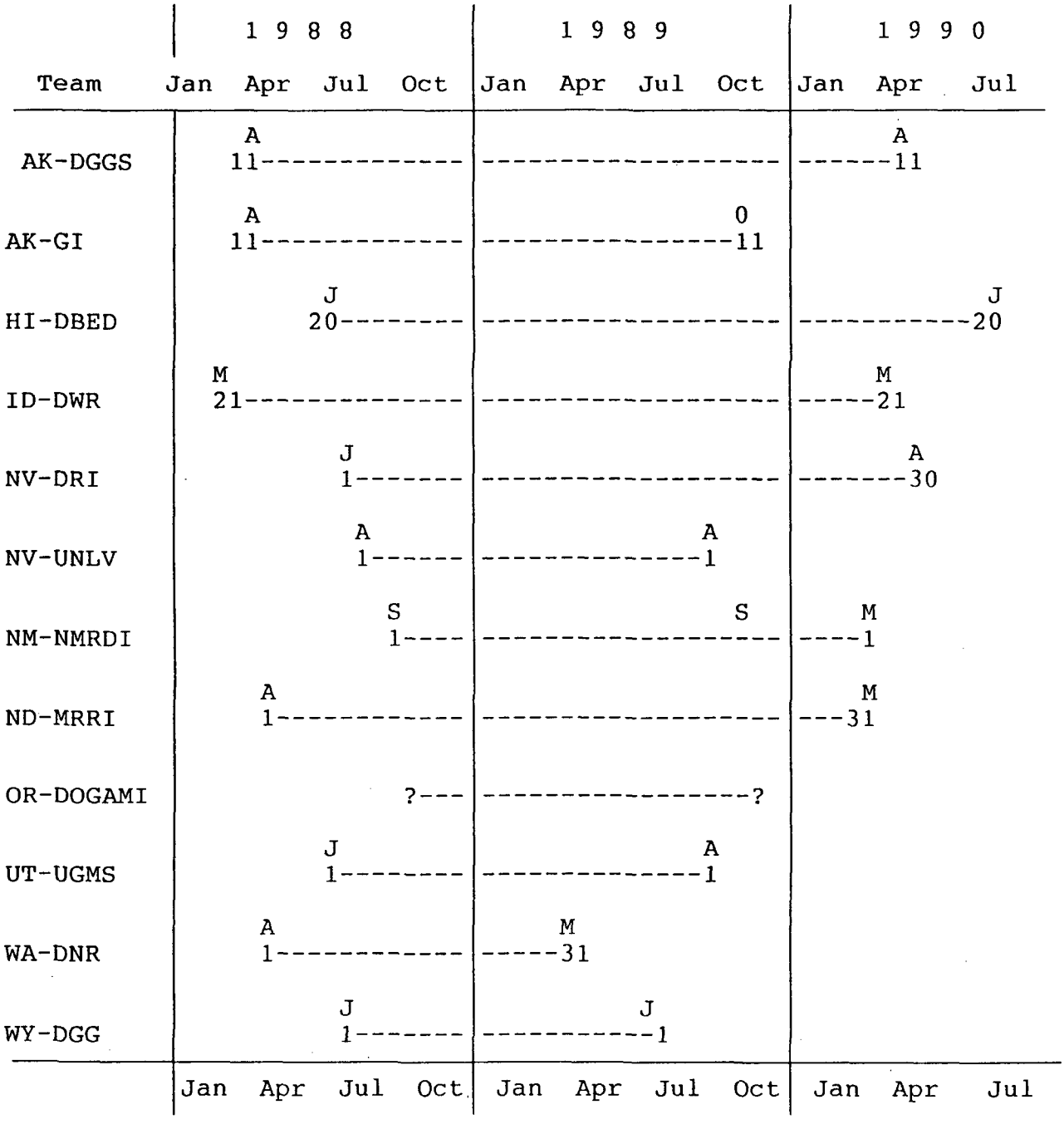
| Deliverables: | Date Received |
|---|---|
| 1. Task 5. Geothermal resource map of South Dakota (scale 1:1,000,000) | overdue |
| 2. Task 7. Final report,"Geothermal Resource Assessment of South Dakota", by W. D. Gosnold, Jr. | 8/28/87 |

Current Issues: Dr. Gosnold continues to work on the final map, which is nearing completion. No date has been set for printing and delivery.

STATE TEAM SCHEDULES

1988 GRANTS

Short Form Summary, 1 February 1989



## STATE TEAM STATUS - 1988 GRANTS

1. Alaska - Dept. of Natural Resources — Grant Number DE-FG07-88ID12744

Financial:
Total Funding Authorized: $72,000
Invoices Through: 1/31/89 $ 0
Total Funds Remaining: $72,000

Project Period: 4-11-90 (24 months)

Deliverables: Date Received
1. Contributions to GI-UAK geologic map of Geyser Creek Valley area (Task 4.1.1)
2. Report on fluid geochemistry, Geyser Bight KGRA (Task 4.1.2)
3. Contributions to GI-UAK final report on Geyser Bight KGRA study (Task 4.1.3)
4. Geothermal resource map of Aleutian Islands-Alaska Peninsula Region (Task 4.2.1)
5. Tables of fluid geochemistry (Task 4.2.2)
6. Descriptive circular to accompany Geothermal Resource Map (Task 4.2.3)

Current Issues:
Compilations underway and field work at Geyser Bight area, Umnak Island, is completed.

2. Univ. of Alaska - Geophysical Institute — Grant Number DE-FG07-88ID12742

Financial:
Total Funding Authorized: $55,593
Invoices Through:1/31/89: $38,097
Total Funds Remaining: $17,496

Project Period: 10-11-89 (18 months)

Deliverables: Date Received
1. Geologic map of Geyser Creek Valley area at 1:25,000 scale (Task 4.1.1)
2. Management, logistical, technical support for Alaska DGGS fluid chemistry study
3. Final report on Geyser Bight geothermal area study (Task 4.1.3)

Current Issues:
Invoices #1-4 received. Field work at Geyser Bight area has been completed. Principal Investigator Don Turner will

be on leave much of time November - February 1988 and Dr. Christopher Nye will cover for him. Field operations cost $17,000 more than expected and supplemental funding has been requested.

3. Hawaii-Dept. Business and Economic Development — Grant Number DE-FG07-88ID12741

Financial:
Total Funding Authorized: $ 87,173
Invoices Through: 1/31/89: $ 0
Total Funds Remaining: $ 87,173

Project Period: 6-20-90 (24 months)

Deliverables: Date Received

1. Final technical report which describes in detail the following studies:
   a. Silica polymerization studies
   b. Low-temperature brine treatment
   c. Fabrication of pilot scale treatment system
   d. Fluid characterization
   e. Preliminary design of pilot scale system
   f. By-product characterization.

Current Issues:
Subcontract between HI-DBED and Univ. of Hawaii was finalized early in this quarter.

4. Idaho - Dept. of Water Resources — Coop. Agreement No. DE-FC07-88ID12748

Financial:
Total Funding Authorized: $154,088
Invoices Through: 1/31/89: $ 15,127
Total Funds Remaining: $138,961

Project Period: 3-21-90 (24 months)

Deliverables: Date Received

1. Final technical report, all new studies, Twin Falls County Geothermal Systems (Task 1.0)
2. Final technical report, Boise geothermal aquifer study, to include all new monitoring results, Consultant's report, and IDWR summary and interpretation (Task 2.0)
3. Final technical report, geochemical studies of Wood River geothermal systems (Task 3.0)

Current Issues:

All field studies underway. Responses to IDWR RFP for consultant reservoir engineer were evaluated 1/23/89, and award is expected in February.

5. Desert Research Institute
University of Nevada System

Grant Number
DE-FG07-88ID12757

Financial:

Total Funding Authorized: $140,639
Invoices Through: 1/31/89: $ 18,794
Total Funds Remaining: $121,845

Project Period: 4/30/90 (22 months)

Deliverables: Date Received

1. Final technical report for the Moana system studies, including monitoring results, interpretation, models (Tasks 4.1-4.5)
2. User's manual for reservoir model, and any new software developed in project (Task 4.5)

Current Issues:

Dr. Elizabeth Jacobson approved by DOE/ID as temporary Project Director (8-1-88 to 6-30-89). Task II - Data Collection (monitoring and fluid sampling) started about 2 months late and has delayed the start of Task III-model calibration.

6. Division of Earth Sciences
Univ. of Nevada-Las Vegas

Grant Number
DE-FG07-88ID12784

Financial:

Total Funding Authorized: $157,114
Invoices Through: 1/31/89:$ 47,431
Total Funds Remaining: $109,683

Project Period: 8/1/89 (12 months)

Deliverables: Date Received

1. Final technical report which describes:
   a. Fluid chemistry study, Great Basin
   b. Geothermal reservoir rock data
   c. Glacial ice study
   d. Archaeological isotope/age date study
   e. Data base summary
   f. Description of sampling and analyses
   g. Great Basin fluid genesis model
2. Technical data base submitted to GEOTHERM

Current Issues:
Data compilation underway. Renegotiating agreements for sampling geothermal fluid with industry groups.

7. New Mexico Research and Development Inst. Grant Number DE-FG07-88ID12794

Financial:
Total Funding Authorized: $129,267
Invoices Through: 1/31/89: $ 0
Total Funds Remaining: $129,267

Project Period: 3-01-90 (18 months)

Deliverables: Date Received
1. Final technical report describing soil-depth radon gas surveys; Tortugas Mountain survey; Radium Springs survey; Rincon survey; final evaluation and interpretations.

Current Issues:
Permitting for radon soil-gas surveys has been approved by US BLM. Soil-depth surveys initiated in December, area surveys began in January.

8. North Dakota Mining and Mineral Res. Inst. Grant Number DE-FG07-88ID12736

Financial:
Total Funding Authorized $194,814
Invoices Through: 1/31/89 $ 46,399
Total Funds Remaining: $148,415

Project Period: 3-31-90 (24 months)

Deliverables: Date Received:
1. Detailed final technical report including all new data, maps, tables (Tasks 4.1-4.8)
2. Presentations of results at state and national meetings (Task 4.9)

Current Issues;
New wells for heat flow have been identified, and drilling is underway by South Dakota Geological Survey.

9. State of Oregon Grant Number
Dept. of Geology and Mineral Industries

Financial:
Total Funding Authorized $ 0
Invoices Through 1/31/89 $ 0
Total Funds Remaining $ 0

Project Period:

Deliverables: Date Received

Current Issues:

Unsolicited proposal from DOGAMI. Agreement between DOGAMI and DOE/ID to fund in two phases. Phase I will include environmental checklist, permitting, and site selection.

10. Utah Geological and Mineral Survey — Grant Number DE-FG07-88ID12756

| Financial: | | |
|---|---|---|
| | Total Funding Authorized: | $61,641 |
| | Invoices Through: 1/31/89 | $ 0 |
| | Total Funds Remaining: | $61,641 |

Project Period: 8-1-89 (14 months)

Deliverables: Date Received

1. Final technical report, which will include all new geological, geochemical, and geological data (Tasks 4.1-4.9)
2. Geological map of the Newcastle geothermal area (scale 1:24,000) (Tasks 4.2, 4.3)

Current Issues: Project well underway.

11. State of Washington, Dept. of Natural Resources — Grant Number DE-FG07-88ID12740

| Financial: | | |
|---|---|---|
| | Total Funding Authorized: | $170,776 |
| | Invoices Through: 1/31/89 | $ 15,398 |
| | Total Funds Remaining: | $155,378 |

Project Period: 3-31-89 (12 months)

Deliverables: Date Received

1. Final technical report for drilling project and heat flow results (Task 4.1)
2. Final technical report, volcanology study, models of Cascade volcanism (Task 4.2)

Current Issues:

Eight thermal gradient holes were drilled to depths of 500 ft. and preliminary temperature gradients have been determined. A contract modification will reflect this change from the original statement of work. A least four drill holes show a stabilized temperature gradient exceeding 50°C/km.

12. State of Washington
State Energy Office

Grant Number

Financial: Total Funding Authorized: $ 51,435

********** Monitoring/Reporting by Ben Lunis, EG&G ********

13. University of Wyoming
Dept. Geology and Geophysics

Grant Number
DE-FG07-88ID17382

Financial:
Total Funding Authorized: $ 45,511
Invoices Through: 1/31/89: $ 25,000
Total Funds Remaining: $ 20,511

Project Period: 7-1-89 (12 months)

Deliverables: Date Received

1. Final technical report describing:
   a. Computer algorithms developed
   b. New temperature data from the Cody or Thermopolis hydrothermal system
   c. Finite-difference model for system studied
   d. Numerical methods and test results

Current Issues:

Mathematics has been largely developed. Now programming algorithms so complex 3-D models can be run on PC's. Delayed due to computer change over.

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

EARTH SCIENCE LABORATORY
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108—1295
TELEPHONE 801-524-3422

May 18,1989

Kenneth J. Taylor
U. S. DOE, Idaho Operations Office
785 DOE Place
Idaho Falls, Idaho 83402

Dear Ken:

Enclosed please find one copy of the final Idaho-DWR report "Geothermal Resource Analysis in Twin Falls County, Idaho" by Leah Street and Robert DeTar.

My records indicate that a camera-ready copy of this report was sent to the Technical Information Center at Oak Ridge, TN on March 9, 1988 following receipt of patent approval.

Sincerely,

Howard

Howard P. Ross
Project Manager

encl.

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United States Government | Department of Energy

# memorandum

DATE: April 18, 1989

REPLY TO ATTN OF: CE-342

SUBJECT: Disposition of Research Equipment from Former Grant

TO: Dr. Clayton R. Nichols, Assistant Manager
DOE/Idaho Operations Office

Since the inception of the State-Cooperative Geothermal Resource Assessment Program, the DOE Geothermal Research Program has had a strong policy of strengthening the capabilities of State Agencies to conduct their own geothermal research. The most important long-term contribution from DOE has been the transfer of ownership of all capital equipment purchased under these grants to develop capability in the State Agency involved. I am sure that you agree with this method of preparing the States to carry on after DOE funding ends.

I would appreciate your assistance in carrying out this DOE policy with respect to equipment used by Dr. William R. Sill of the Montana College of Mineral Science and Technology. Dr. Sill has been contacted by Mr. R. Jeffrey Hoyles, DOE-ID Contracts Officer, with the intention of declaring the DOE equipment surplus so that it might be made available to another organization for environmental or pollution control work.

Grant No. DE-FG07-84ID12525 was awarded to the Montana College of Mineral Science and Technology on June 11, 1984. Dr. Charles J. Wideman and Dr. William R. Sill were the Co-Principal Investigators for this grant. The grant called for detailed gravity and controlled-source audiomagnetotelluric (CSAMT) surveys to be completed at Ennis Hot Springs, Montana, near Yellowstone National Park. Funding of $30,855 was made available for the purchase of the CSAMT equipment. The final report for this grant was received in July 1988 and the grant was closed out shortly afterward.

It is still our intention that ownership of this equipment, purchased under a DOE grant, be transferred to the Montana College of Mineral Science and Technology. This equipment is still used for geothermal research in Montana, and also serves the purpose of instruction of graduate students in the operation of geophysical surveys. We expect that this equipment will continue to be of value to the Geothermal Research Program as it is used by students for geothermal theses.

Marshall Reed

Marshall Reed
Program Manager
Geothermal Technology Division

14

SCP-
DOE Res. Engr
Review - SF
April 1989

# AN ORGANIZED EFFORT TO DEVELOP THE HYDROTHERMAL ENERGY RESOURCE

Kenneth J. Taylor
U.S. Dept. of Energy
Idaho National Engineering Laboratory

## A B S T R A C T

As a response to America's need for Alternate Energy sources, the U.S. Department of Energy has a Geothermal Program. Within this program is a Hydrothermal category. Currently, a wide range of tasks are being addressed as part of the Hydrothermal Program. The tasks include Industrialization, Reservoir Technology, Hard Rock Penetration and Conversion Technology. It is thought that successes already made in this program combined with upcoming successes will increase the likelihood of geothermal energy becoming a contributor to our nations future energy needs.

## INTRODUCTION

During the 1970's America became increasingly concerned about its' dependence on imported fossil energy. As a result, a push was made to locate alternate energy resources. Among the many alternative resources being considered was Geothermal energy. There were, and are, several characteristics about the Geothermal Energy resource which make it advantageous over other resources. It's abundance in the United States and the fact that it poses a minimum hazard to the environment are among the many advantages. However, there were many unknowns concerning this resource. Therefore, the United States Department of Energy (USDOE) increased its' effort in their Geothermal Program. This effort continues today.

Because of the various forms in which the Geothermal resource takes, the USDOE's Geothermal Program consists of four categories: Hydrothermal, Geopressured, Hot Dry Rock and Magma. The intent of this paper is to describe the Hydrothermal category and give a present status for its' projects.

The hydrothermal resource consist of large reservoirs of heated fluid. The temperatures of these reservoirs vary which in turn varies the way they are utilized. Low and moderate temperature resources, (10 to 150 C) are used primarily in direct used applications such as heat pumps aquaculture, and space heating. High temperature resources, (>150 C) are more commonly used for power generation.

There are many challenges to utilizing the hydrothermal resource. These challenges include locating and quantifying the resource, drilling into the resource, handling the brines, answering power plant development and maintenance questions, and injecting the brines. The goal of the Hydrothermal Program is to provide solutions to challenges such as these. By providing solutions to these challenges and others like them, the ultimate goal of reducing the life-cycle cost of electricity produced from the hydrothermal resource at 3 - 10 cents / kWh by 1992 can be achieved.

Because of the wide range of utilization and the accompanying challenges, the Hydrothermal Program has been divided into four tasks. These tasks are Industrialization, Reservoir Technology, Hard Rock Penetration and Conversion Technology. DOE-HQ located in Washington D.C. provides the program management for all of these tasks. The project management for all of the tasks in the Hydrothermal Program with the exception of the Hard Rock Penetration task is provided by DOE-ID located in Idaho Falls, ID. The project management for the Hard Rock Penetration task is provided by Sandia National Laboratory, located in Albuquerque, NM. The fiscal year 1989 funding levels for these tasks is shown in Table 1. It should be noted that since fiscal year 1989 funding for industrialization was $0, prior year funding was used to carry out the task.

| Task | Funding, ($K) |
|---|---|
| Reservoir Technology | 2,900 |
| Hard Rock Penetration | 2,400 |
| Energy Conversion | 2,030 |
| Industrialization | 0 |

TABLE 1 - FY-1989 FUNDING FOR TASKS IN HYDROTHERMAL PROGRAM

Each task consists of several projects. These projects are being carried out by various government labs, universities and contractors. A description and status of the four tasks and their respective projects will now be presented.

## INDUSTRIALIZATION

The goal of the industrialization task is to promote the use of Geothermal Energy throughout the nation and the world. The industrialization task is broken up into two projects. These projects are State-Coupled Grants and Direct Heat Participation & Support.

State Coupled Grants - The State Coupled Grants project consists of 12 cost shared grants to various groups to study aspects of geothermal energy that are not being studied by private industry, but which have the potential for results that will be applicable to industry. The total funding for the grants in this project is $1,319,800. The grant participants and a brief description of their projects follows.

The University of Alaska, Geophysical Institute is performing a geologic and geochemical study of the Geyser Bight geothermal resource, the hottest (180-264 C) and most extensive area of thermal springs in Alaska.

The state of Alaska, Division of Geological and Geophysical Survey in cooperation with the University of Alaska is completing a fluid chemistry investigation and geological map of the Geyser Bight KGRA. In addition, a geothermal energy resource map of the Aleutian Islands is being prepared.

The state of Hawaii, Department of Business and Economic Development is studying methods to control silica deposition from geothermal fluids of the Hawaii East Rift Zone.

The state of Idaho, Department of Water Resources is studying and monitoring three geothermal systems: the Banbary resource, Boise geothermal aquifer and the Wood River geothermal system.

The Desert Research Institute, University of Nevada System is conducting detailed hydrologic monitoring of the Moana geothermal system.

The University of Nevada Las Vegas, Division of Earth Sciences is integrating fluid geochemistry, stable light isotope data, glacial ice data and archaeological information to study the genesis of geothermal fluids in the Great Basin.

The New Mexico Research and Development Institute is conducting an evaluation of time-integrated radon soil-gas surveys in the southern Rio Grande Rift.

The state of North Dakota, Mining and Mineral Research Institute is bringing together the North Dakota and South Dakota Geological Surveys and UND staff for a comprehensive geothermal resource assessment of these two states.

The state of Utah, Geological and Mineral Survey is conducting a geothermal resource assessment at the New Castle geothermal area.

The state of Washington, Department of Natural Resources has drilled eight 150 meter temperature gradient holes to improve the southern Washington Cascade range heat flow data.

The state of Washington, State Energy Office is finalizing a computer program (GEODIM) which optimizes the design of wells, pipes, pumps and heat transfer systems.

The University of Wyoming, Department of Geology and Geophysics is developing an improved three-dimensional computational scheme for solving the combined heat conduction and forced convection equations for determining subsurface temperatures.

The majority of these grants will be completed by October, 1989. If additional funding becomes available for this project, it will be continued with new grants being issued.

Direct Heat Participation & Support - The Direct Heat Participation and Support project is made up of activities which have been or are taking place under three grants. The three grantees are the Oregon Institute of Technology, Geothermal Resource Council and the National Geothermal Association.

The grant with the Oregon Institute of Technology is to perform research and development assistance in areas of geothermal direct-use development, and moderate temperature (90 - 150 C) wellhead electric generating systems. The assistance, which is available at no charge, is generally limited to 8 hours. The Oregon Institute of Technology is also involved in doing research and development on issues which pertain to the geothermal direct use arena. This work results in documents such as the Geothermal Direct Use Engineering and Design Guidebook which will be available to the public in April 1989.

During the past two years, the Geothermal Resource Council has held a grant to promote the international sales of U.S. geothermal equipment. To do this the GRC held a conference in September 1987. Twenty-three participants were present from 18 countries. Over the past year, follow up information has been obtained and a final report summarizing the conclusions of the conference was delivered to DOE in January 1989. Included in this report is a response by the conference attendees indicating that the U.S. geothermal technologies most needed by foreign countries are binary cycle power plant technology and cooling system technology. The final report is available for interested persons.

Currently, a grant is being put in place between the DOE and the National Geothermal Association which will promote U.S. Power Plant technology and U.S. Drilling and completion technology. The activities associated with this grant will consist of meetings between interested foreign developers and U.S. Power Plant and Drilling

Industry Representatives. The intent of these meetings will be to promote sales of U.S. Geothermal Technology in these areas. A final report will be provided to the DOE in September 1989. This report will also be available to the interested persons.

## RESERVOIR TECHNOLOGY

The goal for the Reservoir Technology task is to improve the technology for geothermal energy resource utilization by developing and testing analytical and interpretive methods to more effectively locate, develop and utilize hydrothermal resources. By obtaining this goal, it is thought that:

Industry will be enabled to maximize energy recovery from a resource through more realistic predictions of reservoir performance

The adverse thermal and chemical effects of injection on geothermal reservoirs will be reduced

New techniques to identify fractures in geothermal reservoirs and to locate geothermal reservoirs will be verified.

The task is broken into four projects: Reservoir Analysis, Exploration Technology, Brine Injection, Geothermal Technology Organization.

Reservoir Analysis - The Reservoir Analysis project is intended to provide analytical and interpretive tools for determining reservoir characteristics and reservoir performance with greater certainty. The objectives for the project are to improve production well siting and decrease the uncertainty associated with long-term reservoir decline. Several activities are currently taking place in this project.

The Lawrence Berkeley Laboratory (LBL) and the University of Utah Research Institute (UURI) are developing new geophysical equipment and field testing its' use for monitoring fluid flow in reservoirs. They are also continuing the testing of vertical seismic profiling and microseismic monitoring for detection and mapping of fractures in geothermal systems. Finally, they are developing and verifying computer Dbased methods to evaluate the use of borehole geophysical techniques for locating fractures and permeable zones in geothermal systems.

Stanford University, the Idaho National Engineering Laboratory (INEL) and LBL are analyzing field data from individual production well tests and interference tests. They will refine computer modeling techniques for identifying reservoir processes and evaluating their impact on the response of hydrothermal systems to development. In addition, UURI, LBL and INEL are interpreting field data and attempting a synthesis of knowledge about reservoir processes.

Stanford and LBL are continuing their efforts to develop theoretical and computer models to predict reservoir performance from combined well testing and production history. They are using laboratory physical models to develop techniques for simulating the response of geothermal systems to different reservoir management programs and evaluating the usefulness of these techniques for estimating the generating capacity and longevity of these systems.

Brine Injection Technology - The Brine Injection Technology project addresses industry needs for effective and environmentally acceptable injection systems which reduce adverse impacts on geothermal reservoirs. The objective for this project is to decrease the uncertainty associated with injecting brines into producing reservoirs. The project is focusing on three specific areas: fluid migration, fluid-rock chemical interactions, and injection well placement.

UURI is evaluating potential geothermal tracers in laboratory experiments simulating natural geothermal systems. They will develop, with industry, field operations techniques for tracer injection, sampling, and interpretation to track the transport of injected fluid. INEL and Stanford are applying computer modeling techniques to the tracer return field data for the determination of reservoir physical properties and fluid interactions in the reservoir. UURI, Stanford LBL and INEL are participating in a field test with Oxbow Geothermal Company in the Dixie Valley system to verify tracer usefulness and to develop interpretative methods to analyze tracer results.

LBL and UURI are performing theoretical studies of geophysical techniques to determine if injection of spent geothermal fluids can generate signals which can be detected at the surface with existing geophysical equipment. They will design equipment capable of detecting the theoretically determined signals if existing equipment is found to be unsuitable.

INEL is continuing to develop computer models with the capability to analyze and predict the flow of injected fluids through reservoirs. INEL researchers are investigating the potential for coupling the fluid flow computer model with models of chemical interactions between rocks and the injected fluid. The INEL fluid flow model FRACSL is available for simulation of injection into commercial geothermal systems.

Exploration Technology - The Exploration Technology project is designed to develop techniques to locate and characterize geothermal resources. The objectives for this project are to increase the success ratio of wildcat wells and to devise better methods of discovering hidden geothermal systems. The following work is currently being done in this project.

UURI is collecting and analyzing existing data from geothermal exploration projects and is integrating it with geological, geophysical and geochemical data from field and laboratory investigations to develop conceptual models for exploration of geothermal systems. UURI is also utilizing this data to prepare case studies of resource exploration for the industry.

UURI and LBL are performing numerical analysis to determine theoretical geophysical responses from fluid filled fractures and are designing and conducting field tests of surface geophysical techniques to verify the responses expected. They are investigating the use of new interpretation methods for locating fractured hydrothermal systems. They are concentrating on electromagnetic and passive seismic methods of exploration and will combine the observed geophysical data with laboratory measurement of physical properties and existing geologic data to provide exploration plans for regions like the Cascades volcanic province for which the data sets are available.

Geothermal Technology Organization - The Geothermal Technology Organization (GTO) has been formed by the DOE and Industry to sponsor geothermal technological development. The geothermal industry works with the DOE through a cooperative research agreement between the DOE Idaho Operation Office and the GTO. The DOE is represented in the GTO by the INEL.

Research selected for funding by GTO has a high likelihood of yielding near term benefits.

## HARD ROCK PENETRATION

The goal of the Hard Rock Penetration task is to reduce the cost of drilling in hostile environments where the geothermal resource is most commonly located. The task is broken into four projects: Lost Circulation Control, Rock Penetration Mechanics, Instrumentation and the Geothermal Drilling Organization. All of the projects in this task are being carried out at the Sandia National Laboratory.

Lost Circulation Control - Lost Circulation is seen by industry as a significant expense in drilling geothermal wells. The objective for the Lost Circulation Control Project is to reduce costs associated with lost circulation episodes. Currently, research is being directed toward developing techniques for characterizing and controlling lost circulation in geothermal drilling. There are three primary areas of activity that are currently being pursued.

Development of techniques for detecting and characterizing loss zones in order to determine which control techniques should be employed in a given circumstances

Development or identification of suitable high temperature bridging materials for loss zones characterized by a porous matrix or minor fractures

Development of new techniques for plugging loss zones characterized by large fractures or vugular/cavernous zones.

The majority of work to date has been directed toward the development of bridging materials. This is based on the need for materials that will successfully plug minor loss zones so that more drastic measures such as cement plugs are not necessary. Recent lost circulation material testing and theoretical modeling indicate that easily measured mechanical properties such as compressive strength, elastic modulus and softening temperature control the fracture plugging capabilities of potential lost circulation materials.

Rock Penetration Mechanics - Recovering core economically from deep, hot environments such as those where geothermal resources often are is very difficult. In addition, the current bottomhole tools and assemblies must be improved to reduce deviations and improve drilling rates. Therefore, the objective for the Rock Penetration Mechanics project is to reduce deep coring costs and to reduce costs of deep wells and directionally drilled wells.

Currently, research in the Rock Penetration Mechanics project is directed toward manufacturing insulated drill pipe, studying advanced hard rock drilling and coring systems and building transmitting and receiving transducers for acoustical data telemetry systems. In general a basic description of rock penetration by candidate innovative drilling / coring systems is being derived. Over ten years of work spent determining the behavior of polycrystalline diamond compact drag bits in relation to rock fracture and wear mechanisms is being summarized. Other research areas include development of high temperature drilling systems for operation above 300 C, and advanced concepts for drilling or coring in hard rock. Additional work is directed at collecting real time drilling and formation data from a transducer located on the bit. A data transmission scheme using acoustical carrier waves within the drill string appears promising for improving data rates by 50 fold over commercial mud pulse telemetry.

Instrumentation - Instrumentation used to locate resources and to measure parameters at great depths is often inaccurate. The objective for the Instrumentation project is to increase well siting accuracy at a reduced cost and decrease the uncertainties which accompany down hole measurements.

Electronic memory tools for pressure and temperature measurement to 400 C have been built and successfully used at temperatures to 350 C.

well depths up to 17,000 feet and for extended periods in lower temperature wells. The current R & D effort in the instrumentation project includes two activities. First, a downhole scanning radar operating in the frequency range of 30 to 100 MHz is being developed to locate fracture zones in geothermal resources, and second electronic memory tools are being developed for downhole measurements in wells where the temperature limit of wireline cable is exceeded.

Geothermal Drilling Organization - The Geothermal Drilling Organization is a nonprofit organization between members of industry and the DOE to cooperatively fund projects in the drilling arena. The objective for this project is to develop and transfer drilling technology which will result in additional cost reductions to industry.

The development efforts of the Geothermal Drilling Organization include projects selected by industry for short term payoff. Current, development includes a high temperature acoustic borehole televiewer for fracture identification in open holes and for casing inspection in cased wells; a polyurethane foam tool to control lost circulation problems in zones of high permeability; a pneumatic turbine for directional drilling; high temperature drill pipe protectors; and high temperature elastomers for rotary head seals.

## ENERGY CONVERSION

The goal for the Energy Conversion Task is to develop concepts which will allow better utilization of Geothermal energy at a reduced cost. The Task is broken into three projects: Heat Cycle Research, Materials Development and Advanced Brine Chemistry.

Heat Cycle Research - It has been indicated in several recent studies that geothermal developers are very concerned with power plant technology. In particular, developers have expressed an interest in binary plant technology and cooling systems. The Heat Cycle Research Project is primarily concerned with advancing power plant technology. The objectives for the project are as follows:

Increase net geothermal fluid effectiveness of binary plants

Increase net geothermal fluid effectiveness of conventional binary plants through the utilization of supersaturated vapor expansions in the turbine

Reduce heat rejection system cooling water make-up requirements for geothermal power plants, while retaining performance comparable with conventional wet cooling.

The Heat Cycle project is carried out by the Idaho National Engineering Laboratory, (INEL). The project utilizes a Heat Cycle Research Facility to generate experimental power plant data. This facility is a small (640 kW) power plant located in East Mesa, CA. Data received from this facility is taken to the INEL for analysis.

Since the spring of 1988, the project has been relocating the Heat Cycle Research Facility to GEO's East Mesa McCabe site. The relocation will be completed by May 1989 and testing will resume at that time. The testing to be done in the near future is summarized below.

It is known that if the condenser pressure can be decreased, the efficiency of a binary power plant can be increased. Therefore, the project is examining methods to decrease this pressure. Currently, three methods are being evaluated: countercurrent flow, enhance surface characteristics and integral mixing during condensation. Testing will be completed on this work by October 1989 and evaluation of the data should be completed shortly after.

Supersaturated turbine expansions theoretically can be done to increase net geofluid effectiveness. However, this is not done due to concern of extensive wear to turbine blades if liquid droplets form. The INEL has developed a 2-D nozzle which will be used to determine the limits regarding supersaturated turbine expansion and blade wear. Testing for this activity will begin in the August 1989.

In addition to the Heat Cycle Research Facility activities, work is also being done to evaluate more advanced cycles and to test materials which may result in heat exchanger scale reduction.

Material Development - Geothermal brine is often extremely difficult to work with. It's high temperature and corrosiveness make the selection of materials to use for drilling a well, producing a well, and operating a geothermal power plant very difficult. The objective for the Material Development project is to reduce the costs associated with lost circulation, develop well cementing materials which have a lifetime of 30 years at 400 - 600 C and develop corrosion resistant, low fouling heat exchangers. This project is currently broken into four activities described below. All these activities are being conducted out of Brookhaven National Laboratory, (BNL).

The development of advance high temperature cements is being conducted in three phases. First, light weight cements are being tested in low CO2 containing brines. The testing will be completed prior to October 1989. Second, ceramic-like cements which can be used for well completions at temperatures up to 500 C are being

developed. Third, CO2-resistant high temperature cements are being developed.

A thermally conductive polymer concrete coating has been developed at BNL. This coating is being tested in a heat exchanger apparatus which was built and will be tested by the Idaho National Engineering Laboratory in Hawaii. The results of this experiment will be analyzed and reported in a collaborative effort by both laboratories.

Advanced elastomers for downhole drill motors are currently being developed. These elastomers are being optimized for sealing applications and for use as a stator in a downhole drill motor. To date the work has been focused on developing and doing laboratory tests. If these tests are successful, the elastomers will be fabricated and field tested.

Chemical systems for lost circulation control are currently being developed at BNL in a collaborative effort with Sandia National Laboratory's Hard Rock Penetration Task. Efforts at BNL consist of developing chemical systems which are tested at the Sandia National Laboratory. If the current tests are successful, the chemical systems will be tested in the field.

Advanced Brine Chemistry - Handling and disposing geothermal brine can be difficult. This is often due to the brine chemistry. Brine scaling results in handling difficulties. Brine chemical content often results in disposal problems which arise for environmental reasons. The advanced brine chemistry project is attempting to reduce these obstacles. The project consists of two activities: modeling and waste disposal.

The modeling activities are taking place at the University of California at San Diego, (UCSD). The objective for this activity is to reduce the costs associated with scale deposition on production well casing and power plant equipment. UCSD is carrying out research involving aqueous chemical models for geothermal process design. The University has developed a variable temperature model which accurately calculates solubilities in the sodium, calcium, chlorine, sulfate and water systems from 0 to 250 C and from dilute to high ionic strength. Current modeling activities are focussing on the addition of model parameters for hydrogen sulfide solubility, plus the incorporation of bisulfate species.

The waste disposal activities are taking place at Brookhaven National Laboratory, (BNL). The objective for this activity is to reduce costs of surface disposal of sludge from geothermal brines. In cooperation with industry, BNL is developing low-cost biochemical processes to concentrate and remove toxic materials from geothermal brine residues. Three types of bioreactors have been constructed. Tests are now being carried out to reduce residence times and to compare the overall efficiency of the three bioreactor designs.



## CONCLUSION

It is evident that in the Hydrothermal program, a significant amount of work is being done on a large range of subjects. This work is being done to solve the problems which may inhibit industry from developing the hydrothermal resource. In order for this work to be effective, industry must provide the government with input regarding their specific concerns. This is currently being done in many of the projects, however more industry input and involvement is always needed.

With continued research in the Hydrothermal program, it is hoped that the ultimate objective of reducing the cost of electricity produced from the hydrothermal resource will be achieved. If this takes place, it will be a positive step in our country's search for alternate energy sources. More importantly, it will allow our nation to reduce its' need for foreign energy products.

## ACKNOWLEDGMENT

I wish to thank Howard Ross, University of Utah Research Institute for providing information on the State Coupled Grants; Joel Renner, Idaho National Engineering Laboratory for providing the major portion of the Reservoir Technology section; Jim Dunn, Sandia National Laboratory for providing major portions of the Hard Rock Penetration section; Larry Kukachka, Brookhaven National Laboratory for providing information on the Geothermal Materials project and Gladys Hooper, U.S. Dept. of Energy for providing information on the Advanced Brine Chemistry project.

## REFERENCES

U.S. Dept. of Energy, Washington, D.C., April 14, 1988, "Programmatic Objectives of the Geothermal Technology Division", Volume II- Appendices.

U.S. Department of Energy, Idaho Operations Office, Closing Date: June 19, 1987, "Program Research and Development Announcement, State Geothermal Research and Development".

Idaho National Engineering Laboratory, August 1988, "Annual Operating Plan for Geothermal Reservoir Technology Research".

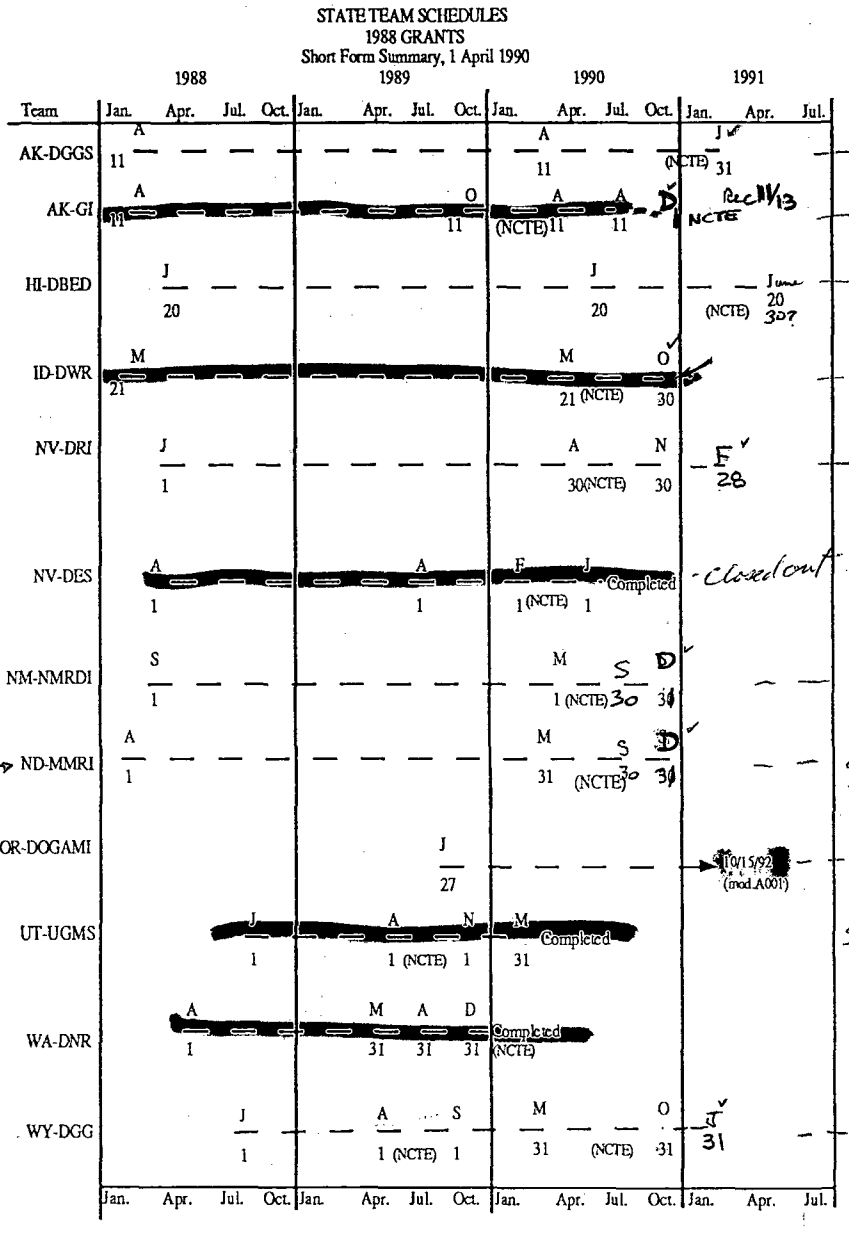
U.S. Dept. of Energy, August 1988, "Annual Operating Plan for the Energy Conversion Task".

# STATE TEAM SCHEDULES

## 1988 GRANTS

### Short Form Summary, 1 July 1990

1988 1989 1990 1991




o.k.; hold up on below

2nd draft final overdue

✓ contract mod info

✓ Paul Castelan

✓ contract mod info, change date.

closeout

draft final due SP work in Sept, Oct.

draft S.D. map & text on the way. GEC paper

drilling in progress reserved 5,000

SP work in Oct, Nov.

✓ status

9/20 NTCE

9/20 NTCE

UNIVERSITY OF UTAH RESEARCH INSTITUTE
UURI
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108-1295
TELEPHONE 801-524-3422

November 20, 1990

Mr. Kenneth Taylor
SCP Coordinator
DOE/ID
785 DOE Place
Idaho Falls, ID 83402

Dear Ken:

Enclosed is the progress report for the State Cooperative Program for the Quarter ending September 30, 1990. Submittal of this report was delayed to include a review of state team invoices, and by my field work in New Mexico.

Please call me with any questions you may have.

Sincerely,

Howard

Howard P. Ross
Project Manager, SCP

HPR:dc

enclosure

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108-1295
TELEPHONE 801-524-3422

M E M O R A N D U M

TO: Ken Taylor

FROM: Howard Ross

DATE: June 22, 1990

SUBJECT: Anticipated Contract Activity for DOE State Cooperative Program, July 1 - October 1, 1990

The following SCP contract activity can be expected before October 1, 1990.

University of Alaska-Geophysical Institute - We should receive the corrected final report by August 11. This will start final payment and grant close out activities.

Hawaii- Dept. of Business and Economic Development - A no cost time extension is in place. Contracts may wish to review expenditures and adjustment of charges previously made to federal to the state cost share. A contract modification will be requested, probably some time after October.

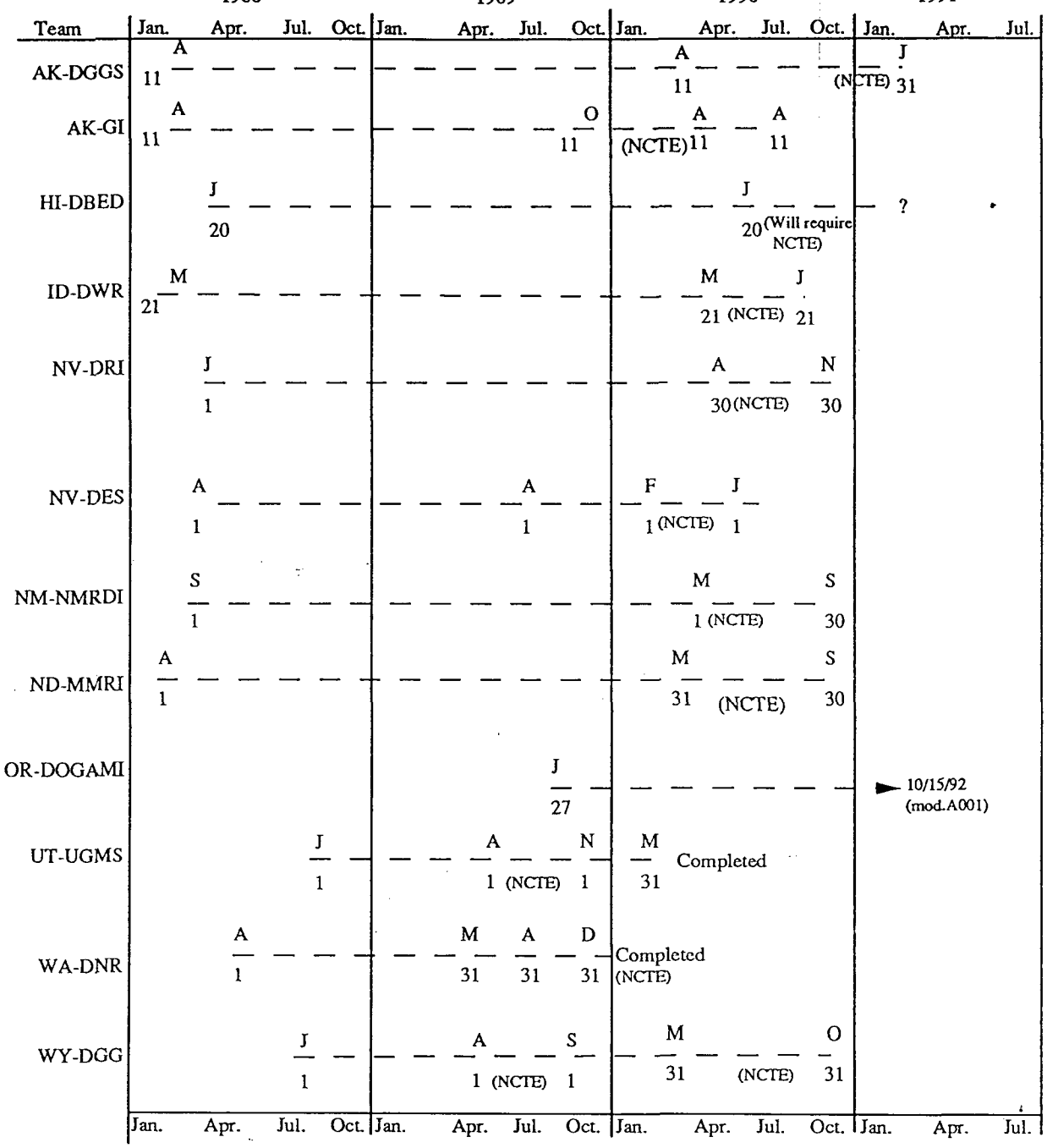
University of Nevada-Division of Earth Sciences - The final report was received on June 1. Final payment and grant close out should be in progress.

Five grants are scheduled for final deliverables betweeen September 30 and November 30, so coonsiderable contract activity can be expected after October 1, 1990.

Howard

Howard P. Ross
Project Manager

## STATE TEAM SCHEDULES
### 1988 GRANTS
Short Form Summary, 1 April 1990



M E M O R A N D U M

TO: Kenneth Taylor

FROM: Howard Ross

DATE: March 9, 1989

SUBJECT: Brief summary of FY-88 SCP grants

**University of Alaska-Geophysical Institute - Dr. Donald L. Turner and Dr. Christopher Nye**

The University of Alaska-Geophysical Institute is conducting a geologic and geochemical study of the Geyser Bight geothermal resource, the hottest (180-264°C) and most extensive area of thermal springs in Alaska, in cooperation with the AK-DGGS. Although the resource is located on a remote uninhabited Aleutian Island, the geological data and K-Ar age dating are expected to contribute to our knowledge of volcanic island arc systems in general.

**Alaska - Division of Geological and Geophysical Surveys - Dr. Roman J. Motyka**

The state of Alaska-DGGS in cooperation with the University of Alaska-Geophysical Institute is completing a fluid chemistry investigation and geological mapping of the Geyser Bight KGRA. A second task requires the preparation of a 1:1,000,000 scale technical geothermal energy resource map for the Aleutian Island - Alaska Peninsula region, and compilation and evaluation of all available geochemical data on geothermal fluids for this region.

**Hawaii - Department of Business and Economic Development - Dr. Donald Thomas**

The state of Hawaii is studying methods of controlling silica deposition from geothermal fluids of the Hawaii East Rift Zone. Principal components of the study include: silica polymerization studies; low temperature (<100°C) brine treatment; design of a pilot scale treatment system; characterization of treated fluids; and characterization/economic evaluation of

precipated silica.

**Idaho - Department of Water Resources - ~~Ms. Leah V. Street~~ Mr. Paul M. Castelin**

The Idaho - DWR is continuing monitoring of the Banbury - Twin Falls resource and studying geothermal resource potential of the Cassia Mountains to the south. Continued monitoring of the Boise geothermal aquifer, and numerical modeling of this system by a consultant constitute a separate work task. A third project involves a study of the geochemistry of the Wood River geothermal systems and evaluation of the fluoride content of the thermal fluids.

**University of Nevada System - Desert Research Institute - Dr. Elizabeth Jacobson**

The Desert Research Institute (DRI) is conducting detailed hydrologic monitoring of the Moana geothermal system, in support of a quantitative evaluation and numerical modeling of this resource. Uncoordinated development of this moderate-temperature resource is rapidly expanding and the long-term productivity of the Moana system may be threatened. This study should provide a solid data base and quantitative model for state regulatory agencies and developers using the resource.

**University of Nevada - Las Vegas - Division of Earth Sciences - Dr. Thomas Flynn**

This study integrates fluid geochemistry, stable light isotope data, glacial ice data and archaeological information to study the genesis of geothermal fluids in the Great Basin. Substantial new chemistry data is being obtained for several moderate-, and high-temperature resources in Nevada. A contemporary fluid recharge model and the paleo recharge model will be developed as part of this study.

**New Mexico Research and Development Institute - ~~Dr. Larry Icerman~~ Mr. Patricio Rodriguez Mr. Jim Witcher**

NMRDI is conducting an evaluation of time-integrated radon soil-gas surveys in the southern Rio Grande Rift. Radon gas concentrations will be determined as a function of depth and caliche development and surveys will be completed over the Radium Springs geothermal area. Surveys will then be completed in the Tortugas Mountain and Rincon areas as preliminary geothermal resource evaluation.

**North Dakota Mining and Mineral Resources Research Institute (MMRRRI) - Dr. William Gosnold**

The North Dakota MMRRI brings together the North Dakota and South Dakota Geological Surveys and UND staff for a comprehensive geothermal resource assessment of these two states. Five new heat flow holes will be drilled in each state, and temperature, hydrologic, and stratigraphic data will be integrated with

existing data to evaluate the production potential for geothermal aquifers in these states.

**Utah Geological and Mineral Survey - Mr. Robert E. Blackett**

The Utah Geological and Mineral Survey (UGMS) is conducting a geothermal resource assessment at the New Castle geothermal area in cooperation with the University of Utah Department of Geology and Geophysics. This study includes detailed mapping in bedrock and Quaternary deposits, a soil mercury geochemical survey, fluid geochemistry, gravity surveys, and temperature monitoring in twelve shallow (<60 feet) gradient holes. A conceptual model will be developed which may be applicable to other blind Basin and Range hydrothermal systems.

**Washington Department of Natural Resources - Mr. Michael Korosec**

The State of Washington - DNR has drilled eight 150 m temperature gradient holes to improve the delineation of the Southern Washington Cascade Range heat flow high. These data, coupled with K-Ar age dating and geochemical analyses will be used to refine time-space-volume models for Cascade volcanism and to evaluate geothermal potential of the region.

**University of Wyoming - Department Geology and Geophysics - Dr. Henry P. Heasler**

Dr. Heasler is working with two University of Wyoming mathematicians to develop improved three-dimensional computational schemes for solving the combined heat conduction and forced convection equations for determining subsurface temperatures. A model will be developed for either the Cody or Thermopolis hydrothermal system in the Bighorn Basin, Wyoming. The computational techniques will be applicable to a large number of mixed convective - conductive geothermal resources.

UNIVERSITY OF UTAH RESEARCH INSTITUTE

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391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108-1295
TELEPHONE 801-524-3422

November 28, 1989

Kenneth Taylor
SCP Coordinator
DOE/ID
785 DOE Place
Idaho Falls ID 83402

Dear Ken:

Enclosed are four copies of the State Cooperative Program report for the last quarter. If you would be kind enough to distribute the others copies at DOE/ID we may save DOE and UURI a few dollars.

My thanks to you and to Ken Osborne for your reviews, corrects and new information.

Sincerely,

Howard

Howard P. Ross
Project Manager

encls.

cc: Sammi Aoki
Peggy Brookshier
Kenneth Osborne

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108-1295
TELEPHONE 801-524-3422

November 28, 1989

Marshall Reed
Geothermal Technology Division
U. S. Department Energy
Forrestal Building-MS CE 342
Washington DC 20585

Dear Marshall:

Transmitted herewith is the quarterly report for the State Cooperative Program. A draft of this report was reviewed by Ken Taylor and Ken Osborne at DOE/ID.

Please let me know of any errors you may note, or questions you may have.

Sincerely,

Howard

Howard P. Ross
Project Manager

encls.

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UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108-1295
TELEPHONE 801-524-3422

December 13, 1989

Dr. Gordon Bloomquist
Wash. State Energy Office
809 Legion Way SE, FA-11
Olympia, WA 98504

Dear Gordon:

I have learned the following regarding digital data tapes used in the compilation of western states "Geothermal Resources Maps", 1978-1982. Only two people who worked on this project remain at NOAA's National Geophysical Data Center. They are David Clark and Joy Ikelman.

David Clark said that USGS mylar base maps were used to post the data for most states. These and overlays for color patterns were sent to the participating state agency at the conclusion of the project. Dave recalls that much of the data was in digital form for Idaho, and perhaps less than 50% for Utah. Other states had less digital data, and formats varied from state to state. What digital data there was is probably archived, along with a more complete digital data file for USGS circular 790 data (hot springs, lat., long.). The 6x10 foot Calcomp plotter and giant light tables used for the project have been retired and shipped off.

This information confirms Duncan Foley's recollection that relatively little of the map information exists in uniformly formatted digital data files. You should contact Joy Ikelman at (FTS)320-6419 or (303)497-6419 for information regarding your specific needs. David Clark (FTS)320-6215 or (303)497-6215 would have less complete information on the data tapes.

Please call me if I can be of additional assistance to your project.

Sincerely,

Howard Ross
Howard P. Ross
Project Manager

cc: Marshall Reed
Mike Wright

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

EARTH SCIENCE LABORATORY
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108—1295
TELEPHONE 801-524-3422

Dr. Marshall Reed
United States Department of Energy
CE 342
Washington, DC 20585

Dear Marshall:

Enclosed are copies of U. Arizona age date information sent to Mike Korosec and letters of explanation sent to Korosec and Paul Hammond. This is all the written information I've been able to get from M. Shafiquallah, and Paul Damon seems to be out of the office much of the time. Although I would have liked a more formal written explanation, I believe that this is adequate, and that we, and Mike Korosec, can accept the new age dates as valid. The University of Arizona is now working on four samples for George Priest which will complete all work under the 1986 U of AZ grant.

While discussing the Santiam Pass project with George Priest, he mentioned that Oregon State had an excellent Geocronology facility headed by Dr. Robert Duncan. I talked to Bob Duncan in the Marine Geology Department and learned the following. OSU has a MS-10 mass spectrometer (about to be upgraded) and on campus reactor for irradiation. They do both K-Ar and Ar40-Ar39, have been providing dates for about 12 years, and have been doing about 300-400 dates per year for the last few years. Bob Duncan says the fee for both types of dates is $400 per sample, subject to some discounts for academic users. Turnaround for K-Ar is about one month, and Ar40-Ar39 is generally about 1.5-2 months depending on the current workload.

Bob Duncan sounds quite enthusiastic and competent, and would like your consideration for the DOE geothermal age date grant. He says much of their work has been volcanic samples from the Pacific Northwest, and that they have done many samples for George Priest. Please call Bob Duncan at (503) 754-2296 if you would like to discuss this topic further, and let me know your wishes regarding a new grant for geochronology services.

I will be at Zunil, Guatemala to review geophysical survey data from June 14-22. Perhaps we can discuss the above in more detail when I return.

Sincerely,

Howard

Howard P. Ross
Project Manager

encl.

Dec 6 1989

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**THE UNIVERSITY OF ARIZONA**
**Tucson**

# INVOICE

52232

Date 17-Apr-89

Invoice No. 1146

Dr. Ken Taylor
Project Manager
Advanced Technologies Division
DOE - Idaho Operations Office
Idaho Falls, Idaho 83402

PE Damon/M Shafiqullah
Geosciences, Bldg # 77
University of Arizona
Tucson, AZ. 85721

Please make check payable to
THE UNIVERSITY OF ARIZONA and mail to Department of:

| Analysis of 6 K-Ar samples at $750 per sample | | | Age Date |
|---|---|---|---|
| 1. | MK 87 9 75 | UAKA- 88 164 | (0.314 +/- 0.054) |
| 2. | MK 88 8 11 | UAKA- 88 168 | (0.277 +/- 0.020) |
| 3. | MK 88 8 14 | UAKA- 88 169 | (1.67 +/- 0.23) |
| 4. | MK 88 8 18 | UAKA- 88 170 | (0.203 +/- 0.036) |
| 5. | MK 88 8 20 | UAKA- 88 171 | (0.292 +/- 0.033) |
| 6. | MK 88 8 24 | UAKA- 88 172 | (0.394 +/- 0.039) |

Amount billed $ 4500

Please return one copy of invoice with your check.

| | Apr. 17, '89 | Dec. 23, '88 |
|---|---|---|
| MK 87-9-70 | 0.125 +/- 0.014 my | 0.510 +/- 0.040 |
| MK 88-8-8 | 0.217 +/- 0.122 my | 1.74 +/- 0.09 |
| MK 88-8-9 | 0.309 +/- 0.075 my | 1.74 +/- 0.13 |
| MK 88-8-10 | 0.492 +/- 0.084 my | 1.58 +/- 0.13 |

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

DEPARTMENT OF GEOSCIENCES
BUILDING #77
GOULD-SIMPSON BUILDING
TEL. (602) 621-6024

rec 6/1/89

Dr. Paul Hammond
Department of Geology
State University
Portland, Oregon 97207

May 31, 1989

Dear Dr. Hammond

It was a great pleasure to talk to you over the telephone last Tuesday and discuss the dates on samples sent by Dr. Korosec. It was a good feeling to hear that you liked the numbers and that they fit the geologic setting of the area you have been mapping for a long time and are familiar with the sample locations. Some of the samples analyzed for this project were close to our analytical limits and we had to reanalyze them. However, Mike was not happy with some of the values and I mentioned that we will be happy to analyze one sample collocted from one of the flows with very low K-content at no cost to DOE if it has about 0.5 percent K or more. Please keep an eye for such a sample.

Please give me a call if I can be of any assistance.

Sincerely

M. Shafiqullah

M. Shafiqullah

Copy to
HP Ross
M. Korosec

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

DEPARTMENT OF GEOSCIENCES
BUILDING #77
GOULD-SIMPSON BUILDING
TEL. (602) 621-6024

Dr. Michael Korosec
State Geologist
Geology and Earth Resources Div.
Mail Stop: PY-12
Olympia, WA 98504

April 17, 1989

Dear Mike

In accordance to our telephone conversation, enclosed please find data on the remaining six samples you submitted for K-Ar dating. Each sample was ground to -100+150 mesh and potassium-rich feldspar groundmass concentrate was separated as far as practical with the removal of pyroxene and olivine by exploiting both magnetic properties and density. Phenocryst feldspars were removed as non-magnetic fraction.

As I mentioned over the telephone this morning, we had too many unusual problems recently. The Research Assistant who started working with us last summer was accident prone and modified both tracer concentration and composition without our knowledge. She is no longer us us. We are recalculating all analyses since last July, and have reanalyzed quite a few samples. Data on your four samples sent in December, on recalculation, came out quite a bit different. It is unfortunate that it had to happen this way. Looking at the hind side, we are glad that we could correct the data before it is in print.

We note that all your samples are geologically young. Even though the percent atmospheric argon appears high, the total atmospheric argon content is low in all but two cases (UAKA 88-164 and 88-169). Measurement of radiogenic argon content in some of your samples with low potassium (<0.3 %) required meticulous attention to details. We tried our best and reanalyzed some samples. We will be happy to analyze one recollected sample at no additional cost to DOE.

The analytical results were checked by Paul Damon before release. It was a pleasure to work on this project and we look forward to continued cooperative research. With season's greeting and best wishes.

Respectfully

M. Shafiqullah

M. Shafiqullah
Research Scientist

Copy to:
Howard P Ross
Ken Taylor

# TECHNICAL PROPOSAL

# AND

# REQUEST FOR INCREMENTAL FUNDING: FY-90

## TECHNICAL AND ADMINISTRATIVE SUPPORT

## STATE COOPERATIVE RESERVOIR ANALYSIS PROGRAM

submitted to

DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE
785 DOE PLACE
IDAHO FALLS, ID 83402

by

University of Utah Research Institute
Earth Science Laboratory
391 Chipeta Way, Suite C
Salt Lake City, UT 84108-1295

September 26, 1989

Howard P. Ross
Principal Investigator
Earth Science Laboratory
University of Utah
Research Institute

Wilford L. Forsberg
Treasurer
Earth Science Laboratory
University of Utah
Research Institute

Phillip M. Wright
Technical Vice President
Earth Science Laboratory
University of Utah
Research Institute

STATEMENT OF WORK

STATE COOPERATIVE RESERVOIR ANALYSIS PROGRAM

## 1.0 Introduction

The State Cooperative Reservoir Analysis Program (SCP) was established by DOE in the late-1970's, as the State Coupled Program to assess low- and moderate-temperature geothermal resources in the United States. Since the inception of this program, UURI has provided technical program monitoring, coordination, and administrative support to DOE for the SCP, and has provided technical support to state teams especially in the areas of geochemistry and geophysics.

As a result of a 1987 solicitation, the DOE/ID Program Research and Development Announcement (PRDA) for State Geothermal Research and Development-PRDA No. DE-PR07-87ID12662, ten grants and one cooperative agreement were signed with state-designated agencies to conduct geothermal research. One additional grant with the Oregon Department of Geology and Mineral Resources (DOGAMI) has since been signed which calls for incremental, phased funding. All of these grants remain active at the end of FY-89. At least eight of these grants will continue into mid FY-90 as a result of original work schedules and no-cost time extensions.

## 2.0 Scope

UURI will continue to provide technical and administrative support to DOE/ID and DOE/HQ for the continuation of the State Cooperative Program for FY-90. Anticipated activities include progress monitoring, review of state-team expenditures, critical review of state-team technical reports and technical assistance in geology, geochemistry, and geophysics to the state teams.

## 3.0 Applicable Documents

Applicable documents are reports submitted on geoscience research and technical assistance conducted under DOE Contract No. DOE-AC07-85ID12489 and DOE/ID Program Research and

Development Announcement (PRDA) for State Geothermal Research and Development-PRDA No. DE-PR07-87ID12662.

## 4.0 Technical Tasks

The following technical tasks will be completed in support of State Cooperative Program activities under the requested FY-90 Incremental Funding.

4.1 Continue monitoring of and technical assistance for 12 SCP grants. At least 8 grants will require no-cost time extensions (NCTEs) and 4 of these may be expected to continue after June 30, 1990.

4.2 Complete a numerical model interpretation of the Newcastle, Utah electrical resistivity survey, in support of the Utah (UGMS) team's case study. Complete a self-potential (SP) survey and possibly two additional resistivity lines to further improve the data base. Submit a paper jointly with the Utah Geological and Mineral Survey for presentation at the 1990 International Symposium on Geothermal Energy.

4.3 Provide support for the OIT Geo-Heat Center inventory of hydrothermal potential (T>120°F) near western cities in 14 western states. Dr. Paul Lineau has scheduled this update and extension of a 1980 report for the period January 1 - March 31, 1990. UURI and the state teams should play a major role in collecting, evaluating, and reviewing the resource data. It may be necessary for UURI to issue small Purchase Orders to State Teams or local consultants to verify that all recent data have been collected and are accurate.

4.4 Provide geologic, geochemical, physical property, laboratory, age dating, and other support for the DOGAMI Santiam Pass drill hole, when final approval is given to the project and when funds are made available to DOGAMI.

4.5 Evaluate possible future initiatives for the State Cooperative Program. Identify high priority states and suggest projects of interest to DOE.

5.0 Reports, Data, and Deliverables

Prepare appropriate reports and deliverables based on the above tasks, including monthly progress reports, and technical reports as appropriate.

6.0 Special Considerations

NONE

7.0 Requested Funding

The funding requested for this project for FY-90 is $44,600.

The requested funding provides support for Howard P. Ross, Project Manager, and other UURI scientists as required for review and advise. The above funding will also provide for travel to the 1990 Geothermal Energy Symposium, to the Oregon Institute of Technology, to DOE/Idaho, and to visit with state teams as may be required.

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

EARTH SCIENCE LABORATORY
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108—1295
TELEPHONE 801-524-3422

June 26, 1989

Dr. George R. Priest
Regional Geologist
Dept. of Geology and Mineral Industries
910 State Office Building
1400 SW 5th Ave.
Portland, OR 97201-5528

Dear George:

I was pleased to hear that drilling at Santiam Pass may begin in August. UURI is pleased to participate with DOGAMI and other members of the scientific team in providing technical support to this project.

We can commit the services of Jeff Hulen, Senior Geologist, to assist with on-site drilling supervision for approximately three weeks in August or September, subject to acceptable scheduling of his time. Jeff was a Co-Principal Investigtor for the drilling of the Continental Scientific Drilling Program corehole VC-2B at Valles caldera and is well qualified for this assignment.

In addition, UURI can contribute up to 20 whole rock chemistry analyses (by high precision ICP), and physical property determinations (density, magnetic susceptibility, electrical resistivity) on drill core. We may be able to provide funding for two to four age dates (at up to $400 each) depending upon other needs for State Cooperative Program support.

UURI scientists would like to participate in the following studies of the drill core:

| | |
|---|---|
| Alteration petrology | (Jeff Hulen) |
| Physical Properties | (Mike Wright, Howard Ross) |
| Fluid inclusions | (Joe Moore) |

We would be pleased to work with you and other members of the technical team in preparing technical reports of the above.

Sincerely,

Phillip M. Wright
Technical Vice President