

STATUS REPORT
EARTH SCIENCE LABORATORY
participation in the
STATE COUPLED PROGRAM
OF THE
DIVISION OF GEOTHERMAL ENERGY
U.S. DEPARTMENT OF ENERGY

by
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INTRODUCTION

P → The DOE/DGE State Coupled program has been active for about one and one-half years; and it is appropriate at this time briefly to assess the progress made by the state teams and by ESL/UURI.

ESL tasks in this program include:

1. Aid in establishing state coupled programs - these programs are now ongoing in 13 western states (Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming). Start up of a 14th (North Dakota) is scheduled for 1979.
2. Provide liason between DOE and state teams - during FY 78, meetings were held with the individual state agencies.
- 3. Appraise DOE of progress reports (see attached list) have been distributed or are included with this report. ^{2 spaces}
4. Provide liason with NOAA - meetings and numerous phone calls have kept ESL in close coordination with state agencies and NOAA.
5. Provide consulting expertise - technical discussions have been held during the course of the meetings mentioned above, and ESL is persuing region-wide exploration & assessment strategies.
- 6. Provide advice to developers - informal discussions were held with several interested groups during FY 78; the User Assistance Program at ESL 79 will expand this task in FY 79.

omit

7. Assemble Background Information and Reference Base - a worldwide map of geoscience and geothermal resource data has been compiled, and is being reviewed for publication.
8. Establish a geothermal sample library - this has been done.
9. Computer retrieval of information - this work in progress.
10. Write and distribute reports - several papers, trip reports, and a management document have been prepared.

Tasks 6-9 will not be discussed further in this report. Tasks 1-4, and in part tasks 5 and 10 will be discussed in the state-by-state summary below; some duties under tasks 5 and 10 are discussed separately.

The Earth Science Laboratory has prepared, for DOE/DGE, a management document that discusses the duties and responsibilities of each participant (state assessment teams, NOAA, USGS, ESL/UURI, DOE/DGE, other federal agencies). This document emphasizes Phase I of the State Coupled Program, resource assessment, and is presently being revised and updated for distribution. A second document will be distributed during FY 79 to discuss strategies for Phase II, site specific studies.

To aid communication among participants, a State Coupled Program Core Group has been established, with members from DOE/DGE, NOAA, USGS, and ESL/UURI. This core group met twice during FY 78; reports from these meetings have been distributed (see attached list). Frequent phone conversations between ESL/UURI and other core group members aided in program management.

Supplemental meetings were held with DGE, NOAA, and the USGS. These meetings clarified data collection and transmission routes, and identified solutions for various problems.

Close cooperation was maintained with the USGS during the data compilation and map depiction phases of the USGS assessment of low temperature geothermal resources. This low temperature resource assessment will be published during January, 1979, as part of USGS Circular 790 "An Assessment of Geothermal Resources of the United States-1978". Meetings were held with most state teams, local and national USGS personnel, and ESL/UURI ^{DMIT} attending, to outline areas generally favorable for the discovery of low temperature resources, and to quantify, as much as possible, the resources in each area.

Although the Circular 790 data base represents the best available knowledge at the time of compilation, it is anticipated that it will be significantly refined during further Phase I activities. This data base has been useful in DOE/DGE regional planning and resource assessment tasks, and in preparing a DOE/DGE response to US Forest Service RARE II studies.

Another area of close cooperation with the USGS has been in the updating of computer file GEOTHERM. As a result of state efforts, GEOTHERM now contains data from nearly 2700 sites in the western United States.

STATE SUMMARY

DOE/DGE reorganization during FY 78 permitted ESL/UURI to concentrate efforts in the Rocky Mountain-Basin and Range Region. Comments on these states will be more complete.


Most of the projects discussed under individual states are in progress; reports on their work will be prepared by the state teams at an appropriate time. Further details on information contained in this status report may be obtained from monthly and quarterly reports of the state agencies.

Individual states are at various stages of progress in assessment efforts. Some, such as Oregon and Nevada, have broad data bases to work with, while others such as North Dakota and Wyoming, will not be funded until FY 79, and South Dakota may not have any assessment effort until FY 80 or FY 81.

ALASKA

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The Alaska resource assessment team has submitted 45 spring and well records to USGS file GEOTHERM. These have been edited, and 70 more records are being prepared. Although no meeting was held between ESL and the state team during Circular 790 activities, close phone contact was maintained. The Alaska team prepared a very useful map from which data was selected and combined with other USGS information for presentation on the Circular 790 map.

Phase I assessment efforts have concentrated on an inventory of existing thermal and chemical data from hot springs, water wells, and oil wells. The emphasis so far has been on two geologic environments that are favorable for resource discovery: the margins of plutons, ~~(the~~ where plutons and surrounding rocks have been highly fractured) and deep sedimentary basins. High temperature systems, generally related to active volcanos, may have associated low temperature resources. The map prepared by the state team as background for Circular 790 is useful as a starting point for the detailed resource maps to be published under Phase I, as it presents data on thermal springs, sedimentary basins, hot test holes, calderas, historically active volcanos, volcanic vents, volcanic fields, and sites where heat flow has been determined. 

While Phase I activities continue, site selection efforts for Phase II are underway. Commercialization interest is high, but much is yet to be learned about the geothermal resource base.

The Earth Science Laboratory has had several discussions with USGS Alaskan Branch personnel about the nature of resources in Alaska. We have been visited twice by _____ of that branch.



Arizona

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The Arizona state team submitted 91 records from thermal springs and wells to the USGS for inclusion in GEOTHERM. With supplemental location information yet to be submitted for some sites, these records will be complete. The Arizona team, in coordination with ESL/UURI and the USGS, was able to identify 20 areas suitable for depiction on the Circular 790 map and inclusion in the Circular 790 tables.

Resource data compilation is continuing as part of Phase I activities. A preliminary map of "Geothermal Energy Resources of Arizona" was distributed by the Bureau of Geology and Mineral Technology in March. Updating of this map is continuing as new information becomes available. Publication of new maps for public and scientific uses, on a revised USGS base map, is slated for late 1979 or early 1980. Phase I data compiled under the program so far includes:

- thermal gradients from water wells in southern Arizona
- geochemical thermometry on most springs and many wells
- microearthquake data from selected areas
- available heat flow data
- lineaments (these have been found to have a better large-scale correlation with geophysical anomalies than with reported geologic data)

- gravity
- thermal gradients in wells at ^{Springerville} Springerville and on the Papago reservation.

Phase I assessment work has pointed out an apparent correlation between thermal areas in this part of the Basin and Range physiographic province and deep (>400 m) sedimentary basins. This correlation is being studied in more detail, and may form part of exploration strategy thinking, especially for low- and moderate-temperature resources.

Twenty-two sites have been identified where Phase II assessment work might be appropriate. Work is planned on reservoir definition tasks for the Castle Hot Springs sites on the Papago reservation. Other important sites are Springerville-St. John, Clifton, and San Bernardino. Also the Arizona team will be assisting ^{with} on geothermal exploration at Williams AFB.

Close coordination exists between the State Coupled Program and the US Bureau of Reclamation funded geothermal program in Arizona (which is looking for higher temperature resources for desalinization purposes) since both projects are being done by the Arizona team.


The Earth Science Laboratory has held several meetings with the Arizona team, and is coordinating closely with their efforts. Primary technical assistance and coordination is being furnished to the Arizona team by Los Alamos Scientific Laboratory.

CALIFORNIA

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The California Division of Mines and Geology staff submitted 633 partial records to GEOTHERM during the summer. Records from southern California have since been updated; some further work is needed on those from the northern part of the state. At a July meeting, 14 areas were designated as having low temperature resource potential. Two of these areas are at the Geysers and the Imperial Valley, where lower temperature resources may be anticipated along the margins of the high temperature systems. Other designated areas are being explored through DOE funding for industrial process and space heating applications.

Phase I assessment work includes the inspection of well drilling records in California Division of Oil and Gas files for temperature data, as well as updating an inventory of thermal springs and wells. A preliminary map is planned for publication at the end of the first year of work, which will be in mid-1979.

Phase II work is ongoing in the ^{Bridgeport-Bodie} Bridge Pot-Bodie area, where interest is high for utilization of geothermal resources. 

ESL has coordinated closely with CDMG from initiation of their project through Circular 790 compilation efforts, and has provided CDMG with detailed information about programmatic relationships.

COLORADO

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Data from 56 thermal areas with more than 120 individual springs and wells form the records submitted by the Colorado Geological Survey to USGS file GEOTHERM. Eight areas in Colorado have been selected for depiction on the Circular 790 map. These include the large, relatively unassessed area along the Rio Grand Rift.

The Phase I data base is almost complete for thermal springs, and includes a few wells. The lack of temperature information on water well completion records means that a potentially large source of data is not available. Some field measurements of well temperatures are being done. Compilation of available heat flow data will help define anomalous areas, and indicate areas where further study is required. Publication of Phase I maps is scheduled for 1979; the digitized Colorado base map is to be produced by the USGS during 1979.

Phase II activities have been concentrated in the Pagosa Springs area, where geological and geophysical investigations preceded the drilling of one producing hole. Forty-six degree C water, at 1400 gpm, can be produced from this 1300' deep well. Although original plans to heat a new high school are now uncertain, due to the failure of a bond issue, community interest in the project remains high, and use of the geothermal water will be made by the town and country governments. The San Luis Valley, along the Rio Grande Rift, is another area where interest for space heating and industrial processing is high.

In Colorado, close ties exist between resource assessment work and the DOE-funded operations research work. Both projects are being handled by the Colorado Geological Survey; This gives a high degree of coordination and perhaps a greater reliability to resource application estimates.

The Earth Science Laboratory has aided the Colorado team in interpretation of geophysical data from the Pagosa Springs area. A significant aspect of ESL's work is that the search of Petroleum Information Corporation files by ESL indicates potential for geothermal resources in the Denver basin. This needs *further investigation*

HAWAII

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Researchers at the Hawaii Institute of Geophysics have submitted 305 records from identified or suspected thermal sites to USGS file GEOTHERM. Although some of the water temperatures are near mean annual air temperature, geochemical analyses of the waters can be interpreted to suggest a large amount of mixing of thermal and non-thermal waters. Several areas will be depicted on the Circular 790 map.


The Phase I data base is being expanded from the preliminary work for the Hawaii Geothermal Project. General *geology*, including identification of rift zones, young volcanic areas, and calderas, *in addition to* as well as well temperature, chemistry, and productivity data *have* ~~has~~ been compiled. Phase I assessment is complicated in Hawaii by locally high rainfall (to >400"/year), which can obscure geothermal waters. It is anticipated, therefore, that geothermal

where's the rest ? ?

IDAHO

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The data set from Idaho is, at this writing, the least complete set in USGS file GEOTHERM. Updating, with at least 300 new points, will begin soon. The ultimate reliability of these data will be excellent, as the sites have been field checked and new chemical analyses have been made. Thirteen areas have been selected for depiction on the map that will accompany USGS Circular 790. One of these areas, the western Snake River Plain, has been divided into six sub-areas that are especially attractive for geothermal development.

The Phase I data base is nearly complete. A list of thermal wells and springs has been compiled, a map of spring deposits has been generated,  lineament studies are in progress, and chemical analyses and data reduction are being finished. All of these data will be transmitted to NOAA. The Idaho resource maps will be the first ^{final maps} published in the State Coupled Program ~~that are not preliminary~~. NOAA will have the updated USGS base map and selected geology prepared for display on the map.

Phase II studies are ongoing in the Nampa-Caldwell and Bruneau-Grandview areas on the Snake River Plain, and in the Pocatello area which is at the margin of the Plain. Potential users have been identified in each of these areas.

The Earth Science Laboratory has had several meetings with the Idaho assessment team concerning discussion of Circular 790, map publication, proposal writing and other tasks.

MONTANA

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Sixty-eight records from thermal springs and wells have been submitted by the Montana Bureau of Mines and Geology to USGS file GEOTHERM. Fourteen areas of moderately restricted areal extent were selected for inclusion on the Circular 790 map.

The Phase I data base now contains a fairly complete listing of thermal springs in Montana; more compilation of thermal wells is needed to better identify abnormally warm areas. A study of mine waters has indicated a few potential resource areas. Montana, unlike most other states in the Rocky Mountains, contains no sites where temperature measurements or geochemical thermometers indicate high temperature resources (>150°C).

Identified geothermal sites in western Montana are fracture controlled, while stratigraphic controls influence the distribution of warm water in the Paleozoic and Mesozoic aquifers (Madison Group) of eastern Montana.


Phase II studies are being concentrated in the Ennis area, where interest for greenhouse and space heating exists and where the USGS has a complimentary program in the West Yellowstone area, where space heating utilization might be made, and in the Deer Lodge Valley, where prison and hospital heating is being considered. Geothermal energy is being used for heating a bank in White Sulphur Springs.

ESL/UURI has aided the Montana team in their proposal writing, coordination with the USGS, and will assist in the evaluation of Phase II areas.

NEVADA

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The first submission to USGS file GEOTHERM by personnel from the Nevada Bureau of Mines and Geology included 439 wells and springs with temperatures above 35°C. An update containing information from wells and springs that have temperatures between 20° and 35°C is being prepared. Twenty-eight areas with proven or potential geothermal resources will be depicted on the map which will accompany Circular 790.

Phase I assessment work has included field checking of many sites that were located incorrectly, lacked adequate chemical analyses, or had not been previously reported. Data that will be required for depiction on the state map of geothermal resources are being collected and analyzed. Publication of the map is scheduled for mid-1979. 

Interest in direct heat applications is high in Nevada. The Nevada Bureau of Mines and Geology is in close contact with several users and has helped assess resources in some areas of high interest. Phase II activities will select sites for further investigation.

ESL/UURI has held several meetings with the Nevada team on proposal writing and other general topics, and will coordinate closely with the team during map publication efforts.

NEW MEXICO

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The New Mexico assessment team, working through the New Mexico Energy Institute, submitted 349 records to USGS file GEOTHERM. These records are incomplete, and need extensive revision to include thermal spring data, more precise locations, and chemical analyses. Thirteen areas were identified in New Mexico as suitable for depiction on the Circular 790 map.

Phase I assessment of New Mexico is showing an apparent correlation between areas with deep sedimentary basins or young volcanic activity, and the presence of low- and moderate-temperature geothermal resources. Most of the data required for map depiction of these resources has been gathered; it is now being reviewed and refined.

Phase II areas near Albuquerque and Las Cruces are planned for investigation. Earth Science Laboratory involvement with the New Mexico team during FY 78 was confined to coordination of USGS Circular 790 map areas. Other tasks were handled by the Los Alamos Scientific Laboratory.

NORTH DAKOTA

No DOE/DGE State Coupled Program for geothermal resource assessment was active during FY 78. A meeting was held, however, with personnel from the North Dakota Geological Survey, DOE/DGE, and ESL/UURI to identify FY 79 program elements. Resources in North Dakota will not be depicted on the Circular 790 map, and no data have been supplied to file GEOTHERM.

North Dakota has no known thermal springs. All of the geothermal resources in the state are expected to be found in the Madison group of aquifers or similar stratigraphic-type reservoirs. Phase I assessment of these resources will be accomplished through a computer inventory and search of temperature records in the nearly 6,000 oil wells in the state. Temperature records in water well drilling reports will also be checked. The water and oil well records will probably be used to plot maps depicting the geothermal resources. Future tasks would also include submission of appropriate data to GEOTHERM.

OREGON

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Slightly over 50 records were submitted to USGS file GEOTHERM by the Oregon Assessment team. These records are complete, but more records may be anticipated as the program continues. Nine areas, including Klamath Falls, where much use of geothermal energy for direct heat is already being made, were selected to be included on the Circular 790 map.

Phase I activities have included extensive preparations for the publication of maps. Most data sets are compiled, and map production steps are beginning. Resources in Oregon are basically of three types: Snake River Plain and Columbia Plateau^a basalt aquifers, Cascade Mountain environments, and Basin and Range-type fracture systems. Some resources are known from each of these environments, but the potential for undiscovered resources is great.

Phase II activities have concentrated so far at Mt. Hood, where a project

to find hot water to heat Timberline Lodge, and a project to locate hot water to pipe to Portland are ongoing.

Several meetings have been held with the Oregon team to explain program elements and coordinate their efforts with work in adjacent Rocky Mountain-Basin and Range States.

SOUTH DAKOTA

No State Coupled Program was active in South Dakota during FY 78.

Previous state publications have covered the thermal springs near the Black Hills and other ^{sites with} geothermal potentials.

Resources in South Dakota will not be depicted on the Circular 790 map, and no data have been delivered through the DOE program to USGS file GEOTHERM.

DOE and ESL approaches to the South Dakota Geological Survey have identified the survey's willingness to participate in research and Phase II deep drilling activities, but other organizations will probably need to be approached for Phase I work.

UTAH

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Personnel at the Utah Geological and Mineral Survey have submitted 263 records to USGS file GEOTHERM. More than 200 additional records will be submitted soon, and data already in the file will be edited. The Circular 790 map will depict eight areas in Utah. One of these, the Wasatch Front, contains more than 140 known thermal wells and about 40 thermal springs, and

also has more than 30% of the population in Utah.

Phase I assessment work has included compiling all available published records of thermal water in Utah. About 1500 sites are included in this list; nearly 500 of these sites have recorded temperatures above 200C; the rest have temperatures above 600F (15.60C). The map of Utah geothermal resources will be the second state map published with the help of NOAA. Anticipated publication is set for June, 1979. P?

Phase II assessment work has so far concentrated on shallow gradient hole drilling in selected areas along and near the Wasatch Front. Some of these areas are located near interested potential users.

ESL/UURI has coordinated closely with the Utah team in many facets of their work, including proposal writing, environmental report preparation, compilation of data sets for geothermal maps, and geophysical technique evaluation.

WASHINGTON

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Researchers from Battelle Pacific Northwest Labs sent approximately 200 well records with thermal data to GEOTHERMA in FY 78. Extensive updating of these data is required, as location, chemical data, and records from springs are missing. The need for further assessment of geothermal resources in Washington is illustrated by only four areas having been selected for inclusion in Circular 790.

The State Coupled resource assessment effort in Washington is now being handled by the geology and Earth Resources Division, DEPARTMENT OF NATURAL RESOURCES.

Phase I activities are now focusing on identifying geologic parameters of geothermal resources in Washington, to be able to select the most favorable areas for Phase II studies. At the present time, the Cascade Mountains look most attractive.

During FY 78, ESL/UURI had no formal role in the Washington assessment effort.

WYOMING

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Although no formal DOE/DGE program was operating in Wyoming during FY 78, some assessment work was accomplished by an ESL/UURI employee who will join the Wyoming team in FY 79. Seventy-seven records from springs and wells were submitted to GEOTHERM, and 3 areas were identified for inclusion on the Circular 790 map.

Phase I activities will concentrate on identifying available well and spring records, collecting and compiling thermal gradient data, and coordinating with operations research personnel on areas with user interest. A Phase 0 report summarizing available data is being prepared.

The Earth Science Laboratory has directly supported the Wyoming effort; without this support, no records would have been available for GEOTHERM, and the identification of areas for the Circular 790 map would have been much more difficult. ESL also coordinated very closely with the FY 79 contractor on proposal writing efforts.

MANAGEMENT SUMMARY

The need for close coordination to maintain uniform quality in state assessment efforts become especially evident during Circular 790 tasks. The states that had the most technical and administrative problems were those that did not have a direct visit by ESL or an ESL-USGS team. Several delays in the map production process occurred as a result of less than ideal coordination. ESL/UURI will maximize efforts during FY 79 to maintain close communication with all appropriate state teams. One step in this process will be a meeting of all state contractors, probably during February, 1979.

Several resource and administrative items that need to be communicated to state teams became evident during FY 78 efforts. These include:

- 1) The very sensitive nature of many of the low-temperature geothermal systems. Drilling can disturb natural equilibrium, and result in drained springs, dry wells, and potential law suits.
- 2) Drilling contractors may not be aware of all the potential problems they might encounter. Artesian flow of hot water, waste disposal problems, and environmental sensitivity are a few of these. State agencies need to assure that drilling rigs have the required capability. In several cases, drillers have tried to drill wells that have been beyond rig limits.
- 3) Environmental reports need to be prepared to meet DOE requirements for drilling; a list of reporting requirements and routes should be developed.

- 4) Closer coordination of governmental projects, such as resource assessment, operations research, and other contractors, needs to be emphasized.
- 5) Emphasis needs to be placed, as soon as financially possible, on assessment of temperatures in water wells. These data have often not been recorded.
- 6) Map production will need to be closely monitored, to insure maximum possible uniformity of data depiction and to eliminate as many "state-line faults" as possible.

WESTERN STATES RESOURCES

At present, it is too early to speculate with much confidence about the ultimate resource base for low-temperature direct-heat applications of geothermal energy. Each geologic province has distinct characteristics for the distribution of known resources. Estimates of the ultimate resource base may be extrapolated from 3 fairly well documented states: Nevada, which has about 1000 sites with $T > 200^{\circ}\text{C}$; Idaho, also with about 1000 thermal sites; and Utah, which has about 1500 sites with $T > 15.6^{\circ}\text{C}$. If these numbers are representative of resources in other states, it is likely that more than 10,000 thermal sites will be identified in the western United States.