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DIRECT UTILIZATION OF GEOTHERMAL ENERGY: DOE'S RESOURCE ASSESSMENT PROGRAM

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ABSTRACT

The Department of Energy in cooperation with state agencies, the U.S. Geological Survey and NOAA has initiated a program for low temperature (35°C<T<100°C) geothermal reservoir identification. Geothermal resources suitable for direct heat applications are not restricted to the geologically youthful and active environments of the western United States. They occur in a variety of geologic environments, deriving their heat from radiogenic sources or simply deep circulation within regions of near-normal heat flow. The Western States' Program has as its objective the preparation of individual state geothermal resource maps which will emphasize the known distribution of low and moderate temperature resources most suitable for direct heat applications. Preliminary maps for most of the western states will be available by October, 1978. A pilot project designed to produce a finished 1:500,000 scale map for the state of Idaho will be completed by October, 1978. Data obtained through the program is being added to the U.S. Geological Survey's GEOTHERM data file. The Eastern States' Cooperative Program has as its objectives the development and application of targeting procedures designed to identify radiogenic heat sources beneath the sediments of the Atlantic Coastal Plain. Sixty 1000 feet deep gradient holes will be drilled during the period April through August, 1978 as part of the targeting program, and the first deep exploratory well will be drilled in September. VPI, various state agencies and the U.S. Geological Survey scientists are participating in the program.

INTRODUCTION

The value of hot water for space heating has long been recognized in western cities such as Boise, Idaho and Klamath Falls, Oregon. Warm or tepid water from shallow aquifers has more often been seen as an inconvenience by those seeking cold ground water for domestic use. Increasing energy costs combined with developing technologies for the cost effective utilization of warm ground water have produced a nationwide "grass roots" interest in the occurence of low temperature geothermal resources. The Department of Energy's (DOE) program for low temperature reservoir assessment is designed to stimulate the development of these resources for direct heat uses by assuring public awareness of their presence. The program is being implemented through a cooperative effort involving the individual state agencies responsible for geothermal resource development, the U.S. Geological Survey, the National Geophysical and Solar-Terrestial Data Center of NOAA, and the DOE's Division of Geothermal Energy (DGE).

GEOTHERMAL RESOURCE TYPES

U.S. Geological Survey Circular 726 (1975) emphasized the potential of intermediate temperature geothermal resources with reservoir temperatures (T_r) of $90°C<T_r<150°C$) and high temperature ($T_r>150°C$). These moderate and high temperature hydrothermal resources of the western U.S. may be differentiated on a generic basis as those associated with "igneous point heat sources" (or magma in the crust) and those associated with deep convective ground water circulation in areas of regionally high heat flow but without a specific magnetic heat source.

The very high temperature geothermal resources sought for electric power generation ($T_r>200°C$) are most often associated with magnetic heat sources, and areas with a possible magnetic heat source have attracted much of the exploration interest. Moderate temperature resources are the "common" type of geothermal occurence in the western U.S.. The thermal gradient is sufficiently high over much of the region to drive convective ground water circulation systems wherever fractures or other aspects of the geologic structure provide a deep "plumbing system". These moderate temperature systems are often encountered during the course of exploration for high temperature systems. Moderate temperature fluids will also be present in the less optimally situated portion of high temperature systems.

In the Gulf Coast, a third type of geothermal resource is present, "Geopressured Resources" which are regional occurences of hot water in deep overpressured, confined aquifers. The deep hot oil field fluids are of interest for their methane as well as their thermal energy. Geopressured resources will not be discussed here as the program

for their assessment is being conducted independently of the program for assessment in support of direct heat applications.

Two additional distinctive types of geothermal resources have recently been recognized, "radiogenic" resources and fracture-related thermal waters in regions of near normal gradient. These occurences have a much broader geographic distribution than the moderate and high temperature geothermal systems common to the western U.S..

Thermal gradient anomolies in the Atlantic Coastal Plain may be associated with heat production from U and Th-rich rocks buried beneath insulating layers of water-bearing sedimentary decay of radioelements. Granites rich in U, Th and K provide the most promising target for heat sources of this type. "Radiogenic" geothermal heat produced by shallow granitic rocks is found in the west as well as the eastern U.S., but in the western states its importance is secondary as compared with the volcanic heat and regions of high heat flow.

In addition to "radiogenic" resources, the eastern U.S. also contains hot water simply related to very deep convective circulation in regions of normal or near normal heat flow. The low temperature resources (T_R<90°C) which result from this deep circulation are of considerable economic interest in regions with a high demand for low grade heat. An example of this type of occurence is the hot water associated with the Balcones Fault Zone in Texas. Residents of cities such as Dallas, Texas have long considered this deep, hot well water to be an annoyance except where it was locally developed for health spas. Today, natural hot water, whatever its origin, constitutes an important potential energy source.

LOW TEMPERATURE RESOURCE ASSESSMENT

Energy companies are actively pursuing the exploration for and development of the high temperature geothermal resources most suitable for electrical generation. Moderate temperature resources are often accidentally encountered during the course of exploration for high temperature resources. The first inventory of geothermal resources published in 1975 as U.S. Geological Survey Circular 726 included data on moderate and high temperature resources but excluded low temperature (<90°C) data. The DGE program discussed here as its objective the stimulation of interest in the exploration for and development of the low temperature geothermal resources by the private sector. An important aspect of the program is the expansion of the geothermal data base to include data for waters in the 35°C - 90°C range. A second major component is the presentation in a form usable by the general public.

Western States COOP Program

In the western states, the DGE program is being implemented through cooperative efforts with the agencies in each state which have the responsibility for geothermal resource assessment and development. A large volume of data is available for low temperature resources as opposed to the few tens of hundreds of data points in each state relevant to high temperature geothermal occurences. The individual states are inputing their data to the USGS geothermal data file, "GEOTHERM", which presently contains data on resources above 90°C. It is being expanded through USGS participation in the program to include data on the low temperature resources.

The National Oceanographic and Atmospheric Administration (NOAA) is also participating in the program through the preparation of individual geothermal energy resource maps for each of the western states. The maps will present in a highly usable form the data on low temperature resource characteristics and distributions. NOAA, the individual states and USGS geoscientists are working together to prepare the data to be shown at a 1:500,000 scale on these maps.

It is anticipated that these maps and accompanying reports will bring the widespread distribution of low temperature fluids to the attention of many potential users of the resource. Preliminary input of data in support of the expansion of the GEOTHERM data base will be completed in August of 1978. The publication of state maps will begin in late 1978 with the publication of an Idaho map and continue at a rate of approximately five maps a year. In this effort the states are receiving technical assistance from several DOE laboratories and contractors including the Los Alamos Scientific Laboratory, Pacific Northwest Laboratory, Idaho National Engineering Laboratory and the University of Utah's Earth Sciences Laboratory.

Eastern COOP Program

In the eastern coop program procedures developed by Virginia Polytechnic Institute and State University (VPI) scientists are being applied in a systematic search for hot water related to radiogenic heat sources. VPI's work has identified the critical parameters as: 1) concentration of radiogenic elements in granitic rocks beneath a sedimentary insulator; 2) the thermal conductivity of the insulator; 3) thickness of the sedimentary insulator; and 4) reservoir conditions in the permeable sedimentary rocks overlying the radiogenic heat source. VPI work to date has confirmed that some of the granites in the Piedmont adjacent to the coastal Plain do have the necessary concentrations of U and Th. Preliminary investigation of gravity data in the Atlantic Coastal Plain do indicate lows which are best interpreted as granites beneath the sediments.

A gradient drilling program which will drill up to 60 one thousand foot deep holes for heat flow measurements will be implemented in April, 1978, with drilling due to be completed in August, 1978. These holes will be located at sites from New Jersey to Jacksonville, Florida selected on the basis of preliminary data. The results of this drilling program, together with all other geologic data, will be evaluated and a site selected for

the first deep geothermal test well. The drilling of this well will begin in late FY 78.

Preliminary evidence indicates the existence of regions with thermal gradients greater than 37 C per kilometer (Figure 1) along with the Atlantic Coastal Plain. These known areas have a potential for development of the identified warm waters by use of existing heat pump technology. The more localized areas being sought through the VPI program would have a sufficiently high thermal gradient (>45°C/km) to encourage their development for a variety of direct heat applications.

Other areas within the eastern U.S. have low temperature geothermal occurences associated with deep convective circulation in regions of normal or near normal heat flow. The previously mentioned occurence of hot water at sites along the Balcones Fault Zone are of this type. The special significance of this type of resource occurence is that it greatly extends the geologic environments where usable geothermal resources may occur. Large volumes of hot water at Hot Springs, Arkansas as well as numerous low temperature warm springs along the Appalachian Mountains are also of this category.

SUMMARY

Low temperature geothermal resources suitable for direct heat applications are widely distributed in both the eastern and western U.S.. A cooperative geothermal program involving state agencies, the USGS and DOE contractors has been initiated to quanitify in general terms the distribution of these resources in order to stimulate their exploitation. In the western states the program is emphasizing the preparation of geothermal resource distribution maps and the expansion of the USGS GEOTHERM geothermal data base to include information on the low temperature resources. In the eastern U.S. the program is addressing the distribution of low temperature resources associated with radiogenic heat sources and warm waters derived from major fault zones. The eastern program to date has concentrated on the targeting of hot water within the Atlantic Coastal Plain and a major drilling initiative is scheduled for mid FY78.

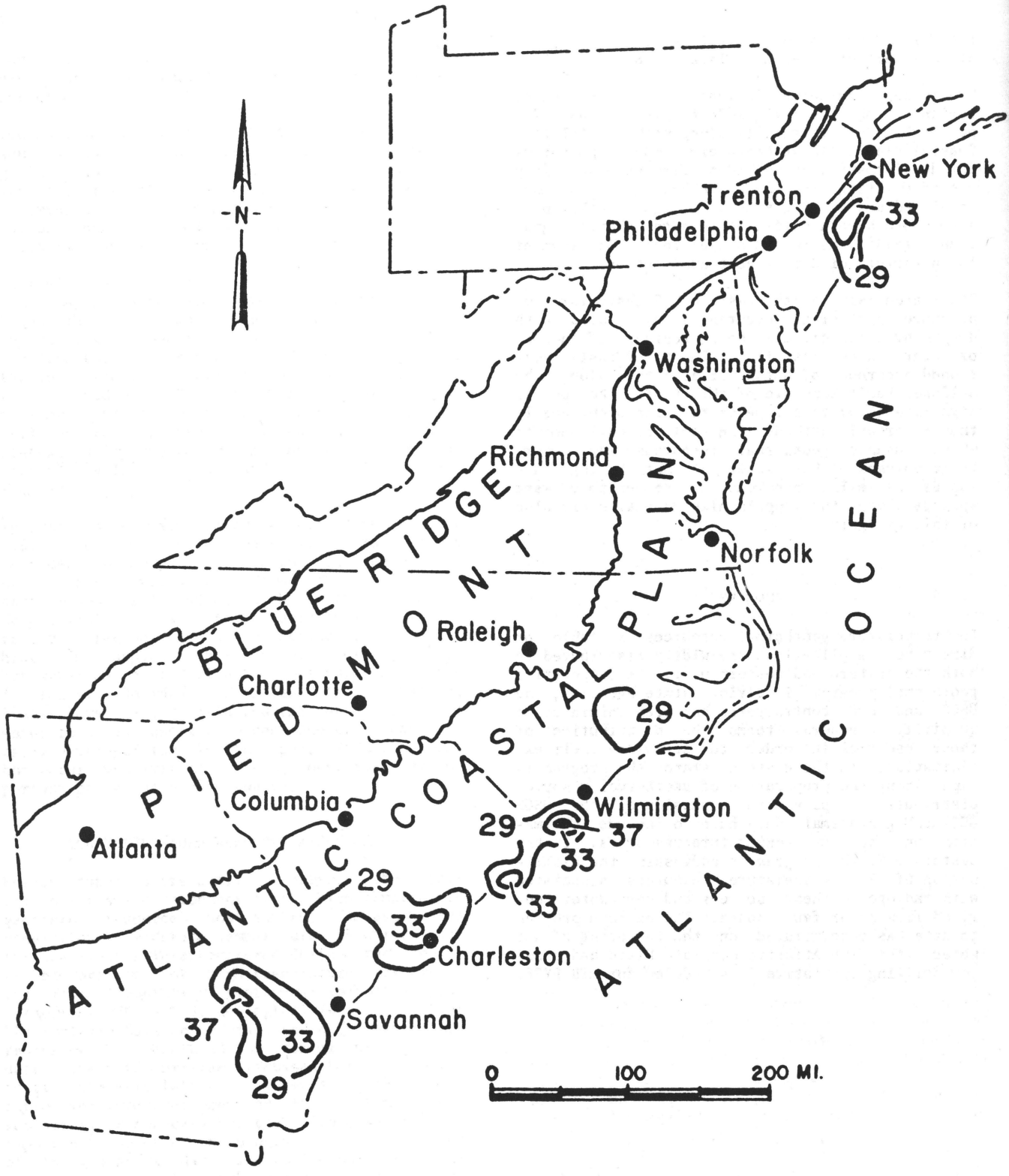

Figure 1. Areas of relatively high geothermal gradient in Coastal Plain sediments in eastern United States. Contoured °C/km. Contour interval = 4°C/km.

After Costain, et al, Evaluation and Targeting of Geothermal Resources in the Southeastern Progress Report, VPI & SU Contract EY-76-05-5103, Nov. 1, 76-March 31, 77