POTENTIAL FOR GEOTHERMAL ENERGY IN SOUTH DAKOTA

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ABSTRACT

In South Dakota, the earth's temperature increases at the rate of 2 F for each 80 to 120 feet of depth. Circulating artesian waters in deep strata are subsequently heated; temperatures as great as 180 F have been reported in 10,000-foot oil tests in the northwestern part of the state. Energy in the form of heat can be extracted from these waters.

Flowing wells within the state have temperatures as high as 160 F; even temperatures of 90 F may justify development as heat sources. Most of the heat now being brought to the surface is wasted, although applications to space heating are being used or considered in Haakon, Tripp, Hughes, and Fall River Counties.

A current research project, pursued jointly by the School of Mines and Technology and the Rushmore Electric Power Cooperative, is attempting to evaluate the energy potential of waters from the Madison Formation, and to design small geothermal heating units and systems suitable for small towns or industrial facilities. The project is sponsored by the Energy Research and Development Administration (ERDA).

Constructive uses must be found for waters from which the heat has been extracted.

INTRODUCTION

It is a long established fact that in the outer crust of the earth the temperature increases gradually with depth. An average geothermal gradient for continental North America is about 2 F per hundred feet of depth. In South Dakota, Schoon and McGregor (1974) have shown that apparent gradients range from 1.2 to 6.1 degrees Fahrenheit per hundred feet, with an average close to three degrees.

This gradient normally places usable geothermal heat too deep for practical development. At present, geothermal utilization has been restricted to geothermal anomalies, where for some particular geological reason, the heat is available within practical depths of the surface. These are popularly known as geothermal areas. Several types may be delineated:

1. Geysers and hot springs, where the flow of heat to the earth's surface may be as much as 10 thousand times the normal for the earth's crust. Yellowstone Park is our best known example, though similar areas of recent volcanic activity are developed in California, New Zealand, Iceland, and Italy. To date, only this type of geothermal area has been developed for electric power generation.

2. Hot spots, or areas of hot rocks concealed beneath a cap of impervious rocks with relatively low heat conductivity. From the development point of view, these areas of buried hot rocks may be divided into two categories:
   a. Areas where the rocks below the impervious layer are highly fractured, so that circulating ground water may move freely through them, allowing heated waters to rise by convection to within practical distances of the surface where they may be tapped by wells. Such areas are now being prospected and evaluated in the Salton Sea area of California, and in New Mexico.
   b. Areas where hot rocks exist beneath a cover of low conductivity rocks, but where they are only slightly fractured so that upward transfer of heat by convection is negligible. If these rocks could be fractured artificially on a large scale, water could be circulated through them by way of recharge and discharge wells, and the temperature of the introduced water could be raised by contact with large surface areas in the fractured rocks. Two methods are proposed: shattering by deep seated blasts, atomic or otherwise, and by hydraulic fracturing similar to that used by the oil industry to stimulate flow of oil and gas from dense rocks. An experimental well of the latter type is now being tested in northern New Mexico by the Los Alamos Scientific Laboratory of the University of California.

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None of the above types of geothermal anomaly is known to exist in South Dakota. There is a lesser but potentially important source of geothermal heat in the artesian waters which circulate through deeply buried permeable strata, and have acquired heat due solely to the normal or near normal geothermal gradient. The potential exists, then, to withdraw this water, extract usable heat, and either utilize this water at the surface or return it to the formation for ultimate reheating.

In a few areas in South Dakota, the artesian waters are abnormally warm, possibly due to upward movement of deeper, warmer waters through natural filtration or through conduits in the buried strata. The geothermal area around Hot Springs has long been known. Adolphson and LeRoux (1968) recorded an area of abnormally warm Dakota water in south central South Dakota, and additional scattered areas of above-average artesian water temperatures have been defined by Schoon and McGregor (1974). Riede (1976) has reviewed the potential for geothermal energy in South Dakota, and has concluded that the warm waters in South Dakota have the greatest potential in the field of space heating. Warm waters from the Mississippian Madison Formation, and from the Cretaceous artesian sandstones, are already being utilized on a small scale at numerous points within the state.

PROBLEMS ASSOCIATED WITH UTILIZATION OF WARM WATERS

Deep waters which are sufficiently hot to be sources of heat are generally highly mineralized. In western South Dakota, the total dissolved solids are generally over 2000 ppm, and in some test wells, concentrations in excess of 6000 ppm have been reported. Some of these waters fall into the hot brine category. Corrosion of well casings limits the life of wells. Casings may have a life of 10 to 20 years, though this can be extended by proper well construction. Corrosion in distribution pipes, in heat exchangers, and in other elements of a heating system at the surface is equally severe, but these items are more accessible for maintenance or replacement. Copper tubing in a heat exchanger at Midland has shown a life of about 11 years. So long as pressures and temperature are maintained, scaling appears to be a minor problem. However, heavy deposits of calcium carbonate and calcium sulfate occur in overflow lines and elsewhere when pressures and temperatures are rapidly reduced.

EXAMPLES OF SPACE HEATING TECHNIQUES

Numerous examples of small scale space heating may already be found in South Dakota; some, such as the Stroppel Hotel in Midland have utilized geothermal heat for as long as 40 years. One specific example of each type of installation known to the author is cited below:

1. Standard heat exchangers, with circulation of non-corrosive water through a regular hot-water heating system. The town of Midland heats two school buildings in this manner, utilizing only a small part of the heat available from their municipal water wells.
2. Circulation of hot mineral water through radiators, then circulating air through the radiator to provide warm air heating to limited areas. Philip utilizes two simple radiators of this type to heat their water treatment plant. Again, only a very small part of the available geothermal heat is utilized.

A modification of the radiator system consists of passing the mineral water through exposed pipes or radiators, but relying solely on radiation rather than air circulation for most of the heating benefits. A limited installation of this type is used for supplemental heating at Little Scotchman Industries at Philip, Haakon County.

3. Hot water lines imbedded a concrete floor slab, to heat the overlying space by radiation. Numerous installations of this type are in operation; perhaps the most notable is that at Little Scotchman Industries, where a fairly large factory building is heated in this manner. Spent water is diverted to the local swimming pool as needed, and the remainder is piped out of town for ranch use.

A modification of this system involves placing the piping in a well drained sand and gravel bed beneath the slab. An interesting installation of this type was recently made in a hog house at the McCollom Ranch in northwestern Tripp County. Two unique features are the abnormally high temperature of the Dakota water, reported to be 146 F, and the fact that the well must be pumped when heat is required, so that only the water necessary for heating and ranch use is extracted from the ground.

CURRENT STUDIES

Under a research grant from the Energy Research and Development Administration (ERDA) the School of Mines in conjunction with Rushmore Electric Power Cooperative, Inc. and the R. W. Beck and Associates engineering firm of Denver, is examining the geothermal potential of the water from the Madison Formation. Preliminary studies indicate that it is feasible, both from the engineering and economic standpoint, to supply geothermal heat to all buildings in a small western South Dakota town, using the excess heat from one or more wells. As it is desirable to find uses for any excess water produced to support the heating operation, consideration is being given to various agribusiness applications, to supplying nearby rural water distribution systems, to small scale irrigation, and to return of the spent water to the same or to other aquifers.

LITERATURE CITED

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