Geothermal Resources Council, TRANSACTIONS Vol. 4, September 1980

SUMMARY OF RESULTS OF A GEOLOGICAL AND GEOPHYSICAL INVESTIGATION OF THE GEOTHERMAL ENERGY POTENTIAL OF THE PILGRIM SPRINGS KGRA, ALASKA

Donald L. Turner, Robert B. Forbes, Eugene M. Wescott, Juergen Kienle, Thomas Osterkamp, Samuel Swanson, Daniel Hawkins, William Harrison and Joan Gosink, Geophysical Institute
University of Alaska, Fairbanks, Alaska 99701

Jeffrey Kline, Roman Motyka, Richard Reger and Mary Moorman
Alaska Division of Geological and Geophysical Surveys
Box 80003, College, Alaska 99708

ABSTRACT

Reconnaissance-level geologic and geophysical studies indicate that the Pilgrim Springs, Alaska, area is underlain by an intermediate-temperature, liquid-dominated geothermal system of substantial magnitude. Initial exploratory drilling has confirmed the presence of the shallow, ≈ 1-1.5 km^2 hot water reservoir delineated by our geophysical surveys. Large artesian flow rates of 200 and 300-400 gallons/minute of 90°C water indicate that at least one good aquifer is present at shallow depths within this reservoir. Resistivity surveys suggest that the reservoir is approximately 50 m thick. Deeper hot water reservoirs may also be contained in the thick sedimentary section identified by seismic and gravity surveys, but they have not as yet been located by our initial resistivity surveys. The power presently being dissipated from the upper 50 m of the system is a minimum of 350 megawatts.

The Pilgrim Springs geothermal area, located about 75 km north of Nome, Alaska, (Figure 1) was the subject of an intensive, reconnaissance-level geophysical and geological study during a 90-day period in the summer of 1979. The thermal springs are located in a northeast-oriented, oval area of thawed ground approximately 1.5 km^2 in size, bordered on the north by the Pilgrim River. A second, much smaller, thermal anomaly was discovered about 3 km northeast of the main thawed area. Continuous permafrost in the surrounding region is on the order of 100 m thick.

The springs are located in the Pilgrim River Valley, a fault-bounded tectonic depression flanked on the north and south by mountains composed of highly-deformed, upper amphibolite facies metamorphic rocks of probable Precambrian age, cut by discordant granitic plutons of Cretaceous age. The ^{40}K-^{40}Ar mineral ages of eleven sampled metamorphic rocks have been reset to about 84 m.y., presumably due to a thermal pulse associated with the Cretaceous plutonic event. Seismic, gravity and resistivity surveys indicate that the crystalline basement of the valley floor is at least 200 m beneath Pilgrim Springs. The gravity data also suggest that Pilgrim Springs is near the intersection of two inferred fault zones forming the corner of a deep, downdropped basement block.

The seismicity of the area indicates currently active normal faulting. Mapped north-south trending faults in the Kigluaik Mountains south of Pilgrim Springs may extend through the downdropped crystalline basement under the Pilgrim River Valley. One or more of these faults could possibly provide a deep conduit for the geothermal system. Surficial geologic mapping indicates considerable subsidence of the Pilgrim River Valley during Quaternary time. A north-south trending Quaternary fault extends across the valley and appears to coincide with the western boundary of the main thawed area. Resistivity studies confirm the presence of this fault but do not suggest that it is presently serving as a hot water conduit in the vicinity of our resistivity profile.

Geologic evidence suggests that the low-lying region extending from the Imuruk Basin through the Kuzitrin Valley to the Imuruk lava fields may represent an incipient rift through the Seward Peninsula. We therefore propose that the manifestations of anomalous heat flow (young basaltic volcanism and alkali-chloride hot springs) in this region may be associated with tensional tectonics and active rifting.

Present surface thermal spring discharge is ≈ 67 gallons/minute of alkali-chloride-type water at a temperature of 81°C. The reason for its high salinity is not yet understood because of conflicting evidence for seawater vs. other possible water sources. Preliminary Na-K-Ca geothermometry suggests deep reservoir temperatures approaching 150°C, but interpretation of these results is difficult because of their dependence on an unknown water mixing history. Based on these estimates, and present surface and drill hole water temperatures, Pilgrim Springs would be classified as an intermediate-temperature, liquid-dominated geothermal system.

Resistivity surveys have located a shallow, 50 m-thick, pancake-shaped reservoir of hot, saline water about 1-1.5 km^2 in area under Pilgrim Springs. Shallow ground electromagnetic surveys, ground temperature surveys and modelling of convection cells have been used in conjunction with deep resistivity surveys to determine drilling targets within the area of this reservoir. Thermal, hydrologic and geologic models of the total geothermal system suggest that hotter reservoirs could be present at greater depths. Computer modelling of resistivity data does not rule out this possibility.

Two 50 m exploratory test holes, separated by 100 meters, were drilled in November, 1979, in the area of the primary drilling target recommended in our preliminary report (Forbes et al., 1979). Artesian aquifers were encountered in a 20-30 m depth interval. Flow rates were estimated at 200 and 300-400 gallons per minute, respectively, at a temperature of 90°C.

Preliminary hydrologic studies involving a Pilgrim River temperature survey and ground water flow estimates calculated from temperature profiles have resulted in a proposed water balance model and power estimates for the geothermal system. Analysis suggests that the power presently being dissipated from the upper 50 m of the system is a minimum of 350 megawatts (MW), with more than 300 MW of this amount in subsurface groundwater discharge beneath the Pilgrim River. The accessible resource base (Muffler, 1979) for the upper 50 m of the system referenced to 0°C is estimated at 500 MW. The beneficial power (Muffler, 1979) available for direct (nonelectric) use is estimated at 30 MW. Referencing these estimates to 15°C would reduce them to 2/3-3/4 of the above values. The mean annual air temperature in the area is approximately -3.5°C. Quantitative estimates of the electrical power potential will depend on engineering and reservoir parameters which are presently unknown. It is clear, however, that the electrical power potential will probably be a small fraction of the 30 MW beneficial power estimate.

We emphasize that many hydrologic measurements are preliminary, based on reconnaissance-level studies. A follow-on program of more extensive geophysical surveys, hydrologic studies, exploratory drilling and geochemical studies has been proposed in order to achieve a more complete understanding of the Pilgrim Springs geothermal system and to provide a basis for future power estimates, production drilling, engineering studies and commercial site development. Details of the present study, as well as a 1:63,360 scale geologic map are contained in our recent report to D.O.E. and the State of Alaska (Turner and Forbes, 1980).

ACKNOWLEDGEMENTS

The Pilgrim Springs study was supported by D.O.E. Cooperative Agreement DE-FC07-79ET27034, Alaska Division of Energy and Power Development Contract 79-580, NSF Grant DPP77-20462 and State of Alaska funds.

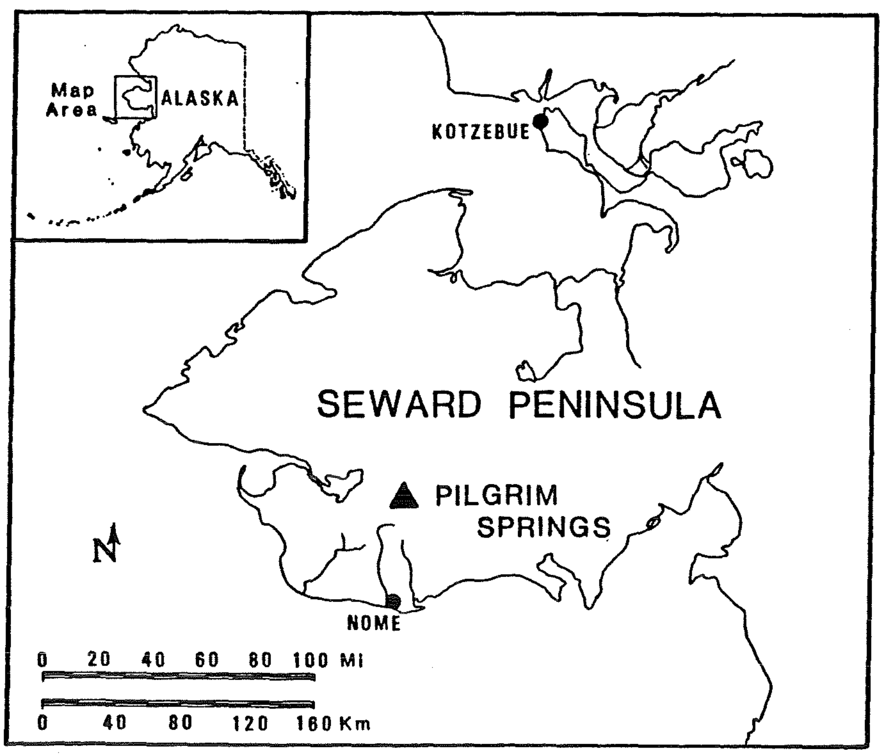

Figure 1. Location of Pilgrim Springs.