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ARIZONA

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During the year 1979, the Bureau of Geology and Mineral Technology, Geothermal Group conducted reconnaissance and detailed exploration in the State of Arizona. This work was funded by the U. S. Department of Energy, Division of Geothermal Energy and the U. S. Department of the Interior, Water and Power Resources Service (formerly the Bureau of Reclamation). These programs complimented each other and were conducted in a manner to avoid duplication of effort. The areas of investigation are Yuma, Willcox, Safford-San Simon, Hyder, Harquahala-Tonopah, Big Sandy (Kingman), Verde Valley, Tucson, Springerville, Clifton-Morenci, San Francisco River and Williams Air Force Base. The following are brief summary statements concerning the areas of investigation.

Yuma: Shallow to deep, sediment-filled basins created by extreme topographic relief in nearly-buried bedrock, and a deep sediment-filled structural trough that is part of the northwest-trending Salton Trough. The yuma area possibly possesses a significant geothermal resource, on the basis of electrical surveys and favorable geologic features.

Willcox: The Willcox Playa area is a deep, Tertiary sedimentary basin formed by the down-dropping of a central graben with subsequent filling of the lower unit with sediments from the topographically higher surrounding blocks. Three anomalous areas were defined where temperatures of 150°C should be encountered at depths of 3km or less.

Safford-San Simon: Deep, sediment-filled Cenozoic structural basin (graben) with a probable granitic basement. Sediment fill is probably underlain by Mid-Tertiary volcanics interbedded with well indurated continental sediments. A 180°C reservoir may exist at depths greater than 3km. Permeability of the rocks is unknown.

Hyder: The north to northwest trending basin (graben) is filled with a mixture of fine to medium-grained clastics, sand lenses and conglomerates. Eighty-eight wells and springs are known to have surface discharge temperatures in excess of 30°C. Abnormal temperature gradients are observed and assuming continuing to depth temperatures in excess of 150°C could be encountered at depths of less than 2.5km.

Harquahala-Tonopah: The basins (graben structures) underlying the Harquahala Plain and Tonopah Desert are deep and filled with Tertiary continental deposits. One hundred twelve wells have recorded discharge temperatures in excess of 30°C. Four areas may have temperatures of 150°C at depths of 3km or less.

Big Sandy Area (Kingman): The graben structure basin is filled with a mixture of conglomerate, gravel, sand, silt and clay. At least 2000 meters of sediments have accumulated in the northern part of the basin. Direct use temperatures are indicated by both well discharge temperature measurements and chemical geothermometers. Higher temperatures may be encountered in the deeper portions of the basin or along the basin-bounding faults.

Lower Verde Valley (Paradise Valley): A north trending graben containing more than 1300 meters of semiconsolidated alluvium and Tertiary continental clastic sediments. Direct use temperatures are indicated by both discharge temperatures and chemical geothermometers.

Tucson: The Tucson basin, a complex graben, is filled with poorly consolidated to well indurated Tertiary continental sediments. The basin is situated in an area of high regional heat flow, >2.0 HFU. Numerous shallow wells less than 300 meters deep encounter water ranging from 28°C to 40°C. Hot water, 50°C to 100°C, is probably within drilling depths of 762 to 1524 meters in areas with anomalous subsurface temperature gradients. Temperatures of 150°C may be expected at depths of 3km.

Northern Hassayampa Plain: The northern Hassayampa Plain is a broad, sediment filled basin with a complexly faulted basement. The three distinct structural trends (NE, NNW and NW) identified from air photo interpretation, Landsat lineaments, and geochemical trends are interpreted as fault traces. The measured geothermal gradients define a single discrete area of hydrologic discharge that is about $30km^2$ and can best be explained as being fault controlled. The maximum reported water temperature is 53°C from a well with an anomalous chemical analysis and a geothermal gradient of 140°C/km.

Springerville: Geologically, the Springerville area is comprised of relatively falt-lying sedimentary rocks of Tertiary to Paleozoic age overlying granitic basement rocks. The sedimentary rocks are only locally exposed, being covered by extrusive igneous rocks of the White Mountain volcanic field dated 32 m.y. to at least 10,000 years ago. Geochemical evidence, locally anomalous silica concentrations in the groundwater that are indicative of high heat flow, supports the probability of a geothermal resource in the Springerville area. Geophysical evidence, measured heat flow, 115 mWm^{-2}, that is above the Colorado Plateau average of 49 mWm^{-2}, as well as a zone of low resistivity and anomalous gravity and magnetic lows further support the probability of a geothermal resource. The conclusion drawn to date is that a geothermal resource of uncertain magnitude exists in the Springerville area.

Clifton-Morenci: Numerous hot springs discharging sodium chloride water occur in two different geologic settings in the Clifton area. Gillard Hot Springs, with temperature to 82°C, occur along the Gila River south of Clifton at the northwestern end of the sediment filled Duncan Basin. Clifton Hot Springs, with temperatures to 66°C, discharge, along a 2 mile zone, from numerous seeps and springs in the thin fluvial sediment filling the bottom of the San Francisco River canyon which is cut through mid-Tertiary volcanic rocks, Paleozoic clastic and carbonate rocks and Precambrian granitic rocks. Geothermometer temperatures range up to 180°C for both silica and Na-K-Ca calculation when mixing models are applied. Gravity data shows a closed low anomaly in the Duncan basin. Several magnetic lows, excluding the ore deposits, may be the result of hydrothermal alteration associated with a geothermal reservoir. Available geologic, geochemical and geophysical data point towards a high temperature geothermal resource.

San Francisco River: Physiographically, the San Francisco River between Clifton, Arizona, and Pleasanton, New Mexico, lies in the transition zone between the Colorado Plateau and the Basin and Range Province. The river cuts through a sequence of nearly flatlying Tertiary volcanics and does not expose pre-Tertiary rocks except immediately north of Clifton. The purpose of this study is to provide timely information on the geothermal resource potential on this segment of the San Francisco River which is a proposed Wild and Scenic River and Wilderness Area. The results of this reconnaissance study and of previous studies at Clifton Hot Springs, Arizona, and the lower San Francisco Hot Springs, New Mexico, show very high potential for significant geothermal energy resources in this area.

William Air Force Base: Williams AFB is situated in the southwestern half of the Higley basin, a small northwest trending basin approximately thirty miles long and fifteen miles wide. The stratigraphic sequence beneath the present valley surface is divided into two parts: an upper basin fill section and a lower pre-basin volcanic section. Geothermal Kinetics, Inc. has drilled two wells just southwest of the base, the deepest being 3186 m. Temperature data from these wells indicate temperatures in excess of 100°C below depths of 2134 meters and temperatures in excess of 150°C below 2743 meters. The reservoir would be in the volcanic rock from fracture zones and porous pyroclastic zones. Whether the reservoir will sustain production is not known. The geothermal energy potential is excellent.