ARIZONA WATER RESOURCES NEWS BULLETIN

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GEOTHERMAL RESOURCES:

What to Look for in Arizona*

by

Nile O. Jones**

Steam produced by the Earth's internal heat has been used to drive generators and produce electricity since the early years of the 20th century. Consequently there has been a tendency for people to believe that generating electricity is the only application of geothermal resources. Spurred by the ever-increasing costs of petroleum, renewed efforts have been launched to bring geothermal and other energy resources into greater use.

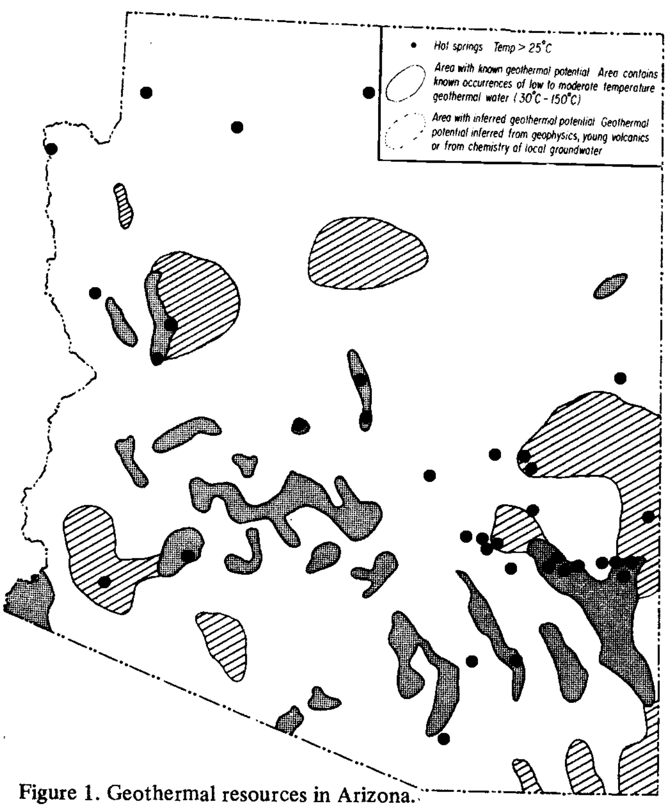

Figure 1. Geothermal resources in Arizona.

Applying or using Arizona geothermal resources (Figure 1) requires an understanding of the geologic setting. The conventional model of a geothermal field has a near-surface heat source such as a magma intrusion or igneous point source as shown in Figure 2. Heat radiating from a cooling magma travels upward and outward through conductive heating of adjacent rocks. Faults and fractures in bedrock can provide avenues through which deep groundwater circulation occurs. Such circulation heats the groundwater and transfers that heat

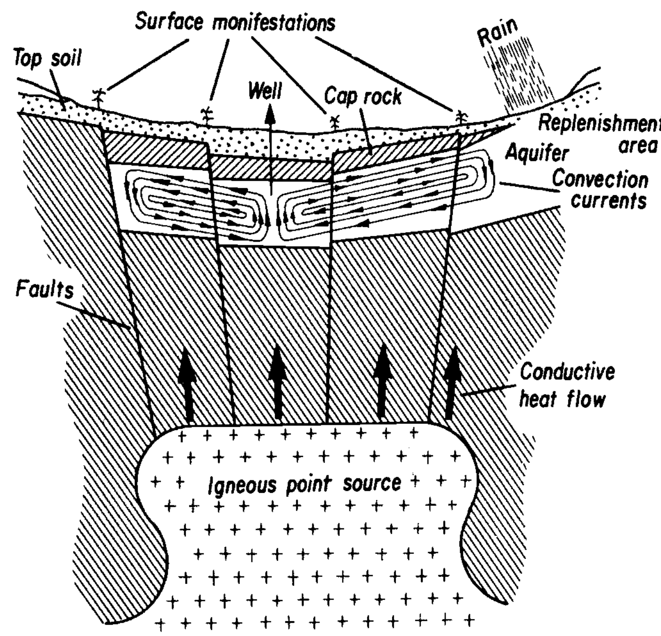

Figure 2. *Geothermal.* Igneous point source for geothermal energy in a Basin and Range setting (Armstead, 1978).

*Adapted from Fieldnotes 9(3):12-13. State of Arizona Bureau of Geology and Mineral Technology, University of Arizona, 845 N. Park Ave., Tucson, Arizona 85719

**Nile O. Jones is Senior Geologist, State of Arizona Bureau of Geology and Mineral Technology, Geothermal Branch.

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upward through convective processes. Hot water springs, fumeroles and possibly geysers occur if the heated water penetrates the Earth's surface.

In addition to these obvious surface phenomena, certain chemical characteristics of the water and geophysical observations also could suggest buried heat sources. For example, the presence of free hydrogen in escaping steam implies subsurface temperatures that exceed 200 C. Certain trace metals in the escaping moisture also could suggest igneous sources, while isotopic ratios of sulfur or oxygen could lead to the same conclusion. Geophysical techniques that could be helpful in detecting geothermal sources include microearthquakes, gravity measurements, seismic reflections and heat flow measurements.

Figure 3 illustrates the relationship of the natural increase in temperature with depth. Observed or measured gradients, in fact, do not form straight, linear relationships because of groundwater circulation, convective heat flow and the varying thermal properties of different lithologies. Nonetheless, the average thermal gradient of a region can be represented as a straight line. The shaded portion of Figure 3 represents an approximation of the deep thermal regions of the world. To obtain geothermal heat with power generation potential within these "world average" zones it would be necessary to drill to depths of at least 6 or 7 kilometers. Direct-use geothermal waters, on the other hand, could be encountered at depths of 2.5 to 3 kilometers under the same gradient conditions.

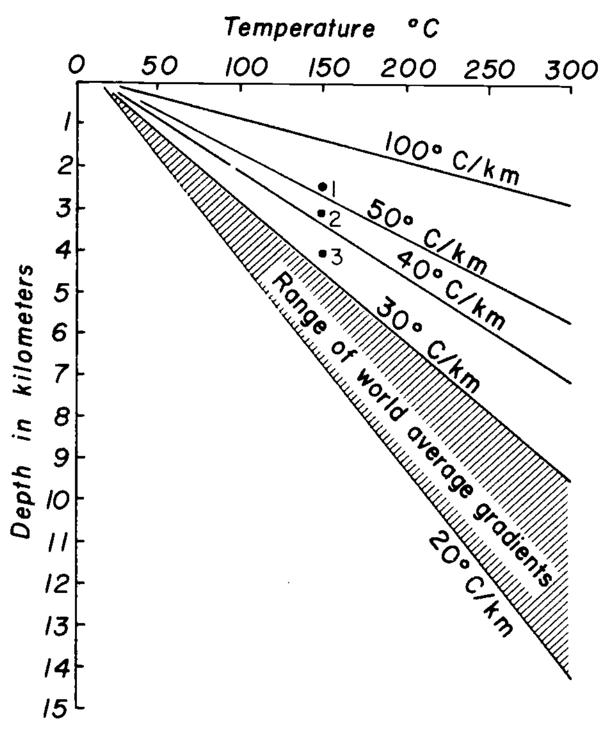

Figure 3. *Geothermal.* Temperature/depth relationships for various temperature gradients (mean average temperature=20°C).
1=minimum electricity producing temperature for 2½ km
2=minimum electricity producing temperature for 3 km
3=depth required for minimum electricity producing temperature using 37°C/km gradient (Armstead, 1978).

During the last two years Bureau of Geology and Mineral Technology staff have conducted studies that have established data showing that the deeper basins throughout Arizona have average gradients exceeding 30 C per kilometer. For example, 37 C per kilometer is considered by Bureau staff to be the average basinwide gradient in the Tucson Basin. Using these data, Bureau staff infer that geothermal sources that have boiling temperatures could be expected to exist at a depth of 3 kilometers. And where regional gradient temperatures are between 45 and 55 C per kilometer it could be assumed that waters with temperatures of 150 C would be encountered. These waters could be hot enough to be used to generate electric power.

The Bureau staff test existing wells and drill exploratory heat flow holes to determine the potential temperatures of geothermal resources in Arizona. Seven old wells in the State have temperatures that exceed 100 C and six of these wells have gradients that exceed the value of 30 C per kilometer. One well near Chandler and another at San Simon greatly exceed assumed deep-basin gradients.

Potential applications of geothermal sources with temperatures less than the 150 C necessary to generate electric power are quite extensive. Figure 4 lists some applications by temperature requirement that are being undertaken. Additional applications geared to Arizona business activities could include concentrating citrus juices, pumping irrigation water, producing cotton seed oil, processing minerals, and pasteurizing milk. One application that is being evaluated is to provide the Safford prison facilities with geothermal heating and cooling.

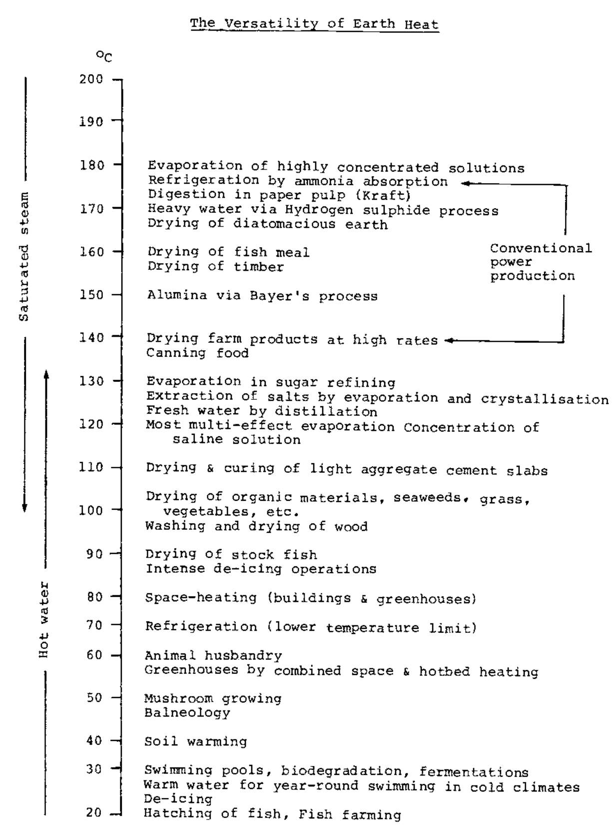

Figure 4. *Geothermal.* Approximate temperature requirements of geothermal fluids for various applications (Lindal).

"The existence of low to moderate temperature waters throughout the State allows for a multitude of applications. Indeed, the uses for geothermal energy are limited only by the imagination of those who wish to put it to work," Jones concludes.

References

Armstead, H.C.H. 1978. Geothermal Energy. Halstead Press, New York. 357 p.

Giardina, S., and Conley, J.N. 1978. Thermal Gradient Anomalies in Southern Arizona: Arizona Oil and Gas Conservation Commission Report 6.

Hahman, W.R., et al. 1978. Geothermal Map No. 1. Bureau of Geology and Mineral Technology.

Lindal, B. 1973. Industrial and Other Applications of Geothermal Energy. UNESCO. 135 p.

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CALL FOR PAPERS

A joint session of the Arizona Section, American Water Resources Association, and the Hydrology Section, Arizona–Nevada Academy of Science, will be held April 10-12, 1980, during the 24th Annual Meeting of the Academy at Las Vegas, Nevada.

Papers are invited on all aspects of hydrology and water resources, ranging from physical systems and analytical methods to legal and institutional problems in water resources management.

Abstracts of 200 words or less should be submitted to Dr. Gerald Harwood, Editor, School of Renewable Natural Resources, Room 204 Biological Sciences East, University of Arizona, Tucson 85721. His telephone number is (602) 626-4406.

Deadline for abstract submittal is December 15, 1979. Instructions regarding abstract format are available from Dr. Harwood or from Dr. K.J. DeCook, Water Resources Research Center, Room 102 Old Psychology Building, University of Arizona, Tucson, 85721. Dr. DeCook's telephone number is (602) 626-1009 or 2144.

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CONDENSATION

WATER RESOURCES RESEARCH GRANTS

Four new water research projects were begun October 1, 1979, under matching grants awarded by the U.S. Department of the Interior Office of Water Research and Technology, according to University of Arizona Water Resources Research Center Director Sol D. Resnick.

Project titles, and principal investigators and their University of Arizona departmental affiliations are listed below.

The Long-Run Profitability of Western Irrigated Agriculture: An In-Depth Analysis, Y. Goldschmidt and W.E. Martin, Agricultural Economics.

Analysis of the Water Status of the Plant-Soil Continuum Using Electrophytograms, W.G. Gensler, Electrical Engineering.

An Evaluation of Ground-Water Management Alternatives Using an Integrated Hydrogeologic and Institutional Modeling Process, Thomas Maddock, Judith M. Dworkin and M.D. Bradley, Hydrology and Water Resources.

The Effect of Vegetation Conversion upon Water Use by Riparian Communities, L.W. Gay, School of Renewable Natural Resources.

USGS FINDS WATER FOR AK–CHIN INDIAN COMMUNITY NORTHWEST OF CASA GRANDE

Sufficient groundwater is contained under federal lands in the Vekol Valley, and the Waterman Wash and Bosque areas to provide 85,000 acre-feet annually to the Ak-Chin Indian Community, according to a recently completed study conducted by the U.S. Geological Survey (USGS) in cooperation with the U.S. Bureau of Indian Affairs.

The report, *Availability of Groundwater on Federal Land near the Ak-Chin Indian Reservation--A Reconnaissance Study*, was prepared for Congress. It was transmitted to Congress by Secretary of the Interior Cecil Andrus pursuant to Section 2, Public Law 95-328 (See Arizona Water Resources News Bulletin 78-4). PL 95-328 contains terms of a water rights settlement between the Ak-Chin Indian Community and the United States.

"Many factors will influence the decision as to which area or combination of areas could or should be developed," according to report authors.

The Waterman Wash area has the greatest potential to contribute to satisfying Community needs. Some 10.3 million acre-feet of groundwater are in storage under the area, but the 50 wells in the region could be affected by increased pumping. The USGS estimates that water level declines there could amount to 8 feet annually.

Groundwater stored in the Vekol Valley totals about 7.7 million acre-feet and no wells exist in the area. The Bosque area contains some 3.6 million acre-feet of groundwater, and 40 wells are operating. Water level declines caused by additional pumping in the Bosque area could amount to 12 feet annually, according to the report. Finally, the USGS estimates that land subsidence could occur as a result of increased withdrawals from the aquifers.

1980 CAP APPROPRIATION

Funding to continue Central Arizona Project (CAP) construction during fiscal year 1980 amounts to $94.2 million, about the same amount appropriated during fiscal year 1979, which ended September 30. CAP funds became available when President Carter signed the Energy and Water Development appropriations bill September 25.

The U.S. Bureau of Reclammation (USBR) plans to award pumping equipment contracts during 1980 for the Havasu and Salt-Gila pumping plants; for the Bouse Hills, Little Harquahala, and Salt-Gila pumping plant structures; and for constructing Granite Reef Aqueduct Reaches 5B and 12, according to USBR Arizona Projects Manager Richard Shunick.

Since 1968 Congress has appropriated $657.5 million to create CAP water and power facilities, including the 1980 appropriation. Constructing the CAP water diversion and delivery systems has required $468.6 million of the appropriations made since 1968.

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PUBLICATIONS

HYDROLOGY AND WATER RESOURCES TECHNICAL REPORT SERIES AVAILABLE

Selected issues of the University of Arizona Department of Hydrology and Water Resources Technical Report series are available now at half price, or $2.50. Report numbers that are available at the reduced cost are listed by number below.

No. 7 *A Random-Walk Simulation Model of Alluvial Fan Deposition*, W.E. Price Jr., June 1972

No. 11 *Spatial Variability of Precipitation in the San Dimas Experimental Forest and Its Effect on Simulated Streamflow*, C.A. Phanartzis, May 1972

No. 12 *Water Quality in the Lower Colorado River and the Effects of Reservoirs*, G.C. Slawson Jr., July 1972

No. 14 *Bayesian Decision Analusis of a Statistical Rainfall/Runoff Relation*, H.A. Gray, October 1972

No. 16 *Bayes Risk Analysis of Regional Regression Estimates of Floods*, W.A. Metler, February 1973

No. 18 *A Stochastic Approach to Space-Time Modeling of Rainfall*, V.K. Gupta, June 1973

No. 19 *Design of Water Resources Systems in Developing Countries: The Lower Mekong Basin*, K. Chaemsaithong, June 1973

No. 20 *A Cost-Effectiveness Study and Analysis of Municipal Refuse Disposal Systems*, M.L. Popovich, June 1973

No. 21 *Eutrophication: A Mathematical Model*, J.H. Friedman, June 1973

No. 22 *Planktonic Cynamics as an Indicator of Water Quality in Lake Mead*, R.D. Staker, June 1974

No. 23 *Coal-Fired Energy Development on Colorado Plateau: Economic, Environmental and Social Impacts*, T.G. Roefs and R.L. Gum (editors) July 1974

These reports can be ordered from Augusta DeSouze, Department of Hydrology and Water Resources, Old Psychology Building, University of Arizona, Tucson 85721.

INTERNATIONAL WATER USE RELATIONS ALONG THE SONORAN DESERT BORDERLANDS PUBLISHED

International Water Use Relations Along the Sonoran Desert Borderlands has been published as Arid Lands Resource Information Paper No. 14 by the University of Arizona Office of Arid Lands Studies (OALS).

"In the arid Southwest along the Sonoran Desert borderlands, water is a scarce commodity, not enough to meet even current demands, much less even greater future demands," said Patricia Paylore, Series editor and principal investigator for the U.S. Department of the Interior grant that supports the Series.

Borderland water use has been a long-standing and highly volatile political issue among competing users on each side of the international boundary, according to authors Milton H. Jamail and Scott J. Ullery.

"Moreover, since water does not abide by political boundaries, the politics of water have been made more complex by the international aspects of contemporary issues, thus moving efforts at solutions beyond the authority of local experts," Miss Paylore added.

Past conflicts between the United States and Mexico have focused on competing agricultural use of Colorado River water. The Mexican Treaty of 1944 and subsequent amendments added to it through Minutes promulgated by the International Boundary and Water Commission (IBWC) have dealt explicitly with those old issues with varying degrees of success.

"But new issues, generated by rapid urbanization along the border, with the accompanying demands from municipal and industrial users imposed on the original agricultural needs, have expanded the range beyond those addressed by the 1944 Treaty. And the potential for conflict thus becomes greater," according to Miss Paylore.

Authors Jamail and Ullery examined literature related to water use problems between the United States and Mexico and interviewed a number of officials on both sides of the border as well as IBWC members to attempt to establish a perspective on how these international water problems are viewed.

As a result of the review of literature pertaining to the Mexican Water Treaty, Minute 242 and the IBWC, Jamail and Ullery produced a computerized bibliography for the Paper consisting of 130 citations with full abstracts and in-depth indexing. An additional 225 file and newspaper citations are included.

Three chapters of the Paper contain case studies that examine the extent of the increasingly critical water supply, water quality, waste water, and pollution parameters inherent in the borderland situation that have been dealt with historically on ad hoc bases, Miss Paylore said.

"While this study focuses on a specific border, it is hoped that its framework will have application for any international situation where two countries must share common water resources," Miss Paylore concluded.

The 139-page Paper contains 11 figures and costs $10 per copy. It can be ordered from Publications, Office of Arid Lands Studies, University of Arizona, 845 N. Park Ave., Tucson 85719.

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Please address your news items or comments on the News Bulletin to any of the three editors:

Phil Briggs, Arizona Water Commission, Suite 800, 222 North Central Avenue, Phoenix, Arizona 85004.

Jim DeCook, Water Resources Research Center, University of Arizona, Tucson, Arizona 85721.

Ken Foster, Office of Arid Lands Studies, University of Arizona, Tucson, Arizona 85721.

Dick Haney, Office of Arid Lands Studies, University of Arizona, Tucson, Arizona 85721.

UNIVERSITY OF ARIZONA
WATER RESOURCES RESEARCH CENTER
WATER INFORMATION SECTION
TUCSON, ARIZONA 85721