

LOW-TEMPERATURE GEOTHERMAL
RESERVOIR SITE EVALUATION
IN ARIZONA

QUARTERLY PROGRESS REPORT FOR PERIOD
AUGUST 1, 1977 - OCTOBER 31, 1977

W. Richard Hahman, Sr.

BUREAU OF GEOLOGY AND MINERAL TECHNOLOGY
GEOLOGICAL SURVEY BRANCH
THE UNIVERSITY OF ARIZONA
845 North Park Avenue
Tucson, Arizona 85719

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ABSTRACT

The Department of Energy, Division of Geothermal Energy, has charged the Bureau of Geology and Mineral Technology, Geological Survey Branch with the development of a cost-effective exploration program for low- to moderate-temperature geothermal resources. As part of this program two or three demonstration projects in Arizona will be brought on stream.

The site-specific exploration, evaluation and development program as well as the state wide reconnaissance exploration program is continuing. The compilation of data for a geothermal energy resource map of Arizona has commenced.

Geological field work was directed towards obtaining a broad overview of Arizona geology and regional reconnaissance in the Springerville - St. Johns area. All outside projects are on schedule and the Landsat lineament map and report have been completed.

RESEARCH OBJECTIVE

The research objective of this program is the exploration for the location, evaluation and development of low- to moderate-temperature geothermal resources for use by the general public and private industry. The development of an efficient cost-effective exploration program for the location and evaluation of low- to moderate-temperature geothermal resources will require the close cooperation and coordination of three geoscience disciplines: geology, geophysics and geochemistry.

For immediate utilization, these low- to moderate-hydrothermal energy resources, to be economic, must be located near the user whether it be space heating or cooling or industrial processing. Current plans call for two demonstration projects, utilizing low- to moderate-temperature hydrothermal geothermal energy, to be brought on stream. These two projects will be the training and testing ground for development of the economical exploration program. The third demonstration project must be brought on stream through utilization of a cost-effective exploration and development program.

While the detailed or site-specific exploration, evaluation and development program is in progress, the reconnaissance exploration program will continue in an attempt to locate additional areas of interest. Current thinking is that the reconnaissance program will cover the entire State of Arizona. At present, however, most of the available data is in the Basin and Range physiographic province.

Another object of this program is the compiling of a special library on geothermal energy. This comprehensive geothermal library will be for public use at the Geological Survey Branch of the Bureau of Geology and Mineral Technology in Tucson, Arizona.

The program has been expanded to include the compilation and publishing of a geothermal energy resources map of the State of Arizona. This map will be produced through a joint effort by the U.S.G.S. Geotherm project, the National Oceanic and Atmospheric Administration and the Arizona Bureau of Geology and Mineral Technology, Geological Survey Branch. It is anticipated that this map will be available to the public in the fall of 1978.

INTRODUCTION AND REVIEW

The Arizona geothermal energy program was initiated in response to prior geothermal research and reconnaissance programs conducted primarily under the aegis of the federal government. The initial program, extremely limited in scope, rapidly expanded to an exploration and development program for geothermal energy covering the State of Arizona. The primary emphasis of the program is the location and development of low- to moderate-temperature geothermal resources. However, moderate- to high-temperature geothermal resources, including hot dry rock, suitable for electrical generation will not be bypassed.

A major mission of the Arizona program is the development of a cost-effective exploration program for low- to moderate-temperature geothermal resources. A second short term project is the compilation and publication of a geothermal energy resource map for the State of Arizona. A third ongoing project is the establishment of a comprehensive library on geothermal energy to be available to the public.

The period August 1, 1977 through October 31, 1977, of the Arizona exploration and development program for low- to moderate-temperature geothermal energy (to 140° - 150°C) was one of considerable progress. All outside projects are on schedule and one has been completed. Geological field investigations in the Springerville area of Apache County have commenced.

PROGRAM PERSONNEL

Principal Investigator

W. Richard Hahman, Sr., Research Geologist
Bureau of Geology and Mineral Technology
Geological Survey Branch
University of Arizona

Research Associate (part time)

H. Wesley Peirce, Geologist
Bureau of Geology and Mineral Technology
Geological Survey Branch
University of Arizona

Research Assistant (part time)

Claudia Stone, Geologist
Bureau of Geology and Mineral Technology
Geological Survey Branch
University of Arizona

Outside Advisor

A.W. Laughlin, Geologist/Geochemist
Los Alamos Scientific Laboratory
University of California
Los Alamos, New Mexico


Francis G. West, Geologist/Hydrologist
Los Alamos Scientific Laboratory
University of California
Los Alamos, New Mexico

Secretary

Tracee Ann Calhoun
Bureau of Geology and Mineral Technology
Geological Survey Branch
University of Arizona

COMPLIANCE WITH CONTRACTUAL REQUIREMENTS

The principal investigator, W. Richard Hahman, Sr., in accordance with Article I and Article A-I of Appendix A of DOE Contract EG-77-S-02-4362 has devoted his full time, from August 1, 1977 through October 31, 1977, to the contract work. He plans to devote his full time to the contract work during the next quarter, November 1, 1977 through January 31, 1978. The principal investigator and the program are in compliance with the requirements of the contract.


W. Richard Hahman, Sr.

OPERATIONS

Geology

The Arizona program has made significant progress during the three month period August through October, 1977.

Field investigations centered on obtaining a broad overview of Arizona geology and regional geological reconnaissance in the Springer-ville - St. Johns area. Several samples of basalt flows in the latter area were collected for age dating by the Geochronology Laboratory at the University of Arizona.

Compilation of the published and unpublished heat flow data as well as all the available well and thermal gradient data in the state is continuing. The major contributors of this information have been the Oil and Gas Conservation Commission and the State Land Department and the U.S. Geological Survey. Also the commanders of military bases throughout the state have been most prompt and very cooperative in furnishing the data on the water wells on their respective installations.

The following data has been obtained from the Oil and Gas Conservation Commission and is on open file in Tucson.

1. Geothermal Areas Map, State of Arizona
2. Temperature map of subsurface basement rocks in Arizona (GT-3A)
3. Temperature map of subsurface suprabasement rocks in Arizona (GT-3B)
4. Temperature data tabulation to accompany maps GT-3A and -3B
5. Mylar base map of Arizona at a scale of 1:1,000,000
6. Preliminary tabulation of well data from Maricopa and Pinal Counties, Arizona

The following data has been obtained from the State Land Department and is on open file in Tucson.

1. Geothermal Potential of the Basin and Range Area of Arizona: report with nine maps and twenty-seven overlays
2. Thermal gradients, Basin and Range Province, State of Arizona
 - a. Southeast Quadrant
 - b. Southwest Quadrant
 - c. Northeast Quadrant
 - d. Northwest Quadrant

The Arizona Oil and Gas Conservation Commission is making good progress on its tabulation of well data in the state (letter, Appendix 1). The data, primarily from water well information, as compiled, shows well location and depth, mean annual temperature, water temperature, and temperature gradient.

The thermal gradients calculated from this data, could contain errors. These errors would probably be caused by mixing of waters in the producing zone and by the fact that the wells were not allowed to come to equilibrium before the measurements were made. Keeping the above restraints in mind and that this data is all that is currently available, it should make an excellent state wide prospecting tool.

Dr. Chandler A. Swanberg, of New Mexico State University, has furnished the program with "An Appraisal Study of the Geothermal Resources of Arizona and Adjacent Areas in New Mexico and Utah and Their Value for Desalination and Other Uses," New Mexico Energy Institute report number 006. This report

is primarily concerned with the location of potential sources of moderate- to high-temperature geothermal resources.

Dr. Swanberg is currently evaluating all of the available well and spring data in Arizona with respect to low- to moderate-temperature geothermal resources. It is anticipated that this report will be available in the spring of 1978.

The Landsat lineament map and report by Dr. Larry K. Lepley was completed in October. The following quotation is the abstract from that report. Figure 1 is the lineament map from the report.

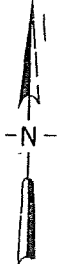
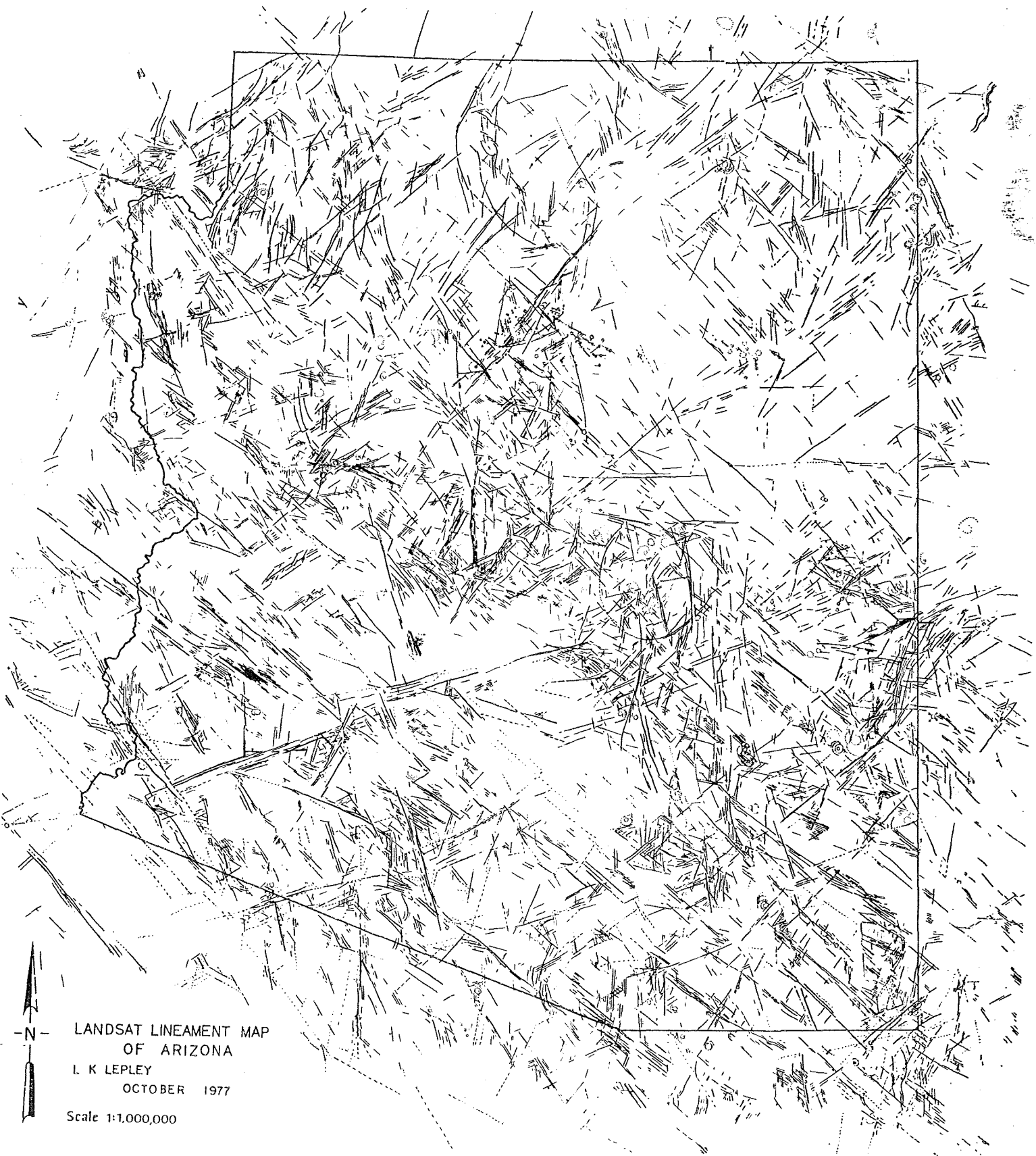
"Regional lineaments were traced from the Landsat photographs. Special attention was given to those believed to represent deep-seated crustal ruptures controlling recent igneous activity. Pre-Quaternary features were included because 1. The configuration of older structures is needed to define the magnitude of Quaternary plate motions; and 2. Accessory data should be used to confirm ages of regional fracture or fault zones. An older lineament map was used to demonstrate optical Fourier processing.

"The new lineament map (Figure 1) compares favorably with the tectonic models of Titley, Purvis and Rehrig and Heidrick. Alignments of recent volcanoes with lineaments suggest NE and NW control on the Colorado Plateau and NNW and ENE control in the Sonoran Desert.

"Recommendations are as follows:

1. The lineament map should be processed with an OFA masking technique to produce a map of probable Quaternary faults;
2. The lineament map should be interpreted synergistically with the following maps:

- a. magnetic and gravity anomaly contours,
 - b. age-dated and petrographically classified recent igneous rocks,
 - c. known thermal and chemical manifestations of geothermal activity,
 - d. fault plane solutions from seismic records;
3. Tectonic models of recent plate motions should be derived."



LANDSAT LINEAMENT MAP
OF ARIZONA

L. K. LEPLEY
OCTOBER 1977

Scale 1:1,000,000

Fig. 1

Geophysics

The following statement by Dr. John S. Sumner, Department of Geosciences, University of Arizona, is the quarterly progress report on the Arizona gravity data analysis as applied to geothermal resources.

"This project is being undertaken by the Geophysics Laboratory in the Department of Geosciences as a contribution to the Arizona DOE/DGE program under the direction of the Arizona Bureau of Geology and Mineral Technology. The purpose of this research is to reformulate the Arizona Gravity Map, first published in 1973, into a more readily useable form. Then the improved gravity map can be interpreted in terms of potential sources of geothermal energy.

" The Arizona Gravity Map, (Figure 2), is a companion to the Aeromagnetic map, (Figure 3), of Arizona. When reviewed and interpreted together with the geologic map of the state and mineral resource locations then trends start to fall into meaningful patterns. Thus it would be useful to have a high quality gravity map of the state.

" One of the problems with the previous gravity map is that the Bouguer anomaly values are strongly influenced by the regional elevation of the land surface. The reason for this relationship is that higher elevations are underlain by a greater thickness of lower density rock, a consequence of isostatic compensation. However, the effect on the gravity data is to cause a regional bias to the extent that the Bouguer gravity map is also a regional elevation map of the state.

The method of treating this problem is to compute a smoothed regional gravity map which reflects only the bias due to regional elevation, and then to subtract this regional map from the Bouguer

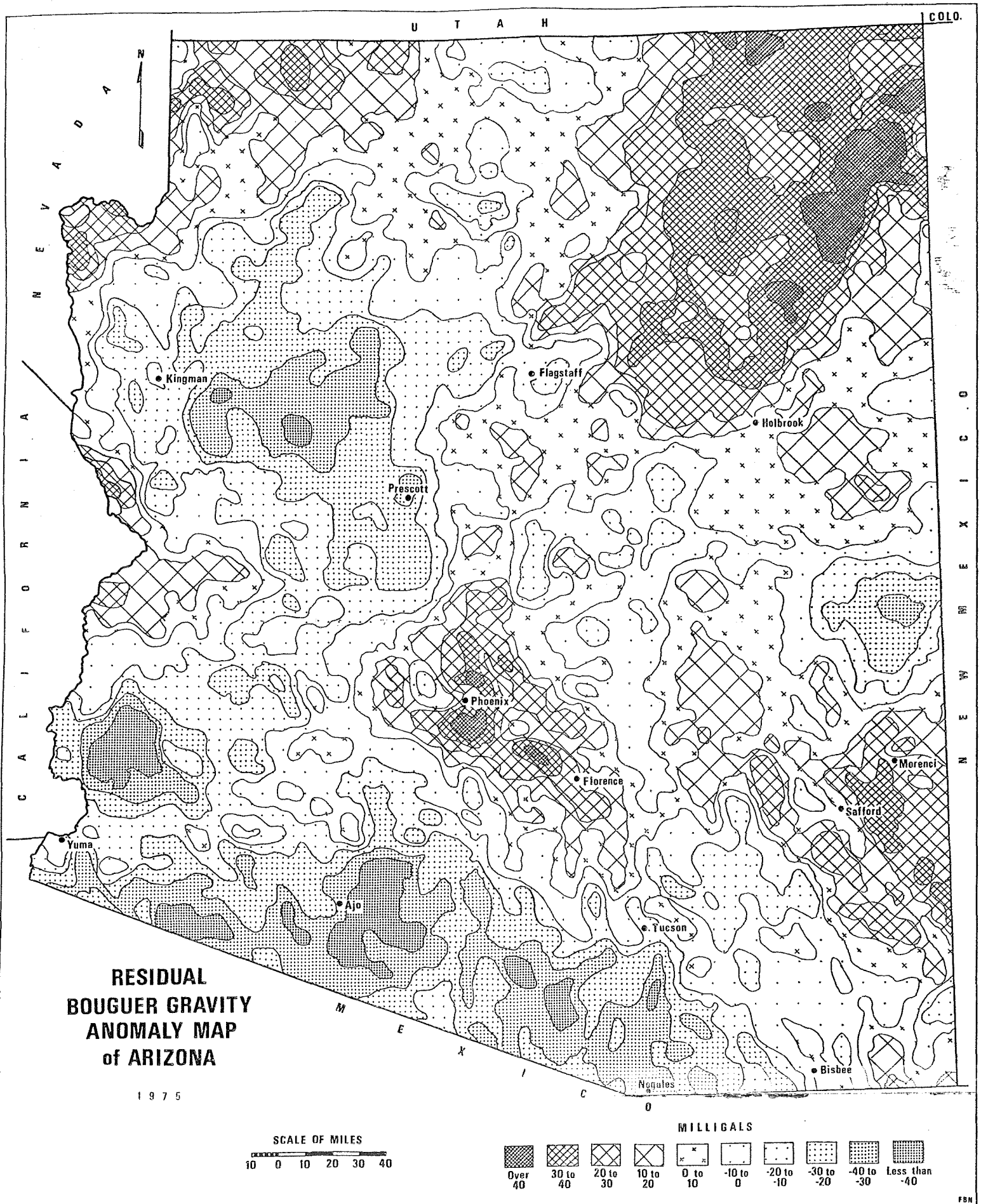


Fig. 2
13

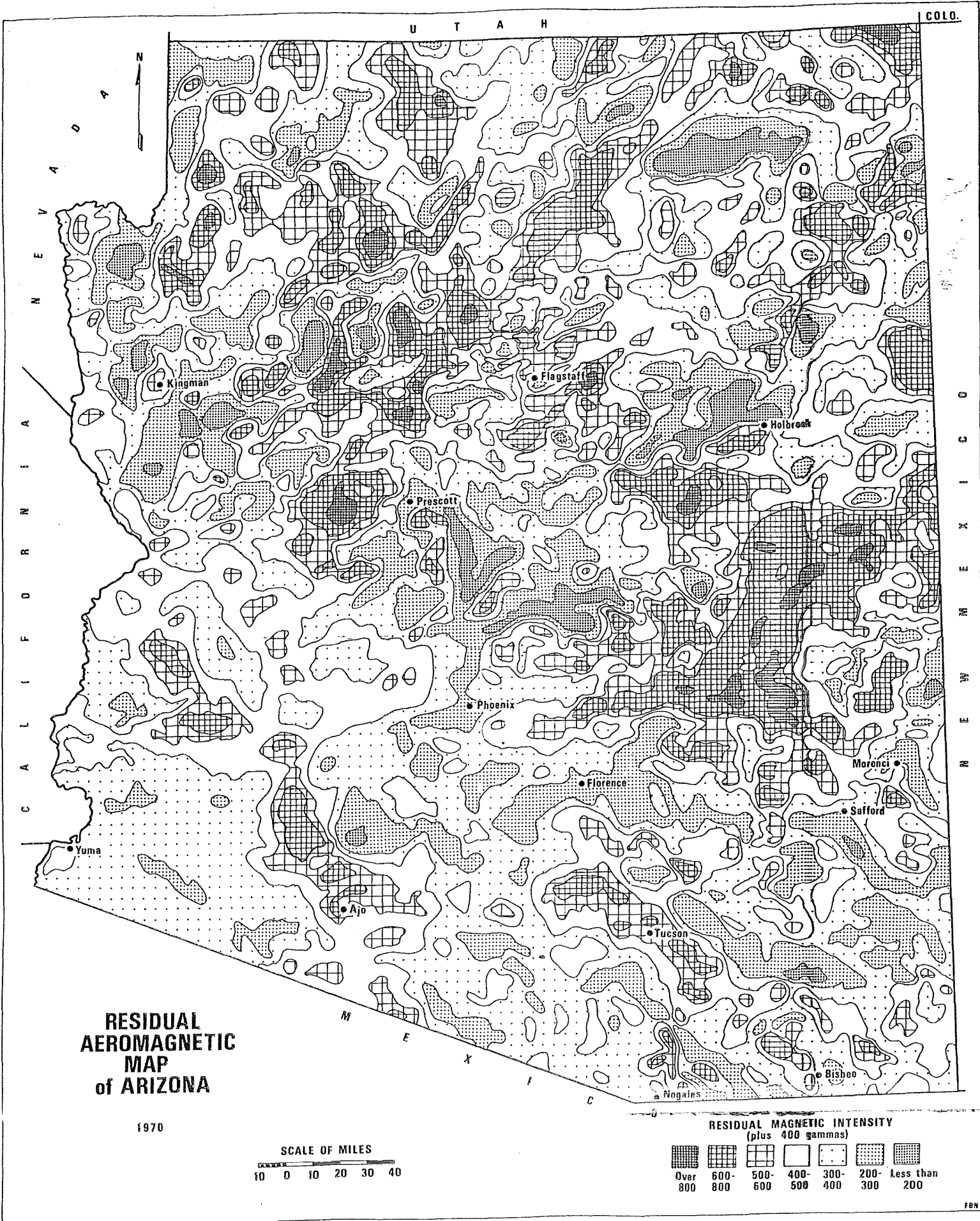


Fig. 3
14

gravity values. Work has been started on this project to the extent that a computation method has been derived and applied to the gravity data. However, more analysis is necessary in order to include recent data and to perfect the computation technique.

"Work during this past quarter has been involved with reviewing computer tapes and gravity data in preparation for map making."

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OFFICE OF
Oil and Gas Conservation Commission

STATE OF ARIZONA
 1645 WEST JEFFERSON, SUITE 420
 PHOENIX, ARIZONA 85007
 PHONE: (602) 271-5161

November 14, 1977

W. Richard Hahman, Sr.
 Bureau of Geology & Mineral Technology
 845 N. Park
 Tucson, Arizona 85719

Dear Mr. Hahman:

This letter outlines our progress in assisting your geothermal research efforts.

Our office has conducted an extensive literature search to obtain data relative to subsurface temperatures throughout the State of Arizona. Nearly all subsurface temperatures have been limited to water-well records, supplemented by several down-hole geophysical logs from geothermal and petroleum test borings.

Temperature data from water wells could not be utilized to determine an accurate geothermal gradient, as down-hole equilibrium temperatures have not been established and the resultant reported water temperatures are modified by the mixing of waters from the total "screened" interval of each well. With this limitation in mind, however, a general thermal gradient may be obtained within those areas where sufficient data could be obtained.

At this writing, all data available to us for Maricopa and Pinal Counties have been abstracted from numerous publications and tabulated. The location, water temperature, and depth are indicated. Thermal gradients have been calculated for 420 wells in Pinal County and 485 wells in Maricopa County.

In addition to the tabulated original data, we are currently evaluating this data in an effort to delineate anomalously high gradient zones. This supplemental information, currently incomplete, will be sent to you in a preliminary format on a county basis as completed.

Very truly yours,

Salvatore Giardina
 Staff Geologist

SG:os