GL03009.5 of 8

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Report on the Geothermal Potential of Yuma Proving Ground, Luke Air Force Range, Luke Air Force Base, Williams Air Force Base, and Navajo Ordinance Depot - Arizona

by

Casey Danielson

Enclosure (4)

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Report on the Geothermal Potential of Yuma Proving Ground, Luke Air Force Range, Luke Air Force Base, Williams Air Force Base, and Navajo Ordinance Depot - Arizona

1977

by Casey Danielson

Abstract of Results

This report is on the geothermal potential of federal military reservations in Arizona. As a result of this study the following evaluations were made:

	Geothermal Potential	
	Space Heating	Power Production
Yuma Proving Grounds	Fair	Poor
Luke Air Force Range	Fair to poor	Poor
Luke Air Force Base	Fair to good	Poor
Williams Air Force Base	Very good	Good
Navajo Ordinance Depot	Unknown	Unknown

The above evaluations are based on data taken from published sources and from materials on file in the office of the Arizona State Land Department and the Arizona Oil and Gas Commission. Published data provided information on the general geology, regional geophysics, and thermal manifestations of Arizona. An exploration model, constructed by the Arizona State Land Department, was used in assessing the potential of the areas of study. The Arizona Oil and Gas Commission supplied information on two geothermal test wells drilled south of Williams Air Force Base and also provided data on the geothermal reservoir encountered in these tests.

General Geology

Arizona lies within parts of two physiographic provinces: the Basin and Range and the Colorado Plateau. The Basin and Range is composed of a series of north to northwest trending fault block mountains and valleys. Extrusions of andesitic to rhyolitic volcanics often accompany these structures (Wilson and Moore, 1959). The structural and volcanic history of this area is similar to the tectonic setting of geothermal fields near Larderello, Italy (McNitt, 1970). Yuma Proving Grounds, Luke Air Force Range, Luke Air Force Base, and Williams Air Force Base are all located in the Basin and Range. The Colorado Plateau is an area of canyon topography, disturbed mainly by late Cenozoic lava flows and intrusives (Hunshbargen, 1972). The Navajo Ordinance Depot is located in the San Francisan volcanic field on the Colorado Plateau.

Basin and Range

The Basin and Range experienced initial deformation at the end of the Cretaceous with events that are associated with the Laramide orogeny. These early structures were disturbed in Middle Tertiary time by block faulting and concurrent intermediate to acidic volcanic activity. $^{87}Sr/^{86}Sr$ data indicates that these magmas were derived from the lower crust (Shafiqullah and Damon, 1976). Damon and others (1962) have dated these events between 56 m.y. and 13 m.y.

Extensive basalt flows later covered much of this area during the Quaternary. These flows are reported to be less than 12 m.y. by Shafiqullah and Damon (1976). Leeman and Rogers (1969) state that these flows came from depths of 40 km. to 60 km. in response to the elevated geothermal gradient found beneath the Basin and Range.

Colorado Plateau

The Colorado Plateau is stratigraphically and topographically high relative to the Basin and Range. North of Flagstaff, Arizona, on the Colorado Plateau, lies the San Francisican volcanic field. Thick sequences of basaltic and intermediate to acidic lavas, cinders, and intrusive rocks accumulated in the late Cenozoic, producing lofty mountain peaks (Robinson, 1913). The most recent volcanism in the state is found in this field at Sunset Crater, where a small basalt flow has been dated at less than 1000 years.

Heat Flow

Heat flow data defines a critical difference between the Basin and Range province and the Colorado Plateau. Surface heat flow in the Basin and Range is high, with reported values between 1.5 $ucal/cm^2$ sec and 3.5 $ucal/cm^2$ sec. This contrasts with a continental mean of 1.4 $ucal/cm^2$ sec. The few values which have been reported for the Colorado Plateau (outside Arizona) are less than this mean at 1.2 $ucal/cm^2$ sec (Roy et al, 1972). Warren et al (1969) attribute this difference to a rise of the isotherms in the subcrustal mantle beneath the Basin and Range. Fig (1) is a map of published heat flow data.

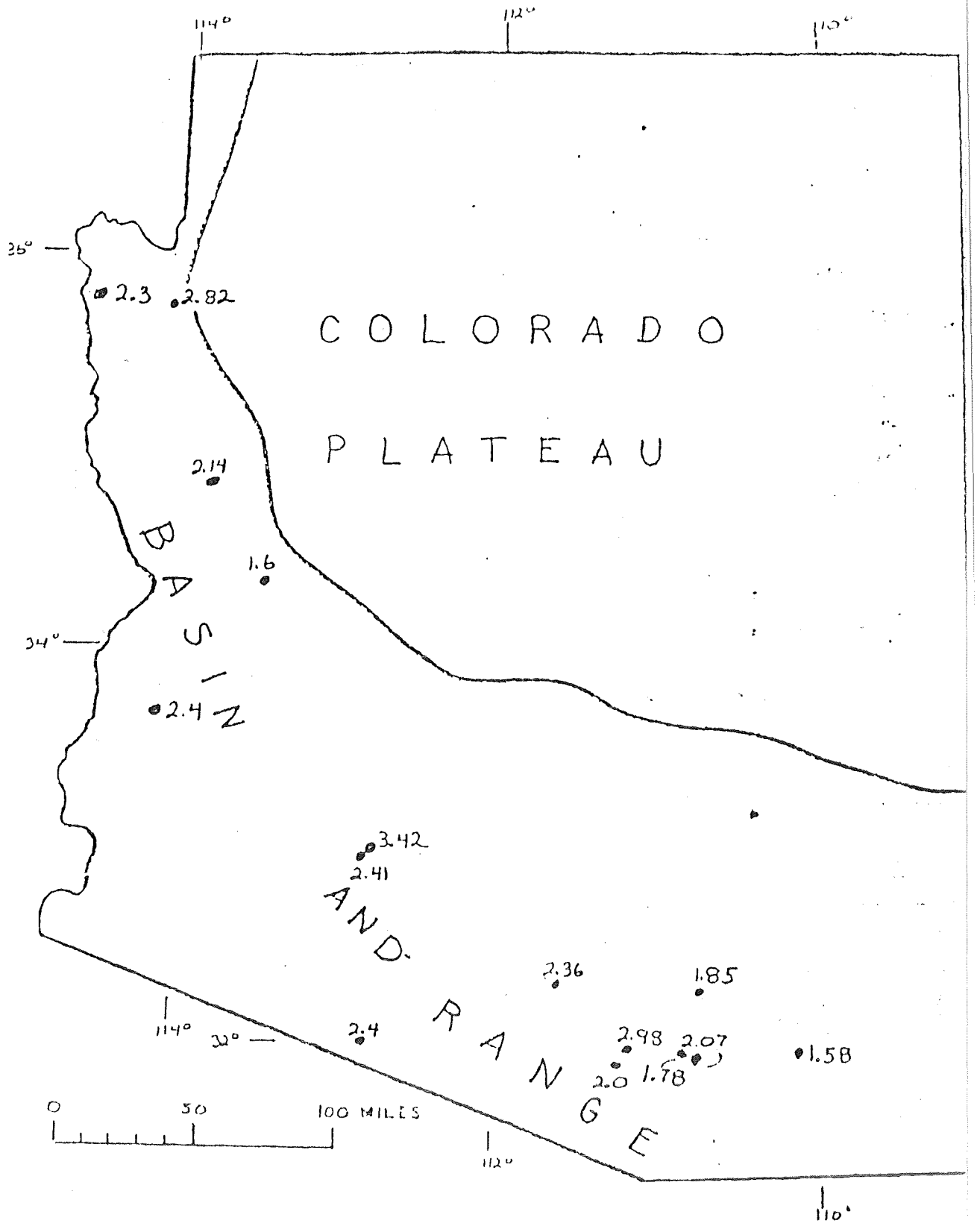
Thermal Manifestations

Table (1) and Fig. (2) are a comprehensive list and location map of all the reported thermal springs and wells in Arizona. The map (Fig. 2) also shows major Basin and Range faults and the location of areas examined in this report.

Most of the wells and springs are located on the downthrown sides of faults in Basin and Range lowlands. Many of these occurrences were located on

county geologic maps, where it was determined that most occurrances are associated with Quaternary basalt. The most active thermal area, which also shows the highest geochemical temperatures, is located in southeastern Arizona in a region of Cenozoic volcanism.

Thermal activity on the Colorado Plateau is sparse. There are no thermal springs near the San Francisco volcanic field; but this does not rule out the possibility of anomalous heat at depth, as reservoir rocks may be deeply buried and the overlying extensive groundwater system could have a cooling effect on any hydrothermal leakage (Harshbarger, 1972)



Heat Flow in the Basin and Range of Arizona

Fig. (1)

From (Warren, et al, 1969)
(Roy et al, 1968)

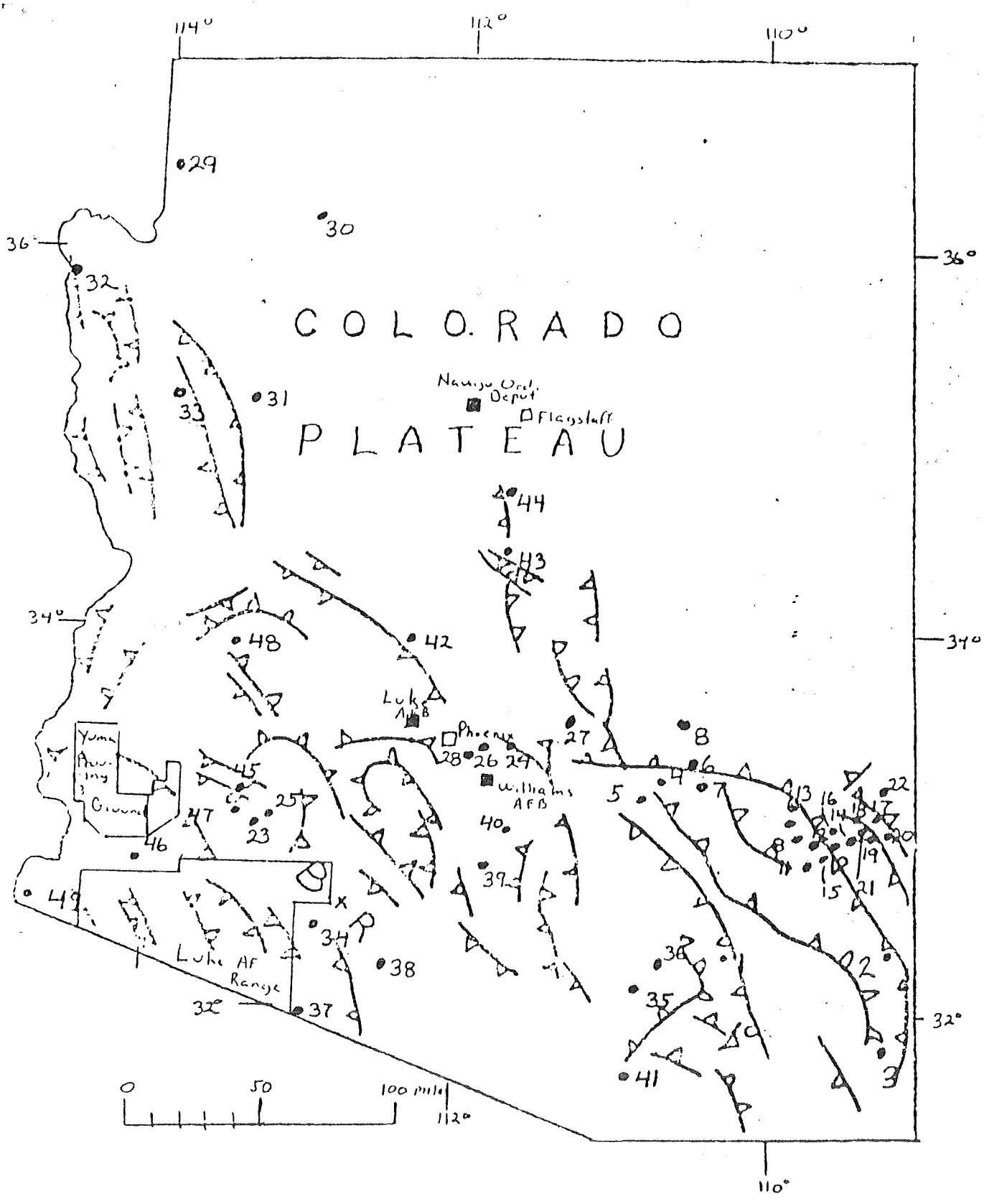


Fig. (2)

Hot Springs and Wells of Arizona with Major Basin and Range Faults

To accompany Table 1

Evaluation of Military Property for Geothermal Potential

On June 23 and 24, 1977 this writer visited the offices of the Arizona State Land Department and the Arizona Oil and Gas Commission in Phoenix. The State Land Department has made a study of the state owned lands of Arizona in order to outline areas of favorable geothermal potential. The Oil and Gas Commission maintains files on deep wells drilled in Arizona. Well logs and correspondence from two geothermal test wells drilled near Williams Air Force Base were released from these files on August 25, 1975. Much of the information contained in this report is from these two sources.

The Cerro Prieto geothermal field in Mexico was used as a model by the State Land Department in assessing the geothermal potential of state lands. Cerro Prieto is located in a basin-range tectonic environment. This field occurs at the intersection of two Quaternary lineations and is associated with a gravity low and a magnetic high.

Dr. L.R. Lepley, then with the University of Arizona, mapped Quaternary lineations in the Basin and Range of Arizona from ERTS imagery. On this basis he designated broad areas of the state as potentially favorable. Jack Conley of the Arizona Oil and Gas Commission also marked broad areas as potentially favorable on the basis of faulting and the presence of Quaternary basalt. The areas marked by the two different methods had fairly good agreement.

The Energy and Minerals Division of the State Land Department then plotted and contoured over 300 thermal gradients. It was found that springs and wells on the downthrown sides of Lepley's Quaternary faults generally were hotter than those on the upthrown sides.

Overlay maps of geology, gravity, aeromagnetics, and Quaternary lineations were then prepared at the same scale as the gradient maps. From this information, eight sites were selected as favorable. To be chosen as favorable, an area must:

1. Have a high thermal gradient
2. Be geophysically anomalous
3. Lie in an area of intersecting lineations
4. Be reasonably close to recent volcanic activity.

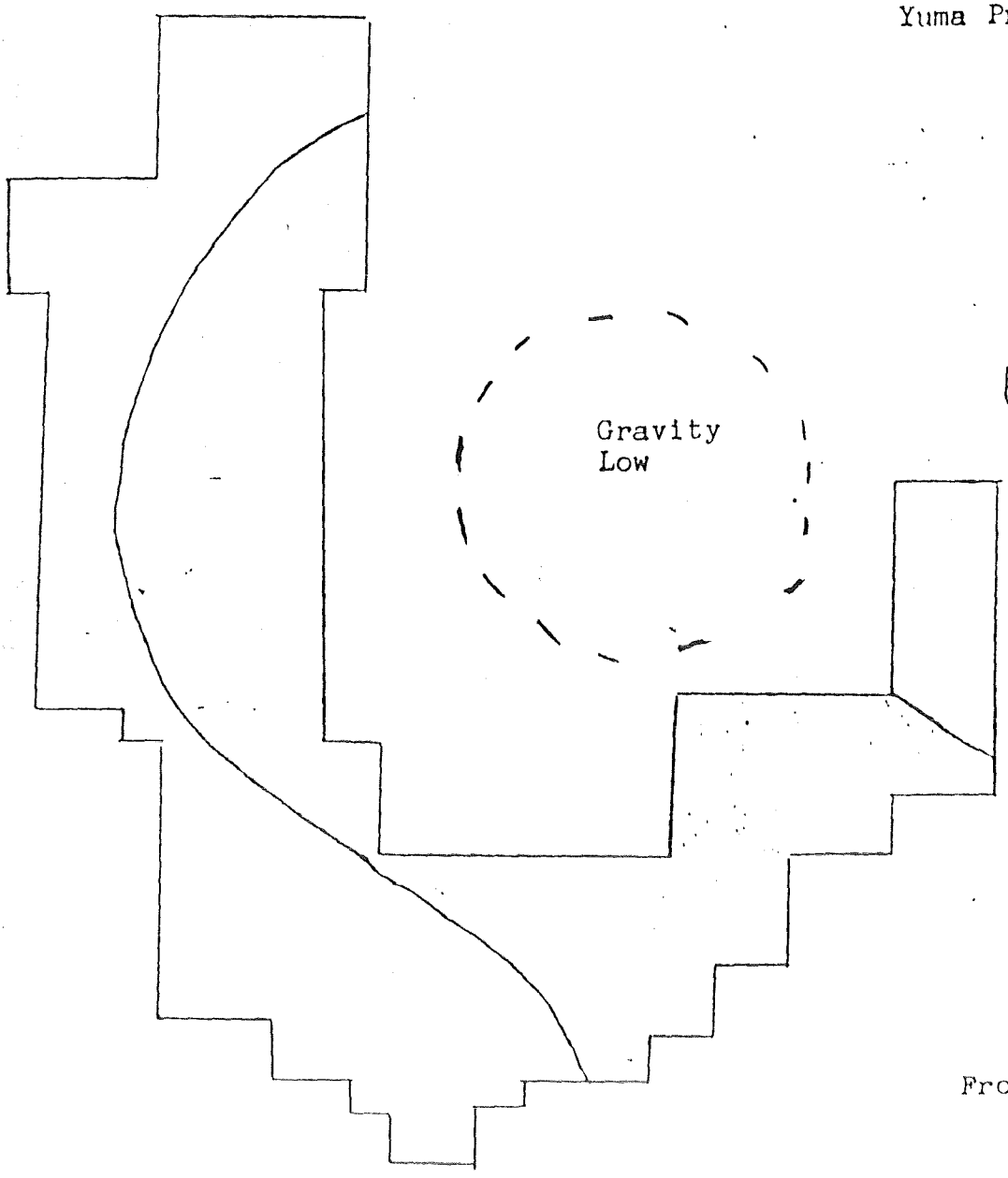
Yuma Proving Grounds

Yuma Proving Grounds is located in Yuma County, Arizona. (Fig. 3) Radium Hot Spring (#46 on Table 1) is located to the south of this area. These springs have gone dry.

Overlay

Areas Thought to have
General Geothermal Potential

Yuma Proving Ground, Ariz



University of
Arizona

From (Doss, 1975)

Fig. (3a)

Geology of Yuma Proving Ground,
Yuma Co. Ariz.

From (Wilson, et al)

Quaternary basalt

Tertiary igneous rocks

Older than Tertiary, includes Sedimentary, igneous and metamorphic

Fig (3)

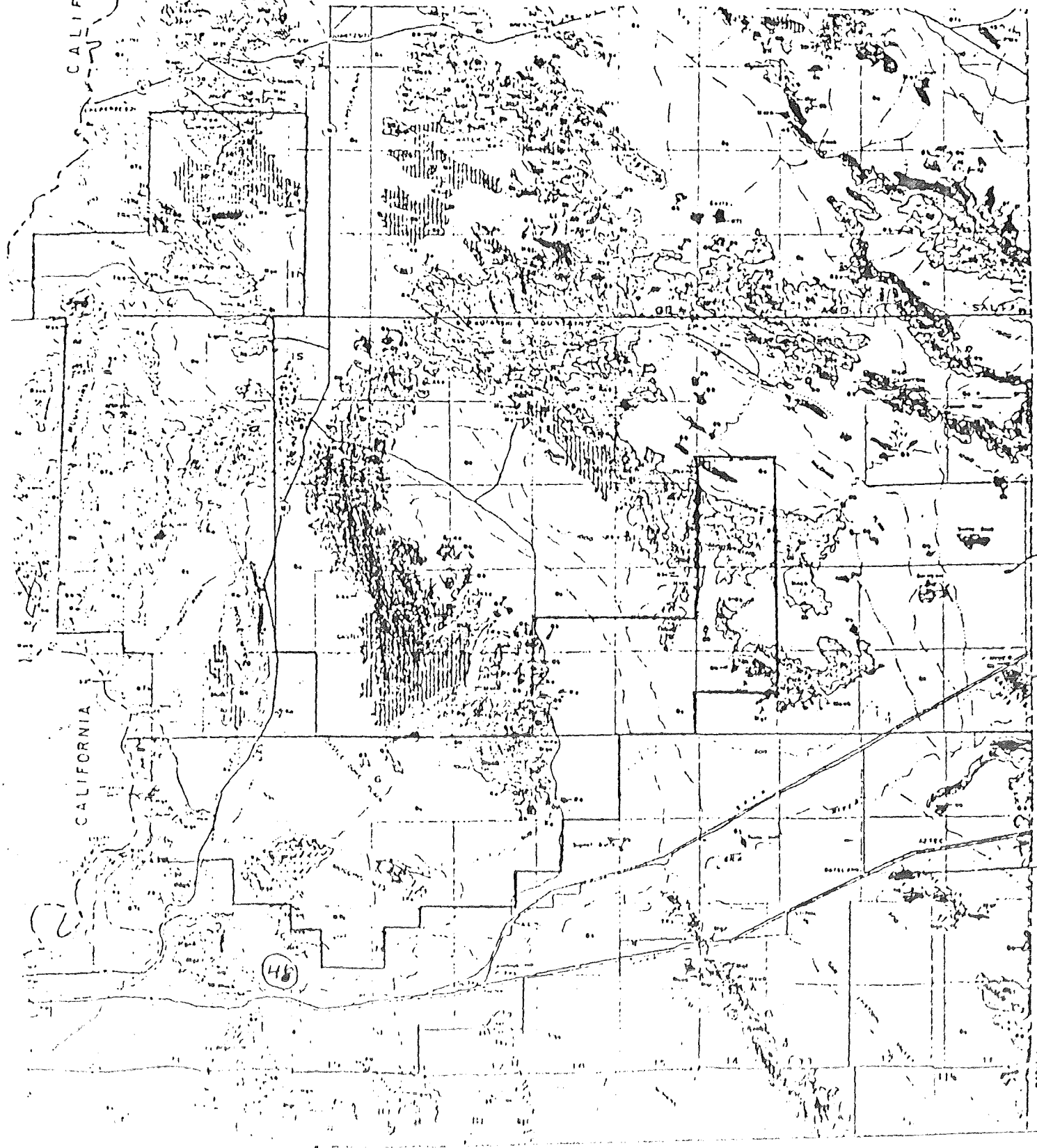


Fig. (5) is a thermal gradient map of the Agua Caliente Hot Spring area, located north of Luke Air Force Range. The Arizona State Land Department has designated this area as a potentially favorable geothermal site. The high gradients follow the drainage of the Gila River and never cross the northern boundry of the Range. These high gradients are associated with a magnetic high to the southwest and a minor gravity low located over Agua Caliente Hot Spring. Intersecting Quaternary lineations also characterize this site. Wells and springs in this area are reported to be of low yield and of unsufficient quality to be used in locomotive boilers (Ross, 1923).

The springs at Quitobaquito issue from crystalline rocks, near the Mexican border and east of Luke Air Force Range. There is no recognizable fault control. Bryan (1925) suggests that these springs originate from a single fracture along which waters circulate, to eventually surface from joints. If this were true, the system probably does not extend onto Luke Air Force Range.

Recommendations

The potential for space heating on Luke Air Force Range in considered to be poor. Geology eliminates most of the area as undesirable. A heat source associated with the Quaternary basalt flows in the eastern portion appears to be located 5 to 10 miles north of the northern border of the range. It is suggested that communication be established with the Arizona Oil and Gas Commission in order to keep abreast of exploration efforts in the Agua Caliente area.

The area west of Quitobaquito could be examined if a need for space heating developed in that area. It is suggested that geophysical techniques be incorporated with hydrologic studies to delineate the fracture system of this spring.

Luke Air Force Base

Luke Air Force Base is located northwest of Phoenix in Maricopa County, Arizona (Fig. 6). Luke Auxiliary Field, #6, is located ten miles southwest of the main base, as shown on Fig. (7).

Luke Air Force Base is located on a broad Tertiary basin filled with Quaternary alluvium and Tertiary evaporites. There are no outcrops near the base..

Fig. (7) is a thermal gradient map of the Luke Air Force Base area. An elongate northeast trending anomally is located southeast of Luke Auxiliary Field #6. Along this northeast trend there are two wells with high gradients, one located south of the main base with a gradient of 8.2 and one located east of the base with a gradient of 8.5. It's possible that these three anomalous areas are controlled by a single fracture or fault.

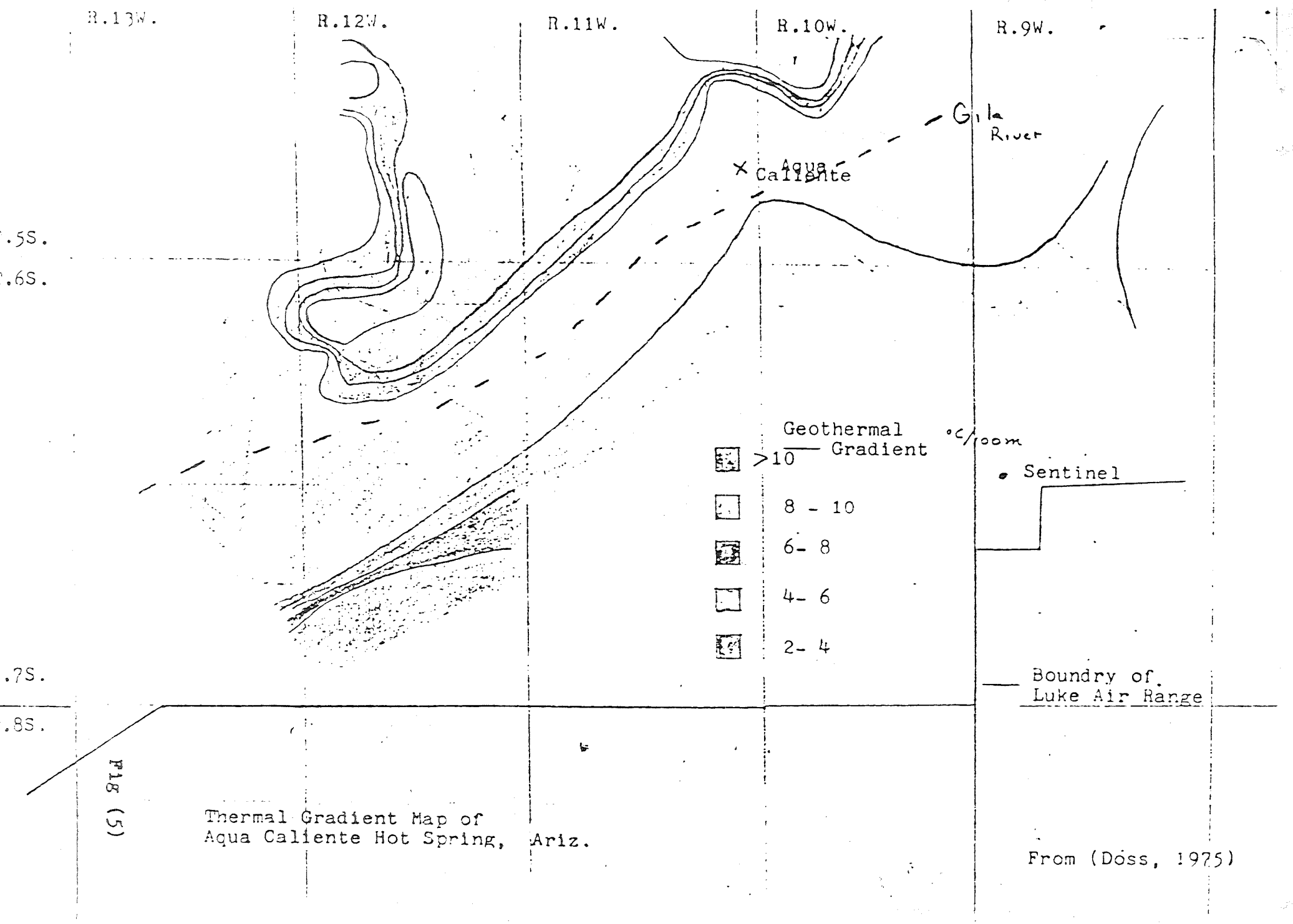


Fig (5)

Thermal Gradient Map of Aqua Caliente Hot Spring, Ariz.

From (Doss, 1975)

Geology of Williams and Luke Air Force Bases, Maricopa Co., Ariz.

From (Wilson, et al)

Quaternary basalt

Tertiary igneous rocks

Older than Tertiary, includes Sedimentary, igneous, and metamorphic

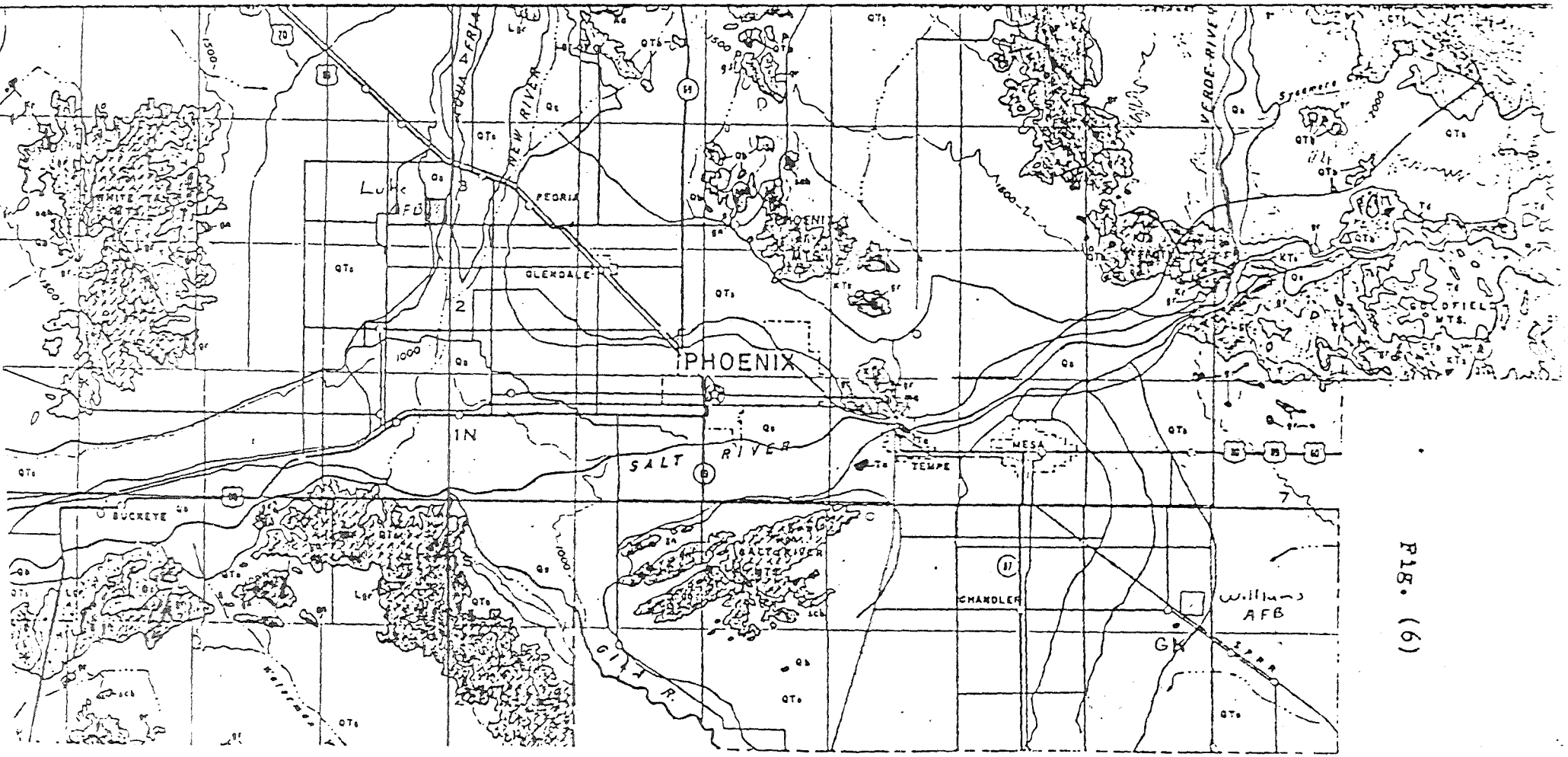


Fig. (6)

Wilson, Eldred D.; Moore, Richard T.; and Pierce, H. Wesley, 1959, Geologic Map of Maricopa County, Arizona: Arizona Bur. Mines

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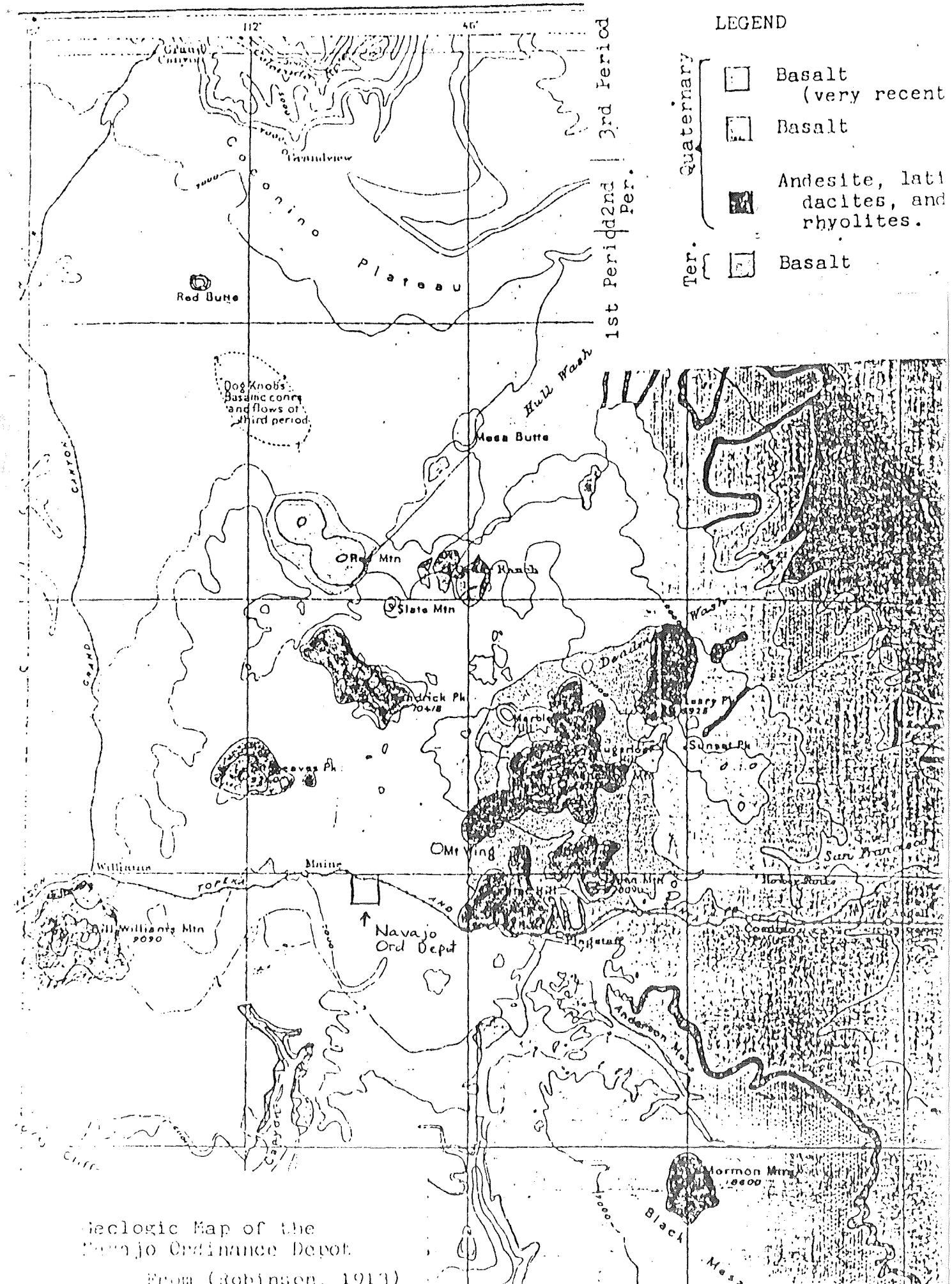
Wilson, Eldred D., 1960, Geologic Map of Yuma County, Arizona: Arizona Bur. Mines

Further information on TR #1 and TR #2, drilled by Geothermal Kinetics south of Williams Air Force Base, may be found in files #605 and #611 of the Arizona Oil and Gas Commission.

This writer would like to thank Mr. A.K. Doss and Mr. John P. Kellog of the Energy and Minerals Division of the Arizona State Land Department for their assistance and for permission to copy information from Mr. Doss' unpublished report.



Geologic Map of the
Navajo Ordinance Depot
From (Robinson, 1913)

It is recommended that communication be established with Geothermal Kinetics in order to obtain geophysical data and well test information. The address is:

Mike O' Donnell - Vice President
301 West Indian School Rd. Suite 117
Phoenix, Arizona 85013
602-248-0202

Navajo Ordinance Depot

The Navajo Ordinance Depot is located west of Flagstaff, Arizona in the San Francisco volcanic field (Fig. 16). Silicic volcanic centers are found east, west and north of the site. Ten miles to the northeast lie the San Francisco Mountains. White and Williams (1975) place the last rhyolitic eruption at 2×10^5 years and the last eruption of basalt at 800 years from this center. To the north lie Kendrick and Sitgreaves Peaks which last erupted silicic rocks 1.4×10^6 and 2.6×10^6 years ago, respectively. Fifteen miles to the west is Bill Williams Mountain. This center last erupted silicic rocks 3.5×10^6 years ago. White and Williams (1975) state that this center is probably too old, with respect to its size, to be reguarded as favorable.

The San Francisco volcanic field is underlain by an extensive groundwater system. This area recharges aquifers of the Plateau Uplands to the north and the Basin and Range lowlands to the south (Harshbarger, 1972). There are no surface indications of subsurface heat, but reservoir rocks may be deeply buried and the overlying groundwater could be cooling leaking hydrothermal fluids.

Recommendations

The geologic setting of the Depot within the San Francisco volcanic field is clearly not the most promising in the area. Much of the information which is needed to make a judgement of the geothermal potential of the Navajo Ordinance Depot is lacking. The USGS is studying the San Francisco field, and recommendations should rest on their work.

Conclusion

Williams Air Force Base is the most promising of all the areas studied in this report. Space heating potential may exist on Luke Air Force Base. Should either area be tested by drilling, Arizona Statute ARS 45-305 would apply. This statute pertains to notice to drill a well for water purposes. Notification should be made to:

Dr. Joe Nelling - Director
Water Rights Division
State Land Department
1624 W. Adams
Phoenix, Arizona 85007

ARIZONA TESTING LABORATORIES

A DIVISION OF CLAUDE E. McLEAN & SON LABORATORIES, INC.
817 WEST MADISON ST. PHOENIX, ARIZONA 85007 PHONE 254-6181

For: Geothermal Kinetics
301 West Indian School Road
Phoenix, Arizona 85013

Date: March 27, 1973

Lab. No.: 4059

Sample: Water

Marked:

Received: ---

Submitted by: Same

REPORT OF LABORATORY TESTS

GKSC #1 Power	0956 hrs. just at end of blow	1236 hrs. near end of blow
Total Dissolved Solids	18,300	17,900
Lithium	15	15
Fluorides	5.4	5.4
Calcium	470	450
Magnesium	4	4
Potassium	94	94
Sodium	6,300	5,900
Chlorides	9,250	9,250
Carbonates	0	0
Bicarbonates	20	15
Sulphates	2,150	2,150
Nitrates		
Boron	8	8
pH	7.2	6.9
Hydroxide		
Total Hardness as $CaCO_3$	123	125

less
*Lt= than

Respectfully submitted,

ARIZONA TESTING LABORATORIES

Claude E. McLean, Jr.

Fig (14)

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APR 2 1973

ARIZONA TESTING LABORATORIES

A DIVISION OF CLAUDE E. McLEAN & SON LABORATORIES, INC.
817 WEST MADISON ST. PHOENIX, ARIZONA 85007 PHONE 254-6181

For: Geothermal Kinetics
301 West Indian School Road
Phoenix, Arizona 85013

Date: March 27, 1973

Lab. No.: 4059

Sample: Water

Marked: ---

Received: ---

Submitted by: Same

REPORT OF LABORATORY TESTS

GKSC #L Power Tr @ 6163 ft Sample taken with fluid level at 4183 ft air drilling only.	0230 hrs. 2nd blow 22 stands off bottom	0835 hrs. just after blow	0900 hrs. 3/4 point in blow and at end
Total Dissolved Solids	17,000	16,100	18,200
Lithium	15	14	16
Fluorides	5.0	5.2	5.5
Calcium	460	450	450
Magnesium	1	4	4
Potassium	93	84	93
Sodium	5,600	5,300	6,100
Chlorides	8,700	8,350	9,250
Carbonates	48	0	0
Bicarbonates	0	12	22
Sulphates	1,970	1,870	2,280
Nitrates	*Lt 1		
Boron	7	7	8
pH	10.0	5.7	7.5
Hydroxide	1		
[illegible] temp.	125	123	123

*Lt = less than

Respectfully submitted,

ARIZONA TESTING LABORATORIES

Claude E. McLean, Jr.

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APR [illegible] 1973

Fig (13)

WELL COMPLETION OR RECOMPLETION REPORT AND LOG

GEOTHERMAL RESOURCE WELL

DESIGNATE TYPE OF COMPLETION: Status: Testing

NEW WELL ☐ WORK OVER ☐ DEEPEN ☐ PLUG BACK ☐ SAME RESERVOIR ☒ DIFFERENT RESERVOIR ☐ DRY STEAM ☐ HOT WATER ☐ DRY ☐

DESCRIPTION OF WELL AND LEASE

OPERATOR: Geothermal Kinetics Inc.	ADDRESS: 301 W. Indian School Road, #117 Phoenix, Arizona 85013
FEDERAL, STATE OR INDIAN LEASE NUMBER OR NAME OF LESSOR IF FEE LEASE: Power Ranches Inc.	WELL NUMBER: 2 FIELD & RESERVOIR: Power Geothermal Prospect
LOCATION: 1980'S & 660'W of the NE Cor. Sec.1, T2S, R6E	COUNTY: Maricopa
SEC. TWP-RANGE OR BLOCK & SURVEY: 1 T2S R6E	

DATE SPUDDED	DATE TOTAL DEPTH REACHED	DATE COMPLETED, READY TO PRODUCE	ELEVATION (DF, RKB, RT OR GR.)	ELEVATION OF CASING HD. FLANGE
5-13-74	8-23-73	testing	1356 K B FEET	FEET

TOTAL DEPTH	P.B.T.D.	AIRDRILLED (INTERVAL)	FLUIDDRILLED (INTERVAL)
10454 ft.	-	none	mud 0-5400 (then to T.D. Water 5400 -

PRODUCING INTERVAL (S) FOR THIS COMPLETION	ROTARY TOOLS USED (INTERVAL)	CABLE TOOLS USED (INTERVAL)
	0 to 10434	-

WAS THIS WELL DIRECTIONALLY DRILLED?	WAS DIRECTIONAL SURVEY MADE?	WAS COPY OF DIRECTIONAL SURVEY FILED?	DATE FILED
no	Totco only	no	

TYPE OF ELECTRICAL, TEMPERATURE, CEMENT BOND OR OTHER LOGS RUN (CHECK LOGS FILED WITH THE COMMISSION): BHC Acousticlog, Temp. Log GRN, I.E., — DATE FILED:

CASING RECORD

CASING (REPORT ALL STRINGS SET IN WELL-CONDUCTOR, SURFACE, INTERMEDIATE, PRODUCING, ETC.)

PURPOSE	SIZE HOLE DRILLED	SIZE CASING SET	WEIGHT (LB./FT.)	DEPTH SET	SACKS CEMENT	AMT. PULLED
Surface	26"	20"	94#	197'	930 sx	2% CaCl
Intermed	17½"	13⅜"	61# 72# 54.5# 68#	surface - 3704	1700 sx	30% SiO2
Top of Pay	12¼"	9⅝"	47#	2537 to 5400	813 sx	30% SiO2 3% CaCl
Pay Zone	8½"	7"		Manu slotted 7253 to 10729	250 sx	30% SiO2 3% CaCl 1% DAX

TUBING RECORD			LINER RECORD				
SIZE	DEPTH SET	PACKER SET AT	SIZE	TOP	BOTTOM	SACKS CEMENT	SCREEN (FT.)
- IN.	- FT.	- FT.	- IN.	- FT.	- FT.	-	-

PERFORATION RECORD			ACID, SHOT, FRACTURE, CEMENT SQUEEZE RECORD	
NUMBER PER FT.	SIZE & TYPE	DEPTH INTERVAL	AMT. & KIND OF MATERIAL USED	DEPTH INTERVAL
-	-	-	-	-

INITIAL PRODUCTION testing

DATE	STATIC TEST SHUT IN WELL HEAD		ANALYSES OF FLUIDS & GASES								
			TOTAL MASS FLOW DATA					SEPARATOR DATA			
	TEMP. °F	PRES. PSIG.	LBS./HR	TEMP. °F	PRES. PSIG.	ENTHALPY	ORIFICE	WATER CU.FT./HR	STEAM LBS./HR	PRES. PSIG.	TEMP. °F

CERTIFICATE: I, THE UNDERSIGNED, UNDER THE PENALTY OF PERJURY, STATE THAT I AM THE Exec, Vice Pres, OF THE Geothermal Kinetics Inc (COMPANY), AND THAT I AM AUTHORIZED BY SAID COMPANY TO MAKE THIS REPORT; AND THAT THIS REPORT WAS PREPARED UNDER MY SUPERVISION AND DIRECTION AND THAT THE FACTS STATED THEREIN ARE TRUE, CORRECT AND COMPLETE TO THE BEST OF MY KNOWLEDGE.

Feb. 27, 1974 — DATE

Mark McDonald — SIGNATURE

Fig (12)

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O & G CONS. COMM.

STATE OF ARIZONA
OIL & GAS CONSERVATION COMMISSION
WELL COMPLETION OR RECOMPLETION REPORT AND WELL LOG
FILE ONE COPY

Production Specialists

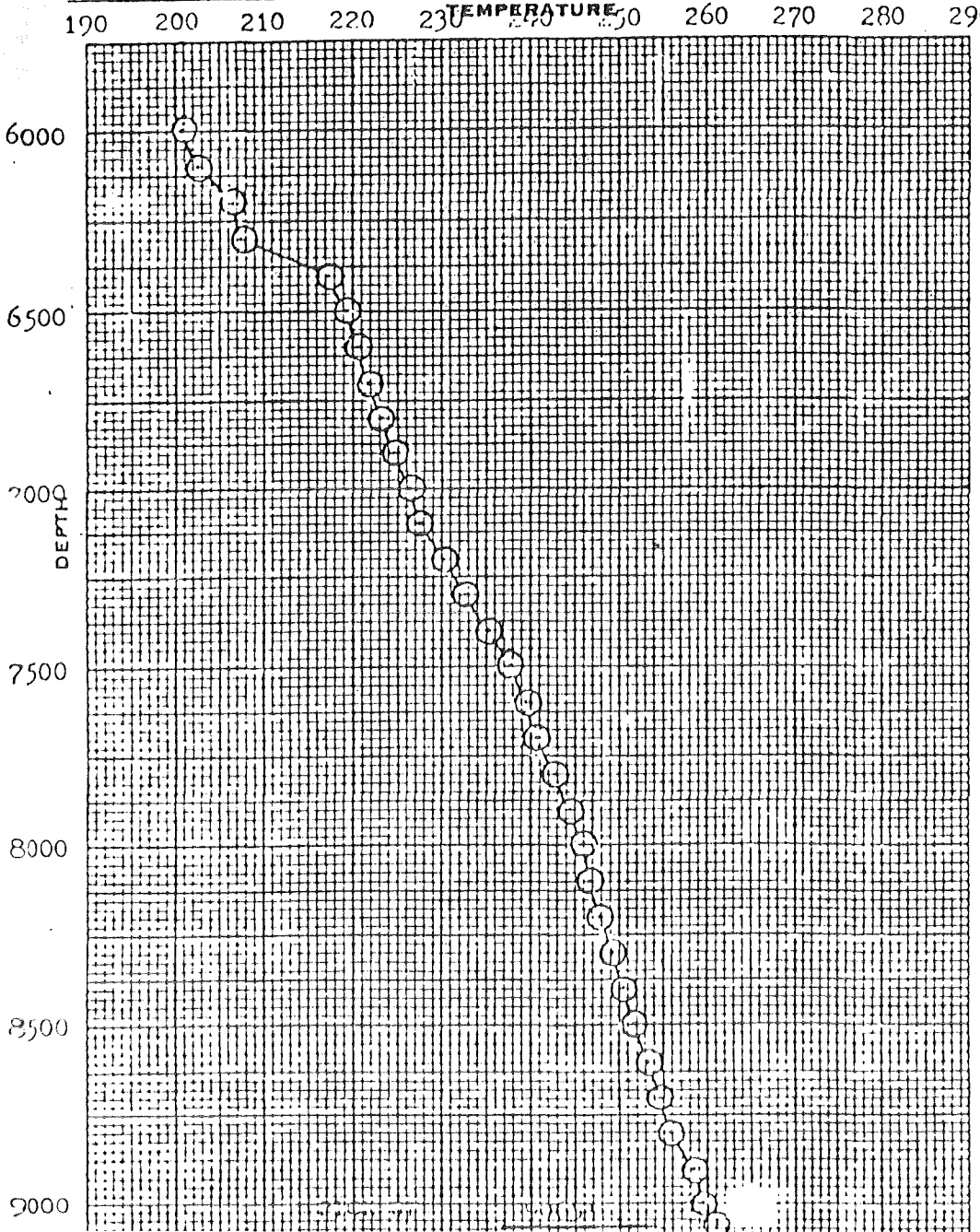
AGNEW AND SWEET

3914 GILMORE AVENUE
BAKERSFIELD, CALIFORNIA
93308

24 HOUR PHONE 327-2
AREA CODE 805

SUBSURFACE TEMPERATURE SURVEY

OWNER GEOTHERMAL KINETICS
FIELD HIGLEY
WELL NAME POWERS NO. 1
CASING
ELEV.
DATE MARCH 24, 1973
LINER DESCRIPTION:
ZERO POINT AT KELLEY
DEPTH 9065'
ZONE
TUBING DETAIL: None
INSTRUMENT 96° - 662°
SERIAL NO 10025
PUMP SHOE GAS ANCHOR INTAKE:
12 Hour 7½ Turns
PURPOSE STATIC TEMPERATURE GRADIENT SURVEY
MAX. TEMP. 261.0 °F @ 9065'
REMARKS: PICK UP AT 9065'
STARLIZATION PERIOD
GROSS OIL RATE B D
NET OIL RATE B D
FORMATION GAS MCF D
GOR CFT BBL
CIRCULATED GAS MCF/D
OIL DRY GRAVITY °API



PRESSURES,	OBS	CO
CASING, PSIG	OPEN	OPE
TUBING, PSIG		

DEPTH	TEMP.	DEPTH	T
6000	200.7	7600	23
6100	202.6	7700	24
6200	206.6	7800	24
6300	207.5	7900	24
6400	217.3	8000	24
6500	219.4	8100	24
6600	220.6	8200	24
6700	221.9	8300	24
6800	223.4	8400	25
6900	224.6	8500	25
7000	226.2	8600	25
7100	227.7	8700	25
7200	230.2	8800	25
7300	232.7	8900	25
7400	235.2	9000	25
7500	237.9	9065	26

TIME ON BOTTOM
12:26 A.M. 3-25-73
TIME OFF BOTTOM
1:26 A.M. 3-25-73

Fig (11)
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APR 2[illegible] 1973
O & G CONS. COM.

WELL CO[illegible]ON OR RECOMPLETION REPORT A[illegible] LOG
GEOTHERMAL RESOURCE WELL

DESIGNATE TYPE OF COMPLETION:

NEW WELL ☒ WORK OVER ☐ DEEPEN ☐ PLUG BACK ☐ SAME RESERVOIR ☐ DIFFERENT RESERVOIR ☐ DRY STEAM ☐ HOT WATER ☒ DRY ☐

DESCRIPTION OF WELL AND LEASE

OPERATOR: Geothermal Kinetics Inc.	ADDRESS: Suite 117, 301 West Indian School, Phoenix, Ariz. 85013
FEDERAL, STATE OR INDIAN LEASE NUMBER OR NAME OF LESSOR IF FEE LEASE	WELL NUMBER: 1 — FIELD & RESERVOIR: Power Geothermal Prospect
LOCATION: 1980 ft N. & 660 ft W. of SE cor	COUNTY: Maricopa
SEC. TWP-RANGE OR BLOCK & SURVEY: 1 T2S R6E	

DATE SPUDDED	DATE TOTAL DEPTH REACHED	DATE COMPLETED, READY TO PRODUCE	ELEVATION (DF, RKB, RT, OR GR.) FEET	ELEVATION OF CASING HD. FLANGE FEET
Jan 31, 1973	April 8, 1973		1358 KB	

TOTAL DEPTH	P.B.T.D.	AIRDRILLED (INTERVAL)	FLUIDDRILLED (INTERVAL)
9207 ft.		5404-6153	0-5404 mud; 6153 to 9207 aerated water

PRODUCING INTERVAL (S) FOR THIS COMPLETION	ROTARY TOOLS USED (INTERVAL)	CABLE TOOLS USED (INTERVAL)
6167 - 8998'	Entire Hole	

WAS THIS WELL DIRECTIONALLY DRILLED?	WAS DIRECTIONAL SURVEY MADE?	WAS COPY OF DIRECTIONAL SURVEY FILED?	DATE FILED

TYPE OF ELECTRICAL, TEMPERATURE, CEMENT BOND OR OTHER LOGS RUN (CHECK LOGS FILED WITH THE COMMISSION): IES, Gamma Ray Neutron, Cement Bond, Temp., Acoustic — DATE FILED:

CASING RECORD

CASING (REPORT ALL STRINGS SET IN WELL-CONDUCTOR, SURFACE, INTERMEDIATE, PRODUCING, ETC.)

PURPOSE	SIZE HOLE DRILLED	SIZE CASING SET	WEIGHT (LB./FT.)	DEPTH SET	SACKS CEMENT	AMT. PULLED
Surface	26"		41#	0-204'	400 sx	1% CaCl
Intermed	17½"	13⅜"	48#	0-3117'	2050 sx	30% SiO2
Set on Top Pay	12¼"	9⅝"	40#	2903-5404	650 sx	30% SiO2 - [illegible]
Blank Prod Liner	8½"	7"	29#	5201-9064	825 sx	20% SiO2 - 1% 7-[illegible] 849 [illegible] 6% [illegible]

TUBING RECORD			LINER RECORD				
SIZE IN.	DEPTH SET FT.	PACKER SET AT FT.	SIZE IN.	TOP FT.	BOTTOM FT.	SACKS CEMENT	SCREEN (FT.)

PERFORATION RECORD			ACID, SHOT, FRACTURE, CEMENT SQUEEZE RECORD	
NUMBER PER FT.	SIZE & TYPE	DEPTH INTERVAL	AMT. & KIND OF MATERIAL USED	DEPTH INTERVAL
20 bullets		6154-6174	4 bullets 6360-6363	8 jets 8148-8152
21 bullets		6212-6232	8 bullets 6314-6322; 10 jets 6140-6150	8 jets 7752-7760; 8 jets 7006-7014
25 bullets		6323-6347	10 jets 6174-6184	4 jets 6309-6313; 2 jets 6167-6168; 4 jets 8998

INITIAL PRODUCTION

ANALYSES OF FLUIDS & GASES: Testing

DATE	STATIC TEST SHUT IN WELL HEAD		TOTAL MASS FLOW DATA					SEPARATOR DATA			
	TEMP. °F	PRES. PSIG.	LBS./HR	TEMP. °F	PRES. PSIG.	ENTHALPY	ORIFICE	WATER CUFT/HR	STEAM LBS/HR	PRES. PSIG.	TEMP. °F

CERTIFICATE: I, THE UNDERSIGNED, UNDER THE PENALTY OF PERJURY, STATE THAT I AM THE Exec. Vice Pres. OF THE Geothermal Kinetics Inc. (COMPANY), AND THAT I AM AUTHORIZED BY SAID COMPANY TO MAKE THIS REPORT; AND THAT THIS REPORT WAS PREPARED UNDER MY SUPERVISION AND DIRECTION AND THAT THE FACTS STATED THEREIN ARE TRUE, CORRECT AND COMPLETE TO THE BEST OF MY KNOWLEDGE.

February 27, 1974 — DATE

Mike O'Donnell — SIGNATURE

Fig (10)

RECEIVED [illegible] 1974 O & G CONS. COMM.

PERMIT NO. 605

STATE OF ARIZONA
OIL & GAS CONSERVATION COMMISSION
WELL COMPLETION OR RECOMPLETION REPORT AND WELL LOG
FILE ONE COPY
FORM NO. G-4

(COMPLETE REVERSE SIDE)

Company, Arizona Public Service Company, and the Salt River Project, drilled the first of two geothermal test wells southwest of Williams Air Force Base on farmlands owned by Power Ranches Inc. This well reached a TD of 9207 feet. It is marked on Fig. (9) as PK. The well completion report filed with the Oil and Gas Commission is included as Fig. (10).

A report on file with the Oil and Gas Commission dated April 27, 1973 reports the permeability in this well as good, with a fluid rate of 3000-6000 gallons per minute and a porosity of 30% from 5300-9065 feet. This report gives the bottom hole temperature as 325 F° and rising. Steam flashing commenced at 5400 feet and continued to 9065 feet. Permeability decreased below 9065 feet.

Fig. (11) is a subsurface temperature survey of this hole made on March 24, 1973. This survey recorded a maximum temperature of 261 F° at 9065 feet.

After a year of testing, the Arizona Republic (a newspaper) reported on April 11, 1974 that this well was shut down "because of its failure to yield steam and hot water in commercial quantity".

A second test well was drilled ½ mile north of Power Ranches #1. This well reached a TD of 10,454 feet. The completion report for this well is included as Fig. (12). The highest reported temperature for this well was 365 F°.

The following Table summarizes the lithology encountered in the two test holes. This information was taken from a copyrighted lithologic log prepared by the American Stratigraphic Company.

Table 2

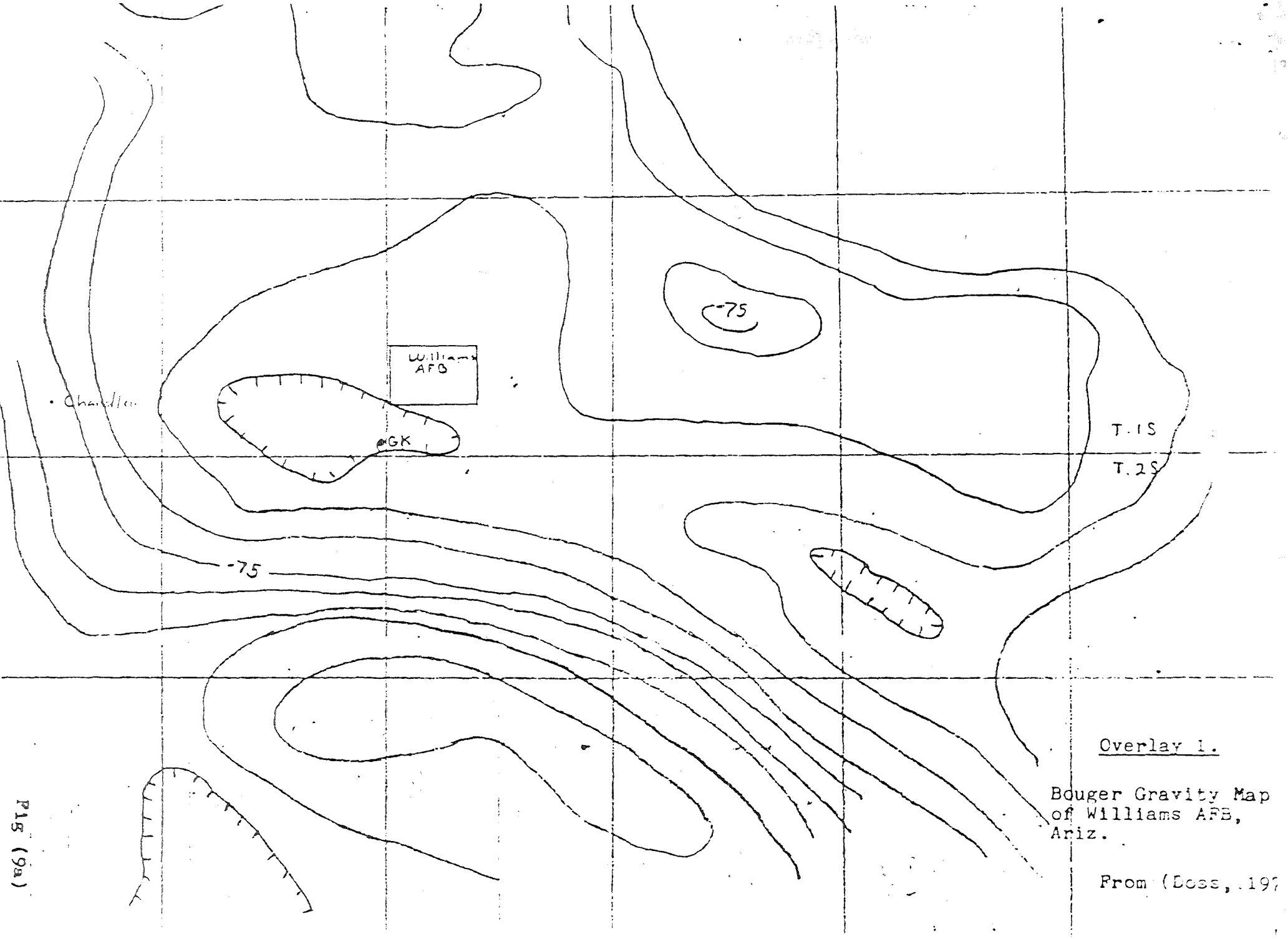
PR#1	Lithologic Log	PR#2
0-1080	Quaternary (ss, sltstn, cong)	0-1113
1080-2298	Tertiary (clays)	1113-2293
2298-6000	Tertiary (evap.)	2293-6612
6000-9160	Volcanics	6612-10,440
Gabbro	Basement	Granite

Figs. (13-15) are water analyses from PR#1 filed with the Arizona Oil and Gas Commission

Recommendations

Definite potential exists for geothermal space heating on Williams Air Force Base. Geothermal power production potential is considered good.

White and Williams (1975) estimate that a reservoir exists beneath the area of Williams Air Force Base with a volume of 2.5 km^3 and a heat content of 2×10^{17} cal.



Overlay 1.

Bouger Gravity Map of Williams AFB, Ariz.

From (Doss, 197

Pl. 5 (9a)

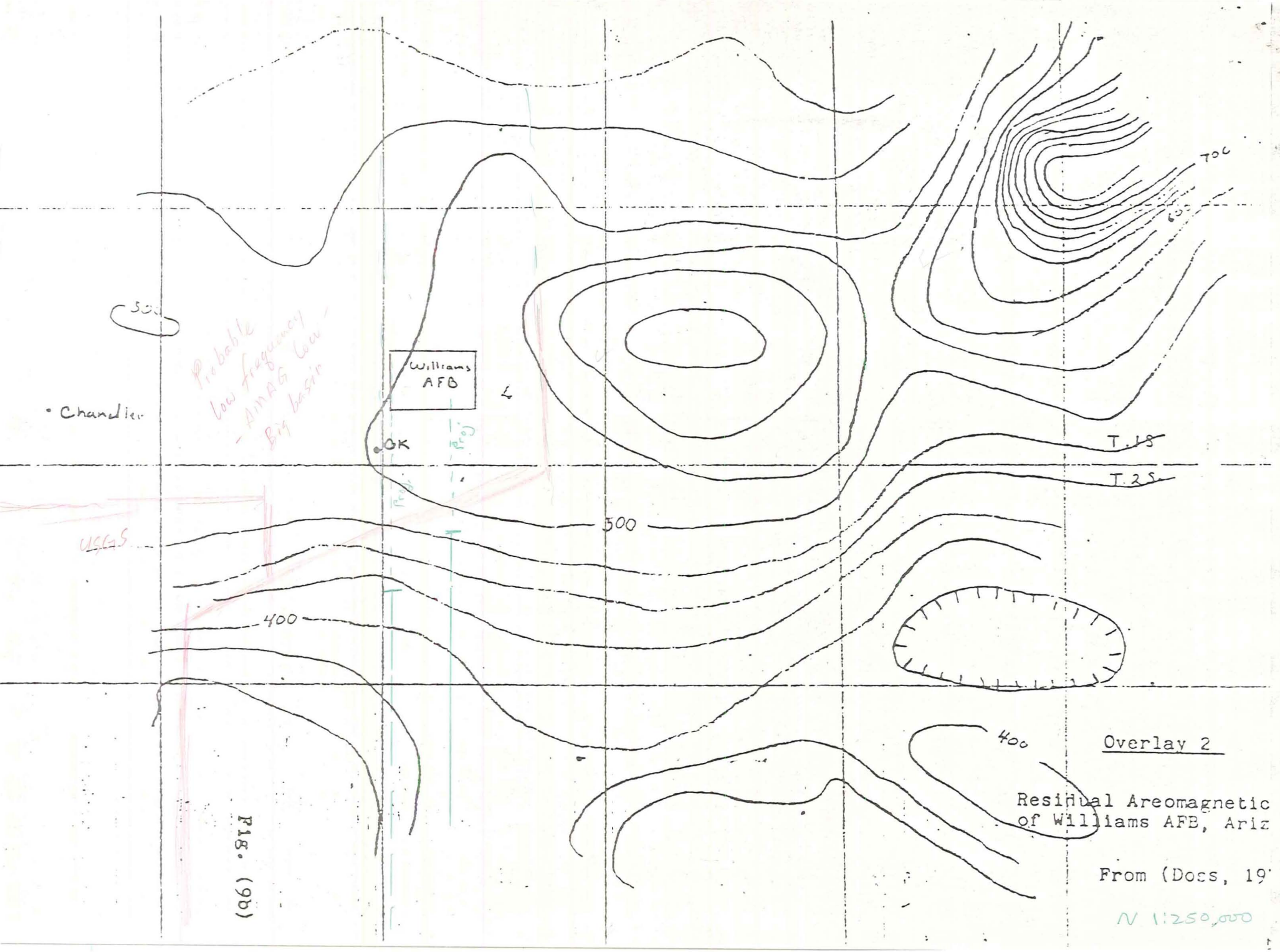


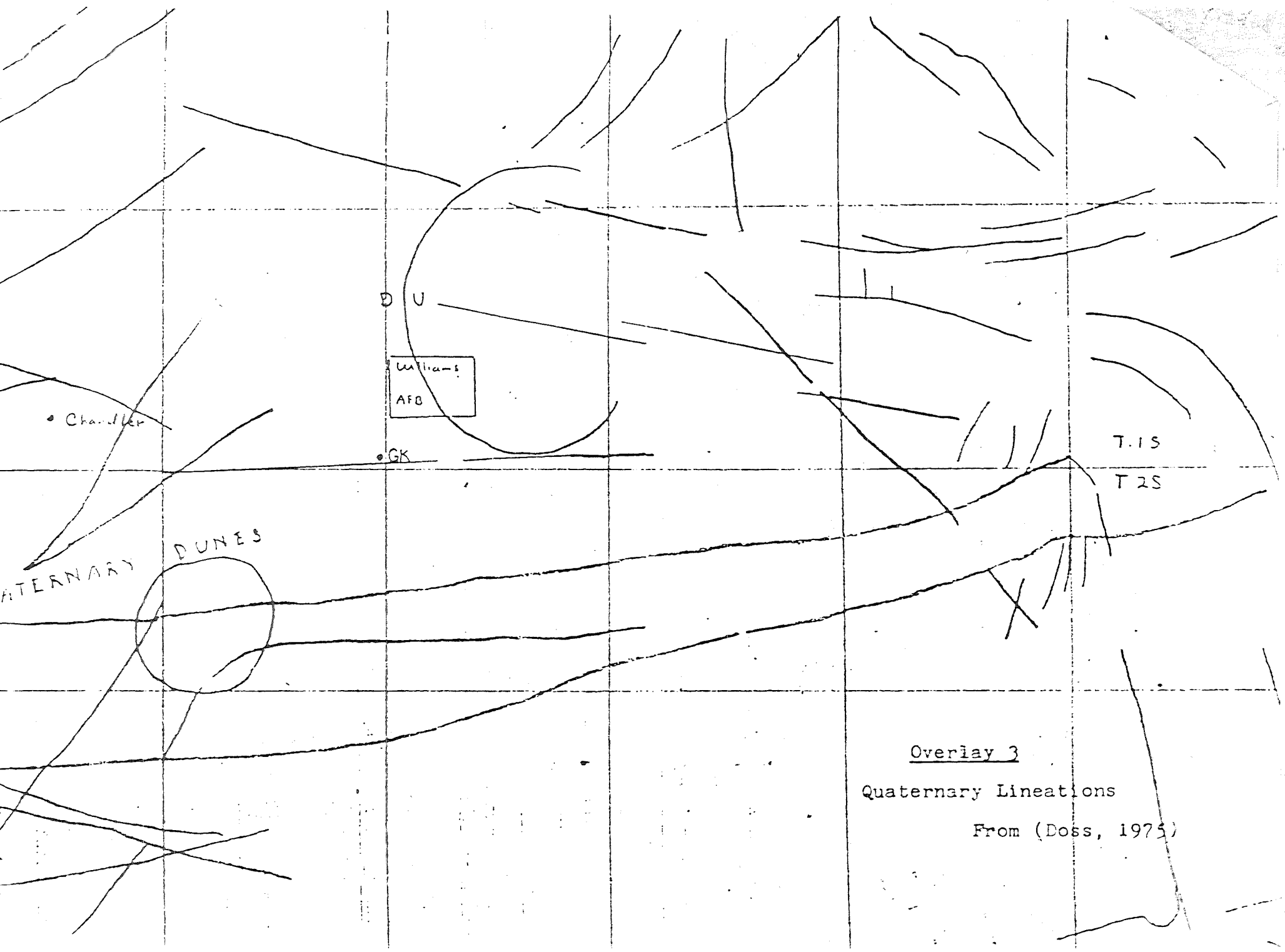
Fig. (96)

Overlay 2

Residual Areomagnetic
of Williams AFB, Ariz

From (Does, 19

N 1:250,000



Overlay 3

Quaternary Lineations

From (Doss, 1975)

Fig (8) is a Bouguer gravity map of the Luke Air Force Base area. The large gravity low is associated with a salt dome. The fault suspected from the thermal gradient data is not apparent on this map.

Recommendations

There are sparse data to indicate that a hot water system may be located beneath Luke Air Force Base. The anomalous trend crosses the southeast portion of the main base, across a zone mapped as 'cool' from thermal gradients drawn by the Arizona State Land Department. It is recommended that the anomalous trend be examined by geophysical methods, and that hydrologic studies be made of area wells.

Williams Air Force Base

Williams Air Force Base is located southwest of Phoenix, in Maricopa County, Arizona. (Fig. 6). A hot spring and two wells drilled near this site are listed in Table 1 as #24, #26, and #28.

Williams Air Force Base is located in a Tertiary basin filled with Quaternary alluvium and Tertiary evaporites. There are no outcrops near the base. The Superstition Mountains volcanic field of Tertiary age is located northeast of the site (Fig. 6).

Fig. (9) is a thermal gradient map of the Williams area. A northeast trending thermal high has been plotted over Williams Air Force Base on the basis of warm wells found to the north and to the south of the base. No wells on the base itself were measured.

Fig. (9a) is a Bouguer gravity map of the Williams area, which shows a gravity low southwest of the base.

Fig. (9b) is a Residual Aeromagnetic map of the same area. This map shows that the thermal anomaly is located at the west end of a southwest trending magnetic high. This high reaches a maximum value of 800 gammas to the northeast.

Fig. (9c) is an overlay of Quaternary lineations mapped from ERTS imagery. This map shows a circular Quaternary fault cutting across Williams Air Force Base. This fault intersects other Quaternary lineaiions both north and south of the base.

This area has been designated by the Arizona State Land Department as a potential geothermal resourse area; based on the high thermal gradient, the anomalous geophysics, and the nature of the Quaternary lineaiions. This area has similar manifestations as the Cerro Prieto field in Mexico.

Exploration History

In 1973 Geothermal Kinetics, acting as operator for Tucson Gas and Electric

R. 3 W.
T. 3 N.

R. 2 W.

R. 1

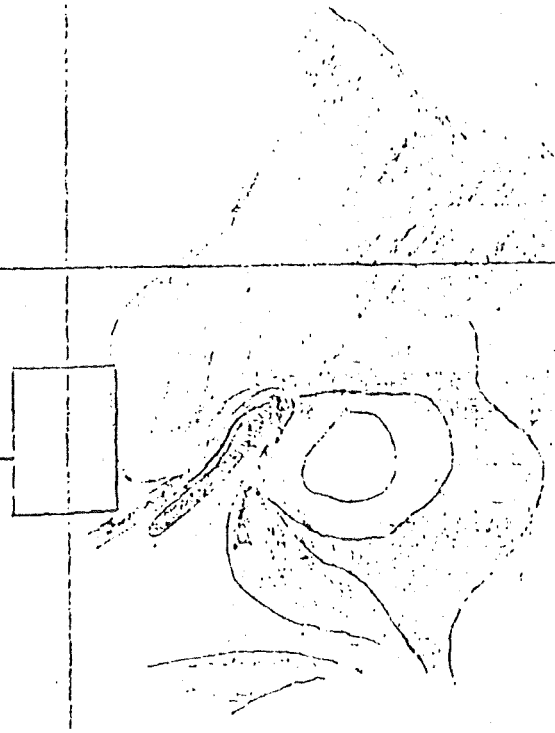
T. 2 N.

Luke
Force B

T. 1 N.

Luke Aux.
Field #6

T. 1 S.



Geothermal Gradient

- > 10
- 8- 10
- 6- 8
- 4- 6
- 2- 4

Thermal Gradient Map of Luke Air Force Base, Ariz.

From (Doss
1

Fig. (7)