

TEC-3

A BRIEF HYDROGEOCHEMICAL STUDY  
OF THE ARAVAIPA AREA, GRAHAM  
AND PINAL COUNTIES, ARIZONA

by

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March 29, 1976  
Amax Exploration, Inc.

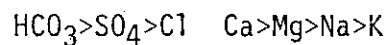
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SUMMARY:

1. The Aravaipa area lies in Graham and Pinal Counties of east-central Arizona. The area contains three warm springs and one warm well.

2. The non-thermal waters of the area generally contain less than 600 mg/l of dissolved solids and an average of 27 mg/l of silica. Cations and anions occur as follows:



3. Thermal waters fall into two groups: bicarbonate-chloride and bicarbonate-sulfate waters. The bicarbonate-chloride waters are the most interesting.

4. Even the best thermal waters of the area are highly diluted with normal groundwater.

4. Subsurface temperatures deduced through the chemistry indicate that all the waters have equilibrated below 100°C.

6. The waters studied have little intrinsic geothermal value. I would, however, recommend that AMAX probe the Superior Oil wells in the future.

INTRODUCTION:

Frank Fritz of Amax Exploration informed the geothermal group of a 3700 foot well drilled by Superior Oil Company, Tucson, in sec. 2 T8S R19E. Charlie Miller of Amax Exploration's Tucson office spoke with Superior Oil on March 25, 1976, and reported the following information: Superior Max 87 was drilled in sec 2 of T8S, R19E to a depth of 3763 feet. A bottom hole temperature of 173°F was measured. I calculate the gradient on this well to be 41°C/km. Superior Max 177 was drilled in sec. 12 of T18S, R19E to a depth of 3502 feet. Bottom hole temperature was 220°F. I calculate the gradient to be 79°C/km. Miller says Superior has gamma ray logs, etc., on the two wells that they will share with us.

I interviewed Ed Lackner, a resident of Klondyke, Arizona, by phone on March 24, 1976, concerning the well in sec. 12. Lackner was employed by the drilling company and has first-hand experience in the drilling. He said, as the drilling proceeded the circulating fluid, "got hot enough for a nice bath". He said the hot zone was not encountered at the bottom of the hole but in the middle. The well was abandoned after the draw-works cable broke on the night crew. Half of the drill string could not be recovered so that the well is no longer 3500 feet deep but about 1500 feet deep.

John Deymonaz visited the well during the summer of 1975. He said that Roy Claridge, one of the three Claridge brothers, large land owners and residents of the area, owns the property. Claridge installed a pump in the well in hopes of recovering stock water. His pump was fouled by mud still present in the hole. He then drilled a 275 foot well a few feet away. The machinery at the shallow well no longer functions. Lackner said he saw the well being pumped two years ago and the water from this 275 foot well was not hot. Deymonaz says that both of these wells can be probed.

#### THERMAL FEATURES

Eleven water samples were collected from the Aravaipa area, Graham and Pinal Counties, Arizona (Figure 1) during July, 1975. Spring and well temperatures range from 27°C at Deer Creek Warm Spring to 19°C at Ranger Station Cold Well. The mean annual temperature is probably about 18 or 19°C. None of the springs or wells deposit salt or sinter.

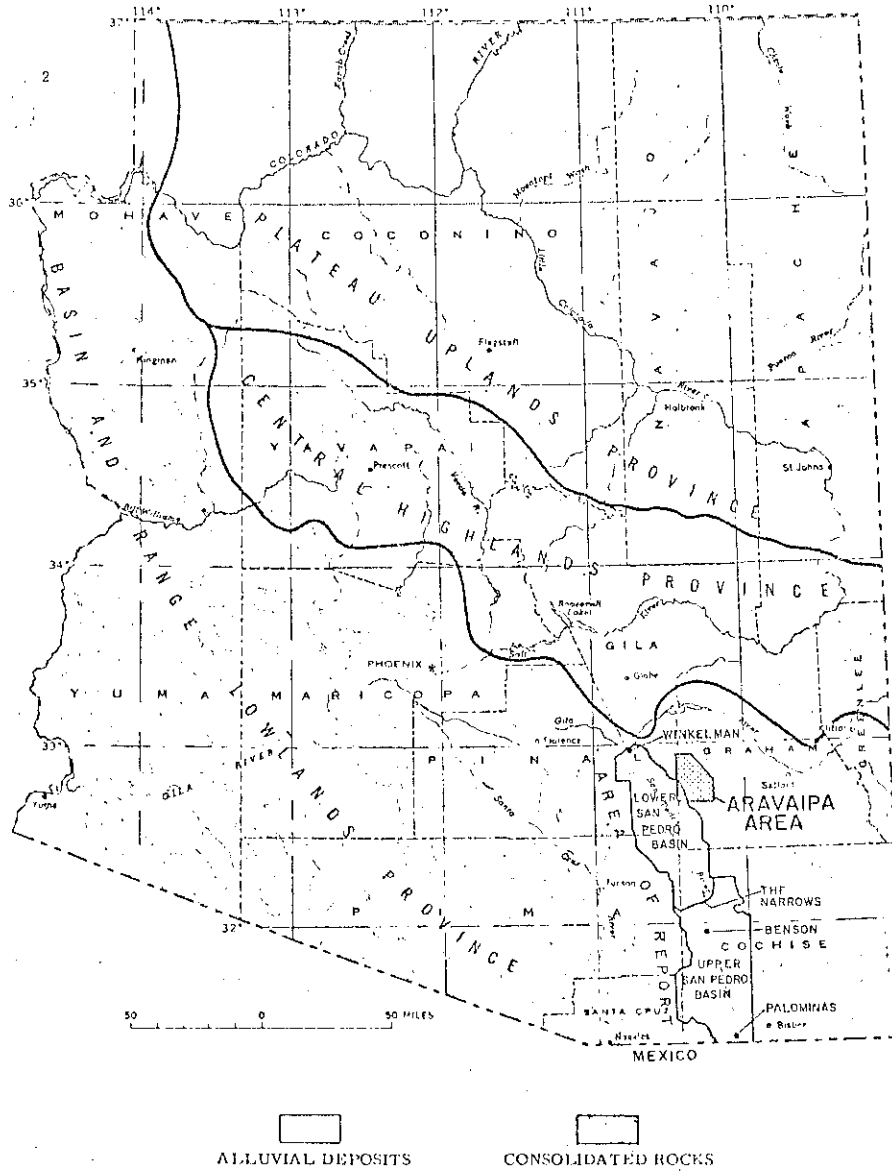


Figure 1. Location of the Aravaipa Area, Arizona

Table 1. The thermal features of the Aravaipa area.

<u>Sample Number and Name</u>	<u>T°C</u>	<u>Flow l/m</u>	<u>Heat Discharge cal/sec.</u>
W90100 Deer Creek Warm Spring	27	189	$2.5 \times 10^4$
W90106 Weathersby Warm Well	25*	0	---
W90108 Section 27 Warm Spring	24.5	95	$8.7 \times 10^3$
W90102 Stowe Warm Spring	23	284	<u><math>1.9 \times 10^4</math></u>
			$5.3 \times 10^4$ cal/sec.
			209 BTU/sec.

\*Measurement may not be accurate owing to the static condition of the well.

The approximate heat discharge of the thermal features of the area, computed as the product of the volume rate and enthalpy of the water in excess of assumed ambient temperature is listed in Table 1.

Descriptions of each thermal feature are listed in Appendix 1. Plates 1 through 3 are pictorial descriptions of the thermal features. A sample location map is included in the pocket at the end of this report.



Plate 1.

Deer Creek Warm Spring  
27°C

Plate 2.

Weathersby Warm Well  
25°C



Plate 3.

Section 27 Warm Spring  
24.5°C



CHEMISTRY:

The non-thermal waters of the Aravaipa area generally contain less than 600 mg/l of dissolved solids. Water pH is generally neutral to slightly basic. Bicarbonate is the principle ion followed by calcium, sulfate, silica and magnesium. Cold waters contain an average of 27 mg/l of silica. Landsman Camp Cold Spring (W10101) was chosen to represent background water chemistry (Table 2).

The thermal waters of the area exhibit neutral to basic pH. Two varieties of thermal waters have been recognized (Table 3).

Table 3. Major anions and cations for the Aravaipa thermal and non-thermal waters.

<u>Sample Number and Name</u>	<u>Anions</u>	<u>Cations</u>
W90106 Weathersby Warm Well	HCO <sub>3</sub> >Cl>SO <sub>4</sub>	Na>Ca>K>Mg
W90108 Section 27 Warm Spring	HCO <sub>3</sub> >Cl≈SO <sub>4</sub>	Ca>Na>Mg>K
W90100 Deer Creek Warm Spring	HCO <sub>3</sub> >SO <sub>4</sub> >Cl	Ca>Na>Mg>K
W90102 Stowe Warm Spring	HCO <sub>3</sub> >SO <sub>4</sub> >Cl	Ca>Na>Mg>K
W90101 Landsman Camp Cold Spg.	HCO <sub>3</sub> >SO <sub>4</sub> >Cl	Ca>Mg>Na>K

1. Weathersby Warm Well and Section 27 Warm Spring located southeast of Klondyke are both bicarbonate-chloride-(sodium) waters.

2. Deer Creek Warm Spring and Stowe Warm Spring located north of Klondyke are both bicarbonate-sulfate-calcium waters. Note the similarity between these springs and Landsman Camp Cold Spring.

Weathersby Warm Well is most similar to the usual constitution of geothermal water, which is:



Table 2. Chemical analysis of the thermal and non-thermal features of the Aravaipa area.  
Units are mg/l unless otherwise noted.

	Deer Creek Warm Spring W90100	Weathersby Warm Well W90106	Section 27 Warm Spring W90108	Stowe Warm Spring X90102	Landsman Camp Cold Spring W90101
pH	7.37	8.30	8.33	7.77	7.49
Cl	8.8	4.2	5.6	8.7	8.3
F	1.1	0.8	0.3	1.6	0.3
HCO <sub>3</sub>	257	160	276	235	298
CO <sub>3</sub>	<1	<1	<1	<1	<1
SO <sub>4</sub>	64	5	5	45	55
SiO <sub>2</sub>	25	24	58	28	33
Na	15	61	27	16	10
K	1.6	1.2	0.8	1.7	2.0
Ca	100	2	60	90	110
Mg	10	0.8	17	11	14
Li	<0.1	<0.1	<0.1	<0.1	<0.1
B	0.3	0.9	0.5	0.5	0.2
NH <sub>3</sub>	<0.1	<0.1	<0.1	<0.1	<0.1
TDS	483	260	450	438	531
T°C	27	25	24.5	23	20
Flow (gpm)	50	0	25	75	1
TSiO <sub>2</sub> °C	72	70	109 B	77	83
TNa/K °C	191 A	50	75	191 A	282 A
TNa-K-Ca °C	3.4	74	1	7	4
Cl/SO <sub>4</sub>	0.4	2.3	3.0	0.5	0.4
Cl/HCO <sub>3</sub>	0.06	0.05	0.03	0.06	0.05
Cl/F	4.2	2.8	9.9	2.9	14

A Does not represent true subsurface conditions, i. e.  $\sqrt{\frac{Ca}{Na}} \rightarrow OR > 1$

B Chalcedony geothermometer is more realistic and indicates 90°C.

Weathersby Warm Well also contains the highest concentration of boron and exhibits the best subsurface temperature correlation (Table 2). The springs of the second group are remarkably similar to meteoric water with the exception of surface temperature and fluoride.

Figures 2 and 3 are chemical plots of the aforementioned waters. Figure 2 does not distinguish any of the thermal waters from groundwater. The similarities in the  $\text{Cl}/\text{HCO}_3$  ratios indicate that all waters are largely groundwater or, in other words, the thermal fraction in any of the thermal waters is quite small. Figure 3 shows that Weathersby Warm Well contains the highest concentration of sodium and boron relative to the other waters.

#### SUBSURFACE TEMPERATURES VIA THE CHEMICAL DATA

Chemistry indicates that all waters have equilibrated below  $100^\circ\text{C}$ . Correlation between the different geothermometers is very poor except for Weathersby Warm Well.

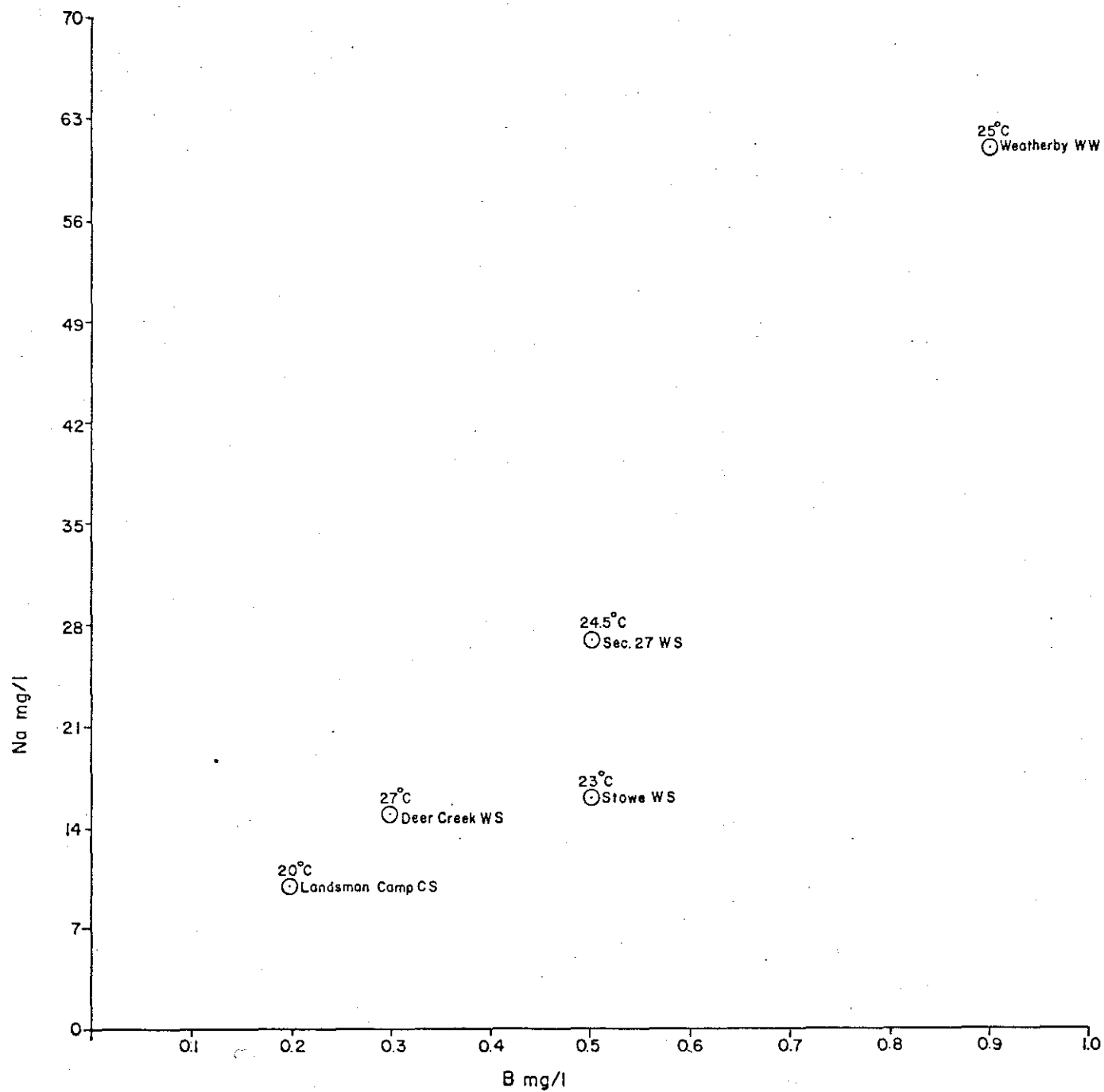


Figure 2. Silica versus the Cl/HCO<sub>3</sub> ratio.

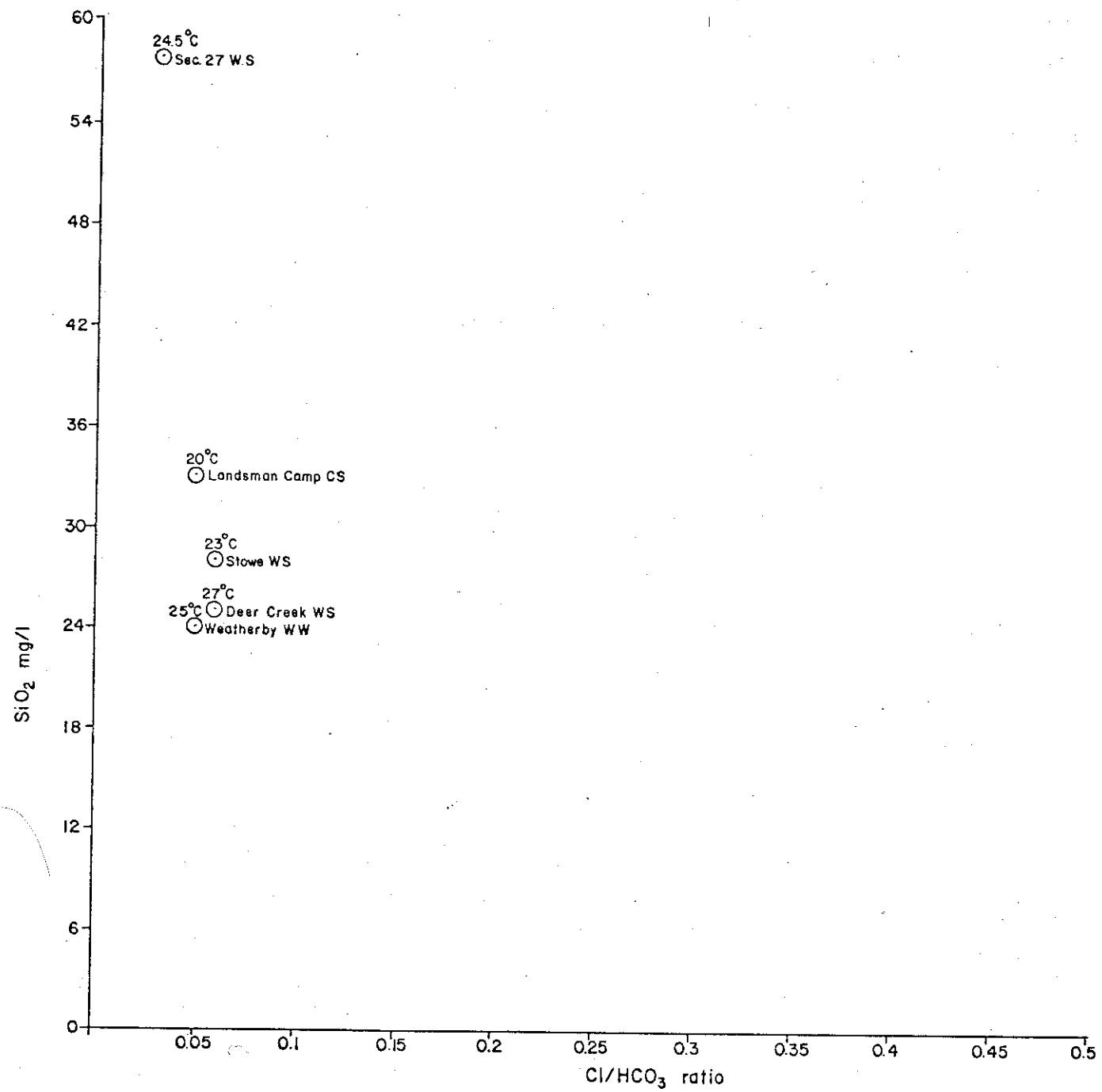


Figure 3. Na versus B.

ANAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. \_\_\_\_\_ Sample No. X 90106 Date 7-7-75 Time 1700

Name: Weathersby W.W. Location: Co. Graham State AZ

NW 1/4 Sec. 21 T 7S R: 20E; \_\_\_\_\_ Km/mi. \_\_\_\_\_ of \_\_\_\_\_

Lat.: \_\_\_\_\_ Long.: \_\_\_\_\_ Sampler: F. Dellechaie

Elevation: 3522 Quad. Klondyke

Sample Type: Spring (p), well (p), creek, river, soil, salt, sinter, travertine, gas, rock, snow.

Description:

Water Temp. °C 25 Discharge: 0 \_\_\_\_\_ gpm/Lpm

Ground Temp. °C \_\_\_\_\_ Well Data: Depth \_\_\_\_\_

Air Temp. \_\_\_\_\_ Bore \_\_\_\_\_

Odor 0 Pump Type \_\_\_\_\_

Fluid Color 0 Level of water in bore \_\_\_\_\_

Fluid Taste 0 Type of piping \_\_\_\_\_

Bubbling 0 Artesian Head \_\_\_\_\_

Boiling 0 Rock Data: \_\_\_\_\_

Vegetation 0 Type (surface) Qal \_\_\_\_\_

Fluid issues from does not Color \_\_\_\_\_

\_\_\_\_\_ Grain size \_\_\_\_\_

\_\_\_\_\_ Megascopic Minerals \_\_\_\_\_

Salt: Type ? \_\_\_\_\_

Quantity \_\_\_\_\_

Color \_\_\_\_\_ Alteration: \_\_\_\_\_

Form \_\_\_\_\_ Rx Type (at depth) \_\_\_\_\_

Sinter: Type ? Water used for \_\_\_\_\_

Quantity \_\_\_\_\_ Immediate area used for: \_\_\_\_\_

Color \_\_\_\_\_

Form \_\_\_\_\_ Quality of sample: Exc., Good, Poor

Probable cause of manifestation well

Property owned by Jake Weathersby, Nevel Klondyke R. Sta. Wellcox 85643 Arizona  
602-828-3313

Previous and/or Current Leases \_\_\_\_\_

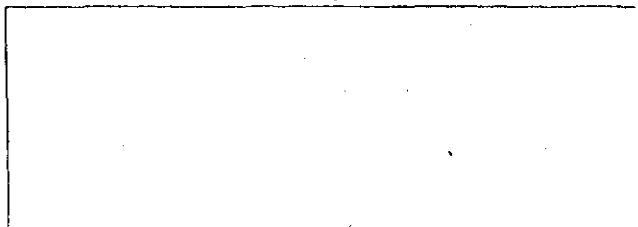
Comments: JED 5-20

used sampling device, temp. may be

conservative owing to static condition

of well.

SKETCHES



ALIA GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. \_\_\_\_\_ Sample No. X 90102 Date 7-6-75 Time 16:00

Name: Stowe Spring Location: Co. Graham State AZ

SW1/4 SE1/4 \_\_\_\_\_ Sec. 1 T \_\_\_\_\_ R: \_\_\_\_\_; \_\_\_\_\_ Km/mi. \_\_\_\_\_ of \_\_\_\_\_

Lat.: \_\_\_\_\_ Long.: \_\_\_\_\_ Sampler: F. Dellechiaie

Elevation: 3990 Quad. Klondyke

Sample Type: Spring (p), well (p), creek, river, soil, salt, sinter, travertine, gas, rock, snow.

Description:

Water Temp. °C 23 Discharge: 75 \_\_\_\_\_ gpm/Lpm

Ground Temp. °C \_\_\_\_\_ Well Data: Depth \_\_\_\_\_

Air Temp. \_\_\_\_\_ Bore \_\_\_\_\_

Odor 0 Pump Type \_\_\_\_\_

Fluid Color 0 Level of water in bore \_\_\_\_\_

Fluid Taste 0 Type of piping \_\_\_\_\_

Bubbling 0 Artesian Head \_\_\_\_\_

Boiling 0 Rock Data: \_\_\_\_\_

Vegetation 0 Type (surface) Rhyolite

Fluid issues from stream bed Color pink-white

Grain size fine

Megascopic Minerals \_\_\_\_\_

Salt: Type 0

Quantity \_\_\_\_\_

Color \_\_\_\_\_ Alteration: no

Form \_\_\_\_\_ Rx Type (at depth) \_\_\_\_\_

Sinter: Type 0 Water used for cattle

Quantity \_\_\_\_\_ Immediate area used for: ranching

Color \_\_\_\_\_

Form \_\_\_\_\_ Quality of sample: Exc., Good, Poor

Probable cause of manifestation natural flow

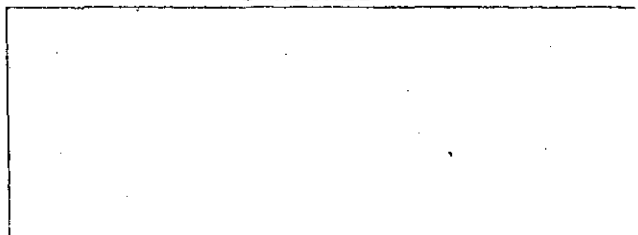
Property owned by Stowe George B. Claridge, Klondyke Rural Station, Wilcox, AZ

Previous and/or Current Leases \_\_\_\_\_

Comments: no picture

SKETCHES

Roy Claridge 602 828 3327 owns the  
3500' hot well in Sec. 1, drilled by  
Superior Oil Company.



AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. \_\_\_\_\_ Sample No. X 90108 Date 7-6-75 Time 15:00

Name: Section 27 Spring Location: Co. Graham State AZ

Se 1/4 SW 1/4 Sec. 27 T 7S R: 19E ; \_\_\_\_\_ Km/mi. \_\_\_\_\_ of \_\_\_\_\_

Lat.: \_\_\_\_\_ Long.: \_\_\_\_\_ Sampler: John E. Deymonaz

Elevation: 4250 Quad. Klondyke

Sample Type: Spring (p), well (p), creek, river, soil, salt, sinter, travertine, gas, rock, snow.

Description:

Water Temp. °C 24.5 Discharge: 25 gpm/Lpm

Ground Temp. °C 0 Well Data: Depth \_\_\_\_\_

Air Temp. 0 Bore \_\_\_\_\_

Odor 0 Pump Type \_\_\_\_\_

Fluid Color 0 Level of water in bore \_\_\_\_\_

Fluid Taste slight organic Type of piping \_\_\_\_\_

Bubbling 0 Artesian Head \_\_\_\_\_

Boiling 0 Rock Data: \_\_\_\_\_

Vegetation 0 Type (surface) Rhyolite

Fluid issues from rocky calluvium Color red

in small vly cut in rhyolite Grain size aph. por.

\_\_\_\_\_ Megascope Minerals \_\_\_\_\_

Salt: Type \_\_\_\_\_

Quantity \_\_\_\_\_

Color \_\_\_\_\_ Alteration: \_\_\_\_\_

Form \_\_\_\_\_ Rx Type (at depth) \_\_\_\_\_

Sinter: Type \_\_\_\_\_ Water used for livestock/ drinking

Quantity \_\_\_\_\_ Immediate area used for: rangeland

Color \_\_\_\_\_

Form \_\_\_\_\_ Quality of sample: Exc., Good, Poor

Probable cause of manifestation \_\_\_\_\_

Property owned by Ed Lackner, 602-828-3327

Previous and/or Current Lease no

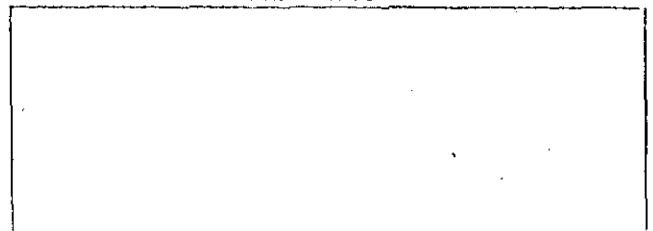
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SKETCHES





AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. \_\_\_\_\_ Sample No. X 90100 Date 7-7-75 Time 15:00

Name: Deer Creek Warm Spring Location: Co. Graham State AZ

Sec. \_\_\_\_\_ T \_\_\_\_\_ R: \_\_\_\_\_; 2.1 Km/mi. NW of Aravaipa

Lat.: \_\_\_\_\_ Long.: \_\_\_\_\_ Sampler: F. Dellechiaie

Elevation: 4250 Quad. Klondkye

Sample Type: Spring (p), well (p), creek, river, soil, salt, sinter, travertine, gas, rock, snow.

Description:

Water Temp. °C 27 Discharge: 50 gpm/Lpm

Ground Temp. °C \_\_\_\_\_ Well Data: Depth \_\_\_\_\_

Air Temp. \_\_\_\_\_ Bore \_\_\_\_\_

Odor 0 Pump Type \_\_\_\_\_

Fluid Color 0 Level of water in bore \_\_\_\_\_

Fluid Taste hard Type of piping \_\_\_\_\_

Bubbling 0 Artesian Head \_\_\_\_\_

Boiling 0 Rock Data: \_\_\_\_\_

Vegetation algae Type (surface) LMS

Fluid issues from cement Color gray

fox in LMS Grain size fine

Megascopeic Minerals chert nodules

Salt: Type 0

Quantity \_\_\_\_\_

Color \_\_\_\_\_ Alteration: no

Form \_\_\_\_\_ Rx Type (at depth) \_\_\_\_\_

Sinter: Type 0 Water used for cattle

Quantity \_\_\_\_\_ Immediate area used for: cattle

Color \_\_\_\_\_

Form \_\_\_\_\_ Quality of sample: Exc., Good, Poor

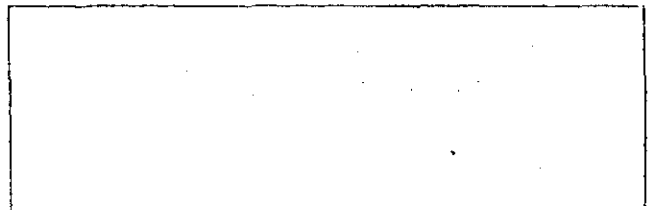
Probable cause of manifestation ?

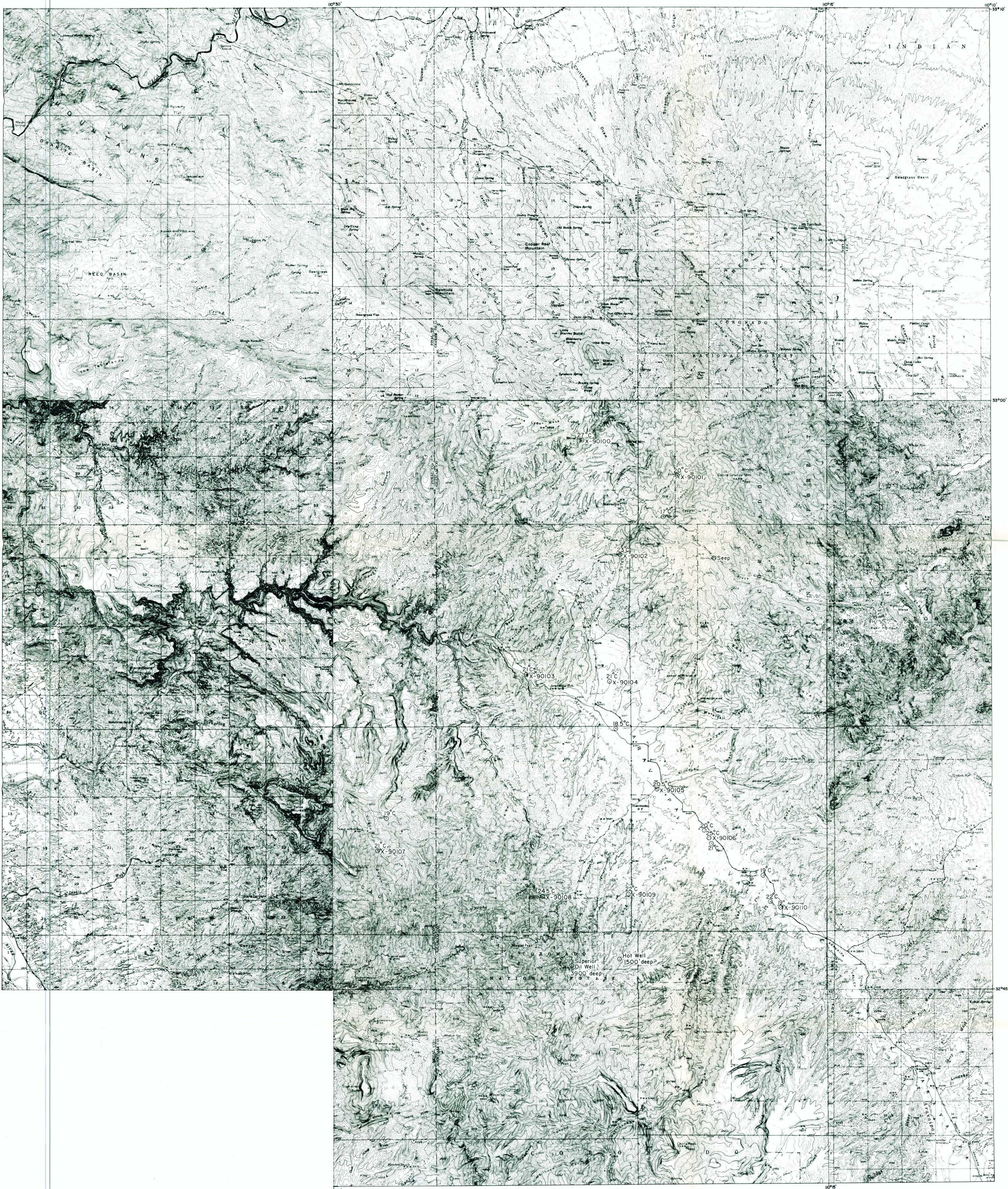
Property owned by ?

Previous and/or Current Leases \_\_\_\_\_

Comments: 3, F11, 12

SKETCHES





**AMAX EXPLORATION, INC.**  
DENVER, COLORADO

ARAVAIPA, ARIZONA  
HYDROGEOCHEMICAL SAMPLE SITES

Source: AMAX Survey, 1975 4-1-75