A HYDROGEOCHEMICAL STUDY OF THE BEULAH RESERVOIR PROSPECT, MALHEUR COUNTY, OREGON

by

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Amax Exploration, Inc.

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SUMMARY

1) The Beulah prospect lies in Malheur County of east-central Oregon. The area contains five hot springs and at least three warm wells or springs.

2) The non-thermal waters of the area contain less than 250 mg/l of dissolved solids and an average of 58 mg/l of silica. Cations and anions occur as follow:

$HCO_3 > SO_4 > Cl$ Ca>Na>Mg>K

3) Beulah Hot Spring West (X89866) is the most interesting spring in the area. This spring deposits sinter consisting of 84.5 percent silica. This water is of the sodium-sulfate variety,

$SO_4 > HCO_3 > Cl$ Na>Ca>K>Mg,

while the remaining springs are of the sodium-bicarbonate variety,

$HCO_3 > SO_4 > Cl$ Na>Ca>K>Mg.

The Beulah Hot Springs are similar to "dry steam springs" based on chloride (51 mg/l) and volatile ions.

4) Stable isotope studies denote a long storage time and/or a sizeable reservoir storage capacity. Isotope analysis does not suggest mixing in the Beulah Hot Springs.

5) Mineral equilibria studies indicate that the water of Beulah Hot Spring West is saturated with several silica minerals.

6) Subsurface temperatures indicated by silica do not exceed 178°C, however this geothermometer may be conservative owing to near surface silica deposition in the Beulah Hot Springs.

7) The hydrogeochemistry of the Beulah Reservoir Prospect is indicative of a shallow, 180-200°C, very low salinity hot water system. All aspects of this chemical study are at least mildly encouraging. Hydrogeochemistry thus argues for a high rating as a geothermal prospect.

THERMAL FEATURES

Twenty-three water samples and one sample of siliceous sinter were collected from the Beulah Reservoir area (Figure 1) during July and August of 1974. Spring temperatures range from 9°C at Kelsey Butte Cold Spring to 72°C at Beulah Hot Spring West. The surface intercepts of thermal gradient wells indicate that the background water temperature is 11°C. The area contains five hot springs and at least three warm wells or springs (Table 1). The hottest spring, at the northern edge of Beulah Reservoir (X89866) is presently depositing siliceous sinter.

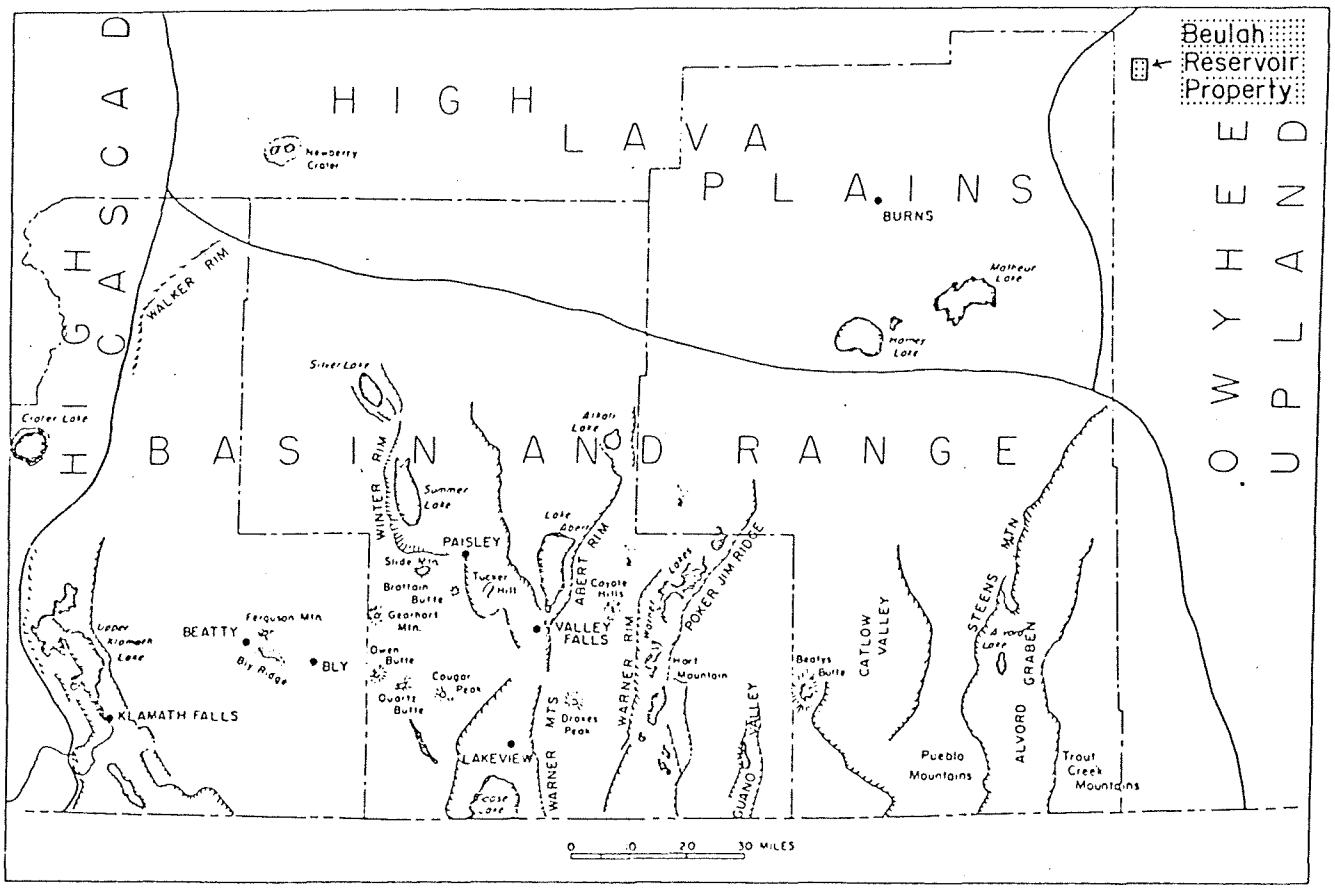


Figure 1. Location map of the Beulah Reservoir Prospect

Table 1. The thermal features of the Beulah Reservoir area.

	Sample Number and Name	T°c	Flow l/m	Heat Discharge cal/sec
X89866	Beulah Hot Spring West	72	38	3.9×10^4
W10140	Westfall Butte Hot Spring	70	27	2.6×10^4
X89867	Beulah Hot Spring East	60	38	3.1×10^4
X89865	Malheur River Hot Spring	58	378	3.0×10^5
X89873	Section 29 Hot Spring	44.5	57	3.2×10^4
X90215	Bath House Warm Spring	35	23	9.2×10^3
X90214	Butler Warm Well	25	189	4.4×10^4
X90213	DeArmond Warm Spring	20.5	38	6.0×10^3
				4.9×10^5 cal/sec
				1.9×10^3 BTU/sec

Descriptions of each thermal feature are listed in Appendix 1. Plates 1 through 7 are pictorial representations of some of the thermal features.

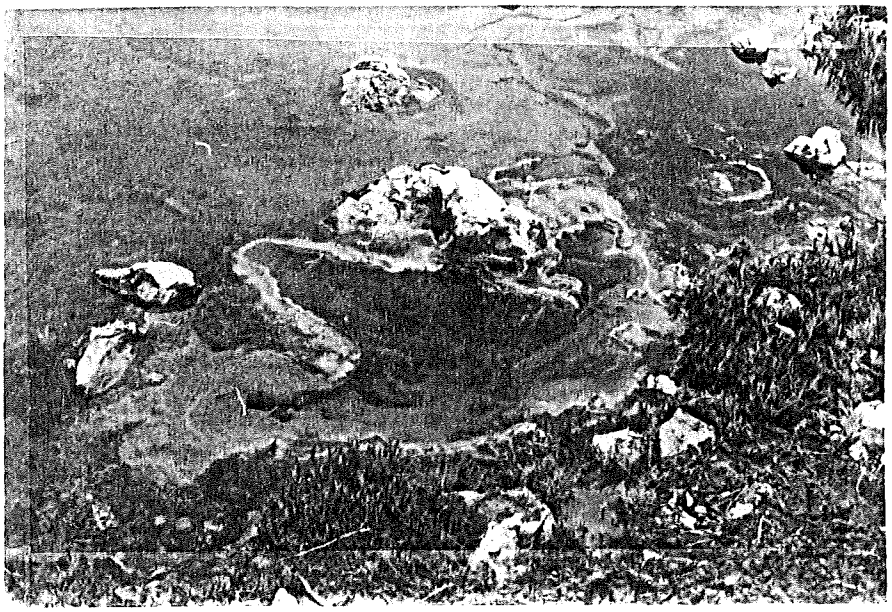


Plate 1. Westfall Butte Hot Spring 70°C W10140

Plate 2. Beulah Hot Spring East, 60°C X89867

Plate 3. Malheur River Hot Spring, 58°C X89865

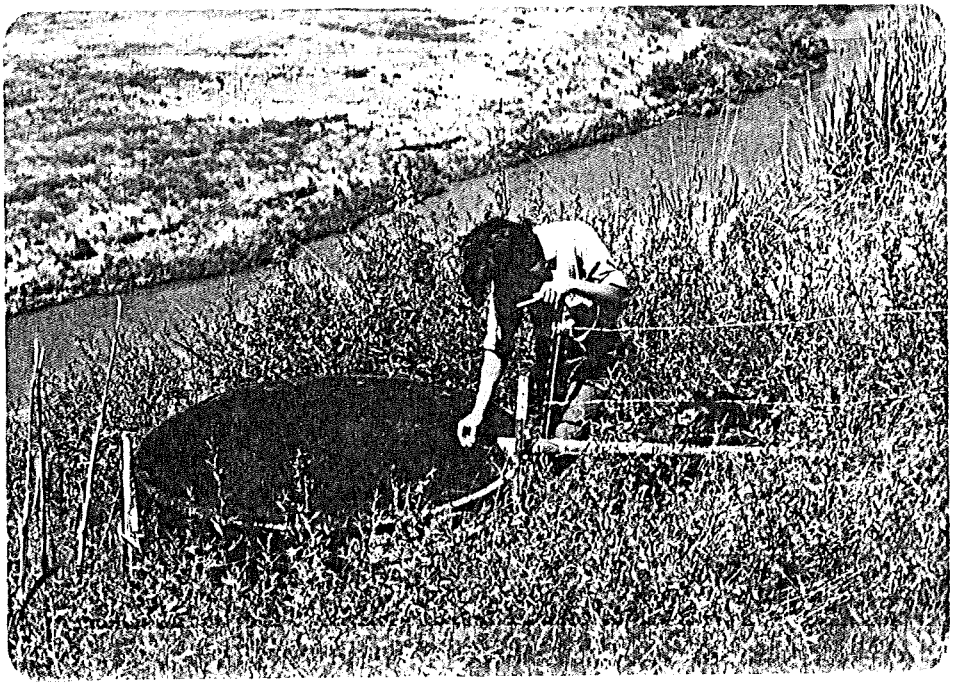


Plate 4, Section 29 Hot Spring, 44.5°C X89873

Plate 5. Bath House Warm Spring, 35°C X90125

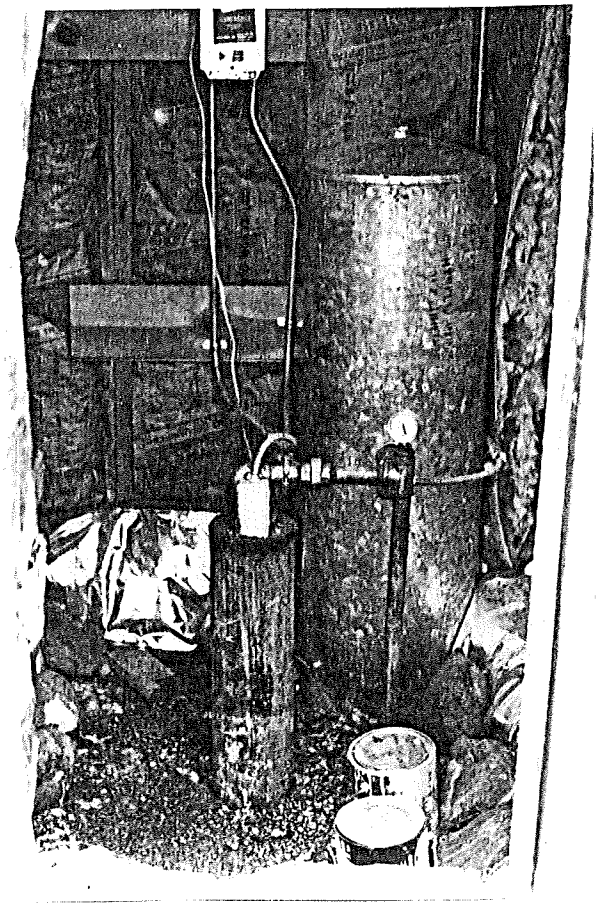


Plate 6. Butler Warm Well, 25°C X90124

Plate 7. Castle Rock Spring, 16.5°C X89862

CHEMISTRY

The non-thermal waters of the Beulah Reservoir area generally contain less than 250 mg/l of dissolved solids. Water pH is neutral to slightly basic. Bicarbonate is the principle ion followed by silica, calcium, sodium and magnesium. Cold waters contain an average of 58 mg/l of silica. Castle Rock Spring (X89862) was chosen to represent background water chemistry (Table 2).

The thermal waters exhibit neutral to basic (9.7) pH. The thermal waters of the area contain bicarbonate as the principle anion except for the Beulah Hot Springs which contain sulfate (Table 3). Westfall Butte Hot Spring (W10140), located 13 miles east of Juntura, just off Highway 20, clearly issues from a hot water source by virtue of the high chloride concentration (440 mg/l). The Beulah Hot Springs (X89866 and X89867) have inordinately low chloride concentrations (51 mg/l) which approach the 20 mg/l chloride content which reportedly separates hot water and dry steam systems. White et al. (1973) report springs associated with vapor-dominated systems having neutral pH, high sodium and bicarbonate and low chloride concentrations. A geochemical comparison between the Beulah Hot Springs and a Carboli Hot Well located on the southern border of the Larderello steam field (Cataldi et al., 1969) is offered in Figure 2. With the exception of chloride, the comparison is not good. The concentrations of fluoride, lithium, boron, ammonia and hydrogen sulfide in the Beulah Hot Springs are roughly in the range of "dry steam springs".

Table 2. Chemical analyses of the thermal and non-thermal waters of the Beulah Reservoir area. Units are mg/l unless otherwise noted.

	Beulah Hot Spring West X89866	Westfall Butte Hot Spring W10140	Beulah Hot Spring East X89867	Malheur River Hot Spring X89865	Section 29 Hot Spring X89873	Bath House Warm Spring X90215	Butler Warm Well X90214	DeArmond Warm Spring X90213	Castle Rock Cold Spring X89862
pH	7.56	7.0	7.60	7.8	9.6	9.7	9.4	8.0	8.1
Cl	51	440	51	20	11	13	10	<10	3.6
F	4.4	4.5	4.8	4.8	0.8	1.3	1.0	0.2	0.2
HCO_3	160	751	162	140	50	76	104	86	90
CO_3	0	0	0	0	48	28	100	0	0
SO_4	290	280	290	70	38	43	16	3	4
SiO_2	194	120	170	78	70	79	55	55	68
Na	220	690	220	120	72	78	24	12	12
K	7.6	30	5.8	1.6	0.7	0.8	8.2	5.4	3.8
Ca	16	70	18	3	1	1	48	16	16
Mg	0.5	42	0.3	0.1	<0.1	<0.1	21	7	7
Li	0.2	1.4	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1
B	4.8	30	4.4	1.1	<1.0	<1.0	<1.0	<1.0	<1.0
Cu	<0.1	NA	<0.1	<0.1	<0.1	NA	NA	NA	<0.1
Mo µg/l	30	NA	30	15	8	NA	NA	NA	<1
Ze	0.1	NA	0.1	0.1	0.2	0.1	0.2	0.2	0.1
Fe	<0.1	NA	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
NH_3	1.1	<0.1	1.3	0.5	NA	NA	NA	NA	NA
H_2S	0.8	NA	0.8	NA	NA	NA	NA	NA	NA
TDS	923	2459	905	439	292	320	387	208	205
T°C	72	70	60	58	44.5	35	25	20.5	16.5
Flow (gpm)	10	7	10	100	15	6	50	10	50
$TSiO_2$ °C	178	148	169	124	118	124	106	106	116
TNa/K°C	86	103	68	25	13	16	393*	487*	374*
TNa-K-Ca°C	135	151	92	82	73	79	59	61	51
Cl/SO_4	0.5	4.3	0.5	0.8	0.8	0.8	1.7	4.5	2.4
Cl/F	6.1	52	5.6	2.2	7.3	5.3	5.3	13	9.5
Cl/HCO_3	0.6	1	0.6	0.2	0.2	0.2	0.1	0.1	0.1

NA = not analyzed
* Does not represent true subsurface conditions

Table 3. Principle anions and cations of the Beulah Reservoir thermal and non-thermal waters.

Sample Number & Name		Anions	Cations
X89866	Beulah Hot Spring West	$SO_4 > HCO_3 > Cl$	Na>Ca>K>Mg
X89867	Beulah Hot Spring East	$SO_4 > HCO_3 > Cl$	Na>Ca>K>Mg
W10140	Westfall Butte Hot Spring	$HCO_3 > Cl > SO_4$	Na>Ca>K>Mg
X89865	Malheur River Hot Spring	$HCO_3 > SO_4 > Cl$	Na>Ca>K>Mg
X89873	Section 29 Hot Spring	$HCO_3 > SO_4 > Cl$	Na>Ca>K>Mg
X90215	Bath House Warm Spring	$HCO_3 > SO_4 > Cl$	Na>Ca>K>Mg
X90214	Butler Warm Well	$HCO_3 > SO_4 > Cl$	Ca>Na>Mg>K
X90213	DeArmond Warm Spring	$HCO_3 > SO_4 > Cl$	Ca>Na>Mg>K
X89862	Castle Rock Spring	$HCO_3 > SO_4 \sim Cl$	Ca>Na>Mg>K

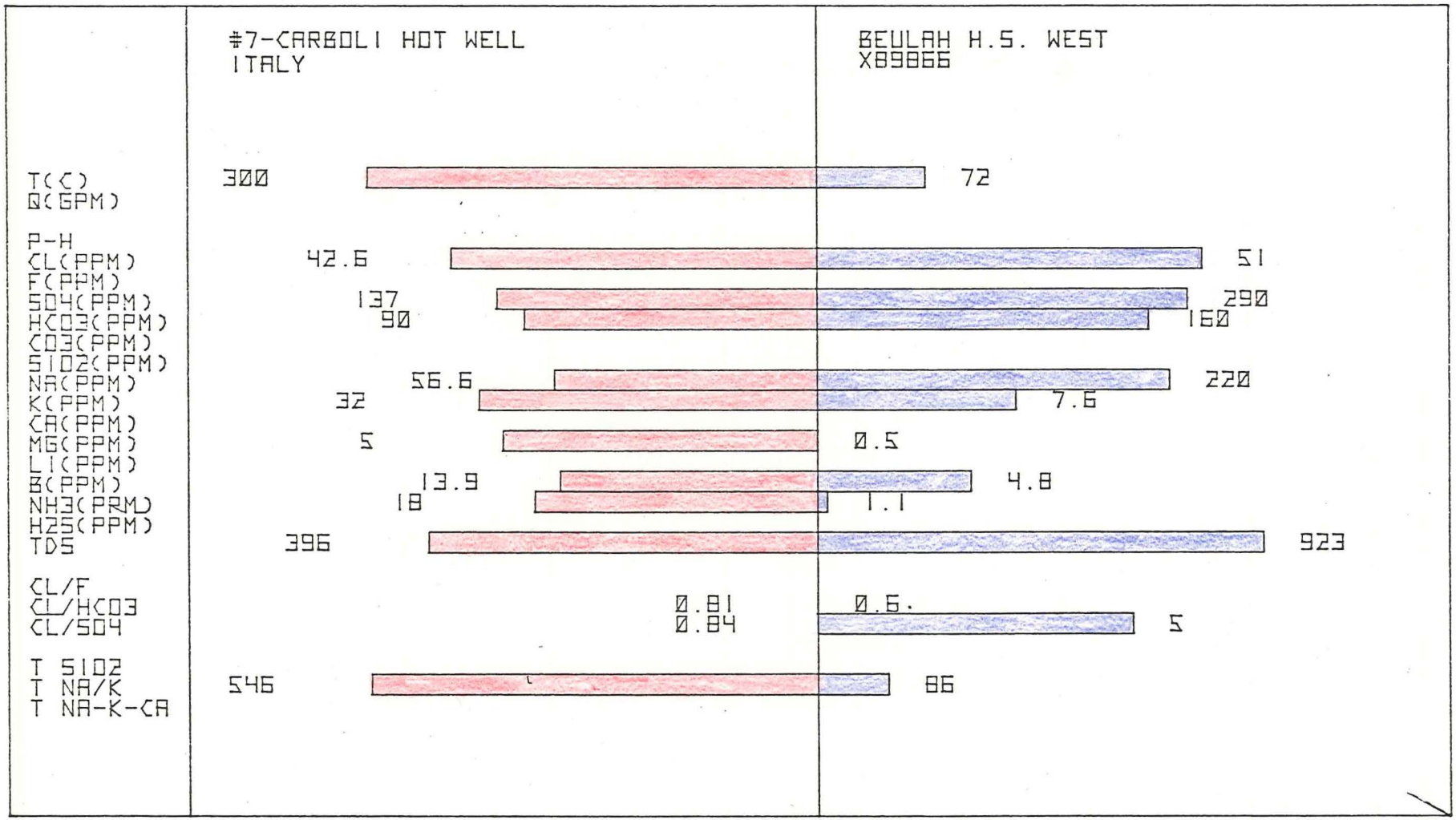


Figure 2. A comparison between Beulah Hot Spring and a Carboli Hot Well, Italy.

Figures 3 through 8 are geochemical plots of the thermal and non-thermal waters of the Beulah Reservoir area. These diagrams show that:

1. Westfall Butte Hot Spring is chemically much different than the remaining springs that are plotted,
2. The Beulah Hot Springs are chemically similar to thermal springs that are nearby, i.e., Malheur River Hot Spring and the remaining warm springs,
3. Figures 3, 4, 6 and 7 clearly show that the Malheur River Hot Spring is a mixed version of the Beulah Hot Springs.

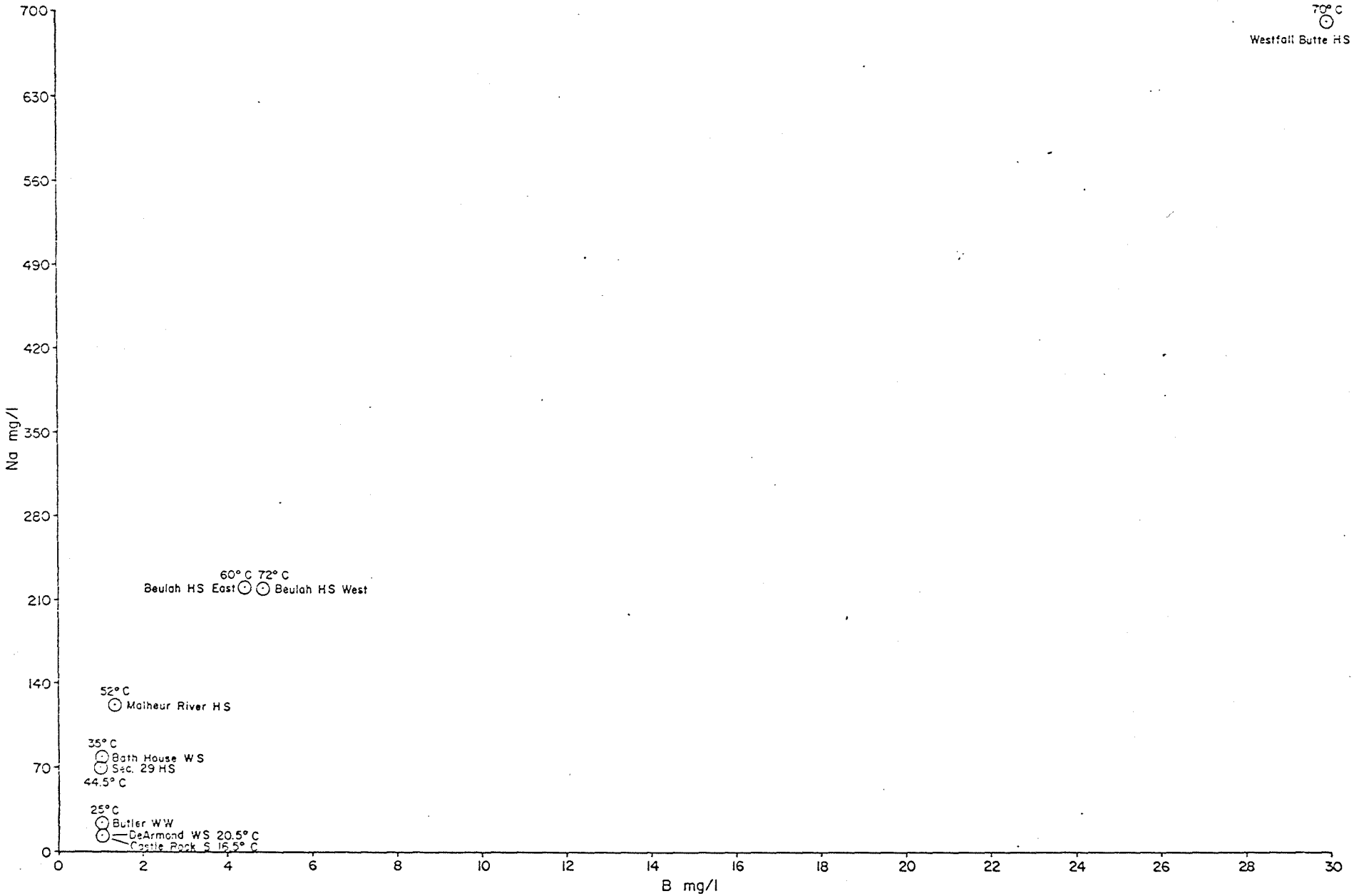


Figure 3. Na versus B in mg/l

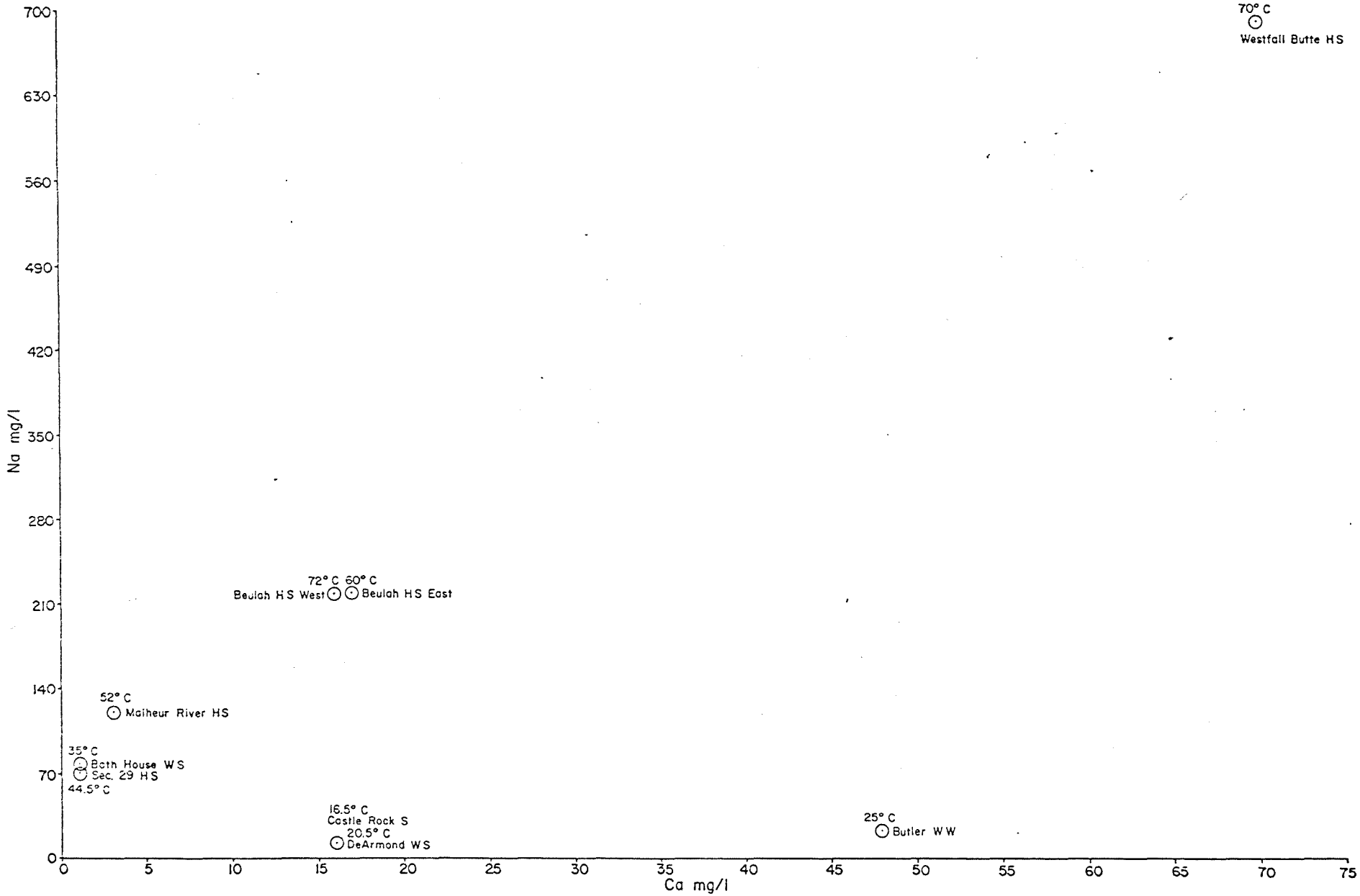


Figure 4. Na versus Ca in mg/l

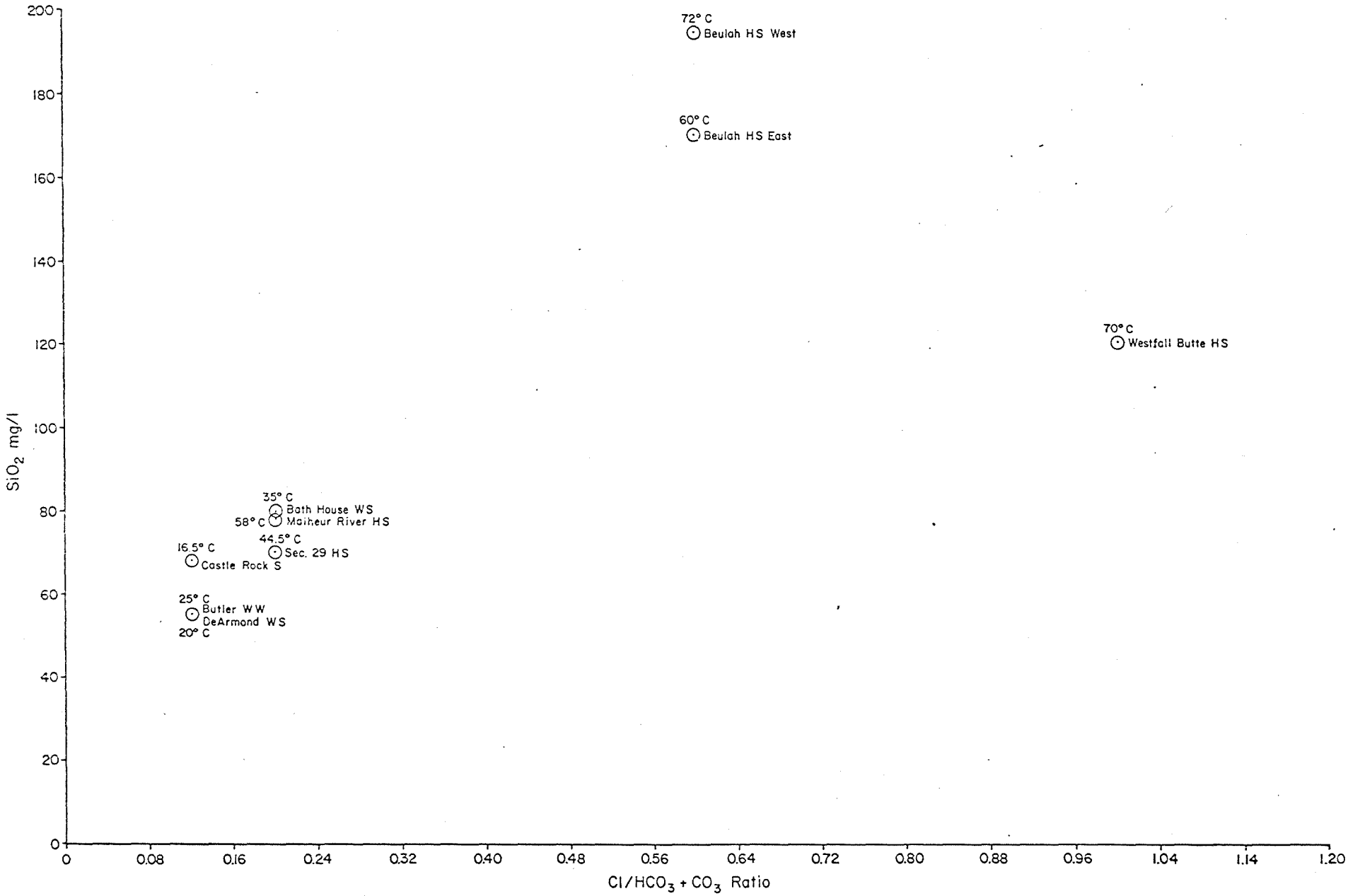


Figure 5. SiO_2 versus the Cl/HCO_3+CO_3 ratio.

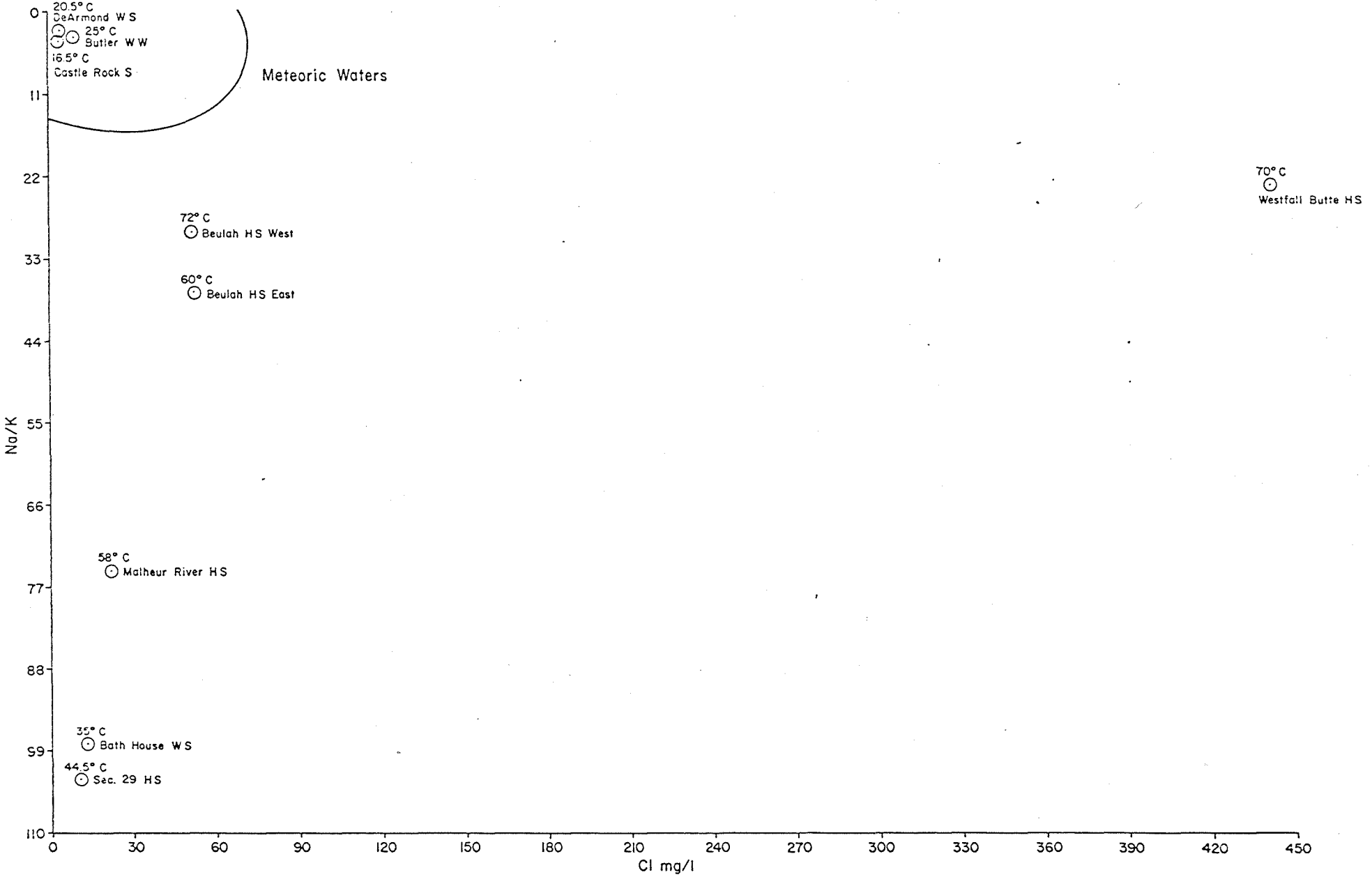


Figure 6. The Na/K ratio versus Cl.

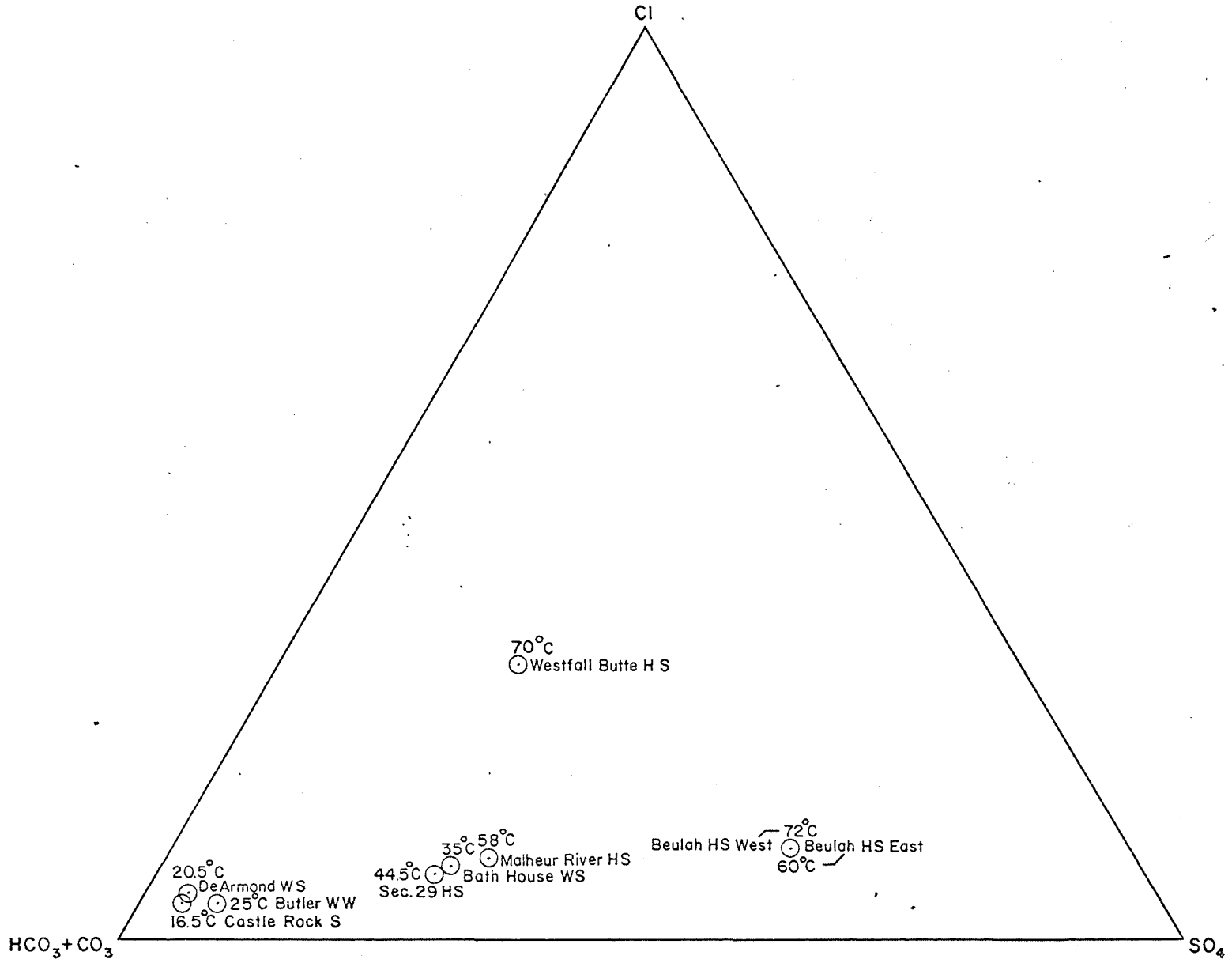


Figure 7. A plot of Cl, HCO_3+CO_3 and SO_4

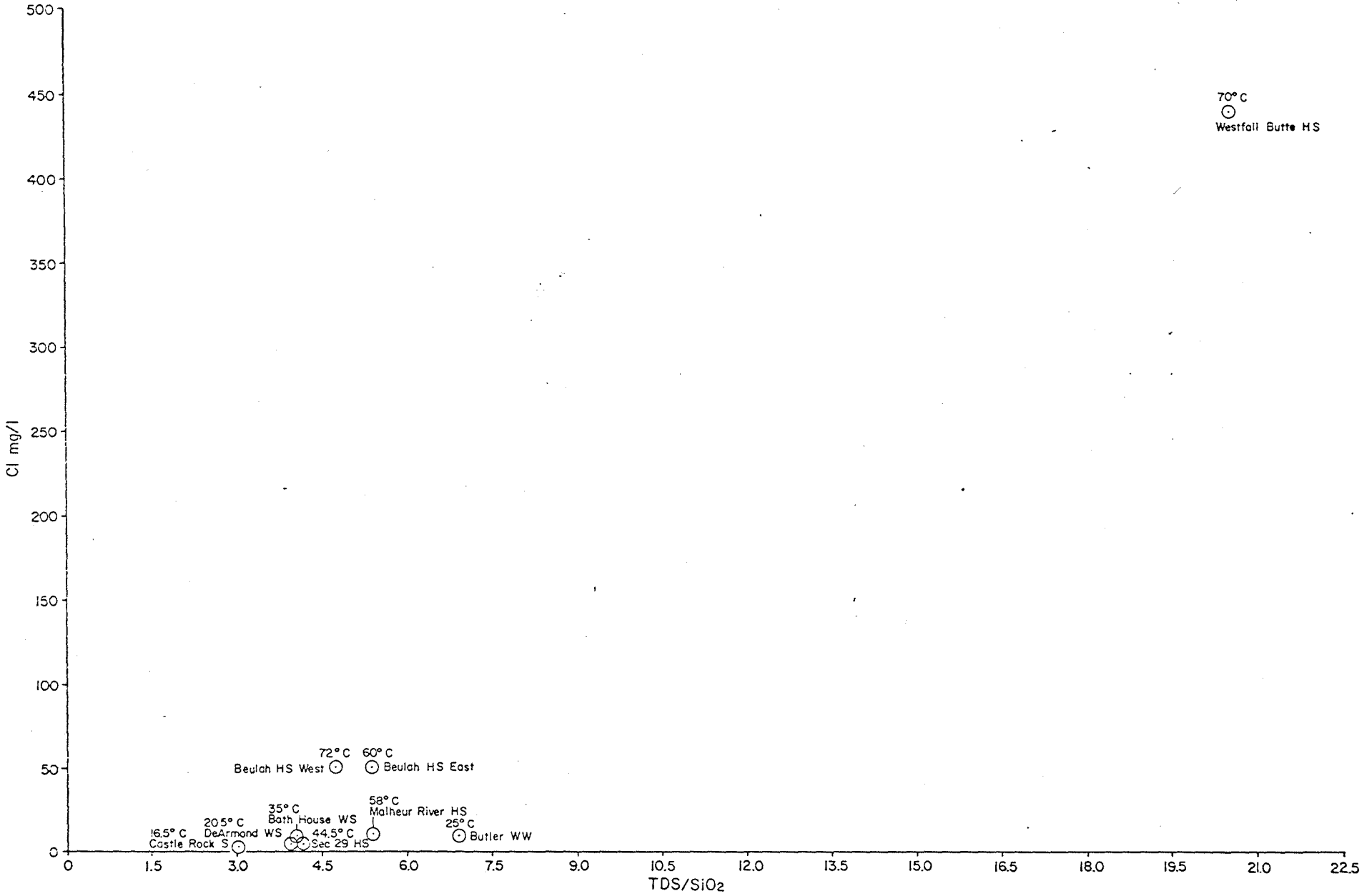


Figure 8. Cl versus the TDS/SiO_2 ratio.

STABLE ISOTOPE STUDIES

Figure 9 shows the variation between δD and δO^{18} relative to SMOW (standard mean ocean water). The straight line represents the almost world wide slope for meteoric waters plotted in this way. The pattern of isotopic variation is seen at once. The deuterium concentration is constant and equal to local meteoric water while O^{18} concentrations show the characteristic enrichment or shift. The simple explanation for the oxygen

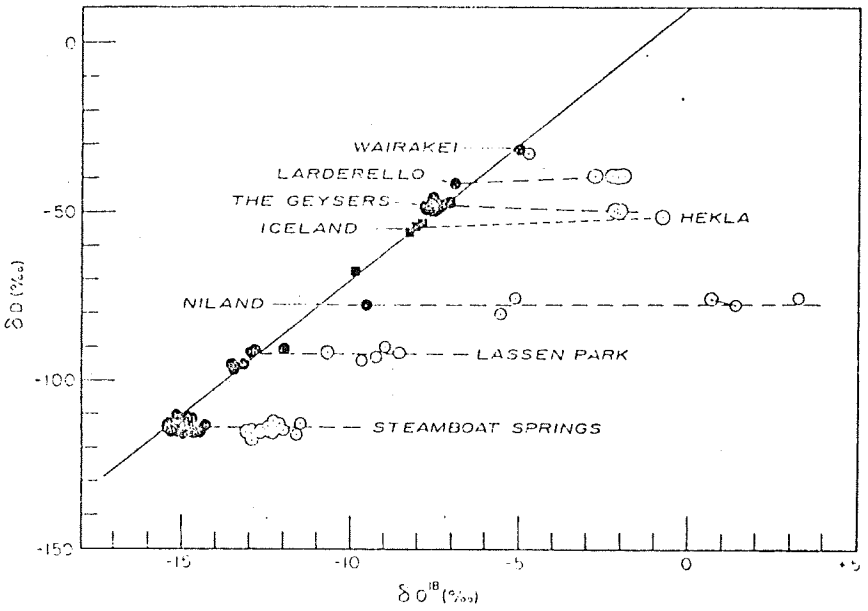


Figure 9. Observed isotopic variations in near-neutral chloride type geothermal waters and in geothermal steam. Solid points are local meteoric waters, or slightly heated near-surface grondwaters. Open circles are hot springs or geothermal water, crinkled circles are high temperature, high pressure, geothermal steam.

shift is an isotopic exchange with carbonates and silicates in the rocks which the waters move. Silicate and carbonate

rocks range from +6 to +30 δO^{18}. δD generally does not vary from the meteoric concentration because rocks contain negligible H or D (heavy hydrogen). Note that the Niland Waters which have mingled with Colorado River sediments, rich in carbonates, shows the greatest shift. On the other end of the scale, Wairakei shows negligible shift. This lack of shift implies that waters descend quickly, stay in storage for a short time and then ascent.

To summarize, a strong shift in δO^{18} implies a long storage time and/or a large reservoir capacity. A very small shift implies one of two situations: first, temperature-pressure conditions are too low to allow waters to exchange O^{18} with rocks almost regardless of storage time, and second, the heat source or the region where waters are heated is so close to the surface that meteoric waters descend and rise quickly, so that the all important time element is unavailable for O^{18} exchange to occur.

Figure 10 is a D-O^{18} plot for some waters of Eastern Oregon and Colorado. Beulah Hot Spring West (X89866) shows a sizeable 2.25 mil O^{18} shift. This positive shift is evidence that the Beulah Hot Spring water is unmixed. The positive O^{18} shift also indicates extensive equilibration time of the water with wall rock and/or a sizeable reservoir storage capacity.

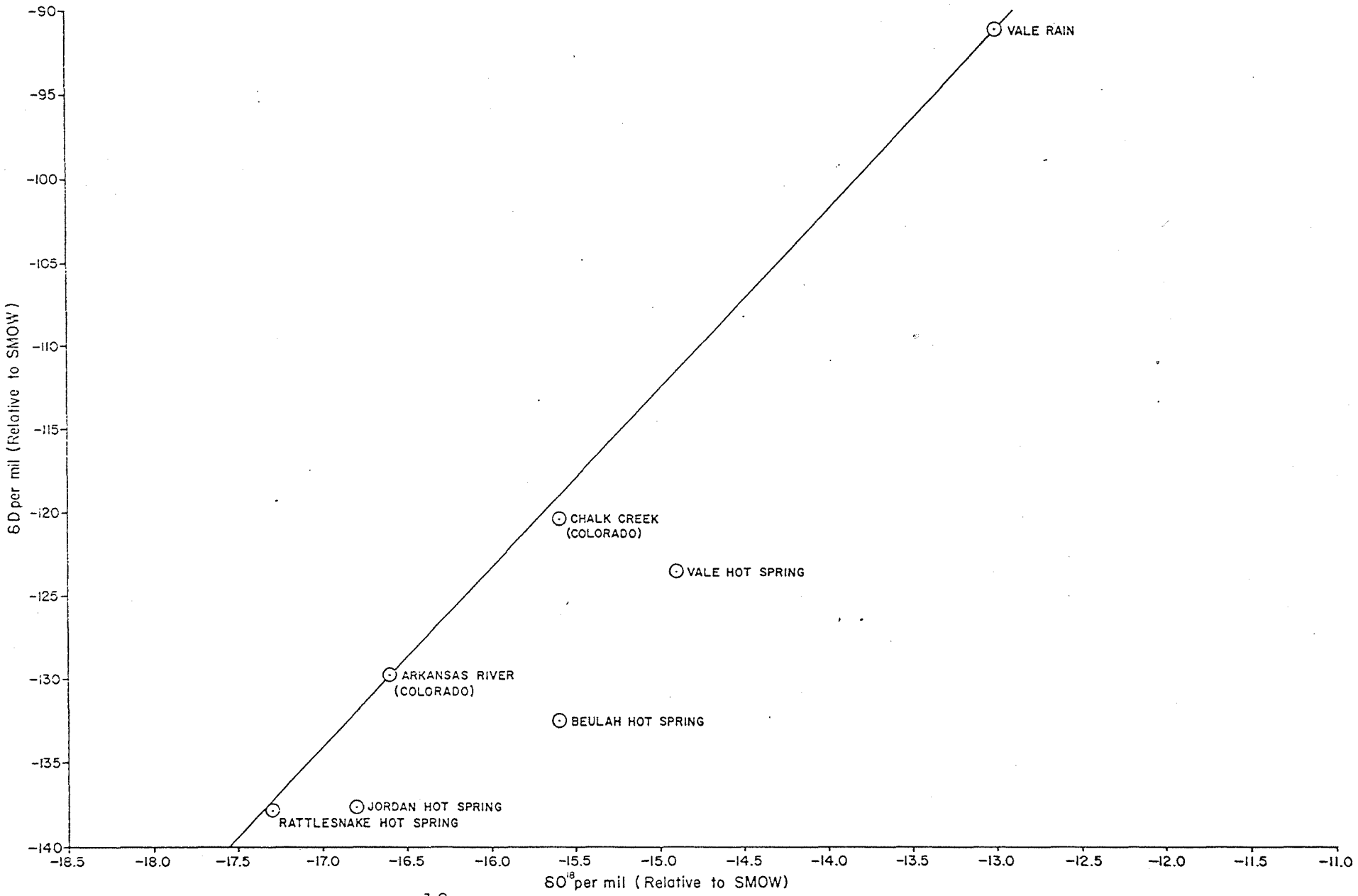


Figure 10. δD versus δO^{18}

MINERAL EQUILIBRIA

The degree of saturation of 285 possible hypothetical minerals has been calculated (Table 4). Westfall Butte Hot Spring is clearly saturated with carbonate minerals which may indicate a low temperature regime. The Beulah Hot Springs are well saturated with quartz minerals and a metamorphic mineral suite.

SUBSURFACE TEMPERATURES

Calculated subsurface temperatures in the Beulah Reservoir area do not exceed 178°C. The highest indicated temperatures belong to the Beulah Hot Spring West (X89866). Correlation between silica and Na-K-Ca geothermometers is generally poor (Table 2). The indicated low alkali temperatures may be the result of very low flow of the Beulah Hot Springs (Bob Fournier, personal communication), and consequently silica thermometry is considered the most reliable for the Beulah Hot Springs. In view of the silica deposition, silica temperatures are at best minimal. The subsurface temperatures may be as high as 200°C.

The extent of silica deposition at Beulah Hot Spring West is large. Much of the silicic mass is probably covered by recent alluvium. An anlysis of the sinter is shown in Table 5. The sinter is cream colored and visually devoid of sulfur and metals unlike the sinter found at Roosevelt Hot Spring.

Table 4. Gibbs Free Energies in kcal/mole for selected water samples from the Beulah Reservoir area. Positive values imply mineral saturation.

	Beulah Hot Spring West		Westfall Butte Hot Spring		Malheur River Hot Spring		Sec. 29 Hot Spring		Bath House Warm Spring		Castle Rock Spring	
T°C	72		70		58		44.5		35		16.5	
TDS	923		2459		439		439		320		205	
Cations meq/l	10.6		37.9		5.4		3.2		3.5		2.0	
Anions meq/l	10.3		30.7		4.6		3.5		3.5		1.7	
Carbonates			Dolomite	2.0								
			Huntite	1.8								
			Calcite	0.6								
			Aragonite	0.7								
Silicates	Tremolite	8.4	Tremolite	9.1	Talc	2.6	Talc	13.8	Tremolite	28.7	Talc	8.0
	Talc	6.6	Talc	8.5	Quartz	1.0	Tremolite	13.7	Talc	16.6	Tremolite	7.9
	Kenyaite	4.6	Magadite	1.3	Chalcedony	0.5	Crusotile	5.6	Crysotile	8.0	Quartz	1.5
	Magadite	3.6	Kenyaite	1.1	Cristobalite	0.2	Diopside	3.8	Diopside	4.5	Chalcedony	0.9
	Quartz	1.4	Quartz	1.0			Quartz	0.5	Sepiolite	1.1	Cristobalite	0.7
	Chalcedony	0.9	Chalcedony	0.6					Quartz	0.7	Silica Am	0.2
	Cristobalite	0.6	Magnesite	0.5					Clinoenstatite	0.3		
	Silica Am.	0.1	Cristobalite	0.3					Chalcedony	0.2		

Table 5. Chemical composition of the Beulah Hot Spring sinter.

SiO_2	84.5 %
Al_2O_3	0.85
CaO	0.23
MgO	0.051
Na_2O	0.20
K_2O	0.084
P_2O_5	<0.004
MnO	<0.005
F	0.053
	85.968%

References cited:

Cataldi, R., Ferrara, G.G., Stefani, G., and Tongiorgi, E., 1969, Contribution to the Knowledge of the Geothermal Field of Larderello: Bull. Volcanol. v. 33, no. 1, p 1-27

Fournier, Bob, Personal communication, 2-6-76

White, D.E., Barnes, I., O'Neil, J.R., 1973, Thermal and Mineral Waters of Nonmeteoric Origin, California Coast Ranges: GSA Bull. U.84, P.547-560

AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. OR404 Sample No. X 89866 Date 7/5/74 Time 1530

Name: Beulah Hot Sp. West Location: Co. Malheur State OR

Center Sec. 2 T 19S R: 37E ; Km/mi. of

Lat.: Long.: Sampler: John Deymonaz ~~Frank Dellechaie~~

Elevation: 3340 Quad. Beulah Quad

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

Description:

Water Temp. °C 72 Discharge: ? gpm/Lpm

Ground Temp. °C 33 Well Data: Depth

Air Temp. Bore

Odor H_2S Pump Type

Fluid Color Level of water in bore

Fluid Taste Sulfide Type of piping

Bubbling minor Artesian Head

Boiling Rock Data:

Vegetation Type (surface) Bslt

Fluid issues from Color

Grain size

Megascopic Minerals

Salt: Type Sulfates

Quantity mod

Color white Alteration:

Form amorphous Rx Type (at depth)

Sinter: Type SiO_2 Water used for

Quantity abundant Immediate area used for: recreation

Color white

Form amorphous Quality of sample: (Exc.) Good, Poor

Probable cause of manifestation

Property owned by

Previous and/or Current Leases

Comments: Hills surrounding valley consist of Bslt flows and ash deposits

SKETCHES

AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. OR403 Sample No. X 89865 Date 7/5/74 Time 1200

Name: Malheur River Hot Sp. Location: Co Malheur State OR

SW¼SE¼ Sec. 33 T18S R:37E ; Km/mi. of

Lat.: Long.: Sampler: John Deymonaz Frank Dellechaie

Elevation: 3400 Quad. Beulah

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

Description:

Water Temp. °C 58 Discharge: 100 (gpm)/Lpm

Ground Temp. °C Well Data: Depth

Air Temp. Bore

Odor H_2S Pump Type

Fluid Color Level of water in bore

Fluid Taste sulfide Type of piping

Bubbling minor Artesian Head

Boiling Rock Data:

Vegetation green & reddish br. algae Type (surface) bslt

Fluid issues from gravel bar Color

along n. side of Malheur River 20' from river. Grain size

Megascopic Minerals

Salt: Type sulfate

Quantity moderate

Color white Alteration:

Form amorphous Rx Type (at depth)

Sinter: Type Water used for

Quantity Immediate area used for: farming

Color

Form Quality of sample: (Exc.), Good, Poor

Probable cause of manifestation reaching surface along flt.

Property owned by

Previous and/or Current Leases

Comments: roll 4 #16

SKETCHES

AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. OR416 Sample No. X 89873 Date 7/4/74 Time 1100

Name: Sec 29 Hot Sp Location: Co. Malheur State OR

SE¼ Sec. 29 T 20S R: 39E ; Km/mi. of

Lat.: Long.: Sampler: John Deymonaz ~~Frank Dellechaie~~

Elevation: 2880 Quad. Westfall Butte

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

Description:

Water Temp. °C 44.5 Discharge: 15 (gpm)/Lpm

Ground Temp. °C Well Data: Depth

Air Temp. Bore

Odor Pump Type

Fluid Color Level of water in bore

Fluid Taste Type of piping

Bubbling Artesian Head

Boiling Rock Data:

Vegetation green & reddish br. algae Type (surface) bslt

Fluid issues from hillside, apparently between bslt flows Color

Grain size

Megascopic Minerals

Salt: Type sulfate

Quantity minor

Color white Alteration:

Form amorphous Rx Type (at depth)

Sinter: Type Water used for livestock

Quantity Immediate area used for: rangeland

Color

Form Quality of sample: (Exc.), Good, Poor

Probable cause of manifestation

Property owned by

Previous and/or Current Leases

Comments: roll 4 fm 6-7

apparent East-West flt. through area.

SKETCHES

AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. OR415 Sample No. X 90215 Date 8/24/74 Time 1100

Name: Bath House WS Location: Co. Malheur State OR

NW¼ Sec. 17 T21S R:38E ; Km/mi. of

Lat.: Long.: Sampler: John Deymonaz

Elevation: 2960 Quad. Beulah Res.

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

Description:

Water Temp. °C 35 Discharge: 6 (gpm)/Lpm

Ground Temp. °C Well Data: Depth

Air Temp. Bore

Odor H_2S Pump Type

Fluid Color Level of water in bore

Fluid Taste sulfide Type of piping

Bubbling Artesian Head

Boiling Rock Data:

Vegetation Type (surface) bslt

Fluid issues from rocky soil (angular bslt frags) at base of hill in ~~small valley filled w/~~ alluvium Color dk. gray

Grain size aphanitic

Megascopic Minerals

Salt: Type sulfates

Quantity minor

Color white Alteration:

Form Rx Type (at depth)

Sinter: Type Water used for

Quantity Immediate area used for: rangeland

Color

Form Quality of sample: (Exc.), Good, Poor

Probable cause of manifestation thermal water reaching surface along flt.

Property owned by

Previous and/or Current Leases

Comments: roll 13 #15

SKETCHES

AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. OR414 Sample No. X 90214 Date 8/24/74 Time 1000

Name: Butler W.W. Location: Co. Malheur State OR

SW¼ Sec. 8 T21S R: 38E ; Km/mi. of

Lat.: Long.: Sampler: John Deymonaz

Elevation: 3040 Quad. Beulah Res.

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

Description:

Water Temp. °C 25 Discharge: 50 (gpm)/Lpm

Ground Temp. °C Well Data: Depth ??

Air Temp. Bore 6"

Odor slight H_2S Pump Type sub

Fluid Color Level of water in bore

Fluid Taste sulfide Type of piping steel

Bubbling Artesian Head

Boiling Rock Data:

Vegetation Type (surface) bslt

Fluid issues from well drilled in rocky soil (angular bslt float) Color dk. gray

Grain size plagioclase

Megascopic Minerals

Salt: Type

Quantity

Color Alteration:

Form Rx Type (at depth)

Sinter: Type Water used for home

Quantity Immediate area used for: ranching

Color

Form Quality of sample: (Exc), Good, Poor

Probable cause of manifestation normal ground water mixing w/thermal water

Property owned by **Bill Butler; Juntura, Oregon

Previous and/or Current Leases

Comments: roll 13 #16

SKETCHES

**owns several sections north of Beulah Res. including Hot Springs. Wants to lease entire area. Refused offer by Magma to lease 40 acres at Beulah H.S. #1.

AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. OR413 Sample No. X 90213 Date 8/24/74 Time 1400

Name: DeArmond W.S. Location: Co. Malheur State OR

NE¼SE¼ Sec. 9 T 19S R: 38E ; Km/mi. of

Lat.: Long.: Sampler: John Deymonaz

Elevation: 4120 Quad. Beulah Res.

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

Description:

Water Temp. °C 20.5 Discharge: 10 (gpm)/Lpm

Ground Temp. °C Well Data: Depth

Air Temp. Bore

Odor Pump Type

Fluid Color Level of water in bore

Fluid Taste Type of piping

Bubbling Artesian Head

Boiling Rock Data:

Vegetation Type (surface) bslt

Fluid issues from rocky soil on Color lt-dk. gray

talus slope Grain size

Megascopic Minerals plagioclase-pyroxene

Salt: Type sulfate

Quantity moderate

Color white Alteration:

Form Rx Type (at depth)

Sinter: Type Water used for livestock

Quantity Immediate area used for: rangeland

Color

Form Quality of sample: (Exc.), Good, Poor

Probable cause of manifestation normal hydro flow

Property owned by

Previous and/or Current Leases

Comments: roll 13 #19

SKETCHES

AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. OR400 Sample No. X 89862 Date 7/4/74 Time 1830

Name: Castle Rock Spring Location: Co. Malheur State OR

NW¼NW¼ Sec 19 T 18S R: 37E ; ____ Km/mi. ____ of ____

Lat.: ____ Long.: ____ Sampler: John Deymonaz ~~Frank Dellechaie~~

Elevation: 3660 Quad. Beulah

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

Description:

Water Temp. °C 16.5 Discharge: 50 (gpm/Lpm)

Ground Temp. °C ____ Well Data: Depth ____

Air Temp. ____ Bore ____

Odor ____ Pump Type ____

Fluid Color ____ Level of water in bore ____

Fluid Taste ____ Type of piping ____

Bubbling ____ Artesian Head ____

Boiling ____ Rock Data:

Vegetation ____ Type (surface) bslt (vesicular)

Fluid issues from steel pipe Color ____

____ Grain size ____

____ Megascopic Minerals ____

Salt: Type ? ____

Quantity ____ ____

Color ____ Alteration: ____

Form ____ Rx Type (at depth) ____

Sinter: Type ____ Water used for livestock

Quantity ____ Immediate area used for: ranching

Color ____ ____

Form ____ Quality of sample: (Exc.), Good, Poor

Probable cause of manifestation normal

Property owned by ? ____

Previous and/or Current Leases ____

____

Comments: roll 4 #11

SKETCHES

AMAX GEOTHERMAL GEOCHEMICAL SAMPLE FORM

Spring No. OR405 Sample No. X 89867 Date 7/4/74 Time 1500

Name: Beulah Hot Sp. East Location: Co. Malheur State OR

SE¼ Sec. 2 T19S R:37E ; Km/mi. of

Lat.: Long.: Sampler: John Deymonaz Frank Dellechaie

Elevation: 3340 Quad. Beulah

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

Description:

Water Temp. °C 60 Discharge: 10 (gpm)/Lpm

Ground Temp. °C 38 Well Data: Depth

Air Temp. Bore

Odor H_2S Pump Type

Fluid Color Level of water in bore

Fluid Taste Sulfide Type of piping

Bubbling minor Artesian Head

Boiling Rock Data:

Vegetation Green and reddish brown algae Type (surface) Bslt nearby

Fluid issues from recent stream alluvium. Several small issuences in pond. Color

Grain size

Megascopic Minerals

Salt: Type Sulfide

Quantity minor

Color white Alteration:

Form amorphous Rx Type (at depth)

Sinter: Type Water used for livestock

Quantity Immediate area used for: livestock; recreation

Color

Form Quality of sample: (Exc.), Good, Poor

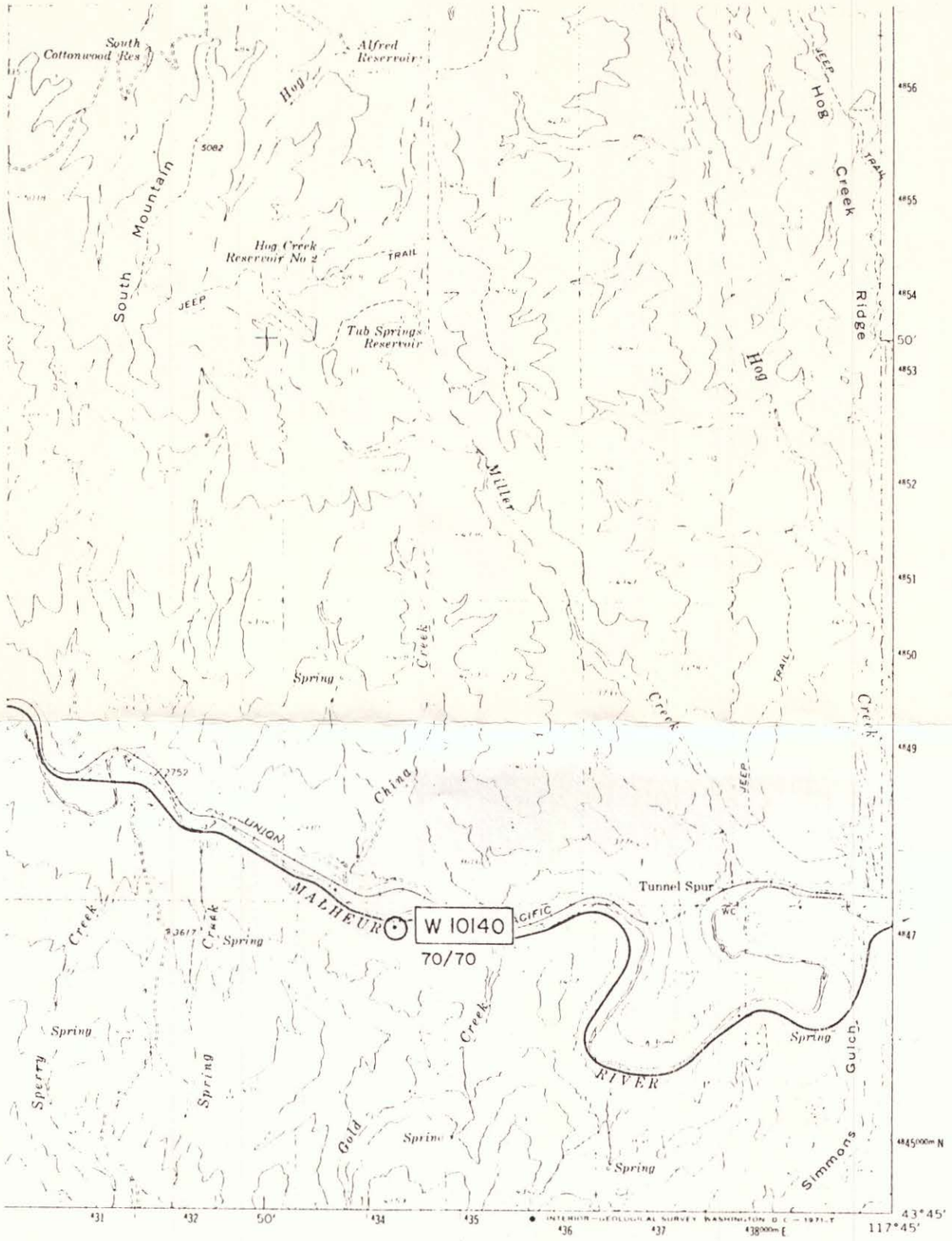
Probable cause of manifestation deep source, surfacing along flt.

Property owned by

Previous and/or Current Leases

Comments: Roll 4 #8

SKETCHES



2 3 4 MILES

15000 18000 21000 FEET

4 5 KILOMETERS

0 FEET
IT 20-FOOT CONTOURS
EVEL

ACCURACY STANDARDS
RADO 80225, OR WASHINGTON, D. C. 20242
MBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

ROAD CLASSIFICATION

Heavy duty ——— Light duty

Unimproved dirt

U.S. Route

WESTFALL BUTTE, OREG.

N4345—W11745/15

1966

AMS 2471 IV-SERIES V792

118°15'

118°00'

44°15'

44°00'

43°45'

T15S
T16S
T16S
T17S
T17S
T18S
T18S
T19S
T19S
T20S
T20S
T21S

X89862
12.0/12.8

X89863
20.0/20.9

X89864
16.5/17.5

X89865
58.0/58.2

X89866
72.0/72.2

X89867
60.0/60.2

X89868
15.0/15.3

X89869
13.0/15.0

X89870
15.0/14.0

X89871
17.0/18.2

X89872
15.0/15.8

X89873
44.5/44.5

X89834
15.0/17.5

X89835
15.5/18.0

X89836
9.0/12.4

X89837
16.0/18.1

X90210
13.0/13.3

X90211
16.0/17.9

X90212
12.0/14.0

X90213
17.0/18.5

X90214
25.0/25.0

X90215
35.0/35.0

SCALE 1:62500

CONTOUR INTERVAL 80 FEET
DOTTED LINES REPRESENT 40-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

UTM GRID AND 1968 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

OREGON
QUADRANGLE LOCATION

X90000
17.0/17.5
Surface Water Temperature Corrected For Elevation
Surface Water Temperature

AMAX EXPLORATION, INC.
PORTLAND, OREGON

BEULAH
OREGON
HYDROGEOCHEMICAL SAMPLE SITES
Source: Amax Survey 1-9-76