TEC-6

A HYDROGEOCHEMICAL STUDY
of the MT. PRINCETON PROSPECT,
CHAFFEE COUNTY, COLORADO

by

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AMAX Exploration, Inc.

Page
SUMMARY....1
THERMAL FEATURES....4
CHEMISTRY....10
STABLE ISOTOPE STUDIES....20
TRITIUM CONTENT-AGE OF THE HOT WATERS....21
MINERAL EQUILIBRIA....24
SUBSURFACE TEMPERATURES DEDUCED THROUGH CHEMICAL DATA....24

TABLES
1. The thermal features of the Mt. Princeton area.... 5
2. Chemical analysis of the thermal features of the Mt. Princeton area....11
3. Principle anions and cations of the Mt. Princeton thermal and non-thermal waters....12
4. Tritium content and age for selected thermal and non-thermal waters of the Mt. Princeton area....23
5. Gibbs Free Energies in kcal/mole for selected water samples from the Mt. Princeton area....25

FIGURES
1. Location map of the Mt. Princeton Property.... 4
2. A comparison of Hortense Hot Spring and Castle Rock Hot Spring, California....14
3. A plot of SiO_2 versus the Cl/HCO_3+CO_3 ratio....15
4. A plot of Cl versus the TDS/SiO_2 ratio.. 16
5. A plot of Na versus Ca....17
6. A plot of the major anions, HCO_3+CO_3, SO_4 and Cl....18
7. A plot of F versus Cl....19
8. Observed isotopic variations....20
9. δD versus δO^{18} for waters of the Mt. Princeton area....22

PLATES
1 through 9....6-9

GEOCHEMICAL SAMPLE FORMS....28-38

MAP
Hydrogeochemical Sample Sites of the Mt. Princeton Area....in pocket

Bibliography....27

SUMMARY

1. The Mount Princeton geothermal prospect lies in Chaffee County, of central Colorado. The area contains at least nine thermal water wells and four thermal springs. The preponderance of thermal features occur just south of the Chalk Cliffs. Here, low pressure steam fumeroles were also observed. The hot water is used for heating homes, greenhouses, bathing and drinking.

2. The non-thermal waters of the area contain less than 150 mg/l of dissolved solids and an average of 22 mg/l of silica. Cations and anions occur as follows:

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

3. The thermal waters of the area can be clearly divided into two groups:

   a) Very low chloride waters of the sulfate-sodium and bicarbonate-sodium variety which issue out near the Chalk Cliffs.

   b) High chloride waters of the sulfate sodium variety which include the remaining thermal features of the area, Poncha Hot Spring near Salida, the Jump Steady Hot Well due west of Buena Vista and the Fluorite Mine Warm Spring west of Browns Canyon.

The low chloride waters of the Chalk Cliffs are unique in all of Colorado. They have nearly similar chemical constitution as Castle Rock Hot Spring which issues out in the production area of The Geysers, Lake County, California. These waters almost certainly represent steam condensate which has equilibrated with the quartz monzonite of the Mt. Princeton Batholith at a shallow depth.

The chemistry of other thermal features of the area, Poncha Hot Spring, Jump Steady Hot Well and the Fluorite Mine Warm Spring indicates a low temperature, low salinity hot water regime, probably derived through deep circulation.

4. The Chalk Cliff waters are isotopically identical to local meteoric and groundwaters. This implies that these waters have been in residence with the reservoir rocks for a very short time and could not exchange ^{18}O.

5. Tritium dating of the Chalk Cliff waters via three different models indicates a maximum age of approximately 60 years. This agrees very well with the chemistry and stable isotope analysis discussed above.

6. The water of Hortense Hot Spring which issues out at the base of the Chalk Cliffs is saturated with three zeolite minerals. Leondarite, the low temperature form of laumontite, has been described petrographically in cores from The Geysers, Larderello and Wairakei. The waters which do not issue out near the Chalk Cliffs are generally saturated with carbonate minerals which may imply a low temperature regime.

7. Subsurface geothermometers generally indicate temperatures of about 100°C for "steam heated springs". The subsurface temperatures for the Chalk Cliff waters are almost identical to the subsurface temperatures for Castle Rock Hot Spring, Lake County, California.

8. Hydrogeochemical analysis indicates that the waters of Poncha Hot Spring, the Jump Steady Hot Well and the Fluorite Mine Warm Spring are of little intrinsic geothermal interest.

The seven thermal features near the Chalk Cliffs exhibit chemical characteristics demanding commercial geothermal interest. These waters are chemically and isotopically permissive of a vapor-dominated regime.

They are similar to a "steam heated spring" at The Geysers, California. Determination of the size and the temperature-pressure conditions of the reservoir are not permitted by this data.

AMAX has a commanding land position in the vicinity of the Chalk Cliffs. I am inclined to conclude that a dry steam reservoir exists in the vicinity.

THERMAL FEATURES

Forty-two water samples and several rock samples were collected from the Mt. Princeton area (Figure 1) during 1974 and 1975. Spring and well temperatures range from 85°C at Hortense Hot Spring to 6.5°C at Americus Cold Spring (X89681). The area contains at least 9 thermal wells and 4 thermal springs (Table 1). Many thermal seeps issue from Chalk Creek, south of the Chalk Cliffs which could not be sampled. Most of the hot wells are used for heating homes, greenhouses, bathing and drinking. Several low pressure fumeroles were observed on the Chalk Cliffs about 100 meters west of Hortense Hot Spring, having temperatures of up to 30°C. The gas composition was apparently pure water vapor. Poncha Hot Spring

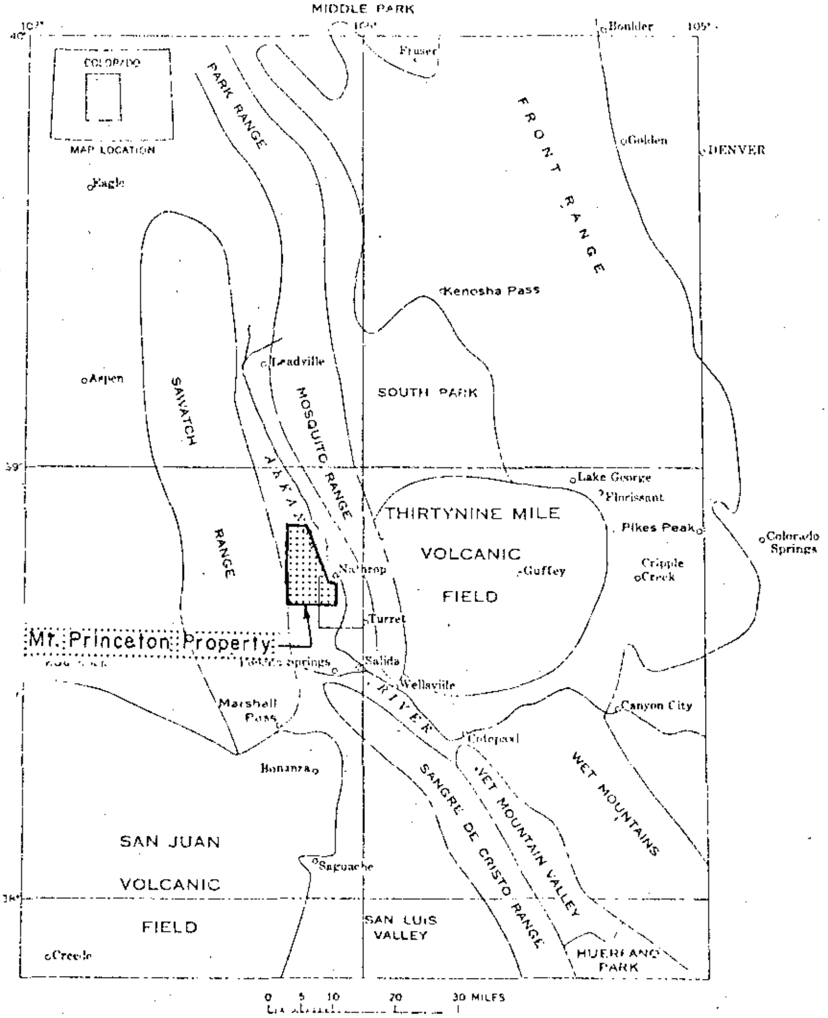


Figure 1. Location map of the Mt. Princeton Property.

has formed an apron of dark travertine. The springs in the area of Mount Princeton deposit only salts.

Table 1. The thermal features of the Mt. Princeton area.

Sample Number and Name		T°C	Flow l/m	Heat Discharge cal/sec.
X89644	Hortense Hot Spring	85	38	4.9×10^4
X89645	Younglife Hot Well East	85	379	4.9×10^5
X89663	Poncha Hot Spring	70	386	4.0×10^5
X89653	Younglife Hot Well West	67	379	3.7×10^5
X89665	Greenhouse Hot Well	68	379	3.8×10^5
X89666	Chalk Creek Greenhouse Hot Well	65	1892	1.8×10^6
X89649	Jump Steady Hot Well	59	568	5.0×10^5
X89652	Mt. Princeton Hot Spring	56	265	2.1×10^5
X89667	Deer Ranch Hot Well	38.5	379	1.9×10^5
X89654	Fluorite Mine Warm Spring	22.5	95	2.3×10^4
				4.4×10^6 cal/sec.
				1.8×10^4 BTU/sec.

The approximate heat discharge for the thermal features of the area, computed as the product of the volume rate and enthalpy of the water in excess of ambient temperature, is seen in Table 1. All the thermal features combine to produce 4×10^6 cal/sec. or enough heat to supply approximately 200 average sized houses.

Descriptions of each thermal feature are listed in Appendix 1. Plates 1 through 9 are pictorial representations of some of the thermal features. A sample location map is included in the pocket at the end of this report.

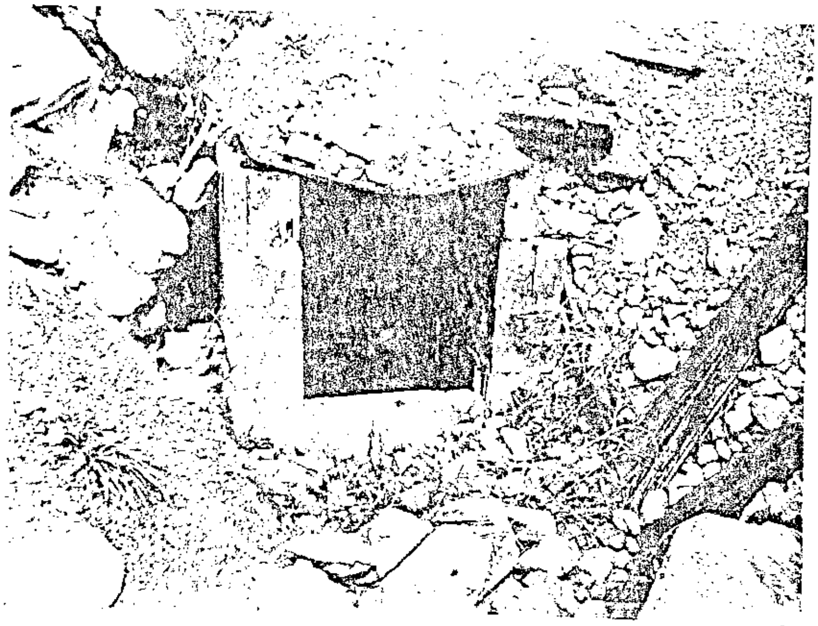


Plate 1. Hortense Hot Spring, 85°C

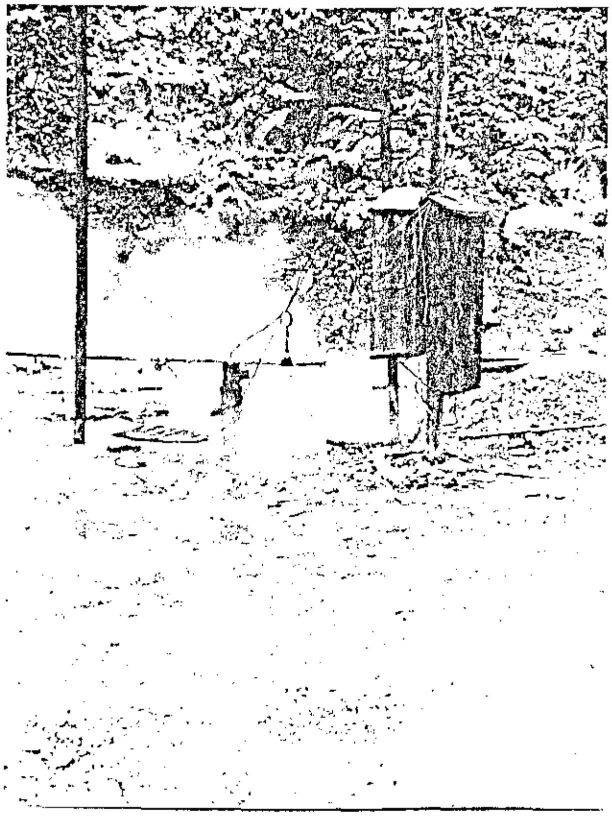
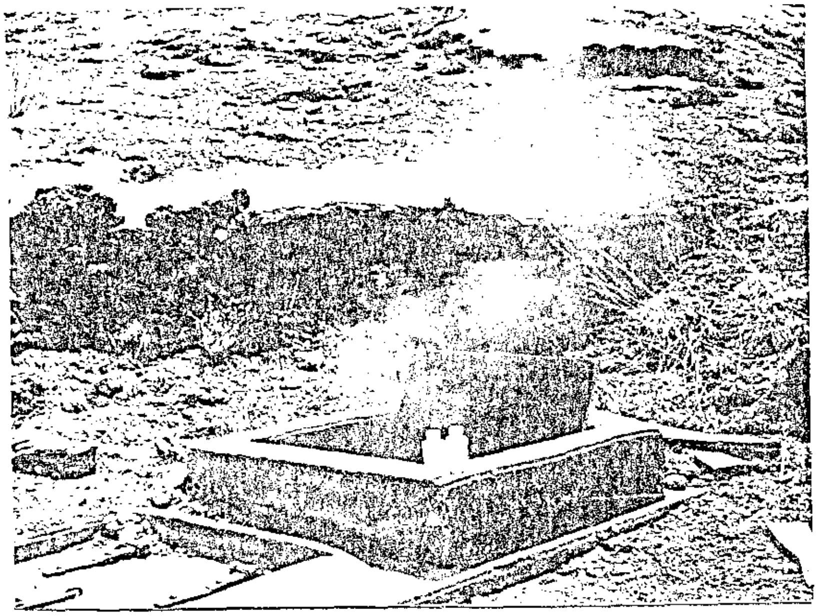


Plate 2. Younglife Hot Well East, 85°C

Plate 3.

Poncha Hot Spring, 70°C



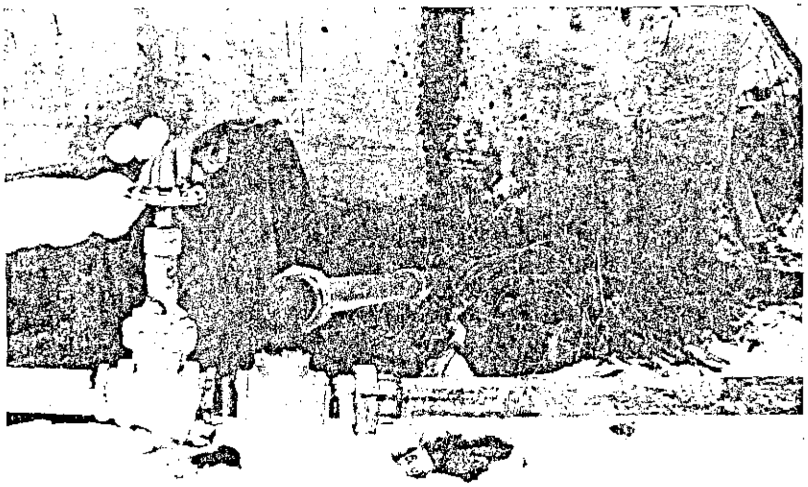


Plate 4.

Younglife Hot Well West, 67°C

Plate 5.

Jump Steady Hot Well, 59°C

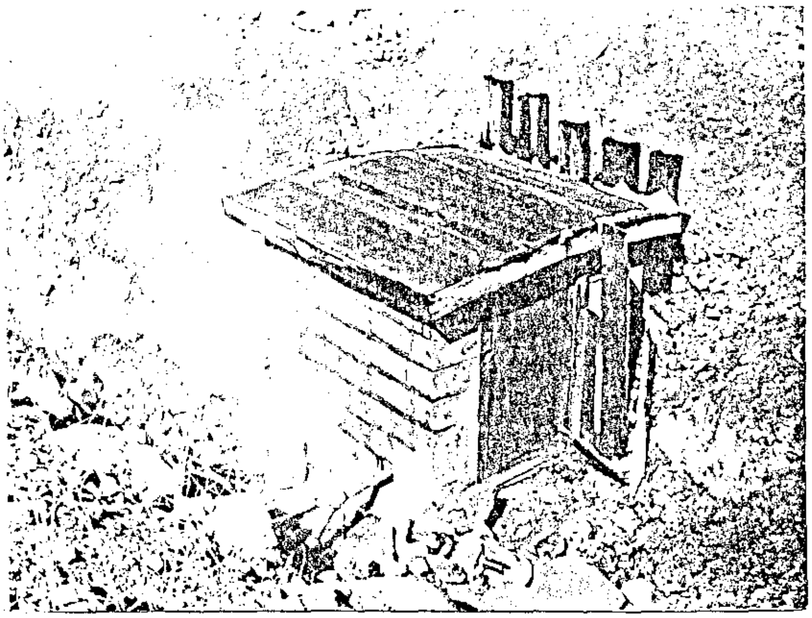


Plate 6. Mt. Princeton Hot Spring, 56°C

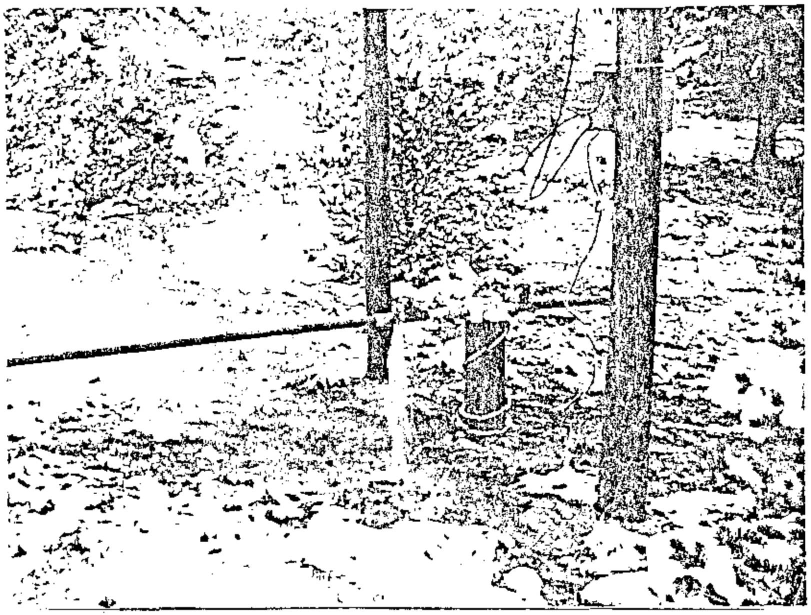


Plate 7. Deer Ranch Hot Well, 38.5°C

Plate 8.

Fluorite Mine Warm Spring, 23.5°C

Plate 9.

Ice Pond Cold Spring, 9°C

Table 2. Chemical analysis of the thermal features of the Mt. Princeton area. Units are mg/l unless otherwise noted.

	Hortense Hot Spring X89644	Younglife Hot Well E. X89645	Poncha Hot Spring X89663	Greenhouse Hot Well X89665	Younglife Hot Well W. X89653	Chalk Creek Greenhouse Hot Well X89666	Jump Steady Hot Well X89649	Mt. Princeton Hot Spring X89652	Deer Ranch Hot Well X89667	Fluorite Mine Warm Spring X89654	Ice Pond Cold Spr X89689
pH	9.6	9.2	8.2	9.1	9.1	8.8	9.2	8.6	8.8	8.5	7.6
Cl	8.8	11	48	6.6	2.2	6.6	28	5.5	4.4	55	3.0
F	16	15	11	13	9.3	10	14	9.4	6.2	16	0.2
HCO_3	46	43	156	79	44	52	31	59	64	106	68
CO_3	16	18	8	20	10	0	24	0	0	0	0
SO_4	100	90	200	80	60	70	110	60	40	145	6
SiO_2	85	80	80	75	75	65	60	60	45	45	25
Na	100	80	210	80	60	60	110	50	40	160	7
K	4.0	2	7	2	2	2	2	2	2	3	1
Ca	15.0	13	20	7	17	10	50	20	20	12	18
Mg	0.1	<0.1	0.5	<0.1	0.4	0.1	0.3	0.4	0.9	0.2	4
Li	0.2	0.1	0.2	NA	0.1	NA	0.2	0.1	0.1	0.2	NA
B	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
NH_3	0.4	0.3	<0.1	<0.1	<0.1	NA	<0.1	<0.1	<0.1	<0.1	<0.1
Cu µg/l	<1	3	9	<1	<1	<1	<1	<1	6	<1	<1
Mo µg/l	80	80	20	80	70	70	40	60	40	80	2
TDS	394	352	741	363	280	276	429	266	223	542	132
T°C	85	85	70	68	67	65	59	56	38.5	22.5	9
Flow (gpm)	10	100	102	100	100	500	150	70	100	25	75
$TSiO_2$°C	125	125	125	122	122	115	110	111	97	97	72
TNa/K°C	97	74	84	64	84	84	45	97	115	47	230*
TNa-K-Ca°C	75	55	96	67	47	57	34	43	41	75	12
Cl/SO_4	0.2	0.3	0.7	0.2	0.1	0.3	0.7	0.3	0.3	1.0	1.4
Cl/F	0.3	0.4	2.3	0.3	0.1	0.1	1.1	0.3	0.4	1.8	8.0
Cl/HCO_3+CO_3	0.5	0.6	1.0	0.2	0.1	0.4	1.7	0.3	0.2	1.8	0.2
Resistivity ohm-m	21.4	24.2	10.0	NA	NA	NA	19.2	32.6	36.2	13.1	63.7

NA = not analysed

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

CHEMISTRY

The non-thermal waters of the Mt. Princeton area generally contain less than 150 mg/l of dissolved solids. Water pH is generally neutral to slightly basic. Bicarbonate is the principle ion followed by silica, calcium, sodium and magnesium. Cold waters contain an average of 22 mg/l of silica. Ice Pond Cold Spring (X90689) was chosen to represent background water chemistry (Table 2).

Thermal waters exhibit basic to very basic pH (Table 2). Four types of thermal water are recognized (Table 3).

1. Sulfate-sodium waters with less than 12 mg/l of chloride clearly represent steam condensate that has equilibrated with the quartz monzonite of the Mount Princeton Batholith. Hortense and Mount Princeton Hot Springs and three hot wells located south of the Chalk Cliffs are included in this category.

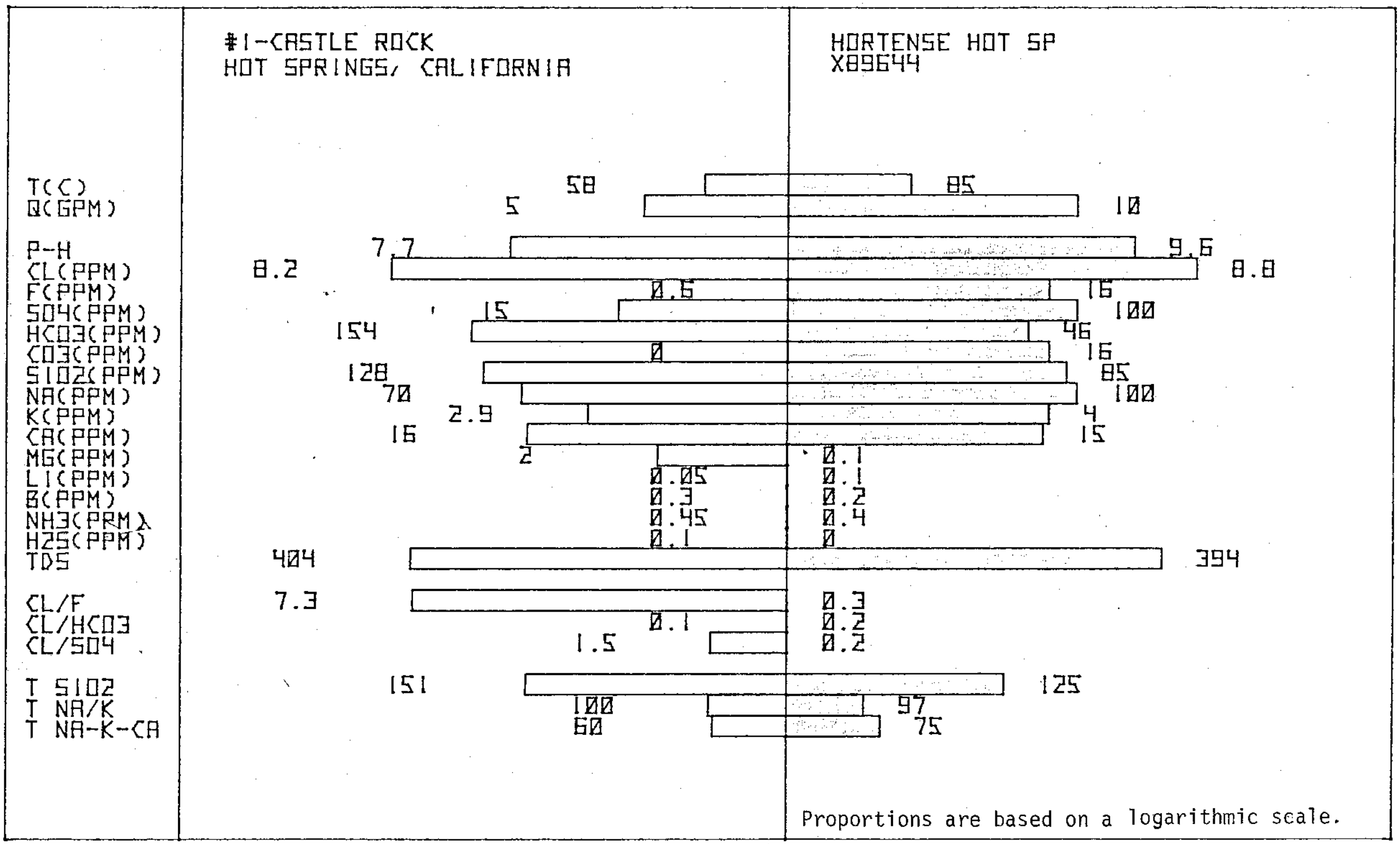
2. Bicarbonate-sodium waters with less than 7 mg/l of chloride are dilutions of sulfate-sodium waters with bicarbonate rich groundwaters (see category 4 below). Greenhouse Hot Well and Deer Ranch Hot Well represent this group.
3. Sulfate-sodium waters with greater than 25 mg/l of chloride probably represent low temperature, low salinity hot water systems, derived through deep circulation. These waters are saturated with calcium carbonate minerals and deposit varying amounts of travertine. Poncha Hot Spring, Jump Steady Hot Well (Cottenwood Hot Spring) and Fluorite Mine Warm Spring comprise this category.
4. Groundwaters are generally rich in bicarbonate.

Table 3. Principle anions and cations of the Mt. Princeton thermal and non-thermal waters.

Sample Number and Name		Anions	Cations
	Sulfate-sodium waters with very low chloride		
X89644	Hortense Hot Spring	$SO_4>HCO_3>>Cl$	Na>Ca>K>Mg
X89645	Younglife Hot Well East	$SO_4>HCO_3>>Cl$	Na>Ca>K>Mg
X89653	Younglife Hot Well West	$SO_4>HCO_3>>Cl$	Na>Ca>K>Mg
X89666	Chalk Creek Greenhouse Hot Well	$SO_4>HCO_3>>Cl$	Na>Ca>K>Mg
X89652	Mt. Princeton Hot Spring	$SO_4 \simeq HCO_3>>Cl$	Na>Ca>K>Mg
	Sulfate-sodium waters with greater than 28 mg/l chloride		
X89663	Poncha Hot Spring	$SO_4>HCO_3>Cl$	Na>Ca>K>Mg
X89649	Jump Steady Hot Well	$SO_4>HCO_3>Cl$	Na>Ca>>K>Mg
X89654	Fluorite Mine Warm Spring	$SO_4>HCO_3>Cl$	Na>Ca>K>Mg
	Bicarbonate-sodium waters with very low chloride		
X89665	Greenhouse Hot Well	$HCO_3>SO_4>>Cl$	Na>Ca>K>Mg
X89667	Deer Ranch Hot Well	$HCO_3>SO_4>>Cl$	Na>Ca>K>Mg
	Cold groundwater		
X89689	Ice Pond Cold Spring	$HCO_3>>SO_4>Cl$	Ca>Na>Mg>K

The most interesting waters in the area issue out near the Chalk Cliffs. These "dry steam waters" are similar to Castle Rock Hot Spring, Lake County, California. Figure 2 is a graphic comparison of Hortense Hot Spring and Castle Rock Hot Spring. Note that the dissimilarities include pH, bicarbonate, carbonate (both of the latter are a function of pH), fluoride and sulfate. Concentrations of the volatile elements are very similar.

Figures 3 through 7 are geochemical plots of the thermal and non-thermal waters of the Mt. Princeton area. Figure 3, a plot of silica versus the Cl/HCO_3+CO_3 ratio shows at least two families of water; first, the low chloride waters from the vicinity of the Chalk Cliffs and second, the chlorided waters of Poncha Hot Spring, Jump Steady Hot Well and Fluorite Mine Warm Spring. Figure 4, a plot of chloride versus the TDS/SiO_2 ratio, lends the same meaning as Figure 3. Figure 5, a plot of sodium versus calcium, shows a dilution trend that extends from Hortense Hot Spring to Ice Pond Cold Spring. Note that waters along this trend generally decrease in termperature and sodium, and increase in calcium. Fluorite Warm Spring, Poncha Hot Spring and Jump Steady Hot Well are clearly chemically different than the Chalk Cliff Group. Figure 6 is a graphic representation of Table 3. The dilution trend seen in Figure 5 is seen in Figure 6 as a progressive change from sulfate to bicarbonate for the Chalk Cliff group. Figure 7 is a plot of fluoride versus chloride which also demonstrates the clear distinction between the Chalk Cliff waters and the other thermal waters of the Mt. Princeton area. The dilution trend for the Chalk Cliff waters seen in Figure 5 is also evident in Figure 7.



Proportions are based on a logarithmic scale.

Figure 2. A comparison of Hortense Hot Spring and Castle Rock Hot Spring, California.

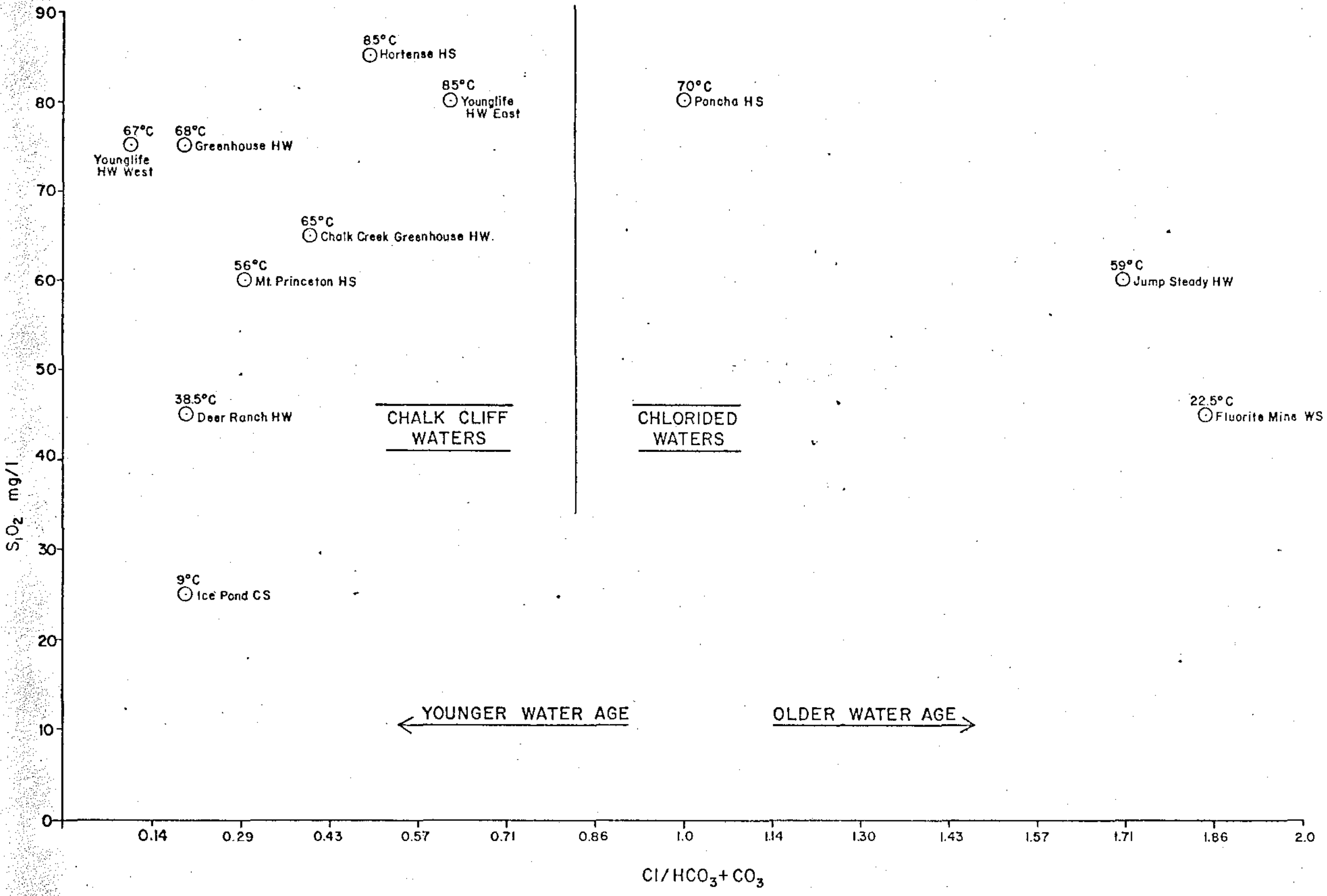


Figure 3. A plot of SiO_2 versus the Cl/HCO_3+CO_3 ratio.

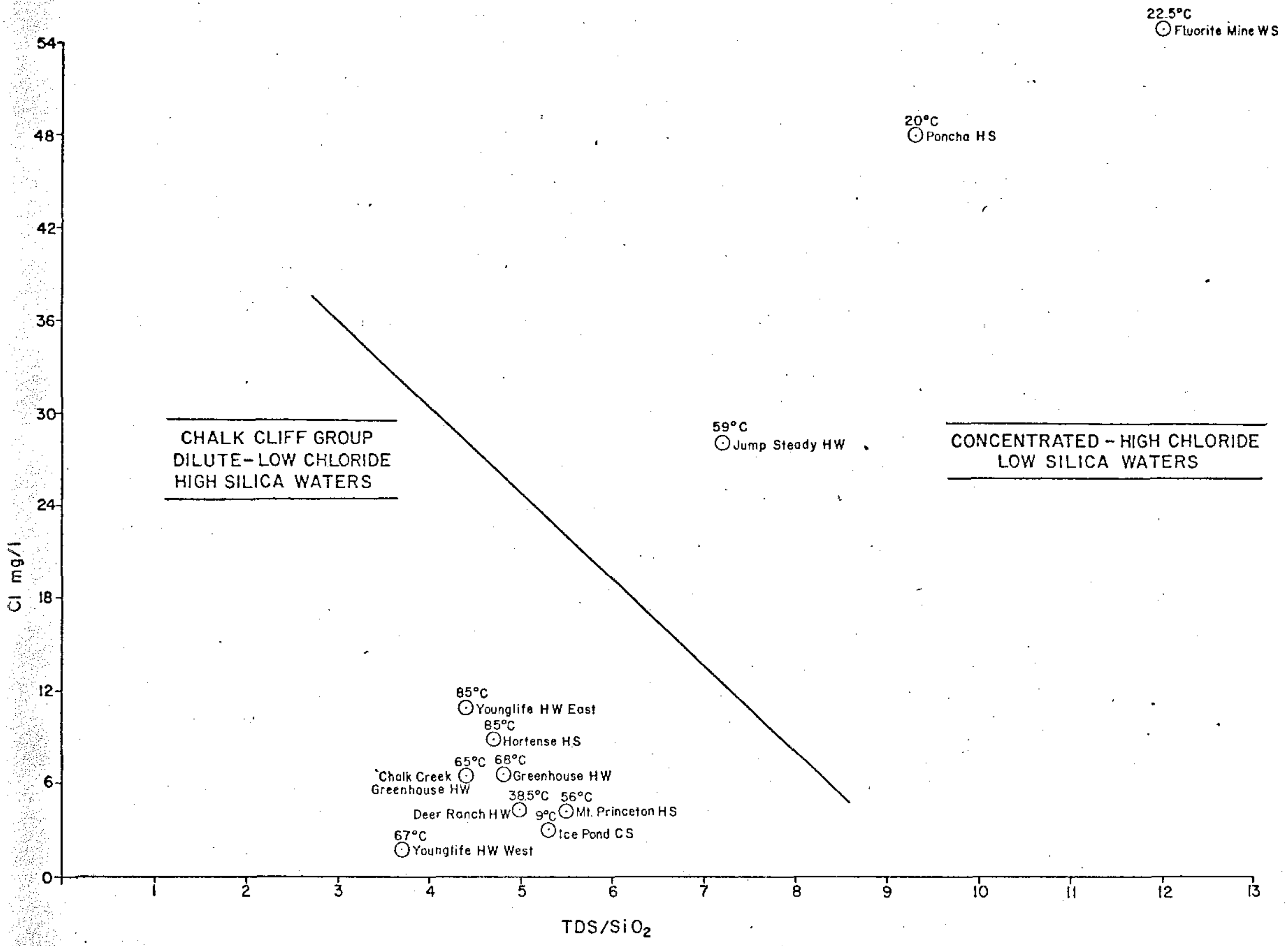


Figure 4. A plot of Cl versus the TDS/SiO_2 ratio.

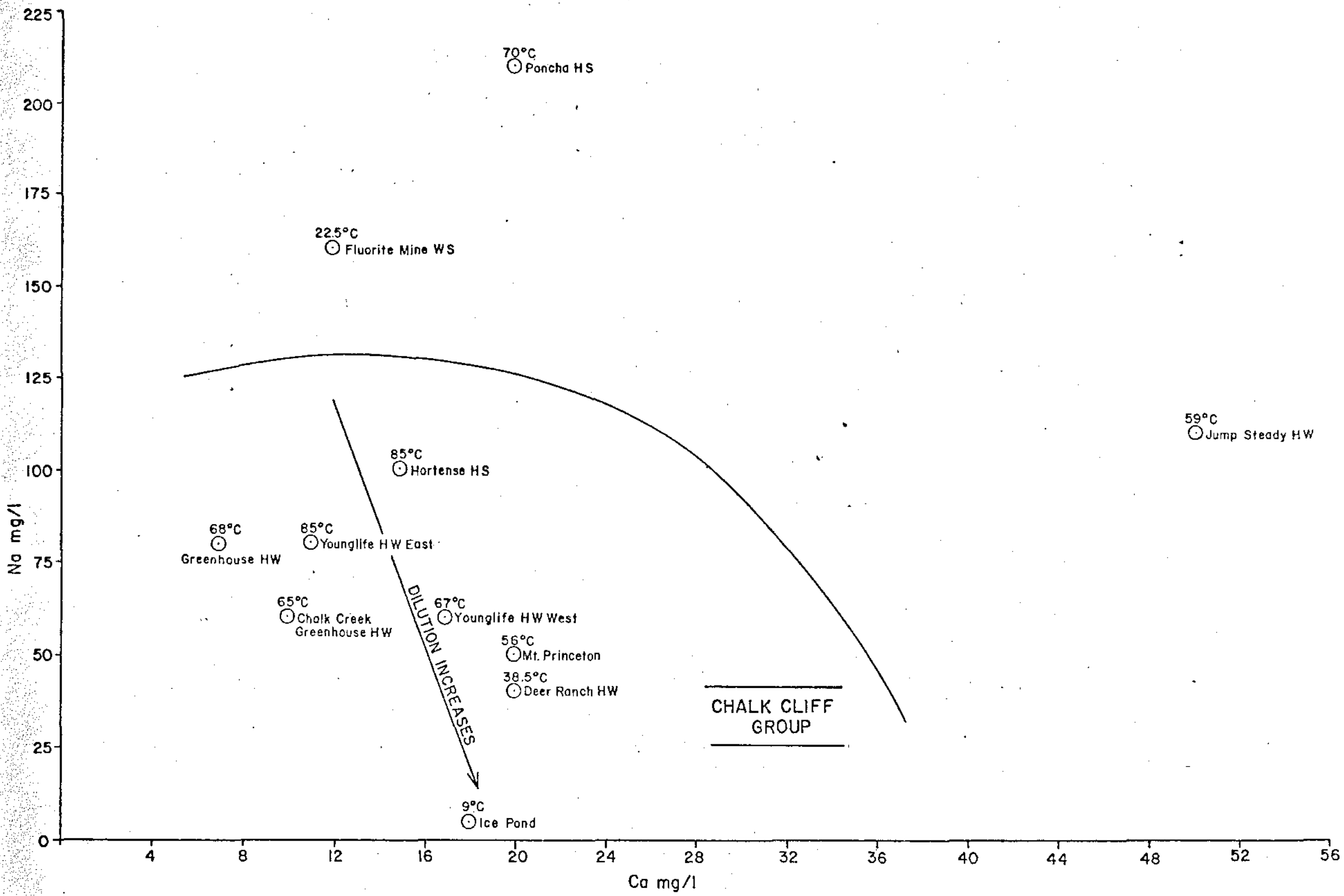


Figure 5. A plot of Na versus Ca.

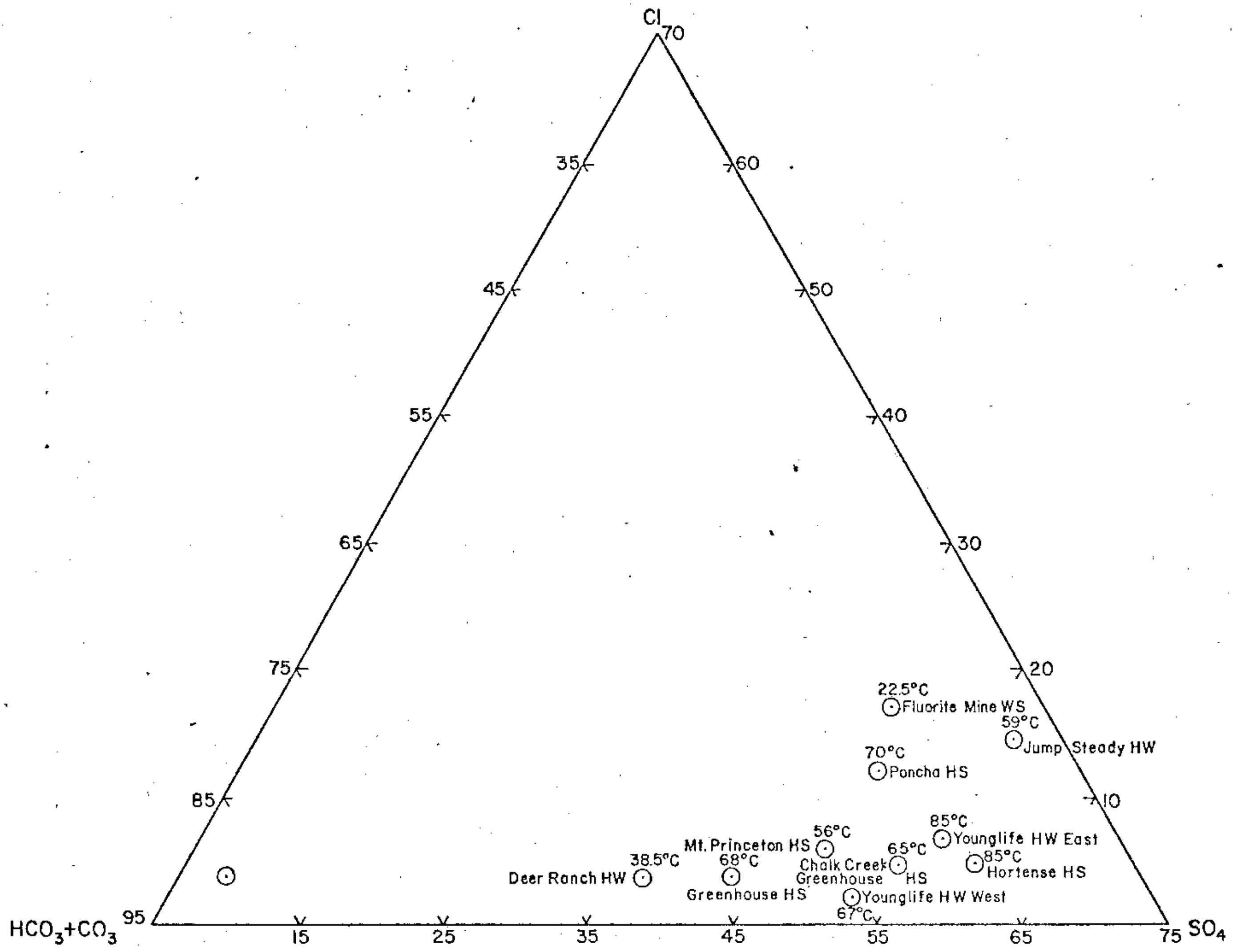


Figure 6. A plot of the major anions, HCO_3+CO_3, SO_4 and Cl.

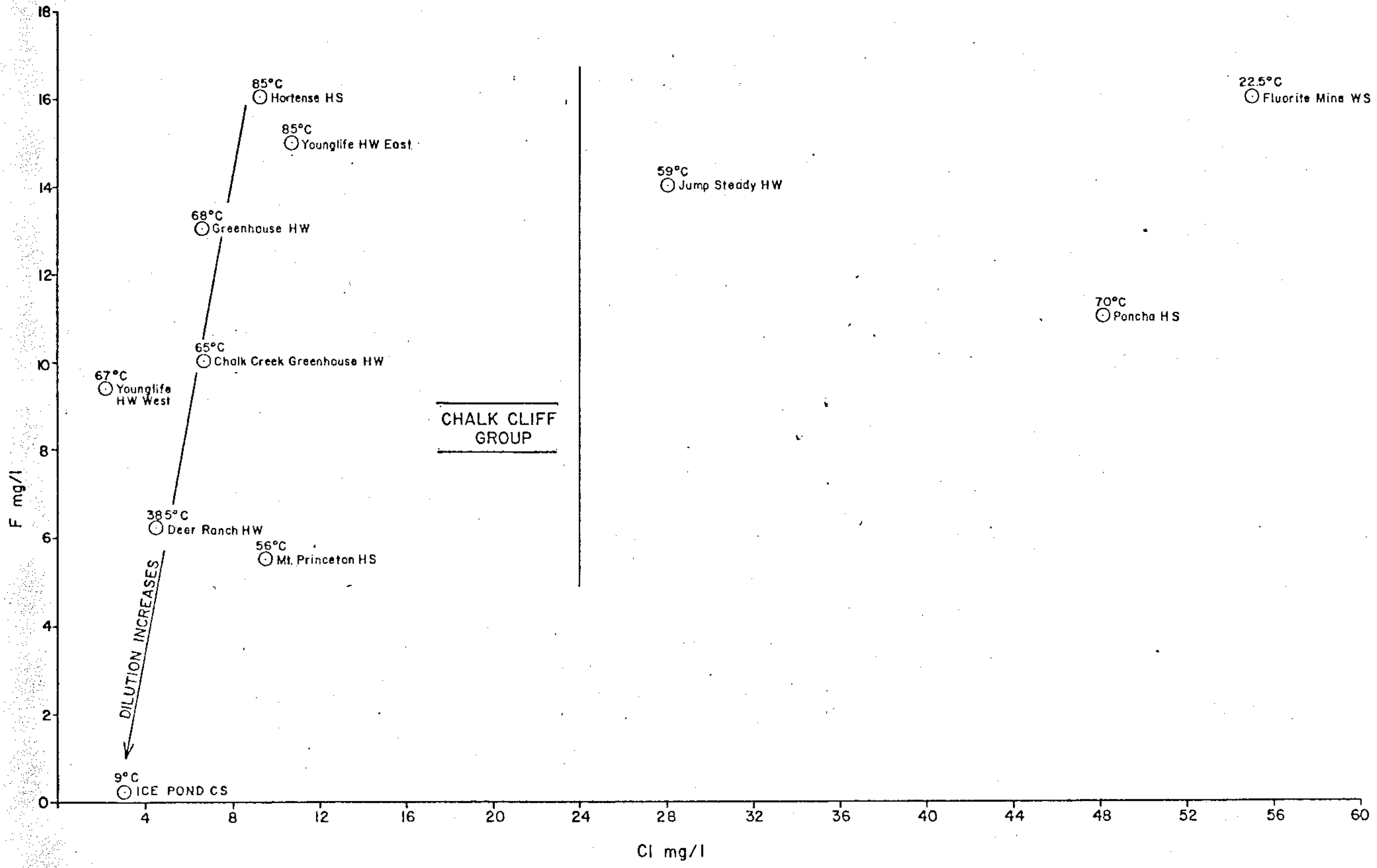


Figure 7. A plot of F versus Cl.

STABLE ISOTOPE STUDIES

Figure 7 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 concentrations are constant and equal to local meteoric water while O^{18} concentrations show the characteristic enrichment or shift. The explanation for the oxygen shift is an isotopic exchange with carbonates and silicates in the rocks which the waters move. Silicate and carbonate rocks contain oxygen ranging from +6 to +30 δO^{18}. δD generally does not vary from the meteoric concentration because rocks contain negligible protium or deuterium. Note that the Niland waters which have mingled with Colorado River sediments, rich in carbonates, show the greatest shift. On the other end of the scale, Wairakei shows negligible shift which implies that waters descend quickly, stay in storage for a short time and then ascend.

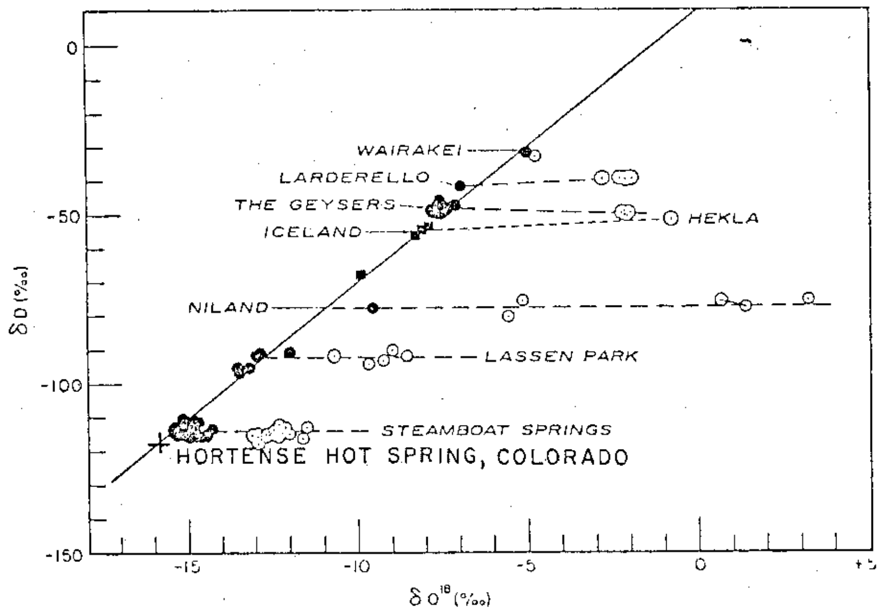


Figure 8. Observed isotopic variations in near-neutral chloride type geothermal waters and in geothermal steam. Solid points are local meteoric waters, or slightly heated near-surface groundwaters. Open circles are hot springs or geothermal water, crinkled circles are high temperature, high pressure, geothermal steam (after Craig, 1963).

To summarize, a strong shift in $\delta 0^{18}$ 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 0^{18} with rocks almost regardless of storage time, and second, 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 0^{18} exchange to occur.

Figure 8 is a plot of deutrium-0^{18} for selected waters of the Mt. Princeton area. It is interesting that the hot waters show no apparent 0^{18} shift, that is they are no different from meteoric waters regarding these two stable isotopes. This analysis implies that these boiling or near boiling waters have been in residence with the reservoir rocks only a short time and have not exchanged stable isotopes.

TRITIUM CONTENT-AGE OF THE HOT WATERS

Tritium is a naturally occurring isotope of hydrogen (^3H) that is produced by cosmic ray interaction with nitrogen and oxygen in the upper atmosphere. It has also been abundantly produced by thermonuclear devices during the last decade. Tritium decays by B-emmision with a half life of 12.26 years.

Various mathematical models have been used in recent years to routinely date groundwaters via tritium. Model A relates to a spring fed by a homogeneous, thick aquifer with constant permeability. The solution for the tritium content of the hot spring (Ts) is:

$$Ts = \frac{To}{\lambda Tmax} \quad (1-e^{-\lambda Tmax})$$

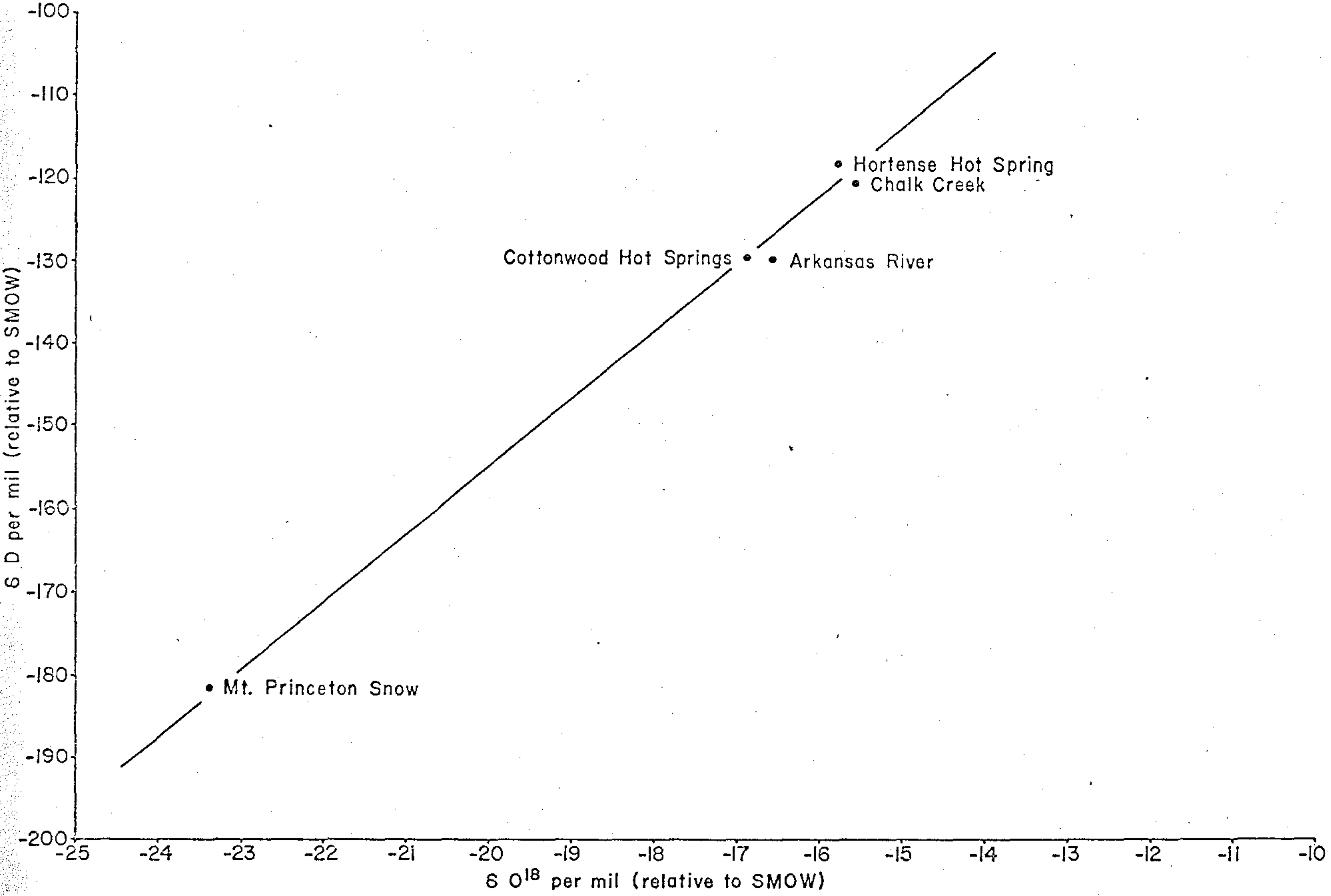


Figure 9. δD versus δO^{18} for waters of the Mt. Princeton area.

where To is the tritium content of cold surface water, λ is the decay constant (5.653×10^{-2}) and Tmax is the maximum travel time of the water in the aquifer or the water age.

Model B describes a fan shaped aquifer with the spring at the narrow end being the only outlet. In this case the velocity of the water must increase approaching the spring as a funnelling effect. The solution for the tritium content of hot water (Ts) is:

$$Ts = \frac{2To}{\lambda^2 T^2 max} [1-(1+\lambda Tmax)e^{-\lambda Tmax}] .$$

Model C assumes that water from the hot spring comes from a very thin aquifer containing water of constant age (T). The solution for the tritium content of the water (Ts) is:

$$Ts = To\ e^{-\lambda T} .$$

Table 4. Tritium content and age for selected thermal and non-thermal waters of the Mt. Princeton area.

Sample Name	^3H(T.U.)	Age of thermal water in years Model A	Model B	Model C
Arkansas River	180			
Chalk Creek	280			
Mt. Princeton Snow	97			
Hortense Hot Spring	92	51	32	20
Jump Steady Hot Well	87	56	35	21

Applying the analytical data in Table 4, it is clear that regardless of which model is used, the water of Hortense Hot Spring is less than 60 years old. These age dates are in good argument with the suggested youth of the same waters via stable isotopes which were discussed in the previous section.

It was suggested in the section on chemistry that the water of the Jump Steady Hot Well was the result of deep circulation seen by the high chloride content. The Jump Steady hot water should then be older than the steam condensate of Hortense Hot Spring formed at very shallow depths. Indeed, tritium dating indicates that the water of the Jump Steady Hot Well is older than the water of Hortense Hot Spring.

MINERAL EQUILIBRIA

The degree of saturation of 285 possible hypothetical minerals in selected waters from the Mt. Princeton area has been calculated (Table 5). Hortense Hot Spring is saturated with a long list of metamorphic and igneous minerals along with three zeolite minerals. Leonhardite has been described petrographically in the rocks of the Chalk Cliffs (Sharp, 1970) and its high temperature relative, laumontite, was predicted at depth. Solution-mineral equilibria studies do show that the water of Hortense Hot Spring was last in equilibrium with laumontite thus lending credence to Sharp's prediction. The presence of these high temperature zeolites in the high water is very encouraging as they have been described in cores from The Geysers, Larderello and Wairakei. Poncha Hot Spring and the Jump Steady Hot Well are both saturated with carbonate minerals which may imply a low temperature regime. It is interesting to note that Poncha Hot Spring has deposited large amounts of dark travertine (Plate 3).

SUBSURFACE TEMPERATURES DEDUCED THROUGH CHEMICAL DATA

The chemical data discussed thus far imply that the hot waters associated with the Chalk Cliffs are basically steam condensate. Hot springs associated with steam systems do not give accurate equilibrium temperatures for the following reasons:

Table 5. Gibbs Free Energies in kcal/mole for selected water samples from the Mt. Princeton area. Positive values imply mineral saturation.

	Hortense Hot Spring X89644		Younglife Hot Well East X89645		Poncha Hot Spring X89663		Jump Steady Hot Well X89649		Mt. Princeton Hot Spring X89652		Fluorite Mine Warm Spring X89654	
T°C	85		85		58		59		56		22.5	
TDS mg/l	394		352		741		429		266		542	
Cations meq/l	5.1		4.2		10.0		6.9		3.2		7.6	
Anions meq/l	4.9		4.3		9.7		6.7		2.9		7.2	
Carbonates					Calcite	0.7	Calcite	1.7	Calcite	0.6		
					Aragonite	0.6	Aragonite	1.6	Aragonite	0.5		
							Dolomite	0.8				
Silicates	Tremolite	35.1	Tremolite	33.2	Tremolite	14.2	Tremolite	31.0	Tremolite	20.1	Talc	4.4
	Chlorite	28.0	Talc	15.5	Talc	8.8	Talc	14.9	Talc	11.2	Tremolite	3.7
	Talc	16.1	Crysotile	8.0	Diopside	1.2	Diopside	6.5	Diopside	3.0	Quartz	1.1
	Crysotile	8.6	Diopside	7.3	Quartz	0.9	Quartz	0.3	Crysotile	2.4	Chalcedony	0.5
	Diopside	8.0	Wollastonite	0.9	Chalcedony	0.4	Wollastonite	0.3	Quartz	0.7	Cristobalite	0.3.
	Zoesite	7.2	Clinoenstatite	0.4	Cristobalite	0.2			Chalcedony	0.2		
	Muscovite	6.3										
	Wollastonite	1.3										
	Clinoenstatite	0.6										
	Sepiolite	0.2										
Zeolites	Phillipsite	11.5										
	Prehnite	7.4										
	Laumontite	5.3										

1. Ions incorporated in the deep-old liquid (if this is saline liquid indeed exists) are not transferred to the steam phase.
2. The very low ionic strength steam condenses at some shallow depth and re-equilibriates with groundwater.
3. Maximum equilibrium temperatures can not exceed the original steam temperature plus normal gradient of the area.
4. The volatiles in steam, NH_3 and H_2S, suffer much greater damage via cold water dilution than would the same volatile in hot water.

"Steam heated springs" are at best reflections of shallow conditions and subsurface temperatures should be in the vicinity of 100°C or below.

The calculated subsurface temperatures (Table 2) for the Chalk Cliff waters range from 75°C to 125°C. These temperatures are in good agreement with the above discussion. Note the remarkable similarities in subsurface temperatures between Hortense Hot Spring and Castle Rock Hot Spring in Figure 2.

Bibliography

Craig, H., 1963, The isotope geochemistry of water and carbon in geothermal areas, in Tangiorgi, E., ed., Nuclear Geology in Geothermal Areas: Consiglio Nazionale Delle Ricerche Laboratorio Di Geologia Nucleare-Pisa, Italy, p17-53.

[illegible]

Spring No. Co 27 Sample No. X 89644 Date 3/19/74 Time

Name: Hortense Hot Spring Location: Co. Chaffee State Colo.

NW¼ Sec. 24 T 15S R: 79W ; Km/mi. of

Lat.: Long.: Sampler: F. Dellechaie

Elevation: 8300 Quad. Poncha Springs

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

Description:

Water Temp. °C 85

Discharge: 10 gpm 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 mineralized

Type of piping

Bubbling 0

Artesian Head

Boiling yes

Rock Data:

Vegetation 0

Type (surface) qtz monzanite

Fluid issues from qtz mon. on hillside

Color

Grain size

Megascopic Minerals

Salt: Type ca mg SO_4

Quantity

Color

Alteration: major

Form

Rx Type (at depth)

Sinter: Type

Water used for heating

Quantity

Immediate area used for: recreation

Color

Form

Quality of sample: [✓ Exc.], Good, Poor

Probable cause of manifestation deep fault

Property owned by young life resort

Previous and/or Current Leases AMAX

Comments:

SKETCHES

Spring No. Co26 Sample No. X 89645 Date 3/19/74 Time

Name: Younglife Hot Well #1 Location: Co. Chaffee State Colo.

NW¼ Sec. 24 T15S R: 79W ; Km/mi. of

Lat.: Long.: Sampler: F. Dellechaie

Elevation: 8280 Quad. Poncha Springs

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

Description:

Water Temp. °C 85

Ground Temp. °C

Air Temp.

Odor o

Fluid Color o

Fluid Taste mineralized

Bubbling o

Boiling o

Vegetation o

Fluid issues from well

Salt: Type ca mg SO_4

Quantity

Color

Form

Sinter: Type

Quantity

Color

Form

Discharge: 100 gpm gpm/Lpm

Well Data: Depth

Bore

Pump Type

Level of water in bore

Type of piping

Artesian Head

Rock Data:

Type (surface) qtz monzanite

Color

Grain size

Megascopic Minerals

Alteration:

Rx Type (at depth)

Water used for heating

Immediate area used for: recreation

Quality of sample: [✓ Exc.], Good, Poor

Probable cause of manifestation well

Property owned by Younglife Bible camp

Previous and/or Current Leases AMAX

Comments:

SKETCHES

Spring No. Co 44 Sample No. X 89663 Date 3-25-74 Time

Name: Poncha Hot Spring Location: Co. Chaffee State Colo.

SW¼ Sec. 10 T 49N R: 8E ; Km/mi. of

Lat.: Long.: Sampler: F. Dellechaie

Elevation: Quad. Poncha Springs

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

Description:

Water Temp. °C 70

Discharge: 102 gpm gpm/Lpm

Ground Temp. °C

Well Data: Depth

Air Temp.

Bore

Odor H_2S

Pump Type

Fluid Color clear

Level of water in bore

Fluid Taste $S^=$, hard

Type of piping

Bubbling 0

Artesian Head

Boiling 0

Rock Data:

Vegetation 0

Type (surface)

Fluid issues from cement box w/steel covers

Color

Grain size

Megascopic Minerals

Salt: Type

Quantity

Color

Alteration:

Form

Rx Type (at depth)

Sinter: Type Mg Ca CO_3

Water used for heating, spa

Quantity large

Immediate area used for: residential

Color dark-gray-cream

Form amorphous

Quality of sample: [✓ Exc.], Good, Poor

Probable cause of manifestation deep fault

Property owned by Poncha Hot Springs

Previous and/or Current Leases ?

Comments: spring has deposited large quantities of $CaCO_3$

SKETCHES

Spring No. Co 25 Sample No. X 89653 Date 3-21-74 Time

Name: Younglife Hot Well #2 Location: Co. Chaffee State Colo

NW¼ Sec. 24 T 15S R:79W ; Km/mi. of

Lat.: Long.: Sampler: F. Dellechaie

Elevation: 8460 Quad. Poncha Springs

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

Description:

Water Temp. °C 67

Discharge: 100 gpm 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 mineralized

Type of piping

Bubbling 0

Artesian Head

Boiling 0

Rook Data:

Vegetation 0

Type (surface) qtz monzanite

Fluid issues from well

Color

Grain size

Megascopic Minerals

Salt: Type ca-mg SO_4

Quantity

Color

Alteration:

Form

Rx Type (at depth)

Sinter: Type

Water used for heating

Quantity

Immediate area used for: recreation

Color

Form

Quality of sample: [✓ Exc.], Good, Poor

Probable cause of manifestation well

Property owned by Younglife Ranch

Previous and/or Current Leases AMAX

Comments:

SKETCHES

Spring No. Co 28 Sample No. X 89665 Date 3-25-74 Time

Name: Greenhouse Hot Well Location: Co. Chaffee State Colo

NE¼ Sec. 24 T 15S R: 79W ; Km/mi. of

Lat.: Long.: Sampler: F. Dellechaie

Elevation: 8280 Quad. Poncha Springs

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

Description:

Water Temp. °C 68 Discharge: 100 gpm 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) qtz monzonite

Fluid issues from well Color

Grain size

Megascopic Minerals

Salt: Type Ca Mg SO_4

Quantity minor

Color white Alteration:

Form amorphous Rx Type (at depth)

Sinter: Type Water used for heating

Quantity Immediate area used for: recreation

Color

Form Quality of sample: [✓ Exc.], Good, Poor

Probable cause of manifestation well

Property owned by ?

Previous and/or Current Leases ?

Comments:

SKETCHES

Spring No. Co Sample No. X 89666 Date 3-25-74 Time

Name: Chalk Creek Greenhouse Hot Well Location: Co. Chaffee State Colo

NE¼ Sec. 24 T 15S R: 79W ; Km/mi. of

Lat.: Long.: Sampler: F. Dellechaie

Elevation: Quad. Poncha Springs

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

Description:

Water Temp. °C 65 Discharge: 500 gpm/Lpm

Ground Temp. °C Well Data: Depth 40'

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)

Fluid issues from well Color

Grain size

Megascopic Minerals

Salt: Type Ca Mg SO_4

Quantity

Color Alteration:

Form Rx Type (at depth)

Sinter: Type Water used for heating

Quantity Immediate area used for: recreation

Color

Form Quality of sample: [✓ Exc.], Good, Poor

Probable cause of manifestation well

Property owned by Bill Wright, Chalk Creek Greenhouse, Nathrop Co.

Previous and/or Current Leases

Comments:

SKETCHES

Spring No. Co 5 Sample No. X 89649 Date 3-19-74 Time

Name: Jump Steady Hot Well Location: Co. Chaffee State Colo.

SE¼ Sec. 21 T 14S R: 79W ; Km/mi. of

Lat.: Long.: Sampler: F. Dellechaie

Elevation: Quad. Buena Vista

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

Description:

Water Temp. °C 59

Ground Temp. °C

Air Temp.

Odor 0

Fluid Color clear

Fluid Taste 0

Bubbling 0

Boiling 0

Vegetation green algae

Fluid issues from well house foundation in altered qtz monzonite

Salt: Type

Quantity

Color

Form

Sinter: Type $CaCO_3$

Quantity minor

Color white

Form amorphous

Discharge: 150 gpm gpm/Lpm

Well Data: Depth

Bore

Pump Type

Level of water in bore

Type of piping

Artesian Head

Rock Data:

Type (surface) qtz Monzonite

Color

Grain size

Megascopic Minerals

Alteration:

Rx Type (at depth)

Water used for greenhouse

Immediate area used for: recreation; farming

Quality of sample: [✓ Exc.], Good, Poor

Probable cause of manifestation deep fault

Property owned by ?

Previous and/or Current Leases ?

Comments:

SKETCHES

Spring No. Co 33 Sample No. X 89652 Date 3-21-74 Time

Name: Mt. Princeton H.S. Location: Co. Chaffee State Colo.

NW¼ Sec. 19 T 15S R: 79W ; Km/mi. of

Lat.: Long.: Sampler: F. Dellechaie

Elevation: Quad. Poncha Springs

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

Description:

Water Temp. °C 56

Ground Temp. °C

Air Temp.

Odor 0

Fluid Color 0

Fluid Taste 0

Bubbling 0

Boiling 0

Vegetation red-green algae

Fluid issues from gravel at north side of creek

Salt: Type

Quantity

Color

Form

Sinter: Type Ca Mg CO_3

Quantity

Color

Form

Discharge: 70 gpm gpm/Lpm

Well Data: Depth

Bore

Pump Type

Level of water in bore

Type of piping

Artesian Head

Rock Data:

Type (surface)

Color

Grain size

Megascopic Minerals

Alteration:

Rx Type (at depth)

Water used for 0

Immediate area used for: recreation

Quality of sample: [✓ Exc.], Good, Poor

Probable cause of manifestation fault?

Property owned by Mt. Princeton H.S.

Previous and/or Current Leases ?

Comments:

SKETCHES

Spring No. Co 24 Sample No. X 89667 Date 3-25-74 Time

Name: Deer Ranch Hot Well Location: Co. Chaffee State Colo.

NE¼ Sec. 24 T 15S R: R78E ; Km/mi. of

Lat.: Long.: Sampler: F. Dellechaie

Elevation: Quad. Poncha Springs

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

Description:

Water Temp. °C 38.5

Ground Temp. °C

Air Temp.

Odor 0

Fluid Color 0

Fluid Taste 0

Bubbling 0

Boiling 0

Vegetation 0

Fluid issues from well

Salt: Type

Quantity

Color

Form

Sinter: Type

Quantity

Color

Form

Discharge: 100 gpm gpm/Lpm

Well Data: Depth

Bore

Pump Type

Level of water in bore

Type of piping

Artesian Head

Rock Data:

Type (surface)

Color

Grain size

Megascopic Minerals

Alteration:

Rx Type (at depth)

Water used for swimming pool

Immediate area used for: recreation

Quality of sample: [✓ Exc.], Good, Poor

Probable cause of manifestation well

Property owned by ~~Deer Ranch resort~~

Previous and/or Current Leases ?

Comments:

SKETCHES

Spring No. Co 40 Sample No. X 89654 Date 3-22-74 Time

Name: Fluorite Mine Warm Spring Location: Co. Chaffee State Colo.

NW¼ Sec. 34 T 51N R: 78W ; Km/mi. of

Lat.: Long.: Sampler: F. Dellechaie

Elevation: Quad. Poncha Springs

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

Description:

Water Temp. °C 22.5

Ground Temp. °C

Air Temp.

Odor 0

Fluid Color 0

Fluid Taste 0

Bubbling 0

Boiling 0

Vegetation algae

Fluid issues from joint in mineralized cliff base

Salt: Type 0

Quantity

Color

Form

Sinter: Type

Quantity

Color

Form

Discharge: 25 gpm gpm/Lpm

Well Data: Depth

Bore

Pump Type

Level of water in bore

Type of piping

Artesian Head

Rock Data:

Type (surface)

Color

Grain size

Megascopic Minerals

Alteration:

Rx Type (at depth)

Water used for 0

Immediate area used for: mining fluorite

Quality of sample: [✓ Exc.], Good, Poor

Probable cause of manifestation deep fault

Property owned by ?

Previous and/or Current Leases ?

Comments:

SKETCHES

Spring No. Co 8 Sample No. X 89689 Date 3-27-74 Time

Name: Ice Pond Cold Spring Location: Co. Chaffee State Colo

NE¼ Sec. 7 T 13S R: 79W ; Km/mi. of

Lat.: Long.: Sampler: F. Dellechaie

Elevation: 8040 Quad. Buena Vista

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

Description:

Water Temp. °C 9

Ground Temp. °C

Air Temp.

Odor 0

Fluid Color 0

Fluid Taste 0

Bubbling 0

Boiling 0

Vegetation fish

Fluid issues from valley fill

Salt: Type 0

Quantity

Color

Form

Sinter: Type

Quantity

Color

Form

Discharge: 75 gpm gpm/Lpm

Well Data: Depth

Bore

Pump Type

Level of water in bore

Type of piping

Artesian Head

Rock Data:

Type (surface)

Color

Grain size

Megascopic Minerals

Alteration:

Rx Type (at depth)

Water used for

Immediate area used for: drinking

Quality of sample: [✓ Exc.], Good, Poor

Probable cause of manifestation natural hydrologic flow

Property owned by ?

Previous and/or Current Leases ?

Comments:

SKETCHES