UNITED STATES
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY.

CHEMICAL ANALYSES OF GROUND WATER RELATED TO GEOTHERMAL INVESTIGATIONS IN THE TETON RIVER AREA, EASTERN IDAHO

Open-File Report 79-687

Prepared in cooperation with the
U.S. Department of Energy

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By E. G. Crosthwaite

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CHEMICAL ANALYSES OF GROUND WATER RELATED TO GEOTHERMAL INVESTIGATIONS IN THE TETON RIVER AREA, EASTERN IDAHO

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ABSTRACT

Water samples were collected from 31 wells and springs in eastern Idaho and western Wyoming to help evaluate the potential geothermal resources in the Teton River area, Idaho. The water analyses included the common anions and cations, oxygen-18, deuterium, and several minor elements. Actual temperatures of the sampled thermal waters ranged from 23° to 49°C. Estimated aquifer temperatures, as derived from geochemical thermometers, ranged from 45° to 145°C based on silica concentrations and 45° to 205°C based on sodium-potassium-calcium ratios. Using the cation thermometer, two analyses indicated aquifer temperatures that were lower than the actual measured temperatures. Estimated temperatures using a mixing-model method ranged from 205° to 320°C, the higher temperature being of questionable value. The different methods used to estimate aquifer temperatures showed little correlation.

On the basis of isotope data, the warm waters may be of local meteoric origin and have not been heated enough to react significantly with the aquifer rocks, or they originated as precipitation at high altitude and great distance from the area.

INTRODUCTION

In response to a request from Sugar City, Ida., and DOE (U.S. Department of Energy), is supporting a study of the feasibility of providing a central heating system for the city. One possible source of energy is geothermal water; other sources are waste timber, oil, gas, and coal (Kuntze and others, 1977). Sugar City (fig. 1) has a population of about 700 and was destroyed when Teton Dam on Teton River failed June 5, 1976. A decision was made to rebuild the town. DOE requested that the USGS (U.S. Geological Survey) make geological, geophysical, and geochemical studies to help evaluate the potential geothermal resources in the area around Sugar City. This report presents basic water-quality data collected from 31 wells and springs in eastern Idaho and western Wyoming (table 1), as shown in figure 1. (Wyoming spring number 44N-117W, about 10 mi east of Driggs, is not shown in the figure.) Reports on the results of geologic and geophysical studies are in preparation.

In addition to the data collected and presented in this report, EG&G Idaho, Inc. (a prime contractor for DOE) collected about 40 ground-water samples from the Sugar City-Rexburg area. The Regional Quality of Water Laboratory, Region I, U.S. Bureau of Reclamation, analyzed the samples for common mineral constituents. The analyses are not included in this report, but some of the data are used for trilinear plotting (see Discussion of Data). To avoid duplication of work, most of the data in this report are from outside the area sampled by EG&G Idaho, Inc., but within or near the drainage basin of the Teton River and presumably in an area of recharge to the thermal aquifer. Water samples for these data were analyzed in the USGS Quality of Water Laboratory in Denver, Colo.

Selected references on geology, hydrology, and geophysics are included in this report.

The study was supported with funds provided by DOE.

Well- and Spring-Numbering System

The numbering system used by the Geological Survey in Idaho indicates the location of wells or springs within the official rectangular subdivision of the public lands, with reference to the Boise base line and meridian. The first two segments of the number designate the township and range. The third segment gives the section number, followed by three letters and a numeral, which indicate the quarter section, the 40-acre tract, the 10-acre tract, and the serial number of the well within the tract, respectively. Quarter sections are lettered A, B, C, and D in counterclockwise order from the northeast quarter of each section (fig. 2). Within the quarter sections, 40-acre and 10-acre tracts are lettered in the same manner. Well 7N-41E-35CDD1 is in the SE¼SE¼SW¼, sec. 35, T. 7 N., R. 41 E., and was the first well inventoried in that tract. Springs are designated by the letter "S" following the last numeral; for example, 5N-43E-6BCA1S.

The two sample sites in Wyoming are springs at U.S. Forest Service campgrounds and are in an unsurveyed area. The townships have been interpolated for this report. The northernmost site is Teton Canyon Campground; the other is Trail Creek Campground.

Table 1. Chemical and isotopic analyses of water from selected wells and springs in the Teton River drainage and adjacent area

(Chemical constituents in milligrams or micrograms per liter)

Well or spring number	Date of sample	Specific conductance (µmhos)[1]	pH (units)	Temperature (°C)	Hardness (Ca, Mg) (mg/L)	Noncarbonate hardness (mg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Percent sodium	$^{2}\delta^{18}O$	$^{2}\delta D$	Sodium adsorption ratio	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Carbonate (CO_3) (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	Bromide (Br) (mg/L)	Iodide (I) (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Dissolved silica (SiO_2) (mg/L)	Dissolved solids (sum of constituents) (mg/L)	Dissolved solids (tons per acre-foot)	Dissolved nitrite plus nitrate (N) (mg/L)	Total phosphorus (P) (mg/L)	Dissolved arsenic (As) (µg/L)	Dissolved barium (Ba) (µg/L)	Dissolved beryllium (Be) (µg/L)	Dissolved boron (B) (µg/L)	Iron (Fe) (µg/L)	Dissolved manganese (Mn) (µg/L)	Dissolved lithium (Li) (µg/L)	Dissolved mercury (Hg) (µg/L)	Dissolved strontium (Sr) (µg/L)
1S-45E-13DAC1S	77-07-13	380	7.5	13.5	230	0	57	20	0.9	1	-17.7	-138	0.0	0.4	280	0	230	0.0	0.00	2.2	1.2	0.1	5.4	225	--	--	0.00	0	0	0	4	--	4	2	0.0	100
3N-44E-20CCC1S	77-07-13	410	7.2	9.0	230	9	61	19	2.6	2	-17.9	-134	.1	.5	270	0	220	.0	.01	18	1.2	.1	10	246	--	--	.02	0	0	0	9	--	0	2	.0	180
3N-44E-24ACD1S	77-07-12	325	7.1	10.0	160	16	49	10	22	22	-17.2	-134	.7	1.3	180	0	150	.1	.00	5.2	45	.1	8.1	230	--	--	.02	0	300	0	20	--	0	2	2.1	170
4N-40E-25DCB1S	70-02-17	9,190	6.7	48.0	1,400	540	430	85	1,530	67	--	--	18	192	1,080	1	887	--	--	756	2,360	3.1	33	5,950	--	--	.02	--	--	--	4	--	0	2	--	--
	72-07-27	8,840	6.7	49.0	1,500	560	450	82	1,500	66	--	--	17	190	1,100	0	902	--	--	740	2,400	3.1	30	5,940	8.08	0.10	.04	--	--	--	--	--	--	--	--	--
	77-06-18	7,000	6.4	59.0	--	--	--	--	--	--	-17.4	-139	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4N-41E-35ADB1S	77-06-18	750	--	11.5	39	0	11	2.7	4.2	18	-17.5	-134	.3	2.6	51	--	42	.0	.00	5.7	2.5	.3	44	100	.14	.41	.04	2	0	0	10	30	10	0	.0	60
4N-45E-30BAA1S	77-07-14	455	8.9	23.0	260	150	61	27	3.5	3	-17.7	-139	.1	1.6	140	0	110	.0	.00	140	1.3	.9	12	317	--	--	.01	1	0	0	20	--	8	10	.0	610
5N-40E-8BCC1	77-06-15	--	7.6	26.0	130	0	33	11	20	25	-18.7	-141	.8	3.9	170	0	140	.0	.00	12	12	1.7	50	231	.31	.81	.01	4	0	0	30	10	8	20	.0	150
5N-40E-12CAA1	77-07-23	300	7.5	20.5	--	--	--	--	--	--	-18.0	-139	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5N-43E-6BCA1S	70-02-17	839	7.5	42.0	460	320	133	31	3.9	2	--	--	.1	4.4	164	1	136	--	--	314	1.0	1.6	24	595	--	--	.01	--	--	--	0	--	--	0	--	--
	72-08-09	846	6.9	44.0	480	340	140	32	3.8	2	--	--	.1	3.8	167	0	137	--	--	330	1.7	1.6	25	621	.84	.13	.01	--	--	--	--	--	--	--	--	--
	77-07-24	800	7.1	39.0	--	--	--	--	--	--	-18.1	-137	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	77-09-06	790	6.7	40.8	450	320	130	30	3.6	2	--	--	.1	3.9	160	0	130	--	--	320	1.4	1.5	26	596	.81	.10	.01	1	--	--	20	--	10	20	--	--
5N-43E-21CCA1S	77-07-14	48	7.2	4.0	17	0	5.4	.9	3.5	29	-17.6	-134	.4	.8	21	0	17	.0	.01	2.4	1.0	.0	23	47	--	--	.02	0	0	0	9	--	0	2	.0	50
5N-43E-26CCD1S	77-07-23	310	7.7	2.0	--	--	--	--	--	--	-18.0	-136	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5N-44E-18ABD1S	77-06-19	285	7.5	12.0	110	0	45	.1	5.4	9	-18.8	-145	.2	3.3	170	0	140	.0	.00	4.1	3.7	.2	44	191	.26	.25	.09	1	0	0	20	10	4	2	.5	110
5N-44E-31ACA1S	77-06-19	490	7.3	7.0	170	0	53	9.1	76	49	-17.8	-136	2.5	1.3	394	0	320	.0	.00	5.5	1.9	.4	8.6	352	.48	.03	.00	0	500	0	50	50	140	20	.0	640
6N-40E-13ADA1	77-07-15	340	7.1	9.5	180	0	50	13	11	12	--	-132	.4	2.5	220	0	180	--	--	6.7	12	.2	28	232	--	--	.07	--	--	--	40	--	--	--	.0	--
6N-40E-31DAA1	77-07-23	350	7.8	16.5	--	--	--	--	--	--	-17.8	-139	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6N-40E-35BDD1	77-06-16	415	7.7	13.0	200	26	47	19	13	12	-18.0	-140	.4	2.6	207	0	170	.1	.00	13	21	.4	33	266	.36	3.2	.02	2	0	0	20	10	8	5	.4	160
6N-41E-10DBB1	77-06-16	470	7.6	26.5	110	0	31	7.6	70	56	-18.4	-141	2.9	8.5	217	0	180	.1	.00	26	25	4.5	80	365	.50	1.1	.01	11	0	0	130	20	0	130	.6	100
6N-41E-11CDB1	77-06-17	435	7.7	21.5	--	--	--	--	--	--	-18.8	-143	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6N-41E-14CAD1	77-07-23	420	7.6	19.0	--	--	--	--	--	--	-18.4	-143	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6N-41E-31AAC1	77-07-23	320	7.6	14.5	--	--	--	--	--	--	-18.0	-140	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6N-43E-24DCA1S	77-06-19	130	7.1	9.5	59	0	17	3.9	4.9	15	-17.9	-137	.3	.9	71	0	58	.0	.00	6.0	1.9	.1	25	105	.14	2.2	.05	1	0	0	9	30	0	0	.0	70
7N-41E-25CBD1	76-07-20	524	7.8	32.0	71	0	23	3.3	88	69	--	--	4.5	12	181	0	148	--	--	26	25	6.2	76	352	.48	.84	.01	--	--	--	--	--	--	--	--	--
	77-07-23	520	7.6	35.0	--	--	--	--	--	--	-19.8	-143	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7N-41E-34ADD1	77-06-16	450	7.6	33.0	87	0	25	5.9	69	61	-18.9	-144	3.2	6.9	204	0	170	.1	.00	26	22	5.7	64	329	.45	.83	.02	12	0	0	150	30	0	140	.4	100
7N-41E-35CDD1	72-08-09	529	7.9	36.0	96	0	28	6.3	78	61	--	--	3.5	8.6	240	0	197	--	--	33	24	5.4	75	380	.52	.79	.02	--	--	--	--	--	--	--	--	--
	77-06-16	535	7.5	32.5	--	--	--	--	--	--	-18.6	-142	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7N-42E-8CAA1	76-06-22	388	7.6	31.5	150	0	38	14	22	23	--	--	.8	4.8	205	0	168	--	--	8.8	14	2.0	65	270	.37	--	.02	--	--	--	--	--	--	--	--	--
	76-07-19	403	7.7	29.0	150	17	40	13	22	23	--	--	.8	5.7	166	0	136	--	--	10	18	2.1	61	260	.35	1.5	.01	--	--	--	--	--	--	--	--	--
	77-07-22	390	7.5	33.5	--	--	--	--	--	--	-17.9	-140	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7N-42E-19BBB1	77-07-23	500	7.7	43.5	--	--	--	--	--	--	-18.4	-143	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9N-42E-23DAC1S	72-08-28	158	7.6	41.0	3	0	1.1	.1	36	94	--	--	8.8	1.6	92	0	75	--	--	4.7	2.9	2.2	110	205	.28	.24	.05	--	--	--	--	--	--	--	--	--
	77-07-22	170	8.5	39.5	--	--	--	--	--	--	-17.8	-137	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10N-44E-10CBA1S	77-07-22	105	7.9	10.0	--	--	--	--	--	--	-17.8	-135	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14N-44E-34BBB1S	72-08-28	102	6.3	12.0	16	0	5.6	.6	14	60	--	--	1.5	3.0	46	0	38	--	--	3.2	2.5	3.1	47	102	.14	.05	.03	--	--	--	--	--	--	--	--	--
	77-07-22	100	7.6	11.5	--	--	--	--	--	--	-18.2	-140	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
[3]41N-118W	77-07-12	480	7.3	10.0	230	0	68	15	3.5	3	-18.2	-142	.1	4.3	290	0	240	.0	.01	6.7	4.4	.1	11	256	--	--	.01	0	300	0	10	--	0	2	.1	200
[4]44N-117W	77-07-12	204	7.4	14.0	130	13	37	8.5	2.2	4	-18.3	-142	.1	.8	140	0	110	.0	.00	1.8	.8	.1	13	133	--	--	.01	0	0	0	2	--	0	2	.1	80

[1]Conductance in micromhos at 25°C

[2] ^{18}O = oxygen-18; δ = reporting unit in o/oo (parts per mil, which is per 1,000)

[3]Unsurveyed township. Teton Canyon Campground

[4]Unsurveyed township. Trail Creek Campground

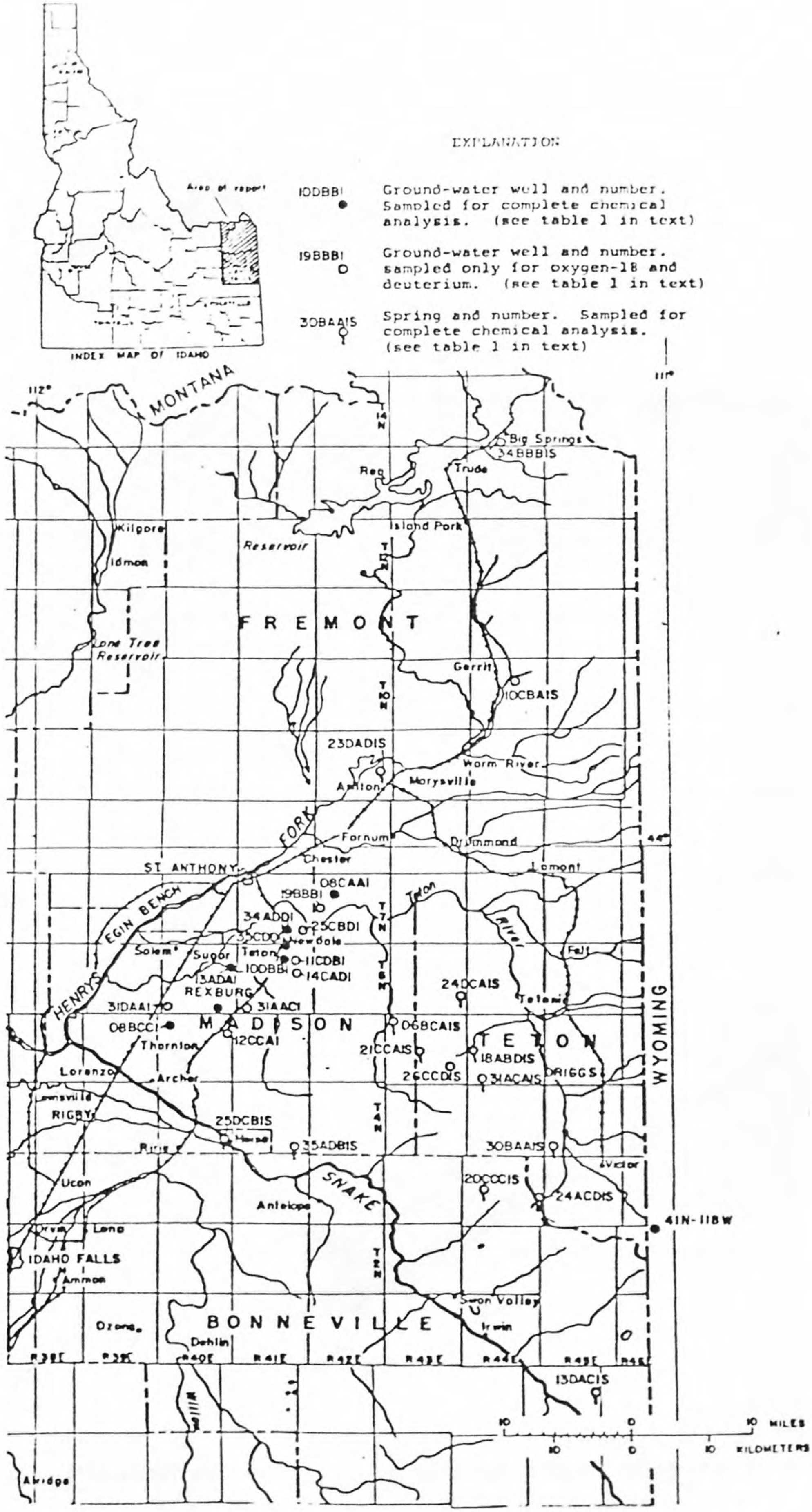


Figure 1. Location of sampled wells and springs

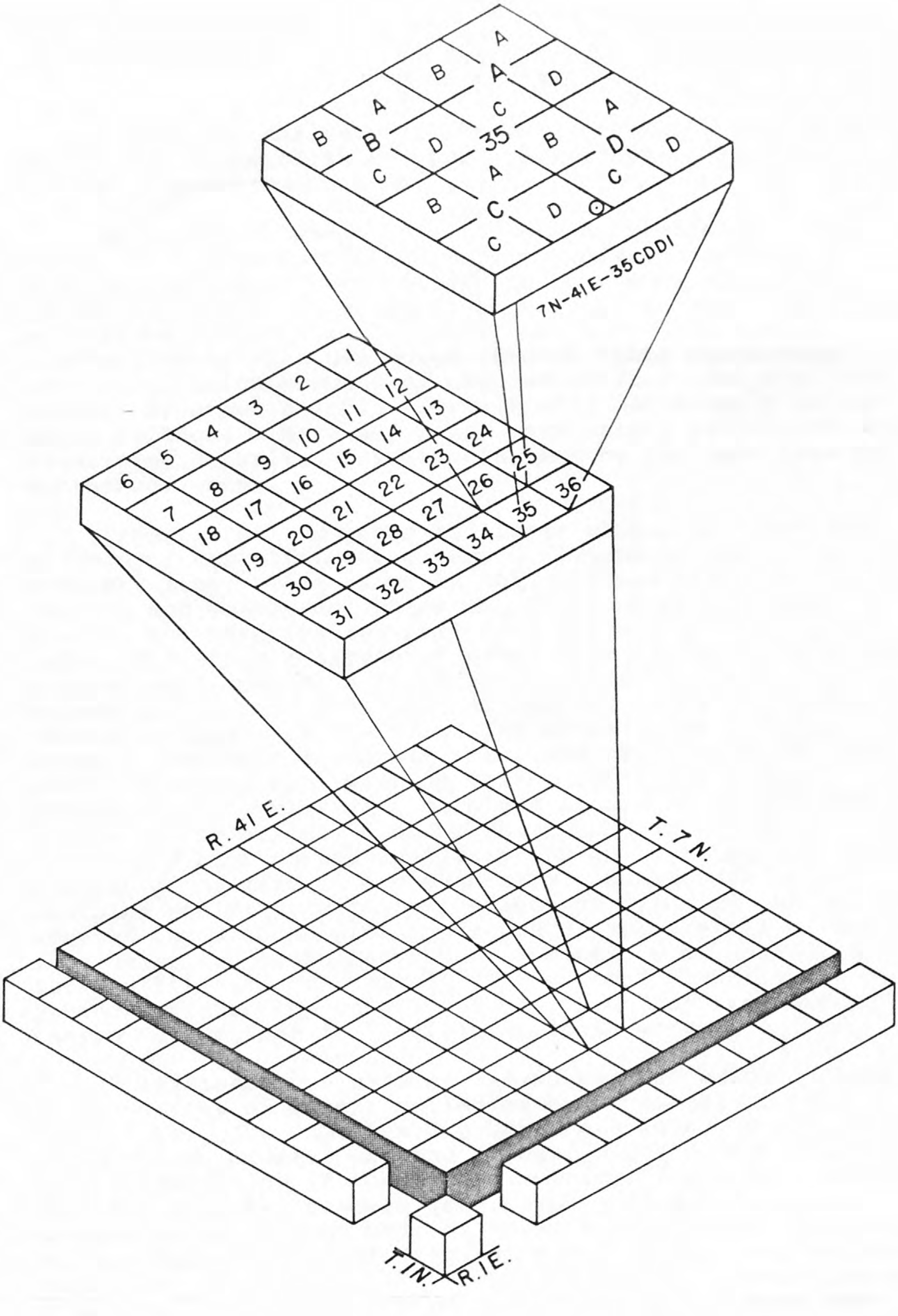


Figure 2. Diagram showing well- and spring-numbering system

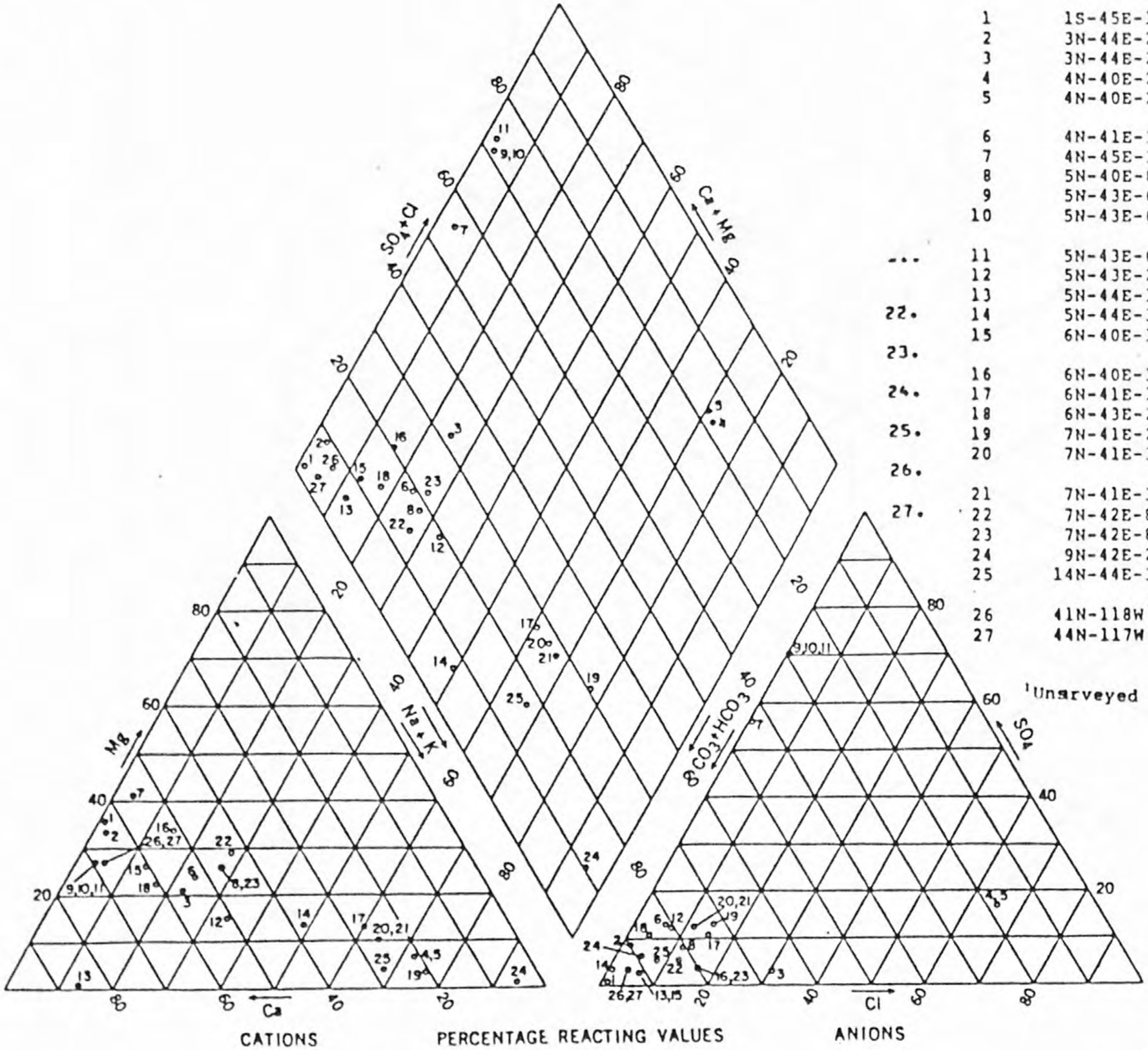
DISCUSSION OF DATA

A complete analysis of the data presented herein is beyond the scope of this report, but a brief discussion of the data is appropriate.

Typically, Idaho thermal waters are the sodium bicarbonate type, containing small to moderate amounts of calcium; nonthermal waters tend to be the calcium bicarbonate type, containing small amounts of sodium. (See Young and Mitchell, 1973, for regional thermal water data.) However, water that has moved through rocks containing relatively large amounts of calcium sulfate, calcium carbonate, or other soluble minerals will be strongly influenced by these minerals. Thus, warm waters associated with travertine deposits, for example, may be the same type as a nonthermal water.

Piper (1944) suggests trilinear graphs may show that a mixture of two different waters will tend to plot as a straight line. This suggests that various mixtures of thermal and nonthermal water can be shown by trilinear graphs, but interpreting ratios of the mixtures is uncertain. Data from analyses of water from the study area are plotted on figure 3, a trilinear plot of the equivalent values of the common anions and cations. The plot shows that bicarbonate is the principal anion in 85 percent of the samples (two or more sample sites are represented at some points on the graph) with no mixing relations evident. Cations tend to plot in a straight line, indicating that the waters may be mixed. Much of the thermal water has a relatively high percentage of sodium and a relatively low percentage of calcium and magnesium. Nonthermal water contains medium to high percentages of calcium. As can be seen on the diamond plot in figure 3, the thermal waters from Heise and Green Canyon Hot Springs (plot nos. 4, 5, 9, 10, and 11) are not typical. The water from Heise Hot Springs is a sodium chloride water, and that from Green Canyon Hot Springs is a calcium sulfate water.

A trilinear graph (fig. 4) was plotted using analyses of 30 samples of water, collected by personnel of EG&G Idaho, Inc., from the Rexburg bench and adjacent area to the north (R. G. Stoker, written commun., 1977). The graph was made to determine if there was any significant variation from the regional pattern (fig. 3). Although the anion diagram is not shown, most of these samples were bicarbonate water. The cation plot (fig. 4) shows more strongly than the regional plot (fig. 3) that most of the warmer waters tend to have a higher percentage of sodium, whereas the cooler waters tend to have a higher percentage of calcium.



Plot no.	Well or spring no.	Local location name
1	1S-45E-13DAC1S	Elk Creek Campground
2	3N-44E-20CCC1S	LDS Campground
3	3N-44E-24ACD1S	Pine Creek Campground
4	4N-40E-25DCB1S	Heise Hot Springs
5	4N-40E-25DCB1S	Heise Hot Springs
6	4N-41E-35ADB1S	Table Rock Campground
7	4N-45E-30BAA1S	Paradise Spring
8	5N-40E-8BCC1	Irrigation well
9	5N-43E-6BCA1S	Green Canyon Hot Springs
10	5N-43E-6BCA1S	Green Canyon Hot Springs
11	5N-43E-6BCA1S	Green Canyon Hot Springs
12	5N-43E-21CCA1S	Graham Spring
13	5N-44E-18ABD1S	Spring on Packsaddle Creek
14	5N-44E-31ACA1S	Spring at abandoned coal mine
15	6N-40E-13ADA1	Domestic well
16	6N-40E-35BDD1	Irrigation well
17	6N-41E-10DBB1	Irrigation well
18	6N-43E-24DCA1S	Neville Spring
19	7N-41E-25CBD1	Warm irrigation well
20	7N-41E-34ADD1	Warm irrigation well
21	7N-41E-35CDD1	Newdale well (warm)
22	7N-42E-8CAA1	Warm irrigation well
23	7N-42E-8CAA1	Warm irrigation well
24	9N-42E-23DAC1S	Ashton warm spring
25	14N-44E-34BBB1S	Big Springs
26	41N-118W[1]	Trail Creek Campground (Wyoming)
27	44N-117W[1]	Teton Campground (Wyoming)

[1] Unsurveyed

Figure 3. Trilinear plot of selected analyses of samples from Teton River drainage and adjacent area

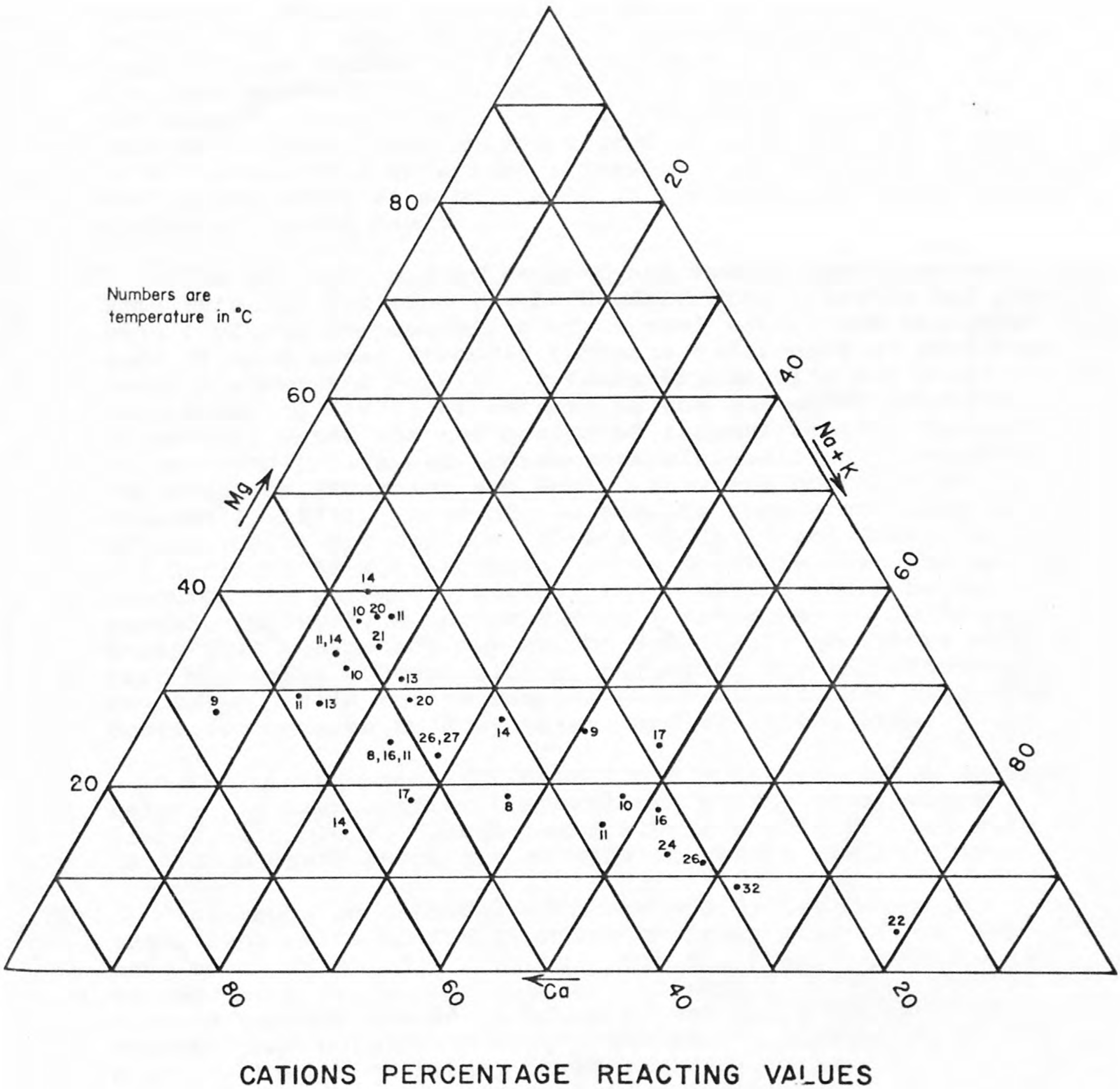


Figure 4. Trilinear plot of cations in ground-water samples from the Rexburg Bench area (Analysis furnished by EG&G Idaho, Inc.)

It is likely that even the warmest waters are a mixture of thermal and nonthermal water. The geochemistry of the water, the geologic framework in which ground water occurs, and the "cold" water hydrology as estimated by Crosthwaite, Mundorff, and Walker (1970) and Haskett (1972) imply that the warm waters found in the wells in Newdale (fig. 1) and vicinity are a mixture. Certain techniques have been developed to determine the proportion of cool and warm water in a thermal well or spring (Truesdell and Fournier, 1977). Mixing may occur at many places in the area; the most likely places are along faults.

The geologic map of Prostka and Embree (1978) shows some inferred faulting in the Newdale area. Faults may provide conduits for upwelling of thermal water, and the presence of warm water strongly supports inferences of faulting. Table 2 shows the results of using Truesdell's and Fournier's method (1977) of estimating the hot-water component of thermal water and the estimated thermal aquifer temperatures using silica and sodium-potassium-calcium geochemical thermometers (Fournier and Rowe, 1966, and Fournier and Truesdell, 1973). Some of the results show significant mixing (Heise Hot Springs, 4N-40E-25DCB1S; and Green Canyon Hot Springs, 5N-43E-6BCA1S). It is unlikely that the spring conduits are perfectly sealed; thus, mixing would be expected. However, A. H. Truesdell (oral commun., 1977) suggests that the method may not be applicable to waters with a high magnesium content without adjusting for the effect of magnesium. Both spring samples had a significant magnesium content, compared to most water sampled in the area.

The mixing model (Truesdell and Fournier, 1977) shows relatively high aquifer temperatures at the other sites listed in table 2. These temperatures should be used with caution because there are no data to verify the results.

Although no chemical data are available, water in irrigation wells on the high southeastern part of the Rexburg bench is 2° to 5°C warmer than the "cool" ground water on the bench (G. I. Haskett, oral commun., 1978). Whether this is because the depth of wells and depth to water is greater than on other parts of the bench, where samples for analysis have been taken, or whether it is because of upwelling of thermal water in the caldera mapped by Prostka and Embree (1978), is unknown.

Comparison of the stable isotopic composition (deuterium, D; and oxygen-18, ^{18}O) may give a clue to the source of ground-water recharge. Natural waters are generally depleted in D and ^{18}O relative to SMOW (Standard Mean Ocean Water). As water evaporates from the ocean, the water vapor

Table 2. Estimated aquifer temperatures, Teton River drainage and adjacent area

Local site No.	Temperature (°C)	Aquifer temperature from geochemical thermometers (°C)[1] [2]: Silica[4]	Aquifer temperature from geochemical thermometers (°C)[1] [2]: Sodium-potassium-calcium[5]	Estimation of temperature and fraction of cold water[3]: Percent of cold water in discharge[1]	Estimation of temperature and fraction of cold water[3]: Temperature (°C)
4N-40E-25DCB1S	49	80	205	50	85
4N-45E-30BAA1S	23	45	0	-	-
5N-40E- 8BCC1	26	100	45	90	205
5N-43E- 6BCA1S	42	70	10	50	70
7N-41E-25CBD1	32	125	185	90	260
7N-41E-34ADD1	33	115	80	90	230
7N-41E-35CDD1	36	120	85	90	240
7N-42E- 8CAA1	31.5	115	48	90	230
9N-42E-23DAC1S	41	145	90	90	[6]320(?)

[1]Rounded to nearest 5° or 5 percent
[2]°F = 1.8 °C + 32
[3]Estimated from method by Truesdell and Fournier, 1977, Model 1
[4]Fournier and Rowe, 1966
[5]Fournier and Truesdell, 1973
[6]Estimated from method by Fournier and Truesdell, 1974, Model 1

is depleted in D and ^{18}O and the amount of depletion increases as the temperature of evaporation decreases. Figure 5 shows the variation of δD and $\delta^{18}O$ at several places and the trend line of meteoric waters (Craig, 1961). As shown in figure 5, thermal waters tend to be enriched in $\delta^{18}O$, probably because of isotopic exchange of the water with aquifer materials. The warm and cold waters sampled for this report also are plotted on figure 5. The average of 15 cold-water samples (temperatures of 2° to 14.5°C) is shown as nonthermal; the average of 10 warm-water samples (temperatures of 26.5° to 48°C) is shown as thermal. The difference between the isotopic composition of the two sets of samples is so small that they can be considered as falling on the trend line. On the basis of the isotope data, it seems that the warm waters are of local meteoric origin and that they have not been heated enough to react significantly with the aquifer rocks.

However, because the hot waters are lighter isotopically than the cold waters, the hot water could originate from high-altitude precipitation at a great distance from the sampling point. Thus, the long and probably deep circulation path could allow an increase in temperature. Water-source areas that meet these criteria lie north and east of the area covered in this report.

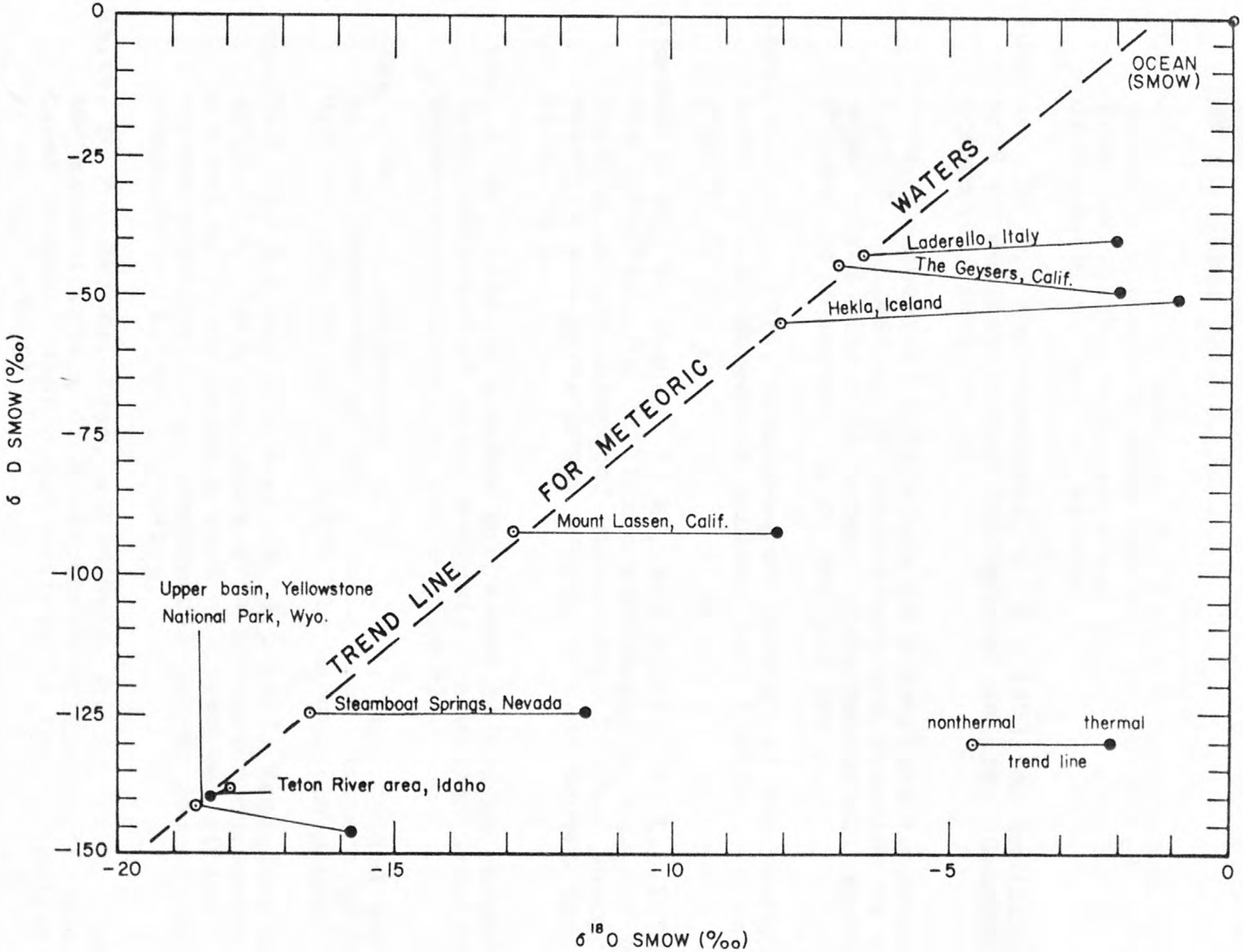


Figure 5. Comparison of isotopic composition of nonthermal and thermal waters, Teton River area, Idaho, and elsewhere

(Modified after White, Barnes, and O'Neil, 1973, fig. 1)

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