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The Chemical Composition and
Estimated Minimum Thermal
Reservoir Temperatures of the ...

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THE CHEMICAL COMPOSITION AND ESTIMATED MINIMUM THERMAL RESERVOIR TEMPERATURES OF THE PRINCIPAL HOT SPRINGS OF NORTHERN AND CENTRAL NEVADA

By

R. H. Mariner, J. B. Rapp, L. M. Willey, and T. S. Presser

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ABSTRACT

Fifty-five of the principal hot springs in northern and central Nevada have been sampled for chemical analyses. Major element constituents, sodium, potassium, calcium, and silica suggest minimum thermal-aquifer temperatures of 140°C or more at 16 of the hot spring complexes. At least five of the hot springs issue mixed waters which may indicate thermal-aquifer temperatures significantly lower than the true thermal-aquifer temperature.

Sodium is the principal cation in almost all the spring waters. Four springs in northern Nye County and adjacent Eureka County have approximately equal amounts of sodium and calcium. Bicarbonate is the principal anion in most of the spring waters. However, the sampled hot springs on the western edge of the State have chloride as the principal anion. A diffuse zone of bicarbonate chloride waters with or without sulfate separates the chloride and bicarbonate regions.

INTRODUCTION

The chemical composition of thermal spring waters is a valuable aid in exploring for geothermal resources. The principal hot springs of Nevada were sampled for detailed chemical analyses during the summers of 1972 and 1973. The major-element part of the analyses has been completed and is being made available at this time. Complete chemical analyses, isotope data, and mineral equilibrium data will be presented in a later report.

Godwin and others (1971) list 13 KGRA's (known geothermal resource areas) in Nevada. In addition, most of the northwestern part of the State is shown as an area of potential geothermal importance. The KGRA's are Beowawe, Leach Hot Springs, Fly Ranch (flowing well near Gerlach), Steamboat Springs, Brady Hot springs, Stillwater-Soda Lake, Darrough Hot Springs, Gerlach (Great Boiling Spring), Moana Springs, Double Hot Springs, Wabuska, Monte Neva, and Elko Hot Springs. Samples were collected from all KGRA's except Monte Neva, Moana Springs, and Brady Hot Springs. Exploratory drilling has altered Brady Hot Springs so that water does not discharge at the surface.

SAMPLE SITE SELECTION

Sample sites were selected on the basis of temperature data in Waring, 1965, as well as discussions with R. K. Hose and F. H. Olmsted of the U.S. Geological Survey. We are indebted to R. K. Hose for visiting most of the thermal springs in northern Nevada, determining which were suitable for detailed sampling, and collecting 19 supplementary samples.

Table 1 lists the spring or well name, location, and topographic map coverage. The distribution of thermal springs and wells from which water samples were collected is shown in figure 1. Spring names are taken from U.S. Geological Survey topographic maps and Nevada Bureau of Mines Bulletins, or are local names used by residents near the spring.

METHODS AND PROCEDURES

Water samples were collected at points as close as possible to the orifice of the thermal springs or wells. If the spring had several orifices, then the discharge from the orifice with the highest temperature and highest specific conductance was sampled. Water was collected in a 12-liter stainless-steel pressure vessel and immediately pressure filtered through a 0.45μm (micrometer) effective pore diameter membrane filter using nitrogen as a pressure source. The filtered water samples were collected and stored in plastic bottles which had been washed with acid to remove any trace contaminants prior to use. Ten milliliters of filtered sample were diluted to one hundred milliliters with distilled deionized water to slow the polymerization of silica.

Field determinations were made of barometric pressure, air temperature, water temperature, conductivity, pH, and alkalinity. Flow rates were estimated based on experience with measured

Table 1.--Location and topographic map coverage of selected hot springs and wells

Spring or well	Location	Topographic map coverage
	Churchill County	
1 Lee Hot Springs	Unsurveyed (lat. 39°12' N., long. 118°43' W.)	Allen Springs, Nev. (15'); Reno, Nev. (2°)
2 Dixie Valley Hot Springs	SE 1/4 sec. 5 and NE 1/4 sec. 8, T. 22N., R. 35E.	Dixie Hot Springs, Nev. (15'); Reno, Nev. (2°)
3 Flowing well in Stillwater	SW 1/4 sec. 7, T. 19N., R. 31E.	Stillwater, Nev. (15'); Reno, Nev. (2°)
	Douglas County	
1 Walleys Hot Springs	NE 1/4 sec. 22, T. 13N., R. 19E.	Minden, Nev.-Calif. (7-1/2'); Walker Lake, Calif.-Nev (2°)
	Elko County	
1 Hot Hole	NE 1/4 sec. 21, T. 34N., R. 55E.	Elko, west, Nev. (7-1/2'); Elko, Nev.-Utah (2°)
2 Sulphur Hot Springs	NW 1/4 sec. 11, T. 31N., R. 59E.	Lamoille, Nev. (15'); Elko, Nev.-Utah (2°)
3 Unnamed hot spring (Hot Creek)	NW 1/4 sec. 12, T. 28N., R. 52E	Pine Valley, Nev. (15'); Winnemucca, Nev. (2°)
4 Nile Spring	SW 1/4 sec. 30, T. 47N., R. 70E.	Goose Creek, Nev.-Utah-Idaho (15'); Wells, Nev.-Utah-Idaho (2°)
5 Mineral Hot Spring	sec. 16, T. 45N., R. 64E.	Delaplain, Nev.-Idaho (15'); Wells, Nev.-Utah-Idaho (2°)
6 Unnamed hot spring near Wells	sec. 20, T. 38N., R. 62E	Oxley Peak, Nev. (7-1/2'); Wells, Nev.-Utah-Idaho (2°)
7 Unnamed hot spring near Wells	NE 1/4 sec. 17, T. 38N., R. 62E.	Oxley Peak, Nev. (7-1/2'); Wells, Nev.-Utah-Idaho (2°)
8 Unnamed hot spring (Wild Horse Reservoir)	SE 1/4 sec. 4, T. 43N., R. 55E.	Wild Horse, Nev. (15'); Wells, Nev.-Utah-Idaho (2°)
9 Unnamed hot spring (SSE Patsville)	Unsurveyed (lat. 41°5' N., long. 115°55' W.)	Mountain City, Nev.-Idaho (15'); Wells, Nev. Utah-Idaho (2°)
10 Hot Sulphur Springs	NE 1/4 sec. 8, T. 41N., R. 52E.	Tuscarora, Nev. (15'); McDermitt, Nev.-Ore.-Idaho (2°)
11 Unnamed hot spring near Carlin	sec. 33, T. 33N., R. 52E.	Carlin, Nev. (15'); Winnemucca, Nev. (2°)
12 Unnamed hot spring near Ruby Marsh	NW 1/4 sec. 2, T. 27N., R. 58E.	Ruby Lake NW, Nev. (7-1/2'); Elko, Nev.-Utah (2°)
	Eureka County	
1 Walti Hot Springs	SW 1/4 sec. 33, T. 24N., R. 48E.	Walti Hot Spring, Nev. (15'); Millet, Nev. (2°)
2 Hot Springs Point	NE 1/4 sec. 11, T. 29N., R. 48E.	Crescent Valley, Nev. (15'); Winnemucca, Nev. (2°)
3 Beowawe "steam" well	NW 1/4 sec. 17, T. 31N., R. 48E.	Dunphy, Nev. (15'); Winnemucca, Nev. (2°)
4 Beowawe Hot Spring	SE 1/4 sec. 8, T. 31N., R. 48E.	Dunphy, Nev. (15'); Winnemucca, Nev. (2°)
5 Bartholomae Hot Springs	SE 1/4 sec. 28, T. 18N., R. 50E.	Antelope Peak, Nev (15'); Millett, Nev. (2°)

Table 1.--Location and topographic map coverage of selected hot springs and wells Continued

Spring or well	Location	Topographic map coverage
	Humboldt County	
1 Unnamed hot spring (Hot Springs Ranch)	SE 1/4 sec. 5, T. 33N., R. 40E.	Edna Mtn., Nev. (15'); Winnemucca, Nev. (2°)
2 Unnamed hot spring near Golconda	SE 1/4 sec. 29, T. 36N., R. 40E.	Edna Mtn., Nev. (15'); Winnemucca, Nev. (2°)
3 Double Hot Springs	sec. 4, T. 36N., R. 26E.	; Vya, Nevada-Oregon (2°)
4 Unnamed hot springs in Soldier Meadows	sec. 23, T. 40N., R. 24E.	; Vya, Nevada-Oregon (2°)
5 West Pinto Hot Spring (well)	Unsurveyed (lat. 41°20'N., long. 118°48'W.)	; Vya, Nevada-Oregon (2°)
6 East Pinto Hot Spring	Unsurveyed (lat. 41°21'N., long. 118°47'W.)	; Vya, Nevada-Oregon (2°)
7 Dyke Hot Spring	SE 1/4 sec. 25, T. 43N., R. 30E.	Duffer Peak, Nev. (15'); Vya, Nevada-Oregon (2°)
8 Flowing well near Baltazor Hot Spring	NW 1/4 sec. 13, T. 46 N., R. 28E.	Denio, Nev.-Ore. (15'); Vya, Nevada-Oregon (2°)
9 Baltazor Hot Spring	NW 1/4 sec. 13, T. 46N., R. 28E.	Denio, Nev.-Ore. (15'); Vya, Nevada-Oregon (2°)
10 Bog Hot Springs	NW 1/4 sec. 18, T. 46N., R. 28E.	Railroad Point, Nev.-Ore. (15'); Vya, Nevada-Oregon (2°)
11 Hot Pot	SW 1/4 sec. 11, T. 35N., R. 43E.	Hot Pot, Nev. (7-1/2'); Winnemucca, Nev. (2°)
12 Howard Hot Spring	NE 1/4 sec. 4, T. 44N., R. 31E.	Duffer Peak, Nev. (15'); Vya, Nevada-Oregon (2°)
13 The Hot Springs	NE 1/4 sec. 20, T. 41N., R. 41E.	Hot Springs Peak, Nev. (15'); McDermitt, Nev.-Ore.-Idaho (2°)
	Lander County	
1 Spencer Hot Springs	Unsurveyed (lat. 39°49' N., long. 116°51' W.)	Spencer Hot Springs, Nev. (15'); Millet, Nev. (2°)
2 Unnamed hot spring (Valley of the Moon)	NE 1/4 sec. 23, T. 27N., R. 43E.	The Cedars, Nev. (15'); Winnemucca, Nev. (2°)
3 Unnamed hot spring (Smith Creek Valley)	sec. 11, T. 17N., R. 39E.	; Millet, Nev. (2°)
4 Buffalo Valley Hot Springs	SE 1/4 sec. 23, T. 29N., R. 41E.	Buffalo Springs, Nev. (15'); Winnemucca, Nev. (2°)
	Lyon County	
1 Wabuska Hot Springs	SE 1/4 sec. 16, T. 15N., R. 25E.	Wabuska, Nev. (15'); Tonopah, Nev. (2°)
2 Nevada Hot Springs	SE 1/4 sec. 16, T. 12N., R. 23E.	Wellington, Nev. (15'); Walker Lake, Calif.-Nev. (2°)
	Mineral County	
1 Soda Springs	SE 1/4 sec. 29, T. 6N., R. 35E.	Sodaville, Nev. (7-1/2'); Walker Lake, Calif.-Nev. (2°)
	Nye County	
1 Darrough "steam" well	sec. 8, T. 11N., R. 43E.	; Tonopah, Nev. (2°)
2 Darrough Hot Springs	sec. 8, T. 11N., R. 43E.	; Tonopah, Nev. (2°)
3 Diana's Punch Bowl	SE 1/4 sec. 22, T. 14N., R. 47E.	Diana's Punch Bowl, Nev. (15'); Millet, Nev. (2°)
4 Hot spring near Diana's Punch Bowl	SE 1/4 sec. 22, T. 14N., R. 47E.	Diana's Punch Bowl, Nev. (15'); Millet, Nev. (2°)
5 Pott's Ranch Hot Spring	NE 1/4 sec. 2, T. 14N., R. 47E.	Diana's Punch Bowl, Nev. (15'); Millet, Nev. (2°)
6 Unnamed warm spring near Warm Springs	SW 1/4 sec. 20, T. 4N., R. 50E.	Warm Springs, Nev. (15'); Tonopah, Nev. (2°)

Table 1.--Location and topographic map coverage of selected hot springs and wells--Continued

Spring or well	Location	Topographic map coverage
	Pershing County	
1 Unnamed hot spring (Jersey Valley)	SW 1/4 sec. 28, T. 27N., R. 40E.	Mt. Moses, Nev. (15'); Winnemucca, Nev. (2°)
2 Kyle Hot Springs	SW 1/4 sec. 1, T. 29N., R. 36E.	Kyle Hot springs, Nev. (15'); Winnemucca, Nev. (2°)
3 Sou Hot Springs	SE 1/4 sec. 29, T. 26N., R. 38E.	Cain Mtn., Nev. (15'); Winnemucca, Nev. (2°)
4 Unnamed hot spring (Lower Ranch)	NW 1/4 sec. 16, T. 25N., R. 39E.	Cain Mtn., Nev. (15'); Winnemucca, Nev. (2°)
5 Unnamed hot spring near Trego	Unsurveyed (lat. 40°46' N., long. 119°7'W)	; Lovelock, Nev.-Calif. (2°)
6 Unnamed hot spring near Black Rock	Unsurveyed (lat. 40°57'N., long. 118°58W)	; Lovelock, Nev.-Calif. (2°)
7 Leach Hot Springs	SE 1/4 sec. 36, T. 32N., R. 38E.	Leach Hot Springs, Nev. (15'); Winnemucca, Nev. (2°)
	Washoe County	
1 Steam Geyser (Needle Rocks)	Unsurveyed (lat. 40°9'N., long. 119°40'W)	The Needle Rocks, Nev. (7-1/2'); Lovelock, Nev.-Calif. (2°)
2 Great Boiling Spring	NW 1/4 sec. 15, T. 32N., R. 23E.	Gerlach, Nev. (15'); Lovelock, Nev.-Calif (2°)
3 Flowing well near Gerlach	sec. 2, T. 34N., R. 23E.	; Lovelock, Nev.-Calif. (2°)
4 Steamboat Springs	NE 1/4 sec. 33, T. 18N., R. 20E.	Steamboat, Nev. (7-1/2'); Reno, Nev. (2°)

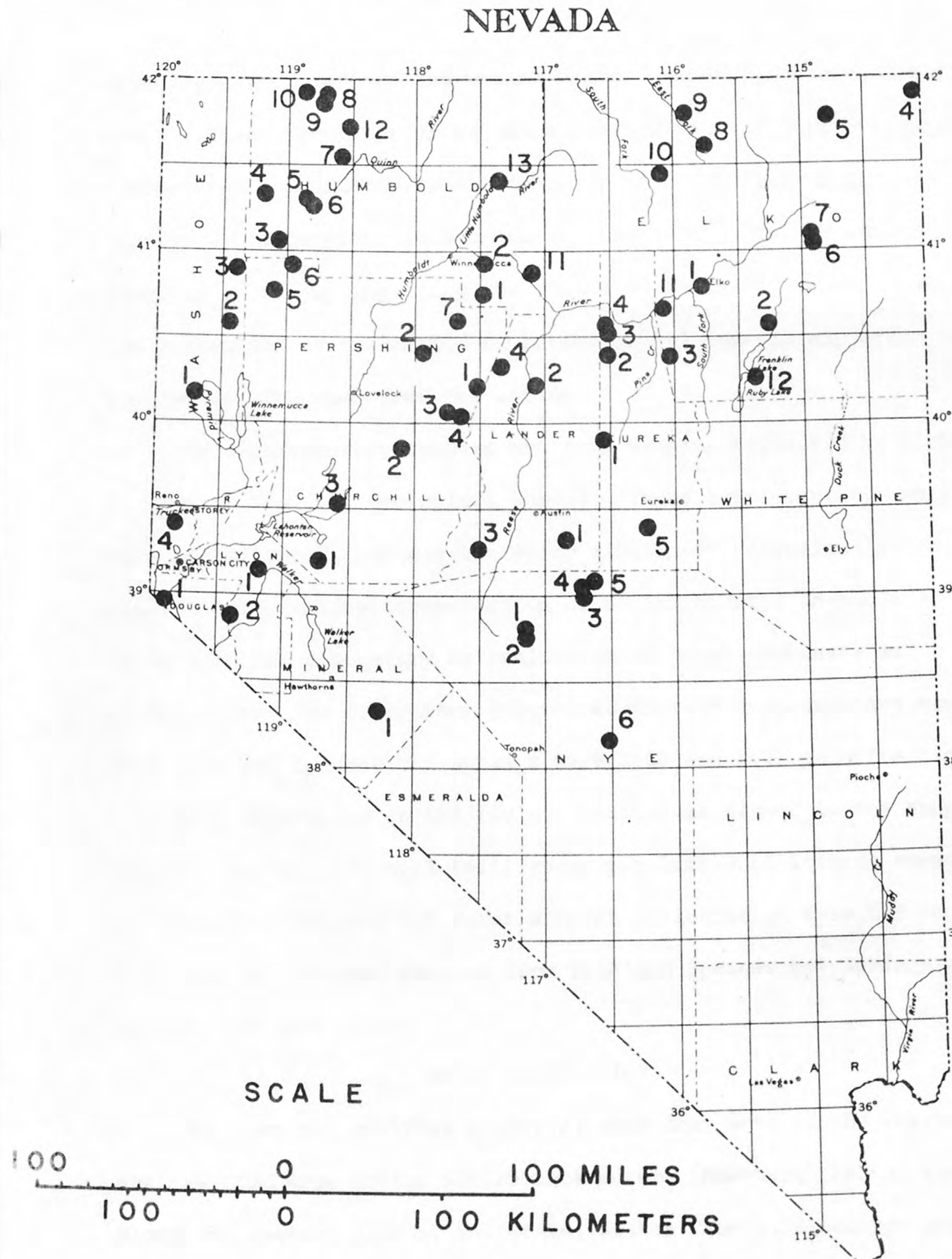

Figure 1. Map of the State of Nevada showing the location of sampled thermal springs and wells. The numbered dots correspond to sampled springs and wells listed by county in tables 1, 2, 3, and 4 of the text.

discharges from springs and wells. Water temperatures were determined with a thermistor probe and a maximum-reading mercury-in-glass thermometer. Conductivity was measured in the spring using a conductivity bridge with a temperature compensator. The pH was measured directly in the spring using the method of Barnes (1964). Alkalinity was determined by the method of Barnes (1964) immediately after the sample was withdrawn from the spring.

The supplementary samples are grab samples collected by Richard K. Hose of the U.S. Geological Survey. These supplementary samples were not filtered, nor was the pH or alkalinity determined in the field. A laboratory determination of pH is reported in table 2, along with the laboratory determination of total carbonate as bicarbonate. The laboratory determined pH's of supplementary samples from Kyle and Spencer hot springs were 1.60 and 1.51 pH units higher than pH's determined in the field. Silica was higher in the supplementary samples, 150 mg/l (milligrams per liter) (filtered) versus 175 mg/l (unfiltered) for water samples collected at Kyle Hot Spring. Only data on filtered samples from Kyle and Spencer hot springs are included in this report.

WATER COMPOSITION

The chemical analyses (table 2) show that most of the thermal springs discharge sodium bicarbonate water. However, thermal springs along the western side of the State, Washoe County, discharge sodium chloride waters. Some sodium mixed anion waters occur around the Black Rock Desert in Humboldt County. Sodium and calcium occur in

Table 2.--Chemical analyses of selected hot springs and wells

[Concentrations in milligrams per liter; parentheses indicate supplementary samples; n.a. indicates not available]

Spring or well	Temperature (°C)	pH	Specific conductance	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Lithium (Li)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Boron (B)
Churchill County															
1 Lee Hot Springs	88	7.36	2,430	180	44	0.6	450	26	0.70	114	<1	470	380	7.9	2.4
2 Dixie Valley Hot Springs	72	8.59	914	115	3.6	.02	190	6.5	.38	111	11	111	126	16.3	.89
3 Flowing well in Stillwater	96	7.57	6,910	170	108	1.7	1,480	42	1.94	90	<1	190	2,200	5.0	15
Douglas County															
1 Walleys Hot Springs	61	8.77	726	58	10	.01	145	3.6	.20	50	9	235	44	4.9	1.2
Elko County															
1 Hot Hole	56	7.21	908	65	60	15.5	120	39	.33	488	1	72	16	1.9	.70
2a Sulphur Hot Springs	93	8.53	601	210	1.0	.03	135	8.9	.46	244	15	40	23	17.7	.20
2b Sulphur Hot Springs	45	8.63	652	230	1.6	.02	150	9.8	.51	247	12	40	4	19.0	.23
3 Unnamed hot spring (Hot Creek)	26	7.30	408	20	46	23.5	10	2.1	.02	226	1	27	4.6	<0.1	.03
(4) Nile Spring	43	7.2	321	31	40	11.5	10	5.6	<.2	149	--	37	8.7	.4	<.02
(5) Mineral Hot Spring	60	9.1	344	83	1.6	<.01	75	2.2	<.2	108	--	45	15	8.9	.47
(6) Unnamed hot spring near Wells	50	7.3	753	165	12	.3	160	16	.8	345	--	61	22	10	1.2
(7) Unnamed hot spring near Wells	61	7.3	1,650	105	75	37	300	31	.8	1,135	--	32	27	7.2	.89
(8) Unnamed hot spring (Wild Horse Reservoir)	54	7.2	818	40	48	12	130	22	.5	482	--	40	14	5.2	.67
(9) Unnamed hot spring (SSE Patsville)	41	7.4	624	23	29	7.7	110	8.3	.4	380	--	36	4.4	3.4	.22
(10) Hot Sulphur Springs	90	7.0	1,760	84	49	13	390	41	.7	1,180	--	18	40	7.2	.77
(11) Unnamed hot spring near Carlin	79	7.6	625	70	60	15	45	16	n.a.	335	--	52	12	n.a.	n.a.
(12) Unnamed hot spring near Ruby Marsh	65	8.0	600	50	45	12	58	14	n.a.	377	--	24	6.5	n.a.	n.a.
Eureka County															
1 Walti Hot Springs	72	6.47	592	68	56	12	44	14	.3	264	<1	64	12	2.5	.12
2 Hot Springs Point	54	6.63	1,730	67	53	35	230	58	1.1	913	<1	7	1	6.6	2.1
3 Beowawe "steam" well	--	9.38	1,490	500	1.3	.2	250	38	2.1	505	81	64	70	<.05	2.5
4 Beowawe Hot Spring	98	8.98	1,020	320	1.0	<.1	230	16	1.3	321	32	130	69	17	2.1

Table 2.--Chemical analyses of selected hot springs and wells--Continued

Spring or well	Temperature (°C)	pH	Specific conductance	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Lithium (Li)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Boron (B)
(5) Bartholomae Hot Springs	54	9.25	295	85	1	<0.1	64	0.7	n.a.	144	--	18	6.3	n.a.	n.a.
Humboldt County															
1 Unnamed hot spring (Hot Springs Ranch)	85	8.36	1,060	125	16	.9	200	18	1.2	385	--	140	41	n.a.	2.6
2 Unnamed hot spring near Golconda	74	6.53	810	66	33	6.8	130	22	.36	429	<1	56	18	1.8	1.1
3 Double Hot Springs	80	7.93	902	105	4.8	.1	180	4.5	.06	261	2	120	59	10	1.8
4 Unnamed hot springs in Soldier Meadows	54	8.55	363	63	3.1	<.1	74	1.1	.17	92	3	41	18	12	.64
5 West Pinto Hot Spring (well)	92	7.65	1,520	160	4.6	.1	320	25	.45	436	2	130	160	14	6.9
6 East Pinto Hot Spring	93	7.14	1,560	150	14	.4	330	23	.45	495	1	120	160	12	7.5
7 Dyke Hot Spring	66	8.86	666	85	1.8	<.1	150	4.3	.09	243	17	82	21	8.0	1.0
8 Flowing well near Baltazor Hot Spring	90	7.50	934	150	10	.1	180	8.2	.22	156	<1	230	47	6.8	2.1
9 Baltazor Hot Spring	80	8.00	947	160	8.4	<.1	180	8.7	n.a.	139	2	220	48	7.1	2.9
10 Bog Hot Springs	54	9.05	356	57	.2	<.1	81	1.0	.03	116	11	45	15	1.7	.91
(11) Hot Pot	58	8.0	1,400	80	29	5	288	33	.72	823	--	60	28	n.a.	n.a.
(12) Howard Hot Spring	56	9.2	400	85	3	<.1	88	1.7	n.a.	127	--	62	10	n.a.	n.a.
(13) The Hot Springs	58	8.0	1,340	55	10	8	296	36	n.a.	881	--	36	26	n.a.	n.a.
Lander County															
1 Spencer Hot Springs	72	6.49	1,180	77	43	9.4	200	36	1.8	672	<1	51	22	4.7	2.6
(2) Unnamed hot spring (Valley of the Moon)	53	8.0	700	40	20	9	118	21	n.a.	333	--	64	21	n.a.	n.a.
3 Unnamed hot spring (Smith Creek Valley)	86	7.72	737	110	4.8	.06	170	8.4	.38	246	5	102	22	8.9	.66
4 Buffalo Valley Hot Springs	49	6.53	1,530	80	45	4.9	250	34	.80	813	<1	110	29	4.8	2.3
Lyon County															
(1) Wabuska Hot Springs	97	8.5	1,550	115	38	.2	277	15	n.a.	70	--	580	46	n.a.	n.a.
2 Nevada Hot Springs	61	8.65	509	52	4.5	.01	102	2.5	.08	54	7	169	17	3.1	.19
Mineral County															
1 Soda Springs	35	7.60	1,640	46	40	3.3	305	16	.65	112	<1	597	87	7.4	2.3

Table 2.--Chemical analyses of selected hot springs and wells--Continued

Spring or well	Temperature (°C)	pH	Specific conductance	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Lithium (Li)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Boron (B)
Nye County															
1 Darrough "steam" well	94	8.29	499	105	1.4	0.1	110	2.9	0.3	165	3	55	12	15	0.24
2 Darrough Hot Springs	95	8.29	479	98	1.3	.1	110	2.6	.3	146	3	53	12	14	.22
3 Diana's Punch Bowl	59	7.14	605	46	50	11	55	15	.4	277	<1	59	8	2.8	.21
4 Hot spring near Diana's Punch Bowl	51	6.73	589	46	47	11	57	15	0.4	270	<1	59	8	2.8	0.23
5 Pott's Ranch Hot Spring	45	6.62	561	36	52	11	47	13	.3	249	<1	57	10	2.0	.17
(6) Unnamed warm spring near Warm Springs	61	8.1	1,250	60	43	24	175	24	n.a.	714	--	120	32	n.a.	n.a.
Pershing County															
1 Unnamed hot spring (Jersey Valley)	29	7.10	1,040	110	36	4.4	180	20	1.2	374	<1	150	40	7.8	1.9
2 Kyle Hot Springs	77	6.50	3,220	150	95	25.5	540	80	3.1	544	<1	51	770	5.7	3.8
(3) Sou Hot Springs	73	8.1	1,407	65	110	22	165	26	n.a.	312	--	370	75	n.a.	n.a.
(4) Unnamed hot spring (Lower Ranch)	40	8.1	850	42	31	15	143	12	n.a.	456	--	63	29	n.a.	n.a.
(5) Unnamed hot spring near Trego	86	8.4	2,300	85	25	.2	463	9.3	n.a.	154	--	86	520	n.a.	n.a.
(6) Unnamed hot spring near Black Rock	90	8.1	6,590	120	35	4	1,500	20	n.a.	932	--	290	787	n.a.	n.a.
7 Leach Hot Spring	92	7.40	811	135	8.8	.5	160	13	1.7	366	1	53	29	7.8	1.2
Washoe County															
1 Steam Geyser (Needle Rocks)	56	8.43	6,200	110	260	.1	1,100	160	.61	24	1	340	1,900	3.0	6.1
2 Great Boiling Spring	86	7.15	7,610	165	68	1.2	1,400	130	1.6	83	<1	400	2,200	4.5	9.9
3 Flowing well near Gerlach	80	7.91	1,800	82	31	4.2	340	17	.46	458	4	46	240	7.0	1.9
4 Steamboat Springs	94	7.19	3,340	270	16	0.7	680	66	7.5	364	2	73	837	2.1	47

approximately equal molar amounts in the water from Diana's Punch Bowl, the springs at Potts Ranch and East Ruby Marsh, and Walti Hot Springs. Water from Nile Spring is a calcium magnesium bicarbonate type.

The waters range in pH from 6.47 at Walti Hot Springs to 9.38 at the Beowawe "steam" well. Specific conductance is highest for sodium chloride waters such as the discharge from Great Boiling Spring at Gerlach and lowest for the sodium calcium bicarbonate or calcium-magnesium bicarbonate waters mentioned above.

CHEMICAL GEOTHERMOMETERS

The chemical composition of thermal spring waters can be used to estimate thermal-aquifer temperatures. Qualitative geochemical indicators include calcium and bicarbonate contents of near-neutral waters (Ellis, 1970); magnesium or magnesium to calcium ratios, low values indicate high thermal-aquifer temperatures (White, 1970); sodium to calcium ratios, high ratios may indicate high temperatures (Mahon, 1970); chloride to total carbonate ratios, highest ratios in related waters indicate the highest subsurface temperatures (Fournier and Truesdell, 1970); and chloride to fluoride ratios, high ratios may indicate high temperature (Mahon, 1970). Quantitative estimates of thermal-aquifer temperatures may be obtained from geothermometers based on silica and sodium to potassium (Na/K) ratios or sodium-potassium-calcium (Na-K-Ca) (Fournier and Rowe, 1966; White, 1965; Fournier and Truesdell, 1973). The basic assumptions in using quantitative geothermometers have been enumerated by Fournier, White, and Truesdell (1974) as follows:

1. Temperature dependent reactions occur at depth.
2. There is an adequate supply of the constituents that are used as a basis for geothermometry.
3. Water-rock equilibrium occurs at the reservoir temperature.
4. There is negligible re-equilibrium at the lower temperatures as the water flows from the reservoir to the surface.
5. There is no dilution or mixing of the hot water coming from depth with shallow water.

The silica geothermometer is based on the solubility of quartz (Fournier and Rowe, 1966). The cation geothermometers are based on exchange reactions between silicates and the aqueous phase (White, 1965; Ellis, 1970; Fournier and Truesdell, 1973). Fournier and Truesdell (1973) have shown that data for most geothermal waters cluster near a straight line when the function log (Na/K) + β log ($\sqrt{Ca}$/Na) is plotted versus the reciprocal of absolute temperature. Beta (β) is 4/3 for solutions that have equilibrated below 100°C and 1/3 for solutions that have equilibrated above 100°C. The Na/K geothermometer should be used only for near-neutral and alkaline waters that do not deposit travertine and have $\sqrt{Ca}$/Na of one or less (Fournier and Truesdell, 1973).

Fournier, White, and Truesdell (1974) present a set of guidelines for determining which subsurface-temperature estimate may best indicate the thermal-aquifer temperature. These authors recommend a procedure based on the temperature and discharge of the spring. A large discharge is taken to be 100 lpm (liters per minute) or more, whereas a small discharge is less than about 20 lpm. Boiling springs having large discharges may be considered to have cooled adiabatically, whereas boiling springs having small discharges may have cooled by conduction. Boiling springs discharging between 20 and 100 lpm are in a range where the selection of the adiabatic or conductive silica estimate of subsurface temperature becomes subjective.

Large discharge springs with temperatures below boiling may be either a mixed water or water which has equilibrated with rock only slightly hotter than the measured spring temperature. The mixed waters are produced by the mixing of high temperature (>100°C) water and cold meteoric water. If the Na-K-Ca geothermometer indicates a temperature of more than 25°C above the measured spring temperature, then the water should be treated as a mixed water by the method of Fournier and Truesdell (1974). Estimated equilibrium temperatures for low discharge springs with temperatures below boiling are difficult to interpret. The discharge may be either a mixed water or water which has cooled by conduction. The equilibrium temperature estimates for the mixed waters, table 3, represent minimum thermal-aquifer temperatures. The underlined numbers in table 3 represent the "best" estimate of thermal-aquifer temperature.

Precipitation of calcium carbonate at the unnamed hot spring (Hot Springs Ranch), the flowing well near Gerlach, Hot Hole, the

Table 3.--Estimated thermal-aquifer temperatures of selected hot springs

	Spring or well	Spring temperature (°C)	Flow (lpm)	Spring deposits: $CaCO_3$	Spring deposits: Silica	Comments	Estimated reservoir temperatures (°C): Silica conductive	Silica adiabatic	Na-K	Na-K-1/3Ca	Na-K-4/3Ca
						Churchill County					
1	Lee Hot Springs	88	130	X	X	High chloride, near boiling	173	162	128	162	138
2	Dixie Valley Hot Springs 1/	72	200	--	--	Low calcium, moderate chloride, moderate silica	145	139	86	144	137
3	Flowing well in Stillwater	96	--	--	--	High chloride, boiling	169	159	72	140	150
						Douglas County					
1	Walleys (Genoa) Hot Springs	61	75	X	--	Na-K-4/3Ca estimate near the spring temperature	109	109	64	119	85
						Elko County					
1	Hot Hole (Elko Hot Springs)	56	75	X	--	Calcite ppt., Na-K-Ca meaningless	114	113	380	234	127
2a	Sulphur Hot Springs	93	75	--	X	Boiling spring, low chloride and calcium	183	171	140	181	190
2b	Sulphur Hot Springs 2/	45	500	--	X	May be boiling at the orifice (?), large lake with a large cooling surface	190	176	139	178	180
3	Unnamed hot spring (Hot Creek)	26	6,000	--	--	Na-K-4/3Ca estimate near the spring temperature	63	69	282	161	18
4	Nile Spring	43	Supplementary sample			Na-K-4/3Ca estimate near the spring temperature	81	84	543	220	44
5	Mineral Hot Spring 1/	60	Supplementary sample			Low calcium, magnesium, and chloride (?), moderate silica	127	124	75	129	103
6	Unnamed hot spring near Wells 1/	50	Supplementary sample			Low calcium and chloride (?), high silica	167	158	184	184	139
7	Unnamed hot spring near Wells	61	Supplementary sample			High calcium and magnesium, low chloride, mixed (?)	140	135	188	181	124
8	Unnamed hot spring (Wild Horse Reservoir)	54	Supplementary sample			High calcium and bicarbonate, low chloride	92	94	255	197	111
9	Unnamed hot spring (SSE Patsville)	41	Supplementary sample			Na-K-4/3Ca estimate near the spring temperature	69	74	153	156	86
10	Hot Sulphur Springs	90	Supplementary sample			High calcium and bicarbonate, low chloride, mixed (?)	128	125	190	191	153
11	Unnamed hot spring near Carlin	79	Supplementary sample			Na-K-4/3Ca estimate near the spring temperature	118	117	395	216	81
12	Unnamed hot spring near Ruby Marsh	65	Supplementary sample			Na-K-4/3Ca estimate near the spring temperature	102	102	314	202	86
						Eureka County					
1	Walti Hot Springs	72	300	X	--	Na-K-4/3Ca estimate near the spring temperature	116	115	375	212	79
2	Hot Springs Point	54	125	X	--	High calcium, very low chloride, mixed water (?)	115	115	325	233	159
3	Beowawe "steam" well	--	--	--	X	Boiling, very low calcium	252	226	238	242	292

Table 3.--Estimated thermal-aquifer temperatures of selected hot springs--Continued

	Spring or well	Spring temperature (°C)	Flow (lpm)	Spring deposits: $CaCO_3$	Spring deposits: Silica	Comments	Estimated reservoir temperatures (°C): Silica conductive	Silica adiabatic	Na-K	Na-K-1/3Ca	Na-K-4/3Ca
4	Beowawe Hot Spring	98	100	--	X	Boiling, very low calcium, superheated	214	196	145	194	237
5	Bartholomae Hot Springs	54	Supplementary sample			Na-K-4/3Ca estimate near the spring temperature	128	125	19	92	73
						Humboldt County					
1	Unnamed hot spring (Hot Springs Ranch)	85	100	X	T	Calcite precipitating, mixed (?)	150	144	172	180	139
2	Unnamed hot spring near Golconda	74	750	X	--	High calcium, bicarbonate, and magnesium, possible mixing (?)	115	114	255	201	121
3	Double Hot Spring[1/]	80	175	T	T	Low calcium, bicarbonate, and magnesium, mixed	140	135	64	127	113
4	Unnamed hot springs in Soldier Meadows	54	50	--	--	Na-K-4/3Ca estimate near the spring temperature	112	112	34	98	65
5	West Pinto Hot Spring (well)	92	100	X	X	Low calcium and magnesium, spring near boiling	165	156	157	192	208
6	East Pinto Hot Spring	93	500	X	X	Low calcium and magnesium, spring near boiling	162	153	145	176	163
7	Dyke Hot Spring[1/]	66	100	T	--	Low calcium and magnesium, spring not boiling	128	126	73	137	136
8	Flowing well near Baltazor Hot Spring	90	25	--	--	Low calcium, nearly boiling, low flow rate	162	153	107	148	118
9	Baltazor Hot Spring	80	100	T	T	Low calcium, may be a mixed water although chloride and magnesium are low	165	156	111	152	100
10	Bog Hot Spring	54	4,000	--	--	Low TDS, deep circulation meteoric or mixed (?)	108	109	25	109	128
11	Hot Pot	58	Supplementary sample			High calcium, bicarbonate, calcite ppt. (?), indeterminate	125	122	200	195	155
12	Howard Hot Spring	56	Supplementary sample			Na-K-4/3Ca estimate near the spring temperature	128	125	49	110	81
13	The Hot Springs	58	Supplementary sample			Calcite ppt. (?), low chloride, indeterminate	106	106	208	209	197
						Lander County					
1	Spencer Hot Springs	72	50	X	--	Low flow rate, low chloride, high calcium and bicarbonate	123	121	264	210	141
2	Unnamed hot spring (Valley of the Moon)	53	Supplementary sample			Very low silica, probably deep circulation meteoric	92	94	263	207	132
3	Unnamed hot spring (Smith Creek Valley)	86	75	T	--	Spring near boiling, low calcium, low chlorite (?)	143	137	114	157	139
4	Buffalo Valley Hot Springs	49	10	T	--	High calcium and bicarbonate, low flow rate	125	122	223	198	140

Table 3.--Estimated thermal-aquifer temperatures of selected hot springs--Continued

Spring or well	Spring temperature (°C)	Flow (lpm)	Spring deposits		Comments	Estimated reservoir temperatures (°C)				
			$CaCO_3$	Silica		Silica conductive	Silica adiabatic	Na-K	Na-K-1/3Ca	Na-K-4/3Ca
Lyon County										
1 Wabuska Hot Springs	97	Supplementary sample			Boiling	145	139	120	152	111
2 Nevada Hot Springs	61	200	X	--	Na-K-4/3Ca estimate near the spring temperature	104	104	64	119	86
Mineral County										
1 Soda Springs	35	100	T	--	High calcium, deep circulation meteoric or mixed water (?)	98	99	122	154	116
Nye County										
1 Darrough "steam" well	94	300	--	--	Boiling	140	135	68	131	122
2 Darrough Hot Springs	95	350	X	T	Boiling	136	132	61	127	120
3 Diana's Punch Bowl	59	--	X	--	Na-K-4/3Ca estimate near the spring temperature	99	100	341	208	86
4 Hot springs near Diana's Punch Bowl	51	200	X	--	Na-K-4/3Ca estimate near the spring temperature	99	100	334	207	88
5 Pott's Ranch Hot Spring	45	125	X	--	Na-K-4/3Ca estimate near the spring temperature	91	92	344	205	79
6 Unnamed warm spring near Warm Springs	61	Supplementary sample			High calcium, magnesium, and bicarbonate, probably low temperature	110	110	225	192	122
Pershing County										
1 Unnamed hot spring (Jersey Valley)	29	20	X	X	Low flow rate, qualitatively high aquifer temperature	142	137	196	182	119
2 Kyle Hot Springs	77	20	X	T	Low flow rate, qualitatively high aquifer temperature	171	161	199	194	154
3 Sou Hot Springs	73	Supplementary sample			Na-K-4/3Ca estimate near spring temperature	114	113	244	190	100
4 Unnamed hot spring (Lower Ranch)	40	Supplementary sample			High calcium, magnesium, and bicarbonate	94	96	162	164	100
5 Unnamed hot spring near Trego	86	Supplementary sample			High chloride, near boiling, flow rate (?)	128	125	51	120	111
6 Unnamed hot spring near Black Rock	90	Supplementary sample			High chloride, near boiling, flow rate (?)	148	142	28	117	151
7 Leach Hot Springs	92	200	T	T	Near boiling, low calcium and magnesium	155	147	161	176	139

Table 3.--Estimated thermal-aquifer temperatures of selected hot springs--Continued

Spring or well	Spring temperature (^{o}C)	Flow (lpm)	Spring deposits		Comments	Estimated reservoir temperatures (^{o}C)				
			$CaCO_3$	Silica		Silica conductive	Silica adiabatic	Na-K	Na-K-1/3Ca	Na-K-4/3Ca
					Washoe County					
1 Steam Geyser (Needle Rocks)	56	--	X	--	High chloride, calcium, calcite ppt. (?), boiling in well (?)	143	137	232	214	184
2 Great Boiling Spring	86	--	T	X	Boiling, high chloride	167	158	175	205	230
3 Flowing well near Gerlach	80	500	X	--	Calcite ppt., Na-K-Ca estimate too high	125	124	115	154	125
4 Steamboat Springs	94	50	--	X	Boiling, high chloride	201	186	180	208	233

1/ Mixed waters

2/ Temperature measured at the outlet of the lake not in the orifice of the spring

Steam Geyser at Needle Rocks, and the flowing well in Stillwater, make the Na-K-Ca subsurface-temperature estimates doubtful for these samples. Thermal-aquifer temperatures estimated from the chemical analyses indicate 16 different spring complexes where the waters have circulated through rock having a temperature of at least 140°C. The flowing well in Stillwater, Beowawe Hot Springs, Wabuska Hot Springs, Leach Hot Springs, Great Boiling Spring, and Steamboat Springs, all have estimated minimum thermal-aquifer temperatures of at least 140°C and are in areas designated as known geothermal resource areas by Godwin and others (1971). Other areas of geothermal potential not in known geothermal resource areas are Lee Hot Springs and Dixie Valley Hot Springs in Churchill County, Sulphur Hot Springs and two unnamed hot springs near Wells in Elko County, Pinto Hot Springs, Baltazor Hot Spring, and an unnamed hot spring (Hot Springs Ranch) in Humboldt County, an unnamed hot spring (Smith Creek Valley) in Lander County, as well as Kyle Hot Springs and an unnamed hot spring (Jersey Valley) in Pershing County. Dixie Valley Hot Springs, Mineral Hot Springs, an unnamed hot spring (near Wells), Double Hot Spring, and Dyke Hot Spring may be mixed waters. The thermal-aquifer temperatures estimated from the water compositions may be significantly below the true thermal-aquifer temperature.

GEOLOGIC SETTING

Nevada, part of the Basin and Range Province, consists of roughly parallel fault-block mountain ranges separated by alluvial-filled valleys. Exposed rocks range in age from Precambrian to

Quaternary. Precambrian and Paleozoic rocks crop out in the mountain ranges of eastern Lander, Eureka, and southern Elko Counties (Montgomery, 1965). Mesozoic sedimentary and volcanic rocks are widespread in Pershing and southeastern Humboldt Counties: Mesozoic granitic intrusive rocks are common in western Pershing and northern Humboldt Counties, as well as near the Sierra Nevada of California. Cenozoic volcanic rocks and related sedimentary rocks are predominant in Washoe, northern Humboldt, northern Elko, Churchill, western Lander, and Nye Counties.

The types and ages of rock exposed near the springs as well as selected references on the geology of the area around the spring are listed in table 4. Most of the thermal springs are along permeable zones associated with faults. Quaternary alluvium and lacustrine rocks cover the fault lines along which many of the springs issue.

TYPES OF THERMAL SYSTEMS

White, Muffler, and Truesdell (1971) discussed vapor-dominated and hot-water-dominated systems. They state that thermal springs associated with either vapor-dominated or hot-water-dominated systems have distinctive physical and chemical characteristics. Vapor-dominated systems are found in impermeable rocks while hot-water-dominated systems are found in relatively permeable rocks. The permeability associated with hot-water-dominated systems may be either fracture permeability or distributive permeability. Vapor-dominated systems have thermal springs with low discharges

Table 4.--Age and type of rock near each spring

Spring or well	Age and type of rock	Geologic reference
	Churchill County	
1 Lee Hot Springs	Miocene to Pliocene volcanic rocks	Willden and Speed (1968)
2 Dixie Valley Hot Springs	Quaternary alluvium, Tertiary volcanic rocks, and possibly late Mesozoic intrusive and metamorphic rocks	Page (1965)
3 Flowing well in Stillwater	Quaternary alluvium and Tertiary basalt(?)	Willden and Speed (1968)
	Douglas County	
1 Walleys Hot Springs	Triassic and Jurassic metavolcanic rocks of greenschist facies	Moore (1969)
	Elko County	
1 Hot Hole	Tertiary limestone, lacustrine rocks and volcanic rocks	Granger, Mendell, Simmons, and Lee (1957)
2 Sulphur Hot Springs	Quarternary alluvium, late Mesozoic granites, and Paleozoic to Precambrian metamorphic rocks	Granger, Mendell, Simmons, and Lee (1957)
3 Unnamed hot spring (Hot Creek)	Paleozoic limestone	Smith and Ketner (1972)
4 Nile Spring	Tertiary lacustrine rocks	Granger, Mendell, Simmons, and Lee (1957)
5 Mineral Hot Spring	Tertiary lacustrine rocks, granite(?) and volcanic flows	Granger, Mendell, Simmons, and Lee (1957)
6 Unnamed hot spring near Wells	Tertiary lacustrine rocks	Granger, Mendell, Simmons, and Lee (1957)
7 Unnamed hot spring near Wells	Tertiary lacustrine rocks	Granger, Mendell, Simmons, and Lee (1957)
8 Unnamed hot spring (Wild Horse Reservoir)	Tertiary volcanic and lacustrine rocks	Granger, Mendell, Simmons, and Lee (1957)
9 Unnamed hot spring (SSE Patsville)	Tertiary volcanic rocks and Paleozoic limestone	Granger, Mendell, Simmons, and Lee (1957)
10 Hot Sulphur Springs	Tertiary volcanic rocks and Paleozoic limestone	Granger, Mendell, Simmons, and Lee (1957)
11 Unnamed hot spring near Carlin	Quaternary alluvium and Tertiary volcanic rocks	Granger, Mendell, Simmons, and Lee (1957)
12 Unnamed hot spring near Ruby Marsh	Quaternary alluvium and Paleozoic(?) marine sedimentary rocks	Granger, Mendell, Simmons, and Lee (1957)
	Eureka County	
1 Walti Hot Springs	Quaternary alluvium, late Mesozoic to early Cenozoic granite, and Paleozoic sedimentary rock	Roberts, Montgomery, and Lehner (1967)
2 Hot Springs Point	Late Miocene and early Pliocene basalts, and Ordovician quartzite and cherts	Gilluly and Gates (1965)
3 Beowawe "steam" well	Miocene basalt and andesite flows	Gilluly and Gates (1965)
4 Beowawe Hot Spring	Miocene basalt and andesite flows	Gilluly and Gates (1965); Stewart and McKee (1970)
5 Bartholomae Hot Springs	Quaternary alluvium and Tertiary volcanic rocks	Roberts, Montgomery, and Lehner (1967)

Table 4.--Age and type of rock near each spring--Continued

Spring or well	Age and type of rock	Geologic reference
	Humboldt County	
1 Unnamed hot spring near Hot Springs Ranch	Cambrian phyllitic shale	Willden (1964)
2 Unnamed hot spring near Golconda	Quaternary alluvium, Cambrian quartzite, and Tertiary volcanic rocks	Ferguson, Roberts, and Muller (1952)
3 Double Hot Springs	Quaternary alluvium, Tertiary basalt and ash-flow rhyolite	Willden (1964)
4 Unnamed hot spring in Soldier Meadows	Quaternary alluvium, Tertiary flows and tuffs	Willden (1964)
5 West Pinto Hot Spring (well)	Cretaceous or Tertiary granodiorite, and Tertiary basalt	Willden (1964)
6 East Pinto Hot Spring	Cretaceous or Tertiary granodiorite	Willden (1964)
7 Dyke Hot Spring	Quaternary alluvium, Triassic and Jurassic metamorphic rocks	Willden (1964)
8 Flowing well near Baltazor Hot Spring	Quaternary alluvium, Tertiary volcanic rocks, and Cretaceous to Tertiary granodiorite	Willden (1964)
9 Baltazor Hot Spring	Quaternary alluvium, Tertiary volcanic rocks, and Cretaceous to Tertiary granodiorite	Willden (1964)
10 Bog Hot Springs	Quaternary alluvium, Pliocene volcanic and sedimentary rocks	Willden (1964)
11 Hot Pot	Quaternary alluvium, Tertiary basalt(?), and Cambrian quartzite(?)	Willden (1964)
12 Howard Hot Spring	Quaternary alluvium and Tertiary flows	Willden (1964)
13 The Hot Springs	Tertiary sedimentary rocks and flows	Willden (1964)
	Lander County	
1 Spencer Hot Springs	Quaternary alluvium, Oligocene or Miocene ash-flow tuff, Jurassic "granite", Ordovician cherts or quartzites	Stewart and McKee (1970); McKee (1968)

Table 4.--Age and type of rock near each spring--Continued

Spring or well	Age and type of rock	Geologic reference
2 Unnamed hot spring (Valley of the Moon)	Quaternary alluvium covering Tertiary volcanic rocks	Stewart and McKee (1970)
3 Unnamed hot spring (Smith Creek Valley)	Quaternary alluvium, Oligocene or Miocene (?) ash-flow rhyolites	McKee (1968)
4 Buffalo Valley Hot Springs	Quaternary alluvium, Quaternary basalts, and Tertiary tuffs	Stewart and McKee (1970)
	Lyon County	
1 Wabuska Hot Springs	Quaternary alluvium, Miocene to Pleistocene basalt and andesite, Triassic and Jurassic metavolcanic rocks	Moore (1969)
2 Nevada Hot Springs	Cretaceous intrusives of granitic to mafic composition	Moore (1969)
	Mineral County	
1 Soda Springs	Quaternary alluvium, Quaternary basalt, and Tertiary tuffaceous rocks	Ross (1961)
	Nye County	
1 Darrough "steam" well	Quaternary alluvium and Paleozoic rhyolite	Kleinhampl and Ziony (1967)
2 Darrough Hot Springs	Quaternary alluvium and Paleozoic rhyolite	Kleinhampl and Ziony (1967)
3 Diana's Punch Bowl	Quaternary alluvium and Tertiary ash-flow rhyolite	Kleinhampl and Ziony (1967)
4 Hot spring at Diana's Punch Bowl	Quaternary alluvium and Tertiary ash-flow rhyolite	Kleinhampl and Ziony (1967)
5 Pott's Ranch Hot Spring	Tertiary ash-flow rhyolite	Kleinhampl and Ziony (1967)
6 Unnamed warm spring near Warm Springs	Tertiary volcanics and Paleozoic sedimentary rocks	Kleinhampl and Ziony (1967)
	Pershing County	
1 Unnamed hot spring (Jersey Valley)	Quaternary alluvium, Tertiary tuffs and flows	Tatlock (1969)
2 Kyle Hot Springs	Quaternary alluvium and Paleozoic metamorphic rocks	Tatlock (1969)
3 Sou Hot Springs	Quaternary alluvium, Tertiary flows and volcanic derived sedimentary rocks	Tatlock (1969)
4 Unnamed hot spring (Lower Ranch)	Quaternary alluvium, Tertiary rhyolite, and metamorphosed Triassic rocks	Tatlock (1969)

Table 4.--Age and type of rock near each spring--Continued

Spring or well	Age and type of bedrock	Geologic reference
5 Unnamed hot spring (Trego)	Quaternary dune sands and Cretaceous granite	Tatlock (1969)
6 Unnamed hot spring (Black Rock)	Quaternary playa sediments, Tertiary volcanic and sedimentary rocks	Tatlock (1969)
7 Leach Hot Springs	Quaternary alluvium, Tertiary sedimentary rocks, basalt of unknown age, Paleozoic metamorphic rocks	Tatlock (1969)
	Washoe County	
1 Steam Geyser (Needle Rocks)	Quaternary tufa and alluvium, Tertiary olivine basalt	Bonham (1969)
2 Great Boiling Spring	Cretaceous or Tertiary granodiorite, Quaternary alluvium and lake sediments	Bonham (1969)
3 Flowing well near Gerlach	Quaternary alluvium, late Tertiary basalts, tuffs, and volcanic sandstone	Bonham (1969)
4 Steamboat Springs	Cretaceous graondiorite	Thompson and White (1964)

(100 lpm or less) of sulfate waters. These sulfate waters are low in chloride and often strongly acidic (pH 2 to 3). The few thermal springs of near-neutral pH discharge sodium bicarbonate waters having chloride contents of less than 20 mg/l. Hot-water-dominated systems have thermal springs with high total discharges (several hundred to several thousand liters per minute) of chloride-rich waters. Individual springs associated with hot-water-dominated systems may have discharge rates as low as a few liters per minute.

The sampled hot springs in Nevada have chemical compositions characteristic of hot-water-dominated systems. Several warm springs having low specific conductances contain less than 20 mg/l chloride and are neutral to slightly acid in pH. These warm springs are in equilibrium with rock at or very near the temperature of the spring.

SUMMARY

Sixteen of the thermal spring complexes of northern and central Nevada have chemical compositions that indicate thermal-aquifer temperatures of at least 140°C. Sodium is the principal cation in these waters, while the anions may be bicarbonate, chloride, or a mixture of chloride, bicarbonate, and sulfate.

Eight of the thermal springs having estimated thermal-aquifer temperatures of 140°C or more have a poorly developed regional trend. This regional trend extends from Wabuska Hot Springs in Lyon County, northeast through Churchill, Pershing, and into south-eastern Humboldt County. The Stillwater Range of Churchill County and East Range of Pershing County parallel this trend. Hot springs

having estimated thermal aquifer temperatures of 140°C or more along this trend include Wabuska Hot Springs in Lyon County, Lee Hot Spring, Stillwater flowing well, and Dixie Valley Hot Spring in Churchill County, Kyle, Leach, and an unnamed hot spring (Jersey Valley) in eastern Pershing County, and an unnamed hot spring (Hot Spring Ranch) in southeastern Humboldt County. Eight other areas scattered over the State where estimated thermal-aquifer temperatures exceed 140°C include Sulphur Hot Springs in Ruby Valley, and two unnamed hot springs near Wells in Elko County, Beowawe in Eureka County, Pinto Hot Springs and Baltazor Hot Springs in Humboldt County, Great Boiling Spring and Steamboat Springs in Washoe County, and an unnamed hot spring in southwestern Lander County. Additional hydrologic data may indicate that the springs issuing mixed waters, Mineral Hot Spring in Elko County, Dyke Hot Spring in Humboldt County, and Double Hot Spring in Humboldt County, have significant geothermal potential.

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