UNITED STATES DEPARTMENT OF THE INTERIOR

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CHEMICAL ANALYSES OF WATERS FROM SPRINGS AND WELLS FROM THE CLEAR LAKE VOLCANIC AREA, NORTHERN CALIFORNIA

By

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INTRODUCTION

In 1971 The Geysers-Clear Lake area was selected by the U.S. Geological Survey Geothermal Research Program as a region for extensive investigation. Studies in that program were designed to determine the origin and structural setting of the geothermal resource, to test and to evaluate methods of geothermal prospecting and resource characterization, and to provide background data to be used to evaluate the effects of resource development. This program involved geologic mapping, petrologic studies, isotopic dating, heat flow measurements, and seismic and other geophysical surveys. The chemical analyses of waters from springs and wells reported here are in support of that program.

Analyses of various thermal water samples from the Clear Lake Volcanics and adjacent areas have been reported by many investigators extending back nearly ninety years. Winslow Anderson prepared the first detailed compendium of spring waters of this area in 1892. His "Mineral springs and health resorts of California" was intended to be a reference for medical practitioners in recommending health resorts for their patients. G. A. Waring (1915) transformed many of Anderson's earlier analyses from grains per gallon into ppm and also included a number of important spring analyses not reported by Anderson (1892). Allen and Day (1927) analyzed numerous springs at The Geysers area collected during the initial drilling there. Berkstresser (1968) reported analyses of about 41 Lake County springs and 11 springs from surrounding counties. Numerous other investigators have analyzed waters in and near The Geysers-Clear Lake geothermal area in recent years. They included, but are not limited to: White and others (1956), White and Roberson (1962), White and others 1963), Barnes and others (1972), Barnes and others (1973), Vollintine (1975), and Goff and others (1977).

SAMPLE COLLECTION

Water samples of springs were collected as close to the main orifice of each spring as possible. Well waters were collected by flowing the well, if possible, or by dropping a weighted bottle attached to a long line (line & bottle). Water samples of streams and lakes were collected at convenient points (docks, piers, etc.). All samples must be considered "grab" samples. No integrated samples from Clear Lake or any major stream or creek were obtained.

Samples were treated in the field as described either by Thompson (1975) or by Thompson and others (1975). The primary difference between the two methods is the method of filtering the samples. The procedure described by Thompson (1975) uses a 50-milliliter syringe and swennex syringe filter for water filtration; the other procedure (Thompson and others, 1975) uses a large 800-milliliter plastic filter assembly with an automobile tire pump to force the water through the filter. All filtered samples were passed through 0.45-micrometer membrane filters (Gelman - GA-6 metricel*). All filtered-acidified (F.A.) samples were acidified with conc (12N) hydrochloric acid (1 mL acid per 250 mL sample). A separate sample was collected for silica by pipetting 10 mL of unfiltered sample into about 50 mL of deionized, distilled water in the field and later diluting to a known volume (100 mL) in the laboratory immediately prior to analysis.

FIELD ANALYSIS

Temperature measurements of springs and wells were obtained with either a total immersion, maximum reading, mercury-in-glass thermometer or with a conventional mercury-in-glass thermometer. Springs having temperatures near that of ambient air temperature required the use of the latter thermometer. Field determinations were usually made for pH (denoted by f pH in table 1) either with a pH electrode or pH strips (colorpHast, EM Laboratories, Inc.), depending upon accessibility of the spring or stream location. A few alkalinity titrations using a pH electrode and standardized sulfuric acid were performed in the field during the December 1974 and February 1975 collections, especially on meteoric water (cold, dilute, low total dissolved solids content springs) samples. Unfortunately, no field analyses for ammonia, hydrogen sulfide or mercury were obtained. A discharge estimate was made if possible.

LABORATORY ANALYSIS

Silica was determined by a modification of the reduced molybdenum blue method. The procedure used is reported in the Shapiro and Brannock silica procedure (1956). On selected samples silica analyses were performed on both those diluted in the field and on non-diluted filtered acidified (F.A.) samples. The analytical results for the two different methods of preserving silica were within 5 percent for the same sample, although the F.A. samples tended to yield a higher silica value. All water samples from The Geysers-Clear Lake area have silica concentrations less than 250 mg/L (table 1). It is not suggested that field acidification be used on water samples containing higher silica concentrations, due to problems with silica polymerization.

Boron was determined by the carmine procedure as described in Brown and others (1970). Selected samples were analyzed on a Spectrospan 3 plasma emission analyzer. The accuracy of the carmine method is within 10 percent of the averaged value.

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* Products mentioned do not constitute a recommendation by the U.S. Geological Survey.

Sodium, potassium, and lithium determinations were made on either a filtered untreated (F.U.) or, preferably, F.A. samples. Lithium ion was added to the sample aliquot for sodium and potassium determinations (1000 mg/L at the concentration analyzed) and sodium ion was added to the lithium sample aliquot (same as above). Calcium and magnesium were determined only on F.A. samples. This is extremely important due to the relatively high concentration of calcium found in many springs of this area. A lanthanum (III) ionization buffer prepared as described by Brown and others (1970) was added to each and every sample aliquot prior to analysis. Later in the study, iron, manganese, cadmium, copper, and zinc were determined by atomic absorption spectrometry. As the samples were only filtered through a 0.45-micrometer filter, the results must be interpreted carefully.

Major anions were determined only from the raw unacidified (R.U.) samples, or preferably, from the filtered unacidified (F.U.) sample. Alkalinity was determined in the laboratory on all samples. For low HCO_3 field values (<60 mg/L), the laboratory determined HCO_3 content was usually twice that determined in the field. Thus, it is imperative that a field determination for alkalinity be performed if the HCO_3 content is low (<100 mg/L). For concentration above 100 mg/L HCO_3 no significant differences between the field and laboratory values were observed. Water that is cold, dilute, and not buffered can dissolve CO_2 which can react to form HCO_3 in solution. Thus, waters near the mean annual temperatures are likely to have HCO_3 contents below 60 mg/L and should have alkalinity determined in the field.

Sulfate was determined by the thorin procedure, described by Brown and others (1970) on all samples above 70 mg/L. The $BaSO_4$ turbidity method (APHA, 1971) was used for screening, and low values (<10 mg/L) are reported for some samples (table 1). Chloride ion was determined by potentiometric titration using an Ag/AgCl-indicating electrode, an Orion double junction reference electrode, and standardized silver nitrate solution. The conditions are specific for chloride at the pH of the sample aliquot. Fluoride was determined electrochemically by a fluoride specific electrode. All samples and standards were adjusted to an ionic strength of 0.5 and buffered at pH 8 by adding equal volumes of ionic strength buffer solution and sample or standard The buffer is described in Thompson and others (1975).

The majority of thermal spring waters in this region may be described as magnesium-calcium bicarbonate. Some water samples, predominantly in the eastern section, are sodium chloride bicarbonate springs. High concentrations of boron are found in all the thermal waters, with the highest concentrations being found in waters to the east of the Clear Lake volcanic field. The results of the analyses are presented in Table 1.

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Table 1. Chemical analyses of thermal water samples from Clear Lake Volcanic area

Table 1. Chemical analyses of thermal water samples from Clear Lake Volcanic area.

Date	Ref #	Sample #	Location	Latitude	Longitude	Flow	Temp.	f pH	l pH
--	1	CLW 1	Spring near Bonanza Springs	38°51.9'	122°41.2'	4	--	--	7.38
3 Aug 74	2	2	Spring near Bonanza Springs	51.9'	41.6'	20	18	--	8.45
7 Aug 74	3	3	Spring near Bonanza Springs	51.4'	42.4'	400	15	--	7.35
--	4	4	Spring near Siegler Springs Well	52.8'	41.1'	--	--	--	8.70
5 Dec 74	5	5	Spring off Harrington Flat Road	51.3'	44.2'	4	13	--	7.85
5 Dec 74	6	LJ-74-3	Open well near Siegler Springs	52.9'	41.1'	8	31	6.4	7.40
5 Dec 74	7	CLW 7	Spring at Salminas Resort	52.7'	43.6'	4	16	--	7.20
5 Dec 74	8	LJ-74-2	Spring in pumphouse at Salminas	52.7'	43.6'	Seep	13	6.6	7.10
5 Dec 74	9	1	Cobb Village Water Supply	49.2'	43.1'	320	12	7.5	7.80
5 Dec 74	10	CLW 10	Small spring near Siegler Well	52.8'	44.0'	4	21	--	6.60
5 Dec 74	11	11	Small spring near Siegler Well	52.9'	41.1'	160	31	--	6.40
5 Dec 74	12	12	Small cold spring near Siegler Well	52.4'	42.2'	4	16	7.4	7.40
5 Dec 74	13	13	Seep below andesite of Perini Hill	52.4'	40.9'	8	13	7.6	7.40
5 Dec 74	14	LJ-74-4	Spring on road near Perini Hill	52.7'	41.1'	16	20	7.5	8.13
6 Dec 74	15	5	Horsehoe Spring	59.6'	44.5'	80	41.5	6.6	7.58
6 Dec 74	16	CLW 16	Artesian Well, Konocti Harbor Inn	59.4'	44.3'	--	25	6.8	7.79
6 Dec 74	17	LJ-74-6	Spring, south side Konocti Harbor Inn	59.2'	44.0'	80	35	6.7	7.94
6 Dec 74	18	CLN 18	Spring, south side Konocti Harbor Inn	59.2'	44.0'	4	35	7	7.22
6 Dec 74	19	19	Cold Spring on Wildcat Road at Bridge	54.0'	45.6'	240	18	7.2	7.72
6 Dec 74	20	LJ-74-7	Kip Neasham's Well	56.6'	43.8'	40	11	6.8	6.95
18 Feb 75	21	LJ-75-1	Highland Springs Area	56.1'	54.6'	Seep	15	6.7	6.43
18 Feb 75	22	2	Clear Lake State Park, Drinking Water	39°01.0'	48.4'	--	--	7.1	7.54
18 Feb 75	23	3	Little Borax Lake	00.1'	45.2'	--	9.4	9	9.75
19 Feb 75	24	CLW 24	Perini Spring	38°53.0'	38.6'	400	17	6.5	7.06
19 Feb 75	25	25	Bardole Spring	52.3'	38.1'	120	17	6	6.97
19 Feb 75	26	26	Carbonate Pool in Siegler Canyon	52.5'	41.8'	Seep	15	6	6.23
19 Feb 75	27	27	Spring N.W. of Siegler Canyon	53.2'	40.8'	200	15	6	7.06
19 Feb 75	28	28	Thurston Lake	55.7'	40.7'	--	14	--	7.75
19 Feb 75	29	29	Well, Konocti Conservation Camp	54.5'	43.4'	--	25	6	7.24
19 Feb 75	30	30	Spring, Flores Ranch	54.3'	38.6'	20	17	6	6.95
19 Feb 75	31	31	Spring, Diener Ranch	54.0'	42.8'	20	13	6	7.20
19 Feb 75	32	LJ-75-4	Spring, east side Borax Lake	59.2'	40.6'	Seep	15	5.3	5.76
19 Feb 75	33	5	Borax Lake, east side	59.1'	40.8'	--	--	9.3	9.74
19 Feb 75	34	6	Spring on east side of Baylis Point	56.8'	41.6'	4	16.5	7.3	7.18
19 Feb 75	35	7	Well at Riviera (line & bottle)	57.7'	43.0'	--	29.5	6.7	6.38
20 Feb 75	36	8	Beeman Residence, well	58.6'	50.3'	--	13	6	9.34
20 Feb 75	37	9	Bradley Well, N. Shaul Valley	57.2'	48.1'	--	13	6	6.86
20 Feb 75	38	10	Ford Ranch Spring, S. Shaul Valley	56.2'	47.3'	2	16	6	5.86

Ref #	SiO_2	Ca	Mg	Na	K	Li	HCO_3	SO_4	Cl	F	B	Fe	Mn	Cd	Cu	Zn
1	96	2.9	1.6	5.5	6.0	<0.01	128	4.	4.	—	—	—	—	—	—	—
2	57	2.8	73.	3.5	2.4	<.01	281	48.	4.3	—	—	—	—	—	—	—
3	46	5.4	2.3	4.3	1.4	<.01	125	<.5	2.4	—	—	—	—	—	—	—
4	47	9.9	18.4	5.8	7.5	.13	274	.5	32.	0.22	1.8	—	—	—	—	—
5	48	10.9	7.2	6.5	1.5	<.01	114	1.	3.0	<.1	<.1	0.15	<0.02	—	—	—
6	106	10.3	18.5	13.5	6.5	.12	204	1.	24.	.15	1.6	1.45	.12	—	—	—
7	52	6.2	3.2	6.1	3.7	<.01	67	2.	3.4	.1	<.1	<.02	<.02	—	—	—
8	63	4.7	3.0	6.5	7.9	.02	54	2.	5.0	<.1	<.1	.38	<.02	—	—	—
9	40	6.1	1.8	4.5	2.0	<.01	30	2.	2.0	<.1	<.1	<.02	<.02	—	—	—
10	102	13.8	20.	40.	.15	.15	225	2.	32.	.12	2.5	2.05	.12	—	—	—
11	106	10.7	20.	35.5	7.1	.13	208	1.	24.	.12	2.0	1.63	.12	—	—	—
12	57	5.4	2.9	7.0	2.6	<.01	76	.5	3.	<.10	<.1	<.02	<.02	—	—	—
13	56	8.7	6.6	6.8	2.5	<.01	96	.5	4.	<.10	<.1	.06	.02	—	—	—
14	74	13.	9.0	7.7	4.1	.01	114	1.3	4.	.10	<.1	<.02	<.02	—	—	—
15	163	155.	144.	125.	21.5	.51	1310	1.0	78.	.37	19.	4.50	.21	—	—	—
16	146	122.	105.	108.	18.	.42	1120	1.0	66.	.29	17.	.12	.24	—	—	—
17	137	100.	82.	84.	13.2	.33	775	<.5	48.	.50	9.	4.51	.23	—	—	—
18	139	105.	85.	87.	13.4	.32	700	1.0	50.	.39	16.5	5.65	.31	—	—	—
19	81	8.6	8.7	8.5	3.0	.05	68	8.	3.3	<.10	<.1	<.02	<.02	—	—	—
20	138	3.6	3.4	11.7	8.5	.02	80	1.0	4.	.24	<.1	1.38	.22	—	—	—
21	87	320.	142.	102.	4.5	.12	2050	1.	8.7	.37	2.1	—	—	—	—	—
22	55	41.	75.	25.5	3.7	.01	612	1.	9.8	<.10	.6	3.10	.77	—	—	—
23	58	1.5	35.	580.	172.	.24	—	7.	130.	.20	58.	<.02	<.02			
24	61	5.5	5.3	7.8	2.9	<.01	69	1.	6.2	<.01	<.1	—	—	—	—	—
25	56	5.5	5.2	7.2	2.6	<.01	60	1.	4.0	<.10	1.0	—	—	—	—	—
26	98	48.	171.	128.	10.8	.36	990	.5	277.	.14	22.	—	—	—	—	—
27	40	2.1	3.5	4.3	1.6	<.01	52	.5	3.7	<.10	<.1	—	—	—	—	—
28	34	3.3	3.8	9.5	4.7	.01	60	1.5	13.	.10	<.1	—	—	—	—	—
29	103	7.0	11.	17.5	4.8	.03	172	—	10.	.18	—	—	—	—	—	—
30	75	75.	4.0	5.5	10.	<.01	77	—	4.8	.12	.2	—	—	—	—	—
31	64	3.2	4.2	9.0	4.3	<.01	67	—	4.8	.11	.2	—	—	—	—	—
32	24	5.0	6.3	5.1	2.4	<.01	86	1.	3.1	<.10	<.1	2.10	.16	—	—	—
33	18	7.0	49.	1900.	195.	.77	4430	36.	3510.	.39	156.	<.02	<.02			
34	49	3.5	6.8	7.8	3.9	.02	69	5.	10.7	.1	<.1	—	<.02	—	—	—
35	120	42.	42.	43.	6.9	.13	447	.5	42.	.22	9.0	8.3	.84	—	—	—
36	64	4.5	15.	26.5	4.8	.66	146	4.	24.	<.10	.7	.02	<.02	—	—	—
37	36	2.1	3.1	6.	3.9	<.01	52	1.	7.8	<.10	<.1	.17	<.02	—	—	—
38	72	4.0	4.8	11.0	6.4	<.01	86	4.0	7.8	<.10	<.1	.15	<.02	—	—	—

Table 1. Chemical analyses of thermal water samples from Clear Lake Volcanic area

Date	Ref #	Sample #	Location	Latitude	Longitude	Flow	Temp.	f pH	l pH
20 Feb 75	39	LJ-75-11	Well, Honeycutt Ranch (line & bottle)	38°56.4'	122°45.7'	—	23	—	6.48
20 Feb 75	40	12	Well, Kip Neasham (line & bottle)	59.5'	43.7'	—	11	6	7.02
20 Feb 75	41	13	Well, Winter Ranch	55.4'	41.8'	—	7	6	6.32
20 Feb 75	42	14	Gordon Warm Springs	50.1'	43.6'	10	36	7	7.56
12 Jun 75	43	CLW 43	Alder Creek Spring	49.0'	46.1'	240	9.7	6	7.10
15 Jun 75	44	44	Gunning Creek Spring	47.8'	44.2'	120	11.1	6	7.60
22 Jun 75	45	45	Rush Creek Spring	52.8'	44.2'	70	13.3	6	7.90
19 Jun 76	46	46	Ida Clayton Spring	41.9'	38.0'	160	12.5	6	7.31
23 Jun 76	47	LC-76-1	Little Pinnacle Spring	39°09.5'	46.4'	1	11	6	7.98
23 Jun 76	48	2	Upper Bartlett	11.0'	42.0'	6	62	6.5	7.36
23 Jun 76	49	3	Main Bartlett	11.1'	42.1'	8	18.5	7	7.48
23 Jun 76	50	4	Upper Crabtree	17.4'	49.3'	0	36	5.8	6.10
23 Jun 76	51	5	Main Crabtree	17.5'	49.4'	8	41	7.3	7.80
23 Jun 76	52	6	Rice Fork Eel River	17.3'	49.1'	100	25	7	7.97
24 Jun 76	53	7	Gas Spring	11.3'	41.3'	.8	12	5.3	6.61
24 Jun 76	54	8	Newman Spring	11.9'	43.0'	18	34.5	7	7.50
24 Jun 76	55	9	Pseudo Complexion Spring	11.9'	30.3'	4	27	7	8.60
24 Jun 76	56	10	Complexion Spring	10.2'	31.2'	.5	19	12	11.79
24 Jun 76	57	11	Wilbur Springs	02.8'	25.3'	80	50	7.9	8.00
24 Jun 76	58	12	Clear Lake at Clear Lake Highlands	38°56.9'	32.3'	—	24	5.7	7.80
25 Jun 76	59	13	Grizzly Spring	39°00.1'	29.9'	4	20	6.8	7.84
25 Jun 76	60	14	Sulphur Spring	05.8'	31.4'	2	20	6.3	8.07
26 Jun 76	61	CLW 61	Turkey Run Mine	01.0'	26.4'	40	22	7.2	7.62
26 Jun 76	62	62	Jones' Fountain of Life Spring	02.0'	26.7'	60	61	7.5	8.75
26 Jun 76	63	63	Toby's Cold Well (line & bottle)	02.1'	25.6'	—	24.5	7.0	8.46
26 Jun 76	64	64	Hayfield Well (line & bottle)	01.1'	24.2'	—	14.5	6.5	8.47
26 Jun 76	65	65	Blanck's Spring	01.4'	26.0'	20	44.5	7.5	8.39
26 Jun 76	66	66	Eagle Rock Spring	04.1'	26.4'	16	15.5	7.0	8.54
26 Jun 76	67	LC-76-15	Chalk Mountain Spring	04.8'	35.0'	.4	24	6.6	7.58
26 Jun 76	68	16	Cross Spring	02.5'	35.4'	80	18	5.7	7.71
26 Jun 76	69	17	Unnamed Cold Spring	03.2'	35.3'	140	19	5.9	7.84
26 Jun 76	70	18	Quigley Soda Spring	03.2'	35.8'	4	28	7.6	7.72
27 Jun 76	71	19	Herman Pit, Sulfur Bank Mine	00.1'	39.8'	—	21	3.5	2.39
27 Jun 76	72	20	Green Pool, Sulfur Bank Mine	00.2'	39.4'	—	26	5.4	6.27
29 Jun 76	73	CLW 73	Pine Cone Spring	38°51.0'	41.6'	4	25.5	6.5	8.88
29 Jun 76	74	74	Spier's Spring	50.2'	39.2'	8	25.5	6.5	8.60
29 Jun 76	75	75	Bad Creek Spring	51.0'	40.0'	1	27	6.5	8.64
27 Jun 76	76	LC-76-21	Aetna Springs Well #1	39.0'	09.0'	24	34	5.7	8.57

Ref #	SiO_2	Ca	Mg	Na	K	Li	HCO_3	SO_4	Cl	F	B	Fe	Mn	Cd	Cu	Zn
39	81	6.5	7.0	11.8	8.3	<0.01	43	22.	4.8	< 0.10	<0.1	0.02	<0.02	--	--	--
40	47	3.5	3.6	10.5	3.9	<.01	60	1.	2.8	<.10	<.1	4.0	<.01	--	--	--
41	64	1.0	.5	10.0	6.3	<.01	95	.5	5.7	.11	<.1	1.1	.31	--	--	--
42	126	5.5	21.	54.	5.0	.15	275	.5	41.	<.10	1.3	.04	.03	--	--	--
43	26	1.7	.72	3.	1.5	<.01	15	1.	3.4	<.10	.12	--	--	--	--	--
44	39	4.7	2.1	4.5	1.9	<.01	40	1.	5.1	<.10	.25	--	--	--	--	--
45	43	6.9	5.7	5.	1.4	<.01	57	<.5	2.5	<.1	.16	--	--	--	--	--
46	37	2.1	.5	5.	2.5	<.01	29	1.	7.0	<.1	<.1	--	--	--	--	--
47	28	25.	10.8	5.	1.2	<.01	146	1.*	4.2	.15	<.1	2.	--	--	--	--
48	94	70.	410.	12.	1.4	.02	2420	1.*	8.4	.32	<.1	2.62	.25	<.01	<.01	.04
49	--	89.	470.	14.	1.4	.02	2750	9.	8.4	.39	<.1	.05	<.02	<.01	<.01	.01
50	52	70.	43.	18.	5.2	.015	104	285.	9.8	.34	.10	4.3	1.4	.01	<.01	.08
51	158	51.	198.	1850.	36.5	4.08	3850	1.*	1240.	.34	277.	.31	.06	<.01	<.01	.02
52	27	32.	9.8	10.	1.4	<.01	164	8.*	9.1	2.3	.33	--	--	--	--	--
53	34	65.	32.	17.	1.3	.01	167	120	4.0	.18	.1	.83	.60	<.01	<.01	.02
54	134	162.	520.	2500.	56.5	20.	4290	2.*	3310.	.18	386.	2.31	.12	--	--	--
55	44	5.4	152.	45.	1.8	0.01	786	1.*	115.	<1	<1	<.02	<.02	.01	<.01	.01
[1]56	32	.55	.30	13200.	460.	<0.01	384	27.	24100.	.34	31.	.50	.04	--	--	--
57	131	2.5	44.	9200.	445.	8.00	2040	390.	9810.	1.9	280.	.16	.02	.02	.03	.01
58	6	24.	16.	22.	3.	.02	232	1.*	30.	.15	1.55	<.02	<.02	<.01	<.01	.04
59	101	10.	132.	465.	11.9	.70	1225	21	310.	.34	325.	.04	.05	.01	<.01	.01
60	146	23.	12.9	322.	9.2	.28	72	26.	331.	.89	18.	<.02	<.02	<.01	<.01	.03
61	70	21.	770.	1064.	34.8	1.68	2300	2400.	1150.	5.2	34.5	.71	.25	.02	<.01	.04
62	84	2.3	30.	10000.	490.	8.40	4100	80.	11900.	3.2	271.	.41	.05	.04	.03	.02
63	23	25.	162.	200.	6.6	.28	972	170.	140.	.34	4.6	.06	.40	<.01	<.01	<.01
64	19	42.	210.	65.	1.6	.04	1060	200.	28.6	.39	.84	.10	.75	<.01	<.01	<.01
65	113	2.2	70.	7600.	409.	6.48	6800	215.	8050.	2.1	158.	.18	.02	.02	.02	.02
66	78	3.1	172.	222.	17.8	.78	1100	1.	262.	.18	11.0	<.02	<.02	<.01	<.01	.01
67	91	66.	495.	1600.	196.	5.20	3300	32.	2410.	.47	190.	.14	.05	<.01	.01	.01
68	60	17.	12.1	17.	3.8	.02	190	1.*	13.	.18	.1	.10	<.02	<.01	<.01	.01
69	60	16.4	11.2	15.	3.6	<.01	88	1.*	22.	.16	<.1	<.02	<.02	<.01	<.01	<.01
70	89	148.	92.	1040.	162.	4.8	2260	1.*	918.	.32	122.	.10	.22	.01	<.01	.08
[2]71	83	210.	195.	880.	21.6	3.7		4430.	205.	<.10	395.	86.	19.	.015	.08	1.70
72	29	22.	13.8	19.	6.5	.015	173	124.	7.	<.10	.3	.15	.60	<.01	<.01	.10
73	120	28.	210.	580.	13.5	.60	2500	1.*	146.	.32	21.5	.71	.80	<.01	<.01	.04
74	102	24.	290.	295.	16.	.89	1760	1.*	86.	.26	51.2	1.21	.20	<.01	<.01	.02
75	104	37.	450.	52.	3.5	.01	2380	18.	68.	.30	39.	.06	.25	<.01	<.01	.02
76	32	10.	9.8	207.	3.6	.06	610	8.	63.	1.12	2.88	.09	.03	<.01	<.01	.02

[1]No. 56 contained 384 ppm CO_3.

[2]No. 71 contained 19.6 meq/L H^+.

*SO_4 determined by $BaSO_4$ turbidity.

Table 1. Chemical analyses of thermal water samples
from Clear Lake Volcanic area

Date	Ref #	Sample #	Location	Latitude	Longitude	Flow	Temp.	f pH	l pH
27 Jun 76	77	LC-76-22	Aetna Springs Well #2	38°39.0'	122°09.0'	—	33	6.4	7.78
13 Jul 76	78	CLW 78	Magnola Mine Well	43.0'	82.5'	6	19	7.0	8.10
29 Jul 76	79	79	Moki Beach Spring	39°01.0'	48.1'	80	27	6.0	6.87
29 Jul 76	80	80	Hog Hollow Spring	01.4'	35.3'	40	30	5.8	7.26
3 Aug 76	81	81	Unnamed Soda Spring in Cache Formation	38°57.0'	34.3'	8	22	6.8	7.72
4 Aug 76	82	82	Reid's Well	58.2'	38.5'	—	25	5.9	7.23
4 Aug 76	83	83	Kono Tayee Well	39°02.4'	45.7'	—	21.5	5.9	7.97
9 Aug 76	84	84	Old Howard (or Howard Soda) Spring	38°51.4'	40.8'	20	28.5	6.2	7.42
9 Aug 76	85	85	Holm's Warm Well (line & bottle)	58.6'	40.5'	—	40	6.2	7.46
10 Aug 76	86	86	Zem-Zem Spring	45.3'	17.1'	2	21	5.5	8.23
30 Aug 76	87	87	Davis' Soda Spring	59.7'	38.5'	.5	23	6.8	7.46
31 Aug 76	88	88	Spring in Sweet Hollow Creek	39°01.1'	35.0'	—	22	6.1	7.47
3 Sep 76	89	89	Salt Lick Spring	06.0'	36.4'	24	22	5.9	7.96
7 Sep 76	90	90	Hildebrande Spring	38°55.5'	46.2'	8	25	5.3	7.29
8 Sep 76	91	91	Anderson Spring	46.5'	42.4'	2	42	5.6	7.45
16 Sep 76	92	92	Well in Benmore Canyon (line & bottle)	39°01.5'	34.2'	—	21	6.8	7.75
22 Sep 76	93	93	Spring N. of Cache Creek; Magnesite Spr.	04.4'	34.0'	20	22	—	7.52
23 Sep 76	94	94	Garner Sulfur Spring	04.7'	41.9'	0.5	22	6.7	8.00
23 Sep 76	95	95	Garner's Salt Lick	04.6'	42.2'	1	23	7.0	8.01
23 Sep 76	96	96	Garner Cold Spring	05.0'	41.8'	30	16	6.2	7.74
25 Sep 76	97	97	Capped Geyser, Calistoga Hot Spring	38°36.0'	36.0'	80	100	8.4	8.93
30 Sep 76	98	98	Hiway 20 Sulfur Spring	39°01.0'	29.4'	12	23	6.7	7.57
30 Sep 76	99	99	Elgin Mine	03.5'	28.5'	20	54	7.6	7.93
30 Sep 76	100	100	Hough Spring	09.7'	36.8'	1	16	6.0	7.37
1 Oct 76	101	101	Allen Spring	09.6'	39.9'	20	18	6.1	7.61
1 Oct 76	102	102	Royal Spring	13.8'	44.7'	8	18	5.9	7.80
19 Oct 76	103	103	Riviera Beach Spring	38°57.5'	42.2'	8	34	—	7.55
18 Feb 77	104	104	Little Geysers Hot Spring	46.0'	44.9'	2	99	5.5	6.71
18 Feb 77	105	105	Honeycutt #2 (line & bottle)	56.4'	43.8'	—	49	5.7	6.96
18 Feb 77	106	106	Bennett's Well	56.5'	46.1'	—	8	5.4	6.89
18 Feb 77	107	107	Rouse's Well	56.5'	46.4'	—	6	6.2	7.17
18 Feb 77	108	108	Fitt's Spring	39°00.0'	40.2'	—	16	6.1	8.09
18 Feb 77	109	109	Sulphur Bank Carbonated well	00.0'	40.3'	—	17	5.7	6.77
5 Feb 77	110	LJ-77-1	Siegler Spring, Lithia	38°52.5'	47.5'	4	25	5.9	7.76
5 Feb 77	111	2	Siegler Spring, Hot Sulfur	52.5'	47.5'	88	53.3	6.5	7.77
5 Feb 77	112	3	Siegler Spring, Iron	52.5'	47.5'	24	40.3	5.9	7.41
5 Feb 77	113	4	Siegler Spring, The Geyser	52.5'	47.5'	—	43	5.9	7.28

Ref #	SiO_2	Ca	Mg	Na	K	Li	HCO_3	SO_4	Cl	F	B	Fe	Mn	Cd	Cu	Zn
77	87	18.4	91.	705.	12.	0.38	2000	1.*	287.	1.5	80.6	0.21	0.12	<0.01	<0.01	<0.01
78	88	22.	33.	40.	2.	.02	324	1.*	9.4	.15	34.2	.18	.20	<.01	<.01	.04
79	129.	79.	104.	90.	13.	.41	936	1.*	58.6	.11	13.5	19.	.40	<.01	<.01	.10
80	136	106.	46.	200.	15.2	.48	862	4.	174.	.33	14.5	4.00	.26	<.01	<.01	<.01
81	98	58.	93.	130.	70.	.24	966	1.*	27.	.21	34.5	.25	.04	<.01	<.01	<.01
82	93	163.	61.	117.	6.6	.13	884	4.	136.	.32	115.	19.	.42	<.01	<.01	.015
83	55	66.	28.	24.	1.6	.01	306	31.	7.3	.21	5.3	21.	.43	<.01	<.01	.05
84	129	52.	320.	166.	20.	.94	1990	2.	187.	.26	125.	1.4	.23	<.01	<.01	<.01
85	124	175.	130.	110.	14.8	.50	1440	8.	74.	.21	152.	6.4	.15	<.01	<.01	.08
86	25	34.	25.	252.	2.0	.01	564	4.	157.	.68	8.9	.04	<.02	<.01	<.01	.01
87	86	210.	51.	30.	3.5	.05	644	38.	4.	.16	<.1	6.90	2.43	<.01	<.01	.015
88	96	155.	78.	580.	47.5	1.8	1170	175.	561.	.10	4.9	1.5	.40	<.01	<.01	.015
89	100	108.	390.	367.	12.3	.67	2280	4.	419.	.16	4.8	3.0	.10	<.01	<.01	.02
90	91	5.0	4.0	12.	6.	.02	76	2.	8.	.11	<.1	.03	.17	<.01	<.01	.03
91	89	120	40.	50.	11.	.17	223	635.	4.	.18	<.1	.65	4.83	<.01	<.01	.01
92	28	100.	360.	2860.	54.	3.4	3050	400	4050.	.71	7.23	4.35	.21	.03	<.01	.01
93	89	183.	735.	950.	47.	3.1	2890	265	1920.	.11	130.	1.3	.20	<.01	<.01	.01
94	23	70.	17.	64.	2.5	.04	420	36.	9.	.37	.42	<.04	.19	<.01	<.01	<.01
95	22	30.	11.	750.	8.0	.30	1610	9.	242.	3.1	225.	<.04	.04	<.01	<.01	<.01
96	29	55.	12.	15.	1.2	.01	228	38.	5.	.55	.1	—	—	—	—	—
97	150	25.	—	193.	8.7	1.90	184	13.	206.	.01	1.2	<.04	<.02	<.01	<.01	.01
98	24	3.5	5.0	1550.	34.	.53	498	7.	2080.	6.7	4.15	.15	.05	.01	<.01	.02
99	152	3.6	26.	9950.	580.	12.5	7300	105.	12100.	3.4	220.	.3	1.88	.04	.02	.03
100	75	385.	43.	98.	7.3	.60	831	3.	5.	.9	.27	7.6	.43	<.01	.01	.06
101	100	130.	360.	292.	8.6	2.37	2000	12.	481.	<.1	4.10	14.9	.13	<.01	.01	.03
102	94	58.	430.	332.	5.6	.23	2780	3.	300.	.18	2.8	5.5	.20	<.01	<.01	.02
103	139	100.	83.	90.	11.	.24	923	38.	31.	.20	1.3	6.0	.20	<.01	<.01	.02
104	57	1.3	5.0	20.	.5	<.01	11	97.	3.	<.1	.1	.4	.2	<.01	.01	.04
105	183	20.	19.	115.	29.5	.80	394	41.	101.	.16	1.63	16.7	.5	<.01	±.01	.02
106	183	25.	24.	120.	30.	.77	435	50.	96.	.18	1.8	1.8	.84	<.01	<.01	.02
107	136	25.	33.	74.	17.6	.43	401	5.	62.	.25	.8	.5	.50	<.01	<.01	.01
108	25	80.	35.	—	—	—		22.	12.	<.10	<.10	—	—	—	—	—
109	45	80.	91.	50.	3.0	.03	862	10.	19.	.18	.5	—	.92	<.01	.02	1.00
110	125	20.	152.	40.	4.5	.05	941	2.	29.	<.10	.23	2.10	.08	.01	.03	.02
111	174	35.	230.	175.	21.	.88	1340	1.	289.	<.10	2.0	.15	.03	.01	.03	.02
112	151	25.	139.	203.	38.	1.30	982	1.	254.	.11	1.2	1.0	.10	<.01	.03	.02
113	159	20.	128.	215.	35.	1.56	831	2.	294	.25	1.5	.8	.1	<.01	.02	.02

*SO_4 determined by $BaSO_4$ turbidity.