STATE OF WASHINGTON
DEPARTMENT OF NATURAL RESOURCES
BRIAN J. BOYLE, Commissioner of Public Lands
ART STEARNS, Department Supervisor

DIVISION OF GEOLOGY AND EARTH RESOURCES
Raymond Lasmanis, State Geologist

CHEMICAL ANALYSES FOR THERMAL AND MINERAL SPRINGS EXAMINED IN 1982-1983

by

Michael A. Korosec

Washington Department of Natural Resources
Division of Geology and Earth Resources
Olympia, WA 98504

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Introduction

During late 1982 and early 1983, six water samples from three different spring systems were collected and analyzed for major element concentrations. This report presents the results of those analyses, along with predicted reservoir temperatures using various geothermometers. In addition, a table of chemical analyses from the U.S. Geological Survey for Washington springs not previously reported in state geothermal reports is included. The tables in this report, together with the tables in Chapter 3 of Open File Report 83-7 (Korosec and others, 1983), present all available major element geochemistry for Washington's thermal and mineral springs determined by the Division and the U.S. Geological Survey.

Methods

At each spring or well, three water samples were collected: unfiltered, filtered, and filtered-acidified waters. Filtered samples were collected by taking up water in a 50 ml plastic syringe and passing it through a 0.4 micron Nuclepore filter, held in a 47 mm Swin-Lok membrane holder. One liter collapsible plastic containers (Cubi-tainers) were used to carry the water. The acidified samples were treated by adding about 3 ml of concentrated nitric acid to about 1 liter of filtered water, using a plastic syringe.

In the field, temperature, pH, conductivity, and alkalinity were measured directly from the spring or well. Temperatures were measured with a portable digital Markson 701, which was found to be accurate to 0.05°C over the range of 5° to about 90°C. Conductivity was measured with a Hach Mini Conductivity Meter model 17250, with built-in temperature compensator. The pH was determined using a combination of ColorpHast Indicator Sticks (+/- 0.2 pH units), portable VWR Mini-pH meter (+/- 0.05 pH units), and/or portable Cole-Palmer Digi-Sense pH Meter (+/- 0.02pH units).

Where wide discrepancies existed between different techniques, the pH was remeasured in the lab as soon as possible (within 2 or 3 days) with an Orion 901 Specific Ion Meter. Alkalinity was determined using a portable kit from Hach with a digital titrator, titrating to color-determined end points (Phenolphthalein and Brom Cresol Green-Methyl Red indicators).

At the Division of Geology and Earth Resources water chemistry lab, the following methods were used:

Cl^-, Br^-, F^-	Specific Ion Electrodes and Orion Specific Ion Meter 901
SiO_2	Molybdosilicate colorimetric technique with sulfite reduction: Bausch and Lomb Spectronic 710
SO_4^{-2}	Turbimetric using Hach Sulfa IV powder pillows and Bausch and Lomb Spectronic 710 (at 450 nm).
Na, K, Ca, Li	Varian AA575 ABQ Atomic Absorption Spectrophotometer using air-acetylene flame.
Ca, Mg, Fe	Varian AA575 ABQ Atomic Absorption Spectrophotometer using nitrous oxide-acetylene flame.

Results

Table 1 presents the results of geochemical analyses for the thermal and mineral springs determined by the Division. Table 2 consists of geochemical analyses determined by the U.S. Geological Survey in Menlo Park that were not listed in earlier Division publications. When added to the tables in Chapter 3 of Division Open File Report 83-7 (Korosec and others, 1983), these tables present all geochemical data for thermal and mineral springs analyzed by the Division and U.S. Geological Survey through the end of 1983.

Table 1 Explanation

The table of chemical analyses includes conductivity (Cond), pH, temperature (Temp), chloride (Cl), sulfate (SO_4), alkalinity (Alk), silica (SiO_2), sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), lithium (Li), flouride (F), bromide (Br), and iron (Fe). All analyses were conducted in the Division of Geology and Earth Resources' geochemistry laboratory.

(1) - Temperature is °C.

(2) - Conductivity is measured in umhos/cm.

(3) - All other analyses are listed as parts per million (ppm), approximately equivalent to milligrams per liter (mg/l).

(4) - "LD" means less than detection limit. The detection limits for the various chemical species are listed in the last row of the table.

(5) - Dashes indicate that analyses were not performed.

(6) - For alkalinity, the Phenolphthalein (P), Brom Cresol Green-Methyl Red (B), and total alkalinity (T) are listed separately and are represented as mg/l $CaCO_3$.

Table 1 - Geochemical data for thermal and mineral springs analyzed by the Division of Geology and Earth Resources, 1982-1983.*

Spring I.D. Code	T	Cond.	pH	Cl	Alk	SO_4	SiO_2	Na	K	Ca	Mg	Li	F	B	Fe
LRA-1	9.2	2600	6.5	224	1200	-	94	313	1.1	233	51	0.2	.05	2.08	12
BKA-2	38.3	730	8.3	111	106	95	105	146	8.4	5.2	LD	0.3	3.0	0.91	LD
BKC-2	24.0	220	6.8	41	32	-	32	37	2.9	5.8	LD	8.9	0.34	0.36	LD
GLA-1	28.0	17,000	6.9	4250	2050	170	107	2640	188	318	90	8.1	1.3	24.4	1
GLB-1	25.3	16,000	7.0	3800	-	160	103	2360	162	300	86	LD	1.3	21.9	15
GLC-1	7.4	345	5.8	60	-	-	16	33	1.8	15	2.6	0.1	0.11	0.43	1
Detection Limit	-	-		1	1	1	1	1	0.1	.1	0.1	0.1	.05	0.1	0.5

*See the explanation for Table 1 on the preceding page.

Spring Identification Code	Spring Name	Location T.	Location R.	Location 1/4 of 1/4 of Sec.
LRA-1	Little Rattlesnake Soda Springs	15N	14E	- - 34
BKA-2	Baker Hot Springs (Main)	38N	9E	NE of NW 35
BKC-2	Baker Hot Springs	38N	9E	NE of NW 35
GLA-1	Garland Mineral Springs (Main)	28N	11E	NW of NE 25
GLB-1	Garland Mineral Springs	28N	11E	NW of NE 25
GLC-1	Garland Mineral Springs	28N	11E	NW of NE 25

Table 2. Geochemical data for thermal and mineral springs analyzed by the U.S. Geological Survey, Menlo Park.*

Spring Name	T	pH	Cl	Alk	SO_4	SiO_2	Na	K	Ca	Mg	Li	F	B	Fe
Wenatchee Soda Springs	7	6.08	805	1715	1	39	660	39	320	54	-	0.30	18	-
Wenatchee Ford Soda Springs	9	6.48	2000	3935	265	105	2120	230	400	73	-	.82	45	-
Olympic Hot Springs	48.5	9.50	11	175	5	66	72	1.1	.9	LD	.04	1.2	.82	LD
Sol Duc Hot Springs	51	9.46	21	181	7	60	80	1.0	.8	LD	.05	1.7	1.4	.04
Goldmeyer Hot Springs	50	8.48	130	61	40	56	125	3.0	6.3	.04	-	.88	LD	-
Lester Hot Springs	46.5	9.19	115	61	19	61	105	2.0	5.3	.03	-	1.6	LD	-
Scenic Hot Springs	47	9.14	22	75	13	44	49	.64	2.1	.02	-	.72	LD	-
St. Martin's Hot Spring	48	8.54	690	19	16	48	360	6.4	76	.30	.28	.74	2.9	LD
Bonneville Hot Spring	36	9.54	180	39	80	46	145	.9	31	.03	-	.66	2.0	-
Gamma Hot Sp.	65	6.13	755	398	30	141	510	80	71	2.8	2.8	1.4	9.0	-
Garland Mineral	29	6.46	3600	2600	160	105	2500	200	390	87	9.4	1.6	64	5.4
Sulphur Hot Springs	37	9.35	51	154	21	76	100	1.9	1.2	LD	.14	3.9	.55	LD
Baker Hot Springs	44	8.56	110	165	87	103	170	9.6	5.5	.18	.36	3.2	2.7	LD
Detection Limit	-	-	-	-	-	-	-	-	-	0.05	-	-	1	0.02

* See the explanation for Table 1. See Korosec and others (1983) for locations.

Discussion

Table 3 summarizes the results of various geothermometers applied to the geochemical values presented in tables 1 and 2 in order to estimate reservoir equilibrium temperatures. Many assumptions are made when applying geothermometers. Any reader unfamiliar with the assumptions and limitations of these methods should consult the references before relying on the results. Formulas used to calculate the geothermometer values from chemical concentrations are as follows:

Silica - Quartz $$T_Q = \frac{1309}{5.19 - \log (SiO_2)} - 273$$

Chalcedony $$T_C = \frac{1032}{4.69 - \log (SiO_2)} - 273$$

Na/Li $$T_{Li} = \frac{1000}{\log (Na/Li) - 0.14} - 273$$

Na-K-Ca $$T_{Cat} = \frac{1647}{\log (Na/K \times 1.7) + 1/3 \log (115\sqrt{Ca/Na} + 2.24)} - 273$$

Magnesium Correction $$T_{Mgc} = 10.66 - 4.7415(R) + 325.87(\log R)^2 - 1.032 \times 10^5 (\log R)^2/T - 1.968 \times 10^7(\log R)^2/T^2 + 1.605 \times 10^7(\log R)^3/T^2$$

Where T = Temperature in ^oK from Na-K-Ca geothermometer ($T_{Cat} + 273^o$), and

$$R = \frac{3134(Mg)}{9.74(K) + 19.01(Ca) + 31.34(Mg)}$$

Na-K-Ca-Mg $$T_{Mg} = T_{Cat} - T_{Mgc}$$

All temperatures are in degrees Celsius and cation concentrations are in parts per million. References for these geothermometers are listed below.

Silica-Quartz (T_Q)	-	Fournier and Potter, 1979
Chalcedony (T_C)	-	Fournier and Potter, 1979
Na/Li (T_{Li})	-	Fouillac and Michard, 1981
Na-K-Ca (T_{Cat})	-	Fournier and Truesdell, 1973
Mg correction (T_{Mgc})	-	Fournier and Potter, 1979

Table 3. Predicted reservoir equilibrium temperatures for springs listed in Tables 1 & 2. (See text for explanation).

Spring Name	I.D. Code	Temp.(°C)	Na-K-Ca	Mg-Corr.	Mg-Corr. Na-K-Ca	Na/Li	SiO_2 Quartz	SiO_2 Chalc.
Little Rattlesnake Soda Spring	LRA-1	6.5	45.3	0	45.3	54.4	133.8	106.7
Baker Hot Sp.	BKA-2	38.3	161.0	0	161.0	119.6	140.0	113.5
Baker Hot Sp.	BKC-2	24.0	152.8	0	152.8	1815.5	82.1	50.9
Garland Mineral Sp.	GLA-1	28.0	186.9	120.5	66.3	148.4	141.0	114.7
Garland Mineral Sp.	GLB-1	25.3	183.3	119.5	63.8	-	138.9	112.3
Garland Mineral Sp.	GLC-1	7.4	127.7	48.1	79.6	147.3	55.3	22.9
Wenatchee Soda Sp.		7.0	153.3	71.7	81.6	-	90.6	59.9
Wenatchee Soda Sp.		9.0	204.8	105.8	99.1	-	139.9	113.5
Olympic Hot Sp.		48.5	105.9	0	105.9	-	115.2	86.4
Sol Duc Hot Sp.		51.0	100.5	0	100.5	-	110.5	81.3
Goldmeyer Hot Sp.		50.0	118.1	0	118.1	-	107.2	77.7
Lester Hot Sp.		46.5	107.9	0	107.9	-	111.3	82.1
Scenic Hot Sp.		47.0	90.4	0	90.4	-	95.9	65.6
St. Martin's Hot Sp.		48.0	104.0	0	104.0	63.8	99.9	69.8
Bonneville Hot Sp.		36.0	63.6	0	63.6	-	98.0	67.8
Gamma Hot Sp.		65.0	216.0	18.1	197.9	198.6	157.3	133.0
Garland Mineral Sp.		29.0	190.5	110.2	80.3	164.7	139.9	113.5
Sulphur Hot Sp.		37.0	116.8	0	116.8	95.5	122.4	94.2
Baker Hot Sp.		44.0	162.1	0	162.1	121.6	138.9	112.3

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