PRELIMINARY PLASMA SPECTROMETRIC ANALYSES FOR SELECTED ELEMENTS IN SOME GEOTHERMAL WATERS FROM CERRO PRIETO, MEXICO

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CONVERSION FACTORS AND ABBREVIATIONS

The metric system of units is used in this report. For readers who prefer inch-pound units, the conversion factors for the terms used in this report are listed below.

Multiply	By	To obtain
µm (micrometer)	0.00003937	in (inch)
mL (milliliter)	0.03382	fl oz (fluid oz)
L (liter)	0.2642	gal (gallon)
g (gram)	0.03520	oz (ounce)

Explanation of abbreviations:

N (Normal, equivalents per liter)
mg L^{-1} or mg/L (milligrams per liter)
nm (nanometer)
µg L^{-1} or µg/L (micrograms per liter)

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ABSTRACT

As part of a cooperative study with the Geologic Division of the U.S. Geological Survey, water samples collected from geothermal power production wells at Cerro Prieto, Mexico, were analyzed for selected elements by d.c. argon plasma emission spectroscopy. Spectral interferences due to the presence of high concentrations of Ca, Si, Na and K in these waters affected the apparent concentration values obtained. These effects were evaluated and correction techniques were developed and applied to the analytical values. Precipitates present in the samples at the time of analysis adversely affected the accuracy, precision and interpretability of the data.

INTRODUCTION

The Cerro Prieto geothermal power production field near Mexicali, Baja California, Mexico, utilizes hot water-steam mixtures coming from depth at various temperatures as its energy source. The hot water must be separated from the steam as completely as possible for the most efficient plant operation. The resulting hot, corrosive brines were analyzed to better formulate strategies for disposal or reinjection of the brines collected from the separators.

EXPERIMENTAL

Sample Collection and Preservation

A two-phase (water and steam) sample was drawn off the brine effluent line of the separator under pressure through a coiled condenser tube submerged in an ice/water mixture. The sample was passed through a 0.45-μm filter membrane and collected in a 250-mL polyethylene bottle. A sample collected using this technique is herinafter referred to as a "condensed" sample. The sample was acidified by addition of 5 mL of concentrated (∿15.7 $\underline{N}$) nitric acid.

A subset of samples was collected by allowing the pressurized brine to flash through the brine sampling valve of the separator into a 1-L container, where a significant amount of steam was allowed to escape. These are subsequently referred to as "flashed" samples. In this case, cooling was accomplished mainly by evaporation. An aliquot of the water remaining in the 1-L container was transferred to a 250-mL bottle, unfiltered, but acidified as above.

Analysis

The samples were analyzed using a Spectraspan III d.c. argon plasma emission spectrometer having a Spectrajet III torch (Spectrametrics, Inc., Andover, Mass.). A set of working standards for each of two groups of elements was prepared by making 1 $\underline{N}$ HNO_3 dilutions of the respective multielement standard solution containing 17 elements in 1 $\underline{N}$ HNO_3. The 1 $\underline{N}$ HNO_3 was used as a blank and was prepared by diluting Ultrex HNO_3 (J. T. Baker, Phillipsburg, N. J.) with deionized distilled water. The multielement solution was composed of alkali and alkaline earth salts of purity 99.99 percent or better and other metal salts, acids, and commercially-prepared solutions of purity 99.999 percent or better. The readout and photomultiplier modules were optimized, according to the manufacturer's instructions, with respect to voltage and gain compatibility to achieve the best combination of sensitivity and stability.

Standard and sample solutions were analyzed as though all were samples, with standards interspersed among samples. In addition to the blank and the undiluted standard, dilutions containing 1/2, 1/4, and 1/10 of the concentration of each element in the original standard were analyzed for construction of standard curves.

A lithium (Li), or sodium (Na) solution was mixed at approximately a 1:11 ratio with the sample just prior to nebulization such that an effective concentration of 2270 mg L^{-1} of Li was realized in the sample (Ball and others, 1978, p. 68). The Li or Na increases thermal contact between the plasma and the measuring zone, located directly below the plasma (Johnson and others, 1979, p. 204). When determining Li, Na was used as a thermal buffer.

Two groups of elements were determined using interchangeable cassettes. Cassette 1 contained slits designed to pass to the photomultiplier tubes the emission lines of the following elements: B, Mn, Cu, Zn, Si, Zr, Be, Mn, Sr, Ti, Ca, Fe, Ba, K, Na, Rb, and Al. The elements determined using cassette 2 were: As, Se, Bi, Zn, Cd, Sb, Cu, Ni, Hg, Mo, Co, Cr, Fe, V, Tl, Li, and Pb. Analytical wavelengths are listed in table 1. The Ag channel (cassette 1) and the Sn channel (cassette 2) were not used because a stable multielement solution did not result from a mixture containing these elements. Neither the background nor the internal standard channels (channels 3 and 6, respectively, on cassette 1, and channels 17 and 1, respectively, on cassette 2) were used with either cassette. They were found by prior experiment to make inaccurate concentration adjustments for some elements. Elements to be adjusted could not be selected individually, as is the case when using the newer Model IIIA or IIIB microprocessors.

Table 1. - Analytical wavelengths for the elements

Cassette 1			Cassette 2		
Channel	Element	Wavelength, nm	Channel	Element	Wavelength, nm
1	B	249.773	1	Not used	265.118
2	Mn	257.610	2	As	193.696
3	Not used	237.1	3	Se	196.026
4	Cu	324.754	4	Bi	223.061
5	Zn	213.856	5	Zn	213.856
6	Not used	265.118	6	Cd	214.438
7	Si	251.611	7	Sb	206.833
8	Zr	339.198	8	Cu	324.754
9	Be	313.061	9	Sn not used	283.999
10	Mg	279.553	10	Ni	341.476
11	Ag not used	328.068	11	Hg	253.652
12	Sr	421.552	12	Mo	379.825
13	Ti	334.941	13	Co	345.350
14	Ca	393.366	14	Cr	425.435
15	Fe	371.994	15	Fe	371.994
16	Ba	455.403	16	V	437.924
17	K	766.490	17	Not used	300.6
18	Na	589.592	18	Ti	535.046
19	Rb	780.023	19	Li	670.784
20	Al	396.152	20	Pb	405.783

Data Collection and Processing

The emission data were collected on a flexible disk storage device and simultaneously displayed on a typewriter terminal. Each sample and approximately 1/10, 1/100, and 1/500 gravimetric dilutions of it were analyzed in order to bring all constituents within the measuring range of the instrument. The machine-readable data were subsequently converted to concentration values, which were stored on a second flexible disk storage medium. When data for all elements were available, sample concentrations were corrected for interelement spectral effects, which are due to the presence of concomitant major elements and are observed when measuring concentrations of minor elements. This correction required collection of apparent concentration data for a representative concentration range of suspected interferent in the absence of analyte at the appropriate wavelengths. The resulting apparent analyte concentration values were fitted to a series of various types of linear and exponential simple regression equations, and the selected fit parameters were recorded. The concentration of the concomitant element in an unknown sample was combined with the fit parameters to yield a numerical value for its interference which was subtracted from the apparent concentration of the analyte. The resulting data were stored in a master data set, from which tabular data were produced (tables 2 and 3).

Table 2. - Corrected concentrations of elements in condensed samples

[Values are rounded to three significant digits; mg/L=milligrams per liter, µg/L=micrograms per liter]

WELL	YEAR	LOG NO	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	Si mg/L	Li mg/L	B mg/L	Sr mg/L	Ba µg/L	Rb mg/L	Cass 1 Fe µg/L	Cass 2 Fe µg/L
M-5	1977	78WA143	7,280	1,290	355	0.54	338	20.7	15.1	0.83	430	15.6	1,980	2,500
M-5	1978	78WA116	7,010	1,620	412	0.46	376	15.7	16.0	0.80	559	15.5	710	592
M-8	1977	78WA140	5,640	1,120	285	0.31	346	16.4	12.2	0.65	765	11.2	633	648
M-8	1978	78WA117	6,520	1,270	317	<0.02	322	17.5	11.5	0.58	944	12.4	1,100	1,100
M-11	1977	78WA132	8,090	1,680	465	0.54	364	27.3	16.7	8.82	939	18.0	390	326
M-11	1978	78WA145	7,450	1,690	455	0.49	359	22.2	17.1	7.64	780	16.3	282	376
M-19A	1977	78WA141	7,550	1,680	444	0.44	386	23.3	15.6	8.74	604	17.5	437	462
M-19A	1978	78WA118	7,550	1,660	439	0.51	376	16.1	14.5	8.59	640	17.3	514	378
M-21A	1977	78WA137	7,450	1,590	490	0.50	365	20.6	16.5	7.33	584	17.2	607	707
M-26	1977	78WA133	6,090	1,020	416	0.73	331	13.9	10.3	0.61	967	15.0	645	650
M-26	1978	78WA121	6,150	1,040	402	0.62	344	14.3	9.82	5.55	881	15.2	767	718
M-27	1977	78WA136	5,130	1,080	270	<0.02	363	13.7	10.6	0.48	284	10.5	315	306
M-27	1978	78WA142	4,050	773	201	<0.02	282	11.1	8.13	0.37	220	8.50	525	524
M-29	1977	78WA134	6,210	1,050	473	1.45	271	19.7	13.9	14.2	900	14.6	649	714
M-29	1978	78WA124	5,740	1,060	455	1.29	290	18.6	13.1	13.6	952	16.1	467	278
M-30	1977	78WA135	7,440	1,630	520	1.05	373	22.0	14.7	10.2	445	17.9	1,420	1,690
M-30	1978	78WA125	7,500	1,570	506	0.99	355	20.0	14.1	9.55	491	18.5	981	972
M-31	1977	78WA138	5,900	1,230	366	0.45	328	17.8	11.8	0.73	513	13.1	322	276
M-31	1978	78WA127	6,680	1,200	351	<0.02	343	16.0	12.0	7.56	588	14.7	450	243
M-35	1977	78WA139	6,740	1,690	387	0.35	404	21.8	14.6	0.74	579	14.9	965	1,140
M-35	1978	78WA128	7,700	1,610	368	0.21	418	18.8	14.4	0.72	557	16.6	6,940	7,030
M-42	1977	78WA144	6,160	1,340	388	0.43	378	16.9	15.3	0.82	572	12.8	249	283
R-98	1978	78WA130	169	4.85	154	45.4	10.8	0.00	0.22	0.18	104	1.71	447	342
244-C	1978	78WA131	276	2.90	40.1	3.86	17.2	0.00	0.15	0.29	55.3	0.56	73.4	49.2

Table 2. - Corrected concentrations of elements in condensed samples—Continued

[Values are rounded to three significant digits; mg/L=milligrams per liter, µg/L=micrograms per liter]

WELL	YEAR	LOG NO	Mn µg/L	Cass 1 Zn µg/L	Cass 2 Zn µg/L	Mo µg/L	Co µg/L	Cr µg/L	Pb µg/L	Ni µg/L	V µg/L	Cd µg/L	Cass 1 Cu µg/L	Cass 2 Cu µg/L
M-5	1977	78WA143	860	126	98.2	137	42.1	41.2	693	31.5	93.9	<10.0	<10.0	<3.00
M-5	1978	78WA116	801	93.1	10.8	149	26.1	17.8	739	25.1	78.8	<10.0	<10.0	<3.00
M-8	1977	78WA140	348	50.4	<6.00	116	41.1	33.8	554	29.6	75.4	<10.0	<10.0	<3.00
M-8	1978	78WA117	435	65.2	<6.00	144	21.6	16.3	618	19.7	65.7	<10.0	<10.0	<3.00
M-11	1977	78WA132	1,020	128	42.0	127	39.0	36.3	679	32.5	93.3	<10.0	<10.0	<3.00
M-11	1978	78WA145	659	140	65.7	117	47.1	42.8	606	35.4	90.8	<10.0	<10.0	<3.00
M-19A	1977	78WA141	1,770	59.7	<6.00	141	62.4	57.7	741	45.1	105	12.3	<10.0	<3.00
M-19A	1978	78WA118	1,510	202	123	160	47.2	38.2	811	34.7	106	13.3	<10.0	<3.00
M-21A	1977	78WA137	446	57.4	<6.00	160	58.3	56.3	684	40.2	99.8	18.0	<10.0	<3.00
M-26	1977	78WA133	326	102	15.9	125	37.0	33.2	584	24.8	83.0	<10.0	<10.0	<3.00
M-26	1978	78WA121	320	35.7	<6.00	136	61.7	54.9	666	36.8	81.7	30.4	<10.0	<3.00
M-27	1977	78WA136	227	56.6	<6.00	122	54.2	49.5	532	32.5	83.3	15.2	<10.0	<3.00
M-27	1978	78WA142	253	50.5	13.1	104	32.9	26.7	437	23.9	58.7	<10.0	<10.0	<3.00
M-29	1977	78WA134	520	111	58.4	120	40.0	43.5	711	30.6	98.9	<10.0	<10.0	<3.00
M-29	1978	78WA124	471	48.2	8.47	147	79.5	67.1	927	49.6	123	20.3	<10.0	<3.00
M-30	1977	78WA135	2,120	137	16.0	135	62.4	60.6	716	40.2	113	<10.0	<10.0	<3.00
M-30	1978	78WA125	2,430	110	<6.00	155	75.0	61.1	843	51.7	123	13.3	<10.0	<3.00
M-31	1977	78WA138	142	335	270	123	51.2	46.6	609	33.5	87.0	21.8	<10.0	<3.00
M-31	1978	78WA127	192	41.6	<6.00	146	59.5	43.7	706	38.9	102	10.2	<10.0	<3.00
M-35	1977	78WA139	547	66.2	18.6	137	62.4	54.7	673	42.2	100	15.2	<10.0	<3.00
M-35	1978	78WA128	892	22.5	<6.00	163	65.0	45.3	748	46.4	120	<10.0	<10.0	<3.00
M-42	1977	78WA144	432	31.5	<6.00	104	39.0	33.6	560	<4.00	81.6	<10.0	<10.0	<3.00
R-98	1978	78WA130	359	<20.0	33.4	93.9	36.1	27.9	318	20.8	55.3	182	<10.0	<3.00
244-C	1978	78WA131	26.0	31.0	<6.00	10.1	<5.00	<3.00	<15.0	<4.00	<5.00	<10.0	<10.0	<3.00

WELL	YEAR	LOG NO	Tl µg/L	As mg/L	Se µg/L	Sb µg/L	Bi µg/L	Hg µg/L	Zr µg/L	Be µg/L	Ti µg/L	Al µg/L
M-5	1977	78WA143	113	0.96	335	449	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-5	1978	78WA116	92.2	1.05	201	439	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-8	1977	78WA140	102	<0.36	439	574	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-8	1978	78WA117	60.2	<0.36	249	316	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-11	1977	78WA132	138	1.30	<200	249	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-11	1978	78WA145	107	1.22	392	730	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-19A	1977	78WA141	143	1.38	502	793	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-19A	1978	78WA118	117	1.03	321	389	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-21A	1977	78WA137	145	3.40	488	658	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-26	1977	78WA133	118	3.14	<200	522	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-26	1978	78WA121	102	2.93	485	<200	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-27	1977	78WA136	112	1.04	540	574	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-27	1978	78WA142	73.2	0.76	367	484	<80.0	<10.0	<20.0	<2.00	<10.0	98.2
M-29	1977	78WA134	132	0.89	279	595	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-29	1978	78WA124	165	0.53	294	<200	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-30	1977	78WA135	165	1.03	469	793	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-30	1978	78WA125	157	0.94	<200	445	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-31	1977	78WA138	118	1.12	467	678	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-31	1978	78WA127	118	0.99	215	649	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-35	1977	78WA139	143	0.96	481	824	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-35	1978	78WA128	137	0.97	<200	723	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-42	1977	78WA144	99.1	0.99	275	400	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
R-98	1978	78WA130	67.2	<0.36	<200	640	<80.0	13.6	<20.0	<2.00	<10.0	<10.0
244-C	1978	78WA131	<7.00	<0.36	<200	<200	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0

Table 3. - Corrected concentrations of elements in flashed samples

[Values are rounded to three significant digits;
mg/L=milligrams per liter, μg/L=micrograms per liter]

WELL	YEAR	LOG NO	Na mg/L	K mg/L	Ca mg/L	Mg μg/L	Si mg/L	Li mg/L	B mg/L	Sr mg/L	Ba μg/L	Rb mg/L	Cass 1 Fe μg/L	Cass 2 Fe μg/L
M19A(F)	1978	78WA119	8,330	1,870	498	487	419	21.6	16.6	10.1	704	20.0	484	333
M-21	1978	78WA120	7,500	1,450	445	592	336	17.7	14.4	7.65	704	17.2	502	346
M-26(F)	1978	78WA122	7,300	1,250	488	927	398	16.8	11.9	6.75	1,060	17.6	632	525
M-27(F)	1978	78WA123	6,420	1,150	289	<20.0	400	15.1	11.8	0.53	478	12.4	456	194
M-30(F)	1978	78WA126	8,140	1,780	577	1,110	413	20.7	16.0	11.5	547	21.3	700	617
M-42(F)	1978	78WA129	6,630	1,410	388	447	402	18.4	16.2	9.85	790	16.1	470	359

WELL	YEAR	LOG NO	Mn mg/L	Cass 1 Zn μg/L	Cass 2 Zn μg/L	Mo μg/L	Co μg/L	Cr μg/L	Pb μg/L	Ni μg/L	V μg/L	Cd μg/L	Cass 1 Cu μg/L	Cass 2 Cu μg/L
M19A(F)	1978	78WA119	1.83	101	18.3	166	72.8	63.9	939	47.4	126	25.3	<10.0	<3.00
M-21	1978	78WA120	0.45	69.5	<6.00	150	71.7	61.8	784	43.2	104	24.3	<10.0	<3.00
M-26(F)	1978	78WA122	0.37	128	34.2	139	69.5	58.5	728	43.2	92.0	32.4	<10.0	<3.00
M-27(F)	1978	78WA123	0.32	36.6	<6.00	133	70.6	55.3	656	43.2	98.1	24.3	<10.0	<3.00
M-30(F)	1978	78WA126	2.93	448	306	167	96.1	75.0	966	61.3	147	16.3	<10.0	<3.00
M-42(F)	1978	78WA129	0.43	59.4	41.1	168	70.6	50.5	840	47.4	132	<10.0	<10.0	<3.00

WELL	YEAR	LOG NO	Tl μg/L	As mg/L	Se μg/L	Sb μg/L	Bi μg/L	Hg μg/L	Zr μg/L	Be μg/L	Ti μg/L	Al μg/L
M19A(F)	1978	78WA119	199	1.31	472	237	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-21	1978	78WA120	130	2.29	418	<200	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-26(F)	1978	78WA122	153	3.43	288	201	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-27(F)	1978	78WA123	145	0.52	245	<200	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-30(F)	1978	78WA126	245	1.10	303	608	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0
M-42(F)	1978	78WA129	205	0.84	<200	931	<80.0	<10.0	<20.0	<2.00	<10.0	<10.0

RESULTS

Accuracy of analysis is variable between elements. The five elements, B, Ca, Mg, Ba, and Sr have been investigated in detail and generally give precise and accurate results. Changes in sensitivity due to movement of either the plasma or the grating greatly affect the precision of the analyses. Table 4 illustrates the magnitude of this effect. The values shown are indicative of typical changes in the relative intensity seen over short time periods during a run in which the instrument has been carefully standardized and optimized. Generally, these values are acceptable for most elements; however, note the difference for Rb (+7.8 percent) on cassette 1 and Cd (+6.6 percent) on cassette 2, the latter only 10 minutes after standardization. Effects such as these are reduced considerably by interspersing the samples and standards, which provide a means of time-averaging the sensitivity changes. Sensitivity is known to change as a function of concentration as well. For example, self-absorption of Na emission causes a reduction in sensitivity at the 20 mg L^{-1} upper measuring limit. Use of the second-order, multipoint standardization, which is part of the data reduction technique, permits closer calibration over the entire analytical range.

A further problem is the possible change in solution chemistry between the time of sampling and the time of analysis. A white precipitate, presumably colloidal silica, was observed in all samples at the time of analysis. Therefore, values listed in Tables 2 and 3 may not be representative of true concentrations at the time of sampling to the extent that precipitation or coprecipitation removed a fraction of the elements from solution by the time of analysis.

Three elements, Fe, Cu, and Zn are analyzable using either cassette. Iron values are seen to vary by as much as ±30 percent of a mean of the two values, while Zn values are even more divergent but vary more systematically, being generally much lower when using cassette 2 than cassette 1. All Cu values are below detection. The variability in Fe values is probably due primarily to the presence of the precipitate. Its sporadic introduction into the sample spray may alter the plasma conditions, or, if it should actually contain coprecipitated Fe, it may cause a "shot" signal elevation as it is excited by the plasma (Vivit and Jenne, written commun., 1978). A secondary source of the variability in Fe values may be stray light in the detector portion of the optical system. As more primary major-element lines are passed by cassette 1, the apparent Fe values would be elevated by this phenomenon. For Zn, the order of importance of the above two phenomena would be reversed because of the very low Zn levels in the samples. The "shot" signal elevation is then a secondary factor, and stray light passing through cassette 1 would be expected to become the primary factor. The correction technique does account for stray light, but accuracy and precision of the correction are presently unknown.

Table 4. - Drift of sensitivity with time

Element	Relative intensity		Magnitude of change (Percent)	Element	Relative intensity		Magnitude of change (Percent)
	Initial	10 min later			Initial	10 min later	
As	20.3	20.3	0	B	1030	1052	+2.1
Se	20.1	21.0	+4.5	Mn	520	527	+1.3
Bi	10.1	10.3	+2.0	Cu	526	544	+3.4
Zn	498	510	+2.4	Zn	515	524	+1.7
Cd	1014	1081	+6.6	Si	21.1	22.2	+0.5
Sb	19.9	21.0	+5.5	Zr	523	523	0
Cu	199	197	-1.0	Be	205	210	+2.4
Ni	496	478	-3.6	Mg	20.8	21.5	+3.4
Hg	4.02	4.19	+4.2	Sr	1056	1087	+2.9
Mo	492	464	-5.7	Ti	525	531	+1.1
Co	990	968	-2.2	Ca	21.1	21.1	0
Cr	495	485	-2.0	Fe	2124	2243	+5.6
Fe	9.93	9.60	-3.3	Ba	1058	1075	+1.6
V	979	924	-5.6	K	21.1	21.5	+1.9
Tl	490	470	-4.1	Na	21.0	21.4	+1.9
Li	19.7	18.7	-5.1	Rb	2124	2290	+7.8
Pb	3.97	3.81	-4.0	Al	529	546	+3.2

The technique for the correction of interelement interferences has been used to correct for the effects of Ca, Si, K, and Na on the apparent concentrations of B, Mn, Cu, Zn, Zr, Sr, Ti, Fe, Rb, Al, As, Bi, Sb, Hg, Mo, Cr, Tl, Li, and Pb. No effects of Ca, Si, K, or Na at their upper concentration limits (600, 600, 2000, and 8000 mg L^{-1}, respectively) were observed on the apparent concentrations of Be, Mg, Ba, Se, Cd, V, Ni, or Co. The effect of Ca is the most serious, followed by the effect of Si, for the analysis of geothermal water. Al, Ti, Li, and Pb are elements upon which Ca, present at 400 mg L^{-1}, interferes due to stray light effects (Johnson, G. W., et al., 1979). The effect of Ca on the apparent concentration of Al or Pb is measurable at Ca concentrations as low as 10 mg L^{-1}. The effect can be as high as 1 µg L^{-1} Al or Pb per 1 mg L^{-1} Ca. In contrast, K and Na, occurring at concentrations of about 1600 and 6000 mg L^{-1}, or 4 and 15 times that of Ca, respectively, have comparatively minor interference effects.

SUMMARY AND CONCLUSIONS

Brine samples from some wells of the geothermal power generating station at Cerro Prieto, Mexico, have been analyzed for selected elements using d.c. argon plasma emission spectroscopy. The accuracy and precision of the individual elemental determinations were found to vary between elements, and, for the same element analyzable using either cassette, between cassettes. Accuracy and precision were affected by the formation of precipitates in the samples after filtration and before analysis, and by spectral interferences due to the presence in the sample solutions of high concentrations of Ca, Si, Na, and K. The latter effects were mitigated insofar as was possible using present knowledge. However, some effects remain, and adversely affect the interpretability of the data presented herein.

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