

Chapter H

The determination of forty four elements in aqueous samples by inductively coupled plasma – mass spectrometry

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Contents

Principle	H-1
Interferences	H-1
Scope	H-1
Apparatus	H-2
Reagents	H-2
Internal standards	H-2
Calibration standards	H-2
Safety precautions	H-2
Procedure	H-3
Calculations	H-4
Correction Equations	H-4
Assignment of uncertainty	H-4
Bibliography	H-11

Tables

1. Operating conditions for Perkin-Elmer Elan 6000 ICP-MS H-3
2. Analytical performance summary for elements in aqueous samples by ICP-MS H-5

The Determination of Forty Four Elements in Aqueous Samples by Inductively Coupled Plasma - Mass Spectrometry

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Principle

In aqueous samples, 44 major, minor, and trace elements are determined using inductively coupled plasma-mass spectrometry (ICP-MS). The ICP-MS is calibrated using 5 commercially available multi-element standard solutions in conjunction with one USGS-WRD standard reference sample. Samples must be filtered and acid-preserved prior to analyses, but no digestion is required for the determination of dissolved elements.

Interferences

ICP-MS interferences come from matrix effects, instrumental drift, and isobaric overlap of some elemental isotopes. Molecular ions formed in the plasma can also result in enhancement of measured ion intensity due to isobaric interferences (Montaser, 1998). Internal standards are added to compensate for matrix effects and instrumental drift. The isotopes measured are selected to minimize isobaric overlap from other elements and molecular species that might be present. For a few isotopes, isobaric overlap corrections are computed based on relative isotopic abundances of the elements involved, and oxide or double-charged ion intensities (Lichte and others, 1987).

Scope

ICP-MS has been applied to the determination of over 60 elements in various matrices. Analytes for which EPA has demonstrated the acceptability of ICP-MS determinations (USEPA SW-846 Method 6020A, 1998) are included in this work. In addition to the 23 EPA approved elements, 21 elements are included in this protocol per the provisions of Method 6020A. The elements analyzed and their 3s and 5s limits are shown in Table 2.

Apparatus

- Inductively Coupled Plasma Mass Spectrometer, Perkin-Elmer Elan 6000
- 13x100 mm disposable polypropylene test tubes with caps

Reagents

- Deionized (DI) water
- Nitric acid (HNO_3), conc ULTREX grade (70 %)
- 1% HNO_3 : Dilute 10 mL conc HNO_3 to 1000 mL with DI water

Internal standards

Prepare 2 L of a solution containing 500 $\mu\text{g/L}$ ^6Li , 20 $\mu\text{g/L}$ Rh, and 10 $\mu\text{g/L}$ Ir by performing serial dilutions of commercial aqueous standards using 1% HNO_3 . This solution is mixed in a 1:1 ratio with the sample to be analyzed using a dual channel peristaltic pump equipped with a mixing manifold and coil.

Calibration standards

- Standard 1 contains 0.200 mg/L of the following elements in 1% HNO_3 : Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cs, Cu, Fe, Ga, K, Li, Mg, Mn, Na, Ni, Pb, Rb, Se, Sr, Tl, U, V, Zn
- Standard 2 contains 0.100 mg/L of the following elements in 1% HNO_3 : Ge, Mo, Nb, P, S, Si, Ta, Ti, W, Zr
- Standard 3 contains 0.010 mg/L of the following elements in 1% HNO_3 : Ce, La, Nd, Sc, Y
- Standard 4 contains 1.00 mg/L of Fe, Al, and Si in 1% HNO_3 .
- Standard 5 is USGS WRD standard reference water sample T-143.
- Standard 6 contains 142.8 mg/L SO_4^{-2}

Safety precautions

All laboratory personnel must wear safety glasses, a lab coat or apron, and gloves when working in the laboratory. All personnel must read the laboratory Chemical Hygiene Plan (CHP) and the Material Safety Data Sheets (MSDS) for each procedure.

Procedure

Prior to analyzing samples, a dual detector calibration and auto-lens adjustment are performed according to manufacturer recommendations (Perkin-Elmer Corp., 1997). The instrument is then calibrated using the calibration solutions listed above, and the operating parameters shown in table 2. The calibration is checked using NIST SRMs 1640 and 1643d (NIST 1995, 1998).

Table 1. Operating conditions for Perkin-Elmer Elan 6000 ICP-MS

Sweeps/Reading: 35
Readings/Replicate: 1
Number of Replicates: 1
Tuning File: default.tun
Optimization File: default.dac
QO Enabled: Yes
Settling Time: Normal

Analyte	Mass	Scan Mode	MCA Channels	Dwell Time	Integration Time
Ag	108.905	Peak Hopping	1	50.0 ms	1750 ms
Al	26.982	Peak Hopping	1	10.0 ms	350 ms
As	74.922	Peak Hopping	1	100.0 ms	3500 ms
Ba	134.906	Peak Hopping	1	30.0 ms	1050 ms
Be	9.012	Peak Hopping	1	50.0 ms	1750 ms
Ca	42.959	Peak Hopping	1	20.0 ms	700 ms
Cd	113.904	Peak Hopping	1	100.0 ms	3500 ms
Ce	139.905	Peak Hopping	1	10.0 ms	350 ms
Co	58.933	Peak Hopping	1	30.0 ms	1050 ms
Cr	51.941	Peak Hopping	1	10.0 ms	350 ms
Cs	132.905	Peak Hopping	1	10.0 ms	350 ms
Cu	64.928	Peak Hopping	1	20.0 ms	700 ms
Fe	53.940	Peak Hopping	1	10.0 ms	350 ms
Ga	70.925	Peak Hopping	1	10.0 ms	350 ms
Ge	73.922	Peak Hopping	1	10.0 ms	350 ms
K	38.964	Peak Hopping	1	10.0 ms	350 ms
La	138.906	Peak Hopping	1	10.0 ms	350 ms
Li	7.016	Peak Hopping	1	50.0 ms	1750 ms
Mg	24.986	Peak Hopping	1	10.0 ms	350 ms
Mn	54.938	Peak Hopping	1	10.0 ms	350 ms
Mo	97.906	Peak Hopping	1	20.0 ms	700 ms
Na	22.990	Peak Hopping	1	10.0 ms	350 ms
Nb	92.906	Peak Hopping	1	20.0 ms	700 ms
Nd	145.913	Peak Hopping	1	10.0 ms	350 ms
Ni	59.933	Peak Hopping	1	20.0 ms	700 ms
P	30.994	Peak Hopping	1	10.0 ms	350 ms
Pb	207.977	Peak Hopping	1	20.0 ms	700 ms

Rb	84.912	Peak Hopping	1	10.0 ms	350 ms
S	33.968	Peak Hopping	1	10.0 ms	350 ms
Sb	120.904	Peak Hopping	1	100.0 ms	3500 ms
Sc	44.956	Peak Hopping	1	10.0 ms	350 ms
Se	81.917	Peak Hopping	1	100.0 ms	3500 ms
Si	28.977	Peak Hopping	1	100.0 ms	3500 ms
Sr	87.906	Peak Hopping	1	10.0 ms	350 ms
Ta	180.948	Peak Hopping	1	10.0 ms	350 ms
Th	232.038	Peak Hopping	1	10.0 ms	350 ms
Ti	48.948	Peak Hopping	1	20.0 ms	700 ms
Tl	204.975	Peak Hopping	1	50.0 ms	1750 ms
U	238.050	Peak Hopping	1	10.0 ms	350 ms
V	50.944	Peak Hopping	1	10.0 ms	350 ms
W	183.951	Peak Hopping	1	10.0 ms	350 ms
Y	88.905	Peak Hopping	1	10.0 ms	350 ms
Zn	65.926	Peak Hopping	1	30.0 ms	1050 ms
Zr	89.904	Peak Hopping	1	10.0 ms	350 ms

Signal Processing

Detector Mode:	Dual
Measurement Units:	Counts/sec
AutoLens:	On
Spectral Peak Processing:	Average
Signal Profile Processing:	Average
Blank Subtraction:	After Internal Standard
Baseline Readings:	0
Smoothing:	Yes, Factor 5

Calculations

$$\text{Concentration (ppm)} = \frac{\text{Final volume (mL)} * \text{ICP-MS reading (ppm)}}{\text{Sample aliquot volume (mL)}}$$

Correction Equations

Analyte	Mass	Corrections
V	50.944	- 3.127 * (ClO53 - (0.113 * Cr52))
Fe	53.940	- 0.028226 * Cr52
Ge	73.922	- 0.116645 * Se77
As	74.922	- 3.087 * (Se77 - (0.825 * Se82))
Se	81.917	- 1.008696 * Kr83
Mo	97.906	- 0.110588 * Ru101
Cd	113.904	- 0.026826 * Sn118
Gd	159.927	- 0.093976 * Dy163
Dy	163.929	- 0.047917 * Er166
W	183.951	- 0.001242 * Os189

Assignment of uncertainty

The analytical results for selected reference materials are summarized in table 2.

Table 2. Analytical performance summary for elements in aqueous samples by ICP-MS

<i>Reference</i>	<i>Description</i>	<i>n</i>	<i>Mean</i>	<i>s</i>	<i>pv</i>	<i>% RSD</i>	<i>% R</i>
Aluminum, Al (µg/L)							
T-151	Surface water	2	8.5	1.0	--	--	--
T-147	Surface water	2	16.3	0.3	14.0	1.7	116
GWT-3	Ground water	3	32.5	0.4	31.4	1.2	104
T-153	Surface water	2	36.1	0.9	35.0	2.4	103
GWT-4	Ground water	2	39.7	0.4	38.4	1.1	103
Antimony, Sb (µg/L)							
GWT-3	Ground water	3	0.39	0.08	--	--	--
T-147	Surface water	2	10.7	0.1	10.5	1.3	102
GWT-4	Ground water	2	14.0	0.1	13.5	1.0	104
T-153	Surface water	2	27.3	0.4	25.7	1.3	106
T-151	Surface water	2	27.7	0.1	26.8	0.5	103
Arsenic, As (µg/L)							
T-151	Surface water	2	<3	--	--	--	--
T-153	Surface water	2	<3	--	--	--	--
GWT-3	Ground water	3	<3	--	0.93	--	--
T-147	Surface water	2	3.3	0.4	2.4	13	138
GWT-4	Ground water	2	13.2	0.1	12.7	0.5	104
Barium, Ba (µg/L)							
GWT-3	Ground water	3	27.5	0.4	25.3	1.3	109
T-151	Surface water	2	43.6	0.5	40.7	1.1	107
T-147	Surface water	2	77.4	2.2	73.0	2.8	106
GWT-4	Ground water	2	92.9	0.5	88.5	0.5	105
T-153	Surface water	2	196	2.1	184	1.1	106
Beryllium, Be (µg/L)							
T-153	Surface water	2	<0.05	--	--	--	--
GWT-4	Ground water	2	12.8	0	12.1	0	106
GWT-3	Ground water	3	16	0.2	15.4	1.3	104
T-147	Surface water	2	16.7	0.2	16.0	1.3	104
T-151	Surface water	2	26.5	0.1	25.6	0.5	103
Cadmium, Cd (µg/L)							
GWT-4	Ground water	2	13.3	0.2	12.8	1.6	104
T-147	Surface water	2	16.4	0.5	15.9	3.0	103
T-153	Surface water	2	16.8	0.3	16.0	1.7	105
T-151	Surface water	2	27.9	0.1	26.8	0.5	104
GWT-3	Ground water	3	47.0	0.2	45.7	0.4	103

Table 2. Analytical performance summary for elements in aqueous samples by ICP-MS

<i>Reference</i>	<i>Description</i>	<i>n</i>	<i>Mean</i>	<i>s</i>	<i>pv</i>	<i>% RSD</i>	<i>% R</i>
Calcium, Ca (mg/L)							
T-153	Surface water	2	27.5	0.2	27.5	0.8	100
GWT-3	Ground water	3	36.8	0.4	35.9	1.0	102
T-151	Surface water	2	37.4	0	37.9	0	99
T-147	Surface water	2	40.9	1.0	41.1	2.6	99
GWT-4	Ground water	2	102	0.7	104	0.7	98
Chromium, Cr (µg/L)							
GWT-3	Ground water	3	1.7	0	1.9	0	89
T-147	Surface water	2	12.6	0.2	12.8	1.7	98
GWT-4	Ground water	2	13.9	0.3	13.6	2.0	102
T-153	Surface water	2	15.6	0.1	14.9	0.5	104
T-151	Surface water	2	30.7	0.3	30.1	0.9	102
Cobalt, Co (µg/L)							
GWT-3	Ground water	3	0.08	0.01	--	7.5	--
T-147	Surface water	2	0.16	0.01	--	4.6	--
GWT-4	Ground water	2	7.5	0.1	7.5	0.9	100
Copper, Cu (µg/L)							
GWT-3	Ground water	3	4.3	0.1	4.2	2.3	103
GWT-4	Ground water	2	10.7	0	10.5	0	102
T-147	Surface water	2	11.8	0.4	11.4	3.0	103
T-153	Surface water	2	24.7	0.2	24.0	0.9	103
T-151	Surface water	2	33.5	0	33.0	0	102
Iron, Fe (µg/L)							
T-147	Surface water	2	<50	--	8.4	--	--
T-151	Surface water	2	<50	--	10.0	--	--
GWT-4	Ground water	2	<50	--	24.2	--	--
GWT-3	Ground water	3	<50	--	57.2	--	--
T-153	Surface water	2	57	1.4	75	2.5	76
Lead, Pb (µg/L)							
GWT-4	Ground water	2	8.1	0.1	8.17	1.8	99
T-147	Surface water	2	13.8	0	13.8	0	100
T-151	Surface water	2	19.2	0.1	19.8	0.4	97
GWT-3	Ground water	3	31.4	0.5	31.4	1.5	100
T-153	Surface water	2	46.1	0.6	46.2	1.4	100
Lithium, Li (µg/L)							
GWT-4	Ground water	2	10.7	0.1	10.4	1.3	103
T-147	Surface water	2	17.8	0.2	18.0	1.2	99
T-151	Surface water	2	28	0.3	27.6	1.0	101
GWT-3	Ground water	3	34.7	0.3	33.9	0.9	102
T-153	Surface water	2	55.4	0.5	53.4	0.9	104

Table 2. Analytical performance summary for elements in aqueous samples by ICP-MS

<i>Reference</i>	<i>Description</i>	<i>n</i>	<i>Mean</i>	<i>s</i>	<i>pv</i>	<i>% RSD</i>	<i>% R</i>
Magnesium, Mg (mg/L)							
T-147	Surface water	2	8.0	0.2	8.2	2.7	98
T-153	Surface water	2	8.7	0.2	8.7	1.9	100
GWT-3	Ground water	3	12.6	0.2	12.5	1.2	101
T-151	Surface water	2	16.9	0.4	17.5	2.1	96
GWT-4	Ground water	2	18.0	0.1	18.6	0.4	97
Manganese, Mn (µg/L)							
GWT-3	Ground water	3	5.9	0.1	5.6	1.7	106
T-151	Surface water	2	13.9	0.1	13.0	0.5	107
T-147	Surface water	2	18.0	0.4	17.2	2.0	104
GWT-4	Ground water	2	22.8	0	21.6	0	106
T-153	Surface water	2	77.7	1.0	74.5	1.3	104
Molybdenum, Mo (µg /L)							
GWT-3	Ground water	3	8.3	1.5	7.0	18	118
T-147	Surface water	2	12.0	0.4	11.8	3.0	101
GWT-4	Ground water	2	13.8	0.4	14.8	2.6	93
T-151	Surface water	2	26.3	2.1	29.6	8.1	89
T-153	Surface water	2	145	0	154	0	94
Nickel, Ni (µg/L)							
T-151	Surface water	2	10.5	0.1	10	0.7	105
GWT-4	Ground water	2	11.7	0.14	11	1.2	106
T-147	Surface water	2	13.9	0.2	13.6	1.5	102
T-153	Surface water	2	32.7	0	32.2	0	102
GWT-3	Ground water	3	36.9	0.2	36.6	0.6	101
Potassium, K (mg/L)							
GWT-3	Ground water	3	0.99	0.01	1.03	1.0	96
T-153	Surface water	2	1.6	0	1.6	0	100
T-151	Surface water	2	1.9	0	1.95	0	97
GWT-4	Ground water	2	2.35	0.1	2.4	3.0	98
T-147	Surface water	2	3.45	0.1	3.52	2.1	98
Selenium, Se (µg/L)							
T-151	Surface water	2	<5	--	1.8	--	--
GWT-4	Ground water	2	8.55	0.4	6.77	4.1	126
T-153	Surface water	2	10.5	0.4	9	3.4	116
T-147	Surface water	2	13.2	0.4	10.1	2.7	130
GWT-3	Ground water	3	15.5	0.4	12.4	2.3	125
Silicon, Si (mg/L)							
T-151	Surface water	2	0.65	0.1	0.66	11	98
T-153	Surface water	2	2.75	0.1	2.7	2.6	102
GWT-4	Ground water	2	7.65	0.1	7.62	0.9	100
GWT-3	Ground water	3	11.2	0.1	10.7	0.9	105
T-147	Surface water	2	11.4	0.1	11.2	1.2	102

Table 2. Analytical performance summary for elements in aqueous samples by ICP-MS

<i>Reference</i>	<i>Description</i>	<i>n</i>	<i>Mean</i>	<i>s</i>	<i>pv</i>	<i>% RSD</i>	<i>% R</i>
Silver, Ag (µg/L)							
GWT-3	Ground water	3	<3	--	--	--	--
GWT-4	Ground water	2	3.9	0.4	6.2	11	63
T-153	Surface water	2	4.5	0.1	6.2	0.8	71
T-147	Surface water	2	5.33	0.4	7.6	6.9	70
T-151	Surface water	2	9.4	0.4	11.1	4.6	84
Sodium, Na (mg/L)							
T-153	Surface water	2	28.4	0.1	28.7	0.5	99
GWT-4	Ground water	2	40.9	0.1	41.4	0.4	99
T-147	Surface water	2	52.3	1.4	52.6	2.7	99
T-151	Surface water	2	54.3	0.6	55	1.0	99
GWT-3	Ground water	3	142	1.1	136	0.8	105
Strontium, Sr (µg/L)							
T-153	Surface water	2	321	1.4	311	0.4	103
T-147	Surface water	2	321	12	313	3.8	102
T-151	Surface water	2	402	6.4	387	1.6	104
GWT-3	Ground water	3	592	5.9	551	1.0	108
GWT-4	Ground water	2	730	7.8	711	1.1	103
Thallium, Tl (µg/L)							
GWT-3	Ground water	3	0.6	0.1	--	22	--
T-147	Surface water	2	18.8	0.3	20	1.5	94
T-153	Surface water	2	19.6	0.1	20.4	0.7	96
T-151	Surface water	2	62.5	0.2	62	0.3	101
Uranium, U (µg/L)							
T-147	Surface water	2	3.2	0.01	3.2	0.2	100
GWT-4	Ground water	2	4.2	0.03	4.3	0.7	99
T-153	Surface water	2	7.3	0.1	6.9	1.2	106
T-151	Surface water	2	15.3	0.2	15	1.4	102
Vanadium, V (µg/L)							
GWT-3	Ground water	3	0.97	0.06	--	6.0	--
GWT-4	Ground water	2	14.4	0.4	14.2	2.5	101
T-147	Surface water	2	15.6	0.4	15.2	2.3	102
T-153	Surface water	2	20.1	0.4	19	2.1	106
T-151	Surface water	2	59.9	0.7	59	1.2	102
Zinc, Zn (µg/L)							
T-151	Surface water	2	10.7	0.07	6.6	0.7	162
T-147	Surface water	2	16.9	0.1	14	0.8	121
GWT-4	Ground water	2	51.9	0.4	51	0.7	102
T-153	Surface water	2	75.8	0.9	72.6	1.1	104
GWT-3	Ground water	3	233	3.2	227	1.4	103

n = number of samples

s = standard deviation

pv = proposed value taken from published reference material compilations (Farrar 1997, 1998).

% RSD = percent relative standard deviation

%R = percent recovery

= no data available

Table 2.—Continued—Duplicate samples results

<i>Duplicate samples</i>	<i>k</i>	<i>Mean</i>	<i>s</i>	<i>%RSD</i>	<i>Concentration range</i>		<i>No. of</i>
					<i>Min</i>	<i>o Max</i>	
Al µg/L	25	120.8	12.30	10.2	43.7	613	1
As µg/L	22	40.2	4.86	12.1	8.8	63.1	4
Ba µg/L	26	267.3	11.67	4.4	13.5	570	0
Bi µg/L	14	7.4	0.22	2.9	0.005	15.8	12
Ca mg/L	26	40.3	1.10	2.7	6.4	546	0
Cd µg/L	23	13.7	0.59	4.3	0.02	24.9	3
Ce µg/L	22	0.6	0.02	4.1	0.01	4.6	4
Co µg/L	25	19.1	0.66	3.5	0.1	31	1
Cr µg/L	25	31.6	1.70	5.4	1.2	206	1
Cs µg/L	21	2.6	0.12	4.9	0.01	7	5
Cu µg/L	25	45.0	1.62	3.6	2.9	90.7	1
Fe µg/L	15	155.7	12.60	8.1	29	554	11
K mg/L	26	2.3	0.09	4.0	0.61	19.2	0
Li µg/L	25	28.9	1.29	4.5	0.5	56.6	1
Mg mg/L	25	7.2	19.70	8.7	1.2	17.7	1
Mn µg/L	25	75.9	5.43	7.1	1.4	211	1
Mo µg/L	23	73.7	2.30	3.1	0.4	134	3
Na mg/L	26	31.4	2.10	6.5	0.8	247	0
Ni µg/L	25	38.1	1.31	3.5	2.5	72.7	1
Pb µg/L	23	20.0	0.53	2.7	0.05	30.3	3
Rb µg/L	26	6.4	0.21	3.3	0.82	16.2	0
Sb µg/L	25	28.0	1.46	5.2	0.2	60.1	1
Sc µg/L	26	2.0	0.33	16.5	0.4	27.5	0
Se µg/L	18	18.0	1.26	6.9	10	26	8
Si mg/L	26	5.5	0.40	7.3	2.7	31.2	0
Sr µg/L	25	191.0	6.70	3.5	24.9	326	1
Th µg/L	23	0.1	0.06	62.0	0.009	0.5	3
Ti µg/L	21	1.2	0.22	18.2	0.1	6.9	5
U µg/L	26	5.0	0.14	2.8	0.01	119	0
V µg/L	26	21.3	2.14	10.0	0.7	45.8	0
W µg/L	16	0.3	0.13	44.0	0.02	2.6	10
Y µg/L	19	44.3	1.30	2.9	0.01	836	7
Yb µg/L	14	3.3	0.04	1.2	0.006	46	12
Zn µg/L	24	54.3	2.71	5.0	0.6	90.6	2
Zr µg/L	16	0.7	0.33	47.4	0.1	5	10

Table 2.–Continued--Method blank results 3s values are considered the lower limit of detection (LOD), and 5s values are considered the lower limits of determination (LLD)

<i>Method blank</i>	<i>n</i>	<i>Mean</i>	<i>s</i>	<i>3s</i>	<i>5s</i>
Ag µg/L	33	0.0244	0.408	1.22	2.04
Al µg/L	34	0.154	0.464	1.39	2.32
As µg/L	34	0.123	0.216	0.647	1.08
Ba µg/L	34	0.0404	0.0740	0.222	0.370
Bi µg/L	34	0.0169	0.0706	0.212	0.353
Ca mg/L	34	-0.00347	0.0655	0.196	0.327
Cd µg/L	34	0.002	0.00354	0.0106	0.0177
Ce µg/L	34	-0.00021	0.00330	0.00990	0.0165
Co µg/L	34	0.00153	0.00560	0.0168	0.0280
Cr µg/L	34	0.0237	0.337	1.13	1.88
Cs µg/L	34	-0.00279	0.00656	0.0197	0.0328
Cu µg/L	34	0.0612	0.149	0.447	0.746
Dy µg/L	34	0.000147	0.000784	0.00235	0.00392
Er µg/L	34	-0.00024	0.000741	0.00222	0.00370
Eu µg/L	34	0.000412	0.000857	0.00257	0.00428
Fe µg/L	34	-5.56	9.63	28.9	48.2
Ga µg/L	34	0.000971	0.0160	0.0480	0.0799
Gd µg/L	34	0.000118	0.00101	0.00302	0.00504
Ge µg/L	34	-0.00253	0.0138	0.0413	0.0689
Ho µg/L	34	-0.00029	0.00204	0.00611	0.0102
K mg/L	34	0.0068	0.00839	0.0252	0.0419
La µg/L	34	-0.00056	0.00257	0.00772	0.0129
Li µg/L	34	-0.206	0.306	0.919	1.53
Lu µg/L	34	-0.00029	0.00228	0.00683	0.0114
Mg mg/L	34	0.000891	0.00211	0.00632	0.0105
Mn µg/L	34	-0.00259	0.0504	0.151	0.252
Mo µg/L	34	0.594	0.635	1.90	3.17
Na mg/L	34	0.0553	0.192	0.576	0.961
Nb µg/L	34	0.0363	0.0384	0.115	0.192
Nd µg/L	34	-0.00027	0.00209	0.00628	0.0105
Ni µg/L	34	0.0126	0.0899	0.270	0.449
Pb µg/L	34	0.00885	0.0181	0.0544	0.0906
Pr µg/L	34	0.000176	0.000576	0.00173	0.00288
Rb µg/L	34	0.00238	0.00433	0.0130	0.0217
Sb µg/L	34	0.0537	0.0853	0.256	0.427
Sc µg/L	34	-0.0627	0.199	0.597	0.995
Se µg/L	34	0.154	0.221	0.662	1.10
Si mg/L	34	-0.0204	0.0427	0.128	0.214
Sm µg/L	34	-0.00015	0.00297	0.00890	0.0148
SO4 mg/L	34	0.996	1.31	3.92	6.54
Sr µg/L	34	0.0595	0.159	0.478	0.797
Ta µg/L	34	0.0396	0.0365	0.110	0.183
Tb µg/L	34	0.0000882	0.000452	0.00136	0.00226
Th µg/L	34	0.0339	0.0577	0.173	0.289
Ti µg/L	34	0.0153	0.192	0.576	0.960
Tl µg/L	34	0.0402	0.0523	0.157	0.261
Tm µg/L	34	0.0000294	0.000388	0.00116	0.00194
U µg/L	34	0.008	0.0467	0.140	0.233
V µg/L	34	0.0512	0.158	0.474	0.789
W µg/L	34	0.0923	0.109	0.327	0.545
Y µg/L	34	0.000794	0.00149	0.00448	0.00747
Yb µg/L	34	0.000147	0.000925	0.00278	0.00463
Zn µg/L	34	0.0256	0.170	0.510	0.850
Zr µg/L	34	0.00918	0.0593	0.178	0.296

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