Master

LA-8473-MS
Informal Report
UC-11
Issued: August 1980

Compilation of Elemental Concentration Data for the United States Geological Survey's Six Geochemical Exploration Reference Materials

Ernest S. Gladney

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

COMPILATION OF ELEMENTAL CONCENTRATION DATA FOR THE
UNITED STATES GEOLOGICAL SURVEY'S SIX GEOCHEMICAL
EXPLORATION REFERENCE MATERIALS

by

Ernest S. Gladney

ABSTRACT

Elemental composition data on USGS GXR1 → GXR6 have been collected and summarized from 13 journal papers and reports. Data from one report concerning the influence of rock dissolution method on subsequent atomic absorption analysis are summarized for aluminum, silver, calcium, iron, and manganese.

INTRODUCTION

This document is intended to provide an updated and more complete survey of literature values reported for the United States Geological Survey's (USGS) Geochemical Exploration Reference Materials (GXR). These six silicate standard materials are being made available through the Denver, CO, office of the USGS. An extensive open file report of original data has been made available (1), but none of these data were summarized until the publication of our Laboratory's original measurement of elemental concentrations in the GXR materials (2). Allcott and Lakin (3) of the USGS have also published their emission spectrographic and atomic absorption data for the GXR materials. This report will summarize data from references 1 and 3 which was not included in our earlier publication (2).

The Environmental Surveillance Group uses standard reference materials from the National Bureau of Standards, the Environmental Protection Agency,

and the Canadian Centre for Mineral and Energy Technology, in addition to those from the USGS as an integral part of our quality assurance program for elemental measurements. High quality "certified" and "recommended" values are available for a number of constituents in these matrices. However, many elements are not reported by the issuing agencies. If enough reliable data from other investigators can be accumulated and summarized, we can use these mean values to extend the range of our quality assurance program within the standard materials already available.

DATA COMPILATION

The GXR rock designations, names, descriptions and sources are shown in Table I. In addition to the USGS data (1,3), eighteen major journals in analytical chemistry and geochemistry shown in Table II have been exhaustively surveyed in an effort to find original analytical data on these six USGS standards. Only ten articles containing original data, in addition to the three sources mentioned above, were located. Since the available data are so limited, no statistical treatment of them are possible.

A summary of the recommended values developed at this Laboratory and published in Ref. 2 is presented in Table III. These elemental concentrations were determined by a combination of analytical procedures including instrumental and radiochemical neutron activation, flame and flameless atomic absorption, thermal neutron capture gamma-ray spectrometry, and delayed neutron assay. A summary of the available data from Allcott and Lakin (1, 3) for these elements was presented in the original paper and will not be reproduced here. Data from Allcott and Lakin (1, 3) for elements not measured in our previous study are presented in Table IV along with the compiled data from ten other investigations. All data in Tables III and IV must be used

with caution since there is only limited basis for judgment of their quality.

The data from 109 laboratories tabulated by Allcott and Lakin (1) are given by both analytical technique used and dissolution method employed (where appropriate). Our previous paper presented a comparison among data taken by various analytical methods (2). In Tables V to X is my summary of the influence of dissolution method on atomic absorption determination of Al, Ag, Ca, Fe, and Mn in the GXR materials. Table V contains the dissolution method code while Tables VI to X are means $\pm$ one standard deviation of the raw data given by Allcott and Lakin (1). For Al, methods M and R yield consistently low results for all six samples. The use of HClO_4 in sample preparation for Al determination is apparently the problem, since HF is successfully used in method L. For Ag, only method B yields low results and then only for the higher concentration samples. Insufficient contact time may be the explanation. For Ca, only method I is completely inadequate, while several methods indicate difficulty with the very high or relatively low Ca levels encountered in GXR-3 and GXR-6, respectively. For Fe, methods A and E yield low results for the highest concentration samples (GXR1 and 3) but all methods seem equivalent for Fe concentrations of less than 6%. Several methods did not work well for the determination of Mn at percent levels encountered in GXR-3. Methods A, E, I, M, and O yielded low values, while method P had high results. With the exception of method A for GXR-6, all methods gave roughly equivalent data for the other GXR samples.

Acknowledgements

I thank Mary Lou Keigher for her assistance with the preparation of this manuscript.

REFERENCES

1. G. H. Allcott, H. W. Lakin, "Tabulation of Geochemical Data Furnished by 109 Laboratories for Six Geochemical Exploration Reference Samples," USGS, Open File Report 78-163, 199 pp., 1978.
2. E. S. Gladney, D. R. Perrin, J. W. Owens, D. Knab, "Elemental Concentrations in the United States Geological Survey's Geochemical Exploration Reference Samples - A Review," *Anal. Chem.*, 51: 1557-1569 (1979).
3. G. H. Allcott, H. W. Lakin, "The Homogeneity of Six Geochemical Exploration Reference Samples," *Geochemical Exploration 1974*, Elsevier, New York, 1975, pp. 659-681.
4. J. G. Viets, "Determination of Silver, Bismuth, Cadmium, Copper, Lead, and Zinc in Geological Materials by Atomic Absorption Spectrometry with Tricaprylmethylammonium Chloride," *Anal. Chem.*, 50: 1097-1101 (1978).
5. J. M. Motooka, E. L. Mosier, S. J. Sutley, J. G. Viets, "Induction-coupled Plasma Determination of Ag, Au, Bi, Cd, Cu, Pb, and Zn in Geological Materials Using a Selective Extraction Technique - Preliminary Investigation," *Applied Spectroscopy*, 33, 456-460 (1979).
6. S. Terashima, "Determination of Arsenic in Rocks, Sediments, and Minerals by Arsine Generation and Atomic Absorption Spectrometry," *Anal. Chim. Acta*, 86: 43-51 (1976).
7. S. Terashima, "Rapid Determination of Total Carbon and Sulfur in Geological Materials by Combustion and Infrared Absorption Photometry," *Anal. Chim. Acta*, 101: 25-31 (1978).
8. R. F. Sanzolone, T. T. Chao, G. L. Crenshaw, "Atomic Absorption Spectrometric Determination of Cobalt, Nickel, and Copper in Geological Materials with Matrix Masking and Chelation-Extraction," *Anal. Chim. Acta*, 105: 247-253 (1979).
9. R. F. Sanzolone, T. T. Chao, "Atomic Absorption Spectrometric Determination of Copper, Zinc, and Lead in Geological Materials," *Anal. Chim. Acta*, 86: 163-168 (1976).
10. E. P. Welsch, T. T. Chao, "Determination of Trace Amounts of Antimony in Geological Materials by Atomic Absorption Spectrometry," *Anal. Chim. Acta*, 76: 65-69 (1975).
11. D. Knab, E. S. Gladney, "Determination of Selenium in Environmental Materials by Neutron Activation and Inorganic Ion Exchange," *Anal. Chem.*, 52: 825-828 (1980).
12. E. P. Welsch, T. T. Chao, "Determination of Trace Amounts of Tin in Geological Materials by Atomic Absorption Spectrometry," *Anal. Chim. Acta*, 82: 337-342 (1976).

REFERENCES (Continued)

13. T. T. Chao, R. F. Sanzolone, A. E. Hubert, "Flame and Flameless Atomic Absorption Determination of Tellurium in Geological Materials," *Anal. Chim. Acta* 96: 251-257 (1978).

TABLE I: SIX USGS GXR MATERIALS

<u>Standard Designation</u>	<u>DESCRIPTION: SOURCE</u>
GXR-1	Jasperoid: Drum Mountains, Utah
GXR-2	Soil: Park City, Utah
GXR-3	Fe-Mn-W-rich Hot Spring Deposit: Humboldt County, Nevada
GXR-4	Porphyry Copper Mill Heads: Utah
GXR-5	Soil (B zone): Somerset County, Maine
GXR-6	Soil (B zone): Davidson County, North Carolina

TABLE II: ARCHIVAL JOURNALS SURVEYED

<u>Journal</u>	<u>Volume Numbers Examined</u>
Analyst	97-104
Analytical Chemistry	43-51
Analytical Chimica Acta	53-106
Analytical Letters	5-12
Applied Spectroscopy	32-33
Atomic Absorption Newsletter	11-18
Chemical Geology	13-25
Environmental Science & Technology	6-13
Geochimica et Cosmochimica Acta	31-43
Geostandards Newsletter	1-3
International Journal of Applied Radiation and Isotopes	23-30
Journal of the Association of Official Analytical Chemists	55-62
Journal of Radioanalytical Chemistry	11-49
Microchemical Journal	17-24
Nuclear Instruments and Methods	114-155
Radiochemical and Radioanalytical Letters	9-39
Talanta	19-26
X-Ray Spectrometry	7

TABLE III
ELEMENTAL CONCENTRATIONS IN USGS GEOCHEMICAL EXPLORATION
REFERENCE SAMPLES DETERMINE BY LASL (2)

(ppm unless % indicated)

Element	GXR-1	GXR-2	GXR-3	GXR-4	GXR-5	GXR-6
Al%	3.54 ± 0.25	18.6 ± 0.4	-	7.40 ± 0.20	20.8 ± 1.6	16.6 ± 0.4
As	460 ± 30	31 ± 5	4000 ± 450	98 ± 10	12 ± 3	340 ± 30
B	15.3 ± 0.5	44 ± 1	180 ± 20	4.3 ± 0.4	25 ± 2	11 ± 1
Ba	560 ± 120	2000 ± 400	4700 ± 800	1350 ± 330	1800 ± 500	1100 ± 300
Be	1.12 ± 0.17	1.64 ± 0.09	26 ± 1	2.1 ± 0.2	1.19 ± 0.16	1.1 ± 0.1
Br	0.39 ± 0.07	3.0 ± 0.1	<100	0.50 ± 0.11	7.8 ± 0.9	1.4 ± 0.3
Ca	8700 ± 800	8200 ± 400	141000 ± 6000	9000 ± 500	7500 ± 600	970 ± 100
Ce	19 ± 4	50 ± 2	16 ± 4	114 ± 8	40 ± 2	38 ± 7
Co	9.3 ± 1.1	9 ± 2	48 ± 5	16 ± 2	30 ± 5	14 ± 3
Cr	10 ± 2	37 ± 10	19 ± 1	64 ± 10	100 ± 5	96 ± 10
Cs	4.0 ± 1.1	5.0 ± 0.9	200 ± 50	3 ± 1	2.2 ± 0.8	4.8 ± 1.7
Cu	1300 ± 100	69 ± 2	10.8 ± 0.8	6500 ± 200	360 ± 20	105 ± 12
Dy	3.1 ± 0.5	3.3 ± 0.6	-	2.6 ± 1.1	2.0 ± 0.4	2.8 ± 0.4
Eu	0.68 ± 0.07	0.80 ± 0.06	0.40 ± 0.10	1.6 ± 0.1	0.94 ± 0.06	0.78 ± 0.04
Fe (%)	24.7 ± 1.8	1.90 ± 0.23	18.6 ± 1.8	2.97 ± 0.43	3.19 ± 0.29	5.58 ± 0.42
Ga	12 ± 2	32 ± 3	<8	15 ± 1	34 ± 3	30 ± 6
Hf	1.1 ± 0.3	9.6 ± 0.3	2.4 ± 0.2	8.0 ± 0.5	6.2 ± 0.4	5.3 ± 0.3
Hg	3.9 ± 0.1	3.2 ± 0.2	0.38 ± 0.06	0.13 ± 0.01	0.17 ± 0.02	0.08 ± 0.01
K (%)	0.053 ± 0.009	1.41 ± 0.23	-	4.3 ± 0.6	0.82 ± 0.11	2.04 ± 0.25
La	6.1 ± 0.3	25 ± 1	8.5 ± 1.0	64 ± 5	19 ± 4	14 ± 2
Mg (%)	0.21 ± 0.01	0.88 ± 0.05	0.64 ± 0.05	1.65 ± 0.05	1.22 ± 0.05	0.62 ± 0.04
Mn	-	960 ± 100	22300 ± 2000	140 ± 20	280 ± 20	1000 ± 50
Mo	10 ± 2	1.5 ± 0.5	<6	310 ± 25	30 ± 4	1.7 ± 0.4
Na	550 ± 110	5540 ± 200	7800 ± 400	5300 ± 300	7700 ± 300	1040 ± 60
Ni	42 ± 10	18 ± 3	55 ± 5	38 ± 4	63 ± 7	22 ± 4
Pb	670 ± 20	615 ± 15	15 ± 2	-	22 ± 2	110 ± 10
Rb	29 ± 6	86 ± 5	116 ± 10	174 ± 7	40 ± 4	107 ± 7
Sb	124 ± 6	48 ± 5	40 ± 3	4.4 ± 0.8	2 ± 1	3.8 ± 0.7
Sc	1.7 ± 0.1	6.8 ± 0.2	18 ± 1	8.3 ± 0.4	7.8 ± 0.4	31 ± 1
Se	18.6 ± 0.8	0.74 ± 0.11	0.22 ± 0.02	6.0 ± 0.5	1.1 ± 0.1	1.07 ± 0.13
Si (%)	23.0 ± 1.3	23.0 ± 2.2	6.1 ± 1.4	31.3 ± 2.1	19.7 ± 1.2	22.9 ± 1.7
Sm	-	3.3 ± 0.6	1.0 ± 0.3	6 ± 1	2.9 ± 0.7	2.4 ± 0.6
Sr	280 ± 60	160 ± 23	1140 ± 100	220 ± 30	120 ± 20	42 ± 9
Ta	0.2 ± 0.1	0.76 ± 0.11	0.32 ± 0.11	0.77 ± 0.07	0.46 ± 0.08	0.52 ± 0.08
Tb	2.3 ± 0.4	8.3 ± 0.5	2.9 ± 0.4	22 ± 2	5.3 ± 0.5	5.2 ± 0.4
Ti	650 ± 50	2800 ± 300	1000 ± 200	2600 ± 300	2100 ± 300	5000 ± 400
U	34.8 ± 0.4	2.95 ± 0.07	3.1 ± 0.1	6.42 ± 0.25	2.13 ± 0.10	1.58 ± 0.08
V	88 ± 9	57 ± 20	39 ± 10	92 ± 15	60 ± 20	180 ± 20
W	-	1.8 ± 0.2	10800 ± 600	28 ± 5	0.5 ± 0.2	0.88 ± 0.18
Yb	1.8 ± 0.5	2.2 ± 0.2	0.76 ± 0.31	1.8 ± 0.1	2.0 ± 0.2	2.7 ± 0.3
Zn	740 ± 110	500 ± 60	220 ± 70	64 ± 10	50 ± 5	120 ± 20
Zr	66 ± 20	200 ± 40	<200	200 ± 40	140 ± 20	106 ± 8

TABLE IV: ELEMENTAL CONCENTRATIONS IN USGS GXR SAMPLES
DETERMINED BY VARIOUS INVESTIGATORS
(ppm unless % indicated)

Ele.	Ref.	Anal. Tech. ^a	GXR-1	GXR-2	GXR-3	GXR-4	GXR-5	GXR-6
Ag	1	A	29	16	2.8	4.3	1.9	1.9
		B	28	15	< 3	< 3	< 2	< 2
	3	C	29 ± 9	15 ± 2	< 0.5	3.6 ± 1.1	< 0.5	< 0.5
		D	29 ± 1	13 ± 1	1.7 ± 0.2	3.6 ± 0.2	1.3 ± 0.1	1.1 ± 0.1
	4	A	32.6 ± 0.9	17.4 ± 0.6	0.06 ± 0.01	3.64 ± 0.05	0.82 ± 0.03	0.29 ± 0.02
	5	C	32.6 ± 1.8	17.7 ± 0.5	0.17 ± 0.04	3.8 ± 0.1	0.77 ± 0.02	0.35 ± 0.03
As	6	A	436	23.3	3980	103	11.8	297
Au	1	A	3.4±0.9	0.10 ± 0.09	0.12 ± 0.16	0.65 ± 0.28	0.08 ± 0.10	0.13 ± 0.07
		E	3.9 ± 0.6	< 0.3	< 0.3	0.75	< 0.3	< 0.3
		F	3.2	0.03 → 0.55	0.03 → 0.16	0.6	0.01 → 0.43	0.11 → 0.41
	3	C	< 10	< 10	< 10	< 10	< 10	< 10
		D	3.1 ± 0.2	0.04 ± 0.01	0.06 ± 0.01	0.64 ± 0.06	0.13 ± 0.03	0.08 ± 0.03
	5	C	3.4 ± 0.2	-	0.6 ± 0.1	0.65 ± 0.19	-	0.12 ± 0.01
Bi	1	F	1000	< 20	105	50	70	60
	3	C	540 ± 97	< 10	< 10	14 ± 2	< 10	< 10
	4	A	1725 ± 24	0.4	< 0.2	21.2 ± 0.8	0.4	0.2
	5	C	1204 ± 23	-	23 ± 4	18.8 ± 0.4	-	-
C(%)	1	G	0.11 → 0.53	2.5 → 5.5	1.2 ± 0.2	< 0.05 → 3.8	1.7 ± 0.2	0.15 ± 0.04
	7	G	0.17	2.64	1.33	0.06	1.65	0.18

Ele.	Ref.	Anal. a					
		Tech. a					
		GXR-1	GXR-2	GXR-3	GXR-4	GXR-5	GXR-6
Cd	3	C	< 20	< 20	< 10	< 20	< 20
		D	2.1 ± 0.1	1.7 ± 0.1	0.89 ± 0.07	< 0.2	< 0.2
	4	A	3.0 ± 0.1	0.39 ± 0.02	0.34 ± 0.02	0.14 ± 0.02	0.11 ± 0.02
	5	C	4.0 ± 0.3	1.6 ± 0.3	0.5 ± 0.1	0.22 ± 0.04	0.18 ± 0.05
Co	8	A	8.8 ± 0.4	8.3 ± 0.4	59 ± 1	16.6 ± 0.7	13.6 ± 0.6
Cu	5	C	999 ± 16	71 ± 2	8.2 ± 0.7	6487 ± 117	323 ± 19
	8	A	1129 ± 36	63 ± 2	14.2 ± 0.4	6780 ± 170	308 ± 14
	9	A	1000 ± 6	74	9	6860 ± 75	360 ± 5
F	7	F	1400	> 40,000	2800	600	600
		H	1300 ± 200	430 ± 200	81000 ± 13000	250 ± 140	270 ± 170
Ge	1	C	< 10	< 10	110 ± 34	< 10	< 10
H ₂ O ⁺ (%)	1	K	3.4 ± 0.6	2.9 ± 0.3	4.8 ± 0.5	2.0 ± 0.3	2.9 ± 0.7
H ₂ O ⁻ (%)	1	K	1.5 ± 0.5	2.24 ± 0.09	3.0	0.7 ± 0.4	2.2 ± 0.8
In	3	D	0.94 ± 0.21	< 0.2	< 0.2	< 0.2	0.35 ± 0.10
Li	1	A	7.7 ± 1.9	52 ± 12	107 ± 28	12 ± 3	39 ± 8
		I	7.7 ± 0.9	56 ± 2	131 ± 2	11 ± 2	42 ± 2
Nb	1	A	52.8	24.8	79.9	42.4	80.8
		B	-	12	-	14	-
		C	14 ± 4	13 ± 6	38 ± 40	< 10	< 10
	3	C	< 10	< 10	< 20	< 20	< 10
Ni	8	A	42 ± 2	14.4 ± 0.6	60 ± 2	43.5 ± 0.4	52 ± 2
							24.8 ± 0.9

Ele.	Ref.	Anal. Tech. ^a	GXR-1	GXR-2	GXR-3	GXR-4	GXR-5	GXR-6
P	1	B	440 ± 220	440 ± 350	< 40 → 2000	480	300 ± 100	300 ± 200
		F	400 ± 200	300 ± 100	700 ± 50	900 ± 100	130 ± 90	220 ± 170
		K	700	1100	1000	1000	740	1000
Pb	5	C	692 ± 32	651 ± 38	23 ± 2	41 ± 1	15 ± 2	96 ± 7
	9	A	825 ± 17	725 ± 8	20 ± 1	54 ± 1	16 ± 1	100 ± 2
Pd	1	C	< 4	< 4	< 4	< 4	< 4	< 4
		F	-	-	1.5	-	-	-
Pt	1	F	0.3	0.1	-	0.1	0.05	0.1
S	1	B	4100 ± 800	-	5000 ± 600	21900±4400	-	-
		J	2600 ± 200	-	2300 ± 400	17500 ± 800	-	-
	7	G	2436	315	2420	17600	278	131
Sb	10	A	98 ± 5	44 ± 2	21.9 ± 0.8	5.1 ± 0.3	1.6 ± 0.1	2.8 ± 0.3
Se	11	L	19 ± 1	0.8 ± 0.2	0.22 ± 0.03	6.0 ± 0.6	1.2 ± 0.2	1.2 ± 0.2
Sn	1	A	64	< 1	< 1	6	1	2
		B	34 → 470	1 → 120	< 1 → < 50	2 → 160	< 1 → 350	3 → 1080
		C	64 ± 30	< 10	< 10	< 10	< 10	< 10
		F	60 ± 32	15 ± 6	108 ± 6b	15 ± 8	12 ± 7	< 0.15 → 30
	3	C	63 ± 11	< 10	< 10	< 10	< 10	< 10
	12	A	55 ± 1	-	-	-	-	-
Te	1	A	16.1	3.3	0.11	1.2	0.15	0.08
	3	D	-	< 0.5	< 0.5	1.0 ± 0.4	< 0.5	< 0.5
	13	A	8.7 ± 0.1	0.88 ± 0.01	0.009 ± 0.002	1.0 ± 0.1	-	0.016±0.001

Ele.	Ref.	Anal.	GXR-1	GXR-2	GXR-3	GXR-4	GXR-5	GXR-6
		Tech. ^a						
Tl	3	D	< 0.02	1.3 ± 0.1	4.2 ± 0.4	3.8 ± 0.3	0.4 ± 0.1	2.8 ± 0.2
Y	1	C	40 ± 14	15 ± 4	18 ± 6	14 ± 5	15 ± 5	15 ± 6
	3	C	57 ± 11	16 ± 1	16 ± 2	12 ± 3	16 ± 3	14 ± 3
Zn	5	C	670 ± 40	425 ± 18	83 ± 7	63 ± 3	37 ± 3	104 ± 12
	9	A	675 ± 8	470 ± 12	204 ± 2	76 ± 2	51 ± 2	100 ± 2

^a A = atomic absorption
 B = x-ray fluorescence
 C = optical emission spectrometry
 D = atomic absorption + colorimetry
 E = fire assay
 F = colorimetry
 G = combustion
 H = ion selective electrode
 I = flame emission
 J = titration
 K = unidentified
 L = radiochemical neutron activation analysis

TABLE V: DISSOLUTION METHODS

<u>Letter Key</u>	<u>Reagents Used for Sample Dissolution</u>
A	Conc. HNO_3
B	Dil. HNO_3
C	6N HCl
D	HF
E	HClO_4
F	Na_2O_2 fusion
G	LiBO_2 fusion
H	$\text{HNO}_3 + \text{HCl}$
I	$\text{HNO}_3 + \text{HClO}_4$
J	$\text{HNO}_3 + \text{HF}$
K	$\text{HNO}_3 + \text{HgNO}_3$
L	$\text{HF} + \text{HCl}$
M	$\text{HF} + \text{HClO}_4$
N	$\text{HF} + \text{HNO}_3 + \text{HCl}$
O	$\text{HF} + \text{HNO}_3 + \text{H}_2\text{SO}_4$
P	$\text{HCl} + \text{HNO}_3 + \text{KClO}_4$
Q	$\text{HCl} + \text{HNO}_3 + \text{HClO}_4$
R	$\text{HF} + \text{HNO}_3 + \text{HClO}_4 + \text{HCl}$
S	$\text{HF} + \text{HClO}_4 + \text{HCl}$
T	$\text{HF} + \text{HNO}_3 + \text{HClO}_4$

TABLE VI: INFLUENCE OF DISSOLUTION METHOD ON THE DETERMINATION
OF ALUMINUM IN GEOLOGICAL MATERIAL BY ATOMIC ABSORPTION

<u>Dissolution Method</u>	<u>No. Samples</u>	<u>Al (%)</u>					
		<u>GXR-1</u>	<u>GXR-2</u>	<u>GXR-3</u>	<u>GXR-4</u>	<u>GXR-5</u>	<u>GXR-6</u>
F	2	3.7	16.3	6.19	7.46	19.2	15.6
G	1	3.62	18.7	5.92	7.04	21.7	16.4
L	2	3.9	17.8	7.14	7.09	21.2	16.5
M	2	0.52	5.19	2.64	4.74	5.45	7.62
N	2	3.22	18.8	6.61	6.40	22.1	18.4
R	4	1.18	7.41	3.32	5.77	7.25	9.68

TABLE VII: INFLUENCE OF DISSOLUTION METHOD ON THE DETERMINATION OF SILVER
IN GEOLOGICAL MATRICES BY ATOMIC ABSORPTION

Dissolution Method	No. Samples	Ag (ppm)					
		GXR-1	GXR-2	GXR-3	GXR-4	GXR-5	GXR-6
A	28	28.5 ± 11.5	15 ± 6	2.8 ± 0.3	3.6 ± 0.9	2.0 ± 1.7	1.7 ± 0.4
B	6	5.5 ± 3.0	8.9 ± 4.8	2.1 ± 0.5	3.7 ± 0.4	2.0 ± 1.1	1.6 ± 0.5
E	16	38 ± 6	20 ± 2	4 ± 1	6 ± 1	3 ± 1	3 ± 1
H	43	31 ± 5	19 ± 8	2.6 ± 1.0	4.2 ± 0.8	1.6 ± 1.1	1.4 ± 0.6
I	38	26 ± 12	12 ± 7	2.9 ± 1.0	4.2 ± 1.2	1.6 ± 0.5	2.1 ± 1.5
R	19	31 ± 6	19 ± 3	2.5 ± 1.0	4.4 ± 1.3	1.8 ± 0.5	2 ± 2

TABLE VIII: INFLUENCE OF DISSOLUTION METHOD ON THE DETERMINATION OF CALCIUM
IN GEOLOGICAL MATERIALS BY ATOMIC ABSORPTION

Dissolution Method	No. Samples	Ca (%)					
		GXR-1	GXR-2	GXR-3	GXR-4	GXR-5	GXR-6
G	4	0.87 ± 0.07	0.93 ± 0.07	13.8 ± 0.2	1.00 ± 0.08	0.79 ± 0.11	0.23 ± 0.04
I	14	0.56 ± 0.14	0.34 ± 0.19	13.8 ± 1.6	0.42 ± 0.17	0.29 ± 0.18	$0.024 \rightarrow 0.14$
L	2	1.1	0.97	15.4	1.1	0.90	0.20
M	8	0.93 ± 0.17	0.88 ± 0.19	12.1 ± 0.7	1.06 ± 0.13	0.85 ± 0.14	0.32 ± 0.12
N	2	1.2	0.92	13.0	1.1	1.0	0.30
R	8	0.93 ± 0.05	0.91 ± 0.11	$6.9 \rightarrow 13.9$	1.06 ± 0.12	0.81 ± 0.07	$0.21 \rightarrow 0.90$

TABLE IX: INFLUENCE OF DISSOLUTION METHOD ON THE DETERMINATION OF IRON
IN GEOLOGICAL MATERIALS BY ATOMIC ABSORPTION

Dissolution Method	Samples	Fe (%)					
		GXR-1	GXR-2	GXR-3	GXR-4	GXR-5	GXR-6
A	24	17.0 ± 1.5	1.56 ± 0.15	13.3 ± 3.9	2.83 ± 0.16	3.02 ± 0.21	4.96 ± 0.38
D	2	> 20	2.10	-	3.00	3.81	6.30
E	2	23.0	2.30	13.4	4.00	3.80	5.70
F	4	24.8 ± 1.9	2.08 ± 0.10	19.6 ± 0.5	2.94 ± 0.18	3.33 ± 0.27	5.37 ± 0.43
G	1	24.6	1.92	19.6	3.13	3.29	5.80
H	2 - 8	23.8 ± 1.7	1.42	19.0 ± 1.2	2.88	2.94	5.37
I	9	24.0 ± 4.0	1.84 ± 0.13	18.1 ± 1.7	2.90 ± 0.85	3.52 ± 0.68	5.43 ± 0.45
N	6	25.9 ± 0.7	1.85 ± 0.25	20.0 ± 0.1	3.17 ± 0.19	3.66 ± 0.08	5.73 ± 0.21
Q	10	24.1 ± 2.0	1.78 ± 0.13	19.6 ± 1.0	3.13 ± 0.15	3.21 ± 0.28	5.60 ± 0.33
R	12 - 20	25.2 ± 1.5	1.94 ± 0.15	19.2 ± 1.3	3.13 ± 0.20	3.51 ± 0.29	5.41 ± 0.34
S	12	24.9 ± 1.7	1.92 ± 0.17	19.4 ± 1.8	3.17 ± 0.19	3.51 ± 0.22	5.47 ± 0.63

TABLE X: INFLUENCE OF DISSOLUTION METHOD ON THE DETERMINATION OF MANGANESE
IN GEOLOGICAL MATERIALS BY ATOMIC ABSORPTION

Dissolution Method	No. Samples	Mn (ppm)					
		GXR-1	GXR-2	GXR-3	GXR-4	GXR-5	GXR-6
A	7	810 ± 100	870 ± 180	3100 ± 1000	100 ± 40	160 ± 60	620 ± 290
C	2	910	1000	22750	140	250	1050
D	2	820	940	23000	160	280	940
E	6	810 ± 160	970 ± 80	9900 ± 900	160 ± 10	240 ± 20	1020 ± 40
F	2	900	980	23200	150	320	1040
G	2	780	860	23400	210	300	1030
H	22	820 ± 140	950 ± 120	20300 ± 5900	140 ± 30	240 ± 40	850 ± 140
I	37	830 ± 150	910 ± 140	14200 ± 8900	130 ± 20	220 ± 30	920 ± 180
L	12	870 ± 60	950 ± 70	23100 ± 1400	170 ± 20	300 ± 20	910 ± 160
M	2	880	850	18000	225	270	850
N	8	940 ± 50	1000 ± 60	23800 ± 500	170 ± 20	310 ± 30	1100 ± 80
O	1	700	800	17600	150	212	900
P	2	1100	1200	32000	180	320	1200
Q	10	970 ± 140	1000 ± 220	24900 ± 4100	140 ± 30	240 ± 50	1030 ± 230
R	20	900 ± 20	1000 ± 70	21700 ± 3100	150 ± 10	290 ± 30	1020 ± 90
T	10	880 ± 80	950 ± 100	23000 ± 1600	150 ± 10	290 ± 60	910 ± 160