SPECTROCHEMICAL ANALYSIS OF THE MOLDAVITES

(Ba, Li, Sr, and Rb)

by

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ABSTRACT

Spectrographic analysis of twenty-six Moldavites was made on the elements of barium, lithium, strontium, and rubidium using G-1 and W-1 as standard mixtures.

The concentration of each element found ranges from 848 to 1220 in barium, 18 to 27 in lithium, 61 to 153 in strontium, and 94 to 155 in rubidium with average relative deviations of 15.5, 8.9, 21.1, and 13.1 % respectively.

The relative accuracies of strontium and rubidium determinations by spectrographic method was compared with those by X-ray fluorescence analysis with average errors of 29.0 and 14.5 % respectively.

The regional variations of the elements in the Moldavites were found insignificant within the experimental errors.

On the basis of strontium, rubidium, and lithium contents it was found that the Moldavites are most similar to the low-calcium granite, while rubidium-strontium ratio most closely resembles to that of shale.

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LIST OF TABLES

LIST OF TABLES (CONTINUED)

TABLE OF CONTENTS

INTRODUCTION

The present paper is concerned mainly with the abundance of trace elements of lithium, rubidium, barium and strontium in Moldavites of which sources are listed in appendix A. A few workers have made estimates of the abundance of lithium (Goldschmidt et al., 1933; Cohen, 1959), rubidium (Pinson et al., 1958; Cohen, 1959; Schnetzler and Pinson, 1963), barium (Vorobév, 1960), and strontium (Pinson et al., 1958; Cohen, 1959; Vorobév, 1960; Schnetzler and Pinson, 1963) in Moldavites.

Doubts as to the unusually high content of lithium and rubidium in Moldavites as reported by Cohen in 1959 have been expressed in the past (Schnetzler and Pinson, 1963; Taylor, 1960). It seemed, therefore, desirable to make careful determinations of those elements in one group of Moldavites.

For the present purpose spectrographic method of analysis was chosen because of its versatility, speed, sensitivity, and satisfactory accuracy and precision.

ANALYTICAL METHOD

Equipment and analytical conditions

Hilger large quartz and glass spectrograph and unit of multisource as power supply (manufactured by Allen B. Du Mont Lab.) were used throughout the experiment. A Hilger non-recording densitometer was, also, used to read the intensities of the analytical lines of each element.

Analytical conditions are listed in Table 1.

Table 1. Analytical conditions

Excitation source	D.C. arc, anode
Amperage	4 amp.
Voltage	320 volts
Analytical gap	7 mm
Spectral region	3200 - 8000 Å
Optics	Quartz
Slit width	30 μ
Electrodes	Cathode: National Carbon Co., Carbon L 3866
	Anode: National Carbon Co., Graphite L 3803

The sample electrode, anode, was of size of a 1.5 mm-diameter crater 3 mm deep. The counter-electrode was a three sixteenths of an inch pointed carbon rod. Samples were arced to completion (about 120 sec.) and the spectral region was recorded on Kodak 1 N plates. Plate calibration was accomplished by a "two-line" procedure for each element.

A 1:4 step-ratio-sector with the first top step unsectored was employed to cover the concentrations of the elements of interest. The following lines were used for analysis:

Rb	7947.60 Å
Li	6707.844 Å
Sr	4607.331 Å
Ba	4554.042 Å

Sample Preparation

The samples submitted for analysis were in powder state which was obtained by crushing them in boron-carbide mortar. Neither screening

the samples nor diluting with graphite powder was made not only to eliminate and reduce the possible contamination during the procedure but also to increase the sensitivities.

The use of an internal standard was avoided in the present analysis. Instead, the samples were weighed out to make weight corrections for the final results. The weight of sample used for a single electrode ranged form 6.00 mg to 8.32 mg.

Standards preparation

Two series of the standards were prepared by mixing a standard Moldavite, T 5310, with G-1 or W-1 in the ratios of 4:1 or 3:1 (the standard Moldavite to G-1 or W-1) by weight. The standards were finely ground again in a boron-carbide mortar, and were kept in plastic capsules.

RESULTS

The standard addition method (Ahrens and Taylor, 1961) was used to determine the elements in the standard Moldavite. Here the successive approximations were also made because of the fortuitous points in each case.

The intensities of the elements in standard Moldavite are shown in Table 2. The intensities were calculated from the quadruplicates of pure standard Moldavite and 1:4 ratio of the standard Moldavite to G-1 or W-1, and triplicate of 1:3 ratio of the standard Moldavite to G-1 or W-1.

The standard Moldavite was recorded in triplicate on each plate to estimate the elements of interest in other Moldavites which were also run in triplicate.

Table 2. Intensities of Ba, Li, Sr, and Rb
in standard Moldavite, T 5310.
(arbitary unit)

Standard Mixtures		Ba		Li		Sr		Rb	
		G-1	W-1	G-1	W-1	G-1	W-1	G-1	W-1
T 5310		7.87	6.88	4.74	4.35	9.12	8.13	3.85	1.69
		5.79	5.64	3.79	4.17	6.29	7.11	3.15	1.47
		6.75	6.09	5.01	4.17	9.64	6.77	4.85	1.41
		6.09	5.73	4.07	4.38	7.52	8.79	3.05	1.59
	Av.	6.63	6.09	4.40	4.27	8.14	7.70	3.72	1.54
	E %	14.9	9.2	13.0	2.7	19.6	11.2	22.6	8.9
4:1		7.47	5.79	4.76	4.09	10.8	10.5	3.96	1.88
		5.16	5.82	3.55	4.20	5.44*	11.1	2.24	1.34
		5.34	5.70	3.97	3.71	8.00	10.4	3.07	1.14
		7.65	6.12	4.27	4.18	9.80	11.4	3.29	1.57
	Av.	6.41	5.86	4.14	4.05	9.54	10.9	3.14	1.48
	E %	20.9	3.1	12.4	4.5	15.3	5.1	5.1	6.9
3:1		6.79	5.17	4.76	4.15	8.41	11.3	4.00	1.33
		5.77	6.23	4.08	4.27	12.5	11.4	3.73	1.34
		6.17	5.80	3.93	3.93	9.75	11.85	3.32	1.31
	Av.	6.27	5.73	4.26	4.12	10.2	11.5	3.68	1.31
	E %	8.3	9.7	10.4	4.3	20.5	2.6	9.3	3.3
Grand	E%	14.7	7.3	11.9	3.8	18.5	6.3	12.0	6.4

* Discarded.

The G-1 and W-1 standard mixtures were recorded in Plate no.10 and 11 respectively.

Precision and accuracy

Precisions were based on the triplicate runs of each Moldavite. They were expressed in the relative deviations (Table 4 to 13). For more accurate results the latest values on rubidium and strontium in G-1 and W-1 were used. These values were determined by Pinson and his coworkers in 1963.

Results of lithium and barium in G-1 and W-1 reported by Fleisher and Stevens in 1961 were also used.

	Ba	Li	Sr	Rb (p.p.m. unit)
G-1	1300	24	258	215
W-1	225	12	194	23.2

From the data listed above and the results shown in Table 2 the following values were obtained for each element in the standard Moldavite.

Table 3. Contents of Ba, Li, Sr, and Rb in the standard Moldavite.

Elements	Found from G-1 std. mix.	Found from W-1 std. mix.	Average (p.p.m.)
Ba	1550	500	1025
Li	30	15	23
Sr	130	65	98
Rb	221	50	136

The relative accuracies of spectrographic determinations on rubidium and strontium were compared with results obtained by X-ray fluorescence method. They were shown in Table 14 and 15.

Table 4. Intensities of the elements

(Plate no. 9)

Samples		Ba, 4554 A	Li, 6708 A	Sr, 4607 A	Rb, 7948 A
T 5310		6.37	4.71	9.81	2.22
		4.89	4.35	7.16	2.19
		5.62	5.17	6.68	2.87
	Av.	5.63	4.74	7.88	2.43
	E %	13.4	8.6	21.5	15.8
T 5296 a		5.26	4.49	5.27	2.06
		4.44	4.16	3.99	2.33
		5.15	5.07	5.47	2.56
	Av.	4.95	4.57	4.91	2.32
	E %	8.9	10.1	16.3	10.8
T 5296 b		6.42	4.34	7.08	2.17
		5.18	4.50	8.74	1.76
		6.74	5.49	11.4	3.15
	Av.	6.11	4.78	9.07	2.36
	E %	13.4	13.0	24.2	30.1
T 5296 c		5.08	4.62	12.2	1.70
		5.54	4.91	7.94	2.67
	Av.	5.31	4.77	10.1	2.19
	E %	4.3	2.9	19.9	25.5

Table 5. Intensities of the elements

(Plate no. 12)

Samples	Ba, 4554 A	Li, 6708 A	Sr, 4607 A	Rb, 7948 A
T 5296 c	6.65	5.25	8.54	1.71
T 5310	6.89	4.55	7.49	2.21
	6.09	4.34	7.04	1.76
	7.38	4.90	10.7	1.74
Av.	6.79	4.60	8.41	1.90
E %	9.6	6.2	24.3	14.0
T 5296 d	6.51	4.96	12.0	2.00
	4.46	3.74	8.11	1.32
	6.75	3.04	12.8	1.26
Av.	5.91	3.91	11.0	1.53
E %	21.3	24.8	15.4	26.8
T 5296 e	6.55	4.41	12.4	1.75
	6.64	4.42	8.26	1.37
Av.	6.60	4.42	10.3	1.56
E %	0.6	0.2	20.4	12.2
T 5296 f	4.19	4.36	8.96	1.71
	7.42	4.73	11.1	1.35
Av.	5.81	4.55	10.0	1.53
E %	27.7	4.0	11.1	11.8

Table 6. Intensities of the elements.

(plate no. 13)

Samples	Ba, 4554 A	Li, 6708 A	Sr, 4607 A	Rb, 7948 A
T 5296 e	7.25	5.35	13.0	1.74
T 5296 f	7.00	5.12	9.80	1.62
T 5310	5.90	4.42	6.89	1.57
	5.84	4.76	6.70	1.67
	5.67	4.68	7.23	1.84
Av.	5.80	4.62	6.94	1.69
E %	2.1	3.9	3.9	8.8
T 5296 g	5.56	4.61	10.6	1.60
	7.31	4.61	7.62	1.86
	5.59	4.55	8.54	1.19
Av.	6.15	4.59	8.92	1.55
E %	16.4	0.7	16.6	21.9
T 5296 h	6.00	4.43	10.2	1.46
	7.52	4.74	12.0	1.58
	6.72	5.03	10.6	1.84
Av.	6.75	4.73	10.9	1.63
E %	11.3	6.3	8.7	11.7

Table 7. Intensities of the elements.

(Plate no. 14)

Samples	Ba, 4554 A	Li, 6708 A	Sr, 4607 A	Rb, 7948 A
T 5310	6.44	5.36	8.87	1.74
	6.60	4.78	7.82	1.63
	7.76	5.51	9.70	1.66
Av.	6.93	5.21	8.80	1.68
E %	10.4	10.6	10.6	3.4
T 5296 i	6.09	5.16	7.54	1.81
	5.93	4.33	8.72	1.02
	5.95	4.19	8.93	1.01
Av.	5.99	4.56	8.40	1.28
E %	1.5	11.4	8.9	35.9
T 5309	6.28	4.71	7.85	2.32
	7.89	4.85	9.33	1.26
	6.14	2.64	7.00	1.37
Av.	6.77	4.07	8.06	1.32
E %	14.3	30.5	14.6	4.5
T 5311	6.36	4.39	6.50	1.27
	7.37	5.09	8.14	1.41
Av.	6.87	4.74	7.32	1.34
E %	7.4	7.4	11.2	5.2

Table 8. Intensities of the elements.

(Plate no. 15)

Samples	Ba, 4554 A	Li, 6708 A	Sr, 4607 A	Rb, 7948 A
T 5311	9.20*	9.37*	8.28*	1.67*
T 5310	9.83*	9.51*	11.8*	1.87*
	3.94	6.95	7.63	1.51
	2.22	6.43	3.37	1.36
	Av. 5.33	7.63	7.60	1.58
	E % 74.7	21.6	55.3	19.1
T 5312	8.89*	10.2*	17.3*	1.94*
	3.43	7.88	6.06	2.20
	2.70	8.63	5.00	1.77
	Av. 5.01	8.91	9.45	1.97
	E % 67.4	13.3	78.5	11.2
T 5313	7.96*	9.32*	12.7*	1.80*
	2.98	7.92	5.06	1.49
	Av. 5.47	8.62	8.88	1.65
	E % 45.5	8.1	42.7	9.1
T 5314	4.64	7.67	6.37	1.52
	2.84	6.94	2.49	1.17
	Av. 3.74	7.31	4.33	1.35
	E % 24.0	4.9	43.7	13.3

* These data were corrected for the final results on the basis of sample T 5310 which also had the serious fluctuations.

Table 9. Intensities of the elements.

(Plate no. 16)

Samples	Ba, 4554 A	Li, 6708 A	Sr, 4607 A	Rb, 7948 A
T 5313	4.80	9.04	8.29	1.96
T 5314	4.00	7.69	3.63	1.36
T 5310	3.93	7.47	6.70	1.43
	3.80	6.94	4.72	1.43
	4.03	7.14	5.43	1.61
	Av. 3.92	7.19	5.62	1.49
	E % 2.8	4.5	17.9	7.0
T 5315	4.00	7.33	7.65	1.56
	3.88	6.88	4.93	1.41
	4.98	6.60	6.75	1.51
	Av. 4.29	6.94	6.44	1.49
	E % 14.0	5.3	21.6	5.4
T 5316	3.91	7.11	5.46	1.36
	4.38	7.33	4.69	2.02
	4.28	7.20	4.78	1.31
	Av. 4.19	7.21	4.98	1.56
	E % 6.0	1.8	8.4	8.0

Table 10. Intensities of the elements.
(Plate no. 17)

Samples		Ba, 4554 A	Li, 6708 A	Sr, 4607 A	Rb, 7948 A
T 5310		6.46	9.47	12.8	2.42
		6.71	8.76	8.40	2.03
		5.94	7.49	8.07	2.27
	Av.	6.37	8.57	9.76	2.24
	E %	6.8	11.7	27.1	7.7
T 5317		6.22	8.50	9.35	1.83
		6.24	8.84	11.1	1.70
		6.55	8.64	11.3	1.91
	Av.	6.34	8.66	10.6	1.81
	E %	3.0	2.0	10.1	6.1
T 5318		7.06	9.24	11.5	1.42
		5.55	8.69	11.4	2.74
		5.65	9.45	10.3	2.66
	Av.	6.09	9.13	11.1	2.27
	E %	13.8	4.3	5.8	32.6
T 5319		3.85	8.38	4.67	1.84
		5.31	8.83	7.06	2.08
	Av.	4.58	8.61	5.87	1.96
	E %	16.6	2.6	20.5	6.1

Table 11. Intensities of the elements.
(Plate no. 18)

Samples	Ba, 4554 A	Li, 6708 A	Sr, 4607 A	Rb, 7948 A
T 5319	6.65	9.59	8.22	2.07
T 5310	5.86	8.95	6.64	2.62
	4.42	8.01	6.71	2.03
	5.51	9.35	7.69	1.86
	Av. 5.26	8.77	7.51	2.17
	E % 14.3	7.8	8.4	18.4
T 5320	4.53	8.97	5.04	1.99
	4.21	8.70	4.15	1.37
	5.56	9.82	6.87	2.43
	Av. 4.77	9.16	5.35	1.93
	E % 14.9	6.3	26.0	21.2
T 5321	5.29	6.67	5.37	1.73
	6.32	9.69	9.40	2.26
	Av. 5.81	8.18	7.39	2.00
	E % 8.8	18.5	27.2	13.0
T 5322	4.80	5.97	3.26	1.11
	4.67	8.15	5.42	2.05
	Av. 4.74	7.06	4.34	1.58
	E % 1.3	15.4	24.9	29.7

Table 12. Intensities of the elements.

(Plate no. 19)

Samples	Ba, 4554 A	Li, 6708 A	Sr, 4607 A	Rb, 7948 A
T 5321	4.82	7.97	5.46	1.40
T 5322	5.41	8.12	6.18	1.79
T 5310	5.01	8.09	5.72	2.49
	5.17	7.44	8.94	2.33
	4.78	7.98	7.91	1.74
Av.	4.99	7.84	7.52	2.19
E %	3.9	4.8	21.6	18.0
T 5323	4.59	8.57	8.01	1.81
	4.73	7.94	5.32	1.50
	5.26	6.62	7.21	1.21
Av.	4.86	7.71	6.85	1.51
E %	7.2	13.0	20.1	19.9
T 5324	3.73	10.4	9.02	2.62
	4.88	8.25	7.64	1.95
	5.02	8.54	6.67	1.99
Av.	4.54	9.06	7.78	2.19
E %	15.6	12.3	15.2	16.0

Table 13. Intensities of the elements.
(Plate no. 20)

Samples	Ba, 4554 A	Li, 6708 A	Sr, 4607 A	Rb, 7948 A
T 5310	8.60	7.72	10.6	1.67
	6.84	7.24	6.60	1.98
	5.36	6.34	6.80	1.79
	Av. 6.93	7.10	8.00	1.81
	E % 23.4	9.9	28.2	8.7
T 5325	6.49	8.01	6.02	1.33
	6.42	7.61	5.62	1.38
	4.76	7.50	6.64	1.36
	Av. 5.89	7.71	6.09	1.36
	E % 16.8	3.5	8.4	2.2
Grand E %	15.5	8.9	21.1	13.1

By using the data in Table 3 and Table 4 to 13, the remaining Tables were made.

Table 14. Accuracy of the strontium anlysis

Samples	Found from G-1 std. mix.	Found from W-1 std. mix.	Average	Found from X-ray anal.	E %
T 5296 a	81	40	61	131	- 53.5
T 5296 b	150	74	112	161	- 30.4
T 5296 c	150	74	112	145	- 22.8
T 5296 d	171	84	128	148	- 13.5
T 5296 e	201	101	151	151	0
T 5296 f	169	84	127	150	- 15.3
T 5296 g	166	83	125	---	---
T 5296 h	204	102	153	---	---
T 5296 i	125	62	94	---	---
T 5309	120	59	90	137	- 34.2
T 5310	130	65	98	134	- 26.3
T 5311	100	50	75	136	- 44.9
T 5312	191	95	143	149	- 4.0
T 5313	166	83	125	138	- 9.4
T 5314	95	47	71	121	- 41.3
T 5315	148	74	111	150	- 26.0
T 5316	116	58	87	123	- 29.2
T 5317	142	71	107	160	- 33.1
T 5318	148	74	111	140	- 20.7
T 5319	116	58	87	123	- 29.2
T 5320	99	50	75	134	- 44.0
T 5321	116	58	87	133	- 34.6
T 5322	94	47	72	137	- 48.1
T 5323	118	59	89	144	- 38.2
T 5324	134	67	101	137	- 26.3
T 5325	99	50	75	131	- 42.7
			Av. 103	140	- 29.0

--- Not determined.

Table 15. Accuracy of the rubidium analysis

Samples	Found from G-1 std. mix.	Found from W- 1 std. mix.	Average	Found from X-ray anal.	± E %
T 5296 a	211	48	130	145	- 10.3
T 5296 b	214	49	132	149	- 11.4
T 5296 c	200	45	123	142	- 13.4
T 5296 d	178	43	111	127	- 12.6
T 5296 e	155	47	101	138	- 26.8
T 5296 f	145	46	96	146	- 34.2
T 5296 g	202	46	124	not determined	not determ.
T 5296 h	213	48	132	not determined	not determ.
T 5296 i	166	38	102	not determined	not determ.
T 5309	173	39	106	130	- 18.4
T 5310	221	50	136	141	- 3.5
T 5311	187	43	115	136	- 11.8
T 5312	230	52	141	148	- 4.7
T 5313	252	57	155	139	+ 11.5
T 5314	176	40	108	136	- 20.6
T 5315	221	50	136	130	+ 4.6
T 5316	232	53	143	140	+ 2.1
T 5317	179	40	110	121	- 9.1
T 5318	226	51	138	133	+ 3.8
T 5319	202	46	124	146	- 15.1
T 5320	248	56	152	147	+ 3.4
T 5321	173	39	106	138	- 23.2
T 5322	171	39	105	142	- 26.0
T 5323	152	35	94	121	- 22.3
T 5324	221	50	136	161	- 15.5
T 5325	166	38	102	145	- 29.8
			Av. 121	139	14.5

Table 16. Barium and lithium in the Moldavites.

	Barium			Lithium		
Samples	Found from G-1 std. mix.	Found from W-1 std. mix.	Av.	Found from G-1 std. mix.	Found from W-1 std. mix.	Av.
T 5296 a	1350	440	895	29	15	22
T 5296 b	1840	600	1220	33	17	25
T 5296 c	1260	435	848	27	14	21
T 5296 d	1340	440	890	36	18	27
T 5296 e	1720	560	1140	33	17	25
T 5296 f	1590	520	1050	32	16	24
T 5296 g	1640	530	1085	30	15	23
T 5296 h	1800	580	1190	34	17	26
T 5296 i	1340	435	898	26	13	20
T 5309	1510	490	1000	23	12	18
T 5310	1550	500	1025	30	15	23
T 5311	1490	485	988	28	14	21
T 5312	1390	450	920	32	16	24
T 5313	1570	425	998	34	17	21
T 5314	1730	560	1145	33	17	25
T 5315	1690	545	1123	29	15	22
T 5316	1650	535	1098	30	15	23
T 5317	1530	485	1008	30	15	23
T 5318	1470	480	975	32	16	24
T 5319	1530	495	1010	32	16	24
T 5320	1520	455	993	31	16	24
T 5321	1590	520	1050	30	15	23
T 5322	1540	500	1010	28	14	21
T 5323	1510	490	1000	30	15	23
T 5324	1410	460	935	35	18	27
T 5325	1310	430	870	33	17	25
		Grand Av.	1015			Grand Av. 23

Table 17. Barium, lithium, strontium, rubidium, and rubidium-strontium ratio.

Samples	Barium	Lithium	Rubidium	Strontium	Rb/Sr
T 5296 a	895	22	130	61	2.24
T 5296 b	1220	25	132	112	1.18
T 5296 c	850	21	123	112	1.10
T 5296 d	890	27	111	128	0.87
T 5296 e	1140	25	101	151	0.67
T 5296 f	1050	24	96	127	0.76
T 5296 g	1085	23	124	125	0.99
T 5296 h	1190	26	132	153	0.86
T 5296 i	890	20	102	94	1.08
T 5309	1000	18	106	90	1.18
T 5310	1025	23	136	98	1.39
T 5311	990	21	115	75	1.53
T 5312	920	24	141	143	0.99
T 5313	1000	21	155	125	1.24
T 5314	1145	25	108	71	1.51
T 5315	1120	22	136	111	1.22
T 5316	1090	23	143	87	1.64
T 5317	1010	23	110	107	1.03
T 5318	975	24	138	111	1.24
T 5319	1010	24	124	87	1.42
T 5320	990	24	152	75	2.03
T 5321	1050	23	106	87	1.21
T 5322	1010	21	105	71	1.48
T 5323	1000	23	94	89	1.06
T 5324	935	27	136	101	1.35
T 5325	870	25	102	75	1.36
Av.	1015	23	121	103	1.26

Discussion of the results

Barium

In 1960 Vorobev reported 3600 p.p.m. of barium in the Moldavites. This value was found significantly different from the average value, 1015, which was found in this experiment. Barium ranged from 848 to 1220 in the Moldavites analyzed.

Lithium

All the determinations reported on lithium have been made by spectrographic analysis. Yet there seems to be no decent agreement among the results reported. The content of lithium found by the present method lies somewhere between 24 and 40 p.p.m. of lithium for average low-calcium granite and 15 p.p.m. of lithium for average sandstone which were reported by Turekian and Wedepohl in 1961.

The range of lithium found in the present work, 18-27, is still in disagreement with Cohen's 650 p.p.m. reported in 1959 from two Moldavites and one Australite.

Rubidium

The average value, 121, for rubidium is in good agreement with reported values of 130 (Pinson et al., 1958) and 146 (Schnetzler and Pinson, 1963). It is in disagreement with Cohen's 950 p.p.m. of rubidium reported in 1959. A fairly range of variability, 94-155, was found for rubidium in the Moldavites.

Tektites are known to contain about 70 to 150 p.p.m. of rubidium.

The found value, 121, can be compared to 170 p.p.m. of rubidium of average low-calcium granite (Turekian and Wedepohl, 1961).

Strontium

Strontium in the Moldavites analyzed ranged from 61 to 153 in this experiment. This is quite comparable to the general range of strontium in tektites, which lies between 80 and 300 p.p.m..

The average strontium content, 103, is lower than both 550 (Cohen, 1959) and 600 (Vorobev, 1960). It is, however, fairly close to 136 (Pinson et al., 1958; Schnetzler and Pinson, 1963).

Average low-calcium granite is known to contain about 100 p.p.m. of strontium (Turekian and Wedepohl, 1961). In 1962 Taylor reported 225 p.p.m. of strontium in the mixture of 75 per cent shale and 25 per cent quartz.

Rubidium-strontium ratio

The average rubidium-strontium ratio, 1.26, is comparable to 1.07, 0.96, and 0.95 which were reported by Schnetzler and Pinson in 1964. Average rubidium-strontium ratio of shale, 1.57 (Faure, 1961; Whitney, 1962) is the closest value to 1.26 among the other terrestrial materials reported.

In chondrites and achondrites the ratios are known 0.54 and 0.003 respectively (Gast, 1960 and 1961).

Disparity of results obtained from G-1 and W-1 series used as the standard mixtures: It is interesting to note that the G-1 standard mixtures give higher values on all the elements than the W-1 standard mixtures as shown in Table 3. It was also found that the G-1 standard mixtures, compared to W-1 standard mixtures, had larger relative deviations as listed in Table 2.

The rather startling disparity between the determinations of all the elements when using the two standard mixtures seems to indicate that there is either a very serious

(1) matrix effect or

(2) poor precision in standard mixtures or

(3) mishandling the standards (weighing and mixing the standards).

The second and third possibilities to introduce such a disparity can be reduced and eliminated by repeating the experiment. The first possibility, however, could not be answered easily unless the samples are identical. The approach to this problem lies partly in the continuous improvement in the standards used.

Considering the poor precision obtained in the present analysis, even though the spectrogrphic analysis is known to be capable of providing data with a precision of at least 10 per cent, it would be worth trying the experiment with various series of standard mixtures such as 1:1, 1:2, 1:3, 1:4 (G-1 or W-1), pure G-1, pure W-1, and even mixture of G-1 and W-1 with Moldavite sample.

CONCLUSION

Under the present experimental conditions the elements can be determined with average relative deviations of 15.5, 8.9, 21.1, and 13.1 % for barium, lithium, strontium, and rubidium.

Compared to X-ray fluorescence technique the average accuracy of the analysis was found 29.0 for strontium and 14.5 % for rubidium.

The present investigation reveals that Cohen's reported values on rubidium and lithium, and Vorobev's value on barium are higher than those found in this experiment. Result on average strontium was ,however, found very close to Pinson, and Schnetzler and Pinson's reported values.

On the basis of strontium, rubidium, lithium contents the Moldavites are found most similar to the low-calcium granite, while the Rb/Sr ratio resembles most closely to shale.

It was also found that the regional variations between the Moldavites analyzed were insignificant in barium, lithium, stromtium, rubidium contents within experimental errors.

Further spectrographic analysis of Moldavites is in progress on nickel, copper, chromium, vanadium, zirconium, manganese, and titanium elements

APPENDIX A.

Source of samples

Samples	Localities
T 5296	Lhenice, Bohemia
T 5309	Lhenice, Bohemia
T 5310	Lhenice, Bohemia
T 5311	Dolut Chvastany, Bohemia
T 5312	Habří, Bohemia
T 5313	Habvi, Bohemia
T 5414	Slávče, Bohemia
T 5415	Vvábče, Bohemia
T 5416	Vvabce, Bohemia
T 5417	Kvoelov, Bohemia
T 5418	Kvoelov, Bohemia
T 5419	Něchov, Bohemia
T 5420	Slavice, Movavia
T 5421	Kožichovice, Movavia
T 5422	Slavětce, Movavia
T 5423	Dukovany, Movavia
T 5424	Dukovany, Movavia
T 5425	Dukovany, Movavia

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