A SEARCH FOR LUNA 20 BASALTS. David J. Lindstrom[1] and Rene R. Martinez[2].
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The soil samples returned by Luna 20 are of highlands composition, similar to those from Apollo 16. Basalts are rare, in spite of the proximity of the Very Low Titanium (VLT) basalts of Mare Crisium only 35 to 40 km to the south and the high-alumina basalts of Mare Fecunditatis about 120 km to the north. This study utilizes a micro-coring technique to remove from thin section grain mounts small samples previously described as basalts and to analyze them for trace elements by micro INAA techniques [1-3]. Only one of the six samples analyzed appears to be a basalt.

Samples. The Luna 20 samples are not attractive candidates for detailed study, being fine-grained soils dominated by highly processed anorthositic highlands rocks. Much of the work done on the samples is described in a volume published soon after the original allocations 23 years ago [4]. Previous petrographic studies of lithic fragments have identified basalts in low abundance ranging from 1 of 236 particles [5] to 8 of 157 [6]. With the exception of one recent analysis [7], no trace element data are available on these basalt samples. We attempted to analyze all 10 of the samples identified as basalts, but were hampered by the loss of several thin sections and the photomosaics or other identifying information. We examined petrographically and in backscattered images the grain mount thin sections from which basalts had been reported, and made our best guesses of which particles might conceivably been called basalts by previous workers. One attractive basalt (SAO 514-11 of [5]) was lost in drilling. We finally succeeded in analyzing seven samples, including two 150 µm cores from the large olivine vitrophyre SAO 504-7 [8], now renumbered 22003,9012.

Major element analysis. Microprobe analyses were required both for comparison with previously published analyses of the particles [8] and for normalization of abundances from INAA, since the core samples are too small (~0.1-6 µg) to weigh accurately. For the fine-grained vitrophyre, the beam was rastered over several 100 µm square areas. For the other samples, digital backscattered electron images were processed to obtain modes, which were combined with spot analyses of the minerals to estimate the bulk composition. Agreement with defocused beam analyses of [8] was not very good, but was at least sufficient to tell whether the right particles were being analyzed.

Discussion. Only one particle actually appears to be a basalt. It contains about 39% plagioclase (~An_{81}), 59% pyroxene, and 2% opaques. The reconstructed bulk composition is given in the table. It is slightly richer in Al and Ca than the analysis of UNM 8,7 given by [8]. The rare earth and other trace element contents show some resemblence to Luna 16 basalts (see table and figure), but differ in important details. This basalt has lower LREE by a factor of two and about 50% lower HREE, but most importantly, it has a deep Eu anomaly, unlike the Luna 16 basalts. It is also much lower in TiO_2 and Hf than Luna 16 basalts.

The two microcore samples of olivine vitrophyre 22003,9012 were quite similar in composition, so their average is given in the table and plotted in the figure. This composition is clearly KREEPY, and to some extent resembles vitrophyres from 14321 [9], being nearly identical in LREE contents and the abundances of alkali and alkaline earth elements. Sizable differences exist, however. This rock is much poorer in Sc (0.2x), Cr (0.4x), and Co (0.15x) and richer in Th

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(2x) and U (4x) than the 14321 vitrophyres. It is also more magnesian, with bulk mg'=77 compared to 52 for the 14321 vitrophyres, and much more aluminous.

Other samples include a particle from 22002, 18, which was chosen as the particle most likely to have been analyzed as UNM 11,34 by [8]. Significant differences in the apparent major element composition may be explained by its small size and coarse grain size, but the mode of 39% plagioclase and 59% pyroxene is not unreasonable. Our INAA analyses of the bulk particle suggest that it is richer in pyroxene and poorer in plagioclase than the analyses of the exposed surface indicate. The very high Sc content and low, upward-sloping rare earth pattern suggest that it is a cumulate of highland affinity. 22002,23 does not resembles the published analysis of UNM 17,57, being far too aluminous and too low in Cr, but is interesting because of its very high HREE and Hf contents. Trace element-enriched phases were not observed in thin section. Finally, 22002,25 resembles the published analysis of UNM 20,44, but contains only 21% plagioclase and is far too low in rare earths etc. to be a basalt.

Conclusions. It was hoped that previous workers' efforts could be used to narrow the search for scarce rock types in grain mounts, but the disappearance of the detailed documentation and the difficulty in reproducing defocused beam analyses made this project largely a failure. The one basalt and one vitrophyre are interesting compositions, but their obvious rarity makes them little more than curiosities.

References

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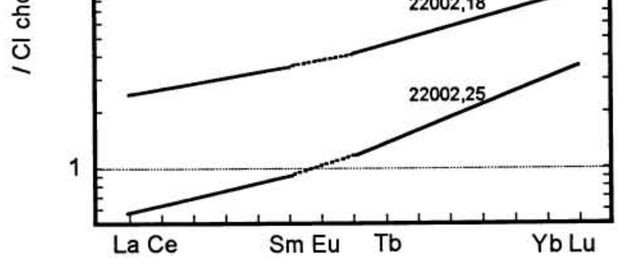
	basalts		vitrophyres		other particles 22002,xx		
	22003 ,29	Luna 16 avg. [10]	22003 ,9012	14321 avg. [9]	,18	,23	,25
μg	4.9		3.9		0.13	0.16	1.2
TiO_2	1.8	5.1	0.4	2.5	0.8	1.5	0.8
Al_2O_3	13.1	13.3	22.7	12.6	14.3	18.5	8.3
FeO	15.7	18.6	4.3	16.8	15.7	13.7	18.0
MgO	5.9	7	8.0	10.4	5.5	4.4	13.7
CaO	13.8	11.8	12.4	10.5	14.6	14.5	10.6
Na_2O	0.39	0.52	0.76	0.80	0.27	0.71	0.05
K_2O	0.08	0.20	0.29	0.1	0.16	0.25	0.02
Sc	72	66	11.0	59	101	29	23
Cr	2270	1500	1150	3000	1510	226	1570
Co	10.9	17	3.9	29	12	6.6	48
Ni	<50	—	50	30	<110	<100	93
La	9.9	19.5	19	19	0.6	15	0.13
Ce	29.	53	50	52	—	42	—
Sm	6.5	13.8	8.6	9.9	0.52	12.8	0.14
Eu	1.1	3.4	0.85	1.2	<0.9	2.0	<0.3
Tb	1.3	2.5	1.5	2.3	<0.4	3.5	<0.1
Yb	5.6	8.2	6.0	6.8	1.3	18	0.5
Lu	0.80	1.2	0.79	0.97	0.2	2.5	0.1
Hf	4.1	11.2	6.7	7.9	<1.4	8.0	<0.4
Th	1.1	1.9	3.3	1.5	<0.6	1.7	<0.2
U	0.4	—	1.7	0.4	<0.7	<1.3	<0.1
mg'	40	41	77	43	39	37	58



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