THE PETROGENETIC INTERPRETATION OF TINY FRAGMENTS OF EVOLVED LUNAR ROCKS: AN ANALOG ANALYSIS OF THE ABRIACHAN GRANITE, SCOTLAND. Graham Ryder and Jeffrey Gillis, Lunar and Planetary Institute, Center for Advanced Space Studies, 3600 Bay Area Blvd., Houston, TX 77058-1113.

Many lunar evolved plutonic rocks such as quartzmonzodiorites and granites exist only as small fragments. Most chemical analyses are performed on very tiny fragments, rarely as much as 50 mg and commonly much less. Frequently these analyses are interpreted as if they are representative of a much larger volume of rock, and quite specific petrogenetic constraints have been placed on the lithologies, the inferred parental magmas, and the evolutionary processes of the Moon from these fragments. We are studying splits of 5 small handsamples from a single exposure of the Abriachan granite (Scotland) in an attempt to see how much can really be inferred from the chemistry of such tiny fragments. We are making chemical analyses of splits in a hierarchy of sizes to see what inferences that are made from analyses of large fragments can still be reasonably inferred from analyses of small fragments. We are using multiple subsamples from each sample that are 1g, 50mg, and 20 mg, as well as mineral separates and thin sections from each sample. We report our first work on chemical analyses. The results suggest that petrogenetic interpretations made even on 50 mg samples should be treated with caution.

The Abriachan granite is one of the smaller of the Newer Caledonian Granites of Scotland, which are dominantly between 410 and 390 Ma old. Samples were collected at a roadcut on the NW shore of Loch Ness. Their grain size is similar to many lunar "granitic" rocks, major phases (quartz, feldspars, biotite, and hornblende) being about 1mm across. All 5 small handsamples (~4 to 7cm) were collected within about 10m of each other. We assume that all have an essentially common origin. Although part of the Abriachan granite is fenitised with secondary crocidolite infilling fractures along with aegirine and hematite [1,2], the outcrop was in the unfenitised part, and did not contain any obvious fenitisation features. Our analyses show that our samples are similar to those of "unaltered" Abriachan granite [2], not fenitised i.e. not enriched in any of Fe, Na, K, or Ba, nor depleted in Rb. The data show that the Abriachan granite is a fairly typical Newer Caledonian Granite, with a sloping rare earth pattern enriched in the light rare earths, and lacking a Eu anomaly (Figs. 1,2).

We have so far subjected 29 subsamples to neutron activation analysis for a typical suite of elements at the Johnson Space Center using the standard irradiation, counting, and reduction techniques. Each sample was broken up. For each sample, two subsamples each with a total mass of about 1g (A1, A2, B1, etc.), and two subsamples each about 50mg (A1-50, A2-50, B1-50, etc.) were taken. From sample D, 7 subsamples of about 20 mg (D1-20, D3-20, etc.) were also taken. Subsamples were selected only on the basis of appropriate size and freshness. All samples were ground to a homogenized fine powder for analysis. For the powders from the 1g samples, about 50mg was irradiated, with duplicates for sample D. Smaller subsamples were entirely irradiated. The Figures show only some of the rare earth element (REE) comparisons. (Because of higher uncertainties and some yet-to-be-explained anomalies in the Tb data, these are not included.)

We have not yet had time to fully investigate the data, and must be content to make general statements. Fig. 1 shows the REE abundances for all subsamples, normalized to chondritic abundances, and Fig. 2 those for the 1g subsamples alone. The REEs vary among subsamples by a factor of about 4 in abundance, although the patterns are reasonably similar; other incompatible elements such as Th vary similarly. The extremes are not 20 mg subsamples but 50 mg samples (A2-50 lowest and C2-50 highest). However, the range in the 1g samples is not much less than the range among all samples, and this is not much less than the range reported among average different rock types from zoned Newer Granites [e.g. 3]. The average for all 50mg subsamples is only slightly different from the average for all 1g samples. Among other elements, Fe varies by factor of 2.7, K by 2.7, Na by 2.5, and Rb by 2.3. In Figs. 3 to 6, the average of the 1g subsamples is used as the normalizing factor because that allows the differences to be seen more clearly.

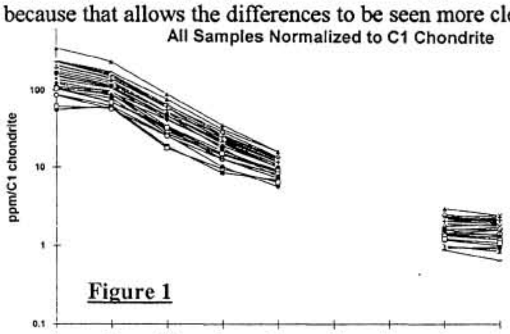

Figure 1

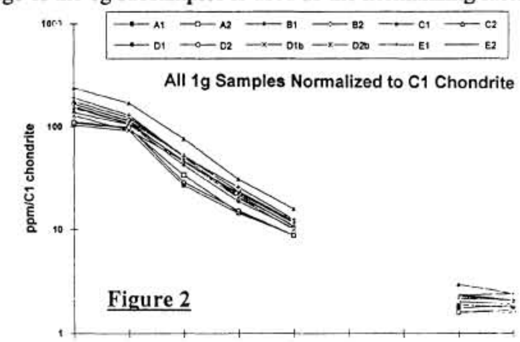

Figure 2

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Differences among 1g samples: There are clear differences among the 5 samples that contribute significantly to the total variation. Figs. 2 and 3 show that each of the subsamples from one sample (e.g. A1 and A2) are more similar to each other than to the other samples, although there is some overlap. The duplicate subsamples of D are reasonably similar, though not within analytical uncertainty. Among all 1g subsamples, REE abundances roughly correlate positively with Fe and K, showing some mineralogical or modal contribution to the variation. Subsamples with higher incompatible element abundances have a slight comparative enrichment in light REEs.

Differences among 1g and 50mg samples: Because of the differences among the samples, the 50mg subsamples are best compared with the 1g samples from the same sample. Figs. 4 to 6 for subsamples from A, C, and D (with 1g samples shown in bolded lines) show that the 50mg subsamples tend to retain roughly the REE pattern of the 1g subsamples. However, this is not very consistent, and the abundances are erratic, varying by a factor of at least 2. Subsamples from B and E are more consistently like the average in pattern.

Differences among 1g and 20mg samples: Only subsamples from D have been analyzed at the 20mg size (Fig. 6). The REEs vary in abundance by a factor of 2 to 3. They deviate in pattern slightly from average D in being slightly more enriched in light rare earths.

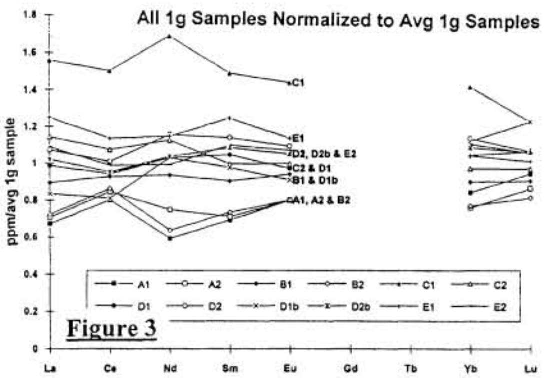

Figure 3

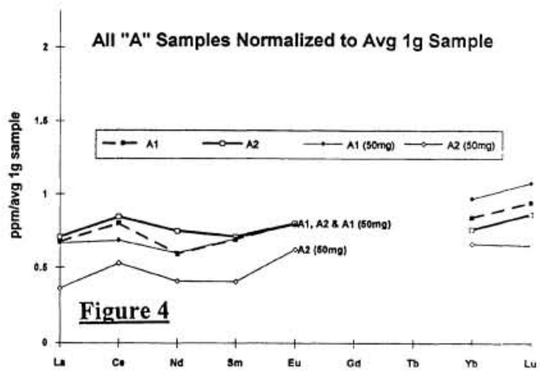

Figure 4

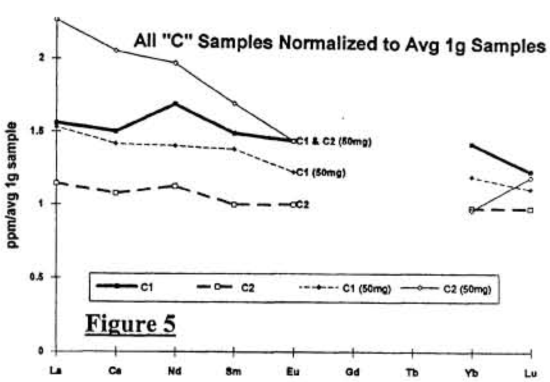

Figure 5

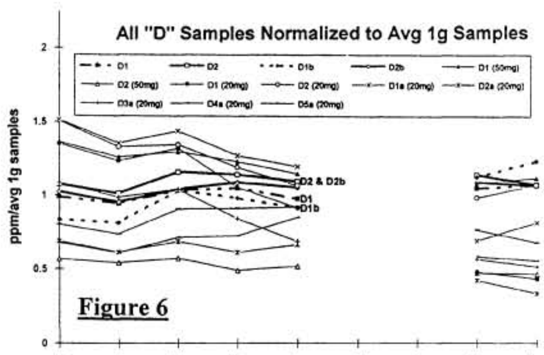

Figure 6

Preliminary conclusions: Small subsamples of the Abriachan granite show that there are significant differences in chemistry at the handsample level even though the samples were collected from a homogeneous-appearing outcrop and from within a few meters of each other. Tiny subsamples deviate from the handsample abundances by factors up to 2 or 3, and to some extent in REE patterns. Without further constraints from the mineralogy and petrography, it is clear that caution should be used in making petrogenetic inferences from the chemistry. We plan to further model the data in terms of petrogenetic constraints, to make analyses of more 20 mg samples, to analyze mineral separates, and to study thin section of each sample to evaluate pitfalls in the interpretation of tiny subsamples of granites.

References: [1] Deans T. et al. (1971) Nat. Phys. Sci. 234, p 145. [2] Garson M. et al. (1984) J. Geol. Soc. London 141, p. 711. [3] Harmon R. et al. (1984) Phil. Trans. R. Soc. London A 310, p. 709.