REE AND SELECTED MINOR AND TRACE ELEMENT MICRODISTRIBUTIONS IN SOME PRISTINE LUNAR HIGHLANDS ROCKS. Christine F. Heavilon and Ghislaine Crozaz. Earth and Planetary Sciences Department and McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130 USA.

Pristine rocks from the lunar highlands generally fall into one of two groups: the ferroan anorthosites, or FAN group, and a Mg-rich suite of rocks which includes norites, troctolites and a dunite. On a graph of anorthite (An) content of the plagioclase vs. mg# in the coexisting mafic minerals (Figure 1), the two groups are clearly separated, indicating that they did not originate from the same magma.

In an attempt to further characterize the nature of the origin of pristine highlands rocks, Bersch et al (1, 2) measured, with the electron microprobe, minor element concentrations in the mafic minerals of a wide variety of pristine samples. They concluded, as previously suggested by others, that numerous parent magmas are required to produce the Mg-rich suite of rocks (1). The FAN suite shows coherent differentiation trends (particularly Cr vs. Mn in low Ca pyroxenes) suggesting that these rocks may be related to a single magma, perhaps a magma ocean (2).

We have recently initiated an ion microprobe study of the major silicate minerals in several pristine lunar highlands rocks. Secondary ion mass spectrometry is a much more sensitive technique for the detection of minor and trace elements than electron beam microanalysis. In particular, rare-earth elements (REE), which are very good indicators of igneous processes, may be measured in individual grains of most major silicates. An additional advantage of SIMS over other techniques available to measure trace elements, is that measurements may be made in-situ. This allows the data to be evaluated in a petrologic context and eliminates contamination problems associated with mineral separates.

We present here preliminary data for three pristine samples. Two are FANs (60055,5 and 67637,7), selected for the difference in their plagioclase composition (Figure 1). The third sample is the troctolite, 76535,46 from the Mg-rich trend. We are particularly interested in determining the extent of REE abundance variations in minerals of the same type throughout the FAN suite.

67637,7 is a cataclastic anorthosite, in which the plagioclase is of composition An94.5. It is thus termed a Na-rich FAN. Figure 2 shows representative REE patterns for plagioclase, olivine and pyroxene from this sample. Plagioclase is LREE-enriched with La = 1xC1and Lu = .2xC1. It has a large positive Eu anomaly (Eu/Eu* ~ 32). Pyroxene has much higher REE concentrations (La = 6xC1, Lu= 68xC1), and the REE pattern has a large negative Eu anomaly (Eu/Eu* = .03). The olivine REE pattern is somewhat irregular, but shows a strong enrichment of the HREE (Lu = 10xC1). The LREE abundances in olivine should be considered as upper limits because of unusually high and variable noise during these measurements.

60055,5, a porous ferroan anorthosite, is 98% plagioclase of composition An96 and 2% tiny pyroxenes, most of which are high Ca pyroxenes (3). The rock has undergone extensive cataclasis, but does not appear to have been annealed. Figure 3 shows a REE pattern for a plagioclase from this sample. The three plagioclase grains analyzed so far have nearly identical patterns. La is at about 0.4xC1, Lu at .08xC1 and Eu/Eu* is 44. The mafic minerals in this sample have not yet been analyzed. A comparison of plagioclase REE patterns in 67637,7 and 60055,5 shows that the 67637,7 plagioclase has higher REE concentrations (by a factor of about 2.5) and a smaller Eu anomaly, as would be expected from the higher Na content in this plagioclase, if the two samples represent different stages of crystallization from the same magma.

76535,46 is a coarse-grained troctolitic granulite (4) that contains olivine (60%), plagioclase (35%) and low Ca pyroxene (5%). It is thought to be an original cumulate, deposited at depths between 10 and 30 km (5). A REE pattern for plagioclase is shown in Figure 3. La is at 10xC1 and Lu is at 1xC1. The size of the Eu anomaly is much smaller than for the two FANs (Eu/Eu* = 4.4). These plagioclase measurements are in agreeement with those obtained by INAA from plagioclase mineral separates by Haskin et al (6). Pyroxenes in this sample are HREE enriched (Yb = 30xC1) but LREE could not be determined because of the unusually high background noise during these measurements.

Data for a number of trace elements vs. Na content in plagioclase plot in distinct regions. The separation is particularly good for the LREE (see La, Fig.4a), Ba (Fig.4b), and K. Nb and Rb abundances show much higher grain-to-grain variations. The three rocks cannot be distinguished by Sr abundances in plagioclase.

(1) M.G. Bersch, G. J.Taylor and K. Keil (1986) LPSC XVII, 44-45. (2) M. G. Bersch, G.J. Taylor and K. Keil (1988) LPSC XIX, 67-68. (3) P.H. Warren and J.T. Wasson (1978) PLPSC 9th, 185-217. (4) R.F. Dymek, A.L. Albee and A.A. Chodos (1975) PLSC 6th, 301-341. (5) R. Gooley, R. Brett and J. Warner (1974) GCA **38**, 1329-1339. (6) L.A. Haskin, C.-Y. Shih, B.M. Bansal, J.M. Rhodes, H. Wiesmann and L.E. Nyquist (1974) PLSC 5th, 1213-1225.

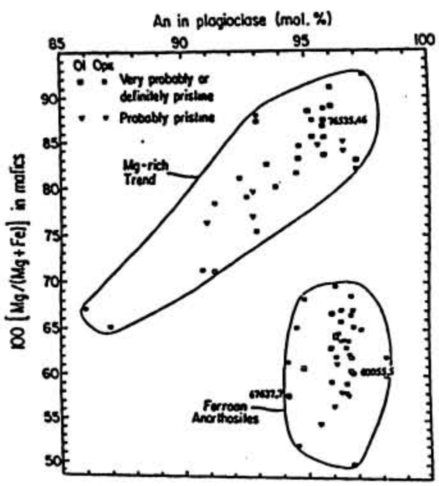

Figure 1. An Content of plagioclase vs. mg# in coexisting mafic minerals in pristine nonmare rocks (Adapted from Warren and Wasson, 1979 Proc. Conf. Lunar Highlands Crust, 81-99).

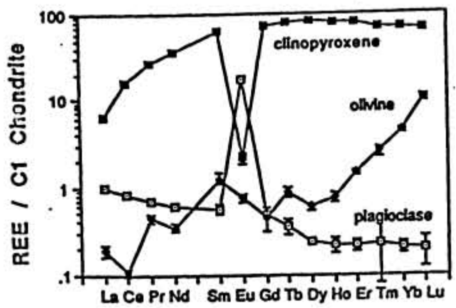

Figure 2. C1 chondrite-normalized REE abundances in individual grains of clinopyroxene, olivine and plagioclase from 67637,7

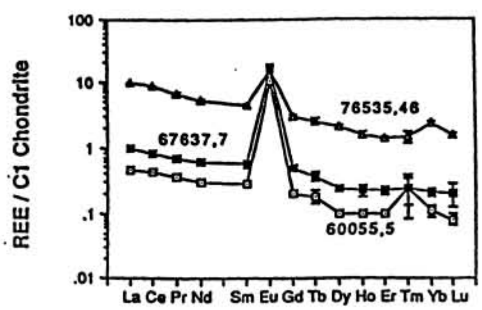

Figure 3. C1 chondrite-normalized REE abundances in individual grains of plagioclase.

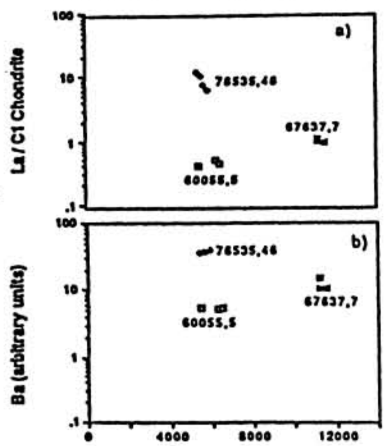

Figure 4. Individual plagioclase analyses from each sample: a) La vs. Na; b) Ba vs. Na.