LUNAR FERROAN ANORTHOSITE SUBGROUPS; J. J. McGee, U. S. Geological Survey, Reston, VA 22092

Introduction: The concept that the entire suite of ferroan anorthosites was derived from a single parent magma, such as might be expected by crystallization of a magma ocean, is being evaluated by comparing internally consistent compositional data for the minerals in the ferroan anorthosite subgroups (mafic magnesian, mafic ferroan, anorthositic ferroan and, anorthositic sodic) identified by James *et al.* [1]. Data for relic igneous clasts are obtained in order to attempt to examine igneous compositional variations. These data will aid in evaluating the petrogenetic significance of the anorthosite subgroups. A previous report [2] presented extensive data for the anorthositic ferroan (or "typical") subgroup. In this report, data are reported for the following samples from the other three subgroups: 67635,8 and 67637,9 (anorthositic sodic); 15437,4 (mafic magnesian); 67915,12 (mafic ferroan).

Characteristics of 'typical' ferroan anorthosites: These rocks have < 5%, relatively ferroan, mafic minerals. In most of the typical anorthosites, low-Ca pyroxene is the dominant mafic mineral; mg' [100 x molar Mg/(Mg+Fe)] generally ranges from 52 to 67. Rocks with homogeneous pyroxenes appear to be monomict, whereas the anorthosites with heterogeneous pyroxenes are interpreted as polymict. The overall continuity of pyroxene compositions, however, suggests that all of the lithologies within the polymict rocks were derived from ferroan anorthosite-suite rocks. Concentrations of the minor elements Al, Ti, Cr, and Mn in pyroxenes show somewhat varied behavior. Cr and Ti contents of low-Ca pyroxenes are approximately constant across the entire range of mg' in the anorthosites, and there is a uniform amount of excess Al, substituting as $^{VI}Al$-$^{IV}Al$, in the pyroxenes. The Mn contents of the pyroxenes show some variation, with the more magnesian pyroxenes having more varied Mn than the Fe-rich pyroxenes. Anorthite [100 x molar Ca/(Ca+Na+K)] contents of plagioclase in the "typical" anorthosites range from $An_{95.9}$ to $An_{98.9}$ [2]. Nearly all the anorthosites show systematic trends of decreasing magnesium and iron concentrations in plagioclase as the An content increases. Post-crystallization reequilibration and shock deformation have redistributed the minor element contents of some samples. For example, 15415 plagioclase shows little variation in either Fe or Mg and has homogeneous An content. This homogeneity appears to be a product of metamorphic recrystallization and reequilibration, as supported by this sample's annealed polygonal texture. Plagioclases in the more highly shocked anorthosites show considerable scatter in their Fe and Mg contents, presumably due to redistribution during shock. The overall variation of plagioclase An content versus low-Ca pyroxene mg' in the typical anorthosites shows no clear trend.

Anorthositic sodic subgroup: The two samples studied, 67635 and 67637, are granulated and sheared and contain abundant plagioclase fragments, as much as 0.5 mm across, and < 1% mafic minerals. Two large (~2 mm), sheared granulitic, partly disaggregated lithic clasts are present in 67635. The mafic minerals in 67635 are homogeneous high-Ca (mg' = 77.5) and low-Ca (mg' = 68.8) pyroxene. In 67637, pyroxene compositions are slightly more varied (high-Ca pyroxene mg' = 72-75; low-Ca pyroxene mg' = 60-70), and olivine (mg' = 57-63.5) is present. Plagioclase compositions (Fig. 1) have similar ranges ($An_{94}$ -$An_{98}$) and averages ($An_{95}$-$An_{96}$) in both samples. Plagioclase FeO and MgO contents show regular trends as a function of An content, with somewhat more variation in FeO in 67637's plagioclase (Fig. 1).

Mafic magnesian subgroup: Anorthosite 15437 is shocked and granulated; most clasts are angular mineral fragments of twinned plagioclase, as much as 1 mm across, but matrix areas have some polygonalized texture, a remnant of annealing. Mafic minerals are locally concentrated and make up ~5-8% of the sample. Mafic-mineral compositions are homogeneous and relatively magnesian (low-Ca pyroxene mg' = 73.5; high-Ca pyroxene mg' = 81.5; olivine mg' = 67.5). Plagioclase compositions have a range of $An_{96.5}$-$An_{99}$ and average $An_{97.3}$ (Fig. 1). Plagioclase FeO and MgO show smooth,

slightly declining trends as An increases (Fig. 1). One nicely preserved lithic clast, 1 mm across, has intergranular texture with twinned plagioclase (0.3 mm) and a large (0.1 x 0.3 mm) interstitial, high-Ca pyroxene grain; the mineral compositions are similar to those in the rest of the sample.

Mafic ferroan subgroup: Anorthosite 67915,12 is a clast from a polymict breccia. The anorthosite has been shocked, granulated and sheared, and its plagioclase has been partly converted to maskelynite. The rock contains ~5% mafic minerals, as much as 1 mm across. Olivine is the most abundant of these. Mafic mineral compositions are fairly homogeneous (low-Ca pyroxene mg' = 67.5; high-Ca pyroxene mg' = 75.5; olivine mg' = 59). Plagioclase compositions have a range of $An_{94.9}$-$An_{98.3}$ and average $An_{95.8}$ (Fig. 1). Plagioclase FeO and MgO trends are somewhat scattered, presumably due to redistribution during shock deformation .

Discussion: As in the "typical" anorthosites, in the samples of the other three subgroups the FeO and MgO contents of plagioclase decrease regularly as An content increases (Fig. 1). FeO contents of plagioclase are higher than MgO contents; in the anorthositic sodic samples, MgO is nearly undetectable in the high-An plagioclase, but increases in the low-An plagioclases, consistent with the trends observed in the other samples (Fig. 1). The mg' of plagioclase shows a weak but negative correlation with An content in 67635, 67637, and 67915. Coexisting relict low-Ca pyroxene/plagioclase pairs among the samples show no clear correlations of mg' in low-Ca pyroxene with plagioclase An content. The consistent patterns of variation of FeO and MgO in plagioclase in all the ferroan anorthosites suggest that the ferroan anorthosite subgroups are related and that crystallization conditions have been partly preserved through their disturbed history.

References: [1] James O.B., Lindstrom M.M. and Flohr M.K. (1989) PLPSC 19, 219-243. [2] McGee J.J. (1993) J. Geophysical Research-*Planets*, v. 98, 9089-9105.

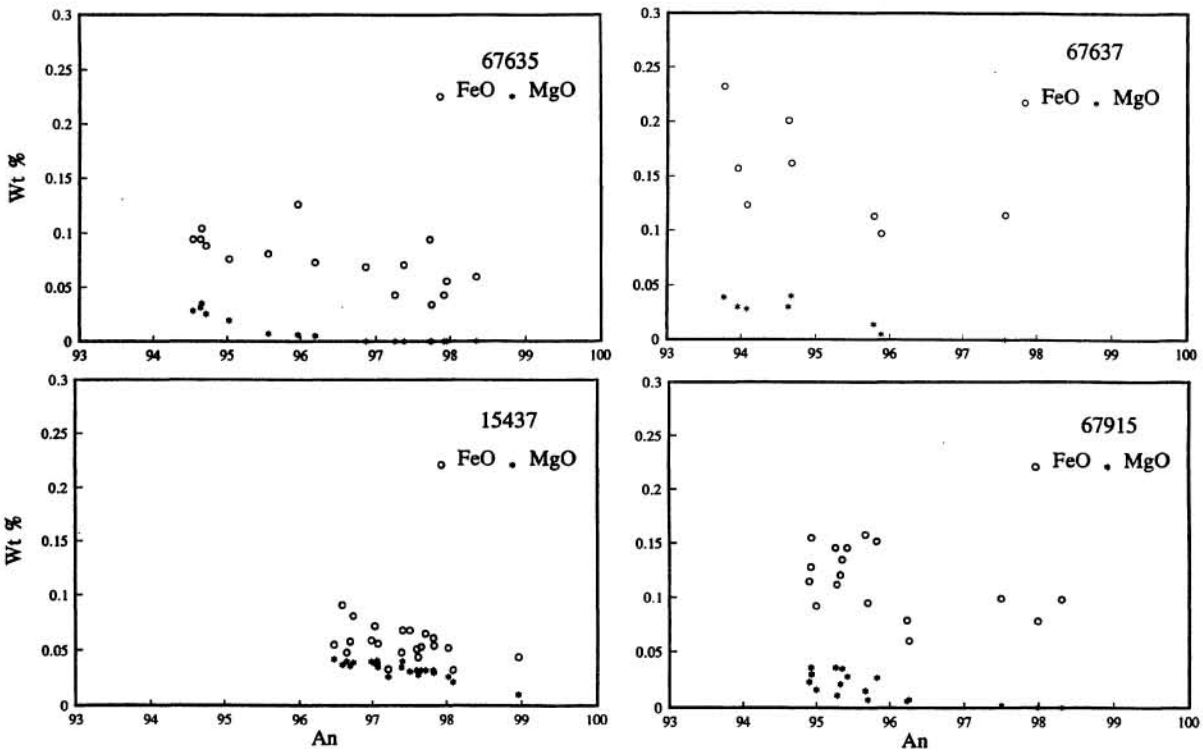


FIGURE 1. FeO and MgO contents (wt %) of plagioclase versus An content for anorthosites 67635, 67637, 15437, and 67915.