ULTRA-KREEPY MELT ROCKS, REE-RICH NORITES AND A DIVERSE SUITE OF CLASTS FROM APOLLO 16 BRECCIAS. Marilyn M. Lindstrom, Department of Earth and Planetary Sciences and McDonnell Center for the Space Sciences, St. Louis, Missouri 63130.

Continued studies of Apollo 16 breccias reveal an ever increasing variety of clast types in these feldspathic breccias. REE-rich norites and ultra-KREEPy melt rocks were found in 67975 by a consortium headed by O. James. Breccias 61015 and 64435 have also been studied.

67975 is a unique breccia. It is a feldspathic fragmental breccia containing many of the lithologies (anorthosites, granulites, melt rocks) typical of that rock type [1]. However, it contains unique REE-rich norites and ultra-KREEPy melt rocks instead of the typical feldspathic or VHA basalt varieties. Forty-nine samples from 67975 have been analyzed. Nine were reported last year [2], including bulk breccia, glass coat, granulites and a norite clast later found to be contaminated with melt rocks. Further studies included additional samples of most of those clast types as well as melt rocks, anorthosites and a spinel troctolite. REE patterns for the plutonic clasts and melt rocks are shown in Fig. 1. The feldspar anorthosites show some variations in composition but most are nearly pure plagioclase. The spinel troctolite clast has a bulk composition of 17% Al2O3, 15% FeO, 26% MgO and 5% CaO with REE levels similar to the anorthosites, but a positive slope to the HREE due to the mafic constituents.

Five samples of the norites were analyzed, two are contaminated with melt rock and none of the remaining three appear to be representative of its bulk composition. Flohr and James [3] describe the norite as a coarse-grained granulated cumulate consisting mainly of alkali-rich plagioclase (An 84-88) and ferroan pyroxenes (Mg* 58). It contains a wide variety of minor and accessory phases including ilmenite, ilmenolite, K-feldspar and zircon. Its coarse grain size, friable nature and intimate association with melt rock have made it impossible to get a representative sample. Our largest sample (44N), weighing 37mg, is probably most representative. However, its high TiO2 content (4.6%) and low Al2O3 (7.2%) suggest a high proportion of ilmenite (8.7%) and low proportion of plagioclase (21%) compared to the modes of 4 thin sections [3]. Clast 117N (5 mg) has very high K2O (1.85%) and Ba (3500 ppm) indicative of K-feldspar enrichment, while clast 131N (1.6 mg) has 363 ppm Hf due to zircon enrichment, which is responsible for the high abundances of Yb and Lu. If REE concentrations for typical norite are assumed to fall in the range of sample 117N and 44N, the 67975 norite is more REE-rich than Mg-suite norites, most of which are 10-20% enriched in REE. The 67975 norites have a flatter pattern compared to the negative slope of the other norites. Both mineralogy (alkali rich plagioclase, ferroan pyroxene) and distinctive REE patterns set the 67975 norite apart from Mg-suite norites and make genetic relationships to KREEP or alkali anorthosites more probable.

The fragment-laden melt rocks are also variable in composition. The eight samples range from 8.9-15.0% FeO, but only two have greater than 10.1% (13.5, 15.0%). These same samples have 9.5% compared to 11.5-16.0% CaO. REE concentrations (Fig. 1) are high and variable (La 56-292 ppm) and do not correlate with major element composition. There is only one sample at lower concentration level (La 58 ppm), then a group of three samples at 90-106 ppm, and a series of 4 samples at 160-282 ppm. Slopes of the LREE change from nearly flat to slightly negative with increasing concentration, while the HREE are nearly parallel. This variation suggests a dilution of very REE-rich melt with clasts of norite. Comparison to KREEP [4] shows that the middle group of samples fall in the concentration range for KREEP, while four of the samples are factors of 1.5 to 2.5 times higher. The LREE slope for the most enriched sample is the same as KREEP, but the HREE slope is slightly steeper. This is the first occurrence of a noritic melt rock with higher than KREEP levels of REE. The only previously identified high REE materials are alkali anorthosites [5] and magnesioanorthosites [6] from Apollo 14. These materials are unlikely to be components in this breccia. This ultra-KREEPy melt rock probably represents a new ultra-KREEPy component. This demonstrates the variability of KREEPy components and the inadequacy of our sampling. It is particularly surprising to find this ultra-KREEPy melt rock in an Apollo 16, rather than Apollo 14, breccia.

65015 is a typical dimict breccia. Last year [7] we presented data for VHA melt rocks, glass coat and a contaminated anorthosite. The present study includes 5 samples of clean anorthosite, three more melt rocks and another sample of glass coat. The REE patterns for several of these samples are plotted in Fig. 2. The analyses of melt rocks and glass coat are similar to our previous analyses but extend the ranges a little. The melt rocks are typical of Apollo 16 VHA basalt melts, the glass coat is poorer in FeO and REE than other Apollo 16 glass coats. The anorthosites are typical of Apollo 16 feldspar anorthosites. They are all low in CaO and REE but show some variation, the more Fe-rich samples have higher REE concentrations and flat to positive slopes to the HREE. 61015 is a simple dike melt breccia made up of ferroan anorthosite and VHA basalt melt.

64435 is not a true dimict breccia. Kempa and James [8,9] showed that it is made up of anorthositic fragmental feldspar melt and two kinds of anorthosite. We [7] presented partial analyses of anorthosites, melt rock, glass coat and anorthosite. Further analyses of those samples showed that melt rocks have Mg* 66, similar to typical Apollo 16 soils and more magnesian than North Ray Crater feldspathic melt rocks. The mafic anorthosites have Mg* 70, at the magnesian end of the range for feldspar anorthosites. The present allocation includes samples of each of the clast types, with the crustal anorthosites. The large clast of noritic anorthosite was separated into its constituent minerals. REE patterns for representative clasts are shown in Fig. 3, and for portions of noritic anorthosite (239) in Fig. 4. The feldspathic melt rock and glass samples are very similar to those analyzed previously. The anorthosites are typical ferroan anorthosites with very low FeO (<1.6%) and REE (La <1xch) contents, with strong negative slopes to...
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Their REE patterns. The mafic anorthosites have 3-7% FeO, with slightly higher REE concentrations (La 1-2xch) and positive slopes for the HREE. The mineralogical reasons for these variations are seen in the separates from the noritic anorthosite. Plagioclase has a strong negative slope while pyroxene has a positive slope. The higher concentrations of LREE in plagioclase give a negative slope to the LREE in the whole rock sample, while pyroxene has higher concentrations of HREE, contributing a positive slope to that portion of the whole rock pattern.

As studies of the Apollo 16 breccias continue they are found to be more complex than previously thought and to exhibit a wider variety of clast types.

References