
Introduction: Main group ureilites are ultramafic (olivine plus mainly low-Ca pyroxene) achondrites interpreted to be residues of early partial melting on a common asteroid [1-4]. No known meteorites represent complementary ureilite melts, but polymict ureilites, which are regolith breccias [2,5], contain a few % feldspathic clasts (Fig. 1). Studies of such clasts in a few samples [6-8] revealed several distinct populations, inferred to represent distinct lithologies (Fig. 2). We are extending characterization of feldspathic clasts in polymict ureilites to new samples. Our goals are to: 1) further define the feldspathic clast populations present; 2) determine relationships between these populations; 3) determine compositions of melts represented by the indigenous clasts and their relationship to main group ureilites; and 4) determine whether melt extraction on the UPB was a fractional or a batch process.

Samples and Methods: X-ray maps were used to identify feldspathic clasts in sections of DaG 319 (new section), FRO 90200, FRO 03022, DaG 1000, DaG 976 and DaG 999. SEI/BEI/EDS observations of clasts used the Zeiss EVO 50-XVP scanning electron microscope at U. Mass. X-ray maps, mineral compositions, and bulk clast compositions by grid analysis [9] used the Cameca SX-50 electron microprobe at U. Mass.

Results: We have obtained data for 60 new feldspathic clasts. Of these, 9 are lithic. Based on plagioclase (An) and pyroxene (Fe/Mg-Fe/Mn) compositions and textures, 5 of these belong to the albitic and 1 to the labradoritic lithology of [6]. The other 3 lithic clasts appear to be chondrite (R and O) fragments. Three clasts consist of Si-Al-rich glass (type C3 of [7]). Forty-eight clasts are plagioclase mineral fragments, ~10-200 μm in size. A histogram of their An contents is shown in Figure 2.

Bulk clast compositions were determined for 3 albrite lithology clasts, ~100×100-200 μm in size (Fig. 3). They show (by wt.) ~52-59% SiO₂, 13-14% Al₂O₃, 2-3% CaO, 5-6% Na₂O, 0.7% K₂O and 1% P₂O₅, with mg# = 44-48. They are plotted in the olivine-quartz-plagioclase (Ol-Qtz-Plag) phase system in Fig. 4.

Discussion: Previous studies of polymict ureilites [6,7] showed that the most abundant population of feldspathic clasts corresponds to a well-defined lithology – the "albitic lithology" of [6], equivalent to type C1 clasts of [7]. This lithology is characterized by albitic (An ~1-25) plagioclase, FeO-rich (Fe/Mg up to ~3.5) pyroxenes, ilmenite, phosphates, silica, and incompatible element-rich glass. It is plagioclase- and pyroxene-porphyritic and shows normal igneous fractionation trends of Fe/Mg vs. Mn in pyroxenes and Fe/Mg vs. An [6,7,12]. Sadly, it is rarely (if ever) representatively sampled by a single clast.

The "labradoritic lithology" of [6], based on only a few clasts, is less well defined. Characteristics distinguishing it from the albitic lithology are higher An (~35-60), a distinct Fe/Mg vs. Fe/Mn fractionation trend, and an absence of incompatible-element enrichment. This lithology may correspond to some type C2 clasts of [7]. Two less abundant populations exist [6-8]: a magnesian anorthite-rich (An ~89-90, Fo ~93) lithology and a ferroan anorthite-rich (An ~95, Fo ~50-70) one [6-8]. The latter was recognized from mineral compositions oxygen isotopes [8,10] to be...
angritic. Clasts representing the albitic, labradoritic and Mg-anorthite-rich lithologies have been shown by oxygen isotopes to be ureilite [8,11].

Our new data are consistent with the albitic lithology being the most abundant population. They also show the presence of significant amounts of intermediate-An and lesser amounts of high-An plagioclase. 

**Albitic Lithology:** The bulk composition of the melt represented by the albitic lithology, and the relationship of this melt to main group ureilites, are critical to understanding the nature of melting and melt extraction on the UPB, as well as the composition(s) of ureilite precursor materials. [14] suggested that the albitic lithology might have the bulk composition of the En-Plag-SiO$_2$ eutectic in Ol-Qtz-Plag (Fig. 4), i.e., might represent the lowest-degree melt of ureilite precursor materials that were silica-saturated (like EC). To test this, we plot compositions determined for various components of the albitic lithology, and the clast bulk compositions determined by grid analysis. Although some albitic lithology components (mesostasis and glass) plot near the eutectic, the bulk clast compositions determined so far plot near the En-Plag-Oliv peritectic point. If the albitic lithology represents a melt of this composition, it implies silica-undersaturated precursor materials (like OC or CC), and the compositions of the various clast components could reflect crystallization fractionation of this melt toward the eutectic (Fig. 4). This interpretation is plausible, given the extensive fractionation trends shown by the albitic clasts [6]. On the other hand, the clasts for which we obtained bulk compositions may not be representative of the bulk lithology. In fact, they appear to contain little mesostasis (Fig. 3), which would bias their compositions away from En-Plag-SiO$_2$. The relative abundance of the albitic lithology ensures that continued work will clarify the bulk composition of this melt lithology. Also, sample MS-MU-011 from the Almahata Sitta polymict ureilite [15], which has similarities to the albitic lithology, may provide a more representative composition.

**Relationships among lithologies:** It is equally important to understand the relationships among the various melt lithologies in polymict ureilites. Based on mineral and inferred bulk compositions, the albitic and labradoritic lithologies could conceivably be related by progressive melting of a common chondritic precursor. If this is the case, preservation of distinct lithologies strongly suggest that melt extraction was fractional.

Calculations of [6] suggested that the albitic and An-rich lithologies could also be related by fractional melting. However, those calculations assumed precursors with highly depleted (<CV) alkali contents and superchondritic Ca/Al ratios. Calculations of [8] based on trace elements imply that the albitic lithology is derived from alkali undepleted precursors; also, superchondritic Ca/Al ratios are unlikely [16]. Our calculations for an average silicate LL composition indicate that even fractional melting will not lead to plagioclase of An 90. Derivation of these distinct lithologies may require source regions that were compositionally distinct, not only in mg# (as is commonly thought), but also in Ca and Al contents. We shall test this.

**Fig. 3.** BEI of albitic lithology clast in FRO 03022.

**Fig. 4.** Ol-Qtz-Plag system [13] for mg# and alkali contents of the albitic lithology. Cyan = compositions of components of albitic lithology clasts. Yellow = bulk compositions of albitic lithology clasts from grid analyses.