MS-MU-012: A PRIMARY PLAGIOCLASE-BEARING MAIN GROUP UREILITE FROM ALMAHATA SITTA, WITH IMPLICATIONS FOR THE IGNEOUS EVOLUTION OF THE UREILITE PARENT BODY.

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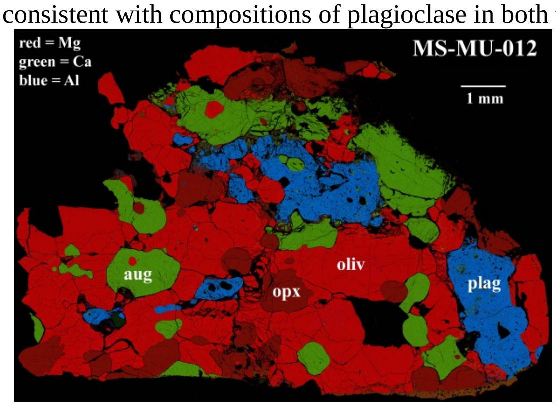
Introduction: Main group ureilites are unbrecciated, ultramafic (olivine + pyroxene) achondrites, inferred to represent the residual mantle of a partially differentiated, carbon-rich asteroid [1-3]. Plagioclase-bearing igneous rocks representing the melts complementary to main group ureilites have not been found as individual meteorites. However, polymict ureilites, which are breccias representing regolith developed on a ureilitic asteroid, contain a few percent feldspathic clasts that appear to be indigenous (from oxygen isotopes) and may be remnants of such igneous rocks [3-7]. The most common of these, the “albitic” and “labradoritic” lithologies, contain plagioclase of An ~0-25 and An ~30-60, respectively, and have been interpreted as products of progressive fractional melting on the ureilite parent body [5,6]. The anomalous polymict ureilite Almahata Sitta (AhS) includes two 24.2 g and 26.9 g clasts of trachyandesite that are the largest samples of the albitic lithology known [8-10]. Almahata Sitta sample MS-MU-012 (15.5 g) was reported to be a ureilitic sample containing plagioclase [11]. We report more detailed study of this sample, and discuss its implications for the igneous evolution of the ureilite parent body.

Results: MS-MU-012 has a coarse-grained (up to ~4 mm-sized), equilibrated texture (Fig. 1) similar to many main group ureilites. It consists of ~52% olivine, 13% orthopyroxene, 21% augite, and 14% plagioclase-rich areas (by area %). Smaller, rounded olivine and orthopyroxene grains are poikilitically enclosed in augite. The plagioclase areas have overall shapes and sizes similar to those of the mafic minerals, indicating that they were primary grains. Internally, they consist largely of small radial sprays of fine feldspar crystals, with interstitial sulfide/metal, indicating secondary remelting of low melting-T phases. A few apparently unmelted areas of plagioclase remain. Some olivine grains have narrow reduction rims. Intergranular areas show a brecciated texture, similar to augite-bearing ureilite Hughes 009 [12]. No graphite was observed. The olivine is Fo 88.1±0.1, with 0.25±0.01% CaO and 0.47±0.01% Cr_2O_3, and molar Fe/Mn = 20.8 (39 analyses). Orthopyroxene is mg# 89.2±0.1, Wo 4.5±0.0, with 1.2% Al_2O_3 and 0.95% Cr_2O_3 (11 analyses). Augite is mg# 90.2±0.1, Wo 37.3±0.1, with 2.0% Al_2O_3 and 1.23% Cr_2O_3 (28 analyses). The apparently unmelted plagioclase areas have stoichiometric plagioclase composition of An 68.4, Or 0.04 (32 analyses). Analyses of remelted areas are similar but not stoichiometric. Melt inclusions consisting of glass ± high-Ca pyroxene occur in several olivine crystals. Oxygen isotope analyses of 3 separates from the plagioclase-rich areas give average $\Delta^{17}O$ = -1.0 ‰, $\delta^{18}O$ = 6.98 ‰. Rare earth element analyses of a separate from the plagioclase areas show very low abundances (<0.15 x CI) except Eu. These may have been affected by remelting.

Discussion: MS-MU-012 belongs to the relatively rare augite-bearing main group ureilites [3]. Except for the presence of the plagioclase areas, it is virtually identical to augite-bearing ureilites Hughes 009 and FRO 90054 [12,13] and AhS #15 [14,15] in mineralogy, mineral compositions, presence of melt inclusions, absence of graphite, and oxygen isotope composition. The large size and overall shapes of the plagioclase-rich areas show that they represent a primary phase in this sample, which makes it the first known plagioclase-bearing main group ureilite.

In contrast to the common olivine + low-Ca pyroxene ureilites, augite-bearing ureilites are interpreted to be cumulates or paracumulates [3,7]. We propose that MS-MU-012 formed as a paracumulate from a late fractional melt that did not completely separate from the olivine-rich residual matrix on the ureilite parent body. Petrologic modeling simulating fractional melting of chondritic (LL-like) material showed that the earliest melts would have An ~20, while the last plagioclase-saturated melts (just before plagioclase depletion from the source) would have An ~65-70, consistent with compositions of plagioclase in both the albitic lithology (early melt) and MS-MU-012 (late melt).



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