

THE SECOND CONFERENCE ON THE LUNAR HIGHLANDS CRUST AND NEW DIRECTIONS

**A rock fragment related to the magnesian suite in lunar meteorite Allan Hills (ALHA)
81005‡**

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ABSTRACT

Among the lunar samples that were returned by the Apollo missions are many cumulate plutonic rocks with high Mg# [molar Mg/(Mg+Fe) in %] and abundances of KREEP elements (potassium, rare earth elements, phosphorus, U, Th, etc.) that imply KREEP-rich parental magmas. These rocks, collectively called the magnesian suite, are nearly absent from sampling sites distant from Imbrium basin ejecta, including those of lunar highlands meteorites. This absence has significant implications for the early differentiation of the Moon and its distribution of heat-producing elements (K, Th, U). Here, we analyze a unique fragment of basalt with the mineralogy and mineral chemistry of a magnesian suite rock, in the lunar highlands meteorite Allan Hills (ALH) A81005. In thin section, the fragment is $700 \times 300 \mu\text{m}$, and has a sub-ophitic texture with olivine phenocrysts, euhedral plagioclase grains (An_{97-70}), and interstitial pyroxenes. Its minerals are chemically equilibrated. Olivine has Fe/Mn ~ 70 (consistent with a lunar origin), and Mg# ~ 80 , which is consistent with rocks of the magnesian suite and far higher than in mare basalts. It has a rich suite of minor minerals: fluorapatite, ilmenite, Zr-armalcolite, chromite, troilite, silica, and Fe metal (Ni = 3.8%, Co = 0.17%). The metal is comparable to that in chondrite meteorites, which suggests that the fragment is from an impact melt. The fragment itself is not a piece of magnesian suite rock (which are plutonic), but its mineralogy and mineral chemistry suggest that its protolith (which was melted by impact) was related to the magnesian suite. However, the fragment's mineral chemistry and minor minerals are not identical to those of known magnesian suite rocks, suggesting that the suite may be more varied than apparent in the Apollo samples. Although ALHA81005 is from the lunar highlands (and likely from the farside), Clast U need not have formed in the highlands. It could have formed in an impact melt pool on the nearside and been transported by meteoroid impact. Lunar highlands meteorites should be searched for rock fragments related to the magnesian-suite rocks, but the fragments are rare and may have mineral compositions similar to some meteoritic (impactor) materials.

Keywords: ALHA81005, Moon, lunar, petrology, magnesian suite, armalcolite, impact melt, lunar meteorite