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Early Martian crustal formation mechnisms inferred from feldspathic units in Jezero Crater, Mars

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Felspathic, evolved igneous rocks provide insight to planetary crustal growth and dynamics, including lunar anorthositic crust that formed by solidification of a magma ocean, and the terrestrial Archean-age tonalite-trondhjemite-granodiorite (TTG), which are thought to form by magmatism associated with early plate tectonics and(or) stagnant lid regime. The Mars 2020 *Perseverance* rover has identified a series of coarsely crystalline (grains up to 2 - 3 mm), feldspar-rich rocks within the crater rim representing ancient crustal material, with one sample cached on the surface for return to Earth. This is the first instance of such intrusive rocks having been examined *in situ* on Mars. Planetary Instrument for X-ray Lithochemistry (PIXL) [1] observations at the abraded Cat Arm Reservoir (CAR; sol 1361) and the coated, natural surface targets at Knapsack Pass (KP; sols 1309 & 1310) and Mother Mountain (MM; sol 1303) link the outcrops. CAR is norite, containing a higher abundance of mafic minerals with 60 vol% An_{64} feldspar and 69.2 vol% LCP and 30.8 vol% high Ca pyroxene (Mg#=49). The LCP in CAR are reversely zoned with fayalitic olivine cores (Fo_{32-37}). Uncoated regions of KP are dominated by plagioclase feldspar (93 vol%, An_{59}) with minor low Ca pyroxene (LCP, Mg#=43.8), classified as anorthosite. MM is similar to CAR in composition, feldspar (An_{60-70}) and pyroxene (Mg#≈45).

In comparison to terrestrial TTG and lunar anorthosite [2], uncoated KP regions and CAR whole-rock An# and Mg# are relatively low, but within range of terrestrial values. As a proxy for LREE/HREE (i.e., La/Yb, which are not reported by PIXL), K/Ti in Martian feldspathic rocks are within the lower range (0.7 K/Ti in CAR) of terrestrial TTG at low whole-rock An. Lunar anorthosite also have low K/Ti (0 – 5), but high An (>95). These observations are consistent with a petrogenesis involving fractional crystallization of a high-degree mantle melt (suggested by high MgO/CaO linked to higher abundance of LCP to HCP) and limited involvement of K-mobilization by H_2O-rich fluids for the Martian feldspar-rich lithologies.

References:

[1] Allwood et al., (2020) *Space Science Reviews*, Vol. 216, No. 134

[2] Sotiriou et al., (2024) *Geoscience Frontiers*, Vol. 15