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Mineralogy, Petrology, and Geochemistry of Martian Regolith Breccias: Insights into The Martian Crust

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NWA 7034, NWA 8171, and NWA 11220 are polymict brecciated meteorites representing Martian surface regolith [1]. We present integrated studies of mineralogy, petrology, and geochemistry of a suite of slabs and thin sections of Martian breccias, determined by *in situ* micro XRD (μXRD), Raman, optical microscopy, and EPMA. μXRD, with a beam size of 300 mm, determines mineral phases in these Martian breccias and yields information about grain size and strain. Fine-grained minerals (< 5 mm) in the matrix, polycrystalline clasts, or secondary reaction products yield homogeneous Debye rings in 2D XRD. Nanocrystalline minerals (< 0.2 mm) in the matrix, such as magnetite and maghemite, display broadened diffraction lines [2,3]. Coarse-grained feldspar and pyroxene grains (> 15 μm) exhibit diffraction spots or elongated streaks to varying degrees related to shock level [3,4]. Martian breccias contain medium- to fine-grained lithic clasts composed of enstatite, augite, pigeonite, plagioclase, alkali feldspar, and magnetite, as well as occasional hematite, rutile, goethite, and ilmenite in the matrix. Enstatite, augite, chromite, plagioclase, and alkali feldspar also exist as single crystal clasts. Pyrite occurs in lithic clasts and has small grain sizes. Cl-rich apatite is widely distributed as small- to medium- crystals. Partial substitution of Cl by OH and F is widespread, leaving most apatites chemically heterogeneous. Elemental concentrations of five apatites from NWA 8171 have been analyzed so far. Each apatite contains an average water-equivalent hydroxyl concentration of 1.05, 0.88, 0.28, 0.88, 1.22 wt %, showing a higher OH abundance than the one in NWA 7034 and NWA 7533 [5-7]. Olivine is found in three different spherules; the one from NWA 7034 shows slightly streaked diffraction spots, likely implying a textural effect of rapid growth. Combined diffraction, Raman spectroscopic, optical and EPMA observations of these breccias provide an extensive record of Martian surface processes.

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