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Introduction: NWA 7042 has previously been described as a missing link among the shergottites [1] due to its intermediate trace element composition. We have begun a systematic study of NWA 7042 using electron-beam and laser based microanalysis. Our aim is to provide a more complete understanding of this potentially informative martian sample, and in particular to gain new insights into magmatic processes, crustal and mantle reservoirs, and the timing of igneous and (shock) metamorphic events that affected NWA 7042.

Results and Discussion: NWA 7042 consists of zoned olivine, zoned clinopyroxene, with interstitial plagioclase laths (optically isotropic), with accessory Mg-rich merrillite, and traces of Fe-sulphides (likely pyrrhotite), ilmenite, chromite, baddeleyite, and pervasive terrestrial weathering veins consisting dominantly of calcite with barite-celestite.

Olivine: Olivine crystals are blocky and subhedral, and commonly have fayalitic rims (Fa46.0-48.1) surrounding more Mg-rich cores (Fa28.5-30.1) [1]. Most olivine crystals contain conspicuous cores with a ‘rusty’ brown appearance in transmitted light. The rims and cores are optically continuous (Fig 1A-B). At high magnification (Fig 1C-D), the cores of NWA 7042 olivines are riddled with inclusions. While it is tempting to ascribe the rusted appearance of olivine to terrestrial weathering, this interpretation is at odds with the higher Mg-number of the olivine cores vs. rims. It is possible that Fe-oxyhydroxide-bearing terrestrial weathering products are precipitating or collecting in a preexisting feature of the olivine cores. At high magnification, the cores appear to have abundant minute inclusions; however, this is not apparent in either BSE or EDS images. The origin of this texture remains enigmatic.

Pyroxene: NWA 7042 pyroxenes all exhibit inclined extinction, and occur as elongate euhedral crystals reaching several mm in longest dimension. Many display a sharp optical contact between cores and rims. Chemically, the rims of NWA 7042 clinopyroxene grains are Ca-rich, compared the complexly-zoned cores (Fig. 2)

Maskelynite: All plagioclase observed in NWA 7042 is optically isotropic. Preservation of grain shapes, lack of flow textures, and preservation of igneous sector zoning all favor a solid-state amorphization mechanism, and we therefore apply the term maskelynite. Maskelynite occurs in clusters of elongate laths interstitial and generally parallel to clinopyroxene (Fig. 2). In some restricted areas, there is evidence for melting of plagioclase, including the formation of SiO2-K2O-rich glass, resorbed grain boundaries, and reaction textures.
Phosphates: Merrillite is interpreted as the primary igneous phosphate in NWA 7042. Merrillite is always observed in association with plagioclase (maskelynite). In some regions the merrillite is partially, or in rare cases, entirely converted to Cl-bearing apatite (Fig. 3A). Apatite replacing merrillite is commonly associated with textural and compositional evidence of melting, including apparent flow features, and optically isotropic SiO₂-K₂O-rich material (Fig 3B), interpreted as melt glass. This assemblage should enable trace element and isotopic dating tests to constrain the extent to which shock-related melting has disturbed the chemical and temporal record of martian igneous processes in NWA 7042.

Shock veins: NWA 0742 contains many shock veins which cross-cut the primary igneous minerals (Fig. 4). Evidence for melting within the veins includes flow textures, rounding of entrained clastic material, and micron-scale quench crystallites (likely Fe-Ti oxides). Many primary igneous minerals near shock veins show evidence of thermal alteration near the contacts with vein material. Several characteristics of the veins, including evidence for heating and melting of host rock near the margins, flow features, entrainment of host rock clasts are similar to pseudotachylite.

Baddeleyite: NWA 7042 baddeleyite crystals are typically smaller than 10 μm in longest dimension and appear to retain primary igneous textures, and are not associated with either shock melt pockets (SiO₂-K₂O-rich glassy material) or shock veins. Baddeleyite is sometimes associated with ilmenite or sulphides.

Terrestrial Weathering: Evidence of terrestrial weathering is pervasive, including calcite and barite within fractures and in veins, but concentrated around the exterior of the meteorite.

Conclusions: NWA 7042 is dominated by primary igneous signatures with some impact metamorphic overprint. The textural relations between primary (merrillite) and postcrystallization-disturbed phosphates present an opportunity to constrain the timing and geochemical signatures of both crystallization and impact metamorphism.