Different fluid-rock interactions on Mars recorded in Northwest Africa (NWA) 7034 and 7533.

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Martian regolith breccias NWA 7034 and 7533 are exceptional samples as they carry a suite of igenous and sedimentary rocks from Mars that are most similar to those measured by surface missions. As such, studies of these samples offer our best opportunity to study surface rocks at the best resolution in the labs on Earth.

In our studies of these samples, we have observed multiple alteration features. We observed wide-occurring Mn(IV)-oxides in different lithic and mineral clasts, but not in the matrix of the rock, which are Martian Mn-rich salts formed at low temperatures in the surface environment. The second feature is monazite inclusions in detrital apatite grains. Monazite occurs as irregular clusters of minute grains inside F-rich regions of the chlorapatite. Texture and chemistry resemble dissolution-precipitation in terrestrial examples involving metasomatic/hydrothermal fluids at T >100 °C (Liu et al., 2016a). These apatite grains also recorded a later alteration event in the form of Fe-O veins. The third feature is irregular eskolaite (Cr_2O_3) crystals mantled by radiating polycrystalline chromite-magnetite (Liu et al., 2016b). Eskolaite is not an igneous mineral. Thus, these assemblages are likely formed through multiple metamorphic events at higher T, with the first event that produced eskolaite and the second event that produced the polycrystalline mantle through possible fluid reacting with eskolaite. Forth feature is the Zn-enrichment in the interior of spherules (Liu et al., 2018). Although we reported Zn in pyroxenes (Liu et al. 2018), a closer examination found that Zn is hosted in spinel. Possible formation includes secondary processes enriched Zn followed by thermal metamorphism. The fifth feature is pyrite-polycrystalline pyrrhotite grains (Hu et al., 2018), suggesting thermal metamorphism in lower S fugacity or higher O fugacity of secondary pyrite. Combined, these features suggest diverse water-rock reactions, that would be useful for the search of habitable environments on Mars.