Investigating putative biosignatures in olivine from the subsurface of Mars

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The subsurface of Mars has been postulated to provide a sizeable potential habitat for life supported by the interaction of liquid water with the mafic crust [1] and a range of potential biosignatures have been suggested from these environments [2]. Both the Nakhla and Yamato meteorites derived from the shallow subsurface of Mars contain olivine hosted microalteration textures and associated organics that have been compared to tubular bioalteration textures found in terrestrial subseafloor volcanic rocks [3, 4]. Here we use FIB-TEM (focussed ion beam-transmission electron microscopy), and NanoSIMS (nanoscale secondary ion mass spectrometry) to characterize the microtextures found in Yamato 000593.

We show that the altered olivine crystals have angular and micro-brecciated margins and are highly strained due to impact induced fracturing. The shape of the olivine microalteration textures is not comparable to microtunnels of inferred biological origin found in terrestrial volcanic glasses and dunites, and rather we argue that the Y-000593 microtextures are abiotic in origin. Vein filling iddingsite extends into the microalteration textures and contains amorphous organic carbon occurring as bands and sub-spherical concentrations <300 nm across. The distribution of carbon in early alteration products is consistent with an origin from hydrothermal alteration on Mars.

We postulate that a Martian impact event produced the micro-brecciated olivine crystal margins that reacted with subsurface hydrothermal fluids to form organics that record abiotic processes in an impact induced hydrothermal system. These findings have implications for how we might seek potential biosignatures in ultramafic rocks and impact craters on both Mars and Earth.

[1] Fisk and Giovannoni (1999). J Geophys Res **104**, 11805–11815. [2] Grosch., et al. (2014). Astrobiology, **14**, 216-228. [3] Fisk et al. (2019). Astrobiology, **19**, 132-144. [4] White et al. (2014). Astrobiology, **14**, 170-181.