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Quantification of the presence of liquid water in the soil of Mars

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The microstructure of a soil can reveal and quantify the dominant processes involved in the soil's formation. The particle size distribution (PSD) for the Martian soil has been determined at the Phoenix site over a range from 0.1 to 200 μm by a combination of optical and atomic-force microscopy. The measured PSD is quite different to those of both terrestrial and lunar soils. Two size categories have been identified: larger grains with a mass-median size of 100 μm and reddish fines of mass-median size 20 μm. Notably, there is a very low mass proportion of particles in the clay-size range compared to terrestrial and martian analogue soils. The ubiquity of clays in terrestrial soil is a result of the prevalence of liquid water at the surface of Earth.

The fragmentation fractal dimension can be derived from the power-law relationships between the cumulative mass and the particle size of the soil. This fractal dimension for the smallest particle domain is close to zero up to 7 μm, indicating that these fines have recorded the smallest-scale formation processes. The microstructure indicates this soil derives from two processes: the grains from a local source such as the nearby Heimdal crater impact; the fines from long-lived global aeolian weathering under very dry conditions, quantified as much less than 10,000 years exposure to liquid water over the history of the soil. This result is in agreement with observations of both perchlorates and carbonates seen by other instrumentation at the Phoenix site, with a best estimate of 1000 years exposure to liquid water derived from all the available data.

The fines at the Phoenix site are likely to be representative of the planet as a whole given the global nature of material transport at this length scale. Hence, as signs of liquid-water activity are minimal as determined by its microstructure, the martian soil in general will be a poor choice of sample for future in-situ investigations of past or present life.