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Global investigation of hydrated exposures on Mars: Evidence for a clay cycle

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The discovery of hydrated minerals including clays, carbonates and sulfates on Mars has spawned a new era of intense scrutiny of its ancient (> 4 Ga) aqueous environments Over the years, many thorough investigations of selected sites have been carried out, from which local alteration scenarios have been derived, some of strong astrobiological relevance and justifying sending rovers there such as the MSL. By comparison, our approach is to investigate the chemical alteration of Mars on a global scale from a systematic overview of the hydrated signatures detected by the NIR imaging spectrometers CRISM and OMEGA. We present the main results of this global investigation in terms of composition, geological settings and age of the hydrated deposits.
Hydrated mineral exposures are predominantly found in Noachian terrains with a homogenous surface density. The northern plains are not devoid of alteration signatures indicating Mars was altered on a planetary scale. Over 80% of the sites exhibit signatures of Fe/Mg smectites/vermiculite with some evidence for inter-stratification. Great mineral diversity is reported: Al-bearing smectites and kaolins, chlorites, opaline silica, zeolites, serpentines, prehnite, micas, carbonates and epidote. Diverse geological settings exist, but the dominant morphological contexts are impact craters which in the majority of cases likely excavated hydrated minerals.
On Earth, clays form, are transformed and accumulate in 6 geological contexts: pedogenic, detrital, authigenic, diagenetic, metamorphic and hydrothermal. Detailed mineral/morphological investigations of sites of interest reveal that all these geological contexts are also found on Mars and hint towards the existence of a clay cycle during the Noachian. While these contexts collectively suggest the presence of a clay cycle on early Mars, their spatial and temporal relationship still remains to be established. In particular, the lack of plate tectonics on Mars renders less likely the possibility of multiple cycles. However the clear association between fluvial structures and hydrated minerals for some deposits supports that alteration at the surface could have occurred. In other locations, the degraded contexts, younger resurfacing processes and inherent limitations of orbital remote sensing make it difficult to constrain the alteration and putative clay cycle during the Pre- to Early-Noachian eons.