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Unraveling the mineralogy of delta deposits on Mars

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Detailed geologic characterizations of three of 50+ fan deltas on Mars have yielded important information on their mineralogy as well as formation processes. Data returned from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) have been used to identify spectroscopic signatures consistent with phyllosilicates in fans or deltas within paleolake basins (i.e. Eberswalde, Holden, and Jezero) that indicate sustained subaqueous sediment deposition. Based on these results, two periods of martian history have been identified when the surface or near surface may have been habitable: (1) during the formation of the iron-magnesium smectite clays, likely in the Early Noachian and (2) during the Late Noachian to Early Hesperian fluvial surface activity that led to the formation of Jezero lake.

On Earth, rapid deposition of deltaic sediments can preserve organic materials; hence Martian fan deltas may be ideal environments to investigate the past habitability of the planet. Rapid burial coupled with the identification of phyllosilicates within at least some of the martian deltas makes an even more intriguing argument for further investigation of the remainder of deltas. This is because phyllosilicates, and specifically smectite clays, have the ability to trap organic matter in the interlayer sites of their mineral structures and in terrestrial settings are commonly associated with the most organic rich units. Organic materials that were transported into paleolakes would likely have been buried relatively quickly. Hence, the organics would have been protected within the clay-rich deltaic and lacustrine deposits from oxidation and photochemical dissociation.

We will present the initial results of a comprehensive study designed to investigate the compositional and mineralogical variability of the remainder of dust-free, previously un-characterized deltas on Mars (of which, there are 33). Our study aims to provide key information regarding differences in formation and preservation processes between the fan delta deposits. Our initial survey of the deltas indicates that almost all sites contain minor phyllosilicate detections, however only nine sites have significant abundances (i.e. spatially cohesive mapped deposits). Most of the phyllosilicate deposits consist of Fe/Mg clays such as nontronite and saponite, with a few sites showing detections of minor amounts of Al clays. Geologic observations indicate that most of the clays outcrop along the bottom edge of the deltas with a few sites showing a larger band of clays located just beyond the base of the delta. HiRISE images provide additional small-scale geologic context and indicate that most of the clay deposits are exposed as thin erosional layers. When clay deposits are located beyond the base of the delta they are typically more massive in outcrop. Our ongoing morphological, watershed, and catchment basin investigations will provide additional constraints on the style and extent of hydrologic activity. Coupling our detailed spectroscopic characterization with our ongoing work will provide key information on the geologic processes that produced the mineralogical diversity of martian deltas and will likely provide important clues regarding the past habitability of these environments.