FRESH EXPOSURES OF ALLOPHANE IN ASSOCIATION WITH CHANNELS AND DEBRIS APRONS IN COPRATES CHASMA, MARS.

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Introduction: We have discovered relatively fresh allophane deposits along the wallrock slopes in Coprates Chasma. In HiRISE images, the deposits appear similar to numerous mass wasting flows and debris aprons visible along the wallrock slopes. It is only with the aid of CRISM spectral data that these deposits appear distinct.

The allophane was mapped using the BD2200 and Doub2200 CRISM spectral parameters [1,2]. The 1.9 μm band depth also identified the allophane detections, but the presence of smectites within the scene limited the usefulness of this parameter for only identifying allophane. The signatures for allophane were overlain onto CTX and HiRISE images, then mapped and correlated to specific morphologies and features.

Spectral Observations: Figure 1 shows a plot of a CRISM spectrum taken from one of the allophane-bearing deposits at Coprates. The CRISM spectrum exhibits broad absorptions at 1.42, 1.94, and ~2.25 μm. These broad absorptions and peaks shifted to longer wavelengths relative to spectra of allophane are most consistent with Fe-allophane (Fig. 1, [3,4]). The three absorptions, especially the 1.4 μm, are very strong relative to most martian hydrated spectra, suggesting high water content that is relatively fresh and has not altered or loss water since formation/exposure.

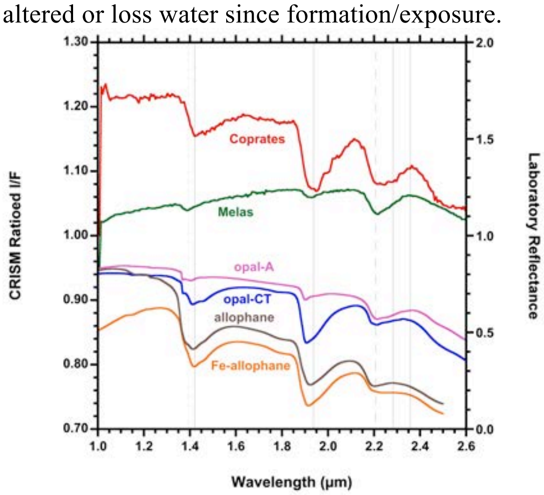

Figure 1. CRISM spectrum taken from an allophane deposit in Coprates (HRLA8F6) compared to an opal deposit spectrum taken from Melas Chasma (offset by -0.05) (FRT44AC). Note the much stronger and broader absorptions in the spectrum of the Coprates relative to that of the Melas deposit. Also shown are laboratory spectra of opal [5] and allophane [3], with 10% of the Al replaced by Fe in one spectrum (Fe-allophane).

Interpretations: The allophane corresponds to debris and debris aprons along the wallrock slopes in an alcolve where a landslide formed (Figs. 2,3). There are several deposits and channels associated with the allophane, suggesting either a long duration flow that changed its course over time, or multiple smaller events. Alternatively, the channels and aprons may be older features, while the allophane represents a younger superimposed deposit. This hypothesis is supported by the whispy bright nature of the allophane deposits, perhaps indicative of a thin mantle of debris covering pre-existing terrain. The confinement and concentration of allophane into channels suggests that there was movement downslope, but the channels may have formed previously and could have been used as a conduit by the younger allophane debris.

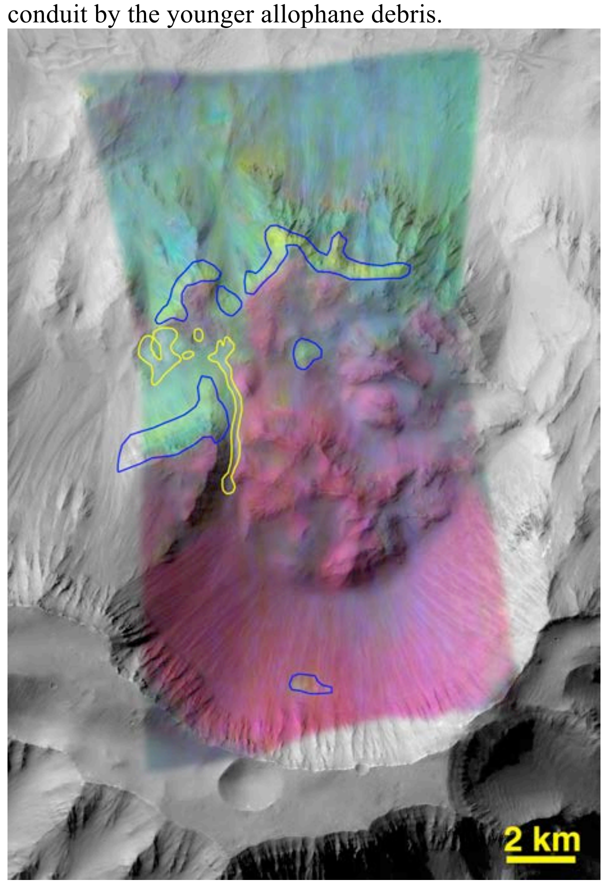

Figure 2. CTX image with CRISM spectral parameters overlain in color (red is olivine index, green is band depth at 1.9 μm, blue is doublet at 2.2 μm). The allophane deposits are outlined in yellow while smectite exposures are mapped by blue lines.

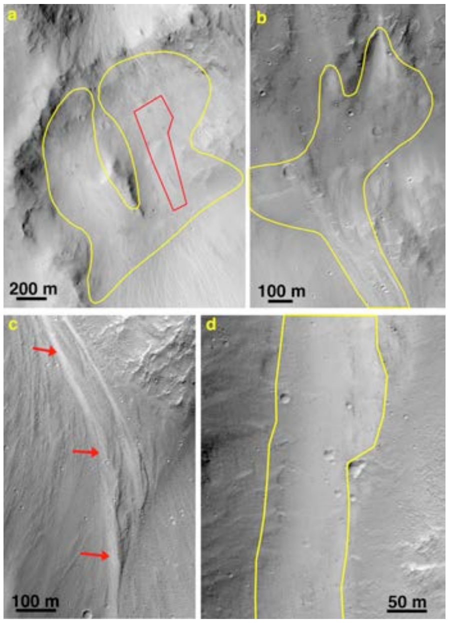

Figure 3. Examples of allophane deposits in HiRISE images. (a,b,d) Allophane corresponds to materials within yellow outlines. (a) The red outline indicates where the CRISM spectrum was extracted. (c) Channel containing allophane (red arrows).

Four allophane-rich deposits are shown in Fig. 2: a long eastern deposit, a wide western deposit, and between them two smaller deposits. These four deposits may have originally been joined into one larger deposit that has subsequently been eroded and/or partially buried by younger mass wasting debris. There is no obvious source for these allophane deposits. The upslope origin for the eastern deposit is covered by eolian debris along a flat-lying region adjacent to the landslide. The deposit continues downslope for a total length of 4600 m across 940 m of elevation. The deposit terminates along a flat-lying ledge just above the smectite layer within the wallrock (Fig. 4). The western and two smaller deposits also lie along this ledge.

Discussion: Allophane is an amorphous or poorly crystalline hydrous aluminum silicate material [e.g. 6]. Because the CRISM spectra are best matched to a laboratory spectrum that also contains Fe, the deposit must also contain Fe mixed with the Si and Al. On Earth, allophane is typically found in association with volcanic ash or fine-grained pumice and forms under mildly acidic to neutral pH conditions [6]. The martian deposits must be fresh because of their strong hydration features since any allophane would have dehydrated or altered if exposed at the surface for an extensive length of time. Crater age dating of the two larger deposits yields ages of 50-100 My, consistent with a young exposure time. Either the allophane represents an older material already contained within the wallrock that was exposed during collapse associated with the landslide event, or it represents a younger material formed during more recent aqueous activity. There is no evidence for allophane within the wallrock, although there is a considerable amount of dark debris shedding along the wallrock slopes that could be covering up any outcrops.

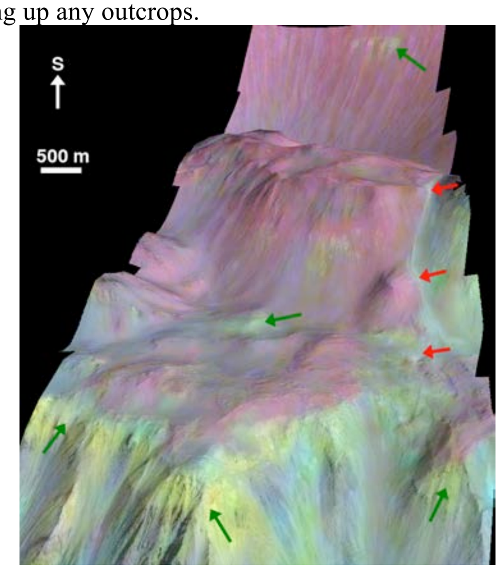

Figure 4. HiRISE DTM at 2X vertical exaggeration with CRISM spectral parameters (see Fig. 2) overlain in color. Red arrows identify the eastern allophane deposit (whitish blue) which extends across 940 m in elevation, while green arrows point out exposures of smectites within the wallrock (yellow-light green).

The allophane deposits are probably unrelated to the smectite layers in the wallrock, suggesting another aqueous event must have produced the allophane. Why allophane is only found at this location within Valles Marineris remains an enigma, but could be a function of the CRISM coverage that limits detectability. Because most CRISM images are targeted to interesting bedrock or sedimentary deposits, the common debris aprons observed along the wallrock have not been covered by many images, thereby limiting the detection of other possible allophane deposits. Allophane has been identified in clay-bearing regions on Mars using TES [7] while Curiosity instruments have detected an amorphous phase in the soils that may contain allophane [8,9], suggesting allophane may be a common component of clay-bearing regions on Mars.

References: [1] Pelkey et al. (2007) *J. Geophys. Res.*, *112;* [2] Murchie et al. (2009) *J. Geophys. Res.*, *114*, E00D06; [3] Bishop et al. (2013) *Clays Clay Minerals 61*, 57-74. [4] Baker et al. (2011) *LPSC* #1939. [5] McKeown et al. (2011) *Clays Clay Minerals 59*, 400-415. [6] Parfitt et al. (1980) Clays Clay Minerals 28, 328-334. [7] Rampe E.B. et al. (2012) *Geology 40*, 995-998; [8] Blake et al. (2013) *Science 341*, 1239505; [9] Meslin et al. (2013) *Science 341*, 1238670.