

ORBITAL DETECTION AND IMPLICATIONS OF AKAGANEITE ON MARS. J. Carter¹, C. Viviano-Beck², L. Le Deit³, J. Bishop⁴, D. Loizeau⁵, ¹IAS (Paris-Sud University, France, john.carter@ias.u-psud.fr), ²JHU/APL (Laurel, MD), ³LPGN (Nantes University, France), ⁴SETI Institute (Mountain View, CA), ⁵LGL (Lyon 1 University, France).

Introduction: Recent orbital and landed investigations of the Martian surface have demonstrated that the planet underwent a complex geological and aqueous alteration history, fragments of which are recorded in the mineralogy of the heavily disrupted surface [1,2,3]. Of particular interest are aqueously altered minerals that trace warmer and wetter surface environments on Early Mars, some of which also exhibit biogenic formation pathways [4,5].

The most abundant alteration minerals on Mars that have likely been detected are hydrated silicates, hydrated sulfates, and chloride salts [6,7,8]. The detection of minor phases remains important, however, as they further constrain localized geochemical environments at different epochs in the timeline of Mars's geological history. Here, we report the detection of a new, chlorine-rich Fe(III) hydroxide at several locations on Mars: akaganéite (β -FeO(OH)Cl). This oxide has very specific formation pathways and is a known biogenic mineral, providing interesting constraints on localized alteration environments on Mars.

Method: Using data from the CRISM orbital imaging spectrometer on MRO [9], we performed a global search for akaganéite on Mars utilizing specific absorption features in near-infrared spectra. Akaganéite exhibits an electronic Fe(III) transition in the form of a spectral slope short-wards of 1.7 μm , as well as OH and H₂O vibration bands around 1.4, 1.9 and 2.47 μm [10,11]. Following the initial detection of akaganéite at Robert Sharp crater, we ran an end-member extraction algorithm on a sample of over 2900 CRISM high-resolution (< 36 m/pix) observations [12] and report the detection of at least 10 candidate sites where the diagnostic spectral signatures of akaganéite have been identified (figures 1-2).

Results: Akaganéite is found to occur within small (<1km²) deposits throughout the planet, preferentially within impact crater central peaks and over the floor of 2 large basins: Robert Sharp and Antoniadi. The occurrence within impact structures may suggest a formation pathway linked to impact-induced hydrothermal systems as proposed for other alteration minerals, but the neof ormation of akaganéite through a different process is favored at the basin sites.

Implications for Mars: Akaganéite is a rare oxide on Earth which occurs preferentially as a corrosion product of iron in marine environments; an oxidation product within acidic sediments in lagoons, inland wet-

lands, and intertidal marshes; and within hydrothermal brines [13,14,15,16]. The main conditions necessary for akaganéite precipitation are high salinity, mild acidity (pH ~6), oxidizing conditions, and most importantly, high iron (II/III) and chlorine concentrations. On Earth, the source of Fe in akaganéite formation is typically iron ore or sulfides (the latter also providing acidity as they dissolve) [15,16]. Highly concentrated chlorine occurs within volcanic fumaroles or deep sea vents as well as within evaporating, closed or semi-closed water systems [15,16,17].

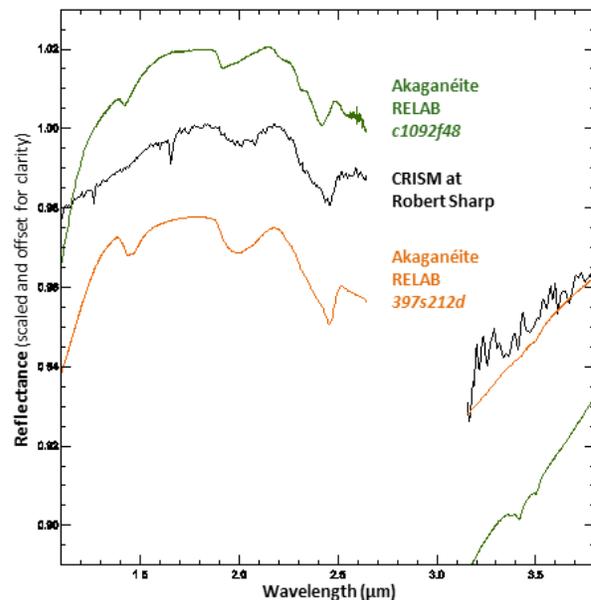


Figure 1. Spectral rationale for the detection of akaganéite on Mars using NIR data from CRISM (black). Color spectra are from natural and synthetic akaganéites.

While the detection of akaganéite within crater central peaks may indicate fumarolic/venting activity as a result of the impact, we propose that the basin floor deposits are the result of evaporating bodies of water (lagoon-type).

Coincidentally, recent in-situ studies of Yellowknife bay mudstones at Gale [18,19] also revealed a minor (< 2wt%) akaganéite occurrence, additionally correlated with minor sulfide detections. Robert Sharp and Gale are neighboring craters, similar in size and both located at the dichotomy boundary. Past water ponding is hypothesized in these craters as the result of the ground-

water table intersecting the surface [20] or run-off towards the northern lowlands. Evidence for ponding of water has been found in the morphology (both exhibit alluvial fans and sedimentary deposits), and confirmed in-situ at Gale with MSL. A proposed common origin for akaganéite at Robert Sharp and Gale involves the shallow ponding of highly saline, mildly acidic and oxidizing waters. Interestingly, the precipitation of akaganéite in such a context requires chlorine to be much more concentrated than sulfur [21], and ferric/ferrous sulfates would not be expected as a major component.

Finally, at Robert Sharp crater, akaganéite is found mixed or at proximity to carbonate (presumably siderite) and iron-rich olivine. This localized association of akaganéite and iron-rich minerals may trace a past alteration setting where both the parent source of iron and the resulting oxide are still in place. Akaganéite is mapped as a superficial and patchy unit above siderite and olivine-rich terrains, suggesting the transformation process was incomplete there.

The detection of akaganéite is particularly compelling as it is a known biogenic mineral, where its formation is enhanced by oxidizing bacteria in an iron-rich medium, or alternatively transformed into siderite by reducing bacteria [22,23]. Akaganéite therefore opens an interesting perspective for benchmarking biogenic minerals on Mars.

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Figure 2. Location of the akaganéite deposits identified from orbit with CRISM. The best detections are located within the Robert Sharp and Antoniadi basin (red dots).

