**WIDESPREAD AQUEOUS SURFACE WEATHERING SOUTH OF COPRATES CHASMA, MARS.**

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**Introduction:** A large diversity of hydrated minerals has been observed on Mars from orbit thanks to spectral imagers like OMEGA/Mars Express and CRISM/MRO [1, 2, 3]. These hydrated minerals are observed in different geologic contexts and in terrains of various ages. Of particular interest are the hydrated minerals formed originally at the surface: they inform us that liquid water was repetedly present or stable at the surface of Mars when they formed.

In particular, similar sequences of clay minerals have been observed in several regions of the planet, in different regional contexts. These sequences have however all been identified in terrains dating from the early Hesperian or earlier. These clay sequences show Fe/Mg smectite-bearing rocks overlain by Al phyllosilicate bearing rocks. On Earth, such a mineralogic sequence is formed by pedogenic top-down leaching: the closer to the surface, the higher the rocks are leached, removing Mg and Fe cations. Places where such a clay sequence is observed on Mars are therefore a clue that sufficient precipitation happened at those places to weather rocks from the surface to tens of meters of depth [4].

One region where these clay sequence has been observed is located in the eastern end of Valles Marineris, on both sides of Coprates Chasma [5]. The present study focuses on the outcrops of this sequence which are exposed on the plateau south of Coprates, where early results showed the most extended occurences. The exact extent of this clay sequence is mapped. This will help in constraining the age of the weathering and the thickness of the clay sequence, in order to evaluate the time and intensity of the aqueous weathering in this region.

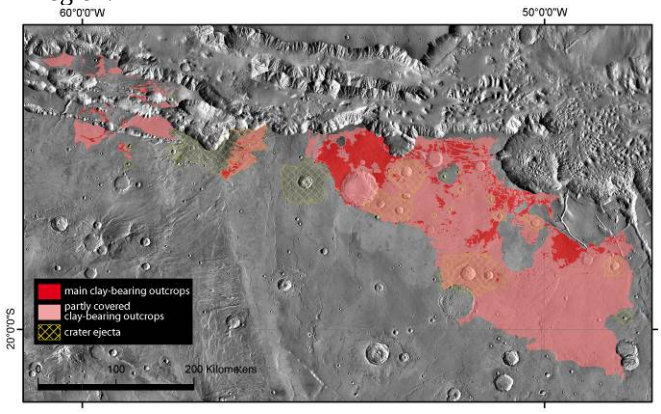


*Figure 1: mapping of the clay-bearing outcrops (red and pink) south of Coprates Chasma.*

**Mapping:** Many clay detections are small in term of surface area and can be studied only with CRISM targeted observations. However, clay detections correlate to a bright geologic unit on the plateau that enables us to map the full extent of the clay sequence even where CRISM targeted observations are unavailable.

The clay sequence is observed both on the eastern and western sides of the Coprates Rise, although the outcrops are much larger on the lower elevation terrains, east of the Rise.

As observed in other regions of Mars, the clay sequence is overlain by a dark capping [4]. The dark capping probably covered the whole region at some point, and the clays are detected today where this capping has been eroded away, or at the top of the walls of Valles Marineris. The dark capping still covers a very large portion of the region, making it impossible to precisely estimate the total area where surface weathering occurred.

**Thickness:** The top part of the clay sequence, where Al-phyllosilicates are identified (spectra are mostly similar to kaolinite), is observed over very small exposures in this region. This is also the case in the other regions where a similar clay sequence has been identified [4]. The Al-clay layer is thus expected to be relatively thin compared to the Fe/Mg-clay layer.

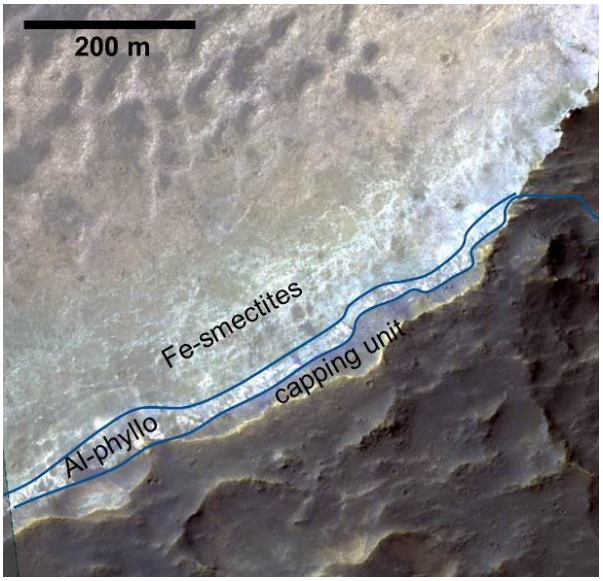


*Figure 2: example of an HiRISE color image on the highest part of a canyon wall. The slope faces North-West. The Al-phyllosilicate horizon is only 2 to 3 CRISM pixels large (FRT0000B6C5).*

In order to mesure a precise value of the thickness of the clay sequence, we tried to identify places where we had together a clear identification of Al-clay and Fe/Mg-clay minerals on a CRISM targeted observation, and a high resolution DEM. We computed HiRISE DEMs where possible with the web GIS application MarsSI (emars.univ-lyon1.fr), that uses the ISIS 3 application [6].

Only one area has both CRISM and HiRISE stereodata, located on the walls of a canyon. The CRISM clay detection map (derived from observation HRL0000BECE) was georeferenced with as much precision as possible on the HiRISE orthoimage and the HiRISE DEM (from HiRISE observations ESP_023160_1650 and ESP_024017_1650). On most areas where Al-clay minerals are identified, the terrain is flat (difference in elevation < 1m), and the largest thickness is < 3m. In this area, Fe/Mg-clay minerals are identified on the top part of the walls of the canyon, over a thickness of ~130 m. However, the Fe/Mg-clays on the walls may have fallen down from their level of origin, creating a larger apparent thickness than the weathering depth.

**Age:** Large surfaces of the clay sequence have been mapped, and the dark capping still covers large areas. The aqueous surface weathering happened after the formation of the crust of the plateaus, but before the deposition of the dark capping, as the last does not show signs of aqueous alteration. Hence, determining the surface ages of both the crust of the plateau and the dark capping above it may give an upper and a lower constraint to the age of the aqueous surface weathering.

A first estimation, east of the Coprates Rise, gives an age of the plateau of 3.77 Ga (±0.03Ga), and an age of the dark capping of 3.54 (+0.08,-0.17) Ga, using the production function from [7] and the Chronology from [8]. This constrains the last episode of aqueous surface weathering in the region to the late Noachian to middle Hesperian [8].

**Conclusion:** Thickness estimate could only be derived at one location so far, but suggest that moderate weathering occurred over a depth >100 m. Additional measurements are needed to evaluate possible variations across the region, that could be due to local topography, variation of the protolith, or variation in the quantity of precipitation. Ages could also be better constrained by doing additional crater counts on other outcrops in the region.

Compared to other regions where similar clay sequences have been reported on Mars, the Al-clay layer is very thin at Coprates (< 3m). The thickest Al-clay layer identified so far is on the plateaus around Mawrth Vallis, where it reaches a thickness of 40 m [9].

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