WIDESPREAD SURFACE WEATHERING ON EARLY MARS: POSSIBLE IMPLICATION ON THE PAST CLIMATE. D. Loizeau[1], J. Carter[2], N. Mangold[3], F. Poulet[2], A.P. Rossi[4], P. Allemand[1], L. Lozac'h[1], C. Quantin[1], J.-P. Bibring[2] [1]Université de Lyon, France (damien.loizeau@univ-lyon1.fr), [2]Université Paris XI, France (john.carter@ias.u-psud.fr), [3]Université de Nantes, France, [4]Jacobs University, Germany.

Introduction: The recent discovery of widespread hydrous clays on Mars with OMEGA/Mars Express and CRISM/MRO [e.g. 1,2] indicates that diverse and widespread aqueous environments existed on Mars, from the surface to kilometric depths [3,4]. The study of the past habitability and past climates of the planet requires assessing the importance of sustained surface water vs. subsurface water in its aqueous history.

Vertical sequences of Al-rich clays on top of Fe/Mg-rich clays in the top tens of meters of the surface are identified on Mars [5-8] (see figure 1) and interpreted as possible weathering profiles, similar to cases of pedogenesis on Earth (e.g. [9,10]).

A global study of these clay sequences has recently been published by Carter et al. [11]. This following work presents detailed geological analysis, performed for each identified candidate, in order to constrain their age and origin.

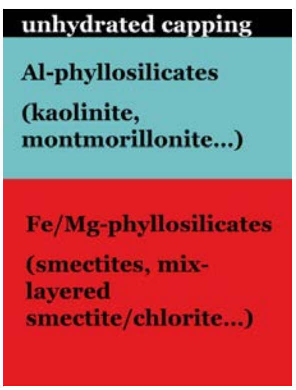

Figure 1: vertical clay sequence

General observations: A large survey of the CRISM dataset leaded to a down-selection of ~100 deposits with such a clear vertical sequence, widely distributed over the southern highlands and grouped in regional clusters [11] (figure 2). Both types of clays show an absorption band at 1.9 µm due to hydration, while the Al-OH band is centered around 2.2 µm and the Fe-OH and Mg-Oh around 2.3 µm, helping to discriminate the type of clay.

These putative weathering sequences are found either on inter-crater plateaus, on the floor of craters and large basins, or on crater ejectas.

With the increasing availability of CTX and HiRISE stereoimages, we investigate the thickness of the altered sequences, the age of the altered units and the different geological contexts to further understand the weathering process(es), and their possible implication on the past climate.

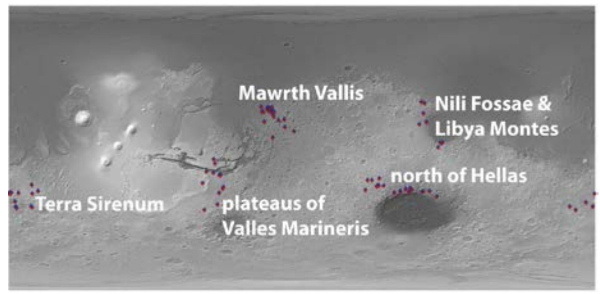

Figure 2: global map of occurences of the clay sequences.

Distribution: The limited thickness of the Al-clays (see below) and their apparent high erodibility produce small outcrops: they are difficult to detect from orbit, and only high resolution targeted CRISM observations can reveal them in most cases; a large number of clay sequences may not have been detected yet, or Al-clays may have been completely eroded away in many cases. Also, the clay sequences are generally capped by a dark unit that has been protecting the Al-clays until their recent exposition: other possible clay sequences may still be hidden underneath dark caps. This is why the frequency of these clay sequences is likely underestimated, and why we identified them in a limited number of clusters.

Thicknesses: Using few HiRISE DEMs where possible, and CTX DEMs, we find that the thickness of the exposed Al clays is on average of the order of several meters to few tens of meters. The thickness of the Fe clays is more difficult to evaluate as erosion most often did not go through the whole sequence, and we cannot access from the orbit the deepest rocks in the sequence. The clay sequences reported here are consistent with terrestrial weathering sequences which form under wet climates over geological timescales ($>10^5$-10^7 years).

Ages: We have been trying to evaluate the age of the alteration of the rocks to form the clay sequence. The presence of a similar vertical sequence, extended over large surface (when observable) indicate that the alteration occurred in situ, on paleo-surfaces. By evaluating the age of the unit that has been altered, and of the dark cap that covers the clay-sequences, we can put constraints on the age of the alteration. All investigated cases point to last stages of active weathering in the late Noachian to early Hesperian, with model ages pointing to alteration between 3.6 and 3.8 Ga.

Regional geologic contexts:

Terra Sirenum. Most outcrops correspond to floor deposits of some of the large basins of this region. Sequences are observed on eroded parts of the floor, or on the flanks of buttes of the chaotic terrains that are present in some basins. The alteration likely occurred before the formation of the chaotic terrains in these cases.

Plateaus of Valles Marineris. Here the sequences are located on the top of the plateaus, each side of the eastern end of Valles Marineris.

North of Hellas Bassin. Most of the sequences of the northern flank of Hellas are situated in layered deposits of small filled basins. One occurrence is at the surface of the ejecta of a partly filled crater (diameter ~50 km). North-west of Hellas, a group of occurrences correspond to the top of inter-crater plateaus.

Nili Fossae & Libya Montes. Around Nili Fossae, possible sequences are located beneath thicker deposits (such as lava flows). In Libya Montes, occurrences are found in eroded buttes, and in the deposits of a filled crater (diameter ~30 km).

Mawrth Vallis. There, thick layered deposits show the sequences over a very extended region, the largest outcrops being concentrated around the Mawrth Vallis outflow channel and along the dichotomy boundary. The outcrops are mainly located on the inter-crater plateaus, but also in few crater floors.

Conclusion: The types of geologic settings where the interpreted weathering profiles are observed are much varied: from basin floor to plateaus, in apparent massive rocks to finely layered rocks. Besides, the number and variety of sequences is/was likely larger. However, in term of chronology, the alteration seems to have stoped in a relatively limited period of time for the studied cases, between 3.8 and 3.6 Ga,. This would point to a formation due to a global process that enabled liquid water at the surface and pedogenesis in various regions, on various terrains, from late Noachian to early Hesperian. This global process would imply regular, widely distributed ice or precipitations in large regions of Mars at that time.

If weathering occurred before that time, during the early or middle Noachian, the sequences may have been erased by the more intense erosion of that time. Also, it is difficult to date older terrains by crater counting on small surfaces.

These observations make a strong constrain concerning the past habitability of Mars: liquid water has been widely available at the surface of the planet, in contact with different rocks, until the early Hesperian time.

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