GEOLOGICAL RELATIONSHIPS BETWEEN PHYLLOSILICATES AND FLUVIAL LANDFORMS IN THREE REGIONS OF MARS. N. Mangold[1], F. Poulet[2], D. Loizeau[1], S. Bouley[1], V. Ansan[1], J.-P. Bibring[2], Y. Langevin[2], B. Gondet[2], P. Masson[1]. [1]IDES, Bat. 509, Université Paris XI, 91405 Orsay cedex, France, [2]Institut d'Astrophysique Spatiale, Bat. 121, Universite Paris XI, 91405 Orsay cedex, France, nicolas.mangold-psud.fr

Introduction: Surface weathering by running water can form phyllosilicate if the action of water is long enough [e.g., 1]. However, hydrothermal circulation can lead to phyllosilicates too, without that liquid water would have to be present at the surface [2]. This questions the origin of phyllosilicates and their relevance to understand the past climate of Mars. Two approaches can improve this question. First, new minerals found with spectral data can provide a better view of the type of alteration, and its surficial characteristics, i.e. kaolinite now found extensively in two regions might be the signature of more extended surface alteration [e.g. 3]. Second, the association of phyllosilicates with geologic units formed at the surface such as fluvial landforms is another potential signature of surface processes. Here, we use this second approach, by showing several chronological and stratigraphical relationships between fluvial landforms and phyllosilicates detected in three regions, Nili Fossae, Mawrth Vallis, and Thyrrena Terra.

Mawrth Vallis region: This region displays extensive clay-rich outcrops distributed in many layers of both Al-rich phyllosilicates and Fe/Mg-rich smectites [2, 4] with proportion of smectites often reaching 50% [5]. Layers were deposited on top of the crust with thickness reaching >300 m extending over a broad area of 300 by 300 km [4, 6, 7]. This region displays different fluvial landforms. The Mawrth Vallis outflow channel is known to be a snapshot episode of aqueous flow as most outflow channels, therefore it is not expected to play a major role in the alteration process. In contrast, small branching valleys exist throughout the region, which appear to erode inside the layered unit. Of interest is an inverted valley located on the eastern side of Mawrth Vallis. This valley appears to be more and more inverted to the west were the erosion exhumes the clay-rich unit deeper. This shows that these valleys formed inside the clay-rich unit which was later eroded enough to invert the alluvial deposit of these valleys. These alluvial deposits likely behaves stronger against erosion than the clay-rich unit composed of fine grained material easy to erode. These examples show that these branching fluvial patterns formed after the layered deposits and dissected them, but there seems to be no genetic relationships between them.

Nili Fossae: In this region phyllosilicates exist as Fe-rich smectites mainly into the outcrops of the exhumed bedrock and associated to olivine rich unit [2,8]. The Nili Fossae floor and the whole Syrtis Major unit, a volcanic early Hesperian unit, is devoid of any alteration which limits the period of activity of this alteration to earlier geologic phases in the Noachian period (crust formation and olivine-rich unit formation). Two main types of fluvial landforms are observed in the Nili Fossae region. First, ancient valleys cross the Noachian highlands. These display sinuous shapes typical of meanders of fluvial origin, having a depth that reaches locally 300 m and extend up to 180 km in length. The valley floor exhibits a large channel with braided patterns typical of high-energy flows. A discharge of 500–900 m^3/s was estimated for the EW oriented valley [9]. The poorly branching geometry of these valleys is different from the usual dendritic valley systems observed on Earth for valleys formed by precipitation. Their width and the presence of large channels suggest better flash floods, subsurface discharge or glacial surges. These valleys are superimposed on the olivine-rich unit that compose many outcrops of the eastern part of the region. This olivine-rich unit is only partially altered compared to the underlying bedrock which displays more extensive alteration. For this reason, the fluvial valleys observed might have participated into the local alteration of the olivine-rich unit, but their participation to the extensive alteration of the bedrock is unlikely, because this early phase of alteration was likely finished at the time of formation of the olivine-rich unit which is not massively altered.

Second, deep but poorly organized valleys emerge on the rim of the Nili Fossae trough system and some other landforms. Their short length, theater-shaped head and constant width are typical of sapping canyons, i.e., valleys formed by headward erosion due to subsurface flows. Several debris fans are associated with their termination in the Nili Fossae trough. These deposits are likely not deltas but alluvial fans (deposited subaerially). Additionally, another unusual fan is observed on high-resolution MOC images in a 80 km large crater. The ejecta of this crater are superimposed on the Nili Fossae floor, therefore involving an age younger than the alteration sequences for these alluvial fans, which formation was finished at the time of the Nili Fossae floor formation. One of this fan shows little alteration in a secondary trough of Nili Fossae [8, Fig. 13]. As the surrounding bedrock displays stronger signature of alteration than the fan, we interpret this fan to present clays mainly due to the transport and deposition of these outcrops rather than any *in situ* formation. In general, to understand if clay deposits in fans, such as in Jezero crater, are due to *in situ* alteration or transport of upward material of the crust is a critical question for the origin of clays. It requires to study outcrops surrounding the fan deposits to understand if the lacustrine system was enough long to permit to the bedrock to be altered or not.

In summary, these fluvial landforms and their depositional products formed late in this region: all of them formed after the emplacement of the Noachian units that are rich in LCP, olivine or phyllosilicates, with some of them (sapping valleys especially) being clearly active during the Hesperian period. It is thus not surprising that most of the observed fluvial landforms are poorly correlated with hydrated regions: they cannot account for the epoch in which the largest outcrops of phyllosilicates formed, but some of them could be correlated to small outcrops altered late.

Thyrrena region: In this region, most outcrops of phyllosilicates are observed on craters walls or ejecta which does not allow an easy correlation with fluvial landforms [2, 10]. Nevertheless, a small plain displays hydrated minerals (single 1.93 micron signature with poor 2.3 micron peak locally). This plain is at the foot of hilly outcrops of Noachian bedrock dissected by few fluvial valleys. The study of this region is under progress to evaluate the relationships between these valleys and the observed signatures.

Conclusion: The timing of formation of most fluvial landforms observed in the vicinity of phyllosilicates indicate that these minerals formed mainly earlier than the fluvial systems still observed at the surface. Transport and deposition might explain many secondary deposits such as clays in alluvial fans. However, late alteration related to river streams is possible in several locations such as Nili Fossae and Thyrrena. Moreover, most of the fluvial landforms observed are the last episodes of aqueous deposition in the early Mars period, so they can not inform on the aqueous episodes that occurred earlier and might have been eroded or buried.

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