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Formation of mud volcanoes, giant polygons and chaotic terrains on Mars as the result of compaction and convection of altered pyroclastic deposits.

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Rheology of crustal material is a key parameter to understand surface morphology on solid planets. Detections of phyllosilicate-rich units on Mars, made by OMEGA and CRISM instruments, over a major part of the Southern Plains [1] and in some specific regions as ejectas and craters central peaks in the Northern Plains [2], suggest a widespread extend of phyllosicate-rich deposits. Analysis of recent experimental characterization of the rheology of phyllosilicates leads us to propose a link between several types of surface features on Mars and the hydrodynamic instabilities that may develop in such material. More precisely, we propose and argue that the formation of mud volcanoes, giant polygons and chaotic terrains results from the interplay of compaction, hydrothermal convection and plastic convection in thick phyllosilicate-rich units.

Indeed, the compaction and hydrothermal convection that may develop in the 4° tilted sedimentary layers in Firsoff crater [3] would lead to the formation of a top light-layered deposit intruded by mud volcanoes. In the same way, compaction coupled with hydrothermal and plastic convection in the 2.5 km thick sediment cover of Utopia [4] and Acidalia Planitiae can explain the formation of the giant polygons and their associated set of mud volcanoes. Besides, strong plastic and hydrothermal convection coupled with compaction acting in the 5 km thick cover of Hydraotes Chaos would explain the formation of (i) the kilometre deep troughs separating the polygonal mesas recorded there, and (ii) the km large pitted mud cones paving these troughs. Finally, we obtain new insights into the sub-surface structure prevailing to the formation of outflow channels. Indeed, we propose the formation of a network of connected deconsolidated clays tubes would provide the necessary hydrological connectivity that eventually led to the major outflow events.

[1] e.g. Ehlmann et al., 2013, Spa. Sci. Rev., 174 (1-4); [2] Carter et al., 2010, Science, 328 (5986); [3] Pondrelli et al., Earth and Planet. Sci. Lett., 304 (3-4); [4] Cooke et al., 2011, J. Geophy. Res., 116.