Experimental approach to understand mineralogy and aqueous alteration history of Oxia Planum, ExoMars 2020 landing site

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In 2020, ESA/ROSCOSMOS will launch ExoMars2020 rover mission to Mars. The selected landing site for the mission is Oxia Planum, a wide Noachian-aged clay mineral-bearing plain. The Fe,Mg-rich clay mineral deposits in Oxia are one of the largest exposures of this type on Mars, with a thickness of more than 10 m and as such are an important source of information about Martian Noachian (>3.9 Ga) water-mediated interactions between lithosphere, hydrosphere, and atmosphere. The regional compositional mapping of Oxia Planum conducted in spectroscopic studies by OMEGA and CRISM suggests that the clay minerals are mainly trioctahedral Fe,Mg-rich in nature, with a local presence of dioctahedral Al-rich varieties. Although no exact spectral match was found for Oxia clay minerals among terrestrial analog rocks, the closest consistency is revealed by vermiculite or Fe,Mg-rich di-trioctahedral smectite.

The mechanism by which vast deposits of vermiculite may have formed on Mars is, however, not entirely clear. Based on the preliminary geomorphological investigation at Oxia, five major environments of basement clay minerals formation are plausible: pedogenic, hydrothermal in shallow sub-surface, related to metamorphism or to diagenesis as well as connected to glacial alteration. However, it is not obvious whether these early Noachian environments may have provided conditions capable to form vermiculite-like minerals. Furthermore, understanding the mechanisms of alteration in specific environments does not bring sufficient information about fluid alteration conditions such as chemical composition, acidity, oxidation state and amount of fluid (i.e. water to rock ratio).

To better understand the plausible mechanism of the formation of vermiculitic-like clay minerals at Oxia Planum as well as fluid alteration conditions, we have been performing laboratory alteration experiments. Comprehended from terrestrial analog environments, we focus our research on possible alteration pathways of biotite and chlorite towards vermiculite. Additionally, considering geomorphological manifestations of plausible past aqueous environments at Oxia Planum, we test various conditions of surface weathering and hydrothermal activity.
Our results show that Fe,Mg-vermiculite may form via alteration of Fe-rich biotite in the CO2-rich atmosphere in Noachian Mars. However, critical factors governing the process are the saturation of solution in K dissolved from biotite and oxidation of solution. In laboratory conditions, vermiculitization occurred only under conditions providing relatively high water to rock ratios or in an open system. It implies that if vermiculite-like clay mineral deposits formed in Oxia Planum, a large amount of water must have been delivered to the subsurface to drive alteration through preferential removal of potassium from interlayer space of primary minerals.