Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.6895

Tardi-magmatic precipitation of Cl-bearing Fe/Mg clay minerals on Mars

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Mars is seen as a basalt-covered world that has been extensively altered by hydrothermal or near surface water-rock interactions: all the Fe/Mg-rich clay minerals detected so far have been interpreted as products of aqueous alteration of pre-existing silicates by (sub)surface water. However, the fine scale petrographic study of the mesostasis of two Martian Nakhlites emplaced ~1.3 Ga [1, 2] (Nakhla and NWA5790) revealed the presence of primary, highly porous, Cl-rich Fe/Mg clay minerals (mixtures of Cl-rich saponite and celadonite) which directly precipitated at high temperature during magmatic processes together with Cl-rich apatites from a water-rich fluid exsolved from the Cl-rich parental melt of nakhlites. These Fe/Mg clays are associated with K-feldspar and quartz in Nakhla. The high Cl content of the melt having likely allowed its evolution to lower temperatures before solidification as would have done a high water content [3]. Even though these clay minerals are not the main constituents of the mesostasis of the nakhlites investigated, they should be taken into account when estimating the magmatic water and halogen budget. In any case, these results demonstrate that some of the Martian Fe/Mg-rich clay minerals are not the products of aqueous alteration and that the halogen content of Martian magmas exerted a key control on the final mineral assemblage of Martian magmatic rocks. The contribution of magmatic precipitation to Martian clay formation may have been more significant during the Noachian given that Noachian magmas were richer in H2O. Altogether, these observations justify a re-evaluation of the origin of the clay minerals detected on Mars so far, with potential consequences for our vision of the early magmatic, climatic and habitability histories of Mars.

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[3] Filiberto & Treiman (2009), Chemical Geology 263, 60–68.