AQUEOUS ALTERATION IN MARTIAN METEORITES: A COMPARISON BETWEEN NAKHLA AND ALH 84001

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Introduction: Water and volatile elements were widely available at early times in Mars' evolution and affected the differentiation and eruptive behavior of martian magma. Most of the Martian crust is basaltic and contains the legacy of ancient processes, including aqueous alteration of their primary minerals. We are currently using Martian meteorites to infer clues on the level of aqueous alteration experienced by rocks formed at different epochs. Our sudies are useful to understand the chemical evolution of Mars' surface and its interaction with the atmosphere, and also provide clues on the feasibility of the creation of a biosphere under episodic warm conditions [1-2].

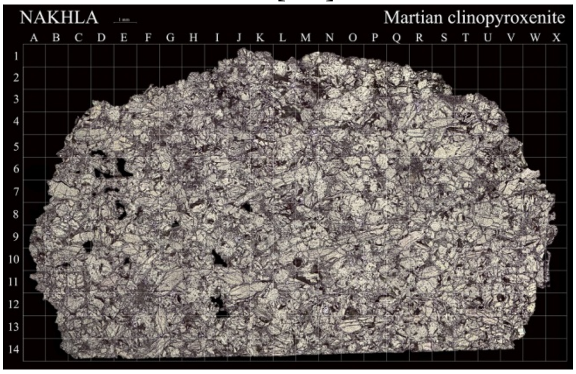

Figura 1: Thin section of Nakhla achondrite (IEEC-CSIC collection)

Results and discusion: Here we present evidence of aqueous alteration in Nakhla and Allan Hills 84001. The first is an augite-rich igneous rock that gives name to a particular class of Martian achondrites known as Nakhlites. The second one is an ortopyroxenite representing some of the oldest crust of the red planet. Both igneous achondrites exhibit secondary minerals that are clear evidence for subsurface hydrothermal alteration, but the extent and nature of such alteration is very different. In fact, while Nakhlites were formed less than 1 Gyr ago in a quite dry time period of Mars known as Amazonian, the ALH 84001 ortopyroxenite represents a basaltic lava solidified about 4.1 Gyr ago during a wet period known as the Noachian. Nahkla exhibits restricted, but somehow evident, aqueous alteration already outlined in [3]. We found in fractures Ca-carbonates (calcite), and Ca-sulfate (gypsum) that percolated and grew from a water solution. We also found melt inclusions in augite with alteration of the voids. Observations are probably consistent with a fast atmospheric deposition of sulphur in the surface due to episodic volcanism, followed by mobilization of S within the regolith in aqueous dissolution, explaining the transferred isotopic signature of this atmospheric chemistry to mineral phases in Nakhla and other SNC meteorites [4]. On the other hand, ALH84001 exhibits secondary minerals appeared by its alteration while it was forming part of Mars' crust. Due to its age and long exposure to the Martian environment, ALH 84001 records early processes, including a highly fractured texture, gases trapped during the ejection event or during formation of the rock, and the presence of spherical Fe-Mg-Ca carbonates [2]. We have used a wide range of techniques (see [2] for instrumental details) to distinguish the different precipitation events of the carbonates. The petrographic features indicate that the carbonates grew in two or more precipitation episodes, probably associated with phases of Martian volcanism. The carbonates have intermediate compositions that are unusual on Earth, and it suggests a terrestrially uncommon formation mechanism. Our preferred scenario invokes different aqueous solutions under changing environmental circumstances [5]

References:

[1] Moyano-Cambero C.E. et al., In *The Early Evolution of the Atmospheres of Terrestrial Planets*, J.M. Trigo-Rodríguez et al. (Eds.), 165–172, 2013. [2] Moyano-Cambero C.E. et al., D. E., **MAPS**, doi: 10.1111/maps.12851 [3] Gooding J.L. et al. **Meteoritics** 26, 135-143, 1991 [4] Farquhar J. et al. **Nature** 404, 50-52, 2000. [5] Fernández-Remolar D. C., et al. **MAPS** 46:1447–1469, 2011.