GROWTH OF CARBONATE GLOBULES IN ALLAN HILLS 84001 MARTIAN ORTHOPYROXENITE BY TRANSIENT FLOODS IN A VARIABLE CLIMATIC ENVIRONMENT

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Introduction: While no sample-return missions from Mars are achieved, the Martian achondrites are the only Martian rocks available in our laboratories. They provide valuable information about current and ancient environmental conditions on Mars because they have different crystallization ages and relevant information about their formation regions in the red planet [1]. Here we focus in the Allan Hills 84001 meteorite (hereafter ALH 84001) that can be used for constraining conditions on early Mars since it formed more than 4 Gyr ago. Due to its age and long exposure to the Martian environment, ALH 84001 has unique features capable of recording early processes: 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. We describe in this abstract the relevance of the carbonates studied within ALH 84001,82 thin section (Fig. 1) [2].

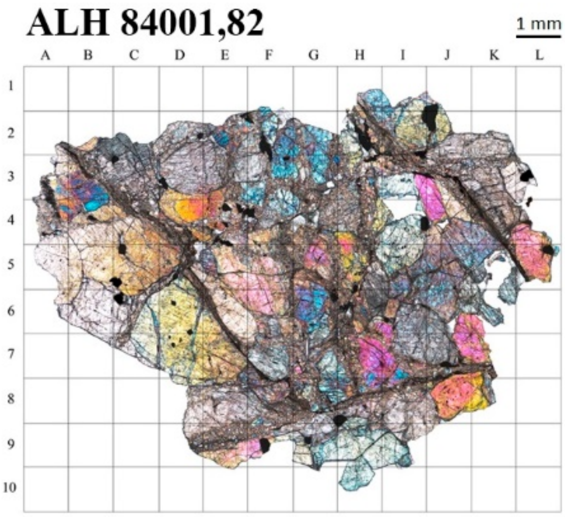

Figure 1: High-resolution mosaic of the ALH 84011,82 section in transmitted light and crossed nichols. A grid to identify the regions of interest (ROIs) was superimposed.

Figure 2: Cathodoluminescence image obtained of the D5 ROI in Fig. 1 (notice the bending crack for further identification) after applying electron bombardment at a voltage of 20-24 keV. As Fe is a typical quencher, the right red areas correspond to Fe-poor and Mn-rich carbonate layers that nicely mark the carbonate globule walls.

Instrumental procedure: As we were concentrated in the study of the carbonates found in our thin section (Fig. 2), we have used several SEM and microprobe to figure out the chemical composition of the globules. In particular, quantitative chemical analyses and BSE images of the carbonate globule walls were obtained using a JEOL JXA-8900 electron microprobe equipped with five wavelength-dispersive spectrometers at the UCM.

Discussion: The results presented are clear evidence for precipitation of the ALH 84001 carbonates after (or during) at least two/three different events. Indeed, the two main fracture systems of the analysed thin section and the presence of fracturing and corrosion previously to precipitation of some layers [2] point towards two/three different formation times.

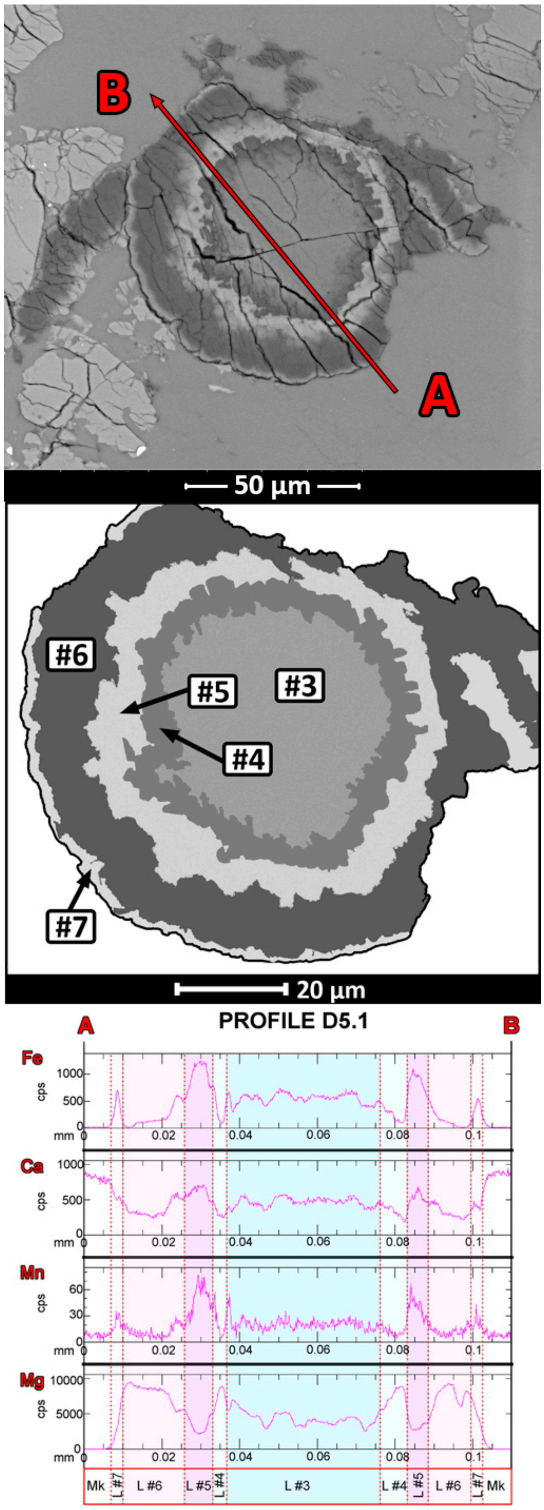

Figure 3: SEM and squematic images showing layers #3 to #7 in one carbonate globule in D5, plus the Fe, Ca, Mn, and Mg microprobe linear profiles from one side to the other.

We have also noticed a sharp change in composition that suggests a change in solution chemistry and saturation state (e.g., the concentration in CO_2 or pH) between formation of the inner (#1 to #4) and outer (#5 to #7) layers. In consequence, the microprobe data reveal two trends that are consistent with the idea of at least two episodes of precipitation to form the carbonate globules. The distribution coefficients for Fe and Mn into carbonates are higher than 1, meaning that any Fe^{2+} or Mn^{2+} in the fluid will preferentially partition into the carbonate. Assuming that the system was closed so that there was no continuous influx of fluid, Fe and Mn would be depleted relative to Mg, and this process may be responsible for creating the geochemical patterns observed in the layers. The studied carbonates display two compositional patterns (at layers #1 to #4 and again at #5 to #7), which implies that a second carbonate formed as an overgrowth on the first generation. Indeed, the contrasting trends imply that the formative fluids differed in composition, possibly pointing to distinct aqueous alteration events, which could be related with the already mentioned necessity of at least two episodes of fracturing.

Conclusions: The petrographic features and compositional properties of these carbonates indicate that a Mg- and Fe-rich solution saturated the rock, leading to their precipitation in at least two different episodes. This is supported by the presence of distinct chemical trends indicating that these carbonates grew in two or more stages. In conclusion, 1) we have found clear evidence of carbonate globule formation when a fluid soaked the host rock of this meteorite, with chemical variations probably associated with atmospheric changes and volcanic outgassing. 2) The presence of these carbonates suggests that secondary minerals produced by aqueous alteration should be more common in the oldest Martian terrains, as suggested by recent remote-sensing studies and their study can provide valuable clues on the long-standing action of water on the Martian environment.

References: [1] Moyano-Cambero C.E. et al., In The Early Evolution of the Atmospheres of Terrestrial Planets, J.M. Trigo-Rodríguez, F. Raulin, C. Muller and C. Nixon (eds.), Springer, New York, 165–172, 2013.
[2] Moyano-Cambero C.E. et al., MAPS *52,* 1030-1047, 2017.

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