

ALLAN HILLS 84001

The meteorite Allan Hills 84001 (hereafter ALH 84001) is a currently unique Martian orthopyroxene specially interesting for the study of the early Mars, as it was formed more than 4 Gyr ago [1]. Due to its age this meteorite contains characteristic features which are consequence of early processes occurred in the red planet, like a high fractured texture [2], the presence of spherical Fe-Mg-Ca carbonates [3], and gases that were trapped during the ejection event or during the formation of the meteorite [4]. The mentioned carbonates led some years ago to the possibility that early biologic activity was present on Mars [5] and have restricted the possible scenarios in which they formed, around 3.9 Gyr ago [6].

Fe-Mg-Ca CARBONATES

One of the most interesting facts on ALH 84001 is the presence of Fe-Mg-Ca carbonates found along fractures and cataclastic areas [3] and formed 3.9 Gyr ago, after plagioclase had been converted to maskelynite [6] and during the time of Ardegassing of plagioclase [7]. There are different opinions about the radiometric age of these carbonates [1], because it seems that there are different types of carbonates and maybe even different generations [8], although similar zoning profiles seem to indicate that they were formed in a single event [3]. It has been suggested that most of the carbonates formed from a CO₂ enriched aqueous fluid in brecciated rock, at the same time when the compositional zoning was established, but after the first carbonates formed by replacement of plagioclase or maskelynite [1]. This formation processes appear to have coincided with impact metamorphism, perhaps via precipitation from an impact crater lake [1].

These carbonates usually appear as globules or rosettes strongly zoned in composition, with Ca-rich cores surrounded by concentric and alternating rims of siderite and magnesite [8] but they can show a multitude of varieties, which could suggest different origins or even different generations [3] (Fig. 3). Multiple features related to these carbonates found with SEM and other techniques, led to the premature conclusion that early biologic activity was present on Mars [5]. Several features gave support to the idea, which made the public and scientific interest in planetary science to grow. However, it has been proven that all these features can also be explained by abiogenic processes [9], so by now none of them is a strong enough proof for the existence of Martian biologic activity, but the mere possibility led to many studies about life in extreme terrestrial environments.

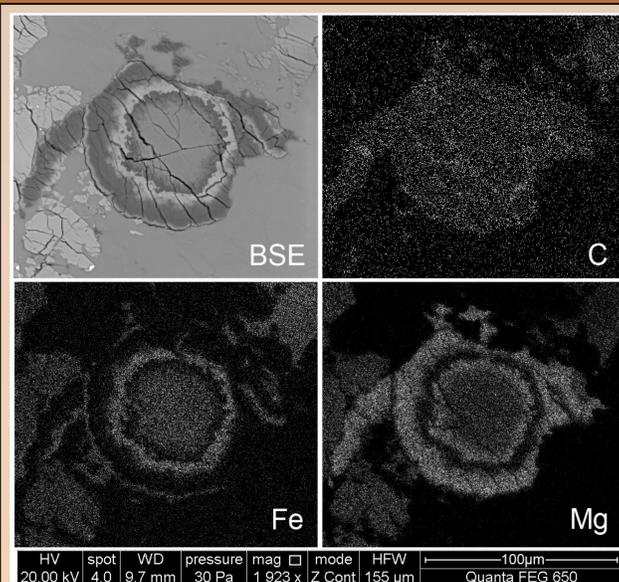


Figure 2: This 4 images show one of the carbonates globules studied in ALH 84001 in a BSE image, and mappings of C, Fe and Mg content, respectively. The alternating Fe and Mg-rich rims can be clearly seen.

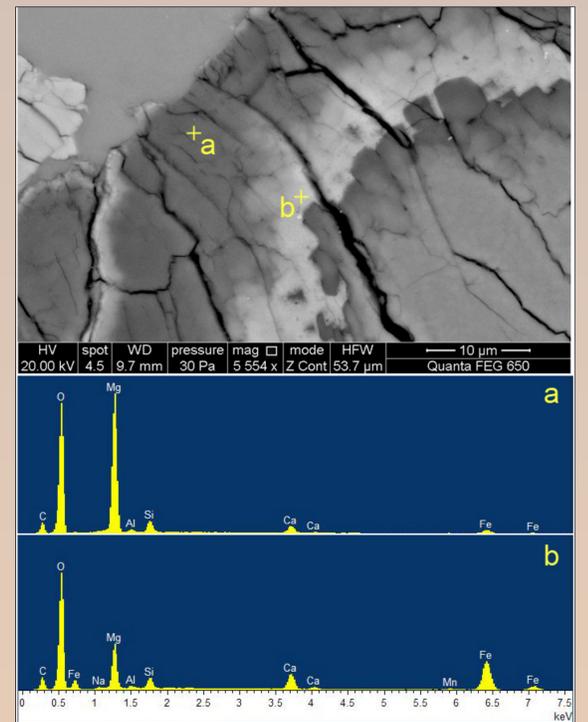


Figure 3: Example of two EDX spectra that reveal a Mg-rich rim (a) and a Fe-rich rim (b) in one of the carbonate globules.

SOME CLUES ON EARLY MARS

There is still debate around the environmental conditions under which these carbonates formed, suggesting low temperature precipitation [2], or precipitation from a fluid with high concentrations of CO₂, at higher temperatures [10], but it was recently suggested that the high temperature conditions were not really consistent with the formation of carbonates [11]. The Mg-Fe rich composition of these carbonates can provide constraints about the aqueous processes that took place on Mars when they were formed [12]. For example, it has been suggested that the fluid where they come obtained its CO₂-rich character in the sub-surface and later was exposed to an arid atmosphere which prompted rapid evaporation, CO₂ degassing, and carbonate precipitation [12].

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TECHNICAL PROCEDURE

A thin section of ALH 84001 called ALH 84001,82 and provided by the Johnson Space Center (NASA) was used for this study. A high-resolution mosaic of the section was generated from separate 50X images taken with a Zeiss Scope petrographic microscope (Fig. 1), which allowed us to establish features to be characterized micro-Raman, SEM, and EDS techniques. We used a FEI Quanta 650 FEG working in low vacuum BSED mode. The EDS detector used to perform elemental analyses is an Inca 250 SSD XMax20 with Peltier cooling with an active area of 20 mm². SEM elemental mapping together with EDX spectra were obtained from the previously selected areas (Fig. 2 and 3).

ALH 84001 Martian (orthopyroxenite)



Figure 1: High resolution mosaic of the ALH 84001,82 thin section. The grid is 1mm wide.