EVIDENCE FOR AN UNUSUAL GENERATION OF CARBONATE IN ALH 84001. G. Holland, I.C. Lyon, J.M. Saxton, T. Frankland, G. Turner. Department of Earth Sciences, University of Manchester, Oxford Road, Manchester, M13 9PL, United Kingdom. Email: gholland@fs1.ge.man.ac.uk

Introduction: Chemical and isotopic zoning have been studied in several carbonate samples of the martian meteorite ALH84001. This ongoing line of research aims to determine the process responsible for the formation of secondary carbonates, quantify the conditions of formation and refine the timing of events in ALH84001.

We have studied four small (2–8 mg) grains of ALH84001 from sample ALH84001,287. These contain carbonate rich areas up to 200µm in diameter often intimately associated with feldspar, and fragments of rosettes up to 70µm across similar to those we and others have studied previously (e.g. [1,2]).

Experimental: Chemical analyses of carbonates were acquired using the Manchester Cameca SX100 electron microprobe. Element maps and spot analyses were obtained with a resolution of ~1µm using WDS for Fe, Mn, Ca, Mg and Si, and EDS for other elements with an accelerating voltage of 15kV and a beam current of 10nA–20nA.

Results: Figure 1 shows an area of Mg-rich carbonate fragments surrounded by calcium carbonate rich growth zones. The largest of these Mg-rich fragments, 15µm across, has an average composition of $Ca_{0.05}Mg_{0.70}Fe_{0.23}Mn_{0.01}$ and appears zoned with a rim of composition $Ca_{0.09}Mg_{0.75}Fe_{0.12}Mn_{0.01}$. The adjacent Ca-rich zone (white area in figure 1) has a composition of $Ca_{0.74}Mg_{0.13}Fe_{0.05}Mn_{0.08}$ and grades to a composition of $Ca_{0.14}Mg_{0.51}Fe_{0.32}Mn_{0.02}$ (point A). A prominent Ca/Mn-rich carbonate band of composition $Ca_{0.25}Mg_{0.39}Fe_{0.29}Mn_{0.05}$ is also present (point B).

Figure 2 shows similar carbonate zoning in a different sample, except that the Mg-rich carbonate at the centre of the Ca-rich region is homogeneous magnesite of composition $Ca_{0.07}Mg_{0.69}Fe_{0.22}Mn_{0.01}$ (region C). The surrounding calcite region of initial composition $Ca_{0.73}Mg_{0.14}Fe_{0.05}Mn_{0.08}$ zones to carbonate of composition $Ca_{0.14}Mg_{0.50}Fe_{0.32}Mn_{0.02}$, again with a prominent Ca/Mn-rich band. Fragmented carbonate rosettes of normal composition ([1,2]) are seen near the top of the image (points D,E). Figure 3 more clearly shows the presence of the Mg-rich carbonate area (white area C) and the intimate association of carbonate and feldspar (black areas distributed throughout carbonate).

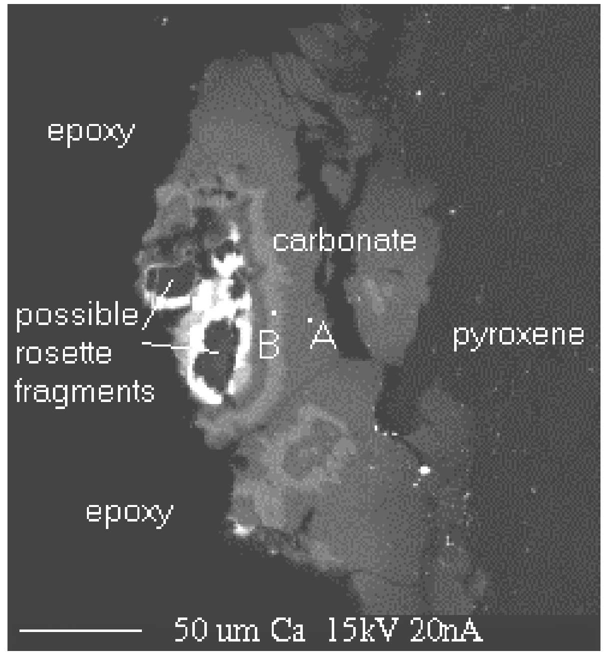

Figure 1: A Calcium element map of possible magnesite rosette fragments as apparent nucleation sites for subsequent Ca-rich carbonate formation (sample 1).

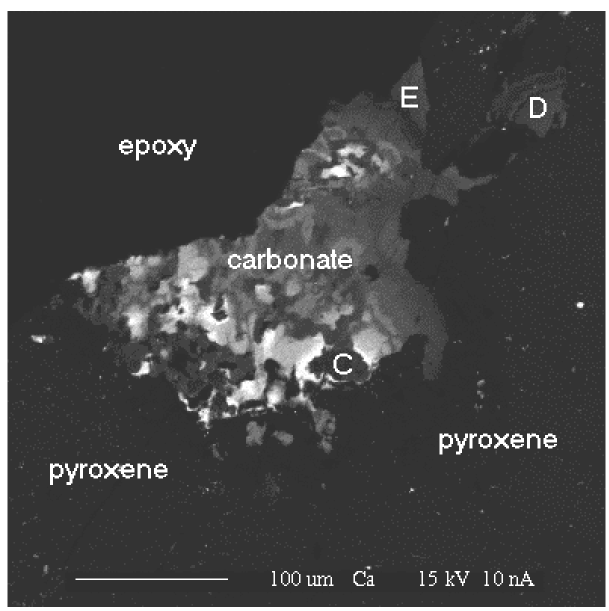

Figure 2: a calcium element map of zoned carbonate with multiple nucleation points, one of which is homogeneous magnesite (sample 2).

Observations: These unusual carbonates with multiple nucleation sites, no observed magnesite rims, ~75% Ca cores and Ca/Mn-rich bands appear rarely to have been observed before [3]. However, the carbonate region in figure 1 appears to have nucleated on fragments of Mg-rich carbonate. If the last carbonate to precipitate is indeed that adjacent to the pyroxene, it is interesting to note that no Mg-rich rim is present, in contrast to typical rosettes. An interesting possibility is that the Mg-rich carbonate fragments are pieces of conventional carbonate rosettes, in which case our sample displays an unusual, later, generation of carbonate growth.

The Mg-rich carbonate region (region C) in figure 2 and figure 3 does not display any zoning similar to a conventional rosette. However, it still appears to act as a point of nucleation for subsequent Ca-rich carbonate. This Mg-rich region also has a similar composition to the outer mantle of normal composition rosettes such as the rosette fragments present in sample 2 (D, E in figure 2) but is less Mg-rich than a normal rosette magnesite rim. Mg-rich carbonate regions within Ca-rich carbonate regions in the other two samples have similar compositions to region C (figure 4). Again the possibility exists that these Mg-rich regions also represent carbonate from the precipitation episode that formed carbonate rosettes. If this were the case, then an unusual, later, generation of carbonates is again implied. Alternatively, if only one generation of carbonate is present, how is the formation of magnesite as the first precipitated carbonate explained?

The relationship between carbonate and feldspar is unknown but the abundant examples of embayed feldspar (white arrows in figure 3) are suggestive of feldspar replacement by carbonate, the feldspar occurring as either crystalline feldspar [4] or feldspathic glass [5] at the time of replacement.

Ion microprobe oxygen isotope analyses are planned.

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References: [1] Saxton J.M. *et al.* (1998) *EPSL, 160*, 811–822. [2] Leshin L.A. *et al.* (1997) *GCA 62*, 3-13. [3] Harvey R.P. and McSween Jr. H.Y. (1996) *Nature 382*, 49-51. [4] Treiman A.H. (1995) *Meteoritics 30*, 294-302. [5] Gleason J.D. *et al*. (1997) *GCA 61*, 3503-3512.

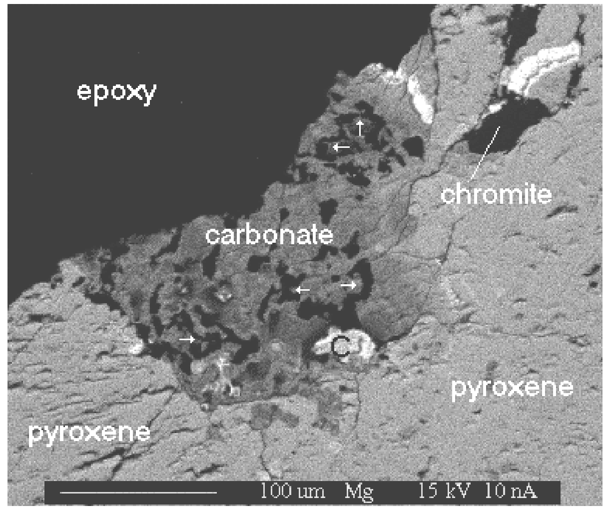

Figure 3: a magnesium element map showing the relationship of feldspar (dark areas arrowed) and carbonate (sample 2).

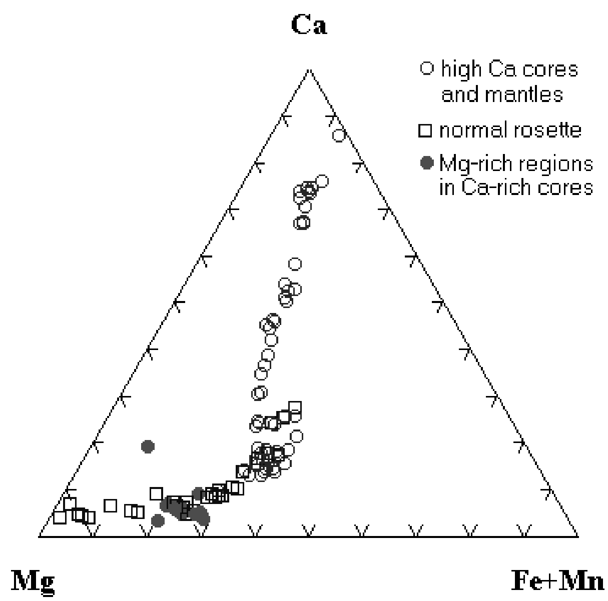

Figure 4: molar composition ternary diagram of ALH84001 carbonate rosettes, high-Ca zoned carbonate and Mg-rich carbonates in the centre of Ca-rich regions.