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INVESTIGATION OF SVALBARD, NORWAY CARBONATES IN BASALTIC SAMPLES AS AN EARTH ANALOG FOR CARBONATE GLOBULES WITHIN MARTIAN METEORITE ALLAN HILLS 84001.

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Introduction: Martian meteorites provide beneficial knowledge about the evolution of current and past geological and climatic conditions on our neighboring planet, Mars. The meteorite Allan Hills 84001(ALH 84001) is critical in understanding the aqueous history of Mars. ALH 84001 is an orthopyroxenite formed from cooling basaltic magma around 4.5 billion years ago [1]. Because of Mars' violent history with asteroids and other impacts ALH84001 has many deformities and alterations [2-3]. This primarily includes extensive crush zones, which will be demonstrated in photographs below. At a later point in its history the orthopyroxene-rich rock experienced Mg/Fe - Ca carbonate deposition [1]. The presence of carbonates infers an aqueous environment, and consensus has centered on low temperature hypotheses of formation, most likely hydrothermal interactions with the orthopyroxenite rock (c.f. [4]). The goal of this undergraduate research is to compare carbonate globules found within ALH84001 and samples from an analog site: volcanic centers on Svalbard, Norway, to better understand the formation of the globules.

Methodology: Three thin sections from Svalbard, Norway (01 SVF-61, 01 SGF-1, and 01 SVF-10) generously lent by Allan H. Treiman along with two ALH 84001 thin sections (ALH 84001,3 and ALH 84001,308) provided by the Johnson Space Center were used to conduct this research. Only optical microscopy was used when examining the thin sections. The microscopes allowed us to examine the thin sections and compare directly between Martian and terrestrial carbonates. The globules, which range from 50 – 250 micrometers in diameter, are best viewed under high power.

General observations: For ALH 84001 thin sections, we immediately noted the orthopyroxene, occurrence of chromite, and the low abundance of carbonate. The crushed zones observed by [2, 3] were obvious and are shown in figures 1 and 2.

For the Svalbard samples, one (01 SVF-61) was of a olivine- and clinopyroxene-rich xenolith. Section 01 SGF-1 was a breccia of at least 2 kinds of volcanic glass, similar to samples described by [5]. Section 01 SVF-10 contained dark volcanic glass with phenocrysts of clinopyroxene and tiny crystallites of plagioclase. Carbonate globules are found in vesicles. Some of these occurences also contain a low relief phase with low first-order interference colors – probably a zeolite, similary to the observations of [6].

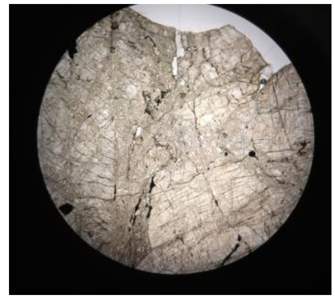

Fig. 1: photomicrograph (low power, plane light) of a portion of the ALH 84001 meteorite. Diameter of the field of view is 5 mm.

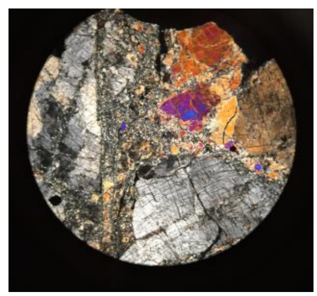

Fig. 2: photomicrograph (low power, cross-polarized light) of a portion of the ALH 84001 meteorite, same field of view as fig. 1.

Carbonate Comparison: The following pictures directly compare carbonate globules found within ALH 84001 and Svalbard, Norway.

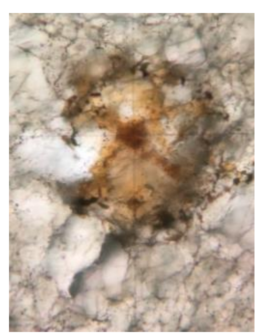

Fig. 3: Above is an ALH carbonate demonstrating chemical zoning, Ca carbonate rich core, with a mag-

nesite rich rim. Interstitial phases are orthopyroxene. The carbonate area is 0.5 mm across.

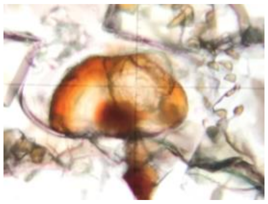

Fig. 4: Svalbard carbonate demonstrating the expected zoning. If this carbonate experienced shocking, it might look nearly identical to the carbonate in Fig 3.

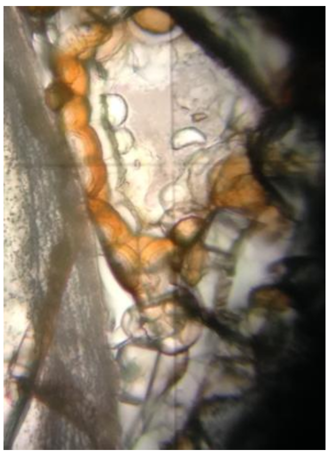

Fig. 5: a group of carbonate hemispheres in an crack within a mantle xenolith (sample 01 SVF-61). Size of globules: 0.1 mm diameter.

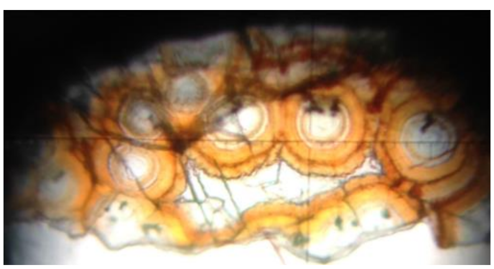

Fig. 6: group of globules in section 01 SVF-10, associated with a small (6 x 2 mm) xenolith. Globules are 0.2 mm in diameter.

Results and Discussion: Carbonates found within ALH84001 are a great indicator of past ancient environments on Mars. Because of the presence of these carbonate globules it must be inferred that early Mars had liquid water, which was most likely very localized. On Earth we find nearly identical carbonates in Svalbard, Norway (figs. 4-6). The area and the carbonate occurences have been previously been described by [6]. These carbonates formed in basaltic volcanoes. Within our samples we find optically zoned Fe/Mg/Ca carbonates within mantle xenoliths and basaltic rocks. Chemical zoning, correlated with the optical zones, has been measured by [6]. This is currently the most studied and persuasive terrestrial analogue for ALH84001 carbonates. Through examination of thin sections from both ALH84001 and Svalbard, Norway we have taken note of the similarities and differences between the two. By simply using optical microscopy we noted several similarities, including size, shape, and chemical zoning of the globules along with similar composition of the host rock. Therefore, we conclude that the globules formed in similar geological environments, this environment being carbonate rich hydrothermal interaction with the rich basaltic host rock (following the work of [6]). The differences between the two sets of carbonates are mostly a result of ALH84001's complex geological history, including multiple shock events, countless years spent in space, and entering through Earth's thick atmosphere.

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References: [1] Treiman A.H. (2005) *LPSC XXXVI*, Abstract # 1107. [2] Treiman A.H. (1995) *Meteoritics, 30*, 294-302. [3] Treiman A.H. (1998) *Meteoritics & Planet. Sci. 33*, 753-764. [4] Halevy, I. et al. (2011) *PNAS, 108*, 16895-16899. [5] Blake, D.F. et al. (2011) *LPSC 42*, abstract # 2167. [6] Treiman, A. H. et al. (2002) *Earth Planet. Sci. Lett. 204*, 323-332.