PRELIMINARY STABLE ISOTOPE RESULTS OF HYDROTHERMAL CALCITE IN VARGEÃO DOME AND IMPLICATIONS FOR MARS

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Introduction:

The possible presence of life on Mars is one of the main questions in planetary science today. Specifically, impact-generated hydrothermal systems (IGHS) are of interest because of the abundance of impact craters on this planet [5]. However, it is not clear how IGHS evolve on Mars. Even though hydrated minerals have been found on the surface of this planet, they may also have been excavated rather than formed by the impact [1,4]. This matter is difficult to resolve due to the difficulties in obtaining direct information from this planet. Therefore, the basalt-hosted Vargeão Dome impact structure in Brazil [2] is used as an analog for impact-craters on Mars.

The isotopic composition of both carbon and oxygen are influenced by the chemical state of the water and the temperature in the hydrothermal system e.g. [6,7]. Hence, these isotope compositions can be used to reconstruct the chemical conditions of the hydrothermal system. This is used to assess the water source of the hydrothermal system, and its relation with the impact.

Methods:

Samples have been collected systematically throughout the Vargeão Dome impact structure. The presence of calcite-holding veins was determined using optical microscopy and scanning-electron microscopy in combination with EDS. Individual calcite crystals were then drilled using a Mercantek Micromill and dissolved in HCl. Carbon and oxygen isotope ratios were determined using a Thermo Finnigan MAT253 mass spectrometer.

Results:

Preliminary isotope measurements are displayed in figure 1. The $\delta^{18}O$ values vary between -7.85 and -10.94 ‰ (against VPDB standard), and the $\delta^{13}C$ values vary between -8,32 and -11.09 ‰ (against VPDB standard). The samples show a negative correlation between $\delta^{18}O$ and $\delta^{13}C$ (fig. 1). $\delta^{18}O$ values tend to decrease (fig. 2) and $\delta^{13}C$ values increase with distance from the vein edge.

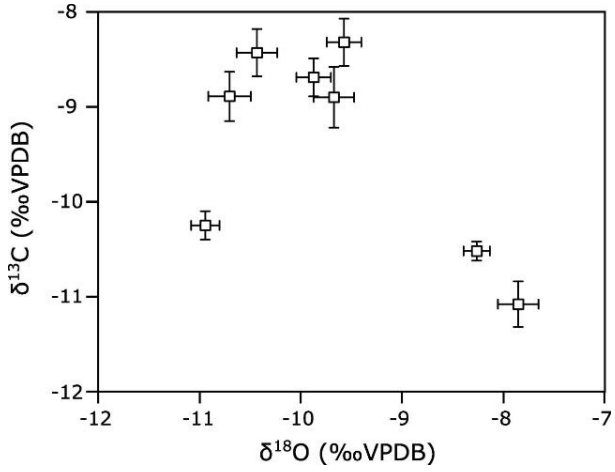

Figure 1: Carbon and oxygen isotopic composition of hydrothermal calcite in Vargeão Dome. Both $\delta^{13}C$ and $\delta^{18}O$ are negative, and $\delta^{13}C$ is negatively related to $\delta^{18}O$.

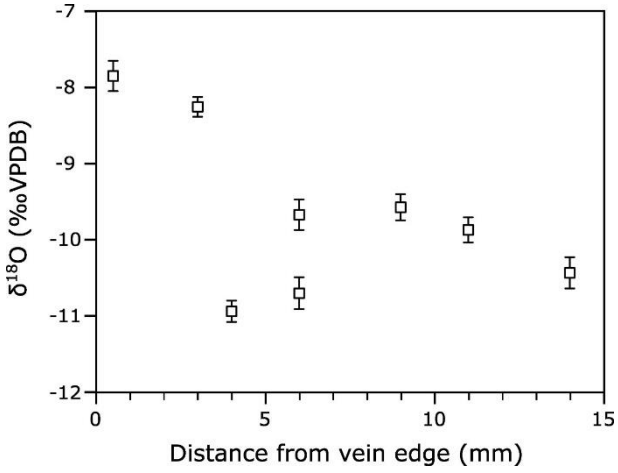

Figure 2: $\delta^{18}O$ values plotted against distance from the vein edge. $\delta^{18}O$ is negatively related to distance. Note that the three samples with the highest distance were taken from a separate piece of calcite that broke off from the original vein. For these measurements, the distance is approximate.

Discussion:

The isotope values are most comparable to the range found for magmatic fluids or deep-seated crustal fluids [8]. This means that the calcite veins were likely formed right after the formation of the basalts, and are not impact related. Furthermore, $\delta^{18}O$ values tend to decrease with distance from the vein edge. Decreased $\delta^{18}O$ values indicate cooling [3], meaning that the system cooled down during vein formation, corresponding to the expected cooling during deposition of basalts.

Consequently, if systems on Mars are similar, hydrous minerals found on this planet are probably excavated by the impact, rather than formed in the IGHS.

Conclusion:

Isotope values obtained from the calcite veins indicate that the water source is a magmatic or deep seated crustal fluid. For Mars this means that the hydrous minerals found at the surface were probably formed pre-impact, after which they were excavated.

References:

[1] Carter et al., 2013, *Journal of Geophysical Research: Planets, 118(4)*, 831-858.
[2] Crósta et al., 2019, *Geochemistry, 79(1)*, 1-61.
[3] Hays & Grossman, 1991, *Geology, 19(5)*, 441-444.
[4] Osinski et al., 2013, *Icarus, 224(2)*, 347-363.
[5] Robbins & Hynek, 2012. *Journal of Geophysical Research: Planets, 117(E5).*
[6] Sackett et al., 1965, *Science, 148(3667)*, 235-237.
[7] Urey, 1948, *Science, 108(2810)*, 489-496.
[8] Zheng & Hoefs, 1993, *Mineralium Deposita, 28(2)*, 79-89.