Changes of fluid flow regimes in a complex calcite vein network (Natih Formation, Oman Mountains): Insights from Stable Isotope Analysis

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We measured $\delta^{13}$C and $\delta^{18}$O compositions of calcite veins and their immediate limestone host-rock from an intensely veined outcrop at the top of the middle Cretaceous (Turonian) Natih A Formation in the Central Oman Mountains (Virgo and Arndt, 2010). The $\delta^{18}$O composition of the limestone host-rock in the studied pavement ranges from 22.5‰ to 23.7‰. The $\delta^{13}$C composition ranges from 1.1‰ to 1.9‰. This range of compositions is depleted in $^{18}$O relative to unaltered Cretaceous marine limestones (24.7-28.8‰ after Veizer and Hoefs, 1976).

However, in a regional isotopic survey of the limestone sequence, Wagner (1990) has shown that the $\delta^{18}$O composition of the Natih A Formation can range from 23.3‰ to 26.3‰. The depleted C/O isotopic compositions are results of meteoric diagenesis during subaerial exposure (Wagner, 1990; Grelaud et al, 2006). The $\delta^{18}$O compositions of vein calcite vary from 22.5‰ to 26.2‰, while $\delta^{13}$C compositions range from -0.8‰ to 2.2‰. Two compositional trends are apparent for vein calcite data. In trend A there is a spread in $\delta^{13}$C values from host rock compositions to values nearly 1.3‰ lower than the immediate host rock, while $\delta^{18}$O remains constant. Microstructural observations have shown high contrasts of $\delta^{13}$C within the same sample, indicating episodic fluid flow. We don’t observe reaction haloes. In the second composition range (trend B) a number of vein calcite samples have $\delta^{18}$O values up to 3.3‰ higher than the immediate host rock range, whereas the $\delta^{13}$C compositions are similar to the host-rock values. The majority of the trend B samples are from a late, E-W trending fault vein that cross cuts any other extension vein of the network and has a normal displacement. Episodic fluid flow is indicated by high contrast of $\delta^{18}$O values within the same sample. By combining our observations with existing literature we propose that (1) meteoric diagenesis has altered the top of Natih A during meteoric diagenesis. (2) After burial a complex and dense network of crack-seal extension veins formed promoting vertical fluid flow (bringing in lower $\delta^{13}$C values) in terms of meters and lateral fluid flow in terms of 10s of meters (rock buffered veins). (3) The change in fluid flow is reflected by trend B of enriched $\delta^{18}$O values constraint to a later fault vein. The fault vein has tapped a fluid reservoir at a deeper stratigraphic level with high $\delta^{18}$O values that have a typical Cretaceous marine limestone composition (26.2‰).


