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

M. Arndt (1), S. Virgo (1), S. Cox (2), and J. Urai (1)

(1) Structural Geology, Tectonics and Geomechanics, RWTH-Aachen University, Aachen, Germany (m.arndt@ged.rwth-aachen.de), (2) Research School of Earth Sciences, The Australian National University, Canberra, Australia (Stephen.Cox@anu.edu.au)

We measured δ^{13}C and δ^{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 δ^{18}O composition of the limestone host-rock in the studied pavement ranges from 22.5‰ to 23.7‰ . The δ^{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 δ^{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 δ^{18}O compositions of vein calcite vary from 22.5‰ to 26.2‰ , while δ^{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 δ^{13}C values from host rock compositions to values nearly 1.3‰ lower than the immediate host rock, while δ^{18}O remains constant. Microstructural observations have shown high contrasts of δ^{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 δ^{18}O values up to 3.3‰ higher than the immediate host rock range, whereas the δ^{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 δ^{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 δ^{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 δ^{18}O values constraint to a later fault vein. The fault vein has tapped a fluid reservoir at a deeper stratigraphic level with high δ^{18}O values that have a typical Cretaceous marine limestone composition (26.2‰).

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