Top-down growth of travertine veins revealed from U-Th dating at Little Grand Wash (Utah)

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Thermogenic travertine mounds may be examined as an outcrop analog for natural CO_2 long-term storage. As they form at the mouth of springs where CO_2 degassing drives carbonate precipitation from waters flowing from depth along active faults, they record the complex history of leakage/sealing of natural deep CO2 reservoirs.

The morphology of these mounds is often characterized by widespread and intriguing decimetric veins of white calcium carbonate, that lay parallel or oblique to the usual stratigraphic travertine. These veins may extend horizontally over several tens of meters, and may represent up to 50% of the total volume of the travertine mound.

We present here U-Th ages obtained from one such vein from the Little Grand Wash area (Utah), near the Crystal Geyser. ^{230}Th/U ages were determined by thermo ionization mass spectrometry. Very high U concentrations (7.2 – 9.2 ppm) combined with high ($^{234}U/^{238}U$) ratios and low detrital ^{232}Th concentrations result in U-Th age uncertainties of ± 9-14 yr for a mean age of the vein of 6 Kyr. Taking advantage of this high accuracy and resolution, we show that the vein grew unexpectedly from top to bottom over about a thousand years. The chemical composition of the geothermal fluid remained stable during this period, as indicated by very small variations of the ($^{234}U/^{238}U)_0$ activity ratio between 4.19 and 4.26 ± 0.005.

We propose that this counter-intuitive downward growth can be driven by the force of crystallization, implying that this mechanism is able to uplift the rock above the vein. We also show that the growth rate of the vein is fully compatible with the over-saturation state and with the expected percolation rate of the fluids. The inferred mechanism may possibly be generalized to the formation of horizontal veins in other geological settings. This study also shows that one must be very careful when interpreting travertine data, for example geochemical evolution, from samples removed from drill hole since the ages of the successive layers are not necessarily continuous from top to bottom or in stratigraphic order.

Atypical depleted mantle components at Mohns Ridge and along the Mid-Atlantic Ridge near the Azores

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Lu-Hf and Sm-Nd isotopic systems have proven useful to track ancient mantle depletion signals in basalts. For both isotopic systems, during mantle melting events, parent-daughter ratios are higher in the residue than in the melt. Since these two isotopic systems have similar geochemical behavior during magmatic processes, a time-integrated evolution is expected to produce a strong correlation. However, in the particular case of mid-oceanic ridges samples, it has long been documented that Hf and Nd isotope compositions can be decoupled [1]. We present Hf, Nd, Pb and Sr isotope and trace element data for basalts from the Lucky Strike segment of the Mid-Atlantic Ridge together with published data from Mohns ridge area [2]. In a Hf-Nd isotope diagram, these two data sets define a similar correlation with a slope significantly steeper than the mantle array (Fig. 1). Two different hypotheses are discussed to explain this atypical Hf-Nd correlation: (i) a kinetic process during the current melting event [2] and (ii) an anomalous mantle source created by an ancient melting event with residual garnet [3]. Based on our sampling of the Lucky Strike segment, we show that the unusual Hf isotope signature can be the result of re-melting a refractory component in the mantle rather than the effect of disequilibrium melting. This observation provides new constraints on the structure of the Mid-Atlantic ridge upper mantle around the Azores and along Mohns ridge.

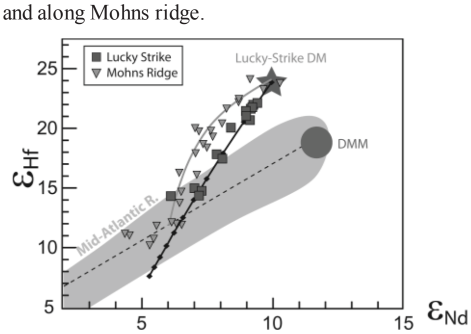

Figure 1: Atypical Hf-Nd isotopes values in Lucky Strike and Mohns ridge depleted mantle.

[1] Salters and Hart (1991) EPSL, 104(2-4), 364-380.
[2] Blichert-Toft (2005) G3, 6(1), Q01E19.
[3] Paulick (2010) EPSL, 296(3-4), 299-310.