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Stable isotope geochemistry of quartz veins from the SW Alps: Evidence of higher paleoaltitudes and of rapid cooling by meteoric water infiltration

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Extensive quartz veins are found throughout the Central Swiss Alps. Temperatures of formation range from 450°C down to 150°C on the basis of phase equilibria, stable isotope thermometry and mineral stability. Vein formation started at 18-20 Ma and continued for over 10 My. Oxygen isotope data support an early vein quartz that was rock buffered, necessitating low fluid/rock ratios. A mechanism of differential pressure and silica diffusion – similar to lower temperature crack-seal mechanisms – is proposed for early vein formation. Fluid inclusions and hydrous minerals in late-formed veins have extremely low δD values, consistent with meteoric water infiltration. The change from rock-buffered, static fluid to infiltration from above can be explained in terms of changes in the large-scale deformation style occurring between 20 and 15 Ma. The rapid cooling of the Central Alps identified in previous studies may be explained by infiltration of cold meteoric waters along fracture systems down to depths of 10 km or more. To lower the geothermal gradient of a rock column by 200°C at 5 km over a 5 million year period requires only 0.1 cm^3/cm^2 of water penetration per year.

The low δD values of <–130 ‰ are far lower than modern meteoric water measured in the region, which range from –60 to –80 ‰. The lower fossil values are best explained in terms of elevation changes. δD values would be expected to be ~50‰ lower if the Central Alps were 3 km higher in the Neogene than today. This conclusion is supported by an earlier work of Jäger and Hantke (1983), where a paleoaltitude of 5000 meters was proposed on the basis of large erratic boulders found far from their origin.