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Hydrothermal quartz: a new tool for stable isotope-based paleoaltimetry in ancient, eroded, orogens?

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The determination of the paleoelevation of ancient orogens is of prime importance to reconstruct and model past climate evolution and to understand relationships between tectonics, climate, and exhumation. The main methods for paleoelevation estimates in presently active orogens are based on the present-day isotopic composition of rainfall and its dependency to elevation: these methods rely on the preservation of ancient surface water isotopic composition in authigenic minerals such as lacustrine sediments or pedogenic carbonates. These methodologies cannot be used in ancient, eroded, orogens because of the poor long-term preservation of these minerals.

Quartz veins are ubiquitous, and rather homogeneously distributed, throughout ancient orogens. Some have been demonstrated to derive from meteoric water, we argue here that they may represent a good target to estimate their paleoelevation. As documented in presently active orogens (e. g. Southern Alps), meteoric waters dissolved silica during their per descensum infiltration in the crust whereas quartz precipitates on their way back to the surface because of the solubility decrease of silica. Under large fluid/rock ratios, fluids tend to buffer the rock in which they flow so that they can keep their original signature. To get information on surface conditions, one need is consequently to use the largest quartz veins as possible because they present the

highest potential for preserving original compositions of meteoric water.

To evaluate this potential new tool, we sampled pluri-kilometric quartz veins in the late-Paleozoic west-european Hercynian belt (Massif Central and Massif Armoricain, France). Microthermometric analysis of fluid inclusions in ten quartz samples points the very low salinity of the fluids involved (max 0.6% NaCl eq. wt.). The trapping temperature of the fluids (a proxy for quartz precipitation temperature estimate) varies between 180˚C and 280˚C. The oxygen isotope composition of the quartz samples ($\delta^{18}O_{qz}$) varies from -3.1‰ to 10.4‰ which gives water $\delta^{18}O_{H2O}$ values typical of meteoric water ($\delta^{18}O_{H2O} < 0$‰ for all ten samples). Five samples have $\delta^{18}O_{H2O}$calculated lower than -10‰, implying paleoelevations higher than 3000 m, using the well know correlation between oxygen isotope depletion in precipitation and altitude. Despite crude at this stage this result is the first paleoaltitude calculated for an ancient orogen. For the 10 samples, the hydrogen isotope composition (δD_{fl}) was also measured in fluid inclusions. δDvalues rank from -1.5 to -68 ‰. Representative points of water plot to the left of the Meteoric Water Line in a δD vs.δ^{18}Odiagram, which indicates either a deuterium excess (up to 80‰) or an oxygen depletion (up to -10‰). To our knowledge, such a shift in stable isotopic compositions has not been documented so far. It can indicate a peculiar primary feature (atmospheric) or a secondary reequilibration (during crustal transfer). To improve the paleoelevation estimate this phenomenon needs further investigation to be fully understood.