Geophysical Research Abstracts
Vol. 19, EGU2017-5187, 2017
EGU General Assembly 2017

Clumped isotopes complement petrological data in the investigation of contact metamorphic aureoles: a case study from the Middle Triassic Monzoni intrusion (Northern Italy)

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Carbonate clumped isotope thermometry is a technique which measures the abundance of the 13C-18O-16O_2 isotopologue in carbonate rocks. Its abundance is solely dependent on the formation temperature of the carbonate minerals, which makes this still novel method very attractive for research on paleoclimate or low temperature diagenetic processes. If carbonate rocks are exposed to high temperatures as during contact metamorphism or deep burial, the clumped isotope thermometer suffers from solid state reordering, destroying the primary temperature signal. However, this does not mean clumped isotopes cannot be applied on carbonates that were heated in high temperature regimes. In contrast it offers a great tool to track the extent a carbonate was heated and reveal secondary carbonate precipitation due to alteration by circulating fluids.
We used carbonates from the contact aureole of the Monzoni intrusion in northern Italy to test the application of clumped isotopes in such an extreme environment. Our measurements show that solid state reordering of the clumped isotope signature and thus an increased temperature signal occurred already 3 km distal from the contact. In contrast, mineral paragenesis studies can only reconstruct the strong temperature decrease within 1.5 km from the contact, whereas carbonates exposed to temperatures below ∼300 °C do not form mineral assemblages allowing the reconstruction of temperatures. Towards the contact of the Monzoni intrusion clumped isotope data showed again decreasing temperatures and a change in their oxygen isotope composition. This probably reflects the later stage alteration of circulating fluids and subsequent precipitation of secondary carbonates.
Our findings show that clumped isotopes are a powerful tool to estimate the extent of contact metamorphism in the cooler part of the aureole at temperatures up to 300 °C. Clumped isotope studies can complement petrological data in the low temperature range to improve thermal modeling. Further, they help to better constrain the circulation of hydrothermal fluids in the carbonate formations that were penetrated by the intrusion.