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Catch me if you can: the microscale record of escaping fluids in the crust

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Aqueous fluids play a critical role during metamorphic processes in the Earth's crust because they have first-order influence on element transport, reaction kinetics and heat transfer. Understanding their fluxes, sources and interaction with minerals is fundamental for the comprehension of these processes. How, when and where does fluid-mineral interaction take place in metamorphic rocks are basic issues that remain poorly constrained, partly because the fluids eventually escape the rock system leaving a concealed, often invisible path behind.

As fluid interaction can occur during events separated in time and under different physicochemical conditions, micro sampling of distinct minerals and mineral zones is best suited to resolve stages of fluid-rock interaction. I will present an approach that combines in situ oxygen isotope measurements in key minerals, with textural analysis, chemical zoning and chronology to address key questions concerning sources, pathways, and composition of fluids in the crust. Are fluids moving in channels or can they penetrate pervasively at depth? How do fluids released from sediments, basalts and serpentinites interact with other lithologies? In subducted crust, can we distinguish metasomatism inherited from the oceanic stage from interactions with subduction zone fluids?

Using case studies from the Alps and Turkey, I will show that the nature of the protolith and ocean floor alteration is preserved in relict accessory phases within eclogites that have been fully modified at high-pressure conditions. High-pressure shear zones and lithological boundaries show evidence of intense fluid metasomatism at depth, but significant fluid exchanges are not limited to such discontinuities. Pervasive fluid exchange between mafic, ultramafic and metasedimentary rocks can be recognised during prograde subduction metamorphism. In most cases analyses of distinct mineral zones enable identification of multiple pulses of fluids during the rock evolution.