

Modeling of concentrations in major elements of subsurface and deep waters in the Ringelbach granitic research catchment (Vosges, France)

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For constraining the nature of water-rock interactions occurring within granitic watersheds and exploring the potential relationships existing between subsurface and deep waters a geochemical study combined with a modeling approach has been undertaken in the small Ringelbach granitic catchment (Vosges, France). Concentrations of major elements were measured in water samples from the main springs emerging within the catchment as well as from two 150-m deep boreholes (deep waters) drilled through the whole weathering profile of the granite bedrock.

The coupled transport/reaction model KIRMAT [1] has been used in this study to discuss and constrain the main spatial and temporal geochemical variations observed in these different waters. It combines geochemical reactions, including clay precipitation [2], and 1D mass transport equations to simulate the reactive transport of a fluid through a rock along a given water pathway.

In the case of the Ringelbach watershed, we have simulated the transfer of rainwaters along different water pathways, from very permeable surficial arenic formation to almost impermeable deep fresh granite. Simulations point out that the initial chemical signature of rainwater is rapidly lost during its transfer through the substratum due to the weathering of rock-forming minerals. Furthermore, simulations indicate that the geochemical characteristics of spring waters and deep waters are mainly controlled by two different water pathways within the substratum: high-rate downslope subsurface flow for the springs, and very low flows through the whole granitic massif for borehole waters. These results suggest therefore that spring waters and deep waters are largely disconnected in the Ringelbach catchment.

[1] Gérard *et al.* (1998) *Chemical Geology*, **151**, 247–258.
[2] Fritz *et al.* (2009) *GCA*, **73**, 1340–1358.

The construction of the Alpine Adamello batholith as recorded by zircon

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Batholiths are formed by incremental melt addition over time scales spanning millions of years. They consist of composite plutons, which are formed through individual melt pulses that cool over a 10 to 100 ka timescale.

Careful laser ablation ICP-MS and CA-ID-TIMS zircon geochronology on the Adamello Batholith in Northern Italy not only reveals these different timescales, but also allows reconstruction of some of the batholith-forming processes: (a) The entire batholith grows from 43 to 33 Ma through melts derived from an increasingly crust-contaminated arc-type source; (b) single mappable plutons are compositionally more or less heterogeneous and consist of a number of melt pulses; (c) each pulse intruded and cooled as a single unit over timescales of several 10 to 100 ka; (d) the Val Fredda pluton in the southernmost Re di Castello unit shows bimodal magmatism with gabbroic melts injecting into tonalite mushes and sharing some 100 ka of crystallization and cooling; (e) the subsequent pulses of diorites and tonalites of the Lago della Vacca pluton are recognized to tap the same source mushes and continuously recycle the crystal cargo [1], while in the case of more evolved tonalites of the Central Adamello unit the pulses consist of fractionated residual melt without inheritance of crystal cargo.

Chemical-abrasion, high-precision ID-TIMS zircon dating also revealed that mapped units show a significant age spread with clear geographic trends interpreted as accretion of pulses that are not discernible in the field. The trace element and Hf isotopic composition of dated zircon is a paramount tool to trace fractionation of major and accessory minerals during zircon crystallization, mixing of melts with different source components or of mixing ante- or xenocrystic crystal cargo into a melt batch [2] In this way, zircon provides a means to trace the thermal and magmatic evolution of deeper crustal reservoirs. Additional titanite U-Pb data may help to quantify the rate of high-temperature cooling down to the solidus or, alternatively, trace prolonged heat advection followed by partial remelting and homogenization of subsequent melt batches, as seen in the Lago della Vacca unit.

[1] Schoene *et al.* (in press) *Earth Planet. Sci. Lett.* [2] Schoene *et al.* (2010) *Geochim. Cosmochim. Acta* **74**, 7144–7159.