Modelling the geochemical variation of granitic mushes

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Straightforward Rayleigh-type fractional crystallisation models have merits to outline the main factors that caused geochemical evolutionary trends of granites, but the implied complete separation of mineral phases from residual liquid is at best a poor approximation of reality. A more elaborate crystallisation model of granitic 'mushes' tracks the trace element variation in two subsystems - a 'congealed mush' and a 'residual mush' - that develop as crystallisation proceeds. It takes into account any separation of less-viscous, water-rich melts and fluid phases from the residual mush during the final stages of solidification. Special attention is paid to the role of accessory minerals on the evolution of the Rare Earth Element (REE) patterns. Petrography learns that accessories are often present as clusters of minerals that crystallised from pockets of trapped interstitial melts. These accessory minerals crystallised too late to significantly affect fractionation trends. Moreover, these clusters frustrate efforts to estimate effective crystallisation rates from modal abundances. Parameters of the model are the fraction of crystals trapped in the congealed mush, and the crystal-to-trapped liquid ratio in the congealed mush. Calculations are based on a 'finite step' numerical simulation of crystallisation and melt expulsion processes.

The model calculations will be illustrated with results for two closely related leuco-granitic series from the Variscan Northern Vosges (France): the Natzwiller granite and the highly evolved Kagenfels granite. The variation trends of the Natzwiller granite demonstrate the crucial role of the accessory minerals apatite, sphene, allanite and zircon. The pronounced decrease of the concentrations of the middle REE (relative to Light and Heavy REE) of the Kagenfels granite cannot be explained by models based on reasonable values of modal abundances of accessory minerals and of partition coefficients. It is argued that the Kagenfels granite matches the composition of expelled liquids from the residual mush at 50 tot 60 % solidification of the Natzwiller body. The expulsion of interstitial liquids is presumably promoted by tectonic activity.

The first Lu-Hf garnet ages of North Penninic alpine eclogites

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Despite a large geochronological database there are still various models for the tectonic evolution of the Alps. Current rapid progress in dating metamorphic minerals such as garnet has given this technique a key role in the ongoing discussion. Recently, [1] recognized the so called Balma Unit in the upper Sesia valley, previously interpreted as part of the Zermatt-Saas Zone (South Penninic Ocean), as a fragment of the North Penninic Ocean. Most previous studies dating peak metamorphism of Alpine ophiolites have focussed on the Zermatt-Saas zone. Here, we present the first Lu-Hf garnet data for eclogites from the North Penninic Ocean.

Electron microprobe analyses show typical prograde zoning profiles in garnet. A selective digestion procedure for garnet was applied, where zircon and rutile inclusions are not dissolved. The garnet-whole rock Lu-Hf ages obtained for three samples are 42.19 ± 0.47 Ma (MSWD: 1.8), 43.19 ± 0.36 Ma (MSWD: 1.2) and 45.4 ± 1.1 Ma (MSWD: 2.3), which is significantly younger than all Lu-Hf ages established so far for South Penninic Units. Notably, existing SHRIMP U-Pb zircon ages [2] of 93.4 ± 1.7 Ma (synmagmatic core) and 40.4 ± 0.7 Ma (synmetamorphic rim) for the sample in wich the Lu-Hf age of 42.19 Ma was obtained, indicate that growth of metamorphic zircon postdates garnet growth.

Despite the fact that all three samples originate from the same tectonic unit, their Lu-Hf ages differ outside of error. The cause of this is not yet known, but if the garnets grew over a long time interval (several million years) it is possible that varying core-to-rim distributions of Lu in garnet could result in the observed age range. Such Lu zoning can occur by Rayleigh fractionation during garnet growth [3] or by diffusion-limited garnet growth [4]. Our new Lu-Hf data indicate that garnet growth, and possibly peak pressure conditions in the North Penninic ophiolites postdates those in the South Penninic ophiolites.

References

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