

Carbonate assimilation in the alkaline Hortavaer igneous complex, Norway

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The Hortavær intrusive complex provides an excellent natural laboratory for detailed study of effects of, and processes controlling carbonate assimilation in an orogenic setting. The intrusion was emplaced into marble and gneiss at ~475 Ma, during Caledonian metamorphism, as numerous subhorizontal sheets, of ne-normative gabbro and diorite to (ne-bearing) monzodiorite, to monzonite and syenite. Carbonate assimilation is apparent because carbon in primary calcite has a sedimentary origin [1]. Experiments [2] show that extensive carbonate assimilation is possible in H₂O-rich mafic magma, especially when evolved fluids can escape. This interaction produced augite at the expense of olivine, K₂O enrichment, and depletion of elements compatible in cpx. Syenite was produced along margins of mafic sheets and loading squeezed syenitic magma laterally away from the assimilation zone. Central interlayered mafic rocks, syenite, and endoskarns were surrounded by an outer zone of syenite sheets. Local homogenization of hybrid magmas was promoted by evolution of mixed H₂O-CO₂ fluid; however, because assimilation was local, syenites vary in silica saturation, K/Na, and trace element contents; a homogeneous syenitic magma never formed. Carbonate assimilation stabilized titanite and locally grossular-andradite garnet and scapolite. Titanite + cpx ± garnet sequestered Zr; zircon is absent in most samples. In cpx, Zr and Hf increase from low ppm levels to 400 ppm and 12 ppm, respectively, with differentiation. Cpx REE patterns vary from “typical” augite patterns in olivine gabbro to light and heavy REE-enriched patterns with negative Eu anomaly and a trough centered on Ho. Less pronounced patterns occur in amphibole. Garnet shows maximum normalized REE at Sm, with flat normalized HREE (~100x chondrites) and titanite REE patterns steepen with differentiation. Compositional variations in cpx may result from equilibrium with garnet + titanite ± apatite or from growth in equilibrium with H₂O-CO₂ fluid, but we find no theoretical reason why Ho should be preferentially depleted by a fluid phase.

References

- [1] Barnes et al. (2005) *Lithos* **80**, 179–199.
- [2] Iacono Marziano, G. and Gaillard, F. (in review) *EPSL*.