Deciphering metamorphic evolution of rocks by means of Hf isotopes

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Hafnium isotopes in minerals can be used as a tracer of mineral reactions in metamorphic rocks. If the reaction products behave as a closed system with respect to Lu and Hf, their present-day Hf isotopic composition ($^{176}Hf/^{177}Hf$) only depends on the Hf isotopic composition of the reacting phases and the partitioning of Lu and Hf during the reaction. The calculated Hf "reaction model ages" between individual metamorphic minerals can then be used not only to test the participation of minerals in the reactions, but also to constrain the timing of reactions. In addition, Hf isotopes can also be used to trace the involvement of Hf-bearing accessory phases, such as zircon or ilmenite, in metamorphic reactions.

We have studied Hf isotopic mass balance in a pyroxene granulite from southern part of the Bohemian Massif in the Czech Republic. The rock has a simple mineralogy with several mafic Hf-bearing mineral phases that were involved in a decompression reaction Grt+Qtz=Opx+Plg. The P-T history of the granulite and the metamorphic evolution in the region are well constrained from numerous previous studies.

The peak of granulite metamorphism has been dated at 343±2 Ma (U-Pb zircon). The subsequent isothermal decompression and near isobaric cooling is recorded in a corona-forming reaction around garnet. The Hf isotopes in major minerals acting in the decompression reaction were used to model their Hf isotopic evolution and to determine that the garnet decompression reaction took place approximately 10 Ma after the metamorphic peak (see Figure). The results of this study point to a rapid decompression of the lower crust in the southern Bohemian Massif during the Variscan orogeny.