Fluid geochemistry in the Ivigtut cryolite deposit, South Greenland

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The 1.27 Ga old Ivigtut intrusion is part of the mid-Proterozoic Gardar Province in South Greenland. The Province represents a failed-rift structure where magmatic activity lasted from 1.35 to 1.14 Ga [1]. The Ivigtut intrusion is world-famous for its cryolite deposit [Na_3AlF_6] which is now mined out. The deposit is situated within an A-type granite stock where F- and alkali-rich fluids led to metasomatism and formation of cryolite, rare fluorides, sulfides and siderite [2].

Little has been known so far about the formation conditions of cryolite and the rare fluorides at Ivigtut. In order to estimate intensive parameters for the assemblages at Ivigtut, thermodynamic modelling was carried out with the computer program TWQ [3]. At a pressure of 1 kbar, most assemblages are stable below 450 °C at high water- and silica-activities.

Microthermometry of fluid inclusions shows that three types of inclusions can be distinguished: (1) pure CO_2, (2) aqueous carbonic and (3) saline aqueous inclusions. Melting temperatures are about -56.6 °C for type 1 inclusions, range between -23 to -15 °C for type 2 and from -15 to -10 °C for type 3 inclusions. Most inclusions homogenise between 110 and 150 °C into the liquid.

Stable isotope compositions of CO_2 and H_2O were measured from crushed inclusions. $\delta^{13}C$ values are about -5 ‰ PDB which is typical of mantle-derived magmas [4]. $\delta^{18}O$ (CO_2) ranges between 21 and 42 ‰ VSMOW while $\delta^{18}O$ (H_2O) varies from -1 to -20 ‰ VSMOW. Theses values suggest low-temperature isotope exchange as proposed by [5]. δD (H_2O) ranges from -19 to -123 ‰ VSMOW. The isotopic composition of inclusion water closely follows the meteoric water line and is comparable to Canadian Shield brines [6]. Ion chromatography revealed the fluid's predomincance in Na, Cl and F. Cl/Br ratios range between 56 and 110 and support the fluid's non-marine derivation.

Our results show that the Ivigtut fluid has the typical characteristics of a hydrothermal, Na-dominated brine. Isotopic data suggest that the CO_2 component is mantle-derived whereas the dominant H_2O part is of meteoric origin and intensively interacted with the host granite.

References

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In situ Fe isotope measurements in gabbros and basalts from the ocean crust

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Fe isotopes were measured in oxides and sulfides of gabbros and basalts drilled by IODP (Integrated Ocean Drilling Program) in recent oceans. Such studies may help to elucidate topics like state of equilibrium of the oxide/sulfide assemblages, temperature of formation, and imprint of seawater. We used the recently in Hannover developed LA-MC-ICPMS system consisting of a femtosecond laser and a multiple collector inductively coupled plasma mass spectrometer. For the analytical and methodical techniques, we followed Horn *et al.* (2006).

The used gabbro was a ferrogabbro from the Southwest Indian Ridge (drill hole 735B) showing ore mineral assemblages consisting of MT (magnetite), ILM (ilmenite) and PYR (pyrrhotite). The textural features suggest equilibrium formation for these assemblages. A temperature of 950°C was estimated as temperature of formation of these ore assemblages, obtained by amphibole geothermometry. In-situ Fe isotope analyses were performed both in the core and rim of the grains. No zoning with respect to Fe isotopes was observed.

The measured $\delta^{56}Fe$ values, the relative isotopic differences between the mineral phases, and the comparison with literature data and equlibrium fractionation factors derived from Mössbauer data (Polyakov and Mineev, 2000), respectively, suggest the following working hypothesis: Below 950°C, at temperatures while PYR was still open, and MT and ILM closed for iron isotope exchange, the rock was infiltrated by a seawater-derived hydrothermal fluid shifting the $\delta^{56}Fe$ values of PYR to significant lighter values. The temperatures for this process must have been fairly high (e.g., > 700°C), since PYR and the other Fe-Ti oxides do not show any sign of typical low- or medium temperature alteration. This method opens interesting perspectives in order to shed light on late stage and alteration processes in oceanic gabbros. Further in-situ Fe isotope measurements in gabbros and in fresh and progressively altered basalts from the IODP Expedition 312 which drilled the basalt/gabbro transition in fast-spreading ocean crust are in progress.

Reference

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