

Carbonatite melt inclusions in coexisting magnetite, apatite and monticellite from Kerimasi carbonatite, Tanzania

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The studied carbonatite consists mainly of calcite, together with lesser apatite, magnetite, and monticellite. Primary multiphase carbonatite melt inclusions and associated fluid inclusions, range in size from 10 to 60 microns. Both of these types occur in apatite, magnetite and monticellite, although calcite hosts mostly fluid inclusions. Raman microprobe and EMPA analyses of the mineral phases present in unheated former melt inclusions demonstrates that: (1) melt inclusions, hosted by a given mineral constituent, contain crystals of all the other coexisting rock forming minerals; (2) melt inclusions also contain Na-K-hydro-carbonates and S-bearing phases. Microthermometric measurements on apatite- and monticellite-hosted melt inclusions give homogenization temperatures that range from 880 and 1150°C. EMPA analyses of heated and quenched magnetite- and apatite-hosted melt inclusions (n=60 and 30, respectively) indicate they are derived from melts with the same chemical composition. This is a Ca-Ka-Na-carbonatite enriched in P, S and Cl containing minor Si. In the quenched melt inclusions, enclosed in both apatite and magnetite, small (<1 micron) calcite crystal occur as quench phases. Some quenched carbonatite melt inclusions in magnetite are extremely enriched in Cl and these inclusions contain Na-K-chlorides. The melt inclusions investigated indicate that this calcite carbonatite crystallized from a P-Cl-S-alkali-rich carbonatite melt that precipitated calcite, apatite, monticellite, alkali-chloride and contained fluid (CO₂-H₂O) components in different proportion during magma evolution. Bulk carbonatite compositions worldwide [1], generally contain lesser amounts of alkalis relative to the studied melt inclusions, and are considered to represent parental magma compositions. However our study suggests that primary melt inclusions are potentially more useful for estimating the composition of carbonatite magmas.

[1] Woolley & Church (2005) *Lithos* **85**, 1-14.

CO₂-water-basalt interaction: Geochemical modelling and experiments

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Increasing anthropogenic CO₂ emission to the atmosphere during the past decades has affected the Earth's climate. Reduction of atmospheric CO₂ level is considered a crucial action in the control of global warming. One possible way is geological CO₂ sequestration into rock formations. The Carbfix project (www.carbfix.com) is a pilot field study in SW Iceland aiming to inject CO₂-charged water from the Hellisheidi geothermal power plant into the surrounding basalts. The main goal is to mineralize CO₂ by releasing divalent cations from the basalts that subsequently react to form Fe-Mg-Ca carbonates. However, the interaction of CO₂ containing water with basalt is complex.

Reaction path simulations and laboratory batch experiments were carried out on CO₂-water-basalt interaction. Both the solution chemistry and associated mineralogy were studied. The results clearly demonstrate that addition of CO₂ (0-20 bar) to the water significantly changes the reaction path at temperatures below 40°C. Initially, the pH was buffered at ~4-7 by the CO₂ and mineral-water interaction. The main secondary minerals formed were Fe-Mg-Ca-(Mn) carbonates and silica (opal/chalcedony). Reduced mobility of Al, Na, K and B also points to mineralization of these elements into clays, hydrated silicates and/or aluminium silicates. The system is buffered at pH<7 until most of the CO₂ has been mineralized. Then it rises to pH >8 and becomes buffered by silica ionization, and H⁺/OH⁻ consumption and release upon water-rock interaction. The associated secondary mineralogy changes with (Ca)-Fe- Mg smectites, SiO₂, Ca-Na zeolites and some calcite dominating.

The carbonate and aluminium silicate (zeolites and clays) mineralization reactions are competing reactions for the major divalent cations, Fe, Mg and Ca. The quantitative interpretation of the results and geochemical modelling was found to be largely dependent on very accurate thermodynamic and kinetic data employed. Therefore, a great effort was undertaken reviewing the datasets taking into account aqueous speciation reactions of importance and secondary minerals and solid solution models for carbonates and clays as well as comparing the modelling and laboratory results with natural analogues.