Fluids exsolved from the Kaiserstuhl carbonatite, SW Germany: Brine generation by boiling

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Studies on fluid inclusions in carbonatitic rocks are essential to understand the physicochemical processes involved in carbonatite-related hydrothermal ore mineralization. Although little is known about the composition of carbonatite-derived fluids. We investigated fluid inclusions in the Kaiserstuhl carbonatites, SW Germany [1,2] and identified four different types typically known from carbonatitic systems worldwide [3]:

(I): Vapor-poor H_2O-NaCl fluids with <50 wt.% salinity.
(II): Vapor-rich H_2O-NaCl-CO_2 fluids with <5 wt.% salinity.
(III): Multi-component fluids with high salinity and CO_2.
(IV): Multi-component fluids with high salinity, no CO_2.

Homogenization temperatures (156 to 530°C) of all fluid types generally show a wide range [this study, 2]. Primary type I fluid inclusions occur in early magmatic olivine/monticellite, as well as paragenetically later apatites and calcites [2]. This indicates a ubiquitous existence of a saline brine, which does not reach saturation with respect to halite, during early to late crystallization stages.

Liquidus surface modelling based quantifications for fluid type III suggest that carbonatite melts predomonantly exsolve Na-K-sulfate-carbonate/bicarbonate-chloride brines (type III or IV, respectively). Such fluid inclusions, with type III (CO_2-free) on one side and type IV (and II, both CO_2-rich) on the other side, may represent immiscible fluids that were trapped after segregation by boiling from a parental highly saline brine (type I). Fluid boiling, in turn, is probably triggered by a rapid pressure release during "pneumatic hammer-like," discontinuous melt ascent.

[1] Walter et al. (2018) *Chemical Geology*, 489, 1-16. [2] Walther (1981) *PhD thesis, University of Karlsruhe,* p 194. [3] Rankin et al. (2005) *Geological Association of Canada*, Short Course Notes, 17, 299-314.