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Silicate-fluoride liquid immiscibility: evidence from melt inclusions study

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Continental rift magmatism often produces abundant alkaline rocks and bimodal associations dominated by basic and felsic igneous rocks. Interest to bimodal associations is heated, in particular, by the fact that alkali-rich felsic rocks, including peralkaline granites and their extrusive analogues, comendites, pantellerites, and trachytes are often accompanied by diverse rare-metal and rare earth mineralization (REE, Zr, Nb, Ta, Li, etc), occasionally reaching the economic level. On of the places where bimodal rift-related magmatism is widespread in Central Asia, but it is still poorly known, although the study of such assemblages may help solving many important problems in the genesis of alkaline salic magmas and accompanying rare-metal mineralization.

This contribution focuses on the compositions and formation conditions of rare-metal (Nb, Zr, REE) comendite magmas from bimodal volcanic assemblage of Dzarta Khuduk, central Mongolia. A sequence of felsic agpaitic volcanics rests on subalkali basalts and consists of intercalating alkaline trachydacites, pantellerites, and comendites. Their mineralogical and chemicall characteristics correspond to silicic peralkaline rocks of the K-Na series with an agpaicity coefficient (K_a) of >1 and high contents of F, Zr, Li, Rb, and REE.

Primary solid and melt inclusions in quartz of the comendites were studied by an electron microprobe and SIMS. Aegirine, fluorite, ilmenite, and chevkinite (rare REE di-orthosilicate with 21 wt % Ce_2O_3, 17 wt % La_2O_3, 1 wt % Nb_2O_5, and 0.5 wt % Y_2O_3) were found as single-phase inclusions. The melt inclusions are composed of glass, gas phase, and a fine-grained villiaumite (NaF)–griceite (LiF) aggregate. To our knowledge, griceite has been reported in the literature only once from sodalite inclusions in hornfels of the Mont Saint-Hilaire massif, Quebec (Canada).

Thermometric experiments were conducted using a microscopic heating stage allowing fast quenching (within 1-2 s). The complete homogenization of melt inclusions was observed at 800–1030^{o}C. The glasses of homogenized inclusions are chemically similar to the host comendites and contain (wt %): 72–80 SiO_2, up to 5 FeO, 4–7 Na_2O, 3.6–4.7 K_2O, and 7.8–11.0 Al_2O_3. The K_a of the melts varies within 0.8–1.6. A conspicuous feature of these melts is extremely high Li and Zr contents, up to 1800–1900 and 1300–3700 ppm, respectively. In addition, the melts show high Rb (300–600 ppm), Nb (100–235 ppm), Y (110–240 ppm), Ce (up to 290 ppm), and La (up to 120 ppm), but very low Sr (2–5 ppm) and Ba (5–9 ppm) abundances. The contents of volatile components are 0.4–1.4 wt % H_2O, 0.8–2.8 wt % F, and up to 0.3 wt % Cl. The majority of trace elements (Rb, Pb, U, Ta, Y, Th, and almost all REE) show direct correlations with Nb.

Thus, our study of melt inclusions in quartz from comendites revealed the occurrence of strongly evolved rare-metal alkaline melts enriched in Na, F, Li, Zr, and REE and allowed us to distinguish main magmatic processes responsible for their formation. The evolution of the comendite melt was controlled by the processes of crystallization differentiation and silicate-salt liquid immiscibility. During the investigation of melt inclusions in quartz of the comendites we directly observed liquid immiscibility phenomena. These observations testify to the possibility of separation of fluoride liquids concentrating Li and Na from evolving alkaline magmas.