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Formation conditions and magma composition of the trachytes from the Pektusan volcano (China and North Korea): evidence from melt inclusions

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The large intraplate volcanic province produced in Central and East Asia in the Late Cenozoic includes numerous manifestations of subalkaline and alkaline basaltic magmatism. Acid magmatic rocks are a rare exception. In the far eastern part of the province, they are related only to the formation of the large Pektusan volcano located at the boundary between China and Northern Korea and composed of alkaline trachytes and rhyolites.

Pektusan volcano is a typical stratovolcano, whose eruptions were highly explosive and which developed in a continental rifting environment. The volcano is made up of trachyte-comendite-rhyolite lava and pyroclastic material cut across by alkali basalt, trachybasalt, and trachyandesite necks and dikes.

We employed data on melt inclusions, including their electron and ion microprobe analyses, to reproduce the composition and formation conditions of the melts parental for the trachytes of Pektusan volcano.

Anorthoclase from the alkaline trachytes contains primary melt and fluid inclusions. The crystalline inclusions consist of hedenbergite, ilmenite, titanomagnetite, and REE-fluorapatite, which contains up to 11 wt % Ce_2O_3, La_2O_3, and Y_2O_3. Melt inclusions in minerals from the rocks partly crystallized and contain residual glass, daughter minerals, and a gaseous phase. Daughter minerals of melt inclusions comprise hedenbergite, fluorite, villiaumite, and anorthoclase (as rims on the walls of the vacuoles). The fluid inclusions consist of a low-density gas phase, with fluorite developing at its boundaries with the host anorthoclase.

The crystallization of trachyte phenocrysts was determined to have proceeded in a heterogeneous system (melt and low-density fluid) at temperatures of 1060 - 1020°C and pressures of 125-375 bar.

The chemical composition of glasses from the homogenized melt inclusions in anorthoclase was proved to be generally close to the composition of the rock. The SiO_2 concentration in the glasses of the homogenized melt inclusions is 64 - 74 wt %, and the concentrations of other major oxides are as follows: Al_2O_3 - 7-10 wt %, TiO_2 – up to 0.6 wt %, FeO – 5-7 wt %, and CaO – up to 1 wt %. The inclusions are rich in alkalis (Na_2O + K_2O) from 8 to 11 wt % ZrO_2 – 0.5-1 wt % and bear elevate concentrations of F (up to 0.9 wt %) and Cl (up to 0.4 wt %). The agpaitic coefficient varies from 1.2 to 2. Note that the glasses of the melt inclusions in anorthoclase from the trachyte are more agpaitic than the rock (agpaitic coefficient = 1), perhaps, because of enrichment in anorthoclase as a result of its flotation.

The concentrations of trace elements in the glasses of the homogenized melt inclusions and in the rocks indicate that the melt inclusions and trachytes exhibit similar distributions of trace elements. Both the glasses and the rocks are higher in Rb, Th, Nb, Zr, Y, and LREE (first of all, La, Ce, and Nd) and lowed in Ba, Sr, U, Ta, and Eu than the primitive mantle. The pronounced Eu anomalies of the glasses testify that the trachyte melts were strongly differentiated. The concentrations of Zr, Ta, Ti, U, Th, Hf, Y, and practically all REE in the homogeneous glasses of melt inclusions in anorthoclase from the trachytes are positively correlated with the Nb concentration, which suggests that crystal fractionation should have played a significant role in the formation of trachytes.

Our experiments reproduce the evolution of the magmatic system that eventually resulted in rare-metal mineral deposits.