Geophysical Research Abstracts
Vol. 12, EGU2010-11421-1, 2010
EGU General Assembly 2010

Carbonate-Silicate Association in the Kamafugite of the Toro-Ankole Province (East African Rift)

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Carbonatite melts play an important role in the magmatism of the East African Rift Zone. A tight spatial association of high-Mg ultrapotassic and carbonatite rocks in the Western branch of the East African Rift suggests the genetic relationship of their parental melts. New evidence of such connection of kamafugitic and carbonatite magmas were obtained during study of the volcanic rocks of kamafugitic affinity in Toro-Ankole province. Primary carbonates (calcite and dolomite) were found as inclusions in olivine from ugandite and mafurite of the Bunyaruguru volcanic field.

In the ugandite carbonates contain in the crystallized melt inclusions in olivine phenocrysts consist also of kalsilite, clinopyroxene, mica, and titanomagnetite. Some inclusions reach up to 40x75μm, the host olivine is 150x300μm in size. In the mafurite carbonates form rare microlites, microphenocrysts, and lenses with cavities in central parts, and occur as inclusions in olivine phenocrysts and aggregates in the adjacent zones. These aggregates are multiphase and in mineral set resemble carbonatites: they contain kalsilite, clinopyroxene, magnetite, phillipsite, and mica. Also the two-phase carbonate–sulfate inclusions in olivine were found.

The most part of carbonates in composition correspond to calcites with low magnesium, iron, sodium, strontium, and barium contents. The carbonates from two-phase inclusions in olivine from the mafurite are significantly higher magnesian, approaching pure dolomite. The different types of carbonate in mafurite vary in Sr, Ba, Na and K. The highest content of these elements is observed in groundmass carbonates, reaching 2.44 wt % SrO, 1.25% BaO, 0.64% Na2O, and 1.23% K2O. Such assemblage in kamafugites have not been described yet.

Some olivines contain microinclusions of sulfate (barite), occurs as fine (10–20 μm) rounded inclusions. The presence of barite inclusions in the olivine of the studied mafurite indicates the high sulfur content in the primary melt. The temperature and oxygen fugacity for the studied rocks was estimated from olivine–spinel equilibrium. Obtained results indicate that crystallization of the mafurite occurred within a wide range of temperature (1230–750°C) and oxygen fugacity (1–3 log units above the QFM buffer). These data demonstrate that crystallization of Toro-Ankole kamafugites occurred in a relatively oxidized setting close to those of wehrlites and subduction-related island-arc oxidized magmas. An increase in oxygen chemical potential resulted from mantle metasomatism widely spread in this area of the East African Rift.

To elucidate the origin of kamafugite carbonate inclusions the bulk composition of initial melt for two crystallized inclusions in the ugandite olivine was calculated from data on analyzed mineral compositions. Obtained melts appear to be carbonatite, close to the bomb of Katwe-Kikorongo and average composition of intrusive carbonatite. According to morphology, these are primary inclusions and obtained composition is close to the composition of melt trapped during olivine crystallization.

The validity of results has been estimated using a multicomponent system (SiO2 + Al2O3 + TiO2) – CaO + MgO + FeO*)–(Na2O + K2O), which is most close to natural rocks. The compositions of the kamafugite rocks of the Toro-Ankole province were plotted on the diagram with calculated "carbonatite melts". Compositions of calculated melts from inclusions in olivine are plotted on the trend of progressive melting carbonatised lherzolite (or fractional crystallization of alkali basalts), which connects fields of primary carbonatite melts and alkali basalts with data points of high-Mg volcanics of Bunyaruguru.

The presence of magmatic carbonates in the olivine from the mafurite and ugandite of the Bunyaruguru volcanic field, the western branch of the East African Rift, indicates that ultrapotassic magmas were in equilibrium with primary carbonatite melts at P-T conditions of their formation.