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Petrology and geochemistry Toro Ankole kamafugite magmas: isotopic constraints.

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Kamafugites are represented a group silica-undersaturated perpotassium volcanic rocks originally named after three petrographically-defined rock types - katungite, mafurite and ugandite from the Toro-Ankole province in the Western branch of the East African rift zone. These ultra-potassium high-magnesian rocks are the deepest on the Earth together with the kimberlites and lamproites. In Toro-Ankole there are three volcanic fields: Fort Portal, Katwe-Kikorongo and Bunyaruguru. This study is focused on the Bunyaruguru volcanic field which stretches southwards from the south shore of Lake George, partly over the floor of the western Rift depression and partly over the adjacent plateau to the south and east of the Rift.

The common minerals of phenocrysts are olivine, leucite, clinopyroxene, Cr-spinelides and phlogopite. There are perovskite and melilite phenocrysts in the katungites. Spinelides are frequently occured as inclusions in the olivines which contain also fluid inclusions and sometimes carbonate, sulfate and sulfide inclusions. The composition of phenocrysts, megacrysts and groundmass minerals were analyzed. The conditions of mineral equilibria were calculated using these data. Unlike lavas from volcanic fields further south in the western branch, the effects of crystal fractionation on the kamafugitic lavas are minor. Primitive features, such as high Mg# - up to 79, and high Ni - up to 780 ppm, Cr - up to 1170 ppm, are in strong contrast to their extreme enrichment in incompatible trace elements. The composition of kamafugite olivines phenocrysts close to the olivines of the mantle xenoliths: forsterite content up to Fo92, NiO - up to 0.48 wt.%, CaO (min) – 0.07 wt.%. Spinelides are the high-chromium varieties: Cr2O3 - up to 58.4 wt.%, Al2O3 - up to 10.65 wt.%, the minimum of TiO2 – 2.36 wt.%. The Ti-content increases in the outer zone of Cr-spinelide phenocrysts and sometimes titanomagnetite forms individual grains. The spinel composition trend of studied samples resembles the kimberlite trend.

The temperature and oxygen fugacity of olivine-spinel equilibrium were calculated (Ballhaus et al., 1991) use data on mineral compositions. The pressure of phenocrysts crystallization was estimated with the Cpx-geobarometer. The obtained results show that the kamafugites crystallization passed over the wide temperature interval - 1300–716C and fO2 exceeding buffer QFM (0.8<QFM<3.6), that is considerably higher the same of most basalts and unchanged upper mantle material. The presence of the sulfate microinclusions in the mafurite olivine confirms the correct results, obtained by olivine-spinel method. High oxygen fugacity values for the primitive melts may be mainly explained by the special features of the upper mantle composition where metasomatism processes were intensively developed and usually accompanied by oxidation of the source.

Sr and Nd isotope signatures for kamafugites form a slightly enriched relative to BSE cluster (87Sr/86Sr = 0.704629 – 0.705356; 143Nd/144Nd = 0.512488 – 0.512550). Some inverse correlation with major element contents is observed: 87Sr/86Sr – CaO, 143Nd/144Nd – Mg#, 87Sr/86Sr - Mg#. Sr-Nd isotope data of Bunyaruguru kamafugites suggest that its mantle source composition is nearly EM1. But the range of Pb composition for investigated is 206Pb/204Pb: 18.998 – 19.566; 207Pb/204Pb: 15.686 – 15.737; 208Pb/204Pb: 39.303 – 40.264. On these data the mantle source composition for studied kamafugites is close to EM2 or Dupal characteristics.

Reference:

Ballhaus C., Berry R.F., Green D.H. High pressure experimental calibration of the olivine-orthopyroxene-spinel oxygen geobarometer: implications for the oxidation state of the upper mantle 1991. Contrib. Mineral. Petrol. vol.107, p.27 – 40.