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Petrography and geochemistry of the Vuorijarvi carbonatite (Kola Peninsula, Russia)

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The Vuoriyarvi ultramafic carbonatite complex belongs to the Palaeozoic Kola Alkaline Province. The poorly exposed dyke system at Vuoriyarvi is composed of silica-rich sövites. Petrographical studies were performed on samples ravealing mosaic texture of calcite due to recrystallisation of the primary (tabular) calcite. Additionally, unusual textures are present such as intergrowths of monticellite and calcite, 'globular' and 'dumbell-like' inclusions of calcite/apatite in monticellite, heavily-embayed contacts between carbonate-silicate boundaries and rare pyroxene/olivine-rich granular regions containing minor calcite and surrounded by curved apatite trail. The observed 'liquid-immiscibility' textures were dismissed in a favour of solid state precipitation of rounded calcite (high temperature polymorph) from a silicate melt. The mafic region could be indicative of silicate-phosphate liquid immiscibility where semi-circular apatite trail could represent numerous small accumulated phosphate globules floated towards the surface after being separated from silica-rich liquid, which itself was globular as it was exolved from carbonate-rich liquid. Occasionally monticellite shows transition to amphibole which reflects the localised alteration from anhydrous to hydrous phase (transfer of water-rich fluids) reflecting processes such as metasomatism (possibly fenitization).

The xenocryst phlogopite, inherited from pyroxenite, has irregular/embayed boundaries and cores free of inclusions. Where inclusions of apatite are present, they are confined to the rim, suggesting late-stage overgrowth. The second generation of phenocryst phlogopite is small, full of acicular apatite inclusions. There is slight but important difference between the mg# number for the xenocrystic phlogopite (0.87-0.91) and the phlogopite phenocryst (0.88-0.92). Variation of MgO is reverse, showing lower mg# for the earlier-formed xenocrystic crystals which perhaps were formed in associated silicate magmas. Resorption of xenocrystic phlogopite would increase the silica content and modify the carbonatitic liquid and perhaps trigger growth of the second generation of phlogopite.

Relict olivine with high mg# around 0.90 is xenocrystic and probably crystallised at a higher temperature, having been mechanically assimilated from clinopyroxenites to a Ca-rich magma where it went through reaction and transformation to monticellite. Pyroxene is Fe-poor diopside. Less Fe-rich (Wo48-52En15-81Fs30-35) and highly Fe-rich (Wo60-65) wollastonite are present as rounded aggregates filling the cracks of monticellite. From the coexisting mafic phases, diopside has the highest mg# (0.932-0.988), olivine slightly lower mg# (0.890-0.902) and monticellite has the lowest mg# (0.769-0.811), thus these minerals show progressive Fe-enrichment.

The presence of rare phases of kimzeyite and perovskite, and similarity regarding their shape, size, sporadic occurrence and association with apatite, raises the question of their origin. Microprobe analyses revealed that kimzeyite have TiO_2 content 9-10 wt%, ZrO_2 concentration of 11-14 wt% and they are rich in SiO_2 (26 wt%) confirming a stronger association with phoscorites/pyroxenites than carbonatites. Nb2O5 in perovskite varies between 3-10 wt% and TiO_2 between 47-52 wt%. Lower content of Na2O+Nb2O5 in the Vuoriyarvi perovskite is compensated by higher concentration of $CaO+TiO_2$. As the crystallisation environment is Ca-rich consequently the amount of CaO in perovskite is high (37 wt%). The Vuoriyarvi Zr-rich and Nb-rich phases show a linear relationship (Zr in kimzeyite and Nb in perovskite plotted against Ti) reflecting close association between both phases.