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Apatite as a tracer for metasomatic processes in nepheline olivine melanogabbros of Uralian-Alaskan-type complexes in the Ural Mountains, Russia

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Nepheline bearing melanogabbros (tilaites) are assumed to represent the most fractionated products of the melt responsible for Uralian-Alaskan-type ultramafic cumulates found in zoned mafic-ultramafic complexes in the Ural Mountains (Russia). These nepheline gabbros consist predominantly of coarse-grained clinopyroxene phenocrysts in a matrix of fine grained olivine, clinopyroxene, plagioclase, K-feldspar and nepheline. Apatite occurs as idiomorphic inclusions ($<15\mu$m) in the clinopyroxene and as xenomorphic grains (<100 μm) in the matrix.

Primary textures in idiomorphic clinopyroxene phenochrysts consist of magmatic oscillatory or hour glass zonation made up of titanomagnetite exsolutions and major elements like Cr, Fe, Mg, Al and Ti. This primary texture is partially overprinted by a complex, patchy distribution of titanomagnetite exsolutions. Here the clinopyroxene is enriched in Ti, Al and Fe and depleted in Si and Mg. This overprint is interpreted to reflect a post-magmatic alteration. Compositional boundaries between the two textures are sharp.

Apatite inclusions located in the original magmatically zoned areas of the clinopyroxene phenochrysts are rich in F (2.4-2.7wt.%) and SrO (0.5-0.6wt.%) and poor in

Cl (0.4-0.8wt.%) and Na_2O (<0.1wt.%). In comparison apatite inclusions from the altered areas of the clinopyroxene, as well as interstitial apatite from the matrix, are enriched in Cl (1.0-2.2wt.%) and Na_2O (0.1-0.5) and depleted in F (1.7-2.3wt.%) and SrO (<0.45wt.%). The OH contents in all apatites are similar at 1.1-1.5wt.%.

In the matrix, plagioclase (An 26-41) is replaced by a fine-grained intergrowth of nepheline and K-feldspar (Or 53-93) in the form of a symplectitic texture. Coloured CL-images indicate the presence of two generations of K-feldspar. The first generation is a primary magmatic phase with a light blue luminescence. The second generation (gray luminescence) forms part of the symplectitic intergrowth with nepheline as well as rims around the magmatic K-feldspar cores. Nepheline also occurs as two different textural varieties, indicating the presence of two different generations. In places the symplectitic intergrowth is dynamically recrystallized.

Mass balance calculations imply that the replacement of plagioclase by nepheline + K-feldspar requires the addition of K_2O, Na_2O and Al_2O_3 and the removal of SiO_2 and CaO. Fine grained xenomorphic clinopyroxene and apatite in or close to the intergrowths of K-feldspar and nepheline can be interpreted to be crystallisation products of this replacement. The high Cl content, seen in apatite inclusions from the altered regions of the clinopyroxene as well as apatite in the matrix, implies that these mafic cumulates have been metasomatically overprinted, presumably by a KCl-rich brine during which plagioclase was replaced by K-feldspar and nepheline. Partial metasomatic alteration of the clinopyroxene by a Cl-enriched fluid can be interpreted as being due to dissolution-reprecipitation, which mobilised Fe, Mg, Al, Si and Ti in the altered areas thereby redistributing the titanomagnetite exsolutions and subsequently enriching the apatite inclusions in Cl. Apatite inclusions in the non-altered areas, i.e. the original magmatic clinopyroxene, did not encounter this Cl-enriched fluid and subsequently retain their original composition and texture.

A metasomatic overprint explains the unusual mineralogical composition of some mafic cumulates in Uralian-Alaskan-type complexes in the Ural Mountains and might also explain the different whole rock ages given by the Nd and Sr isotopic systematics (Brügmann et al. 2003).

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