

Transport of elements in granulite-facies alkali feldspar in charnockites from LofotenHartmann, Katharina¹; Wirth, Richard¹; Markl, Gregor²¹GeoForschungsZentrum Potsdam ²Eberhard-Karls Universität Tübingen

Charnockites from the Lofoten Islands in Northern Norway formed under anhydrous conditions about 1750 Ma ago, at about 800–900°C and 4 kbar. During a crustal thickening event, they reached granulite- to eclogite-facies metamorphic conditions of about 8–11 kbar at 700°C [2]. The charnockites contain alkali feldspars with albite exsolution lamellae enclosing Cl-rich amphiboles, pyroxenes and Fe-Ti-oxides which are evidence of extensive element migration through the feldspar. The inclusions are mostly arranged in rows. They are surrounded by albite lamellae and reach sizes of up to 15 µm. Some have a euhedral shape. Electron microprobe and TEM were used to study this phenomenon in an attempt to understand the transport mechanism during anhydrous, granulite-facies metamorphism. TEM specimens show mainly amorphous probably planar structures, which occur as lines. We will call these structures „pathways“, due to the fact that they show an enrichment in Fe, Mg, Cl, i.e. in the elements needed to form the mafic inclusions. These pathways have widths between 0.2 µm and 5 µm and occur in alkali feldspar, albite and even in amphibol inclusions. They could represent healed fractures or crystallographic faults. The fact that Cl-contents in amphiboles in Lofoten granulites correlate with the evolution of fluids during water-consuming reactions [2] could possibly be used as flow direction tracer of the fluid along such trails in the feldspars. [1] showed loop-shaped nanotunnels along exsolution lamellae of albite in alkali feldspar, which they interpreted to be formed by dissolution of edge dislocations. We found similar features. The process of forming nanotunnels described by [1] could be the beginning of the formation of larger mineral-traversing pathways. So far no convincing association with such tunnels was found. Those pathways would have an effect on the physical properties of the lower crust as well as on metamorphic and diffusion processes.

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[2] Markl, G., Bucher, K. (1998) Composition of fluids in the lower crust inferred from metamorphic salt in lower crustal rocks. *Nature* 391, 781–783.

The stability of iron-rich alluaudites in granitic pegmatites: an experimental investigation of the Na-Fe(II)-Fe(III) (+PO₄) system

Hatert, Frédéric; Fransolet, André-Mathieu

University of Liège, Laboratory of Mineralogy, B-18, B-4000 Liège, Belgium

The alluaudite group of minerals consists of Na-Mn-Fe-bearing phosphates which are known to occur in Li-rich granitic pegmatites. Due to their flexible crystal structure, which is able to accommodate Fe²⁺ and Fe³⁺ in variable amounts, alluaudites are very stable and crystallize from the first stages of pegmatite evolution to the latest oxidation processes. Since the petrogenetic importance of accessory phosphates has been demonstrated in the ultrahigh-pressure rocks of the Dora-Maira massif [1], it now clearly appears that experimental studies on these rare minerals are necessary to better understand the genesis of granitic pegmatites [2]. With this goal in mind, we decided to assess the geothermometric potential of alluaudite-type phosphates.

In the present study, we performed systematic hydrothermal experiments in the Na-Fe²⁺-Fe³⁺ (+PO₄) ternary system, between 400 and 700°C, at 1 kbar. Oxygen fugacity was not buffered, and gold capsules (2 mm diameter, 25 mm length) were used in order to keep the initial Fe²⁺/Fe³⁺ ratio constant. Alluaudite-type phosphates were observed between 400 and 700°C, and occupy the central part of the Na-Fe²⁺-Fe³⁺ diagram. Electron-microprobe analyses indicate that the compositional field of alluaudites covers ca. 10 % of the diagram surface at 400°C, but only ca. 2–3 % at 500 and 600°C. In the Na-rich part of the diagram occur several new phosphates, which were investigated by single-crystal X-ray techniques: Na₆Fe²⁺Fe³⁺(PO₄)₃(HPO₄), Na₄Fe²⁺Fe³⁺(PO₄)₃, or Na₂Fe³⁺(HPO₄)₂(OH).

The results of these experiments are applicable to Fe-rich alluaudites, as for example ferrohagendorfite from Angarf-sud, Morocco, which exhibits an ideal chemical composition Na₂Fe²⁺₂Fe³⁺(PO₄)₃ [3]. Alluaudite-type compounds with similar compositions were obtained between 400 and 700°C in the hydrothermal experiments, thus confirming again the existence of primary alluaudites in granitic pegmatites.

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[2] London D., Wolf B.M., Morgan G.B., Gallego Garrido M. (1999) *J. Petrol.* 40, 215–240.

[3] Fransolet A.-M., Abraham K., Speetjens J.-M. (1985) *Bull. Minéral.* 108, 551–574.