Fluid inclusions in charnockites from the Bjerkreim-Sokndal massif (Rogaland, South-Western Norway): fluid origin and in situ evolution

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Fluid inclusions and mineral associations were studied in late-stage charnockitic granites from the Bjerkreim-Sokndal lopolith (Rogaland anorthositic province). Because the magmatic and tectonic evolutions of the complex appear to be relatively simple, these rocks present a suitable case to discuss the origin and evolution of "granulitic fluids".

Fluid inclusions, primarily contained in quartz, can be divided into four types: carbonic (type I), N_2-bearing (type II), CO_2+H_2O (type III) and aqueous inclusions (type IV). For each type the role of leakage and fluid mixing are discussed from microthermometric and Raman spectrometric data. The most striking features of CO_2-rich inclusions (the predominant fluid) are the presence of graphite in numerous, trail-bound inclusions (Ib) and its absence in a few isolated, very dense (d=1.16), pure CO_2 inclusions (Ia) as well as in the late carbonic inclusions (Ic). Fluid chronology and mineral assemblages suggest that carbonic Ia inclusions represent the first fluid (pure CO_2) trapped at or close to magmatic conditions (T= 780-820°C, $fO_2 = 10^{-15}$ atm and P= 7.4 ± 1 kbar), outside the graphite stability field. In contrast, type Ib inclusions enclosed graphite particles from a channelized fluid during retrograde rock evolution (P= 3-4 kbar and T= 600°C). Decreases in T-fO_2 could explain a progressive evolution from a CO_2-rich fluid to an H_2O-rich fluid in a closed C-O-H system. However, graphite destabilization observed in type Ic inclusions implies some late introduction of external water during the late stage of retrogression.

The main results of this study are the following; 1) a carbonic fluid was present in an early stage of rock evolution (probably in the charnockitic magma), and 2) this granulite occurrence offers good evidence of crossing the graphite stability field during post-magmatic evolution.

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