

Magmatism and metamorphism in the middle-lower crust, SW Sweden

DANIEL HARLOV¹, ALFONS VAN DEN KERKHOFF²,
EDWARD HANSEN³ AND LEIF JOHANSSON⁴

¹GeoForschungsZentrum, D-14473 Potsdam, Germany

²University of Göttingen, D-37077 Göttingen, Germany

³Hope College, Holland, Michigan 49423 USA

⁴Lund University, SE-22362 Lund, Sweden

The 1.4 Ga Varberg-Torpa charnockite-granite intrusion (Kattegatt coast, Varberg, SW Sweden) consists of the Varberg charnockite (Opx-Cpx-Bt-Amph-Gt-Plg-Kfs-Qtz) and the synmagmatic Torpa granite (Bt-Amph-Gt-Plg-Kfs-Qtz), which contains several charnockite enclaves, and has a similar whole rock chemistry. Granite and charnockite were intruded at 650–700°C and 750 MPa (Gt-Opx, Gt-Cpx thermometry; Gt-Opx-Plg-Qtz barometry). Fluid inclusions from the charnockite are characterized by high partial CO₂ densities (40–90 % bulk CO₂; no CH₄ or N₂) and are found in Qtz, Gt, Plg, and FAp. Magmatic fluids in the granite correspond to aqueous-carbonic inclusions with an estimated bulk composition (mol%) of H₂O(73), CO₂(25), and NaCl(2). Fluid inclusion, petrographic, mineralogic, geochemical, and field evidence suggest that charnockite-granite crystallization was more a function of relative H₂O activity than relative depth. The Varberg charnockite is associated with in-situ, highly localized areas of fluid-induced (metamorphic) dehydration in the surrounding regional, amphibolite-facies, migmatized, granitic gneiss. These areas include a 1.4 Ga, Opx-bearing, 3 m wide dehydration zone surrounding a former shear zone 70 km SE of Varberg. They also include numerous Cpx megacryst-bearing veins and patches (5 cm – 2 m wide) in the granitic gneiss, continuing 80 km southwards from the Varberg charnockite in a broad band along the Kattegatt coast. Also found in the same area are Plg-bearing leucosomes (1420–1460 Ma or 970 Ma) of which half contain either Opx or Cpx megacrysts which indicate local, fluid-rich, partial melts with low H₂O activities. Each feature described emphasizes the role of low H₂O activity fluids during magmatism, partial melting, and metamorphism in the lower crust and suggests a connection between the two.

Structural complexity in pyrrhotites: What are the implications for fluid-mineral interactions?

D. HARRIES*, K. POLLOK, K. ETZEL
AND F. LANGENHORST

Bayerisches Geoinstitut, Universität Bayreuth, D-95440
Bayreuth, Germany

(*correspondence: dennis.harries@uni-bayreuth.de)

Pyrrhotite (Fe_{1-x}S with $x < 0.125$) comes a close second after pyrite among the most abundant iron sulfides in ore deposits. At temperatures well below 140°C its various NiAs based superstructures can be described as modulations of vacancy ordering among and within Fe layers along principal crystallographic axes. The many possible modulations are intimately coupled to the deficiency of Fe resulting in large numbers of possible polytypes with distinct Fe/S ratios. Crystallographic models of NC-type modulations – being most common in natural pyrrhotites – suggest the possibility of structural continuity among pyrrhotite polytypes, i.e. widely varying and non-intergral N values of stacking schemes governed by modulation along the *c*-axis are to be expected and allow for high structural variability on smallest scales.

We studied a selection of natural pyrrhotites by analytical transmission electron microscopy (ATEM), atomic force microscopy (AFM), and electron backscatter diffraction (EBSD) techniques which provide the advantage of highly resolved structural analysis. Our results show that structural and compositional heterogeneity of different magnitudes exists on μm to nm scales. Selected area electron diffraction reveals very long range ordering of Fe vacancies being of enigmatic structural (meta?)stability. Slight variations of stacking schemes occur frequently and are accompanied by various defect structures like stacking faults, twin and antiphase boundaries. Exsolution-like lamellae of distinct polytypes within pyrrhotite hosts apparently formed by reordering of vacancies and show more pronounced structural contrasts but still share common crystallographic orientations and coherent displacements by subgrain boundaries.

Etching of pyrrhotite surfaces reveals topography contrasts between lamellae and hosts and indicates different solubilities in low temperature aqueous fluids which we attempt to quantify by AFM to realistically resolve reactivity differences between different pyrrhotite polytypes. Batch experimental designs and bulk X-ray diffraction have so far rendered this impossible. Besides this subject our preliminary studies will furthermore address the replacement relationships with secondary phases encountered during low temperature alteration and weathering.