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Partial eclogitization of granulites in the Bergen Arcs, Western Norway and geodynamic consequences

H. Austrheim

Centre for Physics of Geological Processes,

University of Oslo, P.O. Box 1048-Blindern, 0316, Oslo, Norway

hakon.austrheim@geo.uio.no / Fax: 47 22855101

The Precambrian (ca 950 Ma) granulite facies anorthosite complex of the Bergen Arcs, Western Norway was partially reacted to eclogites (650 $\pm$ 50 ^{o}C, 15-20 kbar) and amphibolites during the Caledonian orogeny (ca 420 Ma). Eclogites and amphibolites are found along fluid channels and in hydrated shear zones varying in thickness from cm to 100 m across. Eclogite breccias where blocks of granulites flow in eclogites cover km^2. The transition between eclogites and granulites occurs over distances of cm. Pseudotachylytes veins with eclogite facies minerals transect the granulites suggesting brittle failure of the "dry" granulites during the eclogite facies event. Rb-Sr and ^{40}Ar-^{39}Ar dating of phlogopite from the granulites give Precambrian ages. Several lines of reasoning suggest that the eclogitization was a rapid process. Based on chemical profiles in garnets Erambert and Austrheim (1993) calculated the metamorphic event to last 1-4 Myr. Perchuk (2002) estimated that the complex cooled from 730 to 600 ^{o}C in 0.8 Myr. Bjørnerud et al. (2002) modeled the eclogitization process to $<<$ 1 Myr. Camacho et al. (2005) combined ^{40}Ar-^{39}Ar data with a thermal model and constrained the burial and exhumation to last $<$ 10 Myr and the metamorphic events 20 Kyr. Three scenarios have been proposed to explain the localized eclogitization:

1. The temperature and pressure recorded by the eclogites prevail also in the granulites, but the reaction occurred only in the hydrated parts.

2. Rapid subduction and exhumation. The granulites remained cold and heating by hot fluids caused localized eclogitization.

3. P and T measured in the eclogites are due to shear heating and local overpressure.

The various models will be evaluated in light of field relations, petrology and isotopic data from the Bergen Arcs. The consequences of the three scenarios for orogenic evolution are: In model 1 the fluid is critical for the transformation of granulites to eclogites and for the density and rheology of the deep crust. Ages obtained on eclogites record the time of fluid infiltration. In model 2 the fluid heats the crust and the rheological differences between granulites and eclogites is seen mainly as a function of temperature. The lack of reaction may be assigned to kinetic hindrance at low temperature. In both models 1 and 2, the evolution of the orogen will be dependent on fluid transport and amounts at depth in the collision zone. Model 3 explains the observed relationships without subduction and requires a completely new thinking on metamorphic transitions and mountain building. The three scenarios must be viewed in light of existing geophysical and geodynamic data.

References

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