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Deformation-induced metasomatism of the lower crust: The importance of brittle mechanisms for fluid infiltration revealed by microstructures at a hydration interface

Jo Moore (1), Håkon Austrheim (2), Andreas Beinlich (1), and Andrew Putnis (1)

(1) The Institute for Geoscience Research, Department of Applied Geology, Curtin University, Australia (josephine.moore@postgrad.curtin.edu.au), (2) Physics and Geological Processes, University of Oslo, Norway (h.o.austrheim@geo.uio.no)

Devolatization of the subducted crust at collisional plates margins is known to produce fluids, weakening the plate boundary and triggering seismicity. The behaviour of fluids produced at subduction margins and how they interact with the overlying crust remains poorly understood, despite having important implications for magma production, element recycling and seismic behaviour. The Bergen Arc of the Scandinavian Caledonides, western Norway, provide an excellent natural laboratory to study the interplay between fluids and deformation in a subduction setting. In eclogites and amphibolites of the Bergen Arc widespread hydration is strongly linked with fracturing and shear zone formation at middle to lower crustal conditions (Austrheim, 1987). Here we characterise the physiochemical response of plagioclase feldspar during early extension in the Caledonian rocks by focusing on a transition between an original unaltered anorthosite and its hydrated counterpart. A combination of wavelength dispersive X-ray spectroscopy (WDS), electron backscatter diffraction (EBSD), and transmission electron microscope (TEM) analysis is used to identify relationships between chemical changes and strain in feldspar. Quantitative WDS mapping reveals complex chemical zoning of feldspar associated with the precipitation of hydrous and volatile-bearing phases. Quantitative analysis of the microstructure using EBSD and imaging of grain structures using TEM indicates that the initial fluid influx leading to the precipitation of hydrous phases is assisted by brittle mechanisms, with hydration of feldspars assisted by pervasive intragranular fracturing. Subsequent to fluid infiltration, the precipitation of alteration phases within the plagioclase crystal structure causes a decrease in grain size and enhanced permeability along these pathways, facilitating a switch to diffusion and dislocation creep assisted grain boundary sliding. The switch to crystal plastic mechanisms along previous fracture pathways allows for the localisation of strain and mass transfer, producing anastomosing shear zones. The focusing of fluid flow along these newly formed shear zones prevents further hydration of the host rock. Pervasive fracturing of plagioclase indicates an early stage of extensive brittle deformation of the rock, producing a damage zone in which fluids may infiltrate.

Austrheim, H. (1987). Eclogitization of lower crustal granulites by fluid migration through shear zones. Earth and Planetary Science Letters, 81(2-3), 221-232.