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Deformation-enhanced metamorphic reactions and the rheology of high-pressure shear zones, Western Gneiss Region, Norway

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Microstructural and petrologic analysis of samples with increasing strain in HP shear zones from the Haram garnet corona gabbro give insights on the deformation mechanisms of minerals, rheologic properties of the shear zone, and the role of deformation in enhancing metamorphic reactions. With increasing strain, the gabbro was progressively changed from a typical igneous textured gabbro to mylonitic gneiss with pronounced foliation, and finally to a fine grained ultramylonite where metamorphic layering becomes increasingly thin resulting in a homogeneous appearance. Scanning electron microscopy with electron backscattering diffraction (SEM-EBSD), composition mapping, and petrographic analysis were used to evaluate the nature of deformation in both reactants and products associated with eclogitization. Ilmenite, which occurs in ilmenite/magnetite layers, deforms by basal and, at higher strains, prism glide in the **a** direction. Plagioclase with a shape preferred orientation (SPO) that occurs in the interior part of layers in the mylonitic sample deformed by intracrystalline glide on the (001)[100] slip system. On the outer part of these layers plagioclase is coarser grained and has no SPO indicating post tectonic growth. Composition maps of Ca in the inner part polycrystalline of garnet layers show changes consistent with mechanical mixing grains of different composition and grain boundary shapes that support our previous interpretation of that garnet deformed by grain boundary sliding with diffusion. The outer part of garnet layers are coarser grained and euhedral and are interpreted to be post tectonic. In omphacite, crystallographic preferred orientations (CPOs) indicate slip on (100)[001] and (110)[001] during deformation. Relationships among the minerals present and petrologic analysis indicate that deformation and metamorphism in the shear zones began 500 to 650˚C and 0.5 to 1.4 GPa and con-

tinued during prograde metamorphism to conditions approaching 780 ˚C and 1.8 GPa. Both products and reactants show evidence of syn- and post-tectonic growth indicating that prograde reactions continued after strain was partitioned away. The restriction of post-tectonic growth to narrow regions at the interface of garnet and plagioclase and preservation of earlier syn-tectonic microstructures in older parts layers that were intimately involved in reactions during deformation show that diffusion distances were significantly shortened when strain was partitioned away demonstrating that deformation played a very important role in enhancing metamorphic reactions. Two important consequences of deformation observed in these shear zones are 1) the homogenization of chemical gradients occurred by mixing and grain boundary migration and 2) composition changes in zoned metamorphic garnet by lengthening diffusion distances. The application of experimental flow laws to the main phases present in monomineralic to near monomineralic layers indicates yield stresses of 100-150 MPa and strain rates of 10-12 to 10-13 sec^{-1} as deformation conditions for the shear zones in the Haram gabbro that were produced during subduction of the Baltica craton and resulted in the production of HP and UHPM rocks.