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Processes of eclogitization and consequences for high-pressure rocks exhumation

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The anorthositic unit on northwestern Holsnoy, within the Bergen Arcs, Norway, is a 5 km scale lower continental crustal unit that was buried and partially eclogitized at depth during the caledonian orogenesis. The granulite-facies protolith and the high-pressure rocks and structures were remarkably preserved throughout exhumation, enabling us to study in detail eclogitization processes and their consequences for exhumation and deep crustal movements.

Due to the very low water content of the granulite-facies assemblage hampering eclogitization, only zones where external fluid was input from external sources through fractures have been eclogitized. As a result, the transformation is highly heterogeneous at the scale of the unit, and slightly transformed zones are juxtaposed with highly transformed zones. The localization of all deformation within the eclogitized fraction, leaving granulite-facies rocks undeformed, clearly evidences that a strong rheological weakening is associated with the metamorphic transformation.

Within the highly eclogitized zones, a large deformation has resulted in the formation of large shear zones (around 10-100m wide, 1 km long), with a relatively constant foliation and lineation geometry throughout the unit. We have collected within these shear zones extensive evidences at different scales indicating systematic top-to-the-ENE shear deformation.

In the slightly eclogitized zones, eclogite is localized in narrow shear zones (around 1-50 cm wide, 1-10 m long) cutting through untransformed granulite. These shear zones can be divided in two distinct sets on the basis of geometry and deformation kinematics. The deformation on these two sets of shear zones can be interpreted as bookshelf tectonics.

Our structural study shows that eclogite-facies deformation is very consistent at the scale of the studied zone and resulted therefore from the action of large-scale tectonic stresses, rather than local stresses related to metamorphic reactions. When the unit is restored to its original position at depth within the caledonian slab, the deformation in the large eclogite-facies shear zones is interpreted as recording the thrusting of kilometer-scale crustal slivers onto each other and onto the underlying mantle. Therefore, we propose the following evolution of continental crust at depth in subduction zones: the lower crust was dragged within the slab up to eclogite facies conditions, where the formation of weak eclogite shear zones enabled the mechanical decoupling between the dense mantle and the light crustal slivers, which started exhuming. This model stresses out the crucial role of eclogitization to trigger the first steps of exhumation.