Geophysical Research Abstracts,
Vol. 11, EGU2009-2319-1, 2009
EGU General Assembly 2009

Deformation microstructures and mechanisms in the high-pressure granulites of the Bacariza Formation (Cabo Ortegal, NW Spain): going up to the surface

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The Cabo Ortegal complex is a nappe stack formed by fragments of subducted continental and oceanic lithosphere emplaced onto the Gondwana edge during the Variscan orogeny. The nappe units of Cabo Ortegal were metamorphosed under different high-pressure (HP) conditions and currently are separated by ductile tectonic contacts. They include mappable ultramafic massifs, N-MORB eclogites, metagabbros, metaserpentinites, metaperidotites, ortho- and paragneisses, and the Bacariza Formation granulites. The primary structure consists of the ultramafic massifs tectonically resting on top of the granulites of the Bacariza Formation, which overlie eclogites and HP gneisses with eclogite boudins.

Granulites of the Bacariza Formation are mainly basic to intermediate in composition, although granulitic, carbonate-rich or mineralogically more exotic varieties also exist. On the basis of modal variations in the abundance of mafic and felsic mineral several lithotypes have been differentiated in order of decreasing outcrop area: (G1) plagio-pyrigarnites or common mafic granulites, (G2) intermediate to felsic, plagioclase-rich granulites, (G3) Mg-rich mafic granulites, (G4) pyrigarnite, or plagioclase-poor ultramafic granulites, and (G5) granulitic orthogneisses.

The Bacariza Formation recorded a high-pressure metamorphic event. This event was polyphasic and two deformational phases are differentiated, D1 and D2, namely. D2 is associated to amalgamation of eclogite, high-pressure granulitic rocks and ultramafic sheets in deep portions of a subduction channel during the initial exhumation of the complex. As a result, transposition of the previous D1 fabrics took place due to the development of spectacular shear zones at the contacts with the bounding units. Pressure and temperature conditions estimated from the D2 mineral assemblage in equilibrium yield values of ca. 1.4 GPa and 740 ºC, respectively. In this work we present a detailed study of a D2 shear zone located at the contact between the mafic (G1) and intermediate (G2) granulites of the high-pressure Bacariza Formation and the structurally underlying eclogite massif. A petrographic, microstructural and crystallographic analysis has been carried out in these rocks in order to characterize ductile deformations at deep crustal levels and to shed some light on the structural imprints recorded at various scales.

On these lines, overprinting relationships of the metamorphic assemblages enable us to interpret that partitioning and deformation localization took place at different scales under similar high-grade conditions, including the localization effect involved in the development of subduction channels at the lithospheric plate boundary scale. First, ductile deformation concentrated, at the map and outcrop scales, along the contact with peridotites and eclogites, rheologically stronger, leading to accommodation of large tectonic displacements under faster strain rates due to its relative weakness. Second, within the shear zones, bands of contrasted lithology exhibit contrasting deformation intensities, getting it concentrated in the leucocratic layers. Thus, every lithological layer behaved as a separate rheological unit. Last, deformation partition occurred within each layer. Layers are often polymineralic and both the microstructures and the lattice-preferred orientation patterns observed denote that crystal-plastic mechanisms dominated mineral deformation, in such a way that deformation of the same mineral assemblage under the same thermobaric conditions also resulted in petrographically different tectonites, depending on the proportions and rheology of the minerals involved.

In order to determine the deformation mechanisms operative in each phase during the initial exhumation of the Bacariza Formation, the lattice-preferred orientation (LPO) of the constituent minerals of these rocks (garnet, augite, plagioclase, quartz and amphibole) has been studied with the Electron Back-Scatter Diffraction (EBSD) technique. The results indicate that although garnet accommodated part of the deformation by dislocation creep and recovery, rigid rotation in a non-coaxial regime also took place. Augite underwent dislocation creep accompanied by mass transfer and anisotropic growth under flattening conditions while quartz deformed by grain boundary migration and dislocation creep. Quartz LPO patterns are indicative of deformation temperatures characteristic at least of the high-T amphibolite-facies. Plagioclase, in turn, suffered dynamic subgrain rotation-recrystallization by climb-accommodated dislocation creep. Amphibole replaced primary clinopyroxene and shows deformation microstructures pointing to dynamic recrystallization processes. The observed shear sense criteria are consistent with a top-to-the-NE displacement of the hanging wall blocks.