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Microstructures and anisotropy of upper mantle shear zones

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Our study concerns the mechanical and thermal evolution of the upper mantle underneath the Mesozoic rift of the North Pyrenean Zone. Recent work on the focal mechanism distribution in the continental lithosphere (Maggi et al, 2000) seriously questions the generally acknowledged idea that the upper mantle is the strongest part of the lithosphere.

In order to explain this possible weak rheology of the uppermost mantle, we address the effects of the progressive development of ultra fine-grained shear zones and the possible role of fluids (water and or metasomatism). A microstructural study is performed on lherzolite samples from the Pyrenees using non polarized Fourier transform infrared spectroscopy (FTIR) to estimate water contents and using electron back-scattered diffraction (EBSD) technique to define lattice preferred orientations (LPO).

The microstructural study has concentrated on mylonitic samples from the Pyrenean lithospheric mantle. Two types of mylonites can be identified based on the orientation of the grains. EBSD work on these samples is a clue in understanding their origin and shows that LPOs of ultra fine-grained minerals are mainly scattered while preferred orientations exist mainly for olivines: (okl) [100] and some (010) [001] fabrics. This is respectively type A and type B identified by Jung & Karato (2001). However, the LPO of the coarse grains close to the mylonite is not affected by the development of these fine-grained materials and have a strong preferred orientation with especially (0kl) [100] and some (010) [001] fabrics. This might be the result of a dislocation creep mechanism in these grains in contrast to probable grain size sensitive creep in the mylonite. This agrees with previous work on Pyrenean samples (Newman et al. 1999). The seismic anisotropy decreases with increasing mylonite strain that is from

granular to ultramylonites.

We find evidence for the presence of magnesite and CO2 peaks in FTIR which shows that CO2 infiltration occurred during shear zone development. It is correlated by the modal composition of these mylonites which display until 5% of amphiboles and also carbonates, where large grains of these same phases do not appear in the coarse grains area of the sample.

The development of fine-grained shear zones will weaken the lithosphere depending on the extent and spatial distribution of the zones. Shear zone development may also influence the seismic signature of the lithosphere producing a reduction in the seismic anisotropy. The seismic reflection coefficients have been calculated for these shear zones and mantle samples. It seems that detectable reflections may be produced between host rocks and mylonites provided that the mylonite zones are wide enough.

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