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Crystal preferred orientations of minerals from mantle xenoliths in alkali basaltic rocks form the Catalan Volcanic Zone (NE Spain)

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Mantle xenoliths in alkali basaltic rocks from the Catalan Volcanic Zone, associated with the Neogene-Quaternary rift system in NE Spain, are formed of anhydrous spinel lherzolites and harzburgites with minor olivine websterites. Both peridotites are considered residues of variable degrees of partial melting, later affected by metasomatism, especially the harzburgites. These and the websterites display protogranular microstructures, whereas lherzolites show continuous variation between protogranular, porphyroclastic and equigranular forms. Thermometric data of new xenoliths indicate that protogranular harzburgites, lherzolites and websterites were equilibrated at higher temperatures than porphyroclastic and equigranular lherzolites. Mineral chemistry also indicates lower equilibrium pressure for porphyroclastic and equigranular lherzolites than for the protogranular ones. Crystal preferred orientations (CPOs) of olivine and pyroxenes from these new xenoliths were determined with the EBSD-SEM technique to identify the deformation stages affecting the lithospheric mantle in this zone and to assess the relationships between the deformation fabrics, processes and microstructures.

Olivine CPOs in protogranular harzburgites, lherzolites and a pyroxenite display [010]-fiber patterns characterized by a strong point concentration of the [010] axis normal to the foliation and girdle distribution of [100] and [001] axes within the foliation plane. Olivine CPO symmetry in porphyroclastic and equigranular lherzolites varies continuously from [010]-fiber to orthorhombic and [100]-fiber types. The orthorhombic patterns are characterized by scattered maxima of the three axes, which are normal between them. The rare [100]-fiber patterns display strong point concentration of [100] axis, with normal girdle distribution of the other two axes, which are aligned with each other. The patterns of pyroxene CPOs are more dispersed than those of olivine, especially for clinopyroxene, but there is good correlation between the [100] olivine axis and the [001] pyroxene axis in most protogranular peridotites. However, the [001] axes of the three silicates are parallel in equigranular and some porphyroclastic lherzolites. CPOs and misorientation axes indicate deformation by dislocation creep accommodated mainly by the [100](010) slip system for olivine and the [001](100), [001](010) for orthopyroxene. Also, subsidiary slip systems for olivine are [100]{0kl}, [001](100), [100](001) in porphyroclastic and equigranular lherzolites. The fabric strength of the three main silicates are consistent, all of them decreasing with grain size reduction.

These results indicate that the lithospheric mantle in this area was affected by several deformation stages that took place at decreasing temperature and pressure. An earlier stage is preserved in protogranular peridotites and a pyroxenite, with olivine [010]-fiber patterns and consistent deformation of pyroxenes. It could be related to axial shortening, transpression and/or subsequent recovery and annealing. Later deformation stages would be recorded by most porphyroclastic and equigranular lherzolites characterized by orthorhombic and [100]-fiber patterns for olivine, and transitions between them and with the [010]-fiber one. These samples would come most likely from an active shear zone at shallower upper mantle depth, where deformation at higher strain rates would explain the olivine [100]-fiber symmetry. Transient deformation patterns for olivine, grain size reduction along with weakening of the fabric strength could be due to dynamic recrystallization through grain boundary migration and subgrain rotation mechanisms.