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Strain localization in the oceanic lithospheric mantle: the Humboldt shear zone of the New Caledonia ophiolite

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Vertical ductile shear zones, of a few tens of meters to kilometers in width, have been described in many ophiolites. In most cases these shear zones are nearly perpendicular to the ridge direction. In contrast, the New Caledonia ophiolite shows a unique example of a subhorizontal shear zone in the Humboldt region of Massif du Sud.

The New Caledonia ophiolite, located on the Norfolk Ridge, to the East of Australia, is a type example of a supra-subduction ultramafic nappe. This nappe, up to 8 km-thick, 550 km-long, 8000 km^2, has been dated at 131$\pm$16 Ma. It is largely composed of harzburgite tectonite overlain by dunite, wehrlite and cumulate gabbro. The contact between the ultramafic and mafic ophiolitic units is regarded as a paleo-Moho and is broadly subhorizontal. The generally horizontal attitude of foliations and the large positive gravity anomalies along the coast (180 mgal) suggests that the nappe gently dips to the East where it is rooted to the oceanic lithosphere. Mineral lineations in Massif du Sud are consistently NNW-SSE which suggests that the oceanic ridge had a WSW-ENE strike.

The Humboldt region hosts a NW-SE trending corridor (40x20 km), in which tectonic peridotites have steeper foliations and strong penetrative fabrics that grade into horizontal foliation outside the shear zone. Five N130° trending zones have been identified from SW to NE: 1) a 3-4 km-thick zone of harzburgites with pyroxenite dikes, 2) a 1-2 km-thick zone of harzburgites with gabbro dikes, 3) a 1-4 km-thick zone of harzburgites without dikes displaying a prominent centimeter-scale layering, 4) a zone similar to zone 2; 5) a zone similar to zone 1. The mineral lineation remains subhorizontal throughout the corridor. The harzburgites display porphyroclastic microstructures while olivine LPOs indicate plastic flow with activation of (010) [100] high temperature slip system. Although the origin of this corridor is still unclear, olivine LPO data indicates that deformation occurred at high temperature in the mantle. The external zones 1 and 5 host numerous dunite boudins. With respect to the nappe, the Humboldt corridor is located about 0.5-1 km below the Moho and about 1 km above the sole of the nappe.

The anisotropy of magnetic susceptibility (AMS) has been measured on 10 stations (40 specimens). The low-field magnetic susceptibility (700-7000 x 10^{-6} [SI]), results from secondary magnetite formed during serpentinization and therefore does not reflect mantle deformation. The high-field AMS represents the contribution of silicates only (olivine and orthopyroxene). Preliminary results show that low-field and high-field AMS principal axes are distinct. The degree of magnetic anisotropy correlates with the intensity of mineral fabric and suggests that deformation is heterogeneous at scales from a few cm up to 1 km. This agrees with the abundance of melt extraction structures and supports the view that melt distribution and strain localization are intimately linked. We speculate that lithospheric mantle zones that have experienced melt segregation might play a significant role in the localization of obducted ultramafic nappes.