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Strain localization in abyssal peridotites from a magma-starved mid-ocean ridge: a microstructural study

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Detachment faults are large offset normal faults that exhume mantle-derived rocks on the seafloor at slow spreading ridges. They are assumed to root at the base of the brittle lithosphere. Magma, if present, can help localize strain at the base of the axial brittle lithosphere by its own presence or crystallization of weaker phases such as plagioclase. This is the case of the Mid-Atlantic Ridge, where ductile shear zones are preferentially formed in and next to magmatic veins (Boschi et al., 2006; Cannat, 1991; Cannat & Casey, 1995; Ceuleneer & Cannat, 1997; Dick et al., 2002; Hansen et al., 2013; Picazo et al., 2012, Schroeder & John, 2004).

Here we focus of a nearly amagmatic case, the eastern part of the Southwest Indian Ridge (SWIR). Partially serpentinized peridotites recovered from dredging on and off axis record variable degrees of a heterogeneous high stress deformation. Orthopyroxene is primarily brittle (kinks, fractures), while olivine displays a wide range of plastic to semi-brittle deformation, ranging from weak to strong with development of extensively recrystallized anastomosing microshear zones. These microshear zones, which are a few mm to cm wide, represent the highest strain localization recorded in these samples. No further evidence of high strain localization, such as high temperature mylonites, has been recovered in this area. The fine-grained microshear zones are preferentially located along orthopyroxene grains or around kinked olivines. Both represent stronger grains (rheological contrast at the grains scale) that produce stress concentrations. Rock-scale thermo-mechanical models using orthopyroxene and olivine flow laws reproduce the observations: ductile shear zones in olivine also initiate preferentially next to brittle orthopyroxene.

We propose that this deformation is linked to the rooting of the detachment faults at depth, where an anastomozed network of microshear zones localizes strain at the base of the lithosphere, allowing the exhumation of variably deformed rocks.