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Evolution of a mantle shear zone and the influence of second phases, Hilti Massif, Oman

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Localization of deformation in shear zones is a common feature in the Earth's crust and upper mantle (e.g., thrusts, strike slip faults). The evolution of such high strain zones is often long lasting incorporating variations in physical (e.g. P, T) and chemical conditions with time. To learn more about the distribution and evolution of deformation in mantle rocks as a function of variable physico-chemical conditions, detailed mapping and microstructural investigations of a peridotite shear zone in the Hilti massif (Oman ophiolite) was performed.

The shear zone investigated shows a total thickness of about 3km, is steeply dipping and characterized by sub-horizontal lineations. Based on these observations, these type of shear zones in the Oman ophiolite were previously interpreted as major strike slip zones, which were related to the exhumation induced thrusting of the ophiolite (e.g. Boudier et al., (1988)). Detailed mapping shows that the largest part of the shear zone experienced moderate deformation, whereas high deformation is localized in relatively narrow parallel bands (∼100m thickness) that occur at regular distances of about 300 meters. A broader high strain band (∼500m) was mapped in the center of the shear zone.

In the high strain zones investigated, both dunites and harzburgites occur. Particularly in case of the harzburgites, both mineralogy and modal compositions can vary. In these rocks, secondary minerals like (opx, cpx, spinel) can affect the grain size of the predominating olivine in the matrix, which can have an influence on the deformation mechanisms (e.g. diffusion vs. dislocation creep). In order to test the effect of such

secondary phases on microstructure, deformation mechanisms and strain localization behavior, microstructures of three different high strain domains were quantitatively investigated. For this purpose, grain size (dp) and volume fractions (fp) of olivine and the second phases (opx, cpx and spinel) as well as CPO's were analyzed. In addition, geothermometry has been performed to gain information on the deformation temperature.

Similar to previous studies performed on calcite mylonites, also the mantle mylonites can be subdivided into two different microfabric types: (a) second phase controlled microstructures, where the olivine grain size increases with increasing Zener parameter (Z = dp/fp, second phase grain size/second phase volume fraction e.g. see Herwegh and Berger, (2004)). In these microfabrics, the olivine grain size increases from 40 μm to 230 μm. (b) Recrystallization controlled microstructures, where the olivine grain size shows no dependence on the second phase content and remains constant at 230 μm. The transition between both microstructure types occurs at a Zener parameter of about 400μm**.** The second phase controlled microstructures show weaker CPO's, indicating a decrease in intracrystalline plasticity with increasing second phase content. Furthermore, the crystallographic a, b and c axes are concentrated in point maxima, which are obliquely oriented with respect to the kinematic axis. Compared to deformation experiments performed on olivine, this obliquity of CPO's suggests deformation of both mono- and polymineralic layers under the presence of water (Jung and Karato, 2001).

Both the trend of olivine grain size vs Zener parameter and the geothermometry analyses are similar for the different high strain zones investigated indicating that these zones were formed under the same conditions (e.g. strain rate, stress and temperature). It can therefore be postulated, that the variations in second phase type and content was no major parameter for strain localization. In contrast, the microstructures adapt to the local Zener parameter, enabling specific combination of dislocation creep and diffusion creep to maintain an overall homogeneous deformation within the high strain zones.

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