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Ridge-parallel-shearing and localized vertical melt migration during spreading: A phenomenon underestimated so far?

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At spreading ridges, melt generation in the asthenospheric mantle followed by melt extraction, ascend, reaction and crystallization is an important mechanism for the generation of new oceanic crust. In contrast to original concepts, assuming a continuous and steady melt supply, recent studies indicate that melt ascend preferentially occurs in spatially restricted areas that both vary in space and time heavily segmenting the ridges.

Based on field investigations in the Semail ophiolite (Oman) we found a close interplay between ductile strike-slip shearing along a vertical ridge-parallel shear zone in mantle harzburgite and melt ascend in the center of the shear zone. Here, melt rise was episodic and started at stages of initial high temperature deformation (>1100°C) but persisted during spreading induced retrograde cooling to deformation temperatures of about 800°C. The locations of ductile deformation and melt ascend (dikes) are very localized and coincide. Moreover, old dikes are spread over wider domains in the shear zones, while young dikes are concentrated in the immediate shear zone center, i.e. in the parts of youngest ductile deformation. These observations suggest that stress concentration along already crystallized dikes, continuous ductile strain localization and lubrication by younger melts all contributed to shear zone focusing with progressive cooling. Hence initial mechanical anisotropies are repeatedly overprinted resulting in a complex 3D shear zone pattern with temporal and spatial hydraulic variations in melt activity.

Extrapolated to the scale of the entire Oman ophiolite we suggest that the ductile shear zones separate major mantle diapirs. They therefore seem to represent important zones of heterogeneous thermo-mechanical strain accommodation between the cooling diapirs and might be more common along spreading ridges than recognized so far contributing to ridge-segmentation.