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Rheology and friction along the Vema transform fault (Central Atlantic) inferred by thermal modeling

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We investigate with 3-D finite element simulations the temperature distribution beneath the Vema transform that offsets the Mid-Atlantic Ridge by ∼300 km in the Central Atlantic. The developed thermal model includes the effects of mantle flow beneath a ridge-transform-ridge geometry and the lateral heat conduction across the transform fault, and of the shear heating generated along the fault. Numerical solutions are presented for a 3-D domain, discretized with a non-uniform tetrahedral mesh, where relative plate kinematics is used as boundary condition, providing passive mantle upwelling. Mantle is modelled as a temperature-dependent viscous fluid, and its dynamics can be described by Stokes and advection-conduction heat equations. The results show that shear heating raises significantly the temperature along the transform fault. In order to test model results, we calculated the thermal structure simulating the mantle dynamics beneath an accretionary plate boundary geometry that duplicates the Vema transform fault, assuming the present-day spreading rate and direction of the Mid Atlantic Ridge at 11 °N. Thus, the modelled heat flow at the surface has been compared with 23 heat flow measurements carried out along the Vema Transform valley. Laboratory studies on the frictional stability of olivine aggregates show that the depth extent of oceanic faulting is thermally controlled and limited by the 600 °C isotherm. The depth of isotherms of the thermal model were compared to the depths of earthquakes along transform faults. Slip on oceanic transform faults is primarily aseismic, only 15% of the tectonic offset is accommodated by earthquakes. Despite extensive fault areas, few large earthquakes occur on the fault and few aftershocks follow large events. Rheology constrained by the thermal model combined with geology and seismicity of the Vema Transform fault allows to better understand friction and the spatial distribution of strength along the fault and provides insight into slip accommodation on oceanic transforms.