Role of faulting at trench and ridge for plate-like motion in mantle convection system

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To understand plate tectonic motion an integral part of mantle convection, we must know how the flow induced by the excess mass of subducted slab produces plate-like flow in the highly viscous surface layer. We propose to represent plate boundaries as velocity discontinuities across them (ridge as open crack, trench as reverse fault and transform fault as strike slip) in Newtonian fluid with high viscosity. We model trench by 45 reverse fault and ridge by a conjugate pair of 45 normal faults in two-dimensional convection system. The role of faulting is different between trench and ridge. The role of faulting in trench is to release shear stress on the fault plane. Fault in ridge acts as tensile crack to relieve horizontal tensile stress. We present the analytical expressions for the flow fields, stress fields, dynamic surface topography and surface gravity due to convection induced by trench faulting, convection induced by slab excess mass and their coupled convection for two-dimensional homogeneous, semi-infinite viscous fluid. In the absence of trench fault the stress field of mass-induced flow is dominated in trench by vertical tensile stress, half of which is converted by faulting to horizontal tensile stress. Now fault-induced flow is generated. It can be shown that horizontal tensile stress so created can transmit to extremely far distances through the surface layer if it is highly viscous and is relieved by crack opening in ridge. We demonstrate that shear faulting at trench and consequent passive crack opening at ridge produces convection very much plate-like in the highly viscous surface layer. A system of shear fault in trench and tensile crack in ridge is essential for plate-like flow. If the relative slip rates are different between the two opposing trenches, the intervening ridge crack opens by the rate determined by the average of the horizontal tensile stresses created at two trenches. The flow rates to the left and right of the ridge are different in this case, suggesting that the passive ridge moves to a trench with the heavier slab.