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eEarth Discuss., 1, 63-80, 2006
www.electronic-earth-discuss.net/1/63/2006/

Horizontal versus vertical plate motions

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Abstract. We review both present and past motions at major plate boundaries, which have the horizontal component in average 10 to 100 times faster (10–100 mm/yr) than the vertical component (0.01–1 mm/yr) in all geodynamic settings. The steady faster horizontal velocity of the lithosphere with respect to the upward or downward velocities at plate boundaries supports dominating tangential forces acting on plates. This suggests a passive role of plate boundaries with respect to far field forces determining the velocity of plates. The forces acting on the lithosphere can be subdivided in coupled and uncoupled, as a function of the shear at the lithosphere base. Higher the asthenosphere viscosity, more significant should be the coupled forces, i.e., the mantle drag and the trench suction. Lower the asthenosphere viscosity, more the effects of uncoupled forces might result determinant, i.e., the ridge push, the slab pull and the tidal drag. Although a combination of all forces acting on the lithosphere is likely, the decoupling between lithosphere and mantle suggests that a torque acts on the lithosphere independently of the mantle drag. Slab pull and ridge push are candidates for generating this torque, but, unlike these boundary forces, the advantage of the tidal drag is to be a volume force, acting simultaneously on the whole plates, and being the decoupling at the lithosphere base controlled by lateral variations in viscosity of the low-velocity layer.

Discussion Paper (PDF, 2699 KB) Interactive Discussion (Final Response, 7 Comments)

Citation: Cuffaro, M., Carminati, E., and Doglioni, C.: Horizontal versus vertical plate motions, eEarth Discuss., 1, 63-80, 2006. Bibtex EndNote Reference Manager

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