Paper Number: 941

Astronomically tuned mantle convection

Ficini, E.[1], Doglioni, C.[1], Garcia, F.[2]

[1]Earth Sciences Department, Sapienza University, Rome, Italy
[2]Applied Physics Department, Universitat Politecnica de Catalunya, Jordi Girona Salgado, Barcelona, Spain

---

Lithospheric re-entering into the mantle through subduction zones is more than three times faster along W-directed subduction zones (232 km3/yr) with respect to the opposite E- or NE-directed subduction zones (74 km3/yr). This asymmetric balance implies an asymmetric mantle return flow to compensate the displaced masses [1]. Therefore an “eastward" mantle flow can be envisaged. This mantle polarization agrees with the notion of the “westward" drift of the lithosphere that results from plate kinematics computed in the hotspot reference frame [2] and can explain the mainstream of plate motion delineated by its tectonic equator and the asymmetry of subduction zones and rift zones as a function of their geographical polarity [3]. During their journey, some plates may experience a further internal rotation. Since any motion of a plate on a sphere is defined by a rotation, this extra movement has been defined as plate subrotation [4], which may perturb the first order mainstream of plates. Furthermore, subduction rates and lithospheric plates speed decrease toward polar areas, according to the distribution of seismicity [5]. These information constrain mantle convection that is faster and more whirling at low latitudes, being polarized by the opposite motion of the lithosphere relative to the underlying mantle (Figure 1).

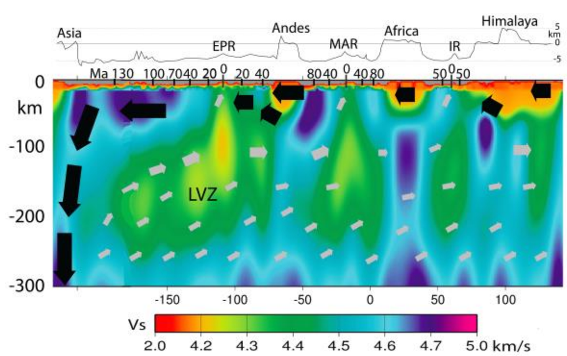

Figure 1: Vs absolute tomography along the tectonic equator in which are schematized the inferred westerly polarized velocity vectors of the lithosphere (black arrows) and of the mantle “eastward” relative motion (grey arrows) after [3]. Concentrated large volumes of lithosphere are recycled along the western Pacific slabs. The mantle compensates for the lithospheric loss with a diffuse relatively easterly-directed upwelling, up to the sheared LVZ, where the lithosphere is decoupled and shifts to the west.

Moreover, the westward drift of the lithosphere and its tectonic equator are tilted about 30° relative to the geographic equator. The tectonic equator is a line that represents the circle of maximum average speed of the lithosphere. It may be interpreted as a circle contained in a plane perpendicular to the vertical axis of the cone described by the precession of the Earth’s axis [3]. In fact, the Maxwell time (the time requested for a solid material to flow) of the lithosphere has the same order of magnitude of the precession cycles (20-26 kyr). This would explain the inclination of the tectonic equator relative to the rotation axis, and its geometry that is close to the projection of the Moon revolution around the Earth, able to tidally drag the lithosphere to the “west” [5]. Starting from the code proposed by [6] we numerically model this convection system that appears to be a self organized chaotic system controlled both by the thermal cooling of the planet and by its astronomical constraints.

References:
[1] Doglioni C and Anderson DL (2015) Geol Soc Am Sp Paper 514
[2] Crespi M et al. (2007) Geophys J Int 168:491-506
[3] Doglioni C and Panza GF (2015) Advances Geophys 56(3):1-167
[4] Cuffaro M et al. (2008) Tectonics 27:TC4007
[5] Riguzzi F et al. (2010) Tectonophysics 484:60–73
[6] Garcia F et al. (2014) Phys Earth Planet Interiors 230:28-44