Flexure Deflection Simulation of Subduction Systems and Relationship with the Seismic Activity

Abstract

Near oceanic trenches, the lithosphere is bent by plate stresses, including vertical and horizontal load. This bending effect, generally known as plate flexure, causes the formation of the outer rise which is often observed on the bathymetry data. The width of the outer rise is directly related to the flexural rigidity of the lithosphere. Moreover, the wavelength and amplitude of this flexure can be used to constrain the state of stress. In a coupled subduction zone, the stress is largely accumulated across the plate boundary which should affect the flexural properties of the subducted plate. Thus, the variation of the outer rise in shape may reflect the seismogenic characteristics of the subduction system. In this study, we estimate the flexural parameters of subducted plate based on the available bathymetry data. The values of the flexural deflection (w_b) are between 100 and 700 m. The worldwide distribution of w_b shows that relatively larger values occur in the center of the trench system. The standard variation of w_b is generally larger in the weak coupling subduction system than in the strong coupling area. Correlation between the numbers of earthquakes with magnitude 5 to 7 and the flexure deflection of the plate is better than the numbers of earthquakes with magnitude 4 to 7 and the flexure deflection.

There are a good relationship between the flexure deflection and the numbers of earthquakes magnitude 5 to 7 at strong coupling subduction zones(R^2>0.4), but there is lower relationship between the flexure deflection and other parameter.The number of earthquake occurrence are small in weakly coupled subduction zones, but the flexure deflection in weak coupling subduction zones changes greater than strong coupling subduction zones.

Weak coupling subduction zones and all parameters are no obvious correlation. There are not likely to suffer plate forces at weak coupling subduction zones, so characteristic of the plate seems to influence the flexure deflection.

Reference

Hayes, G. P., et al. (2012). "Slab1.0: A three-dimensional model of global subduction zone geometries." Journal of Geophysical Research: Solid Earth 117(B1): B01302, doi:10.1029/2011JB008524.

Heuret, A., et al. (2011). "Physical characteristics of subduction interface type seismogenic zones revisited." Geochemistry, Geophysics, Geosystems 12(1): Q01004, doi:10.1029/2010GC003230.

Contreras-Reyes, E. and A. Osses (2010). "Lithospheric flexure modelling seaward of the Chile trench: implications for oceanic plate weakening in the Trench Outer Rise region." Geophysical Journal International 182(1): 97-112.

Turcotte, D. and G. Schubert (2002). "Geodynamics, 2nd edition." Cambridge UniversityPress, New York.: 456 pp.

Smith, W. H. F. and D. T. Sandwell (1997). "Global Sea Floor Topography from Satellite Altimetry and Ship Depth Soundings." Science 277(5334): 1956-1962.

Müller, R. D., et al. (1997). "Digital isochrons of the world's ocean floor." Journal of Geophysical Research: Solid Earth 102(B2): 3211-3214.

Levitt, D. A. and D. T. Sandwell (1995). "Lithospheric bending at subduction zones based on depth soundings and satellite gravity." Journal of Geophysical Research: Solid Earth 100(B1): 379-400.

Heuret, A. and S. Lallemand (2005). "Plate motions, slab dynamics and back-arc deformation." Physics of the Earth and Planetary Interiors 149(1–2): 31-51.

Bird, P. (2003). "An updated digital model of plate boundaries." Geochemistry, Geophysics, Geosystems 4(3): 1027, doi:10.1029/2001GC000252.