Geophysical Research Abstracts
Vol. 15, EGU2013-9847, 2013
EGU General Assembly 2013

Flexural modelling of gravity anomalies seaward of Pacific subduction zones

Johnny Hunter, Anthony Watts, and Daniel Bassett
University of Oxford, Department of Earth Sciences, Oxford, United Kingdom (johnhu@earth.ox.ac.uk)

The strength of the lithosphere is determined by its flexural rigidity, which is commonly expressed through the effective elastic thickness, T_e. In oceanic regions, it is widely accepted that T_e increases as a function of age at the time of loading, due to cooling and thickening of the lithosphere. Evidence for this comes from studies of free-air gravity anomalies and bathymetry at seamounts, fracture zones and subduction zone outer-rises. 75% of T_e estimates from seamounts lie between the 300 ˚C and 600 ˚C isotherms as predicted by a cooling plate model, whilst the majority of subduction zone and fracture zone estimates lie between the 500 ˚C and 800 ˚C isotherms. Recent outer-rise investigations, however, have questioned whether such a simple relationship exists and suggested that either the strength of the lithosphere is independent of plate age, or that T_e cannot be measured with sufficient accuracy to reveal such a relationship.

In order to reassess the relationship between lithospheric strength and age, we use trench-normal, ensemble-averaged profiles of satellite-derived free-air gravity anomalies to model the outer-rise of all the major Pacific subduction zones. Profiles are corrected for sediment loading, as well as for thermal cooling effects. A broken elastic plate model is used, with a finite difference solution that allows $T_e$to vary as a function of distance from the trench. We use an inverse approach, iterating T_e values and inverting for end-conditioning forces (a vertical shear force and a bending moment).

Results show that oceanic lithosphere younger than 90 Ma clearly strengthens with age, with T_e roughly following the 550 ˚C isotherm. For example, the Middle America trench (4 - 25 Ma) has a mean T_e of 14.1 $\pm$ 2.8 km, whilst the Alaska-Aleutian trench (43 - 60 Ma) has a mean T_e of 34.3 $\pm$ 8.0 km. For older lithosphere, the pattern is not as clear. We suggest that this is due to thermal rejuvenation, which has two effects: it weakens the lithosphere, lowering T_e estimates; the associated magmatism masks the flexural signal, producing scatter. For many of the subduction zones, gravity profiles require that the lithosphere has been weakened in the region of the seaward wall of the trench. We attribute this to inelastic yielding - a combination of brittle fracture of the upper lithosphere and ductile flow of the lower lithosphere - due to high bending moments. Evidence for this can be seen in swath bathymetry data, which reveals zones of pervasive extensional faulting. Hydrothermal alteration of the lithosphere might also contribute to weakening, if bend faulting allows hydration and serpentinization of the upper mantle.