Dynamic topography above subduction zones. Evidence from theory, seismic tomography and gravity.

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Can we decipher any systematic trend in the morphology of the upper plate of subductions zones, and why should we? Since modern candidates are not numerous, and because the morphology above subductions is often obscured by irregular features linked to the nearby location of continental units and arc volcanoes, the answer is not straightforward. Mass heterogeneities in the mantle characterize subducting slabs and rising plumes. Because these masses tend to sink in the embedding asthenosphere, they not only induce a current in the asthenosphere but also a vertical surface tension at the Earth surface. We know that the surface warps up above plumes, it should therefore be deflected above subductions.

Intra-oceanic subductions and particularly back-arc basins provide good conditions for this study since less parameters affect the bathymetry than in continental settings. Back-arc basins are correlated to retreating subducting slabs of finite width, typically less than a 1000 km. Bathymetric profiles along the ridges of the oceanic back-arc basins which are the less affected by pre-opening dynamics (east Scotia and Mariana) show that the bathymetry increases towards the center of the basin by a several hundred meters. In the East Scotia sea, when corrected for age / thermal subsidence, the bathymetry shows a striking deepening towards the center of the basin, which is deeper by more than 750-1000 m than the edges. In addition, the Aegean sea -which is not a back-arc basin- also shows an important increase in the bathymetry beneath the Cretan sea, which is probably non isostically compensated, according to the crustal thickness. All three basins therefore suggest that their bathymetry is at least partly non isostatic.

A convenient way to understand the Stokes flow around a body of random shape is to discretize it into elementary bodies approximated as small spheres, for which the Stokes stream function is known. This in turn provides an estimate of the tensional stresses normal to the surface of the Earth. Because the lithosphere is not absolutely rigid, this tension can be counterbalanced by a deflection h giving rise to an outward tension of magnitude $\rho g h$. The results suggest that the maximum deflection is located 100 km to 400 km away from the trench, depending on the dip of the slab, and can reach several thousands of meters, depending on the density contrast between the mantle and the asthenosphere. This depression vanishes towards the edges of the slabs.

Seismic tomography data acknowledge the presence of bodies of variable density in the asthenosphere. I converted the ΔV_P data from Van der Hilst and, assuming a linear relationship with density, I evaluate the deflection of the Earth surface. In all three reference areas (East Scotia, Mariana, and Aegean Sea), well defined deflections appear, that I fit by selecting the best conversion factor

$\frac{\partial\rho}{\partial\Delta V_P}$. The deflections not only matches the prediction of the theoretical models, but also fit the observed bathymetry. Maximum deflections of ∼1000-1500 m are predicted at 170 km, 230 km, and 280 km from the trenches, respectively for the East Scotia, Mariana, and Aegean subductions.

Last, the free air anomaly is positive and reveals the presence of the underlying dense slabs. However it is rather low for such high density bodies (∼30-50 mGal). In addition, it is almost uniform or even decrease towards the center of the basins while it is expected to increase towards the center of mass of the slab, *i.e.* towards the center of the basin. The primary anomaly due to the slab is lowered by a secondary free air anomaly, due to the deflection of both the surface level and the Moho, which is lower in magnitude, of opposite sign, and of shorter spatial wavelength than the primary anomaly.

On the basis of theoretical models, seismic tomography, and gravity, I therefore conclude that the bathymetry of upper plates at the proximity of subduction zones is dynamically lowered by up to 1500-2000 m by the subducting slabs. In chosen areas like the East Scotia sea, the Mariana basin, and the Aegean sea, the bathymetry reflects such dynamic process.

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