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Kinematics to dynamics in the New Zealand plate-boundary zone

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New Zealand straddles the boundary between the Australian and Pacific plate, with a transition from subduction of Pacific plate oceanic lithosphere in the North, beneath North Island to oblique continental collision in South Island. Cenozoic relative plate motion has resulted in a complex pattern of faulting and block rotation in a zone up to 250 km wide, with displacements on individual faults up to 100s of kilometres. Here, I use a compilation of seismic reflection/refraction studies and high quality receiver function analyses, together with simple Airy isostasy, to determine the regional crustal and mantle structure. The buoyancy stress in the deforming layer is calculated by integrating the vertical normal stress with depth. This, in combination with plate-boundary stresses, must drive deformation. Horizontal gradients of buoyancy stress can be compared with horizontal gradients of strain rate, using the method of England & Molnar (1997), in the context of a simple thin sheet model of lithospheric deformation. I derive a velocity field for the New Zealand plate-boundary zone, using the method of Lamb (2000). This is representative of deformation over tens of thousands of years, based on fault slip, strain rate azimuth and paleomagnetic data, in the context of the short term relative plate motions. Comparison of appropriate combinations of horizontal gradients of vorticity and dilatation with horizontal gradients of buoyancy stress shows that deformation has some of the features of a Newtonian fluid. In detail, the minima in buoyancy stress, calculated from the vertical density structure, are offset horizontally from that calculated from gradients of strain rate, suggesting strong lateral contrasts in viscosity if deformation is strongly coupled at all levels in the lithosphere, with viscosities in the range 1 – 10 x 10**21 Pa s. However, subduction of Pacific plate lithosphere along the Hikurangi margin, and evidence for underthrusting beneath the Southern Alps, implies decoupling of deformation at depths > 50 km in these regions. In this case, best-fit viscosities for the top 50 km are in the range 1 – 5 x 10**21 Pa s. Given the characteristic strain rates in the plate-boundary zone, all these viscosities imply plate-boundary deviatoric stresses generally < 20 MPa, and are consistent with previous low estimates of shear stresses on the subduction plate interface based on a simple force balance (Lamb 2006). Fluid-like behaviour of the New Zealand plate-boundary zone is consistent with both geodetic data and the observed pattern of shear wave splitting.

References:
England, P.C., and P. Molnar, Science, 278, 647-649, 1997.
Lamb, S., JGR, 105, 25,627-25,653, 2000.
Lamb, S., JGR, 111, B07401, doi:10.1029/2005JB003916, 2006.