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Deconstructing the New Zealand plate boundary: Implications for plate boundary formation, extent, and deformation

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The active plate boundary through New Zealand is an ideal setting to investigate the manner in which a lithospheric plate boundary forms and evolves, and the manner in which plate boundary deformation is linked to plate interactions. In its present form the New Zealand plate boundary reflects a complex juxtaposition of lithospheric terranes that have been dismembered, deformed and translated. However, this current structure reflects primarily the past ˜ 30 Ma of plate interactions, and through well-defined plate reconstructions coupled with distinctive basement geology we are able to determine the initial (35-30 Ma) configuration of the terranes that make up New Zealand. The ability to deconstruct the current plate tectonics into a relatively recent and reasonably simple initial tectonic configuration allows us to focus on the post-30 Ma processes at work as the plate boundary evolves. In particular we can delineate the location, nature, and deformational signature of the primary Australia/Pacific boundary. To accomplish this we have used recent improvements in plate reconstruction euler poles for the Pacific and Australia plates (Cande and Stock, 2004) to determine a series of stage poles - both the traditional-style stage poles that reflect motions during intervals (on order of 5-7 Ma) determined by the timing of the plate reconstruction poles, and also we have also developed a methodology to estimate shorter time-interval stage poles (typically of 1 Ma duration) that allow us to better explore the impact of the rapid and profound changes in plate interactions that have occurred between Australia and Pacific since 30 Ma. We couple these determinations of plate positions and relative motions with analyses of the history of transient tectonism, geophysical observations of crustal and lithospheric structure and upper mantle seismic properties (anisotropy, wave speed, etc.) to determine the deformational behavior of the plate boundary as plate motions changed. Primary results of this study include: (1) The transpressive plate boundary presently linking the Hikurangi (north) and Puysegur (south) subduction zones - the Alpine Fault - likely had a tectonically-similar precursor - a proto-Alpine Fault - with a similar tectonic signature that separated the North and South Island terranes while they were adjacent between 25 and 10 Ma; (2) Subduction initiation at ˜ 25 Ma exploited the prior oblique extensional tectonics; (3) The Hikurangi (northern) subduction regime has systematically migrated southward, generating a diagnostic signature of vertical tectonism; (4) Much of the present observed pattern of seismic anisotropy - with the exception of measurements close to the present Alpine Fault - is consistent with anisotropy reflecting a relict lithospheric fabric, perhaps associated with Mesozoic and early Cenozoic subduction along the Gondwana margin; the width of the present shear deformation zone as seen through seismic anisotropy appears to be relatively narrow, on order 50-100 km or less. Finally the substantial translation between the Australia and Pacific components of New Zealand that has occurred since 30 Ma has produced significant changes in the nature of plate interaction, the associated strain field, and the consequent tectonics.