Heat Flow along the Hikurangi Margin

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The thermal regime and hydrology of convergent margins play an important role in the evolution, structure and deformation of the margin, the nature of the seismogenic zone and for the generation of slow slip events (SSEs). Over the past few decades New Zealand Earth scientists have collected a vast quantity of data focusing on the Hikurangi margin and subduction zone (Figure 1). These data demonstrate the presence of significant along-strike variations in the seismogenic zone, distribution of SSEs, interseismic coupling, offshore margin structure, seismic velocity and attenuation structure, and geochemistry of fluids emerging at the surface among other properties (Figure 1c) [e.g., *Wallace et al.*, 2009; *Reyners et al.*, 2006; *Wallace & Beavan*, 2010; *Reyes et al*., 2010]. Currently, our understanding of the Hikurangi margin and its along strike variations is fundamentally limited by a lack of knowledge of the thermal regime. No systematic heat flow measurements to understand the tectonics of this margin have been made. Observations of seafloor heat flow are needed to provide direct constraints on subseafloor thermal conditions, and on model constraints to estimate the temperature structure along the subduction fault, pathways and vigor of fluid flow, and a wide range of geophysical, geochemical, and petrologic processes at depth.

We are proposing to collect heat flow measurements and additional seismic reflection data in the northern and southern Hikurangi margin segments to understand differences in the distribution and styles of deformation (Figure 1). The northern area is associated with an aseismic creep-dominated subduction interface and is the site of repeated shallow (< 15 km depth) SSEs [*Wallace & Beavan*, 2010], and historic tsunami earthquakes that nucleated near the trench (Ms 7.0-7.2 in March and May, 1947 [*Doser & Webb*, 2003]). Additionally this area is the focus of a proposed IODP drilling transect with the primary objective of intersecting the source area of SSEs, and is also within a proposed OBS array.

The southern Hikurangi field area contrasts strongly with the northern field area. Here SSEs are deep (> 40 km) and geodetic studies indicate deep interseismic coupling on the plate interface. Heat flow transects can be collected along the passive and controlled source onshore-offshore Seismic Array HiKurangi Experiment (SAHKE [*Henrys et al., 2010*]) designed to image the forearc structure and understand physical processes controlling locking along this portion of the Australian-Pacific plate boundary and along the wide-angle multi-channel Pegasus line 023 [*Geotrace*, 2010] designed to detect hydrocarbons.

Global databases of heat flow show only two measurements offshore the Hikurangi margin. Eleven measurements of heat flow exist onshore. North of Hawke Bay heat flow values are between 80 and 50 mW m^{-2} and south of Hawke Bay heat flow values are somewhat lower at 40-45 mW m^{-2}. Heat flow has been estimated from bottom simulating reflectors (BSRs) which are widely observed along the margin [*Townend*, 1997a; *Henrys et al*., 2003]. These analysis show that, in general, heat flow is nearly constant along strike, ranging between about 40 and 50 mW m^{-2} and decreasing landward consistent with the downward advection of heat and thickening of the margin. In a local methane hydrate study, marine probe values of heat flow were collected offshore the south coast of the North Island [*Schwalenberg et al.*, 2010]. These probe values of heat flow vary between 35 and 50 mW m^{-2} and are generally 5-10 mW m^{-2} higher than the BSR values of heat flow. Discrepancies between these analyses may be due to the use of empirical margin-wide velocity traveltime functions, uncertainties in thermal conductivity [*Pecher et al*., 2010] and/or the impact of sedimentation.

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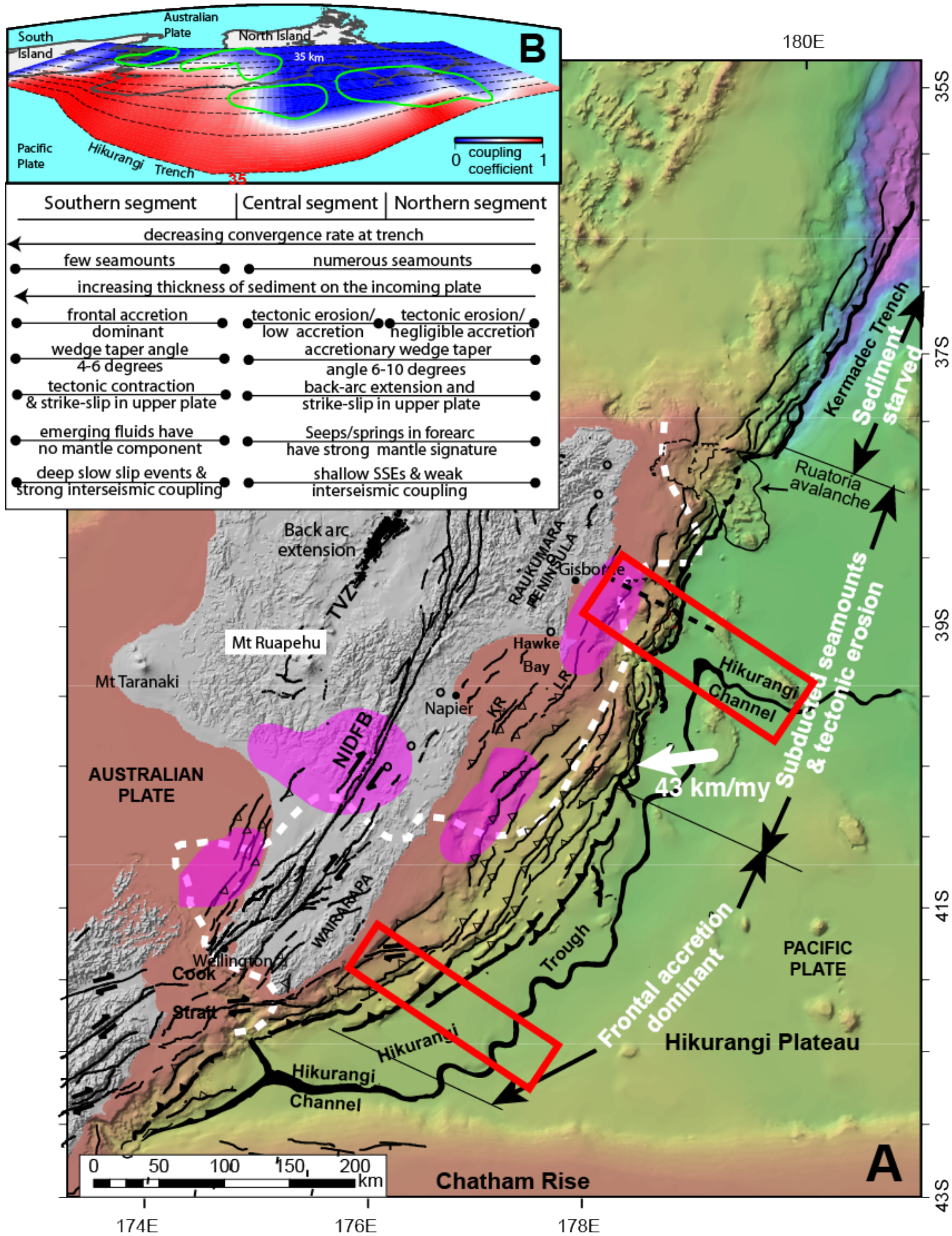

Figure 1. Overview and tectonic setting of the Hikurangi margin, New Zealand [modified from Barnes et al., 2010]. A) Bathymetry, topography, and active faulting of the onshore and offshore margin. White arrow shows plate converge rate and azimuth. Bold white dashed line shows position 20 mm yr^{-1} slip deficit [Wallace et al., 2004]. Magenta areas show region of observed slow slip events. The position of strong coupling is between this contour and the deformation front. Red rectangles show proposed north and south heat flow areas. B) Perspective view of Hikurangi margin [modified from Wallace and Beavan, 2010] illustrating the portions of the subduction interface that undergo stick-slip and aseismic slip in terms of the coupling coefficient. Coupling coefficients of one indicate locked areas and coefficients near zero indicate regions of steady aseismic slip. Green contours show areas slow slip events since 2002. Along strike variations in convergent margin properties are summarized below the plot.