Subduction Inputs to the Hikurangi Margin, New Zealand

Michael Underwood[1], Philip Barnes[2], Joshu Mountjoy[2], Kathleen Marsaglia[3], Laura Wallace[4], Demian Saffer[5], Stuart Henrys[6], Susan Ellis[6], Yoshihiro Ito[7], Harold Tobin[8], Shuichi Kodaira[9], Nathan Bangs[4], Ake Fagereng[10], Heather Savage[11], Marta Torres[12]

[1]Univ. Missouri, [2]NIWA, New Zealand, [3]Cal State Univ. Northridge, [4]Univ. Texas Inst. For Geophysics, [5]Pennsylvania State Univ., [6]GNS Science, New Zealand, [7]Tohoku Univ., Japan, [8]Univ. Wisconsin, [9]JAMSTEC, [10]Univ. Cape Town, South Africa, [11]LDEO Columbia Univ., [12]Oregon State Univ.

UnderwoodM@missouri.edu

Introduction: The overarching goal for scientific ocean drilling across the northern Hikurangi margin transect is to characterize the compositional, thermal, hydrogeological, frictional, geochemical, and diagenetic conditions associated with the rupture area of recent slow slip events (SSE). We propose coring and logging of the incoming stratigraphy and upper oceanic basement to constrain the "initial conditions" prior to subduction of potential SSE host rocks. Correlation along strike (through core-log-seismic integration) will focus on contrasts between northern sections undergoing SSEs and southern sections characterized by strong interseismic coupling.

Subduction of Hikurangi Plateau Basement: At this stage, we know very little about the lithological details of Hikurangi subduction inputs. ODP drilling legs have targeted the regions east and south of New Zealand, including the Canterbury Basin offshore South Island (*Land et al*., 2010; *Expedition 317 Scientists*, 2011). To date, there has been no drilling anywhere in the Hikurangi Trough (Fig. 1). Data from ODP Site 1124 (*Carter et al*., 1999) are the most useful for correlation across the Hikurangi Plateau, which is a large igneous province on the subducting plate. Gravity modelling indicates that the plateau crust is ~12-15 km thick. The plateau formed ~120 Ma. Late-stage volcanism (~100-90 Ma) emplaced many seamounts from which samples of tholeitic and alkali-rich volcanic rocks have been recovered by dredging. The upper part of the basement sequence is relatively reflective in seismic sections, with moderate P-wave velocities (~2.5-3.5 km/s), interpreted as volcaniclastics, limestone and/or chert.

Sediment Inputs to the Subduction Zone: The volcanic/volcaniclastic basement of Hikurangi Plateau is covered by Cretaceous and Paleogene sedimentary strata, whose character is inferred largely by correlation of seismic-reflection data to Site 1124 (*Davy et al*., 2008). An older sequence (~100-70 Ma) contains clastic sediments probably eroded from the continental Chatham Rise to the south and deposited in low-energy marine environments. A younger sequence (70-32 Ma) is a condensed section; correlative strata at ODP Site 1124 consist of nannofossil chalk, mudstone, and subordinate chert, with several unconformities in the Oligocene, Eocene and Paleocene.

As the relative thin (<500 m) Cretaceous-Paleogene strata enter the subduction zone at northern Hikurangi, they are buried by about 1 km of intercalated trench-fill turbidites, hemipelagic sediment, and debris-flow/ mass-transport deposits. At southern Hikurangi, the Cretaceous-Paleogene stratigraphy is thicker (~3 km) and buried by up to 6 km of trench-wedge clastics (*Plaza-Faverola et al*., 2012). The trench floor includes an impressive (>1500 km long) meandering channel (Hikurangi Channel). Just before the channel reaches the vicinity of Gisborne Knolls (i.e., within the proposed drilling transect), it makes an unusual 120° hook to the southeast to carry sediments into the Central Plateau Basin and beyond (*Lewis*, 1994). Rerouting of the channel has been attributed to damming of the trench axis by subducting seamounts (*Lewis et al*., 1998).

Sources/Timing of Hikurangi Trench Sediment: The longer term history of trench sedimentation is important for this project because 3-D distributions of sand and mud influence 3-D distributions of permeability, pore pressure, and mechanical strength within the accretionary prism (*Underwood*, 2007). The Hikurangi Channel is fed primarily by a network of major submarine canyons from off the eastern South Island to Cook Strait Canyon offshore North Island (*Lewis*, 1994; *Lewis and Pantin*, 2002; *Mountjoy et al*., 2009). Poverty Canyon contributes from the north (e.g., *Parra et al*., 2012), whilst others such as Madden Canyon feed only slope basins. The close proximity of canyon heads to the shoreline, and an unusually narrow continental shelf, means that the delivery system remains active during highstands of sea level. Mega-scale collapse of the continental slope is thought to have occurred ~170 ka (*Collot et al., 2001*); however, mass failures into the trench remain poorly constrained in terms of timing and physical character. Accelerated trench sedimentation has probably led to phases of rapid accretionary-prism growth (*Barnes et al*., 2010). Along-strike variations in total sediment thickness seaward of the deformation front have probably modulated the transitions from subduction accretion (S. Hikurangi) to mixed frontal erosion and minimal accretion (N. Hikurangi). To clarify these links between sedimentation and frontal-prism tectonics, we advocate holistic documentation of 4-D facies evolution using riserless drilling and core-log-seismic integration.

Connection from Subduction Inputs to the Deep (Riser) Drilling Targets: Host lithologies for the SSE fault zone at north Hikurangi are unknown but might include Cretaceous volcaniclastic rocks, siliciclastic sandstone and mudstone, slivers of altered basalt, chert, and/or limestone (nannofossil chalk). To test that full range of possibilities, we advocate riserless drilling through the entire sediment package above Hikurangi Plateau, penetrating into the top of the basaltic lava and the volcaniclastic sequence (Fig. 1). We also propose drill ~400 m into the Gisborne Knolls seamount to capture a representative section of the upper, altered basalt.
Sampling the full suite of subduction inputs will allow us to test several overarching questions that relate to fault-slip behavior at depth: (1) What are the frictional properties, textures, interstitial fluid compositions, detrital mineralogy, diagenetic/metamorphic state, porosity, permeability, microfabric, and fracture density throughout the lithologic suite prior to subduction? (2) Can sediment/rock composition be linked in unique ways to mechanical and frictional properties? Are the properties of any incoming lithology (or lithologies) consistent with transitional frictional behavior at greater depths? (3) Did the onset of widespread glaciation and large-amplitude eustatic lowstands at ~2.5 Ma trigger faster sedimentation in the trench? If so, did the initiation of rapid trench sedimentation coincide with an acceleration of frontal accretion, or a change in partitioning of the stratigraphy above/below the frontal fault? (5) Does the trench-wedge stratigraphy retain any textural or compositional evidence of Milankovich cycles during the Pleistocene? Have global and/or local changes in climate caused shifts in clay mineral assemblages, such as those documented at ODP Site 1119 (Canterbury Drifts) by *Land et al*. (2010)? Alternatively, are eustatic cycles overprinted or obliterated by the

effects of local subduction tectonics? All of these questions are central to the North Hikurangi science plan because they ultimately feed back to the temporal and spatial heterogeneity of fluids and fault-slip behavior (i.e., down-dip and along-strike patchiness of SSEs).

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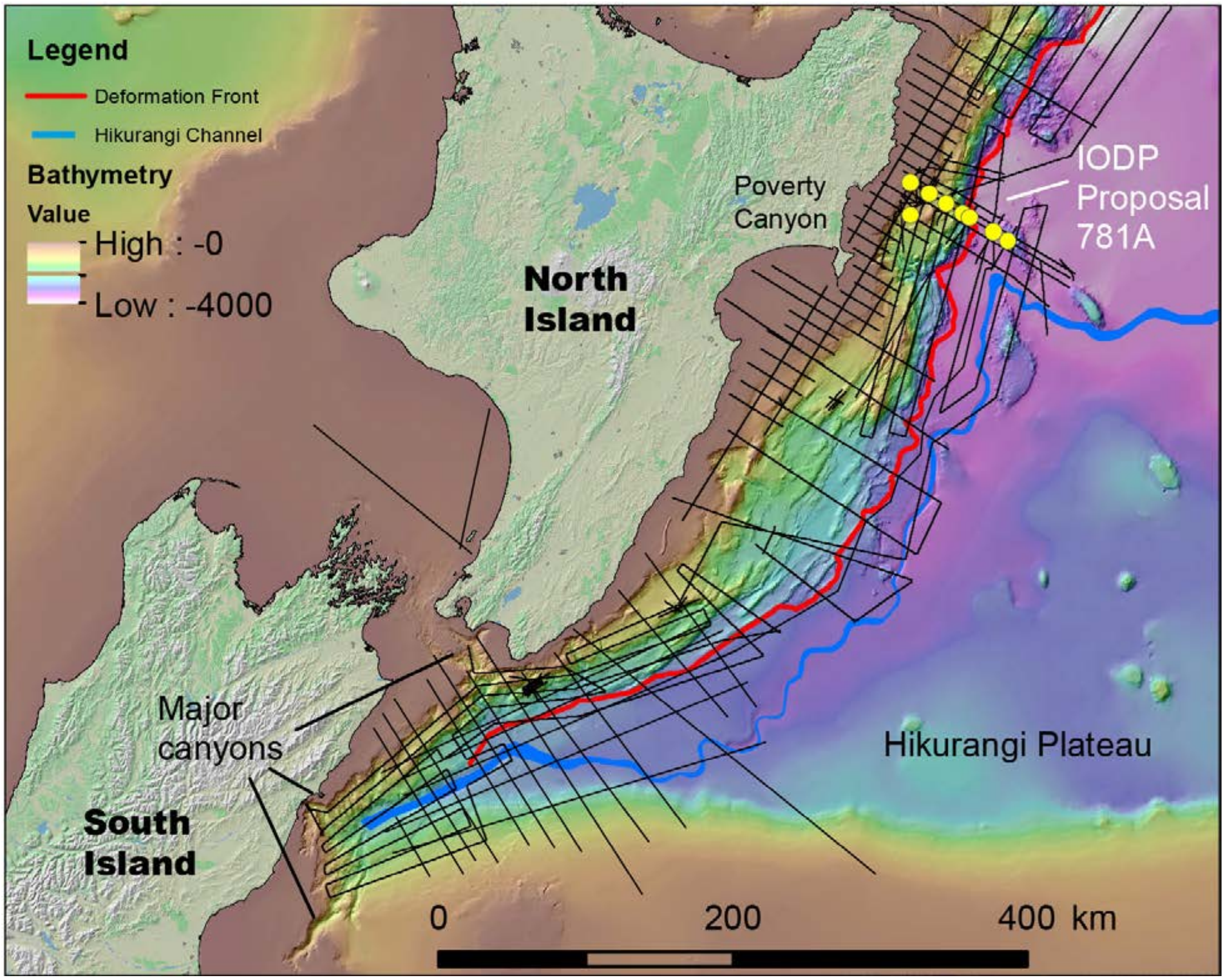

Figure 1. Map of Hikurangi margin with proposed IODP drill sites (yellow dots) and tracklines for seismic reflection profiles.