Proposal to study subduction initiation in northern Zealandia

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Back-arc regions of subduction zones contain sedimentary records that hold clues to the subduction initiation process, and provide complementary insights to fore-arc studies (e.g. Izu-Bonin-Mariana and Tonga). The basins and sedimentary platforms northwest of New Zealand record onset of the Tonga –Kermadec (TK) system during the Eocene-Oligocene (see Gurnis et al. white paper). We propose (mainly) marine geophysical studies that will reveal clues as to how and why TK, and Hikurangi, subduction started.

Key features that require study are: Norfolk Ridge (NR); New Caledonia Trough (NCT); Taranaki-Wanganui basins; and Three Kings Ridge (TKR). The NR is where surface convergence was associated with initial subduction. What was the vergence and timing of thrusting, what vertical motions took place, and how do these observations compare and discriminate alternate geodynamic model predictions?

The New Caledonia Trough lies adjacent to Norfolk Ridge, was deformed in the subduction initiation event and subsided with large magnitude (Sutherland and al., 2010) that is precisely quantified (1.5 km) at its southern end near the north end of Taranaki Basin (Baur et al., 2013). What was the regional timing of NCT subsidence in relation to other aspects of subduction initiation, and what is its significance? Does the 1.5 km of Oligocene "platform subsidence" seen in oil company drill hole data from South Taranaki Basin at ~ 30 Ma (Stern and Holt, 1994) have a common cause as that in the NCT ? If so, the process occurs on a ~1000 km scale and is clearly geodynamically significant. These observations of plate scale vertical movements are possibly unique and have the potential to lead to a shift in thinking not only about subduction initiation, but also the origin of deep-water basins.

The Taranaki-Wanganui region lies at the southern end of the NCT and TK subduction initiation, and a large negative gravity anomaly near Wanganui attests to ongoing downward pull from below. Evidence from onshore Taranaki –Waikato, north of the Taranaki-Ruapehu line, suggests lower crust has been removed by a migrating instability of the mantle lid during the past 5 Ma (Stern et al., 2013). This may be a process common to evolved back arc regions (Levander et al., 2011; Saleeby et al., 2012). Does such a process occur on a large scale during, or after, subduction initiation? This southern region provides an opportunity to obtain insights into the process of lithospheric instability, and may yield a snapshot of the southern termination of subduction initiation that developed since the Eocene.

Satellite-derived, gravity data provide a first–order assessment of the isostatic state of offshore Zealandia (Wood and Davy, 2008). Resolving the true isostatic configuration requires, however, crustal thickness and upper-mantle seismic wave-speed data. Thus, primary data sets to help assess the isostatic state of Zealandia, and vertical movements, are: crustal-upper mantle images; images of sedimentary records of past events; and samples of sediment or volcanic rock associated with subduction initiation that can be dated and provide some constraint on the process. We need to measure lithospheric structure with marine airgun surveys shot into ocean-bottom seismometers, to constrain the final lithospheric configuration achieved by subduction initiation. We need multi-channel seismic-reflection images of strata that record deformation and vertical motions during the early stages of subduction initiation, and then to tie those strata to existing wells or sample them with new IODP boreholes. It may also be possible to directly dredge key samples from the seabed or use shallow-coring technology. The combined observations would provide powerful discrimination between different geodynamic models of subduction initiation, and this may be the only location on Earth that such an integrated study is possible.

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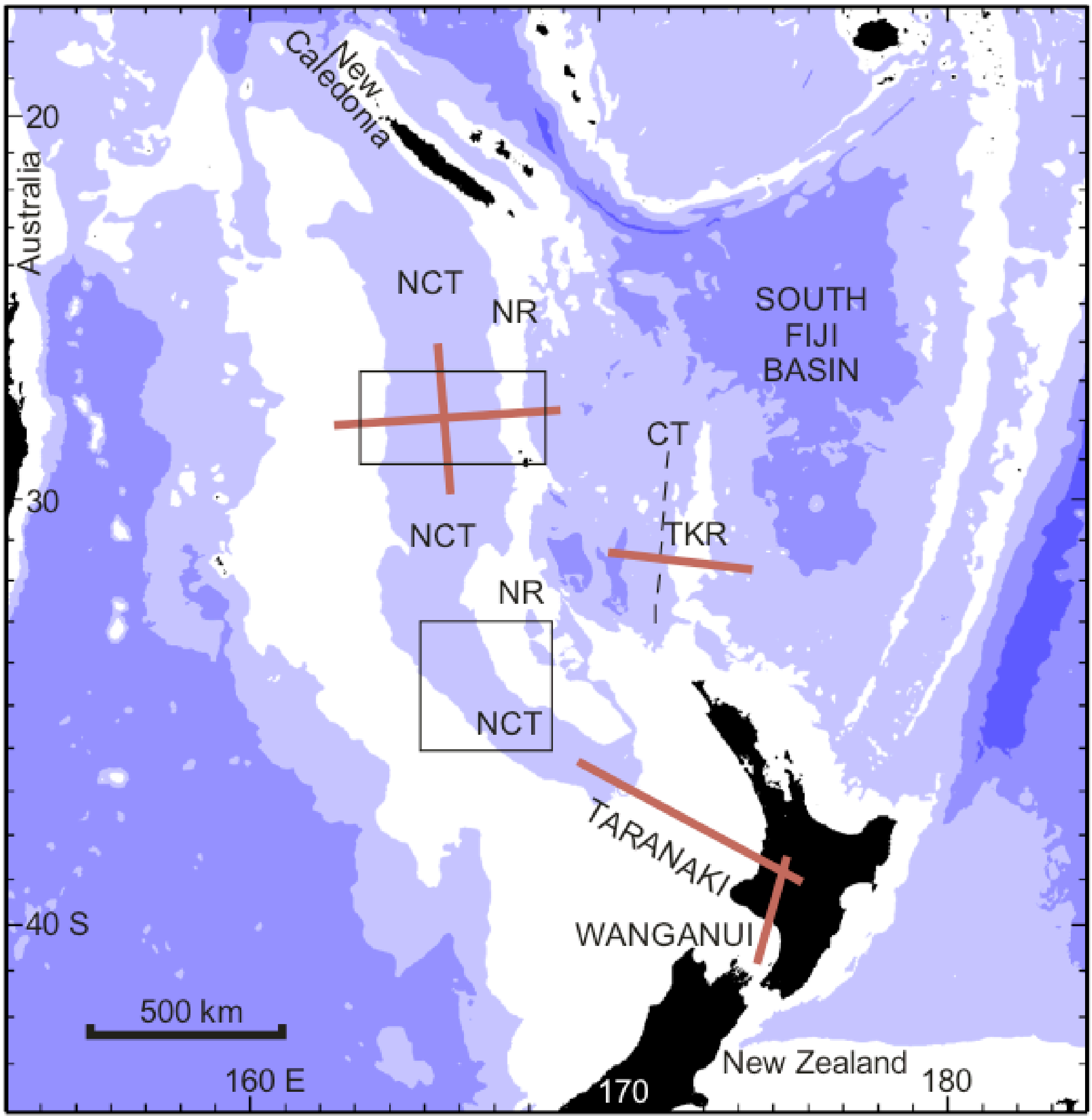

Figure 1. Red lines are proposed refraction transects, boxes show multi-channel seismic-reflection survey areas. New Caledonia Trough (NCT), Norfolk Ridge (NR), Cagou Trough (CT), Three Kings Ridge (TKR).