Preliminary findings from the NZ3D 3D seismic imaging experiment

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The NZ3D 3D seismic imaging experiment was designed to examine structure, tectonics and the role of fluids in shallow slow slip earthquakes along the northern Hikurangi margin of New Zealand. During the initial phase, the University of Texas group has focused on recent mass wasting, fluid flow, and tectonics within the accretionary wedge as indicated by bottom simulating reflections (BSRs). The NZ3D data show a rare double BSR (Fig. 1), which we exploit to examine recent subduction processes. We observe overlapping BSRs where a broadly extensive primary BSR1 lies above a more localized, weaker secondary BSR2. Double BSRs can indicate significant, rapid changes in pressure-temperature conditions that shift the base of gas hydrate stability zone to shallower depths. By mapping the double BSR near IODP Site 1519, we find that BSR2 follows the paleo seafloor defined by an unconformity that was drilled at Site 1519, but has recently been covered by landslide deposits (Fig. 1B).

The landslide deposits likely buried BSR2, shifting the gas hydrate stability boundary to BSR1.

We also found four patches with double BSRs within the NZ3D volume that lie within thrust anticlines and are not related to landslides. These imply recent rapid uplift, potentially as a result of seamount collision, or possibly enhanced fluid flow directed into the anticlines.

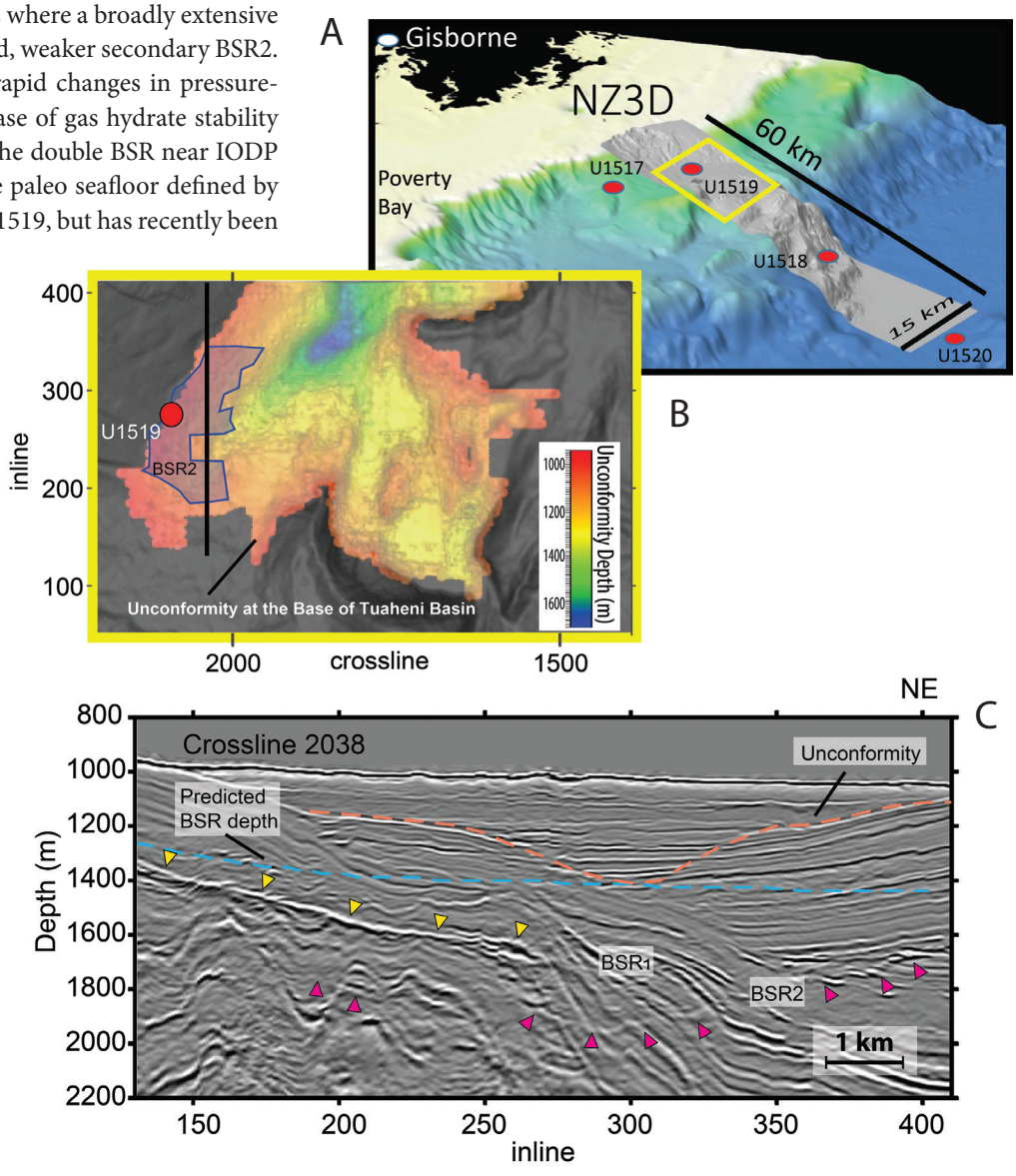


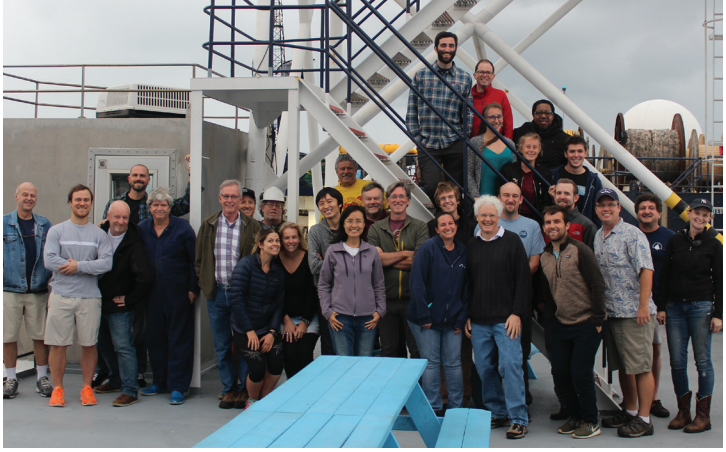
Figure 1. A. Bathymetry of the Hikurangi margin offshore Gisborne, NZ showing the region imaged during the NZ3D experiment (gray shading). Red circles show IODP Exp. 372/375 drill sites. Yellow box shows the region covered in the middle panel B.

B. Depth to unconformity mapped from the NZ3D data and drilled at Site U1519. A patch of BSR2 (blue outline) overlaps with the landward edge of the unconformity. Black line is the track of the seismic profile shown in the bottom panel C.

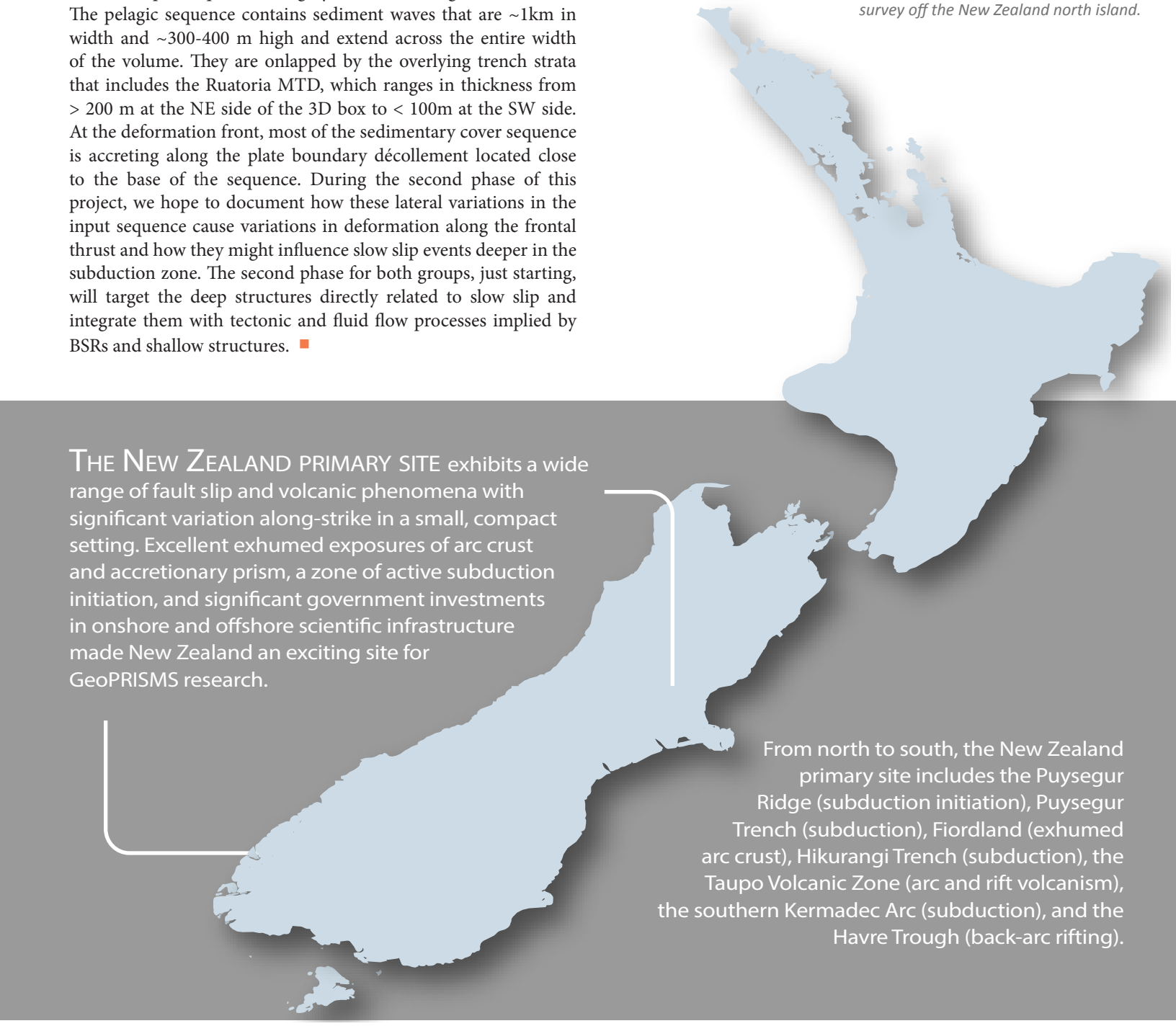
C. Seismic image along crossline 2038 showing BSR2 (magenta arrows), BSR1 (yellow arrows), and predicted BSR position (blue). Note BSR2 follows nearly parallel with the unconformity (orange) and is consistent with a paleo BSR that tracks a seafloor position along the unconformity. The large separation between the BSRs and predicted BSR implies both BSR1 and BSR2 are relict BSRs that may have been buried by landslide deposits and are out of equilibrium with current pressure/temperature conditions.

The University of Hawaii group has integrated regional shallow structure with recent drilling results from IODP Expeditions 372/375. Recent tectonic activity in the trench slope basin is also implied from units imaged in the 3D data and drilled at Site U1519. Significant along strike variations of these units are consistent with continued thrusting within the underlying accretionary prism. Strata within the basin have been trapped by uplift of the seaward edge of the basin. Several sub-units are defined by internal stratal onlap and truncation and help to understand the timing and magnitude of thrusting within the prism.

Strata on the Pacific plate east of the trench, sampled at Site 1520 represent the inputs to the subduction zone. Our 3D data show that the input sequence is highly variable throughout the basin. The pelagic sequence contains sediment waves that are ~1km in width and ~300-400 m high and extend across the entire width of the volume. They are onlapped by the overlying trench strata that includes the Ruatoria MTD, which ranges in thickness from > 200 m at the NE side of the 3D box to < 100m at the SW side. At the deformation front, most of the sedimentary cover sequence is accreting along the plate boundary décollement located close to the base of the sequence. During the second phase of this project, we hope to document how these lateral variations in the input sequence cause variations in deformation along the frontal thrust and how they might influence slow slip events deeper in the subduction zone. The second phase for both groups, just starting, will target the deep structures directly related to slow slip and integrate them with tectonic and fluid flow processes implied by BSRs and shallow structures. ■



The NZ3D science party, technical staff and crew of the R/V Langseth during the January 2018 seismic survey off the New Zealand north island.



THE NEW ZEALAND PRIMARY SITE exhibits a wide range of fault slip and volcanic phenomena with significant variation along-strike in a small, compact setting. Excellent exhumed exposures of arc crust and accretionary prism, a zone of active subduction initiation, and significant government investments in onshore and offshore scientific infrastructure made New Zealand an exciting site for GeoPRISMS research.

From north to south, the New Zealand primary site includes the Puysegur Ridge (subduction initiation), Puysegur Trench (subduction), Fiordland (exhumed arc crust), Hikurangi Trench (subduction), the Taupo Volcanic Zone (arc and rift volcanism), the southern Kermadec Arc (subduction), and the Havre Trough (back-arc rifting).