Look before it leaps: the interplay of magmatism, tectonism and basement structural inheritance in a migrating rifting arc

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The <2 Ma Taupo Volcanic Zone (TVZ) is but the current manifestation of >15 My of continental arc magmatism, volcanism and extension linked to subduction of the Pacific Plate beneath the North Island of New Zealand (Figure 1). The evolution of this system in response to roll-back of the subduction hinge is recorded in surface and subsurface geology (Mauk et al., 2011; Rowland et al., 2010, 2012 and references therein). The age distribution of volcanoes, epithermal mineral deposits and their active geothermal analogues, and fault-bounded volcaniclastic basins is consistent with a punctuated southeastward migration of the loci of heat and mass flux, and extensional strain. Three aspects make this system worthy of attention in relation to Geoprisms Draft Science Plan 5. Rift initiation and evolution (RIE).

1) The TVZ represents a highly active arc-related rift. It is subaerial and occurs where a complex interplay of lateral and perpendicular structural features offer unique insights into structural and magmatic controls on continental rifting processes. Much of our understanding of continental break-up comes from places where the mantle flux of heat and mass is pinned to the locus of rifting in the continent (Ebinger et al., in press). Notable exceptions are Yellowstone, where the plate is overriding the plume (Hannan et al., 2008 and references therein) and western Pacific back-arc basins, incipient and developed. The opening and closing of backarc basins is a critical process, setting in place structural and stratigraphic architecture that exerts a major control on hazards and resources in such settings. However, we do not know whether the lengths and timescales of rifting and magmatism in migrating rifting arcs is unique or similar to those described elsewhere (Ebinger et al., in press).
2) The central TVZ is anomalous with respect to its rhyolitic volcanic productivity, which is inextricably linked to tectonic processes (Allan et al., 2012; Rowland et al., 2010). The apparent rapidity with which large (>100 km^3) magma volumes accumulate within the crust is astonishing (Allan et al., 2013).
3) Oblique convergence of the Pacific and Australian plates is partitioned within the overriding plate into strike-slip along the North Island Fault System (NIFS) and extension within the Taupo Volcanic Zone. Within central TVZ, extension is considered to be localized within the densely-faulted Taupo Fault Belt (Villamor & Berryman, 2001). However, the TFB is one of two parallel depocenters that run between the active calderas (Okataina and Taupo). Each is subsiding at a rate of about 4 mm/yr. Currently, the greatest heat and mass transfer is localized within the active calderas and the intervening Taupo-Reporoa Basin (TRB) – the eastern depocenter that abuts the Kaingaroa Plateau, an enigmatic feature that separates the TVZ from the NIFS. Despite its high heat output (>2000MW_{th}) and subsidence the TRB

has subdued relief, a feature interpreted to indicate little active tectonism. However, the kinematics of the TRB and whether it is an incipient rift-jump are unknown.

A consortium approach involving cGPS, borehole seismology, InSAR, LiDAR, and other geological and geophysical methods is required to: 1) develop a high-fidelity model of rheology as moderated by magma storage and compositional alteration throughout central TVZ and surrounds; 2) image pre-rift and rift fabrics; and 3) evaluate and understand controls on strain partitioning within the TVZ and surrounds.

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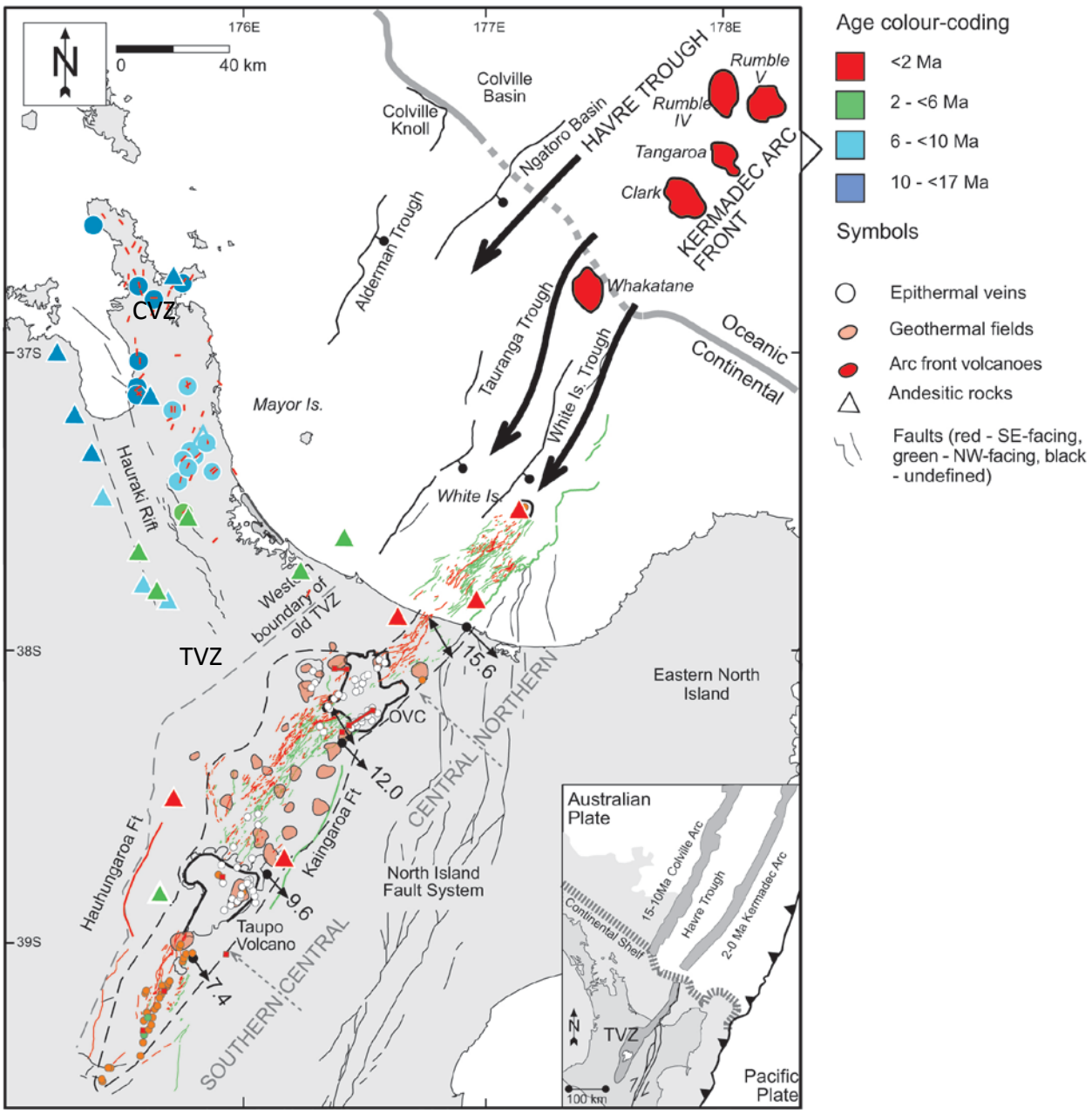

Figure 1. TVZ in its regional context (after Rowland et al., 2010; 2012). CVZ – Coromandel Volcanic Zone. Major basin-bounding offshore faults shown in black ± dip directions. Rift axes in offshore TVZ are arrowed. TVZ is partitioned along its axis into northern and southern TVZ (both andesite dominant) and central TVZ (rhyolite dominant), and also according to age: old TVZ (2.0-0.34 Ma) and young TVZ (< 0.34 Ma), grey and black dashed lines, respectively. All known volcanic vents active <0.61 ka (modern TVZ) are colour-coded according to type: red squares = basalt (linked by red line if associated with dike intrusion), orange small circles = andesite, green small circles = dacite, white small circles = rhyolite. Active calderas, Okataina Volcanic Centre (OVC) and Taupo Volcano, are shown by thick black lines. Other features (faults, epithermal systems, geothermal fields, and older volcanoes) are defined in key. Geodetic extension rates in mm/yr are shown along the length of onshore TVZ. Tension axes defined from earthquake first motion studies are indicated by double-headed arrows.