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"Back-arc" sedimentation at the leading edge of an active subduction margin: the Wanganui basin, New Zealand

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Sedimentary architectures of active subduction margin basins, including in back-arc domains, are only known from few end-members that barely illustrate their natural diversity. Documenting more of these basins and settings is a key to refining our understanding of the tectonic, erosion, and landscape evolution of active continental margins. This paper documents the evolution of incipient back-arc areas that develop at the leading edge of propagating subduction margin from the case example of the Wanganui basin of the Hikurangi subduction margin in North Island of New Zealand.

The Plio-Pleistocene Wanganui basin (WB) is a 200x100km NE-trending half-graben located 200 km west of the Hikurangi subduction margin and at the southern termination of the extensional back-arc basin of the active Central Volcanic Region of New Zealand. The WB is asymmetric with (1) a gentle, inner (craton-ward) margin to the west, bounded by regional, fault-controlled basement ridges along the presently inactive reverse Taranaki Fault and, (2) a steep, thrust-faulted, outer (arc-ward) margin to the east, at the footwall of the North Island Axial Ranges.

WB contains a 4 km-thick succession of Plio-Pleistocene sediments mostly lying offshore, composed of shelf platform sediments. It typically lacks the late molasse-like deposits derived from erosion of a subaerial volcanic arc and basement observed in classical back-arc basins. Detailed seismic stratigraphic interpretations from an intensive seismic reflection data grid tied to oil exploration drill-holes in offshore WB shows that the sediment basin-fill comprises two basin-scale mega-sequences. (1) A

Pliocene (3.8 to 1.35 Ma), subparallel, regressive "pre-growth" sequence that overtops the uplifting craton-ward margin above the reverse Taranaki Fault. (2) A Pleistocene (1.35 Ma to present), divergent, transgressive, "syn-growth" sequence that onlaps (i) the craton-ward high to the west, and (ii) the uplifted basement blocks associated with the high angle reverse faults of the arc-ward margin to the east. Sediment transport funnelled between the craton- and arc-ward highs, towards the Hikurangi Trough through the Cook Strait offlap first progressively southward (mega-sequence 1) and then south-eastward (mega-sequence 2). The change in offlap direction corresponds to the onset of arc-ward thrust faulting and the rise of the Axial Ranges at ca 1.75 Ma, resulting in 5100-5700 m of differential subsidence across the fault system.

Subsidence in WB occurred by mantle flow-driven flexure resulting from the sinking of the subducting Pacific Plate beneath the over-riding Australian Plate, active downdrag of the lithosphere by locking of the Hikurangi subduction interface and also sediment loading. Sedimentation has propagated south- to south-eastwards over the last 4 Myrs at the tip of successive back-arc grabens, volcanic arcs, and the associated thermally uplifted parts of the North Island (2.5km of denudation of the northern rim of the basin), following the southward migration through time of the leading edge of the Hikurangi subduction margin. The WB illustrates the early evolution of an incipient or “proto back”-arc domain where an epicratonic shelf platform is progressively impacted by active margin processes.