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Circum-Pacific accretion of oceanic terranes to continental blocks: accretion of the Early Permian Dun Mountain ophiolite to the E Gondwana continental margin, South Island, New Zealand

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Accretionary orogens, in part, grow as a result of the accretion of oceanic terranes to pre-existing continental blocks, as in the circum-Pacific and central Asian regions. However, the accretionary processes involved remain poorly understood. Here, we consider settings in which oceanic crust formed in a supra-subduction zone setting and later accreted to continental terranes (some, themselves of accretionary origin). Good examples include some Late Cretaceous ophiolites in SE Turkey, the Jurassic Coast Range ophiolite, W USA and the Early Permian Dun Mountain ophiolite of South Island, New Zealand. In the last two cases, the ophiolites are depositionally overlain by coarse clastic sedimentary rocks (e.g. Permian Upukerora Formation of South Island, NZ) that then pass upwards into very thick continental margin fore-arc basin sequences (Great Valley sequence, California; Matai sequence, South Island, NZ). Field observations, together with petrographical and geochemical studies in South Island, NZ, summarised here, provide evidence of terrane accretion processes. In a proposed tectonic model, the Early Permian Dun Mountain ophiolite was created by supra-subduction zone spreading above a W-dipping subduction zone (comparable to the present-day Izu-Bonin arc and fore arc, W Pacific). The SSZ oceanic crust in the New Zealand example is inferred to have included an intra-oceanic magmatic arc, which is no longer exposed (other than within a melange unit in Southland), but which is documented by petrographic and geochemical evidence. An additional subduction zone is likely to have dipped westwards beneath the E Gondwana margin during the Permian. As a result, relatively buoyant Early Permian supra-subduction zone oceanic crust was able to dock with the E Gondwana continental margin, terminating intra-oceanic subduction (although the exact timing is debatable). The amalgamation (‘soft collision’) was accompanied by crustal extension of the newly accreted oceanic slab, and also resulted in the formation of the overlying Maitai continental margin fore-arc basin (possibly related to rollback or a decrease in dip of the remaining subduction zone).Very coarse clastic material (up to ca. 700 m thick) including detached blocks of basaltic and gabbroic rocks, up to tens or metres in size (or more), was shed down fault scarps from relatively shallow water into a deeper water setting by gravity flow processes, ranging from rock fall, to debris flow, to turbidity currents. In addition, relatively fine-grained volcaniclastic-terrigenous sediment was input from an E Gondwana continental margin arc in the form of distal gravity flows, as indicated by geochemical data (e.g. Rare Earth Element analysis of sandstones and shales). The lowest part of the overlying Maitai fore-arc sequence in some areas is represented by hundreds of metres-thick sequences of mixed carbonate-volcaniclastic-terrigenous gravity flows (Wooded Peak Fm.), which are interpreted to have been derived from the E Gondwana continental margin and which finally accumulated in fault-controlled depocentres. Input of shallow-water carbonate material later waned and the Late Permian-Triassic Maitai fore-arc basin was dominated by gravity flows that were largely derived from a contemporaneous continental margin arc (partially preserved in present SE Australia). Subsequent tectonic deformation included on-going subduction, strike-slip and terrane accretion. The sedimentary covers of comparable accreted ophiolites elsewhere (e.g. Coast Range ophiolite, California) may reveal complementary evidence of fundamental terrane accretion processes.
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