**Supplementary material**

Some additional information is included, as below

**Caples Terrane: semi-schists, West Bald Hill, Southland**

Some additional structural and petrographic information is given below:

Onthe northern slopes of East Bald Hill, extending towards the Mararoa River, the stratigraphy of the semischists strikes NW-SE, dips at moderate angles (152/62º SW) and is isoclinally folded (axial plane 118/62º SW; trend & plunge of fold axis 137/05º). Polyphase deformation is indicated by folding and crenulation of primary schistosity, followed by transection by micro-veins, and then by further folding. No stratigraphic way-up indicators are preserved. Petrographic features are illustrated in Figure S1.

**Caples Terrane: Pelorus river area, Marlborough District**

In Marlborough District, the Caples Terrane includes deformed clastic sedimentary rocks that are mapped as the Ward Formation. These are summarised as ‘Well to poorly bedded, grey sandtsone-silstone, with thick sequences of green and grey sandstone and lenses of conglomerate’ (Johnston 1993; Begg & Johnston 2000).

A typical section was examined along the Pelorus River, where sandstones are steeply dipping to the east, to inverted (c. 180°/80° E), based on graded bedding. Medium-grey fine to medium-grained sandstones recur in up to several metre-thick bundles. Occasional thick-bedded sandstones (up to 3-5 metres thick) are relatively massive with abundant small (centimere-sized) dark coloured shale rip-up clasts. Most sandstone beds are <20 cm thick and have sharp bases and normal-graded tops. A few thinner beds (<15 cm thick) exhibit sharp bases as well as tops, suggestive of current activity. Between these sand-rich intervals there are hard black siltstone partings, with the little evidence of bedding; mudrock is minimal. Many bedding planes of the finer-grained facies exhibit strong bioturbation. Soft-sediment deformation is widespread in the form of small-scale slumps and convolute lamination. The succession is extensively faulted and fractured, such that little coherent stratigraphy remains in a several hundred-metre-thick-interval that was studied in detail.

In thin section (e.g. NZ 14. 258), the medium-grained sandstones are relatively well-sorted feldspathic sandstones (subarkose) with abundant angular to sub-rounded grains, set within a fine-grained matrix. The main grains are plagioclase (very altered), together with scattered, colourless, sub-rounded grains of monocrystalline quartz and rare clinopyroxene. Occasional lithoclasts include rare polycrystalline quartz and plagioclase-phyric basalt. Rare grains of exsolved, perthitic feldspar were noted.

An additional, but less well exposed, sequence was examined in road cuttings near the junction between the Nelson highway and the road to French Pass-Owiki Bay. Small outcrops occur in the gutter along the west side of the road for several hundred metres at the start of the road to French Pass. The sediments dip steeply to the SE (020°/60° SE and 152°/68S°). The main lithology is medium to thick-bedded, coarse blue-grey (where fresh) sandstone and pebblestone, with occasional intercalations of siltstone and fissile mudstone. In thin section, the sandstones (NZ 14. 253) are very quartz-rich, together with altered plagioclase. Sparse lithoclasts include microcrystalline quartz (felsic volcanic rock), polycrystalline quartz (quartzite), crenulated muscovite schist, biotite schist and rare basalt with common plagioclase microphenocrysts. Another sandstone sample (NZ 14. 255) contains relatively more basaltic lithoclasts, plus abundant plagioclase and clinopyroxene. Rare elongate, foliated grains of quartz-muscovite schist and quartz-biotite schist are also present.

Poorly bedded matrix-supported pebbly conglomerate (well exposed at the crossroads) is made up of angular, to sub-angular, to rounded pebbles of siliceous volcanic rocks and dark andesite, quartz and feldspar (up to 2 cm in size). Shale rip-up clasts commonly occur. There are also occasional well-rounded clasts of pale sheared, felsic volcanic rock. The outcrop itself is strongly sheared with little trace of bedding. Thin sections (NZ 14. 245) reveal abundant lithoclasts of basaltic extrusive rock with abundant flow-aligned feldspar microphenocrysts, rare altered plagioclase phenocrysts, and rare clinopyroxene, together with scattered colourless, angular quartz grains, felsic volcanic grains and siltstone rip-up clasts. Another sample (NZ 14.247) contains more abundant felsic volcanic grains. A further sample (NZ14.251) includes rare grains of granitic rock with quartz and biotite and rare exsolved feldspar (perthite). A clast within the conglomerate (NZ.251) is packed with quartz grains showing well-preserved (magma-resorbed) embayments, broken plagioclase crystals set in a matrix of quartz-bearing siltstone and rare tabular biotite crystals, interpreted as reworked felsic (rhyolitic) crystal tuff.

In summary, the sedimentary features of both sections indicate deposition as gravity-flow deposits, mostly turbidites, which accumulated in a deep-water, oxygenated setting. The sediments show considerable evidence of accumulation in an unstable seafloor, typical of trench deposits. Some of the material is relatively coarse and accumulated as debris-flow deposits. The material was mostly derived from a relatively evolved (andesitic) volcanic arc, together with a terrigenous component, in agreement with geochemical evidence of a continental island arc setting (Robertson & Palamakumbura 2019c).

**Late Triassic-Early Jurassic potassic Park Volcanics Group**

These distinctive igneous rocks form small extrusions or superficial intrusions **(**Coombs et al. 1992)and thus represent a possible source of volcaniclastic material to the Murihiku Supergroup. However, this is difficult to evaluate using chemical analyses of sandstones because these rocks are not chemically recognisable on tectonic discrimination diagrams (seeFig. S2**).**  Petrographical and chemical evidence from sandstones, instead suggests that most or all of the detrital material was derived from the Western Province and the Median Batholith, or non-exposed equivalents elsewhere along the active margin of Gondwana.

**Further discussion of terrane displacement**

Two main alternative reconstructions are proposed by Adams et al. (2009b), as shown in Figure S3 a-b. In the first type of reconstruction, (a), the Maitai Group, the Caples Terrane and the Waipapa Terrane (older Torlesse) were located adjacent to the New England Orogen, in line with palaeocurrent data from the Tramway Formation (Landis 1974; Owen 1995**)** and the detrital zircon evidence (Adams et al. 1998, 2007, 2009a). The Murikuku Terrane is placed further south in view of the detrital zircon data linking it with the Lachlan Orogen, SE Australia. To reach its present position, an initial c. 500 km of right-lateral strike-slip took place parallel to the Gondwana margin during Late Permian-Late Triassic, followed by a further c. 2,500 km of southward translation probably during Late Jurassic-Early Cretaceous (Adams et al. 2007).Pros: the detrital zircon data are fundamental to any reconstruction and support southward strike-slip parallel to the SE-Gondwana continental margin. Cons: 1. Other than being marginal to the Gondwana margin, the tectonic setting of the sedimentary basins is not specified. The absence of any significant angular discordances in the Maitai basin sequence is difficult to reconcile with simultaneous c. 500 km of strike-slip displacement. Translation may have taken place later (mainly Jurassic-Early Cretaceous?).

In the second type of reconstruction, the Teremba Terrane is interpreted as an oceanic volcanic arc which was separated from the New England Orogen by a marginal basin (Dun Mountain marginal basin), with a subduction trench to the east. Variants involve, either long-distance transport of the detritus in the Triassic Teremba Terrane from northernmost Australia or shorter distance transport, followed by southward strike-slip displacement. Pros: 1. The second option explains the absence of a strong crustal signature in the arc-derived volcaniclastic sediments in the Teremba Terrane and elsewhere (i.e. Maitai, Caples and Murihiku basins) (Frost & Coombs 1989; Mortimer & Roser 1992; Roser et al. 2002; Adams et al.2009b); 2. It also explains the paucity of detrital material in New Caledonia within several Jurassic and/or Cretaceous tectono-stratigraphic units that post-date the Teremba Terrane (Boghen Terrane, Central Terrane and Formation à charbon (Adams et al. 2009b). These units can be interpreted as proximal to distal equivalents of the same overall fore-arc basin system; 3. It can explain the occurrence of mainly Late Triassic-aged, moderately potassic small intrusions and/or extrusions (Parks Volcanic Group) within the Murihiku Supergroup (Coombs et al. 1976); these could have formed in a back-arc setting (albeit with eastward subduction polarity in this option).Cons: 1. The outboard location of the subduction zone positions the Gondwana margin in a remnant arc setting, which is at odds with evidence of contemporaneous arc plutonism in the Western Province **(**Kimbrough et al. 1994; Tulloch et al. 1999; McCoy-West et al. 2014); 2. Some terrigenous sediment is indeed present, especially near the base of the volcanogenic succession in the Teremba Terrane, which, based on detrital zircon age populations (Adams et al. 2009b), suggests a link with the Hodgkinson basin and its Precambrian hinterland in NE Queensland; 3. The Western Province is restored to a position far south of the New England Orogen. However, granite or gabbro rocks (undated) have been dredged from four widely spaced locations on the adjacent northern part of the Lord Howe Rise and the West Norfolk Ridge further east **(**Mortimer et al. 1998; see Adams et al. 2009b**);** 4. The inboard margins of back-arc basins are typically bordered by relatively fine-grained, mud-rich sequences of passive margin type, derived from the inactive remnant arc, as seen for example in the back-arc Woodland Basin, SW Pacific (Robertson & Sharp 2002; Sharp & Robertson 2002). This contrasts with the very thick sandy volcanogenic sequence represented by both the Maitai and Murihiku sequences;5.In a back-arc setting, the Permian-Jurassic Murihiku basin sediments would be expected to the deepen-upwards, as documented, for example, in the Japan Sea marginal basin (Kimura & Tamaki 1986), whereas the sequence generally evolves from open marine, to deltaic, to non-marine overall (Campbell et al. 2003a; Turnbull and Allibone 2003); 4. The Caples Terrane is also placed in a back-arc setting, which is at odds with its favoured interpretation as a fore arc basin and/or subduction trench deposits (Johnston 1981; Turnbull 1979, 1980; Adams et al. 2009a; this study). A modified interpretation is discussed in the main text.

**Summary of lawsonite occurrence in the Maitai Group**

Available information is summarised in Supplementary Table S1, mainly based on Landis (1974).

**References**

**Adams, C.J., Campbell, H.J. & Graham, I.J. 1998.** Torlesse, Waipapa and Caples suspect terranes of New Zealand: integrated studies of the geological history in relation toneighbouring terranes. Episodes, **21**, 235-240.

**Adams, C. J., Campbell, H. J. & Griffin, W. L. 2007**. Provenance comparisons of Permian to Jurassic tectonostratigraphic terranes in New Zealand: perspectives from detrital zircon age patterns. Geological Magazine, **144,** 701–729.

**Adams, C.J., Campbell, H. J. & Griffin, W.L. 2009a**. Tracing the Caples Terrane through New Zealand using detrital zircon age patterns and radiogenic isotope signatures. New Zealand Journal of Geology and Geophysics, **52,** 223-245.

**Adams, C. J., Cluzel, D. & Griffin, W. L. 2009b.** Detrital-zircon ages and geochemistry of sedimentary rocks in basement Mesozoic terranes and their cover rocks in New Caledonia, and provenances at the Eastern Gondwanaland margin. Australian Journal of Earth Sciences, **56**, 1023-1047.

**Begg, J.G., Johnston, M.R. 2000.** Geology of the Wellington area. Institute of Geological and Nuclear Sciences. 1:260,000 geological map 10. 1 sheet, 64 p. Lower Hutt, Institute of Geological and Nuclear Sciences Ltd.

**Campbell, J.D., Coombs D.S. & Grebneff, A. 2003**. Willsher Group and geology of the Triassic Kaka Point coastal section, south-east Otago, New Zealand. Journal of the Royal Society of New Zealand, **33**, 7-38.

**Carman, M. F. Jr. 1968.** A comparison of some Permian rocks on opposite sides of the Alpine Fault, South Island, New Zealand. Transactions of the Royal Society of New Zealand Geology, **6**, 91–130.

**Coombs, D. S. 1960.** Lawsonite metagraywackes in New Zealand. American Mineralogist, **45**, 454–455.

**Crawford, W.A. & Fyfe, W.S. 1965.** Lawsonite equilibria. American Journal of Science, **263**, 262– 270.

**Frost, C. D. & Coombs, D. S. 1989.** Nd isotope character of New Zealand sediments: implications for terrane concepts and crustal evolution. American Journal of Science, **289**,744-770.

**Johnston, M. R. 1993.** Geology of the Rai valley area. Sheets O26 & O27BD southeast Nelson, Sheet N29. Scale 1:50,000. Institute of Geological and Nuclear Sciences Geological Map 5, Institute of Geological and Nuclear Sciences Ltd., Lower Hutt, New Zealand.

**Kimbrough, D. L., Tulloch, A.J., Coombs, D. S., Landis, C. A., Johnston, M. R. & Mattinson, J. M. 1994**. Uranium‐lead zircon ages from the Median Tectonic Zone, New Zealand, New Zealand Journal of Geology and Geophysics, **37**, 393-419.

**Kimura, G. & Tamaki, K. 1986**. **Collision, rotation and backarc spreading: the case of the Okhotsk and Japan Sea**. Tectonics, **5**, 389-401.

**Landis, C. A. 1974.** Stratigraphy, lithology, structure and metamorphism of Permian, Triassic and Tertiary rocks between the Mararoa River and Mount Snowdon, western Southland, New Zealand. Journal of the Royal Society of New Zealand, **4**, 229-251.

**Landis, C. A. & Blake, M. C. Jr. 1987.** Tectonostratigraphic terranes of the Croisilles Harbour region, South Island, New Zealand: In: Leitch, E. C., Scheibner, E. eds. Terrane Accretion and Orogenic Belts*.* American Geophysical Union, Geodynamics Series, **19**, 179-198.

**McCoy-West A.J., Mortimer, N. & Ireland, T.R. 2014.** U–Pb geochronology of Permian plutonic rocks, Longwood Range, New Zealand: implications for Median Batholith–Brook Street Terrane relations. New Zealand Journal of Geology and Geophysics, **57,** 65-85.

**Nitsch, K.-H.** 1972. Das P-T-XCO2 Stabilitatsfeld von Lawsonite. Contributions to Mineralogy and Petrology, **34**, 116–134.

**Owen, S. R. 1995.** Maitai and Murihiku (Permian and Triassic) rocks in Nelson, New Zealand. Unpublished PhD thesis, University of Otago.

**Robertson, A.H.F. & Palamakumbura, R. 2019a**. Geological development and regional significance of an oceanic magmatic arc and its sedimentary cover: Permian Brook Street Terrane, South Island, New Zealand. *In*: Robertson, A.H.F. (ed.) *Paleozoic–Mesozoic Geology of South Island, New Zealand: Subduction-related Processes Adjacent to SE Gondwana*. Geological Society, London, Memoirs, **49**, https://doi.org/10.1144/M49.11

**Robertson, A.H.F. & Palamakumbura, R. 2019c**. Sedimentary geochemistry used to infer provenance of Permian-Triassic marine sandstones related to the SE-Gondwana active continental margin, South Island, New Zealand. *In*: Robertson, A.H.F. (ed.) *Paleozoic–Mesozoic Geology of South Island, New Zealand: Subduction-related Processes Adjacent to SE Gondwana*. Geological Society, London, Memoirs, **49**, https://doi.org/10.1144/M49.14

**Robertson, A.H.F. & Sharp, T.R. 2000**. Geochemical and mineralogical evidence for the provenance of mixed volcanogenic/terrigenous hemipelagic sediments in the Pliocene–Pleistocene Woodlark backarc rift basin, southwest Pacific Ocean: Ocean Drilling Program Leg 180. In: Huchon, P. , Taylor, B. Klaus, A. (eds.) Proceedings ODP, Science Results, 180 [CD-ROM] Ocean Drilling Program, College Station, TX.

**Roser, B.P., Coombs, D.S., Korsch, R.J. & Campbell, J.D. 2002.** Whole-rock geochemical variations and evolution of the arc-derived Murihiku Terrane, New Zealand. Geological Magazine, **139**, 665-685.

**Sharp, T. R. & Robertson A. H. F. 2002**. Petrography and provenance of volcaniclastic sands and sandstones recovered from the Woodlark Rift Basin and Trobriand Forearc Basin, Leg 180. In: HUCHON, P., TAYLOR, B. & KLAUS, A. (eds) Proceeding of the Ocean Drilling Program, Scientific Results, Leg 180 [CD-ROM] Ocean Drilling Program, College Station, TX.

**Tulloch A.J., Kimbrough D.L., Landis C.A., Mortimer N. & Johnston M.R. 1999**. Relationships between the Brook Street Terrane and Median Tectonic Zone (Median Batholith): evidence from Jurassic conglomerates. New Zealand Journal of Geology and Geophysics, **42,** 279–293.

**Turnbull, I.M. 1979.** Stratigraphy and sedimentology of the Caples terrane of the Thomson Mountains, northern Southland, New Zealand. New Zealand Journal of Geology and Geophysics, **22**, 555-574.

**Turnbull, I.M. 1980.** Structure and interpretation of the Caples terrane of the Thomson Mountains, northern Southland, New Zealand Journal of Geology and Geophysics, **23,** 43-62.

**Turnbull, I.M. & Allibone, A.H. (compilers) 2003**. Geology of the Murihiku area. Institute of Geological & Nuclear Sciences 1:250 000 geological map 20. 1 sheet and 74 p. Lower Hutt, New Zealand. Institute of Geological & Nuclear Sciences Limited.