Regional implications of U/Pb SHRIMP age constraints on the tectonic evolution of New Caledonia

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Abstract

U/Pb SHRIMP ages for zircons from plagiogranites indicate a Late Carboniferous age of formation for ophiolitic basement of the Koh terrane in the Central Chain Mountains of New Caledonia. Samples from ophiolites at Koh and Koua yielded ages of 302 ± 7 Ma and 290 ± 5 Ma, respectively. The similarity of these ages to those of plagiogranites in the Dun Mountain Ophiolite Belt/Maitai terrane of New Zealand, and the comparable structural positions of the two terranes, potentially constrain reconstructions of the Cretaceous SW Pacific margin. Detrital zircons from late Mesozoic sediments that overlap the Koh terrane also provide potential constraints on the location of New Caledonia prior to its break-up and dispersal from eastern Australia. © 1998 Elsevier Science B.V. All rights reserved.

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1. Introduction

The islands of New Zealand and New Caledonia present the best exposures of the eastern margin of the Indo–Australian Plate, which mostly lies submerged beneath the SW Pacific Ocean. The collage of terranes that form the islands, and correlations between these and equivalent rocks in Australia and Antarctica, provide the basis for our understanding of the Paleozoic to Tertiary evolution of the eastern Pacific region. Four main tectonic phases

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are reflected in the onland geology of New Caledonia (Paris, 1981; Aitchison et al., 1995): (1) late Paleozoic to early Mesozoic development of subduction-related terranes that were accreted to the Gondwana margin to form the ‘basement’ terranes of New Caledonia (Fig. 1); (2) Cretaceous passive-margin development and sea-floor spreading during Gondwana breakup; (3) foundering of an oceanic basin and the Eocene arrival of thinned Gondwana margin crust at a southwest-facing subduction zone, resulting in collisional orogenesis and obduction of an ophiolitic nappe from the northeast; (4) detachment faulting during extensional collapse, resulting in unroofing of metamorphic core complexes (Clarke et al., 1997).
The basement of New Caledonia (Fig. 1) incorporates three major terranes of Late Paleozoic to Mesozoic age, each of which shows evidence of having developed in convergent-margin settings. These terranes developed along, or were accreted to, the eastern Gondwana margin prior to the Early Cretaceous. The Upper Permian to Jurassic Teremba terrane, on the western side of the island, includes fossiliferous, proximal, calc-alkaline island arc-derived strata (Paris, 1981; Campbell et al., 1985). Whereas western portions of the terrane include calc-alkaline volcanic rocks, further east it is dominated by shallow to deep marine volcaniclastic sedimentary rocks. Enigmatic, predominantly fine-grained volcaniclastic sedimentary rocks lie to the east of what are unequivocal Teremba terrane rocks. These may comprise yet another terrane, the ‘Moindou terrane’, but further work is required to assess this hypothesis.

Little-studied schistose rocks of the Boghen terrane are faulted against the eastern margin of the Teremba terrane. These mostly metafelsic sedimentary rocks have previously been referred to as the ‘ante-Permian’ schists (Paris, 1981) because they contain a foliation that is absent in the Teremba ter-
rane. Metabasic units (Cluzel, 1996) that are tectonically interleaved within the sedimentary assemblage possibly represent fragments of accreted seamounts. Despite numerous attempts to extract a microfauna, the age(s) of formation of rocks within this terrane remains uncertain. Late Jurassic metamorphism locally reached blueschist facies (Blake et al., 1977), indicative of a subduction event of, as yet, indeterminate polarity.

The Koh terrane, discussed further below, crops out in the rugged Central Chain of the island. The Late Cretaceous ‘formation à charbon’ provides a sedimentary assemblage that overlaps all the basement terranes and post-dates their accretion to the margin of Gondwana (eastern Australia).

2. Koh terrane

The Koh terrane comprises four main structural blocks (Fig. 1) containing gabbros, quartz gabbros, diorites, dolerites, tholeiitic and boninitic pillow basalts, and felsic volcanics that represent fragments of a supra-subduction zone (SSZ) ophiolite (Cameron, 1989; Meffre, 1991, 1995; Meffre et al., 1996). Whereas most mafic fragments formed in response to a single tholeiitic magmatic episode, the products of two tholeiitic magmatic episodes separated by boninites are preserved at Koh. The first magmatic episode produced cumulate gabbros, dolerite, plagiogranites and a sequence of pillowed tholeiites. These rocks are overlain by a high-Ca boninitic unit, which includes a basal section of boninite pillows, flows and breccias and an upper section of boninitic dacites and tuffs. The last magmatic episode involved the eruption of evolved tholeiitic pillow basalts and the intrusion of tholeiitic dykes and sills into older plutonic and volcanic sections of the ophiolite. The petrogenesis and geochemistry of these rocks (Meffre et al., 1996), are consistent with their formation in a SSZ environment similar to modern backarc basins.

The upper tholeiites are conformably overlain by red and green pelagic siliceous siltstones that drape the uppermost pillows. These siltstones are up to 130 m thick and are succeeded by tuffaceous siltstones, volcaniclastic sandstones and conglomerates. Approximately 1000 m above the ophiolite, the volcaniclastic rocks are interbedded with micaceous black siltstones. An ammonoid fauna within these siltstones is indicative of a mid-Triassic age (H.J. Campbell, IGNS, New Zealand, written commun., 1990). The black siltstones are themselves approximately 1000 m thick and are overlain by further volcaniclastic sandstones and conglomerates that continue up section and form a Middle Triassic to Upper Jurassic sedimentary sequence reportedly several km thick (Guérangé et al., 1977; Paris, 1981; Maurizot et al., 1985).

Outside of their main occurrence at Koh, several other ophiolitic sequences are exposed along the Central Chain of New Caledonia (Meffre, 1995; Fig. 1). The northernmost body is the Cantaloupaï ophiolite (Fig. 1), which contains both igneous and sedimentary rocks. A strong foliation containing lawsonite and fine-grained blue amphibole reflects the effects of an Eocene collisional event (Aitchison et al., 1995). The Sphinx ophiolite, 50 km to the north of Koh, includes cumulate plutonic gabbros, plagiogranites, dolerite intrusions and a pillowed section, up to 850 m thick, that is similar to the lower tholeiites at Koh. The Tarouimba ophiolite is a fragment that is offset 10 km to the northwest from the main Sphinx ophiolite by a sinistral strike slip fault. South of Koh, the Pocquereux, Koua and Nassirah ophiolite outliers are volcanic and shallow intrusive sections that were disrupted into small fragments (1 to 3 km in length) during the Eocene collision (Aitchison et al., 1995). Well-developed dyke complexes are present in the three southern segments. Most of the ophiolite fragments are overlain by a stratigraphic succession of red pelagic cherts and volcaniclastic sediments similar to those at Koh.

The age of ophiolite fragments in the Koh terrane has not previously been determined, though they must be older than the Anisian ammonoid-bearing strata, which crop out some distance above the igneous section. U/Pb SHRIMP dates from co-magmatic plagiogranites within the ophiolite at two localities are presented in this paper.

3. Late Mesozoic–Early Cenozoic overlap rocks

A transgressive sequence of Upper Cretaceous coal measures and conglomerates (la formation à
charbons, Paris, 1981) overlays all three basement terranes with angular unconformity. Fluvial sediments grade upsection into mineralogically mature shallow-marine sandstones containing *Inoceramus* fossils. This unit provides a minimum (pre-Late Cretaceous) age constraint for the timing of amalgamation of New Caledonian basement terranes to Gondwana.

In the Central Chain area, near the village of Koh, the Cretaceous and Lower Eocene sedimentary sequence has been examined in detail where it overlies the Koh ophiolite on Mt Rembaï, and at Table Unio where it overlies the Boghen terrane (Meffre, 1991, 1995). Sedimentary rocks deposited above the basal unconformity consist of a 20–30 m thickness of sandy matrix-supported conglomerate containing rounded pebble-sized clasts of metamorphic, volcanic and volcaniclastic rocks largely derived from the three pre-Cretaceous terranes. The matrix contains monocrystalline quartz, plagioclase, opaque minerals, epidote and carbonate cement. The conglomerate is overlain by 50–180 m of quartz-rich sandstone containing small bivalves from a marine depositional environment. Turonian to Campanian *inoceramids* (Paris, 1981) and Coniacian to Campanian ammonites (Collignon, 1977) in shallow marine sediments constrain deposition to an interval of approximately 20 million years during the Late Cretaceous. At the top of the sandstone unit there is an increase in carbonate content and the rocks grade into marls containing planktonic foraminifers. These marls are overlain by 100–170 m of fine-grained black chert (typically referred to as ‘phtanite’ by French authors) containing radiolarians, sponge spicules and rare diatoms in a fine-grained siliceous groundmass.

The overall character of this unit is similar throughout New Caledonia, although internal details of units may vary. Evidence for development of localised basins or highs is seen in thickness variations (e.g. 200–300 m at Mt Rembaï and Table Unio, to 1000–2000 m at the Col de la Boghen between Moindou and Bourail). In some areas the basal conglomerate is up to 700–800 m thick (Maurizot et al., 1986) and the sandstone is overlain by fine-grained siltstone. Deltaic and possibly fluvial facies, including cross-bedded sandstone interbedded with coal lenses, occur both in the Moindou area and in the Central Chain (Gonord, 1970; Paris, 1981; Maurizot et al., 1986). In many areas the black chert rests directly on the pre-Cretaceous terranes without sandstone or conglomerate, and is interbedded with pelagic micrite containing pelagic foraminifers in a fine-grained calcareous groundmass. These areas may represent former basement highs. The age of the black chert has not been directly determined, although radiolarians from reworked black chert clasts collected from Eocene breccias suggest that the cherts were deposited between the Campanian and the Late Paleocene (Bodorkos, 1994; Paul, 1994). This is slightly older than the age generally ascribed to these rocks, based on their close association with micrites containing Paleocene to middle Eocene planktonic foraminifers (Paris, 1981; Maurizot et al., 1986). The black chert may be older than the micrites, although this has not yet been confirmed from field observations.

In the Nouméa and Diahot regions Upper Cretaceous sandstones are interbedded with mafic and felsic volcanics, including basalt, diabase, rhyolites and ignimbrites (Paris, 1981; Maurizot et al., 1989; Black, 1995) which denote a short-lived series of volcanic events in the Late Cretaceous. Three distinct volcanic horizons have been recognised in the lower part of the Pilou Formation in the Noumea Basin (Noesmoen and Tissot, 1970; Black, 1995). Rhyolitic and basaltic lavas together with associated volcaniclastic sediments constitute a bimodal igneous association. Geochemical analyses (Black, 1995) show a bimodal association dominated by high-Si rhyolites with minor accompanying calc-alkaline basalts. Mafic rocks exhibit an evolutionary trend towards shoshonitic compositions.

4. Samples

Small volumes of plagiogranite, widely considered to represent late stage differentiates of more basic magmas, are common in most ophiolites. As such granites commonly contain minor amounts of zircon they are useful for dating ophiolite formation. Plagiogranites from the Koh terrane are composed predominantly of granophyric-textured intergrowths of albite plagioclase and quartz, with variable abundances of amphibole. Accordingly, they
include quartz diorites, tonalites and trondhjemites. Clear intrusive relationships can be demonstrated between the plagiogranites and more basic igneous components of the ophiolite. Two samples containing zircons were collected. One is from the Koh ophiolite at a locality within the Koh River (GR5839 7613); the other is from the Koua ophiolite, and was collected from within a small tributary of the Koua River (GR6124 7594).

Aronson and Tilton (1971) reported Precambrian detrital zircons in the Cretaceous formation à charbons which could provide important information about the former position of New Caledonia along the eastern margin of Australia. Aronson and Tilton analyzed gram-size samples from 1000 lb of collected sample and so it is difficult to assess the discordant data from this sandstone. Therefore, we extracted and analyzed age spectra for detrital zircons from a sandstone sample collected from this unit at Table Union.

5. Experimental technique and results

Zircons were separated, mounted in epoxy, and polished to expose interior sections. U–Th–Pb analyses were carried out on the SHRIMP I ion microprobe at the Australian National University, following standard operating procedures (e.g. Williams and Claesson, 1987). Pb/U analysis of the samples was calibrated using an empirical quadratic relationship between 206Pb*/238U* and UO*/U*, and normalised to 206Pb*/U of 0.09279 for the 572 Ma SL13 zircon standard. U and Th concentrations were estimated relative to their concentrations in the SL13 standard and are accurate to ±20%. The common Pb contribution to the analyses was determined from the 207Pb/206Pb ratio, and hence age information is provided by the 206Pb/238U intercept. The composition of common Pb used is that of Cumming and Richards (1975; 300 Ma model Pb). The method is documented in more detail by Muir et al. (1996).

Results for both plagiogranite samples are listed in Table 1 and illustrated in Fig. 2 in Tera–Wasserburg concordia plots. Fourteen analyses were made on both samples. Replicate analyses of Koh grains were required because of a paucity of suitable material free from cracks and inclusions. Common Pb contributions range up to 6.6% of the total 206Pb for Koua and up to 1.7% for Koh. All data lie within 2σ uncertainty of the radiogenic–common Pb mixing line (dashed in Fig. 2). Ages are reported as weighted means of the extrapolated 206Pb/238U ages at concordia. For both samples, all data are included in the weighted means, and the MSWD is consistent with a single magmatic population with a small proportion of common Pb. The ages, 290 ± 5 Ma for Koua and 295 ± 7 Ma (2σ) for Koh, agree within analytical uncertainties. Koua zircons have lower Th and U concentrations and more uniform Th/U ratios than Koh zircons (67–220 ppm U, 21–99 ppm Th, Th/U 0.29–0.45 for Koua versus 140–950 ppm U, 180–1620 ppm Th, Th/U 0.75–2.82 for Koh.

Results for analyses of 50 detrital zircons from the formation à charbons arkose sample are illustrated on a cumulative probability histogram presented in Fig. 3. These ages comprise concordant 206Pb/238U ages for the younger clear grains, and the 207Pb/206Pb ages for the older darker grains because these two grains are discordant (both have 206Pb/238U ages of around 700 Ma). The younger clear and euhedral grains show a range of ages with two distinct populations, one around 90–140 Ma, the other 170–240 Ma. Over half the grains are 90–105 Ma old.

6. Discussion

Previous workers had considered the Koh ophiolite, a significant and widely distributed portion of the basement terranes of New Caledonia, to be Late Permian or Triassic. However, the Late Carboniferous SHRIMP U/Pb age reported herein for constituent plagiogranites substantially revises our knowledge of the time of formation for this ophiolite. The revised age demands a reassessment of plausible correlations of terranes from the continental fragments that once constituted portions of the eastern margin of Gondwana. The new dates are the oldest known for any rocks in New Caledonia, though significantly older detrital zircons occur in sediments of the Cretaceous overlap sequence (Aronson and Tilton, 1971; results published herein).

In any reconstruction of the Mesozoic SW Pacific it is tempting to investigate potential correlations between the few areas of continental crust presently lo-
Table 1
U–Th–Pb data for Koua and Koh plagiogranites

<table>
<thead>
<tr>
<th>No.</th>
<th>U (ppm)</th>
<th>Th (ppm)</th>
<th>Th/U</th>
<th>206Pb/208Pb</th>
<th>238U/206Pb</th>
<th>Age (Ma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kul</td>
<td>1.1</td>
<td>67</td>
<td>21</td>
<td>0.31</td>
<td>6.57 ± 0.47</td>
<td>0.1055 ± 0.0038</td>
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<tr>
<td></td>
<td>2.1</td>
<td>174</td>
<td>75</td>
<td>0.43</td>
<td>1.44 ± 0.16</td>
<td>0.0635 ± 0.0013</td>
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<td></td>
<td>3.1</td>
<td>125</td>
<td>46</td>
<td>0.36</td>
<td>1.91 ± 0.42</td>
<td>0.0676 ± 0.0033</td>
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<tr>
<td></td>
<td>4.1</td>
<td>137</td>
<td>53</td>
<td>0.39</td>
<td>1.54 ± 0.33</td>
<td>0.0647 ± 0.0026</td>
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<tr>
<td></td>
<td>5.1</td>
<td>111</td>
<td>35</td>
<td>0.31</td>
<td>2.44 ± 0.22</td>
<td>0.0719 ± 0.0018</td>
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<tr>
<td></td>
<td>6.1</td>
<td>218</td>
<td>99</td>
<td>0.45</td>
<td>0.96 ± 0.16</td>
<td>0.0599 ± 0.0013</td>
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<tr>
<td></td>
<td>7.1</td>
<td>138</td>
<td>48</td>
<td>0.35</td>
<td>2.21 ± 0.25</td>
<td>0.0699 ± 0.0020</td>
</tr>
<tr>
<td></td>
<td>8.1</td>
<td>128</td>
<td>51</td>
<td>0.40</td>
<td>2.32 ± 0.28</td>
<td>0.0708 ± 0.0023</td>
</tr>
<tr>
<td></td>
<td>9.1</td>
<td>116</td>
<td>33</td>
<td>0.29</td>
<td>1.82 ± 0.39</td>
<td>0.0669 ± 0.0032</td>
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<tr>
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<td>10.1</td>
<td>164</td>
<td>67</td>
<td>0.41</td>
<td>2.09 ± 0.26</td>
<td>0.0690 ± 0.0021</td>
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<tr>
<td></td>
<td>11.1</td>
<td>109</td>
<td>32</td>
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<td>1.89 ± 0.28</td>
<td>0.0673 ± 0.0023</td>
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<tr>
<td></td>
<td>12.1</td>
<td>118</td>
<td>36</td>
<td>0.31</td>
<td>2.42 ± 0.30</td>
<td>0.0718 ± 0.0024</td>
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<tr>
<td></td>
<td>13.1</td>
<td>195</td>
<td>80</td>
<td>0.41</td>
<td>1.53 ± 0.27</td>
<td>0.0644 ± 0.0022</td>
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<td>14.1</td>
<td>124</td>
<td>53</td>
<td>0.43</td>
<td>2.53 ± 0.20</td>
<td>0.0725 ± 0.0016</td>
</tr>
</tbody>
</table>

All analytical errors are 1σ.

\(^{238}\text{U}/^{206}\text{Pb}\) and \(^{207}\text{Pb}/^{206}\text{Pb}\) are the measured values uncorrected for common Pb.

\(^{206}\text{Pb}/^{208}\text{Pb}\) is the proportion of common Pb relative to total measured Pb.

Age is based on \(^{238}\text{U}/^{206}\text{Pb}\) corrected for common Pb.

Cated east of Australia. The most likely area in which extensions of New Caledonian terranes might occur lies to the south in New Zealand. Previous studies have demonstrated similarities in fossil content, sedimentation, age and inferred former tectonic settings between terranes in New Caledonia, and those of similar ages in New Zealand (Benson, 1928; Paris and Bradshaw, 1977; Cawood, 1984; Campbell et al., 1985; Waterhouse and Sivell, 1987). In particular, the Téremba terrane exhibits numerous similarities with the Murihiku terrane (of N.Z.). These include fauna (Campbell and Grant-Mackie, 1984; Ballance and Campbell, 1993), palynomorphs (de Jersey and Grant-Mackie, 1989), a volcaniclastic source dominated by andesite (Roser and Korsch, 1988), and a similar age range, although slightly older rocks are exposed in the Téremba terrane (Campbell and Grant-Mackie, 1984). Notable differences include the presence of granitic and other continentally derived clasts in a thicker stratigraphic sequence in the Murihiku terrane (Boles, 1974; Frost and Coombs, 1989; Ballance and Campbell, 1993). Calc-alkaline volcanic rocks such as those at the base of the Téremba terrane are unknown from the Murihiku terrane, although they do provide a potential source for many of the sediments there. Variations in the
Fig. 2. Tera–Wasserburg concordia plots for SHRIMP analyses of $^\text{206}$Pb from zircons extracted from Koh and Koua plagiogranites. Data are uncorrected for common Pb contributions and all data from their respective samples plot on a mixing line between concordant radiogenic Pb and common Pb indicating that a single magmatic component is required.

stratigraphic thicknesses of rocks in the two terranes may be related to local facies control or section attenuation resulting from local faulting. Despite these minor differences, the evidence for the correlation of the two terranes is compelling.

It has been further suggested (Harrington, 1983; Waterhouse and Sivell, 1987) that the volcanic rocks at Teremba may be correlated with those of the Brook Street terrane in New Zealand. However, this correlation is not supported by geochemical data, which indicate a distinctly different island arc tholeiitic composition for the Brook Street terrane volcanics. More likely equivalents of these rocks occur in the Gympie district of eastern Queensland where the Highbury Volcanics (Sivell and Waterhouse, 1988) are petrographically and geochemically similar and are of comparable age. No likely correlatives are known from New Caledonia.

The correlation of other terranes in New Zealand and New Caledonia, which lie outboard of the Teremba/Murihiku terrane, is more difficult. This is in part related to a lack of detailed study of the less fossiliferous basement terranes in the interior of New Caledonia, and the poorly exposed basement terranes of northernmost New Zealand. Until recently rocks of the Koh terrane were not regarded as an ophiolitic assemblage. Furthermore, because of their inferred Triassic or possibly Permian age they did not appear as obvious candidates for correlation with any New Zealand terrane. Recognition of the supra-subduction zone affinities of rocks at the stratigraphic base of the Koh terrane (Meffre et al., 1996) and the Late Carboniferous age data presented herein (which constrain the age of formation) provide the basis for the reconsideration of possible correlations.

Three large-scale terranes to the south of Auckland, New Zealand (from west to east) are the Murihiku, Dun Mountain/Matai and Waipapa terranes (Fig. 4). These can be traced, at least in subsurface, through Northland to the northern tip of New Zealand (Spörli, 1978; Black, 1994). More recently, Black (1997), has recognised several further terranes within rocks previously mapped (Black, 1994) as Waipapa terrane in the Northland region. The structural disposition of terranes in Northland may be repeated in New Caledonia because late Paleozoic ophiolitic rocks lie east of the Teremba/Murihiku terranes in both places. Late Carboniferous fragments of the Koh ophiolite are potential equivalents of the Dun Mountain/Maitai terrane. $^\text{206}$Pb analyses of zircon from plagiogranites of the Dun Mountain ophiolite have yielded marginally younger ages of around 285 Ma (Kimbrough et al., 1992). Geochemical data indicate that both the Koh and Dun Mountain/Maitai terranes are likely to have formed in similar tectonic settings (Moore, 1991; Meffre et al., 1996).

Isotopic age constraints notwithstanding, differences do exist between the two terranes. In particular, the Dun Mountain ophiolite is overlain by a thick succession of volcaniclastic sandstones of the Maitai Group which, in their lower part, are characterised by mappable units of atomodesmatinid limestone. No such limestone is known from the Koh terrane. Early workers considered the Maitai Group to be entirely Permian but more recent work in New Zealand (Pillai et al., 1991; Owen, in prep.) has shown that much of
Fig. 3. Histogram of detrital ages in the sample from la formation à charbons. The younger ages are $^{206}\text{Pb}/^{238}\text{U}$ ages plotted on a cumulative probability plot (each zircon is given a unit area, Gaussian, and the contributions are summed into bins). Two main populations are evident 90±140 Ma and 170±220 Ma with over half the grains being consistent with a ca. 95 Ma source. The inset shows a histogram for all zircons showing two older grains approaching 1000 Ma.

it is Triassic. The Triassic volcaniclastic sections are not dissimilar to those which overlie the Koh Ophiolite and it is possible that lower portions of the New Caledonia section have been removed by faulting.

In New Zealand the Dun Mountain=Maitai and Murihiku terranes are everywhere juxtaposed along a faulted contact with no intervening terranes, but in New Caledonia the structural position of the Koh terrane differs somewhat from that of its potential correlatives in New Zealand. Koh terrane rocks not only lie to the east of Murihiku-like rocks, but also lie east of schistose rocks of the Boghen terrane. The Boghen terrane of New Caledonia represents an assemblage of rocks similar to those seen to the east of the Dun Mountain=Maitai terrane in New Zealand. The general characteristics of rocks of the Boghen terrane appear to be similar to those seen to the east of the Omahuta terrane (Black, 1997). Metamorphic minerals in both terranes record high P/T metamorphism in the Late Jurassic; further study of these potential correlations is warranted.

Detrital zircon data present an intriguing problem. Existing tectonic reconstructions would place late Mesozoic New Caledonia to the east of the New England Orogen (NEO) of eastern Australia, slightly south of present-day Brisbane. The spectrum of ages from detrital zircons is thus surprising. If the reconstruction is correct, one might expect to see populations of grains clearly derived from the NEO. However, despite the presence of voluminous late Paleozoic/early Mesozoic igneous rocks within the NEO there are only a few grains with apparent Triassic ages, and no Paleozoic grains.

There are several possible explanations for the lack of NEO-derived material. Amongst these are: New Caledonia was not in the position that has been suggested; overlap assemblage sandstones of New Caledonia were transported laterally along the margin of Gondwana from a location further to the north; sediment somehow bypassed the NEO; and/or the NEO was itself masked by covering strata of once more extensive Sydney±Bowen and Clarence±Morton basins.

The above ages are also found in younger (Cretaceous=Jurassic) Torlesse sandstones. The formation à charbon is far more mature than the Torlesse graywackes but a similar provenance is possible. Such a land link would need to be found if the Torlesse is indeed sourced from Queensland (Adams and Kelly, 1998). The presence of grains of ca. 1000 Ma confirms the inferences of Aronson and Tilton (1971) that a Precambrian source was contributing to the detritus.
This age component is familiar throughout southeastern Australian detritus (see for example Ireland et al., 1998); however, it is always associated with a more dominant 500–650 Ma age peak which is lacking from the New Caledonia sandstone. This would suggest that a continental source unaffected by the Dalemarian Orogen must be found. The most proximal location would be northern Queensland, although the potential for Neoproterozoic grains is unknown.

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References


Benson, W.N., 1928. The Mesozoic rocks of New Caledonia


