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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.

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Geochemical and Sr-Nd isotope data for Mesozoic greywackes of New Caledonia terranes, indicate a fore-arc tectonic environment at the Eastern Gondwanaland margin, but they support only minor continental influences. Detrital zircon U-Pb age

patterns for the greywackes similarly reflect an active-margin tectonic environment of Late Triassic, Late Jurassic, and in particular mid-Cretaceous, depocentres which comprise much contemporaneous volcanic detritus, but also include minor sediment inputs from early Paleozoic-Precambrian continental clastic rocks. The contemporary volcanic sources are probably now hidden within a former hinterland to New Caledonia, such as Loyalty and Norfolk Ridges, Lord Howe Rise or Marion Plateau. The older, continental sediment sources were probably in northeasternmost Queensland, and beyond the northern extremity of the New England Orogen. Such sediments could have been supplied on long rivers, and submarine long-shore current systems outboard of the orogen. Alternatively, the depocentres could have been consolidated close to the contemporary Gondwanaland margin and then tectonically transported, as suspect terranes, southwards in Early Cretaceous times to their present New Caledonia position.

KEY WORDS: New Caledonia, Gondwanaland, Mesozoic, volcanoclastic sedimentary rocks, geochronology, detrital zircon, geochemistry, strontium isotopes, neodymium isotopes.

INTRODUCTION

Situated at the Pacific edge of the Mesozoic Australasian continent crust, New Caledonia and New Zealand provide two comparable sectors of the former, late Paleozoic-Mesozoic Gondwanaland continental margin (Fig.1 inset). New Zealand and New Caledonia are part of a large, but mostly submerged, continental crustal block, 'Zealandia'. This extends from the Chatham Rise and Campbell Plateau (southwest Pacific Ocean), through New Zealand, the Challenger Plateau and Lord Howe Rise, to

New Caledonia. It has been extensively studied New Zealand where the Zealandia basement comprises Paleozoic and Mesozoic sedimentary rocks, active-margin volcanic arcs, and associated plutonic complexes. These are divided into an early Paleozoic, Western Province, clearly related to the Lachlan Fold Belt of southeast Australia, and an Eastern Province, which comprises six late Paleozoic-Mesozoic elongate, tectonostratigraphic terranes. Situated between Western and Eastern Provinces, a Median Batholith, of Permian-Cretaceous plutonic rocks (Bishop et al. 1985, Mortimer et al. 1999), may be correlated with the more extensive Carboniferous-Jurassic igneous complexes within the New England Fold Belt of northeast Australia,

The Eastern Province terranes of New Zealand comprise an eastern group (Torlesse, Waipapa and Caples) of Permian to Cretaceous, greywacke-dominated turbiditic sequences deposited in an accretionary prism environment (Bishop et al. 1985). The easternmost, Torlesse Terrane is dominated by relatively quartzose greywacke sediments derived from continental sources which included plutonic and metamorphic rocks (MacKinnon 1985), whilst the Waipapa and Caples Terranes (Sporli 1978, Turnbull, 1979) have more acid-intermediate volcanoclastic sediment inputs, and resemble those of the New Caledonia Central Terrane. The remaining, western, terrane group (Dun Mountain-Maitai, Murihiku, Brook Street), has mainly Permian, Triassic and Jurassic, redeposited volcanoclastic greywacke-dominated successions (Ballance & Campbell 1993, Landis et al. 1999), but in a more shallow-water, probable forearc setting. The Brook Street terrane includes substantial volcanic centres and some minor limestones (probably shallow-water). The Dun Mountain-Maitai terrane contains the major Dun Mountain Ophiolite Belt (Coombs et al. 1976), and also has some limestones

(calc-turbidites). In contrast, the Murihiku Terrane is dominated by volcanoclastic sediments with no limestones, and only rare volcanic horizons. It has excellent biostratigraphic subdivision (Ballance & Campbell 1993), whose faunas closely resemble those of the Teremba Terrane of New Caledonia (Campbell et al. 1985). Extensive references and details of biostratigraphy, geochemistry and geochronology of the Eastern Province terranes that are relevant to possible correlations with their New Caledonia counterparts are given in Mackinnon (1985), Roser & Korsch (1988, 1999), Adams et al. (2007). The relative position of the terranes with respect to the Gondwanaland continental margin, suggests that several, especially the Torlesse composite terrane, are suspect terranes i.e. tectonically displaced from elsewhere along the Gondwanaland margin. Original sedimentary depocentres have been suggested in the New Zealand-West Antarctic region (Cawood et al. 1999, Wandres et al. 2004a,b). Alternatively, original depocentres in the northeastern Australian sector have been suggested (Ireland 1992, Pickard et al 2000, Adams et al. 2007), where there are superior matches of Eastern Province detrital zircon age patterns with appropriate sediment sources.

Despite their similarities in age, tectonic setting, sedimentary petrography and biostratigraphy, the exact relationships between New Zealand and New Caledonia terranes remain unclear. The disposition of New Caledonia terranes with respect to the Gondwana continental margin suggests that a suspect terrane scenario is also possible, similar to that described above for the Eastern Province of New Zealand. Thus to investigate their connection further, we present here new geochemical and detrital zircon age data for greywackes from three pre-Late Cretaceous terranes in New

Caledonia, and compare their sediment provenances with those from terranes of similar age and tectonic association in New Zealand.

NEW CALEDONIA: GEOLOGICAL OUTLINE

Two major terrane groups are distributed along the length of New Caledonia (Fig.1): an older, Late Permian to Early Cretaceous group of three subparallel, elongate terranes on the west coast (*Teremba*) and in the central mountain chain (*Koh-Central*, and *Boghen*); and a younger Late Cretaceous to Oligocene group, overlying the latter, that formed in response to break-up, drift, and subsequent collision of, an island arc (Aitchison et al, 1995). The pre-Late Cretaceous terranes were formed during a period of accretion, and show the closest biostratigraphic correspondences with Eastern Province terranes of New Zealand.

The three terranes that form the central mountains of New Caledonia are as follows:

- (1) Koh-Central Terrane: a disrupted, Early Permian ophiolite suite occurs locally along the centre of the island, comprising gabbro, dolerite, rare plagiogranite, IAT and boninite pillow basalt, and undated chert directly overlying the pillow basalts (the Koh ophiolite of Meffre et al. 1996). The Koh ophiolite rocks are closely associated with a thick deep-water succession of volcano-sedimentary rocks: black shale, volcanoclastic turbidite (greywacke), radiolarian-bearing siltstone and chert. These sequences are regarded as a single terrane (Meffre et al. 1996; Aitchison et al., 1998). The black shales are several hundred metres thick, whilst greywackes are generally associated with 20-50% argillite, giving this terrane a distal and deep-water character. The

greywackes are exclusively composed of volcanic lithic (andesite and basalt) and mineral clasts (feldspar, quartz, amphibole, etc.), and plutonic clasts are generally absent, except for one locality (late Early Cretaceous). Middle Triassic (Anisian), and Late Jurassic faunas are correlated with those of the New Zealand Murihiku Terrane (Campbell et al., 1985; Meffre, 1995). Recently, a fossiliferous succession at Pouembout, formerly considered Late Jurassic, is now considered Early Cretaceous (H.J. Campbell (pers. comm.)).

- (2) Teremba (formerly Teremba-Moindou) Terrane: a succession of very low-grade (zeolite facies), Late Permian to mid-Jurassic, shallow-water, volcanoclastic (calc-alkaline, island arc-derived, andesitic) sedimentary rocks and volcanics (andesites, dacites and rhyolites). The sedimentary rocks are typically medium grain greywackes with only minor (<10%) intercalated argillite, some shallow water volcanoclastic conglomerate and rare black shale, a few tens metres thick. The mineral composition of greywackes is closely similar to that of Central Terrane and similarly lack plutonic clasts. This terrane also contains abundant faunas resembling those of the Murihiku Terrane of New Zealand (Grant-Mackie et al., 1977; Paris 1981, Campbell, 1984, Ballance & Campbell, 1993).
- (3) Boghen Terrane: (the *ante-Permien* of Paris, 1981), an accretionary complex comprising schistose unfossiliferous, volcano-sedimentary rocks (pillow basalts, chert, black shale, sandstone, tuffs, turbiditic greywackes, and mafic melange), at a metamorphic grade (lower greenschist to blueschist facies) that is notably higher than the adjacent terranes. Late Jurassic metamorphic ages

(ca. 150 Ma, whole-rock K-Ar) of the blueschists and metabasalt (Blake et al., 1977) suggest a minimum mid-Jurassic age for metamorphism, and Early Jurassic detrital zircon ages (Cluzel & Meffre, 2002) set a maximum depositional age for the original sediments. However, zircon U-Pb ages of this present work infer a much younger maximum depositional age at ca. 135 Ma (Early Cretaceous). This discrepancy may arise from limitations of the K-Ar whole-rock dating method used (Blake et al. 1977), where presence of excess Ar is possible, and thus the Late Jurassic metamorphic age is rejected here.

Since Triassic to Early Cretaceous shallow-water volcanoclastic sediments occur to the west, and deeper-water sediments (with the same origin) to the east, and volcanic rocks and shallow intrusions are absent in the Central Terrane, Meffre (1995) and Cluzel & Meffre (2002) have suggested that the Teremba and Central Terranes are respectively the onshore and offshore parts of the same fore-arc basin. This view is also supported by a westwards-increasing metamorphic gradient in the HP-LT Boghen terrane (Guérangé et al., 1975; Paris, 1981), thus implying westwards-dipping Mesozoic subduction.

Unconformably overlying the three above-mentioned terranes, there is a prominent Late Cretaceous (Coniacian to Maastrichtian), volcanosedimentary unit (classically referred to as *Formation à Charbon*) composed of marine shallow water sandstone, coal-bearing siltstone, tuffs and volcanic rocks. Sandstones of

this unit contain detrital zircon populations which have a dominant (c. 70%) component at 90-140 Ma, and a minor (c. 25%) component at 170-240 Ma (Aitchison et al., 1998). From probable correlative (Late Cretaceous) sandstones at Dumbéa River, Aronson & Tilton (1971) obtained discordant U-Pb zircon data that suggested dominant Late Cretaceous, and accessory Precambrian (>1000 Ma) age components. The occurrence of unconformable Late Cretaceous sediments upon terranes whose greywackes contain reworked Early Cretaceous zircons suggest that the pre-Late Cretaceous terranes were amalgamated in early Late Cretaceous time.

TECHNICAL METHODS

Samples were initially collected for geochemical and isotopic analysis of both sedimentary rocks, and volcanic horizons in the three New Caledonia terranes. The analytical procedures relating to this study are described in the Appendix 1.

A small group of representative sandstone samples from the three basement terranes, and the Cretaceous cover sequences, were also collected for detrital zircon studies, preferably from localities, or general areas where there was reasonable biostratigraphic control. Details of detrital zircon preparation procedures, LAM-ICPMS dating techniques, and U-Pb data treatment are listed in Appendix 1.

GEOCHEMISTRY OF GREYWACKES AND VOLCANIC ROCKS

Geochemical analyses of 16 volcanic rocks from Teremba Terrane and 21 greywacke samples from Teremba and Central Terranes are used here to constrain their origins. Permian volcanic rocks of the Teremba Terrane are mainly represented by ash fall deposits and/or pyroclastic flows (surge deposits) with occasional massive rhyolite and andesite, whereas Mesozoic volcanics (mainly Triassic) are dacitic to rhyolitic with many hypabyssal intrusions and only a few subaerial volcanic rocks and rare pillow lavas. In the Central terrane, the only volcanic rocks are scarce, massive, island-arc basalts (Meffre, 1995). Consistent with field observations, the major element compositions range from basalt-andesite to rhyolite (Table 1b). However, the trace element patterns allow tholeiitic and calc-alkaline suites to be distinguished. REE patterns (Pearce, 1982, not presented) for tholeiites are generally flat and slightly depleted in LREE, but, in contrast, calc-alkaline rocks are typically enriched in LREE (La to Sm), with the rest of the pattern similar to that of tholeiites. On a REE/trace element expanded spider-diagram (Sun & McDonough, 1989) (Fig. 2), all these rocks are enriched in LILE and typically display a prominent negative Nb-Ta anomaly, of which tholeiites (island-arc tholeiites) have the lowest incompatible element content. Except for the occurrence of biogenic carbonate in some samples, that result in relatively low SiO₂ and high CaO contents (Table 1a), the greywackes, that are almost exclusively composed of volcanic lithic and mineral clasts, logically display geochemical features that are strikingly similar to those of the volcanic rocks. However, on average, the volcanic rocks sampled here are probably more mafic than the bulk of the sediment sources of the greywackes. A few of them display almost flat REE patterns, whereas the rest are enriched in LREE to various degrees. However, the bulk

REE content is more variable in the volcanoclastic sediments than in volcanic rocks, a possible consequence of limited dilution by weathering products and pelagic sediments. REE/trace elements patterns are closely similar to that of volcanic rocks (Fig. 2) and similarly indicate a volcanic-arc origin. Owing to the clastic mineral composition and similar geochemical features, greywackes and volcanic rocks appear to be derived from a similar magmatic source. Considering the westward coarsening and absence of erosion features within Mesozoic series, the greywackes are most likely derived from the erosion of volcanic rocks and coeval plutonic or shallow intrusive rocks which are now located to the west of present-day New Caledonia, e.g. in the Lord Howe Rise (Cluzel & Meffre, 2002).

ND-SR ISOTOPE GEOCHEMISTRY OF GREYWACKES

12 greywacke samples were selected for isotope analysis in order to identify their source rocks. In order to remove the biogenic carbonate which is obvious in some greywackes, all analysed samples have been leached with cold acetic acid. Most of them plot within a very narrow range of variation (Fig. 3) with positive ϵNd ($+0.9 < \epsilon\text{Nd} < +3$) and low ϵSr ($-4 < \epsilon\text{Sr} < +25$) values, that are typical of magmatic rocks derived from an undepleted mantle source with no evidence of contamination by sediment or continental crust rocks. Two samples display slightly negative ϵNd values ($-6.7 < \epsilon\text{Nd} < -2.8$) whereas ϵSr remains only slightly positive ($+9.5 < \epsilon\text{Sr} < +25$), implying a very limited contamination by a lower continental crust component. Only one sample displays a positive ϵSr (+212) together with a high Th content (13.8 ppm) consistent with the

involvement of a terrigenous (sedimentary) component, either by contamination of the mantle source, or more probably by mixing of the volcanoclastic component with a small amount of terrigenous argillite. It is worth noting that such differences in isotope ratios are not accompanied by noticeable geochemical changes (see Fig 2).

In summary, the Mesozoic greywackes are derived from a volcanic-arc source with almost no contamination by continental crust or pelagic sediment. As already pointed out by Meffre (1995), the original material (andesite, dacite and/or rhyolite) is similar to that of most intra-oceanic volcanic arcs; therefore, Permian-Mesozoic volcanic-arc magmas may have been erupted through an oceanic lithosphere or a thinned/intermediate continental crust rather than in a "normal" continental active margin. If this is the case, then any older zircons (pre-Permian) must be recycled either from older sediments derived from continental sources, or entrained as xenoliths within deep primary sources of unknown location. Thus, it appears likely that, as proposed by Cluzel & Meffre (2002), Central and Teremba terrane sediments accumulated in a fore arc region, partly upon a trapped oceanic crust element now represented by the Koh ophiolite (Fig. 1).

DETRITAL ZIRCON GEOCHRONOLOGY

Detrital zircon U-Pb age data for greywackes from nine localities (Table 3) in three New Caledonia terranes are presented in three forms.

Firstly, in Figs. 4-1 to 4-9, all $^{206}\text{Pb}/^{238}\text{U}$ zircon ages are treated with equal weight as combined probability density/histogram diagrams for each sample. These diagrams show individual points of detail well, but taken together, the nine diagrams are difficult

to compare visually. Thus, secondly, a summary table (Table 4) lists only those ages that form statistically significant components on the probability density plots of Fig. 4 (see also Appendix 2), and these are then displayed in Fig. 5, taking into consideration their proportional contribution to the total zircon set. Thirdly, in Tables 5A, and 6A, *all* ages of the New Caledonia age datasets are used, by displaying the percentage of the zircon ages that fall within selected geological periods. In these diagrams, the data are compared with published datasets from New Zealand Eastern Province terranes (Table 5B) and selected northeastern Australian terranes (Table 6B) (Adams et al. 2007, Korsch et al. 2008 in press).

Formation á Charbon

Sandstone at locality (1), correlative with *Formation à Charbon* nearby, has dominant Cretaceous (>80%), and a minor, Triassic-Jurassic (12%) zircon groups, but few (5%) Precambrian zircon ages (Fig. 4-1, Fig. 5, and Table 5A). The small, youngest zircon age component, 85 ± 2 Ma, is in agreement with the estimated Coniacian-Santonian age, but this is overwhelmed (>70%) by several mid- and Early Cretaceous subcomponents, 95 ± 1 , 102 ± 4 , 110 ± 2 , 119 ± 2 and 130 ± 2 Ma. These latter clearly reflect reworking of a long-lived active Cretaceous igneous province, relatively isolated from older, ‘continental’ inputs. Whilst the youngest zircons are probably derived from contemporaneous, dacite-rhyolite volcanic sources, c.85 Ma, it is probable that the older dominant group at 100-120 Ma reflects erosion not only of older parts of the igneous province but also reworking of detrital zircons from underlying Albian greywackes,

such as those at locality (2) (see below). The latter might also contribute the few inherited, Precambrian zircons.

Central Terrane

Central Terrane greywackes at localities (2) and (3) have quite dissimilar detrital zircon age patterns.

The locality (2) was originally mapped as a Late Jurassic succession within the terrane, but arising from the new Cretaceous zircon age data below, a closer search yielded Early Cretaceous fossils (H. Campbell pers. comm.). Its zircon age pattern is similar to that of Formation á Charbon at locality (1), with dominant Cretaceous (>80%), and minor (11%) Precambrian, groups (Fig. 4-1, Fig. 5, and Table 5A). Within the Cretaceous group, the youngest statistically significant age component, 108 ± 2 Ma, is the major one, and provides a maximum Albian age for deposition, supporting the new fossil age assignment.

In contrast, the Late Jurassic locality (3) has far fewer (28%) contemporary zircons (a single statistically significant component is 162 ± 3 Ma), and a dramatically increased early Paleozoic-Precambrian proportion (>70%), with age components at 513 ± 5 , 539 ± 6 , 557 ± 5 , and 592 ± 5 Ma.

Boghen Terrane

The zircon age pattern for the Boghen terrane greywacke (4) is similar to the Late Jurassic, Central (11), and Late Triassic Teremba (6) Terrane samples, having low (<25%) proportions of contemporary zircons, and high proportions (>40%) of inherited,

early Paleozoic-Precambrian zircons (Table 5A). Significant older zircon component ages are Cambrian-late Neoproterozoic, 505 ± 4 , 563 ± 6 , and 584 ± 5 Ma, similar to those in Central (3) and Teremba (5, 6, 8) Terrane samples. At this locality, the greywacke depositional age is uncertain, but the youngest zircon age group, at 170 ± 2 Ma (which is just statistically significant), suggests a Middle Jurassic maximum. However, three younger individual ages, 137 ± 2 , 141 ± 2 and 149 ± 2 Ma reduce this to Early Cretaceous-Late Jurassic.

Teremba Terrane

The Teremba Terrane samples from localities (5)-(8) have their youngest zircon ages close to their estimated Middle-Late Triassic depositional ages (Figs. 4-5 to 4-8, and Table 5A), and with the exception of locality (8), these form statistically significant age components. They thus probably reflect contemporary volcanic-arc sources. This would be particularly true of greywacke at locality (7), which unlike the remainder of the terrane samples, has an extremely high proportion (96%) of Triassic zircons, with the youngest age component, comprising 33% of the total, at 225 ± 2 Ma (Late Triassic, Norian). An age discrepancy is apparent in the sample from locality (6). This is mapped within an area of Middle Triassic rocks (237-245 Ma), although four zircon ages c. 215 Ma (Fig. 5) are clearly younger than this, and suggest that the sample is from a horizon no older than Late Triassic (Norian). With the exception of locality (7), the remaining Teremba Terrane samples have major proportions (>50%) of early Palaeozoic and Precambrian zircons and several statistically significant age components falling in the latest Neoproterozoic, c. 550-590 Ma (Fig. 5).

DISCUSSION

None of the New Caledonia terranes have sandstones with detrital zircon age patterns sufficiently distinctive to discriminate one terrane from another (Fig. 5). Rather, all the zircon patterns fall between two extremes: those dominated by contemporary, volcanic (Fig. 5: 2, 7) sources, and those by inherited, continental (Fig. 5: 4, 8) sources. In this sense, it could be argued that all the terranes had broadly similar depocentres, capable of providing both substantial contemporary volcanoclastic detritus, from island-arc centres (perhaps local) and terrigenous clastic material from an old hinterland of continental character (perhaps more distant). However, the sandstones dominated by contemporary volcanic inputs are more typically Cretaceous, whilst those dominated by inherited inputs are all pre-Cretaceous. This may indicate that New Caledonia became more isolated from direct continental zircon sources in the late Early Cretaceous, probably at a time of extension, before major rifting created Tasman Sea ocean floor at c. 85 Ma (Santonian). Alternatively, the contemporary Cretaceous volcanism may have been so dominant as to completely overwhelm any continuing continental zircon inputs. The zircon sources of the contemporary volcanic and older inherited continental components are thus discussed separately below.

Contemporary zircon sources for sediments in the New Caledonia region

Those youngest zircon age components in the Central and Teremba terrane greywacke samples that overlap estimated depositional ages, probably originate in contemporary volcanic centres and, given the first-cycle immature nature of the sediments, are

probably of local origin. Substantial volcanic centres of appropriate age and composition are absent in New Caledonia, and one must speculate that these are now either entirely eroded away or hidden elsewhere in a hinterland (in Cretaceous times) of the Norfolk or Loyalty Ridges and/or northern Lord Howe Rise. Early Triassic diorites and granodiorites, perhaps connected to volcanic centres, do occur on the Dampier Ridge, and southern Norfolk Ridge (McDougall et al. 1994, Mortimer et al. 1998), but pre-Cretaceous rocks are not known from either the Loyalty Ridge or northern Lord Howe Rise. None of these regions appears to have Late Triassic-Jurassic rocks, of appropriate extent or composition, to provide zircon sources for New Caledonia sediments. For the Late Jurassic-Early Cretaceous sediments, the acidic volcanic centres of Whitsunday Islands, Queensland, which might extend north and south along the northern Lord Howe Rise and Marion Plateau, would provide far more suitable zircon sources. In addition, mid-Cretaceous rhyolites are known from the southern Lord Howe Rise (McDougall and Van der Lingen 1994). To provide zircons for the New Caledonia terrane depocentres from adequate sediment sources, we must therefore speculate that offshore island-arc volcanic centres of Late Triassic to Early Cretaceous age, which are now hidden, once existed along the northern Lord Howe Rise and Marion Plateau. In addition these centres might have formed an intermittent barrier to rivers originating in eastern Gondwanaland which supplied the older, continental zircons.

Inherited continental zircon components

It is notable that the older (>250 Ma), zircons in the New Caledonia sediments are overwhelmingly (>90%) early Paleozoic and Precambrian (mostly 500-700 Ma). In

particular, there are few individual zircons in the Middle Permian-Early Triassic, 245-270 Ma (Figs. 4, 5) age range, and none constitute statistically significant age components. This is surprising, because voluminous plutonic (and volcanic) complexes of this age (and also Early Permian-Late Carboniferous) are extensive within the New England Orogen, along 2000 kilometres of the northeastern, present-day, margin of Australia (Veevers 2000). This fold-belt would be have been undergoing uplift and erosion at this time, sufficiently to supply marine depocentres at the Gondwana continental margin at a latitude similar to present-day New Caledonia. This is indeed the case for Permian-Triassic volcanoclastic sedimentary rocks of the Gympie Terrane of southeast Queensland (Table 4), now situated between the main plutonic/volcanic arcs of the New England Orogen and New Caledonia in its present position (Korsch et al., 2008 *in press*). In addition, the petrological, geochemical, mineralogical, faunal and particularly detrital mineral evidence (Pickard et al. 2000, Adams & Kelley 1998, Adams et al. 2007), indicate that the depocentres of several New Zealand Permian-Jurassic, Eastern Province tectonostratigraphic terranes developed at these latitudes (Fig. 6). Their sedimentary rocks always contain substantial proportions of Early Triassic-Late Permian zircons and micas, c. 245-270 Ma. Depocentres such as those of the Gympie Terrane of Australia and the Eastern Province terranes of New Zealand, would thus explain the absence of Late Permian-Early Triassic zircons in New Caledonia rocks, by providing an effective sediment trap inshore of New Caledonia. There is the additional possibility that present-day Zealandia continental fragments such as the Lord Howe Rise, Marion Plateau, and Queensland Plateau might have existed then, and were elevated, to provide an additional barrier.

However, the early Paleozoic and Precambrian zircon components in New Caledonia sediments clearly indicate major access to older continental sources. The same is true of Late Paleozoic (probable Carboniferous) terrane metasediments of the Shoalwater and Wandilla terranes in eastern Queensland (Table 6, Korsch et al., 2008 *in press*). In contrast, pre-Carboniferous zircons are rare in the Permian-Triassic rocks of the Gympie Terrane (Table 6). It is possible that Early Paleozoic and Precambrian zircons might have originated locally in basement rocks now hidden under Cenozoic cover on the northern Lord Howe Rise, Marion and Queensland Plateaux, but in the absence of any evidence, this is purely speculative. It is perhaps more realistic to look to more distant, interior sources along the Gondwana margin, where early Paleozoic (470-550 Ma) zircons could clearly originate from Early Ordovician granitoids and Cambro-Ordovician rhyolites of the Mt Windsor Volcanics in the Charters Towers Province (Veevers 2000). However, the origin of the Precambrian zircons is more problematical; for the major part, they could be recycled from Paleozoic metasediments (Cambrian-Carboniferous) in the Charters Towers, Broken River and Hodgkinson Provinces of northeastern Queensland. In addition, there are also potential primary igneous sources, mostly late Paleoproterozoic and early Mesoproterozoic metavolcanics and gneisses (1500-1800Ma), in the Georgetown, Coen and Yambo Precambrian inliers of the same region (Blewett et al. 1998). However, no primary igneous sources for the late Mesoproterozoic-early Neoproterozoic (950-1150 Ma) zircons are known.

Comparison of New Caledonia and New Zealand terranes

Similar to the New Caledonia sandstones, Eastern Province terrane metasediments of New Zealand share the same division between contemporary (probably volcanic) and inherited (probably continental) zircon sources. Like New Caledonia, there is difficulty in locating extensive volcanic sources of appropriate composition. The inherited zircon inputs are quite different in their proportions, and this feature suggests that the two regions occupied different positions at the eastern Australian Gondwanaland margin in Permian to Cretaceous times. Although now distant, New Zealand depocentres were then much closer to the New England Orogen, whilst New Caledonia, now adjacent, was formerly remote from it.

TRIASSIC-JURASSIC COMPARISONS

Triassic-Jurassic, Teremba Terrane rocks have tectonic associations and faunal assemblages similar to the New Zealand Murihiku Terrane (Campbell 1984, Ballance & Campbell 1993). However, in the latter, the major to dominant (40-80%) zircon age components are close to the depositional age, characteristic of an active volcanic margin setting. In the Teremba Terrane however, these youngest zircon groups are usually diminished (<25%) and there is instead a substantial component (usually >50%) of inherited early Paleozoic-Precambrian zircons. This latter feature is quite unlike any Permian, Triassic or Jurassic examples from the Murihiku Terrane (Table 5B, MATI4, PIOX5, HURW4 respectively). The proportion of early Paleozoic-Precambrian to Triassic-Permian zircons in the Teremba Terrane samples is particularly high, ratio >2.0 (Table 5A), and cannot be matched in any New Zealand terranes, where the ratio is always <1.0. The closest comparisons are in the New Zealand Torlesse Terrane, where

Triassic samples (Table 5B, RBW1 to PUD1) are the most zircon-rich, carry the highest inherited zircon component (>40%), and the ratio is c. 0.7, e.g. Table 5B, NGQ2. A sole exception to this behaviour occurs in the Akatarawa microterrane (a 1 km² enclave within the Torlesse Terrane) at a Late Permian locality (Table 5B, TAKA10), where the zircon pattern (with ratio, c. 2.0) resembles that from the Late Triassic, Teremba locality (5). Significantly, the microfaunas in this microterrane are considered of Tethyan type (Hada et al. 1995) i.e. of more northerly, lower-latitude origin than that of surrounding Torlesse rocks. (An attempt to pursue this comparison further was unsuccessful, as several Teremba terrane samples of similar Late Permian age were found to be exceptionally zircon-poor and unfavourable for detrital zircon study).

Like the New Caledonia examples, volcanic sources for contemporary zircon inputs into Triassic or Jurassic depocentres of the New Zealand Eastern Province terranes are rarely seen, and where present they are often very minor. This is surprising, as the coarse, first-cycle, immature nature of the sediments suggests short transport from local sources. For this reason, the terranes are considered ‘suspect, i.e. far-travelled, and tectonically transported from sediment depocentres formerly much closer to the Australian (or Antarctic) Gondwanaland margin.

CRETACEOUS COMPARISONS

New Caledonia Cretaceous sedimentary successions have two potential points of comparison with New Zealand: (1) Early Cretaceous rocks form a major part of the Torlesse composite Terrane, as basement accretionary complexes (e.g. Pahau terrane) in eastern North Island and northeastern South Island, and (2) Late Cretaceous successions

are locally present at the base of widespread Cretaceous-Cenozoic cover rocks throughout New Zealand, and also within the Northland, Mt. Camel, and East Cape allochthons of the North Island (Fig. 6, Table 5B) (Suggate 1978). Similar to New Caledonia counterparts, the Cretaceous Torlesse greywackes (Table 5B, Pahau Terrane section) all carry significant proportions (>30%) of early Paleozoic and Precambrian zircons, but in contrast, carry an important additional component (>30%) of Triassic-Permian zircons (a distinctive feature of all Eastern Province terrane rocks) that weakens the comparison. This latter problem does not arise in Cretaceous rocks from the Northland, Mt. Camel, and East Cape allochthons (Table 5B, allochthon section), since they have fewer (<10%) Triassic-Permian zircons, but in turn, their much-diminished proportion (<5%) of early Paleozoic and Precambrian zircons also weakens any comparison too. Unlike New Caledonia there is better evidence for contemporary magmatism in late Early and Late Cretaceous time. Volcanic centres are widespread in the South Island, with major centres that include acid-intermediate magmatism at Mt Somers, Mt Mandamus and in the Clarence/Awatere river valleys, and minor horizons occur in Otago and north Westland (Suggate 1978), and offshore on the southern Lord Howe Rise (McDougall & Van der Lingen 1974). Major Mesozoic granitoid complexes of the Separation Point Batholith of Nelson (and its counterpart in Fiordland) and the Paparoa Suite of north Westland (Muir et al. 1994, 1996) almost certainly supplied contemporary volcanic centres, now uplifted and removed. On this basis, the comparison of New Zealand with New Caledonia during the Cretaceous is poor. Whilst having major volcanic/plutonic late Early and Late Cretaceous zircon sources nearby, the New Zealand sediments maintained access to older continental zircon sources, (1)

by recycling of older zircons from underlying Permian-Triassic and early Paleozoic basement rocks within the New Zealand region, and (2) perhaps more distantly, from primary igneous sources in the southernmost part of the New England Orogen. In contrast the New Caledonia Cretaceous sediments evaded sources within the New England Orogen, yet maintained some access to older zircon sources. The latter might have been recycled from late Early Cretaceous sedimentary rocks (cf. sample NCAL10 of the Central terrane) within New Caledonia, but now largely hidden or eroded away. Prior to 85 Ma (oldest seafloor in the Tasman Sea), during the initiation of rifting in mid-Cretaceous times, the development of the extensive Whitsunday Islands (eastern Queensland) silicic volcanic province, would have provided an important zircon source. This had the additional benefit of proximity to the early Paleozoic and Precambrian provinces of northeastern Queensland. However, it must be recognised that this scenario is much weakened if one accepts a continuation, as suggested by Mortimer et al. (2008), of the New England Orogen beyond of its northernmost onshore occurrence on to the Queensland Plateau. Sediments derived from this sources in this region would then surely contain the Late Permian-Early Triassic zircon components so characteristic of the New England Orogen, but which are mostly absent in New Caledonia.

New Caledonia terranes at the eastern Australia Gondwana margin

The Late Permian-Late Cretaceous terranes in New Caledonia and New Zealand have a similar tectonic setting in an accretionary prism environment. Terrane sediments in both areas show varying combinations of contemporary, redeposited volcanoclastic and inherited, continental clastic sediment inputs. However their geographic positions

relative to the Gondwanaland foreland must be quite different, with older Paleozoic-Precambrian zircon sources more apparent in the New Caledonia terranes, at the expense of the Late Permian-Early Triassic sources which dominate the New Zealand terranes. In New Caledonia, whilst the persistent contemporary volcanoclastic sediment sources are probably local, the older zircons sources are almost certainly outside the immediate New Caledonia region. The nearest available plutonic and metamorphic complexes of early Paleozoic-Precambrian age are in northeasternmost Queensland, at a point where the Australian Precambrian craton comes closest to the Pacific margin of Gondwanaland. However, it should be noted that the available age data for the northernmost Queensland Precambrian basement rocks (Blewett et al. 1998), are dominantly early Mesoproterozoic, 1500-1600 Ma, rather than the younger Precambrian, 900-1100 Ma, ages more commonly seen in the New Caledonia detrital zircon sets. In this scenario, there is a requirement for long sediment transport, up to 2000 kilometres, via a river/delta/submarine canyon system, from sources that includes Cambrian-Ordovician rocks, such as those of the Broken River Province, and Neo- and Mesoproterozoic rocks, such as those in several adjacent Precambrian inliers. In the Triassic-Jurassic, any such river system must direct such sediments from these sources quite far offshore and then transport it by longshore currents into the New Caledonia region, to avoid capture of zircon sources from the northern New England Orogen (Fig. 6). This latter requirement is especially difficult, as there can be no sediment input into such longshore currents along the 500 kilometre sector of the northeast margin of the orogen. However, Leitch et al. (2003) have suggested a similar scenario for derivation of late Paleozoic, Shoalwater and Wandilla terrane sediments in eastern Queensland

from older continental sources in northeastern Queensland. The continental sediment supply must diminish substantially in Cretaceous times, either as a consequence of gradual erosion of the source areas, or the intervention of a sediment trap or barrier e.g. initiation of rift basins or volcanic arcs offshore.

Alternatively, the sediment transport may have been relatively short (c. 200km), into depocentres at the immediate Gondwana margin of northeasternmost Queensland (Fig.6). In Early Cretaceous times, such depocentres would have been consolidated and tectonically transported southwards, as suspect terranes, by dextral strike-slip, margin-parallel displacement, outboard of the New England Orogen, and into the New Caledonia region. The Triassic-Jurassic terranes transported in this way would gradually approach a hinterland to New Caledonia, comprising local Cretaceous volcanic arcs e.g. Whitsunday Islands, Maryborough Basin, and hence become dominated by their contemporary volcanoclastic sediment inputs. Pickard et al. (2000) and Adams et al. (2007) have suggested this kind of scenario for transport the Late Paleozoic–Mesozoic, Torlesse composite terrane of New Zealand from eastern Australia. However, like the New Zealand example, this scenario encounters anomalies, because the relative original positions of the New Caledonia sediment depocentres at the Gondwanaland margin would be the opposite of their final relative terrane positions in New Caledonia. The Boghen terrane, whose sediment depocentre had most ‘continental’ (inherited) zircons, would now be outboard of the Teremba Terrane, whose sediment depocentre was more local, and had the least ‘continental’ influence.

SUMMARY OF CONCLUSIONS

Geochemical and Sr-Nd isotopic characteristics of Mesozoic greywackes in the Teremba and Central Terranes of New Caledonia indicate a uniform offshore, probable subduction-related tectonic environment, with minor continental sediment contribution. Detrital zircon U-Pb age patterns for sandstones of the Formation á Charbon, and greywackes of the Central and Teremba Terranes indicate local offshore depocentres in an active margin tectonic environment, with substantial contemporaneous volcanoclastic sediment supplies in Late Triassic, Late Jurassic and particularly mid-Cretaceous times. In the Teremba Terrane, an older, inherited zircon component from continental sources is usually (but not always) important, most commonly Precambrian and Cambrian in age. In contrast, the Boghen terrane sandstones have much diminished contemporary (Late Jurassic) zircon contributions, and a major contribution (>50%) of Early Paleozoic and Precambrian zircons. In all terranes there are few late Paleozoic-early Mesozoic zircons, especially in the age range Late Permian to Early Triassic, which latter feature would thus probably exclude sediment sources from along the adjacent Gondwana margin in the northern New England Orogen. It is concluded that the primary contemporary zircon sources must lie hidden, or are now eroded, somewhere in the New Caledonia hinterland, on the Loyalty and Norfolk Ridges, or northern Lord Howe Rise and Dampier Ridge, or Marion and Queensland Plateaux. A degree of local zircon reworking, from Triassic into Jurassic, and Jurassic into Cretaceous sediments is possible. The continent-derived zircons probably have primary, and/or reworked detrital sources in Paleozoic and Precambrian rocks of northeast Queensland. Here there are several Proterozoic igneous/metamorphic inliers and Paleozoic sedimentary

successions of the Charters Towers, Broken River and Hodgkinson Provinces, which are close to the Gondwana margin and beyond the northernmost extremity of the New England Orogen. The sediment supplied from these areas must have been transported southwards by longshore currents, outboard of the orogen, to depocentres in New Caledonia. Alternatively, the depocentres themselves may have originated closer to source at the contemporary Gondwana margin, and then transported tectonically southwards, as suspect terranes in Early Cretaceous times, to their present New Caledonia position. This latter scenario resembles that suggested for New Zealand Permian-Cretaceous sediment depocentres that developed close the Gondwana margin of northeastern Australia.

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FIGURE CAPTIONS:

Figure 1a: Geological map of New Caledonia basement terranes and U-Pb geochronology sampling localities.

Figure 1b: New Caledonia in the Southwest Pacific region in Cretaceous times.

Figure 2a: Expanded REE-trace elements spider-diagram normalised to the average MORB for selected New Caledonia terrane greywackes (normalising values are from Sun & McDonough, 1989). Labelled patterns refer to sediments which have slightly negative ϵ_{Nd} (see Fig. 3 and Table 2)

Figure 2b: Expanded REE-trace elements spider-diagram normalised to the average MORB for selected Teremba terrane volcanic rocks (normalising values are from Sun & McDonough, 1989)

Figure 3: Sr-Nd evolution diagram for selected New Caledonia terrane greywackes showing remarkably constant isotopic ratios through time and the quasi-absence of contamination. Arrows with interrogation marks refer to either the array resulting from magma contamination by pelagic sediments (moderately negative ϵ_{Nd} , high ϵ_{Sr}); or, alternatively contamination by lower continental crust (negative ϵ_{Nd} , slightly positive ϵ_{Sr}).

Figure 4: Combined histogram and probability density diagrams of detrital zircon age data from nine greywackes from New Caledonia terranes. Statistically significant age components (expressed in millions of years) are shown in bold italics. Ages >600 Ma are stacked at right side. Ages < 1000 Ma are $^{238}\text{U}/^{206}\text{Pb}$ data, ages > 1000 Ma are $^{207}\text{Pb}/^{206}\text{Pb}$ data.

Figure 5: A summary of detrital zircon $^{238}\text{U}/^{206}\text{Pb}$ age component data from the cumulative probability diagrams (Fig. 4) of nine greywackes from New Caledonia terranes. These component age data are stacked from top to bottom in ascending biostratigraphic age order (where known), or estimated maximum and minimum stratigraphic ages derived respectively from youngest detrital zircon age components, and metamorphic ages. The height of each databox indicates the component's proportion of total (see % scale bar at right) and the width is the component age error (at 95% confidence limits). The dot-dash line is the stratigraphic age limit - all zircon data should be older than this.

Figure 6: Configuration of Eastern Gondwanaland during the Mesozoic (modified from Gaina et al. 1998; Sutherland 1999; and Hall 200), showing possible position of sources of New Caledonia terrane sediments, suggested depocentres, and their final destinations for terrane assembly. Black arrows show generally local transport of sediments derived from contemporary volcanic arc sources. Light grey

arrows show more distant transport of older, continent-derived sediments from the Gondwana margin. Two scenarios are suggested: in Fig. 6A, the continent derived-sediments are supplied to on long-shore river systems to depocentres in New Caledonia and in Fig. 6B, the continent-derived sediments are supplied to more local depocentres at the Gondwana margin, which are then tectonically transported in Early Cretaceous times, as suspect terranes, to a final destination in New Caledonia. The positions of equivalent New Zealand depocentres and terranes are taken from Adams et al. (2007).

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Table 1b: Major and trace element data for New Caledonia Teremba volcanic rocks

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Table 5: New Caledonia detrital zircon ages (5A) summarised in geological periods, and compared with correlative New Zealand data (5B).

Table 6: New Caledonia detrital zircon ages summarised in geological periods (6A), and compared with correlative Australian data (6B).

Appendix I: Technical details

GEOCHEMICAL AND ISOTOPIC ANALYSES

Whole rock geochemical analysis of representative volcanic rocks and greywacke samples are by ICP-AES for major elements and ICP-MS for REE and other trace elements (Table 1) at the Service d'Analyse des Roches et des Minéraux of Vandœuvre (Centre National de la Recherche Scientifique, France), using the methods of

Govindaraju and Mevelle (1987). To avoid pollution by biogenic carbonate without affecting other mineral phases, all the greywackes samples have been leached with acetic acid prior to isotope analysis. Nd and Sr isotopic analyses (Table 2) were determined at the Clermont–Ferrand isotope laboratory by thermal ionization mass spectroscopy (TIMS) using a VG54E instrument in dynamic double collection mode and corrected for mass fractionation by normalization to $^{86}\text{Sr}/^{88}\text{Sr} = 0.1194$ and $^{146}\text{Nd}/^{144}\text{Nd} = 0.7219$. The Sr–Nd sample decomposition and chemical separation procedures are those of Pin and Santos Zalduegui (1997). Sr and Nd isotopic ratios were corrected for radiogenic decay according to their assumed stratigraphic age. The concentrations of Sm, Nd, Rb and Sr are given in $\mu\text{g/g}$, and the precision of $^{147}\text{Sm}/^{144}\text{Nd}$ and $^{87}\text{Rb}/^{86}\text{Sr}$ measurements are 0.2% and 2%, respectively, at the 95% confidence level. The $^{143}\text{Nd}/^{144}\text{Nd}$ ratio measured for the La Jolla isotopic standard during the period of analysis gave a mean value of 0.511849 ($\text{SD} = 8 \times 10^{-6}$, $n = 70$). The ϵNd_i is the initial $^{143}\text{Nd}/^{144}\text{Nd}$ expressed as a fractional deviation in parts per 10^4 from the contemporaneous value of a chondritic (bulk earth) reservoir with present-day $^{143}\text{Nd}/^{144}\text{Nd} = 0.512638$ and $^{147}\text{Sm}/^{144}\text{Nd} = 0.1966$ (Jacobsen & Wasserburg 1980). $^{87}\text{Sr}/^{86}\text{Sr}$ ratios were normalized to $^{86}\text{Sr}/^{88}\text{Sr} = 0.1194$, with an uncertainty equal to or better than ± 0.00004 (two standard errors on the mean). The $^{87}\text{Sr}/^{86}\text{Sr}$ ratio measured for the National Institute of Standards and Technology, Standard Reference Material (NIST – SRM) 987 during the period of analysis gave a mean value of 0.71023 ($\text{SD} = 2.7 \times 10^{-5}$, $n = 29$).

DETRITAL ZIRCON DATING

Detrital zircon dating was done at the ARC Key Centre for Geochemical Evolution and Metallogeny of Continents (GEMOC), Macquarie University, Sydney, Australia. Eight samples for detrital zircon studies were chosen from representative collections taken at stratigraphic horizons where coarse-medium greywacke and sandstone predominate, and preferably with established biostratigraphic age control (Table 3). Since these localities are in lower metamorphic grades (typically zeolite to lower pumpellyite-actinolite mineral facies), they are essentially unfoliated rocks and free of metamorphic zircon.

To minimise sample handling for zircon recovery, a 1 kg sample was collected at the field outcrop as 5 mm-size gravel, removing all weathered rinds, blemishes, inclusions and joint faces. This enabled direct crushing in a tungsten carbide swingmill 2-3 times, for 5-10 seconds, sieving at each stage through a single, 250 micron mesh sieve. The sieved material was washed and decanted several times in water, to remove mud-size fractions, thus retaining a 200-300 g sample in a ~30-250 micron size range, which was then dried. A heavy mineral concentrate was obtained from a 100 g portion in sodium polytungstate liquid, adjusted to a specific gravity of 2.95-2.98, from which about 500 zircon grains were then hand-picked as randomly as possible, i.e. taking all grains within a 1 mm microscope stage field of view. Of these, 50-100 grains were mounted in resin to be polished for LA-ICPMS (laser-ablation inductively-coupled plasma-source mass spectrometry) analysis.

Analytical protocols relating to ablation procedures, mass spectrometric analysis and data treatment are discussed in detail in Jackson et al. (2004). These authors' preferred procedures were followed in this work, using a Merchantek pulsed Nd-YAG laser, frequency-quintupled to operate at 213 nm, and an Agilent 7500S ICPMS instrument.

In all cases, the ablated spot size was in the range 30-40 microns, with the ablation time about 60 seconds, preceded by 60 seconds background measurement, and followed by 60-120 seconds washout. Groups of 10-12 zircon sample grain analyses were preceded and followed by duplicate analyses of firstly, the in-house zircon standard GJ-1, and secondly, by 1-2 analyses each of the international zircon standards, MT-1 and 91500. The GLITTER data interpretation software package (www.els.mq.edu.au/GEMOC/) enabled analysis of U, Pb and Th absolute count rates, and all relevant isotopic ratios, during the run cycle, and the elimination of unstable beam intervals, and rejection of data where zircon core regions were inadvertently encountered.

Using the laser spot size of 30-40 microns enabled age measurements to be made adjacent to crystal margins, rather than cores, and preferably, close to crystal terminations (as defined by two crystal edges). Isotopic data were continually monitored during ablation to check that zircon cores were not being intersected. Efficient use of the instrument time dictated that strongly unimodal patterns were investigated only to analysis totals of N=33-50, bimodal patterns to N=50-70, and strongly polymodal patterns to N=100 (N.B. throughout this work 'N' and 'n' refer to dataset totals and subgroups respectively). This allowed significant age groups (n) comprising >5% of the total to be revealed by three or more analyses (Andersen 2005).

Full $^{207}\text{Pb}/^{206}\text{Pb}$, $^{206}\text{Pb}/^{238}\text{U}$, $^{207}\text{Pb}/^{235}\text{U}$, and $^{208}\text{Pb}/^{232}\text{Th}$ age data (and 1 standard errors) are listed in the Appendix Table 1. All ages used here are $^{206}\text{Pb}/^{238}\text{U}$ zircon ages where <1000 Ma, and $^{207}\text{Pb}/^{206}\text{Pb}$ ages where >1000 Ma. A small minority of the analyses have common Pb corrections (using protocols of Andersen 2002). The age datasets are

shown in Fig. 4 as combined probability density/histogram diagrams (using a common X-axis format, 0-600 Ma, with ages >600 Ma stacked at right).

Age groupings in probability density plots of the zircon age sets (Fig. 4) were determined by visual inspection and using deconvolution (and weighted average) algorithms in the ISOPLOT-Ex (version 3.0) software (kindly provided by K. Ludwig, United States Geological Survey). The treatment of these age datasets was constrained by two conservative criteria imposed to reveal only statistically significant age groups viz. those with $n > 3$ concordant $^{206}\text{Pb}/^{238}\text{U}$ v. $^{207}\text{Pb}/^{235}\text{U}$ ages, *and* which comprise $>4\%$ of the total population (N). This was relaxed to $n \geq 3$ for datasets with $N < 30$. Following Andersen (2005), the age groups are discussed using five categories: ‘dominant’ $>80\%$, ‘large’ 50-79%, ‘major’ 20-49%, ‘minor’ 5-19%, and ‘accessory’ $<5\%$, of the total. A summary of the statistically significant component ages and errors, their number (n) and proportion (as %) of the total (N), is given in Table 4.

Detrital zircon age data for other previously-published and unpublished studies are collated in Tables 5 and 6, and presented with the present New Caledonia datasets. In these tables, *all* zircon age data are divided into selected geological periods. The New Zealand timescale used here is that of Cooper (2005).

Suggested Running Title: New Caledonia terranes.

Version: NCAL08text March 2009

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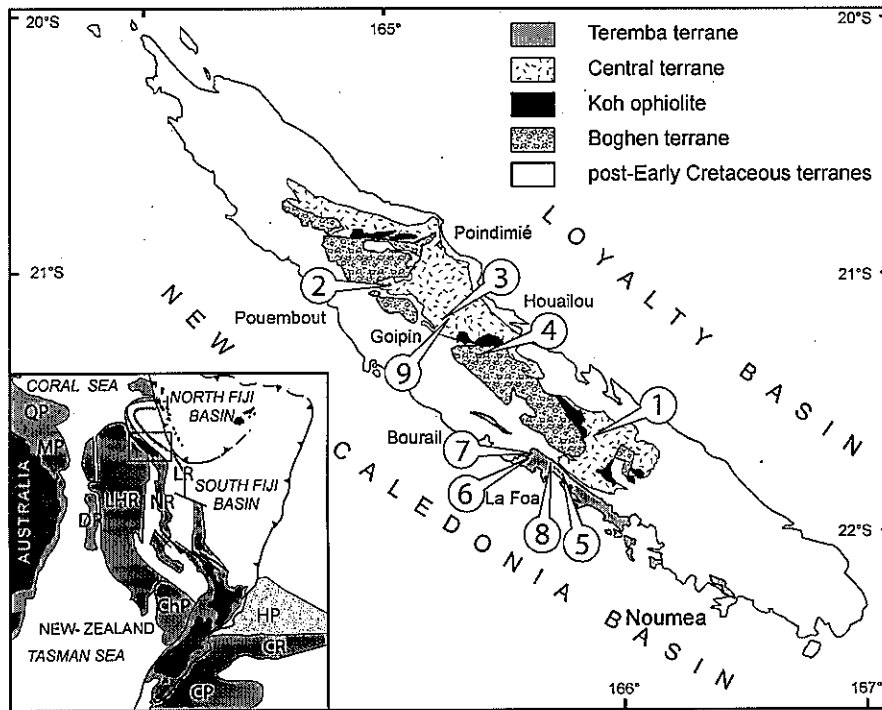
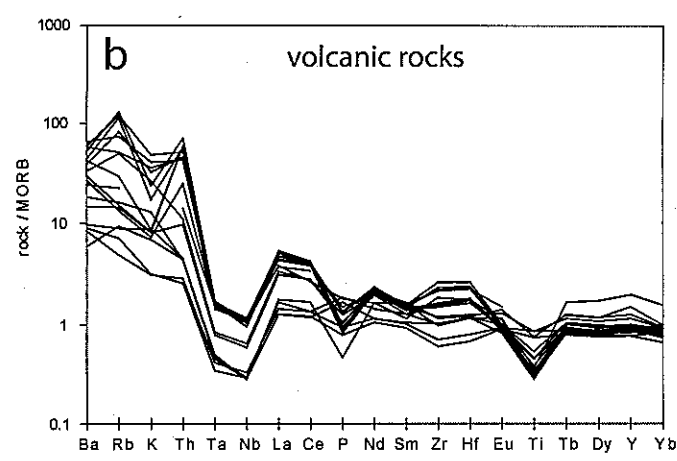
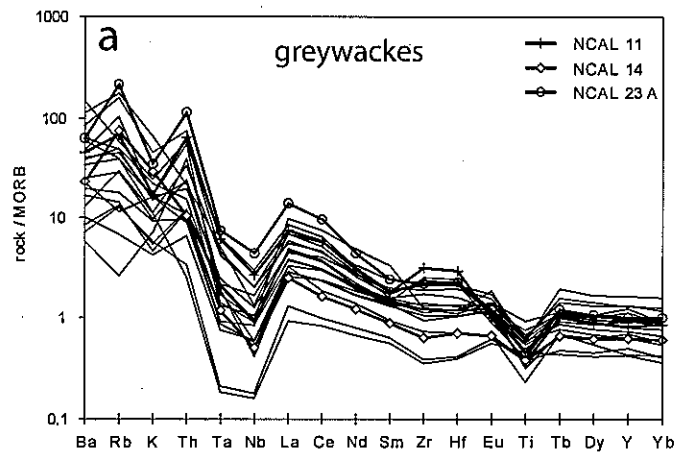
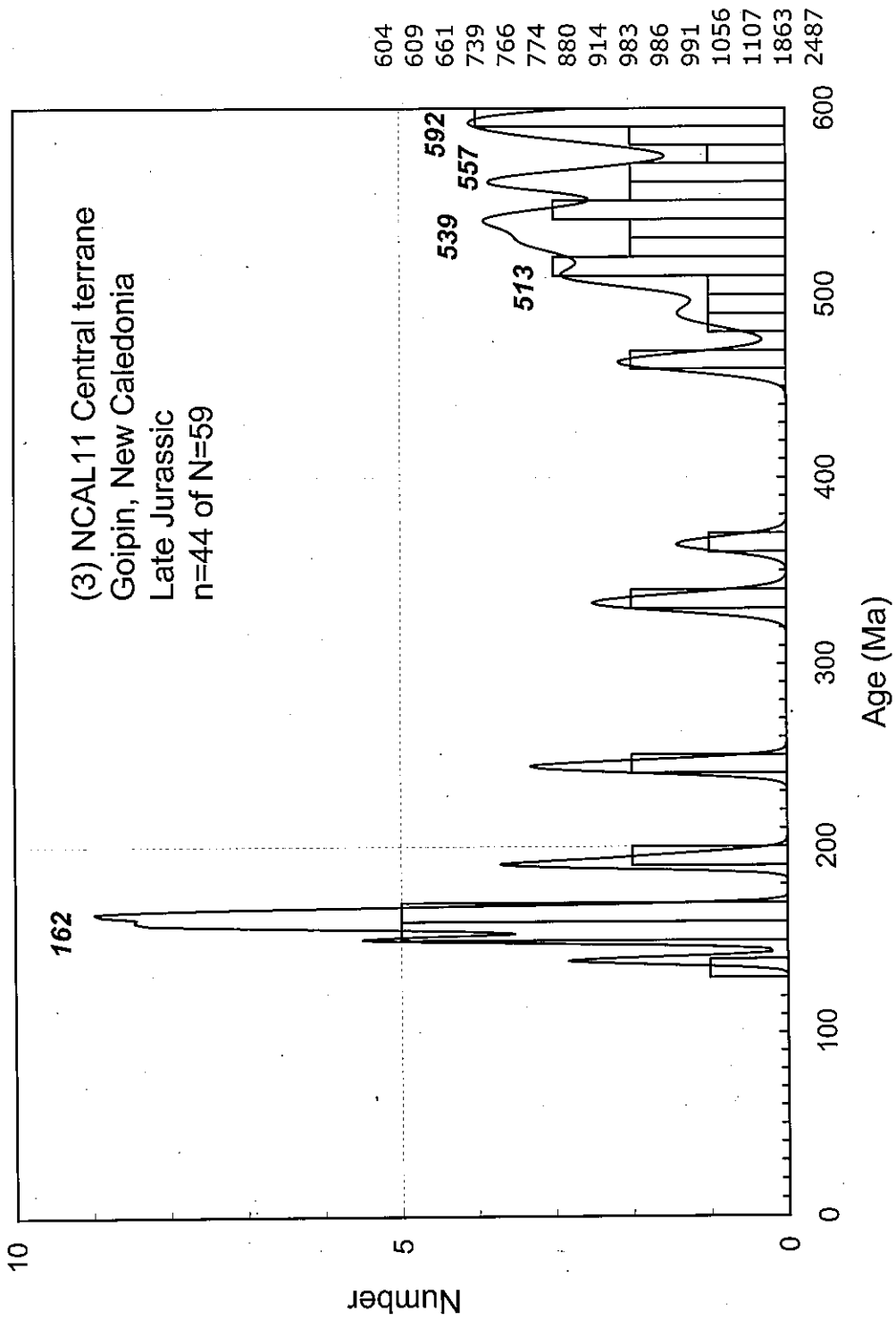
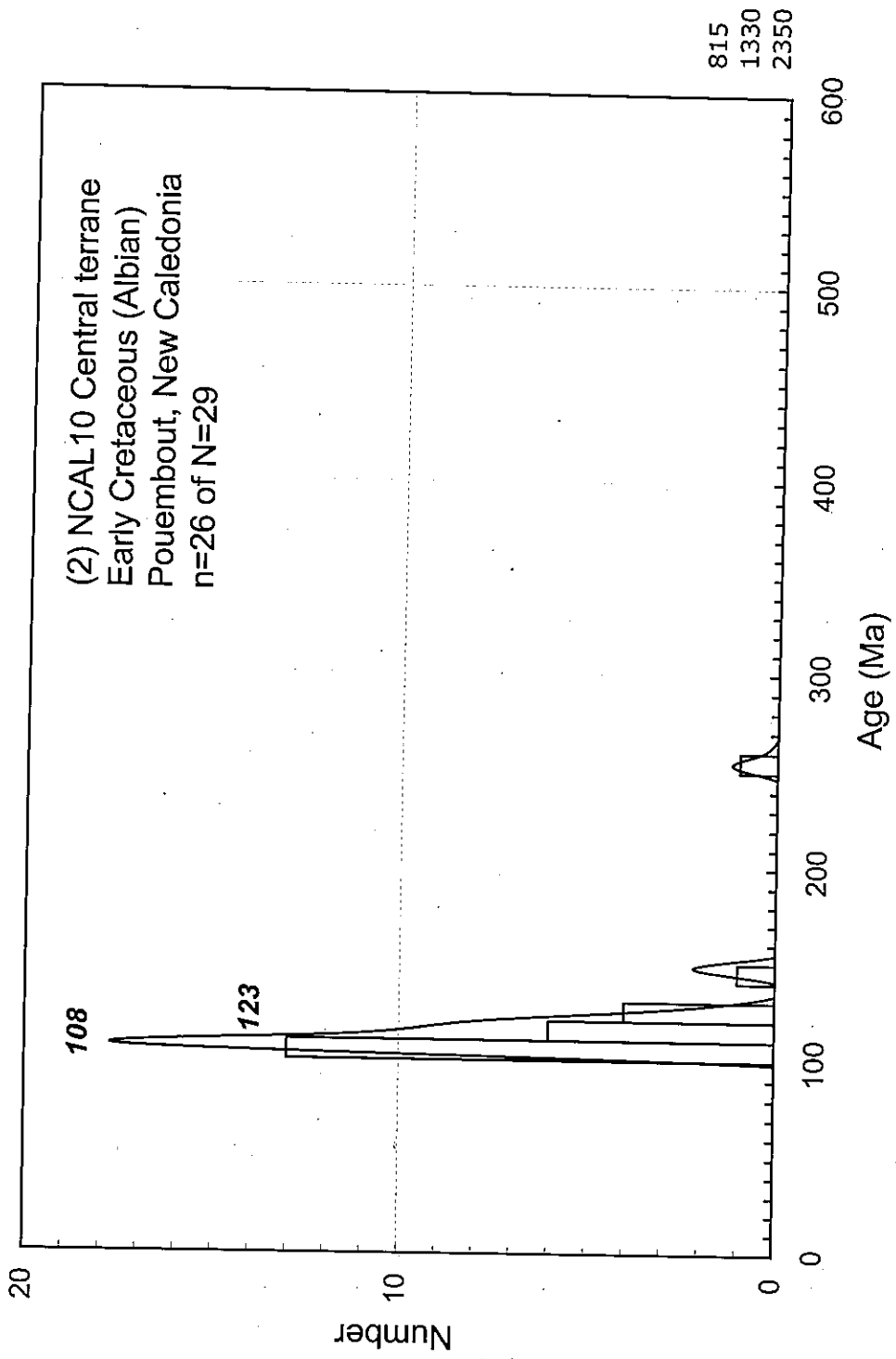
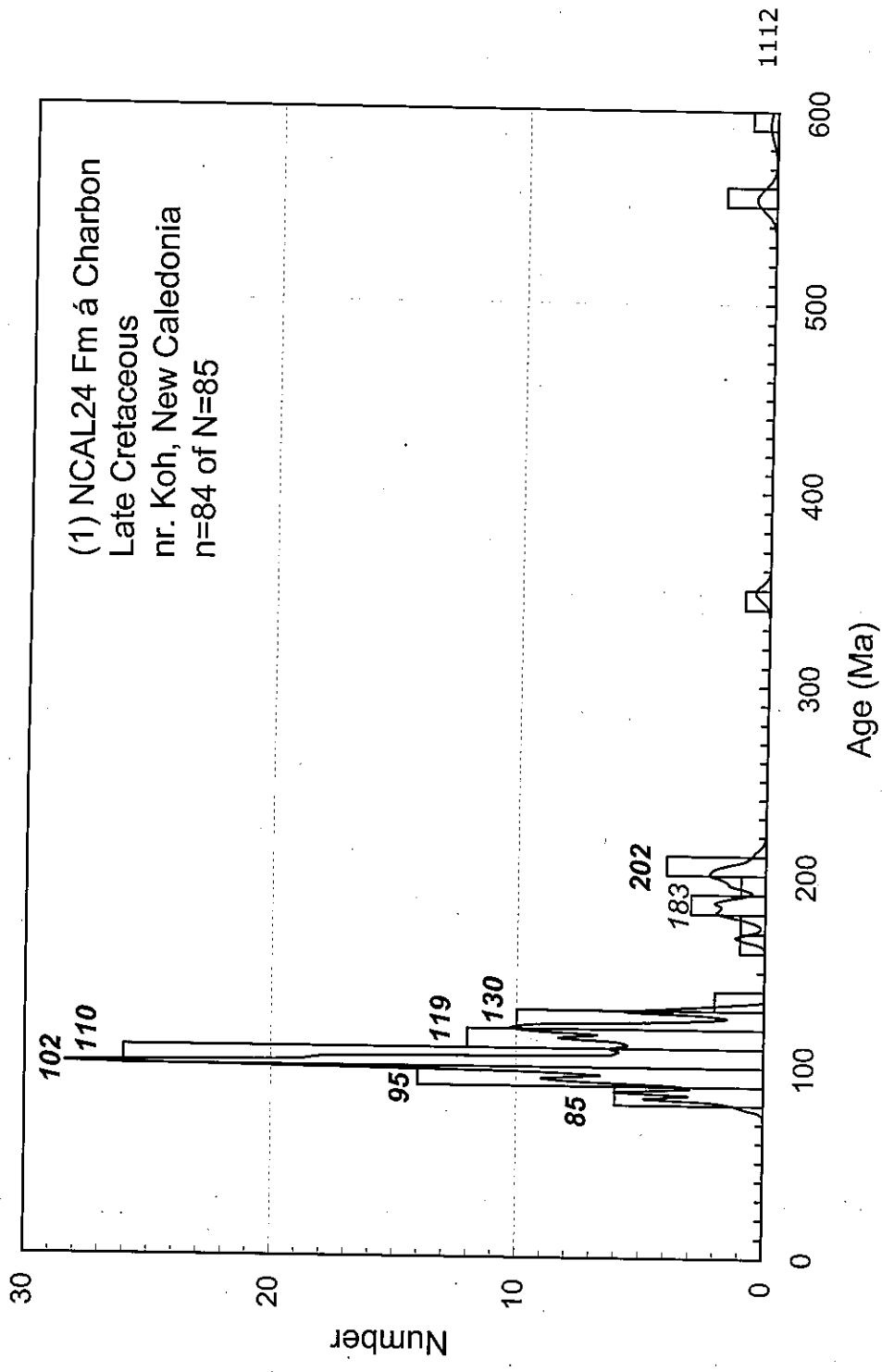


Fig 1

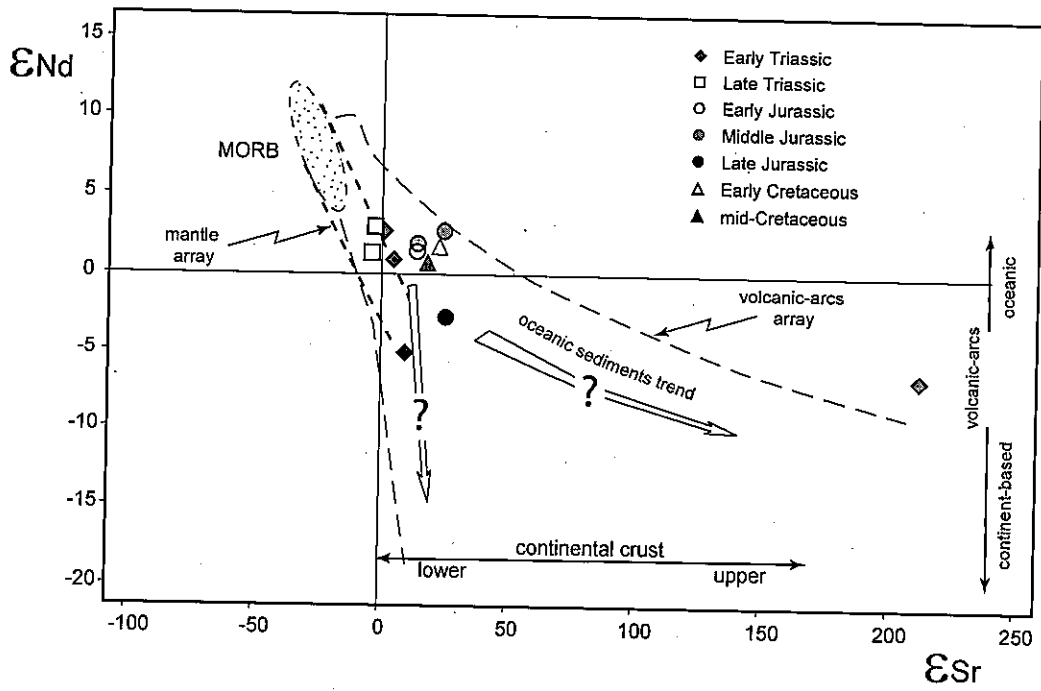








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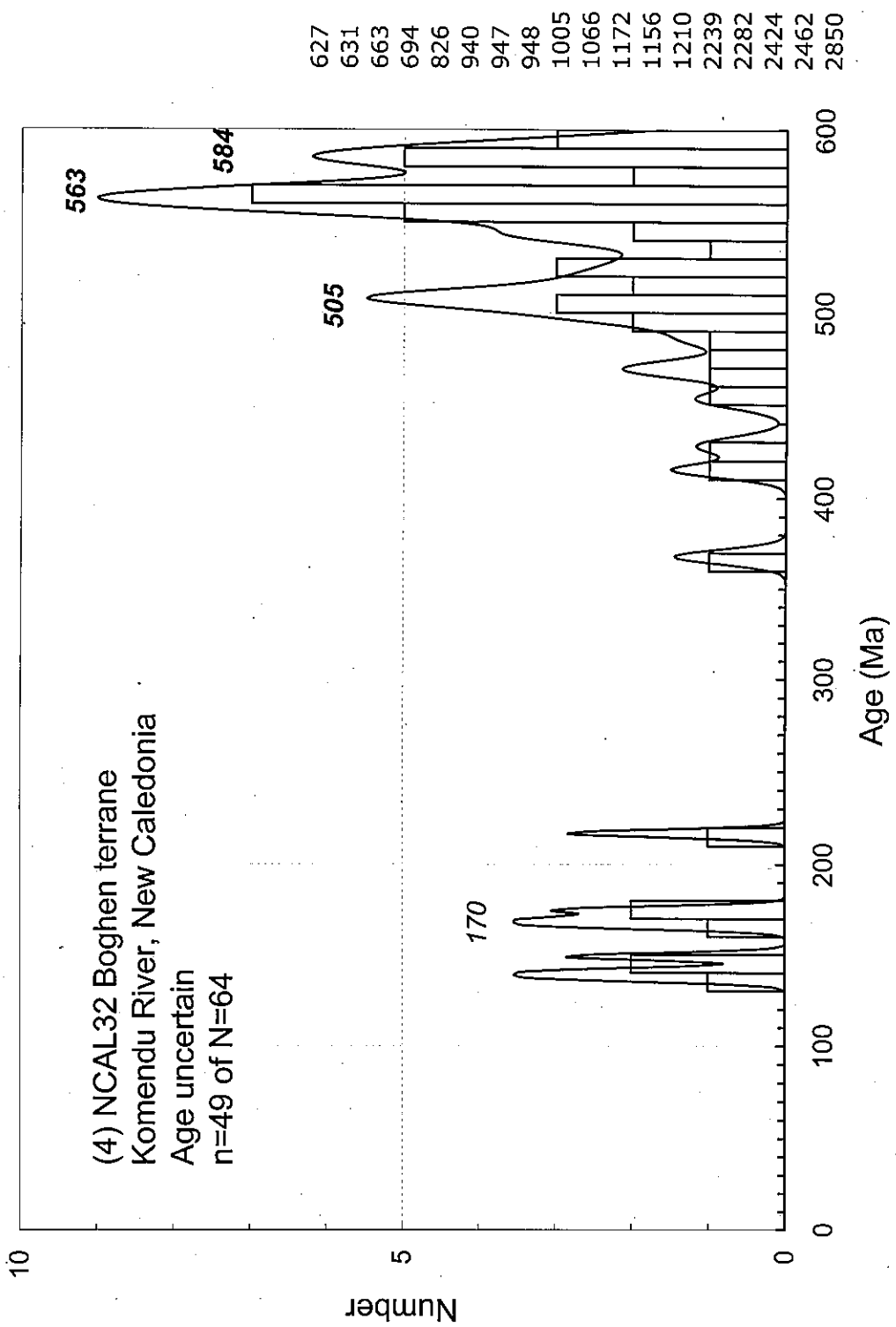


TABLE 4: NEW CALEDONIA MESOZOIC TERRANE SEDIMENTARY ROCKS:
SUMMARY OF DETRITAL ZIRCON U-PB AGE COMPONENTS

Locality No./ zircon component	Detrital zircon age component (Ma)	± 2e	% of total zircon pop.	zircon set total, N
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FORMATION Á CHARBON'

(1) NCAL24 (R23485), sandstone; highway outcrop above Koh village, Late Cretaceous; Lat.21°33'48"S, Long. 165°49'57"E

aa	85 ± 2		6	85
a	95 ± 1		9	
b	102 ± 4		33	
c	110 ± 2		7	
d	119 ± 2		18	
e	130 ± 2		5	
f	183 ± 4		5	
g	202 ± 3		5	

CENTRAL TERRANE

(2) NCAL10 (R23470), greywacke, Pouembout River, streambank outcrop, previously mapped as Late Jurassic; Lat.21°06'41"S, Long.

a	108 ± 2		57	28
b	123 ± 4		18	

(3) NCAL11 (R23471), greywacke; Goipin River, streambank o/c, Late Jurassic; Lat.21°33'48"S, Long. 165°49'57"E

a	162 ± 3		14	59
b	513 ± 5		7	
cc	539 ± 6		7	
c	557 ± 5		7	
d	592 ± 5		8	

(9) GHP1 (R24477), sandstone, Goipin River valley; Late Jurassic; Lat.21°13'23"S Long. 161°16'11"E

a	153	2	10	40
b	585	7	10	40

BOGHEN TERRANE

(4) NCAL32 (R24096), carbonaceous sandstone; Komendou River, streambank o/c, age uncertain; Lat.21°19'26"S, Long. 165°24'40"E

a	170 ± 2		4	67
b	505 ± 4		10	
c	563 ± 6		16	
d	584 ± 5		7	

TEREMBA TERRANE

(5) NCAL15 (R23475), volcaniclastic sandstone; highway near La Foa, roadside outcrop, Middle-Late Triassic; Lat.21°41'31"S, Long. 165°44'50"E

a	227 ± 4		15	47
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Table 3: New Caledonia Permian-Cretaceous basement terranes, greywacke and sandstone sample data

Locality	GNS R No.	Field No.	Rock type	Age	Terrane	Location	Latitude/Longitude
(1)	23485	NCAL24	coarse sandstone	mid-Late Cretaceous	<i>Fm á Charbon</i>	near Koh village	21°33'48"S165°49'57"E
(2)	23470	NCAL10	coarse greywacke	Albian (mapped as Late Jurassic)	Central	Pouembout River	21°06'41"S165°01'25"E
(3)	23471	NCAL11	coarse greywacke	Late Jurassic	Central	Golpin River	21°13'00"S165°14'00"E
(4)	24096	NCAL32	carbonaceous sandstone	<i>uncertain</i>	Boghen	Komendu River	21°19'26"S165°24'40"E
(5)	23475	NCAL15	volcaniclastic sandstone	Middle-Late Triassic	Teremba	near La Foa	21°41'31"S165°44'50"E
(6)	24300	TRB20	medium sandstone	Middle Triassic (Anisian)	Teremba	Col de Boghen, old RT1	21°40'45"S165°39'09"E
(7)	24301	TRB21	coarse sandstone	Middle (Ladinian)-Late Triassic (Norian)	Teremba	Moméa village	21°40'11"S165°38'54"E
(8)	24302	TRB23	coarse sandstone	Late Triassic (Norian-Rhaetian)	Teremba	La Foa, watertank	21°43'21"S165°50'17"E
(9)	24477	GHP2	coarse sandstone	Late Jurassic	Central	Golpin (track to Aoupine)	21°13'23"S165°16'11"E

Table 2: Sr-Nd isotopic data for New Caledonia Teremba and Central terrane greywackes

sample	t in Ma	$(^{143}\text{Nd}/^{144}\text{Nd})$ rock today	$(^{147}\text{Sm}/^{144}\text{Nd})$ rock today	$(^{143}\text{Nd}/^{144}\text{Nd})$ rock at t	CHUR att	$\epsilon\text{Nd}(t)$	$(^{87}\text{Sr}/^{86}\text{Sr})$ rock today	$(^{87}\text{Rb}/^{86}\text{Sr})$ rock today	$(^{87}\text{Sr}/^{86}\text{Sr})$ rock at t	CHUR att	$\epsilon\text{Sr}(t)$
Central Chain and Teremba greywackes											
NCAL 2	170	0.512800	0.2536	0.512518	0.512419	1.93	0.70570	0.1694	0.70529	0.70430	14.1
NCAL 9	105	0.512685	0.2107	0.512540	0.512503	0.73	0.70603	0.2584	0.70565	0.70438	18.1
NCAL 10	140	0.512766	0.2371	0.512549	0.512458	1.77	0.70601	0.0374	0.70595	0.70438	22.4
NCAL 11	150	0.512513	0.2142	0.512303	0.512445	-2.78	0.70642	0.1388	0.70612	0.70432	25.5
NCAL 12	215	0.512926	0.2924	0.512515	0.512361	2.99	0.70429	0.0763	0.70405	0.70425	-2.8
NCAL 13	255	0.512765	0.2448	0.512356	0.512310	0.90	0.70472	0.0546	0.70453	0.70420	4.6
NCAL 14	250	0.512482	0.2620	0.512054	0.512316	-5.12	0.70624	0.3832	0.70487	0.70421	9.5
NCAL 16	225	0.512800	0.2601	0.512417	0.512348	1.34	0.70411	0.0492	0.70395	0.70424	-4.0
NCAL 19	165	0.512858	0.2709	0.512566	0.512426	2.74	0.70620	0.0709	0.70604	0.70431	24.6
NCAL 20	185	0.512765	0.2409	0.512473	0.512400	1.43	0.70531	0.0201	0.70526	0.70428	13.8
NCAL 23	240	0.512295	0.1974	0.512584	0.512329	-6.73	0.72493	1.6896	0.71916	0.70422	212.2
NCAL 25	240	0.512855	0.2464	0.512468	0.512329	2.71	0.70439	0.0345	0.70427	0.70422	0.8

Sr	201.1	149.8	514.4	184	145.4	730	462	442	241.9	244.4	27.08	173.5	91.47	49.8	144
Ta	0.212	0.216	0.203	0.188	0.209	0.206	0.046	0.055	0.111	0.104	0.060	0.198	0.061	0.066	0.226
Tb	0.640	0.576	0.677	0.611	0.634	0.631	0.529	0.588	0.778	0.856	1.122	0.550	0.708	0.592	0.694
Th	6.166	5.102	7.067	5.507	5.314	7.113	0.309	0.343	1.332	1.170	0.537	2.962	0.519	0.529	8.471
Tm	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.739	0.357	0.423	0.417	0.402
Y	26.96	24.05	27.72	25.67	26.45	25.74	21.62	24.97	32.44	35.51	55.79	21.67	26.45	23.23	28.51
Yb	2.447	2.334	2.630	2.413	2.530	2.487	2.025	2.264	2.835	2.932	4.795	2.534	2.948	2.912	2.766
Zr	121.8	121.2	163.8	113.8	110.5	115.5	45.1	52.48	88.7	85.9	73.3	138.0	75.7	76.66	193.8

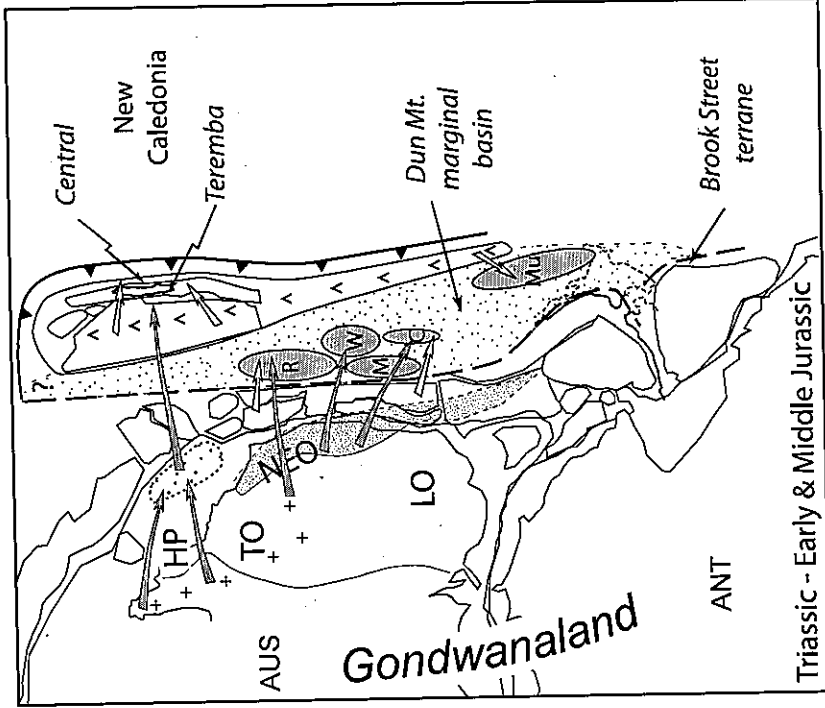
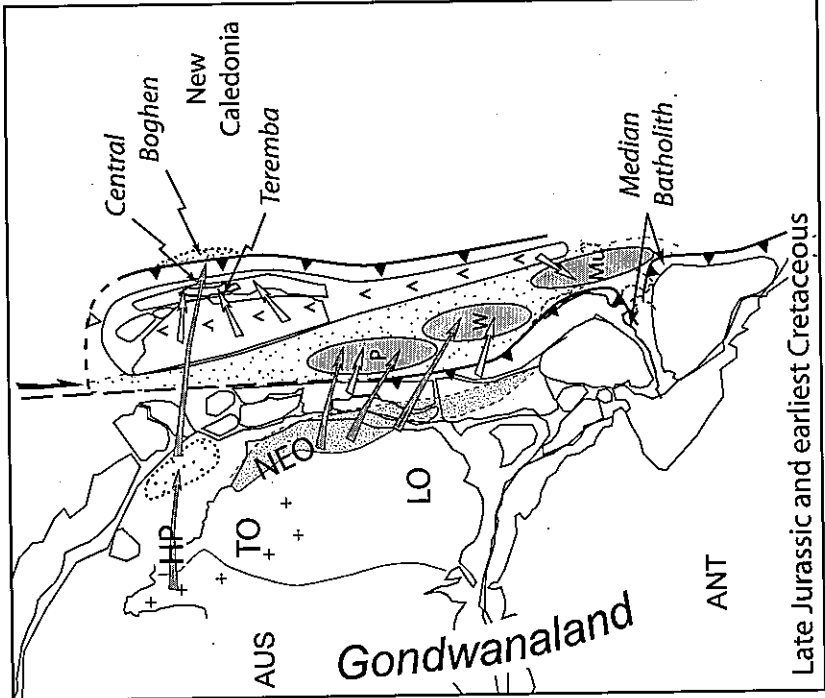
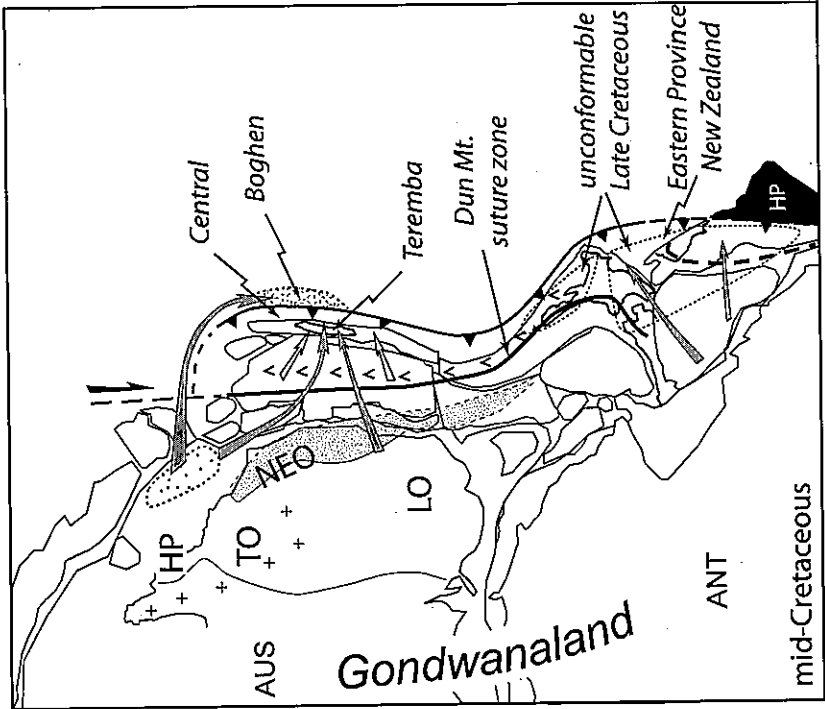
Yb	3.842	2.327	1.642	2.601	2.746	1.761	1.839	2.006	2.703	3.069	3.034	4.769	1.282	2.550
Zr	153.8	162.1	88.89	230	68.72	53.58	46.64	101.4	96.24	170.8	160	91.68	125.5	183.2

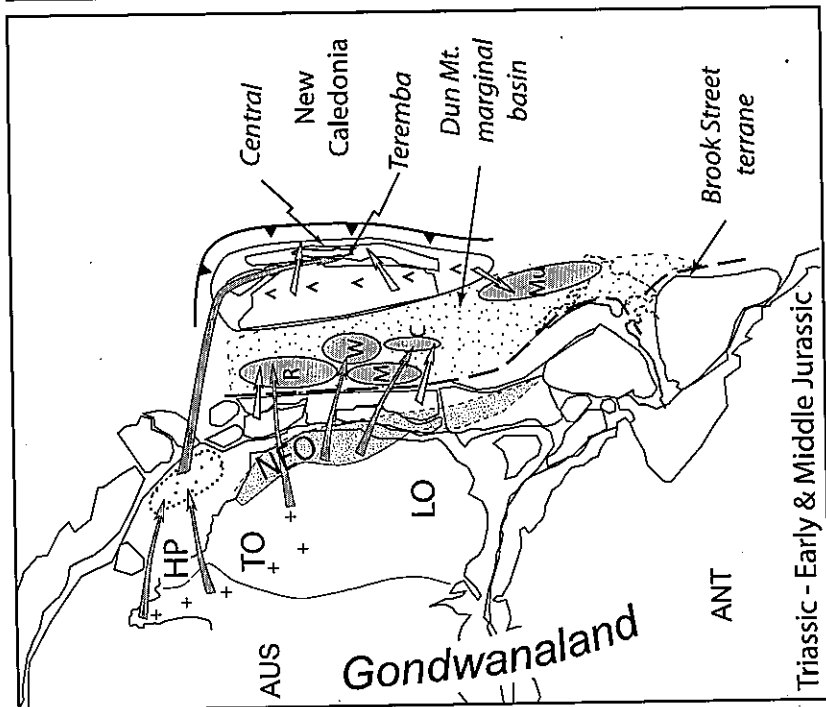
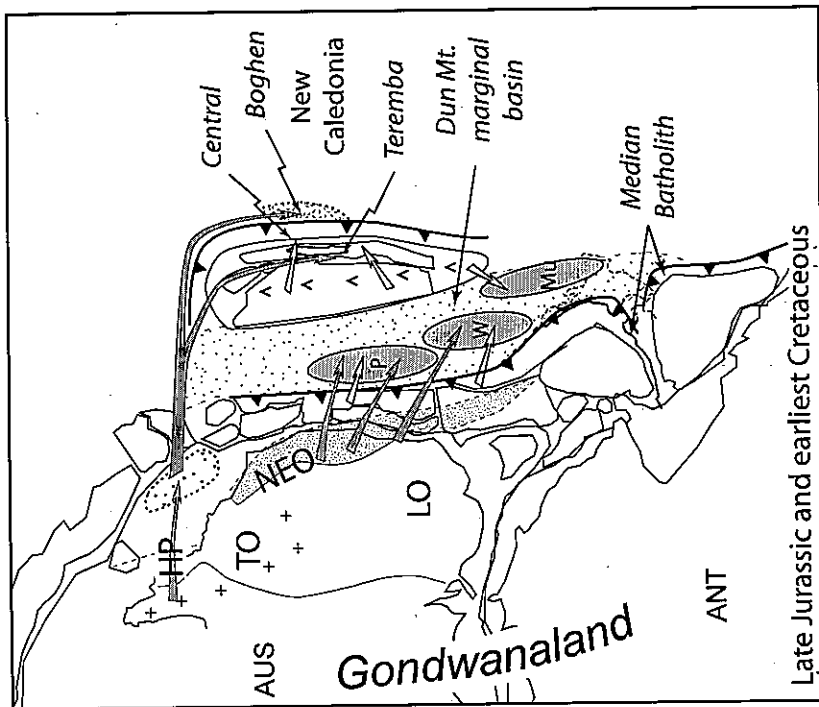
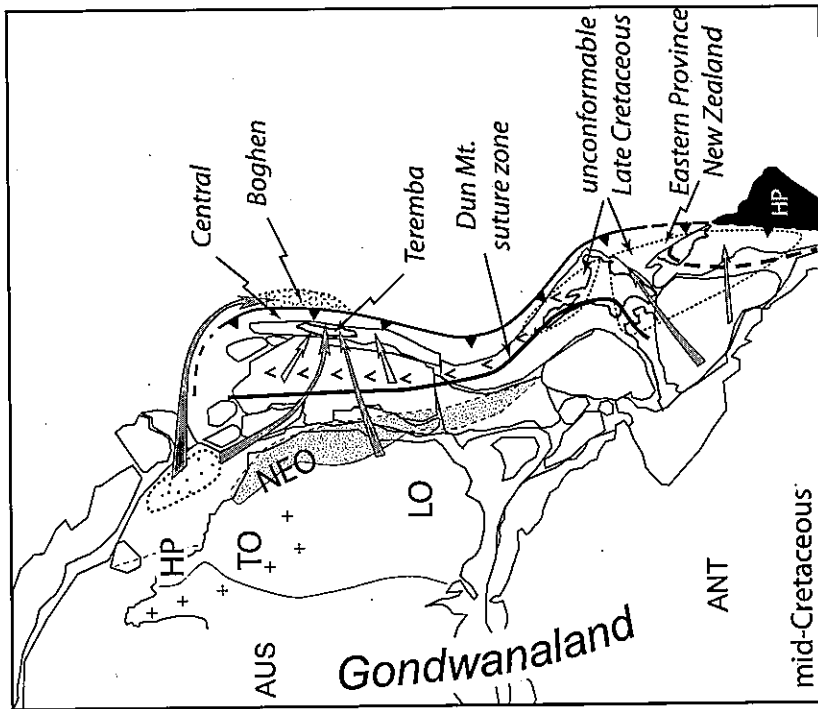
Table 1b: Major and trace element data for New Caledonia Teremba terrane volcanic rocks.

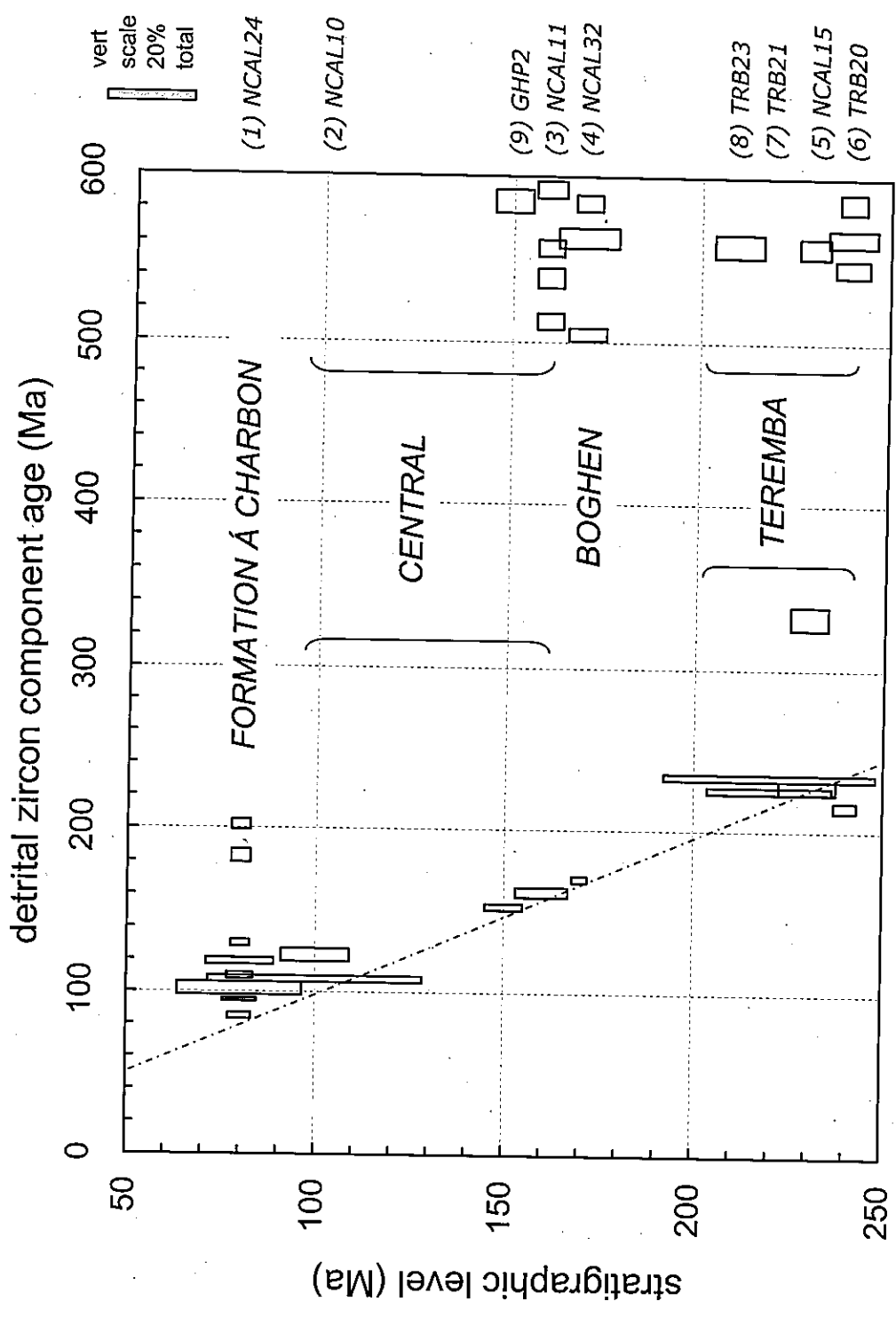
sample	TRB4-1 Teremba	TRB4-2 Teremba	TRB3-1 Teremba	TRB1 Teremba	TRB5-1 Teremba	TRB2-3 Teremba	TRB2-1 Teremba	TRB2-2 Teremba	TRB5-21 Teremba	TRB5-22 Teremba	991 Teremba	1063b Teremba	985a Teremba	985b Teremba	Laf4 Teremba	
Major elements %																
SiO ₂	71.38	74.73	71.48	63.57	67.96	70.64	51.25	48.46	58.80	56.56	77.56	73.89	73.90	74.00	67.60	
TiO ₂	0.43	0.39	0.42	0.59	0.50	0.41	0.94	1.09	1.08	0.96	0.51	0.59	0.62	0.59	0.59	
Al ₂ O ₃	12.90	11.17	13.85	16.90	14.50	15.13	19.61	21.04	15.57	16.76	11.75	12.93	13.53	12.99	15.95	
FeO	3.37	2.71	3.29	4.67	3.83	3.39	9.47	10.49	8.75	9.90	1.29	4.03	2.73	2.78	3.29	
MnO	0.08	0.06	0.06	0.07	0.04	0.06	0.18	0.18	0.23	0.17	0.01	0.05	0.02	0.05	0.08	
MgO	1.01	0.79	1.41	1.61	1.28	1.45	3.95	3.80	2.27	3.69	0.16	0.14	0.51	0.38	0.80	
CaO	2.45	1.73	5.27	4.15	1.90	5.42	9.15	8.85	4.00	4.74	0.08	1.76	0.37	0.73	1.20	
Na ₂ O	4.79	5.34	3.42	5.90	7.29	2.75	5.07	5.70	7.25	6.48	5.40	5.24	5.97	6.61	5.59	
K ₂ O	3.47	2.94	0.62	2.35	2.98	0.59	0.23	0.23	1.90	0.58	0.63	0.53	0.94	0.49	3.39	
P ₂ O ₅	0.10	0.11	0.12	0.17	0.10	0.11	0.09	0.11	0.15	0.12	0.04	0.16	0.16	0.14	0.12	
LOI											1.09	0.75	1.51	1.16	1.87	
Total	98.52	98.52	98.52	98.52	98.52	98.52	98.52	98.52	98.52	98.52	98.52	100.06	100.25	99.91	100.47	
Trace elements ppm																
Ba	372	410	264	247	365	187	56	52	209	92	61	167	114	37	330	
Ce	30.06	29.22	31.840	28.60	28.88	31.272	9.15	10.17	20.69	20.98	12.54	19.96	10.11	8.885	30.96	
Cr	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.100	33.54	6.510	10.62	20.18	
Dy	3.959	3.631	4.207	3.840	3.969	3.909	3.445	3.767	4.964	5.403	7.858	3.587	4.557	4.013	4.393	
Er	2.489	2.292	2.618	2.435	2.528	2.465	2.117	2.322	3.028	3.258	4.994	2.271	2.796	2.614	2.664	
Eu	0.935	0.876	0.963	0.964	0.955	0.944	0.930	0.955	1.329	1.441	1.198	1.151	1.035	0.841	1.020	
Ga	4.104	3.710	4.288	3.769	3.991	3.889	3.068	3.350	4.593	5.071	11.150	11.33	13.41	13.03	13.76	
Gd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	6.022	3.230	4.028	3.353	4.276	
Ge	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.939	1.604	1.218	2.071	1.289	
Hf	3.762	3.707	4.652	3.359	3.373	3.605	1.398	1.639	2.591	2.512	2.401	3.628	2.435	2.420	5.380	
Ho	0.855	0.788	0.905	0.834	0.864	0.843	0.747	0.819	1.079	1.172	1.686	0.751	0.946	0.853	0.912	
La	11.79	10.86	13.31	10.80	11.10	13.10	3.203	3.583	8.363	7.772	4.473	9.555	4.169	3.208	12.92	
Lu	0.387	0.362	0.411	0.374	0.392	0.388	0.314	0.358	0.430	0.437	0.762	0.414	0.463	0.460	0.425	
Nb	2.708	2.743	2.649	2.593	2.718	2.713	0.679	0.779	1.505	1.379	0.661	2.435	0.689	0.663	2.546	
Nd	15.78	14.32	17.29	15.18	15.45	16.83	7.759	8.473	14.30	15.67	12.18	11.99	10.50	8.423	17.15	
Pr	3.793	3.500	4.198	3.575	3.644	4.074	1.506	1.671	3.019	3.191	2.274	2.687	2.036	1.608	4.119	
Rb	68.08	41.42	16.48	46.28	28.74	8.552	3.973	2.718	27.666	8.021	4.978	7.480	9.036	5.243	73.02	
Sm	3.742	3.372	4.006	3.621	3.717	3.846	2.447	2.669	3.955	4.365	4.197	3.042	3.360	2.770	4.137	

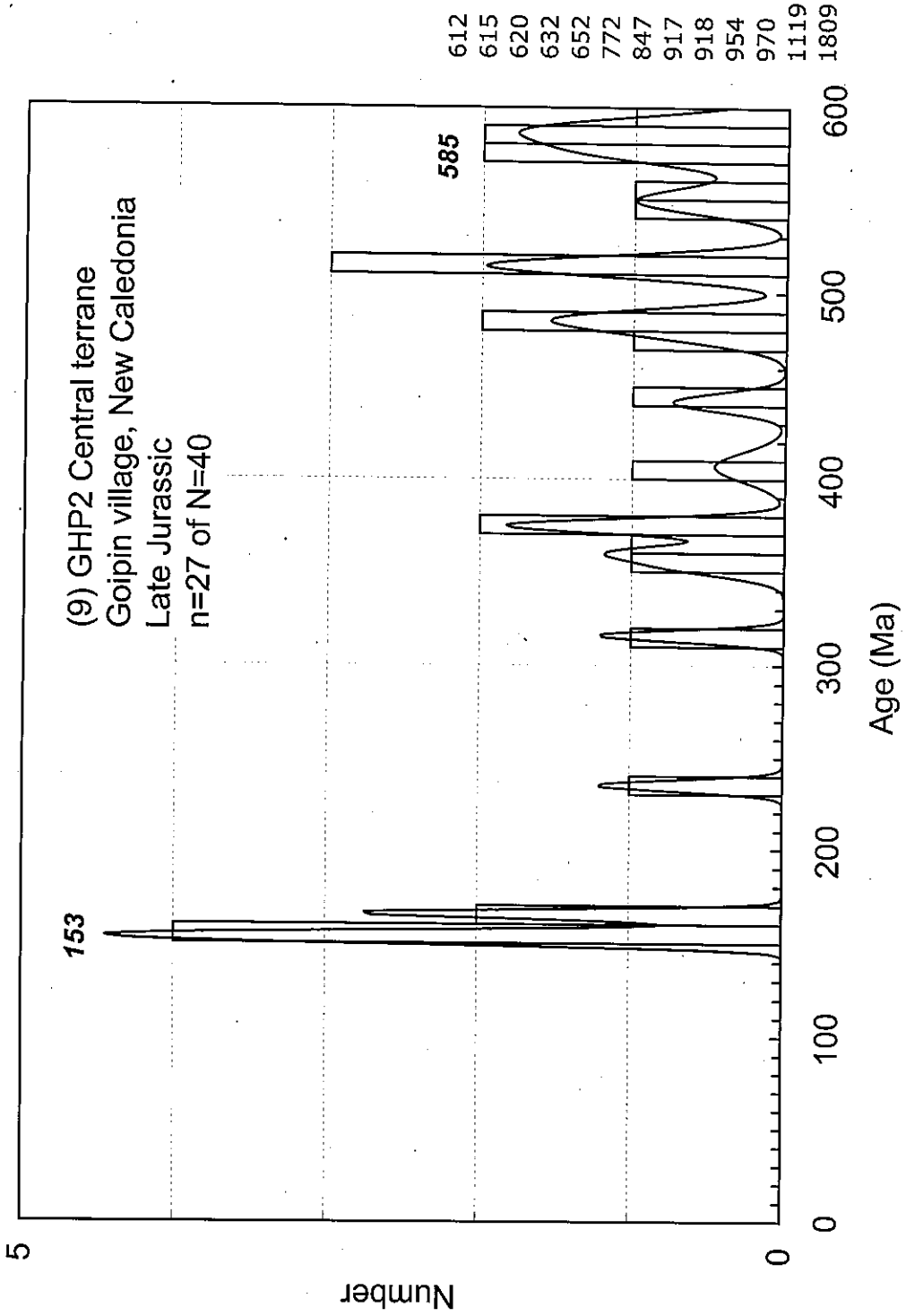
Table 1a: Major and trace element data for New Caledonia Teremba and Central terrane greywackes.

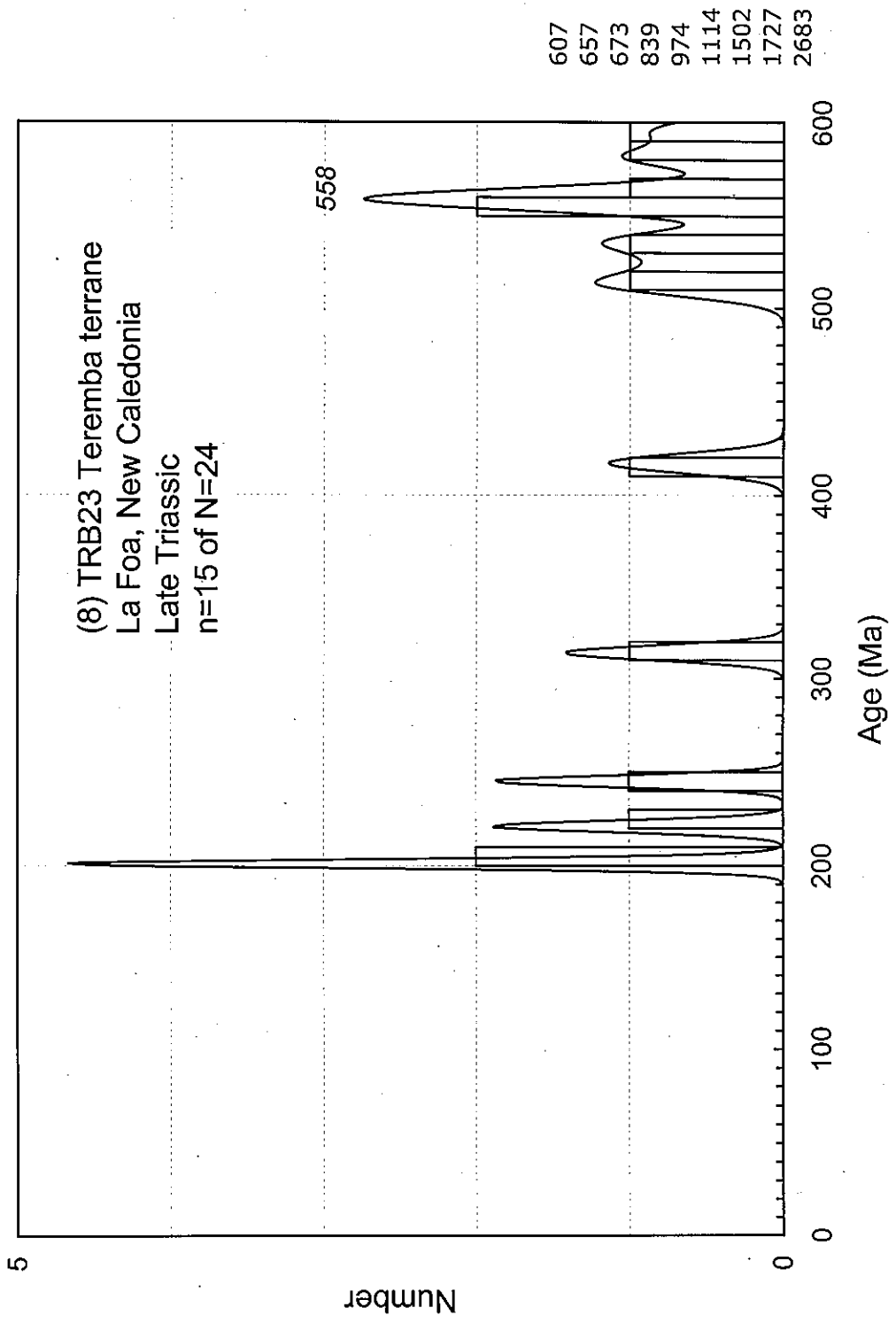
sample	NCAL 2 Central	NCAL 9 Central	NCAL 10 Central	NCAL 11 Central	NCAL 12 Teremba	NCAL 13 Teremba	NCAL 14 Teremba	NCAL 16 Teremba	NCAL 19 Teremba	NCAL 20 Teremba	NCAL 23a Central	NCAL 25 Teremba	NCAL 24 F.Charbon	Laf3 Teremba
Major elements %														
SiO ₂	54.36	63.25	50.53	67.11	57.07	52.04	47.94	38.15	56.04	62.56	59.71	46.94	67.41	65.33
TiO ₂	1.07	0.77	1.04	0.64	0.97	0.40	0.66	0.93	1.07	0.59	0.78	1.00	0.55	2.39
Al ₂ O ₃	18.09	15.23	17.09	13.30	16.03	7.55	11.64	12.56	15.37	14.62	18.55	14.80	12.93	0.62
Fe ₂ O ₃	10.12	5.41	7.74	7.05	8.39	2.95	8.57	7.65	8.24	2.85	7.22	5.52	5.39	16.13
MnO	0.16	0.08	0.12	0.08	0.11	0.19	0.17	0.35	0.19	0.04	0.03	0.28	0.04	4.71
MgO	3.09	2.16	3.75	1.35	3.32	1.45	2.00	2.62	3.39	1.79	1.82	1.29	1.64	0.11
CaO	2.38	2.07	6.01	1.49	3.13	16.79	10.99	19.12	4.27	2.98	0.52	12.80	1.65	1.55
Na ₂ O	5.05	2.77	5.00	3.43	5.11	2.60	1.41	3.14	4.65	2.56	1.43	5.09	2.11	3.70
K ₂ O	0.81	3.31	1.16	1.23	1.17	0.39	2.12	0.70	1.59	1.77	2.53	0.33	4.81	4.33
P ₂ O ₅	0.23	0.22	0.27	0.18	0.24	0.08	0.13	0.42	0.27	0.13	0.21	0.34	0.05	0.12
LOI	4.52	3.35	6.43	3.20	3.36	14.69	13.01	13.97	5.04	9.25	6.27	11.61	3.20	1.55
Total	99.9	98.6	99.1	99.1	98.9	99.1	98.6	99.6	100.1	99.1	99.1	100	99.8	100.5
Trace elements ppm														
Ba	377	530	254	288	215	53	145	159	243	943	399	105	712	303
Ce	41.66	47.42	26.7	43.39	17.39	13.85	12.15	22.62	22.59	34.34	71.76	55.68	38.26	27.85
Cr	19.56	30.01	33.19	28.34	21.23	18.3	18.7	38.43	19.22	5.492	61.72	36.75	76.66	17.17
Dy	6.393	3.96	3.085	4.056	4.568	2.85	2.799	3.486	4.555	4.313	4.823	7.518	2.454	3.868
Er	3.693	2.226	1.709	2.451	2.743	1.71	1.727	2.021	2.737	2.688	2.903	4.502	1.248	2.390
Eu	1.726	1.131	1.242	1.016	1.19	0.679	0.673	1.067	1.381	1.25	1.221	1.865	1.224	1.057
Ga	21.85	20.21	20.58	15.54	17.91	9.671	14.34	17.17	19.1	15.09	25.61	14.8	14.05	17.16
Gd	6.615	4.351	3.43	4.261	4.397	2.871	2.629	3.735	4.558	4.241	5.111	8.671	3.133	3.863
Ge	1.585	1.35	1.402	1.265	1.204	1.506	1.335	1.185	1.578	0.842	1.815	0.727	1.413	1.126
Hf	4.286	4.327	2.429	5.93	2.096	1.447	1.435	2.625	2.726	4.619	4.576	2.409	3.243	4.889
Ho	1.261	0.77	0.597	0.809	0.938	0.586	0.573	0.689	0.922	0.877	0.971	1.525	0.459	0.825
La	17.12	21.21	11.48	18.5	7.017	8.019	6.162	9.574	9.205	13.66	34.68	24.32	17.09	12.14
Lu	0.608	0.375	0.255	0.418	0.431	0.28	0.295	0.321	0.429	0.504	0.47	0.779	0.194	0.405
Nb	4.665	6.859	2.908	6.174	0.961	1.365	1.166	2.058	2.24	4.665	10.15	2.194	3.071	2.105
Nd	24.34	23.01	15.06	21.9	12.23	10.02	8.816	13.8	15.02	18.48	31.82	34.87	20.33	15.99
Pr	5.416	5.718	3.423	5.346	2.493	2.258	1.948	3.089	3.214	4.435	8.407	7.52	5.047	3.663
Rb	21.95	89.68	25.24	38.43	21.85	7.432	42.07	16.05	27.86	32.95	121.5	7.903	98.57	57.53
Sm	6.172	4.848	3.571	4.691	3.576	2.453	2.31	3.589	4.069	4.451	6.282	8.593	4.113	3.810
Sr	129.6	347	675	276.8	278.9	136.1	109.8	326.1	393	1640	71.91	229.4	105.2	268.0
Ta	0.55	0.83	0.32	0.804	0.254	0.238	0.155	0.267	0.221	0.598	0.977	0.283	0.667	0.185
Tb	1.034	0.656	0.51	0.668	0.714	0.454	0.438	0.575	0.728	0.697	1.277	1.277	0.462	0.608
Th	4.02	8.972	2.321	7.805	1.29	1.446	1.249	2.889	1.813	7.161	13.81	1.401	2.594	6.649
Tm	0.551	0.336	0.243	0.377	0.398	0.259	0.261	0.297	0.405	0.428	0.441	0.697	0.188	0.369
Y	35.73	22.15	17.49	22.77	27.59	19.36	17.38	20.3	26.95	24.63	28.13	45.34	11.95	25.74

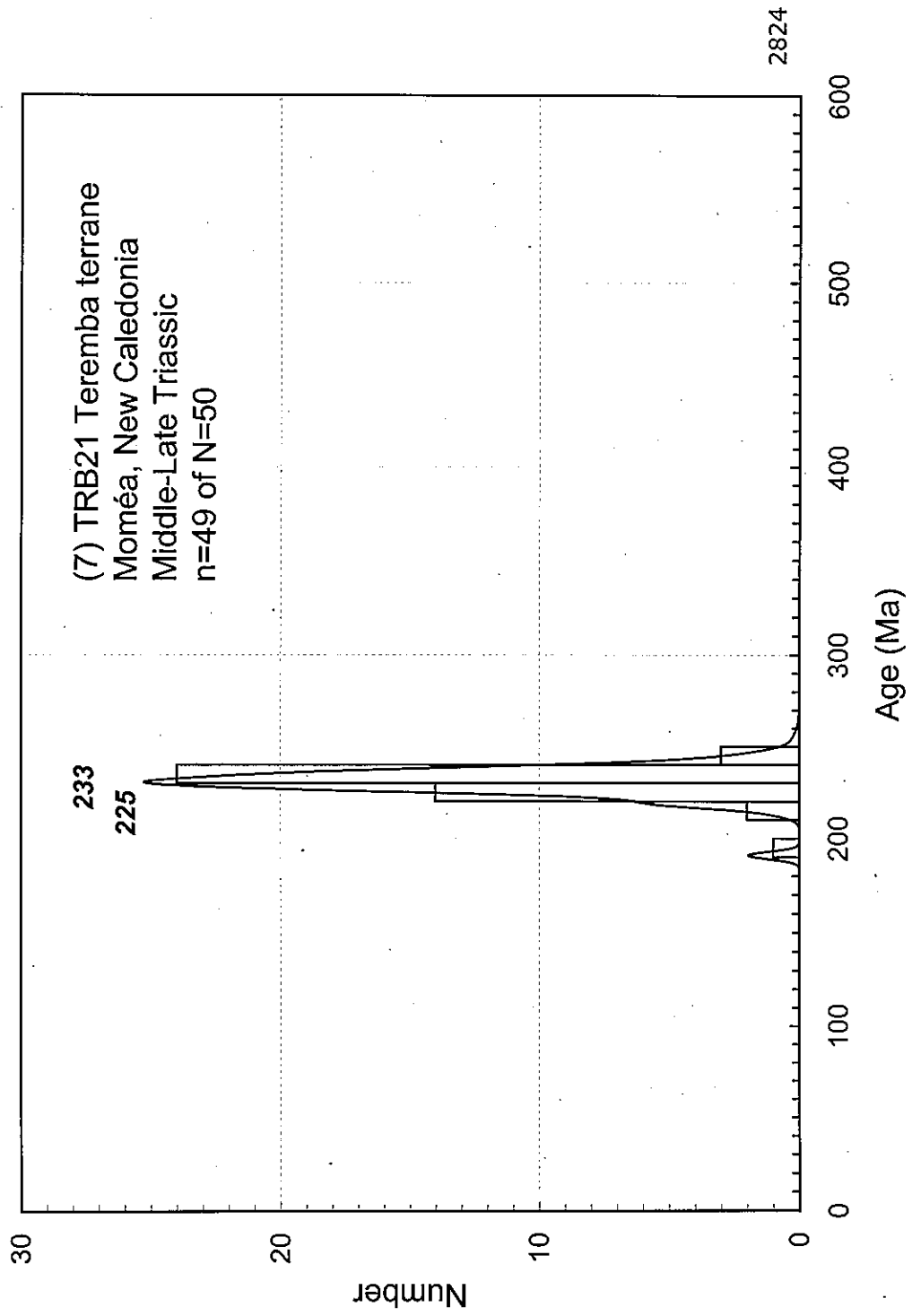


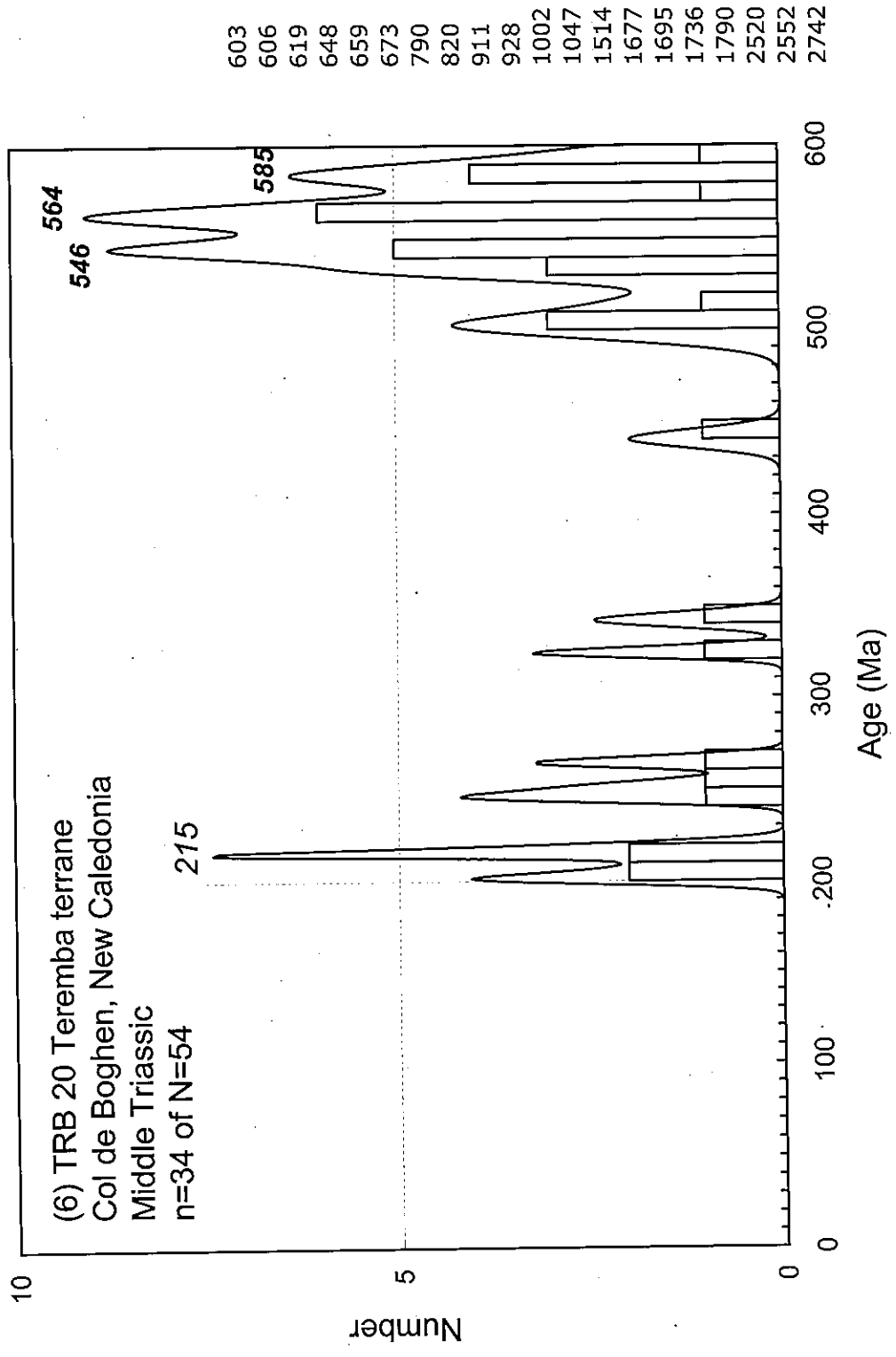


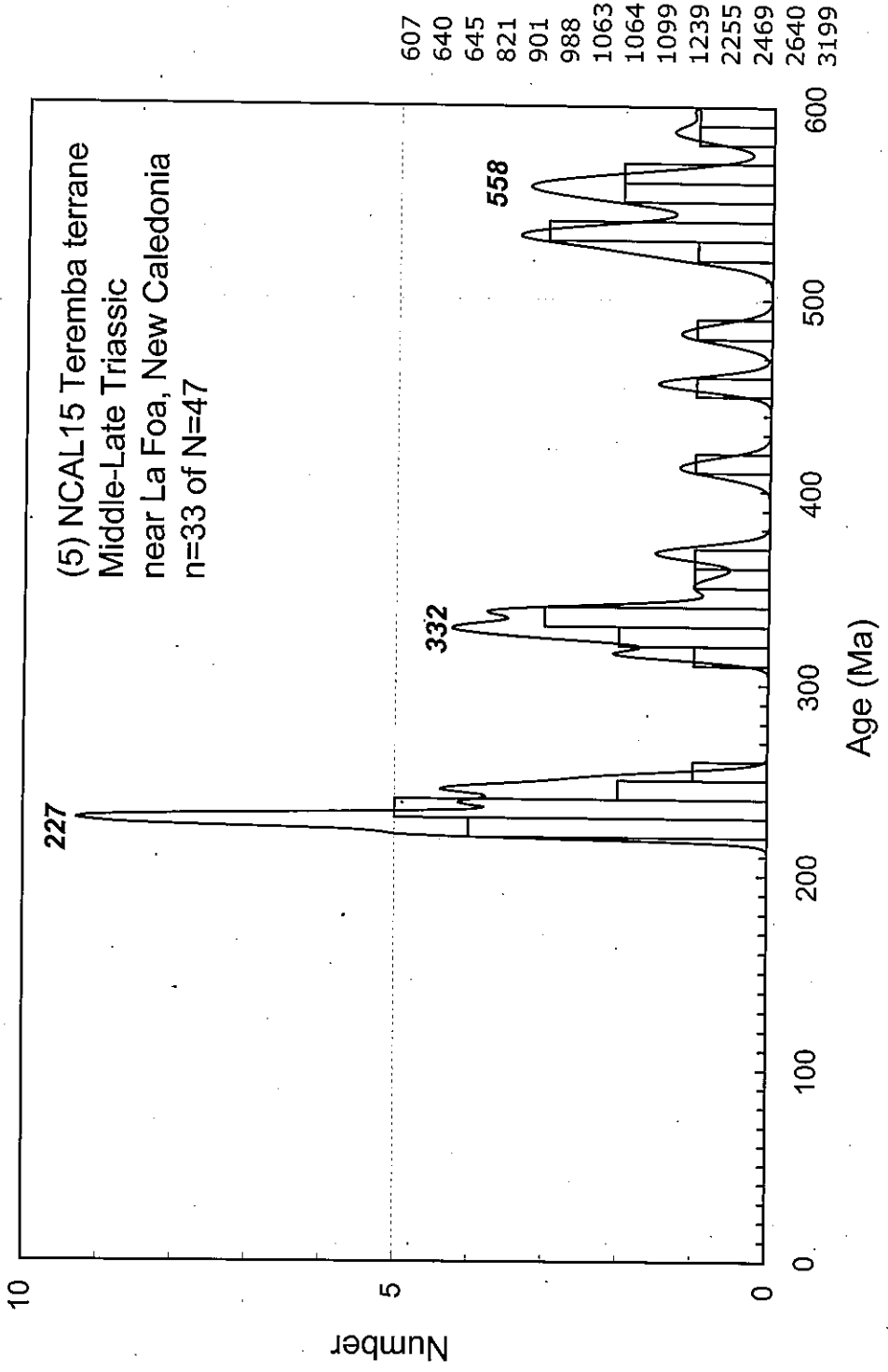












b	332 ± 7	10
c	558 ± 6	8

(6) TRB20 (R4300), sandstone; old highway RT1 at Col de Boghen, roadside outcrop, Middle Triassic (Anisian); Lat. 21°40'45"S Long. 165°39'09"E

a	215 ± 3	6	54
b	546 ± 5	9	
c	564 ± 5	13	
d	585 ± 6	7	

(7) TRB21 (R24301), sandstone, N of Moméa village, roadside outcrop, Middle-Late Triassic (Ladinian-Norian); Lat. 21°40'11"S Long 165°38'54"E

a	225 ± 2	33	45
b	233 ± 2	56	

(8) TRB23 (R24302), sandstone; near La Foa, nr. watertank, Late Triassic (Ladinian-Rhaetian); Lat. 21°43'21"S Long. 165°50'17"E

a	559 ± 7	13	24
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NOTES

Italic numbers in brackets are locality numbers of Table. 1

e standard error

o/c outcrop

version 160109

ANALYST No.	Age	Sex	Height (cm)	Weight (kg)	Waist (cm)	Hip (cm)	Arm span (cm)	Hand span (cm)	Foot length (cm)	Hand length (cm)	Hand width (cm)	Hand area (cm ²)	Hand volume (cm ³)	Hand mass (g)	Hand density (g/cm ³)	Hand mass/area (g/cm ²)	Hand mass/volume (g/cm ³)	Hand mass/density (cm ³)	Hand mass/density/area (g/cm ²)	Hand mass/density/volume (g/cm ³)	Hand mass/density/area/volume (g/cm ³)
NCAL31-1	21	M	170	65	85	95	175	20	20	18	10	150	150	150	150	150	150	150	150	150	
NCAL31-2	22	M	175	70	90	100	180	21	21	19	11	160	160	160	160	160	160	160	160	160	
NCAL31-3	23	M	180	75	95	105	185	22	22	20	12	170	170	170	170	170	170	170	170	170	
NCAL31-4	24	M	185	80	100	110	190	23	23	21	13	180	180	180	180	180	180	180	180	180	
NCAL31-5	25	M	190	85	105	115	195	24	24	22	14	190	190	190	190	190	190	190	190	190	
NCAL31-6	26	M	195	90	110	120	200	25	25	23	15	200	200	200	200	200	200	200	200	200	
NCAL31-7	27	M	200	95	115	125	205	26	26	24	16	210	210	210	210	210	210	210	210	210	
NCAL31-8	28	M	205	100	120	130	210	27	27	25	17	220	220	220	220	220	220	220	220	220	
NCAL31-9	29	M	210	105	125	135	215	28	28	26	18	230	230	230	230	230	230	230	230	230	
NCAL31-10	30	M	215	110	130	140	220	29	29	27	19	240	240	240	240	240	240	240	240	240	
NCAL31-11	31	M	220	115	135	145	225	30	30	28	20	250	250	250	250	250	250	250	250	250	
NCAL31-12	32	M	225	120	140	150	230	31	31	29	21	260	260	260	260	260	260	260	260	260	
NCAL31-13	33	M	230	125	145	155	235	32	32	30	22	270	270	270	270	270	270	270	270	270	
NCAL31-14	34	M	235	130	150	160	240	33	33	31	23	280	280	280	280	280	280	280	280	280	
NCAL31-15	35	M	240	135	155	165	245	34	34	32	24	290	290	290	290	290	290	290	290	290	
NCAL31-16	36	M	245	140	160	170	250	35	35	33	25	300	300	300	300	300	300	300	300	300	
NCAL31-17	37	M	250	145	165	175	255	36	36	34	26	310	310	310	310	310	310	310	310	310	
NCAL31-18	38	M	255	150	170	180	260	37	37	35	27	320	320	320	320	320	320	320	320	320	
NCAL31-19	39	M	260	155	175	185	265	38	38	36	28	330	330	330	330	330	330	330	330	330	
NCAL31-20	40	M	265	160	180	190	270	39	39	37	29	340	340	340	340	340	340	340	340	340	
NCAL31-21	41	M	270	165	185	195	275	40	40	38	30	350	350	350	350	350	350	350	350	350	
NCAL31-22	42	M	275	170	190	200	280	41	41	39	31	360	360	360	360	360	360	360	360	360	
NCAL31-23	43	M	280	175	195	205	285	42	42	40	32	370	370	370	370	370	370	370	370	370	
NCAL31-24	44	M	285	180	200	210	290	43	43	41	33	380	380	380	380	380	380	380	380	380	
NCAL31-25	45	M	290	185	205	215	295	44	44	42	34	390	390	390	390	390	390	390	390	390	
NCAL31-26	46	M	295	190	210	220	300	45	45	43	35	400	400	400	400	400	400	400	400	400	
NCAL31-27	47	M	300	195	215	225	305	46	46	44	36	410	410	410	410	410	410	410	410	410	
NCAL31-28	48	M	305	200	220	230	310	47	47	45	37	420	420	420	420	420	420	420	420	420	
NCAL31-29	49	M	310	205	225	235	315	48	48	46	38	430	430	430	430	430	430	430	430	430	
NCAL31-30	50	M	315	210	230	240	320	49	49	47	39	440	440	440	440	440	440	440	440	440	
NCAL31-31	51	M	320	215	235	245	325	50	50	48	40	450	450	450	450	450	450	450	450	450	
NCAL31-32	52	M	325	220	240	250	330	51	51	49	41	460	460	460	460	460	460	460	460	460	
NCAL31-33	53	M	330	225	245	255	335	52	52	50	42	470	470	470	470	470	470	470	470	470	
NCAL31-34	54	M	335	230	250	260	340	53	53	51	43	480	480	480	480	480	480	480	480	480	
NCAL31-35	55	M	340	235	255	265	345	54	54	52	44	490	490	490	490	490	490	490	490	490	
NCAL31-36	56	M	345	240	260	270	350	55	55	53	45	500	500	500	500	500	500	500	500	500	
NCAL31-37	57	M	350	245	265	275	355	56	56	54	46	510	510	510	510	510	510	510	510	510	
NCAL31-38	58	M	355	250	270	280	360	57	57	55	47	520	520	520	520	520	520	520	520	520	
NCAL31-39	59	M	360	255	275	285	365	58	58	56	48	530	530	530	530	530	530	530	530	530	
NCAL31-40	60	M	365	260	280	290	370	59	59	57	49	540	540	540	540	540	540	540	540	540	
NCAL31-41	61	M	370	265	285	295	375	60	60	58	50	550	550	550	550	550	550	550	550	550	
NCAL31-42	62	M	375	270	290	300	380	61	61	59	51	560	560	560	560	560	560	560	560	560	
NCAL31-43	63	M	380	275	295	305	385	62	62	60	52	570	570	570	570	570	570	570	570	570	
NCAL31-44	64	M	385	280	300	310	390	63	63	61	53	580	580	580	580	580	580	580	580	580	
NCAL31-45	65	M	390	285	305	315	395	64	64	62	54	590	590	590	590	590	590	590	590	590	
NCAL31-46	66	M	395	290	310	320	400	65	65	63	55	600	600	600	600	600	600	600	600	600	
NCAL31-47	67	M	400	295	315	325	405	66	66	64	56	610	610	610	610	610	610	610	610	610	
NCAL31-48	68	M	405	300	320	330	410	67	67	65	57	620	620	620	620	620	620	620	620	620	
NCAL31-49	69	M	410	305	325	335	415	68	68	66	58	630	630	630	630	630	630	630	630	630	
NCAL31-50	70	M	415	310	330	340	420	69	69	67	59	640	640	640	640	640	640	640	640	640	
NCAL31-51	71	M	420	315	335	345	425	70	70	68	60	650	650	650	650	650	650	650	650	650	
NCAL31-52	72	M	425	320	340	350	430	71	71	69	61	660	660	660	660	660	660	660	660	660	
NCAL31-53	73	M	430	325	345	355	435	72	72	70	62	670	670	670	670	670	670	670	670	670	
NCAL31-54	74	M	435	330	350	360	440	73	73	71	63	680	680	680	680	680	680	680	680	680	
NCAL31-55	75	M	440	335	355	365	445	74	74	72	64	690	690	690	690	690	690	690	690	690	
NCAL31-56	76	M	445	340	360	370	450	75	75	73	65	700	700	700	700	700	700	700	700	700	
NCAL31-57	77	M	450	345	365	375	455	76	76	74	66	710	710	710	710	710	710	710	710	710	
NCAL31-58	78	M	455	350	370	380	460	77	77	75	67	720	720	720	720	720	720	720	720	720	
NCAL31-59	79	M	460	355	375	385	465	78	78	76	68	730	730	730	730	730	730	730	730	730	
NCAL31-60	80	M	465	360	380	390	470	79	79	77	69	740	740	740	740	740	740	740	740	740	
NCAL31-61	81	M	470	365	385	395	475	80	80	78	70	750	750	750	750	750	750	750	750	750	
NCAL31-62	82	M	475	370	390	400	480	81	81	79	71	760	760	760	760	760	760	760	760	760	
NCAL31-63	83	M	480	375	395	405	485	82	82	80	72	770	770	770	770	770	770	770	770	770	
NCAL31-64	84	M	485	380	400	410	490	83	83	81	73	780	780	780	780	780	780	780	780	780	
NCAL31-65	85	M	490	385	405	415	495	84	84	82	74	790	790	790	790	790	790	790	790	790	
NCAL31-66	86	M	495	390	410	420	500	85	85	83	75	800	800	800	800	800	800	800	800	800	
NCAL31-67	87	M	500	395	415	425	505	86	86	84	76	810	810	810	810	810	810	810	810	810	
NCAL31-68	88	M	505	400	420	430	510	87	87	85	77	820	820	820	820	820	820	820	820	820	
NCAL31-69	89	M	510	405	425	435	515	88	88	86	78	830	830	830	830	830	830	830	830	830	
NCAL31-70	90	M	515	410	430	440	520	89	89	87	79	840	840	840	840	840	840	840	840	840	
NCAL31-71	91	M	520	415	435	445	525	90	90	88	80	850	850	850	850	850	850	850	850	850	
NCAL31-72	92	M	525	420	440																

TABLE 6A: DETRITAL ZIRCON AGE DATA FOR NEW CALEDONIA: PERCENTAGE PROPORTIONS IN GEOLOGICAL PERIODS

DATA SOURCE	SAMPLE NAME/NO.	Location	Strat. range (Ma)		Zircon percentages in selected age ranges							SAMPLE NAME/NO.	comments	
			young	old	Cret	Juras	Trias	Per	Carb	Dev-Sil	Ord-Cam			Precam
FORMATION À CHARBON														
10 (1)	NCAL24		65	145	82	7	5		1				NCAL24	
CENTRAL TERRANE														
C	PIAMB1				14	14			4				PIAMB1	
C	PIAMB2				100	3							PIAMB2	
C	PIAMB3				82	4							PIAMB3	
10 (2)	NCAL10		145*	157*	3			4					NCAL10	
10 (3)	NCAL11		145	157	3		3		2				NCAL11	
10 (9)	GHP2		145	155		15	3		5				GHP2	
BOGHEM TERRANE														
10 (4)	NCAL32				3	6	1						NCAL32	
C	NCB134					10	10		3	4			NCB134	
C	NCB154				4	13	10		4	4			NCB154	
C	NCB169				7	3	3			4			NCB169	
C	TWK81				19								TWK81	
C	TWKD1									14			TWKD1	
TEREYBA TERRANE														
10 (5)	NCAL15		237*	245*				2	15				NCAL15	
10 (6)	TRB20		241*	245*				4					TRB20	
10 (7)	TRB21		203	241		2	6						TRB21	
10 (8)	TRB23		200	227				4	4	4		2	TRB23	

TABLE 6B: DETRITAL ZIRCON AGE DATA FOR EASTERN QUEENSLAND TERRANES: PERCENTAGE PROPORTIONS IN GEOLOGICAL PERIODS

SHOALWATER - BEENLEIGH COMPOSITE TERRANE														
Shoalwater Terrane														
A	SHW48	Arthur Point							1	10	13		SHW48	
A	SHW13	Hummock Str							10	12	11		SHW13	
K	988	Byfield						3	5	1	19		988	
A	O21/5	Byfield						3	19	5	5		O21/5	
Beenleigh Terrane														
K	983	Miami Beach							4				983	
A	BYR10	Broken Hd							6	14			BYR10	
K	982	Broken Hd							12				982	
Gympie Terrane														
A	GYM36	Kearton	200	241					15	5		3	8	GYM36
A	GYM106	Eldorado Mine	251	260					15	5		3	8	GYM106
Neranwood Fernvale Belt														
K	984	Neranwood								6			984	
SOUTH D'AGUILAR BLOCK														
K	985	Mt. Nebo								3	2		985	
WANDILLA TERRANE														
A	WAN30	Alligator Ck							81	3	3		WAN30	
K	986	Gladstone							97	3			986	
A	WAN1	Gladstone						1	96	3			WAN1	

DATA SOURCES

- 10 this work, data highlighted in bold type
- A Adams, unpublished data
- C Cluzel, unpublished data
- K Korach, unpublished data

- percentage abundance categories
- accessory 1-4% 1-4%
 - minor 5-19% 5-19%
 - major 20-49% 20-49%
 - large 50-79% 50-79%
 - dominant 80-100% 80-100%

Italic numbers in brackets refer to locality numbers of this study (Table 1)

TABLE 5A: DETRITAL ZIRCON AGE DATA FOR NEW CALEDONIA: PERCENTAGE PROPORTIONS IN GEOLOGICAL PERIODS

DATA SOURCE	SAMPLE NAME/NO.	Location	Strat. range (Ma)	young	old	Cret	Juras	Trias	Per	Carb	Dev-Sil	Ord-Cam	Precam	SAMPLE NAME/NO.	comments
FORMATION À CHARBON															
10 (1)	NCAL24		65	145		82	7	5		1				NCAL24	
CENTRAL TERRANE															
C	PIAMB1						14	14		4				PIAMB1	
C	PIAMB2						3							PIAMB2	
C	PIAMB3						100	4						PIAMB3	
10 (2)	NCAL10		145*	157*		82			4					NCAL10	
10 (3)	NCAL11		145	157		3								NCAL11	
10 (9)	GHP2		145	155			15	3		3	2			GHP2	
BOGHEN TERRANE															
10 (4)	NCAL32					3	6	1						NCAL32	
C	NCB134							10	10	3	4			NCB134	
C	NCB154						4	19	10	4	4			NCB154	
C	NCB169							3	3					NCB169	
C	TWKB1						7							TWKB1	
C	TWKD1						19	5						TWKD1	
TEREMBA TERRANE															
10 (5)	NCAL15		227*	245*					2	15	4	13		NCAL15	*mapped as Ladinian, but probably Norian i.e. <227±4 Ma
10 (6)	TRB20		241*	245*					4			17		TRB20	*mapped as Anisian, but probably Norian i.e. <227±4 Ma
10 (7)	TRB21		203	241										TRB21	
10 (8)	TRB23		200	227					4	4		13	2	TRB23	

TABLE 5B: DETRITAL ZIRCON AGE DATA FOR NEW ZEALAND EASTERN PROVINCE TERRANES AND NORTHLAND ALLOCHTHONS: PERCENTAGE PROPORTIONS IN GEOLOGICAL PERIODS

DATA SOURCE	SAMPLE NAME/NO.	Location	Strat. range (Ma)	young	old	Cret	Juras	Trias	Per	Carb	Dev-Sil	Ord-Cam	Precam	SAMPLE NAME/NO.	comments	
NORTHLAND-MOUNT CAMEL ALLOCHTHONS																
A	TK13							7		16	6	4	3	TK13		
A	HOUB							7			2	2		HOUB		
A	KAE012							10	4	3	3	3	1	KAE012		
WAIOTEKA TERRANE																
3	t420		95	108			16	5		6	15	2	2	t420		
PAHAU TERRANE																
7	Ethelton		140	150										Ethelton		
5	HUN4					18	5		10	5	7	13		HUN4		
5	CPOS					13	4		15	5	3	9		CPOS		
9	RUX2		145	160		5			2	9	7			RUX2		
RAKAIA TERRANE																
5	RBW1		205	220					19	6	2	16		RBW1		
2	OTO1		220	230					16	9	4	13		OTO1		
2	HERM2		220	230					18	5	5	15		HERM2		
5	NGO2		220	230					19	4	1	14		NGO2		
5	PUD1		220	230					10	4	1			PUD1		
8	Balmacaan		235	242					14	9	1	12		Balmacaan		
9	SEL4		251	260					5	7	2	15		SEL4		
5	PAR2		251	260					3	1	6	10	13	PAR2		
1	Aviemore								4	3	1	16		Aviemore		
8	KUROW		251	260					7	7	4	16		KUROW		
9	BMOX35								2	7	1	16	10	BMOX35		
Kakahu Terrane																
5	KAK35		251							14	12			KAK35		
Akatarawa Terrane																
5	TAKA10		251							16	19	7		TAKA10		
3	te94		251							16	19	4		te94		
WAIKAPA TERRANE																
3	t44		133	148						19	19	4	10	11	t44	
3	w4		135	152						5	18	11		w4		
3	w1		148	160						5	18	11		w1		
9	TWXX1		148	160						7	3	7	3	TWXX1		
3	w5		144	160						2	3	2	4	w5		
9	TPWX1		150	160						4	2	2	2	TPWX1		
9	TWX1		150	160						13	8	2	2	TWX1		
5	SPE1		150	155						19	9	5	2	SPE1		
5	BLU8A									5	1	10	7	BLU8A		
5	BOIX31									5	3	10	4	BOIX31		
5	ADMX2									2	1	1	4	ADMX2		
9	PKTX1									2	1	1	1	PKTX1		
9	STEPH1		220	230						6		6		STEPH1		
CAPLES TERRANE																
9	QUOX1		220	230						2		14		QUOX1		
9	VON2											5		VON2		
A	WRLB1													WRLB1		
DUN MOUNTAIN-MAITAI TE																
9	STPH12		225	235						16		7	5	STPH12		
9	CST10		235	251										CST10		
6	RODG17		251	260						1		17	11	RODG17		
6	WDX1		251	260						10		17	7	WDX1		
MURIHIKU TERRANE																
9	HURW4		145	160						15				HURW4		
9	ROAR2		210	230						7	12			ROAR2		
9	PIOX5		210	230						4			4	PIOX5		
9	MAT14		251	260							15			MAT14		
BROOK STREET TERRANE																
6	BARZA		160	180						4		5	2	BARZA		
9	MAJX1		251	260						4		6	2	MAJX1		

DATA SOURCES

- 1 Ireland (1992)
- 2 Adams et al. (1998)
- 3 Caswood et al. (1999)
- 4 Caswood et al. (2002)
- 5 Pickard et al. (2000)
- 6 Adams et al. (2002)
- 7 Wandras et al. (2004a)
- 8 Wandras et al. (2004b)
- 9 Adams et al., 2007
- 10 this work, data highlighted in bold type
- A Adams, unpublished data
- C Cluzel, unpublished data

Italic numbers in brackets refer to locality numbers of this study (Table 1)

percentage abundance categories
 accessory 1-4%
 minor 5-19%
 major 20-49%
 large 50-79%
 dominant 80-100%

Analysis No.	Age ^a	Group	Accepted BET (in ascending age order)	Age ^a	Group	Accepted BET (in ascending age order)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	
TR821-15	0.0015	15	657	TR821-16	0.0016	16	658
TR821-16	0.0016	16	658	TR821-17	0.0017	17	659
TR821-17	0.0017	17	659	TR821-18	0.0018	18	660
TR821-18	0.0018	18	660	TR821-19	0.0019	19	661
TR821-19	0.0019	19	661	TR821-20	0.0020	20	662
TR821-20	0.0020	20	662	TR821-21	0.0021	21	663
TR821-21	0.0021	21	663	TR821-22	0.0022	22	664
TR821-22	0.0022	22	664	TR821-23	0.0023	23	665
TR821-23	0.0023	23	665	TR821-24	0.0024	24	666
TR821-24	0.0024	24	666	TR821-25	0.0025	25	667
TR821-25	0.0025	25	667	TR821-26	0.0026	26	668
TR821-26	0.0026	26	668	TR821-27	0.0027	27	669
TR821-27	0.0027	27	669	TR821-28	0.0028	28	670
TR821-28	0.0028	28	670	TR821-29	0.0029	29	671
TR821-29	0.0029	29	671	TR821-30	0.0030	30	672
TR821-30	0.0030	30	672	TR821-31	0.0031	31	673
TR821-31	0.0031	31	673	TR821-32	0.0032	32	674
TR821-32	0.0032	32	674	TR821-33	0.0033	33	675
TR821-33	0.0033	33	675	TR821-34	0.0034	34	676
TR821-34	0.0034	34	676	TR821-35	0.0035	35	677
TR821-35	0.0035	35	677	TR821-36	0.0036	36	678
TR821-36	0.0036	36	678	TR821-37	0.0037	37	679
TR821-37	0.0037	37	679	TR821-38	0.0038	38	680
TR821-38	0.0038	38	680	TR821-39	0.0039	39	681
TR821-39	0.0039	39	681	TR821-40	0.0040	40	682
TR821-40	0.0040	40	682	TR821-41	0.0041	41	683
TR821-41	0.0041	41	683	TR821-42	0.0042	42	684
TR821-42	0.0042	42	684	TR821-43	0.0043	43	685
TR821-43	0.0043	43	685	TR821-44	0.0044	44	686
TR821-44	0.0044	44	686	TR821-45	0.0045	45	687
TR821-45	0.0045	45	687	TR821-46	0.0046	46	688
TR821-46	0.0046	46	688	TR821-47	0.0047	47	689
TR821-47	0.0047	47	689	TR821-48	0.0048	48	690
TR821-48	0.0048	48	690	TR821-49	0.0049	49	691
TR821-49	0.0049	49	691	TR821-50	0.0050	50	692
TR821-50	0.0050	50	692	TR821-51	0.0051	51	693
TR821-51	0.0051	51	693	TR821-52	0.0052	52	694
TR821-52	0.0052	52	694	TR821-53	0.0053	53	695
TR821-53	0.0053	53	695	TR821-54	0.0054	54	696
TR821-54	0.0054	54	696	TR821-55	0.0055	55	697
TR821-55	0.0055	55	697	TR821-56	0.0056	56	698
TR821-56	0.0056	56	698	TR821-57	0.0057	57	699
TR821-57	0.0057	57	699	TR821-58	0.0058	58	700
TR821-58	0.0058	58	700	TR821-59	0.0059	59	701
TR821-59	0.0059	59	701	TR821-60	0.0060	60	702
TR821-60	0.0060	60	702	TR821-61	0.0061	61	703
TR821-61	0.0061	61	703	TR821-62	0.0062	62	704
TR821-62	0.0062	62	704	TR821-63	0.0063	63	705
TR821-63	0.0063	63	705	TR821-64	0.0064	64	706
TR821-64	0.0064	64	706	TR821-65	0.0065	65	707
TR821-65	0.0065	65	707	TR821-66	0.0066	66	708
TR821-66	0.0066	66	708	TR821-67	0.0067	67	709
TR821-67	0.0067	67	709	TR821-68	0.0068	68	710
TR821-68	0.0068	68	710	TR821-69	0.0069	69	711
TR821-69	0.0069	69	711	TR821-70	0.0070	70	712
TR821-70	0.0070	70	712	TR821-71	0.0071	71	713
TR821-71	0.0071	71	713	TR821-72	0.0072	72	714
TR821-72	0.0072	72	714	TR821-73	0.0073	73	715
TR821-73	0.0073	73	715	TR821-74	0.0074	74	716
TR821-74	0.0074	74	716	TR821-75	0.0075	75	717
TR821-75	0.0075	75	717	TR821-76	0.0076	76	718
TR821-76	0.0076	76	718	TR821-77	0.0077	77	719
TR821-77	0.0077	77	719	TR821-78	0.0078	78	720
TR821-78	0.0078	78	720	TR821-79	0.0079	79	721
TR821-79	0.0079	79	721	TR821-80	0.0080	80	722
TR821-80	0.0080	80	722	TR821-81	0.0081	81	723
TR821-81	0.0081	81	723	TR821-82	0.0082	82	724
TR821-82	0.0082	82	724	TR821-83	0.0083	83	725
TR821-83	0.0083	83	725	TR821-84	0.0084	84	726
TR821-84	0.0084	84	726	TR821-85	0.0085	85	727
TR821-85	0.0085	85	727	TR821-86	0.0086	86	728
TR821-86	0.0086	86	728	TR821-87	0.0087	87	729
TR821-87	0.0087	87	729	TR821-88	0.0088	88	730
TR821-88	0.0088	88	730	TR821-89	0.0089	89	731
TR821-89	0.0089	89	731	TR821-90	0.0090	90	732
TR821-90	0.0090	90	732	TR821-91	0.0091	91	733
TR821-91	0.0091	91	733	TR821-92	0.0092	92	734
TR821-92	0.0092	92	734	TR821-93	0.0093	93	735
TR821-93	0.0093	93	735	TR821-94	0.0094	94	736
TR821-94	0.0094	94	736	TR821-95	0.0095	95	737
TR821-95	0.0095	95	737	TR821-96	0.0096	96	738
TR821-96	0.0096	96	738	TR821-97	0.0097	97	739
TR821-97	0.0097	97	739	TR821-98	0.0098	98	740
TR821-98	0.0098	98	740	TR821-99	0.0099	99	741
TR821-99	0.0099	99	741	TR821-100	0.0100	100	742

MEASURED ISOTOPIC RATIOS
 Analysis No. Age^a Group Accepted BET (in ascending age order)
 (1) (2) (3) (4)

ACCEPTED BET (in ascending age order)
 Analysis No. Age^a Group Accepted BET (in ascending age order)
 (1) (2) (3) (4)

ACCEPTED BET (in ascending age order)
 Analysis No. Age^a Group Accepted BET (in ascending age order)
 (1) (2) (3) (4)

Notes:
 * Ages < 1000 Ma are ²³⁸U/²³⁵U data
 ** discordant data
 Values from the number of atoms, and their increase of total, in selected analytical periods.

version 0.10