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Supplementary Material

Continental scale geographic change across Zealandia during Paleogene subduction initiation

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Data

Details of drilling, sampling, and analyses during IODP Expedition 371 are published in the voyage report (Sutherland et al., 2019). We use the ETOPO1 global topography dataset (Figs. 1a, 1b), and separately analyze bedrock elevations beneath ice (Lythe and Vaughan, 2001) to those that include the ice surface. The CRUST1.0 dataset (Laske et al., 2013) is a synthesis of crustal geophysical data that partly uses isostacy arguments to interpolate through regions of no data, and clearly resolves Zealandia as significantly different to other continents (Fig. 1c).

New Caledonia

Geological evidence from New Caledonia was used to construct elements of Figures 2, 3, and 4, so we briefly review evidence here. Our tectonic model (Figs. 3 & 4) is a single hypothesis for how plate boundaries evolved during the time of interest, and we recognize that competing hypotheses exist. We simplify and restrict our discussion to what we think are key observations. Details of plate boundaries shown in Figures 3 and 4 should be taken as tentative (they are cartoons) and are not critical to our conclusions, because our primary focus is observational and our goal is to describe how continental paleogeography of northern Zealandia developed during the Eocene-Oligocene. Of key significance is that we require a geodynamic explanation for large far-field geographic changes. Any future models of New Caledonia need also to explain our observations.

Blueschist (and locally eclogite) metamorphism of the Pouebo Terrane in northern Grande Terre provides direct evidence for high-pressure low-temperature (HPLT) metamorphism that likely reflects early stages of subduction initiation (Cluzel et al., 2001). The onset of HPLT metamorphism is constrained by detrital zircons and prograde mica growth to be during the period 55-50 Ma (Pirard and Spandler, 2017; Vitale-Brovarone et al., 2018). Peak metamorphism at ~44 Ma is dated by zircon growth (Spandler et al., 2005), and subsequent rapid exhumation and cooling until ~34 Ma is determined from Ar-Ar, U-Th/He, and fission-track thermochronology (Baldwin et al., 2007). Exhumation was associated with southwestward emplacement of basalt (Poya) and ultramafic (Peridotite) nappes (Aitchison et al., 1995), and deposition of a thick clastic 'flysch' sequence now exposed on the southwest coast of New Caledonia (Dallanave et al., 2018; Maurizot, 2012; Maurizot and Cluzel, 2014).

Dolerite and basalt of the Poya Terrane reveal a history of seafloor spreading northeast of New Caledonia. Fossil ages from associated abyssal sediments suggest crust formation during the interval 84–55 Ma (Cluzel et al., 2001), and the youngest radiometric ages of basalt cluster at 54 ± 5 Ma (Cluzel et al., 2017). This is similar to the ~83-53 Ma history of seafloor spreading in the Tasman Sea, which is known from magnetic anomaly interpretation (Gaina et al., 1998). It is not clear what the geometry of Poya spreading was, but in our model we assume it was slow spreading at an isolated ridge with a direction of opening similar to that proposed for the Louisiade Trough, which is northwest of New Caledonia and was connected to Coral Sea and Tasman Sea spreading at a triple junction (Fig. 3A) (Gaina et al., 1999).

The ultramafic Peridotite Nappe lies on top of the Poya Terrane. Boninite and felsic dykes with ages 55-50 Ma intrude the Peridotite Nappe, but not the Poya Terrane (Cluzel et al., 2016), and amphibolite along the sole of the Peridotite Nappe has an age of ~56 Ma (Cluzel et al., 2012). The depleted nature of the Peridotite Nappe and suprasubduction geochemical signature, combined with a lack of similar dikes in the Poya Terrane, make it unlikely that the two nappes are genetically linked; and we do not mean to imply that they are genetically linked in our drawing of Figure 4.

In our model (Fig. 3), a regional increase in northeast-southwest directed compressional tectonic stress is invoked at ~56-53 Ma that triggered a series of events: cessation of Tasman, Coral Sea, and Poya seafloor spreading; onset of local convergence that caused HPLT metamorphism; and initial dismemberment of the hot and thin Poya ridge lithosphere, which resulted in local melt production and metamorphism in rocks that it was thrust into contact with. We purposefully avoid trying to draw details on the cross-section through New Caledonia at this time (~56-53 Ma), because these details are outside the scope of this paper. Of key significance for our work is that we propose the event triggered a Subduction Rupture Event (SRE) that led to delamination and slab formation and hence subsidence of New Caledonia Trough and uplift of Lord Howe Rise. We infer that processes were 3D in nature: lateral propagation of the SRE and then roll-back of the slab, which swept eastward across the region (Figs. 3 and 4). We require crustal delamination and mantle circulation around an evolving subducted slab that dipped southwest beneath northern Zealandia to explain the scale and timing of large elevation changes 300-600 km southwest of the paleo-trench (Figs. 3 and 4), which was likely close to Norfolk Ridge. We assume that prograde metamorphism and crustal root growth was occurring at 50 Ma (Fig. 4B), associated with strong coupling to the newly foundering slab. By 40 Ma (Fig. 4C), roll-back of the slab resulted in decoupling and isostatic rebound of the crustal root, topography development, and hence nappe emplacement to the southwest (and northeast into the paleo-trench?) and extensional faulting along the northeastern margin of New Caledonia.

Most alternate plate boundary models were devised to explain nappe emplacement in New Caledonia, and the timing of fossil arcs and back-arc basins. In one variant, northeast-dipping subduction results in Eocene collision of Zealandia with the trench, inducing nappe emplacement in New Caledonia and subduction polarity reversal (Aitchison et al., 1995; Cluzel et al., 2001; Sdrolias et al., 2004). In another variant, southwest-dipping subduction northeast of Norfolk Ridge induces northeast-dipping subduction during the Eocene, which results in collision of Zealandia with the new trench (Crawford et al., 2003; Schellart et al., 2006; Whattam et al., 2008). It is outside the scope of this paper to review all alternate tectonic hypotheses, and we refer the reader to previous review papers (Collot et al., 2019; Matthews et al., 2015). We don't see how any of these models can explain our observations, but believe that variants of our model can be made consistent with the geology of New Caledonia. We do not accept that the observed nappe emplacement directions require northeast-dipping subduction. We argue, in a similar way to some previous authors (Lagabrielle et al., 2013), that it is possible to emplace large nappes towards the southwest if sufficient topography is generated. If subduction dipped southwest, forearc ridge topography could be generated by elastic and viscous strength (ridge-trench paired anomalies), or/and isostatic rebound following crustal thickening and slab rollback. Emplacement of allochthons in the same direction as slab dip is demonstrably possible and happened during a later (~25-23 Ma) part of this regional event: subduction initiation in the southern Kermadec forearc resulted in a west-dipping slab and a nappe emplaced towards the west from a forearc ridge (Sutherland et al., 2009).

Paleogeography

Paleogeography maps (Fig. 3) are constructed based on present day bathymetry (Fig. 2), and paleobathymetry determined from fossils in samples collected during IODP Expedition 371, and DSDP Legs 21 and 90. Northwest New Zealand (Reinga Basin, southern New Caledonia Trough, Taranaki; Fig. 2) paleogeography is constrained by seismic reflection interpretations tied to petroleum exploration wells (Bache et al., 2012; Baur et al., 2014). Limestones and flysch exposed onshore in New Caledonia provide constraints on past geography (Dallanave et al., 2018; Maurizot, 2012; Maurizot and Cluzel, 2014). In the northwestern area (Kenn Plateau to Fairway Basin), dredge samples and seismic stratigraphy provide constraints (Exon et al., 2006; Rouillard et al., 2017). Paleolatitude lines are computed from the Australian apparent polar wander path (Veevers and Li, 1991).

Paleodepth estimates are based on shipboard analyses of benthic foraminifera and ostracod assemblages from core catcher samples, and additional shore-based analysis of samples from Sites

U1506, U1507, U1508, U1509 and U1510. The voyage report (Sutherland et al., 2019) contains paleontological data (also available via online IODP databases), and details of sample preparation methods, taxonomic identification, and paleodepth inferences. To assess proximity to land, planktic/benthic foraminiferal ratios are calculated (Murray, 1991) and palynological assemblages analyzed. Within the latter, dinoflagellate cyst (dinocyst) taxa are characteristic for different habitats within proximal-to-distal continental shelf transects. Here, our interpretation follows established frameworks for (Paleogene) dinocyst assemblages (Brinkhuis, 1994; Dale, 1996; Dale and Dale, 1992; Frieling and Sluijs, 2018; Pross and Brinkhuis, 2005; Sluijs and Brinkhuis, 2009; Sluijs et al., 2005). Differential abundances of indicative taxa are used to reconstruct changes in coastal proximity (relative sea level) and offshore transport. The relative abundance of terrestrial versus marine palynomorphs ([terrestrial palynomorphs] / [terrestrial + marine palynomorphs] *100% = TM%, e.g., refs (Crouch et al., 2003; Sluijs and Dickens, 2012)) is used to further substantiate this signal, as this quantifies transport from land relative to marine dinocyst production. Final paleobathymetric estimates are constrained taking into account assemblage composition, as well as the depth-distribution and upper and lower depth limits of selected taxa (see IODP database, voyage report, and text below).

At Site U1506 (Lord Howe Rise North, present water depth 1494 m), shallow water is inferred from the contents of a Neptunian dyke within a basalt flow at the base of the sedimentary sequence. The Neptunian dike contains a mixed assemblage of marine fossils, including red algae, charophyte and possible dacyclad green algae, bivalves, ostracods, foraminifers, rare calcareous nannofossils, rare echinoderm spines, and rare recrystallized bryozoans. The assemblage indicates a shallow-water carbonate platform paleoenvironment. The occurrence of calcareous nannofossils *Reticulofenestra* spp., *Dictyococcites* spp., and *C. floridanus* in the Neptunian dyke indicates an age younger than 50.50 Ma (early Eocene); but the assemblage in basal chalk, which immediately overlies the basalt, includes *Chiasmolithus gigas* and indicates Subzone NP15b (44.12–45.49 Ma, middle Eocene). The combined benthic foraminiferal assemblage in the chalk indicates a middle bathyal paleodepth, based on the common occurrence of taxa with an upper depth limit of 500-700 m (*Nuttallides truempyi* and *Bulimina tuxpamensis*, the latter being more abundant at lower bathyal paleodepths than at Site U1506 (Tjalsma and Lohmann, 1983; Van Morkhoven et al., 1986; Widmark, 2000)) and common bathyal to abyssal taxa such as *Elphidium hampdenense* or *Cibicidoides truncanus* (Van Morkhoven et al., 1986). Ostracods are consistent with this middle Eocene paleodepth interpretation, but the occurrence of *Cletocythereis rastromarginata* in low abundance (4%) indicates limited downslope transport from a "shallow/shelf" (Ayress, 1995; Yasuhara and Okahashi, 2015).

At Site U1508, Oligocene (26-23 Ma) chalk (321.5-379.3 m bsf) contains a middle to lower bathyal benthic foraminiferal fauna with common *Osangularia culter* (500-1500 m) (Hermelin, 1989), *Trifarina brady* (100-1000 m) (Hayward, 2010), *Cibicides lobatulus* (usually <1000 m, but epiphytic and possibly transported downslope) (Alegret et al., 2008; Van Morkhoven et al., 1986), and *Cibicidoides mundulus* (upper depth limit 1300 ± 300 m) (Hayward et al., 2004); mixed with neritic taxa (*Planorbulina zelandica*, *Amphistegina*, and large, ~1 mm *Lenticulina*) that were transported downslope. The ostracod assemblage includes *Paracytheridea sp*., which indicates lagoon, reef, or coastal environments (Ben Rouina et al., 2016; Eagar, 1999; Mostafawi et al., 2005; Munef et al., 2012; Swain, 1949; Whatley and Watson, 1988), and a minor contribution of shallow-water taxa (*Hemicytherura* spp., *Semicytherura* spp., *Loxoconcha* spp., *Cytheralison* spp., *Callistocythere* sp., *Urocythereis optima*) (Ayress, 1993; Ayress et al., 2017; Ayress, 1995, 2006; Boomer and Eisenhauer, 2002; Cronin, 2015; Gebhardt and Zorn, 2008; Swain, 1974). Saccate and angiosperm pollen, including *Nothofagus* spp., and spores, and a diverse dinocyst assemblage containing many inner neritic taxa and no oceanic taxa indicate nearby land. The Oligocene unit is bounded by unconformities above and below, and a prominent flat angular unconformity is clearly visible on seismic-reflection data adjacent to the site (Fig. S3). The Eocene unit is also seen to be truncated by a local angular unconformity and reworking of older Eocene fossils into upper Eocene and Oligocene strata is noted. Eocene palynological assemblages predominantly consist of dinocysts, with only trace amounts of terrestrial material, reflecting much lower offshore transport compared to younger material, but the uppermost Eocene (~500-440 m) records an increase in abundance of inner shelf species belonging to the *Areoligera-Glaphyrocysta* complex. Some shallow-water ostracods are also noted in this upper Eocene unit: *Hemicytherura* spp. and *Cytherelloidea* spp. (Ayress, 1993; Ayress et al., 2017; Ayress, 1995, 2006; Boomer and Eisenhauer, 2002; Cronin, 2015; Gebhardt and Zorn, 2008).

Site U1510 (water depth 1238 m) is located on southern Lord Howe Rise, where the crest of the ridge is locally as shallow as ~900 m depth (top of Neogene sediment). A thick sequence of rapidly-deposited middle-late Eocene (44-34 Ma) chalk with chert was recovered 148-440 m bsf, with an unconformity bounding the top surface. Benthic foraminifers indicate a middle bathyal setting (600-1000 m) (Sutherland et al., 2019), as inferred from the abundance of *Cibicidoides laurisae* (middle bathyal to abyssal) (Van Morkhoven et al., 1986) and *Turrilina robertsi* (neritic-upper bathyal ecophenotype of *T. brevispira*, upper depth limit 200-300 m) (Van Morkhoven et al., 1986), and the presence of *Loxostomoides applinae* (middle neritic-upper bathyal) (Van Morkhoven et al., 1986), *Osangularia culter* (middle to lower bathyal) (Hermelin, 1989; Szarek et al., 2009), and *Patellina* sp., *Hopkinsina mioindex* and *Anomalinoides capitatus* (upper depth limit 500-600 m) (Van Morkhoven et al., 1986). Reworked benthic foraminifers from neritic settings (Hornibrook, 1961) become more common towards the top of the Eocene section: *Amphistegina*, *Asterigerina* sp., *Arenodosaria antipoda*, large *Vaginulinopsis* spp. (including *V. hochstetteri*), and *Gaudryina proreussi*. Up to 20% of ostracods in the upper Eocene are interpreted as reworked from shallower settings: *Callistocythere* spp., *Cytherelloidea* spp., *Patagonacythere* spp., *Munseyella* spp. (Ayress, 1995; Cronin, 2015). It is clear from the fossil abundances and occurrence of a significant unconformity that the crest of Lord Howe Rise was much shallower during the middle Eocene to early Oligocene.

New Caledonia Trough Sites U1507 and U1509 contain lower bathyal to abyssal sediments from the Eocene through to the Recent, but shallower, neritic to middle bathyal benthic foraminifers (large lenticulinids and nodosariids, Frondicularia, Coryphostoma midwayensis, Bulimina midwayensis) (Berggren and Aubert, 1975) were found in the Paleocene at Site U1509 (Fig. S2).

Figures

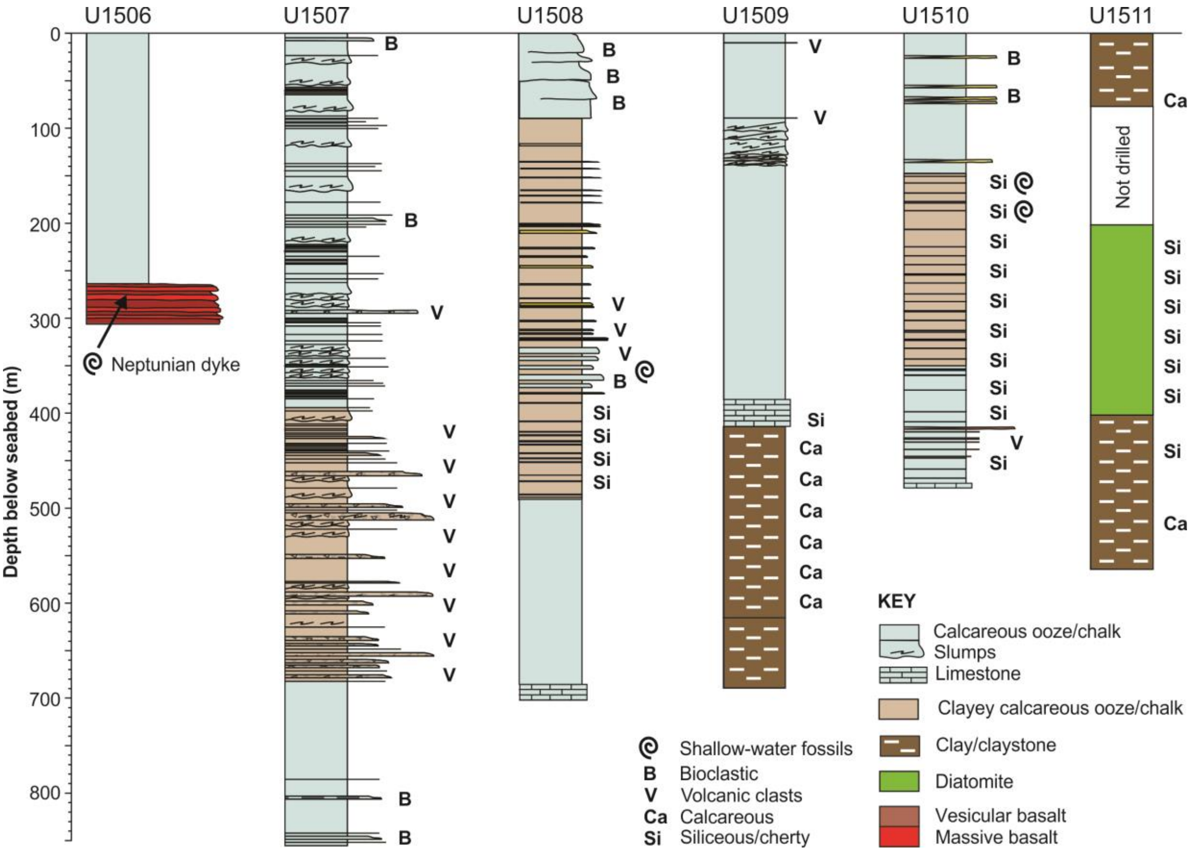

Fig. S1. Summary logs of stratigraphy collected at sites drilled during IODP Expedition 371.

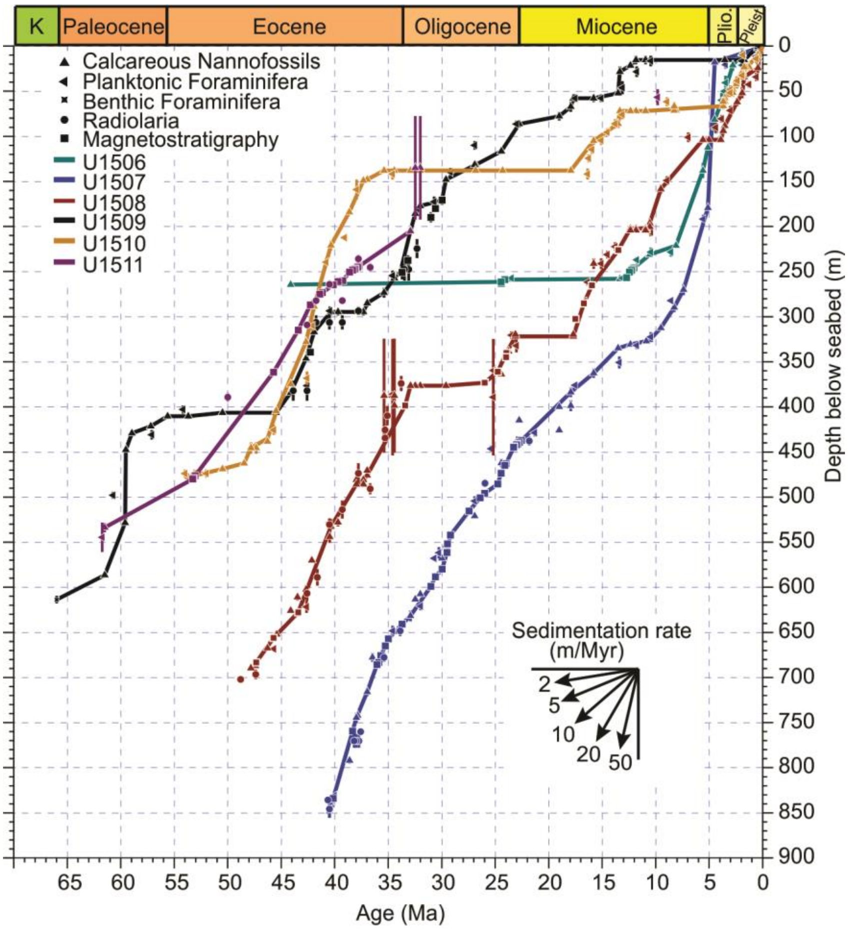

Fig. S2. Stratigraphic age as a function of depth at new sites.

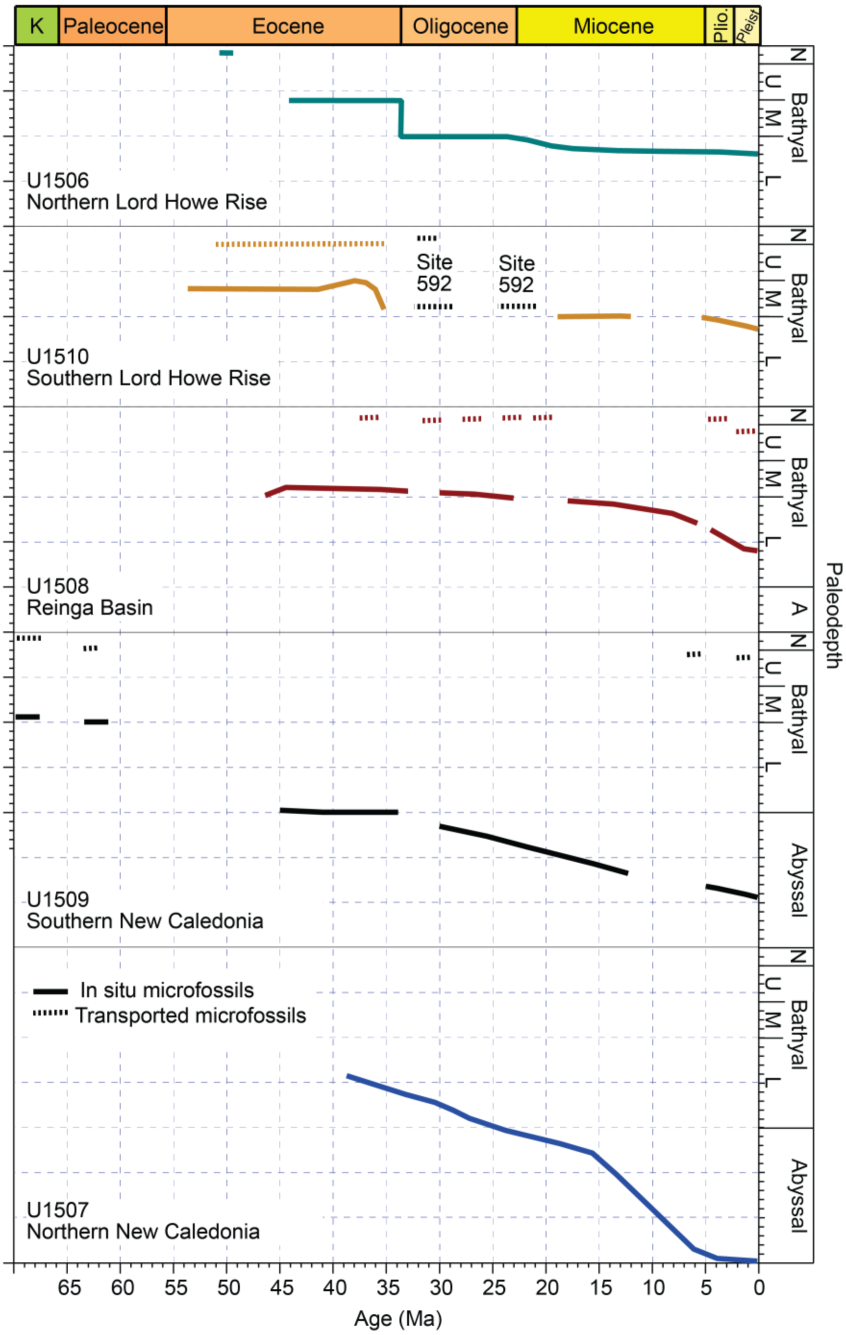

Fig. S3. Best estimate of paleodepth evolution through time at drilled sites (see supplementary text).

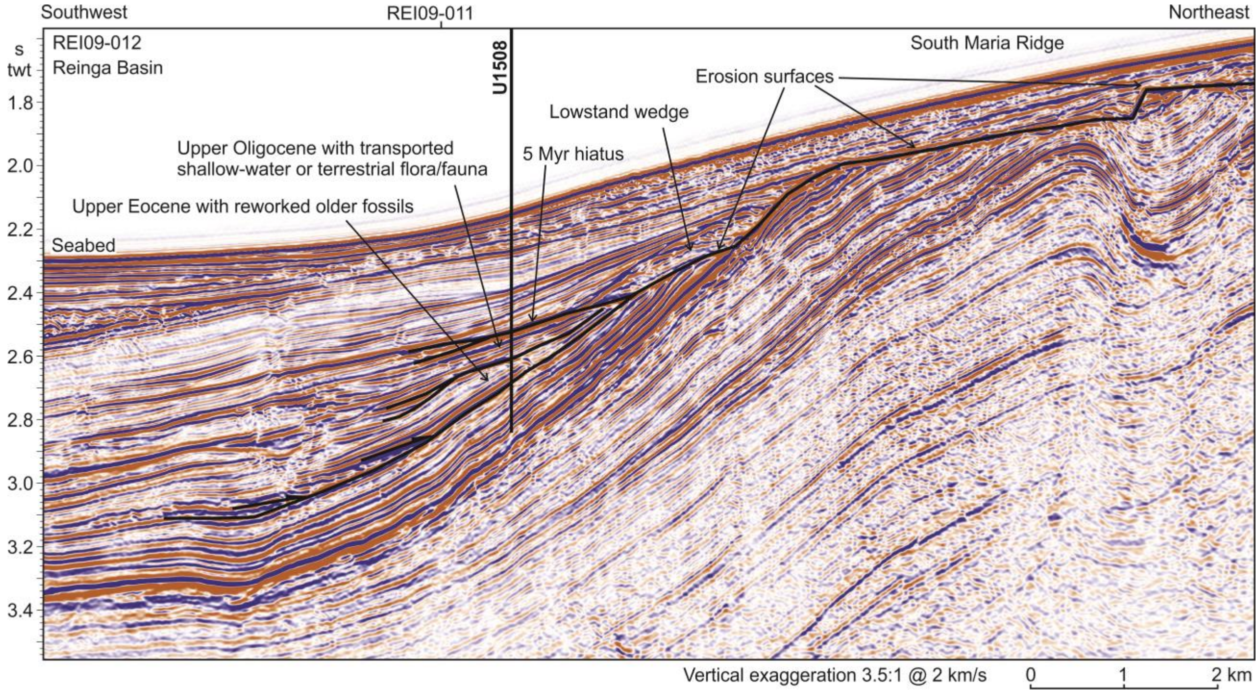

Fig. S4. Seismic reflection interpretation of line REI09-012 at Site U1508 (CDP 8470). The occurrence of reworked fossils in the upper Eocene is consistent with the onset of folding and localized erosion, and the upper Oligocene contains abundant evidence for nearby land, suggesting that the broad flat erosion surfaces on South Maria Ridge formed during the late Oligocene, and possibly part of the subsequent 5 Myr hiatus.

References

Aitchison, J., Clarke, G. L., Meffre, S., and Cluzel, D., 1995, Eocene arc-continent collision in New Caledonia and implications for regional Southwest Pacific tectonic evolution: Geology, v. 23, no. 2, p. 161-164.

Alegret, L., Cruz, L., Fenero, R., Molina, E., Ortiz, S., and Thomas, E., 2008, Effects of the Oligocene climatic events on the foraminiferal record from Fuente Caldera section (Spain, western Tethys): Palaeogeography, Palaeoclimatology, Palaeoecology, v. 269, no. 1-2, p. 94-102.

Ayress, M., 1993, Ostracod biostratigraphy and palaeoecology of the Kokoamu Greensand and Otekaike Limestone (Late Oligocene to Early Miocene), North Otago and South Canterbury, New Zealand: Alcheringa, v. 17, no. 2, p. 125-151.

Ayress, M., Robinson, J., and Lee, D., 2017, Mid-Cenozoic ostracod biostratigraphic range extensions and taxonomic notes on selected species from a new Oligocene (Duntroonian–Waitakian) fauna from southern New Zealand: Alcheringa: An Australasian Journal of Palaeontology, v. 41, no. 4, p. 487-498.

Ayress, M. A., 1995, Late Eocene Ostracoda (Crustacea) from the Waihao District, South Canterbury, New Zealand: Journal of Paleontology, v. 69, no. 5, p. 897-921.

-, 2006, Ostracod biostratigraphy of the Oligocene-Miocene (upper Waitakian to lower Otaian) in southern New Zealand: New Zealand Journal of Geology and Geophysics, v. 49, no. 3, p. 359-373.

Bache, F., Sutherland, R., Stagpoole, V., Herzer, R., Collot, J., and Rouillard, P., 2012, Stratigraphy of the southern Norfolk Ridge and the Reinga Basin: a record of initiation of Tonga-Kermadec-Northland subduction in the southwest Pacific: Earth and Planetary Science Letters, v. 321-322, p. 41-53.

Baldwin, S. L., Rawling, T., and Fitzgerald, P. G., 2007, Thermochronology of the New Caledonian high-pressure terrane: Implications for middle Tertiary plate boundary processes in the southwest Pacific: Geological Society of America Special Paper v. 419, p. 117-134

Baur, J., Sutherland, R., and Stern, T., 2014, Anomalous passive subsidence of deep-water sedimentary basins: a prearc basin example, southern New Caledonia Trough and Taranaki Basin, New Zealand: Basin Research, v. 26, no. 2, p. 242-268.

Ben Rouina, S., Bassetti, M. A., Touir, J., Trabelsi, K., and Berne, S., 2016, Sedimentary and microfaunal evolution in the Quaternary deposits in El Akarit river mouth (Gulf of Gabes, Tunisia): Paleo-environments and extreme events: Journal of African Earth Sciences, v. 121, p. 30-41.

Berggren, W. A., and Aubert, J., 1975, Paleocene benthonic foraminiferal biostratigraphy, paleobiogeography and paleoecology of Atlantic—Tethyan regions: midway-type fauna: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 18, no. 2, p. 73-192.

Boomer, I., and Eisenhauer, G., 2002, Ostracod faunas as palaeoenvironmental indicators in marginal marine environments: The Ostracoda: applications in Quaternary research, p. 135-149.

Brinkhuis, H., 1994, Late Eocene to Early Oligocene dinoflagellate cysts from the Priabonian type-area (Northeast Italy): biostratigraphy and paleoenvironmental interpretation: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 107, no. 1-2, p. 121-163.

Cluzel, D., Aitchison, J. C., and Picard, C., 2001, Tectonic accretion and underplating of mafic terranes in the late Eocene intraoceanic fore-arc of New Caledonia (Southwest Pacific); geodynamic implications: Tectonophysics, v. 340, no. 1-2, p. 23-59.

Cluzel, D., Jourdan, F., Meffre, S., Maurizot, P., and Lesimple, S., 2012, The metamorphic sole of New Caledonia ophiolite: 40Ar/39Ar, U-Pb, and geochemical evidence for subduction inception at a spreading ridge: Tectonics, v. 31, no. 3.

Cluzel, D., Ulrich, M., Jourdan, F., Meffre, S., Paquette, J.-L., Audet, M.-A., Secchiari, A., and Maurizot, P., 2016, Early Eocene clinoenstatite boninite and boninite-series dikes of the ophiolite of New Caledonia; a witness of slab-derived enrichment of the mantle wedge in a nascent volcanic arc: Lithos, v. 260, p. 429-442.

Cluzel, D., Whitten, M., Meffre, S., Aitchison, J. C., and Maurizot, P., 2017, A Reappraisal of the Poya Terrane (New Caledonia): Accreted Late Cretaceous-Paleocene Marginal Basin Upper Crust, Passive Margin Sediments, and Early Eocene E-MORB Sill Complex: Tectonics.

Collot, J., Patriat M., Sutherland R., Williams S., Cluzel D., Seton M., Pelletier B., Roest W.R., Etienne S., Bordenave, A., and Maurizot P., 2019, Geodynamics of the southwest Pacific: a brief review and relations to New Caledonia geology, *in* Mortimer, N., ed., New Caledonia: Geology, Geodynamic Evolution and Mineral Resources: London, UK, Geological Society of London.

Crawford, A. J., Meffre, S., and Symonds, P., 2003, 120 to 0 Ma tectonic evolution of the southwest Pacific and analogous geological evolution of the 600 to 220 Ma Tasman Fold Belt System: Geological Society of Australia Special Publication, v. 22, p. 377-397.

Cronin, T. M., 2015, Ostracods and sea level: Handbook of Sea-Level Research, p. 249-257.

Crouch, E. M., Dickens, G. R., Brinkhuis, H., Aubry, M.-P., Hollis, C. J., Rogers, K. M., and Visscher, H., 2003, The Apectodinium acme and terrestrial discharge during the Paleocene–Eocene thermal maximum: new palynological, geochemical and calcareous nannoplankton observations at Tawanui, New Zealand: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 194, no. 4, p. 387-403.

Dale, B., 1996, Dinoflagellate cyst ecology: modeling and geological applications: Palynology: principles and applications, p. 1249-1275.

Dale, B., and Dale, A. L., 1992, Dinoflagellate contributions to the deep sea, Woods Hole Oceanographic Institution.

Dallanave, E., Agnini, C., Pascher, K. M., Maurizot, P., Bachtadse, V., Hollis, C. J., Dickens, G. R., Collot, J., and Monesi, E., 2018, Magneto-biostratigraphic constraints of the Eocene micrite–calciturbidite transition in New Caledonia: tectonic implications: New Zealand Journal of Geology and Geophysics, v. 61, no. 2, p. 145-163.

Eagar, S. H., 1999, Intraspecific variation in the shell ornamentation of benthic Ostracoda (Crustacea) from Kiribati, Pacific Ocean: Oceanologica acta, v. 22, no. 6, p. 603-608.

Exon, N. F., Hill, P. J., Lafoy, Y., Heine, C., and Bernardel, G., 2006, Kenn Plateau off northeast Australia: a continental fragment in the southwest Pacific jigsaw: Australian Journal of Earth Sciences, v. 53, no. 4, p. 541-564.

Frieling, J., and Sluijs, A., 2018, Towards quantitative environmental reconstructions from ancient non-analogue microfossil assemblages: Ecological preferences of Paleocene–Eocene dinoflagellates: Earth-Science Reviews.

Gaina, C., Mueller, D. R., Royer, J.-Y., Stock, J., Hardebeck, J. L., and Symonds, P., 1998, The tectonic history of the Tasman Sea; a puzzle with 13 pieces: Journal of Geophysical Research, v. 103, no. 6, p. 12,413-412,433.

Gaina, C., Mueller, R. D., Royer, J.-Y., and Symonds, P., 1999, Evolution of the Louisiade triple junction: Journal of Geophysical Research, v. 104, no. 6, p. 12,927-912,940.

Gebhardt, H., and Zorn, I., 2008, Cenomanian ostracods of the Tarfaya upwelling region (Morocco) as palaeoenvironmental indicators: Revue de micropaleontologie, v. 51, no. 4, p. 273-286.

Hayward, B. W., 2010, Recent New Zealand deep-water benthic foraminifera: Taxonomy, ecologic distribution, biogeography and use in paleoenvironmental assessment, GNS Science, Institute of Geological and Nuclear Sciences Monograph, 363 p.:

Hayward, B. W., Sabaa, A., and Grenfell, H. R., 2004, Benthic foraminifera and the late Quaternary (last 150 ka) paleoceanographic and sedimentary history of the Bounty Trough, east of New Zealand: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 211, no. 1, p. 59-93.

Hermelin, J. O. R., 1989, Pliocene benthic foraminifera from the Ontong-Java Plateau (western equatorial Pacific Ocean): Faunal response to changing paleoenvironment: Cushman Foundation for Foraminiferal Research, Special Publication, v. 26, p. 1-143.

Hornibrook, N. d. B., 1961, Tertiary Foraminifera from Oamaru District (NZ), RE Owen, Govt. printer.

Lagabrielle, Y., Chauvet, A., Ulrich, M., and Guillot, S., 2013, Passive obduction and gravity-driven emplacement of large ophiolitic sheets: The New Caledonia ophiolite (SW Pacific) as a case study?: Bulletin de la Société géologique de France, v. 184, no. 6, p. 545-556.

Laske, G., Masters., G., Ma, Z., and Pasyanos, M., 2013, Update on CRUST1.0 - A 1-degree Global Model of Earth's Crust: Geophysical Research Abstracts, v. 15, p. EGU2013-2658.

Lythe, M. B., and Vaughan, D. G., 2001, BEDMAP: A new ice thickness and subglacial topographic model of Antarctica: Journal of Geophysical Research: Solid Earth, v. 106, no. B6, p. 11335-11351.

Matthews, K. J., Williams, S. E., Whittaker, J. M., Müller, R. D., Seton, M., and Clarke, G. L., 2015, Geologic and kinematic constraints on Late Cretaceous to mid Eocene plate boundaries in the southwest Pacific: Earth-Science Reviews, v. 140, p. 72-107.

Maurizot, P., 2012, Palaeocene age for the Adio limestone, New Caledonia: stratigraphic evidence and regional context: New Zealand Journal of Geology and Geophysics.

Maurizot, P., and Cluzel, D., 2014, Pre-obduction records of Eocene foreland basins in central New Caledonia: an appraisal from surface geology and Cadart-1 borehole data: New Zealand Journal of Geology and Geophysics, v. 57, no. 3, p. 300-311.

Mostafawi, N., Colin, J.-P., and Babinot, J.-F., 2005, An account on the taxonomy of ostracodes from recent reefal flat deposits in Bali, Indonesia: Revue de micropaleontologie, v. 48, no. 2, p. 123-140.

Munef, M. A., Al-Wosabi, M. A., Keyser, D., and Al-Kadasi, W. M., 2012, Distribution and taxonomy of shallow marine Ostracods from Northern Socotra Island (Indian Ocean)-Yemen: Revue de micropaléontologie, v. 55, no. 4, p. 149-170.

Murray, J., 1991, Ecology and paleoecology of benthic foraminifera, Harlow, UK, England, Logman Scientific & Technical, 397 p.:

Pirard, C., and Spandler, C., 2017, The zircon record of high-pressure metasedimentary rocks of New Caledonia: Implications for regional tectonics of the south-west Pacific: Gondwana Research, v. 46, p. 79-94.

Pross, J., and Brinkhuis, H., 2005, Organic-walled dinoflagellate cysts as paleoenvironmental indicators in the Paleogene; a synopsis of concepts: Paläontologische Zeitschrift, v. 79, no. 1, p. 53-59.

Rouillard, P., Collot, J., Sutherland, R., Bache, F., Patriat, M., Etienne, S., and Maurizot, P., 2017, Seismic stratigraphy and paleogeographic evolution of Fairway Basin, Northern Zealandia, Southwest Pacific: from Cretaceous Gondwana breakup to Cenozoic Tonga–Kermadec subduction: Basin Research, v. 29, no. S1, p. 189-212.

Schellart, W. P., Lister, G. S., and Toy, V. G., 2006, A Late Cretaceous and Cenozoic reconstruction of the Southwest Pacific region: Tectonics controlled by subduction and slab rollback processes: Earth-Science Reviews, v. 76, no. 3-4, p. 191-233.

Sdrolias, M., Muller, R. D., Mauffret, A., and Bernardel, G., 2004, Enigmatic formation of the Norfolk Basin, SW Pacific: A plume influence on back-arc extension: Geochemistry Geophysics Geosystems, v. 5.

Sluijs, A., and Brinkhuis, H., 2009, A dynamic climate and ecosystem state during the Paleocene-Eocene Thermal Maximum: inferences from dinoflagellate cyst assemblages on the New Jersey Shelf: Biogeosciences, v. 6, no. 8.

Sluijs, A., and Dickens, G. R., 2012, Assessing offsets between the δ13C of sedimentary components and the global exogenic carbon pool across early Paleogene carbon cycle perturbations: Global Biogeochemical Cycles, v. 26, no. 4.

Sluijs, A., Pross, J., and Brinkhuis, H., 2005, From greenhouse to icehouse; organic-walled dinoflagellate cysts as paleoenvironmental indicators in the Paleogene: Earth-Science Reviews, v. 68, no. 3-4, p. 281-315.

Spandler, C., Rubatto, D., and Hermann, R., 2005, Late Cretaceous-Tertiary tectonics of the southwest Pacific: Insights from U-Pb sensitive, high-resolution ion microprobe (SHRIMP) dating of eclogite facies rocks from New Caledonia: Tectonics, v. 24, no. 3.

Sutherland, R., Dickens, G. R., Blum, P., Agnini, C., Alegret, L., Asatryan, G., Bhattacharya, J., Bordenave, A., Chang, L., Collot, J., Cramwinckel, M. J., Dallanave, E., Drake, M. K., Etienne, S. J. G., Giorgioni, M., Gurnis, M., Harper, D. T., Huang, H.-H. M., Keller, A. L., Lam, A. R., Li, H., Matsui, H., Morgans, H. E. G., Newsam, C., Park, Y.-H., Pascher, K. M., Pekar, S. F., Penman, D. E., Saito, S., Stratford, W. R., Westerhold, T., and Zhou, X., 2019, International Ocean Discovery Program Expedition 371: Tasman Frontier Subduction Initiation and Paleogene Climate, College Station, TX, USA, International Ocean Discovery Program, Proceedings of the International Ocean Discovery Program, 318 p.:

Sutherland, R., Stagpoole, V., Uruski, C., Kennedy, C., Bassett, D., Henrys, S., Scherwath, M., Kopp, H., Field, B., Toulmin, S., Barker, D., Bannister, S., Davey, F., Stern, T., and Flueh, E. R., 2009, Reactivation of tectonics, crustal underplating, and uplift after 60 Myr of passive subsidence, Raukumara Basin, Hikurangi-Kermadec fore arc, New Zealand: Implications for global growth and recycling of continents: Tectonics, v. 28.

Swain, F. M., 1949, Early Tertiary ostracoda from the western interior United States: Journal of Paleontology, p. 172-181.

Swain, F. M., 1974, Some upper Miocene and Pliocene (?) Ostracoda of Atlantic Coastal region for use in hydrogeologic studies: Geological Survey Professional Paper, v. 821, p. 20-21.

Szarek, R., Kuhnt, W., Kawamura, H., and Nishi, H., 2009, Distribution of recent benthic foraminifera along continental slope of the Sunda Shelf (South China Sea): Marine Micropaleontology, v. 71, no. 1-2, p. 41-59.

Tjalsma, R. C., and Lohmann, G. P., 1983, Paleocene-Eocene bathyal and abyssal benthic foraminifera from the Atlantic Ocean: Micropaleontology, v. 4, p. 1-90.

Van Morkhoven, F. P., Berggren, W. A., Edwards, A. S., and Oertli, H., 1986, Cenozoic cosmopolitan deep-water benthic foraminifera: Elf Aquitaine Memoir, v. 11, p. 1-421.

Veevers, J. J., and Li, Z. X., 1991, Review of seafloor spreading around Australia. II. Marine magnetic anomaly modelling: Australian Journal of Earth Science, v. 38, p. 391-408.

Vitale-Brovarone, A., Agard, P., Monié, P., Chauvet, A., and Rabaute, A., 2018, Tectonometamorphic architecture of the HP belt of New Caledonia: Earth-Science Reviews.

Whatley, R. C., and Watson, K., 1988, A preliminary account of the distribution of Ostracoda in Recent reef and reef associated environments in the Pulau Seribu or Thousand Island Group, Java Sea, Developments in Palaeontology and Stratigraphy, Volume 11, Elsevier, p. 399-411.

Whattam, S. A., Malpas, J., Ali, J. R., and Smith, I. E. M., 2008, New SW Pacific tectonic model: Cyclical intraoceanic magmatic arc construction and near-coeval emplacement along the Australia-Pacific margin in the Cenozoic: Geochemistry Geophysics Geosystems, v. 9.

Widmark, J. G., 2000, Biogeography of terminal Cretaceous benthic foraminifera: deep-water circulation and trophic gradients in the deep South Atlantic: Cretaceous Research, v. 21, no. 2-3, p. 367-379.

Yasuhara, M., and Okahashi, H., Late Quaternary deep-sea ostracod taxonomy of the eastern North Atlantic Ocean2015, Geological Society of London.