Chapter 2

Geodynamics of the SW Pacific: a brief review and relations with New Caledonian geology

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Abstract: The SW Pacific region consists of a succession of ridges and basins that were created by the fragmentation of Gondwana and the evolution of subduction zones since Mesozoic times. This complex geodynamic evolution shaped the geology of New Caledonia, which lies in the northern part of the Zealandia continent. Alternative tectonic models have been postulated. Most models agree that New Caledonia was situated on an active plate margin of eastern Gondwana during the Mesozoic. Extension affected the region from the Late Cretaceous to the Paleocene and models for this period vary in the location and nature of the plate boundary between the Pacific and Australian plates. Eocene regional tectonic contraction included the obduction of a mantle-derived Peridotite Nappe in New Caledonia. In one class of model, this contractional phase was controlled by an east-dipping subduction zone into which the Norfolk Ridge jammed, whereas and in a second class of model this phase corresponds to the initiation of the west-dipping Tonga–Kermadec subduction zone. Neogene tectonics of the region near New Caledonia was dominated by the eastwards retreat of Tonga–Kermadec subduction, leading to the opening of a back-arc basin east of New Caledonia, and the initiation and southwestwards advance of the New Hebrides–Vanuatu subduction zone towards New Caledonia.

Geological structures of the SW Pacific

New Caledonia sits at the northeastern extremity of the Australian plate, close to the Pacific–Australia plate boundary. Its onshore and offshore geology provides important information on the geodynamic evolution of the SW Pacific (Fig. 2.1 and foldout geological map (Fig. 1.2) in this Memoir). The present day physiography and geology of the region have resulted from the fragmentation of eastern Gondwana since the Mesozoic by successive basin opening and closure associated with the evolution of subduction zones. The basin closures led in some places to folding, faulting and the obduction of nappes during the Cenozoic, including nappes containing ophiolitic material in Papua New Guinea, New Caledonia and New Zealand.

Central to describing and understanding the bathymetry and geology of the SW Pacific is the 94% submerged continent of Zealandia (Mortimer *et al.* 2017). Zealandia is composed of a succession of continental ridges (from west to east): the Dampier Ridge, Lord Howe Rise, Fairway Ridge and Norfolk Ridge. Each ridge and intervening trough has a clear expression on the free air gravity anomaly map (Fig. 2.1). New Caledonia is located at the northern end of Norfolk Ridge. The continental ridges are separated from each other by basins (of probable continental type). From west to east these are the Middleton Basin, the Fairway–Aotea Basin and the New Caledonia Trough. Crustal thicknesses vary from *c.* 25 km beneath ridges to 10–15 km in the basins (Klingelhoefer *et al.* 2007). The water depths of Zealandia are typically 1000–1500 m for the ridges, down to 2000 m in the Fairway Basin and *c.* 3500 m in the New Caledonia Trough near New Caledonia.

Zealandia is surrounded by oceanic basins, back-arc basins and subduction-related volcanic ridges of various ages. Between Zealandia and Australia are the Tasman and Coral seas, two 2000 km wide Late Cretaceous to early Eocene ocean basins containing central spreading centres and sets of continuous distinct oceanic fracture zones (Fig. 2.2). The area to the east of Zealandia is predominantly composed of Cenozoic volcanic ridges that, with the exception of the New Hebrides–Vanuatu arc, are generally younger to the east: the Loyalty Ridge, Three Kings Ridge, Lau–Colville Ridge, Tonga–Kermadec Ridge and the New Hebrides–Vanuatu arc. The latter two, although resulting from oppositely dipping subduction zones, are active with subduction-related volcanic arcs. Between the ridges are back-arc basins: the Norfolk, South Fiji, Lau–Havre and North Fiji basins. In contrast with the Tasman and Coral seas basins, these back-arc basins contain short-segment, poorly organized spreading centres and have few prominent fracture zones (Figs 2.2 & 2.3).

Other prominent features of the SW Pacific are three age-progressive volcanic hotspot tracks that may approximate the motion of the Pacific and Australian plates relative to the mantle during the Cenozoic (McDougall *et al.* 1981; Missègue and Collot 1987; McDougall and Duncan 1988; Knesel *et al.* 2008; Mortimer *et al.* 2018). The Louisville chain is on the

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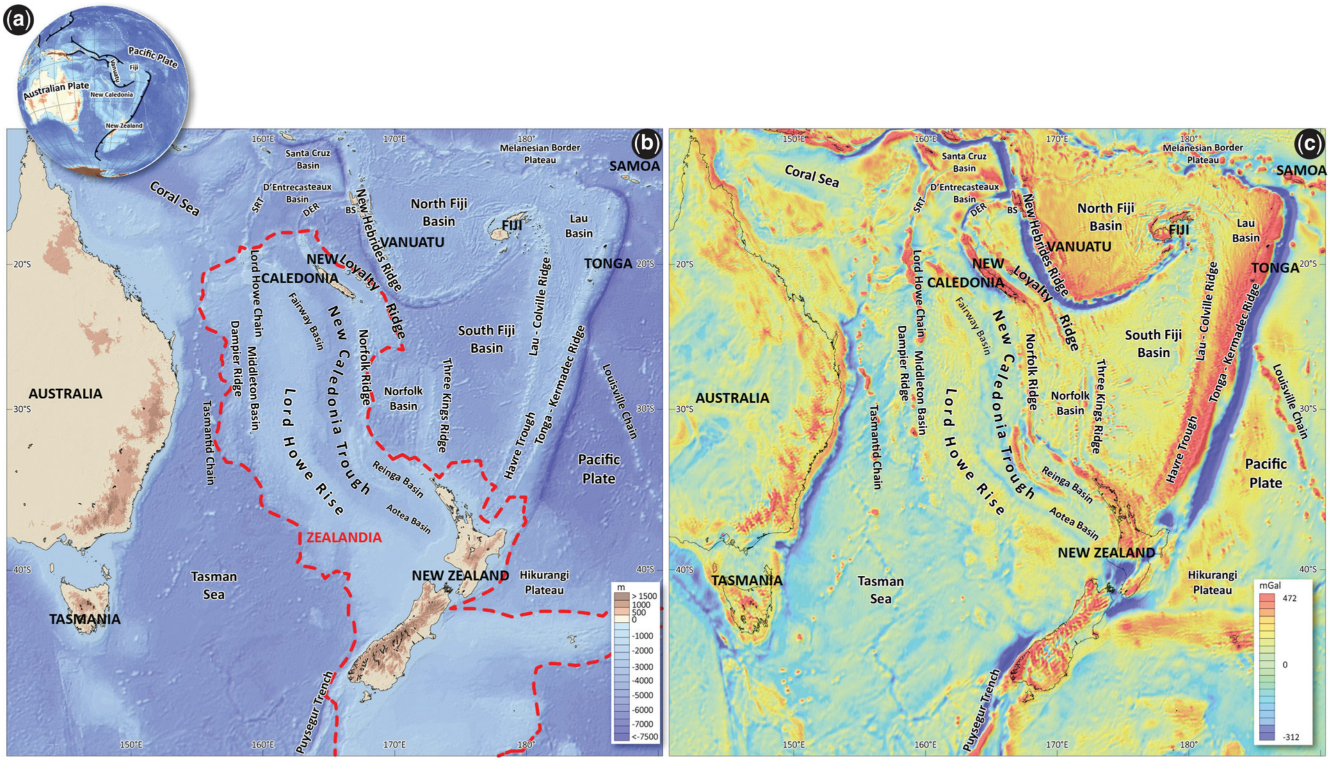


Fig. 2.1. (**a**) New Caledonia in the SW Pacific. (**b**) Bathymetric map of the SW Pacific (Smith and Sandwell 1997). Dashed red line is the outline of the Zealandia continent (Mortimer *et al.* 2017). (**c**) Free air gravity anomaly map of the SW Pacific (Sandwell and Smith 1997). BS, Bougainville Seamount; DER, d'Entrecasteaux Ridge; SRT, South Rennel Trough.

Pacific plate and the Tasmantid and Lord Howe chains are on the Australian plate (Fig. 2.1).

Geodynamics

Present-day geodynamics

The SW Pacific is tectonically active, with very rapid motion between two opposite subduction zones and active back-arc extension. The Mesozoic Pacific plate is subducted at the Tonga–Kermadec Trench at rates that increase northwards. At 16° S the convergence rate reaches 24 cm a^{-1}, which is the fastest convergence rate on Earth (Pelletier and Louat 1989; Bevis *et al.* 1995; Pelletier *et al.* 1998). The convergence rate corresponds to the sum of the Australia–Pacific relative plate motion rate and the Lau basin spreading rate, which is a measure of the rate of trench retreat (see Heuret and Lallemand 2005 for more detail). The Australian plate moves NNE at a rate of 7 cm a^{-1} relative to Antarctica (Petterson *et al.* 1999) and is subducted along the New Hebrides–Vanuatu Trench beneath the Pacific plate at a rate of up to 17 cm a^{-1} (Dubois *et al.* 1977; Pelletier *et al.* 1998; Calmant *et al.* 2003; Bergeot *et al.* 2009). The Fiji Fracture Zone (see Figs 2.2 & 2.3), combined with a complex system of spreading ridges and transform faults in the North Fiji Basin, accommodates the motion between the Australian and Pacific plates (Pelletier *et al.* 1998; Pelletier *et al.* 2001) (Figs 2.2 & 2.3). The northeastern part of the Australian plate is being subducted along the New Hebrides–Vanuatu Trench. South of New Zealand, the Pacific–Australian plate boundary has a dextral strike-slip rate of *c.* 3 cm a^{-1} and has evolved from extension to compression since the Eocene, with oblique subduction of the Australian plate initiating at the Puysegur Trench during the Miocene (Collot *et al.* 1995; Lamarche and Lebrun 2000; Sutherland *et al.* 2000; Sutherland *et al.* 2009).

Mesozoic and Cenozoic geodynamics

Various conceptual geodynamic and tectonic models have attempted to explain the formation and development of the SW Pacific in time and space (e.g. Karig 1971; Ballance *et al.* 1982; Kroenke 1984; Yan and Kroenke 1993; Müller *et al.* 2000; Veevers 2000; Cluzel *et al.* 2001; Hall 2002; Crawford *et al.* 2003*a*; Sdrolias *et al.* 2003; Schellart *et al.* 2006). Most geodynamic models of the SW Pacific follow the model of Karig (1971), which, based on examples from the western Pacific region, introduced the concept that the rollback of a subducted slab may induce the oceanwards retreat of the subduction trench, extension behind the arc, and the associated formation of a series of remnant arcs and back-arc basins.

Magnetic anomalies of the Tasman and Coral seas show that oceanic crust formed from the Late Cretaceous to Early Eocene (Figs 2.2 & 2.3) (Hayes and Ringis 1973; Gaina *et al.* 1998). The New Caledonia Trough and the Fairway and Norfolk basins have a more contentious origin and may be underlain by oceanic crust, continental crust, thinned continental crust or exposed/denuded mantle. Their ages are more difficult to constrain. The long history of subduction in this region has led to the recycling of large swaths of lithosphere into the mantle, thus obliterating much of the geological record (e.g. magnetic anomalies, the age and nature of the crust and the extent of the basin) in some areas. As a result, elements of the geodynamic evolution of the SW Pacific remain poorly controlled and several alternative conceptual models exist. We review here some of the alternative models.

Mesozoic Gondwana subduction

The belt-like distribution of deformed Permian to Early Cretaceous trench-slope and forearc basin sedimentary rocks, arc volcanic and intrusive rocks in New Caledonia and New Zealand (eastern Zealandia) shows that a Pacific basin subducting

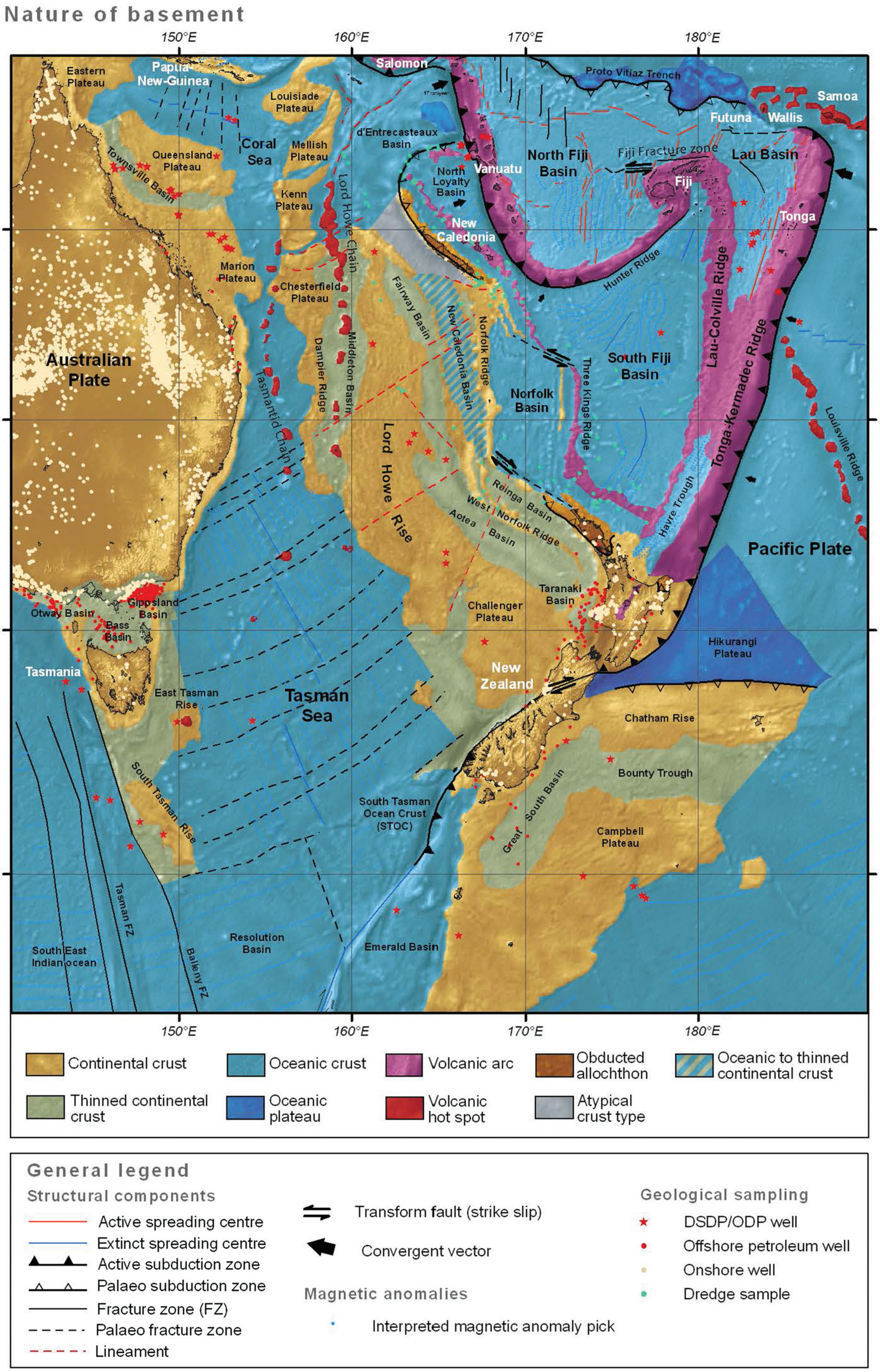


Fig. 2.2. Basement geological map of the SW Pacific (modified after Collot *et al.* 2012).

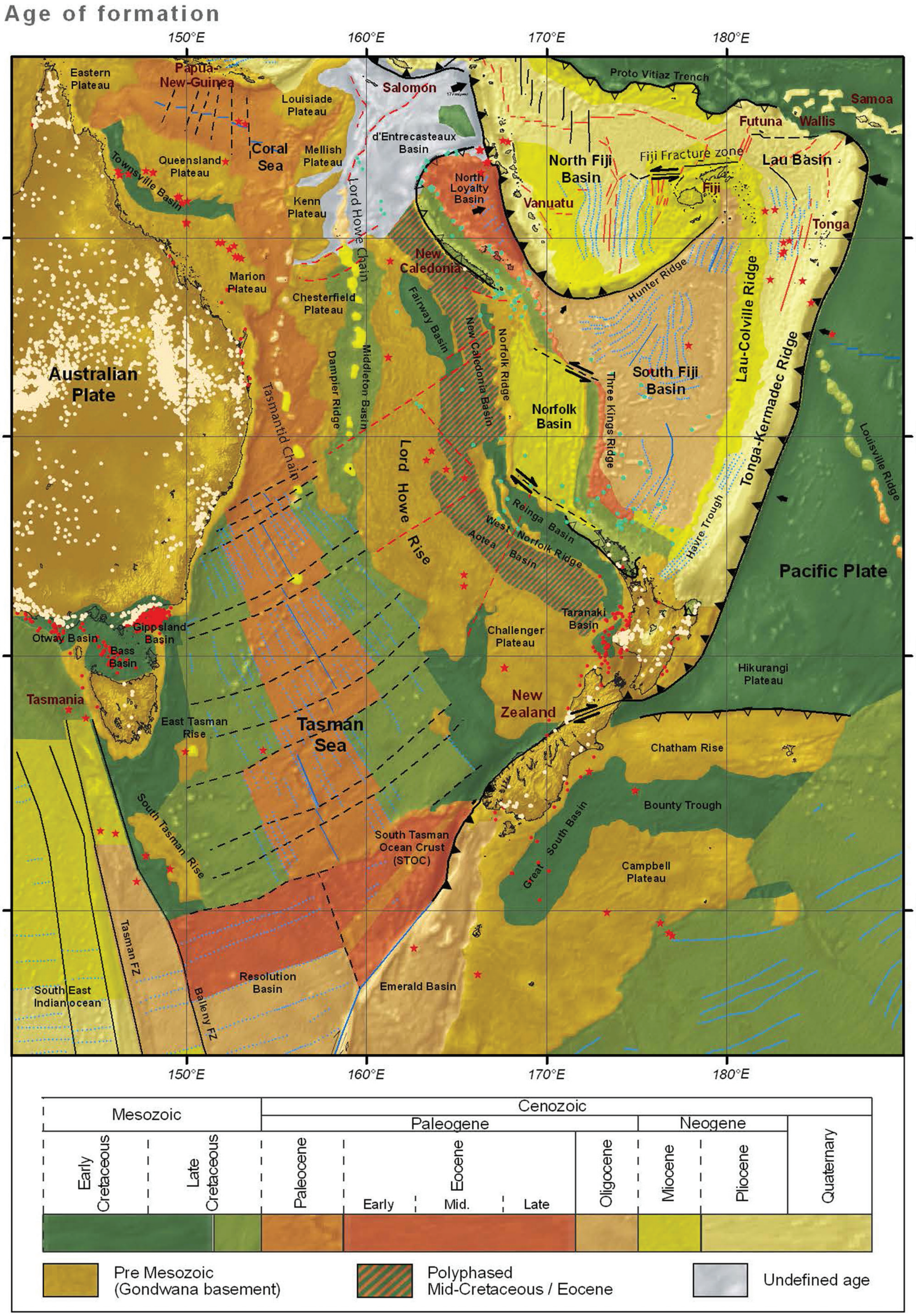


Fig. 2.3. Age of formation of basement of the SW Pacific (modified after Collot *et al.* 2012). See Figure 2.2 for legend.

slab dipped SW beneath the eastern margin of Gondwana throughout much of the 260–110 Ma interval (Bradshaw 1981; Sdrolias *et al.* 2003; Mortimer *et al.* 2008, 2009; Cluzel *et al.* 2010*b*). Some geodynamic models propose that this was complicated by the opening and closing of marginal basins and involved local changes in trench location and/or periods with opposite subduction vergence (Adams *et al.* 2009; Li *et al.* 2012; Maurizot *et al.* 2020*a*, Chapter 3, this Memoir). Evidence for the existence of a Mesozoic volcanic arc along the palaeo-margin of Gondwana comes from the accumulation of Mesozoic volcaniclastic sediments of considerable thickness in the Otway and Gippsland basins (located between Australia and Tasmania), the Great Artesian Basin (located in the middle of the Australian continent), New Zealand and New Caledonia (cf. Maurizot *et al.* 2020*a*, Chapter 3, this Memoir). More directly, Mortimer *et al.* (1999, 2002, 2008) showed that the roots of the Mesozoic continental arc are exposed as the Median Batholith in New Zealand, as well as equivalents in Marie Byrd Land, Antarctica, Queensland and dredged rocks from offshore Zealandia (e.g. the West Norfolk Ridge). Late Mesozoic subduction at the Gondwana margin corresponds to the long-lived subduction that runs from NE of Australia to South America, which subsequently died adjacent to Zealandia and Antarctica, but remains active today beneath South America (Fig. 2.4).

Late Cretaceous: Paleocene extension

The regional tectonic regime along the Pacific margin of Gondwana changed from convergent to extensional at *c.* 110–100 Ma (the end of the Early Cretaceous). An episode of intra-continental rifting lasted until at least *c.* 85 Ma along much of the Gondwana margin, at which time Zealandia began to separate from Gondwana. As well as the termination of deformation and metamorphism in accretionary subduction complexes, there was a switch from subduction-type to rift-type magmatism in New Zealand and New Caledonia in the Early to early Late Cretaceous (Muir *et al.* 1995; Mortimer 2004; Tulloch *et al.* 2009; Cluzel *et al.* 2010*b*). Widespread sedimentary basins associated with normal faulting during the interval *c.* 105–80 Ma are found throughout Zealandia (in New Caledonia, cf. Maurizot *et al.* 2020*b*, Chapter 4, this Memoir), Lord Howe Rise, New Zealand and the Campbell Plateau) and in West Antarctica (Van der Lingen *et al.* 1973; Carter *et al.* 1992; Laird 1992; Herzer *et al.* 1997; Luyendyk *et al.* 2001, 2003; Bache *et al.* 2013; Rouillard *et al.* 2017). It has been suggested that a fundamental cause of this tectonic change from subduction to rifting was due to the jamming of subduction by the Hikurangi Plateau at *c.* 105 Ma (Davy *et al.* 2008; Collot *et al.* 2009). An alternative is waning subduction associated with the interaction of the trench with the adjacent spreading ridges (Matthews *et al.* 2012). The initial break-up of Zealandia from Gondwana is dated at 83–79 Ma (chron 33r), based on marine magnetic anomalies adjacent to much of Zealandia in the Tasman Sea, and propagated towards the north until 57 Ma (chron 26) (Gaina *et al.* 1998). The initial break-up may have occurred slightly earlier at the southern extremity of the Tasman Sea (chron 34) (Gaina *et al.* 1998; Sutherland 1999). The Tasman Sea spreading centre was active until 52 Ma (chron 24) and the resulting oceanic seafloor provides a record of the relative plate motions between Gondwana and Zealandia (Gaina *et al.* 1998).

Tectonic models of Late Cretaceous to Early Eocene plate kinematics in the SW Pacific vary in the nature of the plate boundary east of Zealandia. Options include an east-dipping subduction zone, a west-dipping subduction zone, a strike-slip boundary or no boundary at all.

In one class of geodynamic model (model A, Figs 2.5 & 2.6), the Tasman Sea, New Caledonia Trough and South Loyalty Basin are inferred to be back-arc basins, with extension driven by a west-dipping subduction zone retreating towards the Pacific via a rollback process (Gaina *et al.* 1998; Hall and Spakman 2002; Crawford *et al.* 2003*a*; Sdrolias *et al.* 2003; Schellart *et al.* 2006; Cluzel *et al.* 2012*a*). The South Loyalty Basin would once have been much wider, with its back-arc basin oceanic crust now telescoped and obducted in the allochthons of the Poya Terrane (cf. Maurizot *et al.* 2020*c*, Chapter 5, this Memoir) in New Caledonia (Aitchison *et al.* 1995; Eissen *et al.* 1998; Cluzel *et al.* 2001, 2018) and the Tangihua and Makatoa Volcanics in New Zealand (Nicholson *et al.* 2000*a*, *b*; Cluzel *et al.* 2010*a*). It is notable that arc volcanic rocks have not been conclusively discovered in this period (Pelletier 2007; Mortimer *et al.* 2018).

An alternative class of model proposed the end of eastern Gondwana subduction followed by divergent plate motion (initially intra-continental, then at spreading ridges) that led to the rifting of Gondwana, break-up and then the opening of the Southern Ocean and Tasman Sea (Gaina *et al.* 1998; Sdrolias *et al.* 2003; Williams *et al.* 2011; van der Meer *et al.* 2016). In this class of model (model B, Figs 2.5 & 2.6), the Late Cretaceous plate boundary between Zealandia and the Pacific plate is either thought to be inactive (Steinberger *et al.* 2004; Pirard and Spandler 2017) or to be a transform boundary (Richards and Lithgow-Bertelloni 1996; Müller *et al.* 2000). In this class of model, the South Loyalty Basin could be a relict of the Pacific plate or could be connected with Coral Sea spreading.

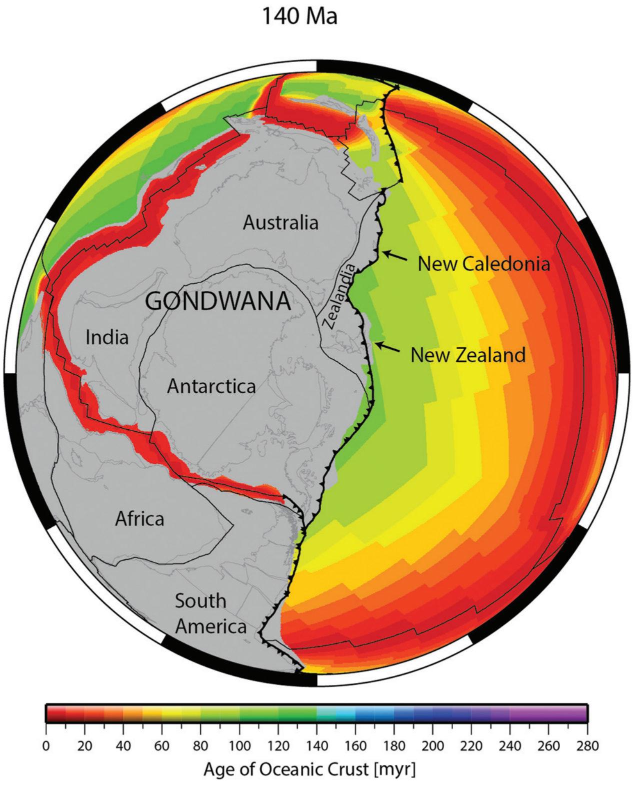


Fig. 2.4. Early Cretaceous plate kinematic reconstruction of Gondwana. Age grids and reconstructions are based on Müller *et al.* (2016). Projection is orthographic, centred on 120°/−90°.

Eocene contraction

Most researchers agree that a phase of regional tectonic contraction started during the latest Paleocene or Eocene (cf. Maurizot *et al.* 2020*b*, *c*, Chapters 4 and 5, this Memoir),

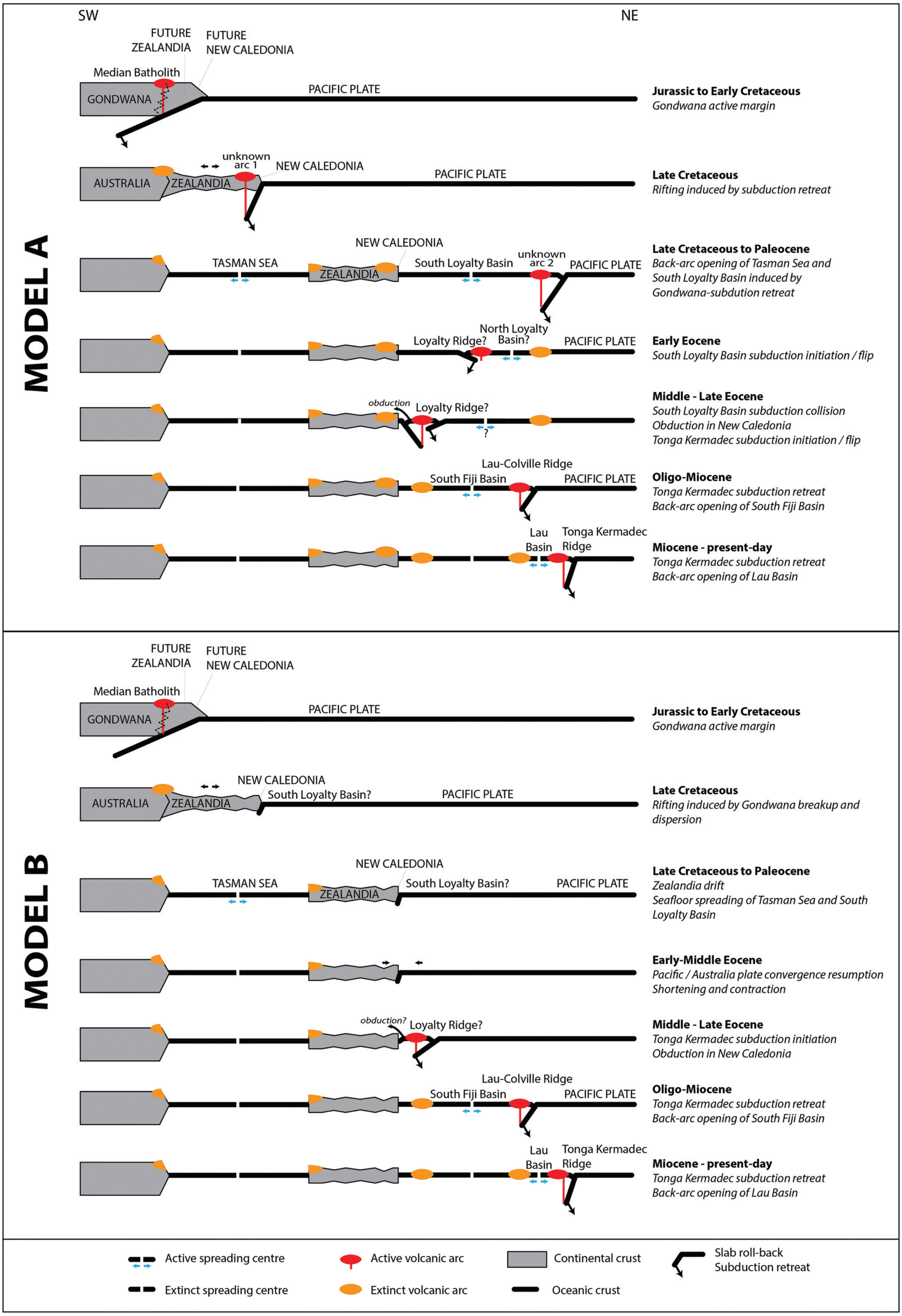


Fig. 2.5. Cross-sections of two classes of models for the geodynamic evolution of the SW Pacific. See Figure 2.6 for location of cross-section.

although the precise magnitude, extent, timing and duration of this phase is still debated (Ballance *et al.* 1982; Kroenke 1984; Ballance 1999; Cluzel *et al.* 2001; Crawford *et al.* 2003*a*; Sdrolias *et al.* 2003; Schellart *et al.* 2006; Whattam *et al.* 2008; Sutherland *et al.* 2010, 2017; Maurizot 2012; Dallanave *et al.* 2018). In New Caledonia, this phase culminates with the obduction of the Peridotite Nappe during the latest Eocene. Lower strain regional Eocene contraction is observed on seismic reflection data across Zealandia and in eastern Australia (Lafoy *et al.* 1994; Sutherland *et al.* 2010, 2017; Bache *et al.* 2012; Etienne *et al.* 2017; Rouillard *et al.* 2017).

The first class of model (model A, Figs 2.5 & 2.6) proposes that a new east-dipping subduction zone initiated in the South Loyalty Basin, possibly near a spreading ridge at *c.* 56 Ma (Cluzel *et al.* 2006, 2012*b*, 2016; Ulrich *et al.* 2010), and then retreated towards the west until *c.* 34 Ma, when the Norfolk Ridge arrived at the trench and blocked it (Aitchison *et al.* 1995). In this class of model, the South Loyalty Basin is almost entirely consumed by the second east-dipping subduction zone. The change in subduction polarity at *c.* 56 Ma (subduction flip from westwards to eastwards slab dip) is invoked to explain the southwards propagation of Eocene foreland basins and the emplacement of nappes (cf. Maurizot *et al.* 2020*b*, Chapter 4, this Memoir), supra-subduction features within the allochthons and eclogite–blueschist (high-pressure–low-temperature) metamorphism in northern New Caledonia (cf. Maurizot *et al.* 2020*c*, Chapter 5, this Memoir).

In a second class of model (model B, Figs 2.5 & 2.6), the west-dipping Gondwana subduction zone that died at the start of the Late Cretaceous reinitiated at *c.* 50 Ma (Gurnis *et al.* 2004; Steinberger *et al.* 2004). In this class of model, new subduction zones initiated throughout the western Pacific during the Eocene (see Miles *et al.* 2016) and are associated with changes in Pacific plate motion manifest as the Emperor–Hawaii seamount bend (Steinberger *et al.* 2004; O'Connor *et al.* 2013).

Although the first class of model can explain the Cenozoic geology of New Caledonia, latest Cretaceous, Paleocene or Eocene volcanic arc material related to the proposed subduction zone have yet to be found in the SW Pacific (Matthews *et al.* 2015; Mortimer *et al.* 2018). The exception is arc material recovered from Bougainville Seamount near the New Hebrides–Vanuatu Trench (see Fig. 2.1 for location), which was dated as Late Eocene (Collot *et al.* 1992; Greene *et al.* 1994) and along the d'Entrecasteaux Ridge (Maillet *et al.* 1983; Mortimer *et al.* 2014). However, the relationship between the Bougainville Seamount, d'Entrecasteaux Ridge, Loyalty Ridge and an east-dipping subduction system is not clear (cf. Maurizot *et al.* 2020*d*, Chapter 6, this Memoir). The second model does not provide a simple explanation for the mechanisms of emplacement of ophiolites in New Caledonia (in the context of SW-dipping subduction). However, Malpas *et al*. (1992) and Mortimer *et al*. (2003) have suggested 'flake tectonic' emplacement of the Northland Allochthon. More recently, Sutherland *et al*. (2020) have proposed obduction in New Caledonia in this configuration. For more details on the geodynamic evolution of this time period, Matthews *et al.* (2015) give a comprehensive analysis and discussion of the available geological and kinematic data.

Oligocene to present-day Tonga–Kermadec subduction

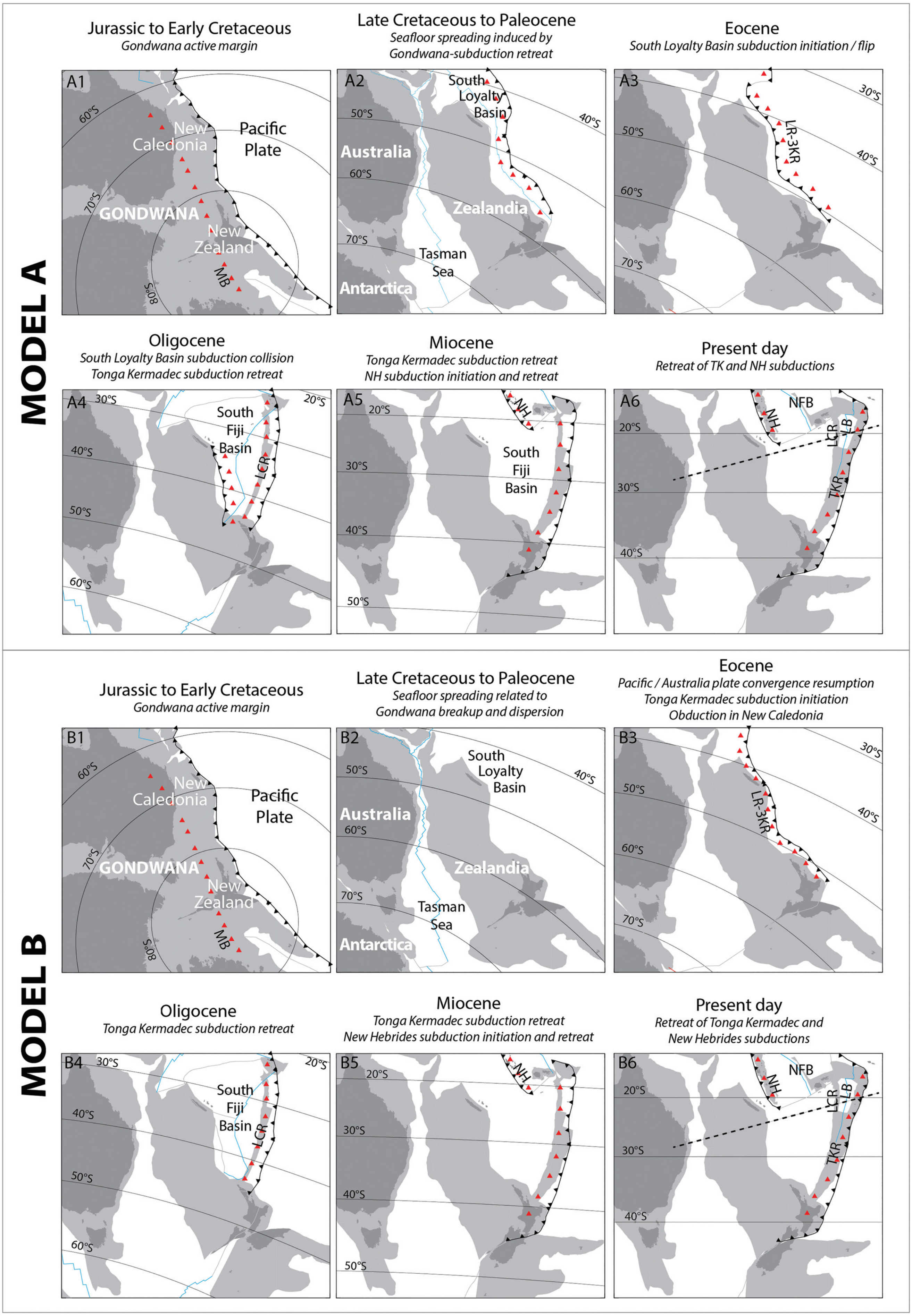
There are an increasing number of dredged rock samples from marginal basins and ridges between the Norfolk Ridge and the Tonga–Kermadec Trench. They reveal an overall history of west to east Tonga–Kermadec subduction rollback to its present-day position, although local uncertainties of subduction polarity exist during the Oligocene.

In one class of model (model A, Figs 2.5 & 2.6), jamming of the east-dipping South Loyalty subduction occurs during the latest Eocene in New Caledonia and propagates to New Zealand throughout the Oligocene (Whattam *et al.* 2008). This propagation explains diachronous ophiolite emplacement: Eocene in New Caledonia (cf. Maurizot *et al.* 2020*c*, Chapter 5, this Memoir) to Oligocene in Northland, New Zealand (Ballance and Spörli 1979; Malpas *et al.* 1992; Jiao *et al.* 2014). In this model, west-dipping Tonga–Kermadec subduction initiates as a subduction flip during or just following this jamming.

In the second class of model (model B, Figs 2.5 & 2.6), west-dipping Tonga–Kermadec subduction initiates along Zealandia's eastern margin during the Eocene and then retreats towards the east from the Eocene to the present day. The pole of rotation describing motion across the retreating trench is inferred to have been close to New Zealand. Deformation continued from the Eocene to the present day in the south (New Zealand), but was restricted to a pulse of Eocene deformation in the north as trench retreat towards the east isolated New Caledonia. All the models are similar for the Neogene. As Tonga–Kermadec subduction retreated towards the east, it preserved a series of remnant volcanic arcs and back-arc basins on the overriding plate.

The models predict that the North Loyalty Basin formed during the Eocene and Oligocene (Sdrolias *et al.* 2003; Mortimer *et al.* 2014) and the South Fiji Basin formed during the Oligocene to early Miocene (Watts *et al.* 1977; Davey 1982; Malahoff *et al.* 1982; Mortimer *et al.* 2007; Herzer *et al.* 2011). The Loyalty–Three Kings volcanic arc and Norfolk Basin formed in the Oligocene and Miocene (Mortimer *et al.* 1998; Nicholson *et al.* 2008).

Arc volcanism in Fiji started in the latest Eocene or Oligocene (Gill 1987). Subduction-related lavas of Oligocene age have been found on the Three Kings Ridge (Mortimer *et al.* 2007). Medium-K and high-K lavas of late Oligocene age on the northern Norfolk Ridge and early Miocene age near Three Kings Ridge are interpreted as an additional magmatic response to rapid Tonga–Kermadec subduction retreat (Mauffret *et al.* 2002; Mortimer *et al.* 2014). The Lau–Colville volcanic arc is presumed to have been active during the Miocene (Ballance *et al.* 1982; Hawkins 1995), but is sparsely sampled compared with other ridges in the region. Its activity appears to be coeval with the formation of the South Fiji Basin and the end of Colville arc activity is interpreted to have resulted from intra-arc tearing associated with slab rollback and the creation of the Lau Basin in the north and the Havre Trough in the south. This isolated the active Tonga–Kermadec arc (Hawkins 1995). The oldest rocks dated in the ODP 841 drill hole in the Tonga forearc cluster around 45 Ma, with the oldest being 46 Ma (McDougall *et al.* 1994). A similar age range has been found from 'Eua, an island on the Tonga platform (Duncan *et al.* 1985). Studies of the Tonga forearc have dredged ultramafic and subduction-related volcanic rocks as old as 52–48 Ma (Bloomer *et al.* 1995; Meffre *et al.* 2012). The Lau Basin and Havre Trough formed since the late Miocene or Pliocene (Malahoff *et al.* 1982; Parson and Wright 1996; Taylor *et al.* 1996; Sdrolias *et al.* 2003). These active basins have been extensively studied, with particular emphasis on their petrological and geochemical signatures. Oceanic accretion occurs along two major spreading ridges that are propagating south: the Valu Fa Ridge and the Lau Ridge (Hawkins 1995). The ocean floor consists of mid-ocean ridge basalts, except in the west of the basin, where a mixture of mid-ocean ridge basalt is found along with transitional rocks and volcanic arc basalts (arc tholeiites). Seismic refraction data shows that the western basin consists of *c.* 100 km width of thinned crust, probably stretched arc, and the eastern basin contains a *c.* 200 km width of 8–9 km



MODEL A
Jurassic to Early Cretaceous
Gondwana active margin
A1
60°S
70°S
80°S
New Caledonia
Pacific Plate
GONDWANA
New Zealand
MB
Late Cretaceous to Paleocene
Seafloor spreading induced by Gondwana-subduction retreat
A2
South Loyalty Basin
50°S
60°S
70°S
40°S
Australia
Zealandia
Tasman Sea
Antarctica
Eocene
South Loyalty Basin subduction initiation / flip
A3
30°S
40°S
50°S
60°S
70°S
LR-3KR
Oligocene
South Loyalty Basin subduction collision
Tonga Kermadec subduction retreat
A4
30°S
20°S
40°S
50°S
60°S
South Fiji Basin
LCR
Miocene
Tonga Kermadec subduction retreat
NH subduction initiation and retreat
A5
20°S
30°S
40°S
50°S
NH
South Fiji Basin
Present day
Retreat of TK and NH subductions
A6
NFB
NH
LCR
LB
TKR
20°S
30°S
40°S
MODEL B
Jurassic to Early Cretaceous
Gondwana active margin
B1
60°S
70°S
80°S
New Caledonia
Pacific Plate
GONDWANA
New Zealand
MB
Late Cretaceous to Paleocene
Seafloor spreading related to Gondwana breakup and dispersion
B2
South Loyalty Basin
50°S
60°S
70°S
40°S
Australia
Zealandia
Tasman Sea
Antarctica
Eocene
Pacific / Australia plate convergence resumption
Tonga Kermadec subduction initiation
Obduction in New Caledonia
B3
30°S
40°S
50°S
60°S
70°S
LR-3KR
Oligocene
Tonga Kermadec subduction retreat
B4
30°S
20°S
40°S
50°S
60°S
South Fiji Basin
LCR
Miocene
Tonga Kermadec subduction retreat
New Hebrides subduction initiation and retreat
B5
20°S
30°S
40°S
50°S
NH
Present day
Retreat of Tonga Kermadec and New Hebrides subductions
B6
NFB
NH
LCR
LB
TKR
20°S
30°S
40°S

thick oceanic crust (Crawford *et al.* 2003*b*). Spreading rates of 4–9.5 cm a^{-1} are comparable with those at the East Pacific Rise (Bevis *et al.* 1995).

The area north of New Caledonia remains poorly studied. Geophysical and dredge sample data have identified the South Rennell Trough and Santa Cruz Basin as an early Oligocene fossil spreading ridge (Mortimer *et al.* 2014; Seton *et al.* 2016), with the age of the flanking d'Entrecasteaux Basin largely unconstrained.

Miocene to present-day New Hebrides–Vanuatu subduction initiation and retreat

At the end of the mid-Miocene, the NE-dipping New Hebrides–Vanuatu subduction zone initiated along the Vitiaz Lineament, possibly in relation to a subduction flip induced by collision of the Ontong Java and Melanesian Border plateaus with the Vitiaz subduction zone (Chase 1971; Falvey 1975; Brocher 1985; Auzende *et al.* 1988*b*; Pelletier and Auzende 1996). The reconfigured subduction zone then formed the Solomon–Vanuatu arc and rolled back towards the south and SW, leading to opening of the North Fiji Basin (Auzende *et al.* 1988*a*, 1995*a*, *b*). Zircons found within the arc suggest that part of the Vanuatu basement comprises old continental material that was rifted and transported thousands of kilometres from northeastern Australia prior to the Cenozoic (Buys *et al.* 2014). The d'Entrecasteaux and Loyalty ridges entered the subduction zone before 2 Ma, resulting in local and regional deformation. The collision of the d'Entrecasteaux Ridge is thought to be responsible for large vertical motions in the central New Hebrides arc (Taylor *et al.* 1987) as well as the initiation of compression in the back-arc area (Collot *et al.* 1985). At the southern extremity, the eastern edge of the Loyalty Ridge (cf. Maurizot *et al.* 2020*d*, Chapter 6, this Memoir) entered the subduction zone, which resulted in local flexural uplift of the Loyalty Ridge and the southern part of Grande Terre of New Caledonia (cf. Sevin *et al.* 2020, Chapter 7, this Memoir; Dubois *et al.* 1974). This collision is thought to be responsible for the initiation of the Matthew–Hunter subduction zone along the southern edge of the North Fiji Basin (Monzier *et al.* 1990; Patriat *et al.* 2015, 2019).

Tectonic impacts on New Caledonian geology

The geology and present day shape and structure of New Caledonia are intimately related to the geodynamic evolution of the SW Pacific. Mesozoic basement terranes, described in Maurizot *et al.* (2020*a*, Chapter 3, this Memoir) (e.g. the Teremba, Boghen and Koh–Central terranes) were deposited and emplaced in the forearc context of the peri-Gondwana subduction zone. Cretaceous to Paleocene break-up and seafloor spreading between Gondwana and Zealandia resulted in the deposition of the syn- and post-rift sedimentary cover described in Maurizot *et al.* (2020*b*, Chapter 4, this Memoir) (e.g. Formation à charbon, Black Cherts). Eocene sedimentary rocks found in New Caledonia (e.g. the Bourail Group turbidites), along with high-pressure–low-temperature metamorphic rocks, record the reconfiguration of subduction and regional contraction across Zealandia (Sutherland *et al.* 2017). Nappe emplacement (described in Maurizot *et al.* 2020*c*, Chapter 5, this Memoir; e.g. the Montagnes Blanches Poya and Peridotite nappes) was associated with the culmination of this tectonic event. Neogene tectonic quiescence reflects the Tonga–Kermadec subduction rollback and isolation of New Caledonia by back-arc basins. During this period, northwards motion of the Australian plate moved New Caledonia to lower latitudes and tropical conditions. These favoured the development of carbonate platforms and the deep weathering of exposed rocks described in Sevin *et al.* (2020, Chapter 7, this Memoir), notably laterite development on the Peridotite Nappe and the formation of supergene nickel ore (cf. Maurizot *et al.* 2020*e*, Chapter 10, this Memoir). Since 2 Ma, the southern tip of Grande Terre and the Loyalty Islands, described in Maurizot *et al.* (2020*d*, Chapter 6, this Memoir), were uplifted by lithospheric flexure associated with subduction at the New Hebrides–Vanuatu Trench.

Conclusions

The SW Pacific contains a diverse assemblage of continents, volcanic arcs, hotspot tracks, large igneous provinces and oceanic basins. The geodynamic evolution was controlled by the dynamics of subduction zone death, reversal, initiation and rollback. This led to the final dispersal of Gondwanaland and the formation of the continent of Zealandia. Two classes of plate kinematic model have been proposed to explain development of features since 100 Ma. In one class of model, subduction evolution was complex, but nearly continuous throughout the entire period. In the other class of model, subduction stopped in the Late Cretaceous and then reinitiated in the Eocene. The main unresolved plate tectonic issues revolve around arc longevity and polarity in the interval 85–25 Ma, which may be better understood by future sampling and analysis in the SW Pacific.

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Fig. 2.6. Map reconstructions of two classes of models for the geodynamic evolution of the SW Pacific. Palaeo-latitudes are based on a hotspot reference frame. Red triangles, active volcanic arc; blue lines, active spreading centre; LB, Lau Basin; LCR, Lau–Colville Ridge; LR-3KR, Loyalty Ridge–Three Kings Ridge; MB, Median Batholith; NFB, North Fiji Basin; NH, New Hebrides–Vanuatu arc; TKR, Tonga–Kermadec Ridge. Dashed line indicates the location of the cross-section in Figure 2.5. Maps generated with Gplates.

conceptualization (equal), writing – review & editing (supporting); **SE**: conceptualization (supporting), writing – original draft (supporting), writing – review & editing (equal); **AB**: writing – review & editing (supporting); **PM**: conceptualization (supporting), project administration (supporting), writing – review & editing (supporting).

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