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Seismic stratigraphic record of transition from Mesozoic subduction to continental breakup in the Zealandia sector of eastern Gondwana

François Bache [a,*], Nick Mortimer [b], Rupert Sutherland [a], Julien Collot [c], Pierrick Rouillard [d], Vaughan Stagpoole [a], Andrew Nicol [a]

[a] GNS Science, Lower Hutt, New Zealand
[b] GNS Science, Dunedin, New Zealand
[c] Service de la géologie de Nouvelle Calédonie (SGNC), Direction de l'Industrie, des Mines et de l'Energie de Nouvelle-Calédonie, Nouméa, New Caledonia
[d] Agence de développement économique de la Nouvelle-Calédonie (ADECAL), Nouméa, New Caledonia

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ABSTRACT

The southwest Pacific between Australia, New Zealand and New Caledonia is a block of continental crust, Zealandia, that moved away from Australia and Antarctica after a long period of subduction beneath eastern Gondwana. We use >100,000 line-km of seismic-reflection profiles to identify intra-continental basins related to the Gondwana active margin, overlain with erosional unconformity by retrogradational strata. We interpret this regional-scale first-order unconformity, the Eastern Gondwana Composite Surface, and seismic-stratigraphic megasequence pattern to represent the transition from subduction to continental breakup and separation of eastern Gondwana. Rocks that make up the lower seismic-stratigraphic megasequence (Zealandia-3, Permian to Early Cretaceous) have been drilled near New Zealand and can be correlated with Murihiku Supergroup rocks. Farther north on the Lord Howe Rise, we correlate this megasequence with Triassic to Jurassic rocks of the Clarence-Moreton Basin of eastern Australia. We reinterpret the Fairway–Aotea Basin to be underlain by a wedge of Zealandia-3 deposits thrust in a retro-arc-like foreland basin that was active immediately prior to breakup. The lower rift and retrogradational megasequence (Zealandia-2, Late Cretaceous to Eocene) we correlate with the Pakawau and Kapuni Groups of Taranaki Basin, New Zealand, and the "Formation à charbon" and "phtanites" of New Caledonia. The boundary with the shallowest megasequence (Zealandia-1, Late Eocene to present) is the "Eocene–Oligocene Unconformity", which is primarily overlain by pelagic carbonate rocks. This regional unconformity likely represents the onset of the modern Tonga–Kermadec subduction system.

1. Introduction

The southwest Pacific region is characterised by oceanic basins, continental ribbons and magmatic ridges that record a complex Mesozoic and Cenozoic geologic evolution (Figs. 1 and 2). This evolution is relatively well understood from studies of onshore rocks in Australia, New Caledonia and New Zealand (Bradshaw, 1989; Mortimer, 2004b; Cluzel et al., 2012). Offshore basins and ridges, which represent the largest part of the southwest Pacific, have also been studied using seismic reflection lines, gravity, magnetic data, dredged rocks, and well samples (Mortimer et al., 1998; Sdrolias et al., 2003; Lafoy et al., 2005; Collot et al., 2008; Mortimer, 2008). However, knowledge of offshore rocks is concentrated in the Cenozoic period, which followed Gondwana breakup, with older buried rocks being poorly sampled and poorly imaged by some seismic-reflection profiles.

Five broad phases of tectonic evolution are usually accepted to explain the evolution of the southwest Pacific region (Fig. 2). From Triassic to early Cretaceous (>100 Ma), the eastern Gondwana margin was characterised by the southwest-dipping subduction of the Pacific–Phoenix plate (Sutherland, 1999; Mortimer, 2004b). The second phase of tectonic evolution (latest Early Cretaceous–early Late Cretaceous, 100–85 Ma) is characterised by widespread intracontinental rifting (breakup) and extension. The end of widespread rifting in New Zealand, New Caledonia and Australia, and the subsequent transition to passive margin conditions (Ballance, 1993) was approximately contemporaneous with seafloor spreading in the Tasman Sea between 85 and 50 Ma (Gaina et al., 1998; Sutherland, 1999). The fourth and fifth tectonic phases are associated with Cenozoic initiation and evolution of Tonga–Kermadec subduction (Sdrolias et al., 2003; Schellart et al., 2006; Sutherland et al., 2010; Herzer et al., 2011; Bache et al., 2012b).

A recent compilation of seismic reflection data permits analysis of sedimentary geometries and unconformities in key areas of Zealandia (Fig. 1), a block of continental crust which moved away from Australia and Antarctica after the long period of subduction of proto-Pacific seafloor beneath eastern Gondwana (Figs. 1 and 2). Here, we focus on

* Corresponding author at: GNS Science, P.O. Box 30368, Lower Hutt 5040, New Zealand. Tel.: +64 4 570 4686; fax: +64 4 570 4600.
E-mail address: f.bache@gns.cri.nz (F. Bache).

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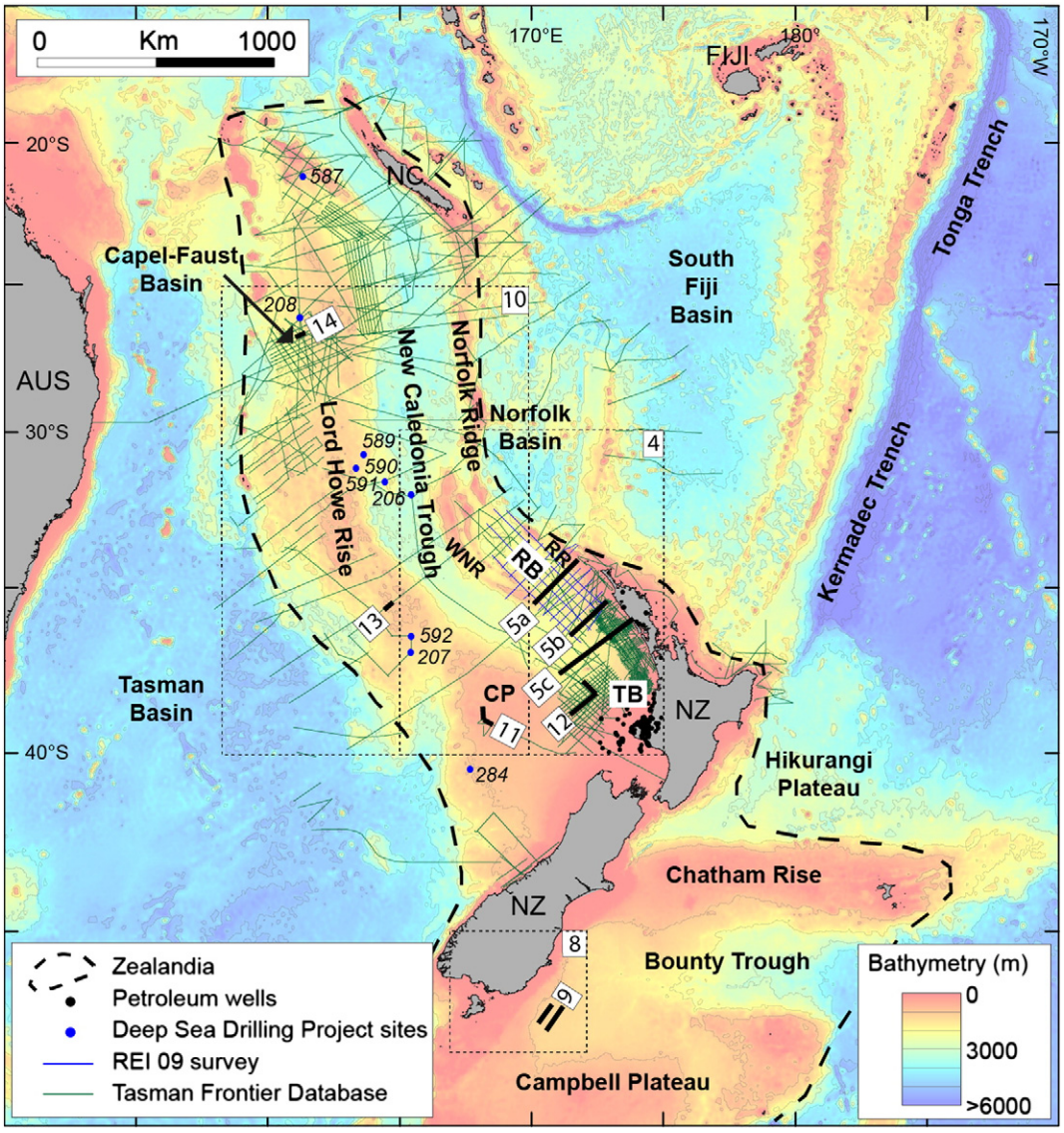

Fig. 1. Bathymetric map of the southwestern Pacific region showing data used for this study. Framed numbers refer to text figures numbers. AUS: Australia, NZ: New Zealand, NC: New Caledonia, CP: Challenger Plateau, TB: Taranaki Basin, RB; Reinga Basin, WNR; West Norfolk Ridge, and RR; Reinga Ridge. The bathymetric data are from ETOPO1 Global Relief Model (Amante and Eakins, 2009).

areas where sedimentary basins related to the Gondwana active margin (i.e. Gondwana subduction prior to 100 Ma) are preserved. We describe the stratal geometry in these basins and the transition to breakup and extensional settings (100–50 Ma). Our seismic-stratigraphic observations are interpreted in terms of rock types and tectonic events, and hence discussed in the context of Zealandia formation and evolution. Key areas, where sedimentary basins related to the long period of Gondwana subduction are preserved, provide new constraints to understand Zealandia palaeogeography prior to the onset of Gondwana breakup (~100 Ma).

2. Previous studies

Zealandia is a 4,500,000 km^2 block of continental crust located between New Caledonia and New Zealand's sub-Antarctic islands (Fig. 1). Major geologic features of this submerged continent are the New Caledonia Trough bounded by the Lord Howe Rise/Challenger Plateau and the Norfolk Ridge northwest of New Zealand (named here North Zealandia) and the Bounty Trough bounded by the Campbell Plateau and the Chatham Rise southeast of New Zealand (named here South Zealandia). The continental basement beneath the bathymetric rises is inferred from seismic velocities, and gravity and magnetic anomalies, and demonstrated from dredge samples, to be composed of metamorphic rocks and batholiths similar to those found in New Zealand, New Caledonia, and eastern Australia (Tulloch et al., 1991; Sutherland, 1999; Wood and Woodward, 2002; Mortimer, 2004a, 2004b; Klingelhoefer et al., 2007; Mortimer, 2008; Mortimer et al., 2008; Collot et al., 2012). Zealandia is bordered by oceanic crust of the Tasman Basin to the west and the Southwest Pacific Basin to the southeast. The Pacific margin of Zealandia is delimited by the Hikurangi Plateau, a large igneous province north of the Chatham Rise, and by the back-arc Norfolk and South Fiji basins east of the Norfolk Ridge (Fig. 1).

Volcanic, sedimentary, plutonic and metamorphic basement rocks of New Zealand and New Caledonia are generally interpreted as accreted terranes and batholith intrusions at an obliquely convergent margin (Aitchison et al., 1998; Cluzel and Meffre, 2002; Mortimer, 2004b; Adams et al., 2009; Cluzel et al., 2010). A Cordilleran batholith (Median Batholith) has been recognised and interpreted to represent subduction-related magmatism from c. 360 to 105 Ma (Mortimer et al., 1999; Tulloch and Kimbrough, 2003). The change from subduction to extension resulted in formation of a major, New Zealand-wide, angular unconformity (Laird, 1993; Laird and Bradshaw, 2004) and