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Melanesian back-arc basin and arc development: Constraints from the eastern Coral Sea

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ABSTRACT

The eastern Coral Sea is a poorly explored area at the north-eastern corner of the Australian Tectonic Plate, where interaction between the Pacific and Australian plate boundaries, and accretion of the world's largest submarine plateau – the Ontong Java Plateau – has resulted in a complex assemblage of back-arc basins, island arcs, continental plateaus and volcanic products. This study combines new and existing magnetic anomaly profiles, seafloor fabric from swath bathymetry data, Ar–Ar dating of E-MORB basalts, palaeontological dating of carbonate sediments, and plate modelling from the eastern Coral Sea. Our results constrain commencement of the opening of the Santa Cruz Basin and South Rennell Trough to c. 48 Ma and termination at 25–28 Ma. Simultaneous opening of the Melanesian Basin/Solomon Sea further north suggests that a single >2000 km long back-arc basin, with at least one triple junction existed landward of the Melanesian subduction zone from Eocene–Oligocene times. The cessation of spreading corresponds with a reorganisation of the plate boundaries in the area and the proposed initial soft collision of the Ontong Java Plateau. The correlation between back-arc basin cessation and a widespread plate reorganisation event suggests that back-arc basins may be used as markers for both local and global plate boundary changes.

1. Introduction

The Coral Sea lies in the north-eastern corner of the Australian Tectonic Plate, in a pivotal position at the juncture between two of the world's most tectonically complex regions: the SW Pacific and SE Asia (Fig. 1). While the origin and evolution of the western part of the Coral Sea, including the Queensland and Marion Plateaus and Coral Sea Basin is relatively well-known (Falvey and Taylor, 1974; Weissel and Watts, 1979; Gaina et al., 1999), the eastern Coral Sea, with its mosaic of ridges, plateaus and basins has a largely unknown history. Previous plate tectonic reconstructions seeking to explain the origin and evolution of the submarine features in the eastern Coral Sea have been limited. The area is either largely ignored in regional plate tectonic models (Weissel and Watts, 1979; Hall, 2002; Sdrolias et al., 2003), or overly simplified with inferred ages for many of the features (Yan and Kroenke, 1993; Schellart et al., 2006; Whattam et al., 2008). These poorly constrained models reflect the scarcity of marine geophysical data and geological samples from the area, the inherent complexity of the many ridges and basins, and substantial volcanic and tectonic overprinting. Such a significant gap in our understanding of the tectonic development of the Coral Sea is unsatisfactory particularly for an area that provides plate boundary continuity between the SW Pacific and SE Asia along the western Pacific boundary, and thus is critical for plate reconstructions of both areas. In addition, this area lies adjacent to the North Solomon subduction zone and Ontong Java Plateau, the site of a major plateau accretion and subduction event, which is believed to have occurred either in the Oligocene (Musgrave, 2013), Miocene (Petterson et al., 1999) or Pliocene (Cowley et al., 2004). This collision induced a subduction polarity reversal in the Pliocene (Cooper and Taylor, 1985). Understanding the evolution of the submarine features in the eastern Coral Sea may provide insights into the timing and processes of the Ontong Java Plateau collision and help identify the effects of a major collision event on the over-riding plate.

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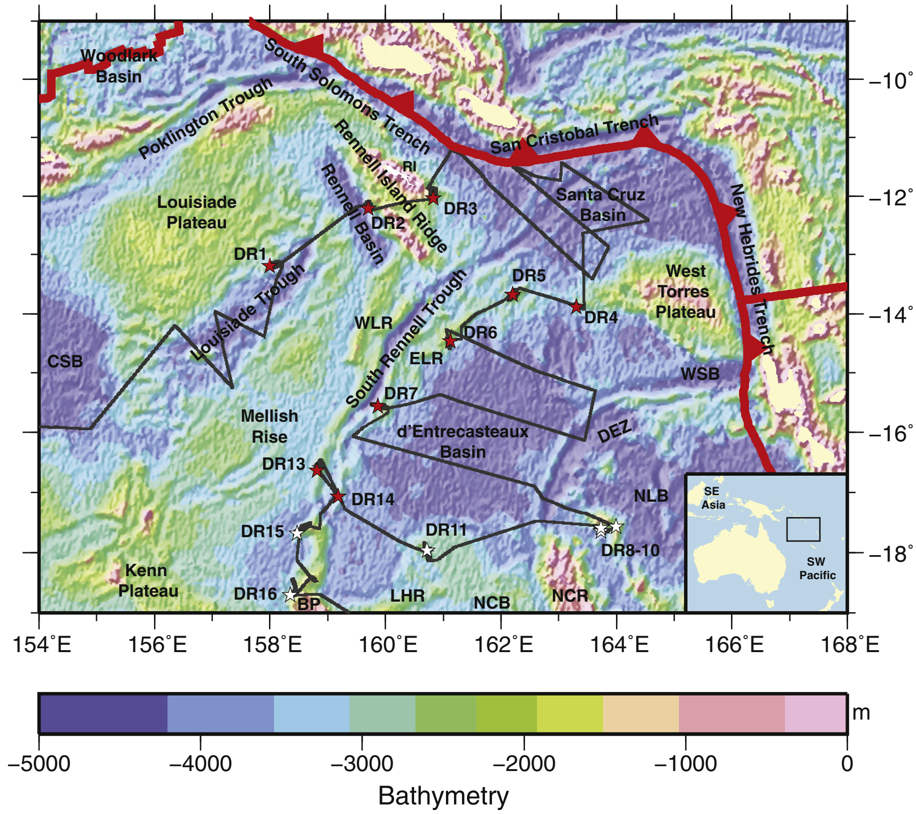

Fig. 1. Regional bathymetry compilation of the eastern Coral Sea from Geoscience Australia, with hill-shade using gravity gradients from Sandwell et al. (2014). Red stars mark the location of dredges from voyage SS2012_V06 used in this study, white stars mark the location of dredges from voyage SS2012_V06 not used in this study and grey line denotes the ship track from voyage *SS2012_V06*. Rennell Island is coloured white as opposed to other land coloured light yellow. BP = Bellona Plateau, CSB = Coral Sea Basin, DEZ = d'Entrecasteaux Zone, ELR = East Lapérouse Rise, LHR = Lord Howe Rise, NCB = New Caledonia Basin, NCR = New Caledonia Ridge, NLB = North Loyalty Basin, RI = Rennell Island, WLR = West Lapérouse Rise, WSB = West Santo Basin.

We present the results of a recent research voyage (SS2012_V06) on *RV Southern Surveyor* to the eastern Coral Sea in October–November, 2012 where approximately 13,600 km^2 of swath bathymetry data, 6200 km of magnetic and 6800 km of gravity data were collected, together with igneous and sedimentary samples from 14 seafloor sites (Fig. 1). Swath bathymetry and magnetic anomaly data are used to model the timing and orientation of seafloor spreading in the Santa Cruz Basin. Geochemical analysis and Ar–Ar dating of recovered igneous samples together with palaeontological age constraints from sedimentary samples at the dredge site locations are used to relate spreading in the Santa Cruz Basin to activity along the South Rennell Trough and the igneous activity along the Rennell Island Ridge. Combining the results of our study with recently dated dredge samples from earlier ORSTOM voyages (Mortimer et al., 2014), we develop plate tectonic reconstructions of the eastern Coral Sea since the Cretaceous underpinned by age constraints from both marine geophysical data and geological samples. Our plate reconstructions include a network of continuously closing plate boundaries (Gurnis et al., 2012), which can be used to provide plate boundary continuity between the SW Pacific and SE Asia during this time period.

2. Regional tectonic framework

The SW Pacific is characterised by a series of marginal basins, submerged continental slivers and back-arc–arc–forearc complexes largely controlled by the interaction of the Australian and Pacific plates since the Mesozoic (Yan and Kroenke, 1993; Crawford et al., 2003; Sdrolias et al., 2003; Schellart et al., 2006; Whattam et al., 2008) (Fig. 1). In contrast, SE Asia is an amalgamation of accretionary continental fragments, exotic terranes and intra-oceanic island arcs, formed largely from the long-term interaction between the Australian, Pacific and Eurasian plates and Gondwana-derived terrane accretion (Acharyya, 1998; Hall, 2002; Stampfli and Borel, 2002; Golonka, 2004; Metcalfe, 2009; Zahirovic et al., 2014). These two tectonically complex regions are connected through the "Melanesian Borderlands" region, which includes the Coral and Solomon Seas.

The Coral Sea is bounded by the passive margin of eastern Australia in the west, the inactive Pocklington Trough and Papuan Peninsula to the north, the active South Solomon/San Cristobal and New Hebrides Trenches to the northeast and east, and the Lord Howe Rise/New Caledonia region to the south (Fig. 1). It consists of the relatively well-explored Coral Sea Basin and Queensland and Marion plateaus in the western part and a complex arrangement of poorly explored and under-sampled submarine plateaus, linear depressions, elongated ridges, oceanic basins and seamounts in the eastern part, including the Rennell Basin, Rennell Island Ridge, South Rennell Trough, West Torres Plateau and Santa Cruz and d'Entrecasteaux Basins (Fig. 1).

Many of the features in the area are named after Rennell Island, which lies in the eastern Coral Sea at 160°E, 11.5°S (Fig. 1). These include: the Rennell Island Ridge, East Rennell Island Ridge, Rennell Trough, Rennell Basin, South Rennell Trough and Rennell Fracture Zone (e.g. Landmesser et al., 1973; Larue et al., 1977; Daniel et al., 1978). As the region becomes better known, we consider this preponderance of the name 'Rennell' to be unhelpful in science communication, especially as some of these features are up to 700 km distant from Rennell Island. In this paper we retain the names South Rennell Trough and Rennell Basin as these are used by all aforementioned authors except Landmesser et al. (1973). Use of these names supersedes Rennell Fracture Zone and Rennell Trough, respectively. We also retain the name Rennell Island Ridge but restrict its use to the NW–SE striking