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Arc-continent collisional orogenesis in the SW Pacific and the nature, source and correlation of emplaced ophiolitic nappe components

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ABSTRACT

Southwest Pacific ophiolitic nappes emplaced upon the former margin of eastern Australia provide a record of cyclical episodes of arc-continent collisional orogenesis that occurred throughout the Paleogene. Cenozoic nappes in Papua-New Guinea, New Caledonia and Northland, New Zealand consist of two key components: (1) a basal and apparently older Late Cretaceous–Eocene, metamorphosed, normal to weakly-enriched MORB-like basaltic ocean floor terrane; and (2) an uppermost supra-subduction zone (SSZ) ophiolite that represents basement of the associated magmatic forearc. A detailed comparison of geochemical characteristics of unequivocal SSZ basalts with those considered as representative of the basaltic ocean floor terranes illustrates that formation of the majority of the latter is consistent with melting of a source transitional to normal (N-) and enriched (E-) MORB. These slight REE-enriched or transitional (T-) MORB have generally been considered as the result of seafloor spreading in a back arc basin (BAB) or basins to the east of Australia in the Late Cretaceous-Paleocene (~85–55 Ma). The enrichment recorded by the BAB basalts is likely a result of upwelling plumes associated with initial fragmentation of eastern Gondwana that left their signature on the mantle source consequently tapped by the BAB basalts. A subset of slightly more enriched basalts may owe their enrichment to source contamination (minor assimilation of thinned Gondwana-derived continental crust). Associated LREE-depleted N-MOR basalts previously considered as part of the basaltic ocean floor terranes on the other hand, are similar to SSZ basalts of the Northland and Papuan Ultramafic Belt ophiolites. Refinement of existing tectonic models is hindered by ambiguities in the stratigraphic relationships of the underlying basaltic ocean floor terranes with the overlying SSZ ophiolites, a paucity of age data and uncertainties in the tectonomagmatic affinities of the underlying basalts. Nonetheless, the geochemical characteristics displayed by LREE-depleted basalts of the basaltic ocean floor terranes suggest that these may instead represent younger, magmatic forearc basement components subsequently overthrust by lower sections of a genetically related ophiolite. Whether these and for that matter the majority of basalts of the basaltic ocean floor terranes, indeed represent complementary forearc crust to the SSZ ophiolite as opposed to a slice of Late Cretaceous-Eocene BAB floor backthrust beneath the SSZ ophiolite upon emplacement, will have to await the acquisition of corresponding radiometric age data.

1. Introduction

SW Pacific ophiolitic nappes in Papua-New Guinea, New Caledonia and Northland, New Zealand (Figs. 1 and 2), owe their emplacement to arc-continent collisions that occurred throughout the Paleogene. The nappes comprise a volumetrically dominant, overlying supra-subduction zone (SSZ) ophiolite and an underlying basaltic oceanic floor terrane (of predominantly MORB-like affinity) and associated sediments (Fig. 3). Tectonic models for each nappe are similar and posit nappe emplacement from the NE to the SW above a NE-dipping subduction system subsequent to arc-eastern Australian Plate collision (Fig. 3b) (e.g., Worthing and Crawford, 1996; Eissen et al., 1998; Cluzel et al., 2001; Whattam et al., 2006). Each model specifies that NE-dipping subduction nucleated in a marginal basin to the NE of each region and that a thin sliver or slivers of the down-going marginal basin slab was thrust beneath and emplaced with the overriding SSZ ophiolite. Tectonic reconstructions of the region for ~70–65 Ma (Crawford et al., 2003; Schellart et al., 2006; Whattam et al., 2008) indicate that a more or less continuous marginal basin spreading centre extended from Papua-New Guinea to New Caledonia to present-day Northland (Fig. 4). It is this massive 'BAB' in which the underlying basaltic ocean floor terranes are inferred to have formed.

Implicit in the aforementioned regional models and tectonic reconstructions, therefore, is that the basaltic ocean floor terranes beneath each SSZ ophiolite should be of: (1) the same age and geochemical affinity; and (2) different geochemical affinity to the SSZ ophiolite. A fundamental problem however, is confusion as to which basalts comprise the underlying basaltic ocean floor terrane and which ones belong to the SSZ ophiolite (see Whattam et al., 2008). In

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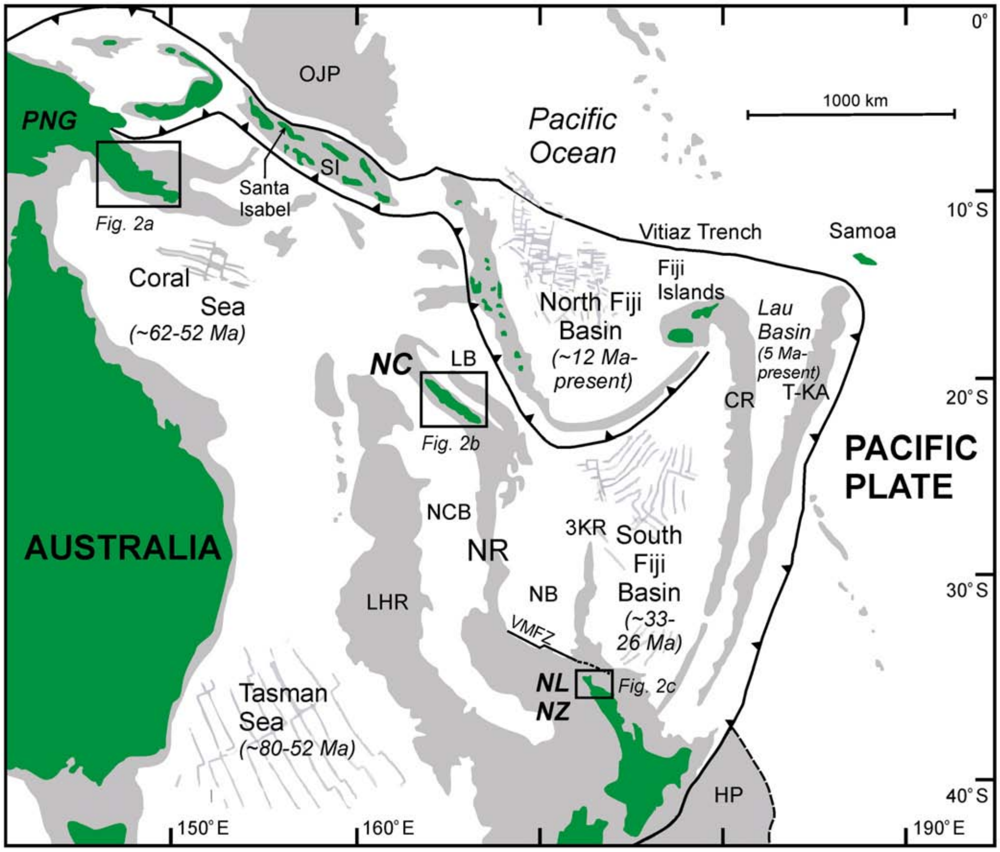

Fig. 1. Present-day tectonic configuration of the SW Pacific showing the distribution of major tectonic features (mainly from Hall, 2002). Abbreviations: CR — Colville Ridge, HP — Hikurangi Plateau; LB — Loyalty Basin; LHR — Lord Howe Rise; NC — New Caledonia; NCB — New Caledonian Basin; NLNZ — Northland New Zealand; NR — Norfolk Ridge; OJP — Ontong Java Plateau; PNG — Papua-New Guinea; T-KA — Tonga-Kermadec Arc; SI — Solomon Islands; VMFZ — Vening Meisnez Fracture Zone. Age ranges in parentheses below the text of Coral Sea (see Gaina et al., 1999), Lau Basin (Parson and Hawkins, 1994), North Fiji Basin (Pelletier et al., 1993), South Fiji Basin (see Sdrolias et al., 2003) and the Tasman Sea (see Gaina et al., 1998) indicate the period of basin formation (spreading). Boxes beside PNG, NC and NLNZ are shown in Fig. 2a,b and c, respectively.

all cases, the age of basalts considered as basaltic ocean floor terrane has been constrained on the basis of rare (c.f. Whattam et al., 2006) and in many cases very poorly preserved (Cluzel et al., 2001; Whattam et al., 2005) Late Cretaceous–Upper Paleocene inter-pillow microfaunal assemblages; complementary, robust radiometric age data do not exist. As a result, it is impossible to quantify the volume of basaltic rocks that are paleontologically constrained as Late Cretaceous–Paleocene. Furthermore, it is apparent that there is ambiguity as to which geochemically defined basaltic suites contain faunal assemblages and which ones do not.

As was pointed out by Whattam et al. (2008), and as explained above, the emplacement models for the Papuan Ultramafic Belt, New Caledonia and Northland ophiolitic nappes are broadly similar. A fundamental difference with the SW Pacific tectonic model of Whattam et al. (2008), however, is that each SSZ ophiolite represents lithosphere generated at subduction inception and forearc basement emplaced within ~10–15 m.y. of its formation. This model is akin to the subduction infancy model of Stern and Bloomer (1992) that posits that many SSZ ophiolites represent forearc lithosphere generated during the earliest stages of intra-oceanic arc formation. On the basis of similarities in trace element and REE patterns of 32–26 Ma Northland ophiolite SSZ basalts, Whattam et al. (2008) also suggested that back arc basin (BAB) and island arc tholeiitic (IAT) basalts of the Poya and Pouebo basaltic ocean floor terranes beneath the New Caledonia SSZ ophiolite formerly considered as Late Cretaceous–Paleocene (Cluzel et al., 2001) probably instead represent Eocene SSZ lithosphere (i.e., complementary crust to the ultramafic nappe that dominates the New Caledonia ophiolite). Resolution of this idea and the age conundrum for the basaltic ocean floor terranes, will have to await the acquisition of high-calibre radiometric age data. Nonetheless, a preliminary test of the accuracy of these reconstructions (e.g., of Whattam et al., 2008) from a geochemical standpoint is possible via further comparison of ophiolitic nappe basalts from each region.

The purpose of the paper is twofold (i) to provide a review of the tectonic evolution of the SW Pacific based on regional models for Papua-New Guinea (Davies and Smith, 1971; Worthing and Crawford, 1996); New Caledonia (Eissen et al., 1998; Cluzel et al., 2001); and Northland, New Zealand (Whattam et al., 2006) and the SW Pacific-scale model of Whattam et al. (2008); and (ii) to provide a comparison, correlation and re-evaluation of SW ophiolitic nappe components, which is fundamental for evaluating the merit of these models. Sections 2 and 3 provide a synopsis of the tectonic evolution of the SW Pacific and a description of the geodynamic processes involved in cyclical episodes of arc-continent collisional orogenesis that played a fundamental role in the regions evolution. A description and comparison of components comprising the Papuan Ultramafic Belt, New Caledonia and Northland ophiolitic nappes is provided in Section 4. As the interpretation and correlation of SW Pacific ophiolitic nappe basaltic rocks is crucial for refining SW Pacific tectonic models, the second segment (Sections 5 and 6) entails a detailed comparison and re-evaluation of geochemical characteristics of basalts and associated rocks of these three key ophiolitic nappes. The geochemical comparison is accomplished using databases of previously published trace and REE data of basaltic rocks comprising these ophiolitic nappes. The result is the first side-by-side geochemical comparison of basalts and related rocks of SW Pacific ophiolitic nappes and a preliminary assessment of regional tectonic models.