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The Watonga Formation and Tacking Point Gabbro, Port Macquarie, Australia: Insights into crustal growth mechanisms on the eastern margin of Gondwana

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ABSTRACT

A diverse assemblage of accretionary complex, island-arc, ophiolitic and high-pressure, low-temperature metamorphic rocks occurs within the serpentinite mélange at Port Macquarie on the eastern extremity of the New England Orogen of eastern Australia. New field observations, U–Pb zircon dating, petrography and geochemistry presented here establish a more robust chronology and interpretation of these rocks. Previously, all basalt, chert and volcaniclastic sandstones at Port Macquarie were grouped into the Watonga Formation. Ordovician to middle Devonian radiolarians and conodonts from 'Watonga' chert-basalt associations shows that they are older than, and unrelated to, 'Watonga' volcaniclastic rocks like those at Green Mound which contain volcanic/detrital zircons as young as 335 Ma that were derived from a Carboniferous arc. Volcanic detritus with pillow lava forming a block within the serpentinite mélange yielded 452 ± 10 Ma igneous zircons, indicating an Ordovician age. The Tacking Point Gabbro has an age of 390 ± 7 Ma (Devonian) and geochemical affinities with intra-oceanic arc igneous suites. It was intruded into deformed cherts of the Watonga Formation giving a spatial link between an Ordovician–Devonian? Accretionary complex and adjacent Devonian island-arc. The MORB-like basalt-chert association of the Watonga Formation and the Devonian Tacking Point gabbro represents a mid-Paleozoic assemblage allochthonous to Gondwana, which possibly correlates with the Djungati and Gamilaroi terranes respectively located further west in the New England Orogen. Zircon dating shows that post-serpentinite mafic–felsic dykes were emplaced into the Port Macquarie serpentinite at 247 ± 20 Ma and further disrupted. Therefore, tectonism affecting the serpentinite continued into the Early Triassic, with final movement during the Hunter-Bowen Orogeny. Our results from Port Macquarie are compatible with a tectonic model for the New England Orogen that involves episodic island-arc collisional events (Gamilaroi and Gympie terranes) interspersed with periods of continental margin "Andean-type" magmatism and accretion along eastern Gondwana.

1. Introduction

The New England Orogen (NEO) of Australia (Fig. 1) developed along the eastern margin of Gondwana by convergent margin accretion and amalgamation of terranes during the Paleozoic and earliest Mesozoic (Murray et al., 1987; Flood and Aitchison, 1988; Cawood and Buchan, 2007; Cawood et al., 2011a). Widespread intrusion of granite plutons occurred episodically within the NEO from the latest Carboniferous (~300 Ma) through to the Triassic (~220 Ma). The Hunter-Bowen Orogeny is the main deformation event within the NEO (Collins, 1991) and broadly corresponds with a magmatic hiatus from the latest Permian to Early Triassic (Holcombe et al., 1997; Li et al., 2012). Together these resulted in the complex tectonic collage now observed in the NEO.

For the eastern Gondwanan margin, there is considerable debate whether crustal accretion was entirely over a single long-lived, westerly-dipping, easterly migrating subduction zone (Cawood and Buchan, 2007; Cawood et al., 2011a) or if there were changes of subduction polarity, with rafting-in of intra-oceanic island-arc domains of Panthalassan origin onto the Gondwanan margin (Aitchison et al., 1992; Aitchison and Ireland, 1995; Offler and Gamble, 2002; Murray, 2007). Furthermore, the timing of these events is much debated. Some studies argue that most crustal development, including the

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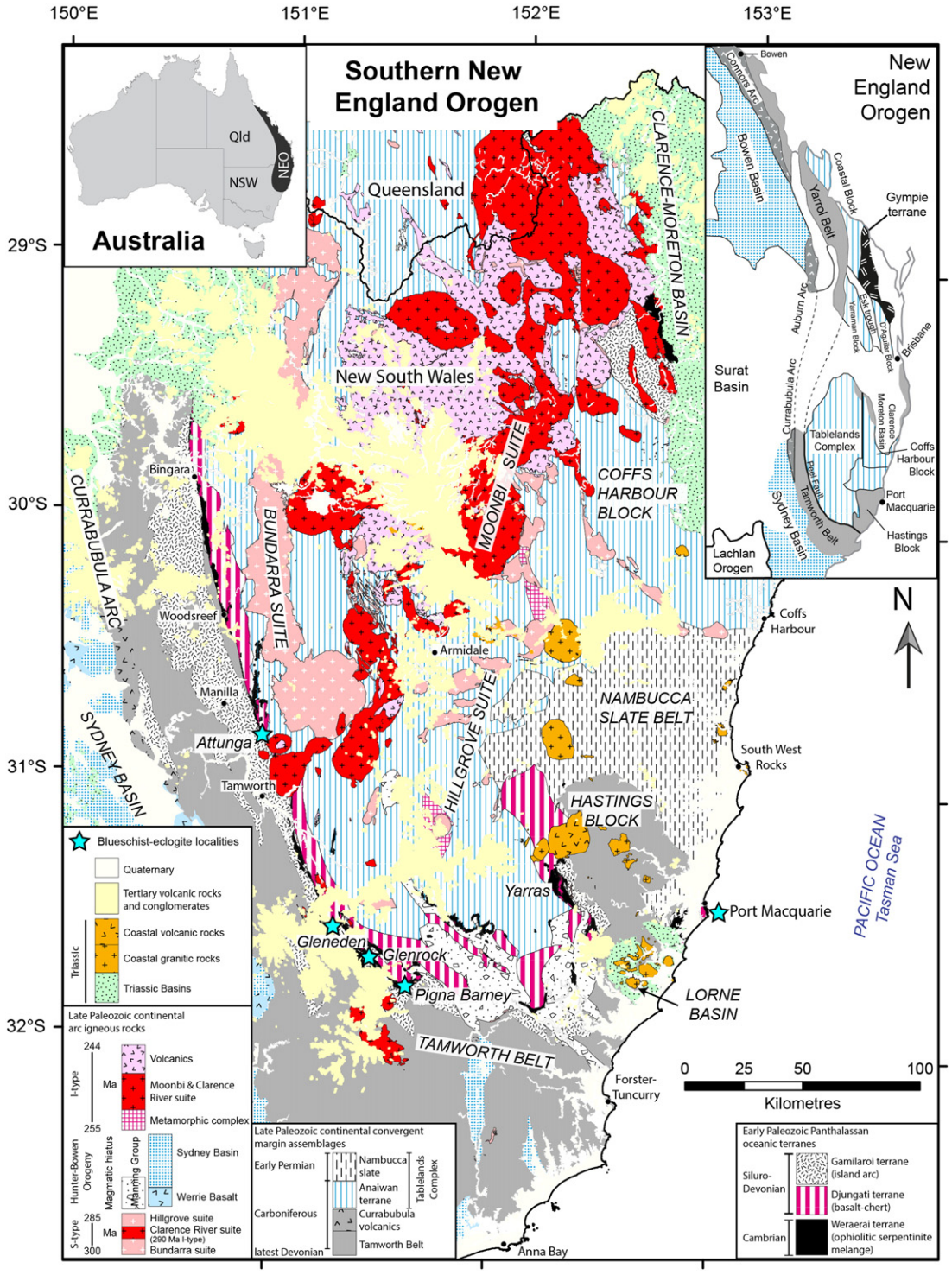

Fig. 1. Geology of the New England Orogen grouping units into the terrane scheme of Aitchison and Flood (1990) and showing the location of the Port Macquarie study area.

emplacement of serpentinites with blocks preserving eclogite and blueschist facies metamorphism, occurred entirely in the early-middle Paleozoic (Fukui et al., 1995; Och et al., 2003; Phillips and Offler, 2011), whereas more recent dating suggests that some important crustal development as well as some high-pressure metamorphism could have occurred as late as ~250 Ma, perhaps early in the Hunter-Bowen Orogeny (Nutman et al., 2013).

In this paper these controversies are explored further by U–Pb zircon dating, petrographic and geochemical studies of the Watonga Formation, the Tacking Point Gabbro and syn-kinematic intrusions (Leitch, 1974; Och, 2007) at Port Macquarie in northern New South Wales (Figs. 1 and 2). The Watonga Formation is one of the easternmost occurrences of basalt–chert–turbidite associations in the NEO, and sedimentary petrology and the dating of detrital zircons can test to what degree it was derived from a simple (intra-oceanic) volcaniclastic source or from a complex early Paleozoic to Precambrian Gondwanan source. The Tacking Point Gabbro is important, because it is the easternmost body of its type in the NEO, and its age, geochemistry and the nature of its country rocks can establish whether or not it formed remote from the Gondwana margin. Results of our study, suggest that it is