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Constraining the VanDieland microcontinent at the edge of East Gondwana, Australia

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ABSTRACT

Using airborne magnetic and marine gravity data, the geological subdivisions of western Tasmania have been interpreted north across Bass Strait into Victoria. The three westernmost Tasmanian zones, the King Island, Rocky Cape and Burnie zones, are inferred to form the largely concealed Selwyn Block in Victoria. The Eastern Tasmania Zone correlates with the Victorian Tabberabbera Zone. Thus the Tasmanian Tamar Fracture Zone corresponds with the Victorian Governor Fault. The Victorian Ceres Gabbro is correlated with magnetic rocks west of King Island that are tentatively considered to be Neoproterozoic. Most of the Cambrian felsic volcanic rocks of the Tasmanian Mount Read Volcanics lie above the Burnie Zone, as do the similar rocks exposed in the Jamieson, Licola and Glen Creek windows in central Victoria. Reinterpretation of a Victorian deep seismic reflection line indicates Burnie Zone equivalent rocks were thrust south-west over Rocky Cape Zone equivalents.
A link between western Tasmania and central Victoria is evident from Upper Devonian granites intruded into the Selwyn Block region. The eastern end of the Upper Devonian Cobaw Complex and the Warburton Granodiorite contain calcsilicate enclaves interpreted to be derived from a northern equivalent to the Smithton Basin. The Mount Disappointment Granodiorite has high Ni and Cr contents and pseudomorphs after orthopyroxenes, consistent with having been partly sourced from the underlying basaltic rocks like those on the eastern margin of the King Island Zone. The magnetic responses under the Strathbogie Complex, the Cerberean Caldera and the Lysterfield Granodiorite are attributed to metamorphism of part of an extension of the Smithton Basin, probably equivalents to the 580 Ma Spinks Creek Volcanics. Quartzite cobbles in a Devonian conglomerate in the southeastern Melbourne Zone may be derived from Rocky Cape Group equivalents. When integrated with the geological interpretation of Tasmania, we provide a stratotectonic map of the VanDieland micro-continent.

1. Introduction

Accretionary orogenic systems record protracted tectonic evolutions that span tens to hundreds of million years. Accretion of buoyant crustal material onto the edges of these margins have a profound influence on the internal geometry of these orogenic systems (Betts et al. 2015; Moresi et al. 2014) including spectacular orocline formation (Li et al. 2012; Musgrave 2015) and tectonic mode switches (Lister and Forster 2009). The Terra Australia Orogen (Cawood 2005) (Fig. 1A) formed along the Gondwanan supercontinent margin during the Phanerozoic and faced an external ocean. The Australian-Antarctic segment of this orogen, the Tasmanides, has been extensively studied (e.g. Collins 2002; Glen 2005; Gray et al. 2006; Kemp et al. 2009; Phillips and Offler 2011; Powell and Baillie 1992). These studies have highlighted a complex evolution dominated by extensional tectonics controlled by subduction roll back (Royden 1993), with transient tectonic mode switches and associated regional shortening and crustal thickening. These repeated tectonic mode switches initiated during the Cambrian and continued until the present-day. A significant advance in the recent literature of the Tasmanides is the recognition of allochthonous crust embedded in the accretionary orogen and the association between accreted terranes and orocline development (Cayley 2012; Moresi et al. 2014; Musgrave 2015) and tectonic mode switches, which have contorted the orogenic system. The most prominent of these accreted terranes is a micro-continent termed VanDieland (Cayley 2011), which comprises the Selwyn Block (Cayley et al. 2002) on mainland Australia, western Tasmania, and its bathymetric extensions preserved in the Southern Ocean (Moore et al. 2015; Moore et al. 2013) (Fig. 1B). The larger tectonic analysis of the Tasmanides treats VanDieland as a single microcontinent. However, the internal geology of the micro-continent provides important insights to both the Cambrian evolution of the Gondwanan margin, as well as earlier correlations with other continents (Halpin et al. 2014; Moore et al. 2015). Our understanding of the internal geology of VanDieland has been limited to the exposed geology of western Tasmania and several sparse and isolated exposures on the coast of mainland Australia. Moore et al. (2015) outlined a strato-tectonic map of the pre-Ordovician rocks of western

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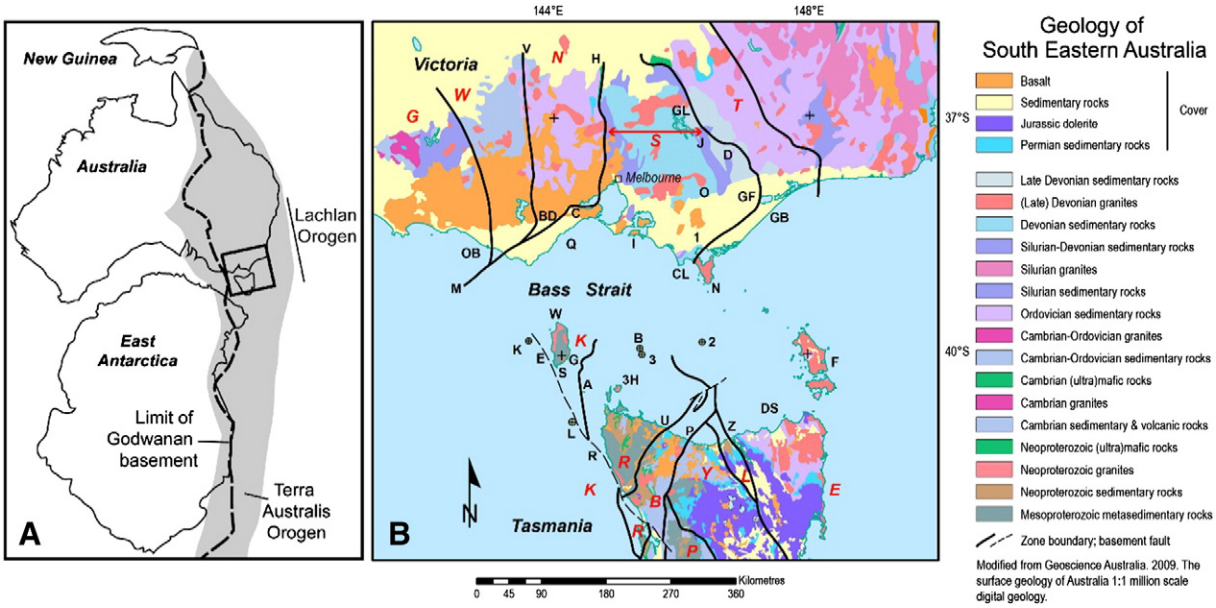

Fig. 1. A. The east Gondwanan part of the Terra Australis Orogen (after Cawood 2005). The box over southern Australia shows the location of Fig.1 B. B. Geology of south eastern Australia. 1 shows the location of borehole FOS 1; 2, borehole Bass 2; 3, borehole Bass 3; 3H Three Hummock Island; A, Albatross Island; B, borehole White Ibis; BD, Barwon Downs Graben; C, the Ceres Gabbro; CL, Cape Liptrap; D, the Dolodrook Window; DS, Durroon Sub-basin; E, Ettrick Beach; F, the Furneaux Group; G, Grassy Group; GB, the Gippsland Basin; GF, the Governor Fault; GL, the Glen Creek window; H, the Heathcote–Mount William Fault system; I, Phillip Island; J, the Jamieson window; K, borehole Whelk 1; L, borehole Clam 1; M, the Bambra Fault; N, Wilsons Promontory; O, the Boola Formation; OB, the Otway Basin; P, Penguin; Q, the Torquay Embayment; R, the Braddon River Fault; S, Stokes Point, on the southern tip of King Island; U, the Arthur Complex; V, the Avoca Fault; N, W Cape Wickham, on the northern tip of King Island; and Z, the Tamar Fracture Zone. Basement zones shown in red italics; *B*, Burnie; *E*, Eastern Tasmania; *GS*, Grampians-Stavely; *K*, King Island; *L*, Sorell-Badger Head; *N*, Bendigo; *P*, Pedder; *R*, Rocky Cape; *S*, the Selwyn Block, which underlies the Melbourne Zone; *T*, Tabberabbera; *W*, Stawell; and *Y*, the Tyennan Zone.

Tasmania. However, no such map exists for the parts of VanDieland under Bass Strait or the Selwyn Block in Victoria, as they mostly lie under the waters of Bass Strait or several kilometres of younger rocks (Norvick and Smith 2001; VandenBerg et al. 2000). This paper presents a geophysical interpretation constrained by geological data to extrapolate the exposed geology of western Tasmania northwards into the Selwyn Block on mainland Australia (Fig. 1B). The result is the first strato-tectonic map of the entire micro-continent and an outline of some of the relationships between VanDieland and the Lachlan Orogen.

The landward margin of the Terra Australis Orogen was formed by the breakup of Rodinia (Cawood 2005). In the eastern Australian-Antarctic sector, the last breakup events took place at approximately 580 Ma (e.g. Greenfield et al. 2011; Moore et al. 2015). Thereafter the Pacific Ocean was kept open by a stable convective cell, upwelling along a mid-ocean ridge system and subducting in a more complex fashion around the Pacific margin (Collins 2003; Coney 1992). For much of the Early Paleozoic the eastern margin of Gondwana was generally in extension but this was punctuated by shorter compressional phases (Collins 2002) several of which coincided with the arrival of exotic terranes (Cayley 2011; Cayley et al. 2002; Moresi et al. 2014). The internal structure and stratigraphy of the accreted terranes are different to the enclosing orogen, and so may have had very different chemical and/or physical properties to the enclosing orogen. This could have led to the generation of mineral systems or igneous rocks with different characteristics to the adjacent crustal blocks. Further, the presence of these exotic terranes along this margin potentially resolves many outstanding issues, such as not being able to correlate the geology of the Terra Australis Orogen along strike (Cawood 2005; Coney et al. 1990; Moresi et al. 2014; Ramos 2010).

1.1. Tasmanian VanDieland

One of the most perplexing issues in the geology of south-eastern Australia is the link between the geology of western Tasmania and the southern Lachlan Orogen in Victoria, which are separated by the relatively narrow Bass Strait (Fig. 1B). In western Tasmania, the exposed stratigraphy is dominated by Proterozoic rocks, with the oldest exposed sequences Mesoproterozoic marginal marine quartzites and siltstones (Halpin et al. 2014) overlain by the Neoproterozoic Smithton Basin and structurally emplaced against the Neoproterozoic turbidite rocks of the Burnie Formation.

Moore et al. (2015) subdivided the rocks into 7 zones (Fig. 1B). From the north and west these are: (1) the King Island Zone, which comprises deep water sedimentary rocks that were metamorphosed at 1290 Ma and 760 Ma (Berry et al. 2005; Turner et al. 1998). These rocks are bounded to the east by 580 Ma rift tholeiites (Grassy Group) (Meffre et al. 2004); (2) the Rocky Cape Zone, which has an upper layer of the Ediacaran-Cryogenian Smithton Basin of 580 Ma rift tholeiite (Spinks Creek Volcanics) (Calver et al. 2004), volcaniclastic rocks, siltstone, mudstone, dolomite, diamictite (Croles Hill Diamictite), chert and conglomerate, overlying the Mesoproterozoic clean marginal marine quartzite and siltstone of the Rocky Cape Group (Everard et al. 2007; Halpin et al. 2014). The Rocky Cape Group in turn overlies an unseen basement containing rocks with a significant component of 1600 to 1650 Ma zircons and with a T_{DM} model age of approximately 1700 Ma (Black et al. 2010); (3) the Burnie Zone, which largely comprises Neoproterozoic deep water turbidites (Burnie Formation) intruded by 710 Ma basaltic rift tholeiite sills (Cooee Dolerite) (Black et al. 2004; Crook 1979; McDougall and Leggo 1965) that are overlain by ?580 Ma mafic volcaniclastic sandstone, shale and rift-related basalt (Crimson Creek Formation). Cambrian mafic-ultramafic rocks (Vicary 2004) and Upper Cambrian Mount Read Volcanics (Mortensen et al. 2015) often overlie the Burnie Zone; (4 and 5) the Pedder Zone and Tyennan Zone, which both comprise similar geology to the Rocky Cape Zone, but are separated by eclogite facies metamorphic rocks (Chmielowski and Berry 2012). Both are overlain by minor amounts of Mount Read Volcanics; (6) the Sorell-Badger Head Zone, which comprises turbidites similar to those in the Burnie Zone and, in the west, ?Ediacaran melange, chert, volcaniclastic sandstone, black shale, rift-related dolerite and dolostone (Calver and Reed 2001); and (7) the Glomar Zone, which is