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# Geochronological, geochemical and Pb isotopic compositions of Tasmanian granites (southeast Australia): Controls on petrogenesis, geodynamic evolution and tin mineralisation

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ABSTRACT

Large volumes of Devonian-Carboniferous granites were emplaced across Tasmania in southeast Australia, which was along the easternmost boundary of mid-Palaeozoic Gondwana. Some of these granites are associated with world class Sn–W deposits. Previous studies have focused mainly on relationships between granite petrogenesis and source rocks, and rarely on geochemical controls on Sn mineralisation. New zircon U-Pb ages of 405 to 396 Ma reveal that the George River Granodiorite, Grant Point Granite and Mt. Pearson Granite from eastern Tasmania intruded prior to the Tabberabberan Orogeny. The Coles Bay Granite has a U-Pb age of 388 ± 7 Ma, implying that it was emplaced simultaneously with the Tabberabberan Orogeny in Tasmania. The western Tasmanian granites mostly intruded from 374 to 360 Ma, after the Tabberabberan Orogeny. Granites associated with Sn–W deposits are moderately to strongly fractionated, including the Housetop, Meredith, Pine Hill and Heemskirk granites. Lead isotopic compositions of K-feldspars from the analysed granites, combined with isotopic evidence from other studies, suggest that differentiated granites in Tasmania had been highly contaminated by a crustal (sedimentary) component, and that western Tasmanian granites had a crustal source with substantially different isotopic characteristics to that of eastern Tasmania, which has a character similar to the Lachlan Orogen in southeast Australia. Tin-mineralised granites in Tasmania formed in a post-collisional extensional margin, a favourable environment for the production of Sn-rich melts from the lower crust. Prolonged fractional crystallisation, low oxygen fugacity and enrichments of volatiles are crucial factors to promote Sn enrichment in magmatic-hydrothermal fluids exsolved from crystallised felsic magmas.


## 1. Introduction

Mid-Palaeozoic granitic intrusions are distributed widely across the island of Tasmania, southeast of mainland Australia (Fig. 1). The Devonian-Carboniferous Tasmanian granite province belongs to part of an enormous mid-Palaeozoic granite belt that formed along the easternmost margin of the Gondwana supercontinent (Gray and Foster, 1997; Foster et al., 2009). This belt records extensive Palaeozoic magmatic activity over a strike length of >3000 km, from the Thomson and Mossman Orogens in Queensland, through the Lachlan Orogen of New South Wales and Victoria, to Tasmania and the Western Province of the South Island of New Zealand, and finally into the North Victoria Land and Marie Byrd Land in Antarctica (Muir et al., 1994, 1996; Fioretti et al., 1997; Pankhurst et al., 1998; Keay et al., 1999; Münker, 2000; Kemp et al., 2005; Black et al., 2005, 2010; Collins and Richards, 2008; Tulloch et al., 2009; Cayley, 2011; Fergusson, 2014; Moresi et al., 2014; Yakymchuk et al., 2015; Turnbull et al., 2016). Because Tasmania lies between mainland Australia, Antarctica and New Zealand, understanding the geodynamic evolution of Tasmanian granites is essential for correlating magmatic events from the Silurian to Early Carboniferous across eastern Gondwana.

Petrogenetic and geochronological features of some Tasmanian granites have been studied in detail during the previous five decades (McDougall and Leggo, 1965; Cocker, 1982; Higgins et al., 1985; Mackenzie et al., 1988; Williams et al., 1989; Sun and Higgins, 1996; McClenaghan, 2006a; Black et al., 2005, 2010; Kositcin and Everard, 2013). McDougall and Leggo (1965) reported comprehensive K-Ar and/or Rb-Sr ages of Tasmanian granites, but their ages were affected largely by the radiogenic loss of Sr and Ar, and by thermal resetting by

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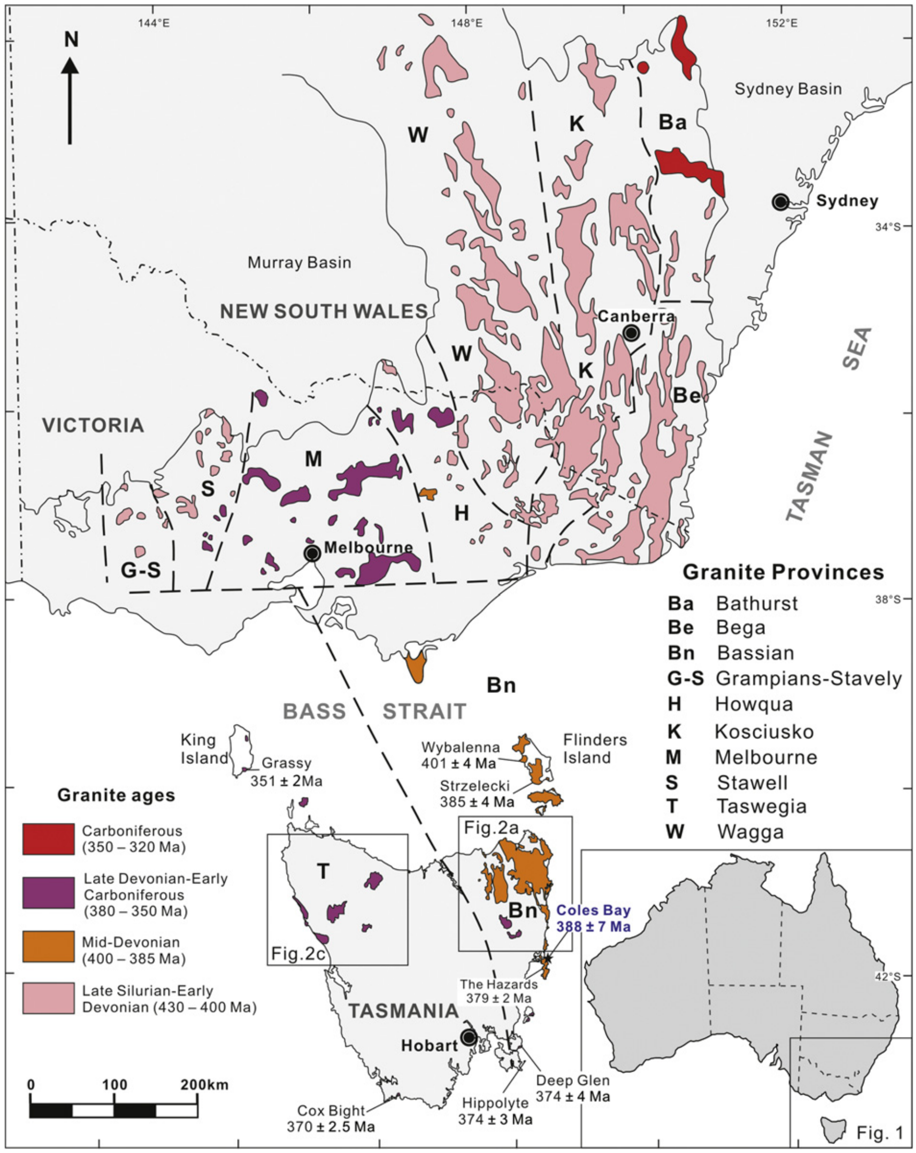


**Fig. 1.** Generalised geological map showing the major distributions of granites and granite provinces in the Lachlan Orogen, Southeastern Australia (after Chappell et al., 1988; Gray and Foster, 1997; Fergusson, 2014). Zircon U-Pb ages of Tasmanian granites are from Black et al. (2005), Kositcin and Everard (2013), and this study (bold blue).

later geological deformation or hydrothermal alteration. Black et al. (2005) and Kositcin and Everard (2013) provided a large number of precise SHRIMP zircon U-Pb results for the intrusive events of Tasmanian granites, which confirmed the progressive westward younging trend in granitic rocks of Tasmania noted by McDougall and Leggo (1965). Previous radiogenic isotope studies for these granites focused primarily on the eastern intrusions (Cocker, 1982; Turner et al., 1986; Mackenzie et al., 1988; Sun and Higgins, 1996), with only limited data available for western Tasmania (Brooks, 1966; Sawka et al., 1990). Black et al. (2010) conducted a systematic Sr-Nd-Pb isotopic study to constrain the genesis of Tasmanian granites. Only limited Pb isotopic analyses are available for the Tasmanian granites and associated mineralisation (e.g., Gulson and Porritt, 1987). Most of these previous studies focused on the relationships between granite genesis and source rocks in Tasmania, and did not consider metal fertility. In addition, Pb isotopic values reported from whole-rock samples have defined a wide and scattered range for fractionated granites (e.g., Black et al., 2010), making it difficult to constrain the sources of Sn-mineralised granites in Tasmania.

Here we reported results of a geochronological (U-Pb zircon ages), geochemical and K-feldspar Pb isotopic study of the mid-Palaeozoic granitic rocks from eastern and western Tasmania, including the George River Granodiorite, Mt. Pearson Granite and Grant Point Granite in St. Helens area, and Bicheno and Coles Bay granites along the eastern coast (Fig. 2a), and the Pieman Heads, Pine Hill, Heemskirk, Housetop and Meredith granites in western Tasmania (Fig. 2c). These data allow a more detailed comparison of the timing of crustal magmatism within the eastern margin of Gondwana, and they provide additional constraints on granite petrogenesis, geodynamic evolution of mid-Palaeozoic Tasmania, and possible controls on world-class Sn mineralisation.

## 2. Geological background and investigated granites

### 2.1. Granite provinces in the Lachlan Orogen

Abundant granitic intrusions crop out widely in the Lachlan Orogen of eastern Australia (Fig. 1), and were emplaced in four magmatic episodes (Gray and Foster, 1997; Black et al., 2005; Fergusson, 2014): Late Silurian – Early Devonian (430–400 Ma), Mid-Devonian (400–385 Ma), Late Devonian–Early Carboniferous (380–350 Ma), and