The geochemistry of Tasmanian Devonian–Carboniferous granites and implications for the composition of their source rocks

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Introduction

The Tasmanian mid-Palaeozoic granites (fig. 1) were emplaced mostly after the main Tabberabberan deformation at high crustal level with narrow contact aureoles. In eastern Tasmania, the granites intruded an Ordovician to Early Devonian (Banks and Smith, 1968; Rickards and Banks, 1979; Rickards *et al.*, 1993) quartzwacke turbidite sequence (Mathinna Supergroup) whereas in western Tasmania they intruded more variable successions ranging in age from Precambrian to Early Devonian. In eastern Tasmania, intrusion took place in the Devonian whereas in western Tasmania intrusion was generally later and took place in the Devonian and Early Carboniferous. Intrusion appears to have occurred mainly by upward displacement or crustal rifting although there is local, marginal evidence for 'shouldering-aside' of the country rock (Gee and Groves, 1971). The granites generally range from granodiorite to alkali-feldspar granite, with granodiorite being much more abundant in eastern Tasmania. The classification used is that of Streckeisen (1973) with the modification that the term adamellite is used for part of the 'granite' field with over 35% modal plagioclase. The term granite will be used to refer to granitic rocks in the wide sense except where specifically discussing composition. Rock types used in body names will be used rather broadly to remain consistent with previous usage.

Recent work

Since the last review of the Devonian–Carboniferous granites (McClenaghan *et al.*, 1989) there have been a number of developments relating to the granites, which are reflected in this report.

Various small changes have taken place to the mapped distribution and improvements made to the characterisation of the granites. In western Tasmania Brown *et al.* (1994) provided the first published map of the distribution of granite types within the Heemskirk Batholith. This built on earlier mapping by Klominsky (1972) who had recognised the division of the Heemskirk Batholith into red and white granite. McClenaghan (1994) described the field characteristics of the Heemskirk Batholith granite types. Mapping of the Meredith Batholith (Turner *et al.*, 1991) established that it consisted of two main bodies. The distribution of these bodies, in an inaccessible part of the batholith, was more accurately delineated by Everard (1999, 2003) based on new Western Tasmanian Regional Minerals Program radiometric data. This radiometric data, together with geological mapping, also allowed refinement of the boundary of the remote Granite Tor body (McClenaghan, 2003).

A minor granite body was recorded at Penguin Islet in southwest Bass Strait which may be an apophysis of the Three Hummock Island body (Everard *et al.*, 1997). Magnetic data from the Western Tasmanian Regional Minerals Program indicated that the Three Hummock Island Granite was part of a much larger submarine body.

In eastern Tasmania, the various granite bodies in the St Helens area were more fully characterised by McClenaghan *et al.* (1992).

Leaman and Richardson (1992) more accurately delineated the subsurface extent of the Devonian–Carboniferous granite bodies by modelling based on gravity data. This is useful for assessing prospectivity for granite-related mineralisation.

An increase in geochemical data (B. W. Chappell, pers. comm., 1995; J. L. Everard, pers. comm., 2005; McClenaghan *et al.*, 1992; McClenaghan, 1994; M. P. McClenaghan, pers. comm., 2005) has improved the characterisation of the granites and their assignment to suites. Poorly-known minor and remote granite bodies have been sampled and analysed in conjunction with a granite dating program (Black *et al.*, 2005; Black, in prep.). Additional geochemical data have been obtained from granites in eastern Tasmania and the Furneaux Group. Changes have been made to the suite assignments in both west and east Tasmania based on these data. New isotope data (Sawka *et al.*, 1990; Sun and Higgins, 1996) have also been used to characterise the granite bodies and make suite assignments.

Many of the Tasmanian granite bodies are moderately or strongly fractionated and Chappell (1999) showed how strongly fractionated granites can be characterised as I-type or S-type based on chemical composition, using two strongly fractionated Tasmanian granite suites as examples. This methodology has been applied to other strongly fractionated Tasmanian granite suites. Mineralogical, isotopic and geochemical characterisation of the granites and their grouping into suites has a bearing on their metallogenic potential and mode of genesis. Blevin and Chappell (1992) have pointed to the importance of magma sources, oxidation states and degree of fractionation of granites in determining the potential for granite-related mineralisation.

Recent U-Pb SHRIMP dating of zircon, both crystallisation and inherited, from many of the Devonian–Carboniferous granites (Black *et al.*, 2005; Black, in prep.) has increased understanding of their intrusive history and has provided data that may assist understanding of their genesis.

Developments in petrogenetic models proposed for Lachlan Fold Belt granites (e.g. Collins, 1998; Chappell *et al.*, 1998; Chappell *et al.*, 1999) and isotopic evidence on the provenance of turbidites from the belt (Gray and Webb, 1995) since the last review (McClenaghan *et al.*, 1989) may be applicable to genetic models for the Tasmanian Devonian–Carboniferous granites.
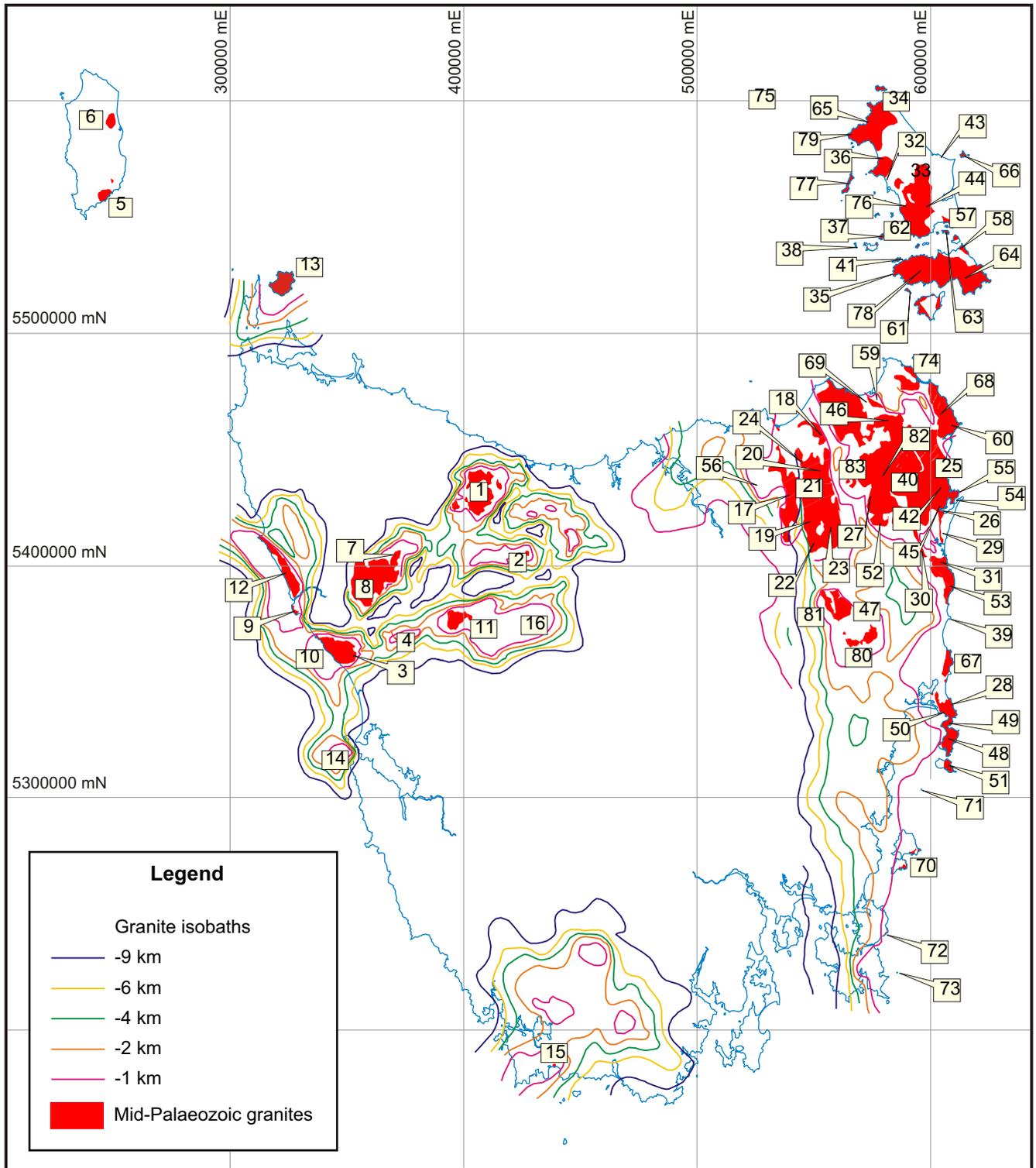
Figure 1

Distribution of mid-Palaeozoic Tasmanian granites. Numbers on the map correspond to the numbers in brackets after granite body names in Table 1.
Isobaths of upper surface of granite, inferred from gravity, after Leaman and Richardson (1992).

Field relationships and petrographic features of the granites

Western Tasmania

Grassy, Bold Head and Sea Elephant adamellites

The Grassy and Sea Elephant adamellites are small bodies in the eastern part of King Island. The Grassy body has sharp discordant contacts with the Cambrian(?) country rock. Another small intrusion at Bold Head, near Grassy, may be a faulted-off sliver of the Grassy intrusion. Work on the granites has concentrated on the Grassy bodies, which are associated with tungsten mineralisation (Haynes, 1973; Tan, 1979; Calcraft, 1980; Wesolowski *et al.*, 1988).

The Grassy granite is porphyritic with megacrysts of pink K-feldspar. The groundmass consists of quartz, K-feldspar, plagioclase ($<An_{32}$), biotite and amphibole, with accessory apatite, allanite, sphene, magnetite and zircon. The Sea Elephant body is more felsic and is texturally similar to the other bodies but differs in that it contains lesser amounts of amphibole and sphene. Although dominantly of adamellite composition granodiorite is also present.

Three Hummock Island Granite

Three Hummock Island, 24 km off the northwest coast of Tasmania, is composed entirely of granite, apart from an extensive thin cover of Tertiary and Quaternary deposits (McDougall and Leggo, 1965; Jennings, 1976; Everard *et al.*, 1997). Aeromagnetic data indicate that the granite is part of a much larger oval-shaped pluton lying mostly to the north of the island. Gravity data indicate that the granite also extends southwest to underlie much of Hunter Island at shallow depth (<1 km) (fig. 1). Biotite-muscovite granite exposed on Penguin Islet, a short distance east of Hunter Island, may represent a small apophysis of the Three Hummock Island body (Everard *et al.*, 1997).

The granite is medium to coarse grained, consisting of K-feldspar, plagioclase, quartz, biotite and muscovite with accessory tourmaline and apatite. K-feldspar megacrysts are variably abundant, and cordierite may be recognised in outcrop as scattered euhedral phenocrysts up to 20 × 10 mm concentrated within zones of K-feldspar accumulation (Wyborn and Chappell, 1998). In the south of the island, the granite is slightly more mafic and locally contains biotite-rich schlieren. At one place a swarm of melanocratic enclaves comprise 30–40% of the overall outcrop (Everard *et al.*, 1997). Composition ranges from adamellite to alkali-feldspar granite.

Housetop Batholith

The Housetop Batholith is a large 157 km^2 red granite body 20 km south of Burnie. Previous field investigations on the body include work by McDougall and Leggo (1965), Calcraft (1980), Baillie *et al.* (1986) and Camacho (1987). The batholith has sharp discordant contacts against folded Precambrian–Devonian rocks (McDougall and Leggo, 1965). In spite of compositional and textural variations, Baillie and Lennox (*in* Seymour, 1989) considered that the granite was not composite, whereas Camacho (1987) distinguished individual granite plutons within the body. It is undeformed, and schlieren are the only form of layering observed.

The following description is drawn from Baillie and Lennox (*in* Seymour, 1989) and Camacho (1987). The rocks of the batholith are generally reddish pink, and have a range of textures with fine to medium-grained groundmass, moderate to strongly porphyritic texture, miarolytic cavities and thin (100–150 mm) vuggy pegmatites. All textural types are cut by porphyritic, aplitic and microgranite dykes. The strongly porphyritic rocks contain many large crystals of K-feldspar and quartz, and to a lesser extent plagioclase in the range 10–20 mm and have a fine-grained granophyric groundmass dominantly of quartz, K-feldspar and plagioclase. The K-feldspar is perthitic and locally shows rapakavi textures. The plagioclase is zoned. Distinct calcic-rich cores are not present, with the most calcium rich composition being An_{26}. Biotite is always present, with the addition of hornblende in the less felsic granites, mostly in the western part of the batholith. Accessory minerals are allanite, zircon, magnetite, ilmenite, sphene, apatite and fluorite. Tourmaline is present in the southern part of the batholith. Mafic hornblende-rich and biotite-rich xenoliths are confined to the least felsic rocks in the western and northern margins of the batholith. Composition ranges from adamellite to alkali-feldspar granite.

Dolcoath Granite

The Dolcoath Granite crops out as a small (<10 km^2) roughly circular body in the Forth Valley near Lake Cethana, where it intrudes folded Cambrian and Ordovician rocks (Jennings, 1963; Gee, 1965; Webb, 1974). Granite isobaths (fig. 1) indicate that the exposure is the tip of a much larger subsurface granite body that extends to the west.

The granite is medium to coarse grained and consists of quartz, perthitic microcline, plagioclase and biotite. Accessory minerals include zircon, apatite, fluorite, topaz, cassiterite and disseminated sulphides (molybdenite and pyrite). Contact metamorphic assemblages are characteristic of the amphibolite hornfels facies (Webb, 1974).

Meredith Batholith

The Meredith Batholith is a large composite granite body that underlies an area of 285 km^2 southwest of Waratah. Contacts with the folded Precambrian–Devonian country rocks are irregular and discordant. There are two main intrusive units in the batholith, a smaller finer-grained and less felsic body in the northeast (Wombat Flat Adamellite) and a much larger coarser-grained and more felsic body (Meredith

Granite) forming the remainder of the batholith (Reid, 1923; Groves, 1968; Stockley, 1972; Groves *et al.*, 1972; Collins, 1983; Camacho, 1987; Turner *et al.*, 1991).

The Wombat Flat body consists of an equigranular fine to medium-grained core comprising quartz, K-feldspar, plagioclase, biotite and hornblende with accessory allanite, zircon, apatite, sphene, ilmenite and magnetite, and a porphyritic rim with phenocrysts of quartz, K-feldspar, plagioclase (An_{20-30}) and hornblende, with the same groundmass mineralogy (Camacho, 1987). The K-feldspar is perthitic; sparse miarolitic cavities occur in the fine-grained variety. Ilmenite is the dominant opaque mineral, while fluorite and monazite are rare accessories.

The Meredith body is composed of adamellite to alkali-feldspar granite. It consists of a very coarse-grained, pale grey to very pale pink, equigranular phase and abundant fine to coarse-grained porphyritic intrusions containing phenocrysts of quartz, K-feldspar and plagioclase (Turner *et al.*, 1991). Aligned K-feldspar megacrysts are common in some places. Groundmass mineralogy consists of quartz, K-feldspar, plagioclase and biotite, with accessory apatite, zircon, monazite, ilmenite and tourmaline. Alteration minerals are fluorite, topaz and sericite. Quartz/tourmaline nodules are abundant, and veins of aplite, quartz, quartz/tourmaline and quartz/muscovite are common. Miarolitic cavities are locally present. This body does not contain allanite or amphibole, has more iron-rich biotite, and contains more monazite than the Wombat Flat body.

Mt Bischoff porphyry dykes

At Mt Bischoff, northeast of the Meredith Batholith, radiating quartz porphyry dykes intrude Precambrian and Cambrian rocks. It has been suggested that these dykes emanate from the cupola of an underlying granite body (Groves and Solomon, 1964). Greisenisation of the porphyries is generally extreme, with the formation of topaz, tourmaline, muscovite, cassiterite and pyrite pseudomorphing primary feldspar.

Birthday Granite

Two small bodies of muscovite-biotite granite, presumed to be of Devonian age (Macleod *et al.*, 1961; Jennings, 1963), intrude Precambrian quartzite and quartz mica schist in the upper part of the Forth valley.

The granite consists of biotite and muscovite, pinkish white feldspar and coarse quartz. The biotite and muscovite is locally predominant. Near the contact the granite commonly contains large phenocrysts of feldspar and abundant biotite. Some associated quartz veins contain wolframite, pyrite, cassiterite and rare molybdenite.

The granite bodies may connect to the same larger subsurface granite (fig. 1) that extends west to the Granite Tor Granite and the Heemskirk Batholith.

Granite Tor Granite

Little information is available on the Granite Tor Granite, which lies to the northeast of Rosebery, intrudes Precambrian rocks, and crops out over an area of 55 km^2 (McDougall and Leggo, 1965). The granite isobaths (fig. 1) suggest it is part of a much larger subsurface body that extends further to the east and also exists as a subsurface ridge westward to the Heemskirk Batholith.

The body is a medium to coarse-grained biotite-muscovite granite with megacrysts of K-feldspar. Accessory minerals include zircon, apatite and garnet (Speijers, 1979). Tourmaline is present, as an accessory or essential phase, at some localities. The uniformity of texture and composition suggests that it intruded in a single event. Small areas of country rocks overlying the granite in several areas suggest that the current outcrops are close to the roof of the intrusion (McClenaghan, 2003).

Renison Complex

Granite of this complex has been intersected below mineralised rocks in the Renison Bell mine. Patterson *et al.* (1981) related it to the strongly greisenised Pine Hill stock, which crops out two kilometres south of the mine. The granite intrudes both the Success Creek Group and Crimson Creek Formation of Neoproterozoic age. Granite isobaths (fig. 1) indicate that the body is the tip of a subsurface granite ridge connecting the Heemskirk Batholith with the Granite Tor Granite.

The granite, described by Patterson (1980), Ward (1981) and Camacho (1987), consists of medium to coarse-grained equigranular and porphyritic (K-feldspar, quartz) varieties with a groundmass of quartz, K-feldspar, plagioclase and biotite. Accessory minerals include apatite, zircon, magnetite, ilmenite, allanite, sphene, monazite, tourmaline, fluorite and topaz. Fluid-rock interaction produced zones of tourmalinisation, sericitisation and albitisation (Bajwah *et al.*, 1995). The granite ranges in composition from adamellite to alkali-feldspar granite.

Heemskirk Batholith

The Heemskirk Batholith is a large elongate body occupying 117 km^2 on the west coast of Tasmania near Zeehan. It has steep, sharp intrusive contacts with Precambrian metasedimentary rocks. The contact aureole on the southern side includes Neoproterozoic, Cambrian and Silurian to Devonian sedimentary rocks (Brooks and Compston, 1965).

The intrusion is composite, consisting of red and white types (Heier and Brooks, 1966; Klominsky, 1972; Hajitaheri, 1985; McClenaghan *in* Brown *et al.*, 1994). The red granite occupies the upper parts of the intrusion and has been intruded by the white granite, which forms the western and major part of the body. A tourmaline nodular facies in the white granite occurs at the contact between the red and white granite, suggesting the trapping of a fluid-rich phase

(Klominsky, 1972). The body has grown by intrusion of granite sheets into space created by subsidence within a semi-circular cauldron-type structure (Hajitaheri, 1985). Isotopic dating shows that the two intrusions are almost contemporaneous (fig. 2).

The southern part of the batholith is dominantly very coarse to coarse grained, with the remaining parts of the red granite having a complex distribution of fine to coarse-grained and very coarse-grained granite. Finer granite varieties generally have small phenocrysts of feldspar and quartz. The white type consists of fine and coarse-grained varieties, with the fine-grained rocks generally near the contact with the red type or the country rock. Prominent quartz-tourmaline nodules and patches occur in both the red and white type but are more abundant in the white, whereas quartz-tourmaline veins are more abundant in the red granite.

The major mineralogy of both rock types is quartz, K-feldspar and plagioclase with varying amounts of biotite and tourmaline. The K-feldspar in the red type is pink; in contrast the K-feldspar of the white type is white. Hornblende ranges up to 3% in the red granite. Accessory minerals are apatite, zircon and fluorite in both types with magnetite, sphene and allanite confined to the red granite, and monazite, cassiterite and muscovite only occurring in the white granite. Biotite from the red granite is higher in Ti and lower in Al than biotite from the white granite (Hajitaheri, 1985). The white granite ranges in composition from adamellite to alkali-feldspar granite and the red granite includes adamellite and granite.

The granite contact has produced a variety of albite-epidote, hornblende and pyroxene hornfels facies mineral assemblages in the mafic and ultramafic country rocks (Green, 1966).

Pieman Granite

The Pieman Granite is a small body (8 km^2) intruded into Precambrian rocks on the southern side of the mouth of the Pieman River 15 km north of the Heemskirk Batholith (Spry and Ford, 1957; Brooks, 1966).

The granite is coarse grained, consisting of K-feldspar, plagioclase, quartz, biotite and muscovite with accessory tourmaline, zircon and apatite. Texture varies from equigranular to distinctly porphyritic, with phenocrysts of altered perthitic K-feldspar. Tourmaline nodules are common. The Pieman Granite, while petrologically similar to the white granite variety of the Heemskirk Batholith, ranges in composition from adamellite to alkali-feldspar granite.

Interview and Sandy Cape granites

The Interview Granite is an elongate body occupying an area of 87 km^2 from the Pieman River to near Sandy Cape, where there is a small granite body of similar character. It intruded a faulted anticline in Precambrian rocks (Spry and Ford, 1957).

The granite is generally equigranular and medium to coarse grained, consisting of K-feldspar, plagioclase, quartz, biotite and muscovite with accessory tourmaline, zircon, apatite and ilmenite. Small amounts (<1%) of subhedral cordierite less than 1 mm across, mostly altered to chlorite, together with rare resorbed almandine-rich garnet are also present (Wyborn and Chappell, 1998). Aligned K-feldspar megacrysts are locally common. A number of intrusive phases are present at Sandy Cape, with a coarse-grained, equigranular, muscovite leucogranite being dominant (Wyborn and Chappell, 1998). The Interview and Sandy Cape granites range in composition from adamellite to alkali-feldspar granite.

Grandfathers Granite

The Grandfathers Granite crops out over a small area on the western coast of the northern part of the Cape Sorell peninsula (Baillie and Corbett, 1985). The granite isobaths (fig. 1) suggest that this is part of a larger subsurface body that occurs adjacent to the coast.

The granite has irregular contacts with Precambrian country rocks and xenoliths of quartzite are common near the margins of the body. It is an unfoliated, leuococratic, equigranular medium to coarse-grained rock consisting of quartz, K-feldspar, plagioclase, biotite, muscovite and tourmaline. Accessory minerals are zircon and apatite. The biotite shows red/brown pleochroic colours where fresh. Secondary muscovite is present as irregular-shaped crystals in cracks, and as small flakes enclosed by plagioclase. Miarolytic cavities and tourmaline segregations are common.

Cox Bight Granite

A small area of contact aureole granite (Hall, 1965) occurs at Cox Bight. The granite isobaths (fig. 1) suggest that this body is part of a much larger volume of granite that underlies a large part of southwest Tasmania. A small, entirely granite island (Mewstone), about 22 km SSE of Cox Bight, may be part of the same granite mass.

The Cox Bight Granite is a medium to fine-grained, leucocratic, biotite granite with rare muscovite. It consists of quartz, K-feldspar, biotite, and rare albite-oligoclase and muscovite. It has a clearly defined intrusive margin with country rock of thick-bedded quartzite and quartz schist. A boulder of greisen was found near the granite margin.

The granite of the Mewstone is a medium light grey fine-grained muscovite granite, with sparse quartz and feldspar phenocrysts and miarolytic cavities. Tourmaline occurs in some samples (Banks, 1993).
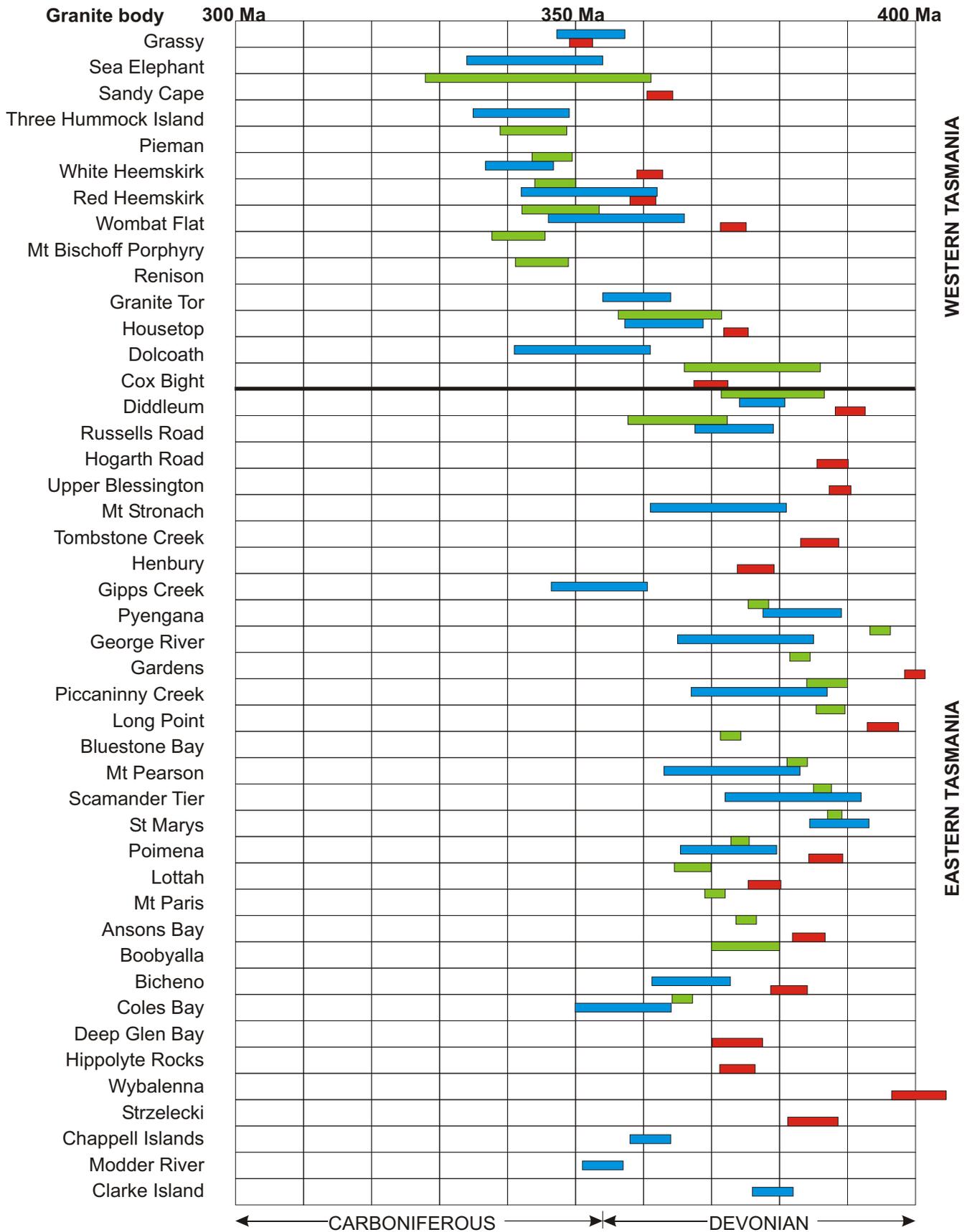
Figure 2

Age range at 95% confidence level for Rb-Sr (shown in green), K-Ar (shown in blue) and U-Pb SHRIMP (shown in red) for Tasmanian granite bodies. Weighted averages are used where multiple dates are available. Data from Brooks and Compston (1965), McDougall and Leggo (1965), Brooks (1966), Brooks (recalculated unpublished data, 1971), Cocker (1982), Turner et al. (1986), Mackenzie et al. (1988), Sawka et al. (1990) and Black et al. (2005).

Introduction

The granites of mainland eastern Tasmania occupy an area of ~3120 km^2 and form the Scottsdale, Ben Lomond, Blue Tier and Eddystone batholiths. A number of disconnected lesser bodies extend south as far as Deep Glen Bay on the Forestier Peninsula and the Hippolyte Rocks (fig. 1). Granites also occur in the Furneaux Group to the northeast of mainland Tasmania where they form about 70% (~1090 km^2) of the Palaeozoic basement. All the granites of eastern Tasmania and the Furneaux Group, together with the granites of Wilsons Promontory in Victoria, have been depicted as constituting the Bassian Batholith by Chappell *et al.* (1991) in order to stress the essential unity of the granites across Bass Strait.

Hornblende-biotite granodiorites

Hornblende-biotite granodiorites occur throughout eastern Tasmania, with the most southerly body on the Freycinet Peninsula and most northerly at Wybalenna on Flinders Island. Isotopic dating and field relationships show that they are generally the earliest intrusive phase. Most are distinguished from later phases by having a tectonic foliation parallel to a foliation in the Mathinna Supergroup country rocks.

The granodiorites show little variation. They are massive, medium to coarse-grained, dark grey rocks, commonly with abundant mafic fine-grained dioritic enclaves. Major minerals are euhedral to anhedral amphibole and biotite, plagioclase and intergranular K-feldspar and quartz. Amphibole ranges in composition from actinolite in the core regions of some crystals to hornblende in the rims and in euhedral crystals. Amphibole and biotite are commonly present in intermingled clusters of crystals. Trace amounts of clinopyroxene are associated with actinolite in the cores of hornblende crystals in some of the granodiorite bodies. Plagioclase commonly contains sericitised unzoned calcium-rich core regions (An$_{80-70}$) which have sharp boundaries with the clear, zoned rims (An$_{60-25}$). Accessory minerals include apatite, zircon, sphene, allanite and ilmenite. Variable amounts of magnetite and ilmenite occur in the Pyengana and Lisle plutons.

Early, foliated, biotite-hornblende granodiorite plutons form the Diddleum, Tulendeena and Porcupine Creek bodies in the Scottsdale Batholith. The Upper Blessington body in the south of the Scottsdale Batholith is slightly younger, non-foliated, contains less hornblende and is coarser grained than the other granodiorite bodies. The Lisle body, a short distance to the west of the Scottsdale Batholith, ranges in composition from granodiorite to tonalite (Roach, 1994; Bottrill, 1996).

In the Blue Tier Batholith, the main early, foliated, biotite-hornblende granodiorite plutons are the Pyengana, Gardens, George River and Long Point bodies. The Akaroa and Grants Point bodies, in the St

Helens area, may have a transitional boundary with the George River pluton but have very little or no hornblende, and range from granodiorite to adamellite. The Wybalenna, Pats River and Cape Sir John bodies in the Furneaux Group are also foliated biotite-hornblende granodiorite.

In the Blue Tier Batholith, later non-foliated granodiorite dykes in the Scamander Tier and Catos Creek area are considered to be the intrusive equivalents of the dacitic, welded, ash-flow tuff that occurs in the St Marys area (Turner *et al.*, 1986). This tuff consists of plagioclase, quartz, biotite, augite, hypersthene and sanidine phenocrysts in an aphanitic groundmass. The pyroxene is pseudomorphed by amphibole at higher levels of the body and in the hypabyssal equivalent micro-granodiorite body; both orthopyroxene and clinopyroxene remnants are found in amphibole cores.

The Bluestone Bay granodiorite bodies on the Freycinet Peninsula are not foliated (J. L. Everard, pers. comm., 2002).

The proportion of granites containing biotite and hornblende decreases from west to east in eastern Tasmania. It is nearly half for the Scottsdale Batholith, less than a third for the Blue Tier Batholith and still less in the Furneaux Group and the Freycinet Peninsula.

Biotite adamellites/granites

Biotite adamellite/granites are the most common granite type in eastern Tasmania and are also abundant in the Furneaux Group. In the Scottsdale Batholith, they locally grade into biotite-hornblende granodiorite and in some cases into alkali-feldspar granite. Elsewhere in eastern Tasmania, gradations to alkali-feldspar granite are more common than gradations to granodiorite. The adamellites/granites are younger than the foliated granodiorites.

Although of varied texture, all biotite adamellite/granites consist of plagioclase, biotite, quartz and K-feldspar, with accessory zircon, monazite, ilmenite and apatite. The plagioclase is zoned, and has relatively Ca-rich cores and thin albite rims. K-feldspar is coarsely perthitic. In the Poimena pluton megacrysts (20–50 mm) of this mineral generally contain up to five concentric zones of plagioclase inclusions (McClenaghan and Williams, 1982).

The Hogarth Road and Russells Road bodies in the Scottsdale Batholith are coarse to very coarse-grained equigranular to sparsely porphyritic, largely adamellite with megacrysts of K-feldspar (20–50 mm). In the southern part of the bodies the rocks grade to granodiorite with minor amounts of hornblende in addition to biotite.

In the Blue Tier Batholith, the main biotite adamellite-granite bodies are the Poimena and Mt Pearson plutons. The Poimena pluton is a very large medium to coarse-grained body with abundant K-feldspar megacrysts (20–50 mm). Several small sheet and dome-shaped intrusions of similar

composition but different texture within the Poimena pluton, in the central Blue Tier area near Lottah, are later phases (McClenaghan and Williams, 1982). The Mt Pearson pluton is compositionally similar to the Poimena body but is very coarse grained with abundant K-feldspar megacrysts (20–60 mm). At the southern margins of the Mt Pearson body, a short distance west of St Helens, the granite is pink and ranges to alkali-feldspar granite in composition. Here it is intruded by irregular-shaped bodies of fine to medium-grained granite.

In the southern part of the Blue Tier Batholith, the Haleys New Country pluton is similar in texture to the Poimena body, but is slightly darker and contains minor amounts of hornblende in addition to biotite.

A small coarse-grained, leucocratic biotite granite body occurs at the base of the cliffs on the eastern coast of the Forestier Peninsula at Deep Glen Bay.

Biotite adamellite-granite bodies in the Furneaux Group are the Palana, Corner, Rooks River, Thirsty Lagoon and Martins Rise plutons. The Palana pluton contains abundant fine-grained dioritic enclaves.

Garnet-cordierite-biotite adamellite/granites

Adamellite/granite plutons containing biotite and minor amounts of garnet and/or cordierite occur in mainland eastern Tasmania in the Boobyalla, Musselroe Point, Ansons Bay, Bicheno and Maria Island bodies. The Mt Kerford, Hogans Hill, Key Bay, Puncheon Point, Lady Barron, Dover River, Clarke Island, Modder River, Kent Bay, Strzelecki, Prime Seal Island and Cape Frankland bodies in the Furneaux Group have similar mineralogy. Small islands in Bass Strait composed of similar granite stretch north to Wilsons Promontory in Victoria.

The garnet-cordierite-biotite adamellite/granite plutons consist of quartz, K-feldspar, plagioclase and red-brown biotite. Garnet and cordierite rarely exceed 0.5% and are commonly less than 0.01% (Cocker, 1977). Garnet-rich and biotite-rich mafic layers in the Mt Kerford and Ansons Bay bodies grade into the normal granite. Other accessory minerals are zircon, apatite, ilmenite, monazite and xenotime. K-feldspar is perthitic, and the plagioclase has generally uniform cores (An_{40-45}), with normal to oscillatory zoned rims (An_{20-10}). Subsolidus phases are tourmaline, white-mica, pale green biotite, chlorite, topaz and andalusite (Cocker, 1977). Replacement of the garnet and cordierite by pale green biotite is widespread. Mafic inclusions are generally rare and occur near the granite/country rock contacts. The inclusions mostly consist of biotite-bearing hornfelsed rock similar to the contact metamorphosed country rocks.

Coarse-grained equigranular to porphyritic granite variants are present. Many of the bodies have complex textural variations with gradational and sharp boundaries between textural types suggesting auto-intrusive relationships. Miarolytic cavities occur in the Hogans Hill, Rooks River and Corner bodies on Cape Barren Island (Cocker, 1980). In several plutons

the principal textural variation is the proportion of K-feldspar megacrysts.

Alkali-feldspar granites

Throughout eastern Tasmania and the Furneaux Group there are granite bodies that range in composition from adamellite to alkali-feldspar granite but are dominantly of the latter composition, and will be described as such. These bodies generally show evidence of hydrothermal alteration.

There are two alkali-feldspar granite plutons in the Scottsdale Batholith, Mt Stronach to the east of Scottsdale and Tombstone Creek further south near the eastern margin of the batholith. These bodies are light coloured, pink, equigranular, coarse to fine grained, and consist of quartz, perthitic K-feldspar, plagioclase and iron-rich biotite. In the Mt Stronach pluton the plagioclase is close to pure albite and the biotite is annite. The Tombstone Creek pluton has a stronger pink colouration at the margins where the plagioclase is close to pure albite. The interior of the body is adamellite and the plagioclase ranges to oligoclase composition.

The Ben Lomond Batholith lies to the south of the Scottsdale Batholith, and is separated from it by younger rocks. There is considerable variation in texture but the most abundant rock type is a coarse-grained, pink, porphyritic granite with K-feldspar megacrysts (Blissett, 1959). The granite consists of quartz, K-feldspar and albite, with minor biotite, muscovite and accessory tourmaline and zircon. Biotite ranges from annite to siderophyllite (J. L. Everard and R. H. Findlay, unpublished data). The main rock type is intruded by irregular dykes of pale grey microgranite, which is commonly porphyritic and greisenised with accompanying tin, tungsten and sulphide minerals (Blissett, 1959). The Henbury and Gipps Creek bodies have been distinguished in the Ben Lomond Batholith mainly on geochemical criteria (Everard and McClenaghan, 2006; Black *et al.*, 2005).

The Royal George granite lies a short distance to the south of the Ben Lomond Batholith and consists of a generally equigranular, coarse-grained granite with minor bodies of microgranite and granite porphyry (Beattie, 1967). The main granite type is very similar to that in the nearby Ben Lomond Batholith, with topaz and fluorite as additional accessory minerals (Beattie, 1967). It has greater geochemical affinity with the Gipps Creek body in the Ben Lomond Batholith (Everard and McClenaghan, 2006; Black *et al.*, 2005).

The two main alkali-feldspar bodies in the central part of the Blue Tier Batholith are the Lottah and Mt Paris plutons. These are composed of pale pink to cream coloured, equigranular to porphyritic granite with K-feldspar phenocrysts. This rock consists of quartz, K-feldspar, albite and biotite (ranging from annite to siderophyllite), with accessory apatite, zircon and monazite, and secondary muscovite. Topaz, fluorite, cassiterite and tourmaline are rare (McClenaghan and

Williams, 1982; Mackenzie *et al.*, 1988). Other smaller bodies of similar character occur at Little Mt Horror and Mt Cameron. These bodies, together with the Lottah pluton, have been described as having a sheet-like form (Gee and Groves, 1971) but in the case of the Lottah pluton a steep-sided dome is more likely (McClenaghan and Williams, 1982). The evidence for a sheet-like form for the body at Little Mt Horror is also equivocal (McClenaghan *et al.*, 1982).

The Mt William alkali-feldspar body occurs a short distance to the north of Ansons Bay in the Eddystone Batholith. It is an equigranular pink, medium-grained biotite-muscovite granite that contains quartz, microperthitic K-feldspar, albite, biotite and muscovite, together with accessory apatite. The muscovite occurs as discrete flakes and as smaller flakes replacing feldspar and biotite (Groves *et al.*, 1977).

The dominant rock type further south on the Freycinet Peninsula is medium to coarse-grained pink alkali-feldspar granite with K-feldspar megacrysts (Dunderdale, 1989; Everard, 2001). The granite consists of quartz, cryptoperthitic microcline, albite and iron-rich mica (transitional from siderophyllite to zinnwaldite). Accessory minerals are apatite, zircon, fluorite, tourmaline and rare cassiterite, together with secondary muscovite. On the basis of fluid inclusion studies, Dunderdale (1989) interpreted the granite as having been hydrothermally altered.

In the Furneaux Group, the Killiecrankie body (at the northern end of Flinders Island) and Babel Island body (off the east coast) are largely alkali-feldspar granite. The Killiecrankie pluton consists of leucocratic, coarse-grained, porphyritic granite with K-feldspar phenocrysts. The mica is intermediate between annite and siderophyllite, and topaz is a common accessory mineral (Vicary, 1987). The Babel Island body comprises medium to coarse-grained, equigranular granite containing miarolytic cavities and with widespread pegmatitic and porphyry intrusions. This granite consists of quartz, K-feldspar, plagioclase ($<An_{30}$) and red-brown biotite. Accessory minerals are apatite, zircon, fluorite, andalusite, tourmaline, rare garnet and secondary muscovite (Reid, 1987). Tourmaline-rich patches occur near porphyry sills and dykes.

Classification and geochemistry of the granites

The Tasmanian granite plutons can be grouped into suites with distinctive chemical, isotopic and petrographic characters (Table 1). The suites have been characterised as having been derived from partial melting of sedimentary (S-type) or igneous (I-type) source rocks using the criteria of the restite model (White and Chappell, 1977; Chappell *et al.*, 1987; Chappell and White, 1992; Chappell, 1999). Some of the suites consist of very felsic granite and have been distinguished as crystal-fractionated on the basis of their major and trace element variation. Chappell

(1999) has suggested that crystal-fractionated granites can be distinguished from unfractionated granites by having less than 50 ppm Sr. In fractionated granites, the decrease in Sr values with increasing fractionation (using total iron as FeO (FeO*) as a fractionation index) is coupled with rises in Rb and falls in Ba. Other indications of crystal fractionation are marked rises in Nb, Ga and U with increasing fractionation.

The Meredith, red Heemskirk, Housetop, Pieman, Renison and Interview suites in western Tasmania consist largely of felsic or very felsic granite. Of these the red Heemskirk, Housetop, Pieman, Renison and Interview suites are crystal-fractionated on the basis of chemical criteria (fig. 3). The very high Rb values of the Interview and Renison suites indicate very strong crystal fractionation, and the Pieman, Housetop and red Heemskirk show progressively lesser degrees of Rb enrichment. The Meredith suite shows only a slight rise of Rb (to about 300 ppm) with falling FeO* (fig. 3), and has a small decrease for Nb, suggesting that it is not significantly crystal fractionated. The Grassy suite is also not significantly crystal fractionated as it shows little variation and has Sr values (305–530 ppm) substantially greater than the 50 ppm limit suggested as an indication of crystal fractionation.

The mineralogical composition of the granite suites has been used to characterise them as either I-type or S-type. The red Heemskirk, Housetop, Meredith and Grassy suites contain minor hornblende which is diagnostic for I-type granites (Chappell and White, 1992). Together with the Renison suite, these contain magnetite, sphene and allanite which are characteristic I-type minerals. The red Heemskirk granite also contains pink K-feldspar, consistent with the I-type character indicated by the other minerals. The Interview suite contains the Al-rich minerals cordierite, garnet and muscovite, typical of S-type granite. The white Heemskirk granite, which is part of the Pieman suite, contains Al-rich biotite (Hajitaheri, 1985) and white K-feldspar characteristic of S-type granite. The Granite Tor granite, which is also included in the Pieman suite, contains accessory garnet (Speijers, 1979).

The Interview and Pieman suites are strongly peraluminous, with the former being markedly more so. They have higher aluminium saturation indices than the moderately peraluminous and metaluminous granites of the Meredith, Renison, Housetop, red Heemskirk and Grassy suites (fig. 3). This supports the S-type and I-type granite assignments, as S-type granites are always peraluminous and I-type granites are metaluminous or moderately peraluminous when more felsic. Because apatite is soluble in peraluminous melts, P may be expected to become progressively more abundant in S-type melts as they undergo crystal fractionation. This leads to contrasts in the abundance of P, Y and Th, between strongly fractionated I-type and S-type granite (Chappell, 1999). Strongly fractionated S-type granites may be expected to show rising P and decreasing Y and Th with increasing

Table 1

Suite assignments for Tasmanian mid-Palaeozoic granite bodies

Suite	Granite body or volcanic unit associated with granite body
Western Tasmanian I-type granites	
Housetop	Housetop (f) (1), Dolcoath (f) (2)
Red Heemskirk	Red Heemskirk (f) (3)
Renison	Renison (f) (4)
Grassy	Grassy (5), Sea Elephant (6)
Meredith	Wombat Flat (7), Meredith (f) (8)
Western Tasmanian S-type granites	
Pieman	Pieman (f) (9), White Heemskirk (f) (10), Granite Tor (f) (11)
Interview	Interview and Sandy Cape (f) (12), Three Hummock Island (f) (13)
Other single body suites	Grandfathers (f) (14), Cox Bight (f) (15), Birthday (f) (16)
Eastern Tasmanian I-type granites	
Diddleum	Diddleum (17), Tulendeena (18), Porcupine Creek (19)
Russells Road,	Russells Road (20), Hogarth Road (21), Upper Blessington (22), Tombstone Creek (23), Mt Stronach (f) (24)
Gardens	Gardens (25), George River (26), Pyengana (27), Bluestone Bay (28)
Scamander Tier	Scamander Tier (29), Catos Creek (30), St Marys (31)
Wybalenna	Wybalenna (32), Pats River (33), Palana (34), Cape Sir John (35), Lughrata (36), Chalky Island (37), Unicorn Point (38)
Long Point	Long Point (39)
Poimena	Poimena (40), Corner and Franklin Sound (41), Mt Pearson (42), Patriarchs (43), The Dutchman and Darling Range (f) (44), Medeas Cove (45), Mt Cameron (46)
Henbury	Henbury (f) (47)
Freycinet	Freycinet (f) (48), The Hazards (f) (49), Coles Bay (f) (50), Schouten Island (f) (51)
Other single body suites	Halleys New Country (52), Piccaninny Creek (53), Akaroa (54), Grants Point (55), Lisle (56).
Eastern Tasmanian S-type granites	
Lady Barron	Lady Barron (57), Puncheon Point (58)
Boobyalla	Boobyalla (f) (59), Ansons Bay and Eddystone Point (60), Key Bay (f) (61), Strzelecki (f) (62), Long Toms Nose (63), Mt Kerford, Hogans Hill (f) and Kent Bay (64), Killiecrankie (f) (65), Babel Island (f) (66), Bicheno (f) (67), Mt William (f) (68), Sheoak Hill (f) (69), Maria Island (f) (70), Isle des Phoques (71), Deep Glen Bay (f) (72), Hippolyte Rocks (f) (73)
Musselroe	Musselroe and Musselroe Point (74), Craggy Island (f) (75), Martins Rise (76), Prime Seal Island (f) (77), Dover River and Modder River (78), Cape Frankland (79)
Royal George	Royal George (f) (80), Gipps Creek (f) (81)
Lottah	Lottah (f) (82), Mt Paris (f) (83).

Numbers in brackets after body name correspond with approximate locations shown in Figure 1.

Crystal fractionated bodies indicated by 'f' in brackets after body name and based on an average Sr value for the body of less than 50 ppm.
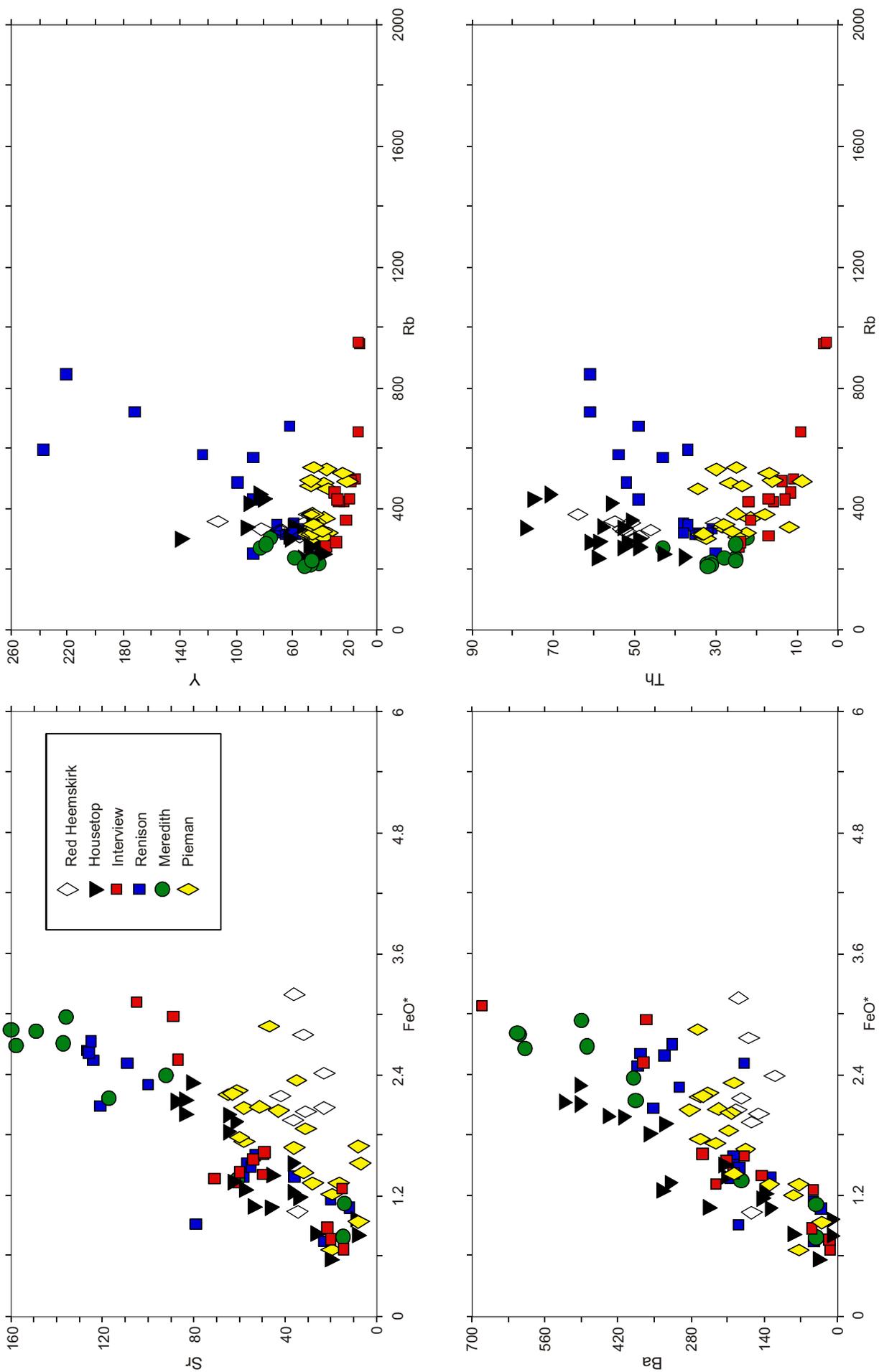
Figure 3. *Variation diagrams for western Tasmanian mid-Palaeozoic granites. FeO* is total iron as FeO, ASI is the aluminium saturation index (mol. Al$_2$O$_3$/(CaO + Na$_2$O + K$_2$O)) and CORUNDUM is normative corundum. Sources of data in descending order of contribution: Chappell (pers. comm., 2001), Camacho (pers. comm., 2001), McClenaghan (unpublished data), McClenaghan (1994), Black (pers. comm., 2001), Everard et al. (1997).*
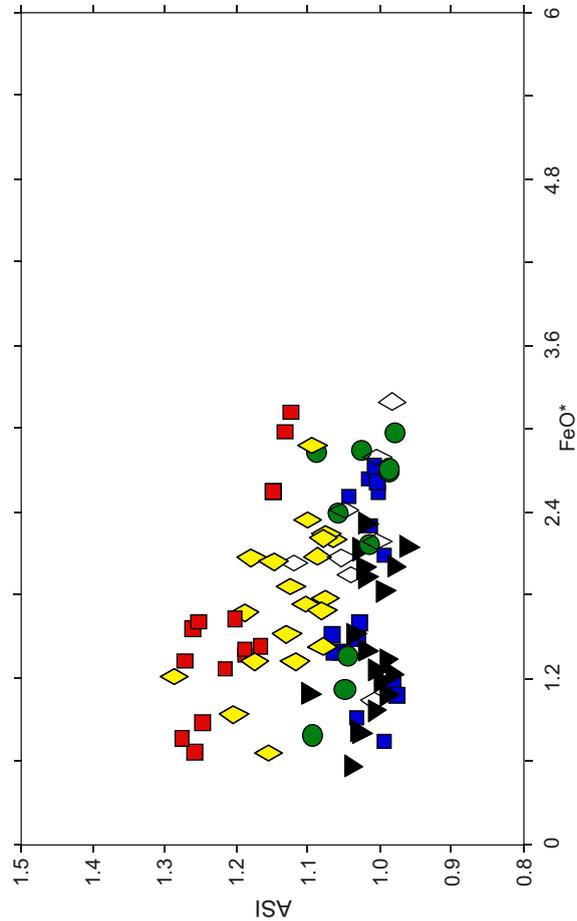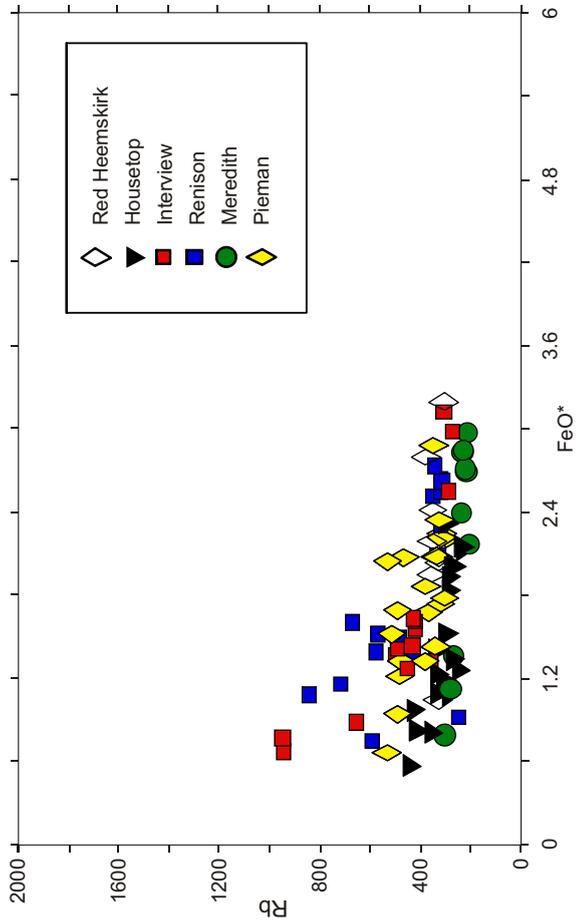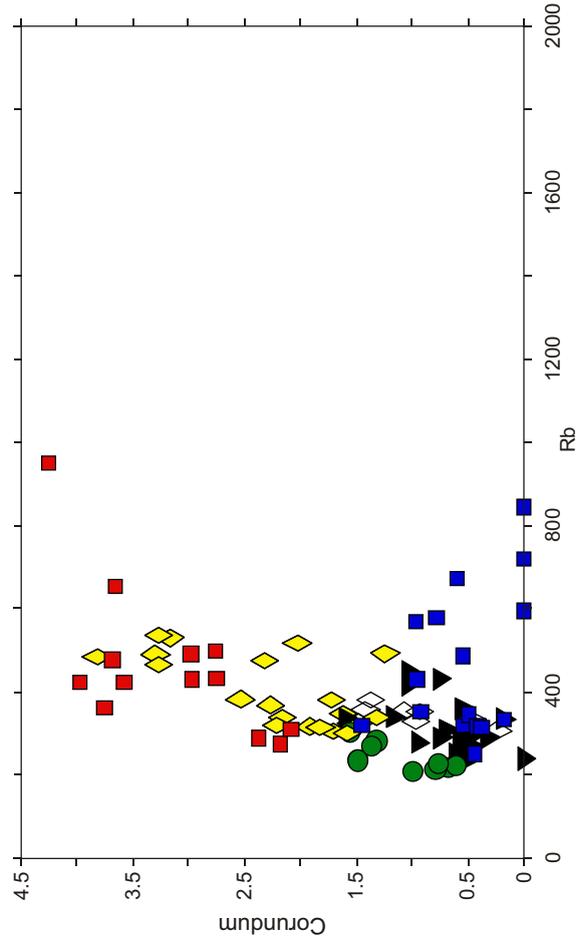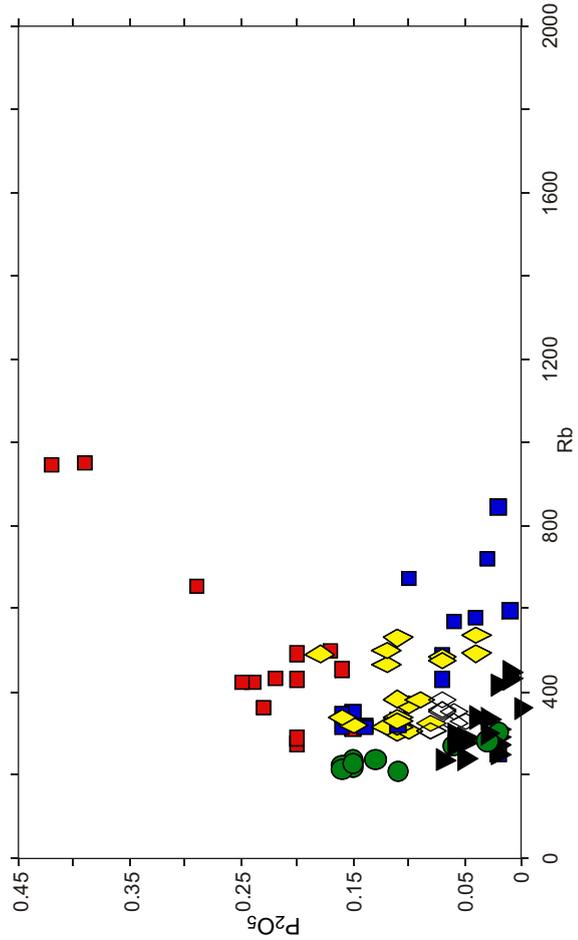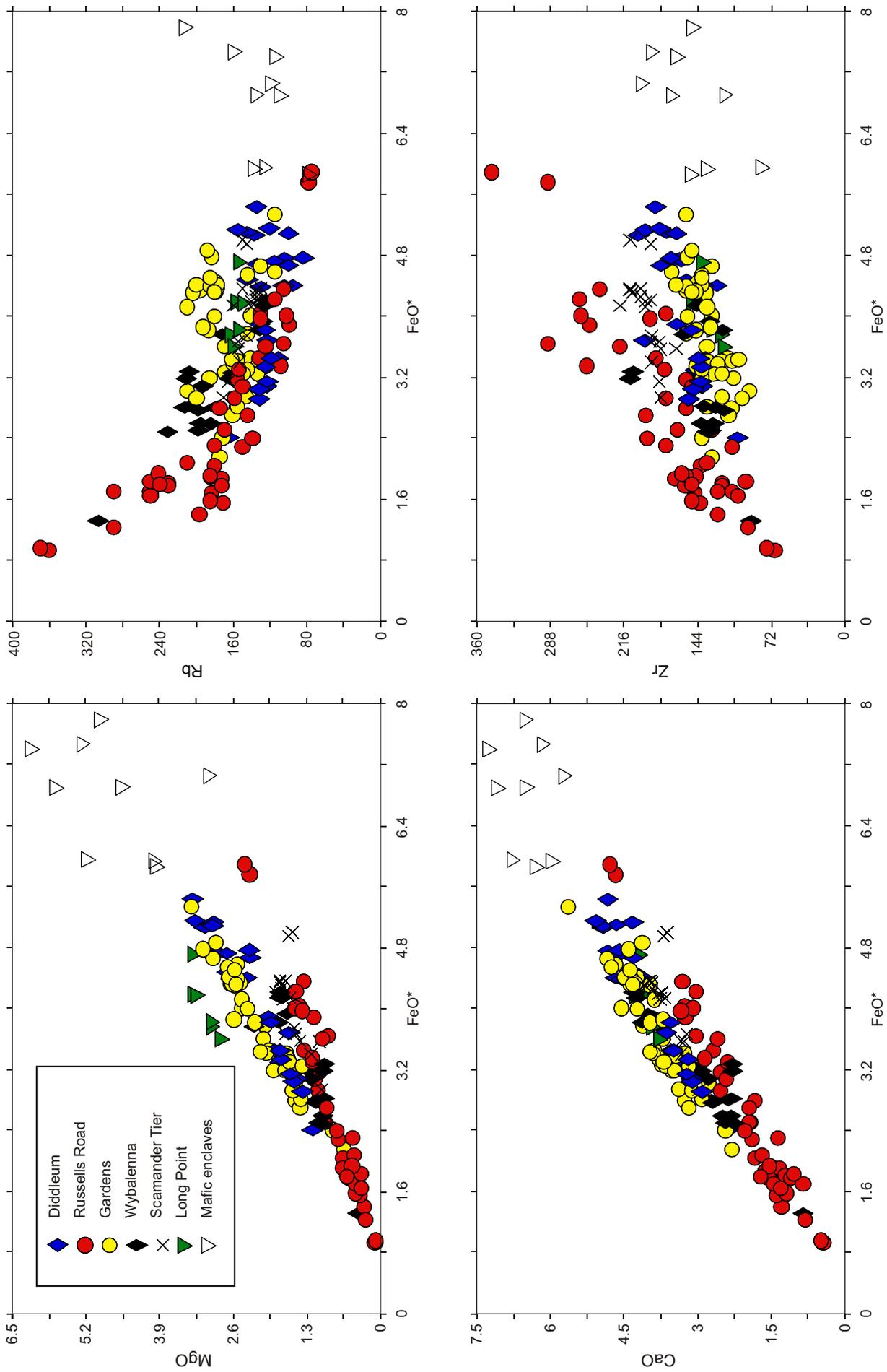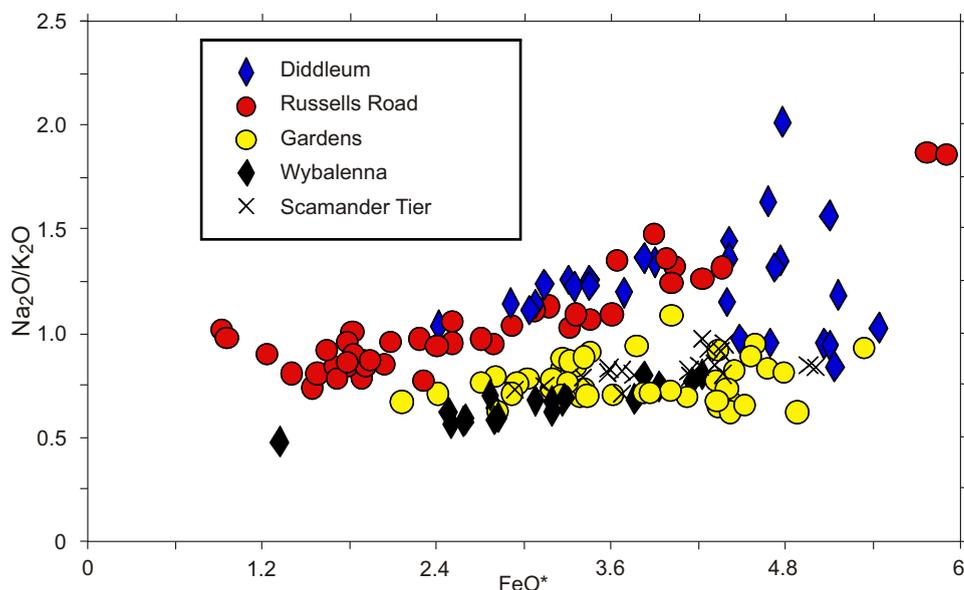
Figure 3 *(continued)*

Figure 4. *Variation diagrams for eastern Tasmanian mid-Palaeozoic I-type granites. FeO* is total iron as FeO. Sources of data in descending order of contribution: Chappell (pers. comm., 2001), McClenaghan (unpublished data), McClenaghan et al. (1992), Black (pers. comm., 2001), Everard (pers. comm., 2001), Baillie (1986).*

fractionation, whereas the I-type granites show low or falling P and rising Y and Th. This effect is shown most clearly with the Renison and Interview suites, which are the most strongly fractionated of the western Tasmanian suites (fig. 3). The effect is also apparent for the Pieman, Housetop, and red Heemskirk suites but to a lesser extent because these suites were less strongly fractionated (fig. 3).

The Birthday, Grandfathers and Cox Bight granite bodies do not have distinctive mineralogy to characterise them as I-type or S-type granite but are strongly peraluminous, suggesting that they are S-type. The Grandfathers and Birthday bodies have Sr values less than 20 ppm and Rb values ~500 to ~700 ppm, indicating that they are strongly crystal fractionated. The Cox Bight body is slightly less fractionated, with Sr values of ~60 ppm and Rb values of ~400 ppm. The low Y and Th values for the three bodies are consistent with fractionated S-type granite.

In eastern Tasmania, granites of the Diddleum, Russells Road, Gardens, Scamander Tier and Wybalenna suites contain hornblende, a diagnostic mineral for I-type granites (Chappell and White, 1992). Granites from the Diddleum, Gardens, Scamander Tier and Wybalenna suites also contain very minor amounts of clinopyroxene, another diagnostic I-type mineral. These suites also contain sphene and allanite, which are minerals characteristic of I-type granite. Magnetite, which is characteristic of I-type granite, occurs only in parts of the Pyengana pluton (part of the Gardens suite) and in the Lisle body.

These I-type suites have a wide range of chemical composition and generally show well-defined linear trends on two element plots (see fig. 4). The lowest Sr values in the suites are generally well in excess of 50 ppm, which suggests they have not undergone significant crystal fractionation. Plagioclase in these suites contains calcic core regions of comparatively uniform composition, which may represent restite material (Chappell *et al.*, 1987). This feature, together

with the linear nature of the chemical variation, is consistent with the suites having undergone restite fractionation, although it does not rule out other possibilities.

Na$_2$O/K$_2$O ratios show a marked difference between the less strongly fractionated I-type suites of the Scottsdale Batholith and those of the Blue Tier Batholith and Furneaux Group. In the Diddleum and Russells Road suites of the Scottsdale Batholith, the ratios generally decrease from ~2 to ~0.75 with falling FeO* values (fig. 5). In the Blue Tier Batholith and Furneaux Group the Gardens, Scamander Tier and Wybalenna suite ratios fall less strongly, from ~1 to ~0.75 with decreasing FeO* (fig. 5). Samples from part of the western Scottsdale Batholith are more potassic and an exception to this generalisation.

The pink granites of the Mt Stronach and Tombstone Creek plutons, which contrast with the grey granites for most of the Scottsdale Batholith, have higher Rb values and depart from the linear trend of the other granites from the Russells Road suite. This suggests that they had shed their restite component and undergone some feldspar fractionation.

A large proportion of the remaining granites in eastern Tasmania have been assigned to three suites, the Poimena, Boobyalla and Musselroe which show poorly defined, approximately linear or slightly curving trends on two element plots and have a similar compositional range (fig. 6). The aluminium saturation index (ASI) values for the Boobyalla suite (average 1.128) and Musselroe suite (average 1.112) are on average slightly higher than for the Poimena suite (average 1.057) but there is considerable overlap (fig. 6). This indicates that the Boobyalla and Musselroe suites have a slightly more S-type character than the Poimena suite. The Poimena suite bodies do not contain any minerals to give a clear indication of their I-type or S-type character, although the CaO content is generally higher than would be expected for an S-type granite and it is tentatively assumed to be an
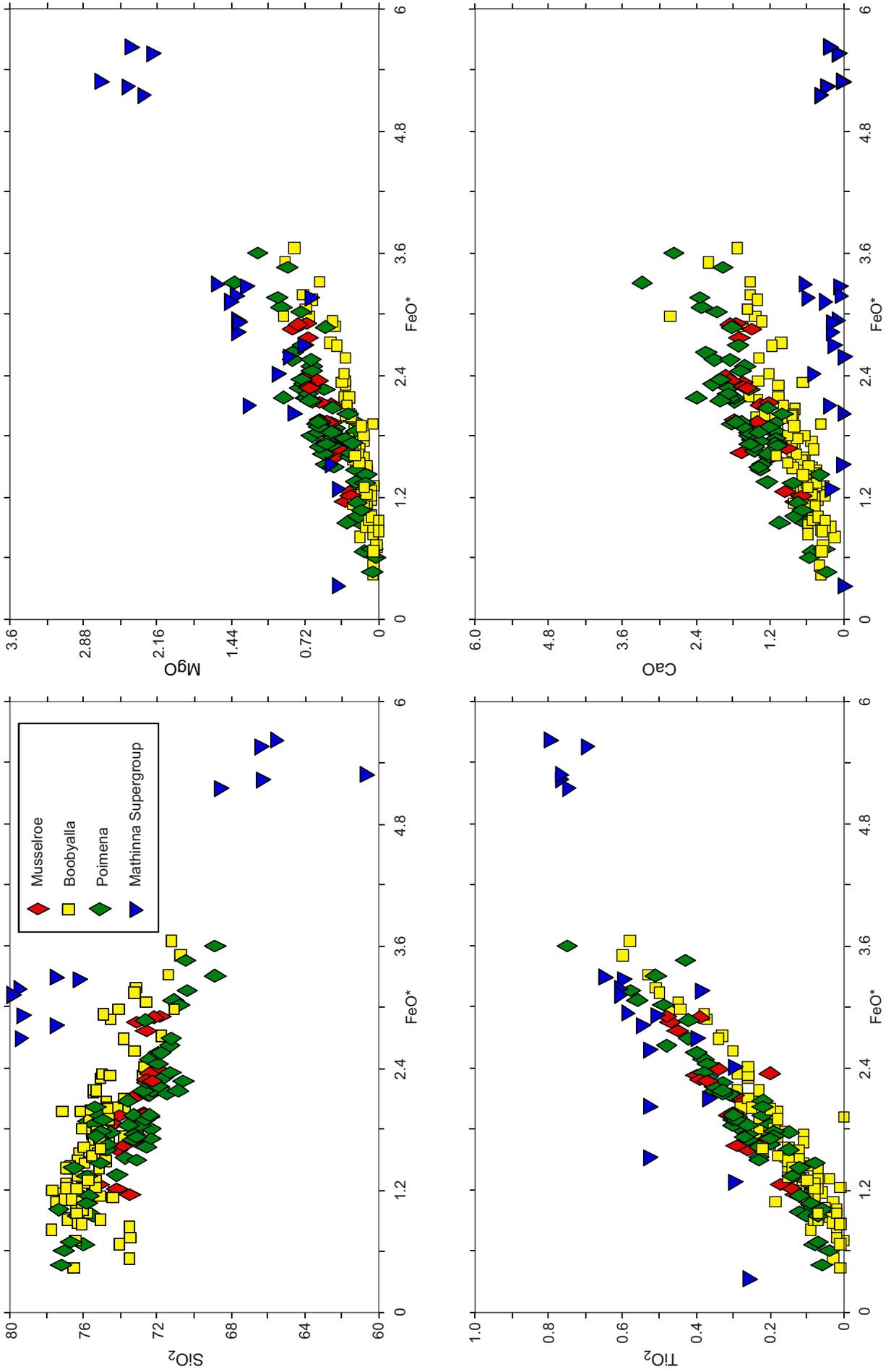
Figure 6. *Variation diagrams for moderately crystal-fractionated eastern Tasmanian mid-Palaeozoic granites and Mathinna Supergroup rocks. FeO* is total iron as FeO. Sources of data in descending order of contribution: Chappell (pers. comm., 2001), McClenaghan (unpublished data), Mackenzie et al. (1988), McClenaghan (1984), Turner et al. (1986), Vicary (1987), Black (pers. comm., 2001), Baillie (1986), Everard (pers. comm., 2001), McClenaghan et al. (1982).*
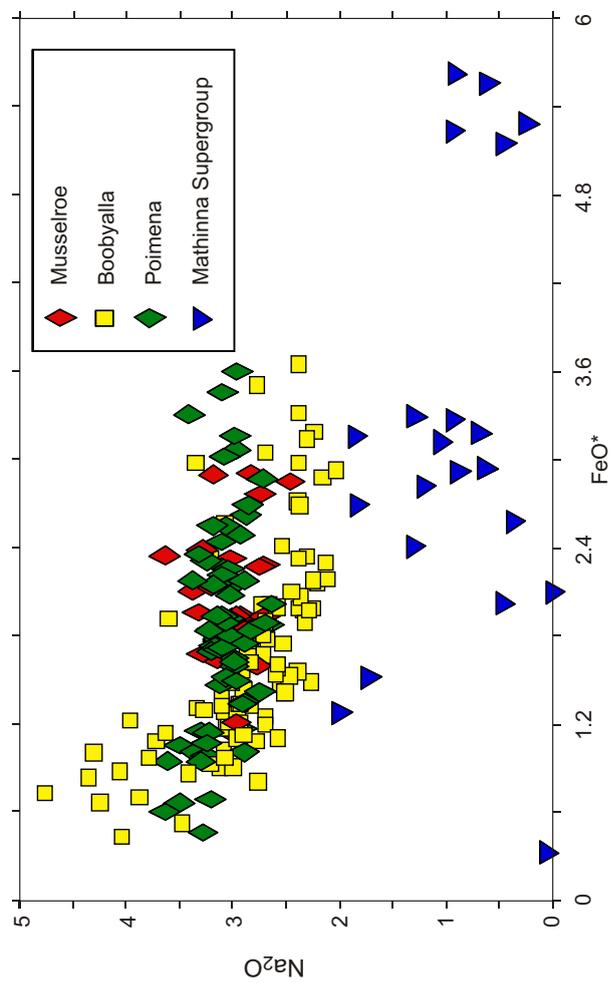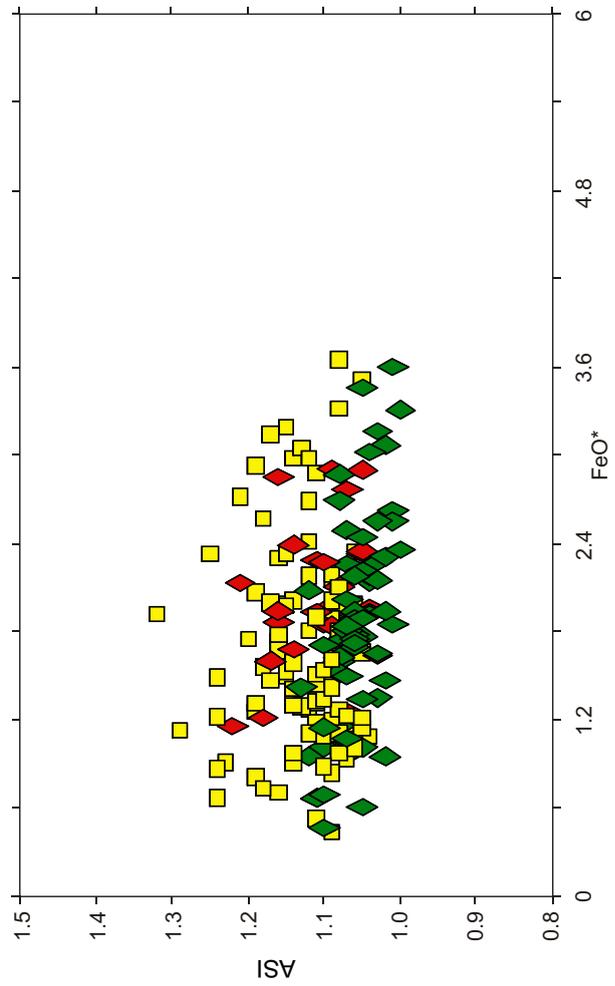
Figure 6 *(continued)*

I-type of different character from the other I-type suites. Most of the plutons making up the Boobyalla and Musselroe suites contain small amounts of Al-rich minerals such as cordierite and garnet, which are diagnostic of S-type granite. These minerals may represent restite. The bodies without diagnostic S-type minerals assigned to the Boobyalla suite are the Killiecrankie, Mt William, Isle des Phoques, Deep Glen Bay and Hippolyte Rocks plutons. This assignment is tentative and based on their ASI values being higher than the average for the Poimena suite, and their physical proximity to other bodies belonging to the Boobyalla suite.

Plagioclase in the Poimena pluton contains calcic core regions of comparatively uniform composition, which may represent restite material (Chappell *et al.*, 1987) and suggests that part of the variation of the Poimena suite is due to restite fractionation. Both the Poimena and Boobyalla suites include a proportion of granite with Sr values less than 50 ppm and Rb greater than 250 ppm, suggesting that feldspar crystal fractionation has produced the more felsic part of their trends. Crystal fractionated granites would be expected to be clear of restite minerals and this may explain the low proportion of minerals which could be considered restite and would be diagnostic of the granite type. The degree of crystal fractionation was not sufficiently extreme to allow distinction to be made between strongly fractionated I-type and S-type granite on the basis of contrasts in the abundance of P, Y and Th (Chappell, 1999).

The Lady Barron suite also shows linear trends on two element plots, although with only a small range in composition. The suite contains cordierite and muscovite and is S-type, as cordierite is an Al-rich mineral diagnostic of S-type granite. The cordierite may be restite and the short linear trend may represent restite fractionation.

High Rb and low Sr values indicate that the Henbury, Royal George, Lottah and Freycinet suites are strongly crystal fractionated (fig. 7). These suites show the contrasts in the abundance of P, Y and Th between strongly fractionated I-type and S-type granite (Chappell, 1999). The Henbury and Freycinet suites are I-type and Lottah and Royal George suites are S-type. The Henbury and Freycinet suites range from metaluminous to peraluminous, whereas the Lottah and Royal George suites are strongly peraluminous (fig. 7). This is consistent with the characterisation of the Henbury and Freycinet suites as I-type and the Lottah and Royal George suites as S-type. The Freycinet suite has previously been described as a strongly fractionated I-type granite by Chappell (1999). The absence of potential restite minerals in the Henbury, Royal George, Lottah and Freycinet suites is consistent with their degree of crystal fractionation which would be expected to clear the magma of restite.

Age of the granites

Isotopic age data for the Tasmanian granites are summarised in Figure 2 and include U-Pb zircon dates. Black *et al.* (2005) showed that the U-Pb zircon isotopic clock has been more resistant to resetting than those for Rb-Sr and K-Ar, with the Rb-Sr and K-Ar dates being generally about 10 Ma to 15 Ma younger than U-Pb zircon dates for the same body. An exception to this generalisation is the Grassy granite body, which has a weighted average K-Ar date of 352.25 ± 5 Ma (McDougall and Leggo, 1965), which is in good agreement with the U-Pb zircon date of 350.7 ± 2.3 Ma suggesting that the geological effects responsible for the resetting did not extend to King Island. The discussion that follows refers to U-Pb zircon dates unless otherwise specified.

In western Tasmania, the I-type Housetop and Wombat Flat bodies are the oldest and are almost the same age. The red Heemskirk granite is also I-type but is distinctly younger and has almost the same age as the S-type white Heemskirk, Interview and Sandy Cape bodies. The Grassy I-type granite represents a third and younger phase of intrusion.

In eastern Tasmania the oldest igneous activity is also I-type granite represented by the foliated Diddleum, Gardens, George River and Long Point bodies. The start of intrusion was about 10 Ma earlier in the Blue Tier Batholith than in the Scottsdale Batholith. In the Blue Tier Batholith igneous activity extended over about 23 Ma and ended with the intrusion of the highly crystal-fractionated S-type Lottah body. The Lottah body is distinctly younger than the Poimena body, which it intrudes.

The earliest age of intrusion shows a progression from east to west and extends over about a 50 Ma period. The youngest intrusion in eastern Tasmania, represented by the Lottah body, is about the same age as the Housetop body, which is the oldest in western Tasmania.

In western Tasmania the closely associated red and white Heemskirk I-type and S-type granite bodies were intruded at almost the same time. In eastern Tasmania the strongly crystal-fractionated Henbury and Gipps Creek I-type and S-type granites are closely associated and may also have been coeval.

Ages of restite zircon inherited from the granite source rocks have been measured for granite bodies from western and eastern Tasmania, and are presented by Black (in prep.). No significant difference was detected between zircon age components for I-type and S-type granites, though I-types contained less inheritance. Inheritance patterns for the granites from western and eastern Tasmania were similar within each region but differed between the two regions. This observation supports the view that the source rocks for the granites in western and eastern Tasmania were different.
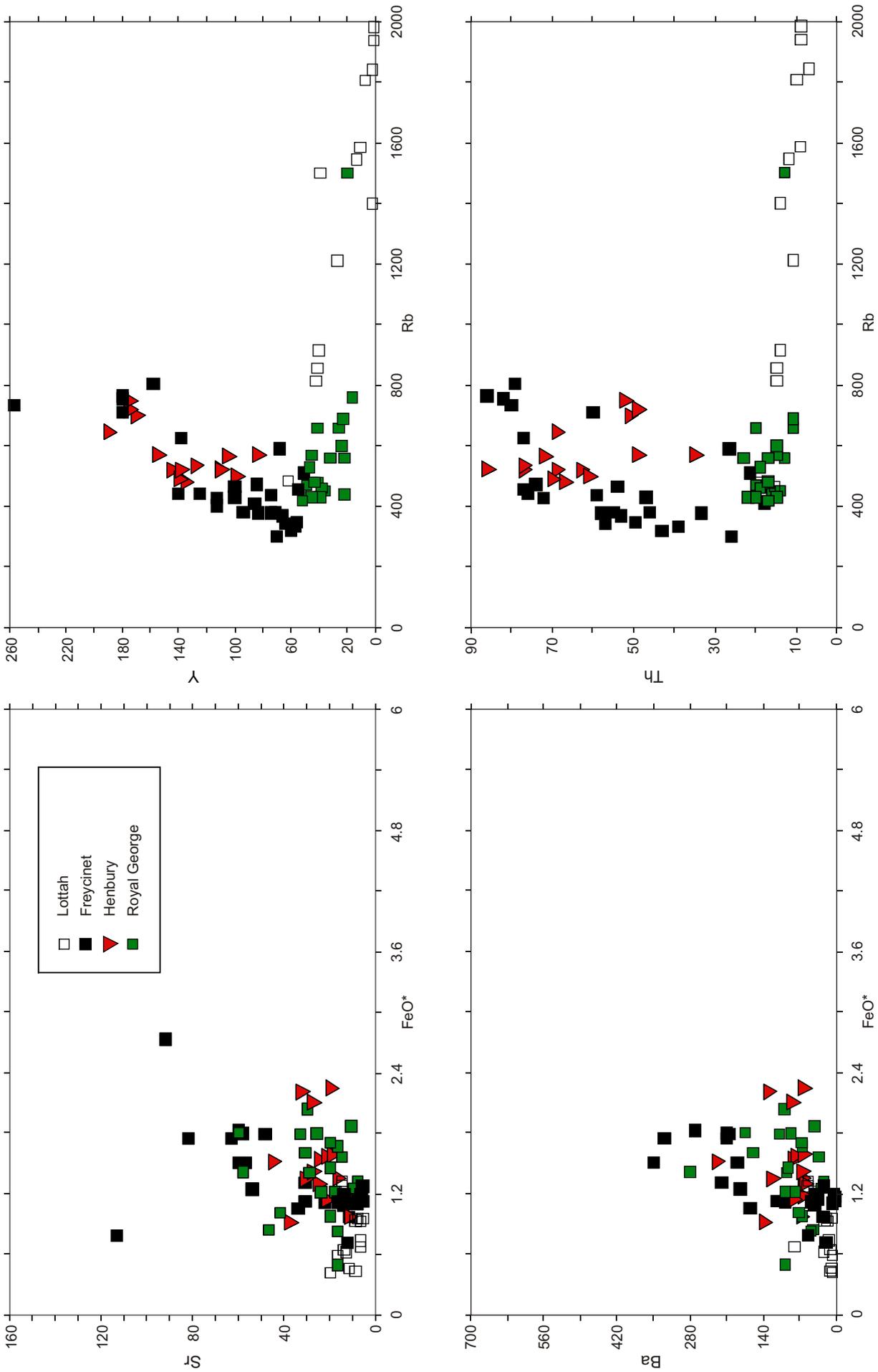
Figure 7. *Variation diagrams for strongly crystal-fractionated eastern Tasmanian mid-Palaeozoic granites. FeO* is total iron as FeO, ASI is the aluminium saturation index (mol. $Al_2O_3/(CaO + Na_2O + K_2O)$) and CORUNDUM is normative corundum.*
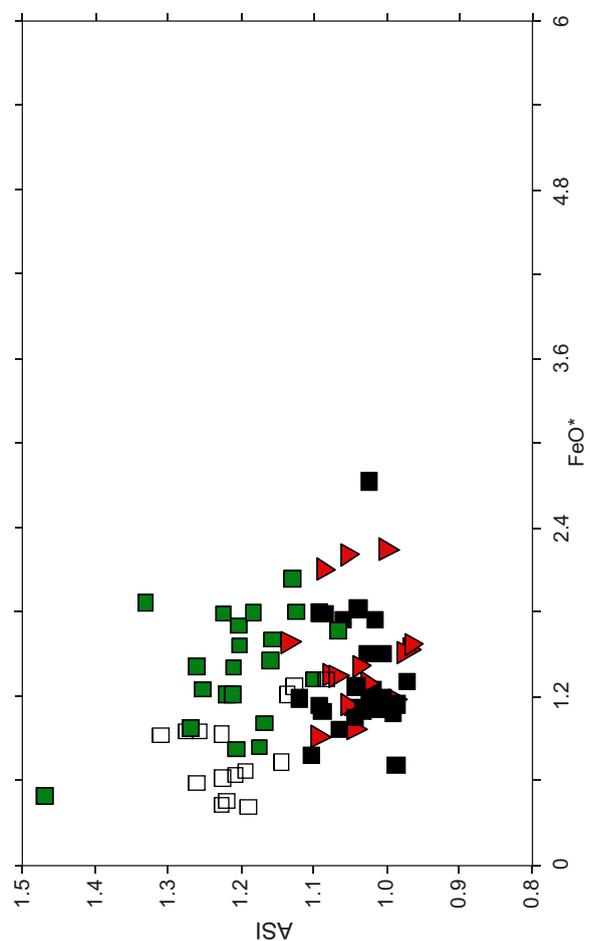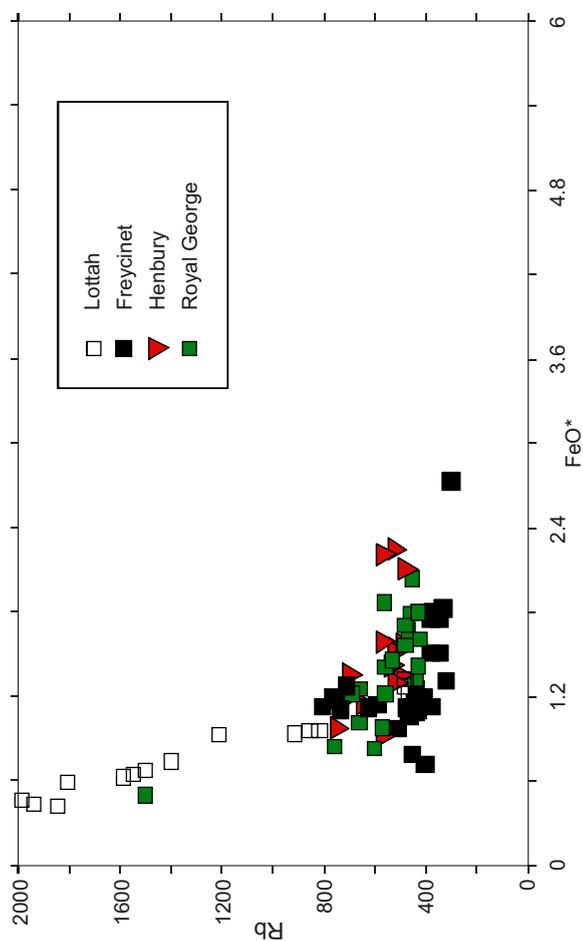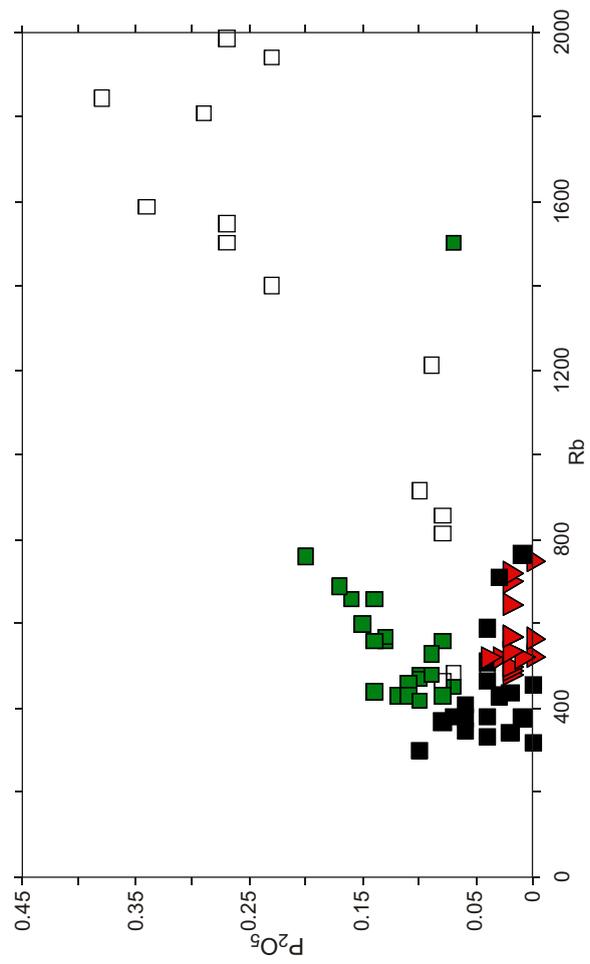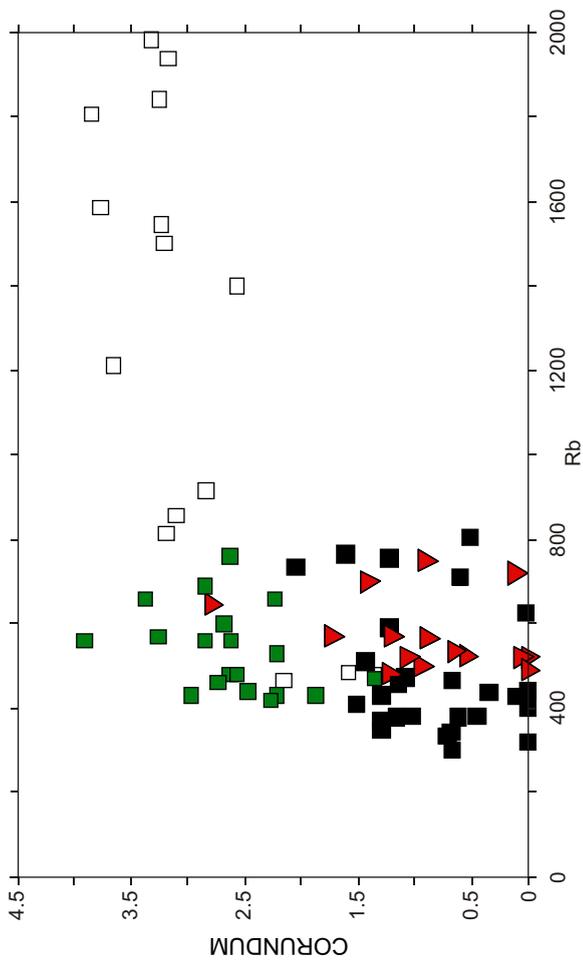
Figure 7 *(continued)*

Isotopic variation of the granites

In western Tasmania the Housetop and Wombat Flat I-type bodies have initial $^{87}Sr/^{86}Sr$ ratios (fig. 8) that overlap with those of the Ansons Bay and Boobyalla S-type granite bodies (fig. 9). The Housetop and Wombat Flat bodies belong to different granite suites and have distinctly different initial $^{87}Sr/^{86}Sr$ ratios.

The white Heemskirk, Pieman and Interview bodies, which are part of the Pieman and Interview S-type granite suites, have very much higher initial $^{87}Sr/^{86}Sr$ ratios (fig. 8) which are very different to those of the S-type granite suites in eastern Tasmania (fig. 9). The values for the Pieman and Interview suites are also very different from each other.

In eastern Tasmania the initial $^{87}Sr/^{86}Sr$ ratios of the foliated I-type granites of the Scottsdale and Blue Tier batholiths are very similar and fall within a small range around 0.707 (fig. 9). The initial $^{87}Sr/^{86}Sr$ ratios for the other I-type granite bodies, including the Freycinet body which is part of a strongly crystal-fractionated suite, have similar values and range. The similarity of these values suggests that these I-type granites may have originated from a moderately homogeneous source rock.

The Mt Pearson and Poimena bodies, which are part of the Poimena I-type granite suite, have only very slightly higher initial $^{87}Sr/^{86}Sr$ ratio values than the other eastern Tasmania I-type granites (fig. 9). The values for the Ansons Bay (north and south parts) and Boobyalla bodies, which are part of the Boobyalla S-type granite suite, are distinctly higher than those of the I-type granite suites and than those of the Mt Pearson and Poimena bodies.

The difference in initial $^{87}Sr/^{86}Sr$ ratios between the granites from eastern and western Tasmania suggests that their source rocks were different and that there was a range of source rocks within each area.

Granites from the I-type and S-type granite suites, excluding the Lottah suite, of the Blue Tier and Eddystone batholiths have similar $^{143}Nd/^{144}Nd$ initial ratios (εNd = -5.0 to -6.5) at 370 Ma (Sun and Higgins, 1996). The source-rock model age for these granites, based on a depleted mantle evolution model (T_{DM}), is about 1.6 Ga (Sun and Higgins, 1996). The Sm-Nd model age represents the time when the major REE fractionation in the components of a rock occurred, that is during their derivation from a mantle reservoir (McCulloch and Chappell, 1982, p.60). The Sm-Nd
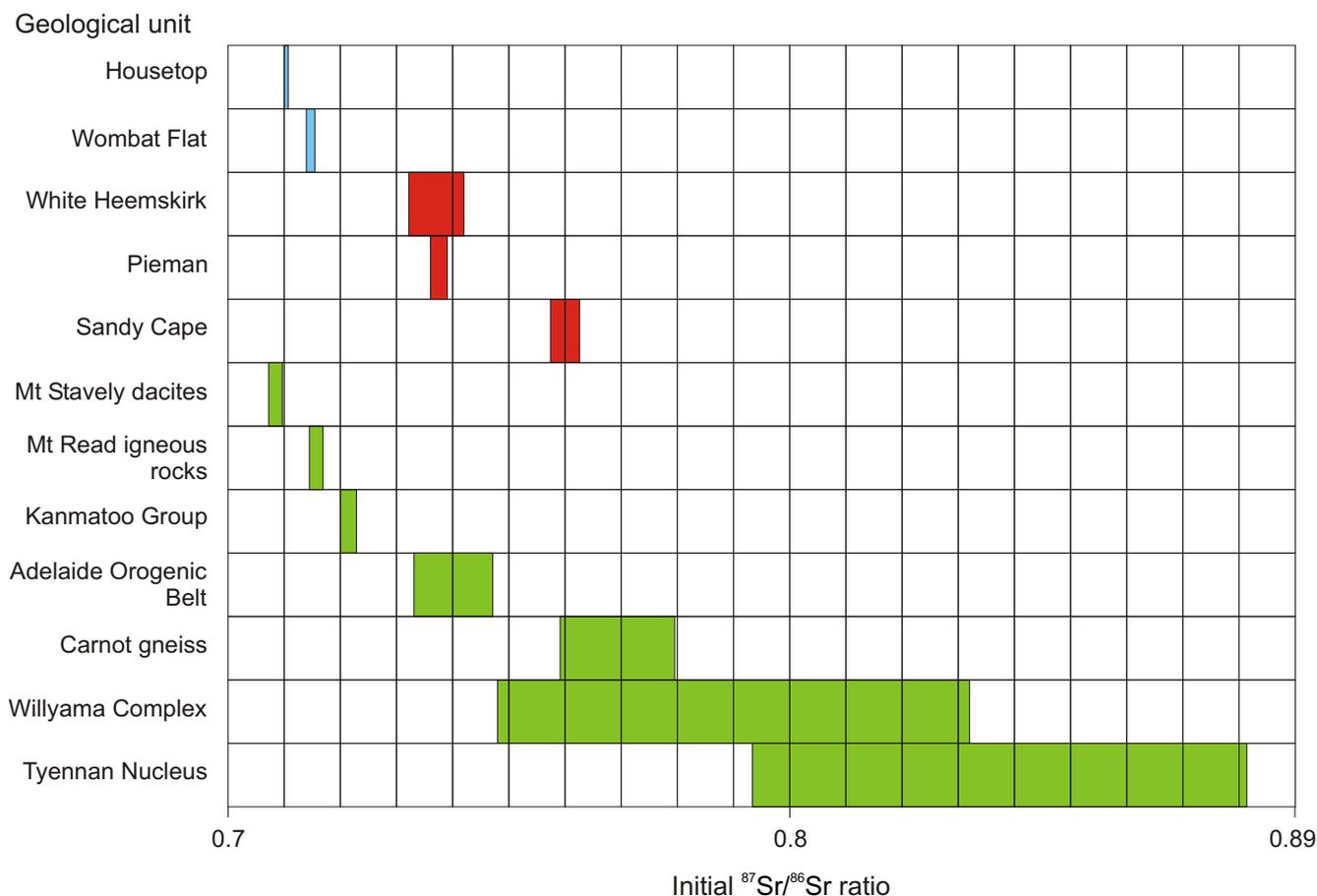
Figure 8

Initial $^{87}Sr/^{86}Sr$ ratios for western Tasmanian granite bodies and $^{87}Sr/^{86}Sr$ ratios for possible source rock terrains at 95% confidence level calculated for age 360 Ma. I-type granite bodies in blue, S-type granite bodies in red and possible source rock terrains in green. Weighted averages are used where multiple values are available. Data from McDougall and Leggo (1965), Brooks and Compston (1965), Brooks (1966), Sawka et al. (1990) and Gray and Webb (1995).
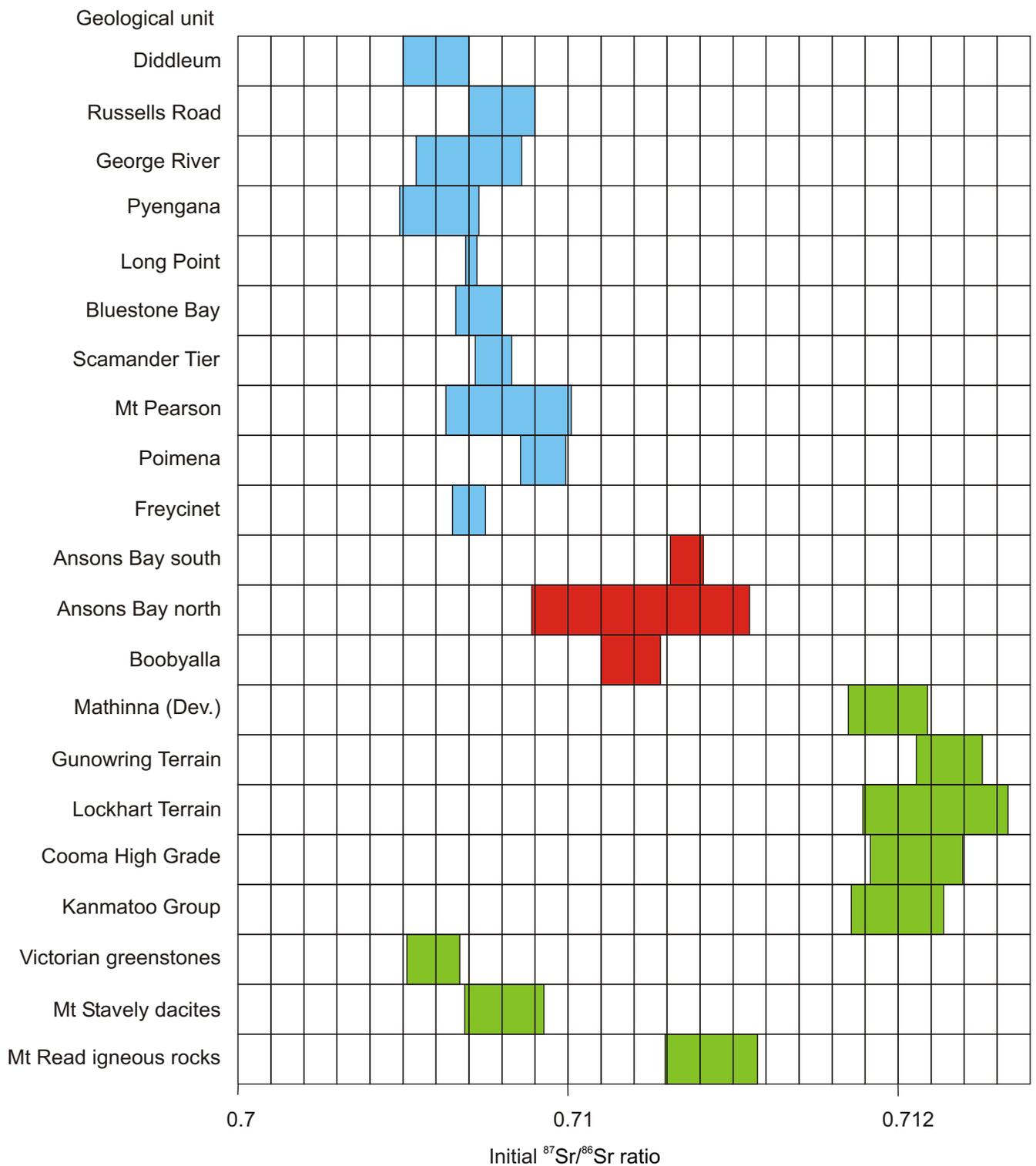
Figure 9

Initial ⁸⁷Sr/⁸⁶Sr ratios for eastern Tasmanian granite bodies and ⁸⁷Sr/⁸⁶Sr ratios for possible source rock terrains at 95% confidence level calculated for age 400 Ma. Foliated I-type granite bodies in blue, S-type granite bodies in red and possible source rock terrains in green. Weighted averages are used where multiple values are available. Data from McDougall and Leggo (1965), Cocker (1982), Turner et al. (1986), Mackenzie et al. (1988) and Gray and Webb (1995).

model age approximates the average age of the components of the source rock, not the age of the source rock itself, and so may be consistent with the presence of a small proportion of inherited zircons of about ~500–600 Ma in eastern Tasmanian granites (Black, in prep.).

Metallogenic potential of the granites

The type of fractionation mechanism that produced the compositional variation in a granite suite is an important factor in concentrating trace elements. Restite fractionation does not cause marked enrichment or depletion of trace elements relative to the original source concentration (Blevin and Chappell, 1992). The ore elements may be contained within restite minerals and not in the melt, and are therefore not available for partitioning into an exsolving aqueous phase. In addition, restite-rich magma would be cooler than the melt-rich equivalent magma and so there would be less crystal fractionation if the magma rid itself of the entrained restite, and less heat would be provided to the wall rocks or would be available to drive hydrothermal systems. Extended crystal fractionation can produce considerable enrichment in incompatible trace elements, and significant feldspar fractionation is indicated by Rb concentrations above 250 ppm (Blevin and Chappell, 1992). The identification of the Diddleum, Russells Road, Gardens and Scamander Tier suites as likely to have been substantially restite-fractionated rather than crystal-fractionated downgrades their mineralisation potential. The higher Rb values for the Mt Stronach and Tombstone Creek bodies indicate that they would have the highest mineralisation potential of the Russells Road suite. Most of the other granite suites in Tasmania have been crystal-fractionated, and so have greater mineralisation potential. In western Tasmania, the Interview and Renison suites are the most strongly fractionated and have the highest potential, while the Pieman, Housetop, Meredith and red Heemskirk suites are less strongly fractionated but also have high potential. In eastern Tasmania the Henbury, Royal George, Lottah and Freycinet suites are strongly crystal fractionated, and have high mineralisation potential. The Poimena and Boobyalla suites are less strongly crystal-fractionated and have a lesser potential.

The type of ore elements associated with a granite suite can be related to its oxidation state (Blevin and Chappell, 1992). Sn can be in the Sn^{4+} or Sn^{2+} state. In the octahedrally coordinated Sn^{4+} state it has an ionic radius similar to that of Ti^{4+} and Fe^{3+}, enabling it to substitute for these ions in biotite, hornblende, sphene, ilmenite and magnetite. If the melt is reduced, Sn will not be in the Sn^{4+} state, and will not be removed from the melt by the crystallisation of these minerals.

Concentration of Sn in the melt by fractional crystallisation would be favoured for less oxidised granite suites. In extreme cases of crystal fractionation, where the fractionation process had become dominated by feldspar, Sn would be concentrated even in more oxidised granite suites.

S-type granites are generally less oxidised than I-type granites, which has been ascribed to the presence of graphite within their S-type source rocks (Flood and Shaw, 1975). The S-type granites in Tasmania are all ilmenite-bearing rather than magnetite-bearing and generally have lower Fe_2O_3/FeO ratios than the magnetite-bearing Grassy and Housetop I-type granite suites of western Tasmania. The red Heemskirk, Meredith and Renison I-type suites, although containing minor magnetite, have Fe_2O_3/FeO ratios that are comparably low to those for the S-type granites. The I-type granites in eastern Tasmania differ from most I-type granites elsewhere in the Lachlan Fold Belt by being ilmenite bearing, except for the Pyengana and Lisle plutons which include some magnetite-bearing granite. Sn mineralisation is most strongly associated with the crystal-fractionated S-type granites of western Tasmania and the crystal-fractionated S-type and I-type granites of eastern Tasmania, as would be predicted from the above discussion. The association of the magnetite-bearing I-type Renison suite (in western Tasmania) with Sn mineralisation may be because it was not strongly oxidised, as it also contains ilmenite and underwent extreme feldspar fractionation, as indicated by Rb values ranging up to 844 ppm.

Mo partitions more into ilmenite in relatively reduced granitic melts and so is depleted in the residual melt by crystal fractionation. In more oxidised conditions Mo is partitioned more into the melt (Blevin and Chappell, 1992). The Housetop and Grassy suites are the most oxidised granite suites and have the most potential for Mo; the other reduced granite suites have low potential. Mo is a component of the scheelite skarn deposits associated with granites of the Grassy and Housetop suites (Collins, 1989). The low potential Russells Road suite in the Mt Stronach pluton does, however, show low-grade Mo mineralisation (Langsford and Westhoff, 1982), which is the most fractionated body in the suite.

W mineralisation shows little dependence on the oxidation state of the granite magma (Blevin and Chappell, 1992), but is enhanced by crystal fractionation. The strongly crystal-fractionated granite suites of both I-type and S-type would be expected to have the highest potential for W mineralisation. Economic deposits of W have been associated with the Grassy, Housetop and Royal George granite suites (Collins, 1989), with the world class scheelite deposits on King Island associated with the former being by far the most important W deposits in Australia. The Grassy suite is not strongly fractionated, but the mineralisation may be related to other factors, such as the fairly deep level of emplacement and the nearby presence of abundant carbonate rocks (Wesolowski *et al.*, 1988).

Petrogenesis of the granites

Groves *et al*. (1972) suggested that the western Tasmanian granites are closely related intrusions, with a sequence of increasing chemical fractionation that is parallel to their relative level of emplacement. The division into suites presented here and the differences in initial $^{87}Sr/^{86}Sr$ ratios of the granite bodies contradicts that model, as it indicates that there were distinct melts derived from different source rocks.

Heier and Brooks (1966) proposed that the Heemskirk white granite was intruded first as a highly differentiated magma, which was then modified by a magmatic vapour phase, and subsequently intruded by a second pulse of the parental magma. This model is inconsistent with later geological mapping (Klominsky, 1972), which showed that the white granite intruded after the red granite (although the radiometric dating shows that there can have been only a small time interval between the two events — see Figure 2). The separation of the red and white granites into different suites, as suggested here, also argues against them being derived from the same magma.

Sawka *et al*. (1990) and Wyborn and Chappell (1998) identified the mainland western Tasmanian granites as having been highly fractionated near the ternary minimum in the Ab-Q-Kf system. Chappell (1999) drew attention to the contrasting behaviour of P, Th and Y for I-type and S-type granites and presented the Interview suite granites as an example of strongly fractionated S-type granite.

A cumulate fractional crystallisation model has been proposed for the Blue Tier Batholith in eastern Tasmania (McCarthy and Groves, 1979). This model envisaged that the batholith formed by fractional crystallisation of a single magma, of adamellite composition, which underwent crystallisation *in situ* by progressive nucleation and solidification from the margins inwards. Progressive changes in liquids and the cumulate mineralogy during crystallisation led to the observed sequence of early granodiorites followed by biotite adamellites and the alkali-feldspar granites. This model has been criticised by Cocker (1982) on the grounds that the apparently unique mineral, chemical and isotopic composition of each pluton points to a number of separate magmas rather than an origin from a single magma. The division into suites suggested here based on chemical and petrographic character, although pointing to a connection between some plutons, also supports the conclusion that the granites have been derived from a number of distinct magmas.

Crystal fractionation models have been proposed to explain the chemical variation in the Pyengana and Gardens granodiorite plutons. McClenaghan (1984) suggested that fractionation in both plutons involved hornblende, plagioclase, biotite and minor amounts of apatite and sphene. Higgins *et al*. (1985) modelled the variation in the Pyengana granodiorite pluton using clinopyroxene, orthopyroxene, biotite and plagioclase as the fractionating phases. Work on the St Marys volcanic body and associated intrusive rocks (Higgins *et al*., 1986) supports a crystal fractionation model for the variation in bodies of granodiorite composition.

McClenaghan and Williams (1982) suggested that chemical variation in the Poimena pluton adamellite could be explained by restite-unmixing or fractional crystallisation. Higgins *et al*. (1985) favoured a fractional crystallisation model involving pyroxene, biotite, plagioclase and K-feldspar. Mackenzie *et al*. (1988) considered that the Poimena pluton adamellite was generated by partial melting of a source of basaltic andesite composition, which underwent limited restite-unmixing.

McClenaghan and Williams (1982) considered that the Lottah pluton alkali-feldspar granite could have been derived from Poimena pluton adamellite by crystal fractionation, or by a combination of restite-unmixing and crystal fractionation. Higgins *et al*. (1985) suggested that the derivation process was one of fractional crystallisation combined with variable metasomatism following aqueous fluid saturation of the magma. They also advocated this process for the derivation of the Mt William alkali-feldspar granite from the Ansons Bay biotite-cordierite-garnet adamellite. Mackenzie *et al*. (1988) concluded that the Lottah alkali-feldspar granite formed from a different magma to the Poimena adamellite. They based this conclusion on the lack of continuity of trends on variation diagrams, the ~10 million year difference in emplacement age (more recently measured as ~7 Ma by Black *et al*., 2005), the difference in initial $^{87}Sr/^{86}Sr$ ratios, and the difference in εNd values between the two granite types. Mackenzie *et al*. (1988) considered that the compositional variation in the Lottah alkali-feldspar granite is consistent with fractional crystallisation of a felsic peraluminous melt rich in F, Li and B, to produce even more peraluminous residual melts, progressively further enriched in these components. They did not consider that there was a significant metasomatic component to the chemical variation.

On the basis of P, Th and Y variation, Chappell (1999) postulated that the granites of the Freycinet suite were produced by strong crystal fractionation of I-type granitic magma.

The similarity of inherited zircon age components for I-type and S-type granites (Black, in prep.) suggests a common component or components to their source rocks. The variation in chemistry between the I-type and S-type granites in Tasmania may reflect varying proportions of igneous and sedimentary material in a mixed source rock sequence.

Inferences for crustal composition

It is generally accepted that most granites of the Lachlan Fold Belt resulted from magmas produced by partial melting of middle and lower crustal rocks. Source regions for S-type granites, as inferred from geobarometric analysis of early crystallising minerals in comagmatic volcanic rocks, were at a depth of ~15–20 km (Wyborn *et al.*, 1981; Clemens and Wall, 1981). Similar analysis of an I-type magma, the Kadoona Dacite, indicates an origin from 700 MPa (Wyborn and Chappell, 1986), corresponding to a slightly greater depth (~25 km). Inferences on the nature of the source rocks for the Tasmanian Devonian granites relate to the Tasmanian crust at those depths.

Two of the most widely applied current models for Lachlan Fold Belt granite genesis are the restite model (White and Chappell 1977; Chappell *et al.*, 1987) and the three-component mixing model (Collins, 1998). Both models will be used, where possible, to make inferences about the composition of the granite source rocks.

The restite model proposes that when granitic melts are first formed they are in equilibrium with the residual phases (restite), and that because of their high viscosity, the restite is not easily extracted to form a body of completely molten magma. Instead, when the 'critical melt fraction' of Van der Molen and Paterson (1979) is reached, the rigid framework of the source rock breaks down and the whole mass becomes a crystal-rich or inclusion-rich magma with lower viscosity. The magma is less dense than the source rocks and moves upward to intrude as a pluton or to erupt. Separation of restite and melt during ascent of the magma may be partial, producing systematic linear chemical variation in the resulting granites. These may be grouped together as a suite with common mineralogical, chemical and isotopic features. Within such a suite, the more mafic granites have compositions that approach those of the source rocks (Chappell *et al.*, 1999). The model recognises that granite magma may become largely or completely separated from restite and might subsequently undergo crystal fractionation. In cases where this model is applicable, granite compositions provide information about the composition of their source rocks and granites have been described as imaging their source (Chappell, 1979).

The Collins (1998) model is more complex and generally involves the mixing of three types of magma. These are mantle-derived basaltic magmas, magmas derived by partial melting of meta-igneous lower crustal rocks, and magmas derived from metasediments in the middle crust. The first two magmas may mix to produce I-type parental magmas, which may fractionate to give a range of granite compositions. Mixing of the I-type parental magma with the metasediment-derived magma type produces magmas parental to S-type granites, which can also fractionate to give a range of granite compositions. This model does not allow the composition of the source regions to be directly inferred from granite compositions.

In addition to chemical and mineralogical compositions, initial $^{87}Sr/^{86}Sr$ ratios and inherited zircon age patterns of granites provide constraints on source rock composition. Some of the inferences drawn from these data depend on the assumption that granites were produced by single melting events and are not the product of magma mixing or assimilation and contamination. On this assumption, the initial $^{87}Sr/^{86}Sr$ ratio will be the same as the $^{87}Sr/^{86}Sr$ ratio of the source rock at the time of melting. The initial $^{87}Sr/^{86}Sr$ ratio for the granite can be compared with average $^{87}Sr/^{86}Sr$ ratios (calculated to the age of the granite) of rock units in adjacent exposed terrains, providing constraints on rock types that might have been present in the source region at the time of the granite genesis. Similarly the pattern of zircon ages in granite, inherited from the source rocks, may also be compared and matched with the patterns of zircon ages in rocks of exposed terrains. Based on the single melting event assumption, granite will have a source rock no older than the age of the youngest inherited zircon.

The division of the granites in western Tasmania into I-type and S-type is based on the restite model and indicates that the source region in the lower crust would be expected to include igneous and sedimentary rocks. However most of the granites (Housetop, red Heemskirk, Renison, Interview and Pieman suites) are strongly crystal-fractionated, and they may be expected to have become largely separate from restite minerals. Consequently, these granites do not display linear chemical variation, and the most mafic granites in the suites may have become quite chemically different from the source rock composition. The Grassy and Meredith suites are less fractionated but they do not display sufficient variation in composition to reliably indicate that they are the most mafic granites of the melting episode, and therefore close to the source rock composition, as suggested by the restite model.

The youngest inherited zircon ages in the I-type and S-type granites from western Tasmania are ~1200 Ma (Black, in prep.). The lack of younger inherited zircon ages suggests a Proterozoic age for the source rocks.

The difference in initial $^{87}Sr/^{86}Sr$ ratios of the Housetop and Wombat Flat I-type granite bodies indicates that they originated from different source rocks (fig. 8). The initial $^{87}Sr/^{86}Sr$ ratios of both bodies are bracketed by $^{87}Sr/^{86}Sr$ ratios for the Mount Read igneous rocks and the Mt Stavely dacites in Victoria (fig. 8). As these rock units are of Cambrian age and there are no inherited zircons of that age in the granites, they are unlikely to be the source rocks.

The western Tasmanian S-type granites have much higher initial $^{87}Sr/^{86}Sr$ ratios than the I-types, and at least two different source rocks are suggested by the large difference in ratios between the Heemskirk white and Pieman granites, and the Interview granite. The

$^{87}Sr/^{86}Sr$ ratio for the Proterozoic Tyennan Region rocks is too high to have been a source rock (fig. 8), while the $^{87}Sr/^{86}Sr$ ratios of rocks from other Proterozoic units, such as the Adelaide Orogenic Belt in South Australia, are similar to the initial ratios of the Heemskirk white and Pieman granites. The 'expected' zircon-age distribution histogram (Pell *et al.*, 1997) for the Adelaide Orogenic Belt differs from the western Tasmanian granite zircon-age histogram (Black, in prep.) by having strong peaks at ~600 Ma, ~800 Ma and 1250 Ma as well as 1650 Ma.

The $^{87}Sr/^{86}Sr$ ratio for the Interview Granite falls within the range for the Archaean Carnot gneiss and the Proterozoic Willyama Complex rock of South Australia. The 'expected' zircon-age distribution histogram (Pell *et al.*, 1997) for the Curnamona Craton (which includes the Willyama Complex) is very similar to the inherited zircon-age histogram for the western Tasmanian granites (Black, in prep.). Both histograms have strong peaks at ~1600 Ma and ~1740 Ma. The western Tasmanian granites include zircon-ages extending to ~1200 Ma, whereas the Curnamona Craton shows a sharp cut off in zircon ages at 1500 Ma and has a small peak at 600 Ma. Another difference is that the western Tasmanian granite zircon-age histogram includes a small peak at ~2800 Ma not present in the Curnamona Craton histogram. Despite these mismatches there is sufficient similarity to suggest that rocks similar to those of the Curnamona Craton may be present at depth in western Tasmania and have been the source rocks for the western Tasmanian S-type granites.

Both I-type and S-type granites have been identified in eastern Tasmania, indicating that the lower or middle crust in that region would be expected to include igneous and sedimentary rock types. The increase in S-type granite towards the east suggests an increase the proportion of sedimentary rocks in the lower or middle crust in that direction.

Both the I-type and S-type granites contain inherited zircon with ages ~500–600 Ma, in addition to less common older zircons (Black, in prep.). This indicates that their source rock cannot be older than Late Proterozoic to Cambrian if all the older zircons are derived from the source rocks and contamination by country rocks during the ascent of the granite is discounted. The proportion of inherited zircons is greater in the S-type granites.

The Diddleum, Russells Road, Gardens, Scamander Tier, Long Point and Wybalenna I-type granite suites may have undergone restite fractionation. Mafic enclaves in granites of these suites commonly have similar but more mafic mineralogy to the host granite. These generally plot beyond the basic end of linear trends on two elements plots (fig. 4). Similar enclaves have been suggested as source rock in the I-type Glenbog and Blue Gum Granite suites on the Australian mainland, on the assumption that they were more refractory due to a lesser degree of hydration prior to melting (Chen *et al.*, 1990). Based on the restite model, the most mafic compositions on trends for the northeast Tasmania I-type suites and the compositions of the mafic enclaves suggest that the igneous source rocks were of intermediate composition.

These I-type granites of eastern Tasmania have generally similar initial $^{87}Sr/^{86}Sr$ ratios of about 0.707 (fig. 9), which may indicate that there was only a moderate amount of variation in the composition of their source rocks. The $^{87}Sr/^{86}Sr$ ratios of the Mt Stavely dacites are similar to the I-type granites and on that basis represent potential source rocks. Their Cambrian age is consistent with the presence of ~500–600 Ma inherited zircons in the I-type granites, and their mineralogical and chemical composition are also close to that suggested by the restite model. The ratios for the Victorian greenstones are a little lower (fig. 7) and, as they do not contain enough of the granite-forming elements (Si, Al, Na and K) to provide substantial quantities of melt, are unlikely to be sole source rocks.

The Poimena I-type suite does show a wide range of composition (fig. 6), which might signify that the most mafic compositions approximate that of the source. This composition would be consistent with an igneous rock type that was more acid (dacite?) than the source suggested for the other eastern Tasmanian I-type suites.

The Boobyalla suite is generally a little lower in CaO and Na_2O (fig. 6) than the Poimena suite and contains Al-rich minerals, suggesting a sedimentary source rock. It shows a similar range of composition to the Poimena suite and its most mafic composition may approximate that of the source. The Musselroe suite also contains Al-rich minerals, suggesting a sedimentary source rock, but has been distinguished from the Boobyalla suite because it has similar CaO and Na_2O values (fig. 6) to the Poimena suite. These compositions are quite different from that of the Mathinna Supergroup country rocks, particularly for CaO and Na_2O (see fig. 6), indicating that rock unit could not be the sole source rock. Elsewhere in the Lachlan Fold Belt, a less mature sedimentary source rock than the country rock Ordovician greywacke has been suggested for the S-type granites of the Bullenbalong and Strathbogie suites (White and Chappell, 1988). The greywacke was considered to have been derived directly from andesites with virtually no weathering (White and Chappell, 1988). It is possible that the source rock for the Boobyalla and Musselroe suites was also immature greywacke derived from dacitic volcanic rocks.

The Lady Barron S-type granite suite may have undergone restite fractionation, although it does not display a sufficient range of composition to reliably indicate that it includes the most mafic granites of the melting episode that produced them.

The initial $^{87}Sr/^{86}Sr$ ratios of the Mt Pearson and Poimena bodies (fig. 9), which belong to the Poimena I-type suite, are only slightly higher than those of the

other I-type granites. This difference, although small, does support the view that their source was different from that of the other I-type granites. The Ansons Bay and Boobyalla granites are clearly S-type and belong to the Boobyalla suite and do have distinctly higher initial $^{87}Sr/^{86}Sr$ ratios (fig. 9), which points to the presence of a third type of source rocks. The initial $^{87}Sr/^{86}Sr$ ratios for these granites are much lower than the $^{87}Sr/^{86}Sr$ ratios of Lachlan Fold Belt Palaeozoic turbidites as represented by the Gundowring and Lockhart terrains, Cooma High Grade and the Mathinna (Devonian) rock units (fig. 9). This supports the view that they were not purely derived from rocks of that composition.

Inherited zircon with ages of ~500–600 Ma in the eastern Tasmanian S-type granites indicates that their postulated source rock could not be older than late Proterozoic to Cambrian. Rocks of this approximate composition and age are not exposed in the Lachlan Fold Belt but may occur at depth.

The mineralogical, chemical and isotopic features of the eastern Tasmanian granites show broad similarities to granites in the Lachlan Fold Belt on mainland Australia. Both the restite model and the three-component mixing model (Collins, 1998) have been used to explain the petrogenesis of the mainland granites. The above discussion has considered the genesis of the eastern Tasmania granites from the point of view of the restite model. However as for mainland Australia, the data may be interpreted to also fit the three-component mixing model. That model has been used to infer the crustal architecture of the eastern part of the Lachlan Fold Belt (Collins, 1998) (fig. 6). Ordovician metasediments are inferred to dominate the upper crust (0–20 km) and a Cambrian greenstone sequence of metabasalt/andesite to form the lower crust (20–30 km). Isotopically primitive I-type granites were considered to be a mix of partial melt from the mantle and from the Cambrian greenstones. Variable contamination of this magma with melt from the Ordovician metasediments produced the other granite magmas. The degree of contamination of the primitive I-type magma by melts from the Ordovician metasediments was related to the depth of the Ordovician metasediment/Cambrian greenstone boundary. In the west, where the depth of this boundary was greatest, the metasediments were at higher temperature and provided more melt, thus giving the granite a more S-type character. In contrast in the east, where the boundary was shallow, the metasediments did not melt and only I-type granites were produced.

The three-component mixing model requires magma mixing on a large scale. Using the Bega Batholith as a suitable area for detailed assessment of magma mixing, Chappell (1996) concluded that it could be excluded as a mechanism for generating the major compositional variations shown by that body. The principal argument against magma mixing was that when the compositions of pairs of suites from the batholith are compared, any difference seen at either end of the range in composition is also seen at the other limit. This is highly unlikely with magma mixing, a conclusion that may also be applicable to the granites in eastern Tasmania.

Synthesis

Variations in the chemistry and Sr isotopic composition of the granites indicate that they have been derived from the partial melting of a range of igneous and sedimentary source rocks. The difference in initial $^{87}Sr/^{86}Sr$ ratios between the I-type and S-type granites of western and eastern Tasmania, together with the difference in the inherited zircon age components, suggest that the crustal source rocks were different in the two areas. Those in western Tasmania were Proterozoic rocks older than those currently exposed in the area, while in eastern Tasmania they were Proterozoic to Cambrian rocks.

A large proportion of the granites show compositional evidence for extreme crystal fractionation, especially in western Tasmania. A proportion of the granites in eastern Tasmania may have undergone restite fractionation, based on linear trends on two elements plots, and the presence of plagioclase core regions of uniform composition. A crystal fractionation interpretation of these composition and textural features is also possible.

Acknowledgements

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