

**Tasmanian Geological Survey
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**Inclusions of high pressure
origin in Tasmanian
Cainozoic basalts:
A catalogue of localities**

by J. L. Everard

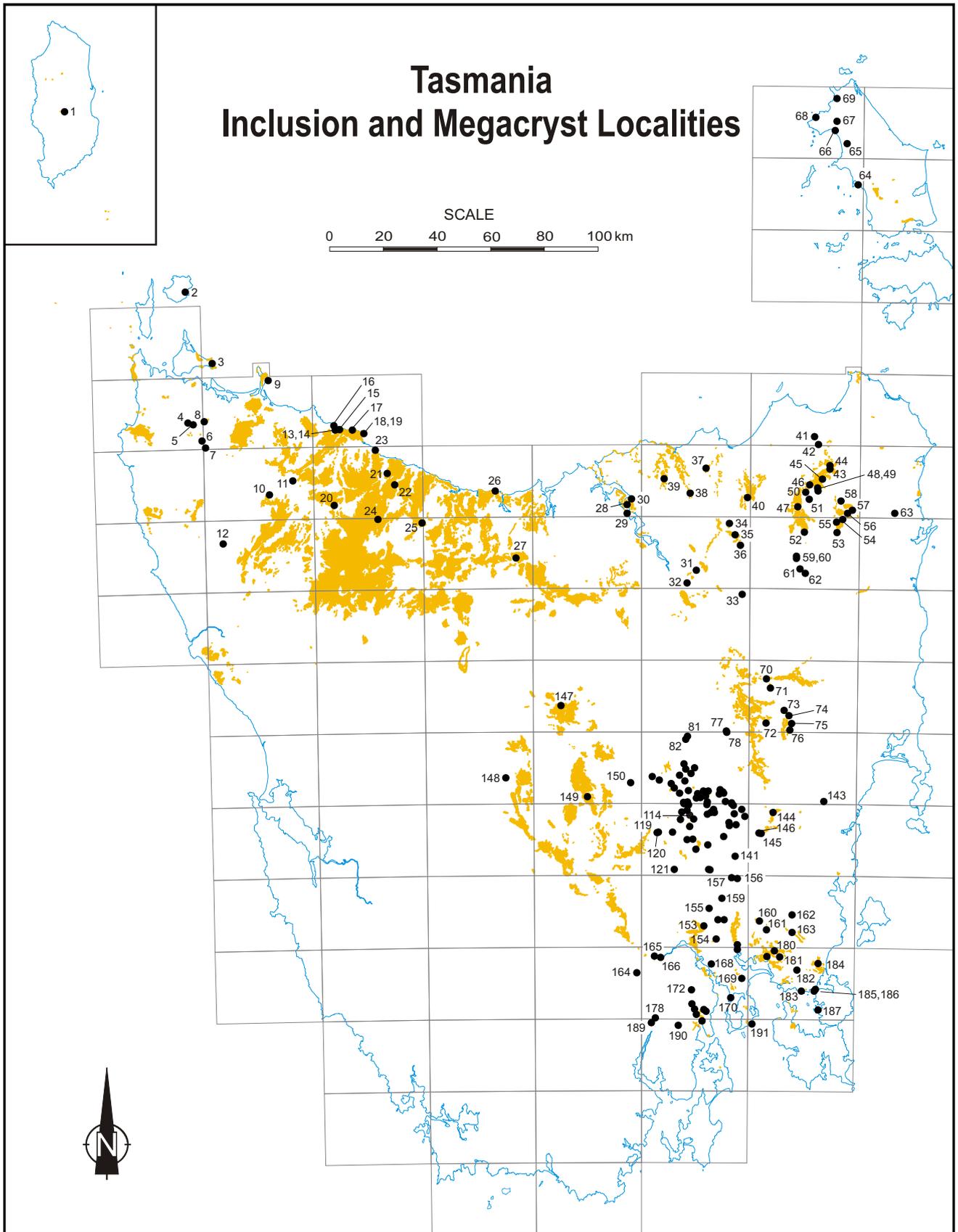


Figure 1

Inclusion and megacryst localities. Basalt distribution and 1:50 000 scale quadrangle boundaries are also shown. See figures 2 and 3 and Table 1 for greater detail.

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Abstract

Xenoliths, cognate inclusions, xenocrysts and megacrysts of upper mantle or lower crustal origin are recorded in Cainozoic basalts and associated rocks at more than 190 localities throughout Tasmania. Hosts include plugs, lava flows and less commonly pyroclastic rocks or diatreme breccias, and are strongly biased towards undersaturated compositions. By far the most common inclusions are spinel lherzolite xenoliths of the Cr-diopside suite, but at about 30 known sites these are accompanied by Al-augite suite inclusions (mostly websterites and wehrlites). Garnet-bearing ultramafic assemblages are recorded from only two localities. Other xenoliths, of probable lower to mid-crustal origin, include granulite, gabbro, dolerite and anorthosite. Megacryst species reported include clinopyroxene, orthopyroxene, olivine, spinels, kaersutitic amphibole, titanbiotite and titanphlogopite, apatite, alkali feldspar (anorthoclase, sanidine), plagioclase (albite to labradorite) and titanomagnetite. Zircon, corundum (sapphire) and possibly diamond occur as heavy minerals in alluvial deposits derived from Cainozoic basalts, but are very seldom found in situ.

Introduction

The following locality catalogue (Table 1) has been compiled using an earlier compilation (Wass and Irving, 1976) as a starting point, with the addition of information from subsequent literature (principally Geological Survey Bulletins and Explanatory Reports), unpublished data supplied by F. L. Sutherland, and observations of the author and colleagues.

The petrology of mantle-derived and other high pressure inclusions from eastern Australia, including Tasmania, has been reviewed by several authors including Wass and Irving (1976), Sutherland (1979), Sutherland and Hollis (1982), O'Reilly *et al.* (1989) and Beyer *et al.* (2002). No new petrological data is presented here, and only a brief review of the petrology of the inclusions and megacrysts is attempted. References to more detailed information on individual localities are given; the principal published sources are Varne (1977), Sutherland (1974), Brown and McClenaghan (1982), Sutherland *et al.* (1984, 1996) and Beyer *et al.* (in prep.).

The number in the first column of Table 1 links a brief description of the geographic locality (column 2) to positions shown on the attached maps (Figures 1 to 6). Some of the localities listed are relatively insignificant, and contain only very sparse and/or small inclusions or xenocrysts. As noted, several localities refer to multiple flow remnants from the same eruptive source, and may not represent discrete, separate eruptions.

Australian map grid co-ordinates are given (columns 3 and 4) to a nominal precision of either 10 or 100 metres. Locations which are considered substantially less precise are indicated (c.; circa), usually because the inclusions are inferred to be present over a substantial area (e.g. in a flow). In a few cases, the location is poorly known (indicated by ?), often because of vague or ambiguous descriptions in the literature. Most locations have been checked and refined if necessary against available geological maps, and many have been field checked by the author. The datum is Zone 55 of the Australian Geodetic Datum 1966 (AGD66), which is used on all recent topographic and geological maps of Tasmania. To convert to geocentric co-ordinates (GDA94) which are now being

introduced, add 112 m to the eastings and 183 m to the northings. The estimated maximum error of this block shift is three metres, far less than the imprecision of the data.

'Quadrangle' (column 5) is for the most part synonymous with the 1:50 000 or 1:63 360 scale Geological Atlas sheets published by the Tasmania Department of Mines from 1956 to 1994. '1:25000 map' (column 6) refers to both topographic sheets published at that scale and digital geological maps produced by Mineral Resources Tasmania since 1995. Sheets that are not available as geological maps at these scales are listed in italics. It will be noted that for most localities relevant 1:50 000 or 1:63 360 scale, but at present not 1:25 000 scale geological maps, are available. For a small number of localities (e.g. Flinders Island and parts of the Central Plateau), the only systematic geological maps available are at 1:250 000 scale.

Distribution

The general map (fig. 1) shows that high pressure inclusions have been found in most districts in which Cainozoic basalts occur. The density of known localities is partly a function of terrain (accessibility and exposure) and intensity of geological mapping, but is largely real.

There are relatively few sites in the extensive, mainly mildly alkalic lava flows of the northwest coast, although much of this country has been cleared for agriculture or forestry, and is geologically relatively well known. No localities are known from the dominantly tholeiitic lava pile east of Waratah, which is locally more than 350 m thick. There may be additional undiscovered localities in remote areas of the far northwest (e.g. the Savage River area), a region that has not been mapped in detail. There are numerous localities in northeast Tasmania, especially from the plugs and extensive flows (partly olivine nephelinite) of the Ringarooma River area. The strongest concentration (about 75 sites) is in the southern Midlands region (fig. 3), a region of numerous small plugs and flow remnants of alkalic basalts (and some highly detailed mapping). This also applies to a lesser degree to southeastern Tasmania (fig. 2), apart from the extreme south where Cainozoic

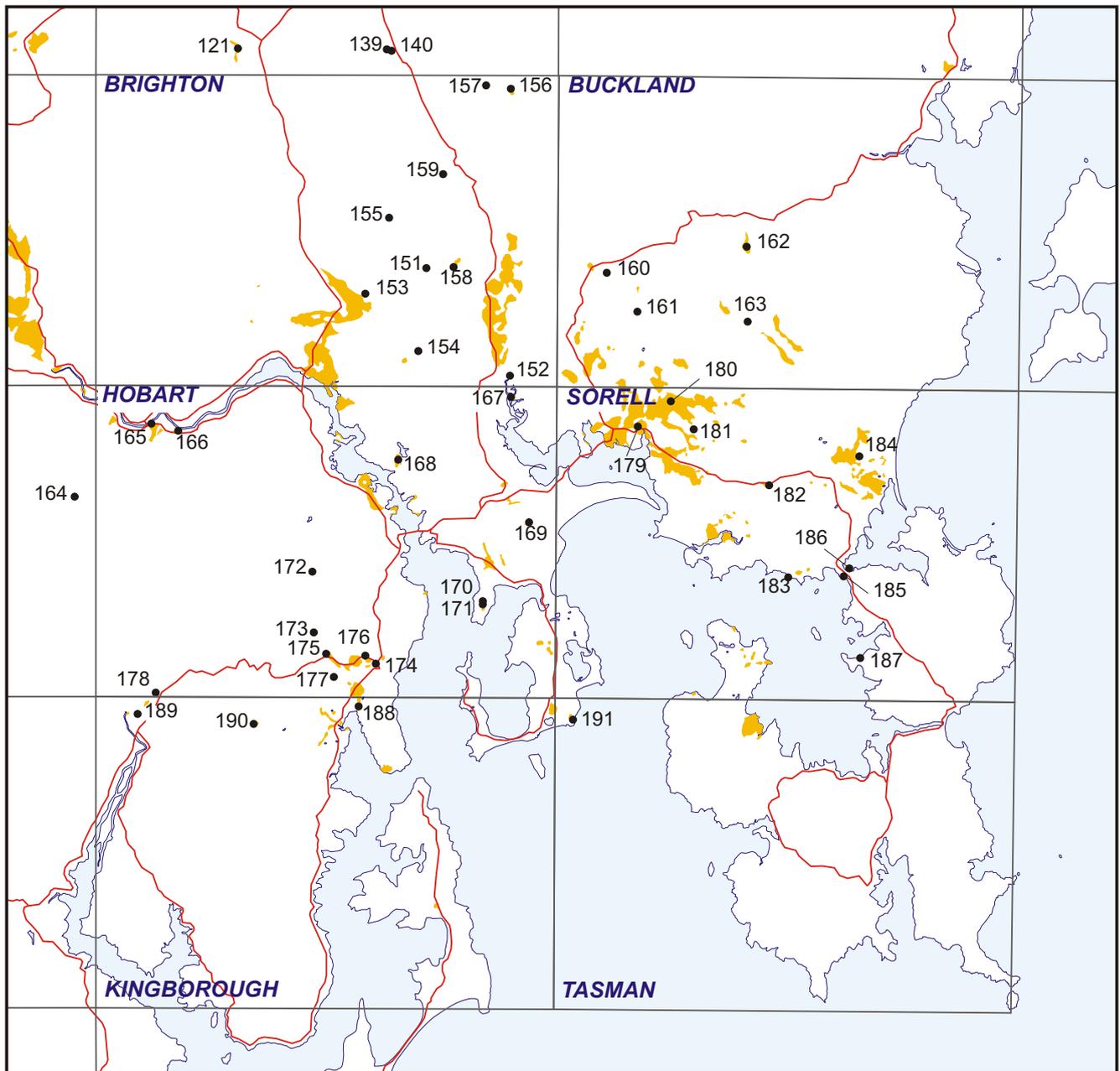


Figure 2

Inclusion and megacryst localities, southeastern Tasmania. Basalt distribution, major roads and 1:50 000 quadrangle boundaries are also shown.

basalt is absent. There are few known localities in the northern Midlands, western Central Plateau or upper Derwent Valley, which are regions of dominantly tholeiitic basalt, although the latter area is relatively poorly known.

Host rocks

The volcanological form of the host rocks (column 7) is varied, but most rocks hosting mantle inclusions in Tasmania are lavas, rather than pyroclastic rocks. This is similar to the usual mode of occurrence in New South Wales, but in contrast to several well-studied localities in young volcanic rocks from western Victoria (Newer Volcanics, 4.5 Ma to 4500 yr BP) and

North Queensland (<5 Ma) (Duncan and McDougall, 1989), where large xenoliths occur in cinder cones, maars and diatremes (e.g. O'Reilly *et al.*, 1989). Such features are relatively easily eroded and are not common in Tasmania, probably due to the greater age of the Tasmanian volcanic rocks (see below). Disaggregated lherzolite debris and/or megacrysts are recorded in breccias within diatremes at Brittons Swamp (location 4), Togari (location 5) and Upper Esk (location 62), and in several alkalic plugs in the Midlands and southeastern Tasmania that were probably emplaced explosively.

Inclusions are most likely to be found in or near plugs or feeders. Many occurrences are in flows, and in some locations (Bow Hill, location 114; West Don Heads,

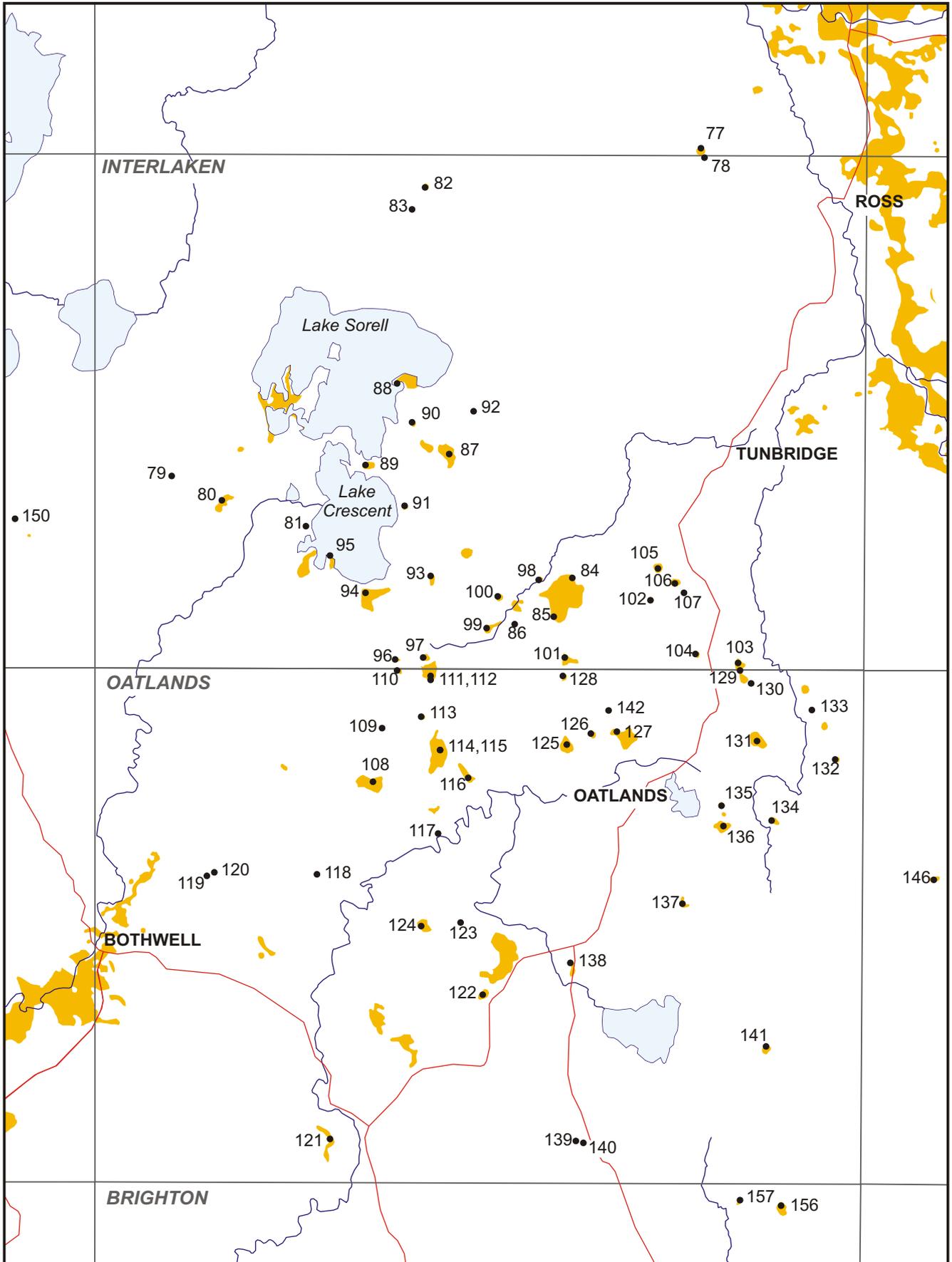


Figure 3

Inclusion and megacryst localities, southern Midlands. Basalt distribution, major roads and 1:50 000 quadrangle boundaries are also shown.

location 26) inclusions are gravitationally concentrated near the flow base.

Tasmanian Cainozoic volcanic rocks are virtually entirely basaltic (e.g. $\text{SiO}_2 < 54\%$). Where chemical analyses are available, basalts hosting inclusions are classified (column 8) according to a CIPW-normative based scheme, modified from that of Johnson and Duggan (1989), as detailed in Table 2. To remove the effects of oxidation, norms are calculated at a $\text{Fe}_2\text{O}_3/\text{FeO}$ ratio of 0.20, even if ferric and ferrous iron have been determined analytically. Hawaiiite, mugearite, nepheline hawaiiite, nepheline mugearite, basanite and olivine nephelinite are subdivided into sub-types, based on their degree of undersaturation (e.g. % normative nepheline) and normative plagioclase (mole % anorthite), with less calcic plagioclase considered indicative of more evolved (fractionated) rocks. The term saturated hawaiiite is introduced for weakly hypersthene normative rocks (hy <10%) with quite sodic plagioclase (An <40 mole%); these rocks would otherwise classify as transitional olivine basalts but have high levels of alkalis and incompatible elements and are clearly alkalic rather than tholeiitic. It is emphasised that all these subdivisions are arbitrary and gradational, and the basalts form a compositional continuum.

Mg# [molar $100\text{Mg}/(\text{Mg}+\text{Fe}^{\text{II}})$] (column 9) is also calculated at a $\text{Fe}_2\text{O}_3/\text{FeO} = 0.20$. For host rocks that have not been analysed, no Mg# number is given and the chemical type (indicated by ?) is quoted from the literature and/or estimated from petrographic observations.

Table 2 tabulates the number of all available analyses of relatively fresh Tasmanian basalts, whether or not they host inclusions, according to this scheme. This provides a rough guide as to the relative abundance of each type, although there is probably a sampling bias towards the more diverse and petrologically unusual but areally and volumetrically limited undersaturated compositions, and away from the more extensive but chemically more uniform tholeiites.

This is compared to the subset of analysed basalts containing mantle-derived xenoliths, xenocrysts or megacrysts. There is a strong bias of inclusion-bearing rocks towards undersaturated compositions. About one-third (35 out of 101) of analysed hosts are nepheline hawaiiites, although they comprise only 14% of all analysed samples. Basanites and olivine nephelinites are also clearly over-represented in inclusion-bearing rocks, and at least four of the five known melilitite occurrences contain mantle-derived material (although it is absent or rare in the relatively evolved Shannon Tier melilitite plugs). In contrast, alkali olivine basalts, hawaiiites and mugearites less commonly contain mantle inclusions, and these are usually small and sparse to rare. Most examples are from southeast Tasmania, especially from the Kingston area ('Southern Hobart Group' of Sutherland, 1976).

Some inclusion hosts are quite strongly evolved rocks, and include sodic hawaiiites (HW-B), mugearites, and their more undersaturated analogues (types NH-1B, NM-1, NH2B, NM-2). Unless heavily contaminated by xenolith-derived material, these rocks usually have low Mg# (44–61) indicating fractionation of olivine \pm pyroxene. As previously noted (e.g. Sutherland, 1974, 1989b) the presence of entrained mantle material in such rocks indicates that fractionation occurred at mantle depths.

The sole example of a tholeiitic host, at Pencil Point near Andover (Sutherland, 1974), appears to be unique in eastern Australia (e.g. O'Reilly *et al.*, 1989).

The range of radiometric (K-Ar) ages of inclusion-bearing basalts (column 10) is 61.7 ± 1.3 to 12.5 ± 0.2 Ma. This is almost as large as the known age range of Tasmanian Cainozoic basalts, c. 64.2 ± 0.6 Ma (early Palaeocene) (Everard *et al.*, 2004) to 8.5 ± 0.1 Ma (late Miocene; Baillie, 1986). Sutherland and Wellman (1986) published 15 dates and reviewed earlier radiometric data. References to these, including data published since 1986, are given in Table 1.

Inclusions

Most inclusions (column 11) are polycrystalline aggregates, usually composed of two or more minerals, and are xenoliths as they are genetically unrelated to their host rock (e.g. Gary *et al.*, 1972). However some inclusions may be cognate and thus cannot strictly be termed xenoliths.

The term xenocryst has been defined as "a crystal resembling a phenocryst in igneous rock that is foreign to the body of rock in which it occurs" (Gary *et al.*, 1972). Megacrysts have been defined as discrete crystals [in basaltic rocks] with a dimension of greater than 5 mm (e.g. O'Reilly *et al.*, 1989). Thus these terms overlap but are not synonymous; xenocrysts may be smaller than 5 mm, and some megacrysts may be cognate.

Inclusion mineralogy, size, and relative abundance at each locality, if described in the literature, are listed. In many cases only reconnaissance petrography has been done, and for some localities only field observations are available. For a few localities, the information is such that only the general terms such as peridotite (implying modal olivine >40%) and pyroxenite (modal olivine <40%) can be applied (see Streckeisen, 1973 for ultramafic rock nomenclature).

Classification

Mantle-derived inclusions have been classified into the Cr-diopside, Al-augite and Fe-rich-Cr-diopside suites (Wilshire and Shervais, 1975). Although this classification was developed mainly in North America, it has been applied to eastern Australia (e.g. review of O'Reilly *et al.*, 1989), including Tasmania (Beyer *et al.*, in prep.), where all three suites are represented.

An alternative classification of Australian inclusions, outlined by Sutherland and Hollis (1982), recognises five groups. Of these, metaperidotites (group A), metapyroxenites (group B), peridotite-pyroxenite (group C, largely unmetamorphosed, partly cumulate) and granulite-gabbros (group E) have been found in Tasmania, whilst the hornblendite-diorites (group D) have not.

Cr-diopside suite

Lherzolite, consisting of olivine (>40 modal %), orthopyroxene and clinopyroxene, is by far the most common inclusion type. The vast majority of Tasmanian lherzolites almost certainly contain spinel (rather than garnet) as an additional aluminous phase. Varne (1977) noted that although smaller inclusions may consist of olivine ± orthopyroxene only, all the larger ones that he examined also contained clinopyroxene and spinel. In Table 1 the term *spinel lherzolite* is used only when specified in the literature, or confirmed in thin section.

Most of these common spinel lherzolites (group A2 of Sutherland and Hollis, 1982) belong to the Cr-diopside suite (Wilshire and Shervais, 1975), which corresponds to group 1 of Frey and Prinz (1978). This suite is characterised by grass-green Cr-diopside (often recognisable in hand specimen), olivine of composition Fo_{88-92} , and a wide range of metamorphic microtextures.

The predominance of Cr-diopside suite spinel lherzolites has been generally noted in eastern Australian xenoliths (e.g. Wass and Irving, 1976).

The average modal composition of 35 xenoliths from Blessington (location 33) is olivine (58.8%), orthopyroxene (26.8%), clinopyroxene (12.6%) and spinel (1.8%) (Piestrzeniewicz, 1972). Point counting of six xenoliths from five localities (locations 23, 33, 40, 137 and 156) by Varne (1977) gave a modal range of olivine (56.7–72.4%), orthopyroxene (16.0–30.0%), clinopyroxene (6.9–28.8%) and spinel (0.2–4.0%).

Varne (1977) studied nine xenoliths from eight localities in detail, and attributed the textures and chemistry of co-existing minerals to exsolution of spinel from aluminous pyroxenes with falling temperature. He noted that they were broadly similar to spinel lherzolite inclusions elsewhere in the world, and concluded that they were accidental inclusions of upper mantle, genetically unrelated to their host rocks.

Because of their small size, there are few 'whole rock' analyses of Tasmanian xenoliths. Major element, Ni and Cr analyses of two spinel lherzolites and two websterites from Wagners Hill (location 43) and Telita (location 46) were published by Brown and McClenaghan (1982). Two major element analyses of spinel lherzolites from Coal Mine Hill (location 131) were reported by Piestrzeniewicz (1972).

Electron microprobe analyses from Tasmanian spinel lherzolites have been published by Sutherland (1974), Varne (1977), Brown and McClenaghan (1982),

Sutherland and Hollis (1982), Sutherland *et al.* (1984, 1996), Everard (1989) and Beyer *et al.* (in prep.). These data show that the composition of the constituent minerals varies within narrow ranges. Thus the majority of olivines are $Fo_{87.3-91.6}$ with ≤0.10% CaO. Orthopyroxene has Mg# 88.0–92.1, 2.5–5.5% Al_2O_3 and 0.40–1.56% CaO; clinopyroxene has Mg# 89.6–94.0, 2.7–7.5% Al_2O_3 , ≤1.36% Cr_2O_3 , ≤1.7% Na_2O and ≤0.88% TiO_2 . Spinel shows a little more variability with Mg# 69.9–80.0, Cr# 5.1–34.8 and ≤0.26% TiO_2 . The mineral chemistry of Tasmanian spinel lherzolites has recently been reviewed in more detail by Beyer *et al.* (in prep.).

Garnet lherzolite xenoliths (group A1 of Sutherland and Hollis, 1982) are rare in basalt hosts worldwide and have only been found at one Tasmanian locality, Bow Hill near Oatlands (location 114) (Sutherland *et al.*, 1984). Only four garnet lherzolite xenoliths were found and the ratio to spinel lherzolite at this locality was estimated as 1:500. The garnet is pyrope (about $Pyp_{74}Alm_{13}Gr_{13}$), olivine about $Fo_{90.1}$ and the pyroxenes relatively aluminous but within the ranges of spinel lherzolite xenoliths. The garnet lherzolites also belong to the Cr-diopside suite.

Peridotite xenoliths from Wattle Hill (location 180) contain more fayalitic olivine (Fo_{86-87}) (Sutherland, 1979) and may belong to the Fe-rich Cr-diopside suite. This suite is thought to represent Cr-diopside suite wall rock that has been metasomatised by adjacent basaltic veins, and is compositionally transitional to the Al-augite suite.

Other peridotitic rock types recorded include harzburgite (locations 40, 82, 179a) and dunite (location 30) (fig. 4d), but their affinities are uncertain as these rock types are known to occur in both the Cr-diopside and Al-augite suites.

Pyroxene-rich members of the Cr-diopside suite are relatively rare in eastern Australia (O'Reilly *et al.*, 1989), and no definite examples have been found amongst Tasmanian pyroxenite xenoliths.

Al-augite suite

Wehrlites (8 localities, fig. 4b) and probably most pyroxenites and metapyroxenites (about 25 localities, fig. 4a) belong to the Al-augite suite, which corresponds to Group II of Frey and Prinz (1978). This suite is characterised by black, more Al-rich and Ti-rich clinopyroxene and is thought to represent basaltic melts that have frozen within the mantle (O'Reilly *et al.*, 1989).

The wehrlite series inclusions include spinel wehrlite and olivine-rich wehrlite (fig. 4b). They typically have igneous, adcumulate or mesocumulate microstructures and range towards pyroxenites. The best studied Tasmanian occurrence is at Bow Hill (location 114) (Sutherland *et al.*, 1984). The metapyroxenite series inclusions (e.g. Round Lagoon, locations 82, 83) have metamorphic microtextures and are the recrystallised equivalents of wehrlite-series

inclusions. Most pyroxenites that have been studied in detail are websterite (11 localities), sometimes accompanied by subordinate olivine, spinel, bytownite (location 145) or biotite (locations 18, 40, 43, 151, 158). Websterite with subcalcic augite occurs at *Rosehill* farm (location 123) and garnet websterite has been recorded from Table Cape (location 18) and Bow Hill (location 114). Spinel clinopyroxenite is reported from King Island (location 1) and Cape Contrariety (location 191). Other clinopyroxenites apparently lack spinel (including locations 110, 114, 151, 180 and 191) and some 'clinopyroxenite mosaics' may form as reaction rims around spinel lherzolites and other inclusions (locations 158, 167).

Electron microprobe analyses of Al-augite suite inclusions have been published by Brown and McClenaghan (1982) (websterite, location 43), Sutherland and Hollis (1982), and Sutherland *et al.* (1984, 1996). Generally pyroxenes and olivine (if present) have lower Mg# than in Cr-diopside suite spinel lherzolite xenoliths.

Other inclusions

Localities bearing cognate or related inclusions are listed (largely after Sutherland, 1989*b*), and the inferred level of origin, whether mantle or crustal, of these is also specified. Cognate inclusions of probable lower crustal origin include granulite (locations 15, 83, 91), banded granulitic microgabbro (location 109), gabbro (locations 105, 114), 'dolerite' (locations 18, 40, 51, 145, 151, 158, 161, 180, 183) (fig. 4*c*) and anorthosite (locations 15, 145; fig. 5*a*). Limited electron microprobe data from some of these inclusions have been published by Sutherland and Hollis (1982) and Sutherland *et al.* (1996).

Feldspathoidal syenite (sodalite malignite and ijolite) inclusions within olivine nephelinite at East Round Lagoon, north of Lake Crescent (location 82), were originally interpreted as cumulates (Sutherland and Hollis, 1982; Sutherland, 1989*a,b*) but detailed investigation has shown that they are coarse miarolitic cavities (F. L. Sutherland, pers. comm.). High-level inclusions of upper crustal or local country rock origin are not listed in Table 1.

Xenocrysts

The most common xenocryst phases in Tasmanian Cainozoic basalts are olivine, orthopyroxene, clinopyroxene and spinel derived from disaggregation of spinel lherzolite xenoliths. They can often be distinguished from [cognate] phenocrysts (particularly of olivine and clinopyroxene) by petrographic criteria such as anhedral form and the presence of reaction coronas. Olivine xenocrysts may have compositions too magnesian to be in equilibrium with the host rock. Pyroxene xenocrysts may be more aluminous than phenocrysts, suggesting crystallisation at greater depths and higher temperatures.

Such lherzolite debris is particularly common in diatremes and mantle-fractionated lavas of alkaline composition (nepheline hawaiites and mugearites). They may form a significant fraction of the host rock and be intimately mixed with it. This may result in whole-rock analyses that do not represent liquid compositions.

Megacrysts

Other clinopyroxene, spinel, orthopyroxene and olivine inclusions (fig. 5*b*, 5*c*, 5*d*, 6*a*), together with clinopyroxene-spinel composites, are unlikely to be derived from spinel lherzolite xenoliths. They are often larger than or compositionally different from typical lherzolite mineral grains, or have well developed crystal faces.

Hydrous or volatile-bearing megacryst minerals are rare in Tasmania. Kaersutitic amphibole has been reported from seven localities, mainly from central-southern Tasmania (fig. 6*b*). Mica (titanbiotite and phlogopite) is reported as discrete megacrysts, together with amphibole and apatite, only at Lees Road, near Brittons Swamp in the far northwest (location 5, fig. 6*c*). Rounded apatite megacrysts (OH- to F-bearing) have recently been found at Weldborough Pass in the northeast (location 56, fig. 6*c*).

Alkali feldspar (anorthoclase, sanidine) megacrysts are known from three widely separated sites (fig. 6*d*) and composite anorthoclase-sanidine xenoliths occur near Weldborough Pass (location 57). The six known localities for sodic plagioclase megacrysts are all in the southeast (fig. 6*d*); they range from potassic albite (location 161) to oligoclase (locations 153, 162, 180, 184, 185) and andesine (location 181). Labradorite megacrysts occur in the Pencil Point olivine tholeiite (location 145).

Titanomagnetite megacrysts, at least in part derived from the disaggregation of Al-augite suite inclusions, are reported from four localities (fig. 6*c*), and ulvospinel was reported from near Campania (location 155).

Irving (1974) described a similar megacryst suite from 21 localities in Victoria and New South Wales, including 15 localities from the Newer Volcanics. They are usually accompanied by Cr-diopside lherzolite xenoliths, and sometimes also by Al-augite suite inclusions. Clinopyroxene and anorthoclase are the most common megacryst species, but orthopyroxene, kaersutite, phlogopite, biotite and apatite were also noted. Irving suggested that the pyroxene, phlogopite and magnesian kaersutite megacrysts in particular may represent fragments of pegmatitic polycrystalline aggregates (e.g. Al-augite inclusions) that precipitated as near-liquidus phases from alkali basaltic melts within the upper mantle at 100–200 MPa. The biotite, ferrokaersutite, anorthoclase and apatite megacrysts were thought to be near solidus precipitates at lower pressures. Other megacrysts may be of cognate origin,

and have not necessarily crystallised at mantle depths (Sutherland, 1989b).

Zircon megacrysts, together with anorthoclase megacrysts, occur in a 13.3 Ma nepheline hawaiite at Boat Harbour in northwest Tasmania (location 15, fig. 6c) (Sutherland *et al.*, 1996). The trace element chemistry of the zircons and the low zirconium of the host rock suggest that they are xenocrystal rather than cognate. Alluvial zircons in the area gave fission track ages of 13.9 ± 0.7 to 9.6 ± 0.6 Ma, indicating that they were partly derived from younger basalts.

Corundum (sapphire) is widespread in cassiterite-bearing alluvial deposits in northeast Tasmania (Anon., 1970). Yim (1991) identified a 'zircospilic' heavy mineral suite of corundum, coarse anhedral zircon, spinel and high Mg-ilmenite in alluvial deposits in the Blue Tier area. He used fission track and electron spin resonance dating of alluvial zircons to show that coarse anhedral types were derived from 47 Ma alkali basalts. There is strong spatial evidence that alluvial corundum is also derived from megacrysts within basalt, although it appears that none has been found actually in situ in northeast Tasmania. Corundum-bearing xenoliths occur at Table Cape in northwest Tasmania (location 18) (Wass and Irving, 1976). Alluvial corundum has been recorded from near Boat Harbour (see above) and Blythe River, Bell Mount and Stanley (Anon., 1970).

Tasmanian diamonds were recently reviewed by Bottrill (1998). All authenticated finds (about 16 to 18 stones, with a maximum size of about 7 mg) were in placer deposits, derived by the reworking of Cainozoic sediments, in the Savage River–Donaldson River area of northwest Tasmania. Their source is unknown, but an analogy with other eastern Australian occurrences suggests that they have been transported from mantle depths by Cainozoic alkali basalts, rather than kimberlites or lamproites, and thus sapphire may be the most appropriate indicator mineral. An ultimate origin by subduction of carbonaceous sediments, associated with depressed geotherms, may enable diamond to form at shallower depths (>75 km) than required for kimberlitic diamond (Barron *et al.*, 1996).

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References

(numbers at right refer to locations in Table 1)

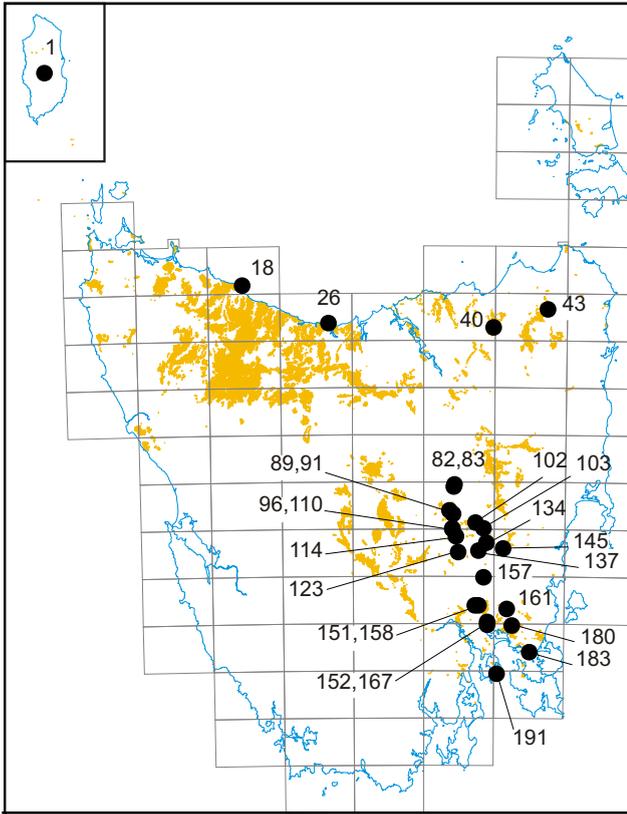
- ADAM, J. 1990. The geochemistry and experimental petrology of sodic alkaline basalts from Oatlands, Tasmania. *Journal of Petrology* 31:1201–1223. [1]
- ANON., 1970. Catalogue of the minerals of Tasmania. *Record Geological Survey Tasmania* 9.
- BAILLIE, P. W. 1986. Radiometric ages for Circular Head and the Green Hills basalt, north-western Tasmania. *Unpublished Report Department of Mines Tasmania* 1986/39.
- BAILLIE, P. W. 1987. A Paleocene radiometric age for basalt at Bream Creek, south-eastern Tasmania. *Unpublished Report Department of Mines Tasmania* 1987/21.
- BARRON, L. M.; LISHMUND, S. R.; OAKES, G. M.; BARRON, B. J.; SUTHERLAND, F. L. 1996. Subduction model for the origin of some diamonds in the Phanerozoic of eastern New South Wales. *Australian Journal of Earth Sciences* 43:257–267.
- BEYER, E. E. 1998. Contrasting characteristics of Proterozoic and Phanerozoic mantle types: preliminary results. *Abstracts Geological Society of Australia* 49:31. [2]
- BEYER, E. E.; O'REILLY, S. Y.; ZHANG, M.; EVERARD, J. L. In prep. Mantle xenoliths, Tertiary geotherms and the Tasmanian lithosphere, in: CORBETT, K. D.; QUILTY, P. G. (ed.). The geological evolution of Tasmania. *Special Publication Geological Society of Australia*. [3]
- BOTTRILL, R. S. 1998. Diamonds in Tasmania. *Record Geological Survey Tasmania* 1998/09.
- BROWN, A. V.; MCCLENAGHAN, M. P.; MOORE, W. R.; TURNER, N. J.; MCCLENAGHAN, J.; WILLIAMS, P. R.; BAILLIE, P. W.; CORBETT, K. D.; CORBETT, E. B.; COX, S. F.; GROVES, D. I.; PIKE, G. P. 1977. *Geological Atlas 1:50 000 series. Sheet 32 (8415N). Ringarooma*. Department of Mines Tasmania. [4]
- BROWN, A. V.; MCCLENAGHAN, M. P. 1982. Tertiary basaltic rocks, in: MCCLENAGHAN, M. P.; TURNER, N. J.; BAILLIE, P. W.; et al. Geology of the Ringarooma–Boobyalla area. *Bulletin Geological Survey Tasmania* 61:92–114. [5]
- DUNCAN, R. A.; MCDUGALL, I. 1989. Volcanic time-space relationships, in: JOHNSON, R. W. (ed.). *Intraplate volcanism in eastern Australia and New Zealand*. 43–54. Cambridge University Press.
- EVERARD, J. L. 1989. Petrology of the Tertiary basalt. Appendix B in: SEYMOUR, D. B. (comp.). *Geological atlas 1:50 000 series. Sheet 36 (8015S). St Valentines*. *Explanatory Report Geological Survey Tasmania*. [6]
- EVERARD, J. L.; SEYMOUR, D. B.; REED, A. R.; MCCLENAGHAN, M. P.; GREEN, D. C.; CALVER, C. R. 2007. Regional geology of the Southern Smithton Synclinorium. Explanatory report for the Roger, Sumac and Dempster 1:25 000 scale geological map sheets, far northwestern Tasmania. *Explanatory Report 1:25 000 scale Digital Geological Map Series 2*. [7]
- EVERARD, J. L.; SEYMOUR, D. B. In prep. Tertiary volcanic rocks of the Marrawah, Brittons Swamp and Montagu areas, Woolnorth quadrangle. *Record Tasmanian Geological Survey*. [8]
- EVERARD, J. L.; ZHANG, MING; LO, CHING-HUA; O'REILLY, S. Y.; FORSYTH, S. M. 2004. Overview of Tasmanian Tertiary basalts, in: MCPHIE, J.; GOLDRICK, P. (ed.). *Dynamic Earth: Past, present and future*. *Abstracts Geological Society of Australia* 73:74.
- FREY, F. A.; PRINZ, M. 1978. Ultramafic inclusions from San Carlos, Arizona: Petrologic and geochemical data bearing on their petrogenesis. *Earth and Planetary Science Letters* 38:129–176.
- GARY, M.; MCAFEE, R.; WOLF, C. L. 1972. *Glossary of Geology*. American Geological Institute: Washington.
- GREEN, D. C. 1961. The geology of the South Arm–Sandford area, Tasmania. *Papers and Proceedings Royal Society of Tasmania* 95:177–199. [9]
- IRVING, A. J. 1974. Megacrysts from the Newer Basalts and other basaltic rocks of southeastern Australia. *Bulletin Geological Society of America* 85:1503–1514.

- JOHNSON, R. W.; DUGGAN, M. B. 1989. Rock classification and analytical data bases, in: JOHNSON, R. W. (ed.). *Intraplate volcanism in eastern Australia and New Zealand*. 12–13. Cambridge University Press.
- MATTHEWS, W. L.; EVERARD, J. L.; CLARKE, M. J. 1996. Geological atlas 1:50 000 series. Sheet 54 (8314S). Lake River. *Explanatory Report Geological Survey Tasmania*. [10]
- O'REILLY, S. Y.; NICHOLLS, I. A.; GRIFFIN, W. L. 1989. Xenoliths and megacrysts of Eastern Australia, in: JOHNSON, R. W. (ed.). *Intraplate volcanism in eastern Australia and New Zealand*. 249–288. Cambridge University Press. [11]
- PIESTRZENIEWICZ, R. 1972. *Ultramafic inclusions in some Tasmanian basic volcanic rocks*. B.Sc. (Hons) thesis, University of Tasmania. [12]
- STRECKEISEN, A. L. 1973. Plutonic rocks. Classification and nomenclature recommended by the IUGS Subcommission on the systematics of igneous rocks. *Geotimes* 18(10):26–30.
- SUTHERLAND, F. L. 1969a. A review of the Tasmanian Cainozoic volcanic province. *Special Publication Geological Society of Australia* 2:133–144. [13]
- SUTHERLAND, F. L. 1969b. The mineralogy, petrochemistry and magmatic history of the Tamar lavas, northern Tasmania. *Papers and Proceedings Royal Society of Tasmania* 103:17–34. [14]
- SUTHERLAND, F. L. 1971. The geology and petrology of the Tertiary volcanic rocks of the Tamar Trough, northern of Tasmania. *Records Queen Victoria Museum* 36. [15]
- SUTHERLAND, F. L. 1972. Igneous rocks, Central Plateau, in: BANKS, M. R. (ed.). *The Lake Country of Tasmania*. 43–54. Royal Society of Tasmania: Hobart. [16]
- SUTHERLAND, F. L. 1974. High-pressure inclusions in tholeiitic basalt and the range of lherzolite-bearing magmas in the Tasmanian volcanic province. *Earth and Planetary Science Letters* 24:317–324. [17]
- SUTHERLAND, F. L. 1976. Cainozoic volcanic rocks, in: LEAMAN, D. E. Geological atlas 1:50 000 series. Sheet 82 (8312S). Hobart. 35–56. *Explanatory Report Geological Survey Tasmania*. [18]
- SUTHERLAND, F. L. 1977. Cainozoic volcanic rocks, in: LEAMAN, D. E. Geological atlas 1:50 000 series. Sheet 75 (8312N). Brighton. 25–37. *Explanatory Report Geological Survey Tasmania*. [19]
- SUTHERLAND, F. L. 1979. Upper mantle–lower crustal xenoliths from the Tasmanian volcanic province, in: DENHAM, D. (comp.). *Crust and upper mantle of southeastern Australia*. *Record Bureau of Mineral Resources, Geology and Geophysics Australia* 1979/2:85–87. [20]
- SUTHERLAND, F. L. 1980. Aquagene volcanism in the Tasmanian Tertiary, in relation to coastal seas and river systems. *Papers and Proceedings Royal Society of Tasmania* 114:177–199. [21]
- SUTHERLAND, F. L. 1984. Cainozoic basalts, in: FORSYTH, S. M. Geological atlas 1:50 000 series. Sheet 68 (8313S). Oatlands. 103–120. *Explanatory Report Geological Survey Tasmania*. [22]
- SUTHERLAND, F. L. 1985. Cainozoic volcanic rocks, in: FARMER, N. Geological atlas 1:50 000 series. Sheet 88 (8311N). Kingborough. 73–83. *Explanatory Report Geological Survey Tasmania*. [23]
- SUTHERLAND, F. L. 1989a. Tertiary basaltic magmas and the Tasmanian lithosphere, in: BURRETT, C. F.; MARTIN, E. L. (ed.). *Geology and mineral resources of Tasmania*. *Special Publication Geological Society of Australia* 15:386–398. [24]
- SUTHERLAND, F. L. 1989b. Cainozoic volcanic rocks, in: FORSYTH, S. M. Geological atlas 1:50 000 series. Sheet 61 (8313N). Interlaken. 48–60. *Explanatory Report Geological Survey Tasmania*. [25]
- SUTHERLAND, F. L.; FORSYTH, S. M.; ZWINGMANN, H. 2002. Bassian basalts: dating, Cenozoic biogeohistory and a new model for Tasmanian volcanism. *Abstracts Geological Society of Australia* 67:251. [31]
- SUTHERLAND, F. L.; HALE, G. E. A. 1970. Cainozoic volcanism in and around Great Lake, central Tasmania. *Papers and Proceedings Royal Society of Tasmania* 104:17–32. [26]
- SUTHERLAND, F. L.; HENDRY, D. F.; BARRON, B. J.; MATTHEWS, W. L.; HOLLIS, J. D. 1996. An unusual Tasmanian Tertiary basalt sequence, near Boat Harbour, northwest Tasmania. *Records of the Australian Museum* 48:131–161. [30]
- SUTHERLAND, F. L.; HOLLIS, J. D. 1982. Mantle–lower crust petrology from inclusions in basaltic rocks in eastern Australia – an outline. *Journal of Volcanology and Geothermal Research* 14:1–29. [28]
- SUTHERLAND, F. L.; HOLLIS, J. D.; BARRON, L. M. 1984. Garnet lherzolite and other inclusions from a basalt flow, Bow Hill, Tasmania, in: KORNPROBST, J. (ed.). *Kimberlites. II. The mantle and crust–mantle relationships*. 145–160. Elsevier: Amsterdam. [29]
- SUTHERLAND, F. L.; KERSHAW, R. C. 1971. The Cainozoic geology of Flinders Island, Bass Strait. *Papers and Proceedings Royal Society of Tasmania* 105:151–176. [27]
- SUTHERLAND, F. L.; WELLMAN, P. 1986. Potassium–argon ages of Tertiary volcanic rocks, Tasmania. *Papers and Proceedings Royal Society of Tasmania* 120:77–86.
- VARNE, R. 1977. On the origin of spinel lherzolite inclusions in basaltic rocks from Tasmania and elsewhere. *Journal of Petrology* 18:1–23. [32]
- WASS, S. Y.; IRVING, A. J. 1976. *XENMEG: A catalogue of occurrences of xenoliths and megacrysts in volcanic rocks of eastern Australia*. The Australian Museum: Sydney. [33]
- WILSHIRE, H. G.; SHERVAIS, J. W. 1975. Al-augite and Cr-diopside ultramafic xenoliths in basaltic rocks from western United States. *Physics and Chemistry of the Earth* 9:257–272.
- YIM, W. W-S. 1991. *Heavy mineral provenance and the genesis of stanniferous placers in northeastern Tasmania*. Ph.D. thesis, University of Tasmania.

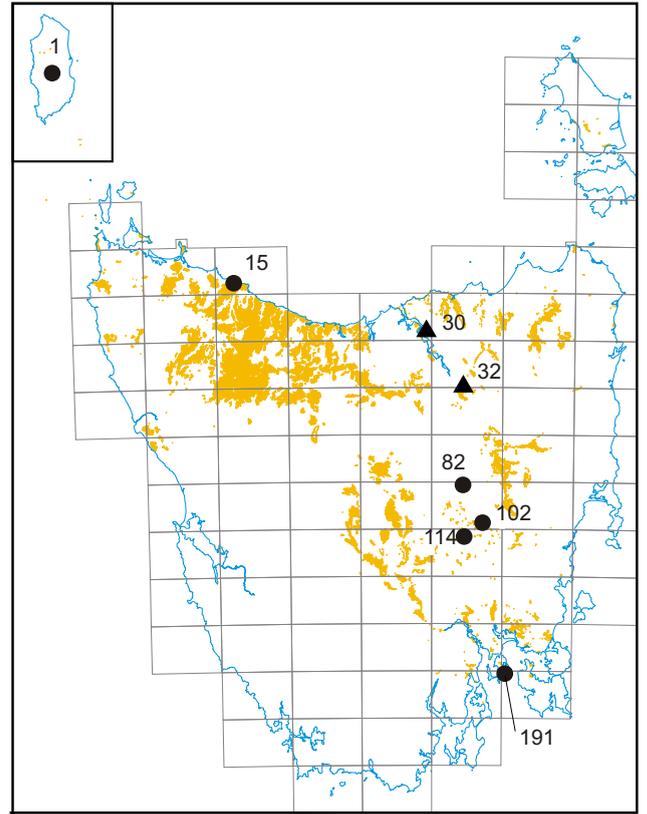
Unpublished sources

- [34] R. S. Bottrill, personal communication.
- [35] J. L. Everard, personal observation.
- [36] J. L. Everard & M. Zhang, personal observation.
- [37] J. L. Everard & M. Latinovic, personal observation.
- [38] M. P. McClenaghan, personal communication.
- [39] W. L. Matthews, personal communication.
- [40] D. Shaw, personal communication.
- [41] F. L. Sutherland, unpublished data (personal communication).

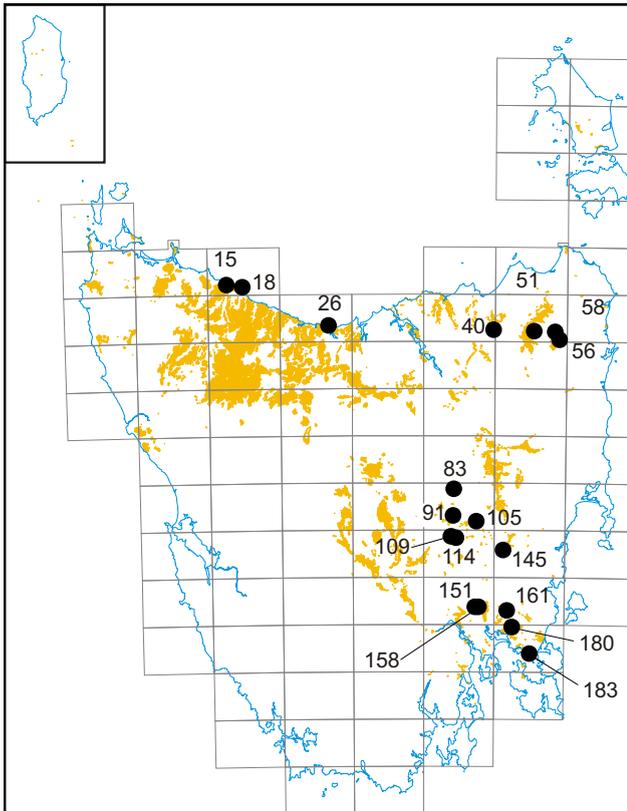
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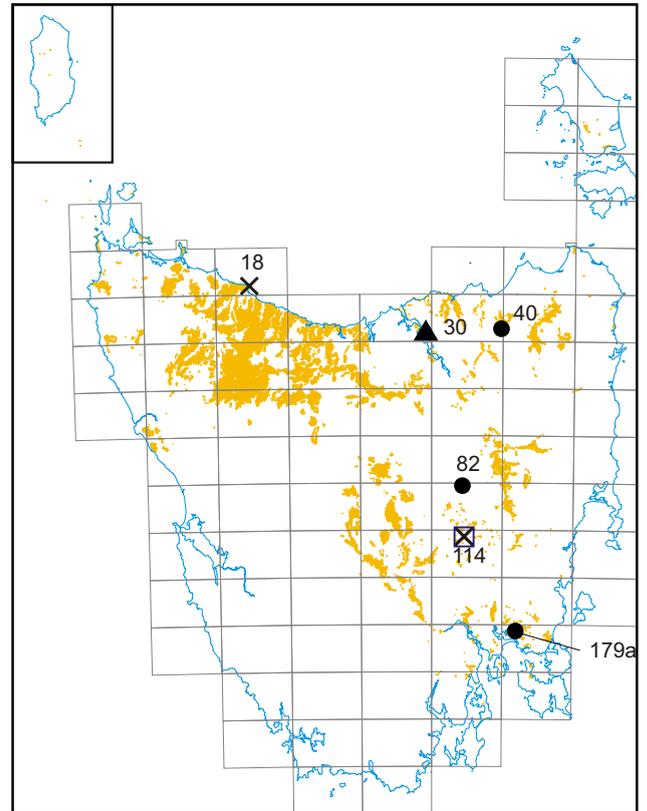
(a) Inclusions: Pyroxenites (websterites, clinopyroxenites, spinel)



(b) Inclusions: Spinel wehrlite (dots), olivine wehrlite (triangles)



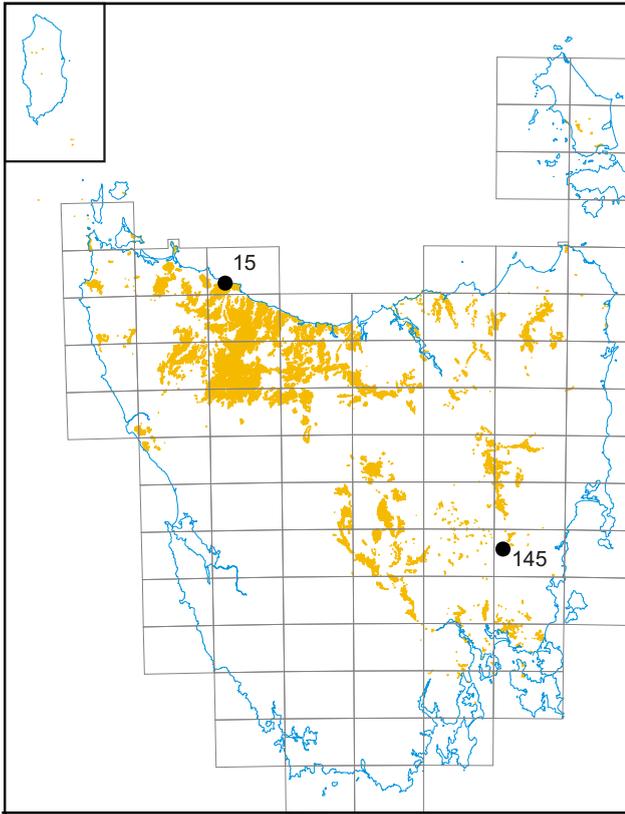
(c) Inclusions: Granulites, gabbros and dolerite



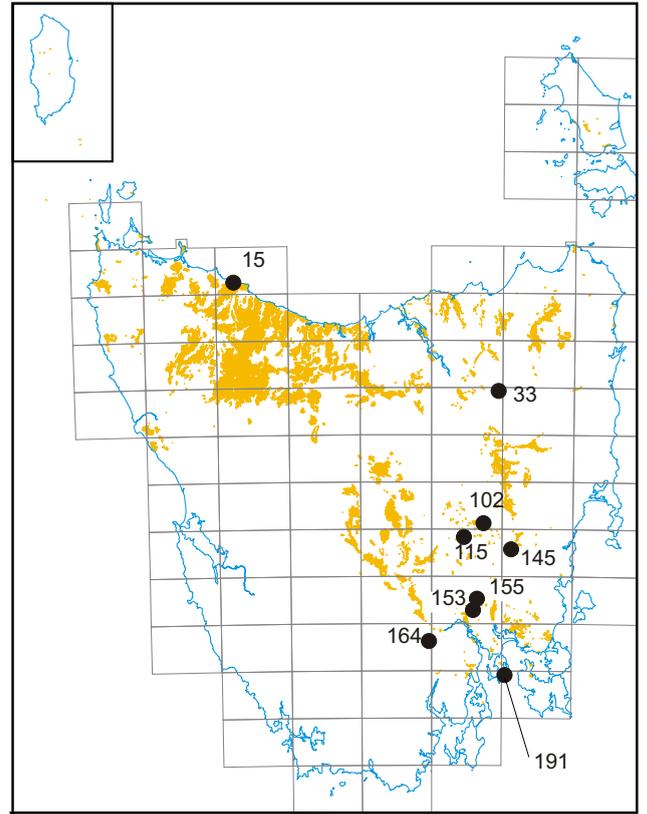
(d) Inclusions: Garnet websterite (crosses), harzburgite (dots), garnet lherzolite (open square), dunite (triangle)

Figure 4

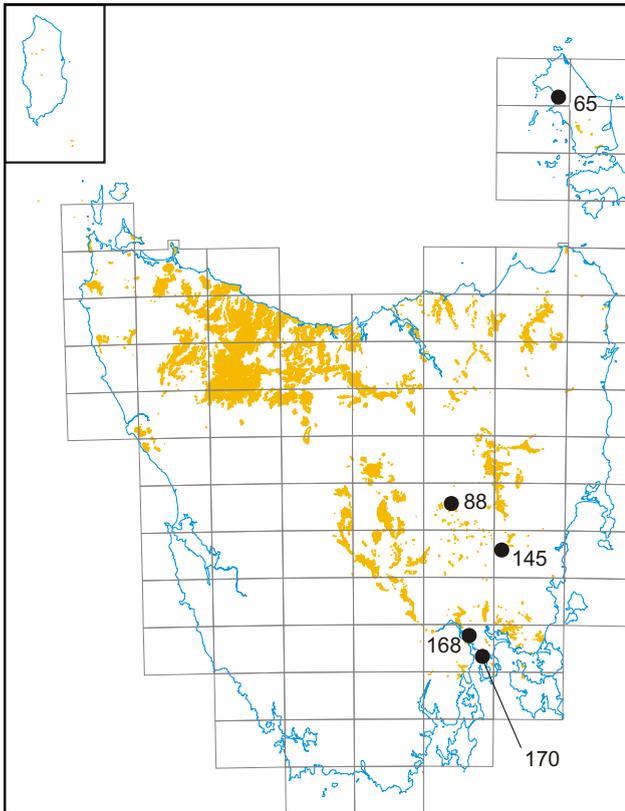
Localities for various inclusion types



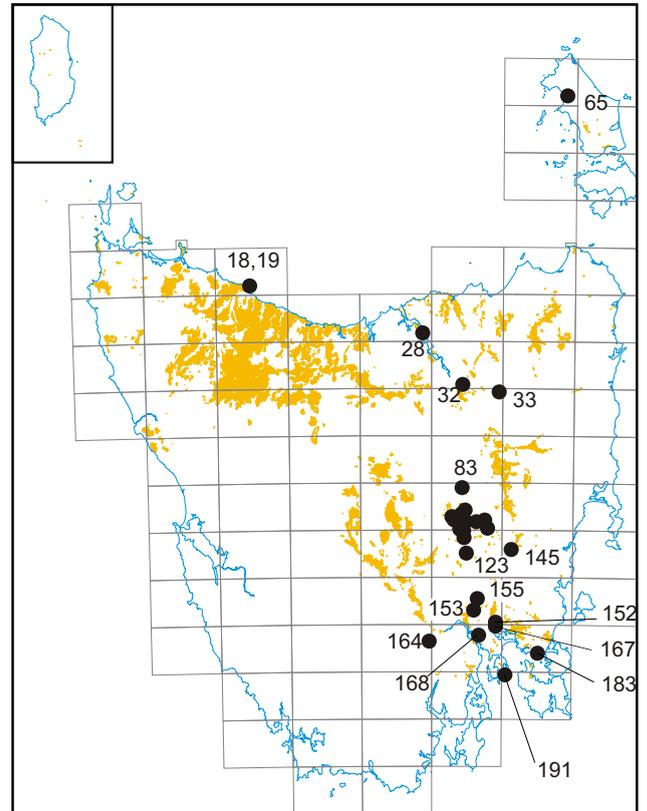
(a) Inclusions: Anorthosite (dots)



(b) Megacrysts: Olivine (other than Iherzolite debris)

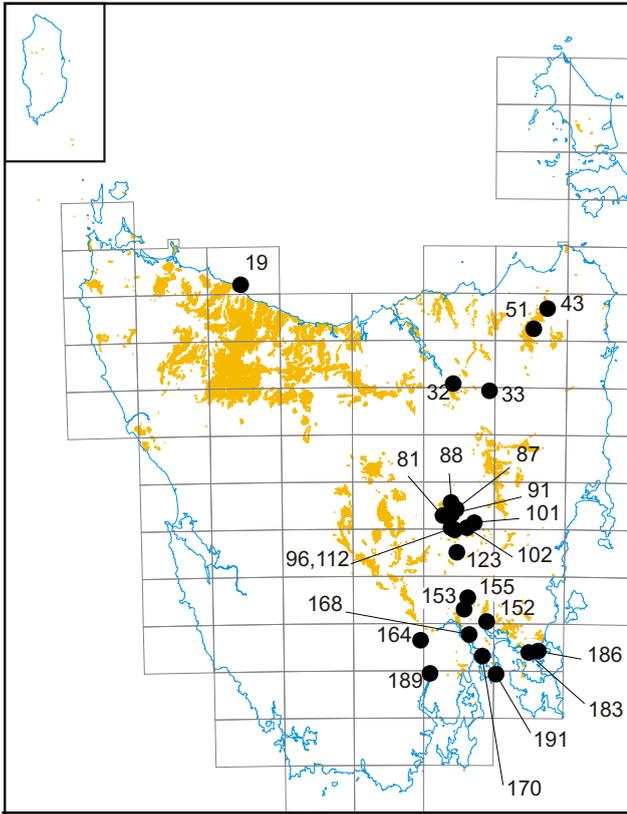


(c) Megacrysts: Orthopyroxene (other than Iherzolite debris)

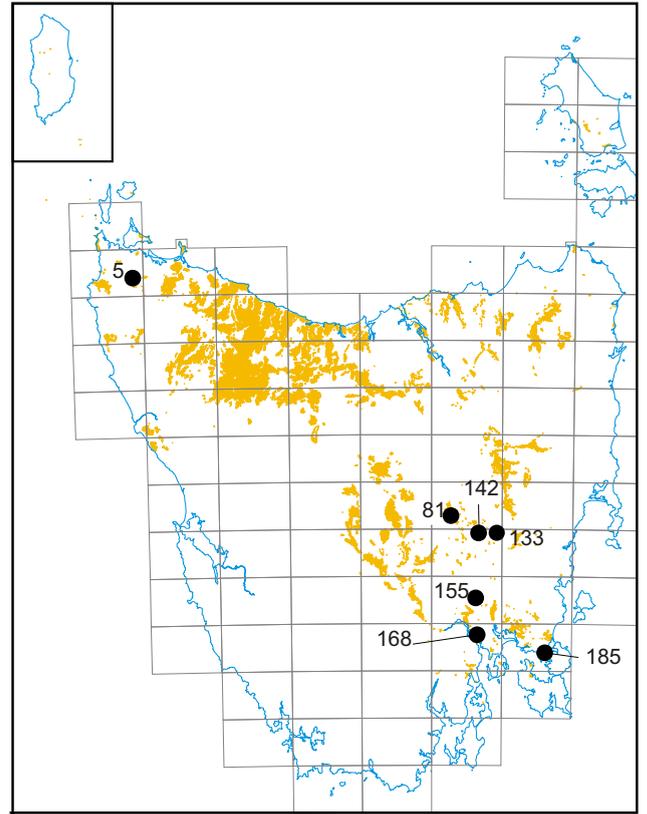


(d) Megacrysts: Clinopyroxene (other than Iherzolite debris)

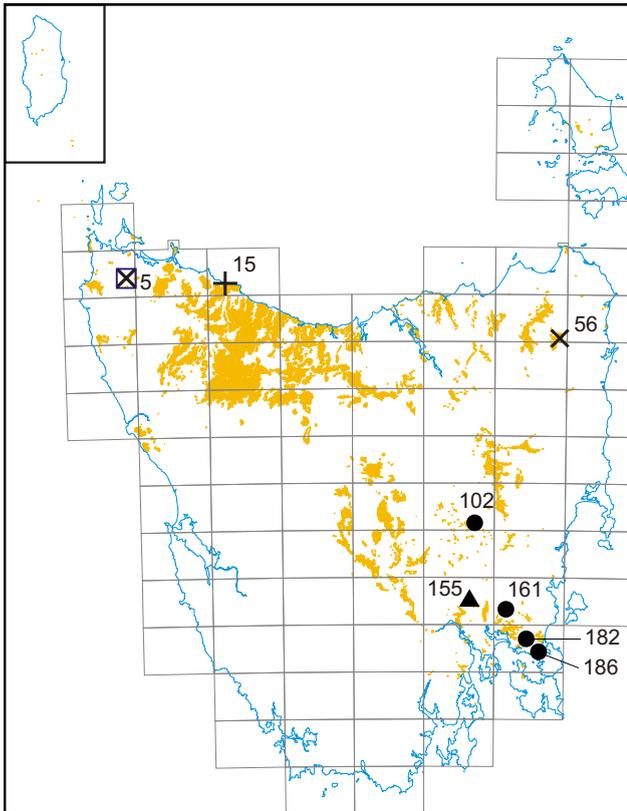
Figure 5
Localities for various inclusion and megacryst types



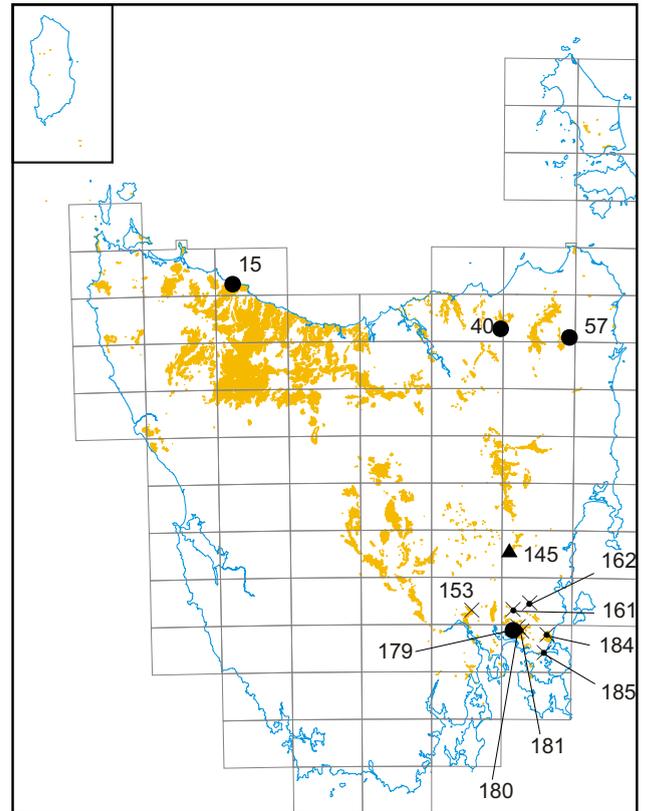
(a) Megacrysts: Spinel (other than Iherzolite debris)



(b) Megacrysts: Amphibole (kaersutite)



(c) Megacrysts: Titanomagnetite (dots), ulvospinel (triangle), apatite (diagonal cross), mica (open square), zircon (upright cross)



(d) Megacrysts: Albite, oligoclase, andesine (crosses), labradorite (triangle), anorthoclase, sanidine (dots)

Figure 6

Localities for various megacryst types

No.	Locality	AMG (mE)	AMG (mN)	Quadrangle	1:25000 sheet	Host – form	Host – type	Mg# (0.20)	Age (Ma)	Xenoliths and/or megacrysts	References
29	0.8 km south of Deviot Yacht Club	494400	5434600	Beaconsfield	Beaconsfield	flows	NH-1A (‘BSN/analitic AOB’)	60.7		spinel lherzolite, rare, small rare derived clinopyroxene megacrysts	33, 15, 14, 13
30	West shore of East Arm	496200	5440200	Beaconsfield	Bell Bay	flow	BSN-2 (‘to analitic AOB’)	67.4		dunite, sparse, small (cognate, crustal) olivine-rich wehrlite, sparse, metamorphic texture, grain size 2–4mm, with rare partly resorbed cpx	33, 24, 14, 13
31	5 km ENE of St Leonards	521100	5412700	Launceston	Nunamara	small flow	ON (?)			olivine-rich lherzolite, rare	33, 15, 13
32	2 km WNW of Corra Linn bridge	517500	5407700	Launceston	Prospect	plug?	BSN-1 (‘limburgitic AOB’)	69.0		olivine-rich wehrlite, with minor plagioclase, lower crustal, rare olivine-rich lherzolite, metamorphic texture, with minor plagioclase, sparse; rare derived debris resorbed Al-clinopyroxene megacrysts with Ti-augite mantles, 5–20 mm, common ferroan spinel megacrysts, <8 mm, grey; rare	33, 13, 14, 15
33	Blessington	538700	5403300	Longford	Blessington	plug	BSN-1 to ON-2	66.8–69.0		spinel lherzolite, <50 mm, common clinopyroxene megacrysts, common olivine megacrysts spinel megacrysts	33, 12, 32, 3 2
34	The Sideling (Knockup)	533700	5430800	Launceston	Lisle	flow cap and possible vent	ON-3	70.4		spinel lherzolite, <30 mm, common	33, 13
35	Georges Plain/Camden Plains	535900	5426400	Launceston	Patersonia	flow remnants	ON (?)			spinel lherzolite, common	33
36	North of Tayene (Camden Plains) to	538000	5422300	Launceston	Patersonia	flow and nearby vent	ON (?)			spinel lherzolite, common	33
37	Ferry Hill, 10 km SW of Bridport	524800	5452100	Pipers River	Bowood	flow	ON (?)			spinel lherzolite, <70 mm, sparse to common	33, 35
38	Lebrina area	c.518600	c.5442500	Pipers River	Retreat	flow remnants (from SE?)	ON (?)			spinel lherzolite, common	33, 13
39	Pipers River	508400 to 509000	5451200 to 5445000	Pipers River	Weymouth, Retreat	basal flow (from SE)	NH-1B	62.4		spinel lherzolite, sparse	33
40	Briggs quarry, West Scottsdale	540600	5440800	Pipers River	Scottsdale	flow and possible vent	potassic ON-2/ON-3	62.1–65.8		spinel lherzolite, <110 mm, common sanidine aggregates (‘sanidine’), <60 mm, some with olivine reaction coronas, sparse (cognate, mantle?) dolerite, (bronzite-salite-labradorite), rare harzburgite websterite, with mica inclusions in Al-bronzite	33, 24, 32, 41 41 20 20, 41
41	NE of Morgans Hill	566400	5464200	Boobyalla	Monarch	small flow, local feeder (?)	ON-2	70.7		spinel lherzolite, <10 mm, scattered	35
42	Sandy Creek, Banca Road	567950	5461290	Boobyalla	Monarch	plug and small flow (?)	ON-1	74.0		spinel lherzolite, <40 mm, abundant	35
43	Wagners Hill	572100 to 572700	5452300 to 5451100	Ringarooma	Pioneer	feeder and flows	ON-3 (to NH-1A?)	70.4–(63.5?)	16.0 ± 0.3	spinel lherzolite, abundant spinel megacrysts with apatite inclusions websterite, mica-olivine(?) bearing	5, 4, 3, 41 41
44	Toronna Hill	572400	5453100	Ringarooma	Pioneer	flow	ON (?)			spinel lherzolite	5, 4
45	2 km south of Winnaleah	569400	5447800	Ringarooma	Derby	flow	ON-3 (to BSN-1?)	66.2		lherzolite debris noted in thin section	35, 5
46	Telita	564500	5445700	Ringarooma	Derby	flow	ON-1	65.5, 66.7		spinel lherzolite	5
47	East of Legerwood	559900	5437200	Ringarooma	Springfield	flow (upper?)	AOB/HW (?)			‘nodular basalt’ indicated on map	4
48	Briseis mine (Derby)	567600	5444500	Ringarooma	Derby	flow	ON-2/BSN-2 (?)	68.0, 66.1		spinel lherzolite xenoliths, large	13, 34
49	South of Derby	567800	5443200	Ringarooma	Derby	dyke				‘nodular basalt’ indicated on map	4
50	Arba mine, Branxholm	563100	5442700	Ringarooma	Derby	flow	ON (?)			peridotite noted	13
51	Grays Hill	564300	5440000	Ringarooma	Victoria, Ringarooma	feeder (?)	BSN-1 to AOB	59.3–62.0		spinel lherzolite, small, sparse spinel megacrysts dolerite (cognate, crustal)	39, 35, 24
52	Olivers Hill	562500	5427400	Alberton	Victoria	major feeder and flows to north	ON-3	66.7		lherzolite locally abundant	35, 13
53	Forest Lodge	575100	5427200	Alberton	Victoria	small flow remnant	BSN-2	66.9		spinel lherzolite, small, sparse	35, 13
54	WNW of Sea View Hill	577200	5432200	Alberton	Ringarooma	flow and nearby feeder	BSN-1	68.6	47.3 ± 0.5	lherzolite noted	35
55	North of Sea View Hill	574900	5431300	Alberton	Ringarooma	flow and nearby feeder	BSN (?)			lherzolite nodules and debris (including spinel)	35
56	Weldborough Pass	579100	5434700	Ringarooma	Ringarooma	flow overlying agglomerate near large feeder	mostly AOB to BSN	54.3–65.7	46.2 ± 0.6	lherzolite, numerous, partly altered to carbonate and zeolite (cowlesite?) felsic xenoliths (with coarse oligoclase, fine andesine and sanidine, hydroxylapatite, altered iron sulphide and mafics). apatite (OH to F) xenocrysts, rounded	34 34 34
57	Fieldwicks quarry, Weldborough Pass	581000	5435800	Ringarooma	Blue Tier	flow and nearby large feeder	porphyritic AOB	64.0	46.2 ± 0.6	anorthoclase-sanidine nodules, <40 mm	34

No.	Locality	AMG (mE)	AMG (mN)	Quadrangle	1:25000 sheet	Host – form	Host – type	Mg# (0.20)	Age (Ma)	Xenoliths and/or megacrysts	References
58	Rio Grande Creek, Weldborough	576650	5439300	Ringarooma	Ringarooma	altered porphyritic basalt in creek wash				small xenoliths noted, including feldspar (anorthoclase?)-pyroxene xenolith (10 mm) with symplectic textures	34
59	Sweets Creek (north)	559420	5417980	Alberton	Ben Nevis	plug, with small flow (?)	BSN-1	70.5		lherzolite, common	35
60	Sweets Creek (south)	559480	5417190	Alberton	Ben Nevis	plug, with small flow (?)	HW-A	65.0		lherzolite, sparse	35
61	Upper Esk (1)	560810	5413200	Alberton	Saddleback	small flow, local feeder?	ON-1	66.5		lherzolite, sparse	35, 38
62	Williams Flat, Upper Esk	562900	5411400	Alberton	Saddleback	diatreme				spinel and olivine xenocrysts in breccia	35
63	Halfway Hill	597200	5434700	Blue Tier	Blue Tier	small plug	NH-2A	59.0		lherzolite noted in thin section	38
64	Parrys Bay, Flinders Island	583200	5561600	Green Island	Leventhorpe	flow	potassic BSN-2	64.5, 65.3		spinel lherzolite, <20 mm, sparse	33, 27
65	Lughrata, Flinders Island	579000	5577600	NW Flinders	Emita	small plug (?)	potassic ON-1	65.5		spinel lherzolite, <20 mm, common augite megacrysts, with reaction rims enstatite megacrysts (cores), partly resorbed	33, 13, 32, 27
66	Tanners Bay, Flinders Island	574300	5582700	NW Flinders	Tanner	'small poor exposure'	AOB(?)			small peridotitic xenoliths	27, 13
67	Tanners Bay north	575000	5586300	NW Flinders	Tanner	in drill holes	AOB(?)			small peridotitic xenoliths	27
68	Boat Harbour, Flinders Island	566900	5587700	NW Flinders	Tanner	pebbles in tree roots	AOB(?)			small peridotitic xenoliths	27, 13
69	Palana, Flinders Island	575000	5595000	NW Flinders	Palana	float	AOB(?)			small peridotitic xenoliths	27
70	Llewellyn	547900	5370700	Snow Hill	Hanleth	flow (from Salisbury Rivulet)	NH-2B to NM-2	69.5, 70.2		spinel lherzolite, <10 mm, and abundant debris	35, 13
71	Salisbury Rivulet	549400	5367100	Snow Hill	Diamond	feeder and flow	BSN-2	69.0		abundant lherzolite debris (including spinel)	35
72	SW of Keach Hill	548800 to 546900	5354900 to 5355800	Snow Hill	Campbell Town	flow (from Keach Hill)	NH-1A	72.2		spinel lherzolite, <30 mm, and abundant debris	35
73	Chequers Plain	554800	5358500	Snow Hill	Campbell Town	flow remnant (?)	NH-1A	71.3		spinel lherzolite, small, scattered	35
74	Chocolate Bank	556600	5356400	Snow Hill	Campbell Town	flow remnant (?)	BSN-2	71.4		spinel lherzolite, <15 mm, common	35
75	Burnt Hill Marsh	557600	5353400	Snow Hill	Campbell Town	flow, local feeder (?)	NM-1	66.5		spinel lherzolite, <30 mm, abundant, with debris	35
76	Swan Banks	556900	5350800	Snow Hill	Campbell Town	flow remnant (?)	NH-1B	72.2		spinel lherzolite, <10 mm	35
77	Burburys Sugarloaf	532500	5350500	Lake River	Jacobs	plug	potassic NH-1A	58.7		spinel lherzolite, typically 10mm, numerous	10
78	Burburys Sugarloaf south	532700	5350000	Interlaken	Jacobs	flow remnant or intrusion related to main plug (?)	potassic NH (?)			lherzolite	25
79	Alma Tier	504100	5332800	Interlaken	Interlaken	small flow remnant	OML	64.8–65.9		spinel lherzolite, small, sparse	25
80	Whites Flat	506800	5331500	Interlaken	Interlaken	flow remnant (underlying less undersaturated flow)	sodic ON-3	67.5		lherzolite fragments, sparse	25
81	Lake Crescent west	511300	5330100	Interlaken	Interlaken	small plug (?)	ON-1	69.5, 69.6		lherzolite, <50 mm, very abundant (<40% of rock) Al-augite megacrysts (with Ti-augite rims) amphibole (pargasitic kaersutite) megacrysts; reaction rims of cpx, nepheline, magnetite, rhonite (?) spinel (Fe-pleonaste) megacrysts	25 41 41 41
82	Round Lagoon east (North Lake Sorell) (Lagoon Plain)	517700	5348400	Interlaken	Penny	plug	potassic ON-1	66.3	24.9+0.2	lherzolite, <210 mm, abundant; fine to medium-grained; rarely with gem olivine <50 mm spinel metapyroxenite (clinopyroxenite) cumulate pyroxenites harzburgite composite xenoliths (including spinel lherzolite with reaction borders of clinopyroxenite and wehrlite)	25, 24, 28
83	Round Lagoon south (Lagoon Plain south)	517000	5347200	Interlaken	Penny	small outcrops (several small plugs?)	NH-1A	65.2		lherzolite, <40 mm, numerous spinel metapyroxenite, rare granulite (?), rare clinopyroxene (megacrysts?), rare	25
84	Headlam Top, capping flow	525600	5327300	Interlaken	Vincent's	capping lava, possibly overlying feeder	BSN-2	58.9		lherzolite, <60 mm, scattered at top, sparse towards base of flow clinopyroxene megacrysts, <100 mm, rare	25
85	Headlam Top, SW side	524600	5325200	Interlaken	Vincent's	flow within sequence	ON (?)			olivine xenocrysts, sporadic	25
86	2 km SW of Headlam Top	522500	5324800	Interlaken	Vincent's	flow remnant	BSN (?)			as for capping flow at Headlam Top (?)	25
87	Dogs Head Tier	519000	5334000	Interlaken	Interlaken	flow remnants; overlying hawaiite/mugearite flow	NH-1B	60.3		lherzolite, abundant spinel and clinopyroxene megacrysts	25
88	Meaghers Bay–Dogs Head (east Lake Sorell)	516200	5337800	Interlaken	Interlaken	flow (?)	saturated HW	55.5		opx (bronzite) megacrysts (cognate?), <15 mm; with reaction outgrowths of olivine and cpx spinel megacrysts, rarer (cognate?)	16, 24, 25, 41

No.	Locality	AMG (mE)	AMG (mN)	Quadrangle	1:25000 sheet	Host – form	Host – type	Mg# (0.20)	Age (Ma)	Xenoliths and/or megacrysts	References
89	Interlaken township	514500	5333400	Interlaken	Interlaken	flow	HW/ NH (?)			lherzolite, numerous pyroxenite, <70 mm, rarer	25, 13
90	Knoll 3 km NE of Interlaken	517000	5335700	Interlaken	Interlaken	flow (or plug?)	HW/ NH (?)			as for Interlaken, xenoliths less common	25
91	Sandbank Shore (east Lake Crescent)	516600	5331200	Interlaken	Interlaken	probable plug	NM-2	51.8		lherzolite, <50 mm, common spinel pyroxenite, common granulite, sparse cpx and spinel megacrysts (cognate, mantle)	25 24
92	Tunbridge Tier Road	520300	5336300	Interlaken	Tunbridge	flow remnant (of Dogs Head Tier flows)	NH (?)			spinel lherzolite, common	25, 35
93	Old Mans Head (north plug)	518000	5327400	Interlaken	Table	plug	NH (?)			lherzolite, abundant cpx megacrysts (cumulate?) with inclusions of olivine (core) and nepheline and opaques (rim)	25
94	Lake Crescent south (860–900 m)	514500	5326500	Interlaken	Table	capping flow (from S plug at Old Mans Head?)	NH (?)			lherzolite, rare	25
95	Lake Crescent SW (810–860 m)	512600	5328500	Interlaken	Table	basal flow (from N plug at Old Mans Head?)	NH-2A	67.4		lherzolite, <100 mm, abundant clinopyroxene megacrysts, <40 mm, rare	25
96	Wild Pig Tier, top	516100	5322900	Interlaken	Table	capping flow	potassic ON (?)			lherzolite, <60 mm but typically 10 mm, abundant clinopyroxene and spinel megacrysts, sparse clinopyroxene-spinel composites, rare, after spinel pyroxenite(?)	25
97	Wild Pig Tier, NE	517600	5323000	Interlaken	Table	flow remnant	HW/MG (?)			lherzolite, rare	25
98	Upper Blackman River	523800	5327200	Interlaken	Vincent	lower flow (from 521799 mE, 5326300 mN)	AOB/HW (?)			lherzolite, sporadic	25
99	Mike Howes Marsh	521000	5324600	Interlaken	Vincent	flow (from Round Hill?)	NH (?)			lherzolite; abundant olivine xenocrysts	25
100	Round Hill ('NW Blackman centre')	521600	5326300	Interlaken	Vincent	vent				as for Mike Howes Marsh	25
101	Rockton Sugarloaf north	525200	5323000	Interlaken	Vincent	vent and flow to south	NH (?) and/or HW(?)			lherzolite, rare pyroxene inclusions, rare Cr spinel megacrysts (in fine-grain basal ?hawaiite on south only)	25
102	The Nipples (3 km WSW of Antill Ponds)	529800	5326100	Interlaken	Vincent	plug	potassic NH-1A	59.1		lherzolite, <100 mm, common Al-augite, olivine (Fo ₈₀), spinel and titanomagnetite megacrysts, numerous, derived from cumulate spinel-wehrlite-pyroxenite.	25 25, 24, 41
103	Vincent Hill	534500	5322700	Interlaken	Vincent	feeder with flow to south	BSN (?)			spinel lherzolite, numerous spinel websterite (Al diopside-Al bronzite-pleonaste), sporadic	22, 25, 41 41
104	2.5 km WNW of Vincent Hill	532200	5323200	Interlaken	Vincent	flow remnant from Vincent Hill (?)	BSN (?)			lherzolite, small, numerous pyroxene megacrysts, with spinel and orthopyroxene inclusions	25
105	Antill Ponds west	530200	5327800	Interlaken	Vincent	flow remnant (from Headlam Top?)	BSN (?)			lherzolite, <50 mm, sparse; debris abundant clinopyroxene megacrysts, <30 mm, sporadic felsic gabbro inclusions, scattered	25
106	Antill Ponds SW	531100	5327000	Interlaken	Vincent	flow remnant, as above	BSN (?)			as above (?)	25
107	Currajong Rivulet (1.5 km WSW of Antill Ponds)	531600	5326500	Interlaken	Vincent	small intrusive bodies in Tertiary stream deposit (or agglomerate?)	HW-A	62.3		lherzolite, numerous orthopyroxene (enstatite) megacrysts, large, from lherzolite(?)	25
108	Howells Hill	c. 514900	c. 5316300	Oatlands	Dennistoun	lower (from Bow Hill?) and upper (AOB) flow remnants	NH (?)			lherzolites in lower flow (extension of upper flow at Bow Hill?)	22, 29
109	NW of Freestone Hill, 530 m ASL (Merrivale Rd, Upper Exe Rivulet)	515400	5319200	Oatlands	Dennistoun	small plug	AOB (?)			lherzolite banded granulitic microgabbro/dolerite (hyperthene-salite-labradorite) probably from felsic lower crust	22
110	Wild Pig Tier south	516200	5322300	Oatlands	Table	small knoll (plug?)	HW (?)			lherzolite, scarce spinel pyroxenite, scarce clinopyroxenite, scarce	22
111	Wild Pig Tier SE (centre) (1)	518000	5322000	Oatlands, Interlaken	Table	feeder and upper flow (?)	NH (?)		24.1 ± 0.2	lherzolite, conspicuous; scarcer on east side clinopyroxene megacrysts, sparse	22
112	Wild Pig Tier SE (centre) (2)	518000	5321800	Oatlands	Table	feeder and lower flow (?)	potassic ON-2 (/NH?)	61.0		lherzolite, abundant clinopyroxene megacrysts, large spinel megacrysts	22
113	Bow Hill NW	517500	5319800	Oatlands	Dennistoun	flow remnant (of upper flow at Bow Hill)	NH (?)			as for upper flow at Bow Hill (?)	22

No.	Locality	AMG (mE)	AMG (mN)	Quadrangle	1:25000 sheet	Host – form	Host – type	Mg# (0.20)	Age (Ma)	Xenoliths and/or megacrysts	References
166	New Norfolk East	507300	5262900	Hobart	New Norfolk	flow remnant	BSN-2 to NH-2A	46.8, 44.4		spinel lherzolite, sparse	33, 18
167	Morgans Point, (Coal River mouth)	536800	5265900	Hobart	Richmond	vent with pyroclastic rocks, cut by dykes, capped by flow	potassic BSN-1	66.0, 66.7		spinel lherzolite <30 mm, rare clinopyroxenite mosaic with minor spinel, <5 mm, rare (cognate, crustal) megacrysts derived from clinopyroxenite and lherzolite	33, 18
168	Risdon Brook Dam	526800	5260300	Hobart	Richmond	vent	pyroclastic rocks; overlies ON flow; capped by HW flow		30.2 ± 1.0 (hbl)	oxidised spinel lherzolite(?) abundant kaersutite, Al-enstatite, Al-augite megacrysts, <20 mm, common; spinel megacrysts, rare	33, 18
169	Acton (3.5 km SE of Cambridge)	538400	5254700	Hobart	Hobart	vent with pyroclastic rocks and capping flow	NH-1B	44.2		spinel lherzolites, <20 mm, common; and derived debris	33, 18, 13
170	Droughty Hill North	534300	5247700	Hobart	Taroona	plug	HW-B to NH-1B	49.0–57.3		orthopyroxene and spinel megacrysts, rare	18
171	Droughty Hill Central	534300	5247400	Hobart	Taroona	flow cap (or plug ?)	potassic NH-2B to NB	60.1, 62.6		spinel lherzolites, <20 mm, sparse, in NW chilled margin	33, 18
172	Mt Wellington (pinnacle)	519200	5250300	Hobart	Collinsvale	small plug	HW-B	54.8		spinel lherzolite, <20 mm, rare	33, 18, 13
173	Neika	519300	5244900	Hobart	Longley	small plug and flow	HW-B	60.4		spinel lherzolite, <20 mm, sparse	33, 18
174	Whitewater Creek (Kingston)	524800	5242100	Hobart	Taroona	plug?	HW-B	46.5, 48.6		spinel lherzolite, <80 mm, sparse	33, 18
175	Pickett Hill (4 km NW of Kingston)	520400	5243000	Hobart	Taroona	vent, with lava and pyroclastic rocks; flow to east	HW-B	64.4–69.5		spinel lherzolite, <100 mm, and derived debris, abundant	33, 18
176	Cades Spur (Kingston)	523900	5242800	Hobart	Taroona	flow, possible local vent	NH-2B/ON-1	69.5–70.2		spinel lherzolite and derived debris, abundant	33, 18, 35, 13
177	North of Parks Hill (Kingston)	521100	5240900	Hobart	Taroona	pyroclastic vent, with dyke and flow cap	HW-B	60.5		spinel lherzolite, <30 mm, rare	33, 18
178	Lucaston (Mountain River)	505300	5239500	Hobart	Huonville	flow	AOB	63.2		spinel lherzolite, <40 mm, sparse to common	33, 18
179	Iron Creek (Arthur Highway to Rosendale Road bridge)	548300 to 547800	5263000 to 5263500	Sorell	Sorell	flow and pyroclastic rocks, local feeder	NH-1B	68.7		spinel lherzolite, <15 mm, and abundant debris enstatite megacrysts (from lherzolite?) sanidine (cognate, mantle?)	35 41 24
179a	Iron Creek Bay	548600	5262900	Sorell	Sorell	pyroclastic rocks underlying flows				spinel lherzolite, <100 mm, common harzburgite, <100 mm, common (up to 70% orthopyroxene, with large altered olivine)	
180	1 km WNW of Wattle Hill PO	551000	5265500	Sorell	Sorell	vent with flow to west	HW-B	50.0		peridotite (spinel lherzolite?), with olivine Fo ₈₆₋₈₇ clinopyroxenite (bronzite bearing) with olivine-anorthoclase reaction coronas dolerite (hypersthene-salite-labradorite-ilmenite) potassic oligoclase megacrysts	20, 41 41 41 41
181	2.3 km SSE of Wattle Hill PO (Delmore Road)	553000?	5263000?	Sorell	Sorell	flow	BSN (?)			andesine megacrysts	41
182	South of Gunns Hill (Forcett)	559700	5258000	Sorell	Carlton	basal flow	BSN-1	70.0		spinel lherzolite, <25 mm, common	37
183	East side of Wykeholm Point (west of Fulham Point)	561400	5249800	Sorell	Murdunna	vent and small flow (?)	BSN-1	68.9		spinel lherzolite, sparse websterite (Al-augite and Al-bronzite) dolerite (Al-diopside/salite, Al-bronzite, labradorite) Al-augite and spinel (Fe-pleonaste/Mg-hercynite) megacrysts	37, 41 41 41 41
184	Benders Hill (Kellevie)	567700	5260600	Sorell	Kellevie	vent and flows (?)	BSN-1	67.0		potassic oligoclase megacrysts	41
185	Dunalley Beach (west of Arthur Highway, 1 km SE of canal)	566300	5249900	Sorell	Dunalley	float boulders (dumped?)	alkali basalt/hawaiite			amphibole (kaersutite), oligoclase, pleonaste, magnetite xenocrysts (cognate)	24, 41
186	East Bay, Dunalley	566800	5250600	Sorell	Dunalley	small flow and adjacent dyke	alkali basalt			spinel (pleonaste) megacrysts titanomagnetite/ulvospinel megacrysts	41 41
187	North of Sommers Bay (Murdunna)	567800	5242600	Sorell	Murdunna	feeder and small flow	AOB	70.5		lherzolite, small, rare	35
188	Coffee Creek (Margate)	523300	5238300	Kingborough	Blackmans Bay	flow	MG	59.6		spinel lherzolite noted	35
189	1 km east of Ranelagh	503700	5237600	Kingborough	Huonville	flow	HW-A to TOB	58.8–63.5		lherzolite noted spinel megacrysts	33, 23, 13
190	Kaoota	514000	5236700	Kingborough	Huonville	flow and possible feeder	NM-1 to NH-1B	56.7–62.7		lherzolite noted	23
191	Cape Contrariety	542300	5237100	Tasman	Communication	plug intruding breccia, with capping flow	HW-A	69.7		spinel lherzolite and derived debris olivine, clinopyroxene and spinel megacrysts (cognate, mantle) spinel wehrlite (crustal, cumulate) spinel clinopyroxenite (crustal, cumulate)	9, 23, 24, 35

*opx = orthopyroxene, cpx = clinopyroxene

Table 2
Xenolith hosts

<i>Abbrev.</i>	<i>Type</i>	<i>Sub type</i>	<i>CIPW norm</i>	<i>Normative plagioclase</i>	<i>Analysed basalts</i>		<i>Basalts hosting mantle xenoliths</i>
					<i>No.</i>	<i>%</i>	
Q	Quartz tholeiite		Q>0		60	9.1	0
OT	Olivine tholeiite		ol; hy>10		104	15.9	1
TOB	Transitional olivine basalt		ol; 0<hy<10	>40	64	9.8	0
SH	Saturated hawaiiite		ol; 0<hy<10	<40	10	1.5	0
AOB	Alkali olivine basalt		0<ne<5	>50	35	5.3	4
HW-A	Hawaiiite	A	0<ne<5	40-50	50	7.6	3
HW-B		B	0<ne<5	30-40	35	5.3	7
MG	Mugearite		0<ne<5	10-30	4	0.6	1
BSN-1	Basanite	1	5<ne<10; ab>5	>50	62	9.5	13
BSN-2		2	ne>10; ab>5	>50	44	6.7	11
NH-1A	Nepheline hawaiiite	1A	5<ne<10; ab>5	40-50	33	5.0	10
NH-2A		2A	ne>10; ab>5	30-40	28	4.3	12
NH-1B		1B	5<ne<10; ab>5	30-40	16	2.4	5
NH-2B		2B	ne>10; ab>5	30-40	16	2.4	8
NM-1	Nepheline mugearite	1	5<ne<10; ab>5	10-30	6	0.9	2
NM-2		2	ne>10; ab>5	10-30	14	2.1	2
NB	Nepheline benmoreite		ne>5	<10	1	0.2	0
ON-1	Olivine nephelinite	1	0<ab<5		42	6.4	8
ON-2		2	lc; ab=cs=0		12	1.8	4
ON-3		3	lc; 0<cs<5		15	2.3	7
OML	Olivine melilitite		lc; cs>5		5	0.8	4
				Totals	656	100.0	102