

1982/23. A review of Tasmania's tin resources and their mineralogy\*

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#### Abstract

The estimated total tin resource in Tasmania is about 475 000 t of contained tin, which occurs predominantly in cassiterite-bearing greisen, vein, metasomatic replacement, and skarn deposits in north-east and western Tasmania. Stannite and stanniferous non-sulphide minerals are significant in some deposits in western Tasmania. Placer deposits, with cassiterite the only stanniferous mineral, contribute about 2.5% of the total tin resource.

#### INTRODUCTION

Tasmania is the major tin producing State in Australia, with tin ore (predominantly cassiterite) being currently mined in south-west, west to north-west, and east to north-east mainland Tasmania, and also previously mined on the Bass Strait islands. Most tin concentrates currently produced are obtained from primary (hard-rock) deposits, with minor production from placer (secondary) deposits. All tin concentrates produced are exported from Tasmania to smelters in either Sydney, New South Wales, or overseas (principally Malaysia).

#### PRIMARY TIN DEPOSITS

Primary tin deposits in Tasmania occur in rocks ranging in age from Late Proterozoic to Late Devonian, and all are genetically associated with the emplacement of post-kinematic granites of Late Devonian-Early Carboniferous age. The tin deposits occur in two major provinces: north-east Tasmania and north-west Tasmania, each with separate styles of mineralisation. In north-eastern Tasmania, most major deposits occur as greisen bodies and as lode/vein deposits, whereas in north-western Tasmania, there is a paucity of greisen deposits, but an abundance of tin-bearing replacement and/or skarn-type mineralisation.

Cassiterite is the dominant tin mineral in most primary deposits in Tasmania, though stannite and stanniferous silicates, borates etc. may be significant, particularly in western Tasmania.

The mineralogy of primary tin deposits varies considerably, but is considered in terms of the four main genetic types of deposits, as follows:

##### *Greisen deposits*

Disseminated, fine to medium-grained cassiterite, with minor wolframite, molybdenite, and base-metal sulphides occurs in layered, greisenised biotite-muscovite alkali granite (e.g. Anchor mine and other greisen bodies in the Blue Tier Batholith, north-east Tasmania; Federation mines in the Heemskirk Granite, western Tasmania), and in topazised quartz porphyry

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\*This report is a summary prepared for the Department of Industrial Development, Tasmania, for inclusion in a report entitled 'The Australian Primary Tin Processing Industry - Potential for Expansion' prepared by the Commonwealth/State Joint Study Group on Raw Materials Processing.

dykes (e.g. Mt Bischoff).

*Vein deposits*

Medium to coarse-grained cassiterite, commonly with wolframite, occurs either in quartz veins penetrating the country rock overlying granite cupolas and occurring as discrete veins or sheeted-vein systems (e.g. Aberfoyle-Lutwyche-Storeys Creek mines, near Rossarden; Shepherd and Murphy mine, Moina), or as quartz-greisen veins in granite (e.g. Mt Paris area). Fine-grained cassiterite occurs in stockwork vein deposits in sedimentary host rocks (e.g. Great Pyramid prospect, near Scamander). Accessory minerals include scheelite, molybdenite, base-metal sulphides, and minor stannite, and in addition to quartz, gangue minerals include fluorite, mica, carbonates, phosphates, tourmaline, and topaz.

*Metasomatic replacement deposits*

Currently, more than 95% of Tasmania's tin production is from cassiterite-sulphide deposits in western Tasmania, occurring mainly as stratabound lenses derived from replacement of carbonate beds, with associated small and/or large scale fissure lodes (e.g. Renison and Cleveland mines; Mt Bischoff and Queen Hill prospects), and also as replacement of carbonate derived from serpentinisation of an ultramafic complex (e.g. Razorback mine). Tin occurs principally as very fine-grained cassiterite (generally <0.1 mm), with up to 10% of the tin occurring as stannite (e.g. Cleveland). The stannite content is higher at Queen Hill, near Zeehan. Sulphides (mainly pyrrhotite, pyrite and arsenopyrite) comprise 20-80% by volume of these deposits. Other major accessory minerals include quartz, carbonates, tourmaline, chlorite, fluorite, amphibole, magnetite, and copper, lead and zinc sulphides.

*Skarn deposits*

Low-grade, tin-bearing skarns occur in sedimentary rocks adjacent to granitic intrusives (e.g. Moina, St Dizier, Mt Lindsay, and Mt Ramsay, all in western Tasmania). Much of the tin occurs in minerals other than cassiterite. Tin substitutes into the lattice of silicate minerals (e.g. garnet, amphibole) and in the lattice of Fe-oxides, and also may occur as borates (e.g. hulsite) and hydroxystannates (e.g. schoenfliesite). Accessory minerals in skarn deposits are mainly silicates and iron oxides (particularly magnetite) with minor sulphides.

Additional information on several deposits is given in Table 1. Data relating to some deposits currently under investigation by companies are either not yet available or are confidential.

As the ore from primary deposits has to be crushed and ground to liberate cassiterite before it can be concentrated, mineral processing techniques are complex, and may not give a high recovery, compared with placer deposits. Where cassiterite occurs as coarse crystals without other similar heavy minerals, processing can achieve a high grade concentrate (e.g. vein and greisen deposits in north-east Tasmania). However, where cassiterite is fine-grained and is associated with sulphides, oxides, tourmaline, siderite etc. (e.g. Renison, Cleveland) current processing achieves neither high recoveries nor high-grade concentrates. Renison, for example, recover about 70% of the Sn and produce a concentrate with 47-48% Sn.

Table 1. ORE MINERALOGY OF MAJOR MINES AND PROSPECTS

Mine/prospect	Company/operator/ prospector	Ore mineralogy
Aberfoyle - Storeys Creek	Rossarden Mines Ltd	Cassiterite and wolframite in quartz veins with sulphides (mainly sphalerite). Includes the Lutwyche deposit (closed 1982).
Rex Hill		Cassiterite in quartz-greisen pipe (in granite) with sulphides.
Royal George	Cornwall Coal Co.	Cassiterite in greisen
Great Pyramid	B.H.P. Co. Ltd	Fine-grained cassiterite in stockwork quartz veins and in matrix of fault breccias.
*Anchor	Hellyer Mining & Exploration Pty Ltd, R.G.C. Ltd	Cassiterite in greisen with minor chalcopryrite, bornite, molybdenite, fluorite, and pyrite
Blue Tier	Hellyer Mining & Exploration Pty Ltd, R.G.C. Ltd	Several greisen deposits with cassiterite and minor sulphides, wolframite, and molybdenite.
Mt Paris area	Several explorers and prospectors.	Cassiterite in greisen veins and pipes with minor sulphides.
Moina	Comm. Alum. Corp. Ltd, Shell Co.	Magnetite-fluorite skarn with accessory fine-grained (<15µm) cassiterite and Sn-rich sphene, minor cassiterite and wolframite in quartz veins.
*Mt Bischoff	C.R.A. Exploration Pty Ltd, Metals Exploration Ltd, Comstaff Pty Ltd	Cassiterite in massive sulphide (mainly pyrrhotite) in dolomite, and in altered porphyry dykes. Minor stannite occurs in massive sulphide ore.
**Cleveland	Cleveland Tin Ltd, Aberfoyle Ltd	Cassiterite, minor chalcopryrite and stannite in strata-bound massive/banded sulphide-silicate-fluorite replacement bodies.
Mt Lindsay	R.G.C. Ltd, Aberfoyle Ltd	Magnetite-silicate skarn with tin occurring as cassiterite(?) and substituting in silicates and ilmenite.

Table 1. (continued)

Mine/prospect	Company/operator/ prospector	Ore mineralogy
**Renison	R.G.C. Ltd	Cassiterite in stratabound massive sulphide (mainly pyrrhotite) replacement bodies and in major fault zones with sulphides.
St Dizier	R.G.C. Ltd, Apollo Minerals Ltd	Magnetite-silicate skarn with cassiterite and other stanniferous minerals.
*Queen Hill-Oonah	Gippsland Minerals, Aberfoyle Ltd, C.R.A. Exploration Pty Ltd	Cassiterite and stannite in sulphide mineralisation in replacement bodies and fault zones.
Federation	R.G.C. Ltd	Cassiterite in pipes and irregular zones of tourmaline-quartz-topaz-mica in granite.
Razorback	C.R.A. Exploration Pty Ltd, Minops Pty Ltd	Cassiterite with sulphides in fracture zone.

\*\* Operating mine

\* Major prospect

Deposits in which cassiterite is not the dominant tin mineral are not currently mined in Tasmania. Improvements in mineral processing techniques (e.g. thermal upgrading and matte fuming are being investigated by at least two companies operating in Tasmania) may permit some of these deposits to become producing mines, and may also allow recycling of mine tailings.

#### PLACER TIN DEPOSITS

Placer deposits (alluvial, eluvial, deep lead, beach sand) are, or have been, exploited mainly by small producers in many places in Tasmania. Historically, much of the tin produced from Tasmania has come from placer deposits, mainly in north-eastern Tasmania, but over the last 50 years production has declined dramatically, and these deposits currently contribute less than 2% of Tasmania's tin production. Cassiterite is the only tin mineral won from placer deposits.

Placer deposits generally occur in sediments of Tertiary age or younger, although 'fossil' placers occur locally in basal Permian sediments such as at Royal George in north-east Tasmania. The richest concentrations of alluvial cassiterite have been found in the tributary 'deep leads' to the Tertiary basin exhumed by the present Ringarooma River, in north-east Tasmania. Offshore exploration in Ringarooma Bay has demonstrated extensive shallow marine resources, possibly occurring in extensions of the 'deep lead' systems.

Most placer deposits currently worked are in north-east Tasmania and are generally one or two-man operations, or are run by small syndicates. Larger scale company-operated mines have included:

- (a) Briseis mine on Cascade lead at Derby (a deep lead operation, in part sub-basaltic), producing some 21 000 t of tin, mainly between 1876 and 1929. Production declined from 1940 and ceased in 1960).
- (b) Endurance mine at South Mount Cameron, a deep lead operation, which produced some 3300 t of tin before operations ceased in 1968.
- (c) Pioneer mine at Pioneer, operated until recently by Amdex Mining, recovered some 6600 t of tin before closing in 1982.
- (d) Dorset Dredge (Aberfoyle) operated on the Ringarooma River flats, recovered some 2300 t of tin before operations ceased in 1971.
- (e) Monarch mine (B.M.I.), north-west of Mount Cameron (closed 1973).
- (f) Arba Mine, Branxholm, recovered 2300 t of tin (closed 1960).
- (g) North Valley, Waratah River near Mount Bischoff, north-west Tasmania (closed 1980).

Mineral processing of placer deposits is affected by the grade (generally expressed as kg cassiterite per m<sup>3</sup>), cassiterite grain size, and accessory heavy minerals. The grade of these deposits is extremely variable, but for deposits currently mined the grade ranges up to 0.5 kg/m<sup>3</sup>. Placer deposits generally yield a high grade (>70% Sn) concentrate, as cassiterite grains have been freed of gangue minerals by natural weathering and sediment transport processes. Deposits in close proximity to their primary source (e.g. eluvial deposits) may produce a lower grade concentrate because of a greater number of composite grains. Associated heavy minerals in the host sediments constitute a problem for those deposits located near a primary source that contains significant amounts of sulphides, Fe/Ti oxides etc. (e.g. Waratah River near Mt Bischoff and Tasman River near Mt Heemskirk, both in western Tasmania).

#### TIN RESERVES AND RESOURCES

The total estimated tin resource in Tasmania is approximately 475 000 t of contained tin (Table 2). The sources of published data for mines and prospects used in the compilation of Table 2 are listed, whereas unpublished data for a number of mines, prospects and deposits have been grouped as 'other deposits'.

The reserves and/or resource data listed in Table 2 includes well established reserves (e.g. producing mines) mixed with *in situ* reserves and estimated resources. Thus the data in Table 2 serve only as a guide to the State's total tin resource, and must be used with caution.

Although some 60% of the total primary resource tonnage is attributed to 'other deposits', the overall grade is low (0.43% Sn), and accounts for only 43% of the contained tin. Much of the tin in 'other deposits' is in ore/mineralisation which may be difficult to process.

Proved and probable reserves at the Renison tin mine account for about 39% of the contained tin in primary deposits.

Table 2. ESTIMATED TIN RESOURCES, TASMANIA

Mine, prospect, deposit	Reserves/resource		Grade (%Sn)	Contained Sn (t)
	Category	x10 <sup>6</sup> t		
<b>PRIMARY DEPOSITS</b>				
<b>A. Producing mines</b>				
Renison <sup>(1)</sup>	Proved	6.22	1.16	72 150
	Probable	<u>10.19</u>	<u>1.09</u>	<u>111.070</u>
Cleveland <sup>(2)</sup>		16.41	1.12	183.220
	Mineable	1.7	0.64	10.880
<b>B. Prospects (published data)</b>				
Mt Bischoff <sup>(3)</sup>	Geological	6.1	0.49	29 890
Zeehan (Queen Hill) <sup>(2)</sup>	Resource	6.0	0.7	42 000
<b>C. Other deposits (unpublished data)</b>				
Total resource <sup>(4)</sup>	Resource + possible ore	<u>45.5</u>	<u>0.43</u>	<u>197 200</u>
	<b>TOTAL</b>	<u>75.71</u>	<u>0.61</u>	<u>463 190</u>
<b>PLACER DEPOSITS*</b>				
	Reserves/resource		Cassiterite (t)	Contained Sn (t)
	Category	x10 <sup>6</sup> m <sup>3</sup>		
<b>A. Prospects (published data)</b>				
Briseis, Derby <sup>(5)</sup>	Probable	0.85	1 630	1 280
Braithwaites, Great Northern Plains <sup>(6)</sup>	Probable	6.50	1 120	880
Scotia lead, Great Northern Plains <sup>(7)</sup>	Probable	8.41	1 700	1 340
Ringarooma Bay <sup>(8)</sup>	Possible ore	22.94	4 250	3 350
<b>B. Other deposits (unpublished data)</b>				
Total resource <sup>(4)</sup>	Resource + possible ore	-	<u>6 500</u>	<u>5 120</u>
	<b>TOTAL</b>		<u>15 200</u>	<u>11 970</u>
<b>TOTAL TIN RESOURCE</b>				<b>475 160</b>

1. Renison Goldfields Consolidated Ltd, Report on the 1981 financial year.
2. Aberfoyle Ltd, Annual Report, 1981.
3. Metals Exploration Ltd, Annual Report, 1981.
4. Total resource estimated from unpublished data for possible ore, 'potential' ore and resources at several mines, prospects and deposits.
5. *Tech.Rep.Mines Tasm.* 9:132-142 (1965).
6. *Tech.Rep.Mines Tasm.* 20:62-76 (1975).
7. Unpublished data, 1963, file reference: Scotia lead (S9).
8. TOE-JV Summary Ringarooma Bay, Tasmania: *Unpubl.Rep.Ocean Mining A.G.*, 1969. (Open File).

\* Reserves and resource calculations are subject to wide variation dependent upon correction factors chosen, areal extent, and assumed cut-off values. Numerous small occurrences have not been assessed.

Placer deposits account for only 2.5% of the total tin resource. Although small mines (*i.e.* one or two-man operations) have not been considered in compiling the resource data, their inclusion would only marginally add to the resource. A recent substantial increase in placer reserves (data not included in Table 2) results from exploration by Hellyer Mining between the Great Northern Plains and Ringarooma Bay.

[23 June 1982]