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GEOLOGY AND MINERAL
RESOURCES OF TASMANIA

by

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PREFACE

In 1938 the Department of Mines issued a Geological Survey Bulletin summarizing the knowledge of the geology and mineral deposits of the State at that time. The fact that this volume was so soon out of print indicates that there is a real need for a concise account of these matters. It is hoped that the present volume, which is completely revised to the end of 1966, will help to satisfy this need.

In 1938 the annual value of minerals and mineral products in Tasmania was £A2.7 million. By 1966 the value of production had increased almost 10 times to an annual value of \$A51.2 million. This increase is a measure of the importance of the mineral industry of the State. The new mining developments now taking place within the State assure that in the years ahead further dramatic increases in the value of mining production may be expected.

Concomitant with this rise in the value of mining products there has been a corresponding increase in our knowledge of the geology and mineral deposits in Tasmania. The quest for new geological knowledge and for new mineral deposits is unceasing, and today the exploration for new deposits is being pursued more vigorously than at any period of the State's history.

This publication summarizes the state of knowledge of the geology and mineral resources of Tasmania at present. It has been prepared in order to provide basic information to guide the future prospecting of our mineral resources.

J. G. SYMONS, Director of Mines.



Frontispiece:

CROCOITE (Chromate of Lead)

|

STICHTITE (Hydrated hydroxycarbonate of Magnesium and Chromium)

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PLATE

Crocoite and Stichtite Minerals	Frontispiece
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The Geological Map of Tasmania (1961) of a scale 8 mls. = 1 inch
may be purchased from the Department of Mines for 50c

← 5 cm →

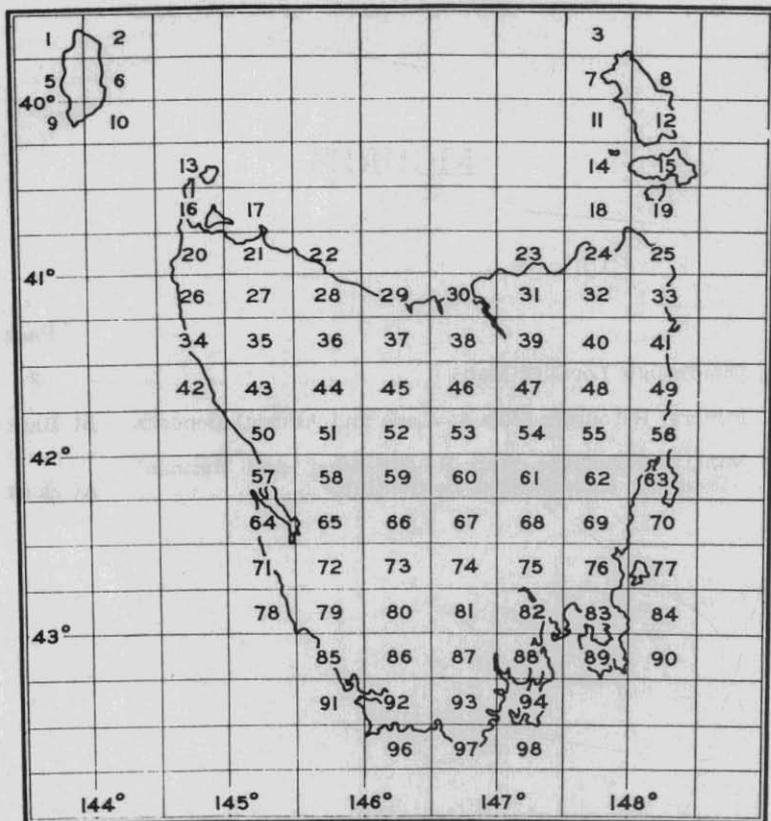


FIGURE 1. QUADRANGLE LOCALITY MAP

- | | | | |
|------------------------|--------------------|---------------------|-----------------|
| 1. Wickham | 27. Trowutta | 51. Murchison | 75. Brighton |
| 2. N. E. King | 28. Burnie | 52. Du Cane | 76. Buckland |
| 3. Kents Group | 29. Devonport | 53. Great Lake | 77. Maria |
| 5. Currie | 30. Beaconsfield | 54. Lake River | 78. Montgomery |
| 6. Sea Elephant | 31. Pipers River | 55. Snow Hill | 79. Rocky Point |
| 7. N. W. Flinders | 32. Ringarooma | 56. Bicheno | 80. Pedder |
| 8. N. E. Flinders | 33. Blue Tier | 57. Strahan | 81. Styx |
| 9. S. W. King | 34. Balfour | 58. Lyell | 82. Hobart |
| 10. S. E. King | 35. Magnet | 59. St. Clair | 83. Sorell |
| 11. Green Island | 36. St. Valentines | 60. Lake Echo | 84. Forestier |
| 12. S. E. Flinders | 37. Sheffield | 61. Interlaken | 85. De Witt |
| 13. Three Hummock | 38. Frankford | 62. Tooms | 86. Arthur |
| 14. Chappell Island | 39. Launceston | 63. Swansea | 87. Picton |
| 15. Cape Barren Island | 40. Alberton | 64. Macquarie Harb. | 88. Kingborough |
| 16. Cape Grim | 41. St. Helens | 65. Pillinger | 89. Tasman |
| 17. Highfield | 42. Pieman Heads | 66. King William | 90. Hippolyte |
| 19. Banks Strait | 43. Corinna | 67. Ouse | 91. Davey |
| 20. Woolnorth | 44. Mackintosh | 68. Oatlands | 92. Bathurst |
| 21. Smithton | 45. Middlesex | 69. Swanston | 93. Adamson |
| 22. Table Cape | 46. Quamby | 70. Schouten | 94. Dover |
| 23. Noland Bay | 47. Longford | 71. Point Hibbs | 96. Maatsuyker |
| 24. Boobyalla | 48. Ben Lomond | 72. Gordon | 97. South Cape |
| 25. Eddystone | 49. St. Marys | 73. Huntley | 98. Friars |
| 26. Bluff Point | 50. Zeehan | 74. Ellendale | |

AN OUTLINE OF THE GEOLOGY OF TASMANIA

by Emyr Williams

INTRODUCTION

This account deals principally with the stratigraphy of Tasmania and serves as an introduction to the descriptions of the economic deposits, which form the greater part of this Bulletin. The writer has depended heavily on the information given in the *Geology of Tasmania* published by the Geological Society of Australia (1962), and on publications that have appeared since. References made in the text, and which are appended, are highly selective.

PRECAMBRIAN SYSTEMS

The oldest rocks occur mainly in the western half of the State and occupy approximately one fifth the area of the island. They are of the Precambrian Era and are divided into two groups. One division consists of those rocks which have been penetratingly deformed, and the deformation has been accompanied by a regional metamorphism. The other division, which at localities where they are adjacent is the upper and probably the younger, consists predominantly of comparatively unmetamorphosed sequences.

The metamorphic rocks have received detailed study in the Lyell and Pillinger Quadrangles* (Gee, 1963; Spry, 1957 b). They have been grouped into a quartzite-phyllite assemblage, which includes the Mary, Scotchfire and Fincham Groups and the Elliot Quartzite, and a schist-quartzite assemblage of mica and garnet schist with quartzite and associated amphibolite and eclogite constituting the Franklin, Joyce and Algonkian Groups. The metamorphic rocks of this area extend into the SW of Tasmania (Scott, 1962; Jennings, 1961) where they are closely folded and are of quartzite, quartz-mica, quartz-albite and garnet-mica schist.

To the N the Precambrian metamorphic division is represented in the Zeehan Quadrangle (Blissett, 1962) by the Concert and Whyte Schists of crenulated quartz, quartz-mica, sericite and graphite schist. In the Corinna Quadrangle (Spry, 1964; Urquhart, 1966) the Whyte Schist consists of mica schist, quartzite, siltstone and phyllite with amphibolite, associated with dolomite and magnetite-sulphide occurrences, derived from basic intrusions, and these rock-types make up the Keith Beds further N in the Bluff Point and Trowutta Quadrangles (McNeil, 1961; Longman and Matthews, 1962).

Near the N coast in the Devonport Quadrangle (Burns, 1964) occur mechanically interlayered quartzite, quartz, garnet, albite and mica schist and amphibolite of the Forth and Ulverstone Metamorphics with deformed conglomerate in the latter.

Thrust over the metamorphic rocks in the Devonport Quadrangle (Burns, 1964) is a sequence of interbedded mudstone and thin poorly sorted but graded sandstone layers, with well developed sole markings and small-scale current bedding. The sandstone is typical of sediment dumped by turbidity currents where normally

* For location of Quadrangles, see Figure 1.

mud accumulated. These unmetamorphosed rocks are intruded by dolerite some 700 m.y. old. To the W of Devonport (Spry, 1957 a; Gee, 1966), representing the Rocky Cape Group, occur unmetamorphosed sedimentary rocks with large-scale current bedding and good sorting which suggest a shallow-water well-worked environment of deposition.

Although the rocks of the metamorphosed assemblages are characterized by complicated deformations which determined even the microscopic features, the more spectacular large contortions are the recumbent folds of many miles extent encountered in the sedimentary rocks of the unmetamorphosed Precambrian W of Devonport and to the E at Badger Head in the Beaconsfield Quadrangle.

The recumbent folds and the contortions of the metamorphic rocks resulted from movements during late Precambrian times.

UPPER PRECAMBRIAN—LOWER CAMBRIAN SYSTEMS

A number of unfossiliferous, comparatively unmetamorphosed sequences from scattered localities have been variously considered Precambrian, Upper Precambrian-Lower Cambrian, or Lower Cambrian in age (for discussions see Banks and Solomon, 1961; Blissett and Gulline, 1961; Campana, 1961 a and b; Campana and King, 1963; Spry, 1964).

In the far SW of Tasmania (Jennings, 1961) occur quartz sandstone and siltstone, with infilled mud cracks indicative of a shallow water origin, which were believed to be Precambrian, and suites of ortho-quartzites and greywacke rocks which were considered to be possibly of Cambrian age.

In the W of SW Tasmania (Scott, 1962) occur strongly folded quartzite, shale, siltstone, calcareous shale and dolomite which were believed to be Precambrian. Further N in the Zeehan Quadrangle (Blissett, 1962) a sequence of more than 7,000 feet of alternating pale grey quartzite, siltstone and slate, with locally developed dark grey limestone, dolomitic limestone, spilitic lava flows and pyroclastic bands, comprises the Oonah Quartzite and Slate which has been considered as Upper Precambrian-Lower Cambrian in age. The Oonah Quartzite and Slate was believed to be followed conformably by the Crimson Creek Formation which consists of 10,000 feet of interbedded turbidite greywacke and mudstone of Lower-Middle Cambrian age, and was considered to pass conformably into overlying fossiliferous Middle Cambrian rocks.

In the N Pieman area (Campana and King, 1963) 8,000 feet of quartzite, slate, breccia and dolomite with interbedded tuff towards the top of the sequence comprise the Success Creek Group, which has been correlated with the Oonah Quartzite and Slate. This group unconformably overlies Precambrian quartzite and quartz schist and was believed to be of Lower Cambrian age. It was considered to be overlain by varicoloured argillite—the Crimson Creek Formation—and dated as Lower Cambrian.

In the Corinna Quadrangle (Spry, 1964) some 5,000 feet of interbedded slate and sandstone comprise the Interview Slate and Quartzite which was considered to overlie the metamorphosed Whyte Schist. This sequence is intruded by dolerite dykes. It is followed by the Corinna Slate, which is an assemblage of slate and siltstone; the Bernafai Volcanics, consisting of 1,300 feet of altered basaltic lava and tuff; and the Delville Chert of black chert and quartzite. All the rocks were considered to be Precambrian.

Further N in the Bluff Point and Trowutta Quadrangles (Longman and Matthews, 1962) the metamorphosed Precambrian Keith Beds was believed to be followed conformably by, and to show a gradational metamorphic relationship with, the Neasey Quartzite and Slate, which consists of well sorted quartzite with occasional cross-bedding and ripple marks, slate and phyllite. Following conformably is a sequence of more than 8,000 feet of laminated flaggy siltstone and mudstone interbedded with greywacke sandstone. This sequence is succeeded conformably by a well-sorted quartzite series some 2,000 feet in thickness. Transgressively overlying these units is 1,000 feet of dolomite and chert. All these unmetamorphosed rock types were believed to be Precambrian. Following them is a sequence, considered Cambrian, of 100 feet of breccia containing dolomite and chert fragments in a dolomite matrix, 500 feet of a dominantly siltstone sequence, which is succeeded by up to 500 feet of tholeiite basalt flows with more than 200 feet of tuff and volcanic breccia.

Thick accumulations of dolomite at Smithton, Savage River, Tim Shea, Jane River and Hastings have been regarded as of the same age and the youngest of the Precambrian rocks (Spry, 1962 GT*). Recently dolomite found in the upper reaches of the Savage River has been considered to be a secondary replacement of amphibolite (Urquhart, 1966).

CAMBRIAN SYSTEM

Whatever the precise age may be of the rock sequences discussed under the heading of Upper Precambrian-Lower Cambrian, the fossiliferous rocks of known Cambrian age reflect a marked change in depositional environment. The former are in the main well-sorted sand, silt and dolomite of the orthoquartzite-limestone suite which accumulated in a comparatively stable, well-worked shallow water area; whereas the fossiliferous Cambrian is represented by poorly sorted but graded suites of sandstone with interbedded mudstone deposited in unstable deepening basins where coarser material was deposited from turbidity currents which from time to time interrupted the normal accumulation of mud. Vulcanism occurred a number of times during the Cambrian.

The fossiliferous Cambrian rocks occur as a belt from Elliot Bay to Point Hibbs, on the W coast, through Rosebery to Waratah, in areas extending from the far NW coast in the vicinity of Smithton to some 20 miles inland, and yet another belt extending from Ulverstone on the N coast some 30 miles to Gunns Plains.

* 1962 GT refers to: *The Geology of Tasmania. J. Geol. Soc. Aust. Vol. 9, Part 2.*

In the Zeehan Quadrangle (Blissett, 1962; Elliston, 1954) rocks of the Crimson Creek Formation pass conformably into the fossiliferous Dundas Group consisting of some 200 feet of Judith Slate and Greywacke at the base; followed by 150-400 feet of Red Lead Conglomerate; 500-600 feet of Hodge Slate with "dendroids", trilobites and cystoids believed to indicate a middle Middle Cambrian age; 250-750 feet of Razorback Conglomerate; 2,000 feet of Brewery Junction Slate and Tuff associated with basic porphyritic lavas; up to 1,950 feet of Fernfields Greywacke and Conglomerate; 500-1,000 feet of Comet Siltstone and Greywacke which contains trilobites considered to indicate an Upper Cambrian age; 500 feet of Fernflow Greywacke and Conglomerate; and 1,500 feet of Climie Siltstone and Greywacke. Possibly conformably overlying this sequence is the Misery Conglomerate considered to be of Cambrian age (Elliston, 1954; Campana and King, 1962), but it has also been correlated with the Mt Zeehan Conglomerate which was believed to be of Ordovician age (Blissett, 1962).

In the Murchison Quadrangle (Campana and King, 1963) occurs a substantial unit of some 8,000 feet of volcanic rocks—Mt Read Volcanics—of keratophyre, quartz porphyry and quartz feldspar porphyry, associated with massive or schistose pyroclastic rocks, tuffaceous slate and ash beds. This volcanic unit was regarded as grading laterally and vertically into the younger Crimson Creek Formation, when present, but where this sedimentary formation is absent the Middle Cambrian Dundas Group was believed to follow unconformably. However, the relationships between the Mt Read Volcanics, the Crimson Creek Formation and the Dundas Group are controversial, for it appeared likely that although the Mt Read Volcanics may in part be older than the Dundas Group it may well be in part equivalent in age (Blissett, 1962).

In the Lyell Quadrangle (Solomon, 1960), to the SE of Zeehan, some of the Cambrian rocks occur as quartz, chlorite and sericite schist. N of Queenstown the amount of volcanic material increases in the succession. The eastern margin of the Cambrian Dundas belt is flanked by dominantly acid volcanics whereas a zone of basic lavas appears flanking the western margin.

The Cambrian meridional belt of the Devonport region (Burns, 1964) is flanked by Precambrian rocks both on the W side at Penguin Creek, and on the E side at Gawler River. This belt, known as the Dial Range trough, widens rapidly near Gunns Plains to join the larger Dundas trough. At the base of the proposed Cambrian succession is the Lobster Creek Volcanics, consisting of more than 1,000 feet of massive acid and intermediate rock types. This formation is followed by the Cateena Group of up to 3,950 feet of a greywacke sequence, with fossils indicating a middle Middle Cambrian age, in which are horizons of keratophyre, tuff and agglomerate. An impersistent horizon may follow of Barrington Chert which is usually thinly laminated in black and white and may attain more than 2,800 feet in thickness. Overlying this may occur another impersistent horizon of up to 1,500 feet of Motton Spillite. Both the Barrington Chert and Motton Spillite were considered to be consequent on tectonic movements. Some 1,200 feet of a greywacke sequence containing keratophyric rocks follows. It is named the Radford Creek Group and contains fossils suggesting an upper Middle Cambrian age. At the top of the Dial Range

sequence is the Beecraft Megabreccia, which was believed to have resulted from the gravity down-sliding of large masses of semi-indurated material from the flanks of the trough into greywacke material, and it has been considered to reflect movements closing Cambrian times.

Immediately S of the Devonport region in the Sheffield and Middlesex Quadrangles (Jennings, 1963) the lowest Cambrian rocks are represented by some 3,000 feet of Barrington Chert, but local accumulations of volcanic material, for example the Motton Spilite which is up to 1,500 feet thick, interrupted chert accumulation. The Gog Range Greywacke, of some 2,000 feet, with fossils indicating a Middle Cambrian age, follows and has horizons of volcanic material and keratophyric lavas. This greywacke sequence is followed by several thousand feet of acid lava, soda rhyolite and keratophyre. A greywacke sequence, often metamorphosed to quartz-chlorite schist, closes the Cambrian.

Late Cambrian igneous activity is believed to be represented by granite emplacements at Mt Darwin in the Pillinger Quadrangle (see Solomon, 1960), in the Murchison Quadrangle, and in the Dove and Mersey Rivers of the Middlesex Quadrangle (McDougall and Leggo, 1965). Basic and ultrabasic rocks ranging in composition from quartz-mica gabbro to dunites, but mainly pyroxenites, occur as slightly transgressive sills and rare dykes in Cambrian and Precambrian rocks (Taylor, 1955). Serpentinite is overlain by conglomerate, sand and silt composed of serpentinite material on the Sawback Range E of Adamsfield in the Huntley Quadrangle (Carey and Banks, 1954). Chromite and osmiridium occur as placer deposits in the sequence which contains fossils of an upper Cambrian age (Opik in Banks, 1962 GT).

The local unconformity described at Adamsfield suggests an Upper Cambrian uplift. Further Cambrian tectonic activity is indicated in the Devonport region where the megabreccia was believed to be associated with active faults. Succeeding Ordovician rocks rest unconformably on Cambrian rocks at a number of places, but are concordant at others as in the Zeehan Quadrangle.

ORDOVICIAN SYSTEM

Ordovician rocks, which may attain a maximum thickness of 7,500 feet, are well represented at the localities of the Cambrian along the West Coast Range in W Tasmania, and in the Dial Range in the Devonport Quadrangle, from where they extend into the Sheffield and Middlesex Quadrangles. The type area is near Maydena, in the Huntley and Ellendale Quadrangles. Ordovician successions are unknown in the far NW of Tasmania, whereas part of the Mathinna Beds of the NE may be of this age.

Beds of the Ordovician System usually rest on the Cambrian unconformably although conformable relationships have been noted, for example near Zeehan and probably at Adamsfield. The Ordovician rocks are overlain concordantly by the Silurian.

Along the West Coast Range lenses of up to 300 feet thick of conglomerate and breccia, which are very poorly stratified, rest unconformably on Cambrian rocks from which they are derived. In addition to the Cambrian rocks of pyroclastics, sediments and

granite the conglomerate may contain fragments of hematite and hematitic sandstone. These deposits constitute the Jukes Conglomerate (see Wade and Solomon, 1958) and its correlates the Sorell Conglomerate and the Dora Conglomerate. Near Maydena and in the Devonport and Beaconsfield Quadrangles deposits correlated with the Jukes Conglomerate are overlain conformably by siliceous conglomerate followed by fossiliferous rocks of Middle and Upper Arenigian age, so that it is believed to be of Lower Ordovician age.

Reconstruction of the land surface during accumulation of the Jukes Conglomerate in the West Coast Range region indicates that the eastern margin of the earlier Cambrian trough continued to rise with steep tilting of the Cambrian rocks resulting in the rapid accumulation of wedge shaped beds of conglomerate (see Hills, 1914; Campana *et al.*, 1960; Banks, 1962 GT) which comprise these basal Lower Ordovician deposits.

Resting in some localities of the West Coast Range conformably, in others disconformably, and in yet others overlapping the Jukes Conglomerate and its correlates onto older rocks unconformably, is the Owen Conglomerate, which is believed to be Lower Ordovician in age. This unit, which is up to 2,400 feet thick, consists of siliceous conglomerate, quartz sandstone and thin shale layers towards the top (Wade and Solomon, 1958). Apart from the upper sequences containing shale horizons the Owen Conglomerate is usually pink and is dominantly siliceous with fragments derived from the Precambrian of the areas to the E and accumulated (Hills, 1914; Campana *et al.*, 1958) as continental alluvial piedmont fans against Precambrian highlands to the E. Towards the top of the Owen Conglomerate marine beds appear which contain abundant worm castings and burrows, brachiopod and marine gastropod fossils. It is therefore evident that the sea encroached the area, and invaded the land mass to the E, since the marine beds overlap in this direction, as well as overlapping other Owen horizons to the W.

Flanking the West Coast Range in the low featureless areas or those with karst topography, is the fossiliferous Gordon Limestone (Banks, 1962 GT), which ranges in age into the Upper Ordovician. It is usually of calcareous silt, sand and occasionally coarser fragments. The limestone is normally light to dark grey with buff dolomitic patches. Stylolites are ubiquitous. At a number of localities the limestone is impure and it may even occur interbedded with shale or quartz siltstone and sandstone, or be represented by 'black pug' as near Mt Darwin (Hills, 1914). Fossils of calcareous algae and coarse current bedding indicate that the Gordon Limestone accumulated in shallow and probably warm seas, which were extensive as the limestone overlaps the Lower Ordovician onto Cambrian and Precambrian rocks.

In the Zeehan Quadrangle (Blissett, 1962) it has been believed that a passage exists from Cambrian beds into siliceous conglomerate which is similar to and has been correlated with the geographically separate Lower Ordovician conglomerate of the West Coast Range. The deposits, known as the Mt Zeehan Conglomerate, are very variable in thickness with a maximum development of 1,500 feet and were believed to have accumulated in shallow seas. The conglomerate is overlapped by dominantly siliceous grit and sandstone,

120-2,000 feet in thickness, which contain worm burrows and castings and were considered to be the equivalent of the marine upper sequence of the Owen Conglomerate of the West Coast Range. These are followed by 1,000-2,000 feet of Gordon Limestone which is usually decomposed into a black and grey pug. On the coast, at Duck Creek, the overlapping nature of the younger Ordovician beds indicated a marine transgression to the NW. Near Zeehan sandy beds at the top of the Gordon Limestone mark a passage into overlying Silurian sandstone.

In the Maydena-Tim Shea area (Banks, 1962 GT) the Ordovician succession comprises the Junee Group. Dolomite breccia occurs at the base, following the Cambrian rocks concordantly, and has been correlated with Jukes Conglomerate. Some 70 feet of red siltstone and sandstone follow and pass into the Tim Shea Conglomerate consisting of some 200 feet of siliceous conglomerate. A sequence of marine siliceous sandstone, siltstone and thin conglomerate layers follows and was believed to be the equivalent of the marine upper sequences of the Owen Conglomerate. These marine beds attain a maximum thickness of 1,300 feet and contain worm burrows and castings and gastropods, cephalopods and trilobites. The Florentine Valley Mudstone, up to 300 feet thick, succeeds and forms a transition through siltstone, calcareous shale and calcareous sandstone into the overlying Gordon Limestone, up to 5,000 feet thick. These transition beds contain brachiopods, trilobites and graptolites of Lower Ordovician age, whereas the Gordon Limestone contains fossils indicating a range to Upper Ordovician in age. The Gordon Limestone is conformably overlain by Silurian rocks.

In the Devonport Quadrangle (Burns, 1964) the base of the Ordovician Dial Group may be represented by up to 30 feet of the Gnomon Mudstone which is a purple mudstone with thin sandstone layers overlying the Cambrian with a concealed unconformity. The Duncan Conglomerate succeeds and is up to 1,800 feet of dominantly siliceous conglomerate which is generally poorly sorted and usually stratified. This deposit was considered to have a similar origin to the Owen Conglomerate of the West Coast Range, i.e. a fanglomerate mantling Cambrian hills. It is composed in the main of chert fragments derived from the Cambrian Barrington Chert to the NE of the area. The Duncan Conglomerate is believed to pass vertically and laterally into the topmost member of the Dial Group, which is a well-bedded sandstone, shale and conglomerate sequence, with marine fossils and worm borings. This marine deposit, correlated with the Moina Sandstone (Jennings, 1958), was believed to be a littoral deposit formed in shallow seas transgressing to the SW. The Dial Group is succeeded by the Gordon Limestone which is up to 2,000 feet thick at Gunns Plains. It is a pure blue limestone with abundant fossils indicating an age ranging through the Middle and Upper Ordovician.

To the S of Devonport in the Sheffield and Middlesex Quadrangles (Jennings, 1963) up to 800 feet of siliceous conglomerate and sandstone, the Roland Conglomerate, form the lowermost sequence of the Ordovician and rest on the Cambrian unconformably. At some localities the basal beds of the Roland Conglomerate are of entirely local derivation matching underlying Cambrian rocks. The Moina Sandstone follows; it consists of up

to 800 feet of dense, siliceous, white or pink, marine sediments of sandstone, shale and conglomerate with calcareous mudstone and calcareous sandstone at the top, which is transitional with the overlying Gordon Limestone. Worm burrows and castings are quite common, and at one locality in the Moina Sandstone occurs a very fossiliferous horizon, the Caroline Creek Beds, previously put at the top of the Cambrian, which has yielded a rich trilobite fauna of Arenigian age (Singleton in Banks, 1962 GT). This marine horizon has been correlated with the upper sequence of the Owen Conglomerate of the West Coast Range. The Roland Conglomerate and Moina Sandstone constitute the Magog Group which is overlain by Gordon Limestone that may exceed 3,000 feet in some localities. The limestone is usually hard, compact, generally massive and frequently stylolitic. Shaly bands occur towards the top of the unit which is followed by at least 600 feet of marine sandstone of probably Silurian age.

SILURIAN AND DEVONIAN SYSTEMS

In Tasmania the Silurian and Devonian rocks constitute the Eldon Group, and show a distribution closely associated with Ordovician occurrences on which they rest generally conformably. Some 5,000 feet of sandstone and mudstone accumulated in the Zeehan area whereas 1,200 feet were deposited near Queenstown.

In the Zeehan Quadrangle, which is the type area (Gill, 1962 GT; Banks, 1962 GT; Blissett, 1962), the basal formation of the Eldon Group follows the Ordovician conformably. This formation, known as the Crotty Quartzite, is up to 1,600 feet thick and is composed of usually cross-bedded siliceous sandstone with pebbly bands and siltstone. Fossils recorded, which include crinoids, a shelly fauna and worm borings and castings, have indicated a likely Lower-Middle Llandoveryan age of the Lower Silurian. The Crotty Quartzite is represented by a thinner finer grained sequence to the SE near Queenstown, suggesting a NW land source for the deposit. Some 800 feet of Amber Slate follows and consists of fine-grained rocks with pelagic fossiliferous bands which have yielded evidence suggestive of Upper Llandoveryan-Wenlockian age. The Keel Quartzite succeeds and is composed of some 200 feet of ripple marked, poorly fossiliferous, siliceous sandstone. Up to 700 feet of Austral Creek Siltstone follows. The Florence Sandstone occurs above and is some 1,600 feet of highly fossiliferous sandstone with Lower Devonian brachiopods, lamellibranchs, polyzoa and crinoid columnals. At the top of the Eldon Group is a sequence of 1,400 feet of interbedded siliceous turbidite sandstone and shale, known as the Bell Shale, which contains a shelly fauna, trilobites, corals and transported fragments of land plants. The marine fossils indicate a Lower Devonian age. The proportion of mudstone to sandstone in the Bell Shale increases from Zeehan to the SE indicating a NW land source for these deposits as well as the Crotty Quartzite. In general, the coarser sedimentary rocks of the Eldon Group appear to have accumulated in a well-worked area in shallow seas. The finer material was deposited in quieter waters and perhaps reflects relative changes in sea levels and elevations of the probable NW land source areas. During the accumulation of the Bell Shale, sand was deposited by turbidity currents interrupting the normal deposition of mud.

At Point Hibbs (Banks, 1957) on the W coast occurs a succession of at least 2,000 feet of dominantly sandstone beds with limestone layers containing Devonian fossils. This succession constitutes the Spero Bay Group which rests unconformably on Precambrian and Cambrian rocks.

Underlying extensive areas in NE Tasmania are the Mathinna Beds (Banks, 1962 GT; Williams, 1959; and Marshall *et al.*, 1964) of probably Siluro-Devonian age, consisting of two type of sequences. One sequence was originally of mudstone, as at Bangor where slate has been quarried, and the other of interbedded mudstone and thin turbidite sandstone layers varying considerably in composition. The mudstone sequence is believed to be the older and is of material normal to the basin of deposition, whereas during the accumulation of the younger sequences the deposition was frequently interrupted by the incoming of turbidity currents dumping sand. The sandstone-mudstone sequences have yielded marine fossils including corals, polyzoa, brachiopods and crinoid columnals.

In the Devonport Quadrangle (Burns, 1964) no rocks have been identified as belonging to the Silurian, but quarrying at Eugenana has exposed terrestrial cavern fillings in folded Gordon Limestone, which have been referred to the Devonian. These spelean deposits known as the Eugenana Beds show no tectonic disturbance although the caverns are in folded Gordon Limestone and blocks of tectonically distorted enclosing rock occur within the deposits. Spore analysis of carbonaceous siltstone has indicated flora of the upper Middle Devonian.

TABBERABBERAN OROGENY

The Cambrian sedimentary and volcanic rocks accumulated in an unstable geosynclinal basin, the main form of which developed during early Cambrian times. Significant tectonic movements occurred in the Devonport region during the Cambrian for deposition closed with the formation of megabreccia resulting from fault developments at the trough flanks.

Early Ordovician deposition occurred in shallow basins, usually with steep eastern sides against land masses which had been uplifted in Cambrian times. Deposition continued quietly through the remainder of the Ordovician, Silurian and Lower Devonian times.

The spelean Eugenana Beds contain cleaved distorted blocks of enclosing Gordon Limestone in the Devonport area, although these cave deposits are not themselves tectonically disturbed. It is therefore evident that the rocks of Gordon Limestone and earlier ages and those Lower Devonian beds following the limestone conformably were deformed before the accumulation of the Eugenana Beds in upper Middle Devonian times. This period of deformation, which was very widespread, is known as the Tabberabberan Orogeny (see Carey, 1953; Solomon, 1962 GT).

Tabberabberan anticlinoria and synclinoria extend from the Queenstown-Zeehan region in W Tasmania, where they trend N-S, pass through Waratah, and then become directed E-W approximately parallel to the N coast. Locally obscuring these broad structures are other fold and fault trends, especially near Queenstown, where WNW trending folds and faults occur and posthumous

west side up movement persisted along the Lower Palaeozoic Great Lyell Fault Zone. Between Zeehan and Lake Lea near Cradle Mountain NW trending folds and faults interfere with the larger NNE folds (see Mackintosh Map Sheet, 1967) whereas at Duck Creek and Rosebery E-W folds and faults become important secondary structures. In N Tasmania, E-W and NW trending folds interfere in the Devonport, Middlesex and Sheffield Quadrangles. In NE Tasmania the Tabberabberan Orogeny is represented by NNW trending folds.

LATE DEVONIAN-EARLY CARBONIFEROUS GRANITES

Many granite masses were emplaced in the rocks after the Tabberabberan Orogeny. The commonest is a coarse grey granodiorite, which forms the largest mass in the State at Blue Tier in NE Tasmania, whereas the red potassic granite, as at Coles Bay in E Tasmania and Mt Heemskirk in NW Tasmania, is rather uncommon.

In general, with the exception of a Precambrian granite on King Island and the probably Cambrian granites at Mt Darwin, Murchison and Dove River, the granites of Tasmania appear to be Late Devonian-Early Carboniferous in age (McDougall and Leggo, 1965). They are characterized by cross-cutting relationships with the country rock, fairly sharp margins and narrow metamorphic aureoles, although extensive mineralization is often associated with their emplacement.

PERMIAN SYSTEM

Prolonged erosion of the rocks followed the Tabberabberan Orogeny and continued until Late Carboniferous times. Extensive glaciation of the region followed and many thousands of feet of deposits accumulated with a profound unconformity between them and the underlying distorted older rocks. The Permian deposits consist of fresh water sequences separated by marine, which form the main basis of the grouping of the rocks.

In N Tasmania detailed work near Poatina (McKellar, 1957; see also Wells, 1957) in the Western Tiers of the Great Lake Quadrangle has established a succession with some 340 feet of Stockers Tillitic Conglomerate at the base which includes mudstone lenses. The Quamby Mudstone follows consisting of up to 330 feet of uniform massive dark grey micaceous mudstone with pebbly layers. The correlates of the Quamby Mudstone, particularly in SE Tasmania (Banks, 1962 GT), display characteristics usually taken as typical of this sequence, such as pyrite nodules, glendonites, calcareous nodules and the crumbling nature of outcrops. Marine fossils have been recovered, the most common being fenestellids, ramose stenoporids and *Strophalosia*. The Golden Valley Group, a calcareous sequence, follows the Quamby Mudstone and has been divided into three formations. Some five feet of shelly limestone occurs at the base of the Golden Valley Group containing fossils including *Spirifer* and *Eurydesma*. Some 35 to 45 feet of a richly fossiliferous black micaceous mudstone follows with especially *Fenestella* and *Stenopora*. Overlying is 10-20 feet of calcareous cemented quartz sandstone and conglomerate with a

number of pebbles encrusted by foraminifera (? *Calcitornella*). The top of the Golden Valley Group is represented by 100-120 feet of mudstone with marl layers. The Liffey Group follows and consists of 90-100 feet of quartz sandstone with carbonaceous shale bearing fossil plants indicative of fresh water conditions. The sandstone of this group is usually well-sorted, medium-grained and commonly has worm castings. The succeeding 270 feet of mudstone and occasional limestone layers contain erratics and common marine fossils, and they comprise the "Woodbridge Group" which has been divided into three formations. The following beds have been correlated with the Fern-tree Group and have been divided into six formations which contain marine fossils and consist of 700 feet of mudstone with thin conglomeratic sandstone layers, such as the Garcia Sandstone. At the top of the Permian succession is 140 feet of fresh water shale with abundant plant fragments, the Jackey Shale, which has yielded elsewhere spores and pollen of a probably Late Permian age.

Further W along the Western Tiers and in the Mersey Valley (Jennings, 1963; see also Wells, 1957), all the formations noted at Poatina are present. Added points of interest include a transgression of basal conglomeratic beds as high as the Liffey Group indicating a considerable pre-Permian deposit basement relief, and an oil shale within the Quamby Mudstone, termed "tasmanite", which at Quamby Brook contains a spore assemblage of the oldest Permian epoch which is the Sakmarian. Above the base of the Liffey Group the Permian has a remarkably uniform thickness averaging 1,100 feet.

In the Du Cane Quadrangle (MacLeod *et al.*, 1961) the complete cycle of Permian sedimentation is present along the extension of the Permian outcrop from Poatina. In contrast to the type area the equivalent of the Jackey Shale reaches a thickness of 300-350 feet. The formation consists of predominantly black shale with abundant plant remains and massive arkosic sandstone with coal layers. Spores from the coal measures have indicated a Kungurian to Upper Permian age.

In the Devonport Quadrangle (Burns, 1964) the Permian basal conglomerate may be up to 180 feet thick and contains a characteristic quartz sand matrix. In the overlying Spreyton Beds, which has been considered equivalent to the Quamby Mudstone and the Golden Valley Group, pebbly bands similar to the basal conglomerate occur, but they are found within a dominantly mudstone sequence more than 550 feet thick. At varying heights above the base of the Spreyton Beds is the tasmanite oil shale. Following this sequence, which contains marine gastropods and brachiopods, is the fresh water Mersey Coal Measures. These coal measures, which have been correlated with the Liffey Group of the Western Tiers, are some 62-95 feet thick. At the bottom of the Mersey Coal Measures is a predominantly sandstone layer with conglomeratic and coal bands. Mudstone with coal seams, one of which is up to 2 feet thick, follows. At the top of the Mersey Coal Measures is a thick flaggy bedded sandstone with lenticular mudstone beds. Overlying is the Kecey Tier Beds of mudstone, pebbly mudstone with bands of siltstone, sandstone and in some localities a fossiliferous shelly marl at the base. The Kecey Tier Beds probably represents the correlates of the "Woodbridge" and Fern-tree Groups of the Western Tiers.

To the W of the Devonport Quadrangle at Wynyard the basal Permian beds include tillite with varved claystone members and cross-bedded ripple marked sandstone and conglomerate which constitute the Wynyard Tillite, more than 1,900 feet thick. Fossiliferous horizons low in the Wynyard Tillite have yielded plant fragments of a Late Carboniferous age (Gulline, 1967). Permian Sakmarian fossil spores have been recovered from beds immediately overlying the Wynyard Tillite.

In S Tasmania (Banks, 1962 GT) basal deposits near Maydena are represented by tillite, containing fragments of stenoporids, fenestellids, spiriferids and crinoid plates. Following is a predominantly glendonitic, pyritic mudstone, correlated with the Quamby Mudstone, which has been divided into the seven formations recognized on Woody Island, near Bruny Island. The calcareous sequence following has been considered the equivalent of the Golden Valley Group and is represented at the base by the Darlington Limestone. The limestone is richly fossiliferous with foraminifera, brachiopods, lamellibranchs and gastropods common, and it often contains layers of *Eurydesma*-calcirudite. To the N and NW of Maria Island the limestone is of finer size of grain and is represented by a polyzoal siltstone. The Darlington Limestone is usually followed by the Bundella Mudstone which contains erratics and pebbly layers and with polyzoa fossils common. In the Hobart area the dominantly fresh water Faulkner Group overlies the correlates of the Golden Valley Group and has been divided into seven formations. This sequence is of well-sorted micaceous sandstone, often cross-bedded or ripple marked, which is either unfossiliferous or with worm castings, plant fragments and carbonaceous siltstone. At Hobart and at equivalent horizons in such localities as Maria Island marine intercalations occur. The Faulkner Group with the overlying Rayner Sandstone has been considered to be approximately the equivalent of the Liffey Group and the Mersey Coal Measures of N Tasmania. The Rayner Sandstone of the Hobart area is followed by the Cascade Group which consists of the Nassau Siltstone at bottom, the Berriedale Limestone, and the Grange Mudstone at the top. This group has been correlated with a part of the lowest formation of the "Woodbridge Group" in N Tasmania. The dominant rock types of the Cascade Group are fossiliferous siltstone, calcareous siltstone and limestone, but fossiliferous sandstone and metabentonite also occur. The limestone layers are clastic and mainly of shell material, and they contain such fossils as productids, fenestellids and thin ramose stenoporids. Overlying the Cascade Group is the Malbina Siltstone and Sandstone which at Hobart consists of interbedded sandstone, containing spiriferids, lamellibranchs and gastropods, and carbonaceous or unfossiliferous siltstone. At the top of this formation is fossiliferous sandstone with limestone lenses. The Malbina Siltstone and Sandstone has been regarded as equivalent to parts of the "Woodbridge Group" at the Western Tiers. The Ferntree Mudstone follows with a characteristic, basal, poorly sorted, pebbly, feldspathic sandstone—the Risdon Sandstone—which has been considered to be equivalent to the Garcia Sandstone near Poatina in the Western Tiers. Above the Risdon Sandstone is a predominantly siltstone sequence which includes several coarse sandstone layers. Both erratics and marine fossils occur but are uncommon. Overlying the Ferntree Mudstone is the Cygnet Coal Measures which is at the top of the

Permian. This formation contains Permian plant fragments and has been considered the equivalent of the Jackey Shale. It is predominantly of well-sorted, usually pebbly, cross-bedded, ripple marked, siliceous sandstone but feldspathic sandstone occurs. Carbonaceous and siliceous siltstone are common. A maximum thickness of 350 feet occurs in the Pelion Range and at Mt La Perouse, S of Hobart, where thin coal seams are found. Coal seams are also present at Bruny Island and Cygnet. This fresh water sequence has at many localities yielded spores indicating a Kungurian to Upper Permian age.

In NE Tasmania the Permian rocks of the Rossarden-Storys Creek district (Blissett, 1959) rest with a marked unconformity upon the local granite and Mathinna Beds. The basal unit is the Aberfoyle Formation, 150 feet thick, which is a rudaceous and arenaceous sequence, particularly at the base. The Castle Carey Mudstone of some 120 feet in thickness follows with marine fossils in the upper layers. Overlying is the Burnt Gully Limestone, 10 feet thick, a dark grey limestone containing productids, spiriferids and polyzoa. The Burnt Gully Limestone is probably equivalent to the Berriedale Limestone at Hobart. The following beds are of the 40 feet thick Mistletoe Sandstone, which consists of sandstone, pebbly grit and gritty mudstone with marine fossils. The Prospect Creek Mudstone, more than 200 feet thick, completes the Permian succession in this area.

Although regionally the Permian rocks may be regarded as flat-lying, shallow domes and basins have been reported (Banks, 1962 GT).

TRIASSIC SYSTEM

Up to 2,000 feet of rocks represent the fresh water lake and river sedimentary deposits of Triassic times (Hale, 1962 GT). East of a line between Ida Bay, in southern Tasmania, and Poatina in the Western Tiers a disconformity occurs between rocks of the Permian and Triassic Systems. The discordance may be marked by either Permian boulders occurring in the basal Triassic conglomerate or by differences in attitude of the beds. Further E, towards the E coast, Triassic rocks rest directly on Devonian granite. To the W of the Ida Bay-Poatina line continuous deposition occurs between concordant Permian and Triassic deposits, for similar conglomerate horizons occur within the sequence of both Systems.

Commonly, the base of the Triassic sequence is represented by up to 50 feet of granule conglomerate and quartzose sandstone with usually an argillaceous cement. Large scale current-bedding, indicative of a shallow water environment of deposition, shows in many cases a supply of material from the W and NW.

The lowermost 200-1,350 feet of the Triassic succession is dominated by well-sorted, medium-grained, grey, quartzose sandstone, usually clean in that it has but little cement. The lower sandstone sequences weather yellow and brown in colour, and contain lenticular beds of conglomerate, some of rounded quartzite pebbles and others of clay pellets, mudstone bands, carbonaceous lenses and mica-rich layers. Shallow water sedimentary structures are common and include large-scale current-bedding and mud cracks.

Quartz sandstone, typical of the lower Triassic sequences, has been considered characteristic of the Ross Sandstone (Hills, 1922; Jennings, 1955; McKellar, 1957).

The upper part of Triassic sections is often represented by some 60-600 feet of clean sandstone consisting of rock fragments, including those of volcanic origin, as well as of quartz, feldspar and mica, and the beds have been termed the "Feldspathic Sandstones" (see Banks, 1952; Jennings, 1955). However, at St Marys in NE Tasmania, similar sandstone occurs near the base of the Triassic succession. Often thick shale and coal horizons are associated with these sandstone sequences.

Shale horizons occur throughout the Triassic column (Hale, 1962 GT) and are dark grey, weathering to a variety of colours and a spotted appearance. On exposure the shale characteristically crumbles rapidly. Sequences of finer grained beds have been considered to occur between the Ross Sandstone and the "Feldspathic Sandstones", and have been termed the Knocklofty Sandstones and Shales (Hills and Carey, 1949; Jennings, 1955). However the stratigraphic position of these sequences is in doubt (Hale, 1962 GT).

Transported carbonaceous material, admixed with much inorganic material, was deposited in a number of small lakes which varied in their position from time to time, and resulted in the formation of coal seams of very variable thickness and persistence. The thickest recorded coal seam is 18 feet and as many as eight seams occur in some districts. The coal is of economic interest and has been mined in such areas as Fingal, St Marys and Langloh.

Abundant fossils have been recorded, which include the remains of plants (Townrow, 1962 GT), vertebrates, insects and brachiopods. Studies of megaspores have revealed (Dettmann, 1961) that deposits at St Marys are not older than Rhaetic, the uppermost Triassic division, and that passage deposits to Lower Jurassic-Liassic times exist.

JURASSIC DOLERITE INTRUSIONS

A thick mass of dolerite underlies the Central Plateau and caps most of the highest mountains in Tasmania (Spry, 1962 GT). It consists of interconnected sheets of about 1,500 feet thick, which are usually sill-like. The dolerite has intruded through Triassic and older rocks and appears to be of one period of igneous activity. It has been dated at 165 m. years, which is the Middle Jurassic period.

The dolerite belongs to the tholeiitic quartz dolerite association, and the composition of the chilled contacts of a number of sheets with the country rock has indicated that the original undifferentiated magma was remarkably uniform (McDougall, 1962). Away from the contacts the bulk of the dolerite is medium-grained but coarse pegmatitic segregations are found within several hundred feet of the upper margins of the intrusions. Associated with these basic igneous rocks are quartz and potassic feldspar acid differentiates, such as the granophyre in the Great Lake Quadrangle and at Red Hill in the Kingborough Quadrangle.

The dolerite appears as inclined sheets dipping at about 40° below the Permian rocks, whereas in the Permian beds dips are at 25° or less and are as little as 10° within the Triassic beds.

CRETACEOUS ALKALINE INTRUSIONS

Syenite masses and related dykes intrude the Jurassic dolerite and Permian sedimentary rocks near Port Cygnet in the Kingborough Quadrangle (Edwards, 1947; Leaman and Naqvi, 1967). The rocks have been dated at 100 m. years, of the Middle Cretaceous period.

TERTIARY PERIOD

Towards the end of the Mesozoic Tasmania was a part of the Australian continent and had a low relief. At the end of Mesozoic times or at the beginning of the Tertiary, when marsupial animals and flowering plants appeared, block faulting isolated Tasmania and formed troughs of a trend commonly between NW and N in which are preserved thick sequences of non-marine Cainozoic rocks. Faulting activity has continued into historical times.

The separation of Tasmania from the Australian mainland is believed to have been completed by Oligocene times for this is indicated by the ages of the coastal occurrences of marine limestone in NW Tasmania from Granville Harbour to Wynyard, on King Island and in the Furneaux Group (Banks, 1962 GT). Near Marrawah the marine limestone horizons have yielded fossils of Upper Oligocene and Miocene ages, and a fauna of Upper Oligocene age has been obtained from calcareous rocks at Fossil Bluff in the Wynyard district. These calcareous beds, which grade downwards into basal Tertiary sandstone, have yielded remains of the oldest known Australian marsupial.

Thick non-marine Tertiary sequences (Gill, 1962 GT) have been preserved in a number of troughs, and dating has depended on palynological evidence for although plant remains are common and varied animal remains are rare. In the Launceston area some 900 feet of clay, sand and gravel with bands of lignite occur, and the earliest fossils recovered are of Eocene-Paleocene age. The trough is believed to have been filled over a long period of time under predominantly shallow water conditions since large-scale current bedding and other shallow water features occur (Longman, 1966). In the Derwent trough hundreds of feet of clay, silt, sandstone and coarser rocks have been reported interlayered with basalt and palynological evidence suggests deposition started, in the main, in post-Eocene times. In the Macquarie Harbour trough over 700 feet of clay, lignite, silt and unconsolidated sand and conglomerate occur. The presence of the sediments in some localities in the Macquarie Harbour area at 1,000-1,200 feet above sea level suggests considerable later fault movement.

Basalt (Banks, 1962 GT) is extensive and Tertiary clay, silt, sand and gravel are often beneath. At both Cape Grim and Doctors Rock basalt horizons underlie and overlie deposits of Upper Oligocene age.

QUATERNARY PERIOD

During Pleistocene times (Davies, 1962 GT) plateau glaciers occurred on the NW part of the Central Plateau, on the West Coast Range, between Drys Bluff and Great Lake, between Great Lake and Bradys Lookout, on Ben Lomond, and on the King William Range. At the head of the Linda Valley wood found in varves has given a radiocarbon date of $26,480 \pm 800$ years. Glaciers also originated in cirques, especially at Frenchmans Cap, Mt Anne, Mt La Perouse, Federation Peak and the Frankland and Arthur Ranges. The results of glaciation and periglacial activities have been noted in the soils and land forms above the 2,000 feet contour, whereas below, particularly in SE Tasmania, the development of the valleys with their sediment infilling, which is far too large to be attributed to the streams they contain, has been related to pluvial times, when greater volumes of water may have been carried by the valleys.

The block faulted Jurassic dolerite and Permo-Triassic rocks comprise flat-topped residual landforms. However, at least five major erosion surfaces have been recognized (Davies, 1962 GT). The youngest, which is the Lower Coastal Surface at about 300-900 feet above sea level, truncates early Miocene sediment, but is overlain in places by late Pleistocene deposits. The oldest surface was considered to be the Higher Plateau of some 3,900-4,400 feet above sea level.

MINERALIZATION

Economically important deposits such as the tin at Renison Bell and Mt Bischoff are associated with Upper Precambrian-Lower Cambrian dolomite and adjacent quartz sandstone. Near Queens-town the Mt Read Volcanics, which may in part be Lower Cambrian and in part equivalent to Middle Cambrian in age, has been an important host to copper mineralization. An interesting Upper Cambrian deposit of conglomerate, sand and silt of serpentinite material contains placer deposits of chromite and osmiridium.

After the Tabberabberan Orogeny, which occurred before the Middle Devonian, many granitic masses were emplaced in Upper Devonian-Lower Carboniferous times. Extensive mineralization is associated with the granite. At King Island, introduction of material into the metamorphic aureole of a granodiorite body has resulted in scheelite occurrences within originally impure limestone and mudstone of (?) Precambrian age. Cassiterite-wolfra-mite vein systems are related to granite intrusions in the Aberfoyle and Storys Creek district in NE Tasmania. Tin-bearing sulphide bodies occur in association at Mt Bischoff, Renison Bell and Mt Cleveland in W Tasmania. Galena-sphalerite lodes in the Zeehan and Dundas areas of W Tasmania and in the Round Mount area near Sheffield in N Tasmania appear to be related to granite intrusions. Cassiterite occurs within the granite at Blue Tier. The gold-quartz reefs occurring in the Palaeozoic rocks at Beaconsfield in the N and Lefroy and Mathinna in the NE are not obviously associated with granite.

Sub-basalt sediments of Tertiary times together with the river deposits of more recent times may contain detrital gold and tin minerals of economic interest as in NE Tasmania.

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THE MINING INDUSTRY

by I. B. Jennings and A. J. Noldart.

INTRODUCTION

The information in this section and the following one on the Mineral Deposits has been drawn from a variety of sources, mainly previously published reports of the Department of Mines, especially the Annual Reports, and grateful acknowledgement is made to contributions by the authors' colleagues, past and present. It is realized that some of the records of the early days are incomplete, but all care has been taken to check the accuracy of statements.

HISTORY

The first record of mineral discovery in Tasmania is that of La Billardiere in 1793 who noted the presence of thin seams of coal in the hills lying inland behind South Cape and South East Cape. It seems that La Billardiere's discovery was also the first record of coal anywhere in Australia.

The mining industry of Tasmania began with the mining of coal on Tasman Peninsula near Saltwater River in 1834 by convict labour and this mine continued in operation until about 1847. By this time numerous other coal mines had been opened up in other parts of the State, such as Southport and the Coal River District. In 1886 coal was discovered in the Fingal Valley and since that time this has been the most important producing locality in Tasmania. Coal production greatly increased to a maximum of 299,368 tons in 1959, but since that time, due to competition from oil, it has decreased. In 1850 coal was discovered in the Mersey Valley District near Latrobe and small quantities of coal from this area were produced intermittently until recent times.

Another early product was Triassic sandstone which was used widely for building purposes, and the numerous old buildings, bridges, and houses which still exist are a tribute to the durability and attractiveness of this stone. The use of limestone also began in the very early days of settlement. For a long time the main use was burnt lime for mortar, but over the years a diversity of limestone products have been produced. From 1918 to 1947 the Broken Hill Company obtained limestone for their Newcastle works from Melrose. The peak production was 300,000 tons in 1939. Today, the Goliath Portland Cement Company, which mines about 275,000 tons per annum of limestone for the manufacture of cement at Railton, is by far the largest producer.

The discovery of gold near Mangana in 1852 was the beginning of extensive mineral exploration and development. At first most of the gold won was from alluvial fields in the Lisle district, where an estimated 75,000 ounces of gold were obtained between 1866 and 1890. However, in 1877 Tasmania's richest gold mine, the Tasmania Mine at Beaconsfield, was discovered and from then

until its closure in 1914 it produced 854,600 ounces of gold. The discovery of gold stimulated widespread prospecting and resulted in the discovery of further gold fields in NE Tasmania and other mineral deposits in the NW and W.

The discovery of tin at Mt Bischoff by "Philosopher" Smith in 1871 stimulated prospecting in the NW and W parts of the State, which resulted in the discovery of tin at Mt Heemskirk in 1876, silver-lead near Mt Zeehan in 1882 and first gold and later copper at Mt Lyell in 1883. Following the discovery of Mt Bischoff a company was formed and after a slow beginning the first dividend was paid in 1878. Approximately 57,800 tons of tin have been produced from the Mt Bischoff mine and it was, for many years, the largest tin mine in the world.

Meanwhile in NE Tasmania alluvial tin was discovered in 1874 and by the turn of the century many alluvial tin mines were scattered through the St Helens, Weldborough, Blue Tier, Gladstone and Branxholm districts. At Blue Tier sluicing of alluvial deposits disclosed tin-bearing granite and several lode mines, the principal being the Anchor mine, were operated in the early days of this century.

In 1882 silver-lead ore was discovered at Zeehan, but the field was not developed until 1887-88. By 1891 more than 150 companies held leases in the Zeehan field, and exploration had extended outwards to the neighbouring Dundas field. The discovery of the Zeehan silver-lead lodes coincided with the great Australian silver boom and the ores were exploited primarily for their silver content. In 1894 the value of silver produced in the State, principally from the Zeehan and Dundas fields, reached almost \$600,000. After this time the price of silver declined and it was not until 1950 that the silver production for the State again reached this figure. Tasmania's richest mine, the Mt Lyell Mine at Queenstown, commenced as a gold mine and passed through a period when silver was the main product, but in 1897 it became an important copper producer, total production of copper from the Mt Lyell mine up till the end of 1966 being 610,685 tons.

The production of zinc in Tasmania commenced in 1919 when 285 tons were produced from ore from the Zeehan field; by 1925 production had commenced from the Electrolytic Zinc Company's mines at Rosebery and Williamsford, and today zinc is second only to copper as the most valuable metalliferous commodity produced.

The production of tungsten from scheelite and wolfram commenced prior to 1899. In 1917 scheelite was first produced from the open cut mine at Grassy, on King Island, although the mineral had been discovered in 1904 in an outcrop on the beach. Wolfram production has accompanied the development of tin mines in the NW and NE of Tasmania. The Shepherd and Murphy mine at Moina produced 242.2 tons up till the time it closed in 1956. The major part of the wolfram production in Tasmania is from the two tin-wolfram mines in the Avoca area: Storeys Creek mine, where wolfram predominates over tin, and the large Aberfoyle mine, where tin is the principal product.

The most spectacular mineral discovery in Tasmania was that of osmiridium, the price of which reached a peak of about \$240 per ounce in 1956. In the early days of this century alluvial gold miners were troubled by a heavy silvery mineral which was difficult to separate from the gold. In about 1910 this mineral was recognized as a natural alloy of osmium and iridium which became very valuable. Production of osmiridium commenced in W Tasmania between Zeehan and Waratah, but in 1925 more extensive deposits in the Adamsfield district were discovered.

Large deposits of iron ore are known in Tasmania, the most important of which occur in the Savage River area. In 1956 the Mines Department in conjunction with the Commonwealth Bureau of Mineral Resources commenced a detailed study of the Savage River deposits which has led to the proving of considerable ore reserves. At present the Savage River deposits are being opened up by Pickands Mather and Co. International with a view to the production of two million tons per annum of iron ore pellets.

Nickel mineralization occurs in association with areas of ultra-basic rocks, mainly in W Tasmania, but the overall grades of the deposits are low and the only recorded production has been from the Five Mile district near Zeehan.

There can be little doubt that sand, gravel and crushed stone were among the first mineral products of the State. The importance of the value to the mining industry of such products is sometimes overlooked. In 1966 the value of the production of sand, gravel, crushed stone and road building materials was \$A6,527,836, slightly more than 12 percent of the total annual value of mineral production in the State. It exceeded the value of all other individual minerals produced with the exception of copper and zinc and was almost double the value of tin production in that year.

MINERAL PRODUCTION

Table 1 gives the quantity and value of all the various minerals and metals that have been produced in Tasmania from 1880 to 1966 inclusive. These figures have been taken from Department of Mines records and are not necessarily complete, particularly for alluvial or detrital deposits worked in the early years of the mineral fields.

From Table 1 can be seen the relative importance of minerals. Those that have a total production exceeding two million dollars include copper, zinc, tin, lead, scheelite, gold, silver, coal, wolfram, limestone, crushed dolerite, pyrite, gravel, cadmium, and sulphur as "sulphuric acid"

Table 2 gives the annual production figures for individual minerals and stone for the year 1966.

TABLE I.

MINERAL PRODUCTION SINCE 1880.

Quantity and Value of Mineral Production as at 31st December, 1966.

<i>Minerals</i>	<i>Total Quantity</i>	<i>Value \$A</i>
METALLIC MINERALS—		
Antimony	(tons) 3	2,034
Bismuth	(tons) 84	59,288
Cadmium	(tons) 1,600	4,473,513
Cobalt Oxide	(tons) 19	34,763
Copper (Blister) to 1918 (now shown under Silver and Copper)	(tons) 166,600	27,577,054
Copper Matte	(tons) 6,227	267,472
Copper Ore to 1918 (now shown under Copper)	(tons) 41,769	1,155,746
Copper (from 1919)	(tons) 466,008	168,010,809
Crocoite	(specimens only)	1,066
Gold	(fine oz.) 2,694,784	33,520,171
Ilmenite	(tons) 550	2,512
Iron Oxide (including Hematite, Limonite and Magnetite)	(tons) 114,288	249,037
Lead (from 1919)	(tons) 376,489	49,013,963
Manganese	(tons) 1	6
Manganese Dioxide (from 1957)	(tons) 2,435	78,022
Monazite	(tons) 33	1,214
Nickel	(tons) 233	81,036
Osmiridium	(oz.) 31,088	1,417,062
Pyrite	(tons) 1,704,897	7,701,984
Rutile	(tons) 1	36
Scheelite	(tons) 22,305	42,823,250
Silica for Silicon Alloy Production	(tons) 15,609	116,664
Silicon as Silicon Alloys	(tons) 1,865	268,560
Silver-Lead Ore to 1918 (now shown under Silver and Lead)	(tons) 1,083,898	12,858,582
Silver from 1919	(fine oz.) 47,264,853	27,196,865
Sulphur as Sulphuric Acid (from 1957)	(mono tons) 407,534	3,940,756
Tin	(tons) 151,048	82,199,357
Wolfram	(tons) 15,932	20,435,372
Zinc	(tons) 836,452	129,134,398
Zinc Sulphate (from 1957)	(tons) 2,613	258,869
NON-METALLIC MINERALS—		
Asbestos	(tons) 3,980	34,284
Barite	(tons) 2,205	16,478
Clay (from 1958)—		
Brick	(cubic yards) 942,717	1,749,815
Tile	(cubic yards) 31,491	36,148
Other	(cubic yards) 177,737	368,377
Dolomite	(tons) 29,446	172,309
Graphite	(tons) 40	214
Kaolin	(tons) 111,086	883,018

<i>Mineral.</i>	<i>Quantity</i>	<i>Value \$A</i>
<i>Non-Metallic Minerals:</i>		
Clay—		
Brick (cubic yards)	106,599	216,853
Tile (cubic yards)	3,765	8,282
Other (cubic yards)	48,584	100,353
Dolomite (tons)	2,606	15,097
Limestone:		
Agricultural (tons)	34,364	77,407
Carbide (tons)	29,218	114,056
Cement (tons)	252,393	494,437
Chemical and Metallurgical (tons)	28,489	88,983
Other (tons)	270	5,670
Ochre (tons)	65	1,008
Pebbles (tons)	895	15,183
Silica (tons)	5,014	10,261
<i>Value of Non-Metallic Minerals</i>	....	1,147,590
<i>Fuel Minerals:</i>		
Coal (tons)	82,664	353,238
<i>Construction Materials:</i>		
Crushed and Broken Stone—		
Basalt (cubic yards)	294,351	537,429
Dolerite (cubic yards)	1,018,180	2,977,616
Limestone (cubic yards)	14,451	35,421
Sandstone (cubic yards)	4,627	6,727
Other (cubic yards)	269,578	651,713
Building Stone—		
Freestone (cubic yards)	757	8,650
Other (cubic yards)	140	300
Gravel (cubic yards)	1,681,381	1,842,479
Sand (cubic yards)	228,559	261,837
Other Road Material (cubic yards)	203,154	214,604
<i>Value of Construction Materials</i>	....	6,536,776
<i>Total value with Australian Metal Prices</i>	....	51,180,693
<i>Metallurgical Production from other than Tasmanian Ores—</i>		
Alumina)		
Aluminium)		
Aluminium Hydrates)		
Aluminium Sulphate)		
Cadmium ..... )	....	72,688,923
Cobalt Oxide)		
Ferro-Manganese)		
Titanium Dioxide)		
Zinc)		
<i>Total value of Mining and Metallurgical Production</i>	....	\$123,869,616

PRESENT STATE OF THE INDUSTRY

The discovery of minerals in Tasmania provided a major lift to the economy which has been sustained ever since. Although many of the early discoveries proved to be minor deposits and some have become exhausted, development of the major fields has increased the value of metal production so that the total value of minerals has continued to rise. Notable among the early fields which are still active are the mines at Mt Lyell, Read-Rosebery and Renison Bell.

Many of the mines which are still active are increasing, or planning to increase production over the next few years, following the discovery of further ore reserves.

In addition to the domestic production of ore, large tonnages of imported ore are treated in Tasmanian plants. Comalco Aluminium (Bell Bay) Ltd. have recently extended plant capacity to 52,000 tons of aluminium annually, using bauxite imported from Weipa. The Australian Titan Products Pty Ltd during 1966 produced over 20,000 tons of titanium oxide from imported rutile and the Tasmanian Electro Metallurgical Company Pty Ltd (Bell Bay) produced over 48,000 tons of ferromanganese from imported ores. The Electrolytic Zinc Company at Risdon produces a significant portion of its zinc from imported ores, together with large quantities of superphosphate from imported phosphate rock.

FUTURE OF THE INDUSTRY

At the present time Tasmania, together with the rest of Australia, is experiencing an unparalleled boom in mineral exploration. At the end of 1966 the following licences and authorities to prospect were in force:—

Exploration Licences	42 in force	The area covered by these is 93,248 square miles
Special Prospector's Licences	16 in force	Covering 132 square miles
Prospector's Licences	124 in force	Covering 6,200 acres
Miner's Rights	99 in force	Covering 50 acres
Authorities to Prospect under Aid to Mining Act 1927	3 in force	Covering 21,220 acres
Permits to Enter and Search on Private Land including Owner's Permission	8 in force	Covering 14,578 acres

Exploration Licences have been issued with respect to oil and natural gas in Bass Strait and on the continental shelves surrounding the State. In addition, companies are also actively engaged in prospecting for phosphates and for tin, gold and associated minerals on the sea floor around the N and NE coasts of Tasmania, off King Island and in Bass Strait. Offshore mineral prospecting requires new and sophisticated techniques and the operations of these companies will have an important impact on the future of the mineral industry in this State.

Onshore all the most modern forms of mineral exploration such as air-borne and ground geophysical surveys, regional and detailed geochemical techniques, geological mapping and diamond drilling are being employed. Almost all of the potential mineral-bearing areas of the State are at present subject to such investigations. In general two methods of approach can be distinguished. One is regional, designed to locate new orebodies away from the main areas of known mineralization, and the other consists of detailed studies around areas of known mineralization. Both of these approaches should ultimately lead to the discovery of additional mineral deposits in the State.

The recent agreement to proceed with the development of the Savage River iron ore deposits has added substantially to the economic growth of Tasmania. In addition to this a substantial increase in production is under way on the tin deposits at Renison Bell, and it is anticipated that other major producers will also increase production in the future. Investigations on the Mt Cleveland tin deposits have proven an economically exploitable orebody and preparations to commence mining operations are in progress.

Prospecting at other known mineral fields such as Mt Bischoff and the Dundas District has indicated ore reserves which may justify exploitation at current metal prices. Tasmania has had a long history of successful tin production and the present high world price for this metal has encouraged prospecting for additional deposits.

The developments at Savage River have placed Tasmania among the iron ore producers of Australia. Continued active prospecting of the known deposits of iron ore in the district is proceeding as well as a search for new iron ore deposits elsewhere in the State.

Huge tonnages of limestone and dolomite situated relatively close to existing transport facilities should ultimately attract interest in these deposits. The present clay-shale deposits suitable for ceramic use are assured of a ready market, and additional reserves of suitable material close to the centres of population are being sought.

The production of coal has been greatly affected by competition from oil, and in the short term the prospects for renewed activity in this field are not bright. However, work is continuing to establish that sufficient reserves of coal are available to justify the establishment of a thermal power station should this prove to be economical.

The production of materials for construction such as gravel, sand and crushed rock increases annually and this trend is expected to continue in the foreseeable future.

Since the very first days of settlement the mineral industry has made a great contribution to the development of Tasmania. In the future this industry will continue to play a dominating role in the economic growth of the State. It can be expected that the existing deposits will be further exploited, that new ore reserves in these deposits will be found, and that new deposits in other areas will be located.

THE MINERAL DEPOSITS

by I. B. Jennings and A. J. Noldart.

GEOGRAPHICAL DISTRIBUTION

Metallic Minerals

The principal metallic deposits are situated in the W, NW, N and NE parts of the State. The W portion contains the copper deposits of Mt Lyell, the lead-zinc and silver deposits of Zeehan, Dundas, Rosebery and Mt Farrell and the tin deposits of Renison Bell. Tin mineralization also occurs at Mt Bischoff, Mt Lindsay, Mt Cleveland, Mt Heemskirk and Dundas in the W; at Moina in the central N and in the Scamander, Blue Tier, Gladstone and Rossarden districts in the NE.

The main gold districts are the Mangana-Mt Victoria-Mt Horror belt in the NE and the Lefroy and Beaconsfield districts in the N.

Tungsten (wolfram) deposits are being worked at Rossarden and Storys Creek in the NE and have been worked at Moina in the central N whilst tungsten (scheelite) deposits are being mined on King Island.

The main osmiridium deposits are in the Heazlewood-Bald Hill-Mt Stewart-Wilson River district and at Dundas in the W of the State, and at Adamsfield in the central S.

Iron ore deposits are located in the Beaconsfield, Blythe River, Highclere and Hampshire districts in the N and at the Savage River, Rocky River and Zeehan districts in the W. An iron ore deposit which may prove of interest is located near Birthday Bay, SW of Macquarie Harbour. Pyrite occurs commonly throughout the W and NW of the State associated with rocks of Cambrian age.

Non-metallic Minerals

Limestone deposits are also widespread in Tasmania, the largest workable deposits being at Flowery Gully, Gunns Plains, Railton and Mole Creek in the N; Gordon River in the W; Ida Bay in the SE. Smaller occurrences of Permian limestone which have locally assumed some importance from time to time are recorded in the Hobart-Bridgewater district and on Maria Island.

Clay and shale suitable for the ceramic industry are available in varying quantity and grade in the vicinity of the main settled areas of the State, as are also the various construction materials such as gravel, crushed stone and sand. However, up to date no large deposits of natural coarse sand have been located in SE Tasmania. Large deposits of dolomite occur in the NW and W of Tasmania, the most accessible being in the Smithton district, but up to date only a small portion of these deposits has been

exploited. Asbestos occurs in association with the ultrabasic rocks throughout the N and W of Tasmania but the only production to date has come from Serpentine Hill, near Renison Bell in the W, with minor amounts from Andersons Creek in the West Tamar district.

Fuel Minerals

Oil shale deposits in the Permian System occur in the N and NW, the main deposits being at Oonah and in the Latrobe district.

Coal deposits are fairly widespread in the State, the major deposits being at Preolenna, Barn Bluff, Mt Pelion and the Mersey district in the N and NW; Fingal, Avoca and Mt Nicholas in the NE; Colebrook, Macquarie Plains, Catamaran and other areas in the SE.

GEOLOGICAL DISTRIBUTION

The geological distribution of mineral deposits in Tasmania is related to distribution of rock types, areas of igneous activity, structural influences, and re-distribution of primary deposits by alluvial processes. Almost the whole of the significant primary mineralization is associated with rocks of pre-Permian age, whilst almost the entire alluvial production comes from rocks of middle Tertiary age.

The extensive dolomite deposits in the Smithton district and other areas are related to rocks of Upper Precambrian-Lower Cambrian age. Extensive deposits of high grade limestone occur in the Ordovician sequences and smaller but useful deposits of lower grade limestone occur in the middle Permian sequence.

The main coal deposits which have been worked in the State occur in the Upper Triassic sequence but some smaller seams have been worked in both the upper and middle Permian sequences.

Primary Deposits

Metallic Minerals

The earliest metallogenic epoch was that associated with the intrusion of basic and ultrabasic rocks of Cambrian age. To this phase is attributed the osmiridium, chromite and nickel occurrences which are found in and associated with these rocks. Some minor copper mineralization associated with Precambrian meta-dolerite is recorded from the NE. The iron ore deposits of the Savage River district may also belong to this group, being associated with sheared amphibolite of probable Cambrian age. However, hydrothermal re-distribution of the iron may have occurred at a later stage.

The porphyries, volcanics and related rocks of middle to late Cambrian age in the W, NW and N are the host rocks for the major mineral deposits of Tasmania.

The genetic relationship between the host rocks and the ore-bodies contained in them is not always clear and there is evidence to suggest that at least some of the deposits may have been formed contemporaneously with these rocks and been subjected to later hydrothermal processes which concentrated and in part re-distributed them in rocks of younger ages.

The most important period of metallogenesis is that associated with the Middle to Upper Devonian granites throughout the State. To this period the main copper, zinc, lead, silver, tin, tungsten, gold, &c. deposits have long been assigned. However, it may well be that during this period metallic deposits, formed during the Cambrian, were re-concentrated and re-distributed. This is particularly so with respect to the copper, silver, lead and zinc ores, but the genetic association of tin and tungsten, and some at least of the gold, with the Devonian granites seems to be assured.

A third and minor period of metallogenesis is associated with the Port Cygnet Alkaline Intrusives of Cretaceous age and is responsible for minor gold occurrences in the Cygnet district.

Non-metallic Minerals

Huge deposits of limestone occur in Tasmania, the most important of which is the Gordon Limestone, of Ordovician age, which reaches a maximum thickness of about 5,000 feet in the Florentine Valley. This formation contains considerable thicknesses of high grade limestone and is widely distributed throughout the State. Smaller but nevertheless important limestone beds occur in the Permian sequence, the lowest unit being the Darlington Limestone and its correlates. The next is the Berriedale Limestone and its correlates and the highest is the lenticular limestone in the "Woodbridge Glacial Formation". The overall grade of the Permian limestone is usually lower than that of the Ordovician rock but it is satisfactory for the production of agricultural lime and for cement, especially as many of the deposits are situated close to settled areas.

Cainozoic limestone, lime sand, and calcareous aeolianite occur in several areas of Tasmania and on the islands in Bass Strait. Locally, they may be significant as a source of lime, for example at Pulbeena in the Smithton district. Recent lime sands are being exploited for agricultural purposes.

Dolomite of possibly late Precambrian age occurs at Smithton, Cam River, Tim Shea, Hastings and at other places in the W portion of the State. Many of these deposits are inaccessible and occupy low-lying areas rendering quarrying difficult. Widespread deposits at Smithton have been worked in the past and offer the most promise for future development. Clay for ceramic uses is derived from the Tertiary freshwater sediments in the Launceston district, from crushed Triassic shale in the Hobart area and from weathered Precambrian dolerite at Cooe. At Wynyard Quaternary clay is being used for brick production and weathered Permian varved clay offers a further source of supply.

Asbestos veinlets occur fairly commonly throughout the Cambrian serpentinite but the only deposits which have so far been exploited are at Argent Hill in the W and at Andersons Creek near Beaconsfield in the N.

Fuel Minerals

Coal seams occur in the Mersey Coal Measures of Middle Permian age and at the top of the Permian succession in the Cygnet Coal Measures. They also occur in the upper part of the Triassic

sequence. Of these, the Triassic has yielded by far the largest quantity of coal produced in the State. Brown coal and lignite occur in the Tertiary sequences at various points in the State but so far they have not proved to be of economic importance.

Extensive deposits of oil shale (tasmanite) occur in the lower Permian beds in the N and NW of the State. The oil shale is associated with marine sandstone and is considered to be derived from shore-line accumulations of marine algal spores.

Secondary Deposits

With the exception of minor accumulations of tin in the basal Permian beds at Roys Hill in the NE and an important osmiridium and chromite bearing placer deposit of Lower Ordovician age at Adamsfield all the secondary deposits occur in rocks of Cainozoic age.

Tertiary sediments in the mining districts often contain minerals such as gold, tin and osmiridium. In many cases they are overlain by basalt and form systems of deep leads, the most important being that of the Ringarooma valley which contains the important tin deposits worked in the Arba, Briseis, Echo, Pioneer and other mines. The leads of the George and Mussel Roe rivers are also tin bearing. Deep leads at Lefroy and Back Creek contain gold, whilst those at Bald Hill contain osmiridium. In many cases where erosion has intersected the Tertiary lead systems later alluvial deposits have been formed containing re-cycled minerals from the earlier deposits.

Alluvial deposits along the present streams frequently contain valuable minerals which have been exploited. Those of the NE and in the W at Heemskirk, Stanley River and Waratah River have been worked for cassiterite. At Lisle, Mangana, Mathinna, Alberton, Lefroy, Corinna and Queenstown they have been worked for gold. Osmiridium has been obtained from recent alluvial deposits at Bald Hill, Nineteen Mile Creek, Savage River, Wilson River and Adamsfield.

Quaternary gravel and sand deposits in the N part of the State form an important source of construction materials in that area. At Beaconsfield Recent talus deposits flanking hills of Ordovician quartzite are used as a source of metallurgical grade silica, and high grade silica deposits occur elsewhere at many places in the State. In the South Arm district of SE Tasmania ample supplies of Recent wind-blown sand are used for building purposes and for the manufacture of glass.

Metallic Minerals

ALUMINIUM

Although the production of aluminium is an important part of the State's economy, none of this production comes from locally produced bauxite.

Bauxite deposits are known in several localities in Tasmania, but the overall grade is generally lower than that of imported ore. Known reserves total a little less than one million tons of bauxite containing on the average about 41 per cent of total aluminium.

Bauxite occurs as the remnants of ferruginous pisolitic laterite developed on dolerite and basalt preserved in down-faulted blocks within Tertiary grabens. The deposits appear to range in age from middle to late Tertiary.

The largest deposits are in the Ouse district, some 45 miles NW of Hobart, where about 500,000 tons of bauxite containing 41 per cent total aluminium is available. These deposits are developed over a Jurassic dolerite sill and underlie Tertiary basalt and fresh-water sediments. At Myalla in the NW about 180,000 tons of bauxite of variable grade occurs in laterite developed over Tertiary basalt flows. In the St Leonards district, near Launceston, detailed sampling has indicated 86,500 cubic yards of bauxite assaying 40.7 per cent Al_2O_3 and 26.3 per cent Fe_2O_3 , overlain by 160,800 cubic yards of overburden, mainly clay, sand, pebbles and sandy clay. The economic bauxite ranges in thickness from 5.0 to 8.5 feet and averages 5.25 feet, whilst the overburden ranges from a few inches to 19.5 feet and averages 9.0 feet in thickness.

The total reserves in the St Leonards district have been estimated at 160,500 tons of dry ore assaying 41.5 per cent Al_2O_3 , overlain by 198,000 cubic yards of overburden.

Small deposits of bauxite also occur in the Campbell Town and Conara districts. The deposits occur as earthy and clayey material in layers of up to 7.0 feet in thickness underlying a thin covering of highly ferruginous lateritic gravel, and more rarely as gibbsitic nodules embedded in clay. The deposits are derived from weathered volcanics. Grade of the deposits is variable with an average of approximately 33 per cent to 36 per cent Al_2O_3 and 2 per cent to 5 per cent SiO_2 .

ANTIMONY

Antimony minerals are widespread throughout the sulphide mineral zones, being particularly associated with lead in the sulphide bodies at Zeehan and Ringville. However, no production of antimony has occurred in the State, except for a small parcel of low grade ore from the Port Davey district in SW Tasmania. Apart from the small stibnite body in the Port Davey area, the principal antimonial sulphides occurring in Tasmania are jamesonite ($2\text{PbS}\cdot\text{Sb}_2\text{S}_3$) bournonite ($2\text{PbS}\cdot\text{Cu}\cdot\text{Sb}_2\text{S}_3$) and tetrahedrite

($3\text{Cu}_2\text{S}\cdot\text{Sb}_2\text{S}_3$). Jamesonite is present in many of the lead-zinc ores, particularly in such fields as Rosebery, Mt Read, NE Dundas and Zeehan. Apart from the NE Dundas field the amount of mineral is too small to be of economic importance. At Dundas, however, there are at least two lodes of jamesonite which appear to offer possibilities for exploration. Bournonite is present in the lead lodes of Zeehan and the zinc-lead ores of Rosebery, but not in commercial quantities. However, electrolytic residues containing antimony from Rosebery as well as from Broken Hill are sent to Port Pirie from the Electrolytic Zinc Company's works at Risdon for further treatment. Tetrahedrite is also present in the Rosebery ores, in the NE Dundas field, and in some of the Zeehan lodes, and the presence of appreciable quantities of these complex sulphides at depth contributed to the closure of some of the Zeehan mines.

ARSENIC

Arsenopyrite occurs fairly commonly as an accessory mineral in many of the ore deposits of Tasmania but nowhere in sufficient quantities to warrant the extraction of arsenic.

At Mt Horror in the NE arsenopyrite with a little chalcopyrite and pyrite occurs in quartz lodes several chains long and up to 8 feet wide. Selected ore contains about 30 per cent arsenic but the quantity of such ore available is small and the average grade of ore contains 3-10 per cent arsenic.

In the Scamander district an orebody has been reported to contain arsenopyrite and pyrite together with quartz and a little tin.

At the Razorback and Frazer mines, Dundas, and at other mines in this district arsenopyrite is a fairly common accessory mineral with cassiterite-sulphide orebodies. It is usually associated with pyrrhotite, chalcopyrite and quartz and has been worked at the Frazer Creek mine where it is reported that ore containing 170 tons of arsenic was shipped to Victoria in 1919. A selected sample of ore from the Razorback mine is reported to have contained 20.93 per cent arsenic.

BERYLLIUM

There is no recorded production of beryllium from Tasmania, although it has been reported from several localities. A pegmatite dyke near the Great Republic tin mine in the Ben Lomond district is reported to have carried large well-formed crystals of beryl with individual crystals up to 10 inches in length. At the Shepherd and Murphy mine, Moina, small slender crystals of beryl have been recorded in the gangue of the tin-wolfram ore, intermixed with quartz, topaz and molybdenum. Beryl crystals were also reported from Sayers mine in the Moina district. Some small occurrences were recorded from quartz veins at Mt Bischoff.

BISMUTH

The only production of bismuth in Tasmania has been from mines in the Moina district and a total of 84 tons has been produced to date, most coming from the Shepherd and Murphy mine (later known as the Moina tungsten-tin mine), which has supplied 71.3 tons of metallic bismuth. The bismuth ores generally do not occur as bismuth lodes, but as accessory minerals in the tin and wolfram lodes at the Shepherd and Murphy and the neighbouring All Nations mine and as bismuthinite and bismutite in the Shepherd and Murphy, Squib and Premier mines. At the Stormont bismuth mine about three miles W of Moina on the Lea River a bismuth orebody was worked during the early 1930s. Bismuthinite is reported to be the principal mineral with smaller amounts of bismutite and bismite. The orebody is formed within the contact metamorphic zones of the nearby Dolcoath Granite, the ore being disseminated through a "skarn" rock resulting from alteration of Ordovician limestone. Up to date this deposit, which is partly obscured by overlying Tertiary basalt, has been worked only on a small scale, though it is in a favourable structural and mineralogical setting and may well repay further exploration. Small amounts of bismuth ore in association with tin have also been recorded from Mt Ramsay, Mt Heemskirk and N Dundas in the W and from Weldborough in the NE.

CADMIUM

Cadmium is produced from lead-zinc ores from the Rosebery and Williamsford mines in the W of Tasmania and from ore from Broken Hill, New South Wales, as a by product at the Electrolytic Zinc Company's works at Risdon, Hobart. The total production to the end of 1966 from Tasmanian ore was 1,600 tons and the production in 1966 was 75 tons.

CHROMIUM

Chromite deposits occur in several parts of Tasmania associated with the Cambrian ultrabasic rocks. At Adamsfield detrital chromite is frequently associated with the osmiridium, and extensive but low grade alluvial deposits of chromite have been recorded at Montagu Swamp in the far NW. Small but high grade deposits of chromiferous Tertiary gravel overlie serpentinite at Andersons Creek in the Beaconsfield district in N Tasmania. More extensive but low grade residual and alluvial deposits derived from the weathering of serpentinite also occur in the same locality. High grade chromiferous gravel has been reported in the Asbestos Point district S of Macquarie Harbour on the W coast.

COBALT

Cobalt is also produced as a by product from the treatment of lead-zinc ores at the Electrolytic Zinc Company's plant at Risdon, Hobart. The total production of cobalt oxide to 1966 is about 19 tons. Cobalt minerals have been recorded from many parts of Tasmania but no production of cobalt from this source has been recorded. Cobaltite has been recorded in small patches associated with pyrite, galena, and copper ores at the Penguin

silver mine on the NW Coast. Smaltite is also recorded from the same locality and from the Hampshire silver mine in the same district. This mineral also occurs in the N Heemskirk district on the W coast and a vein occurrence of this mineral has been reported from the N Pieman area. Cobalt has also been recorded associated with molybdenite and vanadium in pyritic quartz reefs in Precambrian rocks at Mt Remus on the Central Plateau.

COPPER

Copper deposits are restricted almost entirely to the W and NW districts. The most important copper field is at Mt Lyell on the W coast whilst others occur at Jukes-Darwin, Heazlewood and Balfour in the W and Scamander near the E coast. The copper-nickel deposits at the Five Mile district, Zeehan, are discussed elsewhere under "nickel".

MT LYELL DISTRICT

The copper deposits at Mt Lyell occur in a narrow zone of intermittent copper sulphide mineralization extending for 20 miles from Mt Darwin in the S, to the region of Lake Dora, N of Queens-town.

The Mt Lyell deposits were first worked for gold in 1883 when the Iron Blow was opened up. In the following year sulphide lodes were discovered nearby and the field was recognized as a potential copper producer. In 1898, 42 companies had been formed to exploit the deposits at Mt Lyell. Many of the smaller companies were short-lived and by 1903 the Mount Lyell Mining and Railway Company Limited and the North Mount Lyell Copper Company successfully amalgamated to make one profitable company from two uncertain ventures.

To the end of 1966 the field has produced 609,471 tons of copper. Production for 1966 was 13,944 tons of copper as well as 8,307 ounces of gold and 59,878 ounces of silver.

The main rocks present in the Mt Lyell district are as follow:

Lower Devonian to Silurian: Eldon Group—more than 7,000 feet of alternating sandstone, mudstone and rare limestone.

Ordovician: June Group—1,000 feet of Gordon Limestone; 0-2,500 feet of Owen Conglomerate, comprising lenticular siliceous conglomerates and sandstone; 0-500 feet of Jukes Breccia—talus breccia composed largely of Cambrian volcanic material.

Cambrian: Mt Read Volcanic—10,000? feet of acid to basic sodic and potassic lavas, pyroclastics and laminated siltstone.

Mineralization took place at the close of the Devonian Tabberabberan Orogeny. Ore deposition was controlled by structural channels and the sulphides are generally post-cleavage.

All the economic deposits except the Comstock deposit occur in a 1.4 mile wide strip on the divide between Mt Lyell and Mt Owen.

The orebodies are largely in altered Cambrian volcanics adjacent to the steeply upturned base of the Owen Conglomerate and they form a series of en echelon lenses which extend up to 2,000 feet from the Cambrian-Ordovician contact.

Throughout the mineralized area the Cambrian rocks are altered to sericitic and chloritic schist by recrystallization and hydrothermal alteration. The schist, which varies in texture and composition according to the original composition of the rock and the intensity of alteration, is known locally as the Lyell Schist.

The economic deposits have been divided into the following types of ore:—

- (a) massive pyrite-chalcopyrite,
- (b) disseminated pyrite-chalcopyrite,
- (c) chalcopyrite-bornite.

Massive Pyrite-chalcopyrite Ores

These consist of up to 75 per cent pyrite with copper ranging from a trace to about 1 per cent. Principal occurrences are the orebodies at South Lyell and the Big Blow. The South Lyell orebody is low in copper and was originally mined to provide flux for the siliceous ores from North Lyell. The Big Blow orebody differs from it mainly in that it contains more chalcopyrite and more than 0.5 per cent copper. This orebody was worked by both underground and open-cut methods between 1897 and 1922 and yielded 5,497,000 tons of ore which contained 1.28 per cent copper, 2.6 oz/ton silver, 0.65 oz/ton gold. The ore consisted mainly of pyrite but chalcopyrite was important in the upper levels, along with enargite, tetrahedrite, bornite, chalcocite and a little galena and sphalerite.

Disseminated Pyrite-chalcopyrite Ores

These ores differ from the massive type in that the mineralization is weaker, with the total sulphide content varying between 5 per cent and 35 per cent. The chief orebodies are those in the West Lyell Open Cut, Royal Tharsis and Comstock. They are elongated along the cleavage but generally dip slightly more steeply than it.

The West Lyell Open Cut includes an echeloned series of ore lenses which strike nearly W parallel to the foliation, dip steeply and pitch at about 90°. They vary in grade from over 1 per cent to less than 0.5 per cent copper, contain 6-20 per cent pyrite and occur in both quartz-sericite and quartz-chlorite schists. The schist shows coarse compositional banding, and in places remnants of volcanic breccia (?), shale and feldspar porphyry have been recognized.

Annual production from the West Lyell Open Cut is approximately 2,000,000 tons of ore containing about 0.7 per cent copper. Other similar disseminated chalcopyrite orebodies are the Royal Tharsis, the Comstock and the No. 1 Crown Lyell. The Comstock orebodies consist of four lenses arranged in vertical echelon dipping north-westerly. The ore lenses extend from the surface at 1,700 feet to below 700 feet. The top two have been mined out and a

third is partly mined but the fourth is virtually unmined. Minerals in the Comstock orebodies include chalcopyrite, pyrite and a little bornite whilst Edwards (1939) recorded magnetite, galena and free gold. When mining ceased in 1944 about 400,000 tons of developed ore valuing about 2.2 per cent copper remained.

Chalcopyrite-bornite Ores

Ores of this type occur mainly in the North Lyell area, partly in the North Lyell fault zone and partly in the Tharsis schist zone. The North Lyell ores proved to be the richest in the Mount Lyell field and averaged 5.4 per cent copper and yielded 4,642,860 tons of ore up to 1953 when production ceased. Mining recommenced in 1959 and in 1963 reserves of approximately 100,000 tons of 6 per cent copper ore were known to remain.

The orebodies strike approximately NW and they are irregular in shape and difficult to prospect. Original discoveries proved to be steep pipes but orebodies in the North Lyell fault zone were found to be very irregular. The chalcopyrite-bornite ores are very low in pyrite and generally occur in a siliceous gangue. Sulphides other than pyrite, chalcopyrite and bornite are rare but chalcocite, sphalerite, galena, tetrahedrite, enargite and gold have been recorded. Native copper and copper-carbonates have been reported in the fault zones below the surface.

"Copper Clays"

"Copper clays" occur on the E side of the Mt Lyell-Mt Owen divide in the gullies draining into the Linda Valley. Three major deposits, the Blocks, Consuls and King Lyell, were worked between 1895 and 1910 by mining and sluicing. The ore consists mainly of nodular goethite, ramified and replaced by veinlets of native copper and cuprite; clay material and siderite occur in varying amounts. These ores overlie beds of the upper Owen sequence and underlie dark grey siliceous shale of the Gordon Limestone.

JUKES-DARWIN AREA

The Jukes-Darwin field is situated S of Mt Lyell but possesses similar geological features.

The minerals in this area occur in a belt of potash-rich, acid, volcanic rocks which have been altered locally to chloritic schist. The copper generally occurs as chalcopyrite but over much of the area leaching has removed most of the copper leaving iron-rich outcrops. A number of faults occur which displace a N-S zone and are considered to be favourable for lode formation. The sulphide mineralization at Prince Darwin is associated with a zone of hematite and magnetite, some 500 feet long and 150 feet wide, and is exposed to a depth of 250 feet. Copper content about 0.5 per cent copper is indicated together with 2.5 dwt/ton silver and traces of gold. This lode continues at least 1,500 feet further to the S with a similar but more weakly mineralized outcrop. Native copper has been reported in this zone.

Mineralization at the N end of the Jukes-Darwin district consists of chalcopyrite with gold and occurs in chloritic schist associated with fault zones. At Lake Jukes bornite lodes are exposed on a glaciated ridge. They have been poorly prospected in depth and along the strike. A belt of schist extends some 1,500 feet E of the old workings and faulting is present in the area.

MT BALFOUR FIELD

Copper deposits in sediments of probable Upper Precambrian to Lower Cambrian age have been worked in the past in this district. The ore minerals present are chalcopyrite and pyrite in a gangue of quartz, chlorite, sericite and dolomite. The main producers from the field have been the Central mine which has produced 203 tons of ore considered to be valued at \$2,956 and Murray's Reward which produced 6,177 tons of ore valued at \$116,518.

HEAZLEWOOD FIELD

The Heazlewood Field is occupied by intermediate, basic and ultrabasic igneous rocks intruded into Cambrian, Ordovician and Silurian sedimentary rocks. The copper deposits consist of bornite and chalcopyrite in the ultrabasic rocks, probably as segregations. The deposits are small, and the production has been very limited.

SCAMANDER FIELD

A number of small copper occurrences in this district have been prospected and worked on a small scale in the past. The copper orebodies are thought to be associated with shears in the Mathinna Beds not far from Devonian granite intrusions. The only mine from which production is recorded is the Orieco mine which produced a total of 85 tons of metallic copper. Two small orebodies were worked in this mine, the larger one having a strike length of about 170 feet. The vertical extent of mineralization is not known. Primary ore consisted of low grade chalcopyrite and arsenopyrite with quartz but all the production came from the upper levels of the mine where secondary enrichment resulted in higher grade ore.

NORTH DUNDAS AREA

A number of copper-lead-silver deposits were worked in this area between 1891 and 1920. The ores consist of tetrahedrite and chalcopyrite (fahl ore) with jamesonite, arsenopyrite, galena, sphalerite, pyrite and bismuthinite in a gangue of siderite and quartz.

The ores were worked primarily for the silver content of the tetrahedrite and the total reported copper production from the district is about 335 tons. The chief producers were the Ring Valley, SW Curtin-Davis, S Curtin-Davis and Frazer mines whilst small quantities were also produced from the No. 1 Curtin-Davis and Block 302.

OTHER AREAS

Copper production is recorded from the Copper King mine on the Blythe River, Rutherford's mine at Natone, the Oonah and Silver King at Zeehan and from the mining at Rossarden, Rosebery and Williamsford.

Potential copper-tin deposits have been prospected in the Barn Bluff-Mt Pelion district

CROCOITE

Crocoite (lead chromate, $PbCrO_4$) was first discovered in 1895 at the Heazlewood mine in the NW. Since then specimens of it have been distributed as collectors' items to mineral collectors throughout the world. Occurrences in the Whyte River and Magnet mines in the NW and in several mines in the Dundas area in the W, notably the Adelaide, Dundas Extended and West Comet, have been exploited for mineral exchanges and specimen purposes. Direct sales of crocoite recorded to date have been worth \$1,066.

GOLD

Gold was the first metallic mineral discovered in Tasmania in payable quantities. The original discovery was made at The Nook near Fingal in 1852 and the first auriferous quartz mine was started in the same district. Prospecting proved gold-bearing quartz veins to be present in the W and N of the State, but the most important deposits have been in the Beaconsfield and Lefroy districts and in a 56 mile belt from Mangana through Mathinna to Lyndhurst in the NE.

BEACONSFIELD GOLDFIELD

The Beaconsfield deposits are centred on the Cabbagetree Hill-Blue Tier Ridge about 26 miles NW of Launceston. The crest of the ridge is composed of Ordovician conglomerate which is overlain conformably by members of the Caroline Creek Sandstone and Gordon Limestone.

The Tasmania reef, discovered in 1877, is the largest auriferous quartz reef in the field. From 1877 till 1914 it produced a total of 854,600 ounces of gold from the treatment of 1,067,556 tons of ore for an average recovery of 16 dwt/ton. The closure of the mine was attributed mainly to excessive water. The reported intake into the mine in 1912 was estimated at about 17,278,000 gallons per week.

The Tasmania reef is a fissure lode striking about 50° and dipping 50° to 60° to the SE emplaced along a pre-existing fault zone. The reef transgresses most members of the Caroline Creek Sandstone but does not enter either the adjacent limestone or conglomerate formations. The orebody plunges to the SE away from cross faults so that below about 600 feet the whole of the orebody lies E of them.

The reef has an overall length of about 1,300 feet and varies from a few inches up to 25 feet in width and has an average width of 6 to 7 feet. Recovery grades were reported as consistent laterally but showed marked variation with depth. They varied from an average of 28 dwt/ton in the upper levels (400 ft) to as low as 2.5 dwt/ton at the 1370 foot level. Grades of about 9 to 13 dwt/ton were reported from the bottom (1,500 ft level). The gold was freemilling to a depth of about 400 feet with increasing amounts of pyrite, chalcopyrite and galena at further depth.

Another system of reefs, the Moonlight-cum-Wonder system, occupies weak fissures in the conglomerate. It was explored to a depth of 800 feet, but economic grades of ore were found to only about 250 feet. These small deposits occur along the length of the Blue Tier-Cabbagetree Hill ridge, but only the more northerly bodies proved to be payable.

Along the E flank of Cabbagetree Hill a deep lead system of probable Tertiary age was located by the mining activities. This lead extends to a depth of at least 440 feet and is known to contain some payable concentrations of gold N of the Tasmania reef outcrop.

LEFROY GOLDFIELD

This field lies in the East Tamar district 27 miles N of Launceston. It was discovered in 1872, and during the life of the field yielded about 172,000 ounces of gold from 168,765 tons of ore. The main production was from the Golden Point, Native Youth, Pinafore and Volunteer lodes.

The field is situated near the western limit of the Mathinna Beds in tightly folded siltstone and claystone which generally strike 330° and dip 30° to 50° W. Some 30 auriferous reefs occur in a broad en echelon pattern in a fault system with a general strike of 50° . They commonly dip S and are cut by two younger fault systems which are also partly filled with barren quartz. The mineralization on this field consists of pyrite, stibnite, chalcopyrite and arsenopyrite with the gold commonly associated with pyrite and stibnite. Surface enrichment appears to have been important as the grade of ore declines sharply from about 1 oz/ton near the surface to less than 2 dwt/ton from about 400 to 1,200 feet in depth, except for occasional isolated patches of pyritic ore containing higher gold values. The smaller ore bodies rarely extended below 100 feet in depth.

NORTH EASTERN GOLDFIELDS

The principal deposits of NE Tasmania occur in a belt about a half mile wide extending NNW-SSE along the trend of the rock foliation from Mangana in the S through the Mathinna, Dan Rivulet, Alberton, Warrentinna, and Forester fields to Lyndhurst on the NE Coast, a distance of about 56 miles.

Gold was first discovered in 1852 and was extensively exploited in this district for the remainder of the century. A gradual decline in production then followed until in the late 1920s the fields were virtually abandoned. There is no production from this area at present.

The rocks consist of folded sandstone, siltstone and shale members of the Mathinna Beds of probable Silurian age which have been intruded both to the E and W of the auriferous belt by Devonian granite. The Mathinna Beds exhibit a foliation trending NNW and dipping steeply SW.

Mineralization consists of gold-bearing quartz reefs occupying planes of foliation, bedding, jointing, &c. The reefs vary in width from a fraction of an inch to some 30 feet, and in length from a few feet to over 1,000 feet. In addition to gold they contain small amounts of pyrite, arsenopyrite, chalcopyrite, sphalerite and galena. Silver is also present being most abundant in the ores from the Forester, Lyndhurst and Gladstone districts.

Production from these fields was in excess of 527,000 fine ounces of gold of which 234,000 ounces were produced from the Golden Gate mine at Mathinna. Retreatment of the battery sand and slimes at the Golden Gate in 1948 has brought the actual value of gold obtained from this mine to over \$A2 million.

The most important alluvial goldfield in Tasmania has been the Lisle field, about 18 miles NE of Launceston, from which it is estimated that approximately 250,000 fine ounces of gold were recovered, most of this in the last century.

WEST COAST DISTRICT

Most of the main ore bodies in the Mt Lyell and Read-Rosebery district were originally worked for gold contained in the gossanous cappings of the sulphide orebodies. In recent years the main production of gold in Tasmania has been as a by product from these ores. Small quantities of gold have also been won from the Savage River and other localities on the W coast.

Production for 1966 was 32,655 fine ounces making a total production of 2,690,784 fine ounces.

IRON

Many deposits of iron ore, both of magnetite and hematite, have been reported from various parts of Tasmania. However, very little development has taken place up to date and the total recorded production is about 111,000 tons of ore. During the last few years there has been a considerable interest in iron ore and this has resulted in renewed exploration of the known deposits, particularly those in the Savage River district. Following airborne and ground magnetometer surveys a diamond drilling programme showed that the deposits in the Savage River area are of sufficient magnitude to justify mining. Other deposits which have been explored during this period include the Tenth Legion deposits near Zeehan and iron ores in the Highclere and Hampshire districts.

WEST COAST DEPOSITS

Savage River Area

Magnetite deposits which straddle the Savage River between Waratah and Corinna constitute the southern, central and northern Savage River deposits: other deposits are known to occur at Long Plains, Rocky River and as far S as the Meredith and Paradise Rivers.

Northerly trending Precambrian rocks consisting of quartzite, sandstone, siltstone, quartz-mica schist, phyllite, chlorite schist, argillite, graphitic and pyritic schist have been named the Whyte Schist. Concordant and discordant magnetite-bearing amphibolite bodies and dykes of igneous origin are aligned in these isoclinally folded, vertical or steep easterly dipping rocks. The Devonian Meredith Granite lies four to five miles E of the occurrences. Alluvial deposits in the creeks in this vicinity carry traces of gold, osmiridium and chromite.

The host rock of the magnetite is a fine grained amphibolite body up to 200 feet wide present at depth in the ore zone over a distance of 3,500 feet. Zones of alteration into "greenschist" and other metamorphosed rocks accompany the mineralization in the central and northern areas. Amphibolite is emplaced as a body up to 4,500 feet wide in the Savage River section but narrows to a dyke less than 500 feet wide in the southern (Long Plains) area. Magnetite in vertical or steeply dipping lodes and zones is associated with amphibolite over a distance of some four miles.

The mineralized zone in the central Savage River area is about 700 feet wide and consists of low, medium and high grade magnetite lodes alternating with variable widths of barren amphibolite. Many of the medium to high grade (more than 40 per cent iron) ore zones are as much as 100 feet or more in width. Mineralization in the northern area is up to 200 feet wide, and continues without decrease to a depth between 600 and 960 feet below the bed of the Savage River.

"Greenschist" zones in amphibolite initially controlled magnetite deposition. Zones of schistosity widen and narrow, separate and merge, along strike and dip to form sheeted and dilation structures in which magnetite replacement is irregular. Magnetite in places is formed at the contact between the amphibolite and meta-sedimentary rock.

Magnetite is the principal ore with hematite (in the form of martite) and limonite in the weathered zone. Combinations of ilmenite-magnetite-rutile intergrowths have been noted. Pyritic material is associated with magnetite and contains traces of bornite, chalcopyrite, chalcocite, covellite and sphalerite. Introduced and recrystallized minerals include quartz, feldspar, calcite, dolomite, chlorite, epidote, apatite, talc, asbestos, tremolite and serpentine. The deposits appear to be of a magmatic hydrothermal replacement type showing mesothermal characteristics.

To an average depth of 400 feet, indicated ore reserves in the Savage River deposits are given as:—

1. Central area—possibly 100 million tons of 37.6 per cent Fe.
2. Northern area—possibly 30 to 40 million tons of medium grade ore.
3. Southern area—possibly 15 million tons of medium grade ore.

Insufficient exploration work has been carried out on the Long Plains and Rocky River deposits to estimate reserves at this stage. However, moderately high reserves of magnetite ore in a similar environment certainly exist.

Zeehan Area

The Tenth Legion deposits in the Zeehan district consist of magnetite associated with an intrusive mass of gabbro and amphibolite, probably of late Cambrian age, which has been partly serpentinized and dolomitized, injected into members of the Onah Quartzite and Slate of Upper Proterozoic-Lower Cambrian age. The basic intrusives and surrounding sediments were later contact metamorphosed by the intrusion of Devonian granite.

The dominant mineral is magnetite with minor amounts of hematite and limonite occurring as irregular lenses or zoned segregations and concentrations in the basic rocks and associated with calc-silicate hornfels. At the surface the ore is pure and massive but diamond drilling indicates a deterioration in grade with depth, probably due to dilution by the unweathered host rocks.

Macquarie Harbour Area

Deposits of iron ore in the Birthday Bay district S of Macquarie Harbour have been known for many years. Recent work has outlined a zone of massive hematite and magnetite mineralization 1,475 feet in length with a maximum width of 170 feet. It is estimated that to a depth of 300 feet, 4,700,000 tons of iron ore are present.

NORTH-WEST DEPOSITS

Magnetite Deposits

Magnetite deposits of probable contact metamorphic origin occur as roof pendants in the Devonian granite E of Hampshire. The orebodies are probably the result of the replacement of favourable carbonate-rich rocks which have been metamorphosed to a garnet-rich skarn rock consisting of clinozoisite, dravite, quartz and a little feldspar.

Mineralization consists predominantly of magnetite with the development of hematite and limonite in the weathered zone. Diamond drilling and magnetometer surveys indicate overall reserves of about 200,000 tons of 45 per cent iron, with a possible 250,000 tons of lower grade material available in smaller lenses and extensions of the larger deposits.

Magnetite-hematite-limonite deposits of the Hampshire type, i.e., metasomatic replacement bodies in the contact metamorphic zone of granite intrusion, occur E of Highclere. The orebodies are generally small, high grade deposits, shallow in depth with larger low grade subsidiary deposits of a more disseminated nature.

The ore reserves are estimated as less than 30,000 tons of 55-60 per cent Fe and about 250,000 tons of ore averaging approximately 30 per cent Fe.

Additional magnetite-hematite deposits are known to occur in the Natone area but these are thought to be somewhat smaller and as yet have not been tested.

Hematite-limonite Deposits

Deposits of mixed hematite and limonite have been known for many years in the Penguin District and on the Blythe River near Cuprona. The ores in the Penguin district are at present being worked on a small scale for use in cement manufacture and the total production from this area to the end of 1966 is about 70,000 tons.

In the Blythe River area siliceous iron ores outcrop boldly over a distance of about 2,100 feet and have a maximum width of 700 feet. The extensions of this orebody to the SW and NE are covered by basalt. The total ore reserves in this district are unknown but are thought to be of the order of a few million tons. Recent drilling in the area indicated an average grade of about 40 per cent Fe and 35 per cent SiO₂.

Hematite deposits associated with the boundary of a Cambrian granite against Lower Palaeozoic-Precambrian sediments are known in the upper Forth Valley a few miles S of Lorinna and have been prospected at the Powerful mine. The orebodies are stated to have a strike length of 700 feet and the width of the deposits is given by various authors as being 8-14 feet, 40-50 feet, or up to 190 feet.

In the vicinity of Stoodley near Railton superficial deposits of limonite of possible Recent age were worked as a source of iron for use in cement manufacture. The deposits are largely exhausted and the total production from this source up to date is 41,416 tons.

BEACONSFIELD DISTRICT

Superficial iron ore deposits with an appreciable chrome content occur near Beaconsfield in the West Tamar district 26 miles from Launceston. These deposits have been exploited on a small scale in the past. The overall reserves are thought to be low and the variable chrome content of the ores has led to difficulty in treatment.

LEAD

Lead production in Tasmania has resulted from the treatment of argentiferous galena-sphalerite ores such as those from Zeehan, Tullah and Magnet, from lead-zinc-copper ores of the Read-Rosebery district, from complex galena-stannite-tetrahedrite ores from the Zeehan district, and from other smaller deposits in the NW part of the State.

Argentiferous galena occurs largely in the W and NW areas of the State. The Zeehan field in the past was the most important producer, the principal mines being the Zeehan-Montana, British Zeehan, Oonah, Zeehan Queen, Mount Zeehan, Silver King, Zeehan Western, Florence, Silver Queen Extended, and South Comstock. The field contained numerous rich lodes, the chief economic mineral being galena which assayed about 70 oz/ton silver and 70 per cent lead. The total production of the Zeehan field up to 1926 was approximately 5,000,000 tons of argentiferous galena and since that date there has been further production of 17,350 tons mainly from the Oceana Mine.

The ore types range in zones about the Heemskirk Granite with stanniferous ores closest to the granite and lead away from it. The lead ores can be further zoned with galena-sphalerite-pyrite ores in a quartz gangue in the inner zone, and galena-tetrahedrite-pyrite-sphalerite in a siderite gangue in the outer zone.

Most of the deposits occupy irregular fissures in the country rock but occasional irregular tabular deposits occur along sheared zones. Where lodes are in limestone, they are either narrow and tabular or wider disseminated low grade deposits. None of the lodes on the field proved to be payable below about 600 feet.

Many of the deposits of the Dundas field which lies about six miles E of Zeehan are similar to those of the Zeehan field but a higher sphalerite content is common. Jamesonite is also common in the North Dundas mineral field and in places forms the principal mineral in some of the lodes.

Lead-zinc ores occur throughout the Read-Rosebery district in rocks of probable Lower Cambrian age. The principal ore deposits occur in a bed of sericitic schist formed by shearing of tuffaceous beds near the junction with coarse massive pyroclastic rocks. The deposits are regarded as metasomatic replacement bodies.

The orebodies at the Rosebery and Hercules mines are regarded as metasomatic replacement of altered tuffaceous shale. The ore is fine grained and consists of about 75 per cent total sulphides of which 31 per cent is sphalerite, 37 per cent pyrite, and 7 per cent galena, with minor amounts of chalcopyrite, bournonite, arsenopyrite, pyrrhotite, tetrahedrite, pyrargyrite, silver and gold. The gangue minerals are carbonates, quartz, barite and chlorite.

The ore horizon in the Rosebery mine is not continuously mineralized but some shoots extend up to 1,500 feet in length and vary in width from three to 60 feet. At the Hercules mine the orebodies are lenticular in shape with maximum dimensions of 400 feet height, 200 feet length and 60 feet thickness. At both the Rosebery and Hercules mines the mineralization does not enter the formations enclosing the host rock. Ore production of the Rosebery and Hercules mines to 1966 is estimated as 6,126,420 tons with an average grade of 6 per cent lead, 20 per cent zinc, 0.95 per cent copper, 6 oz/ton silver and 2 dwt/ton gold. The combined ore reserves of the two mines in June 1962 were given as 3,500,000 tons.

Smaller argentiferous galena orebodies occur at Tullah in the Mt Farrell district, NW of Rosebery. The lodes are fissure fillings in shear zones along a N trending fault system infilled with argentiferous galena, with pyrite and secondary sphalerite in a quartz-siderite gangue. The total recorded production from the Mt Farrell district amounts to about 89,000 tons of lead.

Argentiferous lead deposits also occur at the Magnet mine four miles W of Waratah. Several lodes consisting of argentiferous galena, sphalerite and pyrite with minor tetrahedrite and pyrargyrite in a gangue of siderite, ankerite, manganosiderite and altered country rock occur in a series of branching shear zones in a large altered composite basic dyke occupying a major fault. The main body of ore lies at the intersection of the shears occupied by the two principal lodes. The lodes decrease in width and grade away from the intersection all becoming uneconomic within a distance of 250 feet although the lode channels can be traced for a considerable distance. Total lead production from the Magnet district is recorded as 37,395 tons.

Galena lodes occupying the apices of faulted anticlines in Ordovician sandstone have been worked in the Round Mount area near Lorinna in NW Tasmania and a total production of 4,690 tons has been recorded from this source. In the same general district galena veins have been worked in the Devon mine on the Dove River S of Lorinna and in some of the small mines in the Five Mile Rise district W of Lorinna. Other galena deposits have been recorded from the Mt Lyell area and small orebodies have been worked for galena in the Mt Stewart and Heazlewood areas.

MANGANESE

Sub-economic manganese mineralization occurs commonly throughout W and NW Tasmania. The only recorded production to date is a trial parcel of approximately one ton from deposits in the Dial Range in NW Tasmania.

In the Zeehan district manganese associated with siderite forms the common gangue for many of the galena deposits, and manganiferous gossans averaging about 10 per cent manganese occur commonly in both the Zeehan and Dundas districts. These deposits have been used in the past as a source of flux for metallurgical processes. Superficial but extensive deposits of manganese and iron oxides occur on Olivers Hill in the Lorinna district in the NW.

Psilomelane is reported from the Heazlewood and Magnet district in the NW, and a soft wad-like manganiferous deposit occurs at Natone. However, the deposits at the Dial Range, whilst not large, form the main known manganese deposits in the State.

Several manganese deposits occur in the Dial Range district but only "Black's" deposit appears to be significant. This is elliptical, about 450 feet long by 200 feet wide, with an average thickness of about 10 feet. Ore deposition was by preferential replacement of portion of a Cambrian breccia with further superficial enrichment by local groundwater movements. Possible reserves in this deposit are estimated at 30,000 tons of 20 per cent manganese ore, averaging about 20 per cent Mn, 27 per cent Fe, 11 per cent SiO_2 and 9 per cent Al_2O_3 .

Manganese dioxide is recovered as a sludge in the electrolysis of zinc sulphate at the Risdon Works of the Electrolytic Zinc Company. Production from this source since 1957 is given as 2,435 tons.

MOLYBDENUM

Molybdenite occurs in small quantities at several localities usually associated with the Devonian granites. The deposits generally are small or low grade and only a small quantity has been produced from the Mt Stronach district in the NE. However, molybdenite is a common mineral associated with the tin and tungsten ores of the Moina district, particularly at the Squib and Shepherd and Murphy mines.

Molybdenum is present in small quantities in the King Island scheelite mine where the scheelite concentrates contain up to 3 per cent molybdenum. At Mt Remus on the Central Plateau molybdenite occurs in pyritic quartz bodies associated with small amounts of cobalt and vanadium in Precambrian schist. Molybdenite is also recorded from Cape Barren Island and from the S part of Flinders Island in the Furneaux Group where it is associated with cassiterite.

MONAZITE

Monazite occurs in alluvial deposits principally associated with tin on the Yellowband Plain in the Mt Meredith region and also in the Stanley River district on the W coast. Monazite is also associated with cassiterite in some of the alluvial tin mines in NE Tasmania, principally the Endurance mine where 32 tons were sold in 1943. Monazite is also reported in beach sands from the E coast of King Island.

NICKEL

Nickel is found associated with ultrabasic rocks of Cambrian age in many parts of N and W Tasmania. Small amounts of garnierite are frequently found in association with serpentinite but nickel sulphides and arsenides are also found associated with these basic and ultrabasic rocks. Four distinct mineral associations have been recognized:—

1. Heazlewoodite-pentlandite, found at Heazlewood River and Trial Harbour.
2. Pentlandite-pyrrhotite-chalcopyrite at the Five Mile, near Zeehan.
3. Millerite-pyrite-chalcopyrite at the Five Mile.
4. Gersdorffite-niccolite at Zeehan, Dundas and Rocky River.

The arsenides (type 4) are of geological interest only.

BEACONSFIELD AREA

A large body of serpentinite with chromite, nickel and magnetite occurs in the vicinity of Beaconsfield, 26 miles NW of Launceston. Intermittent prospecting during recent years has indicated nickel values ranging from 0.03 per cent to 0.7 per cent Ni. The best values were obtained in the vicinity of the hornblende grossularite rock, rodingite. The nickel occurs as garnierite but some may actually replace magnesium in the crystal lattice of the serpentinite. Clay and weathered rock above the serpentinite contains up to 1.25 per cent Ni.

HEAZLEWOOD AREA

Widespread low grade nickel mineralization occurs at the Lord Brassey mine, situated on top of a hill about 500 feet above the Heazlewood River bridge on the Corinna Road. The nickel mineralization here consists of heazlewoodite (Ni_3S_2) and lesser amounts of pentlandite, both of which are oxidized at the surface to zaraitite. The nickel minerals are thought to be associated with magnetite and to have been emplaced during the serpentinitization of an original pyroxenite body, the nickel minerals being deposited principally along shear and joint planes within the serpentinite. The predominant sets of fractures strike NE and the mine development has followed three main sets of these structures. No production has resulted from the work at this mine to date but specimens of heazlewoodite are valued by collectors.

Heazlewoodite and pentlandite are also found in serpentinite at Trial Harbour, 10 miles W of Zeehan, but at this locality the nickel mineralization is low grade and pentlandite is the common mineral.

FIVE MILE AREA

The best developed nickel deposits in Tasmania are situated close to the Emu Bay Railway, five miles NE of Zeehan. In this locality lower Cambrian argillite and tuff have been intruded by irregular masses of basic and ultrabasic rocks. The nickel deposits have been investigated by detailed geophysical work and numerous drill holes. The intrusions have been traced on the surface for a distance of 7,000 feet. The nickel ore occurs in shoots along the footwall of the ultrabasic bodies; these are normally 60 to 150 feet in length, three to six feet in width and up to 120 feet in depth. Two distinct mineral assemblages, a magnetite-pyrite-pentlandite-violarite-chalcopyrite-sphalerite-pyrrhotite association at the North and South Cuni and Vaudeau mines, and a chalcopyrite-pyrite-millerite one at the Nickel Reward and Devereaux prospects. Production from this area has been intermittent, between the years 1894 and 1938 less than 10,000 tons of ore was produced. Incomplete statistics for the various mines are given in Table 3:—

TABLE 3.

<i>Mine</i>	<i>Approx. ore production (tons)</i>	<i>Ni (%)</i>	<i>Cu (%)</i>
Vaudeau	4,000	8-11	4-14
South Cuni	1,200	10-11	5-6
North Cuni	1,000+	13-17	6-9
Genets	1,150	10	5-6

OSMIRIDIUM

In the early years of this century alluvial gold miners in the Savage River-Whyte River-Heazlewood district in the NW of Tasmania found difficulty in separating a heavier than gold, silvery, platy metal from the alluvial gold and were often penalized for including it. It was later recognized that this mineral was osmiridium, a natural alloy of osmium and iridium containing minor amounts of other platinoids, the average composition being osmium 45 per cent, iridium 41 per cent, ruthenium 6 per cent, platinum 1-2 per cent, rhodium 0.3-1 per cent, and a trace of palladium. The metal was originally used for tipping fountain pen nibs but with the advent of the ball point pen this use declined. However, in recent years new markets, particularly in the spinning of synthetic fibres, have opened up new uses for the material.

The first recorded production of osmiridium was in 1910 when 120 ounces were sold for less than \$10 per ounce.

Until 1925 almost all the osmiridium production in Tasmania came from the mineral fields between Waratah and Zeehan. The principal centres of production at that time were at Bald Hill, Mt Stewart, Savage River and Heazlewood River which yielded about 13,000 ounces up to 1925. In that year the Adamsfield deposits

were discovered and since that time a total production of 15,394 ounces or almost 50 per cent of the Tasmanian total has been produced from this field. Production of osmiridium ceased in 1954 by which time an overall recorded total of about 31,088 ounces had been produced.

The production of osmiridium in Tasmania has been almost entirely from alluvial deposits formed from the weathering of Cambrian serpentinite. The Bald Hill osmiridium field, which covers deposits on the Nineteen Mile Creek, the Heazlewood River and indirectly the deposits along the Savage River, was formed from the erosion of a small body of serpentinitized peridotite on Bald Hill. The osmiridium on the Mt Stewart field and possibly the osmiridium-bearing Tertiary leads in Yellowband Creek were derived from a similar peridotite body in Loughnan Creek, Mt Stewart. The osmiridium in the Wilson River field was probably derived from a serpentinitized bronzitite and peridotite, which occurs N of Renison Bell.

Osmiridium deposits in Tasmania vary in type and consist of a variety of Tertiary gravel, fossil river terraces, Recent stream gravel, alluvium, surface soils, clay and detritus. Most of the production has come from Recent gravel and reworked material. An unusual feature of the Adamsfield deposits is the occurrence of rich concentrations of osmiridium in a conglomerate of Upper Cambrian to Lower Devonian age. This conglomerate is composed almost entirely of serpentinite fragments set in a matrix of finely divided serpentiniferous material, resting directly upon partly weathered serpentinite.

Primary deposits are rare, but at Cawdry's Prospect near the Nineteen Mile Post on the Waratah-Corinna Road a crush zone containing serpentine and talc also contains sporadically disseminated osmiridium, and in the workings at Loughnan Creek, Mt Stewart, osmiridium occurred as schlieren on the faces of shear surfaces in the serpentinite.

Associated metallic minerals vary from field to field but magnetite, ilmenite and picotite are common in the Bald Hill field whilst at Adamsfield the only important accessory mineral is chromite.

PYRITE

see "SULPHUR"

SCHEELITE

The only commercial scheelite deposit in Tasmania is at Grassy on SE King Island. This deposit is a large pyrometasomatic orebody which has been formed by the selective replacement of limestone beds within the contact aureole of a nearby granite intrusion. The deposit was originally covered by sand and was discovered in 1904 by a prospector who traced inland a scheelite-bearing formation in a fault which outcropped on the beach at low water mark. To December, 1966, 22,305 tons of scheelite concentrates containing 65.5 per cent WO₃ were obtained from approximately 4,076,374 tons of ore.

Ore reserves at 31st October, 1965, were estimated to be 1,315,700 tons of average assay 0.51 per cent WO_3 down to 110 feet below sea level.

The contact metamorphosed sediments in the mine area are intruded by granite which outcrops about half a mile S of the mine and by porphyry and aplite dykes. The host beds for the deposit are a sequence up to 550 feet thick tabulated below:—

Bed A—Hanging wall.—Actinolite hornfels 70+ feet.

Bed B—Pyroxene-garnet hornfels 0.52 feet.

Bed C—Top orebody bed.—Andradite, skarn, marble, some pyroxene-grossularite hornfels.

Bed D—Marker beds.—Biotite-feldspar hornfels, some pyroxene and pyroxene-grossularite hornfels and andradite skarn.

Bed E—Bottom orebody beds.—Andradite, skarn, marble, pyroxene-grossularite, hornfels 50-110 feet.

Bed F—Transition beds.—Intercalated Bed E and Bed G 0-55 feet.

Bed G—Footwall beds.—Actinolite-feldspar hornfels, some marble, forsterite-phlogopite-spinel-hornblende rock in lower part.

The grade of ore worked reflects the differences in original composition of the rocks.

The top orebody lenses to the W and is generally 20 to 38 feet thick and averages about 25 feet. This orebody contains up to 3.7 per cent WO_3 and has an average grade of 0.84 per cent WO_3 . It is high grade over a strike length at sea level of 1,500 feet but does not occur above 100 feet a.s.l. and thins out down dip. The bottom orebody bed is from 15 to 110 feet thick and averages about 90 feet. At sea level it is almost completely mineralized over a strike length of about 2,400 feet. Up dip small to very large blocks of unreplaced marble are enclosed in the ore and the most northerly portion of the bed appears to be uneconomic. Complete replacement extends down dip to at least 300 feet below sea level.

The scheelite occurs in a finely disseminated form as grains 0.05-0.2 mm across with occasional larger grains. The scheelite grains are concentrated along the bedding but the degree of concentration varies widely locally, while the orebody as a whole is evenly mineralized. Coarser grained andradite with associated visible quartz is visibly richer in scheelite.

Molybdenite is common in the ore and is more abundant near intrusive aplite dykes. It occurs both in the aplite and in thin quartz veins emanating from the dykes. Short quartz-scheelite veins 1-6 inches in width occur in parts of the mineralized zone filling vertical tension fractures which strike 20° - 30° .

A mixed scheelite-wolframite deposit occurs at the Interview River on the W coast and minor occurrences of tabular scheelite crystals have been recorded in the Moina district and at other localities.

SELENIUM

Selenium occurs as an accessory mineral in the Mt Lyell copper orebody and is extracted from copper concentrates at Port Kembla in New South Wales.

SILVER

Tasmania has been an important silver producer for the past 80 years. The total production from the State is about 98 million ounces of silver, most of which has resulted from the treatment of silver-rich galena ores, lead-zinc ores containing small amounts of silver and from the copper deposits of Mt Lyell which contain small amounts of silver.

Until 1918 statistics grouped silver and lead under silver-lead ore and the amount produced up to that time was 1,083,898 tons of ore with a possible silver content of about 50 million ounces. Production in Tasmania from 1919 is recorded as about 47 million fine ounces of which about 25 million has been obtained from lead-zinc ores, 18 million from silver-lead ores, and about 4 million from copper ores.

The production of silver from the various mining fields in Tasmania is shown in Table 4 (approximate figures only):—

TABLE 4.

<i>Field</i>	<i>fine oz.</i>
Dundas	2,717,000
Heazlewood-Magnet	7,887,000
Mt Farrell	9,582,000
Mt Lyell	16,337,000
Rosebery	34,546,000
Rossarden	93,000
Round Mount	390,000
Zeehan	26,650,000
	<hr/>
	98,202,000

Records relating to silver production from the Zeehan district, particularly during the early life of the field, may be inaccurate as ore from some of the smaller mines was treated with those from the major producers.

The silver-lead ore-bodies in the Zeehan district are generally fissure veins striking NNW and NNE formed along zones of faulting, shearing and fracturing resulting from Tabberabberan movements. Orebodies in the Gordon Limestone are of the fissure replacement type. Although many very rich ore shoots were worked at Zeehan, mineralization was associated with fractures close to major faults and proved to be sporadic both laterally and in depth. The average silver values of galena ore from the various mines show that the lodes which intersected the older quartzite sequences were characterized by high silver values with silver exceeding one ounce to the unit of lead. Abnormally high silver contents were invariably found in those lodes which bordered or traversed the spilite members of the Cambrian rocks. Galena deposits worked in the Gordon Limestone were consistently poor in silver.

The Read-Rosebery mines have supplied the main silver production in Tasmania. These ores contain an average silver content of 6 oz/ton. The principal silver minerals in the lead-zinc orebodies are pyrargyrite, tetrahedrite and bournonite.

Treatment of the copper ore from Mt Lyell has resulted in the production of 16,337,330 fine ounces of silver over the years and the present annual production from the mine is about 60,000 fine ounces.

The Mt Farrell silver-lead mines have been a major producer of silver over the years but annual production of silver has declined from a maximum of about 145,000 ounces in 1953 to 41,663 ounces in 1964. Since 1964, production figures for these mines are included in the returns from the Read-Rosebery mines. Production is rising again.

The Dundas, Magnet, Mt Farrell, Round Mount and Zeehan fields were essentially silver-lead deposits. In the case of Zeehan, the deposits were worked mainly for their silver content in the early days but the other fields were discovered later and were worked mainly for their lead content. The main producers from the Zeehan field were the Zeehan-Montana, Mount Zeehan (Tasmania), Zeehan-Western, Oonah, Zeehan Queen, Comet-Maestries, Florence, Oceana, Spray and Comstock lodes.

Silver production in the Round Mount district has come chiefly from the old Round Hill mine where argentiferous galena lodes occupying the apices of faulted anticlines in Lower Ordovician quartzite were worked till about 1927 with a further small production in 1950. Silver mineralization has been reported from the Neptune mine at Penguin and also from the Hampshire silver mine but no production is recorded from these sources.

STRONTIUM

Strontianite is reported to occur in small quantities in the Hampshire silver mine. It is said to be associated with fluor spar and apatite in small veins and pockets.

SULPHUR

Native sulphur formed by the decomposition of pyrite is reported to occur in portions of the Mt Bischoff tin mine, and is also reported from Pleistocene-Tertiary deposits on Flinders Island. However, no production of sulphur has occurred from these sources. The only current production of sulphur is as sulphuric acid derived from the treatment of pyrite from Mt Lyell, which in 1966 produced 68,077 tons of pyrite, and from lead-zinc ores of the Read-Rosebery mines which produced 65,013 mono tons of sulphuric acid in 1966.

The ore from the West Lyell mine consists chiefly of disseminated pyrite and chalcopyrite which vary in grade from over 10 per cent to less than 0.5 per cent copper and contain 6-20 per cent pyrite. In the old Mt Lyell and South Lyell deposits an estimated 1,650,000 tons of pyritic ore remains with an estimated content of 44 per cent sulphur and 0.5 per cent copper. Pyritic concentrates are shipped to the mainland for the manufacture of sulphuric acid.

The Read-Rosebery zinc deposits are predominantly sphalerite with blocks and patches of pyritic ore occurring on the footwall and towards the extremities of most lodes. The ore consists of about 75 per cent total sulphides, the mineral composition being about 31 per cent sphalerite, 37 per cent pyrite, and 7 per cent galena. The sulphide content of the zinc concentrates from these ores is utilized by the Electrolytic Zinc Company at their Risdon works for the manufacture of sulphuric acid.

At the Chester mine an estimated 2,800,000 tons of pyritic ore with an average content of 20 per cent sulphur occurs as lenticular lenses of high grade pyritic ore parallel to the schistosity of the enclosing Cambrian rocks. A total of 36,964 tons of ore with an average sulphur content of 37.2 per cent has been produced from this source.

Pyritic ore for acid manufacture has also been produced from the Oonah, Kynance, Susanite, Queen, Mt Zeehan, Zeehan-Queen and South Comstock mines in the Zeehan district.

The cassiterite orebodies at Renison Bell consist largely of pyrrhotite, pyrite and some arsenopyrite with a total sulphur content of about 30 per cent. The known reserves at this mine are given as about 11 million tons but no sulphur production has been recorded from this area.

At Branches Creek on the E side of Port Sorell, Lower Cambrian to Upper Precambrian slate contains indeterminate reserves of low grade pyrite. The beds containing the pyrite are a series of black and grey pyritic and carbonaceous slates lying above a sequence of hard white to bluish quartzite with thin beds of sheared greywacke. The pyrite-bearing beds have an outcrop width of about 1,600 feet, but the strike length is unknown and may be considerable.

Trenching and diamond drilling of a small portion of these deposits indicate that an open cut 400 feet long, 200 feet deep and 200 feet wide would yield about 750,000 tons of ore containing more than 10 per cent sulphur. However, this is but a very small fraction of the potential ore in the district.

The pyrite is mostly very fine grained with much of it in the size range 2-10 microns. Beneficiation tests indicate that a concentrate containing about 46 per cent sulphur with a recovery of 52.5 per cent can be obtained by flotation methods. For a lower grade concentrate of about 40 per cent sulphur the recovery would be increased to 65 to 70 per cent.

The total recorded production of pyrite in Tasmania to 1966 is 1,704,897 tons with a production since 1957 of 407,534 mono tons of sulphur as sulphuric acid.

TIN

Tin ore is one of the most important mineral products of the State ranking third behind copper and zinc in importance. The total production of tin in Tasmania to the end of 1966 is 151,048 tons valued at more than \$82 million. The production of tin in Tasmania at present averages about 1,000 tons per annum but this is expected to increase over the next few years with the development of the tin deposits at Mt Cleveland and increased production from the Renison Bell tin field.

The discovery of the world famous Mt Bischoff tin field near Waratah in 1871 laid the foundations for the mining industry in Tasmania. In the early part of the century the Mt Bischoff mine was the largest tin producing mine in the world.

Tin ores are widely distributed throughout Tasmania and occur in the NE, NW, W and SW portions of the State. In the NE both primary and detrital deposits occur but the greatest production has been from detrital deposits. In the NW and W districts both primary and detrital tin ores occur but here the production has come chiefly from the primary deposits. Almost all the tin produced in Tasmania has come from cassiterite but at the Onah mine, Zeehan, small quantities of stannite have been produced.

PRIMARY DEPOSITS

The tin deposits at Mt Bischoff, a quarter of a mile N of Waratah in NW Tasmania, have been the most productive in the State and have yielded approximately 59,000 tons of metallic tin to the end of 1966. During the latter part of the last century the annual production from this mine was over 2,000 tons of SnO_2 and throughout the life of the mine a little over 5,500,000 tons of ore have yielded in excess of 80,000 tons of SnO_2 . Most of the production from this mine occurred between its discovery in 1871 and the early part of this century after which production declined to the present figure of about 10 tons per year. However, in the past few years extensive exploration in the area has disclosed additional ore reserves and further production from this mine can be expected in the future. Rocks in the area consist of complexly folded shale, quartzite and dolomite beds of probable Upper Precambrian age overlain by less deformed mudstone, chert and greywacke beds of probable Lower Cambrian age. Locally the contact between the two sequences is a structural one but a regional unconformity is suspected. The sedimentary rocks have been intruded by a system of anastomosing quartz-feldspar porphyry dykes and sills of Devonian age which have been topazized in the vicinity of the orebodies.

Mineralization is limited to a circular area of about 2,000 feet radius from the centre of the mountain. The orebodies comprise:—

- (a) A large replacement body in dolomite;
- (b) Numerous vein deposits;
- (c) Replacements of porphyry; and
- (d) Encrustations in joint faces and adjacent to porphyry dykes.

The main orebody was formed by replacement of a dolomite bed which occurs towards the top of the Upper Precambrian sequence. The replacement was largely by pyrrhotite, pyrite, talc, quartz and an iron-manganese-magnesium carbonate. The distribution of mineralization is extremely irregular within the body, some sections consisting of massive sulphides whilst others are virtually sulphide free. The tin, mainly as cassiterite, is abundant in zones of high sulphide concentration.

The vein orebodies contain quartz with cassiterite and abundant sulphides (including stannite). The largest vein has a proven length of 3,000 feet and an average width of 4 feet and was worked to a depth of 800 feet. Several small bodies occurring in greisenized quartz porphyry dykes and sills were also worked although these were mostly of low grade. Zones of pyrite and quartz-pyrite-tin ore, probably derived from the alteration of pyrrhotite by high temperature, occur within the mineralized dolomite. The leaching of this ore has left a crumbly quartz-pyrite rock generally rich in cassiterite. Portions of the dykes assay 0.3-0.4 per cent tin, the cassiterite occurring as a replacement of the feldspar or with quartz as joint filling. Together with cassiterite in numerous joints in sediments adjacent to the dykes this ore forms most of the visible cassiterite found at the mine. Late Tertiary sand and gravel and Recent deposits have been worked for detrital tin on the S slopes of Mt Bischoff and there have been extensive alluvial workings along the Waratah River.

The Mt Cleveland mine is situated approximately 10 miles W of Waratah. The deposits were originally discovered by prospectors about 1898. The gossans which carry the cassiterite proved to be very shallow and gave way to pyritic lode formations containing pyrite and pyrrhotite with minor chalcopyrite and cassiterite. The cassiterite was very fine grained and difficult to treat economically. During the period from 1909 to 1917 240 tons of metallic tin were produced from the mine. Work lapsed in the district until the mid 1950s when further exploration by the Mines Department and geophysical surveys by the Bureau of Mineral Resources indicated the possibility that the orebodies could be profitably exploited on current metal prices. Since that time the Aberfoyle Tin Development Partnership have carried out extensive investigations including detailed geological mapping, diamond drilling, underground mining and bulk sampling which indicate that current reserves in the mine are about 2,850,000 tons of ore averaging 1.02 per cent metallic tin and 0.43 per cent metallic copper. The lodes are considered to have been emplaced within a particular stratigraphic horizon of the Dundas Group rocks which occur in the area. The shale which forms the host rock is interbedded between volcanics and a massive sandstone sequence. In the mine workings the host rock is intensely deformed and considerable faulting is present. At least four distinct lodes have been recognized. These are generally conformable with the enclosing rocks but are occasionally offset by axial plane faulting. The largest orebody has a proven length of over 1,200 feet with an average width of about 25 feet and an indicated depth in excess of 600 feet. The orebodies contain cassiterite with pyrrhotite, pyrite, chalcopyrite and arsenopyrite. A typical analysis of the metallic elements in the ore is:—

	%
Tin	0.99
Sulphur	9.80
Iron	21.80
Arsenic	0.56
Antimony	Nil
Bismuth	0.01
Copper	0.34
Zinc	0.13
Lead	Nil

The Renison Bell tin field is situated about nine miles NE of Zeehan near Rosebery in W Tasmania. Detrital tin deposits were discovered in this district in 1890 and production since that time from detrital, gossanous and lode ore has produced 4,787 tons of metallic tin. Ore reserves are currently estimated as approximately 14 million tons of ore containing 0.75 per cent tin of which seven million tons is in the Federal Lode and seven million tons in the Bassett Lode.

Tin deposits occur in folded Cambrian Crimson Creek Formation and Precambrian Oonah Quartzite rocks which have been intruded one mile S of the mine by quartz porphyry dykes. Two main types of lode formation occur:—

- (a) Steeply dipping fissure lodes in line or *en echelon*, filling faults and known locally as feeders, and
- (b) Gently dipping, sill-like "floors", extending out from the feeders more or less parallel to the bedding of the enclosing rock.

In places the country rock contains sufficient cassiterite to be regarded as ore. Two main mineral associations have been recognized. Near the quartz porphyry, sulphide mineralization is only minor and the main minerals are quartz, tourmaline, and cassiterite. The lodes in the mining area consist of pyrrhotite, pyrite, quartz and cassiterite. Small amounts of arsenopyrite, sphalerite, galena and stannite together with traces of chalcopyrite are also present.

Tin ores occur in the Heemskirk-Zeehan district of W Tasmania. In the Devonian granite the tin lodes consist of quartz-tourmaline-cassiterite fissure veins, some bounded by greisen, and less commonly by pipes of irregular, branching, stanniferous greisen. The cassiterite is accompanied by tourmaline, quartz, pyrite and arsenopyrite together with small amounts of galena, sphalerite, chalcopyrite and tetrahedrite. Bounding the granite on the N flank massive stanniferous/magnetite sulphide lodes occur in basic and ultrabasic rocks of probable Cambrian age. Stannite is common in some of the silver-lead lodes at Zeehan, notably at the Oonah mine.

Finely disseminated cassiterite in massive sulphide replacement bodies occurs in the Dundas area at the Razorback and Grand Prize mines.

Numerous tin and wolfram orebodies occur in and around the Dolcoath Granite in the Moina district of N Tasmania. Most important of these was at the Shepherd and Murphy mine on Bismuth Creek near Moina. The orebodies at this mine are partly in indurated quartzite of the Moina Sandstone and partly in contact metamorphosed Gordon Limestone. The lode system consists of six roughly parallel quartz veins 8-20 inches in width and up to 1,300 feet long which have been worked to a depth of 340 feet from adits and to a further depth of 150 feet in two levels from a shaft. The veins carry wolframite, cassiterite and bismuthinite together with small amounts of native bismuth, sphalerite, molybdenite, chalcopyrite, pyrite, scheelite, arsenopyrite and galena. The gangue minerals are quartz with minor fluorite, topaz, beryl, phlogopite, muscovite and laumontite. In the upper parts of the

workings the ratio of cassiterite to wolframite to bismuthite was about 20:12:3 but in the lower levels the ratio of cassiterite to wolframite was only about 1:4 showing a decline in the cassiterite content with increasing depth. Ore reserves at the time the mine closed in 1957 were estimated as 42,400 tons of probable ore and 44,600 tons of possible ore. Total production of metallic tin to 1957 was 538.94 tons.

In NE Tasmania the Aberfoyle and Storeys Creek mines are the major producers of primary tin ores. Tin was first discovered in Gipps Creek in 1872 and shortly afterwards in Storeys Creek. The tin-bearing veins in Storeys Creek were worked from 1891 but the veins at Aberfoyle were not discovered until 1916. Production of metallic tin from the Aberfoyle mine has been 11,991 tons and from the Storeys Creek mine 1,919 tons.

Host rocks for the orebodies at these mines are the Mathinna Beds. They consist of between 1,500 and 6,000 feet of shale, quartzite and subgreywacke. The sediments are folded along an axis striking NW and have been intruded by Devonian granite which has been intersected in the lower workings of the Aberfoyle mine and at Storeys Creek. The orebodies in both mines are fissure fillings related to fractures formed during the folding of the Mathinna Beds and also to cupolas in the top of the granite intrusions.

At the Aberfoyle mine there are nine main veins and many small stringers occupying a zone about 200 feet wide and at least 1,600 feet long. The veins are bordered with a selvage of muscovite, and comprise principally cassiterite, wolfram and sphalerite with subordinate scheelite, arsenopyrite, pyrite, pyrrhotite, marcasite, molybdenite, chalcopyrite, stannite, galena, tetrahedrite, magnetite, hematite and native bismuth, copper and gold in a predominantly quartz gangue with some carbonates. The overall proportion of cassiterite to wolfram has decreased markedly with depth. The ratio of metallic tin recovered to tungstic oxide recovered decreased from 15:1 in 1932 to 3:1 below No. 4 level in recent years. At 30th June, 1967, the ore reserves and inferred ore of the Aberfoyle mine are given as 377,000 tons containing 2,000 tons of metallic tin.

At Storeys Creek the veins outcrop over a length of 1,500 feet but increase in length to No. 7 level where they begin to decrease in length. Near the surface the veins are narrow and branching but at depth the width increases rapidly and they remain wide to reach a maximum of 7 feet at No. 9 level. There are two main veins over a horizontal width of 150 to 250 feet together with many branches and splits. Ore reserves and inferred ore at 30th June, 1967, for the Storeys Creek mine are given as 248,000 tons of ore containing 500 tons of metallic tin.

The Branhholm and Blue Tier districts contain a number of primary tin deposits. The rocks of these districts consist of folded Mathinna Beds intruded by Devonian granite and overlain by small areas of Permian sediments and Tertiary basalt. Small Jurassic dolerite intrusions occur in the area.

The tin is associated with an acid "tin" granite which forms zones in an earlier barren porphyritic granodiorite. The major orebodies are flat lying "floor" deposits usually occurring below thin seams of pegmatite which define the top of the ore. Greisenization

is present with the mineralization disseminated through the greisenized rock to a depth in excess of 100 feet. Below the pegmatite are occasional local enrichments in the upper zones. Several such orebodies may occur separated by barren or low grade rock. Ore grades are generally low, the Anchor mine orebody, one of the largest in the field, averaged only 0.2 per cent SnO_2 and during the period from 1890-1951 produced 2,364 tons of metallic tin. Small amounts of wolfram, molybdenite and other sulphides are usually associated with the cassiterite.

Tin was discovered in the Royal George area near Avoca in the 1880s but the deposits were not developed until the formation of the Royal George Tin Mining Company in 1911; from then until 1922 about 969 tons of tin oxide were produced. The deposit consists of disseminated cassiterite accompanied by torbernite in a greisenized porphyritic Devonian granite. The orebody was worked from an open cut nearly 800 feet long with an average width of 80 feet. The floor of the cut is irregular but it probably averages about 40 feet in depth. An adit level was put in about 20 feet below the floor of the cut and continues beneath it for almost its entire length. A lower level reached by an underlay shaft was put in about 70 feet below the adit level. Following the discovery of uranium at the Royal George mine in 1955 three drill holes were put in which intersected the orebody at 370 feet below the open cut. This indicates that at the Royal George mine there is an orebody about 500-800 feet long extending to a depth of 370 feet carrying tin with a probable average grade of about 0.6 per cent tin. Investigations are proceeding in order to establish whether this deposit can be worked profitably under the prevailing economic conditions.

Tin was discovered at the Great Pyramid tin mine, Upper Scamander, in 1909 and the recorded production of metallic tin from the mine to date is 2,931 tons, produced from 331 tons of ore giving a recovery grade of 0.88 per cent tin. The host rocks for the tin mineralization are the Mathinna Beds. At the mine they consist mainly of sandstone, mudstone, siltstone and quartzite resulting from local alteration of sandstone. The general strike of the rocks is NW and they dip steeply SW. No granitic rocks are to be seen in the mine area but there are large granite masses a few miles NW. Mineralization consists mainly of cassiterite, pyrite and chalcopyrite. The cassiterite is present generally as finely crystalline grains associated with limonite, sericite and a little introduced silica. The mineralization occurs very irregularly and appears to be controlled by a combination of fracturing and bedding, the quartzite beds being more brittle are more strongly fractured and thus tend to carry the better tin values.

SECONDARY DEPOSITS

Deep leads of Tertiary age and reworked material derived from Tertiary leads have been exploited for detrital cassiterite at many places in Tasmania but the chief production of alluvial tin has been from the NE.

On the W coast alluvial tin has been produced from the St Dizier Mine in the Heemskirk district and from the Yellowband Creek-Wombat Flat district, together with appreciable

quantities of alluvial tin from the slopes of Mt Bischoff. Small alluvial tin deposits have also been worked in the extreme SW at Cox Bight, Melaleuca Inlet and the Ray River district.

Alluvial tin was found in the Balfour district in the far NW of Tasmania in the early 1880s and had been worked on a small scale for a number of years prior to 1900. Records of production from the area are incomplete but indicate a production of 125.8 tons of metallic tin in the period between 1907 and 1942. The alluvial tin at Balfour was apparently shed from cassiterite-bearing quartz veins on nearby Specimen Hill where similar veins are exposed and all the alluvial concentrations appear to be related to this. No additional large deposits of detrital tin are now known in the district but the area is somewhat remote and little systematic prospecting has been carried out.

NE Tasmania has produced about 43,000 tons of tin or 30 per cent of the total tin production of Tasmania. At present this area produces about 200 tons of tin concentrate per year. Alluvial and detrital deposits have accounted for 40,000 tons or 93 per cent of this total. Alluvial tin was first worked in NE Tasmania in 1882 and production rose rapidly as the rich alluvial deep lead systems and residual detritus deposits were discovered. Mining of primary tin ore in NE Tasmania began about 1895 as veins were exposed following the sluicing of alluvial deposits. The most important of the deep lead systems is the Ringarooma System. The leads consist of fluvialite conglomerate, semi-consolidated sand and clay beds which have been dated by spores as Upper Oligocene-Lower Miocene. The cassiterite in the leads was derived originally from tin lodes in the Devonian granite of the South Mt Cameron-Branxholm-Blue Tier district as well as from primary tin deposits in the Mathinna Beds.

Stream deposits have been worked over much of NE Tasmania particularly along the rivers and their tributaries and in the deep leads where the present streams have removed much of the largely barren overburden. Pleistocene to Recent leads up to 50 feet deep along the Ringarooma River have been worked by a dredge giving an annual production of 90-100 tons of tin concentrate from deposits having a grade of about 0.25 lb/cu.yd of 70 per cent tin.

The most important of the workings was the Briseis mine on the Cascade lead, a tributary of the Ringarooma system, which produced concentrates containing 20,787 tons of metallic tin, the average grade of the alluvium worked being about 1.7 lb/cu.yd of 70 per cent tin. The lead consists of up to 300 feet of sand, gravel and clay which is covered by approximately 150 feet of basalt. Half the cassiterite recovered occurred within 30 feet of the bottom where values were up to 78 lb/cu.yd. Portion of the unworked lead ahead of the old workings has been bored and estimated reserves for this portion total about 2,000 tons of cassiterite. To recover this would involve stripping 8,600,000 yards of overburden and treating 1,128,000 cubic yards of wash containing 320 lb of cassiterite per cu. yd. The overall value of the ground to be moved would be 0.37 lb/cu.yd.

The Branxholm and Valley leads occur as upstream tributaries of the Ringarooma system. The Branxholm lead was worked to a depth of 190 feet including 50 feet of basalt overburden, the

average grade of the material worked being 0.9 lb/cu.yd of 70 per cent tin. The top 45 feet of the Valley lead was worked for an average grade of 1.2 lb/cu.yd, while boring to 120 feet in this lead indicates the grade of the unworked lower part to be about 1.5 lb/cu.yd of 70 per cent tin.

The Endurance Tin Mining Company is currently working the Clifton lead which is up to 120 feet deep, with a grade during recent years of about 0.35 lb/cu.yd of 70 per cent tin. Up to the end of 1966 this lead has produced concentrates containing about 2,900 tons of tin.

Another tributary lead of the Ringarooma system, the Pioneer lead, was worked up till 1929 and produced about 9,050 tons of cassiterite. The grade varied from 2.16 lb/cu.yd in the early workings to 0.74 lb/cu.yd in 1928. This lead is again being actively worked but numerous other small leads throughout this district have now been largely worked out. Further potential cassiterite-bearing areas exist in the deeper areas of the Ringarooma system and its tributary leads. Other areas of interest are possible leads in the valleys of the Mussel Roe and Anson Rivers and the Scotia-Northern Plains lead N of Gladstone where preliminary investigations have indicated 11,000,000 cu.yd of wash containing 0.32 lb/cu.yd of 70 per cent tin.

Alluvial tin in the St Helens district was worked for over 50 years, commencing prior to 1888 when a report on the area was submitted by G. Thureau. This lead subsequently became known as Thureau's Deep Lead. During the time the lead was worked most of the surface was sluiced to a depth of only about 15 feet although it was known that in places the lead was more than 100 feet deep. In early years there were many attempts at boring and sinking in the lead in order to locate tin at depth but all failed. In 1963 the Department of Mines conducted a systematic boring campaign over the lead in which a total of 49 holes were bored in six areas. The boring indicated that no economically workable concentration of alluvial tin occurs in the deeper part of the old stream valley. Spores collected from the upper portion of the lead indicated that the likely age of the upper sediments is Lower Oligocene.

On Flinders Island in the Furneaux Group tin from an alluvial lead was first reported in 1871. Production was recorded from Tanners Bay in the NW in 1882 and from Pats River in the central W in 1898. Spasmodic production has continued to the present but detailed production records are not available. Minor amounts of both alluvial and lode tin have been reported from other localities on the island. On Cape Barren Island some lode mining is reported from the Mt Kerford area but the major production has been from Tertiary sedimentary deposits in the Rooks River and Modder River valleys. The total recorded production from the Furneaux Group is about 104 tons metallic tin, the major portion of which is believed to have come from Cape Barren Island.

Small alluvial tin deposits occur in the Coles Bay district on the E coast of Tasmania. Residual detrital deposits were formed on the tin-bearing granites and associated greisen zones and accounted for much of the early alluvial tin production in NE Tasmania. The main deposits of this kind are in the Blue Tier

and Branxholm-Weldborough areas where high rainfall and the susceptibility of the tin granite and greisen to chemical weathering has produced superficial deposits up to 40 feet deep. The average grade of these deposits was about 0.5 lb/cu.yd of 70 per cent tin.

TITANIUM

Both rutile (titanium oxide) and ilmenite (iron-titanium oxide) occur in Tasmania mainly in beach sand accumulations but also as alluvial deposits and as a constituent of some of the deep leads in NE Tasmania. Alluvial deposits containing rutile occur along the Clayton Rivulet on the NW coast and on the Arthur River. Rutile also occurs in beach sands on Ocean Beach, in the vicinity of Strahan, and on beaches in the SW of the State.

Concentrations of heavy minerals in beach sands in the vicinity of Frazer River on King Island have been known for many years. Recent investigations by private mining companies of portion of this area indicate that more than 2,000,000 tons of sand containing more than 2 per cent rutile are present and additional areas are currently being prospected.

Ilmenite is more plentiful in the beach sands than rutile and occurs along many beaches in S Tasmania, particularly those fringing D'Entrecasteaux Channel and on beaches at Arthurs Lake in the Central Highlands. These accumulations have been derived from the weathering of Jurassic dolerite. Deposits along the Tamar River have been formed from the weathering of both the dolerite and Tertiary basalt.

The only recorded production of titaniferous material in Tasmania is of 550 tons of ilmenite from the Frazer River beaches on King Island.

TUNGSTEN

see "SCHEELITE" and "WOLFRAM"

URANIUM

Several uranium occurrences are known in Tasmania but none have so far proved to be of economic importance. Early in 1955 the first authentic discovery of a uranium mineral was made at the Royal George mine in the Avoca district where torbernite, a hydrated phosphate of uranium and copper, was found in a tin-bearing greisen in the Devonian granite. Further instances of uranium mineralization were subsequently found associated with tin mineralization in granite in the same general district. At Storys Creek there has been some exploration of an occurrence of pitchblende and torbernite developed in narrow veins in sheared granite. However, although specimens of high grade material have been obtained, no appreciable tonnage of ore has been proved. In the vicinity of Castle Carey Creek in the Avoca district complex uranium mineralization has been located in carbonaceous, pyritic black shale at the base of the Permian.

VANADIUM

There has been no production of vanadium in Tasmania but several occurrences of mineralogical interest are recorded. Vanadium occurs in an unknown form associated with molybdenite in pyritic quartz veins at Mt Remus on the NW highlands, as encrustations on siderite at Bells Reward mine in the Waratah district and is reported to occur in the Hampshire silver mine in the NW. Reddish brown crystals are recorded from the Magnet mine near Waratah.

The Savage River iron deposits contain an average of 0.3 to 0.4 per cent vanadium which is believed to be locked in the molecular structure of the magnetite crystals.

WOLFRAM

Wolfram has been produced from several localities in the NW and NE portions of the State but the only production at present is from the Aberfoyle and Storeys Creek mines in the NE. Wolfram in these mines is associated with cassiterite and is distributed irregularly through a system of quartz veins in slate, sandstone and quartzite members of the Mathinna Beds. Minor sulphides including pyrite, pyrrhotite, marcasite, sphalerite, chalcopyrite, stannite and galena occur in places intergrown with the ore. In both these mines the ratio of wolfram to cassiterite increases with depth and although the Aberfoyle mine is worked primarily for cassiterite the wolfram content is steadily becoming more important.

Most of the remaining production of wolfram has come from the Moina district in NW Tasmania. In the past several mines were worked in this district but the main output was from the Shepherd and Murphy mine (Moina tin-tungsten mine). Wolfram lodes are commonly quartz-cassiterite-wolframite lodes situated in and around the margin of a Devonian granite stock. At the Shepherd and Murphy mine six lodes were worked containing in addition to wolfram appreciable quantities of tin which was the prime mineral to be recovered in the early days. Elsewhere, as at the All Nations mine and other mines on Dolcoath Hill, the lodes were primarily wolframite which occurred as irregular bunches in quartz veins with little or no tin. The Shepherd and Murphy mine ceased operations in 1955, at which time an estimated 42,400 tons of indicated ore and 44,600 tons of inferred ore with a probable extractable grade of 0.37 per cent WO_3 remained in the mine.

A number of small wolfram occurrences occur in the upper Forth Valley associated with small granite stocks. The most important of these is the Pelion wolfram mine situated near Oakleigh Creek. A small but unrecorded quantity of wolfram has been produced from this mine and the occurrence is of interest as comparatively little development work has been carried out although the veins can be traced for some distance on the surface.

The wolfram deposits in the Interview River district on the W coast were first recorded in 1901 and have been prospected sporadically from that time up till 1934. The wolfram occurs as veins which are poorly exposed in an area occupied by Devonian

granite intruded into siltstone and quartzite of Upper Precambrian age. The veins contain wolfram, tourmaline, arsenopyrite, scheelite, mica and feldspar in addition to quartz. The percentage of constituent minerals in ore from this area is estimated as quartz 40.9 per cent, wolfram 27.3 per cent, arsenopyrite 10 per cent, pyrite 9.8 per cent, tourmaline-muscovite, &c., 2 per cent, with 10 per cent voids. Numerous veins have been reported in the area but insufficient work has been carried out to make any assessment of the ore reserves.

A total of 15,932 tons of wolfram has been produced in Tasmania up to the end of 1966.

ZINC

Zinc sulphide (sphalerite) is widely distributed in Tasmania and over the years has become the second most important mineral produced in the State.

Almost the whole production of zinc in Tasmania has come from complex lead-zinc ores of the Read-Rosebery orebodies on the W coast. These deposits have been described under "lead".

Sphalerite occurs in the silver-lead deposits of the Mt Farrell district and also in association with galena at the Magnet mine. The total production of zinc to the end of 1966 was 836,452 tons of metallic zinc with a further production (since 1957) of 2,603 tons of zinc sulphate.

Non-Metallic Minerals

ASBESTOS

Asbestos was first discovered in 1866 in the West Tamar district and since that time has been found in widely scattered localities throughout the N, NW and W of Tasmania. The relatively small size and low grade of the deposits so far discovered and the difficulties of access to some of them have limited production to small scale operations. Asbestos has been produced from Andersons Creek in the West Tamar district; from Argent Hill in the Renison Bell area in W Tasmania; and from Asbestos Point on Macquarie Harbour.

All the deposits occur in serpentinized ultrabasic rocks of Upper Cambrian age. The asbestos is of the chrysotile form and usually of the cross fibre variety. A total of 3,980 tons had been produced up to the end of 1945 when production ceased.

At Andersons Creek the deposits occur in serpentinized pyroxenite which has been intruded by younger aplitic and dolerite dykes. In addition to chrysotile asbestos, picrolite and amphibole asbestos are also present in small veins. The lodes are variable with a maximum width of eight feet and consist of narrow, usually composite, veins composed of one or more of the following minerals: chrysotile, amphibole, serpentine, magnetite, chromite, hematite and talc. The fibre is readily separated from the wall rock; it is pale grey-green in colour, often with a bronze sheen, and when teased yields a soft silky white fibre.

A number of small chrysotile deposits are known in the Dundas-Rosebery region but only the Argent Hill deposit has been exploited. The host rock here is a serpentinized bronzitite with narrow cross fibre veins forming narrow zones around kernels of partly altered bronzitite. The fibre has a maximum length of about three quarters of an inch, is pale green in colour and gives a fine white fibre when teased. Slip fibre veins occur throughout the serpentine rock but although the fibre is of good quality the veins are too sporadically developed for systematic working.

At Asbestos Point the country rocks include schistose basic igneous rocks of Precambrian age intruded by a Cambrian pyroxenite dyke which has been partly serpentinized. Narrow cross fibre veins of chrysotile asbestos are present at places along the dyke. Production from this source has amounted to only 34 tons.

Other deposits of asbestos are recorded S of Asbestos Point and at Spero Bay on the W Coast; in the Ulverstone district on the NW Coast; and the Wilson River-Heazlewood-Long Plains area in the W.

BARITE

The main barite deposits occur throughout the N, NW and W of Tasmania. Production has been recorded from Madam Howard Plains, in the Queenstown district; Intercolonial Spur, at Mount Jukes; Beulah, in the Sheffield district; Riana, in the Penguin district; Franklin River, in the Harford district. Minor occurrences are also recorded from the Hummocks, Guildford area; Mt Block, the Pinnacles and Murchison River, Tullah district; Lynch Creek, Queenstown district. The copper deposits at Mt Lyell and the lead-zinc deposits of Mt Read at Rosebery contain barite as a gangue mineral.

The last recorded production of barite in Tasmania was in 1959 and up till that time 2,205 tons had been produced in the State.

All the barite deposits are associated with rocks of Cambrian age. At Madam Howard Plains the deposits occur in fissures in porphyry and are considered to be oriented structurally about the nose of a fold. The main ore zone has been traced over a length of some 2,000 feet and contains a succession of lenticular orebodies varying from 1 to 12 feet in width and up to 220 feet in length. Recent diamond drilling of the deposits indicated that the orebodies are lenticular down dip as well as along strike; drill intersections at depths of 80 feet below outcrop show only minor stringers of barite.

On the Intercolonial Spur, Mt Jukes, high grade barite is recorded in a fissure lode in Cambrian porphyry similar to that at Madam Howard Plains. The lode has a length of some 1,800 feet and width varying up to 8 feet; it is almost vertical and transgresses the bedding.

At Lower Beulah several barite lodes occur in well cleaved greywacke members of the Cambrian succession. The lodes have an almost vertical dip and strike conformably with the enclosing rock. They are lenticular with a maximum width of about 4 feet. The grade of ore varies between lenses, the largest known orebody being high grade whilst smaller veins which outcrop lower down on the S side of the hill contain small amounts of lead and zinc sulphides.

The Riana deposit occurs as a small fissure lode transgressing Cambrian slate. Similar relationships are reported at the Harford deposit. Minor barite deposits at Murchison River, Pinnacles, Lynch Creek, Mt Block, The Hummocks, Paradise Range and Penguin are all small fissure fillings in slaty greywacke and porphyry rocks of Cambrian age. At the Alma mine on the W bank of the Forth River just upstream from its junction with the Wilmot, barite lodes occur associated with copper in Cambrian rocks.

Where barite has been worked the grade is generally high and average assays from the various deposits are given in Table 5.

TABLE 5.

Locality	BaSO ₄	SiO ₂	Fe ₂ O ₃ +Al ₂ O ₃	Ignition Loss
Madam Howard Plains {	99.4	0.40	0.04	0.50
	98.8	0.70	0.06	0.40
	98.6	0.80	0.08	0.30
Lower Beulah	98.2	1.10	0.20	0.38
Riana	93.50	1.30	1.90	0.98
	95.90	1.90	1.06	0.50
Alma	96.40	0.90	1.10	0.90
Paradise Range	92.00	5.30	1.88	1.30
Penguin	96.40	0.46	0.50	0.60

CLAY

Clay is used in Tasmania for the manufacture of cement and in the ceramic industry for the production of bricks, tiles, pipes, &c.

Clay production in Tasmania since 1958 is 1,151,945 cubic yards. It has been used for the following industries:—

Use	cu.yds
Bricks	942,717
Tiles	31,491
Pipes	31,765
Cement	104,858
Other	41,114

Cainozoic clay of mixed origin and variable colour, composition and ceramic properties is widespread in Tasmania. The three principal sedimentary basins in which these deposits occur are the Launceston Basin, the Derwent Graben and the Macquarie Harbour Graben. Clay from the Launceston Basin has been extensively used in the ceramic industry. Clay beds occur as lenses in a succession of sand, clay, poorly sorted gravel and conglomerate with interbedded lignitic material. Similar deposits in the Upper Derwent Valley have not been so extensively worked, being more remote from potential markets. However, some clay from the Hamilton district has been used for the production of clay pipes at Hobart.

Quaternary transported clay is found in many of the river valleys and in coastal areas of low relief. Residual clay derived from the weathering of Permian and Triassic rocks mixed with Quaternary transported clay has been used at Dover and alluvial clay from terraces along Quamby Brook in the N has been used for brick manufacture at Westbury.

The main source of brick-making material in the Hobart district is from crushed Triassic shale and Permian siltstone. In the N of the State residual clay derived from the weathering of pebbly mudstone members of the Permian Quamby Mudstone is abundant and is being exploited at Loira, West Tamar and at Dulverton. At Wynyard weathered Permian claystone and Recent clay have been shown to be suitable for use as brick-making material.

In the S, Permian residual clay is less plentiful but a deposit derived from members of the Grange Mudstone was used to a limited extent in the manufacture of refractory bricks.

Weathered argillaceous Palaeozoic sediments are abundant, especially in the N and NE, and may well be used by the ceramic industry in the future as an alternative supply when present clay deposits become depleted.

Decomposed igneous rock (Precambrian dolerite) is used in conjunction with other clay at Cooe, near Burnie, for the manufacture of bricks.

Clay derived from the in situ weathering of Jurassic dolerite has been widely used for the construction of impermeable clay cores for rock filled dams in the Hydro-Electric Commission's power schemes on the Central Plateau.

DIATOMACEOUS EARTH

No commercial production of diatomite has occurred in Tasmania but small deposits are recorded from Andover, Rushy Lagoon and Bishopsbourne. At Andover the diatomite is of medium grade, buff coloured with occasional darker bands and occurs in shallow erosional depressions on top of Jurassic dolerite. At Rushy Lagoon diatoms have been found in black soil collected from many parts of the Lagoon. The diatomite from Bishopsbourne is grey in colour and contains abundant diatoms.

DOLOMITE

Although extensive deposits of dolomite occur in Tasmania they have been exploited so far only in the Smithton district. The largest exposures of dolomite occur in inaccessible parts of the W Coast and the deposits in the S of the State are mainly in a reserved area and situated not far from extensive limestone deposits. The age of the various dolomite deposits is not completely known but most of the beds are Upper Precambrian in age and it seems possible that at least the larger separate deposits could prove to be a single dolomitic horizon in the Upper Precambrian.

At Smithton deposits of dolomite up to 3,000 feet thick have been quarried at several localities. The grade of the material is variable as the dolomite beds contain lenses and thin bands of quartzite, dolomitic shale, mudstone, &c., with occasional quartz veins and white to dark grey chert inclusions and chert pebble breccias. The dolomite varies in colour from white to light grey; some is thick bedded and coarse grained but in other places the deposits are thinly bedded and fine grained. Analyses of the two varieties are given in Table 6.

TABLE 6.
ANALYSES OF DOLOMITE SAMPLES

<i>Localities</i>	1	2	3	4	5	6	7	8	9	10
CaO	31.28	28.71	.....	25.92	.....	29.40	29.34	29.74	.....	25.60
MgO	21.63	19.32	.....	18.26	.....	20.92	19.96	20.87	.....	22.50
SiO ₂	0.18	4.52	.....	.....	.....	.....	4.64	3.60	.....	5.39
Al ₂ O ₃	0.44	3.66	0.3	1.01	.....	.....	.....	.....	.....	.....
FeO	0.37	0.44	0.4	1.51	.....	.....	.....	.....	.....	.....
Fe ₂ O ₃		0.84		2.37
CaCO ₃ .....	.....	.....	54.3	.....	55.0	.....	.....	.....	54.6	.....
MgCO ₃ .....	.....	.....	43.9	.....	45.0	.....	.....	.....	43.5	.....
P ₂ O ₅	Tr—0.10	0.037	.....	0.16	.....	.....	.....	.....	.....	.....
MnO ₂ .....	.....	.....	.....	0.19	.....	.....	.....	.....	.....	.....
C	0.068	0.30	.....	.....	.....	.....	.....	.....	.....	.....
S .....	.....	.....	.....	0.03	.....	.....	.....	.....	.....	.....
Ign. Loss	46.58	43.38	.....	40.42	.....	.....	.....	.....	.....	43.5
Insol. ....	.....	.....	.....	9.96	.....	.....	.....	.....	.....	.....

Localities.

Smithton District—

1. Crystalline variety (average of six samples).
2. Fine grained variety (average of six samples).
3. General analysis.
4. Jane River.
5. Cressy.
6. Huon-Cracroft Rivers.
- 7 and 8. Surprise River (Upper Franklin River).
9. Mt Bischoff.
10. Savage River.

Other large deposits of probable equivalent age occur at Tim Shea and along the upper reaches of the Franklin, Maxwell and Jane rivers in the central S and at Hastings in the S. Thicknesses of 2,000-4,000 feet of dolomitic rocks are recorded from the first three localities but their inaccessibility precludes successful exploitation at the present time. Spectacular solution cavities developed in the dolomite in the Hastings district have been opened up as a tourist attraction.

Other large deposits of dolomite are recorded from Upper Precambrian successions at the Savage River and at Mt Bischoff in the NW and in the Huon River-Cracroft River district in the S. Small dolomite occurrences have also been recorded from near Cressy and in the Preolenna district in the N and from the Pieman Heads, Albina-Birthday Bay, and Stanley River districts in the W. A sequence of calcareous beds containing impure dolomite and dolomitic mudstone occurs at Grassy on King Island.

To the end of 1966 a total of 29,446 tons of dolomite had been produced from the Smithton deposits.

FELDSPAR

There is no record of feldspar production in Tasmania. Feldspar is recorded from Coles Bay on the E. Coast; Hannans Rivulet, Zeehan area; the Mersey River approximately four miles S of Liena; at Killiecrankie Bay, Flinders Island; and near the Great Republic mine, Ben Lomond. All these deposits occur in pegmatitic dykes in granite of Devonian age. Porphyritic varieties of granite containing large feldspar phenocrysts are common throughout the State.

GRAPHITE

No graphite deposits of economic grade or size have been recorded in Tasmania. Low grade graphite schist at Clayton Rivulet near Ulverstone was worked intermittently between 1940 and 1950 to produce a total of 40 tons. Graphite is also reported from Precambrian rocks near Burnie and from probable Silurian rocks on Cape Barren Island. Thin bands of graphitic material interbedded with Triassic sediments were located in diamond drill holes put down by the Hydro-Electric Commission during investigations in the Wayatinah district of S Tasmania.

KAOLIN

Kaolin deposits in various parts of the State have been worked as a source of filler clay for use in the paper pulp industry but at present there is no production. The kaolin occurs as clean transported clay in alluvial tin leads of the NE, principally in the St Helens and Pioneer-South Mt Cameron areas; also as lenses in sub-basaltic Tertiary deep lead deposits in the Branhholm-Derby district.

Residual kaolin overlying and grading into weathered granite is also widespread and large deposits occur at the Endurance and Garibaldi tin mines near South Mt Cameron. The residual kaolin contains quartz phenocrysts derived from the parent granite rocks.

Kaolin has been obtained from Hellyer near Wynyard where it was formed from the chemical weathering of granite, and also at Surges Bay near Dover where it has been derived from syenite, but the known deposits in these areas have been almost exhausted.

A total of 111,086 tons of kaolin was produced before production ceased in 1962.

LIMESTONE

Limestone sequences occur in the Ordovician, Permian and Cainozoic systems. Ordovician limestone occurs mainly in the S, W and NW districts. It is generally purer than Permian limestone which is confined mainly to the SE portion of the State. Cainozoic limestone is represented by marine limestone, wind blown sand accumulations, calcareous marl deposited in coastal swamp lands, calcareous evaporites and travertine deposits associated with the Jurassic doerite.

Limestone is used for a variety of purposes—for the manufacture of cement and calcium carbide; for the manufacture of paper and newsprint; in metallurgical processes; for agriculture; and for road construction.

The main user of limestone in the State is the Goliath Portland Cement Company at Railton who in 1966 produced 252,393 tons. Also in 1966, the Australian Commonwealth Carbide Company produced 29,218 tons from their quarries at Ida Bay in the S and 28,489 tons of limestone were produced by the chemical and metallurgical industries mainly for use in paper making. A further 34,634 tons of agricultural limestone was produced during 1966 and the total tonnage of limestone produced for all purposes in the State during this year was 344,734 tons.

ORDOVICIAN LIMESTONE

Most of the limestone produced in Tasmania comes from the Gordon Limestone of Ordovician age which contains by far the largest reserves of high grade limestone in the State. The Gordon Limestone consists of up to 5,000 feet of interbedded high grade limestone, low grade limestone and calcareous shale. The beds are usually dark grey to blue in colour and dip at medium to high angles. The texture of the limestone varies from finely crystalline to coarse grained and it is usually massively bedded. Solution cavities, sometimes of very large size, are common and limestone caverns have been opened as tourist attractions at Gunns Plains and in the vicinity of Mole Creek.

At Railton the limestone is between 2,000 and 3,000 feet thick but most of it is covered with a thick mantle of residual clay which must be removed as overburden. This is used by the Goliath Portland Cement Company in the manufacture of cement in conjunction with limestone. The average grade of limestone quarried at Railton is 80-90 per cent CaCO_3 , with some sections as high as 95 per cent. Large quantities of 60 per cent or less grade are also available.

Huge deposits of high grade limestone freely accessible to rail and road transport are available in the Mole Creek district but have not been exploited yet. At Melrose narrow clay bands occur in otherwise good quality limestone. Residual clay covers most of these deposits but large reserves are available.

At Flowery Gully a limestone sequence up to 2,000 feet thick occurs. It is mainly crystalline with veins and lenses of calcite though chert nodules are common throughout the middle and upper portions. Some sections contain a significant proportion of organic matter and masses of dolomitic limestone up to 25 feet thick are irregularly distributed through the sequence.

At Beaconsfield a sequence of hard blue crystalline limestone up to 500 feet in thickness has been worked in the past but the quarries are now flooded.

On the W coast a thick sequence of Ordovician limestone is worked at Halls Creek in the Queenstown district. It is similar to other limestone in that district, containing a mixture of high grade and dolomitic material and thin bands of shaly stone. This sequence has also been worked in the Smelters Quarry, Zeehan, the Smelters Quarry, Queenstown, and at Darwin to the S of Queenstown.

Along the Gordon River a sequence of high grade limestone beds outcrops between eight and 16 miles from the mouth of the river. Reserves in this area have been estimated to exceed 50,000,000 tons but some dolomitic zones are present.

In the S of the State large reserves of Ordovician limestone are available at Maydena and in the Florentine Valley where limestone sequences up to 5,000 feet in thickness have been recorded. The lowermost portion of this sequence is impure, commonly containing siliceous bands, but with high grade, fine grained, massive bedded limestone forming the upper 1,000 feet of the sequence.

At Ida Bay massive well jointed limestone with irregularly distributed graphitic and cherty inclusions occurs in gently dipping deposits up to 200 feet thick which are partly overlain by Jurassic dolerite.

PERMIAN LIMESTONE.

The Permian limestone is generally light grey in colour and of comparatively low grade compared with the Ordovician stone. The silica content ranges up to 20 per cent. The limestone occurs as horizontal or slightly inclined beds, often interbedded with bands of calcareous shale, in deposits up to 100 feet thick. It outcrops along a belt between Glenorchy, near Hobart, and Dromedary 15 miles to the NW and has been quarried in several places. Permian limestone deposits on Maria Island off the E Coast have been worked in the past for use in cement manufacture and for agricultural lime.

CAINOZOIC LIMESTONE.

Tertiary and Recent calcareous deposits occur on King and Flinders Islands, in the Marawah district in the NW, and at Risdon and Geilston Bay in the S.

MAGNESITE

There has been no recorded production of magnesite in Tasmania but magnesite and magnesium-rich dolomite deposits occur in the Savage River district. The deposits are exposed in two deeply dissected tributaries of the Savage River, Main Creek and Bowry Creek.

The deposit in Main Creek is exposed over a continuous distance of about 800 feet along a regional NNW strike and for a width of 600 feet across the strike. The creek is entrenched to a depth of more than 10 feet in magnesite in some places but away from the creek the exposures generally are poor. To the W of Main Creek a lens of magnesite about 200 feet by 70 feet outcrops on the hillside 20-90 feet above the creek bed. Irregular lenses of magnesite are also exposed in the upper reaches of Main Creek over a distance of about 1,000 feet.

The magnesite is white, weathering to a pinkish colour. It is massive and fine grained with recrystallized seams and joints giving a pseudo-bedded appearance in places. Magnesite in the eastern contact zone is banded, with parallel layers of silica up to half an inch in width, and is generally associated with a talc alteration zone, 10-20 feet wide, containing disseminated pyrite and transitional into muscovite-chlorite schist and phyllitic rocks of the Whyte Schist.

The deposit is a conformable zone in the regional NNW strike of the Precambrian rocks and it separates an argillaceous assemblage from an arenaceous assemblage. The rocks dip vertically or steeply to the E. The magnesite is believed to be an altered sedimentary limestone or dolomite.

A deposit similar to that exposed in Main Creek occurs in Bowry Creek in the Long Plains South-Brown Plains area. Dissection by this creek has exposed pinkish white cryptocrystalline magnesite over a width of 300 feet but the deposit is not clearly exposed and may not be continuous over the whole section. The country rock upstream is chlorite-rich schist and phyllite and the rocks downstream are greyish and more arenaceous. Host rocks dip steeply to the E.

Existing information does not allow an accurate assessment of the reserves but a preliminary estimate indicates that the Main Creek deposits would probably contain about 30,000 short tons per foot of depth allowing a 10 per cent dilution factor. Magnesite is exposed over a depth of 10 feet in some creek sections, thus in this area a possible reserve of 300,000 tons is inferred for an area roughly 600 feet square. Less is known of the potential reserves in the Bowry Creek area but it is tentatively suggested that if the width of the magnesite bodies revealed in the creek sections is maintained along strike a reserve of 300,000 tons per foot depth of magnesite and magnesium-rich carbonate rock may be present.

TABLE 7
ANALYSES OF MAGNESITE

<i>Deposit</i>	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MnO	TiO ₂	CaO	MgO	Ign. loss	P ₂ O ₅	SO ₂	S
Main Creek	9.4	1.1	3.5	0.2	Tr	3.6	40.3	42.2	.....	.....	.....
	1.3	0.1	3.5	0.1	Tr	1.7	43.4	50.0	.....	.....	.....
	0.5	Tr	1.7	Tr	Tr	1.8	44.8	51.1	.....	.....	.....
	0.80	0.23	1.00	0.11	Nil	2.65	44.6	50.5	Tr	Nil	Nil
Bowry Creek	0.51	.....	2.17	.....	.....	1.94	42.90	.....	.....	.....

MICA

Muscovite and phlogopite both occur in Tasmania but up to date there has been no production of mica in the State. Near Killiecrankie Bay on Flinders Island, muscovite books occur in quartz and pegmatite veins in granite. Moderately large muscovite flakes occur regularly in quartz-impregnated mica schist on the Cardigan River SW of Queenstown. Phlogopite occurs in the "mica" adit of the Kelvin mine in the Zeehan district as aggregations of small crystals associated with quartz, fluorite and molybdenite. Some alteration from phlogopite to vermiculite has been reported from the same locality.

The most important known source of mica in the State occurs at the old Fly-By-Night tin mine near Gladstone in NE Tasmania. Here muscovite mica occurs as fine clear flakes throughout greisenized granite and forms 20-25 per cent of the rock; it also occurs in the greisen as veins in a rather coarser form. The exposed area is approximately 400 feet by 300 feet and is expected to average at least 14 feet depth of easily worked material. A preliminary estimate indicates that something of the order of 100,000 tons of acceptable mica would be available. Flotation tests on a 150 lb sample of greisenized granite from this mine indicated that about 20-25 per cent by weight of the raw material can be recovered as a high grade mica concentrate. The flotation products contained about 95 per cent mica with a sizing of 6 per cent plus 100 mesh and 70 per cent minus 200 mesh.

OCHRE

Deposits of oxides of iron suitable for the manufacture of pigments occur at several localities in Tasmania. A total of 2,459 tons has been produced to the end of 1966 and production during 1966 was 65 tons. The current production comes from deposits at Spalford lying to the S of Ulverstone where a red ochre derived from the decomposition of basalt occurs.

At Mowbray in the Launceston district, red and yellow ochres of good quality occur as residual deposits produced by the weathering of Jurassic dolerite. This deposit was worked for some years and the product was used for paint manufacture but the total production is unknown. At Mt Vulcan in the Beaconsfield area chrome-bearing iron oxide deposits have also been exploited for a wide variety of pigments including yellow, red, green and chocolate.

Yellow ochre has also been produced from limonitic deposits in the Smithton district, whilst small quantities of red ochre have been produced from deposits in the Carlton district of SE Tasmania.

PEBBLES

Since 1957, pebbles have been collected for grinding purposes from beaches round Ulverstone on the NW Coast. To the end of 1966, 6,390 tons had been gathered; production for 1966 was 895 tons.

PHOSPHATE

Apart from small guano type phosphate deposits formed on small islands off the Tasmanian coastline no phosphate deposits of economic grade have been located in Tasmania up to date. The occurrence of turquoise in the Mathinna Beds in the vicinity of Back Creek indicates that further prospecting of these rocks may be worthwhile. The Cambrian rocks in the Smithton district have been examined and although two analyses of 4 per cent and 5.4 per cent P_2O_5 were obtained from small samples a follow-up exploration programme failed to show economic phosphate values over any significant width in that district. Limestone, presumably Permian, from the St Marys district on the E Coast is reported to carry up to about 5 per cent P_2O_5 .

Guano type deposits have been recorded from Sea Elephant Rocks off the E coast of King Island; from White Rock Island between Freycinet Peninsula and Maria Island; from Sloping Island in Frederick Henry Bay; and from some of the islands in the Furneaux Group.

SALT

Small quantities of salt have been obtained intermittently from salt pans and lakes in the vicinity of Tunbridge and Ellenthorpe Plains in the Midlands. The lakes are formed in shallow depressions in Triassic sandstone and it is thought that the salt is a leaching product from the sandstone.

SILICA

Deposits of high grade quartzite, silica sand and beach pebbles have been utilized for various purposes. Precambrian quartzite at Hastings in the SE has been used in the manufacture of ferro-silicon and Ordovician conglomerate and quartzite beds occurring in the Beaconsfield and Frankford localities are being investigated for this purpose.

Small amounts of silica are currently being produced from Precambrian deposits at Forth on the NW Coast and other high grade silica deposits occur in the same locality. The main production of silica to date has been by the Mt Lyell Railway and Mining Company which quarried silica for use as a smelter flux.

Silica sand deposits on South Arm in the SE are being used for the manufacture of glass.

Large reserves of silica are available from Precambrian and Ordovician rocks in the NW and W of Tasmania. No specific investigation or sampling has been carried out on them but it is probable that large accessible deposits could be readily located.

A total of 179,599 tons of silica has been produced in Tasmania to the end of 1966, production in 1966 being 5,014 tons.

TALC

The only production of talc recorded from Tasmania is 333 tons obtained from a small deposit at Gawler near Ulverstone. The deposit consists of two small lenses in a Precambrian mica-schist. The lenses were 60 and 90 feet long with width of 5 and 6 feet respectively. The grade of the talc mined varied considerably with a reported average of about 20-30 per cent first grade white talc, 50 per cent as a second grade bluish white talc, and the balance as third grade iron stained talc. Production from this source ceased in 1948.

Other occurrences of talc are recorded from Mt Stewart in the NW where a pale green, massive, compact and fairly pure variety occurs in association with Cambrian ultrabasic rocks. About a mile S of Burnie a semi-transparent variety varying from white to pale green occurs, also in association with ultrabasic rocks. A white variety is recorded from near the junction of the Arthur and Hellyer Rivers, and other smaller low grade occurrences are reported from mines and mining districts such as the Razorback mine, Dundas; the Magnet Range-Mt Bischoff area; Andersons Creek, Beaconsfield; the Blue Tier area in the NE, &c.

Fuel Minerals

COAL

The total recorded production of coal in Tasmania to the end of 1966 is 9,409,458 tons and the production in 1966 was 82,664 tons. Of the total production much more than 90 per cent has come from the Triassic coal fields in the NE.

Coal is known to occur in rocks of Permian, Triassic and Tertiary age.

In the Permian the coal occurs at two horizons. The Cygnet Coal Measures are near the top of the Permian sequence and carry such fossils as *Gangamopteris* and *Vertebraria australis*. In the Cygnet district there are two main seams with indications of two others but the uppermost seam which is 3 feet in thickness is the only one to have been mined. The coal is a low volatile type of only fair quality

The lower coal measures in the Permian occur at about the middle of the Permian sequence and have been called the Mersey Coal Measures since they are developed most widely in the lower Mersey valley of NW Tasmania. Many early workers correlated the seams with the Greta Coal Measures of New South Wales. At the Illamatha Colliery, which was the last operating colliery in the Mersey Valley, two seams were present, of which the lowermost was the more important. This seam was very narrow, sometimes being less than 2 feet, but had a low ash content although high in sulphur. A typical analysis of coal from this seam is:—

Moisture	13.5%
Volatile matter	36%
Fixed carbon	46%
Ash	4.5%
B.Th.U	11,000

Fossil plants in shale associated with these coals include *Glossopteris browniana*, *G. ampla*, *G. indica*, *Gangamopteris angustifolia*, *G. cyclopteroides* and *Noeggerathiopsis hislopi*. At Preolenna, at least four seams have been noted, all of them narrow and dipping at angles up to 20°. On account of this there has been no appreciable production from that area. Although the ash content is low and the B.Th.U. value is over 12,000, sulphur content in these coals is high.

The principal commercial coal supplies are obtained from the New Town Coal Measures of Triassic age which are associated with feldspathic sandstone and shale. They occur toward the top of the Triassic sequence in Tasmania. The chief exploitation of the coal has been in the E of the State in the St Marys-Fingal-Avoca district but development has also taken place at Seymour, Coles Bay, Schouten Island and Buckland in the E; York Plains and Colebrook in the Midlands; and Hamilton, Sandfly and Esperance in the S. The earliest mines were on Tasman Peninsula and at New Town, a suburb of Hobart.

Due to competition from oil the production of coal has declined seriously over the past few years and the only collieries at present operating are the Duncan colliery at Fingal, the New Stanhope colliery at Avoca and the Sandfly colliery at Kaoota.

Attempts have been made to correlate the various seams in the NE and eight have been named by earlier workers in the St Marys district. Great variations in thickness, in the included bands and in roof materials have been noted in individual collieries. Faulting and rolling are also prevalent so that correlation is difficult and perhaps unreliable. As the ash content of the Triassic coal often exceeds 20 per cent several collieries installed washing plants to reduce this. The coal is generally non-coking, but a seam at the New Stanhope colliery yields coal with semi-coking qualities.

The general composition of Triassic coal is:—

Moisture (105°C.)	.....	2-4%
Volatile matter	.....	20-28%
Fixed carbon	.....	45-55%
Ash	.....	18-27%
B.Th.U.	..... about	10,000

The coal mined at Sandfly is a low volatile coal and contains up to 63 per cent fixed carbon.

Brown coal of Tertiary age occurs in the Launceston Basin, in the upper Derwent Graben and at Macquarie Harbour but none has so far been exploited.

In 1963 the coal reserves were estimated at 21,000,000 tons indicated, and 120,000,000 tons inferred coal, most of which occurs in the Avoca-Fingal-St Marys area. Of this amount it was estimated that 75 per cent would be recoverable.

OIL SHALE

An oil shale which is rich in the fossil *Tasmanites punctatus* and therefore called locally "tasmanite" occurs near West Takone, Oonah, Dulverton, Latrobe, Kimberley, Beulah, Chudley and Quamby Brook. The tasmanite horizon consists of pebbly and pyritic shale and contains marine fossils as well as *Tasmanites*. The oil shale member is not a facies variant of the Mersey Coal Measures as has been suggested by earlier writers but occurs much lower in the Permian sequence.

The tasmanite beds are not oil-bearing but contain an oil-producing substance that requires heat for the generation of oil. The oil is contained in the tiny disc-like spore cases set in a fine grained matrix.

The first production of oil was in 1910, when the Tasmanian Shale and Oil Company erected four retorts and obtained 4,800 gallons of oil. The industry has had a chequered career. Many companies operated intermittently between 1910 and 1934 and produced 357,115 gallons of oil from 41,572 tons of shale. The shale seam ranges in thickness up to 6 feet but generally it does not exceed 5 feet and in some areas is less than this. The oil yield

on distillation depends upon the numbers of spores present in the shale: in the richest shale 59.2 gallons per ton of oil has been recovered whilst in the poorest band the yield was only 3.6 gallons per ton. Insufficient information is available to determine the average yield for the shale and various figures have been adopted in the past.

An estimate of the reserves of the shale is:—

<i>Area</i>	<i>Tons</i>
Latrobe-Railton-Kimberley Area	17,895,000
Beulah	2,346,750
Quamby Bluff	3,750,000
Nook	1,050,000
Oonah	6,000,000
TOTAL	31,041,000

If the average yield of oil from the shale is taken at 27 gallons per ton the oil reserve therefore amounts to 838,107,000 gallons.

Kerosene shale and cannel coal occur at Preolenna and pelionite in the Barn Bluff-Mt Pelion area. These are distinct from the tasmanite and occur interbedded with the Mersey Coal Measures. The reserves of these materials are very small compared with the tasmanite.

Construction Materials

Over recent years construction materials have assumed a progressively more prominent position in the mining industry with centres of production of various materials distributed throughout the State. The overall annual production for building stone, aggregate, crushed rock, sand, gravel, &c., reached a value of \$6,536,776 for the year 1966.

BUILDING STONE

GRANITE

Devonian granite occurs in many localities particularly in the E, NE and NW districts. The texture and degree of weathering are extremely variable and in many cases the granite or the resultant weathered product is not suitable for exploitation. Colours are restricted to red tonings, pink, and the common light grey (granodiorite). A little grey granite has been produced near Scottsdale.

About 2,000 cubic yards of the granite at Coles Bay on the E Coast has been used for commercial purposes, the red colour, coarse texture and polishing qualities rendering it an attractive facing stone for building and monumental purposes. There is no current production.

In 1964, 3,563 cubic yards of granite from Natone were used in breakwater construction in Burnie harbour.

SANDSTONE (FREESTONE)

Triassic sandstone occurs in the NE, E, Midlands and SE parts of Tasmania. It is well suited for decorative facing and building purposes, monumental uses, &c., and has been extensively quarried throughout these districts for building purposes particularly during the earlier years of the settlement. The older public and other large buildings in the cities of Hobart and Launceston and in townships throughout the State were chiefly constructed of this rock.

Numerous early bridges such as those at Richmond, Ross, Campbell Town, Pontville, &c., were also constructed of this stone, but the main use at present is for decorative purposes such as building facias, paving, monuments, headstones, &c.

Total recorded production to the end of 1966 has been 4,874 cubic yards valued at \$60,712.

SLATE

Good quality roofing slates occur at Bangor 15 miles N of Launceston, at Back Creek and in the Arthur River district 12 miles N of Waratah. The Back Creek deposits were largely quarried up to the turn of the century and little work has been done since.

The Bangor deposits were worked by both open cut and underground methods and considerable quantities of slate were placed on the market. The Arthur River deposits have not been exploited owing to inaccessibility of the deposit.

LIMESTONE

The limestone deposits of the State have not been used directly for decorative or architectural purposes but localized zones in the Gordon Limestone could be used for such purposes.

TERRAZO

Serpentinite, ultrabasic rocks and other amphibolitic rocks of Cambrian age suitable for decorative purposes occur in the Dundas, Heazlewood and Heemskirk districts on the W Coast, at Clayton Rivulet on the NW Coast and at Andersons Creek, near Beaconsfield.

OTHER ROCKS

Jurassic dolerite, abundant throughout the eastern half of the State, and Tertiary basalt in the N of the State have been used locally for minor buildings on farm, &c., but no organized industry has been developed.

CRUSHED AND BROKEN STONE

Crushed rock for aggregate, filling, road construction, &c., is obtained from a variety of sources in Tasmania. Basalt of Tertiary age is quarried at Bridgewater in the Hobart district, at Meadowbank on the upper Derwent River, at Maydena, at George Town on the East Tamar, and along the NW Coast.

Jurassic dolerite, the commonest suitable rock type in Tasmania, is obtained from many localities throughout the State and supplies the bulk of the requirements for crushed material.

Crushed limestone for construction purposes is quarried in the Hobart, Devonport and W Coast districts.

Other rocks such as sandstone, mudstone, shale, &c., are used locally in limited quantities.

The total annual production of crushed material for construction purposes is in excess of 1,600,000 cubic yards.

SAND AND GRAVEL

Extensive deposits of gravel occur throughout the northern part of Tasmania and are principally used for road construction, cement requirements, &c. Large sand deposits in the South Arm area have been worked for several years and smaller quantities have been produced from deposits in the Huonville, Poatina and Meadowbank districts.

Production of sand and gravel exceeds 1,900,000 cubic yards annually.

Gemstones

Although many kinds of gemstones have been reported in Tasmania, few specimens of the more precious varieties have been found. Varieties of crystalline and amorphous silica are by far the most abundant.

There is no recorded economic production of gemstones from Tasmania but considerable interest is shown by private collectors and as a supply for semi-precious jewellery.

DIAMOND

About eight diamonds of small size (average about one-eighth carat and up to one-third carat) have been found in gold-bearing alluvial deposits in a small tributary of the Pieman River and in Harveys Creek, tributary of the Savage River. They were of good crystallization but most specimens were tinged yellow. A report that a small diamond was found in alluvial material in the Hellyer River has not been confirmed.

EMERALD

Crystals of beryl, approaching emerald grade, have been recorded from a number of localities in Tasmania including Flinders Island, Mt Cameron, Moina, Bell Mount and St Pauls River near Brookstead. Some small crystals have been found in Thureaus Deep Lead, St Helens district.

MARCASITE

Marcasite is recorded from several localities such as Mt Lyell, Magnet mine, Scamander, &c., where it is associated with other sulphide mineralization, and from Cox Bight, Cape Barren Island and the Mersey Coal Measures where it occurs as a replacement of wood opal, &c.

There is no record of commercial exploitation although pyrite has been cut and polished and sold under the name of marcasite.

QUARTZ, OPAL AND OTHER SILICATES

Several varieties of quartz, opaline and chalcedonic gemstones have been recorded.

Amethyst has been found in alluvial tin-bearing deposits in the NE of the State in the Blue Tier, Rossarden, and Mt Cameron district; and in the Hampshire district in the NW.

Garnet is a common mineral in the metamorphic rocks of the State and is recorded from numerous localities. The grade and colour of the crystals are extremely variable and few specimens are of gem standard.

Rock crystal is recorded from the Mt Heemskirk, Dundas and Beaconsfield districts and is common in association with cairngorm (smoky quartz) throughout the NE alluvial tin-bearing deposits.

Rose quartz is recorded from the Beaconsfield and Lefroy districts.

Common opal has been recorded from places as widely spaced as Sandy Bay, Bothwell, Flinders and Cape Barren Islands and is common in many localities. Wood opal is equally widespread particularly throughout Tertiary sediments in the N and S of the State.

Chalcedonic stones such as agate, cornelian, onyx, &c., are also commonly associated with Tertiary sediments in most parts of the State and are often associated with wood opal.

RUBY

Small, shattered ruby specimens have been recovered from tin-bearing alluvial deposits in the NE but the colour is usually poor.

SAPPHIRE

Sapphire specimens of varying grade and colour are fairly widespread throughout the tin-bearing alluvial deposits of the NE and in the Wynyard district but only occasional specimens are suitable for cutting. The largest recorded sapphire in Tasmania was a parti-coloured stone of 264 carats weight found in the Weld River.

A few star sapphires have been recovered from the Lottah district.

TOPAZ

Topaz is a common constituent of granitic rocks and is widespread throughout the NE in the tin-bearing alluvium. Stones of gem quality occur in some localities, particularly at Killiecrankie Bay, Flinders Island, where they are referred to as "Killiecrankie Diamonds".

TURQUOISE

Thin seams of turquoise have recently been reported from the Lefroy-Back Creek area, and an occurrence has been recorded at Beaconsfield.

ZIRCON

Small concentrations of poor quality zircons are recorded from the NW and NE parts of the State and from Flinders Island but they are rarely suitable in size or quality for gem cutting.

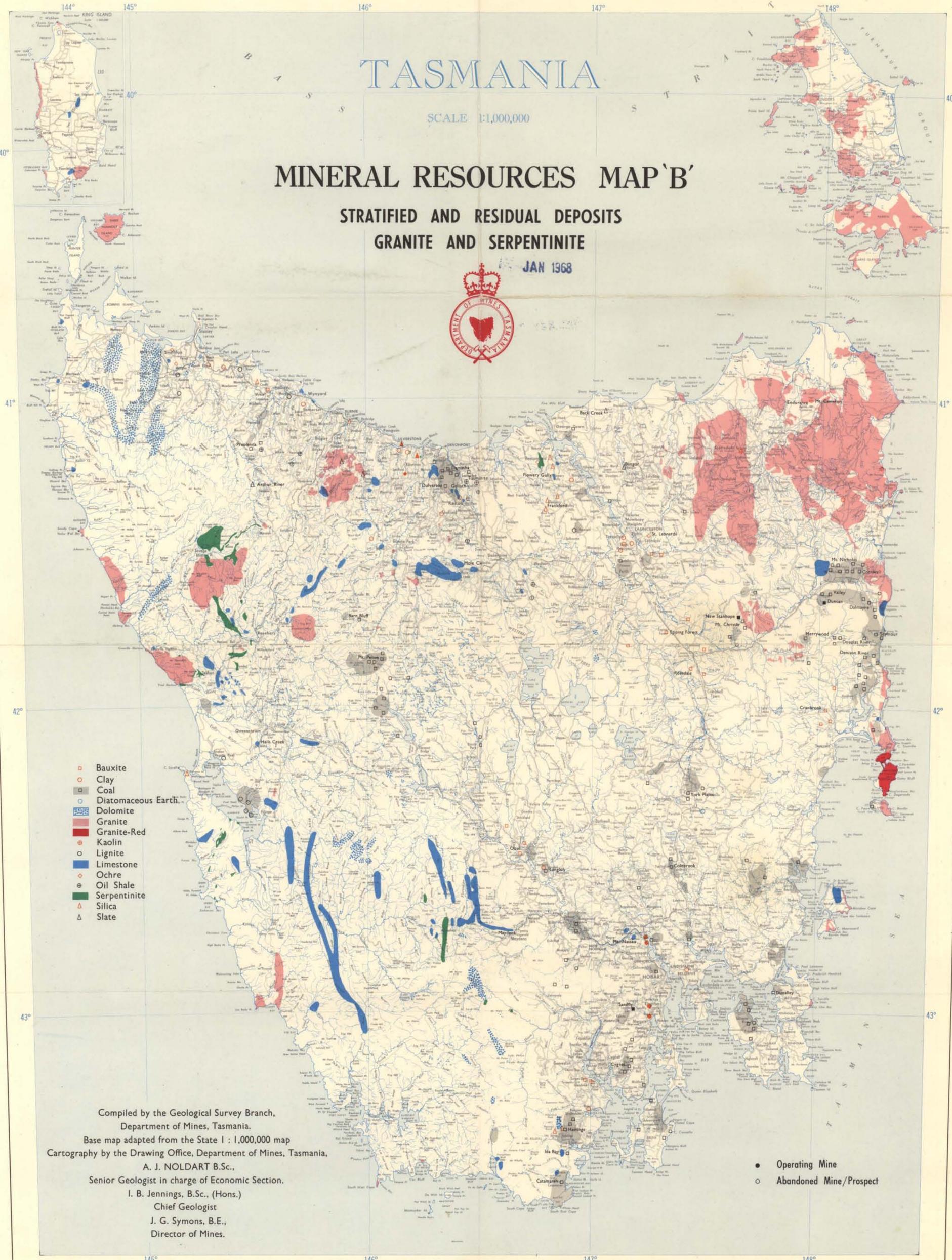
TASMANIA

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MINERAL RESOURCES MAP 'B'

STRATIFIED AND RESIDUAL DEPOSITS GRANITE AND SERPENTINITE

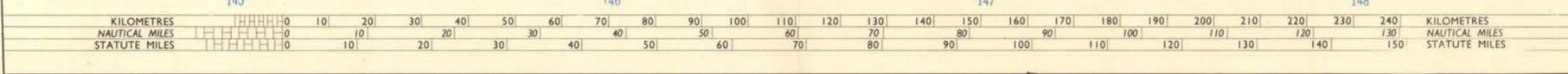
JAN 1968



- Bauxite
- Clay
- Coal
- Diatomaceous Earth
- Dolomite
- Granite
- Granite-Red
- Kaolin
- Lignite
- Limestone
- Ochre
- Oil Shale
- Serpentinite
- △ Silica
- △ Slate

Compiled by the Geological Survey Branch,
Department of Mines, Tasmania.
Base map adapted from the State I : 1,000,000 map
Cartography by the Drawing Office, Department of Mines, Tasmania,
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Director of Mines.

- Operating Mine
- Abandoned Mine/Prospect



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Tasmania. 7001

5 cm

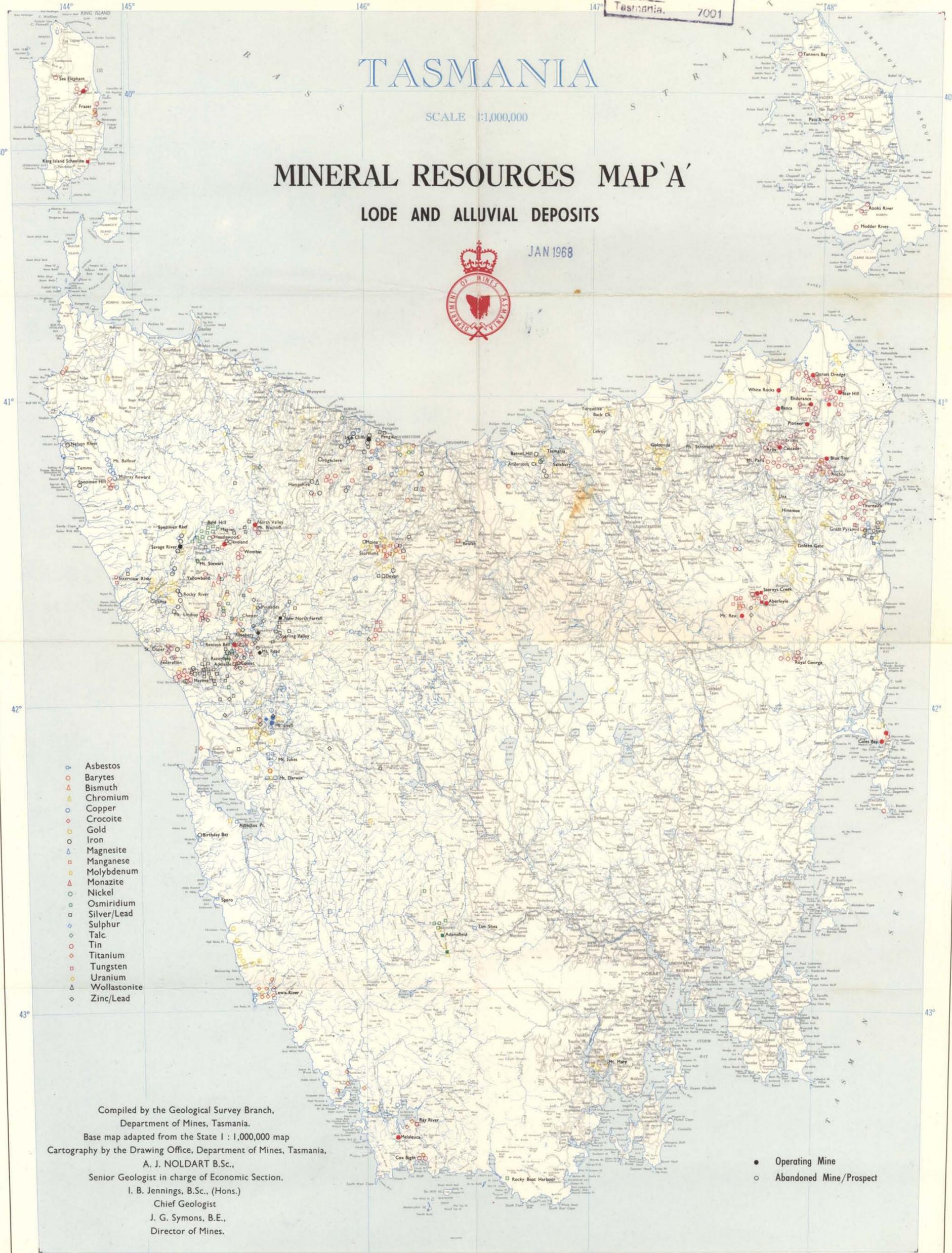
TASMANIA

SCALE 1:1,000,000

MINERAL RESOURCES MAP 'A'

LODE AND ALLUVIAL DEPOSITS

JAN 1968



- ▣ Asbestos
- Barytes
- △ Bismuth
- ▲ Chromium
- Copper
- ◇ Crocoite
- Gold
- Iron
- △ Magnesite
- Manganese
- Molybdenum
- △ Monazite
- Nickel
- Osmiridium
- Silver/Lead
- Sulphur
- ◇ Talc
- Tin
- Titanium
- Tungsten
- Uranium
- Wollastonite
- ◇ Zinc/Lead

- Operating Mine
- Abandoned Mine/Prospect

Compiled by the Geological Survey Branch,
Department of Mines, Tasmania.
Base map adapted from the State 1 : 1,000,000 map
Cartography by the Drawing Office, Department of Mines, Tasmania,
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