Fig. 19 Aplite vein offset by movement along a joint, Mersey River.
Aplitic dykes cut the granodiorite at various places. Figure 19 shows an aplite vein, in granodiorite, that has been offset by movement along a joint. The dykes are up to three feet wide and generally trend roughly east-west. Two other types of dyke rock outcrop in the Mersey River.

The first type is a pink, medium-fine grained rock which, in thin section, consists of orthoclase (50%), plagioclase (30%) and quartz (20%) with occasional chlorite patches and tourmaline crystals. Both the orthoclase and plagioclase are turbid and appear pinkish in plane polarized light. Orthoclase is perthitic and rarely twinned on the Carlsbad law. Plagioclase is altered and twinned according to the albite and pericline laws. Some untwinned albite is also present. Some of those dykes have a layer of dark green material between the dyke and the enclosing granodiorite. Thin sections show the dark grey material to consist of slightly crushed granodiorite with a protomylonitic texture (fig. 20) in a dark greenish, chloritic "matrix". It seems that these dykes intruded up the centre of crushed zones in the granodiorite, sometime after the granodiorite had cooled.

The second type of dyke-like rock is dark greyish-purple containing many angular, platy, pink fragments, biotite flakes, pyrite crystals and rock fragments in a dark grey groundmass. The maximum particle size is 10 mm. long and the rock has a directional texture. Microscopically, embayed volcanic quartz with quartz overgrowths, strained quartz and quartz-feldspar intergrowths, cleavage fragments of orthoclase, biotite,
Fig. 20 Crushed granodiorite (protomylonite?) next to feldspar dyke, Mersey River.
pyrite, graphic granite fragments, magnetite crystals and quartzite and chert fragments, are all set in a dark groundmass of fine grained chlorite and ferruginous material. The rock has a sedimentary texture as in a greywacke and there is no evidence of thermal metamorphism or shearing. Figures 21a and b show photomicrographs taken parallel and perpendicular to the directional texture, respectively. Analyses 5 in Table 3 is of a "dyke rock" which outcrops beside the Mersey Forestry road and whose thin section description is practically identical with the rock described above.

Six of these "dyke rocks" were noted in the Mersey River between one and a half and two miles north of Martha Creek. Due to paucity of outcrop, they can only be traced up to highwater mark in the river but some can be seen to extend for at least thirty feet, generally trending between 260° and 320° and dipping steeply to the south. They are from eight to sixteen inches thick and the contacts with the enclosing granodiorite are sharp.

The occurrence of this "dyke rock" is problematical: in thin section it appears to be a greywacke, in the field it occurs as tabular, dyke-like bodies cutting granodiorite. There are five possible explanations for this rock but on the available evidence, none of these is entirely satisfactory. The "dyke rock" may be:

1. Intrusive dykes
2. Xenolithic "screens"
3. Sedimentary layers
4. Unassimilated rafts of sedimentary material
5. Mylonitic zones.
Specimen 33592

Fig. 21a Section parallel to directional texture of "dyke rock", Mersey River.

Specimen 33592

Fig. 21b Section perpendicular to directional texture of "dyke rock", Mersey River.
1. Evidence for intrusive dykes is their shape in the field and their sharp margins with the granodiorite. The composition of the particles and non-deformed sedimentary texture practically rules out the suggestion of intrusive dykes of either igneous or sedimentary material.

2. Arguments for xenolithic "screens" such as the type commonly found in ring dyke complexes, are the sedimentary texture and their tabular shape. Against this is the lack of baking from the surrounding granodiorite and the composition of the fragments. The fragments include chert and Cambrian (?) lavas and the nearest known occurrences of rocks such as these are given in the Forth River below Lorinna and in the Mersey River below Liena. In the Mersey, the Granodiorite is only known to intrude Precambrian schists which show many effects of thermal metamorphism near the southern boundary of the Granodiorite. This explanation requires multiple intrusions of granodiorite. To propose multiple intrusions on the evidence above alone, would perhaps be a trifle foolhardy.

3. Sedimentary layers or rafts enclosed by granodiorite "flows" require parts of the granodiorite to be extrusive. No effusive forms of granodiorite have been recorded from this vicinity. The location of the "dykes" roughly in the centre of the granodiorite mass, their steep southerly dip, and their lack of thermal metamorphism are against this explanation. The evidence for this is their sedimentary composition and texture.

4. The arguments for unassimilated rafts of sedimentary material is the composition. However, the lack of alteration of either the fragments or the groundmass together with the lack of evidence for assimilation elsewhere, practically rules this out.
5. Mylonitic zones are present elsewhere in the Dove Granodiorite in the Mersey River but these are quite different from the "dykes". The texture of the "dyke rocks" is quite incompatible with their being mylonites or protomylonites.

To solve the problem of these rocks, it will be necessary to carry out more detailed fieldwork and petrological examinations. More chemical analyses would also be advantageous.

Outcrops of granodiorite along the Mersey Forestry road are deeply weathered. These rocks have an earthy lustre and dark green veinlets of chlorite are common. The ferromagnesians have all altered to green chlorite showing anomalous blue interference colours. Plagioclase is almost completely sericitized and the orthoclase is turbid. Several small aplite dykes outcrop near the boundary with the Moina Sandstone but do not pass into the sandstone. The aplites are pale green with a saccaroidal texture of glassy quartz surrounded by altered feldspars and green chlorite.

Analyses of some rocks from the Mersey Forestry Road are given in Jennings (1963) and are reproduced in Table 3. The granodiorites are similar to the average granodiorite in Barth (1962, p.58) but it is interesting to note that the potash content is greater than the soda content in the Mersey rocks. (The Volcanics in the Forth River also have potash:soda ratios greater than one, it is suggested later that the granodiorite magma was the parent magma of the lavas in the Forth River.)

Granodiorites are intrusive into the Dove Schist in the Forth River one quarter of a mile south of the Dove-Forth confluence. Essentially similar to the granodiorites in the Mersey River, the most notable difference
# TABLE 3

CHEMICAL ANALYSES OF GRANODIORITE ROCKS FROM THE MERSEY FORESTRY ROAD.

<table>
<thead>
<tr>
<th>Source</th>
<th>Analysis Description</th>
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<tbody>
<tr>
<td>1</td>
<td>Aplite, Mersey Road, Jennings (1963)</td>
</tr>
<tr>
<td>2</td>
<td>Aplite, Mersey Road, Jennings (1963)</td>
</tr>
<tr>
<td>3</td>
<td>Granodiorite, Mersey Road, Jennings (1963)</td>
</tr>
<tr>
<td>4</td>
<td>Granodiorite, Mersey Road, Jennings (1963)</td>
</tr>
<tr>
<td>5</td>
<td>Dyke rock, Mersey Road, Jennings (1963)</td>
</tr>
<tr>
<td>6</td>
<td>Dyke rock, Mersey Road, Jennings (1963)</td>
</tr>
<tr>
<td>7</td>
<td>Average granodiorite, Barth (1962) p.58</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>Specimen</th>
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<tbody>
<tr>
<td>8</td>
<td>Specimen 33592</td>
</tr>
</tbody>
</table>

## Source

1. Aplite, Mersey Road, Jennings (1963)
2. Aplite, Mersey Road, Jennings (1963)
3. Granodiorite, Mersey Road, Jennings (1963)
4. Granodiorite, Mersey Road, Jennings (1963)
5. Dyke rock, Mersey Road, Jennings (1963)
6. Dyke rock, Mersey Road, Jennings (1963)
7. Average granodiorite, Barth (1962) p.58

### NOTE: The petrological description of analysis 6 is identical with specimen 33592.
Specimen 33572

Fig. 22  Hornblende segregation in Dove Granodiorite, Morsey River.
is the development of epidote. Most thin sections examined showed epidote forming along the cleavage of the biotite laths, in small patches in the hornblende and associated with sericite in altered plagioclase crystals (fig. 15a). Occasional circular patches up to four inches across consist of segregations of small (0.5 mm.) hornblende crystals with interstitial orthoclase and subhedral to euhedral plagioclase (fig. 22b).

An adamellite is exposed in the adit of the Powerful Mine. This contains only about 5% ferromagnesian minerals of which biotite is dominant. The plagioclase is sericitized and orthoclase is partly turbid with microperthitic texture. Quartz tends towards crystal outlines and some subgraphic texture is present (fig 23).

Traversing north from the confluence, the granodiorite appears to become progressively more altered. Plagioclase, without exception, is completely altered to sericite and minor epidote and biotite and hornblende are chloritized. Sericitization of the plagioclase makes them stand out in thin section and small euhedra are commonly poikilitically enclosed in orthoclase, quartz or biotite. Glomeroporphyritic patches of plagioclase euhedra are common. Figure 24a shows the texture of the altered granodiorite and a glomeroporphyritic patch of sericitized plagioclase whilst figure 24b shows an euhedral, sericitized plagioclase crystal in which the original zoning is still quite distinct. Patches of this rock are rich in haematite replaces the groundmass, most of the feldspar and ferromagnesians and is beginning to replace quartz along cracks in the quartz (fig. 25).

Along the road south from Lorinna, haematite is common in the granodiorite, occurring as veins or filling joints and replacing the granodiorite.
Fig. 23a. Subgraphic texture in adammellite, Powerful Mine.
(Quartz is white, orthoclase is black)
Specimen 33576  x14  x nicols

Fig. 24a Glomoporphyritic patch of plagioclase in altered granodiorite, Forth River.

Specimen 33577  x19  x nicols

Fig. 24b Zoned plagioclase in granodiorite, Forth River.
Specimen 33566 v22 Ord. Light

Fig. 25 Haematite replacing granodiorite, Forth River.
The ultimate in alteration is apparently reached in specimen 33567 from a roadcut by the main road one and a half miles south of Lorinna. In handspecimen, (fig. 26a) the rock is mottled green and purple in colour with glassy or milky quartz phenocrysts (to 6 mm.). Outlines of large, euhedral feldspar crystals (10 mm.) can be made out in a greenish, granitic-looking groundmass. Microscopically, this rock consists of irregular quartz crystals in a fine grained, felted sericitic groundmass (fig. 26b). Pools of recrystallized (?) quartz are fairly common with some quartz tending to crystals tending towards crystal outlines. The sericite needles invariably penetrate edges of the quartz crystals. Extremely vague outlines of feldspar (?) crystals can sometimes be seen. Occasional small flakes of muscovite occur and these are generally associated with fine grained haematite which penetrates the muscovite cleavage.

Immediately below the Moina Sandstone at the Golden Cliffs Mine and three quarters of a mile south of the Lorinna bridge, the Dove Granodiorite is represented by a highly altered, greenish-grey rock that, in handspecimen, looks like and altered granitel Microscopically, it has an igneous texture and is very similar to less altered granodiorites further upstream. This rock was originally mapped by Jennings and Burns (1958) as the Lorinna greywacke but in the author's opinion, it represents an altered phase of the Dove Granodiorite.

High on Five Mile Rise south of the Great Caledonian Mine, scarce outcrops of altered tuffs (?) occur. These have large (5 mm.) quartz phenocrysts which are cracked and corroded and generally show well-developed
Specimen 33567

Fig. 26a Altered granodiorite, road south of Lorinna.

Specimen 33567

Fig. 26b Photomicrograph of rock above - quartz-sericite rock.
(lacey) quartz overgrowths (fig. 27a). The feldspars are completely sericitized and the ferromagnesianns are replaced by chlorite and iron oxides, commonly showing fuzzy margins (fig. 27b). The phenocrysts are set in an indeterminate equigranular groundmass that, in many cases, approximates to globular form and may represent devitrified glass (fig. 28). It is suggested that these were originally crystal tuffs that have undergone alteration by hydrothermal solutions originating from the granodiorite intrusive below (see pages beforehand).

The Dove Granodiorite intrudes quartzites of the Dove Group in the Dove Gorge. The contact between these two rock types is irregular and there are large roof pendants of Precambrian rocks both east and west of the Devon Mine. The marginal phases of the intrusive are very porphyritic consisting of large cracked and resorbed quartz crystals (to 10 mm.), sericitized plagioclase (to 8 mm.) and biotite and hornblende laths (5 mm.) in a fine grained equigranular quartz-feldspathic groundmass (fig. 29a, b). The ferromagnesianns are partly chloritized and chlorite veinlets are common.

For the most part, this is a hornblende granodiorite practically identical with those in the Mersey and Forth Rivers. However, parts of the granodiorite must have had a fairly complicated cooling history. Plagioclase is almost without exception, euhedral and very rarely contains inclusions of ferromagnesianns. This implies plagioclase was one of the earliest minerals to crystallize. The glomeroporphyritic patches of plagioclase euhedra here and in the other granodiorite, means that synnensis took place whilst the
Specimen 33598 x 24 x nicols

Fig. 27a Quartz overgrowths in altered tuff (?), Five Mile Rise

Specimen 33600 x 16 x nicols

Fig. 27b Sericitized feldspars and chloritized ferromagnesians in altered tuff (?), Five Mile Rise.
Specimen 33599  x18  x nicols

Fig. 28 Quartz phenocrysts with overgrowths in groundmass of devitrified glass (?), Five Mile Rise.
Fig. 29a Quartz and feldspar phenocrysts in fine grained quartz–
feldspathic groundmass, Dove River.

Fig. 29b Plagioclase and ferromagnesian phenocrysts
in fine grained groundmass - Granite porphyry, Dove
River.
plagioclase (and perhaps some hornblende) was crystallizing. However, synneusis here did not lead to banding of the granodiorite. The larger plagioclase crystals commonly have more altered cores of plagioclase in a different optical orientation (fig. 30a). Figure 30b shows a large albite crystal enclosing smaller plagioclase and quartz crystals. The tabular plagioclase in the core has a relief about the same as quartz which indicates a composition near oligoclase. A partial rim of anhedral quartz surrounds this crystal and quartz anhedral are included in the albite. The albite shows an incipient microperthitic texture. Near the margin of the albite crystal, is a partial ring of anhedral quartz and outside this, is albite again. The central plagioclase crystal must have crystallized first and then become rimmed by quartz. The albite crystallized around this (the plagioclase probably acted as a nucleus for crystallization) but there must have been a change of conditions as the later albite is more soda rich (higher negative relief). Another pause in crystallization allowed a rim of small quartz crystals to form around the albite, then albite again crystallized forming the outermost rim of the albite crystal. The last stage of albite growth must have been quite late in the cooling history as the outermost rim can be traced into the surrounding crystals where it is interstitial.

In the granodiorite from the Dove Gorge, the quartz again shows the curious granular form, tending towards crystal outlines and with a tendency to form graphic intergrowths with potash feldspar, common in high level granitic intrusions.
Specimen 33574

Fig. 30a Plagioclase with altered core in a different optical orientation, granodiorite, Dove River.

Specimen 33574

Fig. 30b Large albite crystal enclosing quartz and plagioclase crystals (see text). Dove Granodiorite, Dove River.
Synthesis of the Dove Igneous Suite

The Bull Creek Volcanics, the Lorinna Volcanics and the Dove Granodiorite together make up the Dove Igneous Suite. It is suggested that the porphyritic acid lavas are the surface or near-surface equivalents of the Dove Granodiorite. According to Moorhouse (1959), dacites are the surface equivalents of quartz diorites but, in chemical composition, they are closer to granodiorites, so it is not unlikely that the dacites of the Bull Creek Volcanics originated from the same magma as the Dove Granodiorite. Toscanites and rhyolites are the surface equivalents of adamellites and granite (s.s.) respectively – both adamellites and granites (s.s.) are present in the Dove Granodiorite. The other recognisable lavas in the Volcanics are keratophyres and quartz keratophyres which Williams, Turner and Gilbert (1954, p.101) state "bear much the same relation to andesites and dacites as spilites do to normal basalts." i.e. quartz keratophyres can be regarded as a variety of alkaline dacite. The indeterminate porphyritic acid lavas of the Volcanics are probably extrusive or intrusive forms of the original acid magma and have been altered hydrothermally and dynamically so that they cannot now be given a specific name.

It is suggested that the origin of the Dove Igneous Suite is similar to the mode of origin of peperites described by Carozzi (1960, p.86-92). "Peperites resulted from the intrusion and fragmentation and mixture of an andesitic or basaltic magma and wet lacustrine, calcareous, argillaceous or diatomaceous sediments." (Carozzi, 1960, p.36) In this area, granodiorite magma is thought to have intruded wet marine acid volcanics, greywackes,
siltstones and cherts. The petrological characteristics of peperites as described in Carozzi are not present here so a detailed discussion of peperites is unwarranted. Sufficeth to say that peperites have two very distinct components: globular, but not water worn, particles of volcanic glass up to 10 cm. in diameter, and a carbonate to argillaceous matrix which locally may display a siliceous character.

The formation of the Dove Igneous Suite is envisaged thus: sedimentation began in an easterly continuation of the Dundas Trough sometime during the Cambrian period. (No definite age can be ascribed to this sedimentation due to the unfossiliferous nature of the sediments, but it is probably Middle to Upper Cambrian by analogy with the Dundas Trough on the West Coast.) A volcanic centre or series of centres developed around the edge of the Tyennan Block and helped to fill the Trough with flows of dacites, keratophyres, rhyolites, quartz porphyries and associated volcanic rocks, all interbedded with the greywackes etc. in the Trough. (Some of the igneous rocks may be intrusive but this cannot be demonstrated in the field.) Towards the end of the volcanic activity, probably late in the Jukesian Movement, granodiorite made its way towards the surface up fractures along the margin of the Tyennan Block. The southern boundary of the granodiorite is intrusive into Precambrian and it is suggested the northern boundary is intrusive into the margin of the Dundas Trough (fig. 31). Hydrothermal solutions associated with the granodiorite caused extensive alteration of the earlier lavas and sediments. According to Moorhouse (1959) secondary enlargement of quartz phenocrysts by the addition of lacy
Dundas Trough

I. Initial sedimentation - greywackes, etc.

II. Volcanism begins along the edge of the Trough - extrusion of lavas, intrusion (?) of porphyries.

III. Further uplift of the Tyennan Block and intrusion of the Dove Granodiorite.


C.E.Gee/1965
rims in optical continuity with the original grain, is typical of hydrothermal alteration of porphyries etc. This possibly explains the overgrowths on quartz crystals in the Bull Creek Volcanics and in the tuffs high on Five Mile Rise. Deuteric solutions caused the extensive sericitization of the plagioclase and chloritization of ferromagnesians in the Dove Granodiorite.

This hypothesis requires the Dove Granodiorite to be hypabyssal. The texture in thin section is apparently characteristic of high-level granites which intrude their own lavas (Joplin, pers. comm., 1965). The euhedral plagioclases in the porphyries and the glomeroporphyritic patches which imply early crystallization of plagioclase, and the interstitial appearance of orthoclase, are characteristic of granitic magmas that began crystallization at depth and finished crystallization at a higher level after intrusion (Tuttle, 1952). The quartz which tends to crystal outlines and shows incipient graphic texture with orthoclase, is also characteristic of high-level granites (Joplin, pers. comm., 1965). Other evidence for high-level granodiorites is their location along the southern margin of the Dundas Trough where it is difficult to envisage a thick succession of Cambrian rocks. One interpretation of the sedimentary "dyke rocks" in the Mersey River requires the granodiorite to be effusive, but as pointed out before, this is a rather tenuous evidence.

Between Liena and the granodiorite in the Mersey River, Cambrian sediments and volcanics are apparently absent. This absence may be due to erosion of the Cambrian volcanics on top of the Dove Granodiorite, before
the deposition of the Moina Sandstone. However, Cambrian volcanics are probably present below the Moina Sandstone and are not exposed as the Mersey has not yet cut a deep enough valley. The only reason the tuffs at the top of Five Mile Rise are exposed beneath the Moina Sandstone, is that the Dove River has cut a deep gorge at this point. If the gorge was not present, Moina Sandstone would directly overlie the Dove Granodiorite.

Petrologically, parts of the Dove Granodiorite and Murchison Granite are identical. The isotopic age dates (Table 2) establish them both as pre-Ordovician and the Murchison Granite is considered to have been emplaced during the Jukesian Movement (Brooks, 1962).

The Bull Creek Volcanics and Lorinna Volcanics are probably formed at the same time as volcanic activity was occurring elsewhere in the Cambrian of Tasmania. This would make the Bull Creek Volcanics and Lorinna Volcanics equivalent in part at least, to the Mt. Read Volcanics on the West Coast.

Minnow Keratophyre

To the north and northwest of the area, several thousands of feet of acid lavas, soda rhyolites and keratophyres with some greywackes and siltstone bands, outcrop. This sequence has been named the Minnow Keratophyre by Jennings, et al. (1959). Good exposures of the Keratophyre are found along the Cradle road around Bell Mount, along the lower Hydro road to the Cethana damsite and on the Lorinna road one mile north of Round Hill.
Beneath the Roland Conglomerate on the Lorinna road, the Minnow Keratophyre is represented by a series of cleaved siltstones with occasional acid lavas. On the Hydro road to the Cethana damsite, cleaved siltstones and pale green quartz keratophyres are exposed. Around Bell Mount, strongly cleaved siltstones, phyllites, slates and schists outcrop with acid lavas, including quartz keratophyres and rhyolites. Deformation has obliterated all texture but the coarser porphyritic texture of the lavas. The lavas contain up to 30% quartz phenocrysts (1-3 mm. diameter) in a foliated sericitic matrix of cloudy feldspar, muscovite or biotite and chlorite. Many of the quartz crystals show resorption embayments.

According to Jennings in Spry and Banks (1962, p. 136), the Gog Range Greywacke grades up into the Minnow Keratophyre. The Gog Range Greywacke is considered to be Upper Cambrian in age (based on fossil evidence) which means the Minnow Keratophyre is also Upper Cambrian. Jennings also tentatively suggests that the Bull Creek Volcanics are above or equivalent to the Minnow Keratophyre.
The Dolcoath Granite outcrops as a roughly circular body about two miles in diameter, between Dolcoath Hill and Tin Spur. The granite intrudes Cambrian and Ordovician rocks and has been dated by McDougall and Leggo (1965) using the K-Ar method on biotite, as 345 million years. In the following discussion, the term granite is used in the strict sense to indicate a granitic rock in which potash feldspar is more than two thirds of the total feldspar.

The granite is extensively weathered to depths of up to sixty feet except near its northern boundary in the Forth River where patches of relatively fresh granite occur in the river bed. Because of the extensive nature of the weathering, the granite was probably quite extensively altered by deuteric solutions in its latter stages of cooling, causing sericitization of the plagioclase and greisenization. The weathered rock is a dark brown or yellow-brown, iron-stained friable rock in which all the feldspars have altered to clay materials and the biotite has altered to chlorite and iron oxides.

An average composition of the granite is potash feldspar (40%), quartz (35%), plagioclase (20%) and biotite (5%) with accessory zircon, fluorite, apatite, cassiterite, topaz and disseminated sulfides (molybdenite and pyrite). The texture is granitic with an average grain-size of 4 mm., but some feldspars reach 7 mm. in length.
Potash feldspar almost always shows microperthite texture in thin section. Only rarely does potash feldspar show the grid-iron twinning of microcline, so it is assumed the majority of the potash feldspar is orthoclase. Orthoclase subhedra are up to 7 mm. long and many show Carlsbad twinning.

Quartz is generally anhedral and interstitial to the other minerals. Anhedra range up to 5 mm. across and liquid-gas inclusions are common.

The plagioclase is generally more or less sericitized but twinning according to the albite, pericline and Carlsbad laws is easily distinguished. Extinction angles on the albite twins give plagioclase compositions in the range $\text{An}_{34}$ to $\text{An}_{24}$ (oligoclase). Normal zoning is present in some crystals. Small, untwinned anhedra of an optically positive mineral with negative relief and low birefringence, are present in some thin sections. This mineral is probably secondary albite that is an alteration product of the plagioclase.

Biotite occurs in laths up to 6 mm. long. It is pleochroic, brown and less commonly olive-green, and commonly contains zircon and apatite are included in the laths. The zircon is surrounded by pleochroic haloes.

The accessory minerals are generally present as small subhedra or euhedra. Fluorite occurs in aggregates up to 3 mm. across. Patches of disseminated sulfides and small wolfram blades occur in the northern part of the granite. Molybdenite is the dominant sulfide in these segregations.
Modifications of the granite are common in the northern areas of the granite outcrop. One quarter of a mile south of Tin Spur, pegmatite dykes outcrop beside the Lorinna road. These are up to three feet wide and are somewhat variable in composition, containing patches of large orthoclase crystals (up to four inches long), large books of biotite (three inches across), and rosettes of muscovite (one and a half inches diameter) with subordinate quartz and plagioclase. The orthoclase crystals show broad Carlsbad twinning, microperthitic texture and well developed graphic intergrowths with quartz (fig. 32a). In the vicinity of Dolcoath Hill, some of the old mines worked pegmatite dykes. A beryl-muscovite-wolfram pegmatite dyke was worked on Sayers' lease.

Patches of greisen have also been the basis of some mines. These are mainly granular quartz and fine grained white mica laths (fig. 32b) with cassiterite, sulfides and some wolfram. Fluorite, topaz, beryl and zircon are rather rare accessory minerals of the greisens. The Hidden Treasure, Premier, Dolcoath and Squib Mines expose greisens in their workings.

Aplite dykes outcrop in the Forth River south of Narrawa Creek and along the Lorinna road. Outcrops are too poor to determine whether or not the aplites penetrate the Ordovician and Cambrian rocks. The aplite dykes are generally about two feet wide, fine grained and pinkish in colour. Thin sections show them to have a sugary texture and consist of orthoclase (45%), quartz (45%) and plagioclase (10%) with traces of small (0.3 mm.) biotite laths.
Fig. 32a  Graphic texture in pegmatite, Lorinna Road.

Specimen 33614  x 11  x nicols

Fig. 32b  Greisen, Lorinna road.

Specimen 33611  x 9  x nicols
Around the southern edge of the granite outcrop, pegmatites and greisens are apparently absent. Aplite dykes are rare and the granite appears remarkably homogeneous. The composition of this area is close to the average composition for the granite given above.

All in all, the Dolcoath Granite seems to be fairly typical of the Devonian granites in Tasmania. It is the source of numerous small tin-tungsten and sulfide deposits in the area.

**Form of intrusion**

Although stock-like in appearance, the Dolcoath Granite is considered to be a northerly or northeasterly dipping body. If the land surface was not deeply dissected by the Forth River and its tributaries here, and the surface was roughly even from the summit of Dolcoath Hill to Tin Spur, then the granite would not outcrop at the surface.

The known lodes associated with the granite (fig. 35) show a marked distribution in and around the northern margins of the granite. The lodes extend in a westerly direction toward the Shepherd and Murphy Mine. The lodes between the granite and the Shepherd and Murphy Mine are wolfram-cassiterite with sulfides, indicative of fairly high temperature deposits whereas the Round Hill deposits, which are closer to the granite than the Shepherd and Murphy Mine, are lower temperature sulfide deposits. To explain this pattern of mineralization, it is necessary to invoke a westerly or northwesterly extension of the Dolcoath Granite to the vicinity of the Shepherd and Murphy Mine.
The lack of mineral deposits or other evidence of residual solutions in the southern area of the granite outcrop and the abundant mineralization, greisenization, etc., in the northern area, seem to indicate that the northern part of the granite represents the top of the intrusion. In order for this to be so, the granite must dip northerly or northeasterly. This would also explain the lack of metamorphism of the Cambrian rocks south of the granite contact in the Forth River as the southern or bottom part of the granite would have been relatively cold. North of the granite boundary there has been metamorphism due to the granite: the Roland Conglomerate has been recrystallized in places, some beds of the Moina Sandstone have been contact metamorphosed to spotted hornfelses and the Gordon Limestone south of Tin Spur and at the Shepherd and Murphy Mine has been altered to a skarn rock.

Calcareous beds in the Round Hill vicinity and limestone in Claude Creek remain unaltered. A few hundred yards northwest of the Shepherd and Murphy Mine in Bismuth Creek, at the Iris bridge and at various places around Moina, unaltered Gordon Limestone outcrops. These examples illustrate the local nature of metamorphism associated with the Dolcoath Granite.

If it is assumed that the Dolcoath Granite is a northerly dipping body roughly tabular in shape, extending from about Tin Spur west to the Shepherd and Murphy Mine, then the above phenomena can be explained, as the residual solutions and volatiles would be concentrated along the northern or uppermost boundary of the granite.
The granite body is only exposed between Dolcoath Hill and Tin Spur as the Forth has cut a deep valley here. Recent geophysical work by the Hydro Electric Commission along the Wilmot-Cethana tunnel line indicates granite below Ordovician rocks at about 800 feet below the surface (S.J. Paterson, pers. comm., 1965). (The tunnel line is planned to be about half a mile north of Narrawa Creek.) This is in accordance with the suggested northerly dip of the granite.

Twelvetrees (1913) reported skarn rock west of the Iris River and along the track to Stormont, whilst Burns (1960) reported mineralized skarn inliers in synclines in the Stormont Mine - Fletchers Adit area (see fig. 50). The presence of skarn in this area probably means a small cupola of granite is present at no great depth in the vicinity of the Stormont Mine.

That the granite in the Dolcoath Hill area punched its way up rather than quietly stoped its way through the country rock, is evident from the buckling of folds in Ordovician rocks near Tin Spur, round the granite. The thrust fault on Tin Spur with the south block up, is attributed to the granite intrusion as is the sheeted vein system west of Dolcoath Hill. The veins are thought to be fractures in Moina Sandstone caused by the intrusion of the granite and later mineralized by mineralizing solutions emanating from the granite.
**TERTIARY**

**Basalt and Agglomerate**

Tertiary basalt flows now form the plateau areas between the Mersey and the Forth and between the Forth and the Iris Rivers. The basalt does not outcrop very much but the road cut near the Shepherd and Murphy Mine exposes olivine basalt with the incipient development of columns. West of the Shepherd and Murphy Mine, agglomerate occupies much of the valley slopes to the Iris River. The presence of agglomerate implies a volcanic vent in this vicinity. Drilling by the H.E.C. in the Bell Mount Goldfields area, suggests a Tertiary (?) fault just west of the Cradle road and striking about north-south. The vent (or vents) from which the basalt and agglomerate originated, may be associated with this fault.
STRUCTURAL GEOLOGY AND TECTONICS

Precambrian rocks

The Dove Group which outcrops in the southern portion of this area was considerably deformed during the Precambrian (Spry, 1962, 1963). First order structures, formed during the Precambrian, are intersected by later Tabberabberan structures. The first-order structures are two to three miles across and there are several sets of smaller folds—one set a few hundred feet across, another set a foot or so across and another set on a microscopic scale. First-order Tabberabberan structures are not expressed in the Precambrian rocks, but numerous northwesterly trending, small scale folds are probably Tabberabberan in age (Jennings, 1963).

Cambrian rocks

Due to paucity of outcrop, it is difficult to determine accurately the fold patterns in Cambrian rocks. A regional pattern can be discerned if the Cambrian rocks on the Sheffield Quadrangle are considered in conjunction with those exposed south of the Dolcoath Granite. According to Jennings (1963), in this area the Cambrian rocks show similar type folding with a strongly developed axial plane cleavage, especially in the axial region of first-order folds. Minor folds plunging to the northwest and southeast are similar to smaller folds in the Ordovician sandstones.
The Bull Creek Volcanics outcropping south of the Dolcoath Granite in the Forth River show a strongly developed schistosity. These rocks are folded here into a regional anticline (the Dolcoath Anticline of Burns, 1961) and the schistosity shows maximum development on the southern side of the anticline. This schistosity is Devonian in age as Gordon Limestone in the Forth north of Oliver's Creek, shows strong shear folding with the cleavage planes parallel to those in the Volcanics (Burns, 1961). The schistosity in the Volcanics north of Oliver's Creek dips 30-40° north near the Cambrian-Ordovician boundary. The dip generally steepens to the north, being 80°N at Geales Bridge, then becoming vertical and overturned further north. Burns (1961) reports drag folds from three places in these rocks with their axial planes parallel to the schistocity. These drag folds have wavelengths of about thirty feet.

In the Lorinna Gorge, the Lorinna Volcanics show a strongly developed schistosity dipping 80-85° at 275°. At the now abandoned H.E.C. damsite in the Lorinna Gorge, the Moina Sandstone is apparently conformably overlying green, cleaved siltstones of the Lorinna Volcanics. However, this apparent conformity is probably due to a low angle thrust fault thrusting the Sandstone over the Volcanics. The shearing in the acid lavas here is probably related to thrusting in this area as, apart from the thrust above, there are several smaller thrusts in the Lorinna Gorge and at the southern end of the Gorge, a powerful fault thrusts the Volcanics over Gordon Limestone. All the thrusts in this area strike approximately east-west and dip quite steeply to the north.
The Dove Granodiorite has in all probability, been quite strongly folded but nowhere can this be demonstrated. In places, the granodiorite shows a weak foliation (?) of ferromagnesian minerals but this is not developed well enough to map.

The southern flank of the Dolcoath Anticline has been faulted off by a powerful, steeply dipping thrust fault. This fault dips northerly with the south block down and there may be some dextral transcurrent movement on it. It is probably a continuation of the Bismuth Creek fault (Q.Y.) in the Moina area.

Bell Mount is a large mass of Cambrian Minnow Keratophyre that has been thrust over Moina Sandstone. This thrust is terminated in the west by a dextral transcurrent fault and in the east by another thrust fault (see fig. 3). In the Forth River about three quarters of a mile north of the Cethana dam site, Minnow Keratophyre is thrust over unassigned Cambrian greywackes and sandstones, which in turn are thrust over Moina Sandstone.

Jennings (7963) gives several lines of evidence that indicate the Cambrian rocks were deformed before the Ordovician.

1. At Cethana and Tin Spur, there is a well marked unconformity between Cambrian and basal Ordovician rocks (fig. 10).

2. The basal Roland Conglomerate at Cethana and other places contains pebbles of sheared Cambrian rocks.

3. The strong axial plane schistosity of the Cambrian rocks does not persist into Ordovician rocks except locally near demonstrably
Tabberabberan structures. Burns (pers. comm., 1965) is of the opinion that the strong cleavage in the Cambrian rocks below the Cethana unconformity, passed up into the overlying Roland Conglomerate. This appears to be a matter of debate as the author has inspected the unconformity and is of the opinion it is pre-Ordovician. Beswick's workings east of the Cradle road expose the Bull Creek Volcanics in contact with the Moina Sandstone. The Volcanics are strongly sheared, whereas the Moina Sandstone is not sheared. The structure here is not an unconformity, however, but the Volcanics are faulted into contact with the Sandstone (see fig. 11).

4. There is a contrast in fold style from similar type folds with accommodation by axial plane schistosity in the Cambrian rocks, to concentric folds with bedding-plane slip in the Ordovician rocks.

5. The schistosity in the Dolcoath Anticline appears to fan, indicating refolding (Burns, 1961).

The pre-Ordovician deformation probably resulted from the Jukesian movement which was, therefore, strong enough to develop folds and a regional schistosity in the Cambrian rocks. This was followed by, or accompanied by, uplift and erosion but the period of erosion and amount of uplift cannot have been great as there are no deposits of material derived from the erosion of extensive highlands of Cambrian rocks. "The most important features of Jukesian time are the cessation of volcanic activity and the rise of the Precambrian craton to the south which became the source area for the Roland Conglomerate and Moina
Sandstone." (Jennings, 1963). The Dove Granodiorite was probably emplaced late in the Jukesian Movement and was deformed in the subsequent Tabberabberan Orogeny (McDougall and Leggo, 1965).

The Cambrian basin (Dundas Trough) began to subside following or contemporaneous with, the Jukesian and at least 5000 and possibly 10,000 feet of sediment were deposited in the Lower Palaeozoic.

**Ordovician rocks**

The structure of the Ordovician rocks has been fully discussed by Jennings (1958, 1963). Except for small, local discrepancies, nothing was found to discredit Jennings' work and the following is a brief summary, with local modifications of the Ordovician structures put forward in his two papers.

As a result of the Tabberabberan Orogeny, the Ordovician rocks were strongly folded and faulted. The fold style is generally concentric with accommodation by bedding-plane slip and small break-thrusts in the cores of anticlines and synclines. Considering the north and northwest of the area, at least two fold trends are present. The larger folds are symmetrical and open, rarely showing a plunge of more than a few degrees and trending east-west; the smaller folds are northwesterly trending, consistently asymmetrical (anticlines facing southwest) and are accompanied by second, third and fourth order drag folding. The latter types are well-developed at Round Hill. The main northwesterly trending folds in the area are the Lorinna Syncline, the Round Hill Synclinorium and the Dolcoath Anticline.
**Lorinna Syncline**

This syncline trends northwesterly from Lorinna to Moina. Much of it is obscured by basalt and southeast of Lorinna, it passes under the basalt of Cads Hill. In the Forth Valley, the southern limb of this fold is formed by the Moina Sandstone on Five Mile Rise which dips regularly to the northeast at about 25°. Gordon Limestone is preserved in the core of the syncline at Lorinna and Moina. A block of Cambrian (Lorinna Volcanics) is thrust up into the axial region of the syncline north of the Lorinna bridge (see fig. 9).

A powerful thrust fault forms the northern boundary of the Lorinna Syncline. This fault, called the Bismuth Creek fault by Blake (1956) and the Shepherd and Murphy fault by Elliston (1954b) and Jennings (1963), is a steeply dipping reverse fault that strikes approximately northwest and according to Blake (1956) has a heave of about 1200 feet with the northeastern block up. The outcrop pattern east of the Cradle road and in the Forth River suggests there has also been dextral transcurrent movement along the fault for about 400 yards.

This fault is best exposed on the Cradle road at 890,250 N, 498,840 E where it shows a crushed zone about forty feet wide and the Moina Sandstone is shattered by numerous small faults for about 250 feet on either side of the main fault. Small scale, tight isoclinal folds are exposed in the road cut about ten chains north of the fault zone (fig. 34). These folds are assymetrical with the anticlines facing south and the synclines faulted out by small break thrusts.
FIG. 34 Sketch map of the structures associated with the Bismuth Creek Fault where it crosses the Cradle road. See also fig. 11.

C.E. Gee, 1965
Exposure is poor in the Moina area, but it can be seen from figure 37 that the Gordon Limestone and Moina Sandstone dip gently to the northeast near the Iris bridge and to the southwest near the Iris-Lea confluence.

**Dolcoath Anticline**

This anticline folds both Ordovician and Cambrian rocks (q.v.). The southern boundary is the Bismuth Creek fault which thrusts Moina Sandstone over Gordon Limestone in the Forth River and the Bull Creek Volcanics over Moina Sandstone northwest of the river. To the north, the anticline has probably been buckled by the intrusion of the Dolcoath Granite (see fig. 9a and b).

**Round Hill Synclinorium**

This is the major structure in the Round Hill area and has been described in detail by Jennings (1958). The northeastern limb is overturned and bounded by the Claude Creek Thrust, a powerful thrust dipping 30-35° northeast and thrusting Roland Conglomerate over Moina Sandstone. The southern boundary is Tin Spur. The synclinorium has been compressed by the intrusion of the granite and plunges about 15° to the northwest. This structure opens out considerably to the southeast in the Olivers Hill area and probably continues across to the Mersey Valley. The width of the synclinorium is about 20,000 feet and it cross cuts a huge east-west trending anticline, the southern limb of which forms Mounts Claude, Van Dyke, Roland, Gog and Magog.
Within the Round Hill area, Jennings (1958) has recognised four orders of folding which are:

First-order structure: Round Hill Synclinorium with a width of about 20,000 feet.

Second-order structures: Claude Creek Synclinorium, Cockatoo Ridge Anticlinorium and Tin Spur Anticlinorium with wavelengths of about 2000 feet.

Third-order structures: Main Anticline, Sales Anticline, Falls Anticline, etc., approximately 200 feet wide.

Fourth-order structures: Small drag folds on third-order folds with wavelengths of about twenty feet. Many of these folds are due to drag dips against faults in this area.

The third-order folds are the most important with regard to ore localization at the Round Hill Mine. These folds are dominantly concentric in nature when found in massive quartzites but in areas of interbedded quartzites and shales, the shales have acted incompetently, flowing into the apices of anticlines and resulting in structures similar to saddle reefs. These folds are generally modified by small break thrusts in the anticline cores. The mineralization replaced the shaley beds in the anticline apices and down the limbs for some way.

Tabberabberan Orogeny

The Tabberabberan Orogeny brought sedimentation to a close in the Lower Palaeozoic with a period of strong folding, faulting and intrusion of the Dolcoath Granite. The northwesterly trends of the folds in this
area is a reflection of the bending of the Tabberabberan fold arcs
around the nose of the Tyennan Geanticline. Further west, the Tabber-
abberan folds trend approximately east-west. This pattern is shown in
figure 68, page 325 in Spry and Banks (1962).

Most of the Tabberabberan faults are thrusts with the northern
block thrust over the southern block. The faults cut both the east-west
and northwesterly trending folds and according to Jennings (1963), the
Bismuth Creek fault and Claude Creek fault acted as channels for
mineralization. However, Blake (1956) and Burns (1958) considered the
Bismuth Creek fault as post-mineralization. The outcrop of this fault
is poor but where it crosses the Cradle road, there is no sign of
mineralization in the crushed zone although wolfram occurs in quartz
veins and on joint planes in the Moina Sandstone about one hundred
yards north of the fault. Other faults in this area do not appear to
be mineralized and the fault on the All Nations property offsets the
wolfram lode. Burns (1958) reports small faults offsetting the lodes in
the Shepherd and Murphy Mine and faulting in the Round Hill area has
offset the orebodies. The general impression is that most faults in
this area are post-mineralization.

The form and method of intrusion of the Dolcoath Granite is
discussed in the section on Form of Intrusion of the Dolcoath Granite.

Post-Tabberabberan Faulting

Tertiary basalt, agglomerate and sediments are the only post-
Ordovician rocks in the area and these are unrewarding from a structural
point of view. Centres of eruption of basalt have not been pinpointed,
but there is a certain amount of evidence to suggest a centre south of Bell Mount and in the Moina area (see page 103).

Jennings (1963) considering a much wider area, states "post-mineralization movement is evident on many, perhaps even most of the Tabberabberan faults .... However, this does not necessarily imply post-Peronian movement."
6. MINERALIZATION

Introduction

There have been two periods of mineralization in this area. The earlier period is Cambrian in age and is associated with the Dove Granodiorite. This mineralization consists of silver lead deposits at the Devon Mine, small galena veins in the Dove River and haematite deposits at the Powerful and Unión Mines.

The second period of mineralization is that associated with the Devonian Dolcoath Granite when wolfram-cassiterite-bismuthinite-molybdenite and sulfide deposits were introduced into Ordovician and rarely, Cambrian rocks.

Controls of Mineralization

Cambrian

No control of the Cambrian deposits is evident. The galena lode at the Devon Mine strikes about north-south and dips steeply east or west. It is probably related to a shear zone in the host granodiorite.

The quartz-haematite lode at the Powerful Mine strikes approximately 320° and probably has a variable dip to the southwest. This lode is also probably a sheared zone in the granodiorite. "A wide specularite formation contained in quartz porphyry" (Reid, 1919) is the only information on the haematite mineralization at the Union Mine.

Elsewhere, small (three inch wide) galena veins occur in the Dove River east of the granodiorite, and haematite veins are associated with joints in the granodiorite south of Lorinna.
Devonian

The majority of the mines are in Moina Sandstone or in the Dolcoath Granite itself. Mineralization in the granite is in the form of stockworks in greisen or associated with pegmatite dykes and quartz veins. With the exception of the Round Hill, Round Hill Extended and Wilmot Mines where ore replaces shaley beds in the Moina Sandstone, mineralization in the Moina Sandstone is associated with quartz veins originating from the Dolcoath Granite. As mentioned above, most of the faulting around the granite is post-mineralization.

Notable features of the distribution of the mines in Sandstone is their close proximity to the Ordovician-Cambrian boundary and the lack of mineralization in the Cambrian rocks (see fig. 35). The Pig and Whistle, Lady Barron and possibly part of the Narrawa Reward Mines are the only known occurrences of Devonian mineralization in Cambrian rocks. All lodes on the Five Mile Rise are just above the Dove Granodiorite-Moina Sandstone boundary. Here, the Moina Sandstone is cut by a conjugate set of fractures striking roughly $140^\circ$ and $230^\circ$. The lodes so far discovered are along small faults striking at or close to $140^\circ$. In the Union Mine, the granodiorite-sandstone boundary is mineralized (Reid, 1919) and the Bull Creek Volcanics-Ordovician boundary is probably mineralized in the Pig and Whistle and Lady Barron Mines.

Thus there are three main controls of Devonian ore localization:

1. The Cambrian-Ordovician boundary which probably acted as a channel for mineralizing solutions.
FIG. 36. Sketch section NNE from the Pig & Whistle Mine

N.B. Bedding in Moine Sandstone interpretive only.

Known mineralization

Vertical scale exaggerated.

C.E.Gee, 1965
2. The vein system, sheeted in places, related to fractures formed by the intrusion of the Dolcoath Granite.

3. The ore bodies in the Round Hill area (~q. y.) and at the Wilmot Mine are similar in form to saddle reefs, occurring in the apices of concentric folds in Moina Sandstone where sulfides replace shaly beds.

Figure 36 is a sketch section from the Pig and Whistle Mine north-northeast to Bell Mount showing the general structure and form of mineralization in this area.

**Description of Mine Workings**

For the purposes of this and following discussions, the lode deposits in the area are divided into three groups:

1. Wolfram-cassiterite lodes with associated sulfides.
2. Sulfide deposits in Moina Sandstone, both of which are Devonian ores, and
3. Cambrian deposits.

Reasons for subdividing the Devonian deposits are given in the section on zoning.

Most of the mine workings in the area are now inaccessible due to falls of ground or thick secondary regrowth. The descriptions below are taken from the previous literature, mainly from the reports of Twelvetrees (1913) and Reid (1919) and supplemented with any further information gathered from visits to the mines by the author. The mines north and west of the granite are located as accurately as possible on figure 37 and the number in parenthesis after the mine name below, refers to the mine number on figure 37.
1. WOLFRAM-CASSITERITE LODES

(a) In Ordovician rocks

The Shepherd and Murphy Mine (4)

This was the largest mine in the area and the one about which most has been written, so it is described in some detail. The mine is located just south of the Moina road, one and a half miles from the Moina turnoff. The lodes were discovered in 1893 by Thomas Shepherd and Thomas Murphy, in whose honour the mine was named.

At present, all underground workings are inaccessible with the exception of the drive from Bismuth Creek (the No.4 Creek Drive) which can be entered for about 250 feet before a fall blocks the drive. Previous work on this mine has been carried out by Twelvetrees (1913), Reid (1919), Keid (1943), Blake (1956), Robinson (1958) and Williams (1958).

An easterly striking sheeted vein systems with the veins vertical or dipping steeply to the south, comprises these orebodies. The mineralogy is described in greater detail later but briefly, the lodes are quartz-cassiterite-wolfram with molybdenite and bismuthinite and accompanying sulfides. The wolfram:cassiterite ratio increases with depth. Considerable development of these lodes has been carried out (fig. 38).

The veins are regarded as fillings of a fracture system produced by the intrusion of the Dolcoath Granite. Faulting is common in the underground workings but the veins are rarely displaced more than ten feet and no trouble was experienced in picking up the veins across faults.
SHEPHERD & MURPHY MINE — MOINA

SECTION ALONG N.E. LODE

SECTION ALONG N.E. LODE

SECTION ALONG N.W. BRANCH LODE

SECTION ALONG N.W. BRANCH LODE

FIG 38 (Blake, 1956)
According to Blake (1956) the Bismuth Creek fault which is east of the mine, offsets the lodes but it is not clear whether the veins have been located east of the fault.

Robinson (1958) calculated possible and probable ore reserves. He made a number of assumptions after which he arrived at an extractable grade in broken ore of 0.21% Sn and 0.37% WO₃. The probable ore reserves, which is that ore above 3 level, was estimated to be 42,400 tons and possible ore, which is that ore below the floor of 3 level and extending downwards for about 110 feet, was estimated as 34,600 tons. Using the figures and the prices of $A 3,600 per ton for the price of tin and $A 1,800 per ton for 70% WO₃ concentrate, the value of these ore reserves is:

- Probable ore: value of tin $A 32,054
  value of wolfram $A 28,240
  $A 60,294

- Possible ore: value of tin $A 26,160
  value of wolfram $A 23,040
  $A 49,200

Total $A 109,494

The host rocks are quartzites and shales of the Moina Sandstone and Gordon Limestone (fig. 39). In general, the host rocks do not contain workable ore deposits but disseminated sulfides and wolfram are
common in patches, especially in the Moina Sandstone. The sandstones have been partially recrystallized and altered to dense brown quartzite. Topaz and garnet have been introduced in places and the clay in the shales has generally been altered to sericite.

Gordon Limestone has undergone wholesale metasomatism in the mine area. The altered limestone is a dark green or black rock, commonly veined with pink orthoclase (fig. 40). In thin section, this rock consists of finely granular diopside, garnet and magnetite. The orthoclase veins generally have a central core of fluorite and rarely, garnet. Other parts of the altered limestone are pinkish brown in colour with irregular dark green patches. This rock consists of colourless (in thin section) garnet and the green patches are due to fine crystals of epidote and rare diopside. An X-ray powder photograph of the garnet was taken (Appendix A) and the garnet has a calculated unit cell edge of 11.967 Å which is close to the unit cell edge of grossularite (11.85 Å).

Andradite (Ca$_3$Fe$_2$(SiO$_4$)$_3$) has a unit cell edge of 12.05 Å so it appears that the garnet from the Shepherd and Murphy Mine is grossularite (Ca$_3$Al$_2$(SiO$_4$)$_3$) with a little iron in the molecule.

Williams (1968) discussed the metamorphism of the host rocks. There is considerable evidence to indicate the limestone was contact metamorphosed before the mineralization of the fissures. Optical and X-ray data on the garnet indicate it is close to grossularite in composition. Williams goes on "the presence of the tactites (skarn) and of early generation lode magnetite indicates that the first phases of mineralization
Fig. 40 Orthoclase veins through garnet-pyroxene-magnetite rock (skarn), Shepherd and Murphy Mine.
were iron rich; if they had been present at the time of formation of the garnet, the andradite variety should have been produced as at King Island (Edwards, Baker and Callow, 1958).

Further evidence for this is in the lack of significant primary scheelite as it has been shown by Kerr (1946) that scheelite is the most likely mineral to form whenever calcium and tungsten are together in the free form. The general absence of scheelite here implies that the calcium must have been "locked up" - i.e. in the garnet-epidote-pyroxene rock - before the tungsten bearing solutions reached the veins in the limestones. "The development of fluorite in the tactite zones can be attributed to the action of fluorine-bearing vapours - free or set free by hydrolysis of other minerals - on the grossularite and diopside. The failure of tungsten to obtain lime in this way was due to the overwhelming abundance of iron oxide, whose presence favoured the formation of wolfram." (Williams, 1958)

The All Nations Mine (5)

The properties between the Squib Mine and the Cradle road have been worked under different names at different times in the past. According to Twelvetrees (1913), the mine was originally known as the All Nations Wolfram Mine but the name was changed to the Lady Barron when the lease changed hands. Reid (1919) reports on the All Nations Wolfram Mine and Reid (1943) refers to the southern workings as the Lady Barron Mine. Mr. J. Smith of Erriba who has worked the area in a desultory fashion for many years and now holds a lease on the workings
south of Narrawa Creek, states that the northerly workings are the All Nations Mine and the workings on top of the hill are the Lady Barron Mine. The lodes on the south-western slopes of Dolcoath Hill were taken up as a separate concern in the 1930's and are referred to by Mr. Smith as the Pig and Whistle Mine. In September, 1965, Messrs. J. Smith and J. Smythe took up a lease covering ground from Narrawa Creek to the top of the hill to the south, including the All Nations Mine and part of the Lady Barron workings. This lease presumably will be known as the All Nations Mine. In the following descriptions, to avoid confusion, the workings south of Narrawa Creek are referred to as the All Nations Mine, those on top of the hill are referred to as the Lady Barron Mine (No.6 on fig. 37) and those on the southern side of the hill are referred to as the Pig and Whistle Mine (7).

The All Nations' workings extend for about 12½ chains east from 809,300 N, 408,700 E. Access is by a good track from the Cradle road one mile south of the Moina turnoff. Quartzites of the Moina Sandstone which dip 50° N at 295°, are the host rocks to a 1500 feet long quartz vein carrying rich patches of wolfram. The vein strikes about 270° and dips from 50 to 80° to the south and in places splits into two or three smaller veins. It is from eight to twenty inches wide, and pinches out to the west; in the east it thins to about three inches and is barren. Towards the western end of the lode it is cut by a fault striking 30° and dipping easterly about 30°. Judging by Mr. Smith's description of the behaviour of the lode, it is a reverse fault with some dextral transcurrent movement.
Reid (1919) reports the ore minerals to be wolfram and bismuthinite in the proportions of 12:1, with accessory native bismuth, molybdenite, gold and pyrite in quartz gangue. Along the hanging wall there was a selvage of bismutite giving good gold values. A peculiarity of this lode is the absence of cassiterite. Alluvial material a few yards below the main workings contains a large proportion of cassiterite which must have shed from smaller cassiterite-bearing veins further up the hill to the south. Mr. Smith reports that since he took over the lease (about 1950), the only minerals he has seen have been wolfram in quartz with very minor pyrite and occasional particles of molybdenite. From observations of the lode (where exposed) and the dumps by the author, it seems that Reid's description was one of the southerly lodes, probably the Lady Barron.

The lode contains many large pockets of wolfram but, as is characteristic of quartz-wolfram veins, these are very irregular in occurrence. It is quite a simple matter to separate the wolfram from the quartz by crushing and jigging.

Development consists of an open cut or tunnel for practically the whole length of the lode. In places, the tunnel is ninety feet deep and has been stoped to the surface. Numerous trenches have been dug around the lode. Most of the workings and trenches are filled with water and inaccessible.

The future of this particular area is quite promising. There are no apparent signs of the lode pinching or dying out at depth. To the west of the open cut, wolfram in quartz veinlets is quite common in the
Moina Sandstone and joints in the sandstone are commonly encrusted with small wolfram blades, especially in the Cradle road area.

The Lady Barron (6)

This mine occupies most of the ridge extending west from Dolcoath Hill. The shaft at 890,150 N, 408,740 E can be reached by a track heading west from the Iris access track at the top of the ridge. The workings are along the Cambrian-Ordovician boundary which dips to the north. From the shaft, drives were put in for about 500 feet to the east and about 200 feet to the west, with rises every 60 feet or so. The eastern drive is along the Roland Conglomerate-Bull Creek Volcanics boundary which is apparently mineralized with wolfram, cassiterite, bismuthinite and other sulfides in quartz. To the west, the Conglomerate lenses out and the workings are in Moina Sandstone carrying mineralised veins. Surface trenches just north of the main lode expose many barren quartz veins through Roland Conglomerate.

The shaft is about sixty feet deep and in poor condition. Both drives are blocked within thirty feet of the shaft and for the first thirty feet or so, square-set timbering has been carried out.

The Pig and Whistle Mine (7)

These workings are about half a mile east of the Iris Mine at the head of a small creek flowing into Dolcoath Creek, at 890,000 N, 409,200 E. Reid (1919) refers to these as Lawson and Riley's workings. Extensive tunnelling has been carried out in grey porphyritic lavas of the Bull Creek Volcanics and in the overlying Roland Conglomerate. The
upper workings in conglomerate are now inaccessible but the lower workings are in good condition. The latter consist of an adit driven into the hill for about 200 feet on a northerly bearing. Two cross drives, one about 120 feet from the entrance and the other at the end of the adit have been driven east and west for considerable distances. The last cross drive has been stoped to the upper workings in a number of places.

Wolfram was again the dominant ore mineral with cassiterite, bismuthinite, molybdenite in quartz, topaz, beryl and muscovite gangue. Trenches show both rock types to be cut by numerous quartz-wolfram veins that are too small to be of economic value.

The lower workings appear to be completely worked out and judging by the extensive nature of the upper workings, these are also worked out.

The Tin Spur Area

On the northern slopes of Tin Spur there are a number of workings that have been abandoned for many years. These workings were mainly developing quartz lodes that carried cassiterite and/or gold. Fine-grained cassiterite is common studding joint planes in Moina Sandstone but these occurrences are quite uneconomic. Some alluvial workings returned good quantities of cassiterite and gold. These alluvial deposits are derived from weathering of the Moina Sandstone and the subsequent concentration of the cassiterite and gold in the sandstone.

Jennings (1958) gives a full report on these workings and suggests prospecting by small parties on the detrital deposits may reveal small pockets enriched in cassiterite and perhaps, gold.
Reid (1919) reported a lode of cassiterite and gold on Morgans Section (Goreys Tunnel), in skarn and overlain by sandstone. However, Jennings (1958) visited this tunnel and found the host rock was "a sheared quartzite, fairly heavily iron stained .... which may superficially resemble skarn rock."

The Falls Mine is just above the Lorinna road at 890,100 N, 413,500 E. Reid (1919) described the original lode as "a lode consisting of gossanous material carrying tinstone in considerable quantity." This lode has since been removed by the development of an open cut. Reid considered the lode to be in situ, cutting through decomposed Cambrian porphyry at the foot of the Tin Spur Creek Fault Scarp. However, no porphyry can be found in situ in the open cut or in road cuts in this area. Jennings (1958) decided the in situ rocks at the Falls Mine "consist of deeply weathered ferruginous sandstones and siltstones" and that in the overlying talus there are numerous boulders of porphyry, some of which are large enough to be taken as in situ outcrops in small exposures. These boulders are derived from the Bull Creek Volcanics which are exposed unconformably below the Roland Conglomerate on the upthrown block of the Tin Spur Creek Fault. Jennings concludes that the concentration at the Falls Mine was probably due to "simple gravity concentration of the metal in the detritus below the scarp of the Tin Spur Creek."
(b) Mines in Dolcoath Granite

**Squib Mine (10)**

The Squib Mine is incorrectly shown in the Sheffield Sheet as the Sayers Mine. The Squib at 891,100 N, 411,000 E and the workings extend from the track down to valley side to Narrawa Creek. Access is via a graded track which leaves the Iris access track at 890,600 N, 209,860 E. This track is passable for most of the way with four-wheel drive vehicles.

Development consists of a large open cut in a greisen orebody, an adit 100 feet west of this beginning in Moina Sandstone and passing into granite, the main tunnel about 120 feet below the end of the track and numerous small trenches. The main tunnel has been considerably stoped and there are many branches from this. It extends for about 300 feet on a southwesterly bearing. The tunnel and adit are in poor condition and some of the tunnels associated with the open cut, are in very dangerous condition.

Wolframite was the dominant ore mineral with molybdenite, bismuthinite and cassiterite and subordinate gold, pyrite, chalcopyrite, sphalerite and arsenopyrite. Gangue minerals are quartz, topaz, fluorite, beryl and white mica. Numerous ore-bearing quartz veins traverse the greisen, striking about 320° and dipping 30-45° to the southwest. Reid (1919) reports very little change in character of the veins when they pass out of granite into the quartzite. Disseminated wolfram blades are common in the greisen.
It appears as though this mine is worked out but further exploration on the property may reveal more mineralized veins or greisen patches. The most promising area is between the open cut and the pegmatites at Sayers Mine.

**Sayers Mine (13)**

The Sayers Mine is further east than its position on the Sheffield Sheet. It is located on gently sloping ground northeast of Dolcoath Hill, at 890,900 N, 411,600 E. The northern and eastern parts of the property fall steeply to Narrawa Creek and the Forth River. The workings can be reached from the Squib open cut by walking slightly north of east for about \( \frac{1}{2} \) mile.

A number of trenches and small shafts have been sunk on the lodes and these are in poor condition as they have been abandoned since about 1920. The ore occurs in pegmatite veins enclosed in aplite and greisen phases of the granite. Several lodes exist, persisting for 300 to 1400 feet along strike and up to 300 feet deep: the principle lode is about 1200 feet long in an east-west direction (Reid, 1919). Ore minerals are the same as at the Squib Mine. Both wolfram and molybdenite are disseminated in patches through the granite. Some quartz-wolfram veins are barren of tin and the lode exposed in No. 8 and 9 trenches consists of a beryl-muscovite pegmatite carrying a fair amount of coarse wolfram blades.

This property, together with the adjoining Princess Mine, is quite promising with regard to the production of wolfram and perhaps beryl may be mined if the beryl-bearing pegmatites prove extensive.
Princess Mine (12)

This is between the Sayers Mine and the Forth River at 891,000 N, 411,800 E. The lodes are practically identical with those described above on the Sayers property. Reid (1919) reported abundant bismutite as well as tungstite and ferrotungstite incrustations in the oxidized portions of the orebodies.

A short tunnel, now collapsed, has been driven from a long, deep trench on the main lode which strikes at 310° and dips southwesterly at 45°. The tunnel exposed a very rich wolfram-bismuthinite vein.

Reid's description of the open cut does not fit in with his geological map. He states trenches a little west of the open cut show a thin cover of quartzite over the granite, yet the only quartzite shown on his map is in the very northern portion of the area where Dolcoath Hill falls steeply to Narrawa Creek. The open cut, which was not found in this survey, showed that the extent of the ore here was far greater than in the lower workings. If this is so, prospecting in this area could prove profitable.

The Dolcoath Mine (11)

Most of the excavations of this mine were inaccessible at the time of Tweivetrees' visit in 1913 and they were not located in this survey. The workings consisted of numerous trenches and a shaft on the southeastern slopes of Dolcoath Hill. The top trenches were on numerous quartz veinlets carrying wolfram, in Moina Sandstone.
The lower workings were in greisenized granite carrying cassiterite and wolframite with molybdenite, pyrite and arsenopyrite in topaz and white mica gangue. The ore was patchy and quartz veins occasionally contained bands of ore. Twelvetrees considered the area as a whole to be a poor prospect.

**Povey and Johnson's Workings**

These are referred to as Sullivan's workings by Reid (1943) and are located at 891,200 N, 410,900 E north of Sayers Mine on the northern slopes of Dolcoath Hill and extend north of Narrawa Creek for a few chains. The adits are now inaccessible and the trenches filled with water and mullock. Reid (1919) reported a 3-8 inch wide quartz lode carrying small clusters of balded wolfram crystals and bunches of molybdenite. The adit driven south from above Narrawa Creek began in sandstone and probably passed into granite.

The lodes strike northwesterly and dip about $45^\circ$ to the southwest and pass into Sayers lease to the south. Thin wolfram and cassiterite veins are reported from the side of a steep spur on the northern side of Narrawa Creek.

**The Hidden Treasure Mine (15)**

Soon after Reid's visit in 1919, this mine was abandoned. The workings are located about 400 feet above the old Lorinna road at 890,500 N, 412,400 E and consist of a number of shallow trenches and an open cut about thirty feet long from which a tunnel was driven for sixteen feet. The trenches are now in bad repair, the tunnel is inaccessible, and the open cut is overgrown.
Irregular pegmatite veins from two to fifty feet wide traverse the Dolcoath Granite. The pegmatites enclose the lodes which are from three to eight inches wide and consist of wolfram with bismuthinite, molybdenite, pyrite and chalcopyrite in a gangue of fluorite, topaz, muscovite and quartz. Wolfram and molybdenite are commonly finely disseminated in the surrounding granite. In the lode, the ore occurs as disseminations and irregular patches and vughs. The lodes trend northwesterly and dip to the southeast at about 60°. Reid (1919) quotes production as thirty hundredweight of high grade ore containing 20% WO₃. Other parallel lodes have not been developed but it was Reid's opinion that these had promise of becoming profitable sources of wolfram.

A great deal of difficulty was experienced during the summer months, in obtaining an adequate water supply as the several small creeks in the vicinity dried up. However, adequate water is present during the winter.

The Premier Mine (16)

The Premier workings are south of the Hidden Treasure Mine, at 890,300 N, 422,400 E between the old and present roads to Lorimna. These workings were abandoned before Reid's visit (1919). Development consists of a number of small trenches and open cuts, all of which are now more or less overgrown.

The lodes are essentially similar to those on the Hidden Treasure lease. The lowest workings (the No. 4 workings) are notable for their lack of wolfram and cassiterite, bismuthinite and molybdenite being the economic minerals. These veins strike 300° and dip steeply to the southwest.
In this area, the country is much steeper than at the adjoining Hidden Treasure and this, together with lack of water during summer, greatly hindered operations on this property.

However, these two properties could probably be worked at a reasonable profit by a small party provided a good water supply could be arranged during summer.

2. Sulfide Deposits

    The Round Hill Mine (17)

These workings have been described in a comprehensive report by Jennings (1958) and anything but a brief summary of this mine, would be quite unwarranted.

The Round Hill Mine is situated beside the Lorinna road three miles south of Cethana at 891,100 N, 415,900 E, about one and a half miles from the nearest granite outcrop. There are two types of ore deposit here:

1. Bedding plane lodes consisting of massive ore of galena and pyrite with subordinate sphalerite and chalcopyrite in gangue of milky quartz.

2. Orebodies in the apices of small folds - similar to saddle reefs - with some mineralization extending down the limbs but no worthwhile mineralization in the synclines. Small break-thrusts modify the anticlines and mineralization extends along these for little distance. These were the major orebodies and consisted of coarse and fine grained
galena, abundant chalcopyrite, some pyrite, sphalerite, arsenopyrite, and small amounts of bismuthinite in a quartz, pinite and siderite gangue. The anticlines plunge 10-15° to the northwest with the ore shoots plunging parallel to them. These orebodies, which are now practically worked out, were about twenty-five feet wide and twenty feet deep measured perpendicular to the pitch of the fold. The pitch length has not been determined as the structure is complicated by a great deal of faulting, but it appears to be about two hundred feet.

Considerable development has been carried out and most of the workings of this mine are still in good condition except for No. 1 adit which is blocked twenty feet from the entrance.

**The Round Hill Extended Mine**

Galena deposits similar in form to those at Round Hill have been prospected a mile southeast of the Round Hill Mine beside Claude Creek. The deposits were much smaller and apparently uneconomic. These workings were not located in this survey but are described in Jennings (1958).

**The Wilmot Mine (3)**

The Wilmot Mine (also known as the Washington Mine) is located about two miles west of the Cradle road at 893,800 N, 407,500 E. It is reached by track leading from the Cradle road at the southern end of the road round Bell Mount.
Here, the Moina Sandstone is folded into westerly trending folds, very similar to those at Round Hill. The country rock is apparently traversed by numerous veinlets of galena, chalcopyrite and pyrite in quartz. Twelvetrees (1913) reports the lower tunnel shows clean galena in quartz but the veins were not large enough to warrant further work unless further exploration on the surface found economic veins. Reid (1919) reported concentrations of the ore in the limbs and apices of anticlines in a manner analogous to the saddle reefs at Round Hill.

Just east of the mine a dextral wrench fault marks the boundary between the Moina Sandstone and Minnow Keratophyre and the ore apparently does not cross the fault. It is not known whether the fault is mineralized.

The workings are halfway down the precipitous slope to the Wilmot River and are in no fit shape for inspection according to Mr. J. Smith of Erriba. The workings were not located on this survey.

East and north of this area tiny galena-quartz veinlets cut the Minnow Keratophyre and at two places on the track to the summit of Bell Mount, one inch thick quartz-galena-pyrite veins cut keratophyre.

**The Narrawa Reward Mine (9)**

This mine has been referred to in the past as the Sunrise Mine, Higgs Mine, and Higgs Prospect. It is sited on Narrawa Creek at 891,100 N, 409,600 E at the end of a good access road from the Cradle road. The mine shown on the Sheffield Sheet as the Squib, is actually the Narrawa Reward.
Gold was first discovered in this vicinity in 1893 and since then it is estimated that 1000 ounces of gold have been recovered (Jack, 1960). Since its discovery, the area has been worked in fits and starts by various lessees. Twelvetrees (1913) and Reid (1919) report on workings in a steep face of Moina Sandstone fifty feet north of Narrawa Creek - the workings south of the Creek have apparently been developed since 1919.

The northern workings were inaccessible at the time of Reid's visit and were not found on this survey. A drive was put in on a lode of pyrite, chalcopyrite, arsenopyrite and galena disseminated through hard grey quartzite cut by quartz veins. Some of the sulfide carried gold and silver. Twelvetrees found quartz-wolfram veins on the dump. Reid reported a porphyry footwall and it seems likely that this porphyry belonged to the Bull Creek Volcanics or the Minnow Keratophyre, probably the former.

No mention is made of movement along the quartzite-porphyry boundary and the Roland Conglomerate is apparently absent here.

The ore in the workings south of the creek is pyrite with galena, chalcopyrite and arsenopyrite apparently replacing favourable beds in Moina Sandstone. Bedding is disturbed by shearing and minor faulting and a major fault is postulated roughly following the line of Narrawa Creek (see fig. 37). The shearing is parallel to bedding which dips 70° north at 298°. The major orebody was between two shears and it has been stopped to the surface over a length of about two hundred feet.

The mine is at present being worked during weekends, for gold carried in the sulfides and is apparently producing enough gold to keep the lessee interested in the property.
The Five Mile Rise Goldfield

This gold field extends up the spur known as the Five Mile Rise, one mile southwest of Lorinna and directly west of the Lorinna bridge. The old Van Dieman's Land Company road from Sheffield to the Middlesex Plains follows the crest of the spur and most of the mines are situated on creeks on the northern slopes of the Rise. The road is now impassable due to deep ruts and fallen timber. Most of the leases were abandoned by the time of Twelvetrees' visit in 1913, and are now quite overgrown or water filled though one or two adits can still be entered. The host rocks are sandstones and shales which dip generally 25-30° to the northeast, and overlie the Cambrian rocks of the Dove Granodiorite.

The lodes in this area are generally confined to small tensional faults at about 140°, parallel to one set of conjugate fractures in the Moina Sandstone. Secondary enrichment produced relatively rich gold and silver values in gossans outcropping at the surface. The grade decreased abruptly as sulfides were met underground. Most of the mines were begun on these surface gossans and were abandoned when the sulfides were encountered below the water table.

The Golden Hills Mine

This is the lowest mine of the Rise, situated at 882,300 N, 410,600 E on Dooley Creek. It was surveyed in detail in 1953 (see Nixon in Jennings, 1963). Some of the drives can still be entered but most of the trenches are overgrown. The sulfides present are galena, pyrite, sphalerite and chalcopyrite which carry small amounts of gold, silver and bismuth.
The Golden Cliffs Mine

The Golden Cliffs Mine is situated at 882,400 N, 410,800 E about a mile south of the Lorinna bridge. A timber track now passes over the mine and in construction of the track, all but a rise to the surface, has been filled in. According to Reid (1919) the mine was begun on a three to four inch quartz vein studded with free gold. Near the surface, the lode was rich, but at depth, barren sulfides were encountered. Twelvetrees (1913) states the lower tunnel to have passed through Moina Sandstone into "granular dark green mica granite" (the Dove Granodiorite).

The Thistle Mine

This mine is about halfway up Five Mile Rise at 883,100 N, 410,250 E. The adits are still in fair condition though much of the walls are covered with moss and slime. Jennings (1963) concludes that these are the most promising veins on the Rise and could perhaps repay prospecting by a small party at times of high metal prices.

The Union Mine

Situated at 882,750 N, 409,300 E, two miles southwest of the Lorinna bridge on a tributary of Sunday Creek, this mine has been abandoned since 1917 and was not visited on this survey. Reid (1919) reported a southerly drive from the bottom of a shaft passed through Moina Sandstone into a quartz porphyry. The sandstone-porphyry boundary is mineralized with sulfides and a quartz-haematite lode was encountered in the porphyry. Reid considered this to be the most promising lode on the Rise.
The Great Caledonian Mine

This is located at the top of Five Mile Rise at 882,650 N, 406,380 E immediately north of the old V.D.L. Company road.

Following good gold values at the surface, a 15-head battery was erected at enormous cost but after a few crushings returning approximately twelve dwt. of gold, the lode was proved unpayable at depth. The battery was transferred to the Golden Hills Mine and the buildings were later destroyed by fire. All that remains now is a shaft filled with water to four feet from the top.

The Stormont Mine (1 & 2)

This mine was not visited on this survey and the following description is taken from reports by Twelvetrees (1913) and Burns (1959).

There are two groups of workings - the main workings on Castle Creek, a tributary of the Lea River at 890,300 N, 402,600 E, and the workings (known as Fletchers Adit) on the eastern bank of the Lea, at 890,700 N, 403,200 E.

Twelvetrees (1913) reported only on the main workings which were then for gold. The gold was free, in wire form and sometimes crystallized in thin leaves on quartz crystals and in pink pug. Pyrite veins were also present. These workings, with Fletchers Adit, were later worked for their bismuth content.

Ore bearing rocks is the Moina Sandstone which has been folded and faulted, the structures trending northwesterly. Altered Gordon Limestone
(skarn rock) has been preserved in the cores of small synclines which disappear to the east under Tertiary basalt and agglomerate. There are two types of bismuth ore - disseminated orebodies and lode deposits.

The lode deposits are developed in the Fletchers Adit area. Galena, chalcopyrite, sphalerite and wolframite are the main minerals with bunches of bismuthinite scattered through the veins. Quartz, biotite, and magnetite are the gangue minerals. The veins are reported to carry a little gold and silver.

Disseminated orebodies in skarn were developed in the main workings on Castle Creek. The ore minerals are galena, sphalerite, bismuthinite, and bismuth and bismutite with magnetite, garnet, epidote and quartz. Burns states these deposits are stratigraphically controlled and concludes that the Fletchers Adit workings are quite uneconomic but recommends detailed mapping in the Castle Creek area to determine the extent of the orebody.

**Campbell's Reward Mine**

Gold in a kaolinized feldspar vein was the basis for a drive on the east bank of the Forth about one and a half miles downstream from Olivers Creek at 886,600 N, 411,700 E. Twelvetrees (1913) reported the drive inaccessible but Jennings (1963) found work had been done since then and the adit was in poor condition though accessible for 230 feet. The adit was not located on this survey. Similar altered feldspar veins occur in this general area but there is no known gold mineralization associated with them.
2. **Cambrian Deposits**

**The Devon Mine**

The Devon Mine is situated on the steep southern bank of the Dove River at 880,900 N, 406,900 E approximately one mile upstream from its position as shown on the Middlesex Sheet. The last recorded production was in 1941 and before this time, ore has been mined by several lessees from its discovery in 1892. Access is via an old pack track, now very much overgrown, which leaves the V.D.L. Co. road at the top of Five Mile Rise (882,300 N, 407,000 E).

The main or Devon lode, strikes approximately north-south and dips steeply to the east or west. Several other smaller lodes roughly parallel with the main lode, are exposed in the underground workings. Primary ore minerals are galena, chalcopyrite, sphalerite and pyrite in a quartz-siderite gangue. Cerussite, azurite, malachite, anglesite, pyromorphite and limonite are oxidized minerals that have formed from the ore.

Granodiorite porphyrite of the Dove Granodiorite is the host rock. It is in contact with quartzites of the Dove Group but the mineralization is confined to the porphyrite.

A considerable amount of development has been carried out on two main adit levels (Nos. 1 & 2). According to Nye (1928) a winze was sunk from 2 level and a third level opened up. Three adits are on 1 level and the central one of these has been stoped about sixty feet to the surface. Numbers 2 and 3 levels are filled with water but Number 1 level is still in good condition. The ore on 1 level is almost completely mined out and all ore between 2 and 3 levels is probably stoped out (Jennings, 1963).
The mine, although quite rich, was uneconomic because of its situation at the bottom of a steep gorge in the Dove Valley, approximately 1800 feet deep. In the past all machinery and ore had to be packed in and out of the mine from the V.D.L. Co. road. Trouble was also experienced with flooding on the lower levels.

Total recorded production from this mine is about 420 tons of fairly high grade galena ore.

**The Powerful Mine**

This mine, which has been referred to as Reardon and Days Mine in earlier reports, is situated east of the Forth River at 880,900 N, 411,400 E. The Dove Mill Road south of Lorinna passes the adit which is in good condition. Trenches up the hill from the adit are in bad repair.

The lode is quartz-specularite with accessory pyrite reputedly carrying gold, silver and zinc. Twelvetrees (1913) gives an assay of one dwt. Au and one dwt. Ag per ton from the lode exposed in the trenches but Jennings (1963) reports that "recent samples from the lode both at the surface workings and in the adit have not shown any values of gold, silver, copper, wolfram, tin or bismuth." The lode strikes about 320° and dips variably to the southwest and is exposed in the trenches and in the back wall of the adit.

Host rocks are weathered and altered granodiorites of the Dove Granodiorite. In the adit, aplite dykes up to six inches wide, cut the granodiorite and there is a band of relatively fresh adamellite.
Although this mine is a potential source of iron ore (see Jennings, 1963) it is unlikely to prove economic due to its distance from the markets, apparently small size and poor road access.

Alluvial Deposits

The Bell Mount Gold Diggings

Gold was discovered southwest of Bell Mount in 1892 and feverish activity ensued for the next eighteen months or so. Four thousand ounces of gold are reported to have been won during this time, the largest nuggets weighing twenty-two ounces and eighteen ounces. The field was abandoned by 1898 and little work has been done since then.

The gold is in alluvial gravels in jagged form, some grains having flat sides as if they had peeled off quartz crystals. No wolfram or bismuthinite has been reported and cassiterite is present only in small amounts, the coarseness of the cassiterite decreasing to the southeast. The origin of the gold has not yet been determined. The auriferous wash contains angular and subangular pebbles with some well rounded quartz pebbles, the latter probably being reworked Roland Conglomerate. This, together with the angular nature of the gold, suggests the source is near at hand. It seems extremely unlikely that the gold was shed from veins in the Shepherd and Murphy area as wolfram and bismuthinite are absent from the wash and the sub-basaltic drainage went the wrong way (see fig. 5). The Bell Mount Deep Lead suggests an origin to the east, the most likely source being auriferous sulfide veins in Ordovician rocks beneath the basalt southwest of Bell Mount.
The area has been thoroughly prospected and all payable alluvial gold has probably been removed although colours can still be obtained by panning in Bell Creek.

The Iris Mine

The Iris Mine is situated above the Cradle road at 889,800 N, 402,300 E and is reached by a track leaving the Cradle road one mile south of the Moina turnoff. During its history, the mine has also been known as the Red Robin and Rainbow Mine. It has been worked sporadically since its discovery in 1892 and at present is worked by Mr. F. Townsend of Devonport who reports that it returns a profit, even though he works it only for a few months a year.

The wash carries cassiterite and wolfram with subordinate bismuthinite, bismutite and topaz. The wash contains pebbles of Moina Sandstone, weathered Bull Creek Volcanics and vein quartz. The lead trends northwesterly and there is about five feet of overburden before the two to three feet payable wash is reached. The metalliferous material was probably derived from reefs in the area west of the Lady Barron Mine and the original lead probably flowed southeast. The lead may continue under the basalt to the southeast, eventually joining with the Moina Deep Lead (see fig. 5).
As mentioned above, many of the lodes are now quite inaccessible and consequently ore specimens could not be obtained. The only mines from which ore was collected, are the Shepherd and Murphy, Round Hill, Golden Hills, Devon and Powerful. Polished sections have been prepared and examined from these ores and, in addition, the author was able to re-examine the polished sections and chips prepared by Williams (1958). The latter were kindly loaned by Dr. G. Baker, Head of the Bureau of Mineral Investigations, C.S.I.R.O. Ore specimens from the Shepherd and Murphy Mine were also loaned by Mr. W. F. Ellis, Director of the Queen Victoria Museum and Art Gallery, Launceston.

1. Wolfram-cassiterite deposits

These deposits contain wolfram, cassiterite, bismuthinite, molybdenite and bismuth as the economic minerals with sulfides such as arsenopyrite, chalcopyrite, galena, sphalerite and pyrite. Gangue minerals are quartz, topaz, beryl, fluorite, mica, calcite, garnet-epidote-pyroxene-magnetite (at the Shepherd and Murphy Mine) and feldspar. The ore is generally auriferous and argentiferous. Secondary minerals such as scheelite, molybdenite, bismutite, iron salts, chlorite and clay are generally, but not necessarily present.

Wolfram Bladed and tabular crystals up to several inches wide are well developed in these deposits (fig. 41a). Irregular pockets of wolfram up to twelve inches across are common at the All Nations Mine. This mineral
Fig. 41a Wolfram in quartz, Shepherd and Murphy Mine (L'ton Mus. Spec.)

Fig. 41b Bismuthinite, Shepherd and Murphy Mine (L'ton Mus. Spec.)
generally occurs in quartz veins but it may be disseminated in granite or along joint planes in sandstone. Polished sections show the wolfram at the Shepherd and Murphy Mine to be fractured, the fractures being filled with sulfides and occasionally, scheelite.

Cassiterite generally occurs as well-formed, dark brown crystals up to 10 mm. across and commonly intergrown with wolfram. Aggregates of nearly pure cassiterite were found at the Shepherd and Murphy Mine and disseminated crystals (2 mm.) occur on joint planes in sandstone near Tin Spur. In thin section, the cassiterite is strongly zoned and twin forms are common. Tiny inclusions of magnetite (0.02 mm.) are common in the cassiterite from the Shepherd and Murphy Mine.

Bismuthinite Massive patches and acicular crystals of bismuthinite occur associated with sulfides at the Shepherd and Murphy, Princess, Premier and Squib Mines (fig. 41b). It is steely gray with a bright metallic lustre and alters to native bismuth or bismutite. Bismutite occurred in large masses, some weighing up to two tons, in the upper levels of the Shepherd and Murphy Mine.

Molybdenite is fairly common in these deposits occurring as small lamellar aggregates with a rosette-like form, up to 10 mm. in diameter. Twinning is common and the lamellae are often split along the cleavage (fig. 42a). According to Williams (1958) it fills fractures in pyrite and arsenopyrite and is in turn, replaced by chalcopyrite.

Magnetite Williams (1958) recognized three generations of magnetite at the Shepherd and Murphy Mine.
Fig. 42a Molybdenite lamellae, Shepherd and Murphy Mine

Fig. 42b Granular magnetite (medium grey) with pyrite (light grey) in gangue (dark grey and black), Shepherd and Murphy Mine.
1. Magnetite in the skarn rock
2. Early magnetite associated with cassiterite, and
3. Late magnetite apparently related to the breakdown of pyrrhotite.

The first two generations are probably closely related. Granular magnetite associated with granular pyrite was noted in some polished sections (fig. 42b).

**Sulfides** The most common sulfide material is pyrite which is found in varying amounts in all these deposits. It is generally euhedral or subhedral or in aggregates up to eight inches across and commonly fills fractures in the oxide minerals. Pyrrhotite is rare but occurs as small grains in the sulfides (Williams, 1958). Alteration of pyrite to haematite, magnetite and iron carbonates is reported by Williams.

Chalcopyrite and sphalerite are closely associated throughout these orebodies. These two minerals were apparently in solid solution as exsolution textures are common to both. "Stars" and rods of sphalerite are particularly common in the chalcopyrite (fig. 46c). The "stars" range in size from 0.01 to 0.1 mm. across and the rods are up to 0.05 mm. long. Blebs of chalcopyrite are extremely common in the sphalerite, giving the later an anomalous anisotropism. The blebs range from submicroscopic to 0.15 mm. long and some of the larger blebs tend toward crystal forms. Segregation (?) veinlets of chalcopyrite in sphalerite are surrounded by miriads of submicroscopic chalcopyrite blebs. Towards the edge of sphalerite crystals, the chalcopyrite blebs become larger, giving the
appearance of the smaller blebs migrating from the centre of the crystal and coalescing into larger blebs.

**Gangue minerals**  Quartz is the most common gangue mineral, occurring in many different forms. Well-developed crystals up to one inch long are present in most mines but magnificent specimens are found at the All Nations Mine. Some of these are up to twelve inches long and two inches thick with perfectly developed crystal faces. Milky and clear quartz are dominant but smoky and amethyst quartz occur in small patches. The best developed crystals are found in vughs and some contain inclusions of bladed wolfram and lamellar molybdenite.

**Fluorite** is widely distributed. It is colourless and generally occurs in small (to 1 cm. long) crystals associated with vein material. A modification of topaz is found at the Shepherd and Murphy Mine. This is a dull green mineral with a hardness of 2.5-3 on Moh's scale. X-ray powder photographs prepared by Mr. R. J. Ford have failed to reveal any differences between the "soft topaz" and normal hard topaz. At the author's request, Mr. P. Leverett carried out Infra-red spectrum analyses of "soft topaz" and hard topaz from the Mine and from the Cradle road but apart from slight differences in the OH bending mode, no significant bonding differences could be discerned. Thus the reason for the softness of some of the topaz from the Shepherd and Murphy Mine remains unexplained.

Two varieties of mica are common. The less abundant mica is greenish-grey and occurs in radial clusters up to 1 cm. in diameter. Optical data suggests this mica approaches phlogopite in composition.
Small books and aggregates of white or colourless muscovite are common associates of ore-bearing veins in the granite.

Beryl crystals occur with the gangue at the Pig and Whistle and Shepherd and Murphy Mines and in pegmatites on Sayers lease (fig. 43). The beryl is in slender ice-blue or pale green crystals (to two inches long) at the former mines and is iron-stained, blue or green, fractured crystals up to four inches long in the pegmatites in Sayers Mine.

**Paragenesis**

Williams (1958) worked out the paragenetic sequence of the Shepherd and Murphy lode minerals and this sequence is probably applicable to the other wolfram-cassiterite-sulfide deposits in this area. The three stages of paragenesis proposed by Williams are:

1. **The Halide Stage.** Tin, tungsten, iron and aluminium were the first minerals introduced, probably in the form of their volatile halides (fluorides and chlorides), together with some silica. The halides were almost certainly gaseous and upon hydrolysis, cassiterite, wolfram, magnetite, topaz and fluorite were deposited. Skarn rock resulted from reaction between the liberated HF and limestone.

2. **The Sulfide Stage.** The bulk of the sulfides were deposited after the formation of the stage 1 minerals. Pyrite and arsenopyrite were the first sulfides deposited, followed by molybdenite, pyrrhotite, chalcopyrite and sphalerite, then bismuthinite and galena, though there was considerable overlaps in this sequence. Most of the quartz was probably introduced at this stage.
Fig. 43 Beryl crystals, Sayers Mine.
3. The Carbonate Stage. Solutions rich in carbonates were introduced as the temperature fell and scheelite apparently resulted from reaction between these solutions and wolfram.

2. Sulfide deposits

These deposits consist dominantly of galena with chalcopyrite, pyrite, sphalerite, arsenopyrite, bismuthinite and rarely, native bismuth (Stormont Mine) in Moine Sandstone host rock. Gangue minerals are quartz, carbonates and piritite. Some secondary cerussite has developed in the No.7 Adit at Round Hill and in the drive at the Golden Hills. Polished sections were prepared from ore collected from Round Hill and the Golden Hills Mine. Pyrite is generally cubic in form with individual cubes up to 2 mm. across. Patches of pyrite appear to be fractured and "cemented" with later galena, sphalerite or chalcopyrite. Some cubes contain tiny gangue inclusions symmetrically arranged showing growth zones in the pyrite (fig. 44a). Galena is replacing pyrite as many galena-pyrite borders show caries texture and small skeletal crystals of pyrite, tending toward atoll texture, are common (fig. 45a, b). Tiny blebs of galena, sphalerite, chalcopyrite and bornite rarely occur in pyrite crystals (fig. 45c). Even rarer are "stars" of sphalerite (0.1 mm. across). These blebs and "stars" appear to have exsolved from the pyrite.

Arsenopyrite is relatively rare and more extensively replaced by galena than the pyrite. Galena fills fractures in the arsenopyrite (fig. 44b). It commonly forms partial rims around pyrite cubes.

Chalcopyrite and Sphalerite These two minerals show almost identical relations with each other as they do in the Shepherd and Murphy ore.
Fig. 44a Pyrite (light grey) showing inclusions arranged in growth zones. The pyrite is also fractured and "cemented" with galena (medium grey), sphalerite (dark grey) and gangue (black). Round Hill Mine.

Fig. 44b Galena (medium grey) replacing fractured arsenopyrite (white). Large light grey mineral is pyrite, Golden Hills Mine.
FIG. 4-5

a. Pyrite in galena, Golden Hills Mine.
b. Skeletal pyrite in galena, Round Hill Mine.
c. Inclusions in pyrite, Round Hill Mine.
d. Supergene covellite, Golden Hills Mine.
FIG. 46

a. Corroded sphalerite in galena, Round Hill Mine.

b. Exsolved tetrahedrite in galena, Round Hill Mine.

c. "Stars" of exsolved sphalerite in chalcopyrite, Shepherd & Murphy Mine.

C.E. Gee, 1965
Chalcopyrite occasionally occurs as blebs in sphalerite. Larger patches of chalcopyrite (up to 1 cm. across) show very corroded edges against galena. In rare patches, covellite has formed from the chalcopyrite in the Golden Hills ore (fig. 45d). Rare, irregular patches of a reddish-brown mineral with strong anisotropism and incomplete extinction also occurs in the Golden Hills ore. These patches are up to 0.2 mm. across and the mineral is tentatively identified as tenorite (CuO) which has formed from the chalcopyrite. Sphalerite contains numerous segregations veins and blebs of chalcopyrite (fig. 47a). In many cases, the exsolved chalcopyrite seems to have migrated to the edge of sphalerite crystals and begun replacing the galena (fig. 48b). Next to galena, the sphalerite is very corroded and shows caries texture (fig. 46a). Veins of galena through sphalerite are common. Irregular veins of a mineral identical in optical properties with sphalerite but a slightly darker grey colour, cut the sphalerite. These veins are probably sphalerite of a slightly different composition and it is noticeable they do not contain blebs of chalcopyrite. Rare blebs of stannite (to 0.03 mm. long) are exsolved from the sphalerite.

Galena was apparently the last mineral to form as it veins and/or replaces all other primary minerals (fig. 47b). Inclusions are common in the galena. Apart from the minerals above, tetrahedrite, bournonite, pyrargyrite (?) and miagyrite (?) are included in the galena. Tetrahedrite is common in blebs (to 0.1 mm. long), rods (to 0.15 mm. long) and irregular patches (to 1.5 mm. across). The tetrahedrite patches show well developed caries.
Fig. 47a Chalcopyrite veins and blebs in sphalerite
Golden Hills Mine.

Fig. 47b Galena veining sphalerite and pyrite, Round Hill Mine.
**FIG. 48a** Tetrahedrite in galena, Round Hill Mine.

**FIG. 48b** Chalcopyrite exsolving from sphalerite into galena, Golden Hills Mine.

C.E.Gee, 1965
texture against the galena (fig. 48a) and the rods show preferred orientations (fig. 48b). The bournonite blebs range from submicroscopic to 0.03 mm. long. Bournonite-tetrahedrite blebs showing mutual boundaries within the blebs, are fairly common. Pyrargyrite (?) and miargyrite (?) are present in spindles (0.01 mm.) and blebs (0.02 mm.) respectively but these are rare and their identification is only tentative.

Although not enough polished sections were examined to determine a precise paragenetic sequence, a general sequence for the sulfide deposits is:

1. Arsenopyrite, pyrite
2. Chalcopyrite-sphalerite, stannite
3. Tetrahedrite (?), galena, bournonite-tetrahedrite-pyrargyrite-miargyrite.
4. Supergene minerals - covellite, tenorite (?) etc.

This sequence is in agreement with the generally established sequence as given in Park and McIver (1964, 157-160).

3. Cambrian deposits
   Devon Mine

The Devon lode consists of galena, chalcopyrite, pyrite, arsenopyrite and sphalerite in a quartz siderite gangue. Galena is by far the dominant sulfide and the other sulfides, with the exception of chalcopyrite, are decidedly minor in amount. Secondary cerussite, azurite, malachite, anglesite and iron oxides resulted from oxidation of the sulfides. Galena contains many rods, spindles, blebs and globular bodies of several
minerals. Of these, tetrahedrite rods and blebs are the most common being up to 0.8 mm. across. In places, globular bodies of tetrahedrite show an almost subgraphic texture with the galena. Pyrargyrite occurs in blebs up to 0.2 mm. long. Blebs and spindles (to 0.3 mm. long) of a bluish-green mineral are relatively common. This mineral is darker than pyrargyrite, softer than galena and shows distinct anisotropism with a deep-red internal reflection. Reflectivity values were kindly determined by Mr. R. Both, using a photometric ocular and green light. The values ranged from 29 to 32 which, together with the other properties, indicate either polybasite or perocite. The optical properties seem to fit the former mineral a little better. Uytenbogaardt (1951) quotes reflectivity values in green light for polybasite and perocite as 29.5 and 30.2 respectively.

Small areas of galena were etched with HBr and cut back slightly with MgO powder to reveal grain boundaries. The etched areas showed a polygonal pattern with the polygons tending to hexagons about 0.3 mm. across. In another section, chalcocite and chalcocite-neodigenite intergrowths occur in galena. These intergrowths form a polygonal pattern with the polygons of galena having a diameter of about 0.4 mm. It seems likely from the etch results that these intergrowths of supergene copper minerals are forming along galena grain boundaries.

Chalcopyrite occurs in blebs (to 0.1 mm.) in galena and small, irregular masses traversed by galena veins. Tetrahedrite is sometimes adjoining the chalcopyrite masses and where this happens, the tetrahedrite invariably veins the chalcopyrite. Resolved sphalerite in chalcopyrite is extremely rare. Chalcopyrite is altering to covellite, chalcocite and neodigenite (a.r.).
Sphalerite is rather rare. Near grain boundaries, sphalerite is speckled with chalcopyrite blebs from submicroscopic to 0.04 mm. long. At the grain boundaries, chalcopyrite appears to be replacing the galena as in figure 48b. The centres of sphalerite masses are free from chalcopyrite blebs which leads one to conclude that all of the exsolved chalcopyrite has migrated to or near to, the grain boundaries.

Pyrite and arsenopyrite These two minerals occur in rare crystals up to 1 mm. long in galena which appears to be replacing them. The crystals are ragged and some pyrite shows well-developed stoll texture.

Covellite, chalcopyrite and neodigenite result from secondary alteration of chalcopyrite. Chalcopyrite and neodigenite (the term neodigenite is used as defined in Uytendabaardt, 1951) commonly form fine intergrowths whilst covellite tends to occur on its own, although some covellite-chalcopyrite intergrowths were noted. Covellite and covellite-chalcopyrite are generally restricted to rims around chalcopyrite masses or veins and patches in the chalcopyrite. The patches are up to 0.5 mm. across and the rims up to 0.3 mm. wide. Where gangue is present in the polished sections, it is invariably rimmed by chalcopyrite-neodigenite intergrowths up to 1 mm. wide. The galena-chalcopyrite-neodigenite boundary is cuspatel with the cusps into the galena. As mentioned above, chalcopyrite-neodigenite intergrowths have apparently formed along grain boundaries in galena.
A tentative paragenesis for the Devon Lode is:

1. Arsenopyrite-pyrite
2. Chalcopyrite, sphalerite
3. Galena-tetrahedrite-pyrrargyrite-polybasite
4. Covellite-neodigenite-chalccosite
5. Oxidation products – cerussite, malachite etc.

**Powerful Mine**

The Powerful Lode consists of specularite (micaceous haematite) in quartz, with minor amounts of pyrite.

The haematite is intimately associated with quartz and polished sections reveal haematite lamellae up to 4 mm. long, separated by gangue (fig. 49). Lamellar twinning is common and well developed. Exsolution (?) blebs of magnetite up to 0.1 mm. across, are quite common as is alteration of the haematite to hydrous iron oxides.

Pyrite generally occurs in granular aggregates up to three inches across and rarely, as small cubes with sides up to 2 mm. long. Its distribution is patchy.

**Zoning**

Referring to the orebodies in this area, Elliston (1953) stated: "These various orebodies show a zonal distribution relative to the granite stock outcropping at Dolcoath Hill, with tin-tungsten-bismuthinite-molybdenite ores in and adjacent to the granite, passing outwards to tin
x 15

Fig. 49 Lamellar haematite in gangue (black), Powerful Mine.
ores carrying sulfides and gold, to gold-copper ores and to silver-lead ores in that general sequence." Although the deposits are zoned around the Dolcoath Granite, the zones proposed by Elliston are very difficult to determine and some of his zones must have been based on alluvial deposits and Cambrian ores.

It is suggested there are two major zones around the Dolcoath Granite. In and close to the granite, wolfram-cassiterite deposits with subordinate sulfides, dominate. This zone extends westwards from the granite outcrop (fig. 50) as the granite is suggested to occur below the surface west of Dolcoath Hill.

Surrounding the wolfram-cassiterite zone is the sulfide zone. Galena is the dominant sulfide but subordinate pyrite, chalcopyrite, sphalerite and arsenopyrite are present. The sulfides are auriferous and argentiferous and relatively rich gold deposits formed where gold was concentrated in the gossan at the surface.

Emmons (1940) gives a zonal distribution that applies to vertical and/or lateral variations in veins associated with a granitic intrusion. His zones, applied to the minerals found in this area, would be:

1. Tin with topaz (closest to granite)
2. Wolfram with arsenopyrite and topaz
3. Bismuthinite and native bismuth with pyrite
4. Chalcopyrite
5. Sphalerite
FIG. 50  Zoning around the Dolcoath Granite. This figure should be used in conjunction with figure 35.

C.E. GEE, 1965
However, as the granite is approached here, wolfram becomes dominant over cassiterite, and due to considerable overlaps during deposition of the sulfides, the sulfide zones cannot be subdivided. The vertical zonation in the Shepherd and Murphy Mine is also different. In the upper levels, the cassiterite : wolfram : bismuthinite ratio was 20:13:3 (Twelvetrees, 1913). Bismuth minerals declined rapidly below No. 1 level and the cassiterite : wolfram ratio decreased with depth (i.e., as the proposed granite below the surface is approached). The last ore mined from No. 3 level had a cassiterite : wolfram ratio of 1:4 (Williams, 1958) and the amount of sulfides present (galena and pyrite mainly) also increased with depth. This is the reverse of zoning found in other tin-tungsten deposits such as Torrington, N.S.W., (Mulholland, 1953) and the Cornish tin granites (Park and McDairmid, 1964).

The wolfram-cassiterite deposits at Storeys Creek and Rossarden show a similar reverse zoning, the Sn:WO₃ ratio decreasing from 12:1 in the upper levels, to less than 2:1 in the lower level at Rossarden (Edwards and Lyons, 1957) whilst the amount of sulfides (mainly marmatite and galena) increases with depth (also as the subsurface granite is approached).

The reason for these reverse zonations is, at present, unknown.

It appears that the development of skarn rock is restricted to areas close to the granite and if this is so, the skarn is restricted to the higher temperature wolfram-cassiterite zone. The occurrence of skarn in the Stormont area is interesting as it is associated with auriferous sulfides containing bismuthinite and bismuth. These deposits may be the
upper levels of veins associated with a cupola of granite below and if this is so, it is reasonable to assume the sulfides may give way to wolfram-cassiterite at depth.

**Comparison with other deposits**

Apart from the reverse zoning discussed above, these deposits are very similar in mineralogy to the Cornwall-Devonshire tin deposits. Here, the surface lodes of silver-lead give way to copper lodes which in turn give way to cassiterite lodes at depth and laterally, sulfide zones give way to a cassiterite zone as granite is approached.

Again, apart from the reverse zoning, the Moina-Lorinna field is similar to tungsten-tin mineralization at Torrington, N.S.W., where an early Mesozoic or Late Permian acid porphyritic biotite granite encloses an isolated roof pendant of Lower Marine (?) (Permian) mudstone, sandstone and conglomerate beds.

The cassiterite-wolfram veins mined at Rossarden and Storeys Creek are practically identical with the cassiterite-wolfram lodes in Moina Sandstone. The Rossarden-Storeys Creek deposits are larger but the mineralogy and geological setting are extremely similar.
8. SUGGESTED EXPLORATION PROGRAMME

As the area has been mapped on a regional, and in places, detailed scale, the first stage of an exploration programme has been carried out. It now remains to pick out smaller areas that show promise of containing mineral deposits and mapping these in detail to draw up a drilling programme.

The area between the Shepherd and Murphy Mine and Sayers Mine should be the first to consider further. This area has been intensively prospected at the surface and it is unlikely that any surface deposits remain undiscovered. Many trenches have been cut in attempts to intersect quartz lodes and several shafts and drives have been put in, but the shafts do not exceed ninety feet. Diamond drilling is the next logical step in exploration as it is unlikely that any geophysical methods could be applied to exploration here as the area is small and the lodes consist of quartz-ore veins through quartzite, sandstone or granite. The quartz veins rarely exceed two feet in width and would be difficult to pick up by geophysical means.

Suggested drill sites

1. On the hillside between the All Nations and Lady Barron Mines (this lease is at present held by Messrs. J. Smith and J. Smythe). Two holes could be drilled here, one vertical and the other horizontal on a bearing of 180°. The quartz veins in this area dip to the south and strike easterly. The vertical hole would serve to locate the southerly extension of the All Nations lode and may pass into granite at a depth of
the order of 200 feet. The granite should be drilled for fifty feet or so in the hope of locating greisen patches etc. Most of this hole should be in quartzites and sandstones of the Moina Sandstone but there may be some acid volcanics between these and the granite.

The horizontal hole could be drilled for about 400 feet to pick up any subsurface lodes north of the Lady Barron and determine the extent of mineralization of the Cambrian-Ordovician boundary. The first 300 feet or so of this hole would be in Moina Sandstone and it is recommended the Bull Creek Volcanics be drilled to see if they are mineralized.

Access to this site is good but a track would have to be cut from the Iris access track to the actual site. Water may be a problem but it may be possible to pipe water from the dam on the Iris property.

2. In the creek below the Pig and Whistle, a hole depressed 50° on a bearing of 0° is suggested. This would pick up extensions to the Pig and Whistle lodes. The hole should be drilled for about 500 feet and would be in acid volcanics, although granite may be encountered near the end of the hole. Access would be a problem as a track would have to be cut from the Iris property. The creek should be a suitable supply of water.

3. One hundred feet below the track at the Squib Mine. This hole should be horizontal or slightly depressed, on a bearing of 210°. It would serve to determine extensions of the Squib lodes and the presence of granite which may carry further greisen patches and pegmatite dykes.
Granite should be met in the first hundred feet of this hole and it should be drilled for a further hundred feet or so. Access to this site is poor - the Squib track would have to be repaired and a track cut from the Squib Mine to the drill site. Water could be pumped up from Narrawa Creek, a distance of about one hundred feet vertically.

4. One quarter of a mile north of Beswick's workings, between the Cradle road and the Iris track. Here, a vertical hole should be drilled to search for westward extensions of the All Nations lode. The hole should be drilled for about five hundred feet in quartzite and may encounter granite in the latter stages of the hole. An access track could be cut from the Iris track but water would be a problem as there are no creeks in this area.

5. Two hundred yards southeast of No.4 Creek Drive between the Cradle road and Bismuth Creek. This hole should be depressed at about 50° on a bearing of 340° to pick up easterly extensions of the Shepherd and Murphy lodes that may have been offset by the Bismuth Creek fault. It should be in quartzite and drilled to a depth of about four hundred feet. Access would be a problem as the valley here is steep but a track could probably be cut from the Cradle road. Bismuth Creek should provide ample water for drilling operations.

6. Below the Moine road, sixty yards west of Bismuth Creek a horizontal hole should be drilled on a bearing of 180°. This hole should be in Moine Sandstone for its entire length of 3000 feet in order to prove the Shepherd and Murphy lodes at depth. Access and water would be no problem.
The cost of this drilling programme is calculated below. It is difficult to give the cost per foot of drilling such as this for drilling costs per foot vary greatly with:

1. The skill of the operator
2. The type of machine
3. The type of down-the-hole equipment
4. The quality of the diamond bits
5. The suitability of the diamond bits
6. The angle of depression of the hole.

However, a price of $A 12 per foot for total core recovery is an estimate made after discussion with Mr. J. Maldart of the Tasmanian Department of Mines. The cost would probably be more per foot, for the non-vertical holes. Using $A 12 per foot, the cost of this drilling programme is:

<table>
<thead>
<tr>
<th>Site</th>
<th>Nature of hole</th>
<th>Length</th>
<th>Cost ($A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hole 1, vertical</td>
<td>300 feet</td>
<td>3,600</td>
</tr>
<tr>
<td></td>
<td>Hole 2, horizontal</td>
<td>400 feet</td>
<td>4,800</td>
</tr>
<tr>
<td>2</td>
<td>Depressed 50(^\circ)</td>
<td>500 feet</td>
<td>6,000</td>
</tr>
<tr>
<td>3</td>
<td>Horizontal</td>
<td>200 feet</td>
<td>2,400</td>
</tr>
<tr>
<td>4</td>
<td>Vertical</td>
<td>500 feet</td>
<td>6,000</td>
</tr>
<tr>
<td>5</td>
<td>Depressed 50(^\circ)</td>
<td>400 feet</td>
<td>4,800</td>
</tr>
<tr>
<td>6</td>
<td>Horizontal</td>
<td>3,000 feet</td>
<td>18,000</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>5,300 feet</td>
<td><strong>$A 63,600</strong></td>
</tr>
</tbody>
</table>


It should be noted in the interpretation of the drill core that the distribution of wolfram or cassiterite in the quartz veins is very patchy so the core will rarely, if ever, be representative of the grade of wolfram-cassiterite ore. Therefore, likely horizons picked up in this preliminary drilling, would have to be drilled much more extensively to accurately determine the grade and extent of the orebody.

The areas discussed below should be mapped in more detail to see if further exploration by drilling, is warranted.

1. The Tin Spur area below the present Lorinna road. Although no new surface lodes are likely to be discovered, analyses of the structure of the Moina Sandstone may possibly predict suitable ore horizons.

2. In the vicinity of the Stormont Mine and Fletchers Adit. The Moina Sandstone is gently folded and contains inliers of skarn. The structures apparently disappear under basalt to the east and detailed mapping may be able to predict the course of the orebody exposed in the main workings on Castle Creek. It may prove profitable to drill a vertical hole here to find out if the sulfide veins give way to wolfram-cassiterite lodes at depth, as predicted on page 102.

Jennings (1958) has prepared a comprehensive exploration drilling programme for the Round Hill area.
9. GEOLOGICAL HISTORY

Sedimentation in this area began in the Precambrian. The sediments formed were subjected to two (?) periods of folding and regional metamorphism during the Precambrian, forming quartzites and schists of the Dove Group.

With the initiation of the Dundas Trough in the Cambrian, greywackes, siltstones, cherts and quartzites were deposited. Sometime during the Upper (?) Cambrian, a series of volcanic centres probably formed along the southern edge of the Trough and contributed acid lavas and volcanics to the deposits accumulating in the Trough, giving rise to the Bull Creek Volcanics and the Lorinna Volcanics. The keratophyres and rhyolites of the Minnow Keratophyre to the north of the area, were probably extruded at this time. During Late Jukesian (?) times, the granodioritic magma which gave rise to the lavas and volcanics, was intruded into the Precambrian rocks and its own lavas to the north. The granodiorite intruded along the southern margin of the Dundas Trough. Small silver-lead and iron deposits are associated with the granodiorite which is now known as the Dove Granodiorite. The Jukesian Movement brought sedimentation and igneous activity in the Cambrian to a close and brought about the uplift of the Tyennan Block which became the source area for the Ordovician conglomerates and sandstones.

After a short period of erosion, sedimentation in the Ordovician began with the deposition of the Roland Conglomerate, probably under terrestrial conditions. Sandstones and shales of the Moina Sandstone were deposited
conformably over the Conglomerate as a marine basin developed, occupying much the same position as the Dundas Trough. Some eight hundred feet or so of sandstones were deposited, followed by an unknown thickness of limestone (Gordon Limestone).

During the Tabberabberan Orogeny, the rocks were folded and faulted into northwesterly trending structures. Towards the end of the Orogeny the Dolcoath Granite was intruded, causing some metamorphism of the country rocks. Mineralizing solutions accompanying the granite created the majority of the mineral deposits in the area.

Between the Tabberabberan Orogeny and the Tertiary, there is no record of geological events and it is assumed normal erosion took place. In the Tertiary, shallow lakes formed in the Moina area and received sediment from the surrounding areas. Conglomerate sands and clays were thus deposited and alluvial gold and cassiterite-wolfram deposits formed in the pre-basalt rivers. Basalt extruded during the Tertiary blocking many of the pre-basalt streams. The occurrence of agglomerate around Moina suggests a volcanic vent was located in this area. The basalt caused silicification of the Tertiary conglomerates, transforming them into greybillsies.

Since the basalt extrusion, normal subaerial erosion has gone on with the formation of placer deposits in the Forth and Dove Rivers and deposition of alluvium and river gravels.