THE GEOLOGY

of the

MANGANA - WATERHOUSE

GOLDFIELDS

with particular reference to structure and mineralisation

by

V.M. THREADER B.Sc.

Submitted in partial fulfilment of the requirements for the degree of:

Master of Science

UNIVERSITY OF TASMANIA

January 1967

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

The study covers an area of approximately 300 square miles and incorporates eight defunct goldfields in the northeast of Tasmania.

The principal rock unit in the area mapped is the Mathinna Beds which is the host rock of the mineralisation.

The Mathinna Beds consists of a lower lutite member and an upper predominantly arenite unit. Both units exceed 1,000 feet thickness in the area mapped but total thickness is unknown.

The main fold structure strikes NNW - SSE with a wavelength of the order of 2 miles on which is superimposed folding on several smaller scales.

Two directions of shearing are recognised: one striking parallel to the folding and one at right angles to it. The former is in part contemporaneous with the folding and the latter is mainly of later age but evidence suggests that recurrent movements on both sets have occurred. The later shearing movements (ENE - WSW) are considered to have given rise to several major lineaments with which later igneous activity and epeirogenic movements have been associated.

Gold mineralisation is related to a major shear zone and does not appear to bear any direct relationship to granite masses nor to fold structures.

It is recommended that future exploratory work be confined to the shear zone and several lines of research are suggested as a means of locating areas of mineral concentrations in this zone.

Attention is also drawn to the gold producing potential of the extensive alluvial plains of the major watercourses.

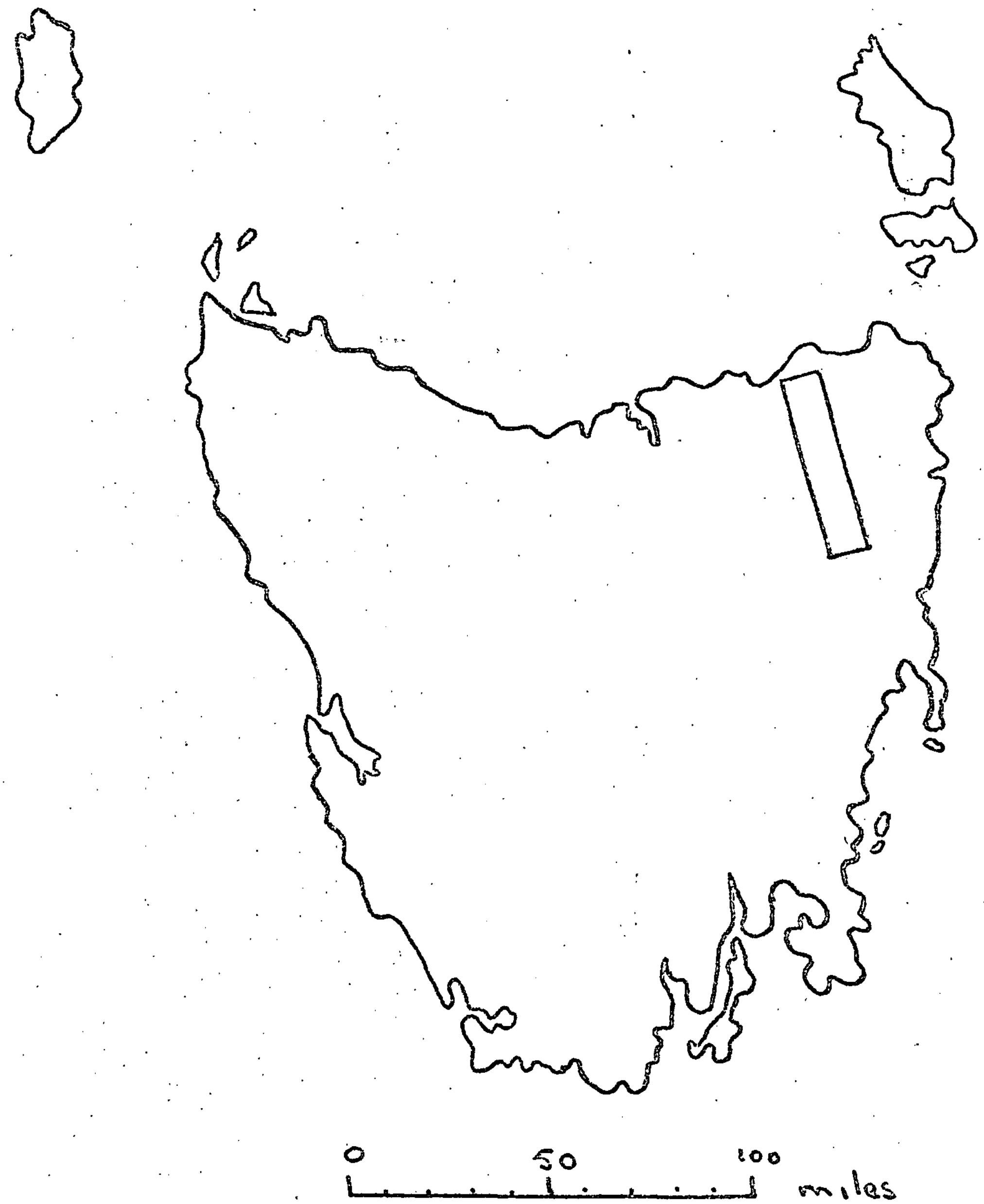


FIGURE 1 LOCALITY MAP

INTRODUCTION

The area studied extends from Fingal to Waterhouse (locality map, figure 1), a distance of 56 miles, and includes Mangana, Tower Hill, Mathinna, Dan Rivulet, Alberton, Warrentinna, Forester and Waterhouse goldfields.

Gold mining commenced in 1852 and continued until the late 1920's. The most active period was 1880-1910. The fields are now inactive.

Numerous geological investigations by the Department of Mines were carried out during these and later times but only in restricted areas. The present survey treats the line of goldfields as a whole. Its purpose is to aid in the selection of suitable sites for diamond drilling to facilitate an economic appraisal of the goldfields. This problem is primarily one of the geological structure and its relation to mineralisation. This study has occupied three years, of which half the time was spent in the field and one half in the office. The latter time was divided equally between plotting, literature and laboratory studies.

The Mathinna Beds (see under General Geology) occupy about one half of the area mapped but are very poorly exposed over this area. They are covered by a thin soil cover and open eucalypt forest in the interfluves and by a thick soil cover and dense scrub along the water-courses. Excellent outcrop is to be found in the deep gullies on the flank of Mathinna Plains and Cotton Plain and good exposures also occur in disused mine workings and in road cuttings. There are, however, large areas occupied by Mathinna Beds for which no data can be obtained. The other half of the area is covered by small areas of granite, dolerite and basalt and large areas of Cainozoic sediments.

The paucity of outcrop of Mathinna Beds, which are the host rocks of the mineralisation, and the lack of marker horizons in the succession, has made mapping difficult and particular attention has been paid to geomorphology as an aid to structural interpretation.

The base for the geological map (figure 57) is the 30 chains = 1 inch forest type map of the State Forestry Department. All compass bearings refer to the magnetic meridian and the average magnetic deviation is 12° East of true North.

GEOMORPHOLOGY

The area is bounded on the north by a coastal plain and in the south by a dolerite plateau - the Fingal Tier, which forms the southern valley wall of the South Esk River. Between these two units, the outstanding topographic feature is the elevated and exhumed pre Permian erosion surface (figures 2, 3, 4, 50 and others). This surface is commonly known as the pre Permian surface and was extensively developed over Tasmania. In the area studied, the lowest Permian member is the basal conglomerate underlying rocks of the Mersey Group. This unit has been given the age of mid Artinskian (Banks, 1962, table III p.200). This surface has been heavily dissected to expose the underlying Mathinna Beds and now remains as interfluves of the main watercourses and beneath the Permian and Dolerite cover of scattered monadnocks.

Previous Literature. Nye and Blake (1938) stated that this ancient surface had become incorporated in a later one - the Eastern Peneplain. This (the Eastern Peneplain) included the whole of the elevated eastern portion of the state with the exception of the Ben

Figure 2: Mt. Victoria, a dolerite capped Monadnock viewed from the eastern margin of Cotton Plain looking south across the South George River. Foreground: granite, middle distance: Mathinna Beds, terminating at the pre-Permian surface. Background: Mt. Victoria.

Figure 3: Mathinna Plains, a remnant of the pre-Permian surface. Looking south towards Mt. Saddleback, a dolerite capped monadnock.

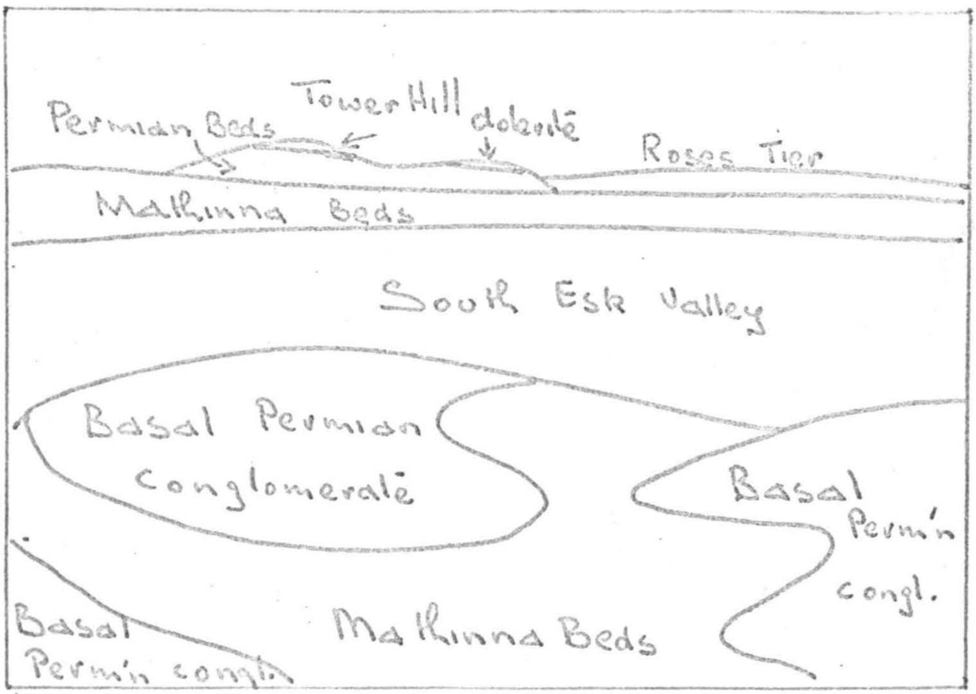


Figure 4: Tower Hill, a monadnock rising above the level of the pre-Permian surface. Looking west from a remnant of the pre-Permian surface on the east bank of the South Esk River in the Evercreech Forestry Department plantation. The river lies in the thickly timbered area in the middle of the photograph and occupies a fault line. The Permian beds in the foreground are down faulted 200 feet with respect to those in the background.

Lomond Plateau which lies 10 miles west of the southern portion of the mapped area.

There are two interpretations of the post Jurassic history of the island especially with respect to the relative age of the faults and erosion surfaces:

(1) Carey (1946) gave the following sequence: widespread intrusion of dolerite during the Jurassic Period followed by a prolonged period of denudation which resulted in a peneplain surface in lower Tertiary times. This surface was broken up in the Lower Miocene Period by violent faulting. The faults were normal with steeply dipping fault planes and the faulted blocks were tilted and warped. The age of the faulting was based on the recognition of Miocene plant remains in the lower lacustrine sediments of the Launceston basin. These plant remains are now known to be of Palaeocene or Eocene age (Gill and Banks 1956) and the faulting therefore occurred early in the Tertiary Era or late in the Cretaceous.

(2) Davies (1959) challenged this concept of a faulted peneplain on the grounds that there is a marked concordance of summits and ridges at certain significant levels. He suggested that the main period of faulting occurred in Cretaceous - Eocene times and was followed by further planation possibly until the Miocene period.

During the later half of the Cainozoic Era, intermittent uplift during planation gave rise to a stepped landscape. Grabens became re-excavated and differential erosion on either side of older faults has resulted in the formation of fault line scarps. Davies concluded that the evidence of the erosion surfaces precludes the possibility of late Cainozoic faulting except for small (up to 100 feet) local movements.

The various levels are designated thus:

Higher Plateau surface	3,900 - 4,300	feet
Lower " "	3,000 - 3,500	"
St. Clair "	2,400 - 2,700	"
Higher Coastal "	1,200 - 1,500	"
Lower Coastal "	300 - 900	"

There is little evidence for the accurate dating of Tertiary faults and it is therefore difficult to choose between the two interpretations but the dating of faults as lower Tertiary favours an earlier break-up of the pre-Artinskian surface than Carey suggested.

Dolerite masses. Davies considers that as dolerite sheets are generally transgressive, tilted, intruded at different levels and faulted they are not planar until stripped and eroded. He suggested therefore that the dolerite sheet which caps the central plateau is an erosion surface. Davies states that the surfaces continue off dolerite on to softer rocks at similar levels but Jennings (1963) does not accept the evidence. There are no dolerite sheets in the area mapped; dolerite occurs as minor monadnocks rising above the pre Permian surface: Tower Hill (3,703 ft.), Blackboy Hill (2,850 ft.), Mts. Victoria and Albert (3,054 ft.), Mt. Saddleback (4,188 ft.), Mt. Young (2,964 ft.) and as minor sills and dykes intruding Permian and Mathinna rocks at several different levels.

Just beyond the area mapped are the two extensive dolerite sheets: Ben Lomond Plateau (app. 5,000 ft.) and Fingal Tier (app. 2,500 ft.). These surfaces are confined to dolerite and do not continue on to softer rocks. Davies correlates these two areas with two of the newer surfaces but there is no evidence to show that they represent different amounts of uplift of a late Cainozoic surface. They are fault controlled surfaces and the faults are not related to uplifts but to movements which gave rise to the Launceston basin and the South Esk valley. Davies implies that such structures, if due to faulting, were formed in the Cretaceous Period, filled during early Tertiary times and re-excavated in late Cainozoic times (late Tertiary and Quaternary).

There is no objection to the thesis that they were formed before the commencement of the Tertiary Period; in fact it is suggested elsewhere in this work that the trends are even older than that and have been subjected to movements connected with Tabberaberan orogeny and with more than one period of movement during the Mesozoic - Cainozoic epeirogeny.

Erosion Surfaces. Davies indicates that the five surfaces are present in the northeast of the state. The relevant portion of Davies' map is reproduced here as figure 5a and in figure 5b the levels shown on the state map (4 miles = 1 inch) are shown for comparison.

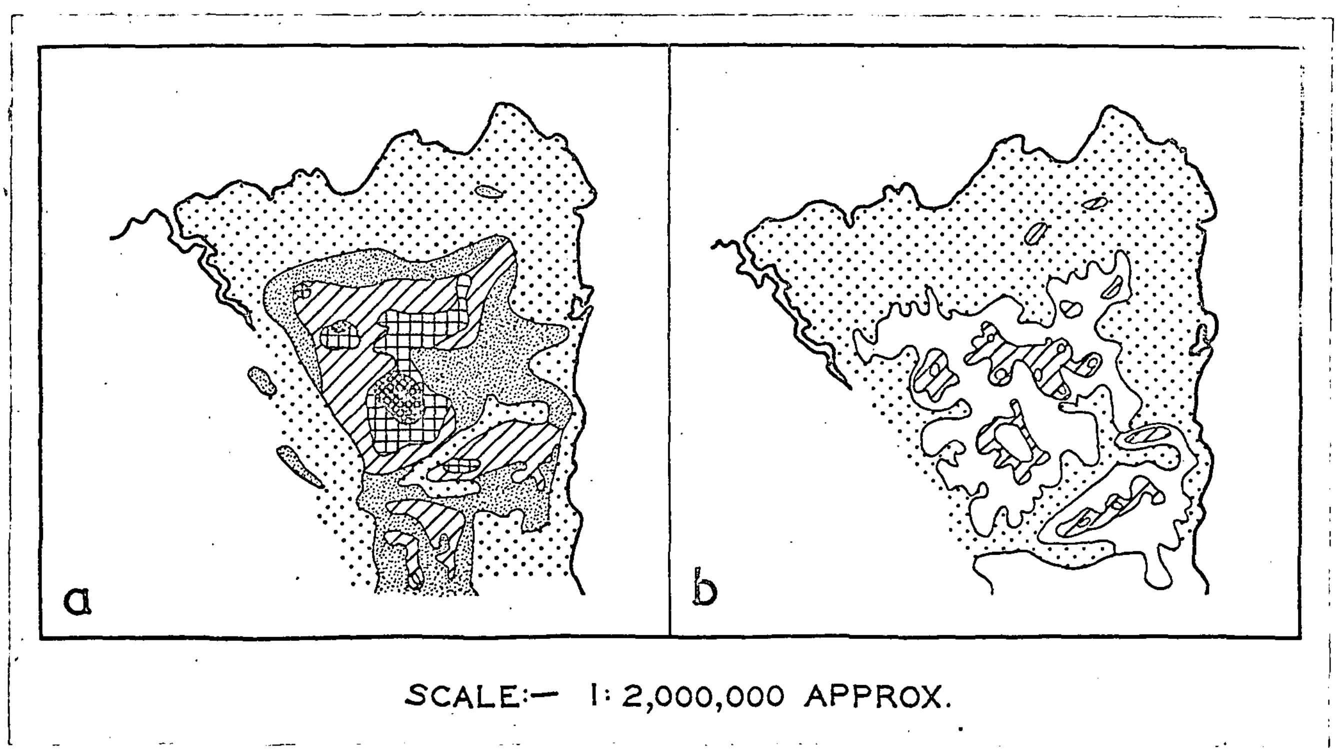
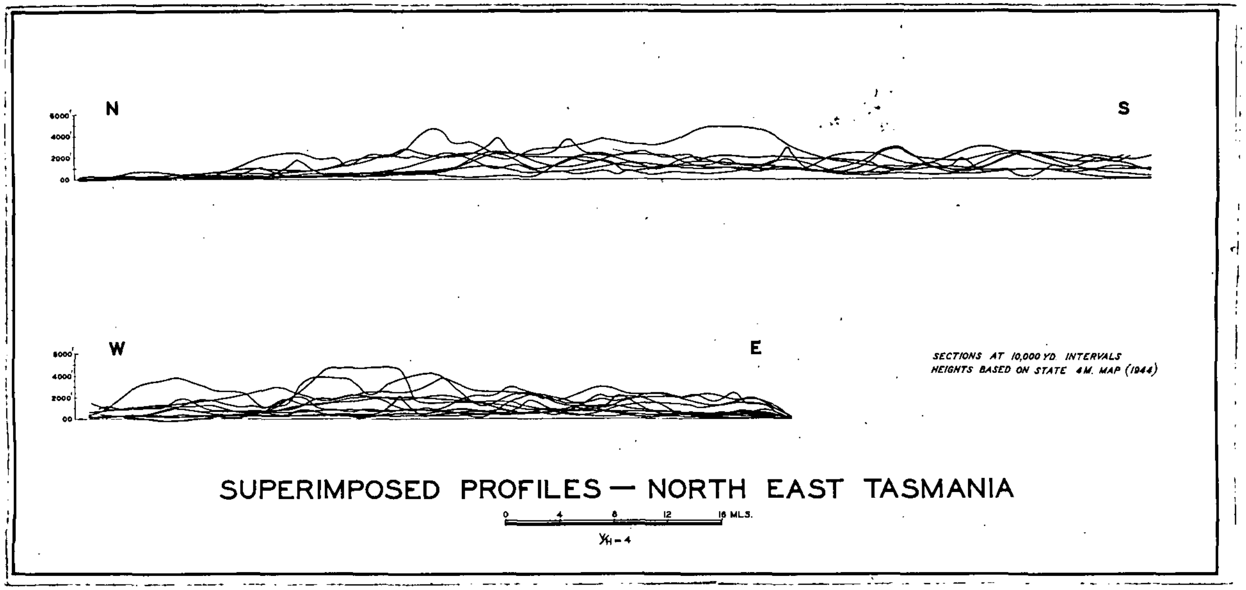


Figure 5



SUPERIMPOSED PROFILES — NORTH EAST TASMANIA

Figure 6

In figure 5a Davies implies that the topography is entirely made up of erosion surfaces bounded by changes of slope which, on the scale of his map (1:2,000,000), can be represented by lines indicating knick points in the profiles. In figure 5b, large areas are shown which do not conform to the proposed erosion surfaces; in figure 6, sets of east - west and north - south superimposed topographic profiles are shown to illustrate the general lack of concordant levels. The topography in figure 5b is shown to consist of the following units:

(1) 0-900 ft. The main streams are graded to present sea level from 900 feet to form the coastal plain and there are no knick points at 300 ft. to correspond to the lower limit of the lower coastal surface.

(2) 2,400-2,700 ft. The St. Clair surface is generally recognised over most of Tasmania including the northeastern area. This surface is shown hachured on figure 5b and is also evident in figure 6.

Davies' higher coastal surface is represented by a single solid line between the lower coastal and St. Clair surfaces on figure 5b and is nowhere in the area extensively developed. Above the St. Clair surface, the lower and higher plateau surfaces appear to be absent, the Mathinna Plains do not belong to either of these postulated surfaces and the only land above the St. Clair surface is isolated dolerite monadnocks which occur at various levels between 2,000 and 5,000 feet.

With regard to the Mathinna Plains, Davies stated that extensive stripping of the pre Permian surface seems to have progressed only at heights which can be correlated with the newer surfaces. He quoted Fenneman (1936) who stated that the stripping of ancient erosion surfaces can only occur at base level. The unconformity is stripped extensively, except where it is protected by dolerite cover, from the coast to the South Esk River, but south of the river it lies concealed beneath one thousand feet of sediments and dolerite. If this stripping occurred at base level, the unconformity should also have been exposed south of the river. Exhumation of the surface therefore probably occurred above base level and was made possible by the marked difference in resistance to erosion between the soft Mesozoic cover and the relatively tough underlying Mathinna Beds. Further, the dip of the surface is opposite to that expected for a present day surface and has an elevation of 2,600 feet at the Cotton Plain escarpment and 700 feet in the vicinity of Fingal. It therefore cuts across three of the erosion surfaces postulated by Davies.

The foregoing evidence does not preclude intermittent uplift but it is suggested that the topography of the area studied can be explained in terms of structure and differential erosion. The present day topography may be the result of a combination of all these factors, but a more accurate assessment of their respective roles must await the publication of more accurate contour maps.

Davies' suggestion that there has been no significant faulting since Cretaceous times is not in agreement with evidence presented under the heading: Post Taberraberran Faulting. This includes post basaltic faulting on the South Esk River; reversal of drainage in the South Esk River by upfaulting or tilting between St. Marys and the east coast; upfaulting of late Tertiary river sediments in the vicinity of Ormley. The fault truncated spurs in the Ormley - Tullochgorum area may have formed earlier but it is unlikely that the South Esk River valley was ever filled and then re-excavated, it is considered preferable to date them as late Tertiary rather than to suggest that the scarps have remained intact since early Tertiary times. A similar argument may be advanced for the northern escarpment which terminates the exhumed pre Permian surface (Mathinna and Cotton Plains).

Cotton (1949) considers that Miocene fault scarps do not survive into present day and therefore present day scarps are more likely to be of Pliocene age or of fault line origin - due to differential erosion across an ancient structure. There is no difference in lithology across this scarp and the fault(s) is therefore of Pliocene age. It is considered that the headward erosion of Dorset and New Rivers which produced the considerable embayment in the Ringarooma - South Esk divide, has resulted from scarp retreat to form the present prominent feature which represents a total fall of 1,600 feet (2,700 ft. - 900 ft.). This retreat was well advanced by the time of the basalt extrusion and is still proceeding. In the upper reaches of these streams the escarpment begins with shear drops of over 300 feet (figure 33c). The Kapai Hill - Mt. Horror block is also considered to owe its prominence to faulting, there being no lithological distinction between the rocks composing this block and those composing the lower lying surroundings, rather the reverse, as granite forms much of the surroundings. This faulting, for the same reasons, must be of Pliocene age.

Late Tertiary faulting is difficult to authenticate and the evidence cited here is suggestive rather than conclusive of postulated late age.

<u>Drainage</u> (figure 47). There are three trunk streams of the goldfields area; 1) the Boobyalla River, which drains elevated blocks of Mathinna Beds in the vicinity of Kapai Hill and Mt. Horror, and flows northwards through granitic rocks and Tertiary sediments to Bass Strait. 2) the Ringarooma River also drains northwards and two of its tributaries, the Dorset and New River rise in the centre of the

area on the north flanks of the Mt. Victoria - Mt. Albert block. They flow off the deeply embayed Cotton Plain escarpment. 3) the South Esk River drains southwards from the same block and its tributaries have become entrenched in the pre-Permian surface. The divide between the South Esk and Ringarooma Rivers is retreating southwards due to the more rapid headward erosion of the north flowing streams plunging over the escarpment. In the extreme south of the area the South Esk River is joined by the Break O'Day River flowing westerly from St. Marys. These rivers join at Fingal and flow southwesterly into the Launceston basin and finally join the North Esk River at Launceston to form the Tamar River.

The subject of drainage is treated more fully in a later section (see Drainage Pattern and Structure).

GENERAL GEOLOGY

Mathinna Beds. All pre-Permian sediments in the north east of Tasmania are grouped under this heading (Banks 1962 p.184). The unit consists of at least 6,000 ft. of sandstone, siltstone and claystone or their metamorphic equivalents. Two lithological associations are recognised:

1. Lutite with a subordinate arenite content.
2. Arenite with a subordinate lutite content.

The associations may be facies equivalents or separate formations but structural evidence suggests the latter, the lutite association being the older (Banks 1962 p.183 - based on unpublished work by Banks and Williams).

The Mathinna Beds are poorly fossiliferous, but on plant remains from Warrentinna and on marine fossils at Scamander, the unit has been correlated with the Eldon (Silurian) Group of Western Tasmania by

Banks (1962 p.187) who suggested that the Eldon Group rocks were deposited on a mildly unstable shelf and the Mathinna Beds in deeper water further off shore.

Williams (1959) described a sequence of the Mathinna Beds in the Upper Scamander area consisting of graded greywackes containing a variety of soft sediment structures which he ascribed to turbidity current activity. These currents introduced sand and silt into the deep water environment of clay and fine silt deposition.

Green (1959) suggested an Ordovician age for the lutite association of the Mathinna Beds. This is justifiable on lithological grounds by comparison with the Victorian Ordovician Beds. The lithology of the arenite association may also be compared with the Victorian Silurian beds thus supporting the original suggestion by Banks op. cit. that the lutite association is the older.

In recent works (Williams G.E. (1964) and Moore (1965) the age of the Victorian equivalent has been given as Siluro - Devonian. This age may apply equally to the Tasmanian arenites but fossil evidence is lacking.

Mapping in the goldfields area further substantiates this age relationship; lutite beds only extensively outcrop in the hinge zones of the major anticlines indicating that they are the older beds. Using the arenite - lutite contact as a marker horizon, the maximum thicknesses of the Mathinna Beds encountered are estimated to be 2,000 feet for the arenite association and 3,000 feet for the lutite association. These are minimum thicknesses as an unknown thickness has been eroded from the succession and the base of the succession has not been found (see geological cross sections, figure 58).

There is no clear boundary between these two units. Thin graded siltstones occur in the lutite association (figure 35) indicating that turbidity current activity began during the deposition of the lower beds. Between the two units is a transition zone of approximately 100 feet thick in which they are of equal development. This grades into the arenite association in which graded and sole marked greywacke beds of average 9 - 12 inches are interbedded with the normal deep water lutite beds of an average 2 - 3 inch thickness. Higher in the arenite association the interbedded lutites are thinner and at the top of the unit, sole markings are rare and the association consists of a succession of ungraded greywackes with very few interbedded lutites. Bedding in these rocks is almost indistinguishable in the field as can be seen in figure 33a, where the only clue to the structure is given by the presence of an occasional clay (weathered slate) band. There was therefore an increase in turbidity current activity, implying an increase in tectonic activity dating from the deposition of graded siltstone beds in the lutite association throughout the arenite association deposition and which presumably culminated in uplift and the orogeny which resulted in the folding of these rocks.

In the following petrological descriptions the rock types are named according to the following definitions:

Greywacke: (Pettijohn 1957). A sandstone with a high detrital matrix content (over 15%) - p.291, and a high content of unstable material (rock fragments and felspar) in the sand size fraction (over 25%) - p.301. Greywackes occur in relatively thin beds - a few inches to a few feet. They are characteristically massive, unsorted, graded and frequently are sole marked. "Of the two definitive properties of greywackes, texture and composition, texture is the most significant, since it alone distinguishes greywacke from all other sandstones" p.302.

Slate: "A compact aphanitic rock formed from fine grained deposits... and having the property of easy fissibility along planes independent of bedding..... (Holmes 1920).

Phyllite: "A compact lustrous schistose rock with its minerals less defined than in a mica schist, the characteristic mineral by which the foliation is controlled is sericite" (Holmes op. cit.).

The difference between slate and phyllite is one of metamorphic grade and hence of degree of recrystallisation. In phyllites, clastic grains of quartz, mica and felspar are therefore almost entirely absent. The fine grained material from which slate and phyllite are derived is a clay - silt mixture having the same composition as the greywacke matrix (Pettijohn p.304).

The following descriptions are primarily structural rather than petrological. The detrital quartz grains have undergone cataclastic metamorphism and the matrix is largely recrystallised. The original grain shapes and mineral composition of the unstable material are therefore difficult to establish.

Grain sizes were measured with a graduated ocular and mineral percentages were estimated by eye.

In 15 thin sections of Mathinna Beds greywackes examined, three lithological types were recognised on the basis of sand grain to matrix ratio:

1. Quartz sandstone. (Dept. of Mines Serial No. 63-183, 64 - 399, 64-400, 65-9).
2. Normal greywacke (Dept. of Mines Serial no. 63-179a, 63-180a, 63-182, 63-187, 63-189a, 63-193, 65-7).
3. Argillaceous greywacke or gritty slate. (Dept. of Mines Serial No. 63-179c, 63-185, 63-186).

These types are gradational, type 1 ranges from almost a pure quartz sandstone through types 2 and 3 to a gritty slate rock. Overall composition is also controlled by the quartz (silt grain) to mica ratio of the matrix. These compositional differences are evident between different beds and also within graded beds in which the decrease in grain size from bottom to top is largely effected by a corresponding decrease in detrital content.

In the upper (arenite) association of the Mathinna Beds, the interbedded lutites are either of slate grade (Dept. of Mines Serial No. 68-179b, 63-184, 63-190, 63-194, 63-196) or low grade schist or phyllite grade (Dept. of Mines Serial No. 63-181a, 63-189b).

In the lower (lutite) association of the Mathinna Beds, the metamorphic grade is almost invariably phyllitic (Dept. of Mines Serial No. 65-183 to 188, 65-190 to 192. Narrow (0.1 mm - 2.0 cm) siltstone bands are commonly interbedded with the phyllites (Dept. of Mines Serial No. 63-185, 65-190 and 191). A more detailed account of these thin sections is given under "Cleavage", together with photomicrographs (figures 21 - 30).

Granitic Rocks. The line of goldfields separates the two largest bodies of granite in the northeast of Tasmania. McDougall and Leggo (1965) referred to these as the Scottsdale and Blue Tier batholiths (figure 55). These batholiths outcrop over 300 and 700 square miles respectively and these authors determined their ages as 363-367 million years and considered them to be of similar age. The granitic rocks are discordant bodies intrusive into the Mathinna Beds. They are unfoliated and unsheared and are therefore post orogenic.

No detailed work on the granitic rocks of the area has been undertaken, but the following brief account summarises the available data.

Spry (1962) states that the most abundant rock type is a coarse, grey granodiorite or adamellite; it is described by others as a porphyritic granite.

Reid and Henderson (1928) gave complex sequences of granitic intrusion and metasomatism and stated that tin mineralisation is associated with greisenisation during the final phase.

Reid (1929) considered that gold mineralisation is genetically related to the hornblende granodiorite which is the oldest of the various phases of granitic intrusion. Twelvetrees (1909) had previously made this suggestion and Hughes (1947) reached the same conclusion in the Dan Rivulet goldfield. There is a spatial relationship between goldfields and hornblende granodiorite in plan but the relationship in depth is not known (see later under "Mineralisation").

Basic intrusive rocks of probable Devonian age are known from many centres, they are found in granites as in the Blue Tier tinfield and in Mathinna Beds as at Tower Hill, the Crown Prince Mine at Alberton, Diana's basin, and Freycinet peninsula.

Permian Sediments. A study of Permian stratigraphy is outside the scope of this report. An area is indicated on the geological map within which Permian beds occur. It represents a remnant of the pre-Permian erosion surface which has been almost completely re-exposed by the Cretaceous - Eocene peneplanation. Boulders of coarse grained sandstone containing pebbles and grits are found scattered over the surface. They are considered to represent basal members of the Permian succession. North west of Cotton Plain similar rocks were found outcropping and resting on Mathinna beds outcrop. In this outcrop, the top few inches of Mathinna beds sandstone was fragmented, disorientated, and recemented by coarse grained sandstone.

The thickness of the Permian section is estimated to total 500 feet in the Storeys Creek area (Blissett 1959) and 300+ feet in the St. Helens area (Walker 1957). Drilling by the Department of Mines in the Break O'Day Valley (Hills et.al.1922) indicated 400 - 500 feet. Thicknesses of this order could be expected in the area mapped but would only be preserved under the dolerite cover of the higher monadnocks where the superficial cover of dolerite scree prevents a measurement of the section. Prior to denudation and faulting, there was probably a continuous Permian cover over most of the area.

Triassic Sediments. There are no Triassic beds in the area mapped but thicknesses of several hundreds of feet are known in the coalfields from St. Marys to Avoca. These occurrences are all preserved beneath dolerite masses and it is assumed therefore that these sediments were previously more widely distributed, probably through the greater part of the area under consideration, but all, except those mentioned, have been stripped by subsequent erosion.

Jurassic Dolerite. The northeast of the state is bounded by a continuous dolerite sheet to the west and south but within this area dolerite outcrops on the higher monadnocks and as numerous isolated masses at different levels. The distribution of these masses is structurally significant and will be referred to in a later chapter.

In some areas dolerite and basalt occur together; in such cases it is not always clear whether the dolerites are all of Jurassic age nor whether all the basalts are of Tertiary age.

The form of Jurassic dolerite intrusions in the area mapped is difficult to determine as the occurrences are small and isolated sill like hill cappings on Permian sediments on the higher monadnocks and dyke like masses intruding the Mathinna sediments. The hill cappings are probably isolated occurrences as enormous areas would need to have been stripped of dolerite to form the present distribution if they were once part of a continuous sheet. Dolerites form highly resistant masses and there is no evidence to suggest such large scale stripping of dolerite. The prevalence of dolerite dykes in the Mathinna Beds would suggest that the Monadnocks are situated over individual feeder channels.

To the south of the mapped area is the Fingal Tier, a large dolerite mass which rises to 2,500 feet A.S.L. This dolerite forms the south valley wall of the South Esk River between St. Marys and Conara.

The Mt. Nicholas range is capped by a dolerite sill and a second sill occurs between the Triassic and Permian Beds (Hills et. al.1922). Walker (1957) agrees with this and states that a dolerite sill also occurs between the Permian and Mathinna Beds.

Specimens from the smaller dolerite intrusions have been sectioned and examined under the microscope:

Greys Hill	61 - 48
Talawah	64 - 401
Alberton	64 - 402
Cotton Plain	65 - 287
Llewellyn (West of Avoca)	66 - 94
Fingal - Mathinna Rd.	66 - 102 (figure 14)

The rocks do not differ markedly from the dolerite in the larger sheets intrusive into Permian and Triassic beds. They are ophitic or subophitic medium grained assemblages of augite and plagioclase felspar and accessory magnetite. The average size of augite is between 1 and 2 mm but in the Alberton specimen they range up to 3.5 mm. The Fingal - Mathinna road specimen was slightly different from the others in being fine grained, containing a few olivine crystals and in possessing a fine grained aggregate of magnetite and an indeterminate elongate mineral. This aggregate, constituting 10% of the slide may be devitrified glass. This specimen is from the margin of the outcrop and probably represents a chilled contact.

Tertiary Basalt. Several localities of basalt occur within the area mapped 1, 2 and 3 below. Two others, 4 and 5, occurring east and west of the southern portion of the map, are also discussed because of their structural significance. They are all confined valley flows and are not considered by the writer to be remnants of formerly continuous sheets.

1. Ringarooma Valley.
2. Forest Lodge.
3. Sheoak Hill.
4. St. Marys.
5. Avoca.

1. The Ringarooma Valley. The main flow which occupies an old river valley is a fine grained nephelinite (Edwards 1950). The source of this flow is probably Olive Rise, which is capped by an extremely coarse grained variety of the same rock. Other local occurrences of coarse grained basalts of different composition probably mark other volcanic centres. They occur on Warrentinna Hill and north of Winnaleah. A similar type has been described by Marshall et. al (1965) from West Scottsdale, a few miles west of the Ringarooma Valley.

Kapai Hill and Greys Hill are local occurrences of completely different composition from the main flow in the valley and the outcrops occur at least 1,000 feet above it. It seems probable therefore that these hills were minor volcanic vents.

Winnaleah (62-235). 2 mm crystals of augite and plagioclase laths in a matrix of devitrified glass. The felspars are partially or wholly enclosed in augite and are frequently bent. (figure 7.)

Warrentinna Hill (65-101). 4 mm crystals of pink zoned augite and 5 mm aggregates of smaller crystals with 1 mm olivine in a groundmass of plagioclase, olivine, augite, magnetite and devitrified glass. (figure 8.)

Kapai Hill and Greys Hill (65-290a and 61-48). Microphenocrysts (0.15 mm) of olivine in a highly flow textured groundmass of plagioclase laths.

Olive Rise (65-288a to e). Nephelinite of two distinct textures are recognisable in this outcrop but the compositions appear similar. It is probable that the coarse grained variety partially crystallised before extrusion.

a and b. Olivine phenocrysts (0.1 - 1.0 mm) and partially iddingsitised in a flow textured ground mass of augite and magnetite with subordinate nepheline (0.05 mm) and calcite.

c, d and e. Phenocrysts of nepheline (4 mm) enclosing augite, magnetite and glass, some nepheline altered to radiate growths of natrolite. Phenocrysts of augite (up to 4 mm) with aegerine rims in d and pale pink with hour glass zoning in e. Some larger augite crystals are altered to skeletal masses of magnetite. The groundmass consists of augite (0.02 mm) magnetite and glass, in part devitrified into palagonite or spherulites. (figure 9.)

2. Forest Lodge. Isolated hill cappings on the eastern edge of Cotton Plain and colinear with the Weldborough Pass - Blue Tier basalts east of the mapped area. This rock contains, in places, 7 cm aggregates of 5 mm olivine crystals, (thin section 65-293). The rock consists of large olivine phenocrysts with calcite in fractures, 2 mm augite crystals with reaction rims and a flow textured groundmass of plagioclase, magnetite and calcite.

3. Sheoak Hill. A line of seven outcrops terminating at the South Esk River betweenFingal and Mathinna where it forms a polygonal pavement on the east bank. Eight specimens were collected along this line of outcrops. Two distinct types of basalt were recognised but the two types were not determinable on field relationships. 66-100a to g were taken from east to west in order and 65-8 was taken from the river bank.

(i) 65-8, 66-100 a, d & f: Porphyritic or microporphyritic with olivines 0.5 to 2 mm and in 100a, 2 mm augite, in a groundmass of plagioclase,magnetite, augite and black glass. In 100 f zeolites were present, and radiate intergrowths of felspar and augite.

(ii) 66-100 b, c, e, g: Ophitic or sub-ophitic basalts but with augite phenocrysts up to 2 mm. More felspathic than type (i) vesicular and with interstitial glass; g contains a few 1 mm aggregates of olivine microphenocrysts.

4. St. Marys. Three outcrops have been mapped in this area, they appear to be sufficiently similar to warrant grouping together. (66-98) Germantown and Dublintown (66-99) are two farming settlements five miles northwest of St. Marys and the St. Marys outcrop 66-110a - d occurs on the west of the town boundary but extends two miles northerly to an isolated hill which from field evidence would appear to have been a volcanic vent.

These basalts areophitic with olivine and augite phenocrysts up to 1.5 mm in a felt of fine grained (0.15 mm) plagioclase with abundant magnetite. The St. Marys basalt has abundant interstitial glass, and the Dublintown basalt contains no olivine phenocrysts but has a higher magnetite content. Both the Dublintown and Germantown basalts contain large zeolite filled vugs.

5. Avoca. An extensive flow, confined to an ancient river valley

extends from Avoca towards Fingal for three miles, towards Royal George for six miles and down the South Esk valley to Conara, Campbelltown and Ross. This flow is west of the area mapped but is considered to have some structural significance with respect to lineaments which traverse the area. The St. Marys basalt is included for the same reason. Eight thin sections of this flow have been examined: 66-89, 90 and 91 (Ross), 92 (Campbelltown), 93 (Conara), 95 and 96 (Avoca) and 97 (Royal George). All of these were markedly similar and consisted of phenocrysts between 1 and 2 mm of olivine and/or augite in a glassy matrix with plagioclase of slightly acid composition either intergrown with augite or in ophitic relationship with it. The Campbelltown specimen (Fig.13) is slightly coarser grained than the others with 1 mm plagioclase with corroded tips.

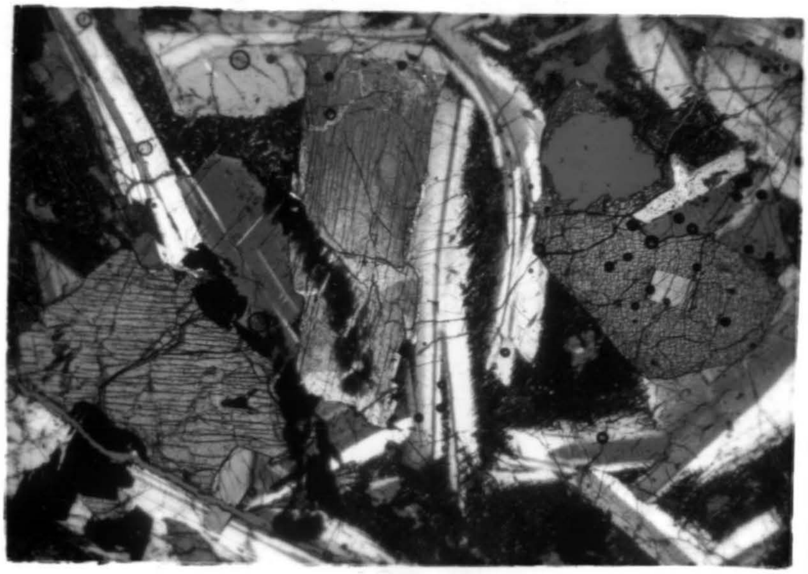


Figure 7: Coarse grained basalt from vicinity of Winnaleah (62-235) x 20, showing ophitic relationship of plagioclase and augite and bent plagioclase laths.

Figure 8: Coarse grained basalt from Warrentinna (66-101) x 20 showing 4 mm zoned augite and 1 mm olivine euhedra in a fine grained plagioclase groundmass.

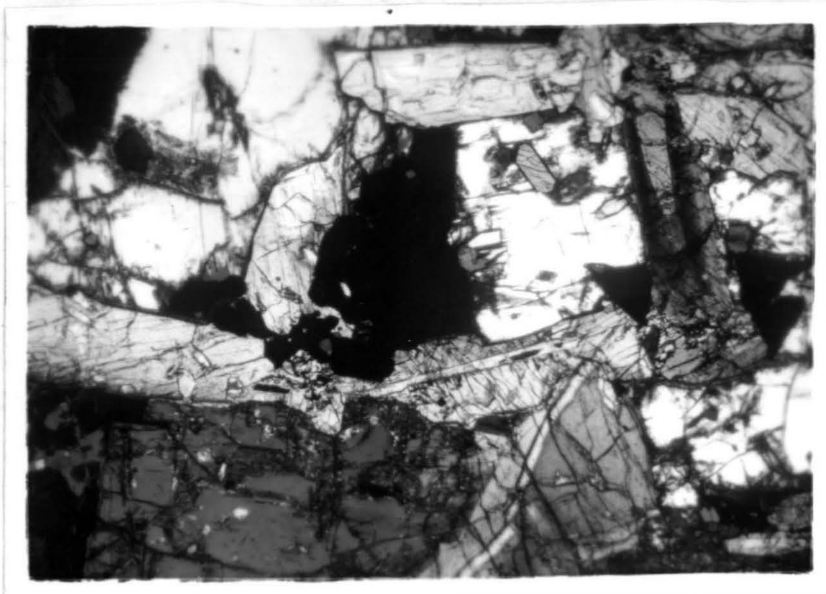


Figure 9: Coarse grained poikilitic nephelinite from Olive Rise (63-288E) x 20. a) nepheline b) augite.

Figure 10: Medium grained ophitic basalt from Sheoak Hill basaltic dyke (66-100G) x 20. a) Plagioclase laths frequently with corroded tips. b) Augite.

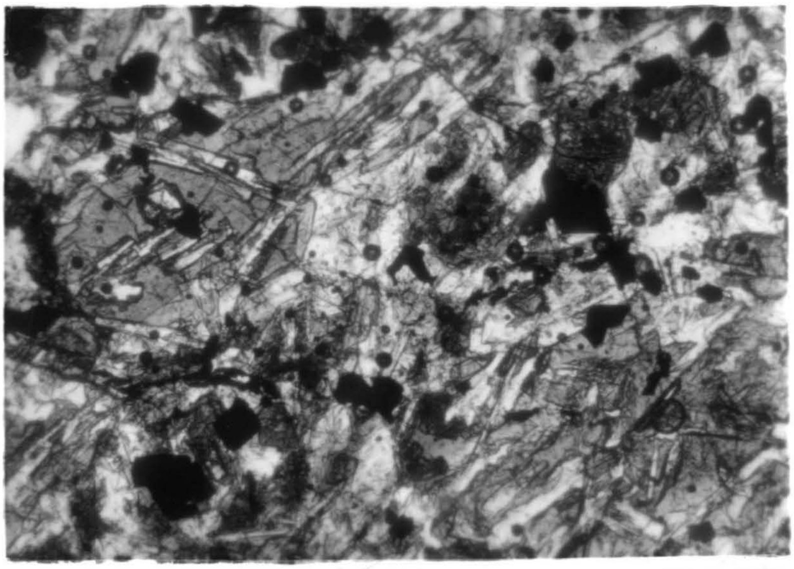


Figure 11: Basalt from Germantown (66-98) x50

Figure 12: Basalt from Dublintown (66-99) x50

Fine grained ophitic basalts with abundant magnetite and corroded plagioclase laths.

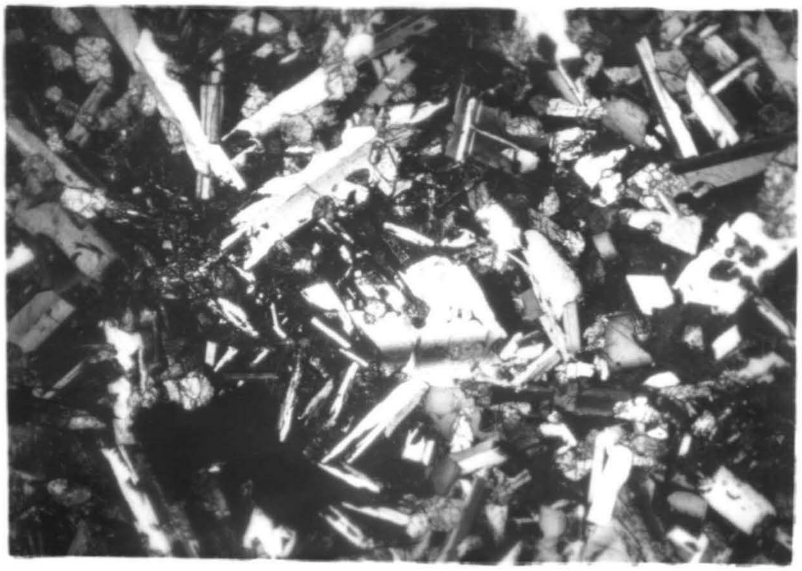


Figure 13: Medium grained ophitic basalt from Campbelltown (66-92) x 20, showing 1 mm plagioclase laths with corroded margins

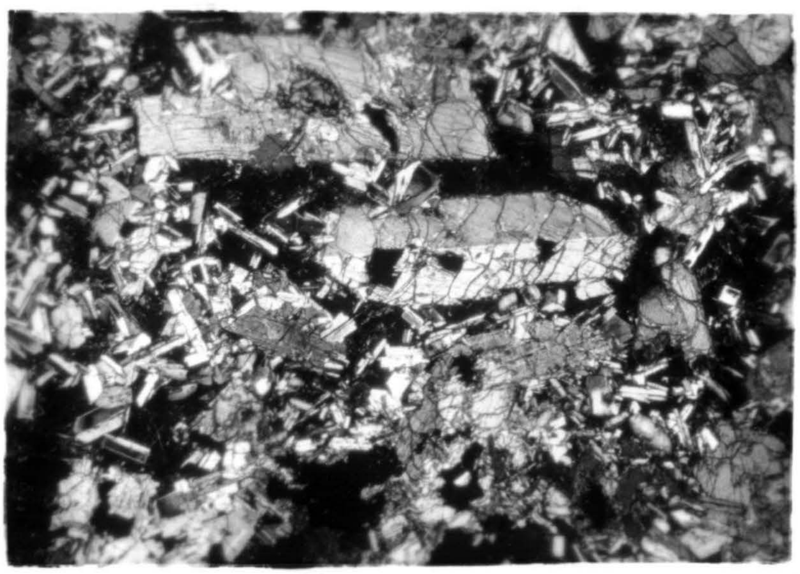


Figure 14: Ophitic dolerite from dolerite dyke on the Mathinna - Fingal Rd., showing 1½mm augite euhedra in a groundmass of plagioclase and augite and magnetite and interstitial glass. (x20)

Unusual textures occur in a number of the specimens examined. The Winnaleah (Fig.7) basalt is markedly ophitic and several of the larger felspar crystals have been bent, indicating that they also crystallised early and were disturbed by the force of crystallisation of later minerals - augite. The Warrentinna (Fig.8) and Olive Rise (Fig.9) basalts are also markedly inequigranular, the former being porphyritic and the latter poikilitic. The Campbelltown basalt plagioclase crystals are well formed but corroded at the tips and several of the fine grained specimens are ophitic (see figures 10, 11 and 12 of basalts from Sheoak Hill, Germantown and Dublintown). It is noted that corroded felspars are also common in figure 10.

Ophitic texture is caused by an inverted order of crystallisation of felspar and augite or where their relationship is subophitic or intergrown, their crystallisation is simultaneous. The textures are typical of hypabyssal rocks and by this comparison, these basaltic rocks have undergone at least partial crystallisation prior to extrusion which argues a proximity to volcanic vent. The order of crystallisation could be controlled by the composition of the basaltic magma but field relationships (see under "Structure and Igneous Activity) and the local distribution of these basalts supports the view that they occur close to their point of extrusion.

Cainozoic Sediments. Clean quartz pebble beds occur extensively from Mt. Horror to the north coast, in the Evercreech plantation (where the gravel beds lie on the pre-Permian surface) (Figure 15), and between Warrentinna and Winnaleah (where they form a prominent ridge on the south bank of the Boobyalla River lying on the pre-Permian surface and overlain in part by basalt of probably Pliocene age) (figure 16).

Figure 15a

Figure 15b.

Figure 15: Lower Tertiary quartz gravel bed on the pre-Permian surface. a) Public Works Department gravel pit. b) Boulders of recemented gravels forming a basal conglomerate.

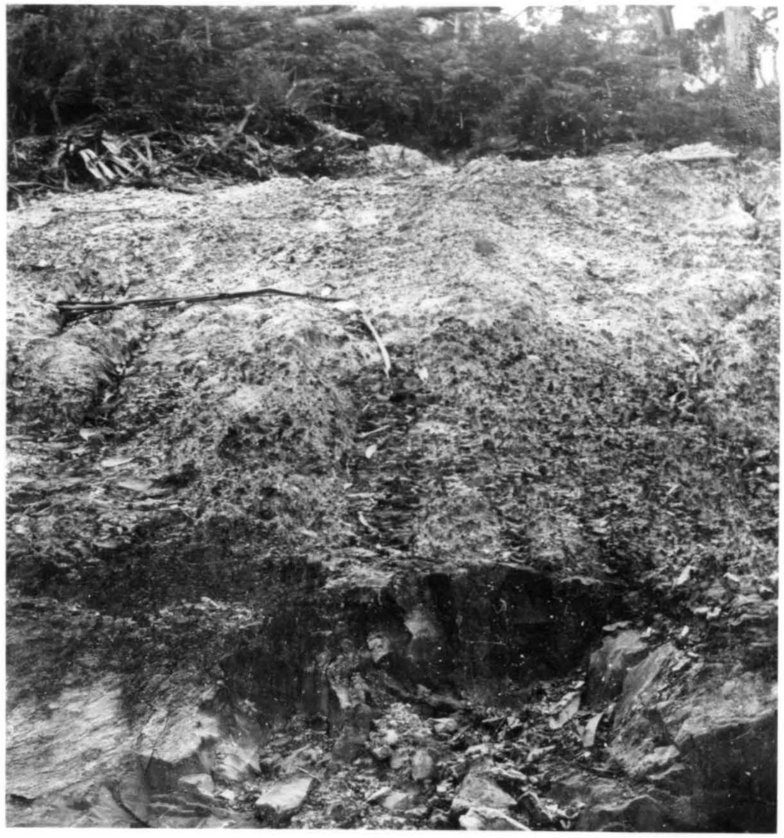


Figure 16: Lower Tertiary quartz gravels on the Warrentinna-Winnaleah Rd., showing the underlying Mathinna Beds. The gravels are here benched 5 ft. above the base but are continuous to the top of the slope in the left background which is approx. 200 ft. above the bottom of the gravel bed.

Figure 17: Upper Cainozoic (Pliocene?) river gravels overlying Mathinna Beds in road cuttings on the Esk Highway at Ormley. The gravels are immature and poorly sorted and occur approx. 100 ft. above present river level. The upper surface is an older river terrace.

These gravels are composed exclusively of rounded grains of quartz ranging in size from fine sand to boulders. There is no dolerite detritus nor a heavy mineral fraction in these beds and it is concluded therefore that they are composed solely of vein quartz derived from Mathinna Beds (and to a lesser extent Devonian granite). This material was incorporated into later Permian sediments and can be seen in the Permian basal conglomerate or littering the stripped surface where the conglomerate has been removed. It is suggested that the gravel deposits mark down-faulted portions of the old surface where abnormal thicknesses of this material could accumulate.

South Esk River. A line of boreholes was drilled across the valley of the South Esk River. The exact location of this work is not known but Thureau (1884) describes it as being approximately one mile below the junction of Mangana Creek (Tower Rivulet?) with the South Esk River. The sediments were described by Krause (1883) as:

1. Recent alluvial river sediments.

2. "Upper Pliocene terrace drifts which are extensively developed on the left side (south?) of the Esk valley between Fingal and Ormley where it crops out in terraces rising up to 50 feet above the river flat."

3. Middle Pliocene deep lead drifts. Thureau (op. cit.) quotes Selwyn of the Victorian Geological Survey as suggesting a Miocene age for sediments underlying the deep leads of Victoria.

By analogy, Krause suggested a similar age for the South Esk beds. Recent spore datings suggest that the "deep lead" deposits are at least Oligocene (Jack 1963) and may be Eocene (Gill and Banks op. cit.). The terrace deposits may be Pliocene or Pleistocene.

River gravels occur along the Esk highway road cutting at Ormley

100 feet above present river level. They are poorly sorted accumulations of Permian sediments, Mathinna Beds and Jurassic dolerite and are similar in maturity of composition to present day river gravels (figure 17). These gravels occur at the same level of the basalt which reaches upstream from Avoca to a point immediately to the west of the gravels. It is conceivable therefore that the damming of the river by basalt was responsible for the gravel accumulation, implying a Pliocene age. Elsewhere along the South Esk River and tributaries post basaltic fluviatile deposition is restricted to tens of feet thickness as at St. Marys and between Fingal and Mathinna.

Ringarooma River. Both pre basaltic and post basaltic sediments occur. The former are clean, well sorted quartz gravels, which, in the old river valley, are tin and gold bearing. The latter are terrace deposits and recent alluvium similar to those found elsewhere.

Also of post basaltic age and occupying a divide between the Boobyalla and Ringarooma Rivers are the Warrentinna - Winnaleah lower Tertiary quartz gravel beds (already discussed). These beds rest on an eroded Mathinna surface and are capped by basalt of probable Pliocene age.

STRUCTURAL GEOLOGY

Summary of Previous Literature. Twelvetrees (1904 and 1906) recognised that the Mathinna and Mt. Victoria (Alberton) goldfields formed a geological unit but made no attempt to deduce the structure apart from suggesting that the fault in the New Golden Gate mine was of pre-mineralisation age.

Hills (1923) considered that the Alberton goldfield occupied an inter-cupola trough, which he thought favourable for silver-lead-copper-gold mineralisation, the bulk of the cupola horizon, now mostly removed by erosion, being favourable for tin mineralisation. The structure within this cupola trough consisted of folded Mathinna rocks, the Dorset River occupying a syncline and the Alberton goldfield to the east of the Dorset River occupying an anticline. This folding, he concluded, was the outcome of thrust faulting which was observed a few miles to the southwest in cliffs terminating Cotton Plain at the headwaters of Dorset River and New River. He envisaged a stable, unfaulted, east block with a mobile west block riding eastwards over it and becoming crumpled in the process. The thrust fault or faults (for there are two parallel ones 50 - 100 feet apart) dip at a low angle (about 45°) to the west, and would lie about 1,000 feet below the surface of the Alberton goldfield. They acted as ore channels and favourable loci for reefs which were formed as conjugate shear planes in the axial zone of the anticline. The fold axes had a strike between 330° and 345° and the conjugate shears were on lines NE-SW and NW-SE. He considered that the majority of lodes in the Alberton goldfield were of the fault fissure type on the evidence of veins with well defined smooth straight walls which were sometimes striated and polished. Other types of lode on the goldfield were saddle reefs, simple joint infillings and veins without smooth walls and of irregular width and orientation (probably tension gash veins).

Nye and Blake (1938) agreed with Hills' interpretation of the Alberton goldfield but referred to a second set of folds striking NE-SW initiated by a second lateral compression in the NW-SE direction.

Finucane (1935) did not attempt to interpret the regional structure. He stated that "the most obvious structural feature of the Mathinna slates and quartzites is a pronounced schistosity or slaty cleavage. The strike of the schist or cleavage planes varies from N 10°W to N 40°W and the dip is generally to the west or south-west at angles ranging from 45° to 80°, though the steeper angles are the most common." According to Finucane the cleavage frequently masked the bedding, particularly in the mineralised area, because the zone in which the cleavage is prominent really represents a zone of dynamic metamorphism. Bedding strikes were given as N 10°W to N 50°W, an average being N 30°W. A zone of close folding was traced for a distance of 1.5 miles in a SW direction from the New Golden Gate mine and eight anticlines were mapped over a twenty chain width. The conclusion reached was that mineralisation in the Mathinna goldfield was concentrated in a zone of close folding: this zone corresponds to maximum development of slate and maximum development of cleavage in slate but "with a few exceptions there was no close relationship between the rock structures as indicated by the bedding and that of the reefs." He suggested that the zone of folding became a single fold to the south of the goldfield as he was only able to find one fold in the bed of Cox's Creek which crossed the southerly extension of this zone of close folding. His map indicates a single anticline of similar strike to the zone of close folding and half-a-mile to the west of it.

Nye and Blake (op. cit.) stated that in the Mathinna and Alberton goldfields there is no relationship between reefs and rock structures but that the most important reefs occur in a narrow zone of close folding. The "main slide", a fault which terminates the southerly extension of the big reefs worked in the New Golden Gate mine, is pre-mineralisation and regarded by them as being the main ore channel.

Blake (1939). In the Mangana goldfield the general strike of the beds was north-north-west to north-west. West of Mangana the dips were westerly at steep angles 65°- 80°, while on the east of Mangana dips were both to the east and west at high angles 80° - 85°. No definite folding was observed but it was inferred that there was a zone of close folding with axes along the general strike of the beds. All reefs in the goldfield had a similar trend.

Hughes (op. cit. 1947) interpreted the Dan Rivulet goldfield structure as consisting of a northerly plunging anticline with a strike of 320° to 335° occupying a more or less central position in the goldfield, with a conjugate set of shears striking N - S and E - W. The presumed stress direction was NE - SW and the mineralised zone was considered to lie on the western limb of the anticline.

Hughes (1952) interpreted the Alberton goldfield similarly but here considered that there was a subsequent compressive stress in the N - S direction causing a new set of shears to develop on a NE and NW strike. He considered that most of mineralised quartz veins occurred in the areas of most intense super imposed folding.

Carey (1953) gave an account of the tectonic history of the State in which Taberraberran (late Devonian) structures are arranged symmetrically about a stable block which he called the Tyennan Uplift block (later renamed the Tyennan geanticline) (Geology of Tasmania p.314). In the northeast there are three anticlinoria called the Scottsdale, Ringarooma and Furneaux: they are associated with granite and are the tin mineralisation zones. Between these anticlinoria lie belts of Mathinna rocks with gold-quartz mineralisation: (1) Lefroy, Back Creek, Golconda and Lisle goldfields, (2) Fingal, Mangana, Mathinna, Dan Rivulet, Alberton, Warrentinna, Forester and Lyndhurst goldfields, and (3) Gladstone district (cf. Cupolas and intercupolar troughs of Hills 1923).

Blissett (1959) found that in the Rossarden-Storeys Creek district west of the southern part of the goldfields the quartzites and slates dip constantly southwestwards at angles over 45° and "cleavages indicate that axial planes generally strike between 330° and 350° and dip at steep angles towards the southwest." His conclusion was that the main structure was a complex faulted anticlinorium plunging southeastward and with subsidiary minor folds.

McNeill (1965) stated that wavelengths of folding are in the range 10-100 feet for the Mt. Elephant area and Lyons (1957) gave a range of 50 - 200 feet for the Aberfoyle area. These folds were considered to be minor plications on the limbs of larger folds with wavelengths of 7 to 8,000 feet and similar trend.

Solomon (1962) summarised previous work and stated that the absence of marker beds in the succession makes it difficult to determine heights and widths of the major folds. Previous workers have shown that although the granite masses of the northeast are roughly concordant with the Taberraberran fold trends, even detailed work in the Mathinna Beds has failed to locate the hinges of the major folds and consequently the structural position of the granite is not known.

Definitions of terms.

Slaty Cleavage: A foliation which is independent of bedding and dependent on the parallel arrangement of mineral constituents (Leith 1913 p.76).

Fracture Cleavage: a foliation independent of bedding and or mineral arrangement (Mead 1940 pp 1009 - 1010).

Strain Slip Cleavage: a structure in which cleavage planes are separated by thin slices of rock containing a crenulated cross lamination (Rickard 1961).

The Development of Cleavage. Fracture cleavage is a consequence of shear which has been considered to result from i) interlayer slip incidental to folding (Leith 1913 pp.23-25 and 62) Figure 18a.

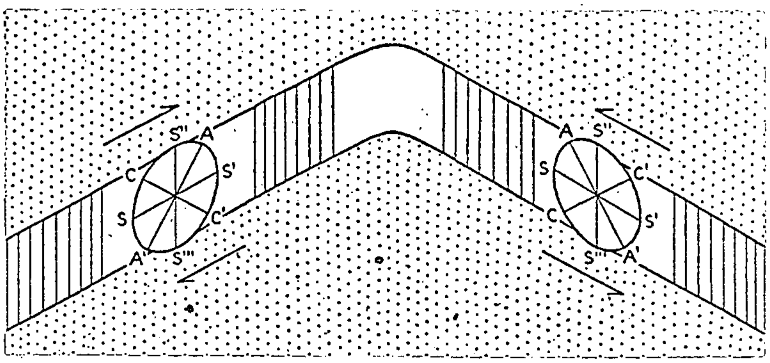


Figure 18a
(from Billings 1942)

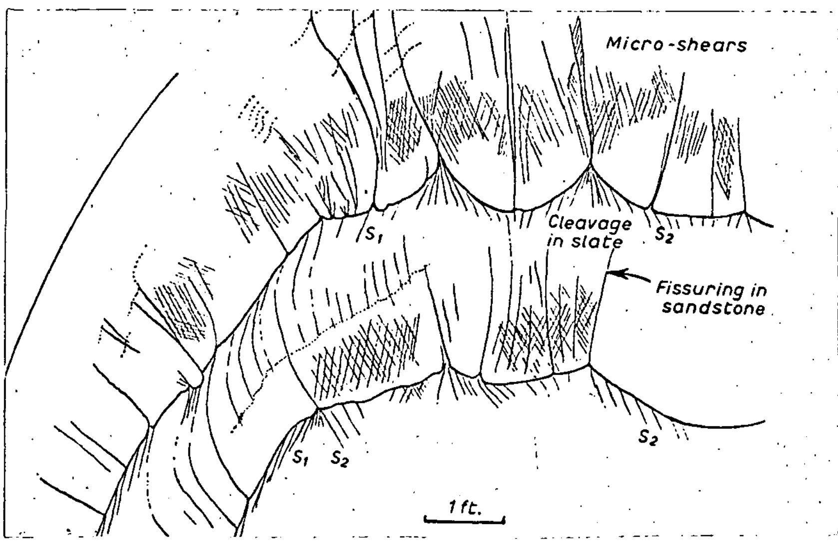


Figure 18b
(from Hills 1963)

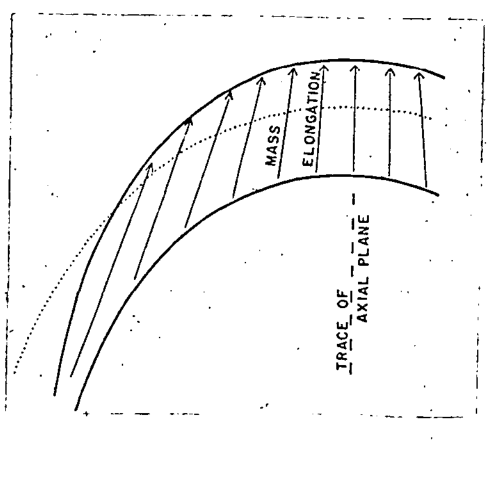


Figure 18c
(from Williams 1961)

ii) Primary stresses initiating the folding and developing conjugate shear planes (Hills 1963 P.292) Figure 18b.

iii) Differential movements involved in laminar type flow (Williams 1961) Figure 18c.

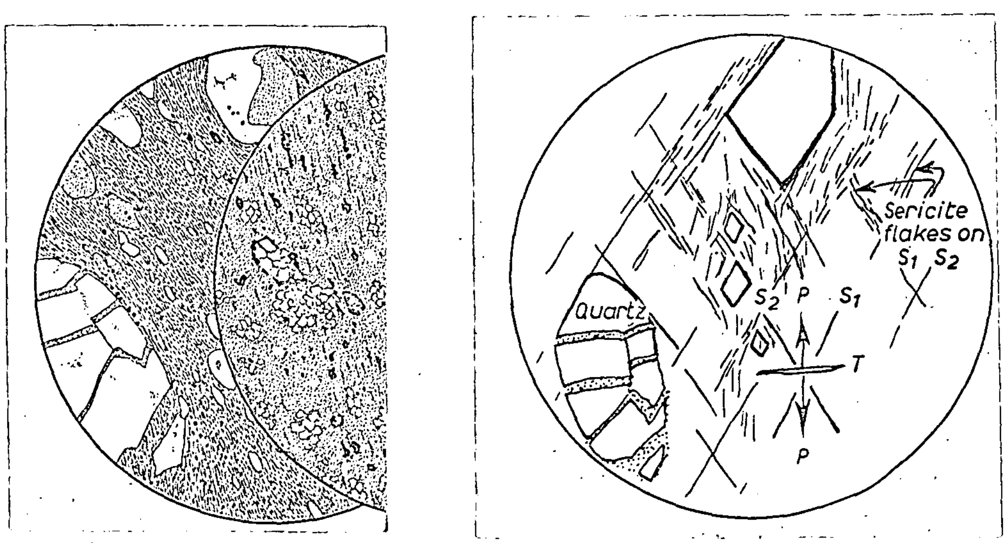
In sequences of interbedded competent and incompetent strata, it has been shown (by Williams 1961) that bedding plane slip is in the opposite sense to that required to produce fracture cleavage. He states that fracture cleavage forms parallel to mass elongation and is therefore due to laminar type flow.

Slaty cleavage can arise from fracture cleavage (De Sitter 1956 p.98 and Hills 1963 Pp.287-8). Williams (1961) has suggested that if the differential movements between laminae takes place at a rate that will allow internal re-arrangements, slaty cleavage will develop.

The complementary shear planes figure 18b which are developed as a consequence of lateral compression are considered by many to be fracture cleavage planes. Hills (1963 p.292 figure x - 5, in part reproduced here as figure 19b) shows a fold in which slaty cleavage has developed in slate from shear planes and in the interbedded sandstone layers, intersecting shear planes (micro shears) and a coarse cleavage or fissuring which he considered to represent zones of excessive shearing and flattening. Hills suggests that the convergence of slaty cleavage upwards and sandstone fissuring down (in anticlines) is due to rotation of the fold limbs - the former by a pack of cards shear movement and the latter by rotation along with the beds.

His interpretation is, in some cases, in doubt. In figure 19, an illustration of Harker (1952) is compared with Hills' (1963) interpretation of this figure. It is considered that the curvature of the cleavage trace may only be the deflection of cleavage around sand grains and not the consequence of conjugate shear.

Hills (1965 pp 120-121 & 299) suggested that the dilatation caused by overriding of grains which occurs during the deformation of a close packed aggregate, is a contribubary effect in the development of cleavage. This effect, (i), together with (ii) dilatation due to shearing within constraining beds (Hills p299 figure x - 15), and (iii) the breaking of atomic bonds (during shearing) are considered to be offset by a reduction in volume caused by a reduction of voids during compaction and loss of combined water during recrystallisation, so maintaining constant volume.



a. b.

Figure 19

The over-riding of grains occurs in conjugate shear zones which are symmetrically disposed about the compressive stress (Hills 1963 p.121 figure V - 17) but Williams (1965) suggests that the dilatation results from over-riding of grains during flexure. The effect is envisaged as a consequence of bedding plane slip and zones of open packing are formed at right angles to the bedding (figure 20).

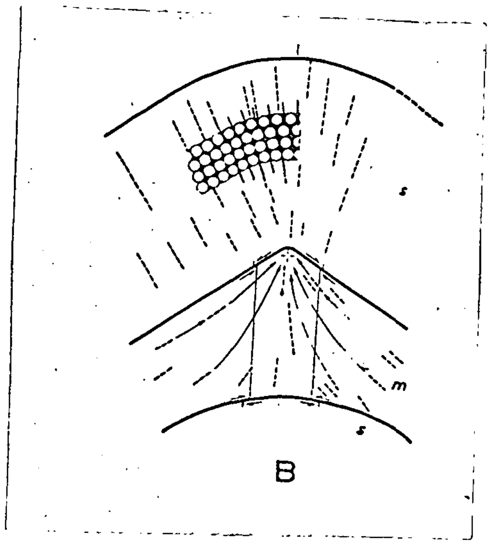


Figure 20

A reversion to loose packing is prevented by filling of the voids by granulation of the quartz grains during over-riding. This allows over-riding without accompanying dilatation so that the aggregate remains as a rigid framework. Continued folding results in the breakdown of the continuous framework and allows deformation to continue by the incompetent phenomenon of flattening. The cleavage trend is established by the over-riding mechanism and further adjustments due to continued shearing are confined to the finer interstitial material as in the deformation of mudstones.

It is not known whether zones of open packing are a major contributory factor in the development of cleavage nor whether they are caused by conjugate shear or bedding plane slip but the former appears the more likely of the two to produce continuous surfaces.

Slaty Cleavage. The development of slaty cleavage with or without the prior formation of fracture cleavage is dependent on the parallel arrangement of mineral constituents. It is generally agreed that recrystallisation is essential in the development of slaty cleavage but cataclastic metamorphism is an important preliminary process during which grains are granulated, sliced and rotated.

Cataclasis and recrystallisation are evidenced in practically all rock types of the Mathinna Beds. The lutite members are composed of recrystallised argillaceous material, in which a well defined slaty cleavage has been developed, and a small percentage (10%) of clastic silt grains which remain more or less unaltered.

In the following tables, numbers 1, 2 and 3 refer to the sandstones defined and described under "Mathinna Beds".

1. Quartz sandstone.
2. Normal greywacke.
3. Argillaceous greywacke.

It is emphasised that these three rock types differ only in percentage of sand grains and in argillaceous content. They are all greywackes and it is not intended to imply any differences in depositional environment. The differences are, however, considered to be of significance from considerations of cleavage development.

Tables 4 and 5 show interbedded lutites, slate and phyllite respectively, whilst table 6 shows phyllites from the lower (lutite) association.

Table 1

Thin Section	Locality	Sand grains Av. Size mm.	Sand grains % of Whole mm.	Remarks	Rock Type
63-181b	Esk Highway Tulloch-gorum	0.3	50	Essentially sand grains in a quartzose matrix of quartz of silt size. A low micaceous content of groundmass. Quartz grains exhibit very weak dimensional orientation and marginal corrosion.	
63-183	Dilgers Rd. Dan Rivulet	0.3	95	A close packed aggregate of sliced and sigmoidal quartz grains. The interstitial material content is low and consists of orientated wisps of sericite. (Figure 21)	
64-399	Tyne River Mathinna	0.2	95	A close packed aggregate of interlocking quartz grains having a granoblastic texture due to recrystallisation. (Figure 22)	
65-9	Golden Hinges Adit	0.5	100	Coarse grain due to recrystallisation and grain growth. Strong strain shadows and shattering of grains due to post recrystallisation deformation. (Figure 23)	

Table 2

63-179a	Abbotsford Creek Mine	0.2	50	The interstitial material is predominantly quartz of silt size. The argillaceous content consists of widely spaced anastomosing wisps of secondary micas delineating the cleavage and abundant clastic mica delineating the bedding.

Thin Section	Locality	Sand grains Av. Size mm.	% of Whole mm.	Remarks
63-180a	Road cutting, Mathinna area	0.15	50	Similar to 63-179a but with very weak dimensional orientation of quartz grains.
63-182		0.3	50	Sliced and orientated quartz grains indicating cataclasis and rotation. Occasional clastic acid plagioclase crystals (av. 15° on albite twins) (Figure 24).
63-187	New Golden King Mine Dan Rivulet	.1 to .6	20	Predominantly interfingering lenses of chlorite and sericite - silt aggregates with few quartz grains. Quartz grains are mostly unstrained and intergrown with the argillaceous material indicating re-crystallisation. Numerous small pyrite crystals occur throughout the slide. Most of the larger quartz crystals become detached from the soft matrix during thin section preparation. (Figure 25)
63-189a	Miami adit	0.4	70	Quartz grains with corroded margins in a groundmass of silt grains with subordinate mica. Very little preferred orientation in micas and slight dimensional orientation of large grains. The composition is tending towards that of orthoquartzite.
63-193	Dilgers Rd cutting	0.4	60	Sliced quartz grains in a predominantly argillaceous matrix of secondary micas forming an anastomosing pattern about the larger grains. Numerous granular quartz aggregates orientated parallel to cleavage. The composition tends towards that of a gritty slate.

Thin Section	Locality	Sand grains Av. Size mm.	% of Whole mm.	Remarks
65-7	BH2-487ft. Golden Gate Mathinna	0.2	50	Sliced quartz grains which are intergrown with secondary micas at their tips. A strong cleavage trace outlined by anastomosing wisps of mica. Quartz grains are shattered by shearing - due to proximity to "Main Slide". (Figure 26)
Table 3				
63-179c	Abbotsford Creek Mine adit	0.3	30	Sand grains are characteristically sigmoidal due to slicing of tips and attenuation in the cleavage plane. Lenses of quartz aggregates. Tips of grains intergrown with secondary micas. Abundant aggregates of quartz granules. High matrix content and high argillaceous content of matrix. (Figure 27)
63-185 and 186	Bowl Creek Mathinna	0.2	30	Numerous clastic mica and felspar grains. Quartz grains are strongly sliced and attenuated in plane of cleavage, frequently with length/width - 30. (Figure 28)
Table 4				
63179b	Abbotsford Creek Mine Adit			Abundant grains of quartz of silt grade and clastic plates of mica in a groundmass of recrystallised orientated mica with well defined slaty cleavage. The clastic grains constitute 5% of the rock. 63-190 is highly chloritised.
63-184	Dilgers Road cutting			
63-190	New Golden King adit			
63-194	Carnegie adit Dan Rivulet.			
63-196	-do-			

Table 5

Thin Section	Locality	Remarks
63-181a	Road cutting Tullochgorum	No clastic material present in lutite. The shear folded quartz band is probably a silt bed which has been recrystallised. The interface is diffused due to shearing.
63-189b	Miami adit near Fingal.	Similar with orientated limonite (after pyrite) and en echelon arrangement of segregation bands which probably represents incipient strain slip cleavage. (Figures 29 and 30).

Table 6

65-183 65-185 65-191 65-192	Cox's Creek Rd. BH No.3 Golden Gate area. False Creek. Tower Hill Rd.	Mudstone metamorphosed to phyllite with interbedded siltstone layers 1-2 cm. thick. Mudstone bands are completely recrystallised with strong slaty cleavage. Siltstone layers contain numerous clastic mud plates parallel to bedding, there is little or no recrystallisation of mica nor dimensional orientation of quartz silt grains. This is most typical of the lutite association and is similar to that illustrated by Hills (1963 fig. X - 1)
65-184 65-185	Cox's Creek Rd. BH No.3 Golden Gate area (see above).	Kink bands in phyllite - bedding is not discernable and limbs of fold extinguish separately due to post crystalline deformation. In 65-185 en echelon gash veins cut across the kink fold and represent a later deformation.

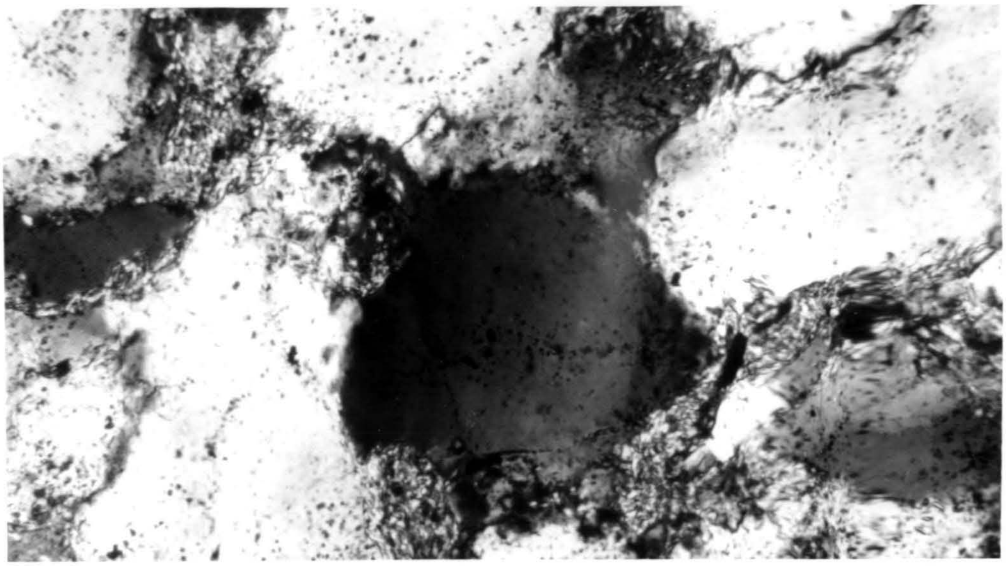


Figure 21: A close packed quartz sandstone containing little interstitial material. Faint dimensional orientation of grains and a sigmoidal grain in right upper corner indicate cleavage. Strain extinction is evident (63-183) x 50.

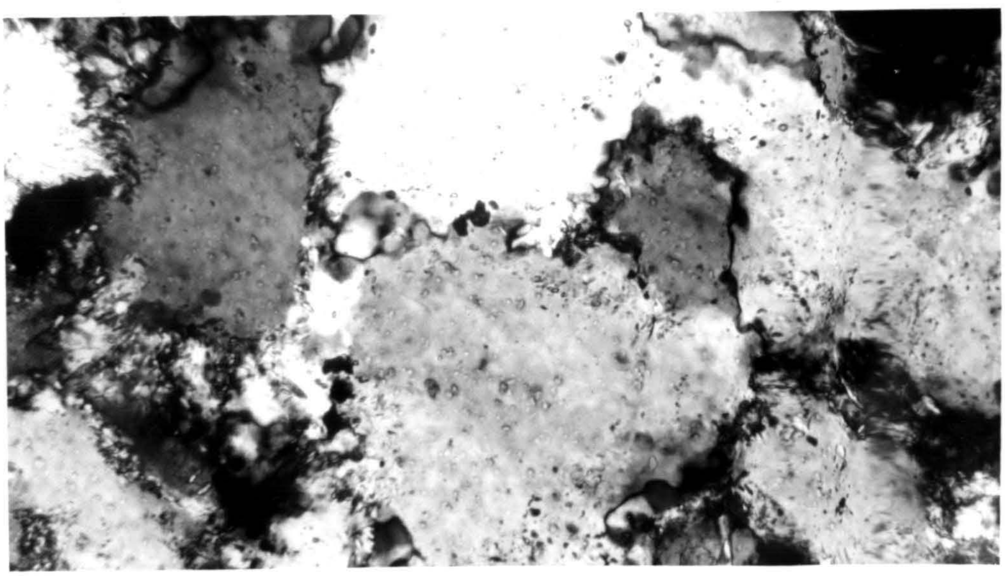


Figure 22: A close packed quartz sandstone in which all detrital grain shapes and cataclastic effects have been destroyed by recrystallisation (64-399) x 50.

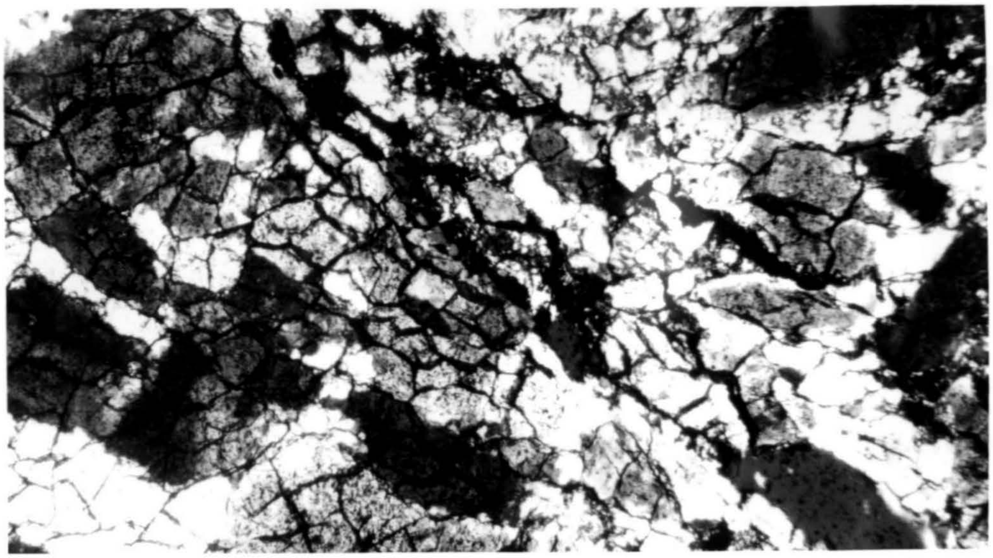


Figure 23: A quartz sandstone which has undergone recrystallisation and subsequent shearing which has caused shattering and strain shadows in the quartz. (65-9) x 50.

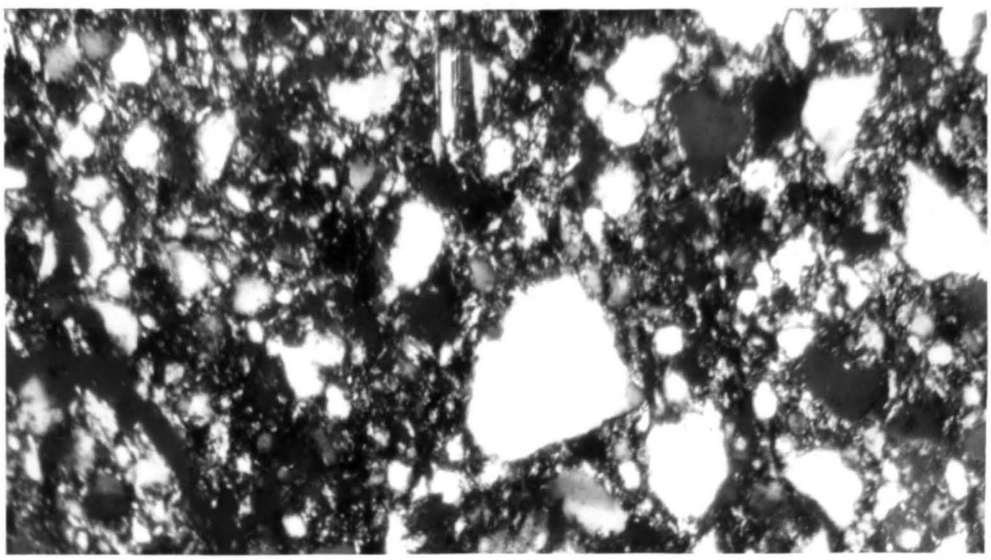
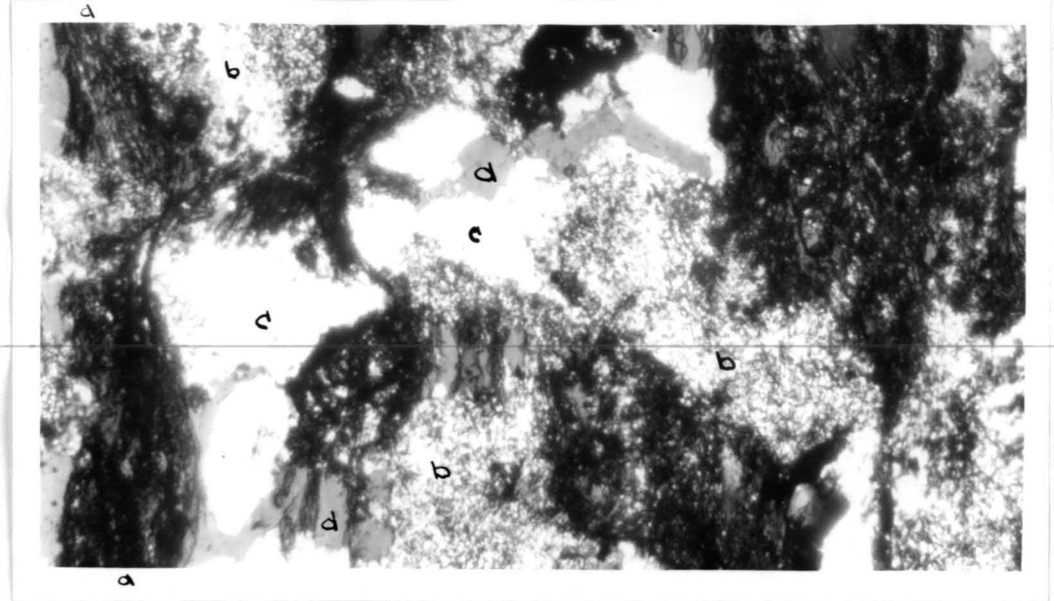
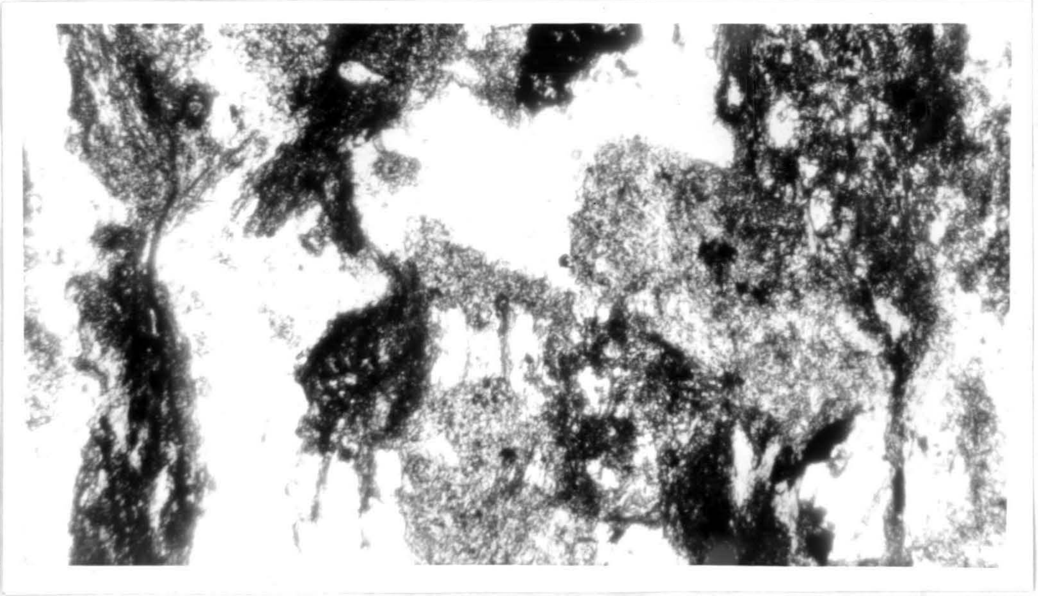


Figure 24: A normal greywacke consisting of clastic quartz and felspar of fine sand grade in a quartz-sericite matrix - a weak dimensional orientation is present indicating the cleavage plane. (63-182) x 50.

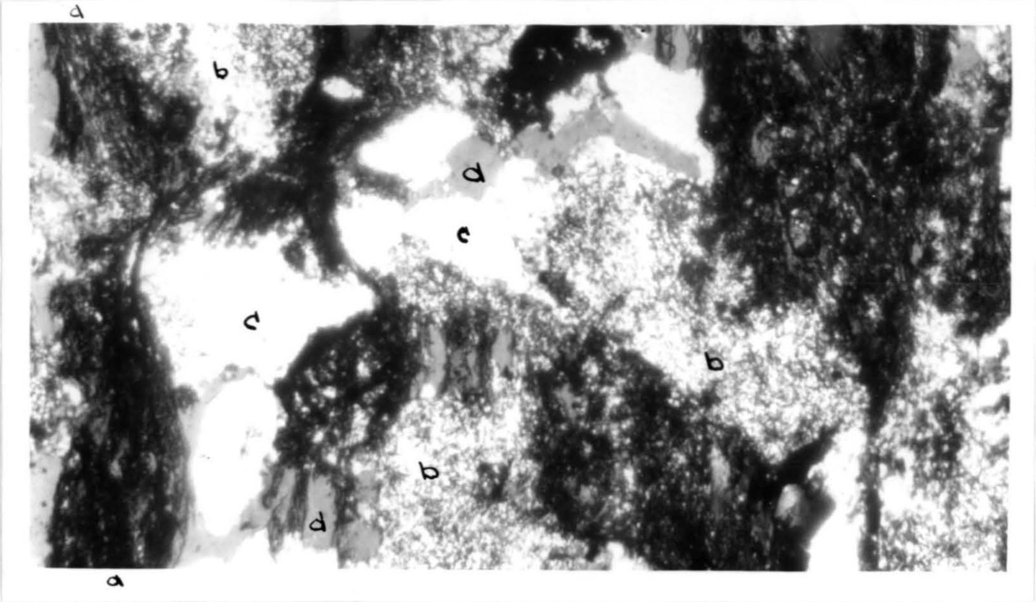


(Crossed nicols)

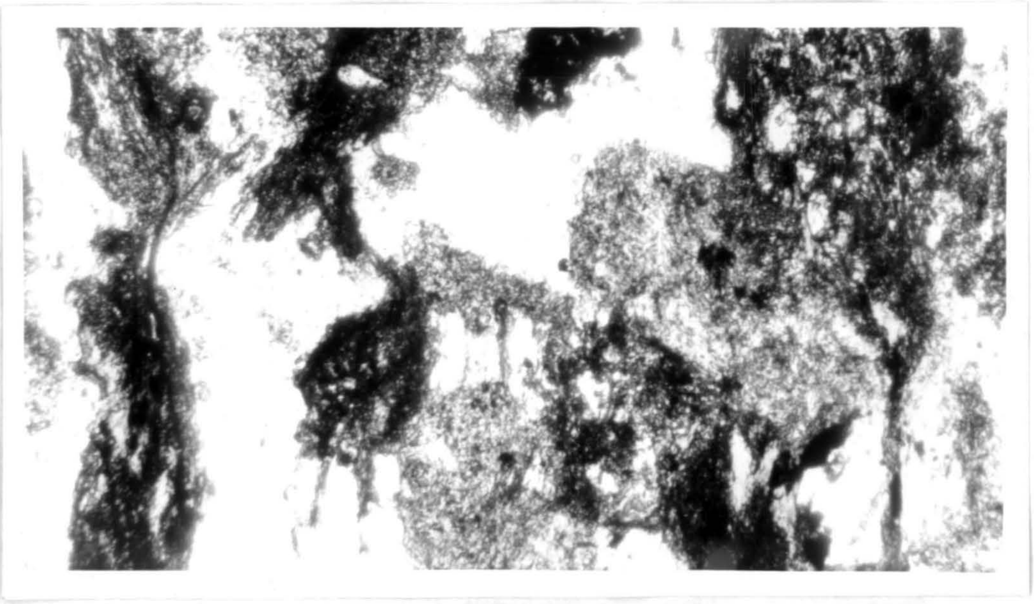


(Ordinary light)

Figure 25: Sheared greywacke containing: a) wisps of chlorite (after secondary mica) delineating the cleavage. b) quartz-sericite aggregates, and c) recrystallised quartz grains - note grain shape and absence of strain shadows. d) spaces indicating plucking of quartz grains from the soft matrix during slide preparation (63-187) x 50.



(Crossed nicols)



(Ordinary light)

Figure 25: Sheared greywacke containing: a) wisps of chlorite (after secondary mica) delineating the cleavage. b) quartz-sericite aggregates, and c) recrystallised quartz grains - note grain shape and absence of strain shadows. d) spaces indicating plucking of quartz grains from the soft matrix during slide preparation (63-187) x 50.

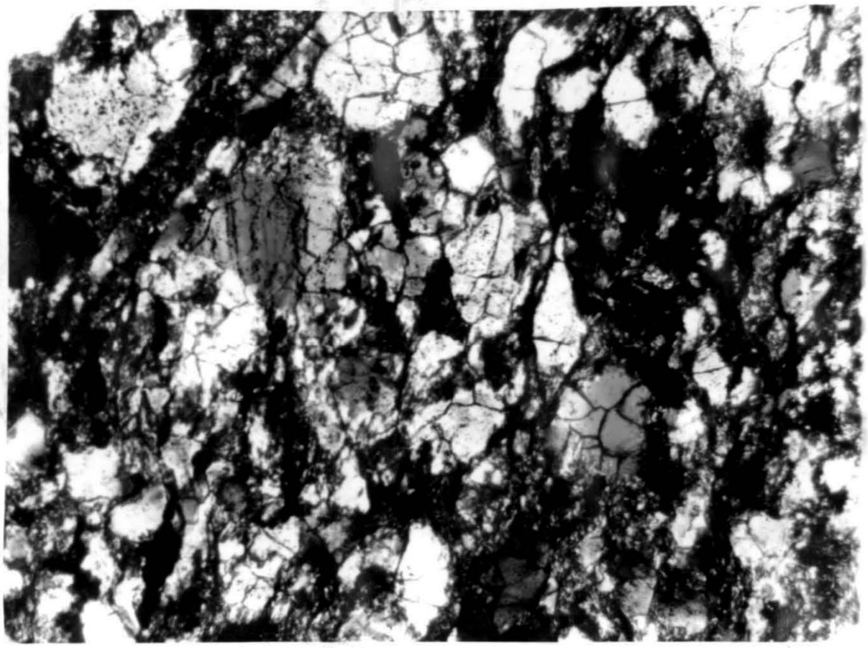


Figure 26: Normal greywacke containing sliced quartz grains and anastomosing wisps of mica. The shattering of grains is due to subsequent shearing (65-7) x 50.

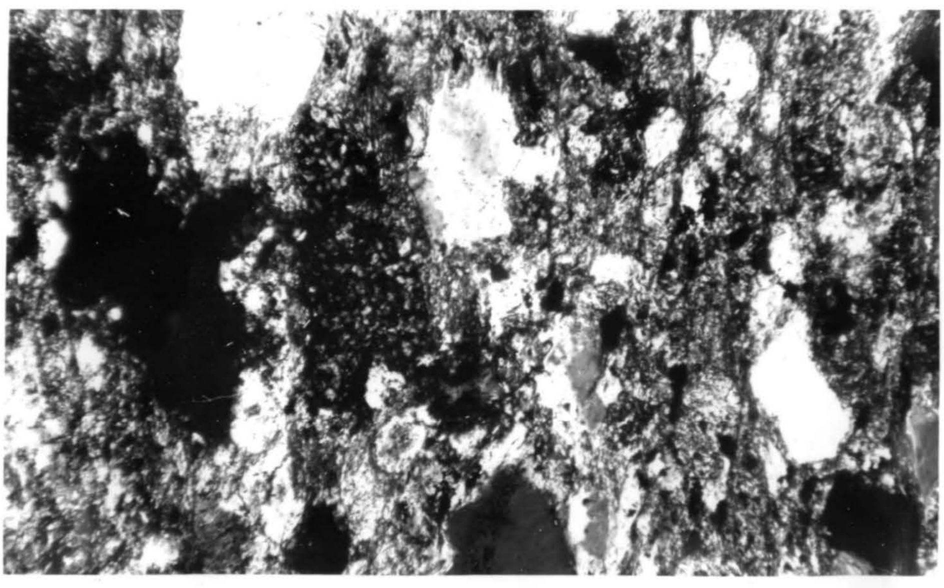


Figure 27a: Argillaceous greywacke containing sliced and rotated quartz grains, quartz aggregates and a quartz-sericite groundmass (63-179c) x 50.

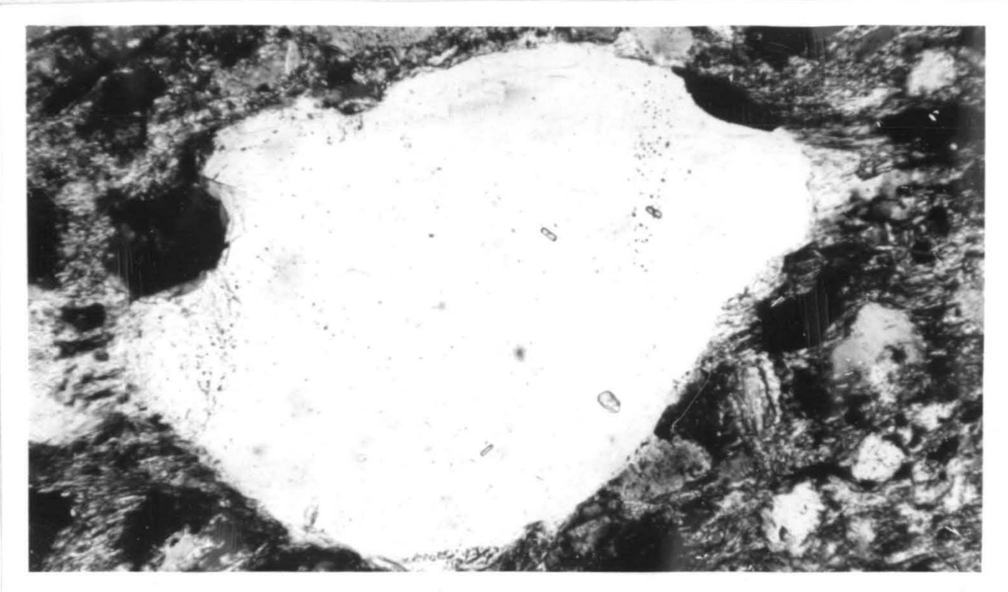


Figure 27b: Single lenticular quartz grains, slightly sigmoidal due to grain rotation. Note silt grains in argillaceous matrix and intergrowth of secondary mica with quartz grain terminations (63-179c) x 150.

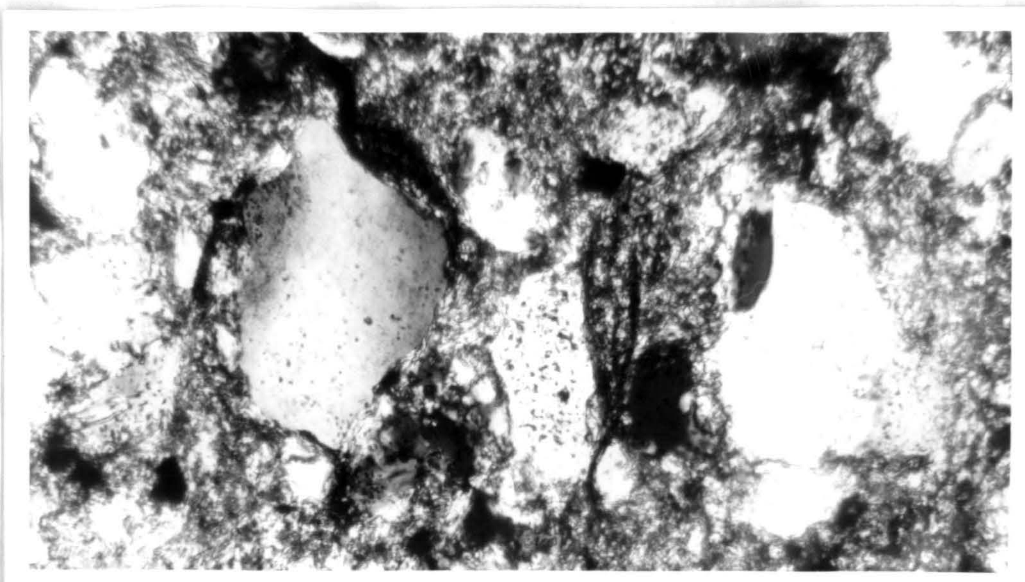


Figure 28: Argillaceous greywacke of similar composition and metamorphic grade to Figure 27 (63-186) x 50.

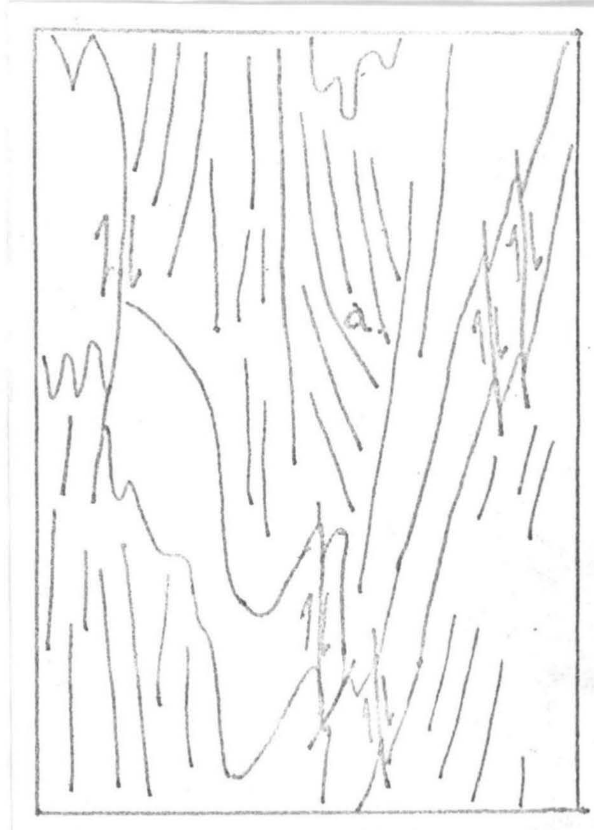
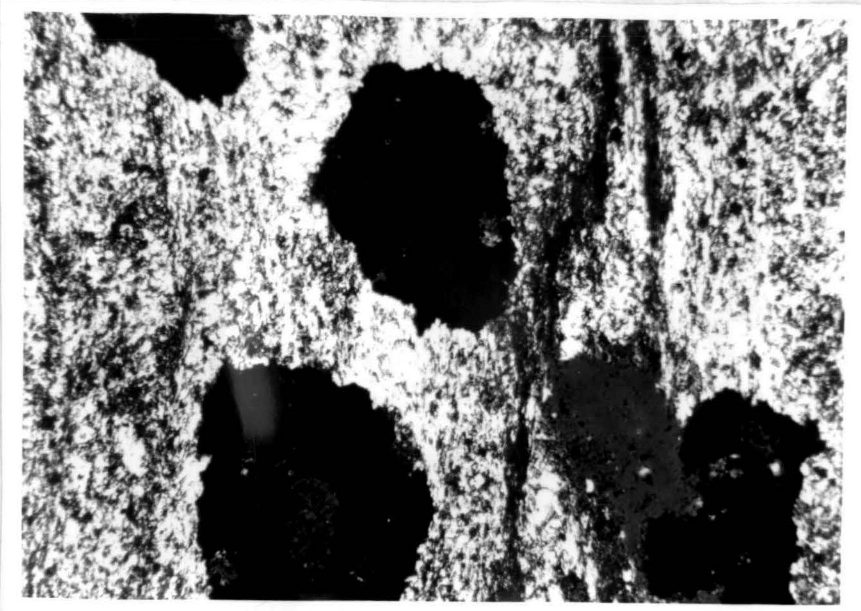


Figure 29: Shear folded siltstone band in phyllite with bands of more intense shearing (gleit bretter) on some cleavage planes. The planes have produced a strain slip cleavage effect as at (a) (63-181a) x 100.



a (x 100)

b (x 150)

Figure 30: Limonite pseudomorphs after pyrite in slate. The Limonite inclusions are orientated parallel to the individual layers in the segregation bands. The en echelon effect in these bands is a form of strain slip cleavage - see b. for detail. Slaty cleavage is parallel to the long axis of the bands (63-189b).

In regard to the development of cleavage, the type 1 sandstone (see p17) which contains little or no argillaceous matrix is virtually uncleaved. Occasionally a dimensional orientation may be discernible as in fig.21, while elsewhere even this faint cleavage development has been destroyed by recrystallisation of the constituent grains to produce a granoblastic texture as in figs.22 and 23. In fig.23 the shattering of new grains and strain extinction are considered to be due to post recrystallisation deformation consequent on movement along the "Main Slide". In the second type of sandstone, i.e. normal greywacke, the individual grains are separated by films of argillaceous material, the sandstone behaves competently and cataclastic effects are evident in all specimens of this type. Incipient recrystallisation has resulted in corroded margins of quartz grains and peripheral granulation has resulted in the formation of lenticular grain shapes with tails of granules in the cleavage trace. The argillaceous material forms anastomosing wisps of secondary mica to form a weak slaty cleavage. In type 3 sandstones the argillaceous content is high and individual quartz grains are not in mutual contact. This type of sandstone behaves incompetently and cataclastic effects are minimal. Slaty cleavage is well developed, modified only by the size of the sand grains.

Lenticular and sigmoidal grain shapes are formed in all of these sandstone types, indicating that cataclasis is never entirely absent. Individual grains become rotated into alignment with the cleavage surface or remain oblique to it. Relative slip on cleavage planes produces lenses or sigmoidal shapes respectively by granulation and attenuation of grains. An enlargement of a single grain (fig.27b) illustrates this and shows that the grain tips are intergrown with sericite which may be due to replacement of some of the granulated grain boundary by secondary mica.

It is concluded that cleavage in greywackes is developed firstly as a result of cataclastic metamorphism and secondly as a result of recrystallisation to produce a slaty cleavage and the degree to which this is developed is dependent on the argillaceous content of the sediment and the grain size of the quartz grains which determines the distance apart of the cleavage planes.

Cleavage which develops in slates and phyllites has a similar origin and the finer anastomosing pattern of cleavage (figure 29) emphasises the fineness of the clastic particles present.

Williams considers that structural continuity in sandstones is maintained even after the breakdown of the continuous sedimentary contacts between grains, but in the experience of the writer, cleavage is best developed in the type 3 sandstone and hardly at all in type 1 sandstones in which grain contact still exists. Therefore it is felt that cleavage is not characteristically developed in close packed granular aggregates.

The rocks figured have been taken from areas where mesoscopic folding is absent and so are affected by regional folding and cleavage development only. In this regard, they may be expected to differ in degree of cleavage development from the rocks studied by Williams which were in the cores of mesoscopic folds.

<u>Factors affecting Fold Style in general</u>. Variations in fold style reflect a delicate balance between physical conditions and the rheologic properties of different materials in a heterogeneously layered body. These rheologic properties (elastic, plastic and viscous) govern the degree of competence of a material and so determine whether parallel or similar folding will occur in a given stress system. (Turner and Weiss 1963 p.472).

When the elastic factor is subordinate, a material under stress will behave like a plastic fluid (Carey 1954). This type of deformation probably accounts for the movement of interbedded incompetent material during folding (Hills 1940 and Williams 1961).

Parallel and similar folds are theoretical end members of a range of fold styles. In practical examples there is not always a clear distinction between them and most folds are due to shortening by both flexure and flattening.

Fold Trends. The major fold structure in the area mapped has a wave-length of approximately two miles. This deduction is based on evidence presented in the geological map (figure 57). Folds on several smaller scales also occur and these are presumed to be minor plications on the limbs of the larger folds.

The trend of folding is given on stereograms of bedding, cleavage and jointing (figures 31 and 32). Measurements of bedding were recorded in the arenite-lutite association, and measurements of slaty cleavage were measured in both associations but principally in the lutite beds of the arenite-lutite association.

There are inconsistencies in comparing the bedding and cleavage diagram (figures 31a and b and 32a) where the strike of the modal cleavage is inclined at 11^{o} to that of the axial plane of the folds. This has been further illustrated by plotting the data for smaller area, viz.:

32 b. South of Mathinna.

32 c. West of Dan Rivulet.

32 d. East of Dan Rivulet.

32 e. Alberton goldfield area.

The Warrentinna - Forester area was not analysed in this way as the Mathinna Beds are more poorly exposed there.

Figures 31 & 32 Equal area (1%) contour diagrams of spatial data.

Fig. 31 a. Poles to 651 bedding planes (Fingal to Alberton)
b. " " 737 cleavage planes (" " ")
c. " " 530 joint planes (" " ")
d. " " 140 bedding planes (Warrentinna - Forester)
e. " " 328 bedding - cleavage lineations (Fingal - Alberton)
f. " " 192 Gold - Quartz lodes (all goldfields)

Fig. 32 a. " " bedding, cleavage and joint planes (Fingal to ")
b. " " " " " " " (Fingal to Mathinna)
c. " " " " " " " Dan Rivulet area (E.)
d. " " " " " " " " " " (W.)
e. " " " " " " " Alberton area

Fig. 32a comprises figure 31 a, b & c.
Fig. 32b, c, d, e, represent individual areas within the area of figure 32a, thus:

b. southern section.
c. middle section east of Dan Rivulet.
d. " " west " " "
e. northern section.

The legend for all diagrams is given on p.59.

In figure 32 girdles embracing maxima of bedding plane poles are indicated by solid lines and those suggested by the symmetry of the figures are indicated by broken lines.

Planes denoted AA embrace joint plane maxima; BB is perpendicular to AA and represents the joint strike.

There is a double symmetry in the bedding plane plots and reflected in a spread of joint and cleavage directions which suggests either a shift in the direction of applied stress during folding or the influence of wrench faulting. A double symmetry is also apparent in the plot of bedding plane - cleavage lineation. The joint plane maxima appear to represent AC planes of the folding but in general are slightly inclined to the theoretical position.

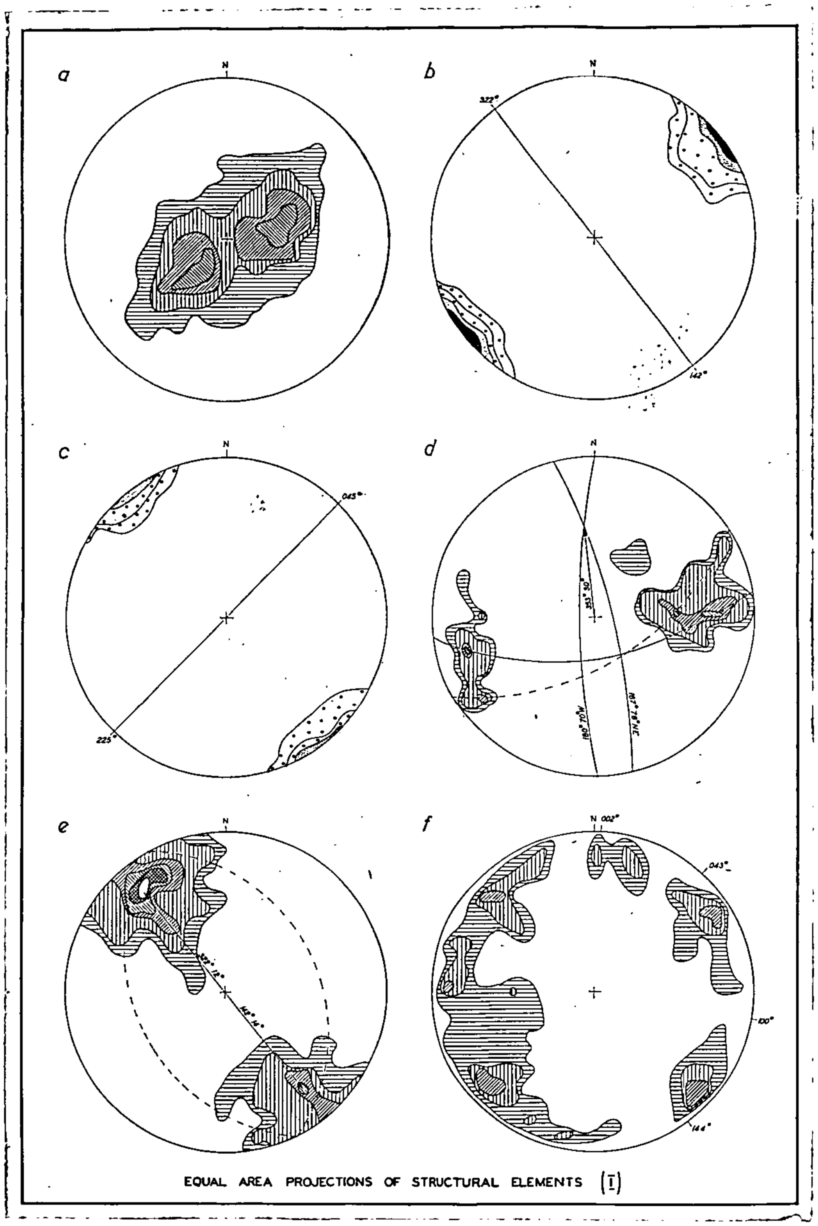

a
N
b
N
322°
142°
c
N
045°
225°
d
N
353° 30°
190° 70°W
183° 78°NE
e
N
f
N 002°
043°
100°
144°
EQUAL AREA PROJECTIONS OF STRUCTURAL ELEMENTS (I)

Figure 31

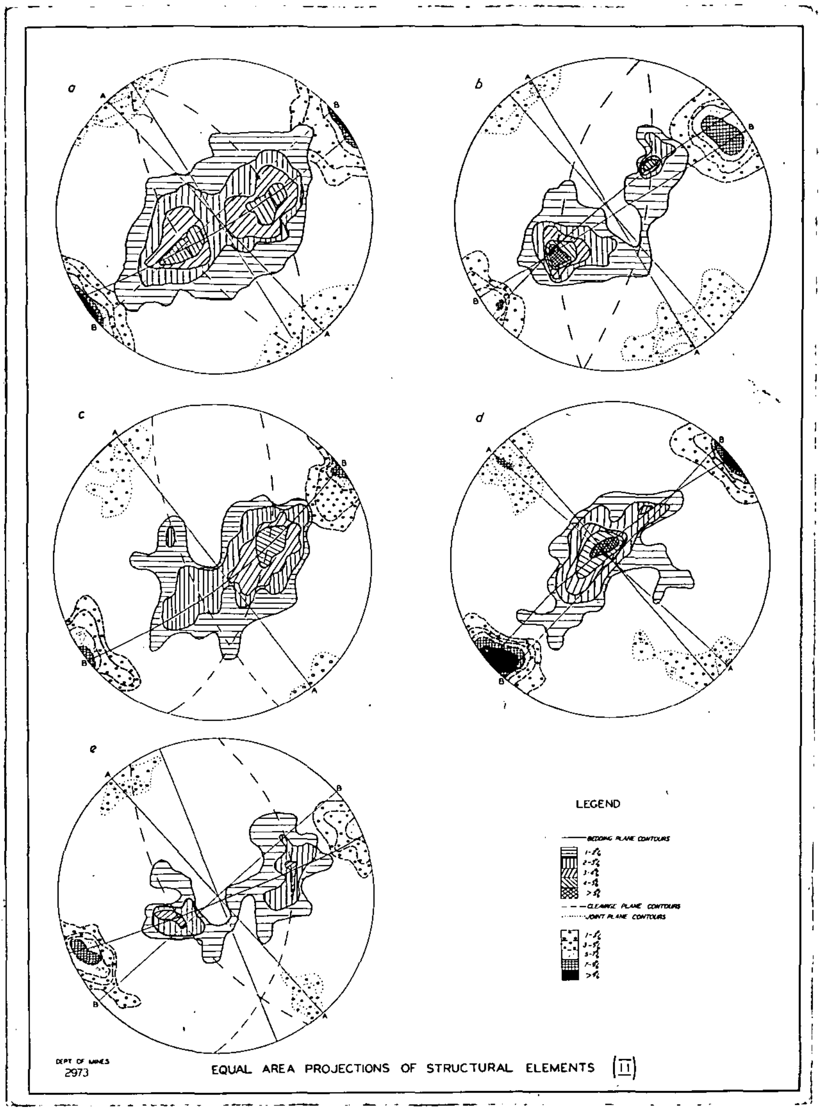

a
b
c
d
e
LEGEND
BEDDING PLANE CONTOURS
CLEAVAGE PLANE CONTOURS
JOINT PLANE CONTOURS
DEPT OF MINES
2973
EQUAL AREA PROJECTIONS OF STRUCTURAL ELEMENTS (II)

Figure 32

Plot	Cleavage	Bedding	Jointing	Angular Relationships		
				Bedding and Cleavage	Jointing and Cleavage	Jointing and Bedding
a (composite)	323-143 (740)	332-152 (650)	045-225 (530)	9° cw	8° acw	9° cw
b	324-144 (237)	316-136 (231)	048-228 (235)	8° acw	6° acw	2° cw
c	320-140 (128)	316-136 (132)	042-222 (90)	4° acw	8° acw	4° acw
d	320-140 (135)	324-144 (180)	054-234 (166)	4° cw	0°	4° acw
e	336-156 (114)	344-164 (131)	051-231 (60)	8° cw	15° acw	22° acw

(Numbers in brackets refer to number of observations)

The discrepancy between modal cleavage and regional folding is variable and slight and so may be casual. On the other hand, folding may not have been initiated by uniaxial compression but by lateral compression combined with rotational stress. Discrepancies in this case would arise particularly if cleavage developed during the late stages of folding, i.e. after a certain amount of rotation of folds had already occurred. If bedding is inclined to cleavage in an anticlockwise direction, the cause could be a sinistral wrench movement on the regional fold trend. This would also account for a similar attitude of lutite outliers in anticlinal fold cores. Both anticlockwise and clockwise inclinations are evident in figures 32b, c, d, and e, and this may be due to the above rotational effects occurring in the vicinity of shear zones and parallelism of bedding and cleavage in areas away from shear zones.

It is also noted that joint maxima do not bear constant relationships to either bedding or cleavage. This variation is attributable to causes other than folding and is discussed under "Jointing".

Fold Styles. As already stated the fold style is determined by the rock competence. In an interbedded sequence, the style is determined not only by the competence of the rock units but by their relative thickness.

The stratigraphic sequence of the Mathinna Beds, although not yet known in any detail is deduced to consist of a lower, wholly lutite member, and an upper predominantly arenite member with interbedded lutites. This upper member becomes progressively more arenaceous towards the top of the succession.

(1) The fold style in the arenite-lutite beds consists of parallel (concentric) folded arenite beds (figures 33a - d) with the interbedded lutites accommodating themselves to the spaces between the folded beds.

Fold in arenite association Mathinna Beds in road cutting Warrentinna pine plantation. Bedding is faintly indicated by weathered lutite bands. A & B are joints.

Figure 33a

Figure 33b: Fold in arenite association Mathinna Beds, plunging at low angle to observer. 1 mile west of Fingal between railway and the Esk highway.

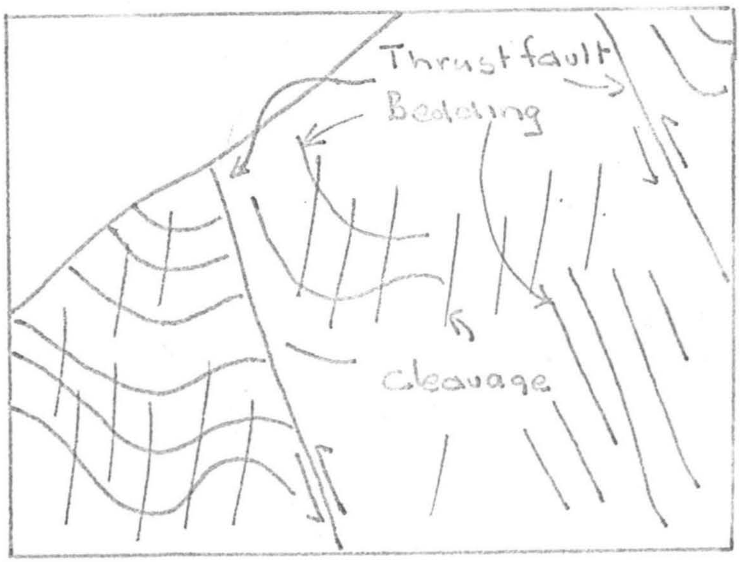


Figure 33c: Folded arenite association Mathinna Beds, headwaters of Dorset River, Cotton Plain escarpment.

Figure 33d: A long straight, steeply dipping fold limb in arenite association Mathinna Beds. This represents a fold style which allows shortening beyond the theoretical maximum for 90° folding in competent beds, without rupture.

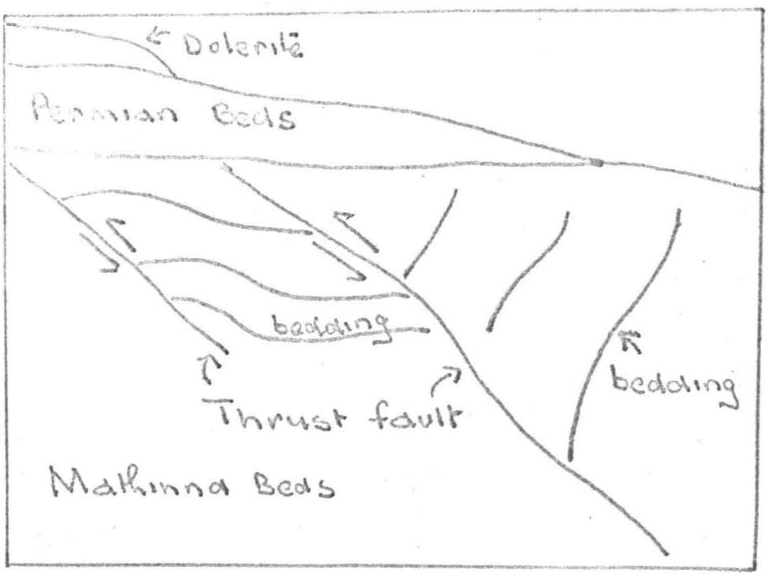


Figure 34: Thrust faults in arenite association Mathinna Beds, Cotton Plain escarpment. The faults strike parallel to the cleavage indicating their genetic relationship with the folding stresses.

In the lower portion of the arenite - lutite association the lutite layers are sufficiently thick to allow arenite layers to deform more or less competently while allowing the overall fold style to be of similar type and maintain itself with depth. Higher in the succession the lutite members are of negligible thickness and consequently the folding is of parallel type.

There is a limit to the degree of shortening which can be accomplished by pure flexure beyond which continued stress application will result in flattening or rupture. Figure 33c shows a folded series of competent Mathinna Beds with a set of strike faults due probably to adjustments of this nature. In figure 34 a set of strike thrust faults may be similarly interpreted.

(2) The fold style of the lutite association is more difficult to study in detail as these rocks are only exposed in fold cores. Owing to the soft nature of the rocks, the lutite association rarely forms prominent outcrops. A further difficulty is that cleavage frequently masks the bedding particularly in the sections of most uniform lithology. Bedding, if indiscernible in the field, is usually seen quite clearly in cut and polished specimens (figure 35).

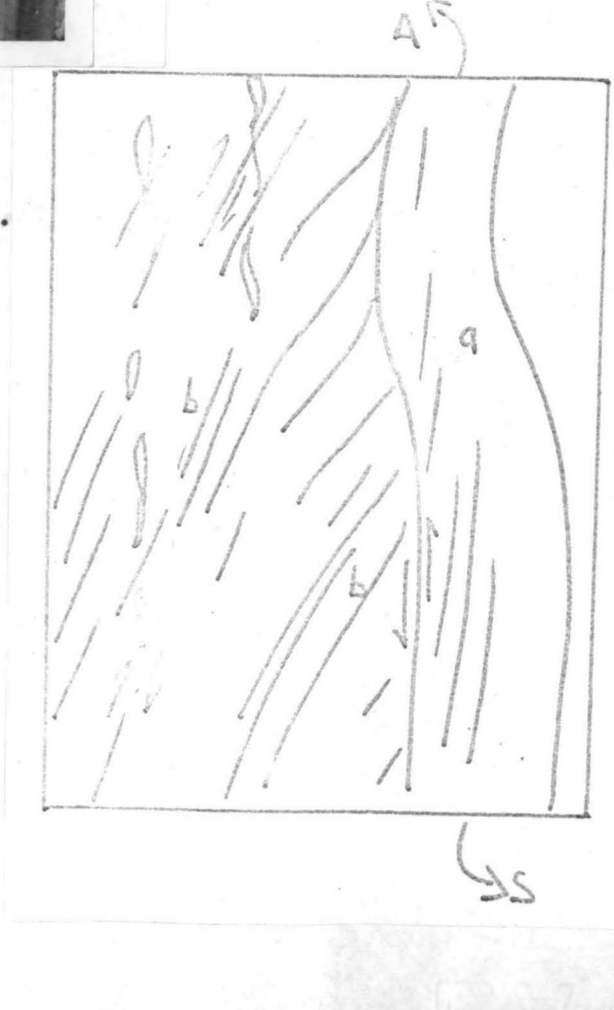


Figure 35: Bedding (a) and cleavage (b) in folded lutite association beds Mathinna Beds. Note: curvature of cleavage trace due to slip on phyllite-siltstone interface and micro-shearing on cleavage planes causing offset of bedding quartz veinlets. The assumed positions of the fold axes are indicated.

The style is inferred from the lithology to be similar type and, from the frequent near parallelism of bedding and cleavage strike, to be sharply folded or kink folded.

In some thin sections of these rocks, cleavage plane slip is evidentl Two types of movement have been recognised: a) An en echelon arrangement of cleavage flakes to form dark bands across the modal cleavage (figures 29 and 30). This may have formed during folding and as a consequence of folding or subsequently due to fault movement; and b) Shear folding. This has been recognised in micro-folds (figure 29) but as pointed out by Hills (1963 p.238) its contributions to the formation of large folds is unknown. A feature of this type of folding is that similar folding can be accomplished without shortening, therefore if the mechanism has operated in the formation of similar folds in the lutite association beds there must be a plane of detachment separating the two associations. The position of the hinge zones of the lower Mathinna Beds is not known and therefore the presence or absence of this plane cannot be determined. The style of folding at the contact of the associations would have been determined by that of the more competent upper beds which means that the change of fold style would occur at a depth sufficiently far removed from the influence of the upper association. Furthermore the gradational nature of the contact would preclude a detachment between the associations.

The structure of the lower Palaeozoic rocks of Victoria affords an interesting comparison with that of the Mathinna Beds. The Victorian Ordovician rocks are folded into long, parallel anticlinoria and synclinoria which can be traced horizontally for several miles and vertically for thousands of feet. The structure in the overlying beds - the Siluro-Devonian succession - consists of elongated domes and basins, for which Thomas (1939) proposed the terms brachy anticlines and brachy synclines. Williams G.E. (1964) described a set of arcuate folds in these rocks and demonstrated with the aid of experiments that the structure was best explained as a combination of compression and sinistral strike slip faulting of basement rocks approximately at right angles to the folding.

Dome and basin type structure can arise from simple compression or by folding (or shearing) of an already folded sedimentary series (De Sitter 1964 pp.257-260). In the former case a symmetrical pattern arises but in the latter, the individual fold axes are usually inclined to the regional strike to form an en echelon arrangement. It has been suggested that the Victorian example is a second order structure due to primary fault movements on the major fold trend.

It is noted that some lutite inliers are similarly orientated in the Mathinna Beds, notably in the area around Merry Creek, west of the Dan Rivulet goldfield. There is strong evidence for similar primary fault movements on the major fold trend which will be dealt with in the next chapter.

Shearing. A number of structures which are probably related to a later period of deformation but in some instances may have occurred during a late stage of folding, are included under this heading.

1. Faulting parallel to the major folding.
2. Kink banding.
3. Crenulation cleavage.
4. Faulting approximately at right angles to the major folding.

1. A fault, locally known as the "Main Slide" occurred in the underground workings of the New Golden Gate Mine, Mathinna. The strike of this fault was 140°m. and the dip 70° to the west. The fault is marked by a 200 ft. wide zone of shearing and sporadic mineralisation and the principal lodes in this mine occurred in the footwall of the fault and ended abruptly in contact with it.

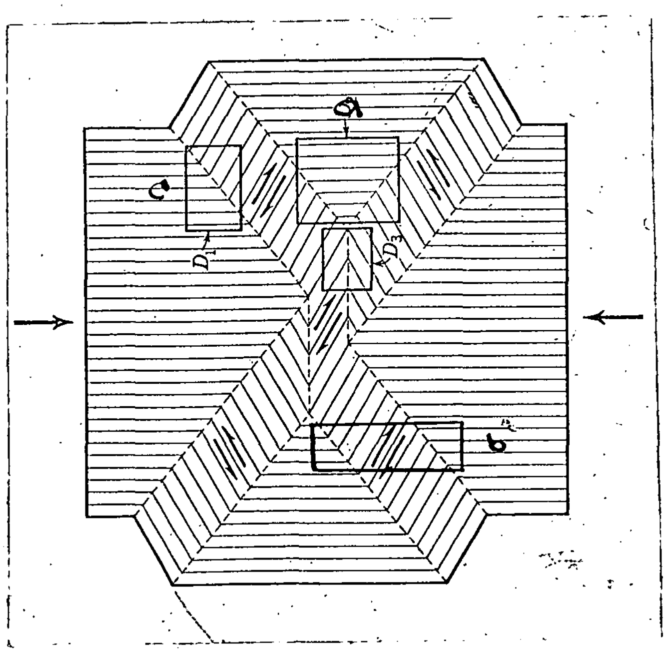
Details of this fault have been drawn from reports by Twelvetrees (1906) and have been verified by recent drilling in the area by the Department of Mines. There is an undoubted spatial relationship between the fault and the mineralisation and if this relationship is of genetic significance in the Mathinna area, it probably is also for the whole of the mineralised belt from Mangana to Waterhouse. In the individual goldfields it has been noted that folding is more intense than it is in the unmineralised areas (Finucane 1937, Blake 1939).

The term intensity is inferred to have been used in a qualitative sense to indicate closeness of folding. Finucane (1937) mentions that seven anticlinal axes were counted over a distance of a few chains. As indicated on the geological map, close folding appears more typical of the goldfields than of the surrounding area. This would suggest that movement in the shear zone took place during folding, but as there is also evidence for offsetting of fold axes across this shear zone, there was probably a post folding movement as well.

2. Kink banding. Kink bands are narrow zones transecting the foliation in which the foliation has been rotated. The bounding surfaces of the zones are kink planes. Kink bands occur in conjugate sets with opposite sense of movement (figure 36a), singly, or as sets of the same sense of movement (figure 36b).

Kink folds are sharply angular similar type folds which may be (i) folding of bedding, i.e. first order structures, usually on a regional scale. Such folds are often called chevron, zig-zag, concertina or accordian folds (figure 36c). The Kink plane, being a surface of low cohesion, is frequently a fault or dyke. (ii) folding of cleavage as in the angular portion of a kink band, i.e. a second order structure, usually small and local. A series of closely spaced parallel kink bands constitutes a type of fracture cleavage or strain slip cleavage. Kink bands have been observed at several localities in the area mapped but only in the vicinity of the "Main Slide" (figures 37 and 38) do they occur in concentration. It is suggested therefore that they are genetically related to this fault.

Two attitudes of kink bands were observed, viz. 020° sinistral and 080° dextral, both vertical and occurring singly and as conjugate pairs. Approaching the main slide on the footwall (east) side the kink bands become more numerous. Finally in contact with the fault there is only one set present, the 080° dextral set, which occurs as closely spaced concertina folds complementary to the fault (figure 39). This relationship establishes a sinistral movement on the fault.



(T & W 1963)

Figure 36

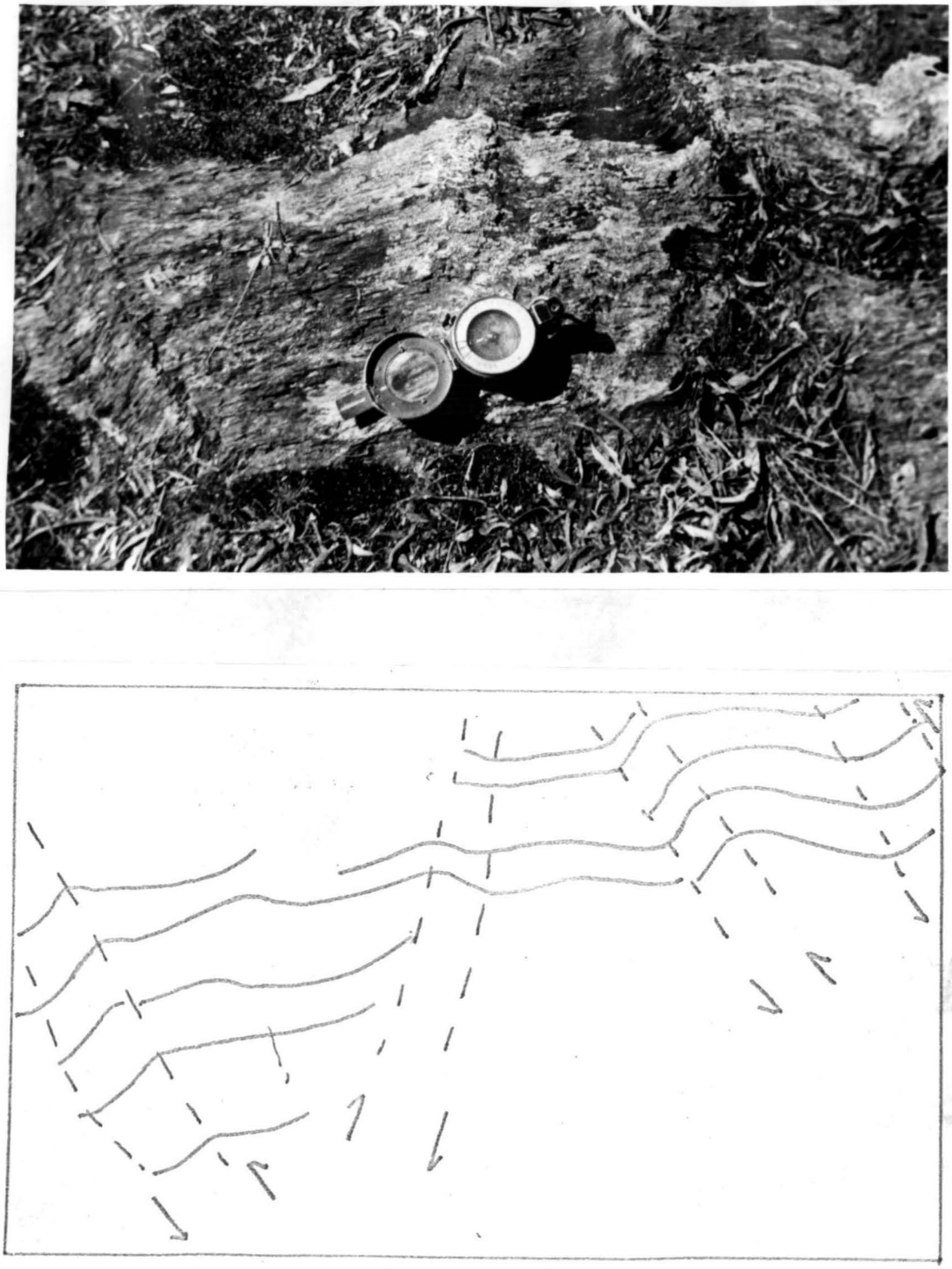


Figure 37: Kink bands, New Golden Gate Mine, Mathinna; both dextral and sinistral movements occur but are not necessarily conjugate as their intersection can not be seen.

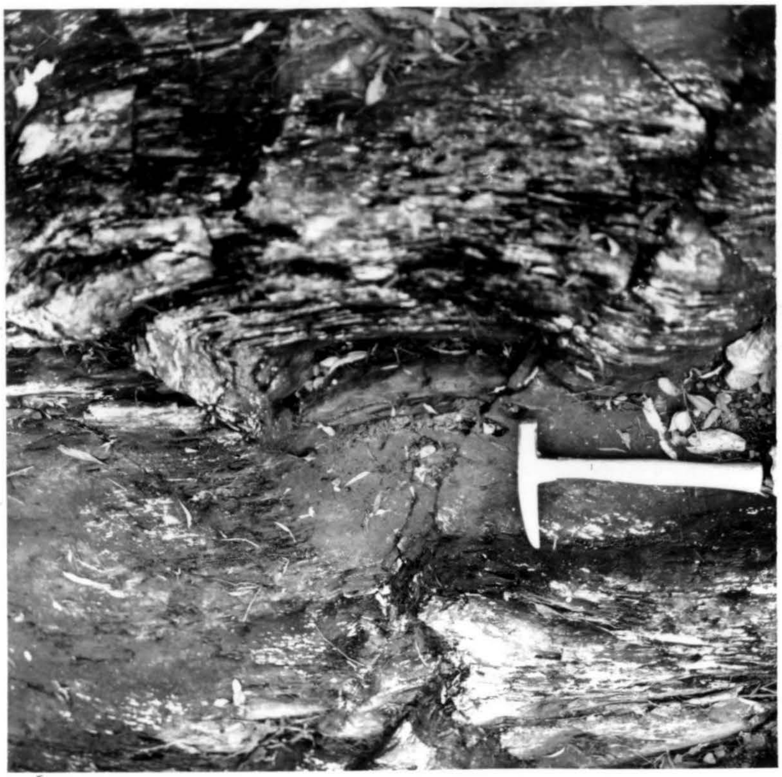


Figure 38: Conjugate kink bands Mullens Creek, south of Mathinna. The handle of the pick is parallel to the modal cleavage which is the direction of the maximum principal stress. The stress angle is 105°. Note the sinistral displacement of the dextral kink band in the upper portion of the photograph.

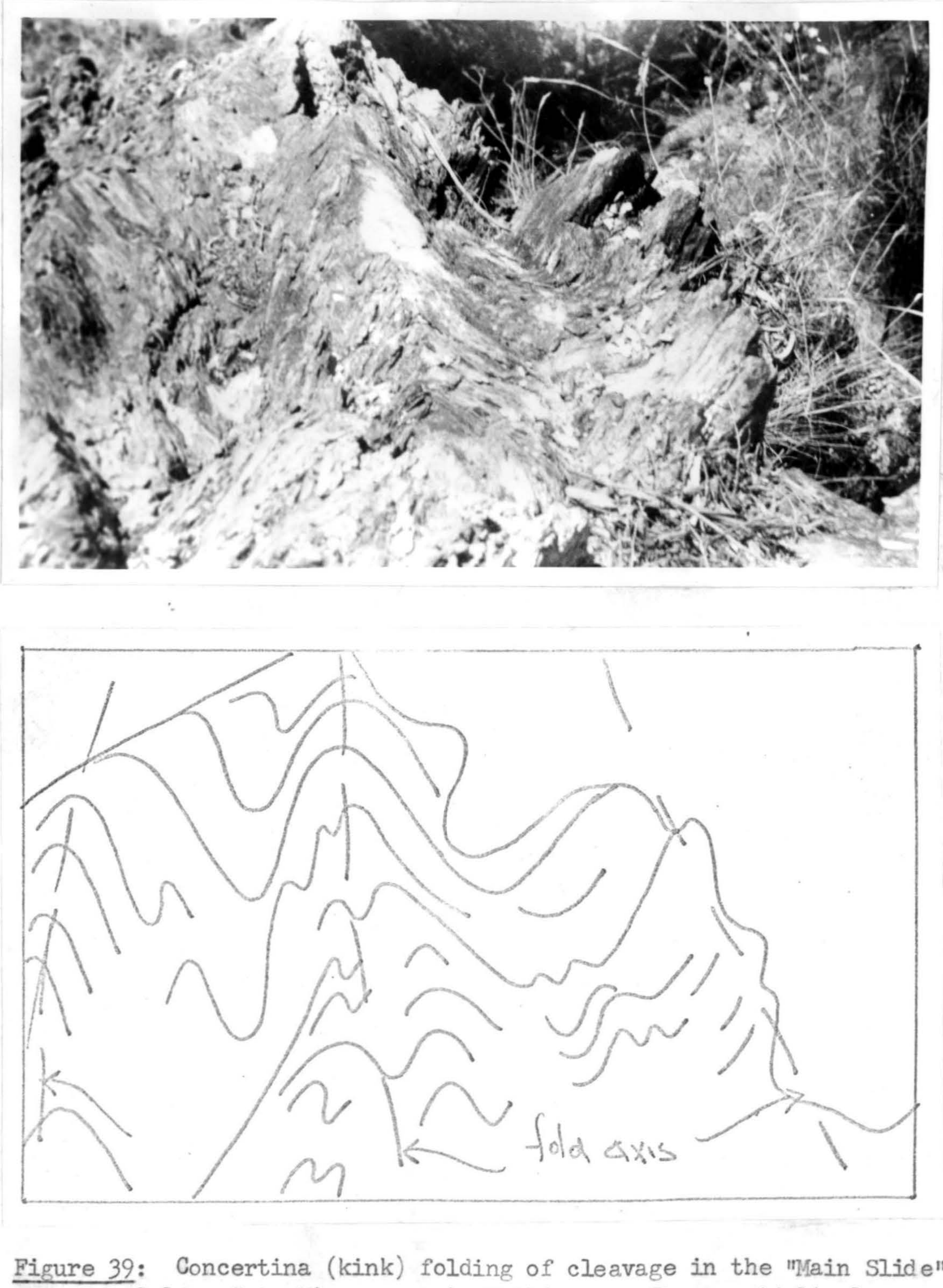


Figure 39: Concertina (kink) folding of cleavage in the "Main Slide" zone New Golden Gate Mine opencut, Mathinna. Three anticlinal axes are shown striking 080°m.

Anderson (1964) studied kink bands in the Ards peninsula, Northern Ireland and formulated a general theory of origin for them. The main points of this theory are that the maximum principal stress acted within the cleavage and the orientation of the kink planes was determined by rotational movements on the folia between the pairs of kink planes.

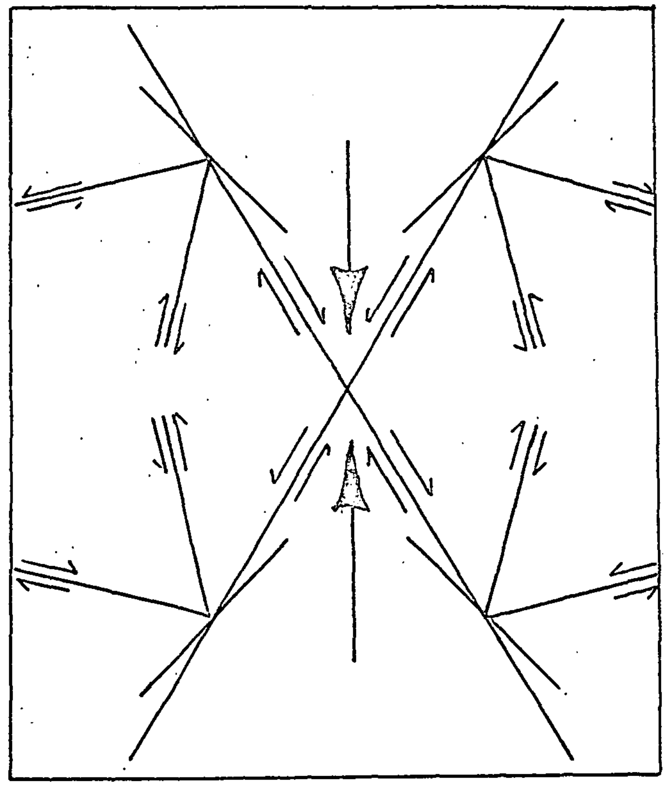
Paterson and Weiss (1962) produced these structures experimentally and showed that (i) conjugate kink bands form when a previously foliated rock is compressed in a direction parallel to the foliation or up to 25° to the foliation. (ii) when compressed at between 25° and 45° to the foliation only one set formed. (iii) when compressed at an angle of greater than 45° to the foliation, there was no kink banding but a gliding on the foliation in the central portion of the constrained specimen. The authors concluded that this was the basic mechanism of deformation and always occurred if the rock was free to change its shape under the action of the compression. (iv) kink bands grow in number and width as the strain increases and fill the whole specimen at 30 - 40% shortening. (v) further deformation results in gliding on the foliation accompanied by external rotation of the glide plane.

Marshall (1964 and 1966) criticised Anderson's theory on the grounds that: (1) In planar anisotropic rocks, the maximum principal stress cannot be given unless the kink bands are truly symmetrical about the anisotropy. If they are not, the stress is rotational and the kink bands would be asymmetrical about both the anisotropy and the maximum stress. Marshall points out that Anderson's figures do not indicate conjugate shear planes since they do not intersect and they may therefore be explained in terms of a first order shear on which a second order shear has developed, and (2) If rotation of intra kink band folia has determined the orientation of kink bands it must also have determined the sense of movement on them. This, Marshall states, is demonstrably not so as pairs of kink planes usually converge into a single plane in which there are no intra kink band folia but the sense of movement remains the same and must therefore be the primary movement.

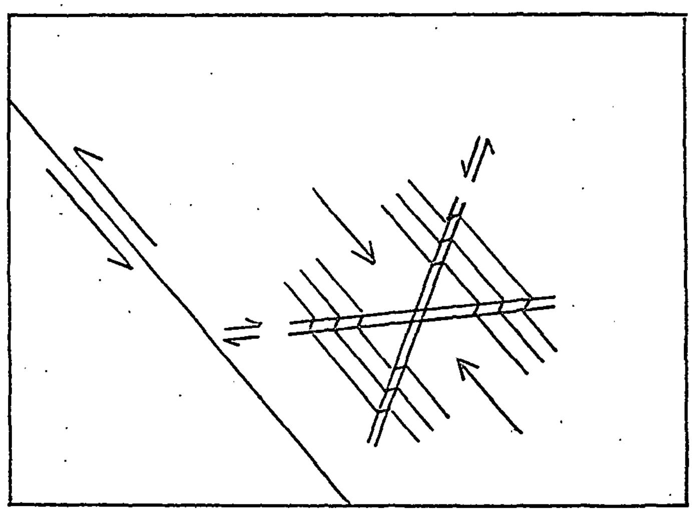
Dextral kink bands conjugate to sinistral wrench faults have been described by Knill (1961) and Anderson (1964) states that the relationship is a feature of many structurally complicated areas in the British Isles.

A relationship between kink bands and wrench faults is inferred in the area studied. If kink banding was a consequence of movement on the wrench fault a system of second order shear planes may develop in accordance with the principles put forward by Moody and Hill (1956). The kink band directions which have developed agree with the second order shear directions but the sense of movement is reversed (figure 40). This indicates that the conjugate kink bands are not related to the wrench fault.

The Golden Gate area possesses both conjugate kink bands not apparently related to faulting and dextral kink bands conjugate to inferred sinistral wrench faulting. It seems unlikely that kink banding would occur under the action of a stress directed in the plane of cleavage if the stresses were relieved by wrench faulting, the kink banding must therefore have preceded faulting, probably during the initial stages of stress. When fault movement occurred, one kink band was suppressed and the other (080° dextral) remained as a complementary shear direction. The dihedral shear angle bisected by the maximum principal stress (P1) is 60° and the stress is not in the plane of cleavage but inclined at 30° to it (290°-110°m).



a.



b.

Figure 40
Conjugate system of wrench faults of Moody & Hill (a) compared with the "Main Slide" and the conjugate kink bands (b).

The stress which produced the conjugate kink bands is not known but from the experimental evidence of Paterson and Weiss, it would be somewhere in the range $320^\circ \pm 25^\circ - 140^\circ \pm 25^\circ$ i.e. up to 25° oblique to the cleavage. The extreme value of $295\text{-}115^\circ$m is nearly the theoretical value $290\text{-}110^\circ$m assumed for the wrench faulting. This suggests that the two structures were formed independently by the same stress at slightly different times and with a slight re-orientation of the stress.

Hills (op. cit. p.96) states that (in an isotropic medium) the directions of shear failure never exceed a 90° dihedral angle about the stress. In conjugate kink bands, however, this angle often exceeds 90°. It is 120° in the Mathinna area; Ramsay (1962) gives 45° or less for angles between single kink bands and the maximum principal stress; Hoepener (1955) recorded values ranging between 105° and 140°; Anderson (1964) gives a range of 115° to 120° and Marshall (1964) noted values from less than 90° to 140°. Dewey (1965) stated that P1 cannot bisect the obtuse angle of a conjugate kink band system as this invokes a negative angle of internal friction which is clearly impossible. He suggested that if the shear angle exceeded 90° the kink bands did not form on planes of maximum shearing stress but as a direct result of bend gliding on planes parallel to P1.

Turner and Weiss (1965) state that P1 invariably bisects the obtuse angle between conjugate kink bands. These authors further state that the kink bands cannot be interpreted as planes of shear failure in the mechanical sense and that the process is not a brittle phenomenon but plastic deformation. This statement supports Dewey's contention that Kink bands are not planes of maximum shearing stress.

Paterson and Weiss (1962 figure 7) show that in deformed, constrained phyllite specimens a single kink band set formed at 30°

to the stress when compressed at 25° to the foliation. This condition is markedly similar to that given by Dewey (1965 figure 26d). It would appear therefore that in single kink band systems a conjugate movement occurs in the invariant foliation. P1 bisects the acute angle between the kink band and the foliation. In the area studied this condition occurs at the intersection of the "Main Slide" and the 080 dextral kink bands. Away from the Main Slide, in the zone of conjugate kink bands P1 bisects the obtuse shear angle but as yet there is no satisfactory explanation of this obtuse angle. It may be that strain becomes localised in pre-existing planes which formed at an acute angle about the uniaxial folding stress, i.e. the shear joints of the folding.

3. Crenulation cleavage. En echelon cleavage and inclusion arrangements (figures 29 and 30) and sigmoidal cleavage traces (figure 35) are evidence of disturbance of first cleavage. The effects are attributable to either a secondary fracture cleavage (crenulation or strain slip cleavage) or gliding on the foliation incidental to folding. Kink banding is described as a form of strain slip cleavage by Knill (1962), Anderson (1964) and Marshall (1964). In the area studied, no relationship between these disturbances to cleavage and kink bands has been deduced.

4. Faulting approximately at right angles to the folding is inferred from several lines of evidence: a) dislocation of the fold pattern giving anomalous cleavage directions, NE-SW instead of NW-SE, it was also noted that the major joints in these areas, presumed to be AC plane joints of the folding, retained their attitude at right angles to the cleavage so that they lay in the NW-SE quadrants in the disturbed areas. Where these features have been observed, axial planes of folds are in some instances tilted by as much as 45°. In kink banded areas, this feature is clearly seen in the rotation of cleavage and kink bands in which their angular relationships have been preserved (fig.41).

__Figure 41__ shows three structures in the following sequence:

1. Folding and development of axial plane cleavage.

2. Kinking of cleavage and wrench faulting ("Chain Slide") on the line of cleavage and fold trend.

3. Lateral shearing in a northeast direction causing broad swings in cleavage strike. The kink bands retain their angular relationship with the cleavage indicating the relative ages of the two shear movements.

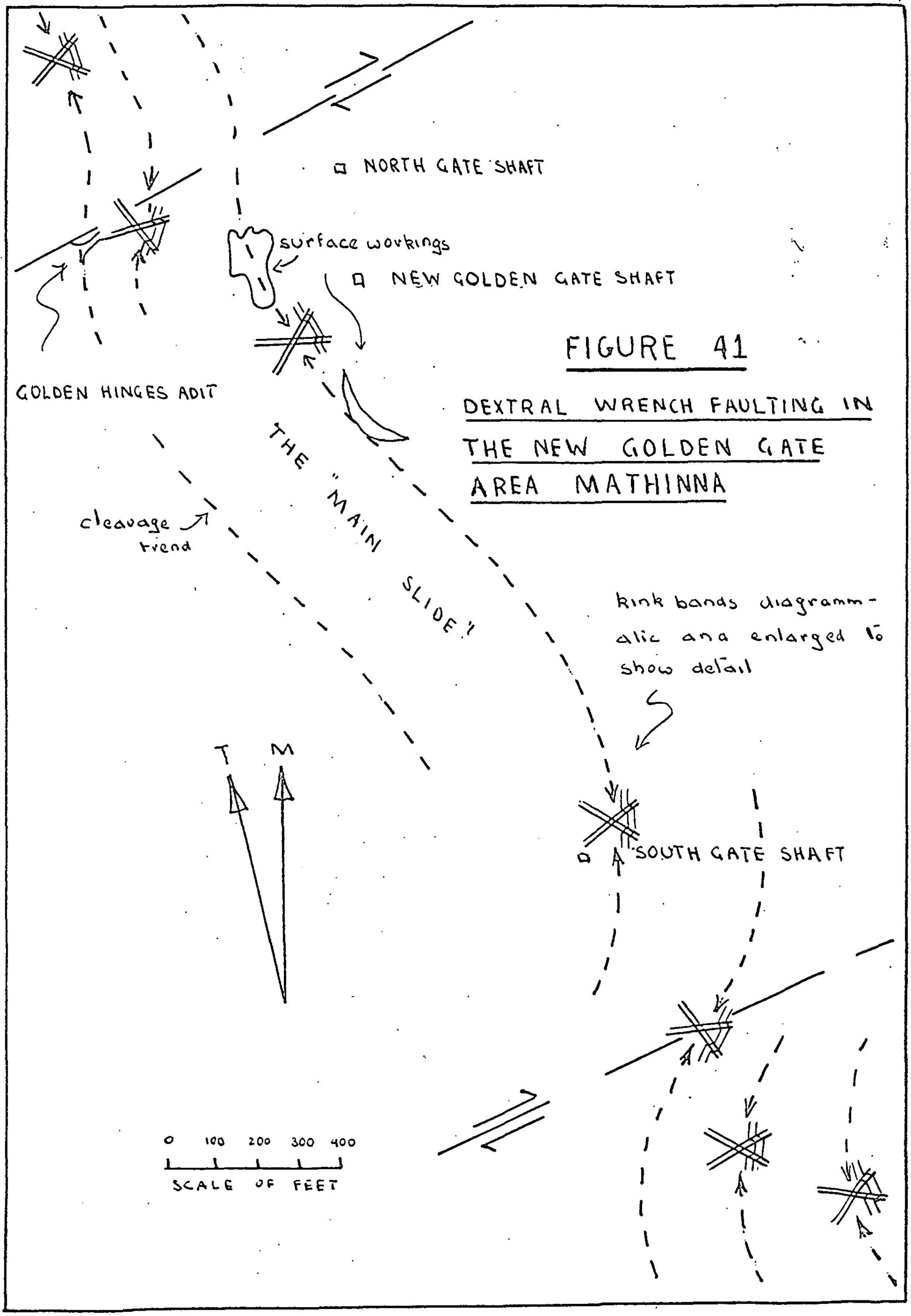


FIGURE 41

DEXTRAL WRENCH FAULTING IN THE NEW GOLDEN GATE AREA MATHINNA

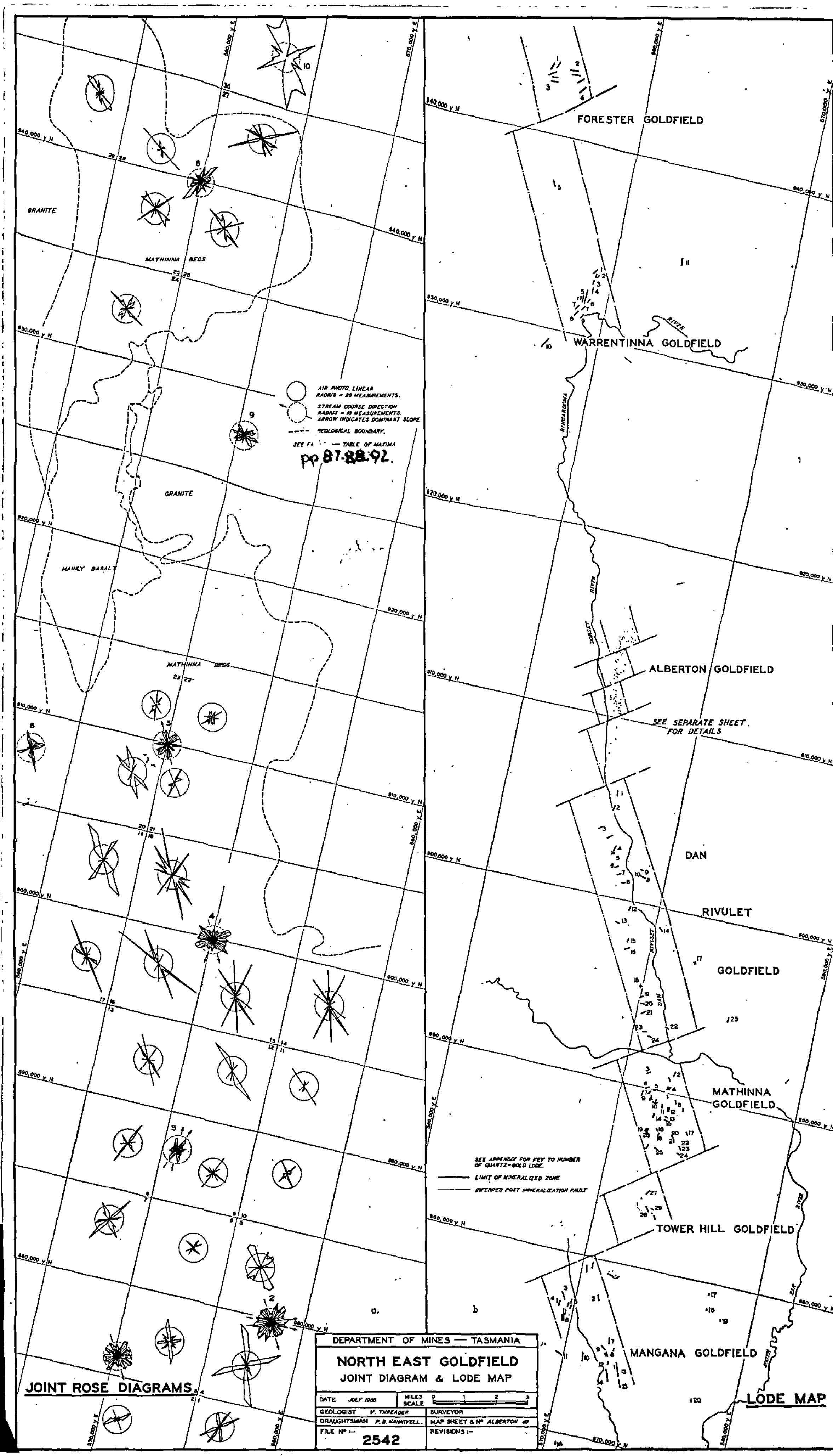
b. Puckering of cleavage is probably also caused by this shear direction as well as that already discussed, i.e. with respect to the northwest shear planes. In several localities kink planes of disturbed cleavage strike at 050°m which is approximately at right angles to the modal cleavage - see insets on the geological map.

c. The lode distribution pattern (figures 42b and 43) appears to consist of a series of en echelon mineralised belts. The regional trend of the goldfields line is 150 - 330°m but in individual areas the trend is 140 - 320°m. This disparity is considered to be the effects of a series of dextral shearing movements on the northeast planes. An alternative explanation is that the en echelon arrangement is caused by rotational (sinistral) stress on the goldfield line. In this event, there would be an element of overlap rather than an offset of individual shear planes. There is moreover an offset of irregular amount indicating fault movements. For these reasons, the former explanation, viz. offset by later faulting, appears the more satisfactory one.

d. Later igneous activity and epeirogenic movements probably utilised these same fault planes. The tectonic control of Jurassic and Tertiary igneous activity is discussed in a later chapter.

A unique occurrence of kink bands in two directions at a locality outside the area mapped has been studied with regard to shearing in two directions. Noland Bay lies thirty miles to the west of the northern extremity of the goldfield line. Here kink bands occur in highly cleaved sandstone in a sandstone-mudstone sequence. The interbedded mudstones are highly sheared and impregnated with vein quartz. The sequence is intensely folded with axial surfaces dipping at a flat angle to the south-west. Owing to the low cleavage dip, kink bands are viewed on almost vertical surfaces and not in the

Figure 42


DEPARTMENT OF MINES — TASMANIA
NORTH EAST GOLDFIELD
JOINT DIAGRAM & LODE MAP
JOINT ROSE DIAGRAMS
LODE MAP
GRANITE
MATHINNA BEDS
MAINLY BASALT
AIR PHOTO LINEAR RADIUS = 20 MEASUREMENTS.
STREAM COURSE DIRECTION RADIUS = 10 MEASUREMENTS. ARROW INDICATES DOMINANT SLOPE
GEOLOGICAL BOUNDARY.
pp 87.88.92.
FORESTER GOLDFIELD
WARRENTINNA GOLDFIELD
ALBERTON GOLDFIELD
SEE SEPARATE SHEET FOR DETAILS
DAN RIVULET GOLDFIELD
MATHINNA GOLDFIELD
TOWER HILL GOLDFIELD
MANGANA GOLDFIELD
RINGAROOMA RIVER
DORSET RIVER
SEE APPENDIX FOR KEY TO NUMBER OF QUARTZ-GOLD LODE.
LIMIT OF MINERALIZED ZONE
INFERRED POST MINERALIZATION FAULT
DATE JULY 1965
GEOLOGIST V. THREADER
DRAUGHTSMAN P. B. HANNIVELL.
FILE No :- 2542
MILES SCALE
SURVEYOR
MAP SHEET & No ALBERTON 40
REVISIONS :-

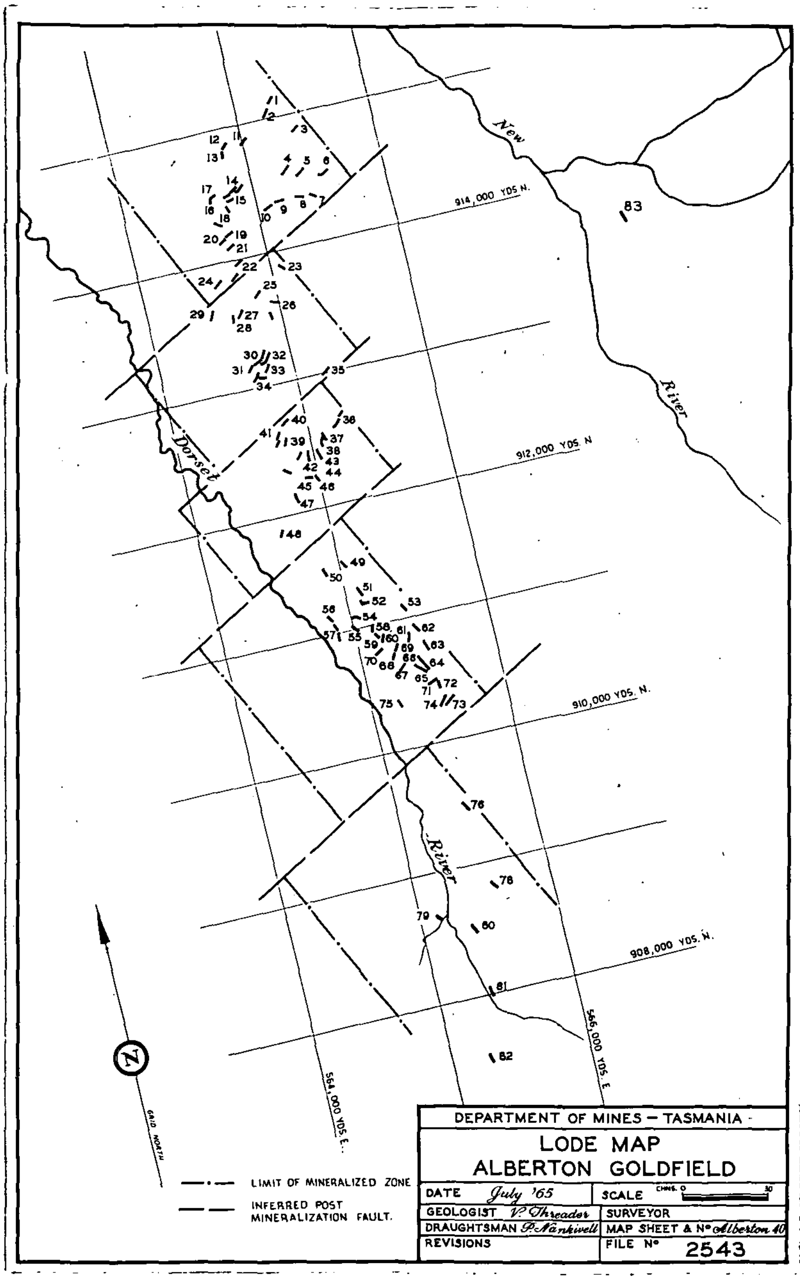

DEPARTMENT OF MINES — TASMANIA
LODE MAP
ALBERTON GOLDFIELD
DATE July '65
SCALE
GEOLOGIST V. Threader
SURVEYOR
DRAUGHTSMAN P. Nankivell
MAP SHEET & Nº Alberton 40
REVISIONS
FILE Nº 2543
LIMIT OF MINERALIZED ZONE
INFERRED POST MINERALIZATION FAULT.
New River
Dorset River
914,000 YDS N.
912,000 YDS N
910,000 YDS. N.
908,000 YDS. N.
564,000 YDS. E.
566,000 YDS. E
GRID NORTH
N

Figure 43

horizontal plane as at Mathinna. At Noland Bay the strike of the kink bands form anastomosing patterns on horizontal surfaces.

The kink bands:

(i) A set of north east striking kink bands occur as conjugate sets but more commonly as sets of sinistral kink bands. (figure 44a).

(ii) A set of northwest striking kink bands parallel to the modal cleavage occur as conjugate sets but more commonly as sets of dextral kink bands (figure 44b and c).

In these two photographs, the two sets are plainly visible crossing each other. Two other structures of widespread occurrence are Riedel Shear planes with tension gashes cutting aacross the succession and drag folded quartz veins confined to the interbedded lutites. The deduced stress fields are given in figure 45.

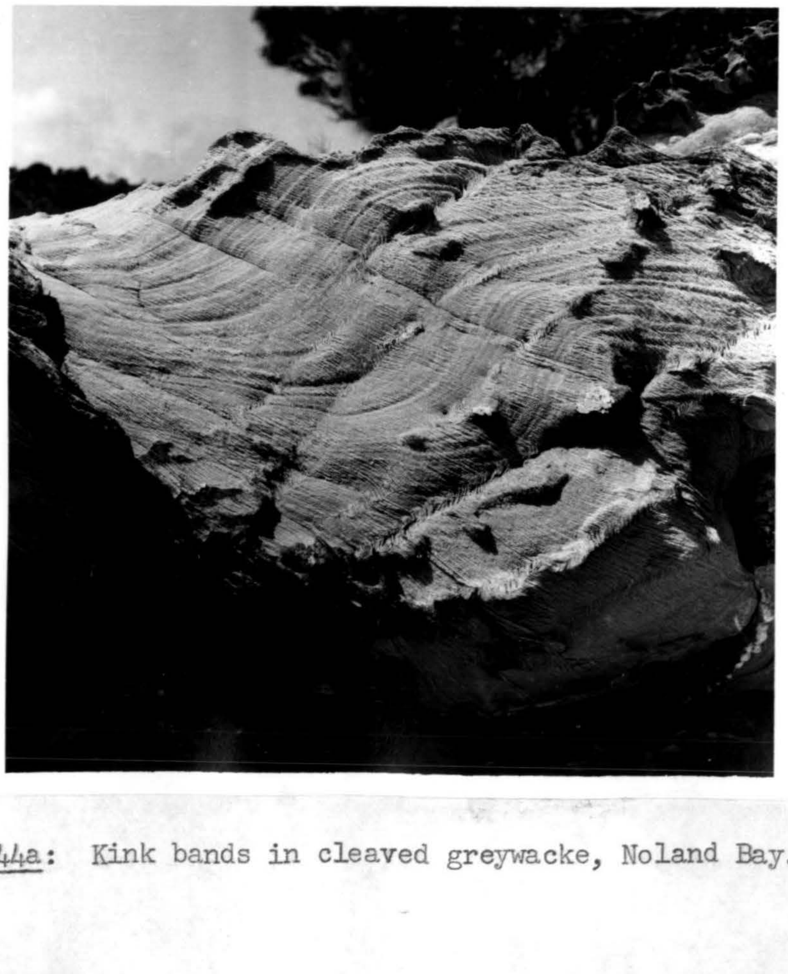
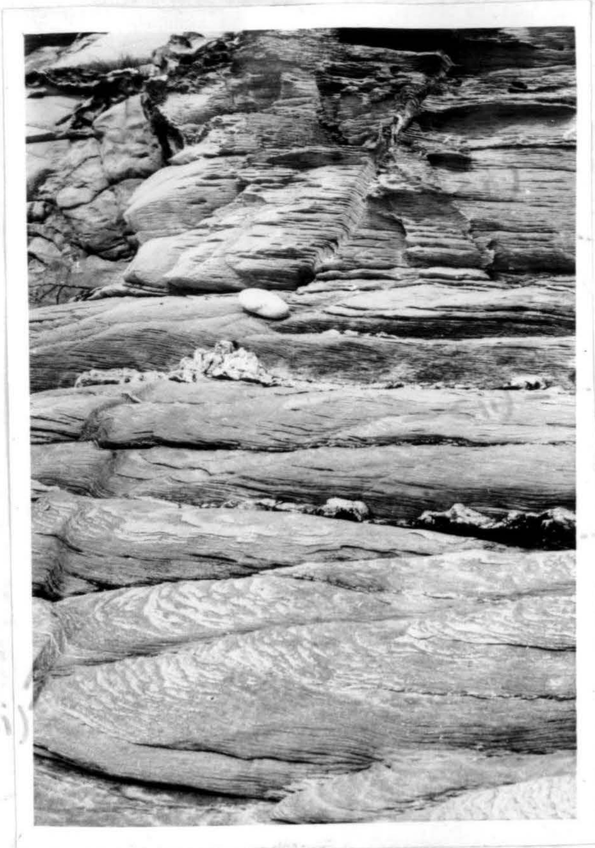


Figure 44a: Kink bands in cleaved greywacke, Noland Bay.



<u>Figure 44</u>: Kink bands at Noland Bay.

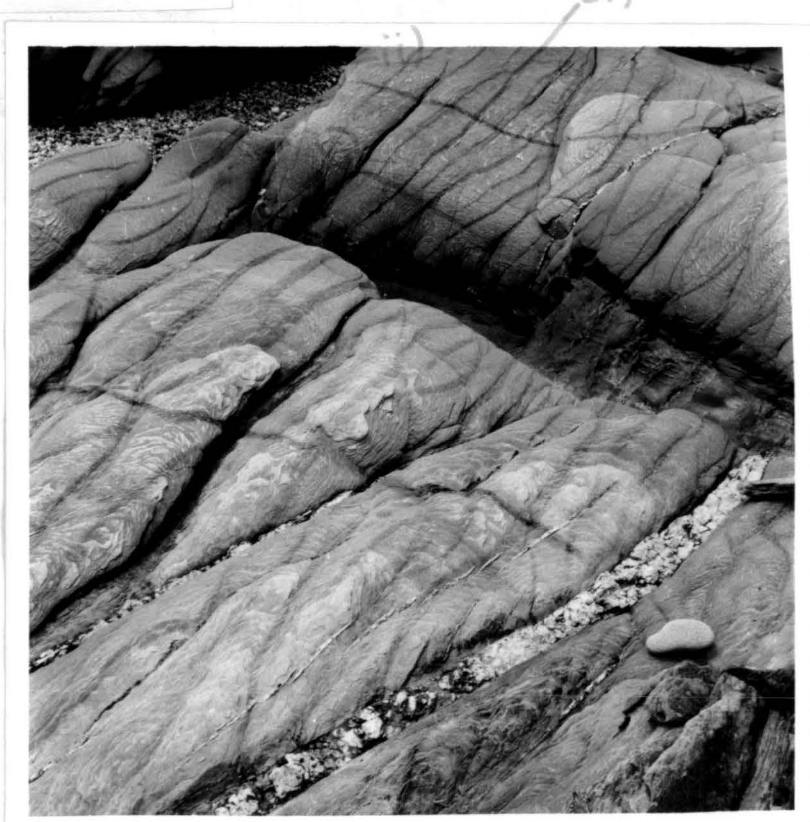
a) Bedding

b) Cleavage

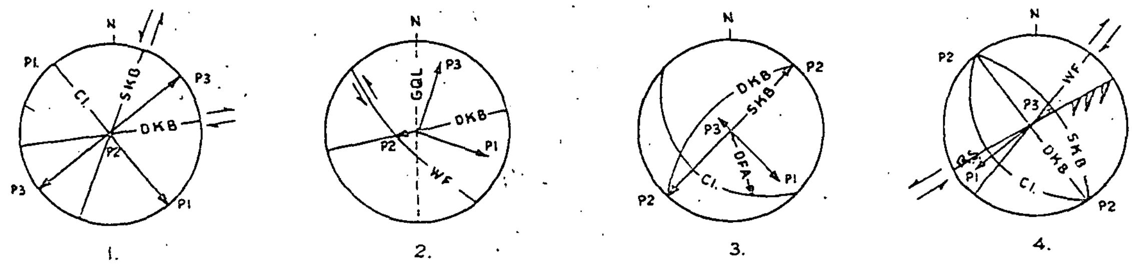
c) Kink bands:
   i) north east striking set conjugate in upper portion of 44b.

   ii) northwest striking set.

b.



c.



Legend for Figures: Cl: cleavage; SKB & DKB: sinistral and dextral kink banks: P1, P2, P3: the principal stresses; WF: wrench fault; DFA: drag fold axis; RS: Riedel Shear; GQL: Gold-quartz lode.

<u>Figure 45</u>

Stereograms depicting:

1) Conjugate kink bands at Mathinna.
2) Sinistral wrench fault and dextral kink bands at Mathinna.
3) Conjugate kink bands (NE Set) in cleaved greywackes and drag folds in interbedded lutites at Noland Bay.
4) Conjugate kink bands (NW Set) and Riedel Shear planes at Noland Bay.

It is noted that (i) the northeast set of kink bands at Noland Bay (c) and the conjugate kink bands at Mathinna (a) were produced by a similarly directed maximum principal stress P1 and an interchanged P2 and P3, and (ii) the northwest set of kink bands at Noland Bay (d) and the northeast dextral wrench faults at Mathinna (W.F.) were produced by a similarly directed stress. Kink bands could not form at Mathinna in response to this stress as the cleavage is vertical and so at right angles to the stress. The difference in response to the appropriate stress is considered to be a consequence of the different cleavage attitude in these two localities. It is concluded therefore that the same two directions of shearing were operative in the Noland Bay and Mathinna areas.

Jointing. (i) Air photo lineaments. In areas of Mathinna Beds, a joint pattern is discernible on the air photos. The lineaments are confined to areas of natural vegetation and were not detected in cultivated or burnt ground nor on rock outcrop. This reflection of jointing by differences in vegetation is probably due to a greater depth of weathering and consequently a greater thickness of soil on the line of the master joints. These lineaments were transferred to the working plans with the Leitz "airtopo" and rose diagrams were prepared for each 1,000 yard square (figure 42a). The principal directions are given in the following table:

Air Photo Lineaments

Magnetic Bearing

	N - S	NNE	NE	ENE	E	ESE	SE	SSE	Fold Trends
1		012	044					148	143
2			043				128,146	153	138
3		024	054		(093)	(113)		153	128
4			048				128	148	138

Air Photo Lineaments Contd.

	N - S	NNE	NE	ENE	E	ESE	SE	SSE	Fold Trends
5	003	032		063			133		138
6	011		043			111			133-163
7		022	051			(113)	133		128-143
8		012		061		122			103-128
9	(172)	012,033			101	121			123-143
10		025	(053)				133		138
11		023				123		(165)	138
12		015				123	143	163	118
13		013		071		122	143	(163)	118
14	004		(035)			105,123		153	103-143
15	(002)		(034)		103	123		153	118
16	003				103		132	153	128-158
17	003	(033)			097		133	152	123-143
18	011		(053)	(073)			132		143
19	174	013			083	104,123	143		143
20	004					113	143		133-153
21	001		042				131		133
22	002	033		074			141		148-018
23		014	(052)			123		162	151-178
24	003	023	043			113,123			178-030
25	002		034		098	121		(151)	146-168
26		033	054			114	143		148-178
27			053		084	122	143		148
28			(048)			113		153	093-153
29		(012)	(048)			113	143		178 & 98-123

( ) : minor maxima

(ii) Joint measurements taken in the field on outcropping Mathinna Beds are shown on a stereogram (figure 31c). The strongest joint plane was observed to strike perpendicular to the plane of cleavage, this was true for all cleavage directions which indicates that these joints are related to the cleavage, they are therefore interpreted as cross (AC) joints of the folding. This direction (NE - SW) is the principal maximum of the stereogram. The widespread spread of values is due partly to post folding tectonics which has resulted in wide swings in axial trend of folds. The other maximum may be interpreted as representing longitudinal joints of the folding and a similar wide spread of values is also noted.

The average fold trend in each section is given in the table of air photo lineaments; swings in fold trend are sometimes not accompanied by a swing in joint directions. This indicates that some of the jointing is of post folding age. The joint pattern in granitic areas is similar to that in the Mathinna Beds; as the emplacement of granites is of post folding age, this is further evidence of two ages of jointing. The similarity of joints related to folding and those of later age is probably due to the utilisation of pre-existing planes of weakness by joints caused during later faulting.

(iii) Gold - quartz lodes. The date given in the appendix and figures 42b and 43 are shown on stereogram 31f showing that four principal directions of reef occur in the goldfields. Plots of lodes on individual goldfields (figure 46) indicate that locally only one or two of these directions are present.

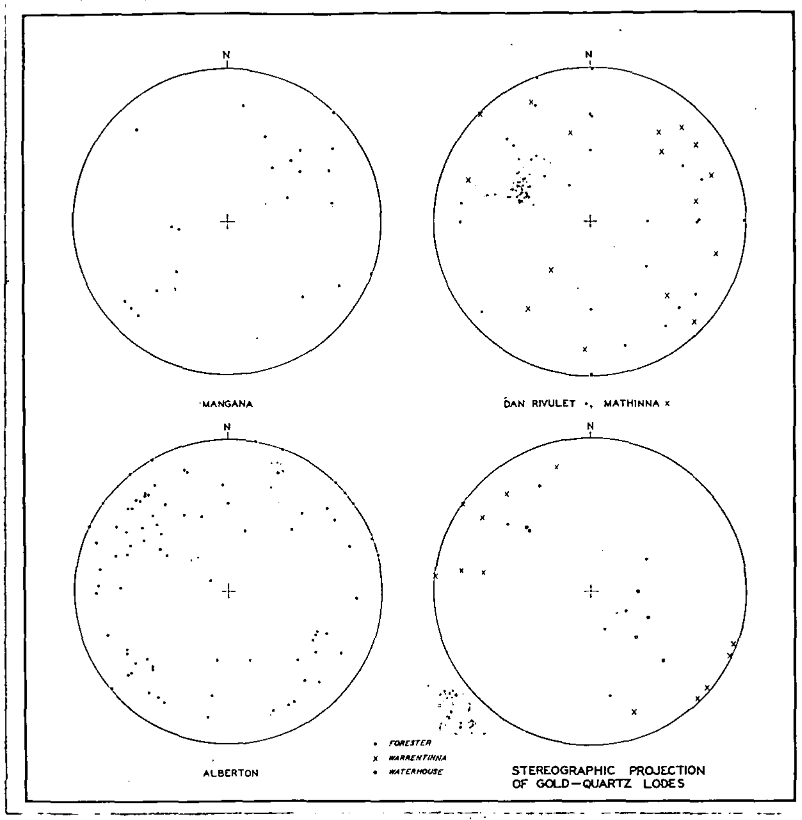

N
N
MANGANA
DAN RIVULET •, MATHINNA x
N
N
ALBERTON
• FORESTER
x WARRENTINNA
• WATERHOUSE
STEREOGRAPHIC PROJECTION
OF GOLD-QUARTZ LODES

Figure 46

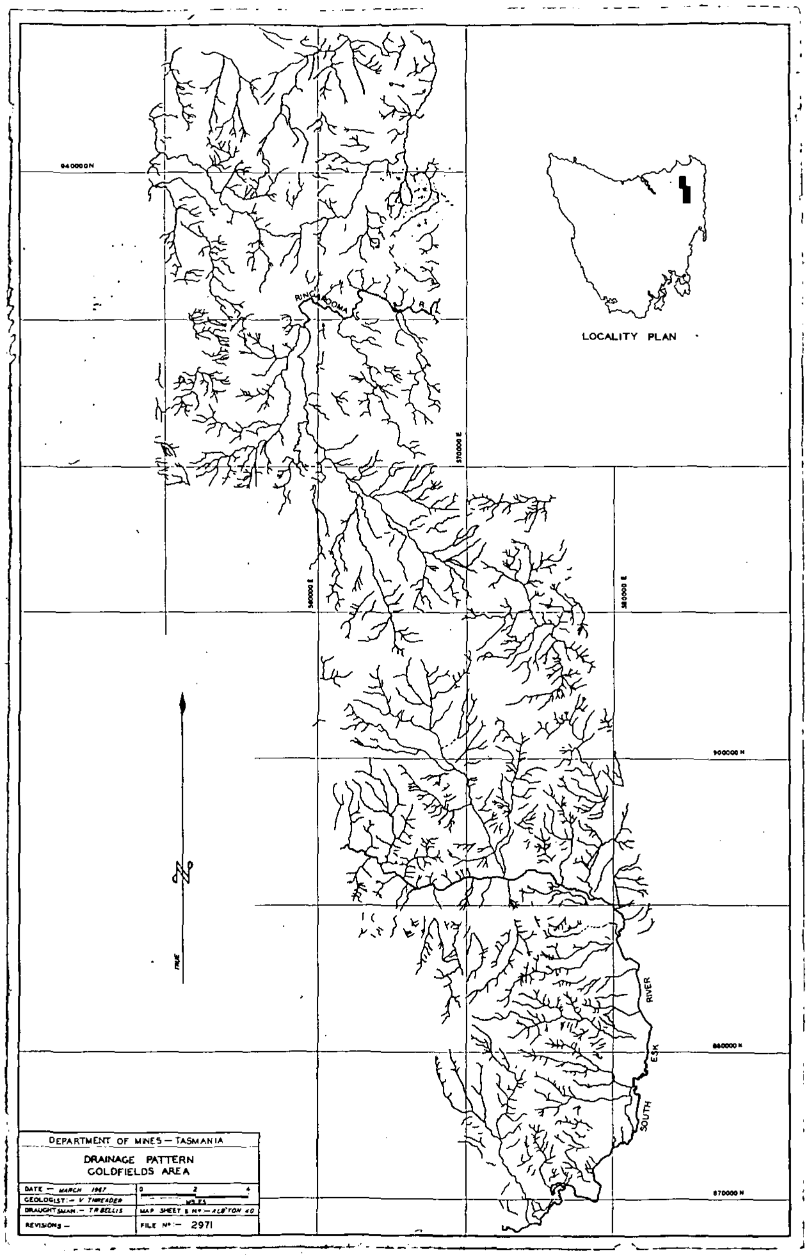

RINGAROOMA
LOCALITY PLAN
SOUTH ESK RIVER
DEPARTMENT OF MINES — TASMANIA
DRAINAGE PATTERN
GOLDFIELDS AREA
DATE — MARCH 1967
GEOLOGIST:— V THREADER
DRAUGHTSMAN.— T R BELLIS
REVISIONS —
0 2 4
MILES
FILE Nº:— 2971

Figure 47

(iv) An analysis of the drainage pattern (figure 47) is shown in figure 42a and the results have been tabulated:

Summary of Stream Course Rose Diagrams

Direction (Mag.Bg.)	N-S	NNE	NE	ENE	E	ESE	SE	SSE	Dominant Slope	
Diagram No.										
1		015	045		100		130		140	Math. rocks
2	010	020		060	090		130		070-140	"
3		020		070				160	010-030	"
4			050	075		120		165	145-180	"
5		025	045		085 100			150 335	145	"
6	175	025	050		095		125		nil	"
7		020								Composite
8	175		040	060	100			130		Granites
9			055				145			"
10			043		103	122		152		"

The measurements are not average directions of stream courses but are directions of each and every portion of individual streams. The trunk stream courses are determined by primary structural features - mainly faults - and the secondary stream courses are, in the main, consequent streams draining the slopes of the dolerite monadnocks. It is the tertiary stream pattern which is considered most likely to reflect joint trends in the Mathinna Beds. The results of these four approaches to joint interpretation are grouped in figure 33. Spencer Jones (1964) found that the joint pattern in Carboniferous sandstones in the Grampian Mountains, Victoria, were independent of lithology and unrelated to folding. He also found similar joint patterns in the sediments and in the neighbouring granites and concluded that the dominant joint pattern post dated granite emplacement and was genetically related to a later period of faulting. The origin of the joints will be discussed again in the following chapter.

Stress Orientation. In figure 48 three stress orientations are given to account for: a) the fold pattern, the cleavage and longitudinal joints (320), cross joints (050) and shear joints (020 and 080), b) sinistral wrench faults (320) and c) dextral wrench faults (050).

These orientations are theoretical and are based on an assumed angle of 30° between shear plane and applied stress. As the other evidence already cited points to fault movements during folding, a more realistic interpretation of the stress would be at some angle between 050° and 110°. It is conceivable therefore that one stress system is responsible for both directions of faulting as well as the folding. A summary of all spatial data is given in figure 49 and it is noted that:

i) The cleavage/longitudinal tension joint direction (320) is reflected in air photo lineaments quartz lodes and in field measurements but only weakly in stream course directions.

ii) Shear joints (020 and 080) directions are represented by minor maxima in field measurements and a strong maximum (020) in stream course directions. The presence of kink planes parallel to these directions has already been noted.

iii) The cross (AC) tension joint direction is strongly represented by air photo lineaments, quartz lodes, field measurements and stream course directions. The reason for this may lie in the repeated use of this direction by later Taberraberran faulting (the northeast shear direction) and again by tension faulting in Jurassic and Tertiary times.

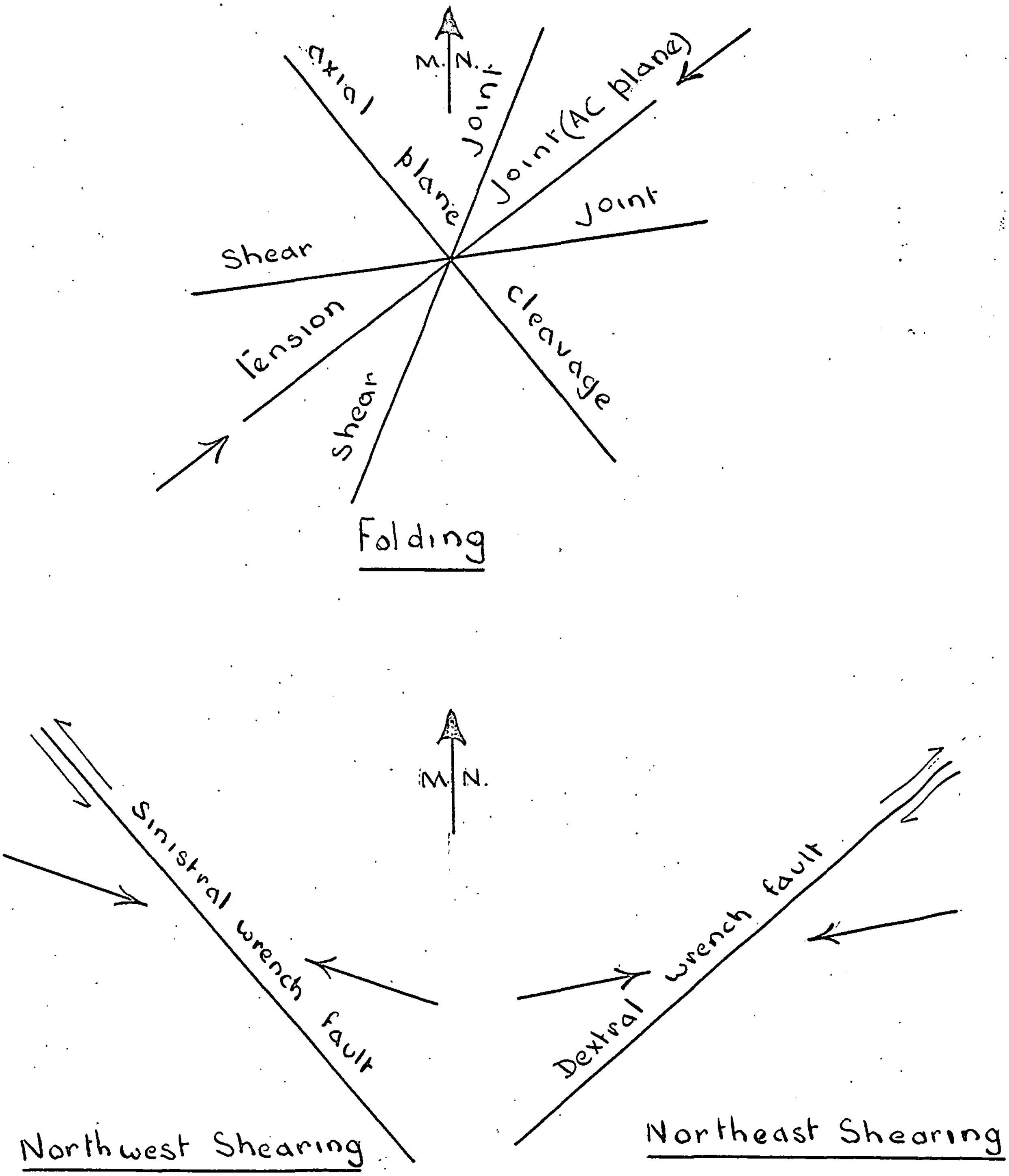
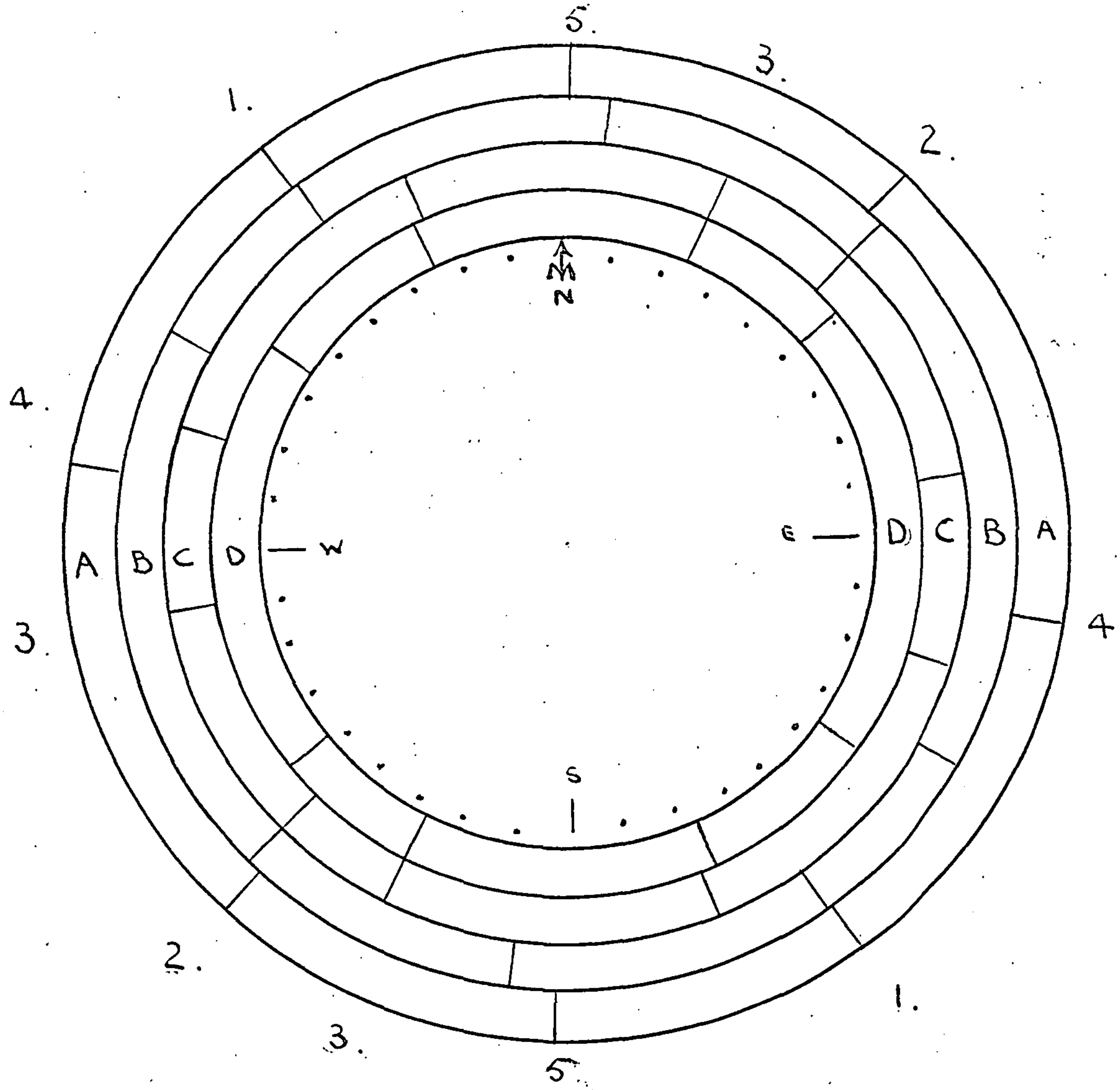


FIGURE 48

Theoretical Stress Systems

Figure 49 Structural Interpretation



A Gold - Quartz lodes

B Air photo lineaments

C Joints

D Stream course directions

1. AB plane of folding (longitudinal joints & cleavage planes)
2. AC plane of folding (tension joints)
3. Shear joints of folding
4. Shear joints of northeast shearing
5. Shear joints of northwest shearing

The north - south lodes known as Loane's, Main, East and Lower West Reefs are problematic. They are cut off in the south by the "Main Slide" but do not bear any obvious angular relationship to this fault even though the mineralisation is related to the fault (see later under "Main Slide and its Relationship to Mineralisation").

If the lodes were shear planes or tension gashes developed by strike slip displacement on this fault, the sense of movement would have been dextral, whereas the evidence of kink banding favours sinistral movement. Sheldon (1928) figures what he terms a fracture cleavage which formed during movement on a fault and made an acute angle with the fault in the opposite direction to the direction of movement on that side of the fault, i.e. similar to the lode/fault relationship being discussed. This is a possible explanation but the lodes do not form a type of cleavage, they are replacement ore-bodies developed in a few major north-south shear zones. Two possibilities are suggested:

1. The Main Slide has suffered both sinistral and dextral movements. There is some evidence for a north - south compression in the presence of open folds striking east - west in the vicinity of the Una Mine and in the Alberton goldfield. The objection to this explanation is that there is no east-west set of shear planes developed to correspond with the sinistral movement.

2. The lodes are pre-existing shear planes unrelated to the "Main Slide" sinistral wrench movement. This is feasible if the lodes were developed on shear planes of the folding but the complementary shear plane of the folding is not a major lode direction even though its strike is a more favourable direction in terms of sinistral movement on the "Slide". In this explanation the shear planes are displaced by fault movement and not developed by it as in the case of the first explanation.

There are objections to both no.1 and no.2 and more data is required before this problem can be solved.

A remarkable feature of these lodes is that they contain very little quartz and are described as differing little from contorted country rock. From this consideration alone they are obviously fault planes and may well prove to be complementary to the "Main Slide". This lode strike is not so prominent in neighbouring mines so the north - south lodes on the New Golden Gate Mine may be a local structure only.

STRUCTURE AND IGNEOUS ACTIVITY

1. Granite. The structural relationship between granite and folding is not evident in the area mapped. It is noted however that folding is more intense in the line of goldfields shear zone and there is a spatial relationship between granite outcrop and shear zone. This relationship could perhaps be extended to embrace the northeast shear planes but the relationship here may be the consequence of post granitic wrench faulting and therefore of no genetic significance. The two directions of shearing viz. NE and NW are also evident in the granitic jointing and so are, in part at least, of post granite age.

2. Mineralisation. The relationship between gold mineralisation and structure has already been discussed. Briefly, the evidence points to a genetic relationship with the shear zone but none with the regional fold pattern. It is also noted that although granitic activity and mineralisation are both considered to be genetically related to the northwest shearing, there is no evidence that they are related to each other.

3. Dolerite. Fingal Tier and Mt. Nicholas Range are separated by the Break O'Day - South Esk lineament. Faulting is considered to have occurred on this line during the Taberraberran orogeny as the

goldfield line (shear zone) cannot be traced south of the river. Faulting probably also occurred on this line during the Jurassic - Tertiary epeirogeny (see under "Post Taberraberran Faulting"). It is probable, therefore, that the emplacement of these dolerite masses was influenced by this lineament. With regard to the dolerite monadnocks of the goldfields area there is a spatial relationship between them and northeast shear lines which suggests that they are discrete sills or dykes which have been fed by intrusion along these ancient faults.

4. Basalt. The basalt outcrops are similarly related to these northeast shear planes. Several occurrences have features indicating proximity to point of eruption and their spatial relationship can therefore be considered. A basalt flow extends from Avoca up the South Esk valley for $2\frac{1}{2}$ miles, up the St. Pauls River Valley for several miles and down the South Esk valley to Conara and beyond and is probably continuous with the Basalts of the Campbelltown - Ross district. Krause (op. cit.) states that in boreholes at Corners (Conara) 90 feet of scoriae and tuff were exposed and at Avoca 75 feet of basalt are exposed between township level and the South Esk River, it is not known what thickness of basalt lies below river level. The basalt occurs only on the South bank of the river except at the easternmost limit of the flow where it is found on the north bank. The present South Esk River course is therefore a lateral stream. The basalt flow is of limited extent, it is confined to the river valley or more precisely it is confined to the old river channel. This channel should therefore occur immediately to the south of the present river channel.

Edwards (1938) suggested that the basalt dammed back the drainage of the South Esk and St. Paul's Rivers for a period giving rise to lakes which slowly spread over the basalts until the waters finally escaped over its surface.

Nye (1926) used the basalt as an arbitrary datum for subdividing the Tertiary Era into upper and lower subdivisions. Subsequently Nye and Blake (1938 op. cit. p.26) correlated most of the basalts of Tasmania including the South Esk flow with the Newer Volcanic Series of Victoria. Edwards (1938 op. cit.) agrees with this on the grounds that a lower basalt surface would not have remained level up to present day as has the South Esk basalt. Reid and Henderson (1929 op. cit.) suggested that the South Esk valley basalt found its way to surface through narrow fissures coursing parallel to or perhaps coincident with lines of upper mesozoic faulting on the grounds that volcanic centres were absent and the basalt was confined to narrow strips. The strips are not significant however as the form of a confined basalt flow is dependent on the topography.

b. At Dublintown and Germantown approximately four miles north of St. Mary's, basalts occur as hill cappings on Permian sediments. They are obviously of local origin and were probably extruded from nearby vents but there is no evidence for fissure eruption. The two basalts are separated by Gould's fault, the Germantown basalt being 205 feet higher than the Dublintown basalt. If these occurrences are remnants of one flow their extrusion must predate the faulting. These occurrences lie close to the South Esk - Break O'Day lineament.

c. Sheoak Hill. An outcrop of basalt three miles long and 100 to 1,000 feet wide occurs on the east bank of the South Esk River approximately halfway between Fingal and Mathinna. The trend of this outcrop is 060^{o}m and the line if extended easterly follows the course of the upper reaches of the Avenue River, the ridge of Scamander Tier and parallels the coastal configuration at St. George's Bay. Westerly, this line passes through the Mangana goldfield where an inferred northeasterly trending fault plane is shown on the geological map. Further west this line is probably continuous with one of the faults mapped by Blissett (1959 op. cit.).

d. Ringarooma Valley. The basalts of the Ringarooma River valley have been mapped in detail by Nye (1925) and Nye and Blake (1938) gave a post Miocene, probably Upper Miocene age for them. Edwards (1938) states that this is in agreement with the youthful profile of the basalt plain. In the Ringarooma area three outcrops of basalt occur on remnants of the pre Permian surface. These are: i) Olive Rise, probably a volcanic centre as indicated by the coarse grained nepheline basalt covering it and its prominent position and relationship to the flow (see Geological map). ii) Grey's Hill, considered by Nye and Blake (1938 op. cit.) to be an earlier flow on to a pre Miocene surface. They place periods of uplift faulting and tilting, 1,000 ft. of erosion, 350 ft. of depression and Miocene sedimentation between the Miocene and Pliocene-basalts. iii) Kapai Hill is portion of the upfaulted Mt. Horror block. Near its summit Mathinna Beds are overlain by cobbles of waterworn vein quartz at an elevation of approximately 1,000 feet above the level of the Ringarooma River. This material is considered to have been derived from basal Permian beds by comparison with a similar mantle on Mathinna Plains. The alternative interpretation involves upfaulting of Tertiary gravel which appears unrealistic.

The question of whether these occurrences were extruded at high level or upfaulted is bound up with the ages of faulting and of volcanic activity. The more recent view is that volcanicity and faulting occurred throughout the greater part of the Cainozoic (Spry p.278 and Solomon p.338, 1962 op. cit.). These hills musthhave attained their present altitude prior to the basalt extrusion and so were capped by separate flows. There is a lithological difference between these basalts viz. the valley flow is a fine grained nepheline basalt (Edwards 1950 op. cit.) while that on Greys Hill and Kapai Hill is a normal olivine basalt so they probably belong to different periods of extrusion or at least separate flows.

e. The Forest Lodge occurrence consists of several isolated outcrops of dense olivine basalt which are colinear with the Weldborough Pass - Mt. Littlechild basalt outcrop. In the Forest Lodge area east of Cotton Plain is an arched outcrop of sandstone containing pebble and grit bands and resting on granite (figure 50). This is correlated with basal Permian beds resting on Mathinna Beds on Mathinna and Cotton Plains. This outcrop occurs at the western end of the Blue Tier - Weldborough - Forest Lodge line of basalt and the abnormal dip of the sediments was probably caused by volcanic activity. The unusual mineralogical and textural characters of some of these basalts suggest a degree of differentiation prior to extrusion which argues a proximity of volcanic vent. This conclusion was reached by Marshall in respect of similar rocks at West Scottsdale. It is also noted that alkaline dolerites at Stanley and Table Cape are close to volcanic centres (Spry 1962 op. cit.).

5. Basalt and dolerites. That the emplacement of basalts and dolerite has been controlled by the northeasterly faults is borne out by the frequent association of both rock types as on Greys Hill, Kapai Hill, Sheoak Hill basalt dyke and Forest Lodge. Banks (1958 op. cit. p.236) refers to basaltic dolerite dykes of Tertiary age and to dolerite dykes (of Jurassic age?) genetically associated with Tertiary basalts so the association is widespread and may be significant with regard to structural trends i.e. repeated use of the same channelway by igneous activity of different ages. It is significant that some of these basalt/dolerite dykes occur on Taberraberran shear planes notably the Mt. Littlechild (Blue Tier) - Forest Lodge - (Olivers Hill?) fault/dyke and the St. Helens - Sheoak Hill - Mangana - Aberfoyle fault/dyke.

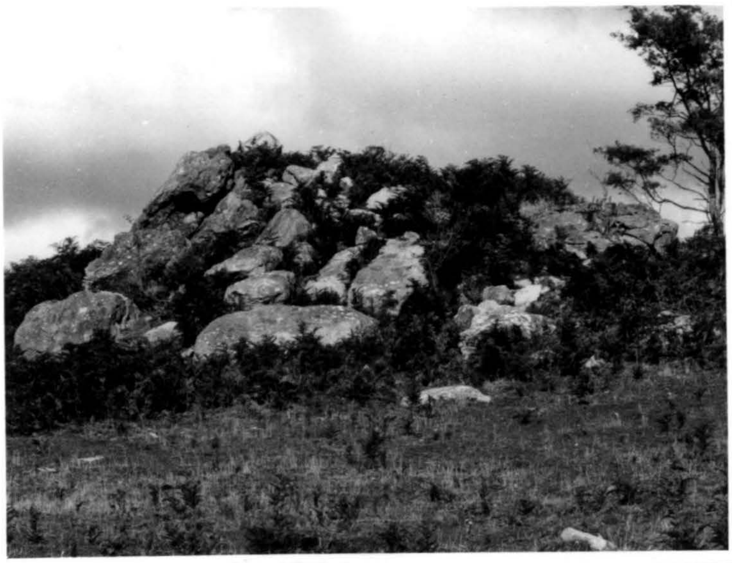


Figure 50: Arched basal Permian beds resting on an eroded granite surface. Vicinity of Forest Lodge. Beds on the left of the photograph are dipping 50^{o} to the left - note line of quartz pebbles indicating bedding. Beds in the centre dip towards observer. Beds on the right are horizontal. The abnormal dips are attributable to either proximity of volcanic vent or dolerite intrusion.

Post Taberraberran Faulting. Structural contours of the Mathinna/Permian plane of unconformity have been constructed from Aneroid spot heights. Levels were taken at all exposures of the unconformity and on the exhumed surface which was assumed to represent the same horizon within the limits of accuracy of the instrument used. The major Post Permian fault movements were detected by this means (figure 51). It was not possible to use a marker horizon within the Permian succession as most of the beds have been removed by erosion. The use of the unconformity as a marker is only justified if it is a near perfect plane. This assumption has been made with respect to the Mathinna Beds where variations in thickness of Permian beds from base first marine marker are less than 100 feet. This is not so on granites, where in places thicknesses of Permian beds differ by as much as 300 feet. The area of this map includes the South Esk and Break O'Day Valleys as well as the goldfields area because it was possible to determine the height of the unconformity more precisely in this area. The dip of the unconformity was estimated to be approximately $1\frac{1}{2}^{\circ}$ (150 feet/mile) to the south east.

Between Fingal and the Cotton Plain escarpment there is only an elevation difference of the unconformity of 1,800 feet or 56 feet/mile. The disparity between these two dips, actual and regional, is the result of some thousands of feet of faulting with downthrow to the north.

Several of these faults are coincident with Taberraberran faults and may represent later movements on pre-existing planes of weakness.

A longitudinal NNW - SSE section (figure 52) has been drawn to illustrate these fault movements and where the location of the pre Permian surface is unknown, a broken line is shown in such a position as to indicate minimum fault displacements.

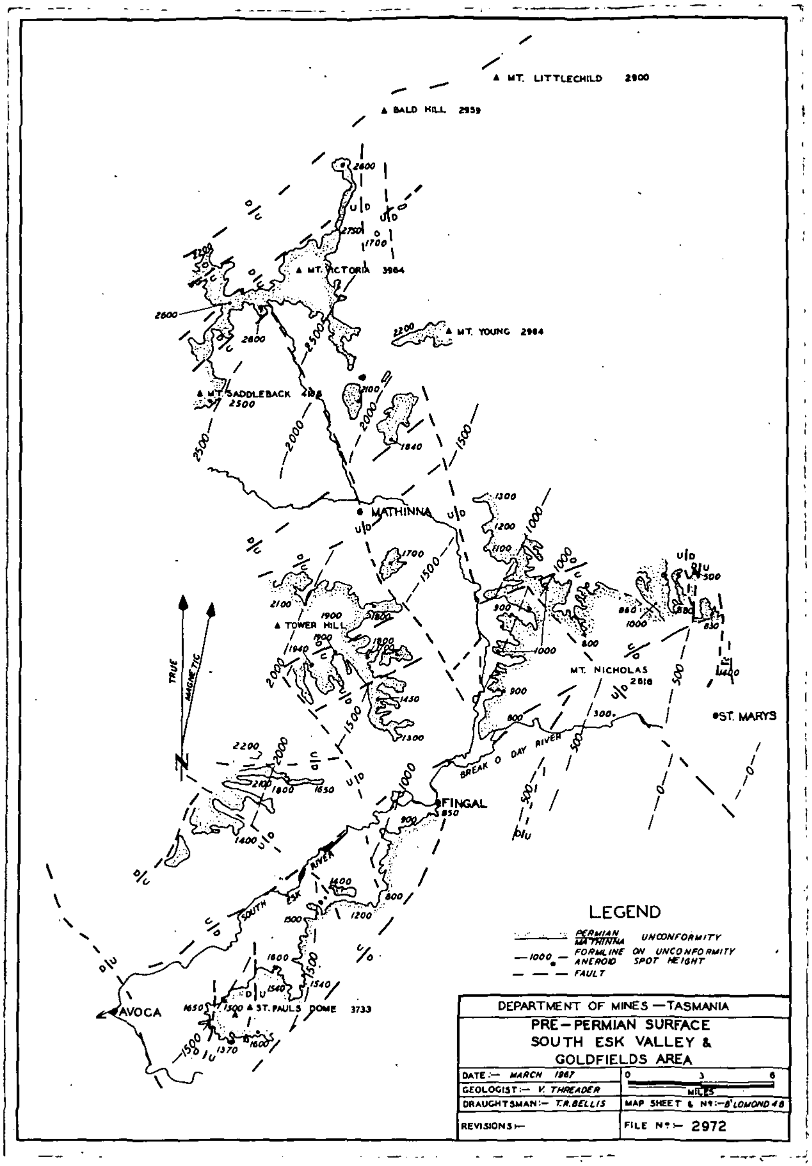

MT. LITTLECHILD 2900
BALD HILL 2959
MT. VICTORIA 3964
MT. YOUNG 2984
MT. SADDLEBACK
MATHINNA
TOWER HILL
MT. NICHOLAS
ST. MARYS
FINGAL
BREAK O DAY RIVER
SOUTH ESK RIVER
AVOCA
ST. PAULS DOME 3733
TRUE
MAGNETIC
LEGEND
PERMIAN MATHINNA UNCONFORMITY
FORMLINE ON UNCONFORMITY
ANEROID SPOT HEIGHT
FAULT
DEPARTMENT OF MINES — TASMANIA
PRE-PERMIAN SURFACE
SOUTH ESK VALLEY &
GOLDFIELDS AREA
DATE:— MARCH 1967
GEOLOGIST:— V. THREADER
DRAUGHTSMAN:— T.R. BELLIS
REVISIONS:—
MILES
FILE No:— 2972

Figure 51

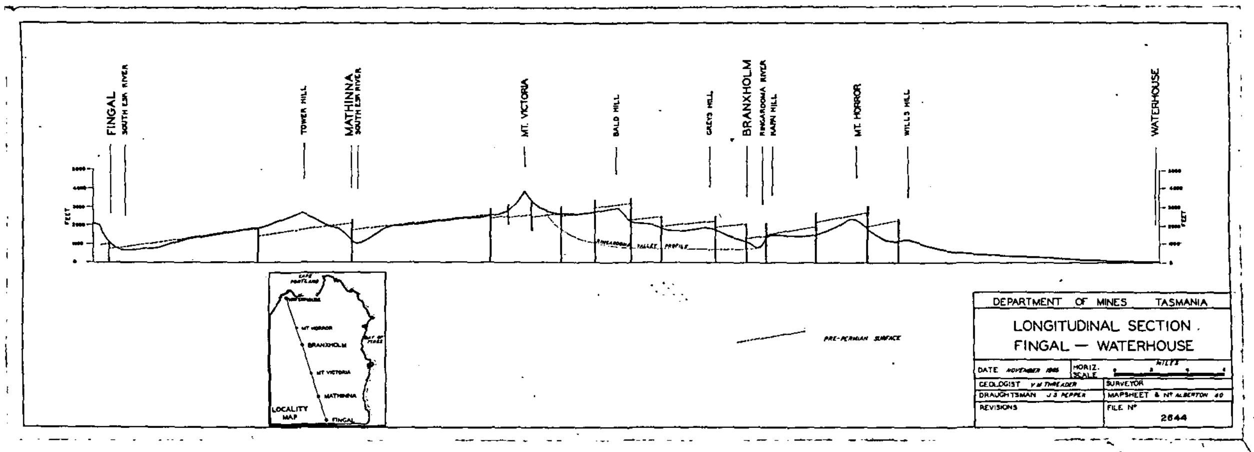

FINGAL
SOUTH ESK RIVER
TOWER HILL
MATHINNA
SOUTH ESK RIVER
MT. VICTORIA
BALD HILL
GREYS HILL
BRANXHOLM
RINGAROOMA RIVER
KAPN HILL
MT. HORROR
WILLS HILL
WATERHOUSE
FEET
PRE-PERMIAN SURFACE
LOCALITY MAP
DEPARTMENT OF MINES TASMANIA
LONGITUDINAL SECTION.
FINGAL — WATERHOUSE
DATE
HORIZ. SCALE
MILES
GEOLOGIST V M THREADER
SURVEYOR
DRAUGHTSMAN J S PEPPER
MAPSHEET & Nº ALBERTON 40
REVISIONS
FILE Nº
2644

Figure 52

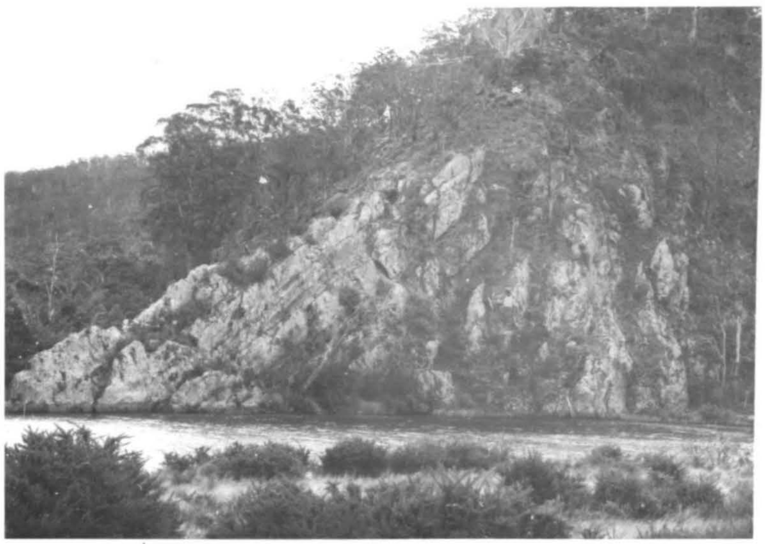


Figure 53: Fault truncated spur, South Esk River with Ormley broadwater in foreground.

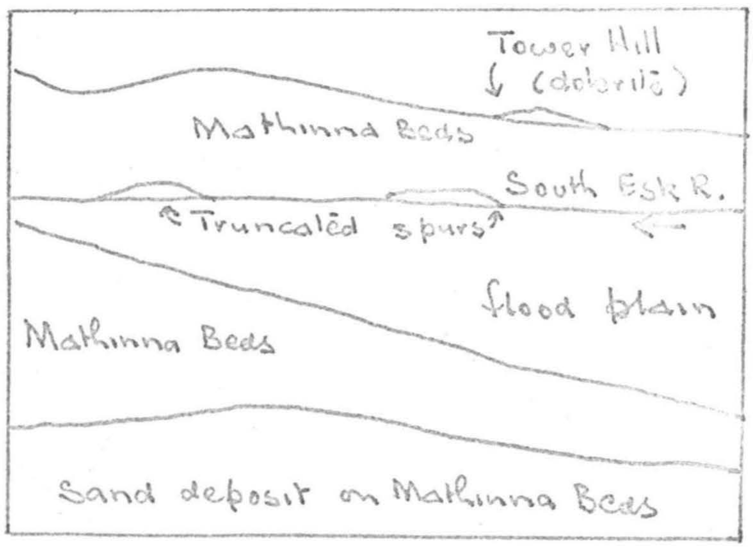


Figure 54: View across the South Esk Valley at Ormley from west bank of Rostrevor Creek. Sands in the foreground occur 400 ft. above present river level and 700 ft. below Permian beds outcrop. The deposit is probably a remnant of a downfaulted block of Permian sediments.

The distribution of Cainozoic gravel deposits, which are derived by weathering of Permian sediments is determined by the location of fault troughs between upraised blocks. On the geological map (figure 57) the location of marsh lands in the north of the map suggest that the Tomahawk and Boobyalla Rivers are situated in fault troughs. It is in these low lying areas that the most extensive gravel deposits occur. It is suggested that this interpretation applies equally to the gravel deposits of the remainder of the north east of Tasmania and also to Beaconsfield-Frankford in the West Tamar district.

Immediately to the north of Mt. Victoria is a 1,600 ft. escarpment. The section line (figure 52) indicates the continuation of the surface through Bald Hill, Greys Hill etc. which lie to the east of the Ringarooma River. There is no trace of the surface north of Warrentinna but Permian sediments at Gladstone indicate that the whole of the area was probably underlain by a continuous Permian cover prior to the post Cretaceous planation.

Faults other than those indicated by discontinuities of the plane of unconformity are suggested by air photo lineaments. This is particularly noticeable along steeply dipping river banks with truncated spurs as at Ormley and Tullochgorum (figures 53 and 54). Many of the faults strike roughly N - S but the northeasterly and northwesterly trends are also represented; in places they are coincident with known Taberraberran faults, indicating reactivation of these ancient fault planes.

The ages of post Taberraberran fault movements probably cover a wide range. Banks (1958 op. cit. p.237) gives the ages as pre-dolerite to Miocene. Several Jurassic faults are known in the Fingal and Cornwall coalfields but they are due to the dilatational effects of dolerite sills. (Carey 1958 and De Sitter 1965 - after McGregor).

These faults only affect the beds above sills and are unrelated to structural trends as they are determined solely by the location and thickness of the dolerite.

Banks (1958 op. cit.) records the following trends:

pre dolerite faults 296, 025, 032

dolerite dykes 338, 357, 013, 028

dolerite joints 357, 323

Tertiary faults 321

Minor Tertiary faults 304

Maxima Tertiary faults 347

(Banks recorded true bearings, the figures given above have been converted to magnetic bearings by subtracting 12°). The principal Tertiary fault maximum is the same direction as the principal Taberraberran structure viz. 320°m which is the regional fold trend and the strike of the major shear planes. The Taberraberran northeast shear planes approx. 050°m are entirely absent from the Jurassic and Tertiary trend maxima of Banks. Faults on the northeast trend have been mapped in adjoining areas: Rossarden - Storeys Creek (Blissett 1959 op. cit.), Launceston area (Carey 1946 & Longman 1964), Scamander - St. Helens (Walker 1957), Beaconsfield (Green 1959 op. cit.). They are subordinate in number to northwesterly trending faults, and in every case, in the area studied, are co-incident with Taberraberran faults. It may be that northeasterly trending Tertiary (or Jurassic) faulting did not occur except on the pre-existing fault planes. Levels on the pre Permian surface reveal a displacement on the goldfields line of 400 feet in the Mangana goldfield 300 feet at Tower Hill and 200 feet in the Dan Rivulet goldfield. In these fields it has been noted that the Lutite (lower) association of the Mathinna Beds is more widespread on the west side i.e. in the upfaulted block.

So much so in fact that lutite outcrop areas are too extensive to indicate anticlinal hinge zones of the folding.

The Drainage Pattern and Structure. During the Cretaceous-Eocene denudation, a radial drainage pattern was developed on the flanks of the dolerite monadnocks as the Permian and Triassic cover was being stripped from the older rocks. This consequent drainage became superimposed on the Mathinna Beds and is still evident in the pattern of the second order streams (figure 47). The goldfield line is delineated over part of its length by major watercourses. This is particularly striking in the Alberton and Dan Rivulet goldfields (figure 42).

The Ringarooma River, between Ringarooma and Branxholm continues approximately on the same line. Over this stretch, the river is a basalt lateral stream; the pre basaltic course, being the structurally determined one, probably formed a continuous lineament with the Dorset River at Alberton. Further south, the Mangana goldfield is similarly delineated by Tower Rivulet. The remainder of the goldfields line lies in upfaulted blocks, it is probable therefore that pre faulting drainage followed the line of Mathinna and Tower Hill goldfields also.

The structural contours of the pre Permian surface confirm that the Mathinna - Tower Hill block is upfaulted and that the river to the north and east is situated on a fault.

The goldfields line south of the South Esk River may be represented by Tullochgorum or Rostrevor Creeks but no mineralisation has been recorded there and the Mathinna Beds are largely overlain by Permian and Triassic sediments.

The remainder of the goldfields line i.e. from Branxholm to the coast is also upfaulted ground. *Warin (personal communication) has suggested that the elevated country from Kapai Hill to Mt. Cameron is

* (O. Warin - Utah Development Co.)

a northeast striking Tertiary host. An alternative step faulted interpretation is shown in the longitudinal section (figure 39) but the effect is the same, namely diverting the Ringarooma River at Branxholm from a northwesterly course to its pre basaltic northeasterly course which is determined by the form of the granite mass to the east. This course is parallel to the general trend of northeast lineaments (shear direction).

The South Esk River is joined by the Break O'Day River at Fingal and flows southwesterly along the line of the northeast shear direction. There has been no continuous movement along this direction in later times but faulting has occurred across the line of the river(s) in several places while elsewhere the structural contours remain unbroken across this line.

The Break O'Day River valley widens in an easterly direction while the flow is westwards and its flood plain in the vicinity of St. Marys is considerably wider than the South Esk River valley. It is suggested on this evidence that the flow was originally in an easterly direction prior to faulting or tilting. Thismovement presumably occurred late in the Cainozoic Era to account for the maturity of the valley. It is suggested that the drainage reversal was caused by elevation of the coast range east of St. Marys. As this range is probably the consequence of movement on Cornwall and Gould's faults, it appears likely that these faults are of late Cainozoic age, and it has been suggested elsewhere that these faults are of post basaltic age. Such a flow would have had an average gradient of 50 feet per mile from Fingal to the east coast. The present gradient is 7 - 8 feet per mile from Fingal to Launceston. The easterly drainage would therefore have been more vigorous than the present flow and consequently the valley would be wider.

Further evidence to support this is the presence of several lakes in the vicinity of Fingal and Frodsly which occur in the South Esk and Break O'Day Rivers (figure 51) but with dolerite bars at their present upstream ends and meandering courses at their downstream ends. This feature could only result from drainage in an easterly direction. The South Esk River west of Fingal must then also have flowed eastwards. The upfaulted St. Paul's Dome - Aberfoyle block probably had formed a drainage divide and drainage reversal was effected by a combination of upfaulting at St. Marys and river capture at Avoca.

Adjustment of drainage to Mathinna beds structure is indicated by prevalence of the 020 shear direction, of the folding, and to a lesser extent by the longitudinal and cross (AB and AC) jointing 150° and 050°. An indirect adjustment is also evident in the geomorphological expression of the lutite outcrops of the anticlinal fold cores. Rivers meander over the lutite outcrops and form rapids over the arenite beds. This has been noted in the Boobyalla River (9410N/5660E) and in the South Esk River (8939N/5630E) and possibly also (8779N/5818E). A meandering stretch of the South Esk River between Mathinna and the Evercreech Rivulet confluence is possibly due to another anticlinal axis but faulting of Tertiary age crosses the river here and may have been responsible by temporarily damming the river. Anticlines are indicated by broad lutite areas also in the Winnaleah farmland area and on the west bank of the South Esk River south of the Evercreech Rivulet where it has, due to its softness and east of weathering, contributed to the width of the flood plain.

Regional Structure. In the Beaconsfield area, a number of dextral transcurrent faults were described by Green (op. cit.).

These faults had a strike of 060^{o}m and Green put a maximum displacement of 1,000 feet on them and stated that they were confined to the central west portions of the Beaconsfield map square. More recent work has shown that this faulting is much more extensive. There are approximately four miles of dextral displacement of Ordovician beds in a ten mile distance between Beaconsfield and Frankford (Dept. Mines Plan 2629-30). The extensive Tertiary gravel deposits of this region indicates, as already suggested that these faults have undergone movement in Tertiary times causing a redistribution of the early Tertiary products of peneplanation.

The strike slip displacements based on an interpretation of the distribution of lodes (figures 42b and43) between Forester and Mangana are estimated to be of the orderof eight miles. The similar displacements recorded in the Beaconsfield - Frankford area, when projected easterly along the fault strike, would lie north of the goldfields belt and they probably represent additional movements which occurred at the coast or in Bass Strait i.e. north of the known goldfields.

Mass transfer of material as is envisaged here, i.e. without compensating movements on any of the shear planes, suggests sympathetic movements parallel to a master shear.

It is noteworthy that structures in the Waterhouse district (Blake 1947) and those on Cape Barren Island strike in a northeasterly direction, which points to the effects of shearing as has been noted in the goldfields area. There is therefore a probability that large scale shearing of dextral sense has occurred between the Tasmanian coast and islands of the Furneaux group. The lineament formed by the line of the northeast coast also suggests this and the belt of granitic rocks and associated basic intrusives in Flinders and Cape Barren

Islands may once have been continuous with those in northeastern Tasmania (see Figure 55 and Structural Map of Tasmania 1960).

Structural History. 1. Folding on a NNW-SSE trend combined with shearing on a parallel direction and shearing at right angles. Recurrent movements on these two directions is inferred but that on the regional fold trend is in the main earlier and probably occurred during the final stages of folding.

2. Intrusions of granites and gold mineralisation.

3. Intrusion of Jurassic dolerite as small isolated dykes and sills on northeast shear lines.

4. Epeirogenic movements on both ancient shear lines during Jurassic and Tertiary times.

5. Extrusion of lavas during Tertiary times, as isolated flows along northeast shear lines.

The folding and shearing are correlated with the Taberraberran orogeny of Victoria (Solomon 1962 p.323). Turbidity current activity commenced during the closing stages of deposition of the lower (lutite association) Mathinna Beds and continued throughout the deposition of the Upper (arenite association) Mathinna Beds (see pp.14 and 15). These currents were probably initiated by unstable conditions on the continental shelf; they may have been caused by subaqueous slumping unrelated to diastrophism but the evidence of their increasing frequency during sedimentation suggests that the opening phases of the orogeny which culminated in uplift, folding and shearing, initiated them.

The following evidence of recurrent shear movements has been noted:

1. Kink banding south of Mathinna Beds in Mullens Creek (inset on Geol. map Figure 57) indicates that there has been recurrence of

Key to lineaments on figure 55

1. Tasmania - Furneaux Group (NW)lineament)
2. Cotton Plain - Eddystone Point
3. South Esk Valley
4. Tamar valley
5. Goldfields lineament
6. Tasmania - Furneaux group (NE lineament).

(Note the similarity to the network of shears proposed by F.A. Vening Meinesz (1947) "Shear Patterns in the Earth's Crust". Trans Amer. Geophys Union Vol.28 1-61).

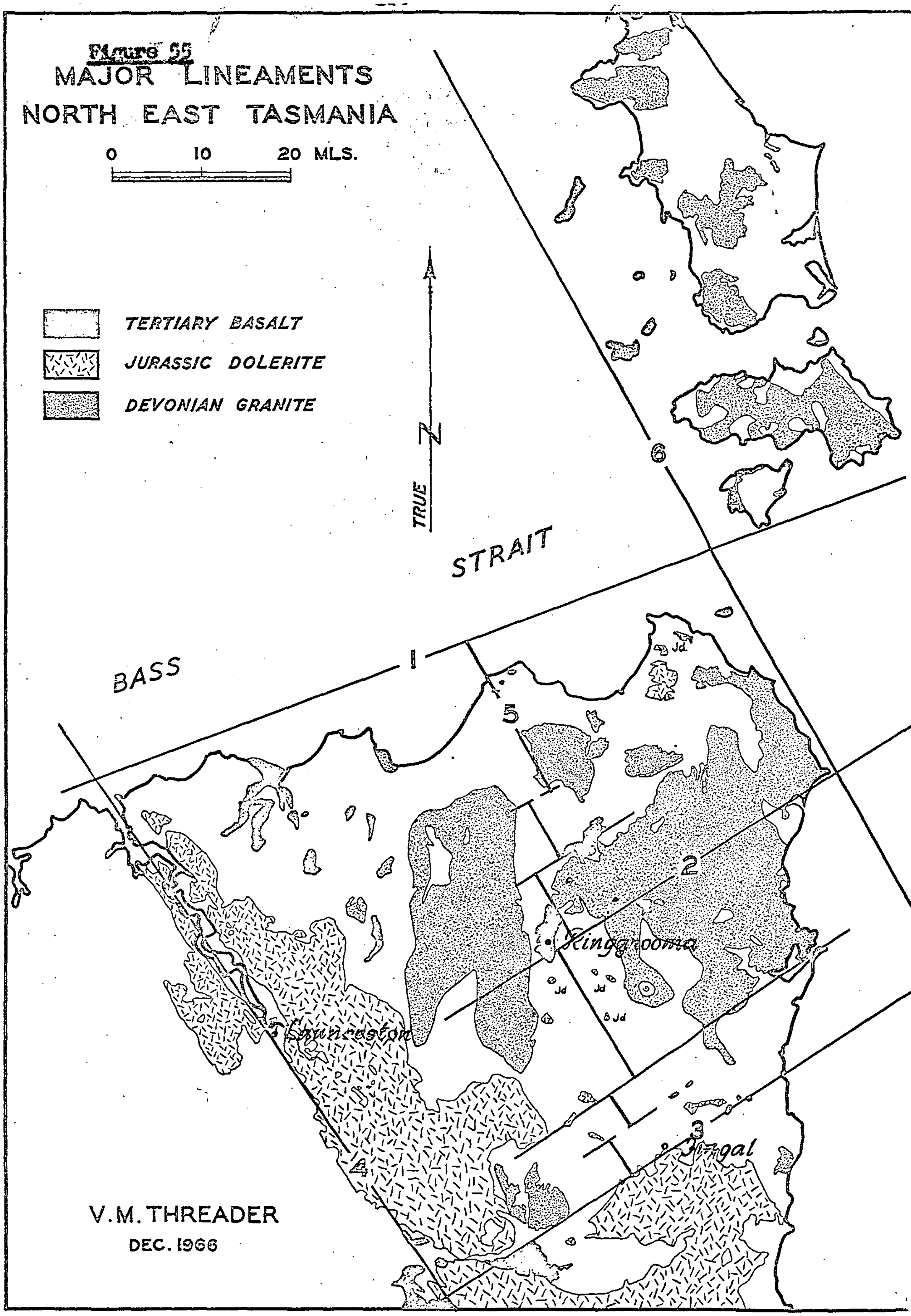


Figure 55
MAJOR LINEAMENTS
NORTH EAST TASMANIA
0 10 20 MLS.
TERTIARY BASALT
JURASSIC DOLERITE
DEVONIAN GRANITE
TRUE N
BASS STRAIT
1
2
3
4
5
6
Jd
Ringarooma
Launceston
Fingal
V.M. THREADER
DEC. 1966

northwest shearing after the northeast shearing.

2. In somepolished ore specimens from the New Golden Gate mine, gold fills fissures in sheared arsenopyrite grains (figure 56).

3. Jointing in granitic rocks is parallel to pre-granite faulting.

4. The strike slip displacement of mineralised areas on northeast striking shear planes appears to be less than that of fold axes. This suggests a pre-mineralisation movement on these planes.

Hills (1945) referred to structures which utilised pre-existing planes of weakness as "consequent tectonics" - by analogy with consequent drainage. There are many convincing examples of this in Australian geological structure: 1) The Tertiary faulting in the Shatter Belt of South Australia follows almost exactly Cambrian and Pre-Cambrian structural lines. 2) In the Kimberley area of Western Australia Permian, Devonian and Pre-Cambrian structures all follow the same trends even though each of these groups of rocks is separated from the other by an unconformity. In the same area numerous Leucitite plugs are aligned on the same trend. 3) In Victoria, ancient strike slip faults have displaced Pliocene basalt, Palaeogene auriferous gravels, and, in the case of Selwyns Fault, to havecaused an earthquake in recent years (Hills 1961). Recurrence of movement on the two sets of shear planes is considered by the author to be of great importance in the geological history of the goldfield area.

ECONOMIC GEOLOGY

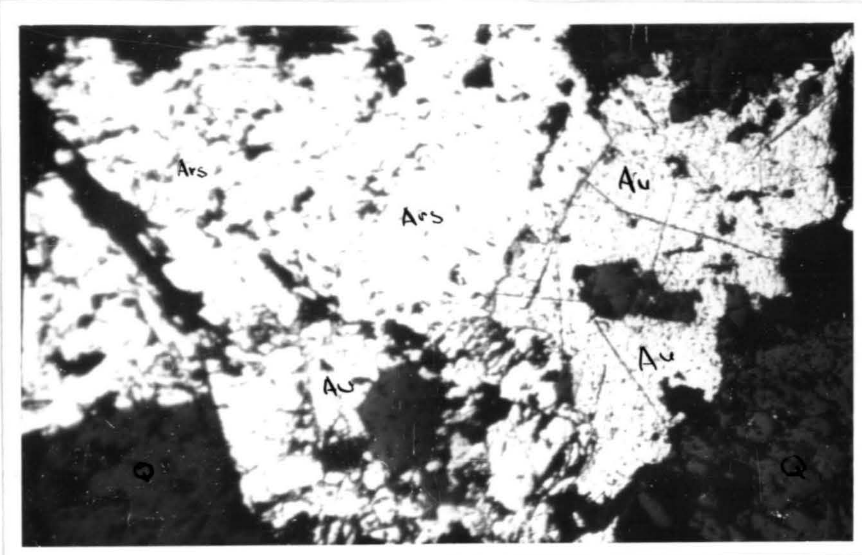
The Ore Minerals. Twenty four polished ore specimens were examined under reflected light and the following table summarises the mineral contents and relationships. Owing to the fact that the fields are now defunct, it is difficult to obtain suitable material for a mineragraphic study, but certain deductions regarding mineral paragenesis, temperatures of formation and ore genesis appear justified.

Polished Section Descriptions

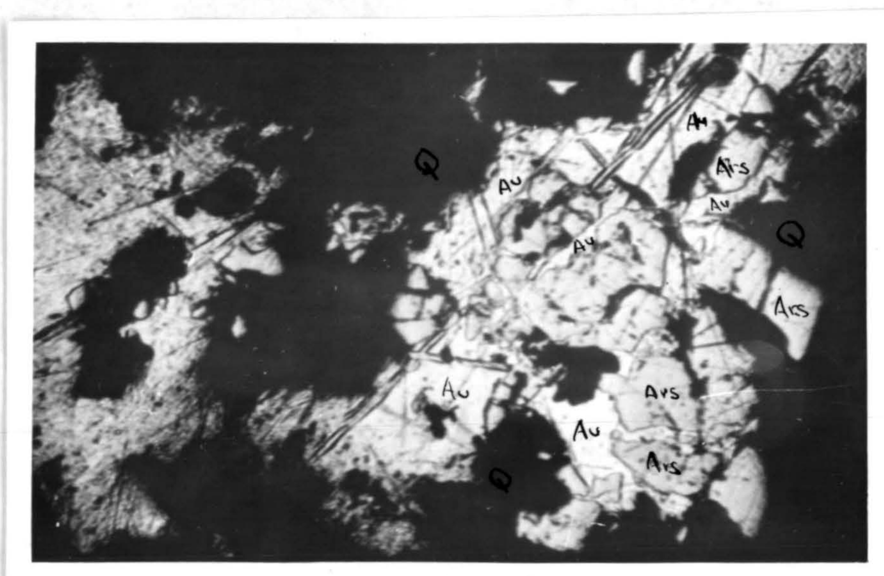
No.	Locality	Ore Minerals present and important Relationships
1	New Jubilee Mine	Pyrite enclosing sphalerite. Sphalerite enclosing chalcopyrite. Galena.
2.	New Golden Gate Mine, Mathinna	Arsenopyrite, chalcopyrite, Galena, Sphalerite.
3.	Royal Standard Mine, Gladstone	Stannite containing exsolved chalcopyrite, Marcasite, Pyrite.
4.	Volunteer Consolidated	Arsenopyrite enclosing chalcopyrite and gold.
5.	Victory Mine, Mt. Victoria (possibly Mt. Victoria Mine, Alberton or Mt. Victoria Goldfield.	Gold, Arsenopyrite.
6.	Pennefathers Shaft, Alberton.	Gold.
7.	West Volunteer Mine, Lefroy.	Pyrite, Arsenopyrite, Chalcopyrite, Tetrahedrite.
8.	New Jubilee Mine	Arsenopyrite (very fine grained) Pyrite (occasional grains)
9.	Mercury Mine, Alberton	Arsenopyrite as separate grains and within gold.
10.	Premier Mine, Alberton	Pyrite enclosing chalcopyrite.
11.	New Panama Mine, Golconda.	Covellite occurs as separate grains and also within arsenopyrite. Chalcopyrite (very little).
12.	New Imperial Mine	Arsenopyrite, pyrite and covellite.
13.	Royal Standard Mine Gladstone.	Arsenopyrite.

Polished Section Descriptions Contd.

No.	Locality	Ore Minerals present and important Relationships
14.	Golden Crest, Golconda	Colloform banding and stock work texture in pyrite. Marcasite.
15.	Central Ringarooma Mine Alberton.	Few Arsenopyrite grains.
16.	Una Mine, Dan Rivulet	Arsenopyrite, pyrite, chalcopyrite, gold
17.	Jubilee Mine, Mathinna	Arsenopyrite, enclosing tetrahedrite and gold enclosing arsenopyrite.
18.	Lady Mary Mine, Dan Rivulet	Arsenopyrite, covellite (a little).
19.	New Golden Gate Mine Mathinna	Shattered arsenopyrite enclosing gold (figure 56a)
20.	Golden Entrance Mine Mangana.	Limonite, gold.
21.	Waterhouse	Gold lining fractures in arsenopyrite and arsenopyrite in gold (figure 56b).
22.	Gladstone	Arsenopyrite, tetrahedrite, gold.
23.	Mt. Horror arsenopyrite lode.	Fractured arsenopyrite
24.	Fault gouge from Golden Hinges adit.	Quartz, haematite and crushed rock (cf. description of thin section 65-9).



Specimen from Waterhouse goldfield (Tasmanian museum collection) showing arsenopyrite and gold in quartz (x 50).



Gold in fractured arsenopyrite. New Golden Gate Mine, Mathinna. (x 50).

Only seven sulphide minerals were observed in the sections examined and the order of abundance is:

arsenopyrite	(in 17 polished sections)
pyrite	(" 8 " ")
chalcopyrite	(" 8 " ")
covellite	(" 3 " ")
sphalerite	(" 2 " ")
galena	(" 2 " ")
marcasite	(" 2 " ")
tetrahedrite	(" 2 " ")
stannite	(" 1 " ")

The mineral assemblage in individual ore specimens is simple and only four of the sections examined contained more than three sulphide minerals. The following associations were detected:

i. sphalerite enclosing chalcopyrite

ii. stannite containing exsolved chalcopyrite

iii. arsenopyrite enclosing chalcopyrite

iv. pyrite enclosing chalcopyrite and sphalerite

v. arsenopyrite enclosing covellite and sphalerite

vi. arsenopyrite enclosing tetrahedrite.

vii. arsenopyrite in contact with pyrite

viii. arsenopyrite enclosing gold.

ix. gold enclosing arsenopyrite

From this evidence, it appears that the order of deposition is: chalcopyrite, stannite and sphalerite, tetrahedrite, covellite, pyrite and arsenopyrite. There are no indications with regard to galena or marcasite. Gold was probably the last to crystallise but there was overlapping of periods of deposition of gold and arsenopyrite and arsenopyrite was found locked in grains of gold (nos. 9, 17 and figure 56).

<u>The Temperature of Formation</u>. Edwards (1947) made the following sub-division of hydrothermal deposits:

High temperature	600 - 300°C
Medium "	300 - 175°C
Low "	175 - 50°C

He regarded galena, tetrahedrite and stannite as diagnostic of the medium temperature range; these minerals, although not plentiful, were all found in the sections examined.

The exsolution texture: chalcopyrite from stannite (in no.3) has been established by experiment (Edwards p.72) at 500°C. This is not consistent with the presence of marcasite, which Edwards classed as a low temperature mineral, it is unstable above 450°C and converts to pyrite. This anomaly disappears if the marcasite occurs not as a hypogene mineral but as a replacement after pyrrhotite which is a high temperature mineral. This is consistent with the presence of cassiterite and wolfram in some gold lodes in the Gladstone district. These are high temperature minerals and the gold associated with them is obviously a different mineralisation from the silver rich lodes of the Portland Mine.

The Golconda lodes are stated to be near granite contacts or actually within granites, however this is not necessarily evidence for a high temperature of deposition of the mineral content of the lodes. The presence of chalcopyrite in sphalerite indicates a temperature below 350°C which is the unmixing temperature of the solid solution in which sphalerite is the host mineral.

The co-existence of arsenopyrite and pyrite has been shown by Clark (1960) to occur only below 491° (approx.) in the natural environment of ore deposition. These two minerals are both plentiful in the sections examined but only in two were they found to be in equilibrium. The association can therefore be used as a further indicator of the temperature of formation of the lodes. Clark (op. cit.) drew attention to the sympathetic relationship between gold and arsenopyrite in many of the world's gold ore bodies and pointed out that a solid solution of gold in arsenopyrite as low as 0.1% could be of great economic interest as it represents 30 oz/ton of arsenopyrite. He advanced a theory that in many gold ores, gold has been introduced in solution in arsenopyrite. He quotes several examples of gold ores in which gold fills fractures in arsenopyrite or occurs along grain boundaries and suggests that gold comes out of solution with falling temperature and solid diffusion is sufficiently rapid to allow the exsolved gold to migrate to fractures and/or grain boundaries, so that ex solution textures do not develop. Bichan (1947) suggested that in gold ore bodies there are often two ages of deposition of gold: that which crystallised with the sulphides, either in solid solution or locked within sulphide grains and a later accession of gold into zones of fracture.

Edwards (1958) demonstrated that there were two generations of gold in the Maud and Yellow Girl lode, Glen Wills, Victoria. The early gold which was associated with sulphide minerals, had a high fineness and the later crystallised gold which occurred as discrete grains, had a lower fineness. This was explained as being due to the lower melting point of silver which caused it to be excluded from the early gold.

The presence of gold in sulphides and free gold in the specimens examined accords with this theory. In the northern fields: Warrentinna, Forester and Lefroy, the gold was of exceptionally low fineness as shown in the summary of mines data. This is also true for the northern fields outside the area studied. Twelvetrees (1916 p.41) shows that silver values were two to three times the gold value in the Gladstone district. Reid (1926 op. cit. pp.37 & 38) quotes similar gold:silver ratios for some lodes in the Golconda field.

The principal gangue mineral is quartz which is sometimes the white cloudy variety but when gold bearing, is usually dark grey or bluish grey due to finely divided inclusions. Twelvetrees refers to this quartz as the arsenical variety but the inclusions may well be remnants of country rock. The blue quartz is characteristically deposited in sheared ground. This type of lode quartz is well illustrated at Hog Mountain, Alabama; Park and McDiarmid (1964), state that the quartz appears to be under a form of internal stress and weathers to a sugary texture by the development of myriads of fractures. In the goldfields studied the bluish grey quartz is widespread in sheared areas. It is also plentiful in the vicinity of the low angle thrust faults in the Cotton Plain escarpment. A further occurrence of bluish grey quartz in the road section near Ormley railway station may be of significance with regard to the southern continuation of the goldfields line on the south side of the South Esk River.

Montgomery (op. cit.) described quartz in the Main Reef, New Golden Gate Mine as being like loaf sugar in places, elsewhere it was brecciated or slickensided. Highly fractured quartz is also typical of the "Main Slide".

<u>The Gold-Sulphide Relationship</u>. Edwards (op. cit.) recognised four groups of gold ore:

1. Gold - quartz ores in which quartz is the chief mineral and the gold occurs scattered through it. Small amounts of sulphide minerals may be present and a small proportion of the gold may occur locked in these sulphides. Both gold and sulphides tend to be coarse grained.
2. Gold - sulphide ores in which gold is the only valuable mineral. Both gold and sulphides tend to be fine grained.
3. Gold - sulphide ores containing valuable base metals.

4. Gold - telluride ores.

The mode of occurrence of the gold will depend largely on whether the gold was deposited simultaneously with, or subsequent to, the associated sulphides. The ores examined belong to Group 1, gold occurs within sulphides (nos. 4, 9 and 21), and as discrete grains (5, 6, 9, 16, 20, 22). The New Golden Gate production figures indicate that the gold content of sulphides was approximately 9 oz/ton. The average grade of the ore, during the working life of the mine was 3/4 ozs./ton. In the neighbouring Tasmanian Consuls Mine, 12% of the gold was in sulphide minerals (5 oz./tom). The average grade of the ore from this mine was ½oz./ton. In the Golconda field, the gold content of the sulphides was frequently greater than that of the quartz (Reid 1926 op. cit.).

In Group 1 ore movement commonly occurs within the ore body subsequent to the deposition of sulphides but prior to the deposition of gold. This was noted in specimens 19 and 21. The sulphide was severely fractured and the gold occurred as veinlets filling fractures and groin boundaries in the sulphide (figure 56). This fracturing is also evident in quartz grains in sheared country rock from the Main Slide zone (figs. 23 & 26).

Although the bulk of the ores in the Golconda district are low fineness ores (as much as 300 oz. of silver/ton) they are quite different from those already discussed, and are almost certainly a later mineralisation than the main period. Evidence for a high temperature of formation (500°C) of the Gladstone ore has already been given; the presence of low fineness ore in the same field indicates a temperature of formation in the 50°C to 175°C range. It is concluded therefore that gold deposition occurred in at least two periods.

Mode of Emplacement of the Lodes. The Alberton goldfield lodes were described by Hills L. (1923 op. cit.) as being of the fault fissure type. They were characterised by persistence of strike and dip, commonly slickensided and filled with fault gouge. He noted that tension gash veins, joint fillings and saddle reefs occurred also but were uncommon.

Two of the richest lodes in the New Golden Gate Mine Mathinna were Loanes Reef and Main Reef. The following description was given by Montgomery (1895):

"The two lode channels appear very little different from the rest of the country, being filled with broken slate and clayey matter but with little quartz".

In the same report, Montgomery referred to broken and twisted lode slate and to polished and striated surfaces in the lodes and sometimes on the lode wall. Frequently however the lodes did not have definite walls. These descriptions point to the importance of replacement as the principal mechanism of ore emplacement. Cavity filled veins, by contrast, have well defined walls and frequently have highly characteristic textures - crustification, comb structure, drusy structure etc. The characteristic structure of the goldfields lodes is book or ribbon structure (depending on the size and shape of the country rock inclusions). Lindgren (1933 p.170) states that the force of crystallisation detaches sheets of country rock from the walls of veins to produce this structure. McKinstry and Ohle (1949) suggested that it develops by a process of highly selective replacement in sheared zones and state that it is characteristic of replacement ore bodies in many parts of the world including Bendigo, California (Grass Valley, Alleghany and Mother Lode), Kalgoorlie, Western Australia and Porcupine, Canada. It is thus most commonly developed in deep seated mineralisations.

The "Main Slide" and its Relationship to the lodes. The Main Slide was penetrated in underground workings in the New Golden Gate Mathinna. It was 160 feet thick on the 500 feet level and 270 feet thick on the 1,200 feet level, it was made up of several gouge filled shear zones with contorted ground between them. It has also been penetrated by diamond drilling from the surface both north and south of the mine workings and found to be of comparable thickness. The "Main Slide" zone is parallel to the cleavage of the Mathinna Beds (strike 320°m; dip 70°SW) and the principal lodes had a north - south strike and vertical dip. Both faults and lodes were, from their general appearance, produced by shear. Twelvetrees (1906) stated that the fault is the older structure on the evidence that the lodes did not appear to have been displaced by the fault. He recorded that the lodes increased in width and gold content as they approached the "Main Slide" (i.e. to the south) and the "reef" dwindled and disappeared beyond the "slide". Several new lodes were discovered by driving along the footwall of the slide. It is apparent from this that the fault and the lodes are integral parts of the same structure.

Twelvetrees considered that the reefs were developed on opposite limbs of an anticline but Finucane (1935 op. cit.) suggested that "the majority of reefs were related in some way to a belt of close folding which constituted the main structural line of weakness". In the opinion of the writer, this "belt of close folding" marks the "Main Slide" or main shear zone with which the mineralised quartz veins are associated.

Twelvetrees (1914) described a fault striking 050° and dipping 50° to the southeast in the Jubilee Mine workings which was also related to mineralisation. The lodes were strongest in the vicinity of the fault and occurred mainly in the hanging wall zone. This is the only known northeast striking fault which has influenced mineralisation but it indicates that some pre-mineralisation movement occurred on these shear planes as well as on the northwest striking faults.

Lodes from other parts of the Mathinna goldfield are similar to those from the New Golden Gate Mine. Montgomery (op. cit.) refers to "the constant occurrence of lode slate wonderfully contorted by pressure" in the Old Boys Mine in the west of the goldfield. A "slide" is described in this mine, which is roughly parallel to the "Main Slide" in the New Golden Gate Mine. The goldfield as a whole probably consists of two or three parallel major faults which constitute one shear zone.

The Mathinna goldfield lies in an upfaulted block, whereas the Mangana, Dan Rivulet and Alberton fields are delineated by major watercourses. It is conceivable therefore that the major shear zone in these fields lies beneath the flood plains and has not yet been prospected.

Secondary enrichment. It has been argued by previous workers in the field that certain characteristics of the lodes can be explained in terms of secondary gold enrichment. Twelvetrees (1907 p.10) suggests that the exceptionally rich gold (39 oz./ton) near the surface at the Golden Entrance Mine Mangana is the result of solution and reprecipitation. He records that oxidised parallel partings are usually gold bearing. Specimen No.20 is typical of this type of ore, it is rich in coarse gold and the matrix is almost exclusively limonite. Blake (1939 op. cit.) states that no economic mining was carried out below 200 feet from the surface in this field. This limit was presumed to be the water table below which only primary ore occurred.

Twelvetrees (1906 op. cit.) quoted battery returns from the New

Golden Gate Mine Mathinna which showed a slight decrease in the gold/silver ratio over a period of thirteen years. This was taken as representing a decrease of silver content with depth and therefore to indicate secondary gold enrichment. The variation in fineness in the figures quoted was 920 to 900. Twelvetrees also quoted similar battery returns from the New Pinafore reef Lefroy (approximately 35 miles west of Forester) which showed a similar tendency to decrease in fineness with depth - in this case from 954 to 925. Broadhurst (1935) stated that the limit of payability was the permanent water level which occurred at 400 feet; he estimated that 2,000 feet of the upper parts of the reefs had been eroded away to have brought about the degree of enrichment in this field.

The above quoted evidence of refinement of surface gold is not in itself evidence of surface enrichment of gold. Refinement can take place by solution and removal of part of the silver content of the gold. Refinement will also occur, and to a greater degree, if the gold is completely dissolved, for the silver will be almost entirely removed in solution and fine gold will be reprecipitated. This can take place in the presence of an oxidising agent and mascent chlorine (Krauskopf 1951), and Cloke and Kelly (1964) have produced evidence for this process, but enrichment of the order claimed, in the goldfields studied is not substantiated. The lower limit of payability recorded in various fields is probably a measure of the extent of the individual lodes combined with inadequacy of underground prospecting. It has been noted that the New Golden Gate lodes were payable to depths of more than 1,000 feet below the water table.

The refinement of gold may occur without secondary enrichment of the lode, as stated above, but the converse is not possible.

This rules out the likelihood of secondary enrichment in the silver rich lodes of the Golconda, Warrentinna, Forester, Lyndhurst or Gladstone districts for practically all of the silver content would have been transported away from this lode before reprecipitation. It is therefore unlikely to have occurred to any extent anywhere in the goldfields.

The Present State of the Goldfields. The main characteristic of the mineralisation is the large number of gold-quartz lodes mostly of rather limited extent. This has made prospecting difficult and expensive and, in part, accounts for the inadequacy of the prospecting and for the present poor state of the goldfields.

Only in a few mines has there been any attempt at systematic prospecting, development and stoping. The fields were mined in gold rush conditions, by unskilled workers with the minimum amount of equipment and capital. Outcropping lodes were stoped from the surface with no regard for economy or safety and abandoned when they became unprofitable. This resulted in the field as a whole becoming worked out at the surface but being virtually unexplored below 200 feet. At the present time there are no working mines in any of the goldfields, nor has there been one for many years.

Alluvial Gold. The history of these fields began with the discovery of gold in the alluvium of Tower Rivulet. Alluvial gold was mined from many parts of the fields but mostly from shallow dippings in youthful gullies. In the Mangana field several small gullies tributary to Tower Rivulet were worked to shallow depth - Twelvetrees (1907). Black Horse and Long Gullies were profitably worked to a shallow depth in the Mathinna Field, and in the New River area an alluvial mining syndicate worked a shallow lead to 25 feet (Twelvetrees 1904) where approximately 1,000 ozs. were won.

No attempt has been made to drill systematically for alluvial gold in the flood plains of the older river valleys. The Tullochgorum drilling in 1883 was abandoned before completion and there is no record of any bore logs or assay results. It is considered that Dorset and New Rivers, Dan Rivulet and Tower Rivulet belong to this category and have therefore been receiving alluvial gold derived from adjacent lode areas for a considerable time; as these watercourses are structurally determined it is probable that gold has been washed into their channels since the time when the gold bearing Mathinna Beds were first exposed, probably in late Mesozoic times.

Gold is recorded from basal Permian beds in the Mangana area (Twelvetrees 1907, p.10). The process of weathering of Mathinna Beds in pre Permian times (late Devonian to Carboniferous and probably early Permian) must therefore have also produced concentrations of alluvial gold in favourable areas on the old surface. Much of this gold would have been redistributed when early Tertiary planations stripped the Permian rocks from the underlying Mathinna Beds. Thus the major river channels under discussion have received this additional gold. Although there is no evidence that the prePermian topography was other than a near perfect plain as suggested by Carey (1946 op. cit.) it is probable that these structurally determined valleys were in existence during the late Palaeozoic erosion which led to the pre Permian peneplain.

These flood plains are privately owned farm lands, a fact which has deterred active prospecting in the past. The areas are potentially rich alluvial gold fields but as their gold content would probably lie in a number of channels, only large scale methods of mining would be profitable. The areas involved are considerable, in the South Esk Valley and tributaries alone, the surface area of flood plain which has received alluvial gold from the Dan Rivulet, Mathinna and Mangana goldfields is of the order of 50 square miles. The alluvium is of varying thickness and is proven to exceed 200 feet at Tullochgorum.

It is therefore conceivable that many millions of cubic yards of unprospected ground lie in this area. The ground further downstream in the South Esk valley is partly covered by a confined basalt flow. The pre basaltic course may be gold bearing and as it passes through the foothills of the Rossarden - Storeys Creek tinfield there is a strong likelihood of tin bearing gravels also occurring in the old channel or channels, i.e. in the pre-basaltic lead or between it and bedrock.

The same comments apply also to the Dorset and New Rivers which drain the Alberton and New River goldfields. These streams unite to form a basalt lateral and join the Ringarooma River. The alluvial ground is much smaller than the South Esk area but is still worthy of investigation.

Nothing is known of the Break O'Day gold content. This river does not drain any goldfield, the presence (or absence) of gold in its floodplain would therefore serve to prove (or disprove) the drainage reversal theory already suggested.

CONCLUSION

The "Main Slide" is 200 feet wide and is proven over a strike length of 1,000 feet and to a depth of 1,600 feet, in the underground workings of the Mathinna goldfield. It is concluded that similar, parallel faults account for adjacent mineralised areas in this field and that all of these separate faults comprise one major shear zone. This shear zone is remarkably linear over a distance of more than 50 miles and obtains pronounced topographic expression over much of this distance.

These features are characteristic of strike slip or wrench faults generally. There is no evidenceof displacement of homologous elements but the above characteristics, the kink banding and arcuate fold forms all support the conclusion that the goldfield line is a wrench fault.

The shear zone is thought to have had a long history beginning with tectonic activity during deposition with further movements during and after folding. Gold mineralisation is considered to have been influenced by the presence of this shear zone. Although gold lodes occur within the "Main Slide" in the New Golden Gate workings there is no recorded occurrence of anything that could be construed as an ore channel in it, nor any lodes possessing the characteristic texture of fissure fillings. The lodes were emplaced by selective replacement of sheared country rock.

The granites are unfolded and unfoliated and are therefore of post orogenic age. The shearing is related to the folding and is therefore probably pre granitic. As the shear zone separates the two batholiths, a more than casual relationship is inferred. The outcrop pattern of these batholiths appears to be governed by the northeast and northwest shear directions but this may be the effect of jointing in the granites due to Tertiary faulting which utilised these two pre existing directions.

There is no known relationship connecting the granites and the gold mineralisation. The two are commonly juxtaposed in many parts of the world and this is commonly assumed to indicate a genetic relationship in depth as well as on surface. In the goldfields area, the only proven relationships are those connecting mineralisations to structures (rather than to granites), or, more specifically, shear zones (rather than folds).

The final phase of the tectonic activity was dextral movement on a set of northeasterly striking shear planes. This resulted in displacement of mineralised areas and flexuring of fold axes. It is suggested that earlier movements on these faults may account for the off-setting of mineralised areas and fold axes by different amounts.

During the Mesozoic - Cainozoic epeirogeny and igneous activity both the northwest and the northeast shear planes were reactivated. The northeast set is particularly important as a geomorphologic factor (figure 55).

The utilisation of existing structures during later periods of diastrophism is well documented in Australian geological structure. Hills (1961) referred to it as "resurgent tectonics" which, he stated, was particularly important with regard to ancient strike slip faults. He noted that several important metal mining fields lay on or near megalineaments. Many of the structural features of the goldfields are evident in the geomorphology, partly as a result of resurgent tectonics. It should be possible to apply this principle in reverse and use geomorphology as an aid to interpreting structures and thereby locating new mining fields or extensions of known ones.

Further geological work is required as an aid to prospecting. This work has laid emphasis on the presence of zones of shear in relation to mineralisation. This could form the broad basis of a prospecting programme but additional work is required to locate concentrations of mineralisation. For this purpose geochemical methods may be applicable. As gold and arsenic are associated in these fields, it may be possible to locate gold concentrations by determining primary arsenic dispersion patterns on the assumption of a sympathetic ratio of the two elements. A secondary arsenic dispersion pattern would be more easily determined but the effect of existing mine dumps would lead to some artificial values being recorded.

It may be possible to verify the shear zone on the goldfields line by petrofabric or geophysical (gravimetric) means. If this was found to be possible, the method could be employed in the neighbouring fields - Gladstone, Golconda, Lefroy etc. to ascertain the presence or absence of shear zones and possibly to predict new areas to search. The gravimetric method may also be usefully employed to verify the existence of the shear zone beneath the floodplains of the Dorset and Ringarooma Rivers and Dan and Tower Rivulets.

Without further information such as may be supplied by the application of one or more of these methods, the drilling programme would be haphazard and probably unsuccessful.

A further aid to drilling may be supplied by seismic methods in connection with determining valley profiles in the search for alluvial gold in the bigger floodplains. It has already been suggested in this work that the flood plains of the Dorset River, Dan Rivulet and Tower Rivulet overlie mineralised shear zones and should be also considered in any future prospecting programme.

With regard to the Warrentinna, Forester and Waterhouse goldfields, there is no evidence to suggest that shearing and mineralisation is in any way different from that elsewhere in the goldfield line. The fields are partially covered by superficial sediments which inhibit prospecting, and mining operations are hampered by the prevalence of underground water. The concept that payable gold only occurs in an enriched upper zone is not proven and is probably false but may also have acted as a deterrent to active mining in these fields.

LIST OF REFERENCES

Anderson T.B. (1964) Kink Bands and Related Geological Structures. Nature 202 272-274.

Andrade E. da C. & Fox J.W. (1949) The Mechanism of Dilatancy. Proc. Phys. Soc. Lond. Vol.62 Sect.B.483-500.

Banks M.R. (1958) A Comparison of Jurassic and Tertiary Trends in Tasmania. Dolerite. A Symposium (Univ. of Tasmania) 231-264.

" (1962) Geology of Tasmania. Geol. Soc. Aust. Vol.9 No.2 pp.183, 184.

Bichan W.J. (1947) The Ubiquity of Gold Values and their Relation to Zones of Tensional Dilatation. Econ. Geol. XLII/4 396-403.

Billings M.P. (1942) Structural Geology. (Pitman, Lond.) 473 p.

Blake F. (1939) The Mangana Goldfield. Dept. of Mines Tas. (unpub.)

Blissett A.H. (1959) The Geology of the Rossarden - Storeys Creek District. Geol. Surv. Bull.46 Dept. of Mines, Tas.

Broadhurst E. (1935) The Lefroy and Back Creek Goldfields. Geol. Surv. Bull. No.42 Dept. of Mines, Tas.

Carey S.W. (1946) Geology of the Launceston District. Records of the Queen Victoria Museum, Launceston.

" (1953) Geological Structure of Tasmania in Relation to Mineralisation. The Geology of Australian Ore Deposits 5th Empire. M. & Met. Congr. A.IIM.M. (1958) 1108-1128.

" (1954) The Rheid Concept in Geotectonics. Journ. Geol. Soc. Aust. Vol.1 (67-119).

Clark L.F. (1960) The Fe - As - S System. Phase relations and Applications. Econ. Geol.55 1345-81 & 1631-52.

Cloke P.L. and Kelly W.C. (1964) The Solubility of Gold under Inorganic Supergene Conditions. Econ.Geol. 59 (259-70).

Cotton C.A. (1949) A Review of Tectonic Relief in Australia.
Jour. Geol. Vol.57 no.3 (280-296).

Davies J.L. (1959) High Level Erosion Surfaces and Landscape
Development in Tasmania.
Aust. Geog. (193-203) Vol.VII no.5.

De Sitter L.U. (1956) Structural Geology. McGraw Hill 1st Edition N.Y.

" (1964) " " " " 2nd " "

Donath F.H. (1961) Experimental Study of Shear Failure in Anisotropic
Rocks. Geol. Soc. Am. Bull. V.72 (985-990).

Edwards A.B. (1938) The Age and Physiographical Relationships of some
Cainozoic Basalts in Central and Eastern Tasmania.
Pap. & Proc. Roy. Soc. Tas. (175-200).

" (1947) Textures of the Ore Minerals. A.I.M.M. (185p.)

" (1950) The Petrology of the Cainozoic Basaltic Rocks of
Tasmania. Proc. Roy. Soc. Vict.62 (97-120).

" (1958) The Mineral Composition of the Maud and Yellow
Girl gold ore, Glen Wills, Victoria (396-403).
F.L. Stillwell Anniversary Volume A.I.M.M. (125-7).

Finucane K.J. (1935) Mathinna and Tower Hill Goldfields.
Geol. Surv. Bull.43 Dept. of Mines, Tasmania.

Fenneman N.M. (1936) Cyclic and Non Cyclic Aspects of Erosion.
Bull. Geol. Soc. Amer. 47 (173-186).

Gill E.D. and Banks M.R. (1956) Cainozoic History of Mowbray Swamp and
Other Areas of North-Western Tasmania.
Rec. Q. Vict. Mus. Tas. New Series 6.

Green D.H. (1959) Geology of the Beaconsfield District, Including the
Anderson Creek Ultra Basic Complex.
Rec. Q.Vict. Mus. Tas. No.10.

Harker A. (1952) Metamorphism. Methuen (302 p.)

Hills E.S. (1940) Outlines of Structural Geology. Methuen Lond. 172p.

" (1946) Some Aspects of the Tectonics of Australia. Jour. Roy. Soc. N.S.W. 79 (67-91).

" (1961) Morphotectonics and the Geomorphological Sciences with Special Reference to Australia. Q.J.G.S. Vol. CXVII Pt.1 (77-89).

" (1963) Elements of Structural Geology 485p. Methuen Lond.

Hills L. (et. at.) (1922) Coal Resources of Tasmania. Geol. Surv. Min. Res. No.7 Geol. Surv. Dept. of Mines, Tasmania.

Hills L. (1923) The Mt. Victoria Goldfield. Dept. of Mines (unpub.)

Hoepener R. (1955) Tektonik im Schiefergebirge, eine Einführung. Geol. Rundschau 44 (26-58).

Holmes A. (1920) The Nomenclature of Petrology.

Hughes T.D. (1947) The Dan Rivulet Goldfield. Dept. of Mines, Tas. (unpub.)

" (1952) The Alberton Goldfield. Dept. of Mines, Tas. (unpub.)

Jack R. (1963) Thureaus Deep Lead, St. Helens. Tech. Repts. No.8 Dept. of Mines, Tasmania.

Jaeger J.C. (1960) Shear Failure of Anisotropic Rocks. Geol. Mag.97 (65-72).

Jennings I.B. (1963) Explanatory Report, One Mile Geol. Map Series Middlesex. Geol. Survey Dept. of Mines, Tasmania.

Knill J.L. (1961) Joint Drags in Mid Argyllshire. Proc. Geol. Assoc. V.72 (13-19).

Krause F.M. (1883) The Auriferous Drifts of the South Esk Valley in the Neighbourhood of Fingal. Dept. of Mines Tas. (unpub.)

Krauskopf K.B. (1951) The Solubility of Gold. Econ. Geol. 46/8 (858-70).

Leith C.K. (1905) Rock Cleavage Bull. 239 U.S. Geol. Surv.

Leith C.K. (1913) Structural Geology. Holt & Co. N.Y. 169p.

Lindgren W. (1933) Mineral Deposits. McGraw Hill (930p).

Longman M.J. (1964) Geological Map, Launceston Quadrangle 1" - 1 mile. Geol. Surv. Dept. of Mines, Tasmania.

Lyons R.J.P. (1957) The Aberfoyle Vein System Rossarden Tasmania. Proc. Aust. Inst. Min. Eng. 181 (75-93).

Marshall B. (1964) & (1966) Kink Bands and Related Geological Structures. (Discussion of Anderson's paper) Nature Vol.204 (772-773) and Vol. 210 (1249-1251).

" (et al.)(1965) Scottsdale - Pipers River - Bridport region. Excursions for ANZAAS 38th Congress. Dept. of Mines Tas. pp.49 & 50.

McDougall I. & Leggo P.J. (1965) Isotopic Age Determinations on Granitic Rocks from Tasmania. Jour. Geol. Soc. Aust. 12(2) 295-332.

McKinstry H.E. & Ohle E.L. (1949) Ribbon Structure in Gold-Quartz Veins. Econ. Geol. XLIV/2 (87-109).

McNeil R.D. (1965) The Geology of Mt. Elephant - Piccaninny Point Area, Tasmania. Pap. & Proc. Roy. Soc. Tas. Vol.99 (27-50).

Mead W.J. & M.J. (1940) Folding, Rock Flowage and Foliate Structures. Journ. Geol. 48 1007-1021.

Montgomery A. (1892) Report on the Mathinna Goldfield. Dept. of Mines, Tas

Moody J.D. & Hill M.J. (1956) Wrench Fault Tectonics. Bull.Geol. Soc. Amer. Vol.67 (1207-46).

Moore B.R. (1965) The Geology of the Upper Yarra Region, Central Victoria. Prov. Roy. Soc. Vict. Vol.78 Pt.2 (221-239).

Nye P.B. (1925) The Sub-Basaltic Tin Deposits of the Ringarooma Valley. Geol. Surv. Bull.35 Dept. of Mines, Tasmania.

" (1926) The Campbelltown - Conara - St. Marys District. Underground Water Supply Paper No.4 Dept. of Mines, Tasmania.

Nye P.B. & Blake F. (1933) Alberton goldfield Lode map only.
Dept. of Mines, Tas. (unpub.)

" " (1938) The Geology and Mineral Deposits of Tasmania. Geol. Surv. Bull.44 Dept. of Mines, Tas.

Park C.F. & McDiarmid R.A. (1963) Ore Deposits. Freeman (475p).

Paterson M.S. & Weiss L.E. (1962) Experimental Folding in Rocks. Nature 195 (1046-8).

Pettijohn F.J. (1957) Sedimentary Rocks (2nd Edition) Harper N.Y. 718p.

Prider R.T. (1948) Geology of the Country Around Tarraleah. Pap. Proc. Roy. Soc. Tas. (1947) (127-150).

Ramsay J.G. (1962) The Geometry and Mechanics of Formation of "Similar" Type Folds. Jour. Geol. 70 (309-327).

Reid A.M. & Henderson Q.J. (1928) The Blue Tier Tinfield. Geol. Surv. Bull. No.38 Dept. of Mines, Tasmania.

" " (1929) Avoca Mineral District. Geol. Surv. Bull.40. Dept. of Mines, Tasmania.

Rickard M.J. (1961) A Note on Cleavage in Crenulated Rocks. Geol. Mag. 98 (324-332).

Sheldon P. (1928) Note on the Angle of Fracture Cleavage. Jour. Geol.36 (171-5).

Spencer Jones D. (1963) Joint Patterns and Their Relationship to Regional Trends. Jour. Geol. Soc. Aust. Vol.10 No.2 (279-297).

Solomon M. (1962) Geology of Tasmania. Geol. Soc. Aust. Vol.9 Pt.2

Spry A. (1958) Some Observations of the Jurassic Dolerite of the Eureka Core Sheet near Zeehan, Tasmania. Dolerite, A Symposium, University of Tasmania.

" (1962) Geology of Tasmania. Geol. Soc. Aust. Vol.9 Pt.2

Thomas D.E. (1939) The Structure of Victoria with respect to the Lower Palaeozoic Rocks.
Min. & Geol. Jnl. Mines Dept. Vict. Vol.1 No.4 59-64.

Thureau G. (1884) Report on the Mt. Victoria Dan Rivulet, Black Boy and Mangana Goldfields, also Remarks after examination of the Tullochgorum Prospecting Area.
Parliamentary Papers No.61 (1885).

Turner F.J. & Weiss L.E. (1963) Structural Analysis of Metamorphic Tectonites 545p. McGraw Hill N.Y.

" " (1965) Distribution of Strain in Deformed Crystals and Phyllite with Special Reference to Kinking - In Studies of Heterogeneous Strain in Experimentally Deformed Calcite, Marble and Phyllite.
Univ. Cal. Publ. Geol. Sci. Vol.46 No.3 (81-152).

Twelvetrees W.H. (1904) Report on South Mt. Victoria Mining Field.
Dept. of Mines Tasmania (unpub.)

" (1906) Report on the Mathinna Goldfield.

" (1907) The Mangana Goldfield. Geol. Surv. Bull. No.1 Dept. of Mines, Tasmania.

" (1907) The Mathinna Goldfield. Geol. Surv. Bull. No.2 Dept. of Mines, Tasmania.

" (1909) The Lisle Goldfield. Geol. Surv. Bull. No.4 Dept. of Mines, Tasmania.

" (1914) On Some Gold Mining Properties at Mathinna. Dept. of Mines, Tasmania. (unpub.)

" (1916) The Gladstone Mineral District.
Geol. Surv. Bull. No.25 Dept. of Mines, Tasmania.

Walker K.R. (1957) The Geology of the St. Helena - Scamander Area, Tas.
Pap. & Proc. Roy. Soc. Tas. Vol.91 (23-40).

Williams E. (1959) The Sedimentary Structures of the Upper Scamander Sequence and their Significance.
Roy. Soc. Tas. Papers and Proc. V93 (29-32).

Williams E. (1960) Interstratal Flow and Convolute Folding. Geol. Mag.97 (208-214).

" (1961) The Deformation of Confined Incompetent Layers in Folding. Geol. Mag.98 (317-323).

" (1965) The Deformation of Competent Granular Layers in Folding. Am. Journ. Sci. 263 (229-237).

" (1966) An Analysis of the Deformation in a Fold in Northeast Tasmania. Geol. Mag. 103 No.2 (115-119).

Williams G.E. (1964) The Geology of the King Lake District Central Victoria. Proc. Roy. Soc. Vict. N.S. Vol.77 pt.2 (273-327).

APPENDIX

(A Summary of Mine Workings)

Goldfield	Reef No.	Reef Name	Summary of Mine Workings	Strike	Depth	Reef Details Width ft.	Width in.	Length ft.	Grade oz.	Grade dwt./ton	Remarks
Alberton	1	Homestead	Surface stope in banks of small creek	340	-	4	6	15	-	5	from 5 ton sample
	2	Battery	Surface stope	030	65SE	3	-	45	-	-	-
	3	No. 1	Surface stope to 10 ft. and reef drives from 2 shafts	040	60SE	1	-	40	1	-	from 8 ton sample
	4	Drunkards Dream8	Line of trenches over 300 ft. and 2 shafts	039	80W	2	6	75	3	-	-
	5	Tiger	Surface stope to 75 ft. 2 shafts and 80 ft. adit	045	65SW	2	-	75	1	-	100 ozs. output
	6	Singline	Surface stope shaft and trench	070	55S	-	-	60	-	-	-
	7	B	Two trenches	090	60S	-	-	80) 50)	-	-	2 parallel reef 130 ft. apart
	8	A	Trench	112	-S	-	-	27	-	-	-
	9	No. 3	Surface stope to 3oft. and 60 ft. shaft.	060	Vert.		5	20	-	12	-
	10	No. 5	Surface stope and 100 ft. line of trenches	045	80SE	-(av)	8	40	2	-	-
	11 12 13	Sulphide) Browns) Mystery)	A group of 3 reefs, prospected and stoped at surface only.	010 050 050	- - -	- - -	- - -	- - -	- 1 -	- 10 10	- 25 ozs. output -
	14	Prendergast	80 ft. shaft and 40 ft. reef drive and 2 adits 400 ft. and 250 ft.	055	80SE	2 to 5	-	145	1	-	Gold valued at £1,800 (probably about 6000 oz. output.)
	15	Standard	Shallow shaft and surface stope	070	80SW	-	-	145	1	-	-

	..dyline	..ft. Trench	070	-	-	-	60	-	-	
17	Crest	230ft. line of trenches.	030	75NW	1	-	200	-	-	-
18	Pennefathers	165ft. line of trenches 2 shafts and 100 ft. reef drive.	285	45W	-	9	70	1	3	-
19	Central Ringarooma	200 ft. adit and 230 ft. of underground stoping and driving	027	75W	-	-	100	2	-	-
20	Cooks	80ft. line of trenches.	025	-SE	-	-	15	-	-	-
21	Lanes	15ft. trench	028	60SW	-	-	15	-	-	-
22	McCauls A1	200ft. Line of trenches and 35ft. shaft.	045	80N	1	3	30	1	-	-
23	Burrs	60ft. Surface stope	145	Vert	-	-	60	-	-	-
24	Almora	165ft. line of trenches	030	-	9in.to 2ft.		290	-	-	-
25	Jimmy Governor	70ft. Shaft and 2 sh shallow pits	037	70S	-	-	30	-	-	-
26	Sowells	40ft. Surface stope	087	70S	1	-	40	-	-	-
27	Holloway No 1	70ft. Shaft and 2 trenches	045	80E	1	-	40	-	-	-
28	Holloway No. 2	120ft. line of trenches	140	70E	1	-	120	-	-	-
29	Malunnah	260ft. line of trenches and an adit 55ft. below outcrop	020	70S	7in.to 4ft.		20 to 90	-	6	-
30	Alberton No.1	80ft. surface stope and 2 shafts 12ft. and 40ft.	040	80SE	1	-	60	-	6	from 12 ton sample
31	" No.2	Line of trenches, surface stopes and an adit	054	70SE	3	-	318		(av)12	-
32	Forest King	300ft. line of trenches adits and shallow shaft	025	Vert	1ft.to 2ft. 6 ins.		180	9dwt/ton to 2 oz. 10dwt/ton		-
33	Queen	100ft. surface stope and 40ft. shaft	025	65W	-	-	-	-	-	-

34	Endurance	-	070	-	-	-	-	-	-	-
35	Crown Prince	250ft. line of trenches and 490ft. adit.	043	65Se	-	-	100	-	-	17 ozs output
36	Cannon	Shallow surface workings only	030	50SE	2	-	200	4	-	-
37	Maggs	60ft. line of trenches and 60ft. adit	120	80E	9in. to 2ft.		60	2	-(av)	-
38	Endeavour	130ft. line of trenches	360	80E	-	6	20	-	-	-
39	Premier	Worked in conjunction with No. 41	150 - 178	80W	1 to 6		140	-	7 - 8	-
40	No. 3	Worked in conjunction with No. 41. Lowest adit	005 - 320	Vert	3in. to 3ft.		40 to 120	1	-	-
41	Gumsucker - Rosalind	3 adits 1100ft, 260ft. and 200ft. stoped to 65ft. below lowest adit	017	75E	3in. to 2ft.		150 to 320	1	-	-
42	Hannah	400ft. adit	040	- SE	-	-	-	-	-	-
43	Strahan	2 x 300ft. adits and 280ft. line of surface stopes	308	80E	1	6	160	1	-	-
44	McCauls No.1	260ft. line of trenches and 2 shafts 15ft. and 50ft.	001	70E	1	-	94	-	-	-
45	Chatterbox	20ft. surface stope	100	70N	-	-	20	-	-	-
46	Duke	30ft. adit	140	85NE	-	-	-	-	-	-
47	Baltic Searls	80ft. surface stope	-	-	-	-	-	-	-	-
48	Golden Hinges	50ft. line of trenches	150	75E	-	5	30	-	-	-
49	Frog	35ft. shaft and 300ft. adit	060	-	-	-	-	3	6	(10 ton sample)
50	Bobby Evans	10ft. trench	160	-	-	-	10	-	-	-
51	Mercury No.2)	700ft. of adits at different levels stoped	123	-NE	-	-	130	-	-	-
52	No.1)	to lowest level adit	145	45E	4in. to 1ft. 3 in.		100	1 to 5	-	-

53	Hope	130ft. line of trenches	123	-NE	-	-	130	-	-	-
54	Searls	Surface prospected only	050	-	-	-	-	-	-	-
55	Martins	" " "	029	-	-	-	-	-	-	-
56	Point	12ft. and 15ft. shafts and 40ft. and 100ft. adits	142	75E	-	8	190	up to 17 oz./ ton		-
57	Boundary	80ft. trench	002	80E	-	9	40	-	18	(5 ton sample)
58	Reform	5 lodes prospected and stoped surface only	135, 110, 050, 140, 100	-	-	-	-	-	-	-
59	Cobbings	Surface prospected only	140	-	-	-	-	-	-	-
60	Rich Youth	Shallow shaft and surface stope	031	55S	1	9	100	2	-	(locally up to 1½ oz. per lb)
61	Flat	40ft. Surface stope	020	85E	-	-	40	-	-	-
62	New Wilson	200ft. adit stoped from surface to adit 150ft. depth.	140	80E	2	6	200	-	-	-
63	Caxton No.1	540ft. line of surface stopes	135	70E	1	-	540	-	5 to 15	-
64	" No.2	200ft. line of surface stopes	150	75E	-	-	260	-	-	-
65	(Short Struggle	Line of surface stopes and 1200ft.	100	80N	1ft.3in.to 3ft.		50	-	-	-
66	(Long "	500ft. and 200ft. adits	135	70E	1	3	200	1	16	107 oz. in 1904 output
67	(Cross		045	70SE	4in to 1ft. 4in.		300	1	7	-
68	Battery	15ft. adit	035	-	-	-	-	-	-	-
69	Telegraph	Surface stope and 60ft. adit	003	80W	-	10	130	-	-	-
70	Ragged Youth	60ft. shaft, 100ft. and 200ft. adits and 200ft. surface stopes	024	70N	1	6	40	1	-	oz 7/output

	71	Beckers	40ft. surface stopes and trenches	050	75NW	1	6	40	-	-	oz, 7/output
	72	Scotsman	Shallow shaft	030	75SE	4	-	10	-	-	-
	73	Central	3 adits: 1000ft, 750ft and 140ft.	133	70SW	9in. to 1ft. 6 in.		100	2	-	-
	74	Montana	Numerous surface stopes and trenches	035	70NW	6in. to 3ft.		150	-	-	-
	75	Marrs	130ft. adit, shaft with reef rise and stope	135 040	60W SE	1 -	- -	30 -	- -	- -	- -
	76	Mammoth	60ft. trench and 9ft. shaft	063 115	80N 65N	- -	- -	30 60	- -	- -	- -
	77	Bright Star	3 Shallow shafts	146	80W	-	10	100	1	-	22 oz. 10 dwt output
	78	Esk	Shaft and 240ft. adit also several trenches and surface stopes	100	50N	-	-	200	1	5	-
	79	South Star	90ft. adit and 5 shallow shafts	140	80SW	1	-	50	-	-	-
	80	McCauls little show	30ft. shaft and 4 trenches	153	-	-	3	-	-	-	-
	81	Everetts	Surface stope and shaft with reef rise.	140	80W	4	-	50	-	-	-
	82	Farrells	Surface stope	167	-	-	-	30	-	-	-
	83	Heathorns)	New River area	NW	-	-	5	-	2 - 5	-	-
	84	Carltons)		140	-	-	-	300	-	-	-
	85	Cash's)		030	15SE	-	-	-	-	-	(Contains galena and silver but little gold)
Dan Rivulet	1	Una	2 adits and several surface stopes over 1200ft.	150	70W	-	-	1200	-	14	(up to 9oz/ton [illegible])
	2	Hinemoa	3 adits and line of trenches	360	40W	up to 3ft.		-	-	15	-
	3	Strickland	2 adits and 200ft. inclined shaft.	040	80NW	9 in.to 2ft.		-	2	10	-

4	Larandah	2 adits and 30ft. shaft	160	75SW	-	4	-	-	7	-
5	Lady Havelock	30ft. shaft 40ft. and 110ft. adits	045	45SW	-	2	-	1	8	-
6	Havelock	170ft. adit and 30 ft. and 200ft. shafts	065	80S	1	3	600	-	15	188oz. output
7	National Investment	100ft. adit	090	50S	-	5	-	-	-	-
8	Obriens	160ft. main shaft stoped down to 50ft. also 2 adits	070	Vert	1	6	-	1	-	800oz. output
9 10 11	King Edward) Carnegie) Starlight)									
12	Baileys	200ft. adit and 2 shallow shafts	360	80E	2	6	-	-	-	-
13	Revenue	200ft. adit and shallow shafts and trenches	045	78NW	2	-	-	-	-	-
14	Sections 819 and 821/939	70ft. adit and trenches	-	-	-	-	-	-	-	-
15	Mabel (Dans Reward)	100ft. inclined shaft	140	85NE	-	-	-	-	8	38oz. output
16	October	84ft. shaft, 2 inclined shafts and trenches	055 360	80NW 70W	2 5	- -	17 to 20 dwt/ton	- -	- -	- -
17	Waterfall	260ft. adit, inclined shaft, shallow shaft and surface stope.	008 075	80E 80N	4in to 9in -	 -	- -	- -	- -	- -
18	Bright Star	40ft. adit, inclined shaft and trenches	090 360 060	- - 30E	- - -	- - -	- - -	- - -	- - -	- - -
19	King Solomon	4 shallow vertical shafts	035	80NW	-	3	-	-	-	-
20	Heaton	Main Shaft several shallow shafts and surface stopes	090	70 (2 parallel veins)	-	-	-	-	-	-

	21	Lady Mary	105ft. shaft and several shallow shafts and surface stopes	045	75E (3 subparallel veins)	-	-	-	-	-	-
	22	Golden Horse-Shoe	110ft. shaft with 40ft. crosscut, 80ft. shaft and 60ft. adit	090 "	60N Vert	- -	3 4	- -	- -	- -	224 oz output -
	23	True Blue	45ft. inclined shaft and shallow vertical shaft	090	80S	-	-	- -	-	-	-
	24	City of Melbourne	5 shafts with some reef drives	045 090	70S 70S	- -	- -	- -	- -	- 15	- 88.5 oz output
	25	New Golden King	192ft. shaft with 2 levels and 3 adits	360	70W	3in to 5ft.		-	-		593 oz output
Forester	1	Forest King	Shallow shaft and 2 trenches	030 070	30NW 30N	- -	- -	70 -	- -	- -	- -
	2	Mt. Horror	180ft. adit with small reef drive	220 255	70S 60S	3in to 8in 3in to 8in		- -	- -	9 -	(also 9dwt Ag/ton)
	3	Linton	167ft and 600ft adits with reef drives and surface workings	260 278 250	70N - -	3in to 15in - 1	 3 -	160 - -	2 - -	- - -	(also 1oz. 16dwt Ag/ton)
	4	Imperial	60ft. adit and several shallow shafts and trenches	065	75S	-	9	90	-	15	-
	5	Malabar (Golden Era)	90ft. adit and surface workings	150	45W	-	-	130	-	-	-
Manjana	1	Tower Hill Freehold	3 adits	NW	80SW	I to 5ft.		L060	up to 2 oz/ton		-
	2	Golden Gully	54ft. vertical shaft and 247ft. adit and surface stope	138	40to 70E	1 to 6 ft. 10 " 6		430	-	1	-
	3	Alpine		NW	60W	1 to 2 ft.		630	-	-	Valued at £2378 which represents about 500oz.
	4	Richardsons Creek	No information available other than position of reef								
	5	Buckland	25?ft. adit with drive and winze with 2 levels also surface workings	NW	65SW	1	6	-	-	18	-

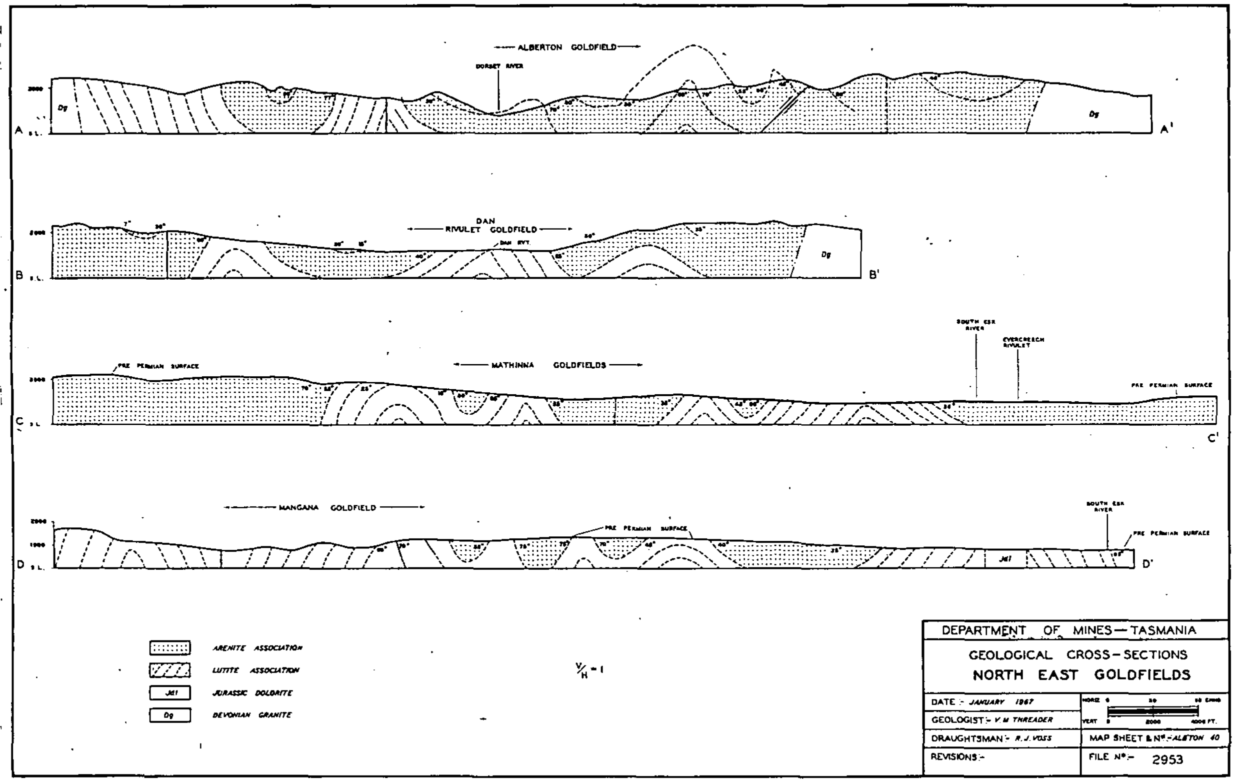
6	Cardinal	270ft. line of shafts and trenches	154	73SW	1	-	270	-	13	117oz/output
7	Fingal	Shallow inclined shafts on reef	175 158	40E 45E	2 1	6 3	- -	- -	- -	317oz/output
8	Union Jack	Adit, tunnel and shallow shafts	-	-	-	-	-	-	10	10oz/output
9	Pincher Reef	85ft. adit and surface workings	133	80E	2'0" to 12'0"		470	1	-	10oz/output
10	Specimen Hill	Position only	-	-	-	-	-	-	-	-
11	Otways Creek	150ft. adit and 2 reef drives	294	63SW	av. 1'0" and 22'0"		300	2 parallel lodes		-
12	Underlay	3 shallow inclined shafts on reef, an adit and several trenches	350	35E	-	-	-	-	6	-
13	Golden Entrance	3 adits on reef, a tunnel and 4 shafts	321	80E	3" to 7'0"		1100	2	-	2392oz/output
14	Mangana Gold Reefs	4 adits at 100ft. intervals and a main shaft and stopes at 5 levels. Total depth 1600 ft.	315	68SE	var. up to 20ft.		1150	-	6	791oz/output
15	Argyle	3 adits and several trenches and surface stopes	310 -	50W 60NE	- 2 to 5ft	-	- -	- -	- 15	(These reefs (are continu- (ations of (Nos. 13 & 14
16	Abbotsford	195ft. and 435ft. adits 700ft. tunnel and some reef development and stoping	020	Vert.	2ft. to 16ft.		-	-	-	5dwt/ton at outcrop but only 1dwt ton av.
17	Hit or Miss	400ft. shaft	NW 210	Vert 80N	-	-	-	-	-	Payable down to 200ft.
18	West Miami	165ft. shaft and 2 adits with some reef development	NW	Vert	-	-	-	-	7	7.3oz in 1941 output
19	Miami (Salmon Syndicate)	400ft. shaft and 2 adits	278	75S	2	-	-	-	-	-
20	(Daylight	60ft. shaft and connecting adit.	NE	80SE	-	9	-	-	-	-
	(Great Fingal	2 x 30ft. shafts and a 90ft. surface stope to 23ft.	-	-	-	-	90	-	-	-

Mathinna	1	Welcome Stranger	40ft. and 20ft. shafts No information other than position of lodes.								
	2	Golden Stairs	53ft., 30ft. and 48ft. shafts and a main shaft app. 250ft. with 2 levels	350	70W	7	-	-	-	-	-
	3	Volunteer	4 shallow shafts, main shaft 418ft. small adit and several surface stopes	045	70NW	3	-	-	-	7	2550 oz. output
	4	Enterprise (Hen and chickens) (Gold Estates) (Golden Spur)	76ft. inclined shaft with reef development and 50ft. shaft with 2 levels	NE	68NW	-	8	-	2	6	-
				325	80W	-	-	-	-	-	-
	5	Yellow Boys	115ft. shaft and numerous surface workings	065	80S	2	6	400	-	7	60 oz. (1904) output
	6	Volunteer Consols	90ft. shaft and 450ft. shaft with 4 levels	045	87NW	-	7	58	-	15	1,185 oz. output
	7	Old Boys (Brock Bros)	375ft. Main shaft with 3 levels	NE	(several small lodes worked)		-	-	-	7	-
	8	Caledonian (Gate Extended) (Golden Ladder) (Star of Mathinna) (Reece and Lawson)	317ft. adit, stoped in part, numerous surface workings adjoins the Caledonian 157 shaft	093 020 136 126 130 078	80N 80E 65W 70E 45E 60E	Several lodes worked over distances up to 200ft. All values were low.					
	9	Chester and Murray (Hatherton)	350ft. shaft with 3 levels and surface stopes	128	72S	-	-	150	-	12	30 oz. output
				340	W	-	9	100	-	7	-
	10	City of Hobart	2 shafts 100ft. and 660ft. and an adit	015	W	3	-	500	1	-	-
				NW	-	-	3	-	-	13	16,000 oz. out
	11	Golden Hinges	274ft. adit - Irregular masses of barren vein quartz in sheared and contorted slate								

12	New Golden Gate	Main working consisted of a main shaft to 1963ft. with levels at 100ft. intervals	Most important reefs were Loanes, Main, Lower West and East, striking N-S with dips from 65E to vertical, width up to 20ft. and strike length over 1,000 feet. Each of these reefs persisted for approximately 800ft. down dip					-	16	oz. 253,865/output
	Tas. Consols	1,600ft. main shaft with 11 levels - the mine worked the northerly extension of the Golden Gate reefs.							9	oz. 10, 115/output
	South Golden Gate	Prospect shaft to 400ft. with 2 levels but no lodes.								
13	El Dorado North	20ft, 110ft. and 121ft. shafts and surface workings	280	80S	-	-	-	-	-	-
14	Victorian Golden Gate	241 adit and one other adit with stopes and surface workings	114	63SW	4	-	-	-	-	-
15	El Dorado New	171ft. shaft with reef development and adits, trenches and 150ft. surface stopes	295	65S	6in. to 2ft.		-	1 2	10 5	from 535 tons 1886-18 from 61 tons in 92 1906
16	(Miners Dream (" " ((South)	150ft. inclined shaft with reef drive and stopes 403ft. adit	202 350 (Several small low grade reefs recorded)	35E 65S	- -	- -	- -	2 -	- -	oz. 433/output -
17	Section 359G	Adit with some development but no stoping	140	-	-	3				
18	Gladstone	40ft. shaft and surface workings	290	S	-	2	-	-	10	oz. 30/output
19	Pride of The Hills	70ft. shaft and surface workings	342	-	6in. to 3ft.		1100	-	-	-
20	Horseshoe	Shallow workings and adit with stopes saddle reef							13	42 oz. output overall average only [illegible]/ton

	21	Telegraph	161ft. adit, shaft and trenches	NW	-	1	-	-	-	-	-
	22	City P.A	4 adits	355	85E	-	-	-			) Variable values with rich patches near faults
	23	Jubilee	272ft. shaft with 2 levels	Derby reef300	65SW	-	-	700			)
				Flat reef328	20SE	-	-	-			)
	24	Mountaineer	2 adits	128	V	-	-	-			)
	25	Commercial	Shallow shaft	28	80N	3in.to 3ft.		30	1 to 6dwt		-
	26	Scott and Pickett	Main shaft, 2 adits and surface workings	027	80NW	10in to 3ft. followed for 112ft. on dip		30	-	8(1907) 3(1908)	oz 38/ output 9" "
	27	Twilight	200ft. shaft, 3 shallow shafts and surface stopes	025	80W	1in.to 2ft.		590	-	-	-
	28	Tower Hill	3 shafts - the mineralised gound consisted of a group of low grade quartz veins in a massive barren quartzite bed 60ft. to 100ft. wide and shown on Finucane's map as 40 yards long on strike.								
	29	Sunbeam	2 shafts	290	70W	4	-	220	-	-	-
Warrentinna	1	Renown)	No information available	045	-	-	-	-	-	-	-
	2	Golden Dike)		-	-	-	-	-	-	-	-
	3	Derby)		-	-	-	-	-	-	-	-
	4	North Mara)		-	-	-	-	-	-	-	-
	5	Golden Mara	2 x 1,000ft. adits								
			Branxholm reef	040	Vert	-	-	330	-	-	-oz
			Little " "	010	70E	-	-	1000	1	10	857/ output(1908)
			Blue "	005	-	-	-	100	-	-	-
	6	Golden Crest	Shallow workings only	010	E	-	-	90	-	trace	-
				075	80S	-	-	70	-	1	-
	7	Rebel	40ft. and 70ft. shafts	050	-	-	-	100	-	-	-

	8	Pearces	35ft, 45ft. and 70ft shafts	035	80SE	-	-	45	-	-	-
	9	Golden King	35ft, 40ft, 50ft and 90ft. shafts	035	-	-	-	60	-	-	-
	10	Dawn of Peace	2 adits, shaft on reef to adit and line of trenches	020	-	-	-	580	-	19 (from 6 ton sample)	
	11	Kerrisons	2 adits, several shafts of unknown depth and surface workings	025 070	- 80N	- -	- -	60 -	- -	- -	- -
Waterhouse	1	Alliance	Shallow workings and surface stopes	NE	-	-	9	50	-	11	Most of the gold was recovered from pyrite concentrates.
	2	Hope	Surface workings only	-	-	-	-	-	-	-	-
	3	Martial Call		NE (3 separate reefs)				660	-	-	-
	4	New Monarch	Trenches and prospecting shafts	N-S	35W	4in. to 4ft.		-	-	-	-
	5	Pioneer	Surface workings and stopes and shafts over 100 ft.	NE	W	3	-	300	-	-	-
	6	Railway	Shallow workings only	Ne 025 NE	67NW 45NW 45NW	1 to 6ft 3in. to 2ft. 2	 -	160 - -	- - -	- - -	- - -
	7	Southern Cross	270ft. of surface stopes and 25ft. and 100ft. shafts surface workings only	- -	58SE 60SE	- 8in. to 2ft. 6ins.	7	650 1200 (?)	- -	- -	- -
	8	North Southern Cross	Surface workings only	-	-	-	-	900	-	-	-



ALBERTON GOLDFIELD
DORSET RIVER
Dg
A
A'
DAN RIVULET GOLDFIELD
DAN RVT
B
B'
MATHINNA GOLDFIELDS
PRE PERMIAN SURFACE
SOUTH ESK RIVER
EVERCREECH RIVULET
C
C'
MANGANA GOLDFIELD
Jdl
D
D'
ARENITE ASSOCIATION
LUTITE ASSOCIATION
JURASSIC DOLORITE
DEVONIAN GRANITE
DEPARTMENT OF MINES — TASMANIA
GEOLOGICAL CROSS-SECTIONS
NORTH EAST GOLDFIELDS
DATE :- JANUARY 1967
GEOLOGIST :- V. M THREADER
DRAUGHTSMAN :- R. J. VOSS
REVISIONS :-
MAP SHEET & Nº :- ALBTON 40
FILE Nº :- 2953

<u>Figure 58</u>