PRECAMBRIAN ROCKS OF TASMANIA, PART II, MT. MARY AREA

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(With 5 Text Figures, 3 Plates and 1 Map)

ABSTRACT

The Mt. Mary area (S. lat. 42° 12', long. 145°50') is underlain almost entirely by rocks of Pre-Cambrian age, the exception being a small downfaulted block of Crotty (?) Sandstone, (Silurian). The Pre-Cambrian rocks are divided into three main groups. The oldest is the Joyce Group which consists of mica-garnet schists, quartzites and amphibolites. This is overlain unconformably by quartz schists, massive quartzites and phyllites of the Mary Group. Above these are quartzites, mica schists, garnet-mica schists and amphibolites of the Franklin Group. Igneous rocks are recognized as premetamorphic amphibolites (Older Basic Igneous Group) and post-metamorphic dolerites (Younger Basic Igneous Group).

The sediments are broadly folded into the Mary Anticline. Tight, recumbent drag folds are abundant and are shown by all formations. Cleavage or schistosity, generally parallel to the bedding, is well developed in phyllites and schists. A regular, regional lineation plunges flatly to the west and is cut by a sporadic lineation almost at right angles. Faulting is very abundant and makes the interpretation of the structure very difficult. Three sets of faults trend (in order of importance) at 120°, 10° and 60°-80°. The major faults are high angle reverse faults.

There is some degree of structural control of the physiography. All rivers are superimposed and two streams show maturity in their central reaches due to resistant quartzites forming local base levels. There is evidence of rejuvenation of some rivers.

Rocks of the Joyce and Franklin Groups are metamorphosed to garnet grade while the Mary Group is less altered. Selective metamorphism is demonstrated and is probably due to the favourable chemical and physical nature of the Joyce and Franklin Groups.

INTRODUCTION

The area described is located just south of the Lyell Highway and about 20 miles east of Queenstown. The mapping was carried out for the Hydro-Electric Commission by whose courtesy this report is published. Typical rock specimens were collected and are housed in the Geology Department of the University of Tasmania; the numbers in this report are those of the Geology Department rock catalogue.

The map is accurate as far as the distribution of *groups* is concerned but as it is very difficult to map *formations* because of the complexity of the faulting and soil or vegetation cover in critical areas, the degree of accuracy of the *formation* boundaries is only of reconnaissance standard.

ACKNOWLEDGEMENTS

The base map was prepared by the Hydro-Electric Commission. A preliminary photo-interpretation carried out by Professor S. Warren Carey revealed much of the major structure. A. Rundle, S. Makeham and I. Sanker assisted in the field mapping.

PREVIOUS LITERATURE

No previous work has been done in this area although the results of a traverse north of the Raglan Range were published by Ward (1908). A reconnaissance in the Loddon River and Jane River area was described by Ward (1909) and the knowledge of the Pre-Cambrian rocks of Tasmania summarized by Ward (1909). Brief surveys of the Jane River, Prince of Wales Range, Surveyor Range and Deception Range were described by Finucane and Blake (1933), Blake (1936) and Blake (1937).

PHYSIOGRAPHY

The area shows considerable relief and is quite rugged with altitudes over 3000 feet in places. The land surface is at a stage of early maturity and has been moulded probably entirely by fluviatile action. Mountain glaciers were active during the Pleistocene Epoch, only a few miles to the south at Frenchmans Cap, but there is no substantial evidence that any landform in the Mt. Mary area is the result of glaciation. Although the upper Joyce Creek superficially resembles a glacial valley it probably has not been glaciated.

There is a moderate relation between the physiography and the geology in that—

(*a*) certain groups or formations generally form ridges or hills while others are easily eroded and form valleys;
(*b*) faults and major joints frequently lie along valleys or saddles.

The highest point in the district is Raglan Bluff (3080 feet) on the eastern end of the Raglan Range. The Raglan Quartzite of the Franklin Group forms the backbone of this range.

For "Pre-Cambrian" read "Precambrian" throughout the paper.

Ward's Bluff (3020 feet) is the highest point of the arcuate ridge which is topographically (but not structurally) the south-easterly continuation of the Raglan Range. This high ridge is underlain by flatly dipping (25°) quartzites of the Mary Group; Plate I, No. 4 shows the form of this mountain with the massive quartzites forming prominent cliffs and the phyllites being easily eroded. Quartz schists form steep slopes and small cliffs.

Mount Mary (2940 feet) and Flat Bluff show similar geological controls. Both are capped by the quartz schist of the Mary Group which forms a cliffed top and this is underlain by soft, grey phyllite which forms the steep to moderate slopes around the north, west and south of the Mary Creek Plain.

There is a series of ridges in the south-western corner of the area which are formed of resistant quartzites and quartz schists of the Mary Group. These continue, increasing in height and steepness, to Philp's Peak and Frenchman's Cap.

The three major rivers in the area (Franklin, Joyce and Mary) are so independent of the geological structure that they are probably superimposed streams.

The Joyce Creek is youthful at its head and mouth but is quite mature in its central reaches where it has been held up by quartzites which form a local base level. The river begins on the very steep slopes of Raglan Bluff and then flattens off for two miles where it occupies a broad U-shaped valley. As mentioned previously, the shape of this valley at first suggests glaciation, but it is probably due to the fact that the stream flows along the strike of faulted phyllites and schists. The valley narrows about two miles east of Raglan Bluff and the river cuts a narrow steep gorge in the floor of the valley before swinging to the south. The next stretch (three miles) of the river is quite different in character. The gorge and rapids are replaced by a flat-bottomed valley with a narrow flood plain. The river meanders within the rather narrow confines of the valley and there are terraces (one at eight feet above the present river level) and cut-off meanders. The river falls about 700 feet in its first quarter-mile, 700 feet in its next three miles but only 100 feet in the next three miles. The last half-mile before the Joyce joins the Franklin is different again as the river straightens its path and cuts a steep gorge (6-800 feet deep) across the strike of the quartz schist and massive quartzite which act as the local base level.

The form of the Mary Creek is somewhat similar but shows some differences. The small creeks which run southwards across Flat Bluff, drop over the edge in small waterfalls and steep gullies and fall 1400 feet in the first half-mile. They then meander across the flat, button-grass covered Mary Creek Plain following two main paths. Here the creeks are about four feet deep and three feet wide with steep to vertical sides. There is 150 feet of fall in this one and a half mile stretch where the river has been held up by the resistant quartz-schist which caps Mount Mary. The high-level (1600 feet) Mary Creek Plain, plate I, No. 1, is quite a prominent physiographic feature of the area. The Mary Creek has reached a much more advanced state of maturity in its central tract than the Joyce Creek. The Joyce to the east, and the Maude to the west, have cut their valleys some 800 to 900 feet lower than this plain. The Mary Creek enters the quartzites to the south, straightens its course and descends approximately 1200 feet in the next two miles before it joins the Franklin River. About one mile north of the Franklin, it has a knife-cut gorge about five feet wide and 50 feet deep with practically vertical sides. Immediately south of this it plunges over a waterfall about 100 feet high.

The Franklin River is the largest watercourse in the area and flows from east to west across the southern portion. It is confined by a steep-sided, V-shaped valley which becomes a 400 foot gorge in parts. The sides usually slope at about 50° and are from 400 feet to 800 feet high with a cover of dense rain forest. The river displays a complex mountain tract with all the features of youth (steep valley, straight course, gorges and rapids). Some of its tributaries join through saw-cut gorges.

Two miles east of the junction of the Joyce and the Franklin are button-grass flats about 1000 feet above the present river level as shown in plate I, No. 2, while immediately east of the junction of the Mary and the Franklin is a small flat, about half-mile by quarter-mile which is about 150 feet above river level. This evidence suggests that there were at least two periods of still-stand when the river began to develop a broad valley tract in the softer rocks and that there has been later rejuvenation which caused the Franklin (and upper Joyce) to cut a narrow gorge below the level of the old valley.

The course of the Franklin is chiefly independent of the structure although it follows softer beds (phyllites) for distances of a quarter-mile or so before turning away. No evidence was found to suggest that the river follows a major fault zone, nor that it follows minor faults in parts.

Structural control of the rivers is not important although many minor streams show joint or fault control, e.g.:—

(*a*) There is a strong joint control of the streams on air photo 2487, Run 9, Lyell at one inch north-west of the photo-centre.

(*b*) The upper Joyce Creek is controlled by faults.

(*c*) The stream which flows to the east on air photo 2490, Run 9, Lyell, one and a half inches north of photo-centre lies along a fault. It joins another stream which flows along the western side of the Collingwood Range in a southerly direction, also along a fault.

(*d*) There is a fault control of the stream which flows east-south-east to join the Joyce Creek at the photo-centre of air photo 2632, Run 11, Lyell. This fault also controls the course of other streams.

Large landslides occur in several places and usually occur on steep slopes underlain by schists which weather to a clayey soil, e.g., in the upper Joyce Creek valley and south of Ward's Bluff.

Physiographic Expression of the Chief Rock Types

The Mary Group usually forms the highest points, e.g., Mount Mary, Ward's Bluff, Frenchman's Cap, and Philps Peak. The massive quartzites are most resistant and form the largest cliffs while the quartz schists are only a little more easily eroded and form steep slopes and smaller cliffs. The phyllites of this group are soft and form saddles or gullies.

The platy structure of the quartz schists frequently allows fritting by frost and wind to give pits and small caves.

The interbedded schists and quartzites of the Joyce Group are easily eroded and form the lower parts of the area, e.g., Mary Creek Plain and the country north of the Franklin in the south-east of the area.

The Franklin Group usually forms moderately high, rounded and rolling hills which are covered with a thick clayey soil supporting a dense cover of gum, bauera and tea-tree The joints frequently control the drainage pattern of the lesser streams. The thick quartzite which occurs just above the base of this group is resistant and forms the backbone of the Raglan Range.

STRATIGRAPHY

The area is chiefly underlain by rocks of probable Pre-Cambrian age. These have been divided into three groups, viz., Joyce Group (oldest), Mary Group and Franklin Group (youngest). These are chiefly sediments showing a low to medium grade of regional metamorphism together with lesser pre- and post-metamorphic basic intrusions. The total thickness is almost 20,000 feet. A little Crotty (?) Sandstone occurs in the north-east.

Crotty Sandstone

A wedge-shaped block of sandstone has been downfaulted into the Pre-Cambrian rocks in the north-eastern corner of the area. This rock is a soft, white, incoherent, sparsely fossiliferous sandstone which outcrops extremely poorly. The fossils remain merely as moulds and include unidentifiable spiriferids and brachiopods with abundant crinoid stems. Cubic cavities are common in some specimens and are probably moulds of pyrite crystals. Some specimens are strongly silicified to a massive quartzite and others show some mineralization. This formation is best observed along the curved track shown on air photo 2416, Run 8, Lyell and on the southern end of the button-grass area on air photo 2414, Run 8, Lyell, three inches south of the photo-centre.

The age of this formation cannot be properly determined because of the lack of diagnostic fossils and it is correlated with the Crotty Sandstone on lithological grounds. It belongs to the system of fault blocks containing Junee and Eldon Group rocks along the Lyell Highway in the vicinity of Bubb's Hill which is about five miles to the northwest.

Pre-Cambrian Rocks

The unfossiliferous, deformed and metamorphosed sediments which outcrop over the main part of the area are believed to be Pre-Cambrian in age. They unconformably underlie Ordovician rocks to the west at the Engineer Range and to the east at the Loddon Plains. They are lithologically similar to rocks which are unconformably below Middle Cambrian rocks elsewhere in the State.

Franklin Group

The Franklin Group was first recognized and named informally by Professor Carey. The first detailed field examination was made by J. B. McKellar and is defined by him (personal communication) as follows: it consists of those schists and quartzites lying below the Fincham Group and above the Mary Group and outcropping between the Franklin River and the Engineer Range west of Frenchman's Cap.

The rocks of the Raglan Range overlie the Mary Group unconformably (?) and appear to be structurally continuous with the Franklin Group which occurs on the other limb of the Mary Anticline. The group extends from the Raglan Range along the Cardigan River to the Collingwood River and the Lyell Highway, outcropping well between the 20 and 26-mile posts from Queenstown. The top of the group is not seen here and it is at least 5000 feet thick, and a tentative sequence is given below:

Top not visible	
Collingwood Schist	1000′+
Cardigan Schist and Quartzite	2000′
Raglan Quartzite	900′
Basal Schists	
Mica Schist	600′
Garnet Schist	600′
Bottom	

The uppermost phyllites of the Mary Group appears to grade upwards into fine-grained bimica schists which become increasingly garnetiferous upwards. This is followed by the Raglan Quartzite which is a prominent formation and could be a good marker horizon in this group. It is defined as that quartzite which occurs at Raglan Bluff, lying above the basal schists and below the Cardigan Schist. It is approximately 900 feet thick and has a distinctive lithology which is described on page 101. A similar formation occurs at the 26-mile post on the Lyell Highway as the northerly topographic (but not structural) continuation of the Collingwood Range.

Above the Raglan Quartzite, along the disused timber haulage track from Raglan Bluff down to the Cardigan River bridge is a considerable thickness (2000 feet?) of mica schists, garnet-mica schists, thin quartzites and amphibolites. This formation is named the Cardigan Schist and Quartzite.

The youngest formation in the area is named the Collingwood Schist. The type locality is along the Cardigan River just south of the bridge on the Lyell Highway but it outcrops well along the Highway in the area. There is at least 1000 feet and probably much more of mica schists characterized by albite porphyroblasts.

Lithologically the rocks of the Joyce Group strongly resemble those of the Franklin Group and these might well be correlated by their lithology. They are separated only on structural grounds.

Mary Group

This is defined as that group of quartz schists, massive quartzites and phyllites which occur on Mount Mary and in the area between the Mary Creek Plain and the Franklin River. It overlies the Joyce Group with probable unconformity and is overlain by the Franklin Group with possible unconformity. It is at least 8000 feet thick.

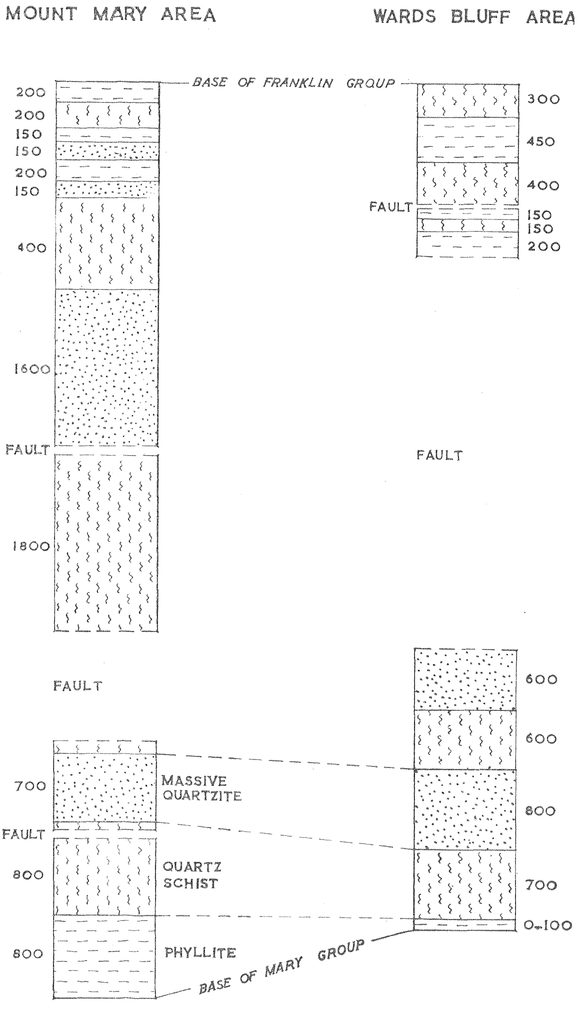


FIG. 1.—Stratigraphic sections through the Mary Group at Mt. Mary and Ward's Bluff.

Stratigraphic sections are shown in fig. 1 for the Mount Mary and Ward's Bluff areas. The lack of correspondence between two sections only three miles apart may be due to faulting, differential metamorphism or silicification, or to sedimentary facies change, and supports the contention given at the end of this section, viz., that any attempts at stratigraphy at a *formation* (as opposed to a *group*) level should be treated with the utmost caution at this stage.

Evidence is given in the petrology section that the phyllites may become silicified to quartz-schists some of which are massive enough to be regarded as massive quartzites. In general the three main rock types of this group (quartz-schist, massive quartzite and phyllite) may be mapped in restricted areas but formations cannot be traced for long distances. The phyllites are most irregular and thicken or thin out and disappear in short distances; thus it is believed that the phyllite in one section may be the time equivalent of a quartz-schist in another.

The quartz-schists are white, platy, mica-rich quartzites which are considerably contorted and crumpled. They have a well developed schistosity which is due to fine mica and some show two distinct lineations. They form bold, resistant outcrops and occupy the summits of many of the higher hills, e.g., Mount Mary and Flat Bluff.

The massive quartzites are white and thickly bedded. They are contorted and some specimens show a lineation while ripple marks and cross bedding are prominent in others. These rocks form steep cliffs and cap prominent hills such as Ward's Bluff.

The phyllites are soft, grey, lustrous rocks with a pronounced cleavage. Crenulation is prominent and two lineations may be present. Silicification has produced many quartz lenses, along the cleavage with boudinage structure, as shown in plate III, No. 3.

Beds of this group can be traced on the air photos from the Mount Mary area across to Philps Peak and Frenchman's Cap.

Joyce Group

This is defined as that group of schists, quartzites and amphibolites which outcrop along the middle reaches of the Joyce Creek and the country immediately to the east, and the Mary Creek Plain. It consists of approximately 5000 feet of garnet-muscovite schist, laminated muscovite quartzite, massive quartzite and diopside-amphibolite. It lies below the Mary Group but its lower limit is not known. The contact between the Joyce and Mary Groups is conformable on the limbs of the Mary Anticline; e.g., on the long spur which runs south from Ward's Bluff, garnet-mica schist dips at 10°-15° beneath quartz-schist of the Mary Group. The unconformable nature is shown at the Mary Creek Plain where the Joyce Group strikes at 75° and dips steeply north while the Mary Group strikes at 120° and dips at 10°-16° to the south.

It is not possible at this stage to give a sequence of formations in this group due to complexity of structure, lack of outcrop and dense vegetation cover.

Stratigraphic Principles

It must be emphasized that the stratigraphy outlined above must only be tentative for the following reasons:—

(i) Strong faulting and lack of outcrop combine to prevent the accurate determination of sequences and thicknesses of formations and groups. Strike faulting is common.

(ii) Rocks of identical lithology are repeated many times through the whole sequence and lithological correlation is not reliable. The structural complexity prevents the tracing of individual formations or even groups for any distance and this is the only reliable method of correlation.

(iii) The position above an unconformity is often useful as a correlation guide but in this area the sequence above the same unconformity differs in sections only a few miles apart.

(iv) Silicification of certain formations causes a very rapid and irregular change in lithology. It is suspected that a phyllite in one section is represented by a quartz schist in another. This implies that any detailed sequence measured in the Mary Group may be stratigraphically meaningless.

(v) Differential metamorphism of certain groups has resulted in the younger beds being more altered than older beds.

(vi) Tight, isoclinal folding causes thickening of individual formations, probably as much as 100 per cent so that there may be great errors made in taking the structural thickness to be the same as the stratigraphic thickness.

Unconformities

It is difficult to demonstrate conclusively an unconformity in this area, and in any of the adjacent parts which the author visited. It has been shown that the mildly altered Mary Group rests on the comparatively strongly altered Joyce Group, but this difference in degree of metamorphism and deformation cannot be taken as evidence of an unconformity between them, as the strongly altered Franklin Group rests on the Mary Group.

Faulting is so common, particularly parallel to the strike that discordance of strike or dip cannot be accepted as evidence of an unconformity.

On the western side of the Mary Creek Plain, the phyllites at the base of the Mary Group swing around the nose of the plunging Mary Anticline and are sharply discordant with the structure of the underlying Joyce Group. The form of the contact is such that faulting does not appear possible. This unconformity is not apparent a few miles east where the Joyce Group garnet schists dip conformably below the Mary Group. It is considered that there was not much folding between the deposition of these groups and that the contact is more in the nature of a disconformity between different phases of sedimentation.

It is considered that only regional mapping will reveal the presence of unconformities and that the classical evidence of a visible plane of discordance with the base of the upper group containing pebbles of the older, will not be found. The section on fig. 1 show that the top of the Mary Group sequence differs in different places and this may indicate that there is not conformity between the Mary and Franklin Groups and that the latter overlaps the former. The abrupt thinning of the Mary Group around the nose of the Mary Anticline seems to be due to overlap by the Franklin Group and also suggests mild unconformity.

Igneous Rocks

Two periods of basic igneous intrusion are recognized. There are pre-metamorphic intrusives which lie among the Joyce and Franklin Groups and which have been regionally metamorphosed to amphibolites. These are probably related to the similar rocks at the Forth River, Port Davey, Whyte River and the Interview River dyke swarm. They will be referred to at present as the Older Basic Group, although this will only be a temporary name.

Post-metamorphic dolerites intrude the Franklin Group and petrographic examination reveals that they resemble the Cooee Dolerite with which they have been correlated (Spry 1956).

PETROLOGY

The origin of the metamorphic rocks presents a considerable problem which can only be solved by the systematic investigation of a wider area than is here described. The adjacent area, totalling some 500 square miles, has been mapped by geologists of the Tasmanian Hydro-Electric Commission and the petrology of these rocks will be published shortly. For this reason, the general petrographic nature of the rocks is given here but a discussion of the problems associated with their metamorphism will be deferred.

The Pre-Cambrian rocks in this area consist almost entirely of sediments (arenites and argillites) which have been regionally metamorphosed. The Joyce and Franklin Groups have reached garnet grade and contain garnetiferous schists, quartzites and amphibolites while the Mary Group would be related to chlorite grade. The Joyce and Franklin Groups are much more recrystallized and deformed than the Mary Group. Extending outside of this area it has been seen repeatedly that the most striking characteristic of the Pre-Cambrian rocks of Tasmania is the occurrence of interbedded strata showing differing degrees of metamorphism.

Joyce Group

This group consists chiefly of garnet-mica schist and mica-quartzite with a little pyroxene-amphibolite. The rocks are recrystallized and regionally metamorphosed to garnet grade (albite-epidote-amphibolite chloritoid-almandine sub facies of Turner (1951)) with the development of a new fabric. The rocks are thus similar to the Franklin Group but distinct from the Mary Group. This group lacks the hornblende amphibolite, and albite schists of the Franklin Group.

Garnet-mica schist is the most abundant member of this group. It is a grey, medium grained schistose rock consisting chiefly of muscovite and quartz with porphyroblasts of garnet giving the rock a knotted appearance. Some specimens are very coarse and contain garnets and muscovite flakes a quarter-inch across. These schists occur on the long spur leading south from Ward's Bluff to the Franklin River, on the saddle on the east side of Mary Creek Plain and on the hill of the camp-site in the middle of that Plain.

Muscovite quartzite is a white, thinly bedded laminated quartzite containing abundant muscovite flakes giving a schistosity parallel to the bedding. It shows tight isoclinal folding in some localities with a lineation parallel to these fold axes. It outcrops sporadically across the southern parts of the Mary Creek Plain and on the saddle to the east, and is very prominent across the middle reaches of the Joyce Creek and to the west of Ward's Bluff.

A little pyroxene amphibolite (e.g., 6887) outcrops poorly on the Mary Creek Plain. It closely resembles the pyroxene amphibolite of the Franklin Group and is a member of the Older Basic Group.

Mary Group

This group differs considerably from the Joyce and Franklin Group in that it is dominantly siliceous and contains rocks which show only a low grade metamorphism and much less deformation. Three rock types only have been recognized and the group consists of a repetition of these.

Quartz schist (6226) is the most abundant rock in this group. It is a mica-rich quartzite which might equally well be called a schistose quartzite or a siliceous phyllite. It is a white, schistose rock with a characteristic platy appearance in outcrop. In some outcrops it is light-grey to yellow with a phyllitic appearance whereas in others it is less schistose and rather massive. The schistosity is parallel to the bedding which is usually contorted and tightly folded as shown in plate II, No. 2. In thin section it shows a fine, even texture with abundant tiny, parallel sericite flakes but with no obvious preferred orientation or elongation of the quartz grains.

Massive quartzites are common in this group. Some specimens, e.g., 6223, are fine grained, massive, well bedded rocks with cross bedding and ripple marks. The pure white colour of the outcrops is partly due to leaching of the surface as the rock is generally a rusty-brown within, due to weathering. Apart from a few folds such as shown in plate II, No. 1, these quartzites do not show much sign of contortion although some specimens (6251) show a distinct lineation. Thin sections show the rock to be generally a pure quartzite with only a little muscovite, tourmaline, zircon and iron ore. The least deformed specimens have a sutured texture with the quartz showing undulose extinction and "Boehme" lamellae and the mica with a random orientation. More strongly sheared rocks show granulation and a reduction in grain size of the quartz which tends to become elongated. These specimens show a preferred orientation of the mica and have a distinct lineation in the hand specimen.

The phyllites (e.g., 6222, 6227, 6239, 6241, 6253, 6309) are light to dark-grey rocks which are fine-grained, soft and lustrous with a strong cleavage. The cleavage is generally parallel to the bedding which is poorly developed. The phyllites are invariably crenulated with white quartz lenses along the cleavage as shown in plate III, No. 3. Thin sections show them to be fine-grained and rich in quartz and muscovite with accessory tourmaline, zircon, rutile, iron ore and rare chlorite. At least one cleavage is strongly developed and many specimens show two or even three. The replacement nature of the quartz lenses is clearly seen in thin sections.

It is possible that the quartz schists have been formed by silicification of the phyllites for the following reasons.

Phyllites are not persistent and disappear rapidly along the strike. The base of the Mary Group at Mount Mary is a thick phyllite but the base at Ward's Bluff shows a thin siliceous phyllite followed upwards by thick quartz schist. Stratigraphic sections in different parts of the area are difficult, if not impossible to match. Quartz schist passes into siliceous phyllite on the top of Flat Bluff. Replacement of phyllite by quartz schist is demonstrable on a microscopic scale.

The evidence against this hypothesis is not strong and is as follows:—

Adjacent beds of phyllite and quartz schist show sharp, non-gradational contacts. Nowhere in the field was a transition along the strike from typical phyllite to typical quartz schist found.

It is also possible that some of the massive quartzite may result from further silicification but this probably is not common.

Franklin Group

The rocks of this group are typical products of medium-grade regional metamorphism on a mixture of sandstones and shales with some pre-metamorphic basic intrusions. Muscovite and garnet rich schists are common with knotted albite-schists, garnet-gneisses, muscovite-quartzites and garnet-quartzites. Effects of deformation are shown by the strong schistosity of the schists and quartzites and the strong lineation of the quartzites.

The lowest bed of this group in this area is exposed in the saddle and valley immediately south of Raglan Bluff. It is a dark-grey, fine-grained, lustrous schist consisting chiefly of muscovite and quartz with a little biotite and garnet. Garnet becomes increasingly abundant upwards and just below the Raglan Quartzite is found a typical knotted garnet schist. The garnet is replaced by haematite in some mineralized specimens and by limonite in weathered specimens. Thin sections show that the rock consists chiefly of parallel laths of muscovite and elongated crystals of quartz with biotite, garnet, a little chlorite and accessory apatite, zircon and rutile. Albite is usually present as fresh twinned or untwinned crystals showing "rolled" structure.

There are thin beds of black lustrous phyllite which lack garnet and one unusual specimen is a garnet-chlorite schist. This is a contorted, schistose rock consisting of tiny chlorite flakes which are interlocking and undulating, with large (quarter-inch) porphyroblasts of garnet and accessory zircon and rutile.

Thin beds of garnet quartzite occur within this horizon and 6260 and 6264 are typical of these. These are dark-brown to black, fine-grained rocks with a banded and knotted texture. They consist chiefly of quartz and haematite. The iron ore clearly pseudomorphs garnet in some places but much of it has replaced quartz along intergranular contacts. There are patches of very fine-grained chloritic material and it appears that the quartz was first chloritized and them haematitized.

The next formation is the Raglan Quartzite which is well exposed at Raglan Bluff. It is a well-bedded to laminated, white to pale-grey, muscovite rich quartzite which shows contortion and isoclinal folding (from two inches to 200 feet across) and has a district cleavage parallel to the bedding and a pronounced lineation. Tourmaline needles occur abundantly in random orientation along the bedding plane-cleavage. Some varieties are rather massive and saccharoidal. The rock consists chiefly of quartz which is flattened and elongated, with parallel muscovite flakes, a little biotite and garnet (pseudomorphed by chlorite in some specimens) with accessory tourmaline, rutile, apatite and zircon.

The rocks in the Cardigan Schist and Quartzite do not differ apreciably from the above rocks individually. The formation is rich in knotted garnet-mica schists and mica quartzites.

Some varieties of the Collingwood Schist are characterized by the presence of porphyroblasts of albite. The typical albite schist is a light-coloured, schistose rock, rich in muscovite and containing porphyroblasts of albite which are generally about 5 mm. across but ranging up to 1 cm. in some coarse varieties. The albite gives the hand specimen a characteristic knotted appearance. Thin sections show that abundant mica wraps around the porphyroblasts of albite which are separated by quartz, muscovite, and biotite with accessory rutile and zircon. The albite is of two varieties. The large porphyroblasts are riddled with inclusions of quartz, are shattered and are twinned on combinations of the Albite and Carlsbad laws and are post-kinematic. The smaller albite crystals are lenticular in shape and display no twinning but have a strong rotational structure shown by "s" shaped trails of inclusions, and these are syn-kinematic.

A band of coarse gneiss which occurs along the Lyell Highway on both sides of the 21-mile post is characterized by containing garnets up to 1 cm. in diameter as well as streaks of pegmatitic material.

Older Basic Igneous Group

Two distinct varieties of amphibolite occur within the Joyce and Franklin Groups and these are regarded as being pre-metamorphic basic intrusives. Definite evidence of the intrusive nature of these rocks was not found in this area but J. B. McKellar and R. B. Mather (personal communication) have found intrusive amphibolites near the Franklin River. The two varieties are referred to as amphibolite and pyroxene-amphibolite.

Normal amphibolites are found in the Cardigan Schist and Quartzite of the Franklin Group in this area and are particularly well developed in the type area of this group according to McKellar (personal communication).

Typical is 6890 which is a fine, even grained but schistose dark-green rock. A thin section shows that it has an irregular texture and consists of green hornblende showing a moderate degree of preferred orientation together with albite and lesser garnet, biotite, calcite, zoisite, quartz and sphene. Some varieties are extremely rich in garnet and would be classed as garnet amphibolites.

Pyroxene-amphibolites occur in the Joyce Group and also among the Cardigan Schist and quartzite of the Franklin Group. The mineralogical composition is most peculiar and has not been recorded elsewhere. Chemical analysis shows that it has a composition similar to the normal amphibolites and the reason for the abnormal mineralogy is at present being investigated.

It is a medium to coarse-grained rock, even textured, heavy and green in colour. Pyroxene, garnet and amphibole are recognizable in the hand specimen with some difficulty but muscovite is prominent. It has a feeble banding, schistosity and lineation. A thin section shows that it is an even grained aggregate of garnet, diopside, pale actinolitic hornblende and muscovite with accessory rutile.

Younger Basic Igneous Group

A number of small dyke-like intrusions outcrop along Bradshaw's timber track between Mount Raglan and the huts to the west. The dolerite shows some alteration but is not regionally metamorphosed as are the garnet schists which it intrudes. These dolerites are related to the Cooee Dolerite (Spry, this volume) and details are given there.

Metamorphism

All the Pre-Cambrian rocks in this area are metamorphosed to some degree, but the intensity is so variable that it is evident that selective metamorphism has taken place. The Joyce and Franklin Groups show a higher grade of metamorphism and are more intensely deformed than the Mary Group.

The stratigraphic sequence in the western part of the Franklin Area appears to be as follows:—

Fincham Group
Franklin Group
Mary Group
Joyce Group

The Joyce Group belongs to the garnet zone and above this are the scarcely metamorphosed phyllites and quartzites of the Mary Group which belong to the chlorite zone. Next are the garnetiferous schists of the Franklin Group which belong to the garnet zone, overlain by the phyllites and quartzites (chlorite zone) of Mt. Fincham.

It can be seen that there is no relation between degree of metamorphism and age. In such terrain as this it is usually found that the youngest beds are least metamorphosed, or that less metomorphosed sediments are separated from schists by an unconformity. The only reasonable structural interpretation of this area indicates a stratigraphic succession in which slightly and moderately metamorphosed groups are interbedded.

The problems to be answered are:—

(1) Why have the Joyce and Franklin Groups apparently reached a higher grade of metamorphism than the rocks above, below and in between?

(2) Why do the Joyce and Franklin Groups show a better development of recrystallization, tectonic fabric and strong lineation?

As indicated earlier these problems will be discussed elsewhere.

STRUCTURE

The structure of the area is dominated by the broad Mary Anticline whose regional axis trends diagonally across the area from the south-eastern to the north-western corner. The oldest rocks (Joyce Group) occur as a core to the fold while the area is chiefly occupied by Mary Group rocks on the flanks. The Franklin Group outcrops in the north-east where it is folded into a small syncline and an anticline. Faults are common throughout the area and most important is a set striking at 120°. Two of these are high angle thrusts dipping inwards towards the axis of the Mary Anticline. Another important set is at right angles to these and strikes at 0-20°. Cleavage is well developed parallel to the bedding in most rocks and the mica schists are strongly schistose. There is a regular regional lineation which plunges flatly to the west. A small wedge-shaped fault block containing Crotty Sandstone occurs in the north-east of the area. The age of the folding and faulting is not known but it is considered that the major folding is both Pre-Cambrian and Tabberabberan although the metamorphism was Pre-Cambrian.

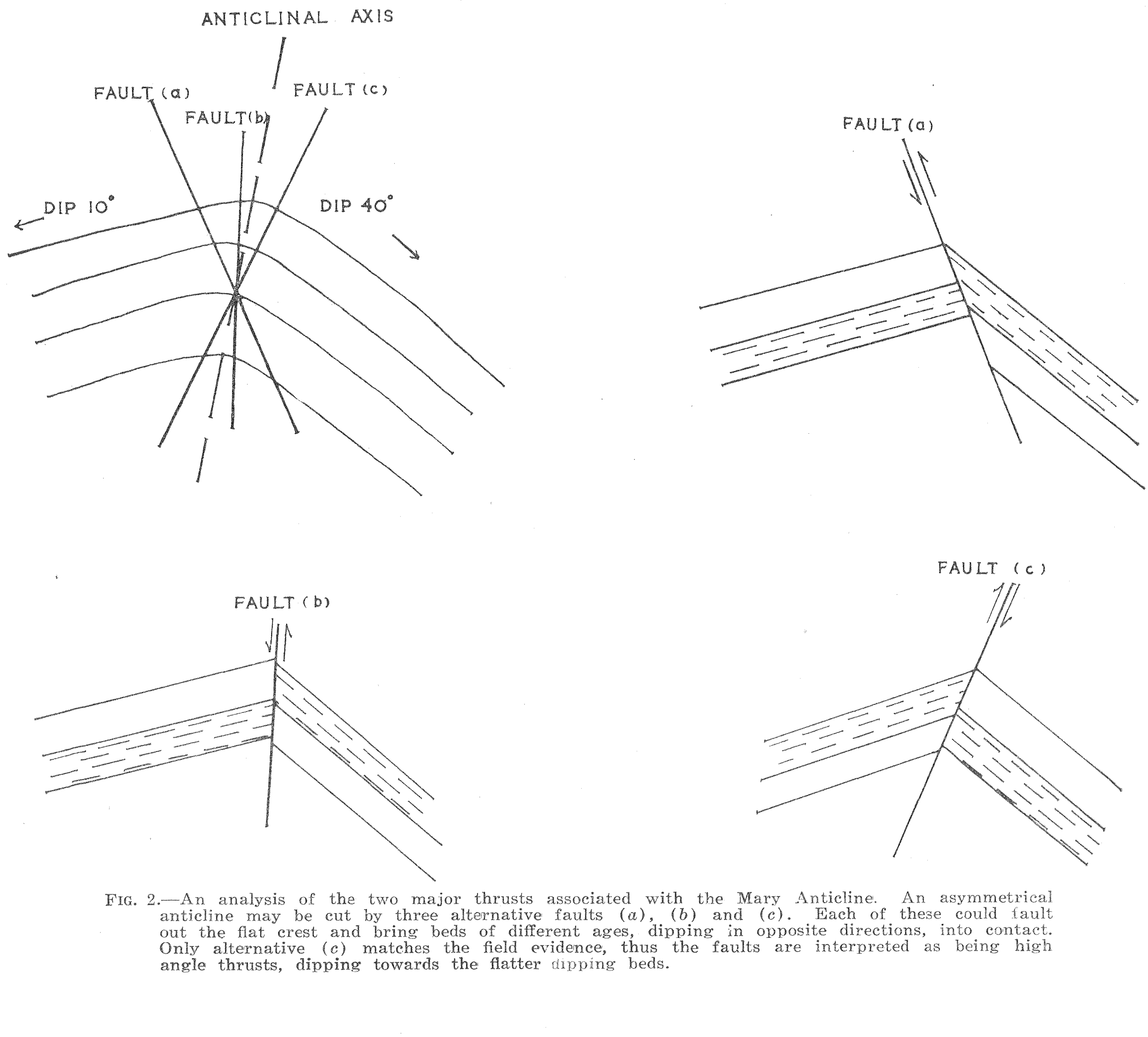
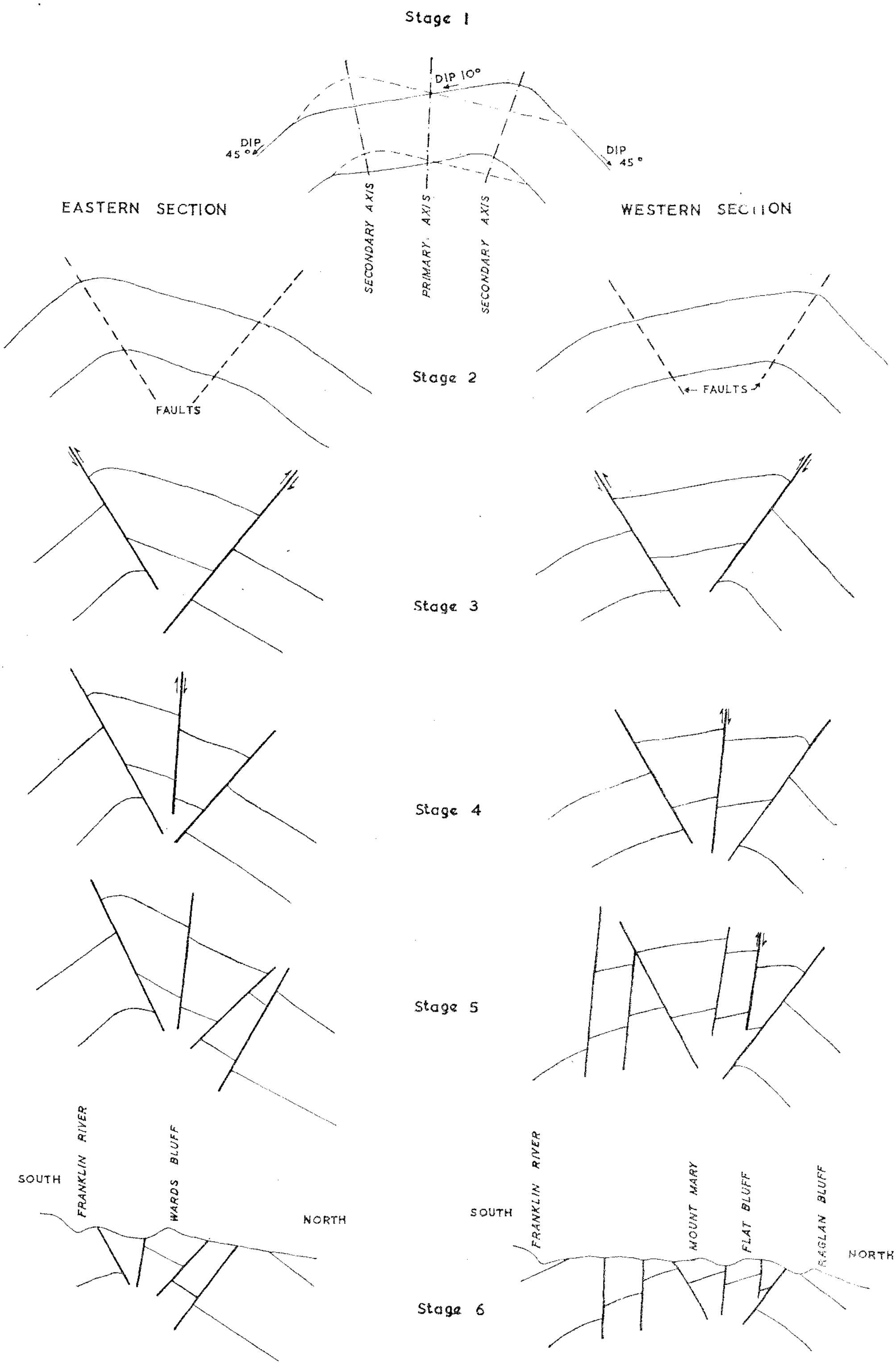


FIG. 2.—An analysis of the two major thrusts associated with the Mary Anticline. An asymmetrical anticline may be cut by three alternative faults (*a*), (*b*) and (*c*). Each of these could fault out the flat crest and bring beds of different ages, dipping in opposite directions, into contact. Only alternative (*c*) matches the field evidence, thus the faults are interpreted as being high angle thrusts, dipping towards the flatter dipping beds.



STRUCTURAL EVOLUTION OF THE MARY ANTICLINE

FIG. 3.—The structural evolution of the Mary Anticline taken stage by stage. The two sections are taken at right angles to the fold axis through Mt. Mary and Ward's Bluff. For more details see fig. 4.

Mary Anticline

The major axis of this symmetrical anticline runs from the north-west corner to the south-east corner of the area in a direction 300°. In the north-west the axis plunges flatly west. The fold appears simple on a regional view but in detail is quite complex due to faulting. The axis appears to lie between Flat Bluff and Raglan Bluff where Franklin Group rocks dipping at 40° to the north are faulted against Mary Group rocks dipping at 10° to the south. The axis appears also to be south of Ward's Bluff where Joyce Group schist dipping north at 12° is faulted against Mary Group quartz-schist dipping south at 40°. Thus faulting along the axis has removed the horizontal crestal zone but more important is the appearance of the axis being displaced two miles at a cross fault. This fault then appears to be a right-handed transcurrent fault but observations in the field and inspection of the air photos show that it does not continue to the south. Also this fault displaces the base of the Franklin Group north of the Joyce Creek in a left-handed sense.

An explanation for the apparent displacement of the axis is given in fig. 2. It is considered that two puckers were developed along the main axial zone concurrently with a pivotal fault perpendicular to the axis as shown in plate III. Two steep reverse faults formed along these minor axes and movement along these raised the central block and faulted out the horizontal zone of the fault. Fig. 3 shows why only a steep reverse fault could bring the flatter older beds up against the younger steeper beds. Later vertical normal faults striking in the same direction caused additional complication. There appears to have been further movement on a northern extension of the pivotal fault, accounting for the displacement of the base of the Franklin Group, just north of the Joyce Creek.

The Mary Anticline is a minor anticline lying between synclines of the Loddon and King Rivers where Palaezoic rocks are down-folded into the Pre-Cambrian.

There is a faulted syncline which runs from the Lyell Highway south along the western side of the Collingwood Range. It cuts across the north-eastern corner of the area where a wedge of Crotty (?) Sandstone has been faulted down into the axial zone. In this area there are rocks of the Franklin Group on each side of the axis, but to the south-east quartz schists of the Mary Group appear along the faulted axis, thus the fold appears to be plunging to the north.

Minor Folds

Most formations show tight, recumbent, isoclinal folds and crenulation. These folds are commonly a foot or so across as in plate II, but may be of a microscopic scale or up to several hundred feet across. These folds are associated with a period of metamorphism and deformation and do not seem to be related to the major folds. They are seen to be incongruent flow folds and not drag fold where they—

(*a*) indicate that a bed is overturned in one place but right way up only a foot away along the strike.

(*b*) indicate that a bed is overturned while the regional structure indicates that it is not.

The pronounced crenulation shown particularly by the phyllites of the Mary Group appears to be independent of this drag folding as the lineation which is parallel to the axes of the drag folds if folded by the crenulation. Some zones of crenulation indicate tiny transcurrent movements. Probably the crenulation is related to the folding of the Tabberabberan while the isoclinal folding and lineation are related to the earlier Pre-Cambrian orogeny which produced the metamorphism.

Cleavage

Only the massive quartzites of the Mary Group lack the cleavage which is developed parallel to the bedding of phyllites, quartz schists, mica schists and mica-quartzites.

Cleavage and bedding are clearly discordant in the phyllite which outcrops in the bed of the Franklin River one mile upstream from the mouth of the Mary Creek.

Lineation

A number of different kinds of lineation are developed in this area but these may be divided into two genetic groups. There is an older, general lineation which is of considerable structural significance together with a later superficial lineation.

The fine crenulation in phyllites and mica schists, ribbing in quartzites, parallelism of amphibole laths in amphibolites and of muscovite flakes in mica quartzite are all remarkably constant in direction throughout the area. This lineation generally plunges at 10° in a direction 300°, although some plunge as steeply as 45° west, while others plunge 2-5° to the east although still on the same strike. This lineation is parallel to the axes of the isoclinal folds and also with the axis of Mary Anticline. Lineation may become an important tool in regional mapping as it is probably parallel to the axis of Pre-Cambrian but not Tabberabberan folds and thus might be useful for distinguishing between them.

The massive quartzites of the Mary Group show little deformation and some specimens show no appreciable recrystallization or tectonite fabric. Cross bedding and ripple marks may be prominent in some rocks which are seen under the microscope to be severely deformed. In some cases it is difficult to ascertain whether the ripples are of sedimentary or tectonic origin but the evidence for them being of a primary depositional origin is as follows:—

(*a*) Some specimens show the typical cuspate form of the stationary wave ripple.

(*b*) In some outcrops the ripples are not parallel in beds a few feet apart.

(*c*) Some specimens show ripple marks which have been deformed by a corrugation at an angle to them.

The massive quartzites show a very pronounced corrugation where the ripple marks happen to have been parallel to the lineation direction.

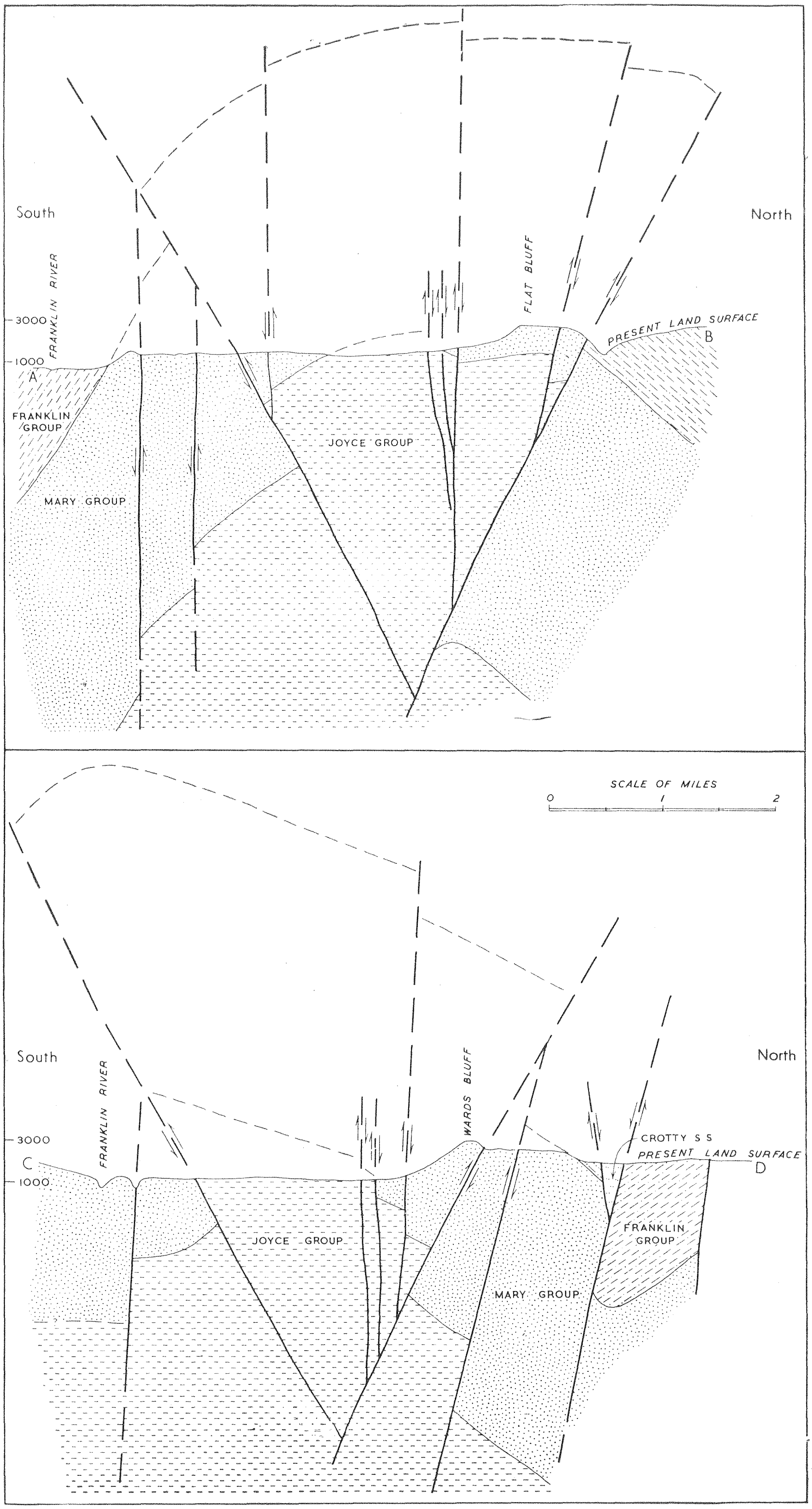


FIG. 4.—Interpretive cross-sections across the area along sections A-B and C-D of the map on page 20.

Joints

All rocks in the area are jointed to some degree but apart from the "a-c" joints normal to the lineation, no joints which could be related to a major structure were found.

Faults

As in all areas of Pre-Cambrian rocks so far studied in Tasmania, faulting is abundant. The presence of several distinct sets of faults makes the detailed structure so complex as to be practically insoluble. In most cases the amount of (or even the direction of) displacement can not be determined because details of the stratigraphic sequence are not known.

Most of the faults shown on the map were recognized first on the air photos because of their topographic expression and many of these remain unconfirmed because of the lack of recognisable displacement. Most difficult to prove are the major strike faults which show no displacement in plan and which can only be proven if the stratigraphy is known in detail. Strike faulting appears to be very common in the Pre-Cambrian rocks in Tasmania.

Minor structures such as contortion, drag dip, slickensides and crush breccias are of limited use in proving the presence of faults for the following reasons.

(*a*) All rocks in the area are so contorted that contortion and drag in a fault zone is not often recognizable with certainty.

(*b*) Slickensides are abundant and it is not possible to recognise whether they occur on major faults or on the innumerable small faults. A further difficulty is that some slickensided surfaces show several sets of striations at various angles (even 90°) to each other.

(*c*) Excellent crush breccias are found in the quartzites of the Raglan Range and Ward's Bluff. In the latter locality lines of breccia resist erosion and stand up like walls of coarse concrete. As far as can be determined, crush breccias are only developed on the small faults.

(*d*) Where the major faults can be observed there is no outstanding contortion, drag, slickensiding or brecciation.

Strike faults frequently separate beds which dip in opposite directions or the same direction but in different amounts and may thus resemble an unconformity. This aspect was discussed in the stratigraphy section.

A number of different sets of parallel faults are recognisable but only the more important ones are shown on the map.

(*a*) One group consists of a considerable number of faults of small throw striking at 350° at Flat Bluff but varying up to 35° at Ward's Bluff. They are vertical normal faults with throws from 10 feet to 100 feet. These are recognisable only in areas of flat-lying sediments where displacements of a contact between two formations may be followed. These faults, although abundant, are not of great importance and no attempt was made to map them over the whole area.

(*b*) There is a group of faults trending between 60° and 80°, which have considerable displacements although the exact magnitude cannot be determined because of lack of knowledge of the direction of movement. They are oblique to the strike and are therefore easily recognisable. The large displacements and occasional drag visible in plan suggest that they might be transcurrent faults although it is more likely that they are vertical, normal faults as they do not persist for more than two miles.

(*c*) The most important are those strike faults trending at 120°. Two of these are steep reverse faults associated with the development of the Mary Anticline but the others appear to be vertical, normal faults related to those which affect the Eldon Group near Bubb's Hill. Thus there may be two genetically separate sets parallel to this direction; one compressional, the other tensional. Both the thrusts and the normal faults displaced the Eldon Group and are Tabberabban. These faults are persistent, two extending across the full width of the area mapped, thus being at least six miles long. Regional studies suggest that one of these faults continues off to the east and passes south of the East Loddon River while another heads off towards the King River Valley to the west. The majority of the normal faults in this direction have downthrows to the north. The related faults near Bubb's Hill lower the Eldon down into a graben parallel to the Lyell Highway. In the north-eastern corner of this area a wedge of Crotty (?) Sandstone has been downfaulted into the Pre-Cambrian by faults which strike at 130° and 150° but which nevertheless probably belong to this set. Faults of this set abut against, are displaced by, and themselves displace the set of faults striking meridionally and thus these two sets of faults at right angles are probably conjugate.

Age of the Orogenies

The Ordovician to Devonian sediments in this area are folded and as the Pre-Cambrian rocks are similarly folded and there is no strong unconformity, it is probable that a considerable part of the folding is Tabberabberan.

During the Pre-Cambrian orogeny the sediments were under a considerable load and were first subjected to powerful horizontal forces acting in a couple which may be regarded as overthrust to the south and underthrust to the north. This resulted in gently folded, mildly (but selectively) metamorphosed beds with a schistosity parallel to the bedding and a regional lineation.

Erosion to a flat surface produced a basement on which the Junee and Eldon were deposited. The Pre-Cambrian folding was broad and gentle. The Tabberabberan orogeny folded both Palaeozoic and Pre-Cambrian rocks thus superimposing later folds on the earlier ones but did not produce sharp structural unconformities. The Mary Anticline was initiated during the Frenchman Orogeny because the lineation which was formed during regional metamorphism is parallel to the axis of the fold. However, during the Tabberabberan the folding was repeated, but this time was accompanied by faulting. The two thrusts are clearly related to the folding and it appears that the anticline was formed by horizontal compression combined with an upwards movement of a block along the centre. The normal faults parallel to the thrusts appear to be contemporaneous and are compatible with this movement. These relations are shown in detail in figs. 3 and 4.

There does not seem to be any Tertiary or Jurassic faulting present. No faults show the topographic expression of Tertiary faults and the depression along the Lyell Highway in the Nelson and Collingwood River valleys is probably an old graben with the softer Palaeozoic rocks weathered out of the centre.

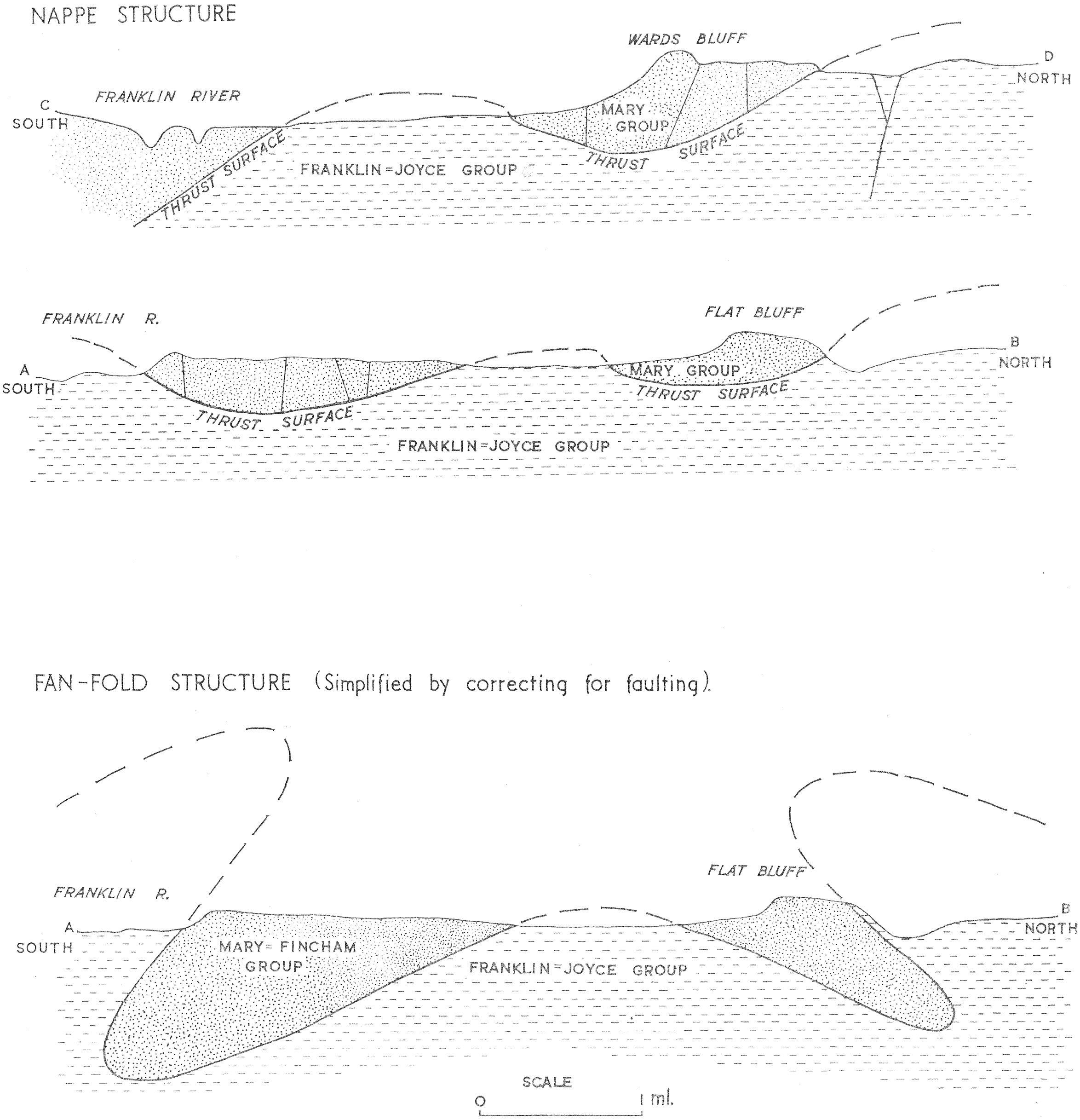


FIG. 5.—The lithological similarity of the Joyce and Franklin Groups suggest that they might be stratigraphically identical. The three sections show two alternative structural explanations on the basis of large scale overthrusting or overturning. While these explanations seem possible in cross-sections, the regional structure disproves them. This will be shown in detail in a paper now in preparation.

REFERENCES

BLAKE, F., 1936.—" District between Jane River and Prince of Wales Range." *Tas. Dept. Mines Typewritten Rept.* Unpublished.

————, 1937.—" Report on Geological Reconnaissance of Surveyor and Deception Ranges." *Tas. Dept. Mines Typewritten Rept.* Unpublished.

FINUCANE, K. J. AND BLAKE, F., 1933.—" Country between the West Coast Road and the Jane River." *Tas. Dept. Mines Typewritten Rept.* Unpublished.

TURNER, F. J., 1951.—" Igneous and Metamorphic Petrology." *London.*

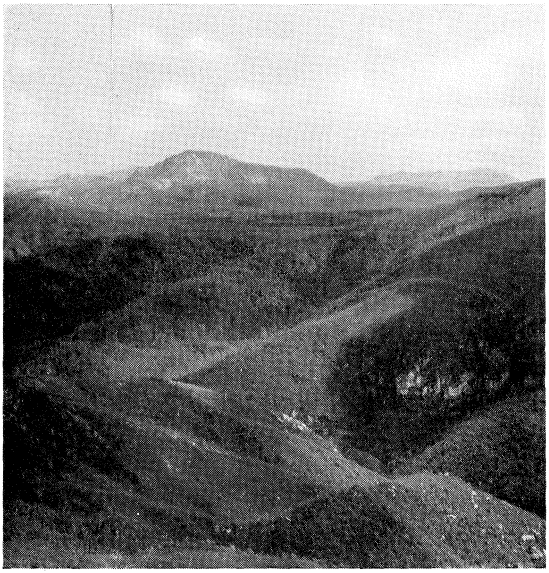
WARD, L. K., 1908.—" King William River to King William Range." *Dept. Lands and Surveys Rept.* 1903-1908.

————, 1909.—" Contribution to the Geology of Tasmania—The Pre-Cambrian." *Proc. Roy. Soc. Tas.* 1909.

————, 1909.—" Report on the Geological Exploration of the Loddon and Jane River Country." *Rept. of Dept. Lands and Surveys* 1908-1909.

LOCALITY INDEX

	Quadrangle	S. Lat.	E. Long.
Bubb's Hill	Lyell 58	42° 7′	145° 45′
Cardigan River	Lyell 58	42° 8′	145° 49′
Collingwood Range	Lyell 58	42° 10′	145° 53′
Collingwood River	Lyell 58	42° 10′	145° 44′
Deception Range	Lyell 58	42° 22′	145° 50′
Engineer Range	Pillinger 65	42° 18′	145° 44′
Flat Bluff	Lyell 58	42° 10′	145° 48′
Forth River	Sheffield 37 Middlesex 45	41° 25′	146° 15′
Franklin River	St. Clair 52 Pillinger 65	42° 22′	145° 46′
Frenchman's Cap	Pillinger 65	42° 17′	145° 50′
Jane River	Pillinger	42° 28′	145° 50′
Joyce Creek	Lyell 58	42° 10′	145° 48′
King River	Strahan 57 Lyell 58	42° 10′	145° 30′
Loddon Plains	Pillinger 65	42° 17′	145° 57′
Mary Creek	Lyell 58	42° 12′	145° 48′
Mary Creek Plain	Lyell 58	42° 10′	145° 48′
Maude Creek	Lyell 58	42° 12′	145° 47′
Mount Mary	Lyell 58	42° 12′	145° 50′
Philp's Peak	Pillinger 65	42° 17′	145° 52′
Port Davey	Davey 91	43° 20′	145° 55′
Prince of Wales Range	King William 66 Huntley 73	42° 30′	146° 31′
Queenstown	Lyell 58	42° 5′	145° 33′
Raglan Bluff	Lyell 58	42° 9′	145° 47′
Raglan Range	Lyell 58	42° 8′	145° 46′
Surveyor Range	Pillinger 65	42° 24′	145° 52′
Tim Shea (Mt. Stephens)	Huntley 73	42° 43′	146° 29′
Ward's Bluff	Lyell 58	42° 11′	145° 52′
Whyte River	Magnet Corinna	41° 30′	145° 14′



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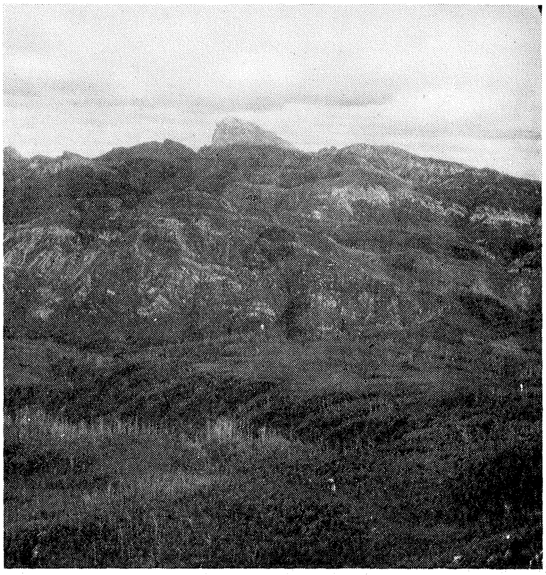

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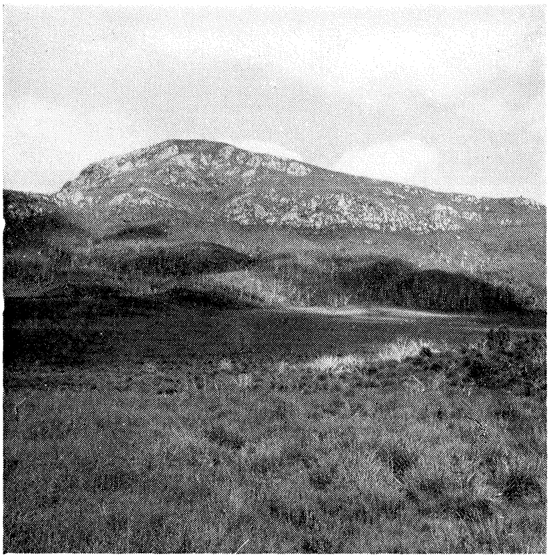

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4

No. 1.—Mount Mary from the north-east. The high level Mary Creek Plain stands at the foot of Mount Mary, and the Joyce Creek cuts well below this in the foreground.

No. 2.—Across the Franklin River to Frenchman's Cap from near Wards Bluff. The high level river flats are visible in the foreground.

No. 3.—Mount Mary from Mary Creek Plain. Basal phyllite and quartz schist of the Mary Group overlie the Joyce Group which outcrops on the plain.

No. 4.—Ward's Bluff from the south. Massive quartzites interbedded with quartz schist at the base of the Mary Group.

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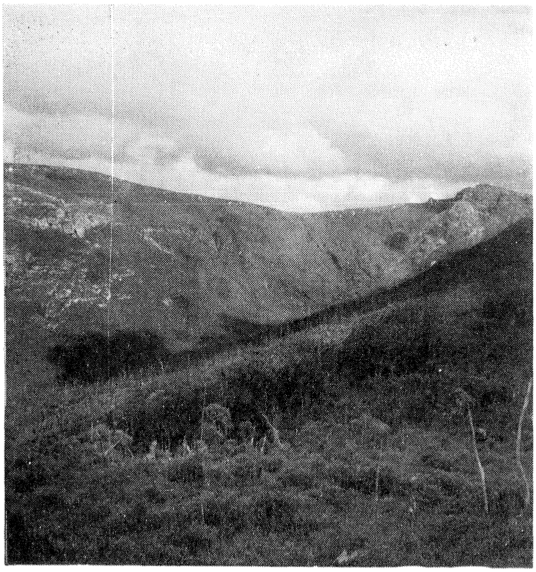

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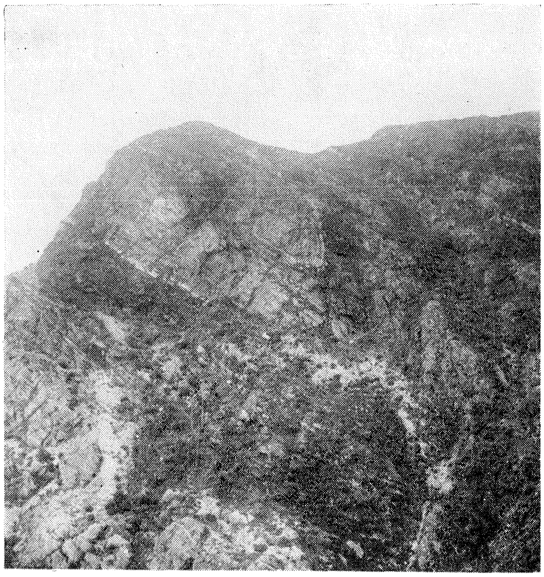
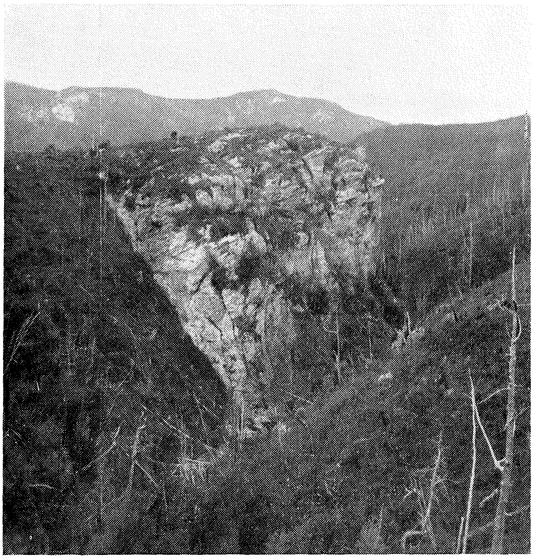


4

No. 1.—Folds in massive quartzite of the Mary Group, south-east of Ward's Bluff.
No. 2.—Recumbent isoclinal folds in quartz schist of the Mary Group.
No. 3.—Raglan Bluff from the east. It stands at the head of Joyce Creek which runs east. Franklin Group dips steeply north on the right-hand side of the photo and is separated by a major thrust fault from the Joyce Group dipping flatly south on the left.
No. 4.—Folding and overthrust faulting in quartzite of the Raglan Bluff. The area shown is about 50 yards across.



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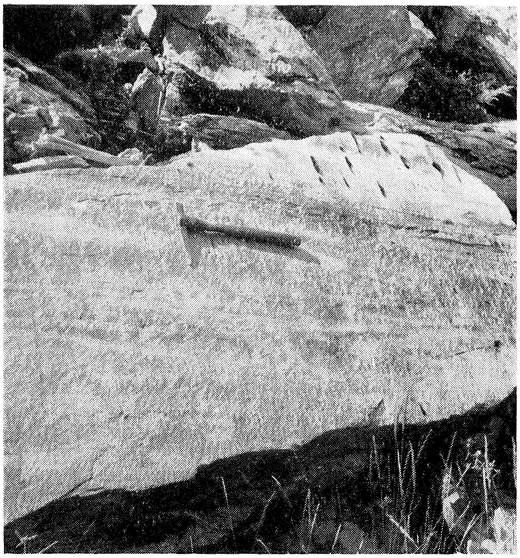

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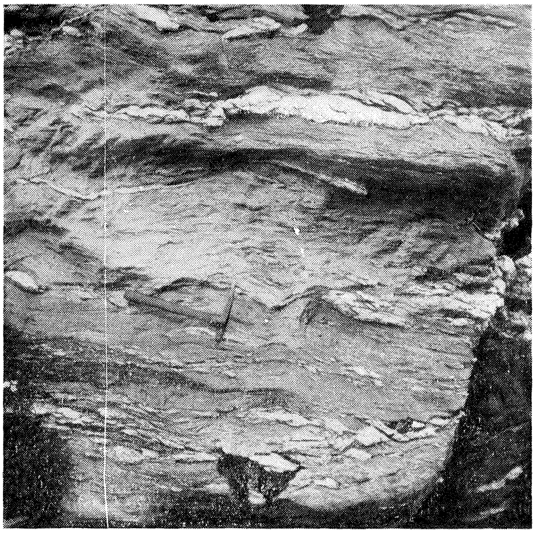

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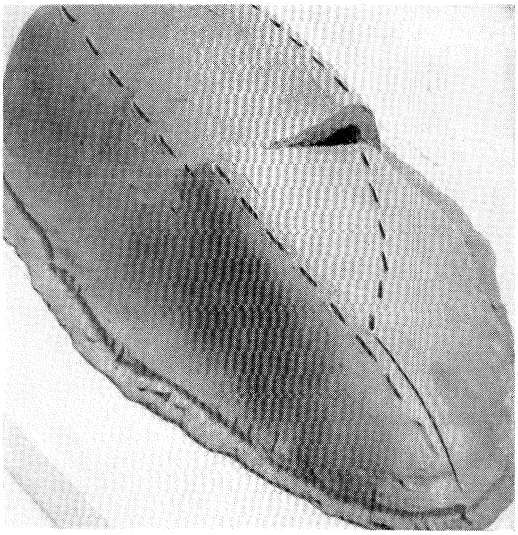
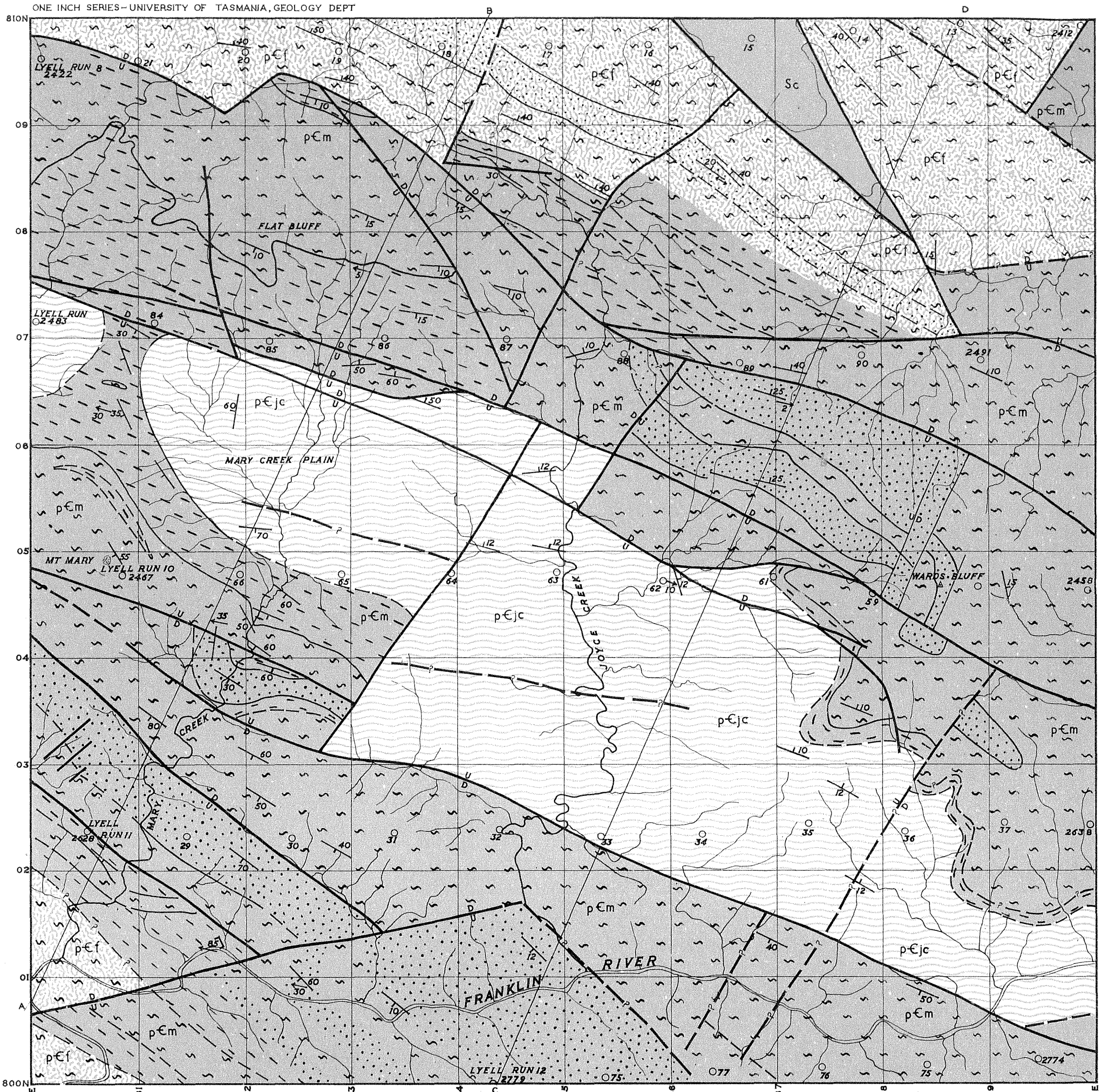
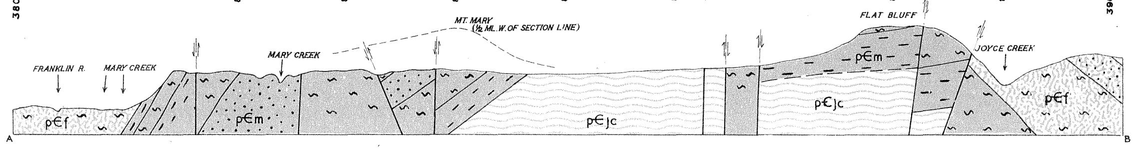


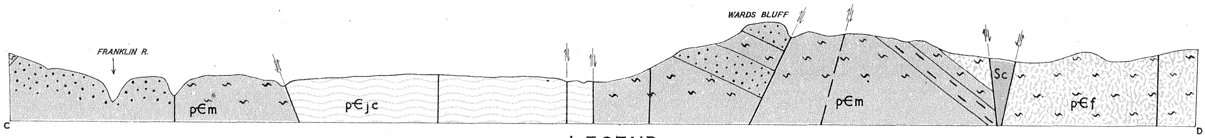
4

No. 1.—Steep thrust fault in the Mary Group in the upper Joyce Creek.
No. 2.—Strong lineation (ribbing) in Franklin Group quartzite of Raglan Bluff with "*a-c*" joints normal to the lineation.
No. 3.—The basal phyllite of the Mary Group at the base of Flat Bluff. Silicification has produced quartz lenses along the schistosity; typical corrugation is visible.
No. 4.—Photograph of a plasticene model of the Mary Anticline showing the secondary folds and the hinge fault developed on the crest, with the positions of the major thrust faults marked. Sections across this structure are shown in fig. 3.

MT. MARY







LEGEND

- FAULT
- FAULT POSITION APPROXIMATE
- FAULT INFERRED
- FORMATION BOUNDARY
- FORMATION BOUNDARY APPROXIMATE
- FORMATION BOUNDARY INFERRED
- STRIKE AND DIP
- DIRECTION AND PLUNGE OF LINEATION
- STRIKE AND DIP OF CLEAVAGE

Silurian

- Sc — CROTTY(?)SANDSTONE

Precambrian

FRANKLIN GROUP

- pЄf — SCHISTS & QUARTZITE
- pЄf — QUARTZITE

MARY GROUP

- pЄm — PHYLLITE
- pЄm — MASSIVE QUARTZITE
- pЄm — QUARTZ SCHIST
- pЄjc — JOYCE GROUP

Compilation from Aerial Photographs. Trigonometric Station Control by courtesy Hydro-Electric Commission. Origin of Co-ordinates 400,000 yds. West and 1,800,000 yds South of True Origin of Zone 7

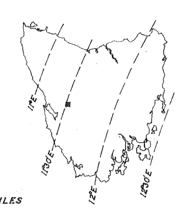
MAPPED AND COMPILED BY A.H. SPRY. 1955

SCALE

0 — 1 — 2 MILES

0 1 2 3 4 5000 10,000 FEET

KEY MAP SHOWING MAGNETIC DECLINATIONS SECULAR VARIATION 7MINS PER ANNUM



GEOLOGY OF THE MT. MARY AREA

1. BIBLIOGRAPHY:

WARD, L. K., 1909: "Contribution to the Geology of Tasmania—The Precambrian". **Pap. and Proc. Roy. Soc. Tas.,** 1909, pp. 124-156.

WARD, L. K., "King William River to King William Range". **Dept. Lands and Surveys Rept.,** 1903-1908.

2. STRATIGRAPHIC TABLE:

AGE	GROUP	FORMATION	LITHOLOGY	THICKNESS
		TABBERABBERAN OROGENY		
Silurian	Eldon	Crotty	Sandstone	200'?
		TYENNAN OROGENY		
	Younger Basic Igneous Rocks		Dolerites	
	OROGENY WITH REGIONAL METAMORPHISM			
	Older Basic Igneous Rocks		Amphibolites	
	Franklin	Cardigan	Schist (mica, garnet) and Quartzite	2000'?
		Raglan	Quartzite	900'
			Schists	1200'
Precambrian		**MINOR UNCONFORMITY (?)**		
	Mary		Quartz schists, massive quartzites, phyllites	10,000'
		MINOR UNCONFORMITY (?)		
	Joyce		Mica and garnet schists	5000'(?)

3. LOCALITIES OF SPECIAL INTEREST:

Major thrust fault between Mary and Franklin Groups	E382000.N809300
Minor thrust fault	E384600.N808600
Minor isoclinal folds	E380700.N805200
Ripple marks	E381600.N804000
Pyroxene amphibolite	E382600.N806200