Part II

STRUCTURAL GEOLOGY

STRUCTURAL GEOLOGY

Chapter 3

Introduction

It is obvious that an understanding of the structural aspects of these rocks is essential to the interpretation of their overall geologic evolution. The brief descriptions in Part I suggest that much of the mapped area is underlain by metamorphic rocks that have undergone complex multiple folding. A broad structural analysis of these rocks was attempted, and the structural successions established within each subdivision used to derive structural history.

In a study of this type it is customary to determine the orientation of the structural elements throughout the area, followed by their division into sub-areas or domains in which there is some degree of homogeneity of the fabric. These methods are outlined and discussed in detail by Turner and Weiss (1963). The criteria of recognition of the successive generations of structures are essentially those of Weiss and McIntyre (1957), p. 578, (see also Hobbs, 1965, p. 1).

"(1) Structures of similar style and similar patterns of preferred orientation (not necessarily with same directions of preferred orientation) are assumed to be of the same generation;

(2) structures of consistently dissimialr patterns of preferred orientation are ascribed to separate generations; and

(3) where structures of one style and with one pattern of preferred orientation consistently overprint structures of another style and another pattern of preferred orientation, the former are considered to have formed later than the latter".

The terminology and notation used for the various structural elements follows essentially that of Turner and Weiss, (1963).

Structural Outline

This investigation resulted in the recognition within each of the subdivisions of a structural succession made up of a series of episodes of folding, (F1, F2, F3, etc.). It is found that correlation of these episodes between the various subdivisions is possible. For example, the Tia Complex has episodes of folding that can be correlated throughout all its three subdivisions.

To simplify the discussion and assist in the more detailed description of the structures of these rocks, Fig. 2 was constructed to illustrate the various correlations that have been made. Reference to this clarifies much of the discussion to follow. An unbroken line in Fig. 2 means that the correlation is believed to be well defined, a broken line indicates a possible correlation only.

Subsequent to the folding the metamorphic rocks were extensively faulted, as described briefly in Part I. The faulting will also be described and discussed in more detail in this Part.

Presentation of the Structural Data

Much of the structural data collected within the area mapped is shown on Map 2, from which the major features of the regional structure are reasonably clear. This data is also used to construct Map Fig. 3, showing the relationship of the structural domains together with the data for the successive deformations of each domain. The size of the area mapped meant that in the time available it was impossible to rigorously define each of these domains, however a relatively high degree of structural unity characterizes each one, either or

PROPOSED CORRELATION OF FOLD EPISODES

THE TIA COMPLEX						
OXLEY METAMORPHICS	WYBEENA METAMORPHICS	BRACKENDALE METAMORPHICS	TIA GRANODIORITE	NOWENDOC ULTRABASIC BELT	KARINYA METAMORPHICS LOCHABER GREYWACKES	AGNES GREYWACKES
POSSIBLE PRE F1	POSSIBLE PRE F1					
F1	F1					
F2	F2	F1			F1	F1
F3	F3	F2	F1			
F4		F3				
				EMPLACEMENT		

FIG. 2.

both in terms of the fabric orientation and the style of the deformation.

In the description that follows of the structural aspects of each subdivision, the fold episodes referred to are as shown in Fig. 2.

Chapter 4

THE OXLEY AND WYBEENA METAMORPHICS

The Oxley Metamorphics

Six structural domains, shown in Map Fig. 3, have been delineated within this subdivision.

Domain I

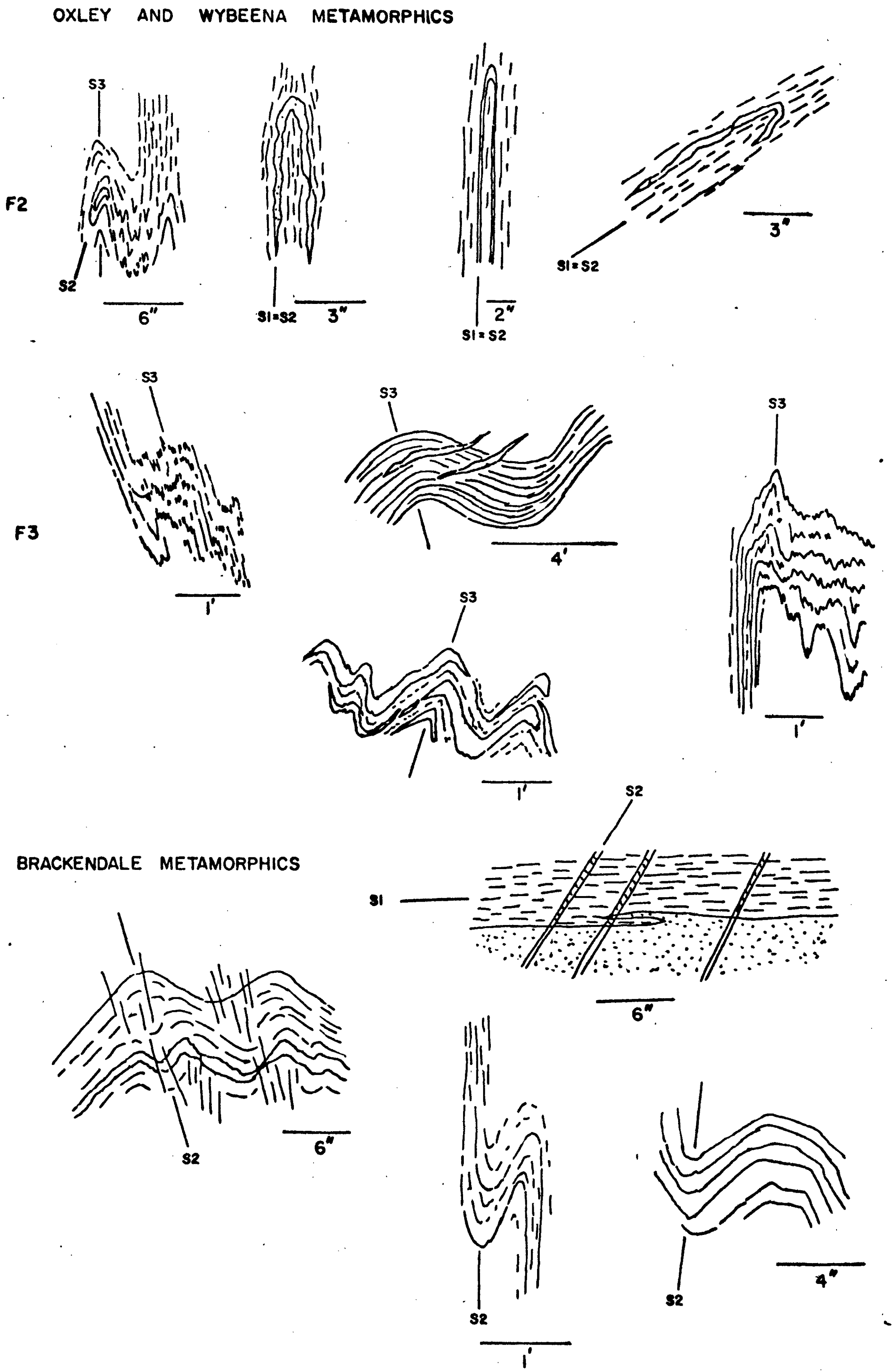
Sedimentary layering or bedding is absent in the majority of the rocks of this domain, the only exception being cherts and jaspers outcropping along the lower Cooplacurripa River. The latter have retained a fine rhythmic banding which is probably inherited from an original sedimentary layering. The pelitic and semi-pelitic horizons are of muscovite-chlorite to biotite metamorphic grade and consist of completely reconstituted phyllites and mica-rich schists. These contain a penetrative layering, consisting of alternating lensoidal and pod-like quartz segregation laminae and mica-rich laminae. This lamination is best developed in the biotite grade schists of the upper Cooplacurripa River (e.g. Plate 1A), and becomes less well developed downstream towards lower grades of metamorphism, (e.g. Plate 1B).

F1 Folds. These laminae and parallel mica schistosity represent the earliest recognizable surface of deformational origin (S1), and are inferred to have originated as a planar axial surface to F1 folds during an early deformation period concurrent with regional metamorphism. The accompanying metabasic horizons are transposed parallel to and contain the S1 foliation, however they do not in general possess S1 segregation laminae of similar style to those of the adjacent schists.

In the majority of their outcrops, the inherited sedimentary layering of the metacherts and jaspers has been transposed parallel to the layering of the accompanying schists. This does not mean that the pre-S1 folded surface is necessarily S0, i.e. relatively undisturbed bedding, as pre-F1 structural deformations could have transposed and/or obliterated S0 of the original schist lithology and developed pre-S1 surfaces of deformational origin. These could then have been subsequently transposed during F1 to give the observed layering. The survival of the early layering within the cherts and jaspers is thus seen as the result of their much greater competency relative to the mica-rich schists.

Fig. 3.

FOLD STYLES



<u>F2 Folds</u> Hinges of tightly appressed mesoscopic folds of the S1 layering are preserved in some of the more highly laminated and veined outcrops, but overall are not very common. Fold hinges on a micro-scale also inferred to be of this generation are observed in thin section. The existence of these hinges indicates an F2 deformation of the S1 layering, with the axial plane (S2) of these hinges parallel to the S1 layering in the majority of the schist outcrops, (see Fig. 3). This suggests transposition of S1 to S2 during F2, and means that through much of this domain the two surfaces S1 and S2 are essentially identical, with only a relatively small number of outcrops, containing F2 hinges, in which they can be distinguished.

In general the inherited sedimentary layering of the metacherts and jaspers has also been transposed parallel to S1 (= S2) of the accompanying schists. At one locality within the lower Cooplacurripa River however, a fold hinge within a layered metachert horizon is exposed (e.g. Plate 1C). This fold approaches isoclinal similar style, with considerable thickening of the quartz layers at the hinge, and possesses an axis plunging approximately 55° to the SW (227) with axial plane oriented 170W72. The orientation of its axis suggests this belongs to the F2 generation, but further analysis of the relationship between F1 and F2 is needed. The L1 and L2 lineation could not be distinguished in this domain, suggesting either obliteration of L1 during F2, or approximate co-axiality of F1 and F2.

Until further analysis of this structurally complex region, F1 and F2 will be collectively described as "early" folds, and their axial surface referred to as S1/S2. In Map Fig. (3), the axes of these early folds show considerable scatter as a result of F3 refolding. The planes plotted as great circles on the stereograms contain the folded early lineation, as measured across the hinge of several F3 folds of the upper Cooplacurripa River.

F3 Folds Following the formation of the early folds the S1/S2 schistosity and layering was deformed on a smaller scale, producing abundant mesoscopic F3 folds throughout the layered schist horizons, (see Plates 1A and 1B). They possess a relatively open symmetrical style, with a crenulation cleavage parallel to the axial plane (S3), (e.g. Plate 2A), in the southern half of this domain, and developing to a more penetrative axial-plane schistosity in the higher metamorphic grade schists of the northern half of this domain. A strong L3 lineation is generated by the intersection of S3 and the earlier surface. There is considerable variation in axial plunge of F3 folds throughout Domain 1, however the similarity in style and the progressive variation of the axial plunge suggests that they are all of the same generation.

Along Back Creek and Uriamukki Creek, northwest of Nowendoc (see Map 2), layered and veined coarse mica-rich schists with spectacular mesoscopic F3 folds, outlined by thick quartzose layering, abut directly against the Nowendoc Fault zone. The F3 fold style and structural succession of these schists are identical to that of the schists of the Cooplacurripa River.

Domain II

The schist lithologies remain completely reconstituted, with no inherited sedimentary layering or surviving clastic textural features. Quartzite and amphibolite, believed to represent original depositional units, have again been transposed parallel to the S1/S2 axial surfaces of the early folds.

<u>F1 Folds</u> S1 is again inferred to have originated as a planar structure parallel to the axial plane of F1 folds, (see Plate 2B). No F1 fold hinges were identified and as the rocks have undergone complete reconstitution, there is no evidence of the nature of the pre-S1 surface, i.e. whether it was bedding (SO), or an earlier S-surface generated during a pre-F1 folding. The macroscopic fold hinge outlined by amphibolite horizons southwest of Tia village (see Map 1), contains a metamorphic lamination as the folded surface, suggesting this is a post-F1 structure.

<u>F2 folding</u> In general, the outcrops of highly veined and contorted schist are difficult to interpret, however in a limited number it is possible to discern two super-imposed post F1 mesoscopic fold generations, denoted respectively as F2 and F3. The small F2 folds possess an appressed near symmetric style with attenuated limbs, resembling in style the F2 folds of Domain 1, (see Fig. 3). Where relatively undisturbed by F3, the F2 axes were steeply plunging parallel to a well developed lineation contained in S1. Away from F2 fold hinges it is apparent that on a slightly larger scale, transposition of S1 has occurred during F2 such that

the S1 and S2 surfaces are indistinguishable.

F3 folding Where the relationship between F2 and F3 could be observed, the F2 axes are steeply plunging, and are, in general, recognizably discordant with the more shallowly plunging F3 axes. F3 mesoscopic folds dominate the outcrops of this domain, and are of an open symmetrical style with an axial surface ranging in character from an S3 schistosity to a crenulation style cleavage along which a later S3 generation of quartz laminae have segregated. F3 folds range in amplitude from greater than outcrop to the micro-scale with the majority occurring on the mesoscopic scale.

F4 Folds The layering within the highest grade amphibolite horizon adjacent to the granodiorite contains several weakly developed, isolated post-F3 folds. These are open asymmetrical kink-like structures lacking a well developed axial surface. This F4 episode of apparently only local significance could not be recognized in the nearby heavily veined and contorted contact schists.

Domain III

The phyllites and schists of this domain are of low metamorphic grade, however they exhibit a structural style and succession similar to that of Domains I and II. Complete reconstitution with no inherited sedimentary layering is again typical. The earliest recognizable S-surface is again inferred to have developed as an axial plane structure to F1 folds and is the site of development of alternating quartz and mica-rich laminae. The laminae progressively develop from the northern to southern part of this domain. F2 folds similar to those of Domains I and II are not observed but an early lineation similar in style to the L2 lineation of I and II is contained in S1. Based on a structural correlation with Domains I and II this is inferred to be the axial lineation of F2 folds.

F3 mesoscopic folds with an open similar style dominate practically every outcrop and show little variation in orientation of axis and axial plane throughout, (see Map Fig. 3). Plate 3A illustrates F3 folds from the southern part of this domain showing the S1/S2 quartz and mica-rich layering and a coarse crenulation style cleavage parallel to the axial plane. Plate 3B illustrates an example from the northern part, in which the S1 layering is not as prominent and S3 is less strongly developed as a crenulation style cleavage.

The field relationships between the above lithologies and the massive iron and manganese-bearing quartzite is difficult to decipher, but it is clear that the latter bear little imprint of the F3 fold episode.

Domain IV

Domains III and IV are separated by an area of Tertiary basalt but their direct correlation is established by identity of lithology, fold style, and orientation of structural elements. Most geometric data for this domain comes from outcrop in the bed of the Cobrabald River where the fabric elements of symmetrical mesoscopic F3 folds show a high degree of preferred orientation. An axial plane crenulation style cleavage is typical and non-penetrative thick veins and irregularly shaped bodies of milky quartz are common. At an upstream outcrop adjacent to "Mirrabooka" homestead, a weakly developed post-F3 cross-folding (F4) occurs, (see Map Fig. 3), however determination of the extent and importance of this episode is impossible because of the Tertiary basalt.

Domain V

Downstream from the Cobrabald River bridge on the

Walcha-The Flags road, the axes and axial-planes of F3 folds undergo a progressive change in orientation (see Map Fig. 3). The F3 fold style and lithology are identical to those of IV.

Domain VI

This domain encompasses a small area beside the Nowendoc Fault, in which the fabric of Domain V has undergone complete re-orientation such that S3 parallels the fault plane, while F3 folds adjacent to the fault are plunging near vertically, (see Map Fig. 3).

The Wybeena Metamorphics - Domain VIII

The lithologic similarity and correlation of these rocks with the more extensive Oxley Metamorphics is outlined in Part I. This subdivision is divided into Domains VIIIA and VIIIB, the southern and northern parts respectively, which are separated by an extensive Tertiary basalt outlier. Domain VIIIA is occupied by folded laminated schists with abundant intercalations of amphibolites and quartzites, while the lithologies of VIIIB are intensely folded low grade schists and phyllites unaccompanied by metabasic horizons.

F1 Folds The folded schists of Domain VIIIA, like those of the Oxley Metamorphics, contain a metamorphic lamination consisting of alternating quartz and mica rich laminae. This is the earliest recognizable surface of deformational origin (S1), developed as axial plane structure to F1 folds.

F2 Folds Throughout VIIIA, the S1 described above has been folded about a steeply plunging F2 axis. These F2 folds range in amplitude from large macroscopic structures, outlined by the metabasalt (see Map 1), to microfolding of the S1 layering in finely laminated pelitic schists. A strong L2 lineation has been generated parallel to the axes of the F2 folds. An earlier L1 lineation could not be identified, suggesting either obliteration of L1 during the F2 event or co-axiality of the two fold generations.

F3 Folds Along Stoney Creek in the northern part of VIIIA, isolated mesoscopic folds with axes parallel to a shallowly plunging lineation are superimposed on the S2 and F2 structures. In Domain VIIIB, these F3 folds become very strongly developed, with an open mesoscopic symmetrical style and a moderately well developed crenulation style cleavage parallel to the axial plane S3 (e.g. Plate 3C). The F3 fold axes are shallow

plunging, with only slight progressive variation in orientation throughout the domain (see Map Fig. 3).
A well developed L3 lineation is present and an earlier lineation, inferred to be L2 has been preserved, folded over the hinges of F3 folds at approximately right angles to the F3 axis

Chapter 5

THE BRACKENDALE METAMORPHICS AND TIA GRANODIORITE

Five structural domains have been delineated throughout these subdivisions, (see Map Fig. 3).

Domain IX

F1 folds The lithologies of this domain are still recognizably greywackes with interbedded siltstones and shales, possessing a strongly developed S1 cleavage, (e.g. Plate 4A), the surface of which exhibits a black sheen resulting from the schistose alignment of finely divided metamorphic biotite. This S1 surface contains a steeply plunging to almost vertical L1 lineation parallel to the axis of the first generation F1 folds of this domain. A lithologic layering inherited from the original bedding has been preserved but transposed into parallelism with S1. No fold hinges were located where S1 could be observed as axial plane to folds in bedding, however the preservation of the sedimentary layering, the small amount of reconstitution of the greywacke fabric, and the absence of any evidence of an earlier fold period suggests that F1 folds with axes parallel to L1 developed from relatively undisturbed original sedimentary layering. The degree of transposition into the S1 foliation indicates that F1 folds approach isoclinal similar style, and the schistosity indicates that F1 was concurrent with a period of regional metamorphism.

Several transposed horizons were originally conglomeratic, and during formation of F1 folds, the coarse clastic material was stretched and flattened parallel to the S1 foliation, (Plate 4B). Large mudstone clasts within accompanying greywacke horizons have also assumed exotic flattened shapes parallel to S1.

F2 Folds Intersecting S1 at a high angle is the second surface S2 of deformational origin. Within the northern part of the domain this surface is represented by an imperfectly developed crenulation cleavage and isolated kink-like bands producing a faint lineation pitching at a low angle on S1 surfaces. Scattered mesoscopic folds of S1 with S2 as axial plane (e.g. Plate 4C) are encountered southwards as the S2 surface progressively develops and the L2 lineation becomes more pronounced parallel to the F2 fold axes.

The distribution of the effects of the F1 and F2 folds suggests that F1 was of much wider regional extent, while the effects of F2 folds are slight in the northern part of Domain IX, intensifying southwards towards Domains X and XI.

Domain X

Between Domain IX and the Tia Granodiorite, F2 generation folds become more common and better developed, (e.g. Plate 5A). These F2 folds are typically symmetrical, relatively open structures, on all scales up to outcrop size, with a penetrative S2 axial plane schistosity identical with S2 of Domain IX. The greywackes have undergone complete textural reconstitution, with the folded S1 surface consisting of a lithologic layering of alternating light and dark bands, parallel to a fine quartzose lamination and thicker pod-like milky quartz veins. The earlier lineation L1, Parallel to the folded F1 fold axis is preserved as a streaking or microcrenulation of S1 oblique to the F2 fold axis.

Towards the contact of the granodiorite the outcrops appear much more complex, with considerable quartz and quartz-feldspar veining of the contact schists and local migmatization. F2 folds may still be recognized but they show considerable vatiation in axial plunge. Much of the veining at the contact is non-penetrative but is folded on a small scale, an effect that adds to the impression of local structural complexity, and makes identification of F2 folds more difficult in such outcrops.

Domain XI

The structural style of this domain is similar to that of Domain X. The mesoscopic F2 folds have slightly different orientation, with a near vertical axial plane, and F2 axes with a relatively constant axial plunge of 30° - 40°W. F2 folds are again of symmetric mesoscopic style, with the folded S1 surface consisting of alternating light and dark bands parallel to quartz laminae and pod-like quartz veins.

In the neighbourhood of the granodiorite non-penetrative as well as the penetrative S1 and S2 veining are folded on a small scale, again giving an impression of local structural complexity (e.g. Plate 5B). Small scale doming and basining (e.g. Plate 5C) is confined to the highly veined schists immediately adjacent to the granodiorite.

F3 Folds Within this domain, mesoscopic folds of an apparently post-F2 episode are confined to the area adjacent to the northwest and western granodiorite contact.

Although a correlation of the F3 folding with the doming and basining of the F2 axial traces appears probable, a more detailed structural analysis is needed.

Domain XII

F1 Folds S1 of this domain is a lithologic layering derived from the preservation of the original psammitic and pelitic sedimentary layers, parallel to which a penetrative quartz lamination has developed, (e.g. Plate 6). The early L1 lineation, parallel to F1 fold axes is preserved as a streaking or micro-corrugation of the S1 surface.

F2 Folds Numerous mesoscopic folds of the S1 layering are of virtually identical style to those developed during F2 in Domains X and XI. The orientation of these F2 folds is also consistent with a geometric extrapolation (via S of the granodiorite) to the F2 folds of Domains XI and XII. An S2 axial plane schistosity crystallized during the F2 event and in many outcrops of this domain, a second generation of penetrative lensoidal quartz laminae has segregated parallel and sub-parallel to the axial planes of F2 folds. S2 possesses a near constant vertical orientation throughout (see Map Fig. 3), however the F2 fold axes again vary in amount and direction of axial plunge, producing small scale doming and basining similar to that described in Domains XI and XII.

The Tia Granodiorite

Domain XIII

A preferred orientation of micas and the alignment of metasedimentary xenoliths constitutes a moderate to weak foliation throughout most of the intrusion. This foliation has also been the site of emplacement of quartz, aplite and pegmatite veins, some of which describe simple symmetrical folds.

The foliation is near vertical to vertical throughout and is of almost identical orientation to S2 of the surrounding metasediments. No lineation could be measured in this foliation, due in part to the lack of suitable exposure, as most outcrops consisted of large tors or low rounded outcrops. In the northern part of this intrusion, the foliation is more intensely developed in many narrow zones, an effect related to movement along the nearby Netherton Fault.

Throughout the remainder of the granodiorite, the identical orientation and continuity of S2 of the metasediments and S of the granodiorite suggests they are related and developed during the same structural event.

Chapter 6

STRUCTURAL GEOLOGY OF THE OTHER SUBDIVISIONS

The Karinya Metamorphics and Lochaber Greywacke - Domain XIV

These subdivisions, described briefly in Part I, show evidence of a much simpler structural history than that described above. The metamorphosed greywacke, siltstones, slates and metabasalt horizons possess a single foliation S1, which is developed as a slaty cleavage in the more pelitic horizons, as a semi-schistosity in the metamorphosed greywackes, while the amphibolites and quartzites are generally poorly foliated. This S1 foliation marks the earliest and only recognizable surface of deformational origin in this domain, and is inferred to have developed during an F1 fold episode, with a steeply plunging to almost vertical axis, parallel to a well developed lineation. Bedding remnants, consisting of lenses of greywacke horizons and thin silty bands that have been transposed parallel to S1 are commonly preserved. The scale of F1 folds is unknown, but they are inferred to be of large amplitude with the parallelism of the foliation and lithological boundaries and the extreme transposition of the bedding remnants suggesting an approach to isoclinal similar style.

The absence of evidence of a pre-F1 fold episode suggests that the succession in this domain has a history of a single deformation accompanied by regional metamorphism, the F1 folds developing essentially from original sedimentary layering or bedding.

The Agnes Greywacke

Domain XV

The greywackes and interlaminated siltstones and slates of this domain possess a single S-surface of deformational origin (S1). This takes the form of a penetrative semi-schistosity within the greywackes and a well developed slaty cleavage in the more pelitic horizons. S1 shows little change in orientation throughout, and contains a steeply plunging to vertical L1 lineation. The L1 lineation is inferred to be parallel to the axis, and S1 the axial plane, of F1 folds. The greywackes and slates have undergone little textural reconstitution throughout most of this domain. The original bedding lamination is preserved in many outcrops, generally transposed parallel to S1. Lensoidal horizons and pods of altered igneous rock, also transposed parallel to S1, are rarer members of the succession.

In the northern part of this domain, there is a progressive increase in metamorphic grade towards the granitic intrusions at Moona Plains. The greywackes and slates appear to have recrystallized with little accompanying deformation during this metamorphism, resulting in massive hornfelsic greywackes and slates with no new S-surfaces nor any development of alternating segregation laminae of quartz and mica. This suggests this metamorphism is the result of a regional,, essentially static, thermal event clearly of a different character to that associated with the Tia Granodiorite.

Domain XVI

Towards the Yarrowitch Fault the greywackes and slates of this subdivision become progressively reconstituted, and within the mylonite zone adjacent to the fault plane, the rocks possess a well developed penetrative planar lamination. This mylonitic lamination is attributed to localized strong deformation associated with fault movement.

S1 of this domain still retains the steeply plunging L1 lineation parallel to the axis of F1 folds of Domain XV, but the mylonites contain several generations of kink bands expressed as additional lineations on the S1 surface.

Chapter 7

FAULTING

Introduction

The widespread faulting, outlined and used to subdivide the Tia Complex in Part I, is now described and discussed in more detail. The irregular distribution and general paucity of outcrop in the neighbourhood of the faults meant that the actual fault plane was only rarely exposed, and that evidence of its presence was, in general, of an indirect nature. Each fault delineated is based on the following evidence:

(1) Structural discordance

(2) Gross change in metamorphic grade over a short interval.

(3) Gross and rapid lithologic change

(4) Shearing or mylonitisation which intensifies toward the suspected fault plane.

In general, it is also found that relative movement took place within a zone rather than a single fault plane, and because of limited exposure, only the larger scale and most obvious discontinuities could be delineated.

The Nowendoc Fault

Near Glen Morrison, north of the main area of Tertiary Basalt, the fault zone is relatively narrow and is only several yards wide where exposed crossing the Cobrabald River. Crushing and production of a crude fracture cleavage in general extends for several hundred yards into the unmetamorphosed Permian sediments west of the fault.

South of the Tertiary basalt in the Nowendoc area, the fault line separating the metamorphics and the unmetamorphosed Permian is again very narrow. A serpentinite-Permian conglomerate contact exposed in Couatwong Creek adjacent to the Nowendoc schoolhouse shows that the conglomerate has suffered negligible shearing and/or alteration. The zone within which movement has taken place is however much wider, with several individual sub-parallel faults, some of which were sites for the emplacement of serpentinite. The south-eastern extremity of the Nowendoc Fault has been cut by a north-south striking younger fault, however its continuation is believed to follow the southern boundary of the Mummel River Serpentinite. Extrapolation of the mapped faults beneath the Tertiary Basalt just west of Walcha suggests that the northern extremity of the Nowendoc Fault is also cut by a younger fault.

At Nowendoc, a moderate to steep north-east dipping fault plane is indicated by:

(1) the attitude of the cataclastic foliation of the peridotite within the Nowendoc Serpentinite.

(2) the asymmetry of the aeromagnetic anomaly parallel to the Nowendoc Ultrabasic Belt, (data made available by the N.S.W. Department of Mines). Northwards the fault steepens, parallel to the near vertical foliation on either side and within the fault zone.

Throughout the Nowendoc Ultrabasic Belt, the attitude of the Nowendoc Fault and the relationship of the rocks on either side are consistent with a high angle reverse fault movement, with the metamorphics pushed upwards over the unmetamorphosed Permian. As the fault steepens northwards, the upward movement was such that metamorphics are now beside unmetamorphosed Permian. This movement is consistent with the localized re-orientation of the fabric in Domains V and VI, ascribed to broad folding akin to "drag" during faulting. A considerable strike-slip component is also possible, but there is no means of estimating its magnitude.

The Nowendoc Fault is approximately parallel to and about 30 miles east of the Peel Fault (see Fig.1). As both faults also contain serpentinite intrusions,a contemporaneous relationship appears likely.

Yarrowitch Fault

This fault has been briefly discussed in Chapter (6) in which some characters of the mylonite zone were outlined. The fault is well exposed on the floor and walls of the Apsley River Gorge, and in Peters Creek to the south. The fault plane dips at approximately 45^{o} to the west, parallel to the well developed cataclastic foliation of the mylonite zone.

The attitude of the fault plane and the relationship of the lithologies on either side are consistent with a reverse or high-angle thrust movement, with the deformed and metamorphosed Agnes Greywackes moving upwards over the unmetamorphosed Permian. Considerable strike-slip movement is also possible, however there is no evidence as to its likely magnitude. The multiple generations of minor structures within the mylonite zone suggest a complex history of movement.

The Double Hut Fault

This fault was mapped by tracing the abrupt change from the metamorphosed, highly foliated, greywackes of Domain IX and the layered and folded phyllites and schists of Domain III. The greywackes of Domain IX are rich in metamorphic biotite and have only a weakly developed S2 surface occurring as a widely spaced crenulation style cleavage with accompanied by a shallow plunging L2 lineation on S1. The nearby Domain III schists and phyllites, containing only muscovite and chlorite, have an almost identically oriented S3 and L3, but in highly folded phyllites and schists of completely differnet structural style to the lithologics of Domain IX.

The difference in structural style and metamorphic grade suggests that the two successions could not have been conformable during the concurrent F3 of Domain III and F2 of Domain IX. A possible explanation of the concordance of the later structural elements across the fault is that the two successions, prior to faulting, underwent contemporaneous deformation to give identically oriented fabrics, followed by fault movement that possessed no rotational component.

Netherton Fault

This fault separating Domains IX and VIIIB is marked by an abrupt change from the mesoscopically folded phyllites of VIIIB to the sheared and metamorphosed greywackes of IX. That structural discordance exists can be seen in Map Fig. 3, in which the axial planes of mesoscopic VIIIB folds have a near-vertical attitude, whereas S2 of Domain X is dipping at a low to moderate angle to the NE. This fault can then be traced southwards across Stoney Creek where it is marked by a transition from the amphibolite-quartzite-schist succession of VIIIA to the siliceous schists of X, and a structural discordance consisting of an abundance of shallow plunging F2 mesofolds of X and rarity of shallowly plunging F3 in Domain VIIIA.

Outcrop is rather poor south of where the fault crosses Tiara Creek, but the distribution of the slightly lower grade rocks of the southern part of Domain VIIIA and the higher grade, heavily veined lithologies of Domain II suggests that the fault changes direction slightly and, as shown on Maps 1 and 2, cuts the Tiara Fault, then terminates against a younger, north-south Mummel River Fault. At its northern extremity the

Netherton Fault terminates against the younger Walcha Fault.

Zones of more intense deformation at the contact and localized shearing within the northern part of the granodiorite are believed to be associated with the Netherton Fault. This suggests that this fault has both a post-metamorphic and post-granodiorite relative age.

The Tiara Fault

This fault's existence is deduced from the following observations:

(1) Mylonitization of Lochaber Greywacke parallel to the northern extremity of the fault.

(2) Mylonitization and associated retrogressive metamorphism of amphibolite horizons where the fault crosses Stoney Creek.

(3) As the fault crosses Tiara Creek, there is a structural and metamorphic discordance between the low grade, relatively undeformed metabasalt of the Woombi Greenstones and nearby fine grained schistose amphibolite of Domain VIIIA.

(4) Where the Netherton and Tiara Faults intersect, the Woombi Greenstones show progressive mylonitization parallel to the latter fault, which separates them from amphibolites of Domain VIIIA. Existence of an important

structural discontinuity is also indicated by the structural discordance between Domains VIII and XIV and a similar discordance between the Woombi Greenstones and VIIIA.

At the northern extremity of this fault, the poor and scattered outcrop is predominantly sheared greywacke, without basic volcanic horizons. In this area the main Tiara Fault appears to diverge into several individual faults, and mapping of these is based on mylonitization of greywackes accompanied by subtle lithologic changes, for example, from a schistose greywacke to a siliceous siltstone containing traces of metamorphic biotite. The discordance between the mesofolded phyllites of VIIIB and these lithologies is more obvious. At the southern extremity, useful outcrop is also limited, but is consistent with the interpretation that the Tiara Fault is terminated by the Netherton Fault. The structural information suggests that the fault is very steeply dipping to near vertical, but the direction and amount of movement is impossible to estimate from available information.

The Woombi Greenstones are separated from Domain XIV by an unnamed fault diverging from the Tiara Fault. There is local disturbance of the structural elements along this discontinuity, and there are significant differences in the lithology and metamorphic grade of these adjoining areas. The low grade, slightly metamorphosed basalts of the Woombi Greenstones are associated with abundant cherts and jaspers whereas the lithologies of Domain XIV are predominantly amphibolites, metamorphosed greywackes and slates with less abundant quartzites.

The Mummel River Fault

East of Tia this fault is clearly marked by a discontinuity between the Agnes Greywacke and the highly folded and metamorphosed schists and amphibolites of Domain II. North of where the Netherton Fault is cut by the Mummel River Fault, the discontinuity exists between the metamorphosed basalts of the Woombi Greenstones and the sheared Agnes Greywackes. At Moona Plains the probable continuation of the Mummel River Fault is named the Rowley's Fault (Binns et al, 1967). At this locality, the fault separates a succession of unmetamorphosed greywackes west of the fault from metamorphosed greywackes associated with the granitic intrusions at Moona Plains.

The fault appears to consist of a zone of movement, containing several individual minor faults. Examples of these small scale fault offsets within the Agnes Greywacke suggest a zone of faulting approximately half a mile wide, with a significant increase in the degree of shearing of greywackes within this zone.

Southeast of Tia, the fault passes beneath the Tertiary basalt and reappears in the headwaters of the Mummel River, where it divides highly folded and veined schists and amphibolites from deformed but slightly metamorphosed greywackes. This discontinuity is traceable further southwards through rugged and heavily timbered country to connect up with two semi-parallel faults that have displaced the Nowendoc Fault. These two faults appear to have displaced the small Kangaroo-Tops Serpentinite from the main serpentine line, and both faults are believed to belong to the Mummel River Fault zone.

The attitude of the foliation adjacent to the fault suggests an approximately vertical attitude. Direction and amount of relative movement is unknown, but transcurrent movement is suggested by the displacement of the Nowendoc Fault.

The Walcha Fault

This fault, which passes just south of Walcha township, is marked by a lithologic and structural discordance between the pyhllites and schists of Domain III and VIIIB and the greywackes and slates outcropping within the township, and may be contemporaneous with a large number of similarly oriented faults in the area north-east of Walcha, (Binns et al, 1967). Extrapolation of this fault beneath the Tertiary Basalt just west of the township suggests it is cut by the younger Glen Morrison Fault.

The Glen Morrison Fault

In the north-west corner of the mapped area, extrapolation of this fault beneath the Tertiary basalt suggests it cuts and is therefore younger than both the Nowendoc and Walcha Faults. The wedge shaped area between the Nowendoc and Glen Morrison Faults contains a narrow belt of unmetamorphosed Permian rocks which widen southwards in the direction of Glen Morrison village. On the western side of the Glen Morrison Fault are found highly contorted and veined chlorite rich rocks with rare riebeckite bearing quartzites.

These gradually change westward to sheared greywackes and deformed pebbly mudstone. This succession may be inspected beside the Walcha-Niangala road approximately 9 - 10 miles south-west of Walcha.

The Glen Morrison Fault also truncates the eastern end of the small Linden Hill Adamellite, separating it from sheared greywackes, slates and quartzites, similar to those outcropping within Walcha. The attitude of the foliation within the metamorphics and sheared greywacke suggests the fault is vertical, but there is little evidence concerning the amount and direction of movement.

Chapter 8

SUMMARY AND CONCLUSIONS

The correlation of the fold episodes shown in Fig. 2 is based on the similarity of structural style of the generations in each subdivision, and their patterns of preferred orientation, (see Map Fig. 3). This correlation shows that within the Tia Complex, the later fold episodes of the Oxley and Wybeena Metamorphics developed concurrently with those of the Brackendale metamorphics, but that the former have evidence of earlier periods of folding which are not represented in the Brackendale Metamorphics. This supports the possibility that the latter represents a younger, upper Palaeozoic succession which has been deformed along with a previously folded older mid-Palaeozoic succession typified by the Oxley and Wybeena Metamorphics.

The Netherton and Double Hut Faults divide the Brackendale from the Oxley and Wybeena Metamorphics, except in the area just to the west and south-west of Tia. In this area the inferred older and younger successions appear to have been folded together. This could have arisen in two ways. The contact could represent an unconformity that has been folded, or alternatively it could be a fault, along which relative movement juxtaposed the two successions prior to deformation. Further structural work is needed to decide between these alternatives.

The similarity of structural style throughout the Tia Complex clearly distinguishes it from the other subdivisions. The latter have much simpler structural histories, involving only a single, large scale episode of folding. This structural work supports the idea of the Tia Complex as a large fault-bounded block throughout which structural unity can be clearly demonstrated. Large scale faulting has been responsible for the juxtaposition of these multifolded lithologies with the less deformed rocks of the other subdivisions.

The post-Brackendale episodes of deformation throughout the Tia Complex were accompanied by regional metamorphism connected with the generation and emplacement of the Tia Granodiorite. All these events are viewed as related to a major cycle of tectonism and orogenic activity.