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THE GEOLOGY OF THE AUSTRALIA PLAINS AREA, NORTHERN MT. LOFTY RANGES, SOUTH AUSTRALIA

by A.J. Drummond

1972

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THE GEOLOGY OF THE AUSTRALIA PLAINS AREA, NORTHERN MT. LOFTY RANGES, SOUTH AUSTRALIA

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This thesis is submitted as partial fulfilment of the course requirements of the Honours Degree of Bachelor of Science in Geology at the University of Adelaide, 1972.

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ABSTRACT

The most northerly Kanmantoo Group sediments occur in a synclinorium near Australia Plains. They, and the underlying Proterozoic units, have been mapped. On the west of the syncline, the contact does not outcrop and it is not possible to determine whether an unconformity exists between the two. On the east, the contact is fault bounded; probably by an extension of the Palmer Fault Zone.

A flood plain and then a shallow marine or lacustrine palaeo-environment is postulated during the time of deposition of the Kanmantoo Group.

Biotite grade metamorphism has been attained in the area; a slaty cleavage and a mineral lineation are variably developed. Micro scale investigations show that the cleavage and lineation are both due to preferrentially oriented grain growth in response to the stress field which was present during the single deformation period.

1. INTRODUCTION

The area investigated consists of some 33 sq. km centred around the town of Australia Plains, which is situated 110 km NE of Adelaide and 10 km NE of Eudunda. K. R. Hamdorf mapped an adjacent area to the NW, and L. J. Morris an area around Eudunda. Previously it had been mapped on the Adelaide 4 mile and Eudunda 1 mile sheets by B. P. Thompson (1969) and W. B. Robinson (1966) respectively.

A network of unsealed roads and tracks of varied quality give easy access to the entire area.

A century of assiduous farming, together with deep weathering, has resulted in a paucity of outcrop. This is now almost wholly confined to either the coarser, or the most deformed, units. Consequently, only broad stratigraphic units could be mapped. The position of many litho-stratigraphic boundaries mapped are uncertain, having been often fixed from float mapping.

Low native scrub and mallee cover the uncleared areas. Rainfall decreases eastwards; Goyder's line passes slightly to the east of Australia Plains.

Geomorphologically the area is one of low rolling hills and plains, whose relative positions are fixed by the underlying lithology.

Field work was undertaken during April and May and a week in August. This involved photoscale geological mapping directly onto Lands Dept. air photos (Survey 881, Nos. 7703, 7742).

Laboratory work was primarily concerned with the petrography of the rock suite. collected; thin sections of representative or unusual lithologies were prepared. Petrofabric analysis of certain oriented thin sections was undertaken to gain information on the slaty cleavage and mineral lineation observed in the field. Details of the petrographic investigations have been described in Appendices I and II. The specimens and thin sections have been presented to the Geology Department of the

University of Adelaide to be retained under the accessum number A385.

The effects of metamorphism are varied, but generally slight, on the macro scale. They have been mentally "removed" when possible and the lithologies have been described from a sedimentary viewpoint. The dual classification scheme of Folk (1970) is used.

For the Kanmantoo Group, the stratigraphic nomenclature of Daily and Milnes (1972) is adopted.

2. STRATIGRAPHY

2.1. THE ADELAIDEAN

2.1.1. TAPLEY HILL FORMATION:

Outcrop is very poorly exposed, being confined to graded tracks and unploughed land In outcrop, this unit is a soft, fissile, ochreous siltstone which is usually capped by calcrete. Less weathered samples occasionally occur as float and consist of a well laminated, sometimes cross bedded, well sorted, light green fissile siltstone. Weathering tends to etch the laminations.

The Eudunda Arkose Member does not outcrop in the area but float of a khaki fine sand size semi quartzite and a green fine sand size quartzite (HS 385/041A, 041C resp.) is thought to belong to it.

2.1.2. TARCOWIE SILTSTONE EQUIVALENT? and PEPUARTA TILLITE:

As both these units are mudstones the Mines Department boundary between them is considered arbitrary and unnecessary. There is a regular increase in size of the coarser fraction (from silt to pebble) from the base of the Tarcowie Siltstone to the top of the Pepuarta Tillite. The location of a boundary is a function of the subjective selection of the clast size and for this reason subdivision is not attempted in this thesis.

The two units total approximately 1200m in thickness.

The base of this sequence is poorly exposed and has been determined by float mapping. The lower portion consists of pink, grey and green, finely laminated, occasionally cross bedded mudstones (HS 385/034, 035). Float of a grey, structureless dolomite occurs at Station 35 (TS 385/035).

The upper half of the units conforms more closely to the traditional characteristics of a tillite. A well laminated siltstone with a few sand size grains gradually passes into one in which gravel and pebbles become common. Many of the larger clasts are moderately and well rounded (Pl. 3W); distortions in laminae indicate that some are drop stones (Pl. 1F).

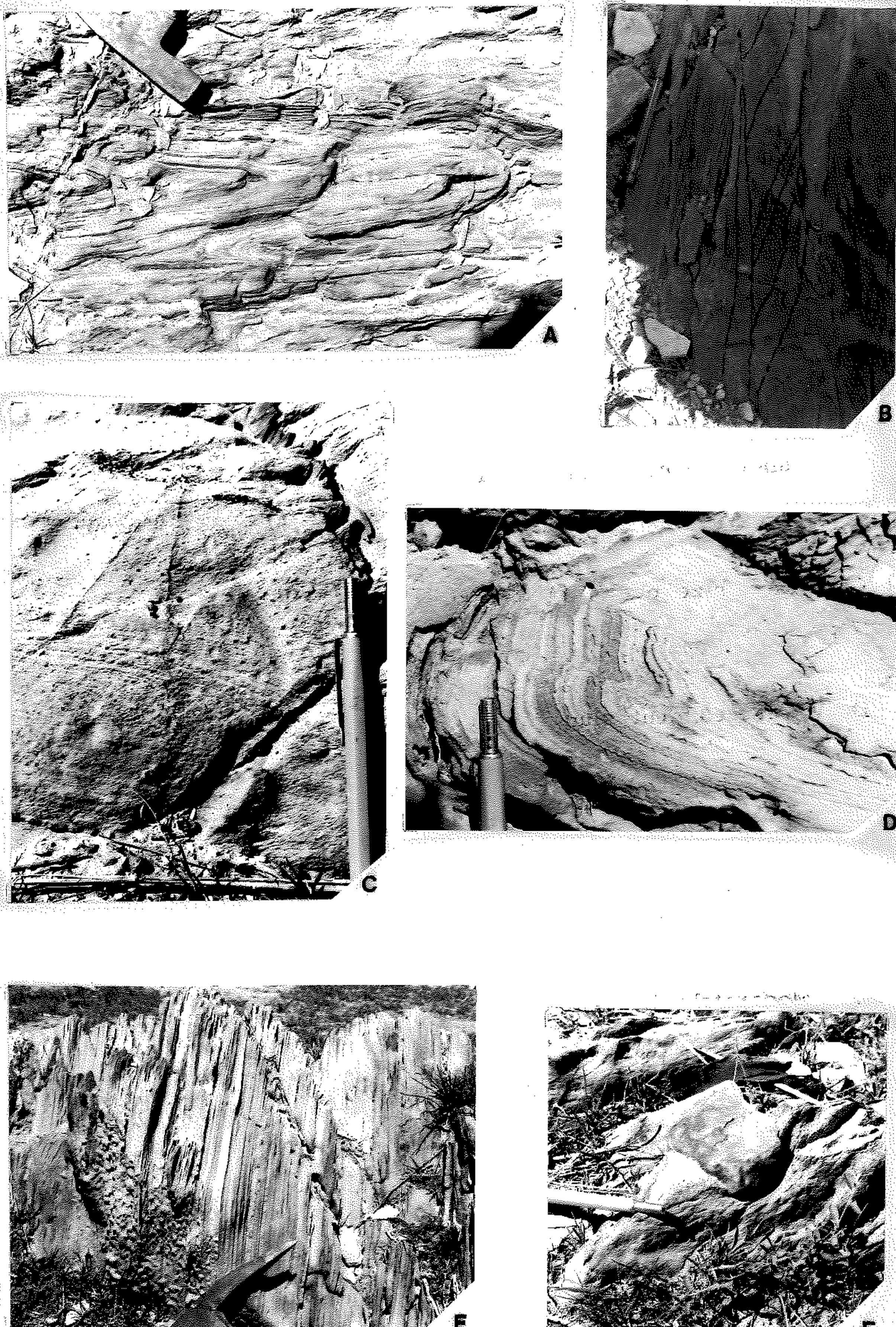
The tillite varies in appearance on either side of the regional syncline. In the west, there is 50m of a grey, brown and ochreous, slightly sandy and gravelly mudstone with rare pebble size clasts (Pl. 1c). Wet sediment slumping was noted at Station 61A (Pl. 1A, D). Cross bedding is locally evident (Pl. 1B) and indicates a palaeo province area from the W or NW.

In the east, the tillite lies closer to the synclinal axes and its deformation is greater. Slaty cleavage is well developed, governing outcrop shapes. The clasts are both larger (up to cobble size), and more numerous, and often are well rounded. The colour now consists of dark shades of grey, brown and green and the matrix is pyritic. There is some 200m of tillite in the east.

There is a wide range of clast composition. Clasts consist predominantly of quartz and quartzite, with subordinate green siltstone, granite and gneiss; and rare dolomite.

THE QUARTZITE FACIES:

This is a prominently outcropping unit and is a positive relief former. It appears to be diachronous, exhibiting changes in facies both within itself and with the tillite which variably underlies and overlies it.



A
B
C
D
E
F

PLATE 1

PEPUARTA TILLITE

A. Wet Sediment Slumping.

B. Quartzite Facies. Cross bedding. Photograph oriented to show correct attitude, facing east.

C. Sand size clasts in a variably bedded mudstone.

D. Wet sediment slumping and micro faulting.

E. Laminations in mudstone, etched by weathering.

F. Moderately to well rounded pebble in a mud matrix.

On the western side of the regional syncline it averages 30m (Section A-A', Appendix 1A). There are bands of tillite, quartzite and siltstone, (sometimes cross bedded), and it marks the top of the Pepuarta Tillite.

In the east, it is approximately 200m thick, being overlain by Pepuarta Tillite and underlain by Tarcowie Siltstone. Although predominantly massive quartzite, there are mudstone interbeds which have generally weathered to soil. The quartzite was originally white, but weathers to cream, red, brown and purple blocks. Grain size varies from fine sand to granule; cross bedding and scour and fill structures are common.

The Quartzite Facies grades downwards from a white fine sand size quartzite into green Tarcowie Siltstone. The top is less massive, and near the contact with the Tillite proper it is thinly bedded (2cm) and more fissile.

2.1.3. ULUPA SILTSTONE:

This consists of up to 900m of variably coloured, occasionally pyritic siltstones with minor quartzite and greywacke lenses (Station 51, 54). On the western side of the syncline, there is an abrupt contact between the Quartzite Facies and the Ulupa Siltstone. On the east (Section C-C', Appendix 1C), the contact is gradational with pebbly mudstone occurring 50m into the siltstone sequence.

The Ulupa Siltstone is light green, well laminated and blocky in the west. The effects of the deformation phase are more intense in the east where it becomes a dark green and grey siltstone which has a good slaty cleavage. Prominent slaty outcrops result.

Bedding forms vary: Laminations are very common often manifested by very fine sand layers in a silt matrix (Stations 50, 54, 83, 131, 213) or by medium sand size layers (Station 131); graded bedding (Station 16) as medium sand size grains decrease to silt size; cross bedding is common; ripple marks (Station 24). Cross bedding was used to determine palaeocurrent directions, values from the SW and NNW resulting.

Locally there are thin lenticular bands of quartzite and greywacke (Station 51, 54) which usually show well developed cross-beds, and which are sometimes pyritic.

At the top of the measured Section C-C' (Appendix I) is an outcrop of weathered siderite (TS 385/055). It is patchily developed and is intimately mixed with non detrital quartz. Although it strikes for 300m it is not thought to be of sedimentary origin and is presumed to have intruded "dyke-like" along the fault.

The Ulupa Siltstone has the only economic mineral deposit thus far found in the area, namely a small occurrence of barytes. This mineralization has a strike length of 50m and its trend is that of the cleavage.

2.1.4. PALAEOENVIRONMENTAL INTERPRETATION:

The appearance of the Tapley Hill Formation in the Australia Plains area is consistent with Parkins' (1969) contention that it was deposited in a shallow marine environment. The consistent fineness of the sediments probably implies : (i) a distal source or (ii) the streams supplying the sediments were of low competence or (iii) the fines were the result of winnowing of less well sorted sediments elsewhere.

The boundary with the overlying Tarcowie Siltstone Equivalent? is not observable but is not thought to be unconformable.

The Tarcowie Siltstone and Pepuarta Tillite are considered to have been deposited in proglacial lakes or streams. The cross beds, drop stones, laminations and preferred orientation of clasts imply sedimentation in aqueous conditions in which current activity was present and in which some ice rafting had occurred.

As the glacial influence became more marked, there would have been a corresponding increase in the number and size of the clasts, as is observed.

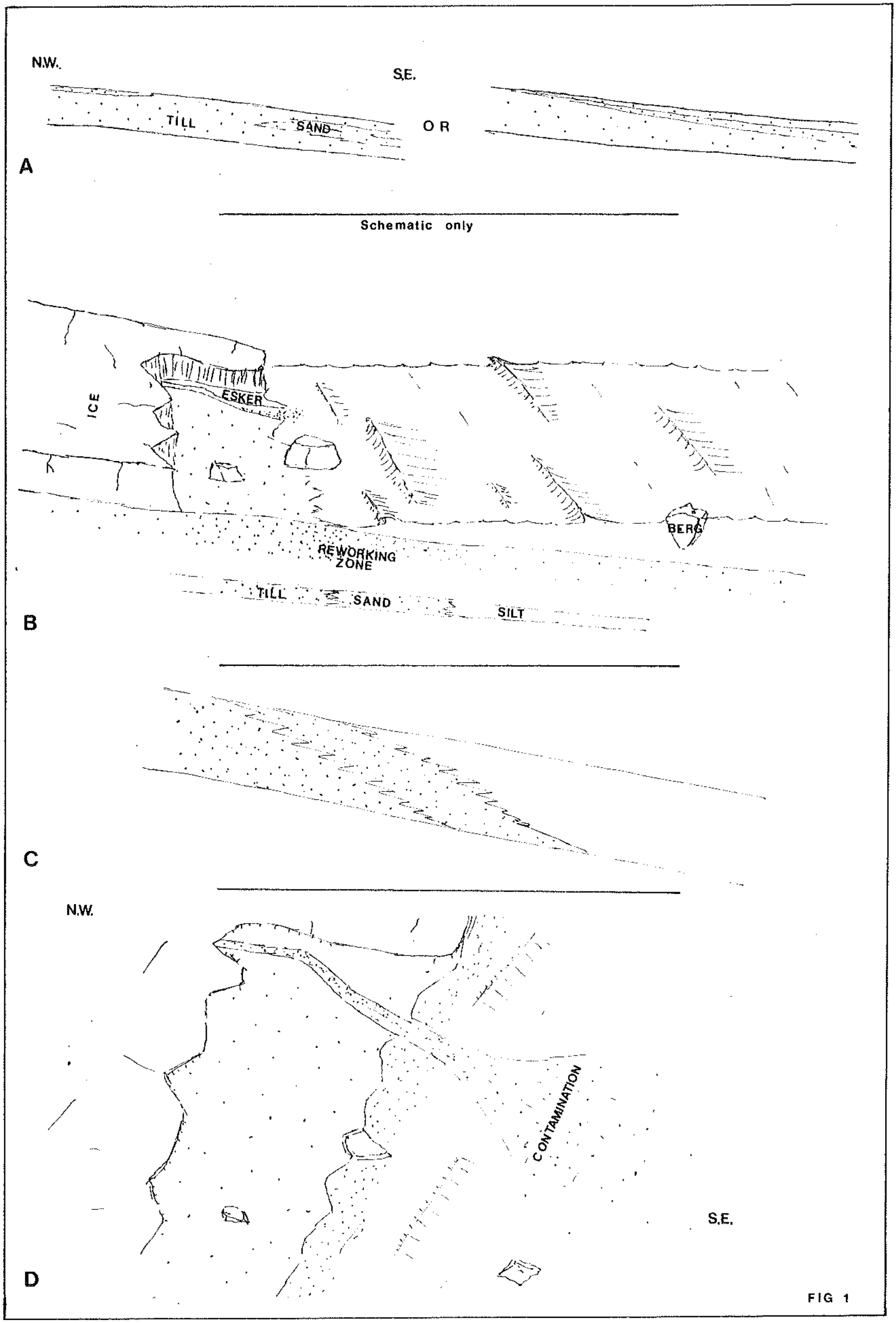

N.W.
S.E.
TILL
SAND
O R
A
Schematic only
ICE
ESKER
BERG
REWORKING ZONE
TILL
SAND
SILT
B
C
N.W.
CONTAMINATION
S.E.
D

FIG 1

The Quartzite Facies, as it is so variable in thickness and relative stratigraphic position, may not be a single unit but instead could consist of several which interfinger into the Tillite (Fig. 1A).

If, on the other hand, it is one continuous unit (and its strike length of 8 km on the eastern side of the regional syncline is an argument in favour of this) then it is markedly diachronous and a mechanism to account for its variability in thickness and stratigraphic level needs to be proposed. The following reconstruction of events would account for the observed properties but, of course, need not be the correct one. Till, carried by meltwaters flowing rapidly in a SE direction, was deposited near the edges of a proglacial lake or sea large enough for significant wave and current action to occur. These were able to rework the unconsolidated till and by winnowing out the fines left a predominantly sandy deposit near shore (the Quartzite Facies); silt was deposited further from shore. Fig. 2B shows the distribution of the various types of sediment at a given time.

As the ice began to retreat, there would have been a sympathetic retreat of the various facies as shown in Fig. 1C. However, some sand grains and pebbles would have contaminated the predominantly silty facies as they would have been carried beyond the sandy facies in rapidly flowing water in submarine and/or tidal channels or would have dropped into the silt after they had been ice rafted past the sandy facies. This is represented in Fig. 1D.

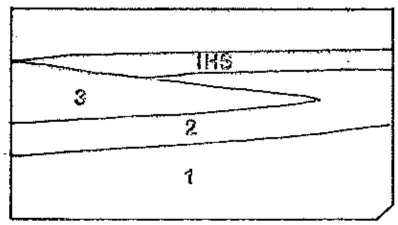
The silty horizons in the Quartzite Facies could be due to fluctuations in water level or to storm action.

At the time of deposition of the Ulupa Siltstone, the source area still lay to the NW. The laminations, cross bedding, local coarser bands and graded bedding are consistent with either a marine or lacustrine environment (Conybeare and Crook 1968); the poor outcrop makes any further refinement somewhat dubious.

The abrupt boundary between the Ulupa Siltstone and the Pepuarta Tillite in the W is in sharp contrast with the transitional one in the E.

PLATE 2

a.



1. Brown Hill Subgroup, Unit 1
2. Brown Hill Subgroup, Unit 2
3. Brown Hill Subgroup, Unit 3

Topographical relief is affected by the underlying lithological units.

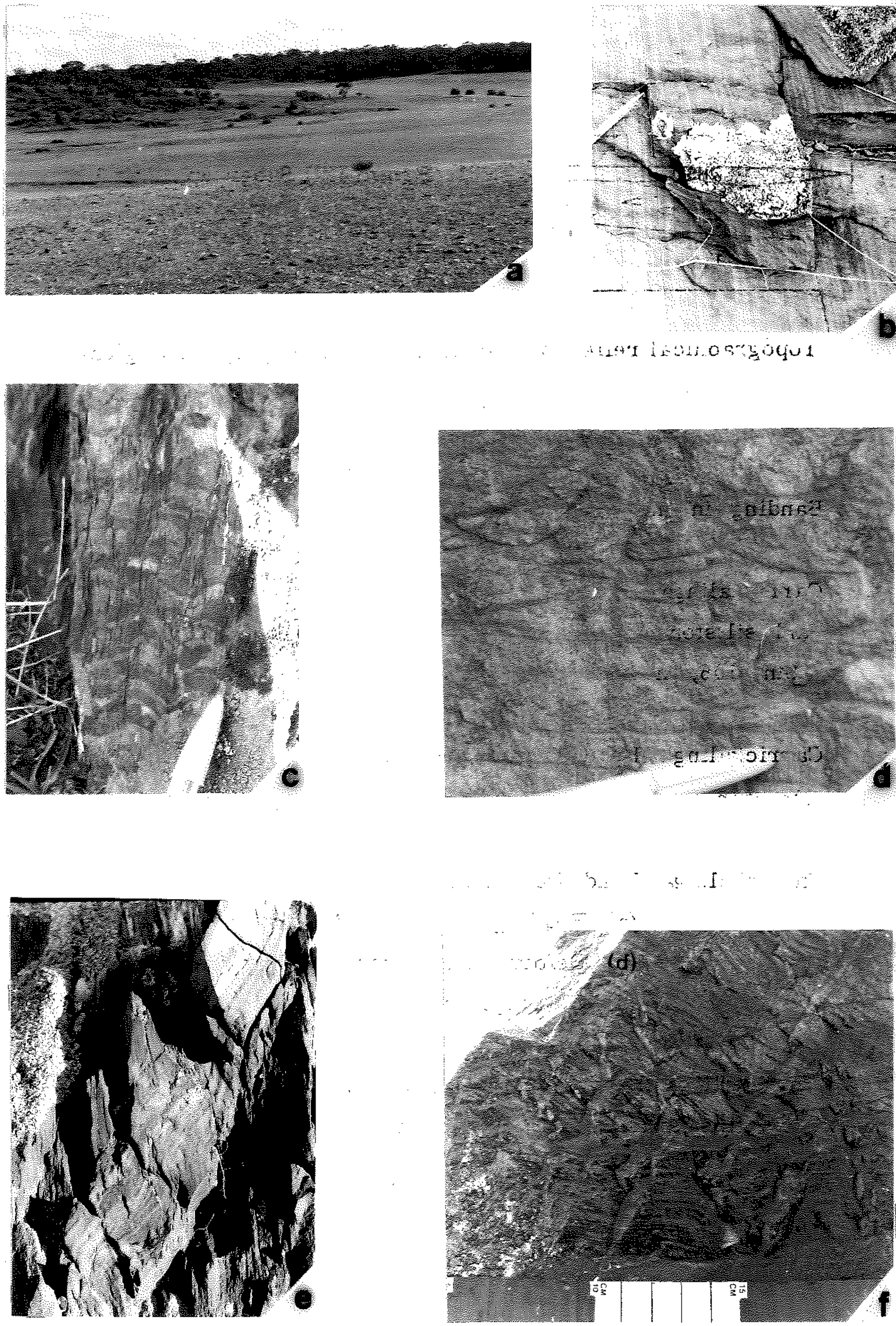
b. Banding in Inman Hill Subgroup.

c. Carrickalinga Head Formation. Interbedded fine sandstone and siltstone. Compression caused similar folding. (Stn. 106, near synclinal axis)

d. Carrickalinga Head Formation. Small scale scour and fill structures.

e. Carrickalinga Head Formation.
   (a) Bedding / cleavage intersection.
   (b) Deformation caused folding in sandstone unit.
   (c) Cleavage fans in the claystone.

f. Carrickalinga Head Formation. Cross bedding in a fine and very fine sandstone is defined by heavy mineral concentrations.



This opposes the classical concept of sediments fining palaeobasinwards and, as no information is available from the area in the centre of the regional syncline, cannot easily be accounted for.

2.2. THE KANMANTOO GROUP

2.2.1. CARRICKALINGA HEAD FORMATION:

In the west, there is no outcropping contact between the Kanmantoo Group and the Adelaidean. A fault defines the contact in the east. It is not possible to infer a hiatus on the basis of the evidence observable in this area.

The Carrickalinga Head Formation is approximately 850m thick and has two different facies: a siltstone facies which rarely outcrops, and a coarser facies which now being a quartzite, outcrops strongly.

The former is by far the ~~most~~ more common and consists of green and grey, finely laminated and often banded, rippled and cross bedded, moderately to well sorted siltstones with a variably developed slaty cleavage. (TS 385/018A, 116, 131A).

It is often difficult to differentiate between this facies and the Ulupa Siltstone, especially in the east where they both are dark in colour and possess a good cleavage.

The latter consists of quartzite bands and lenses, as interbedded siltstones and greywackes, and as sandy laminae (Pl. 2c) (TS 385/112A, 119). It has an abundance of sedimentary structures including slumps (Pl. 2e), cross beds (Pl. 2f), heavy mineral bands, scour and fill (Pl. 2d), ripple marks and banding. The banding is quite extensive and can be traced for up to 20m along strike. It is due to both thin clay layers (Stn. 116) and to heavy minerals (Stn. 105). Limonite pseudomorphs after pyrite are common in the coarser beds. Slaty cleavage is not as prominent in the sandy layers; diffraction and fanning of cleavage can often be observed (Pl. 2e).

The widely variable thickness of the Carrickalinga Head Formation is controlled by the structural characteristics of the region.

2.2.2. INMAN HILL SUBGROUP:

This unit is approximately 550m thick (Section B-B', Appendix 1B). The contact between it and the underlying Carrickalinga Head Formation is abrupt. Locally, coarser beds are developed at the base (Stns. 170, 53A).

It is a positive relief former and outcrops strongly, generally occurring as brown, green, cream or grey massive blocks. Slaty cleavage is variably developed but its intensity is comparatively low.

It is comprised of a monotonous sequence of muddy medium to fine sandstones with interbedded coarse siltstones and mudstones. Feldspar accounts for 0-10% of the volume and this results in most of the Subgroup being of subfeldsarenite and quartzarenite composition. Pyrite cubes are occasionally seen.

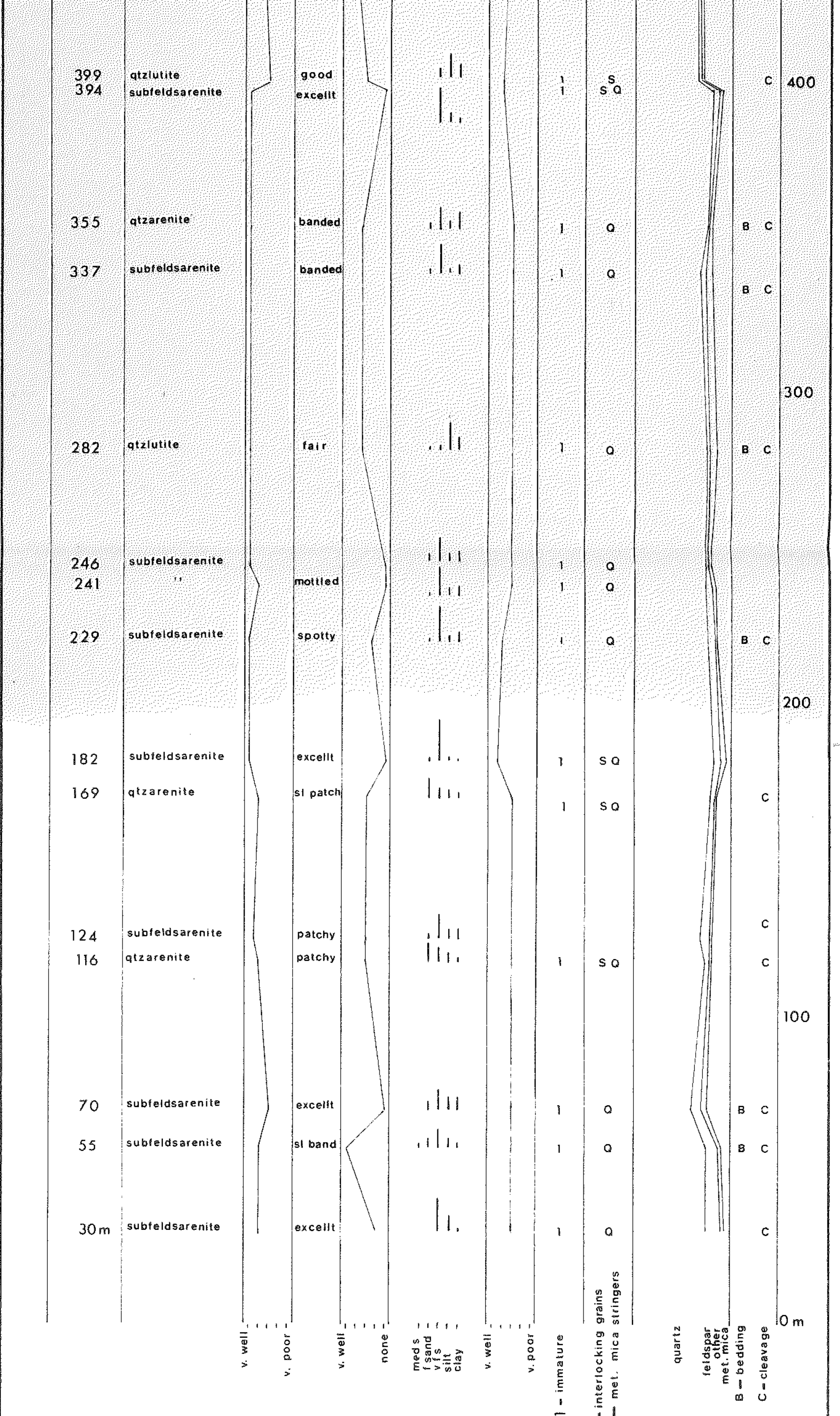
Sorting is variable, there generally being an interstitial mud matrix. The original detrital grain shapes have nearly all been altered by pressure and solution and are now usually unrecognizable.

There are several distinct facies present in the area:

(a) the most obvious, and probably the most common, is marked by a banding of sedimentary origin (Pl. 2b). The bands are darker than the matrix and are often very extensive. They were traced continuously for 150m near Station 179. Thin section investigation revealed that the banding is usually due to an intensive concentration of biotite along layers which were originally clay concentrations (TS 385/086, (337,470,542)).

Upon weathering, the opaques alter to an orange limonitic stain which results in a spotty appearance and a facies change more apparent than real. It is particularly common in the NE portion of the unit (TS 385/173, 157).

(b) a large portion of the Subgroup consists of an unbanded facies. This is the only distinction between it and the banded facies. It appears as



INMAN HILL SUBGROUP

CORRELATION OF THIN SECTIONS

FIG 2

cream to dark grey, massive blocks (TS385/076, 080A, 157, 158).
(c) there are occasional patches of an extremely well indurated, very dark grey to black, slightly banded coarse siltstone (TS 385/155). Its extreme induration seems to result from the low clay of this facies.

It is important to note that the distribution of the facies seems quite random and that they cannot be used as stratigraphic markers. For example, in Section B-B' the lower half is predominantly unbanded but a traverse from Stations 157 (the base) to 162 (near the top) crosses a banded facies throughout. The changes in facies were considered to be of not sufficient importance, and to be too complex, to attempt to map.

Apart from the banding, sedimentary structures are not common. Cross bedding (Stns. 104, 105, 157, 212) is locally evident and generally indicates a palaeocurrent direction from the N to NW; one reading (Stn. 160) is from the SE.

Because of the lateral variations, and the general monotony of the sequence, it was felt that stratigraphic column (e.g. B-B'), dealing as it does with macro properties, would not give an accurate representation of the sequence of events in such a case as this.

Hence it was decided to construct a "stratigraphic column" to compare various micro scale properties. It was hoped to determine some significant variations through the sequence which were of too small a scale to notice in the field.

From the 71 hand specimens collected along B-B', 17 were chosen at random, placed in stratigraphic order, thin sectioned, described, and their properties were tabulated. Figure 2 summarizes this work.

The only significant variation is the overall decreasing ratio of total feldspar to quartz. This could be explained by more intense weathering of the source area, a changing source area, or exhaustion of the feldspar provinces.

The sorting and grain size distribution show no significant trends;

packing and perfection of orientation appear to be governed by lithology and hence are dependent on which samples are chosen.

Therefore it appears that the micro scale mirrors the macro and again shows the Inman Hill Subgroup to be monotonous in this area.

Although the results are rather disappointing in this case, it is not felt that this invalidates the concept which could well be of importance in other areas.

2.2.3. BROWN HILL SUBGROUP:

UNIT 3. This is the lowermost unit and is approximately 50m thick. At its base it is a micaceous, dark grey, finely laminated and well banded, locally cross bedded, coarse siltstone. It has occasional coarser bands and a moderately developed slaty cleavage (HS 385/003B). It passes upwards into a dark green/grey, fissile, micaceous siltstone (HS 385/139, 148B), and then into a lighter grey micaceous coarse siltstone.

UNIT 2. Overlying Unit 3 is approximately 70m of black, pyritic slate containing flattened and lineated clay pellets (Pl. 4n). It weathers and bleaches very easily, now appearing as float of white to black, often streaked, slate, commonly with limonite pseudomorphs after pyrite (TS 385/134, 135A, 140). Large ($\leqslant$15cm), red ironstone concretions commonly lie on the surface. Thompson (1969) correlates Unit 2 with the Karinya Shale Member and if this is correct then it does not occupy its usual stratigraphic position viz. at the base of the Brown Hill Subgroup.

UNIT 1. This comprises approximately 80m of very dark grey to black, variably calcareous phyllitic slates (Pl. 4p). On weathering, it alters to micaceous, green and brown, friable, very fine sandstones and coarse siltstones. Overall, it is very well indurated; this increases towards the synclinal axis. Large prominent outcrops are common (Pl. 41).

2.2.4. PALAEOENVIRONMENTAL INTERPRETATION:

The Carrickalinga Head Formation, with its bands and lenses of cross bedded and heavy mineral banded coarser material contained in finely laminated, cross bedded and rippled argillaceous sediments, indicates that although most of the sediments were deposited in comparitively calm conditions, some were deposited in the channels of rapidly flowing, and hence more competent, streams.

A meandering river and its flood plain would adequately explain the observed depositional structures. The laminated and cross bedded argillites would result from rapid deposition after flooding; the river channels would carry the heavy minerals and coarser grains. Active meandering would account for the lensoid shape of many of the sand units.

The existence of a flood plain should normally imply periods of subaerial exposure; no evidence of this was seen but little outcrop of the silty facies is exposed. Alternatively, the area could have been continuously inundated by a shallow sheet of water interspersed with deeper channels. As there would have been no vegetation to bind the sediments, the channels would have been able to move without restriction.

However, deposition may also have occurred in somewhat deeper water, in the medial regions of a comparitively steep slope leading into a deep basin or trough. The coarser fraction would have been deposited in submarine or sublacustrine channels; the fines in quieter interchannel areas. Storm waves could account for the presence of the laminations, ripples and cross beds now observed in the finer sediments.

Further work in areas of better outcrop might be able to determine which, if either, of the alternatives are correct.

Following deposition of the Carrickalinga Head Formation, consistently coarser sediments were laid down. The variably banded sandstones and interbedded mudstones attest to fluctuating energy conditions although, overall, the competence of the medium bearing the sediments must have been relatively high.

The observed lithology of the Inman Hill Subgroup is compatible with either of the theories outlined above. For the first, there would have to have been a fairly rapid transgression. This would effectively shorten the distance to the source of the supply of clastics; local reworking as the water advanced would result in winnowing of fines, leaving a coarse sand base (Stns. 170, 53A); and a large lake or sea would result. The observed sedimentary features are all explicable in terms of a lacustrine environment (Selley 1970, p 66; Conybeare and Crook 1968).

Alternatively the Inman Hill Subgroup could represent the more distal part of a deep basin with steep slopes. The coarser sediments would have been carried along submarine channels in streams of high competency and could then have been deposited beyond a considerable proportion of the fines. The clay banding would be due to settling from suspension during periods when sands were not being carried into the basin.

It is not thought to be a Flysch sequence (c.f. Sprigg and Campana, 1953).

Unit 3 of the Brown Hill Subgroup is finer than the Inman Hill Subgroup. It was possibly formed in like manner, except that the coarser fraction was not introduced into the basin at that stage.

A barrier then probably formed resulting in restricted circulation; reducing conditions prevailed and a carbonaceous black shale deposited; pyrite formed in abundance.

The bar was then removed with the result that silts and fine sands were then transported into the basin; in the oxidising conditions prevalent, calcareous sediments were able to be formed.

Any further sediments originally present in the Australia Plains area have been stripped off by erosion.

At this stage, it is pertinent to note that any reconstruction of the varying palaeoenvironments in, and the geological history of, a large area which is based on examination of only a few square kilometres, should be regarded as both tentative and speculative. Nevertheless, any overall consideration of the two time periods must be enhanced by studies of individual areas such as this one.

2.3.1. IGNEOUS INTRUSIONS:

Two small bodies intrude the country rock. At Station 114, there is an area of 20m diameter on which lie scattered weathered blocks of green and white mottled, coarse grained diorite (TS 385/114).

A dark green/grey dolerite dyke outcrops at Station 084 and extends parallel to the strike of the country rock for 300m, averaging 50cm in thickness. It has a foliation parallel to the cleavage of the country rock but it is not known whether this is a flow feature formed during emplacement or whether it is related to the regional cleavage (TS 385/084).

3. STRUCTURE AND METAMORPHISM

3.1. ON THE REGIONAL SCALE

3.1.1. FOLDING:

The mapped strata are located in a southerly plunging synclinorium which is tight in the north but opens out southwards.

It is suggested that the 3-D diagrams (in the envelope inside the back cover) be consulted at this stage. These diagrams show that the regional structure does not consist of a single plunging syncline. Rather, the three synclinal axes define en echelon folds, corresponding to the right hand, elliptical type of Campbell (1958).

In this case, there are some divergences from the theoretical model however. The easternmost syncline is probably a parasitic, rather than a true en echelon, fold. In addition, the large thickness variations in Unit 2 are considered to be due to a local complex deformation, this concept being supported by the anomalously low values of both dip and plunge observed on the only outcrop of this unit. In the south of the area the large fault may have been localized by a very tight syncline (see 4.1.2.).

Although the synclines are close, the intervening anticlines are more open and this, coupled with steep plunges and poor outcrop, makes

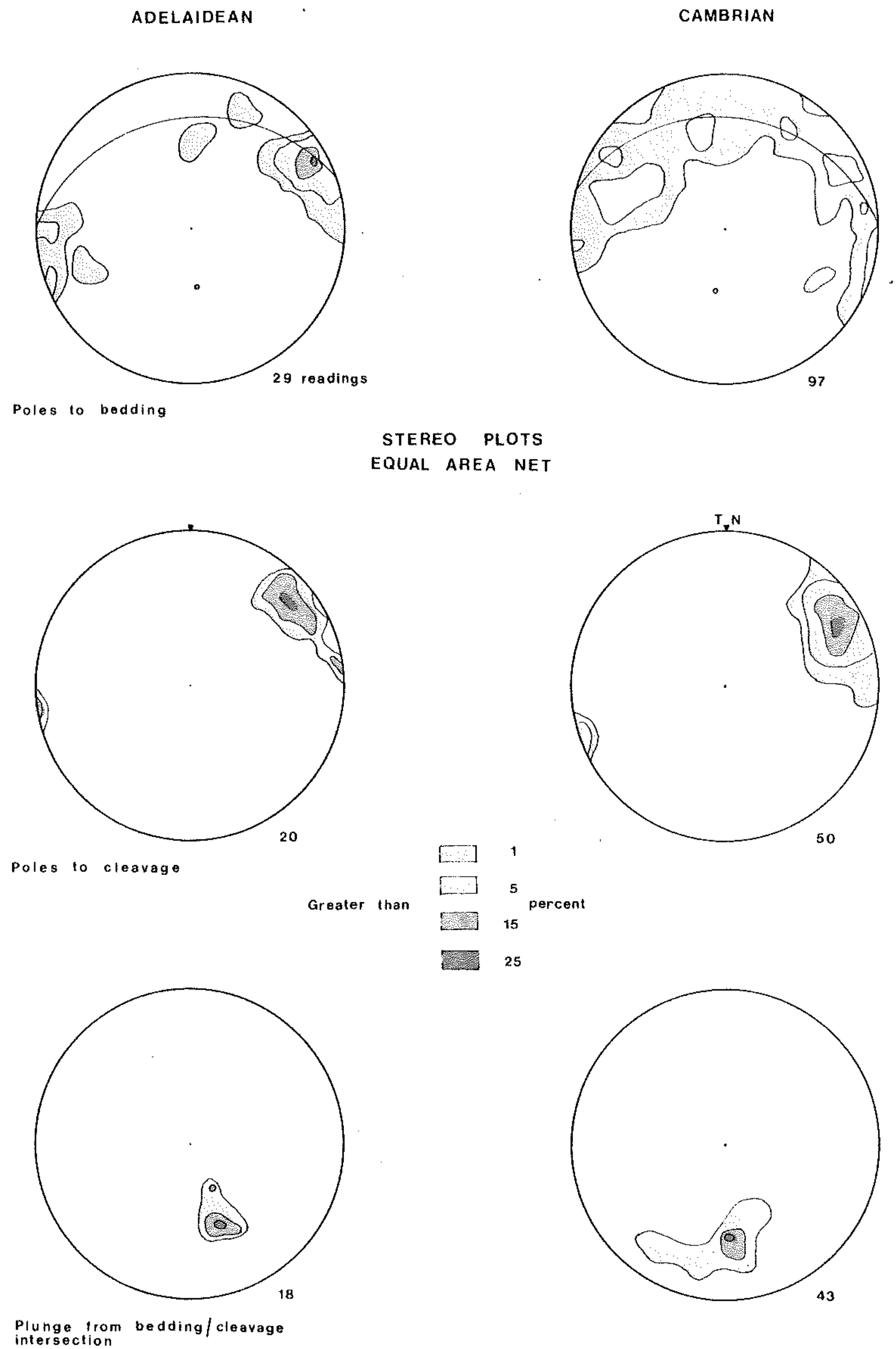

ADELAIDEAN
CAMBRIAN
29 readings
97
Poles to bedding
STEREO PLOTS
EQUAL AREA NET
T N
20
50
Poles to cleavage
Greater than
1
5
15
25
percent
18
43
Plunge from bedding/cleavage intersection

FIG 3

accurate positioning of the anticlinal axes impossible.

The en echelon folding is best seen by tracing the westernmost synclinal axis in a southwards direction. Vergence relations show it gradually changing from a close syncline to a monocline.

Several features, which would otherwise be quite puzzling, are explained when the nature of the folding is recognized:

(a) At ground level, the en echelon folding is confined to the Cambrian units. The folding in the Adelaidean is a simple syncline. Comparison of the stereo plots (Fig. 3) shows the plunge in the Cambrian to be westwards from that in the Adelaidean. This is a result of the en echelon folds trending across the synclinorium.

(b) The greater spread of the plots of plunge for the Cambrian is partly due to the morphology of the en echelon folds. They occur as ellipsoidal 'pods' along which the plunge must vary in magnitude. These 'pods' also account for the large spread of bedding attitudes in the Cambrian (through 220^{o}).

(c) The overall shallowing in plunge from the north to the south, which is observed in the area, is consistent with the morphology of en echelon folds (Campbell, 1958, p 459).

(d) The consistently high plunge noted throughout the area, coupled with the thickness of the stratigraphic sequence, would normally imply that the sediments plunge to a great depth. However, in the case of en echelon folding, it is only the minor folds which need plunge steeply; the plunge of the overall synclinorium is less steep.

3.1.2. FAULTING:

There is only one major fault but it bisects the area, to form the eastern contact between the Kanmantoo Group and the Proterozoic units. It is in the same relative position as, and is probably an extension of, the Palmer Fault Zone. K. Hamdorf (pers. comm.) considers that it continues northwards into the area which he has studied.

The trace of the fault is not affected by topography and hence it is assumed to be vertical. Although this is basically a normal fault, there has been a rotational movement on it. The throw decreases from south to north; the displacements calculated from the block diagrams being:

GH 2500m, EF 1700m, CD 1600m, AB 1000m.

K. Hamdorf finds the displacements to be in the opposite sense in the area that he studied; there must be a "fulcrum" at, or slightly north of, the northern boundary for the Australia Plains area.

At Station 209, the bedding, but not the cleavage turns into the fault. Over a distance of 40m the bedding swings through 90° (Pl. 4, k, m). Although it was first thought to be due to drag during the faulting phase, the fact that the cleavage does not deviate implies either that the faulting occurred before the folding phase, which is regarded as unlikely, or that the fault followed a tight syncline there.

The fault, and also the easternmost synclinal axis, can be traced on the surface by a succession of "blows" of white quartz. Their significance is not understood.

3.1.3. CLEAVAGE AND LINEATION:

Slaty cleavage is developed throughout the area, but varies in intensity. This depends upon:

(a) Lithology. The coarser units e.g. the sandy bands, the Inman Hill Subgroup and the Quartzite Facies, do not possess a good slaty cleavage. They sometimes split along sub parallel surfaces. The argillaceous units generally part easily along cleavage planes (Pl. 4p).

(b) Proximity of synclinal axes. The orientation of the cleavage shows it to be axial plane. The most intense cleavage is seen in areas near the axial traces of the synclines. For example, a hand specimen of the Pepuarta Tillite from the west shows no cleavage; in the east it forms prominent slaty outcrops.

(c) Proximity of the fault. In the field it appears that those areas close to the fault may have a better developed slaty cleavage. This may not be so however, and in any case, may be related to the tight syncline described in 4.1.2.

Variations in lithology caused the development of cleavage fans and diffraction (Pl. 2e). In alternating sandy and argillaceous layers which lie close to a synclinal axis (e.g. Stn. 106) localized intense deformation has often resulted in a tendency for the sandy layers to be ruptured and split into lenses (Pl. 4o ; 2c).

This is regarded as being a result of the viscosity difference between the two layers when under compression. The coarser bands initially buckle; the slates are more mobile and eventually penetrate into, and sometimes through the sandy layers.

A mineral lineation exists in the area, but with the exception of Unit 2 of the Brown Hill Subgroup, where it is defined by an elongation of the clay concentrations, it is not usually visible in hand specimen.

Its average attitude is 52° - 343° which is approximately at right angles to the plunge of the synclinorium. This is in contradiction to Anderson (1948) who stated that a lineation should be parallel to the plunge of the folds.

3.1.4. KINKS:

Single sets of kink bands are common in Unit 1 of the Brown Hill Subgroup (Pl. 41). Their presence results from the operation of a shear couple (Dewey 1965), presumeably that which caused the development of the en echelon folds. The kinking appears to be the final stage of the deformation event in the area and only affects Unit 1 which is in the centre of the synclinorium.

3.2. ON THE MICRO SCALE

In an endeavour to determine how and why, the slaty cleavage and the lineation developed, sixteen oriented pairs of thin sections were

PLATE 3

W. Pepuarta Tillite. Larger clasts show significant rounding. (TS 385/086; crossed polars, 35X approx.)

X. Brown Hill Subgroup, Unit 2. Carbonaceous material is oriented parallel to cleavage.
(TS 385/135A; crossed polars, 35X approx.)

Y. Pepuarta Tillite.

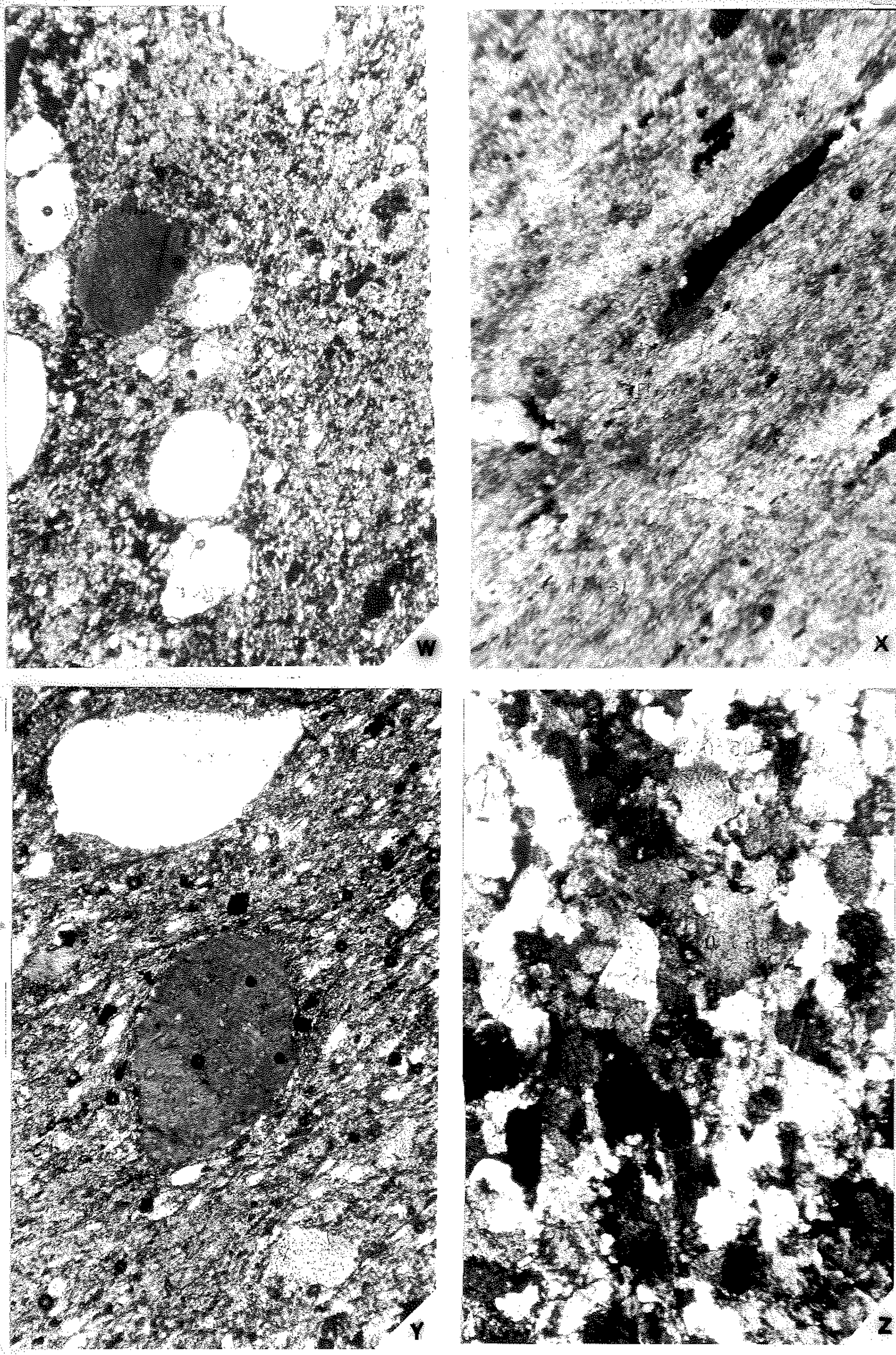
(a) Preferred orientation of larger clasts parallel to cleavage.

(b) Beard effect around the grey grain.

(c) Black limonite pseudomorph after pyrite.

(TS 385/058 (+940); crossed polars, 35X approx.)

Z. Inman Hill Subgroup. Welding, sutured contacts and interpenetration of grains.
(TS 385/076; crossed polars, 35X approx.)


W
X
Y
Z

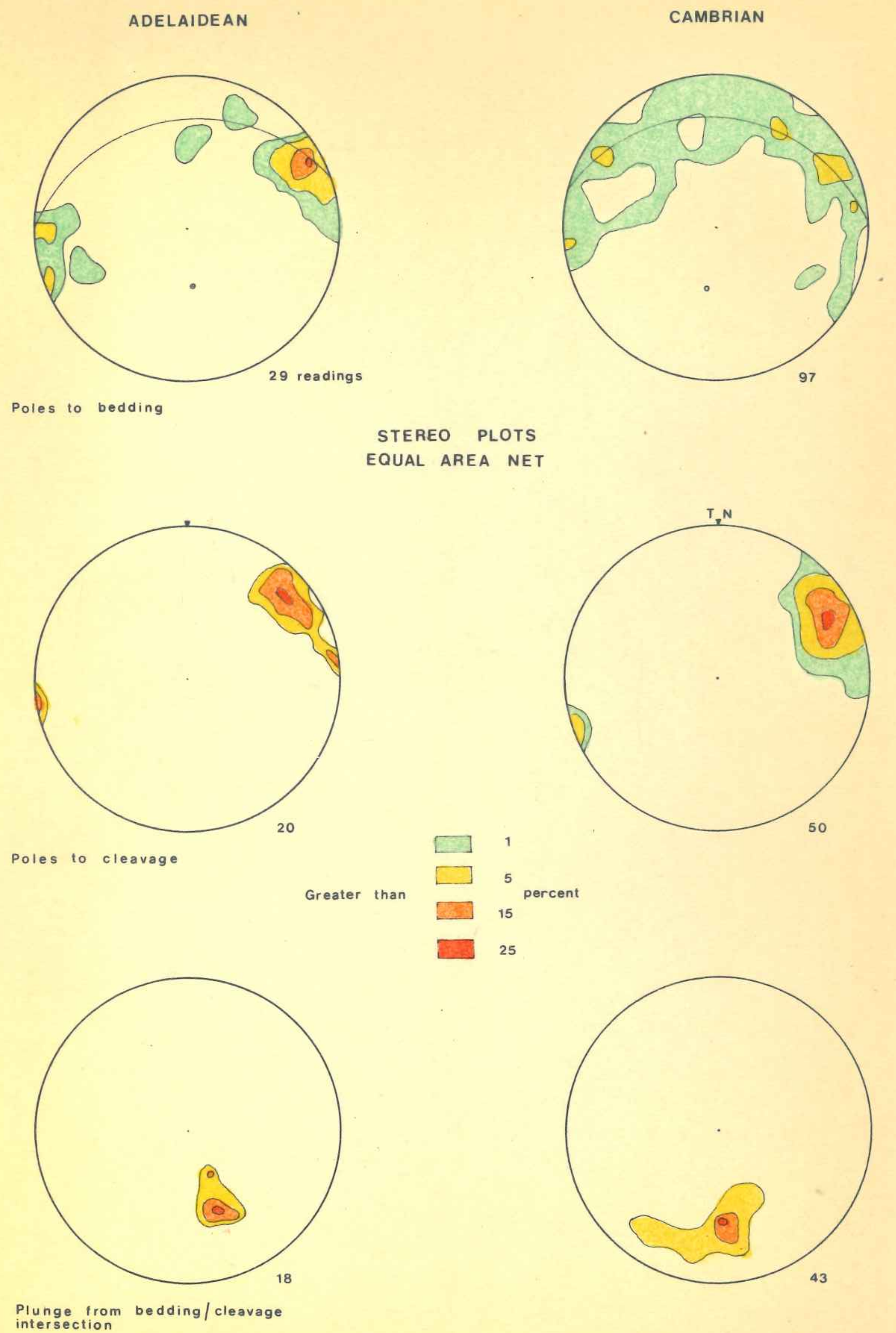

ADELAIDEAN
CAMBRIAN
29 readings
97
Poles to bedding
STEREO PLOTS
EQUAL AREA NET
T N
20
50
Poles to cleavage
Greater than
1
5
15
25
percent
18
43
Plunge from bedding/cleavage intersection

FIG 3

PLATE 4

m+k.

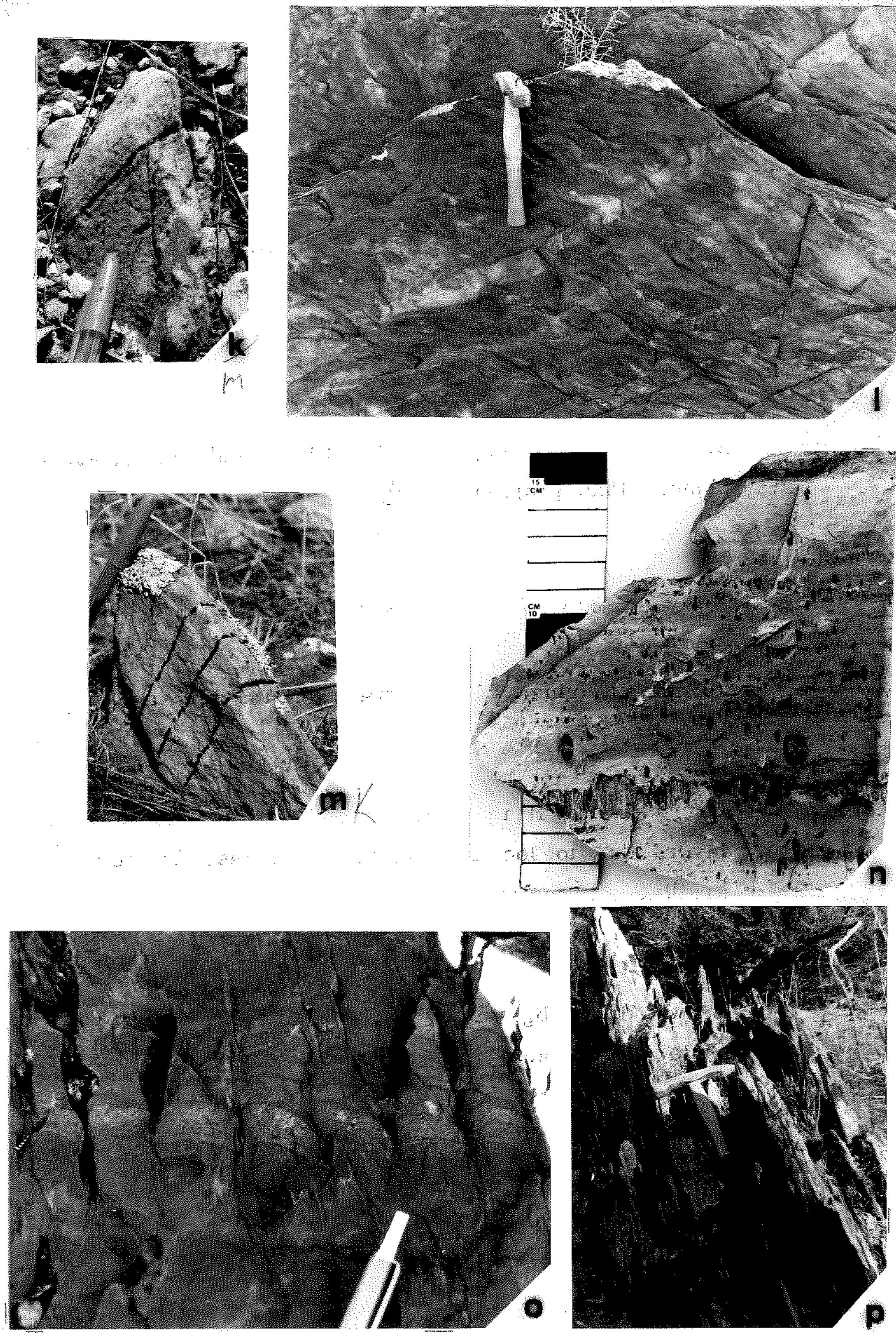
k and m. Inman Hill Subgroup. Vergence relations: k is taken 5m W of main fault, m is 20m W. This implies fault is localized along a tight synclinal axis.

l. Brown Hill Subgroup, Unit 1. Kink bands on cleavage plane. Photographer facing W.

n. Brown Hill Subgroup, Unit 2. The lineation is shown by the elongation of clay rich pellets perpendicular to the original bedding trace on the cleavage plane.

o. Carrickalinga Head Formation. Cusp shapes in sandy layers due to localized intrusion of less competent argillaceous material.

p. Brown Hill Subgroup, Unit 1. Slaty cleavage photographer facing S.


k
l
m
15
CM
CM
10
n
o
p

produced. The orientation of each slide and a description of its properties, together with an expla nation fo the terminology used (after A. Collins 1971), are presented in Appendix II.

It was found that the intensity of development of cleavage and lineation was dependent on both the lithology and on the proximity of synclinal axes (as it did on the macro scale) and also on the orientation of the slide.

(a) Arenites. (+145, 132, 88, 107, 53, 106, 121)

A crystalloblastic texture is formed, the majority of grains being highly irregular in outline. A mineral lineation is not common. When present, it is caused by comparitively more elongate quartz-mica (Q-M) domains and larger biotite grains in one slide than in the other. The slaty cleavage is defined principally by the sub parallel orientation of individual biotite flakes and of anastomosing biotite stringers. In the mica (M) domains, the biotite is oriented parallel to domain boundaries; in Q-M domains the biotite often has a random orientation. Individual quartz grains are often elongated in the direction of cleavage.

(b) Mudstones. (+ 122, 174, 119, 111, 125)

In all cases, cleavage is defined by the parallel orientation of flakes and stringers of biotite, and often by the elongation of Q-M domains (Pl. 7j) sometimes into a lensoid shape (+ 174). The intensity of development of domain structures varies between, and within, each slide of a pair.

The mineral lineation cannot always be observed (+ 119, 125). It is best seen by comparing the two slides of a pair (+ 122, Pl. 5) where the lineation is manifested by better oriented, and larger, biotite grains in one slide than the other.

In those mudstones which show relict bedding features e. g. silt and clay laminations, there is often extensive deformation of the silty bands (Q-M domains) by locally intense cleavage (+122, Pl. 6H, I, J, & 7g, h). The orientation of these deformations can be used to define the cleavage.

(c) Slates. (+124, 20, 61, 126)

The slaty cleavage is defined by:

PLATE 5

THE MINERAL LINEATION

D and E. There is a more preferred orientation and larger size of the mica flakes (white) in D than in E. The lineation lies in the plane of D.
(Slides + 20A, B resp.; crossed polars, 100X approx.)

F and G. The mineral lineation lies in the plane of F and is caused by the more preferred orientation of mica (white) in F than G.
(Slides+61A, B resp.; crossed polars, 100X approx.)

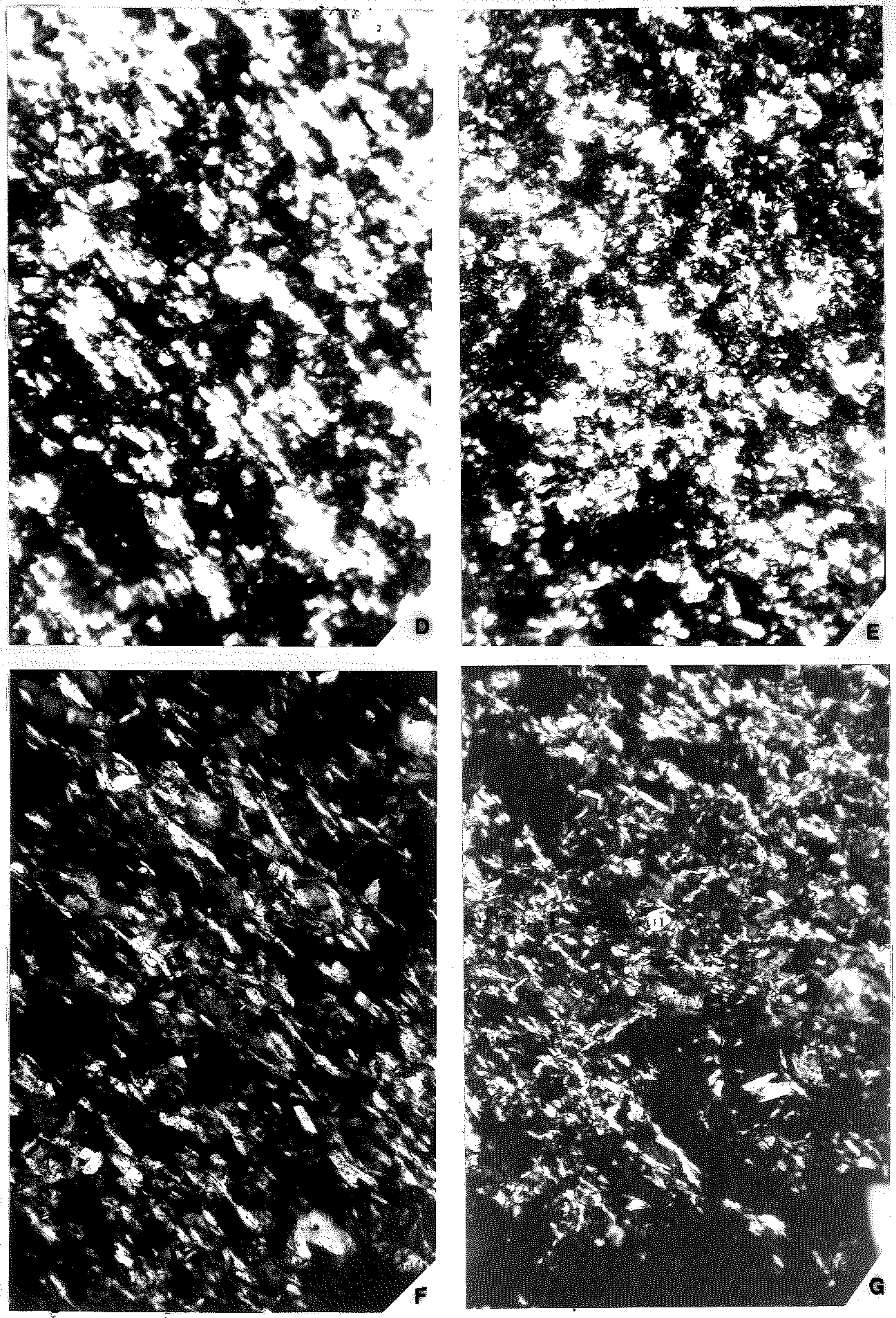

D
E
F
G

PLATE 6

MICRO SCALE DEFORMATION

H. Rupturing of a Q-M domain (the coarser zone) by the local intrusion of M domains. The resultant elongation of the Q-M domain is parallel to the cleavage trace.
(Slide + 26A; crossed polars, 35X approx.)

I. Complex deformation of an originally tabular band of very fine silt between two coarser silt layers.
(Slide +122A; crossed polars, 35X approx.)

J. M domains vary in intensity. When well developed, they can penetrate into Q-M domains, sometimes resulting in cusp-shaped boundaries.
(Slide + 126B; crossed polars, 35X approx.)

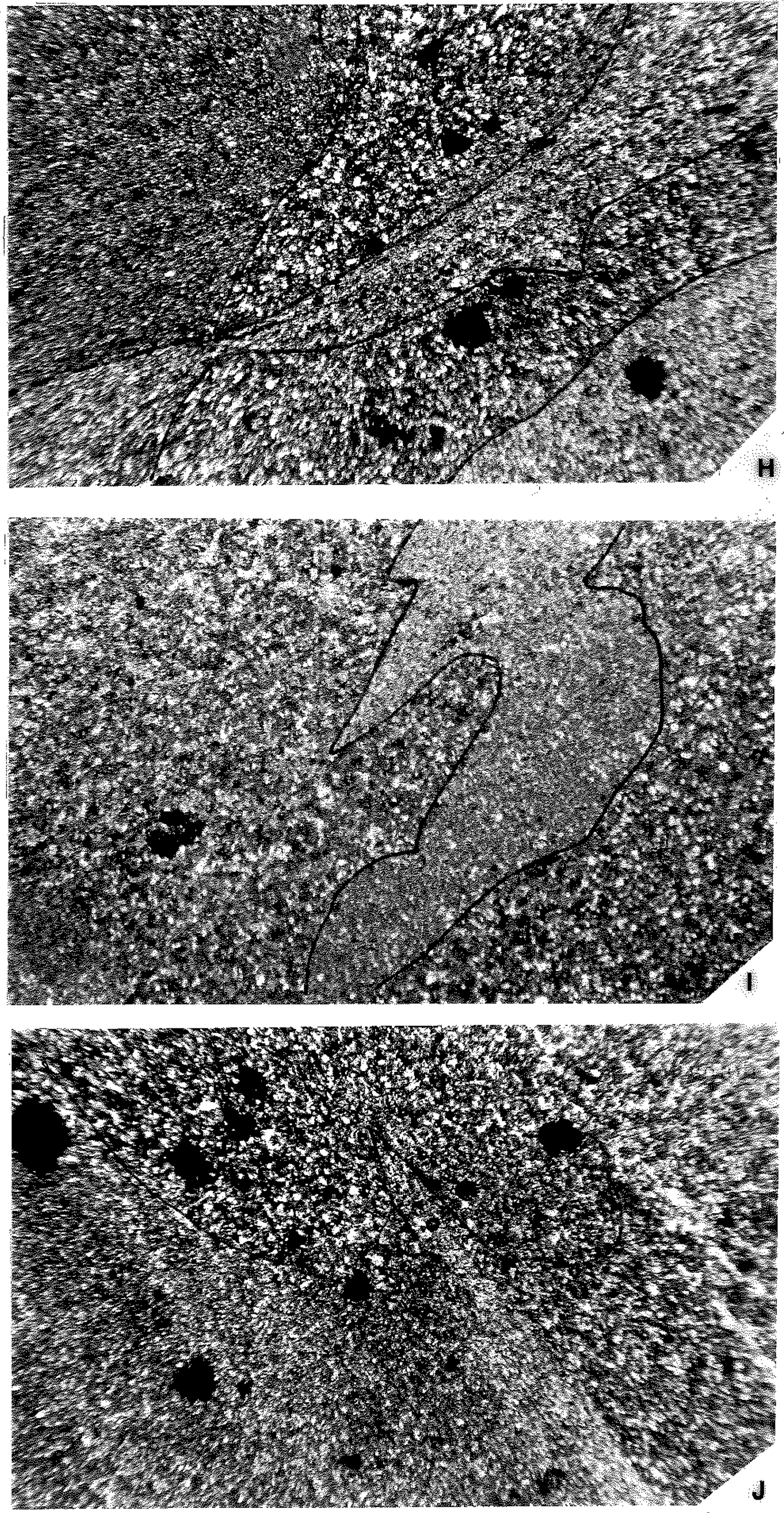

H
I
J

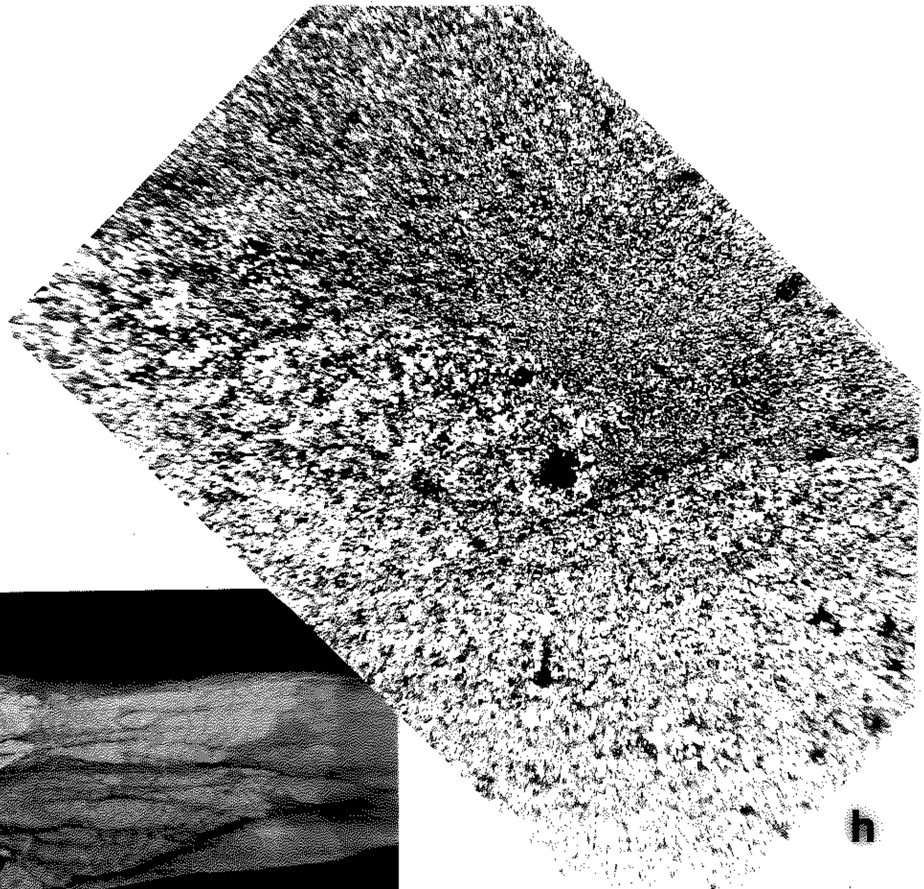
PLATE 7

g. Originally a mudstone with cross bedding defined both by grain size distribution and heavy mineral bands.
Zones of intense cleavage have developed in the clay component resulting in a smearing and 'faulting' of the siltier zones.
Rafts have been transported and rotated during the deformation.
(Slide 385/023, unpolarized light, 2.5X approx.)

h. An enlargement of the red rectangle on g. Note that the intrusion, into Q-M domains by M domains results in the non-linear boundary.
(Slide 385/023; crossed polars, 35X approx.)

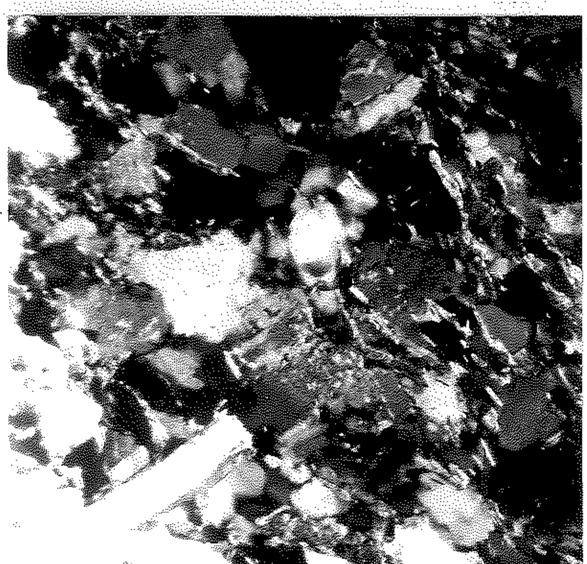
i. Two detrital muscovite flakes (crosses) trend at right angles to cleavage as defined by the sub parallel orientation of mica flakes. This suggests cleavage did not form by grain rotation.
(Slide + 106A; crossed polars, 35X approx.)

j. Elongation of a Q-M domain defines the mineral lineation.
(Slide + 174B; crossed polars, 35X approx.)

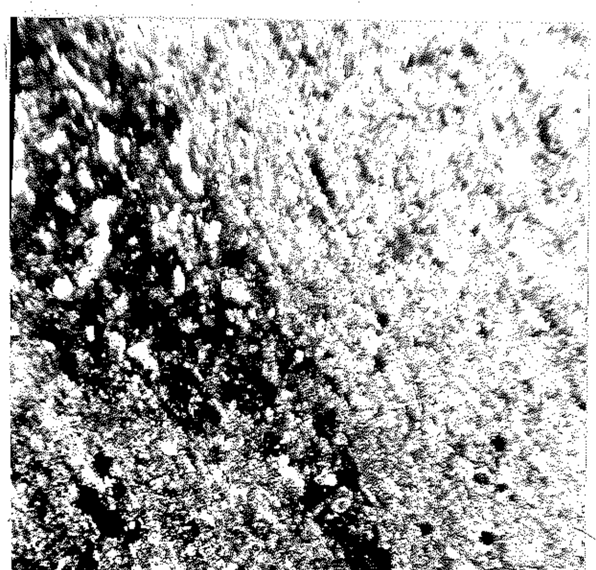


h

g



i



j

(1) a preferred orientation of individual mica flakes and of mica stringers.

(2) a preferred orientation of elongate Q-M lenses and individual quartz grains.

The lineation is defined by the variation in length and orientation of mica between the two slides of a pair.

3.2.1. CONCLUSIONS.

(a) The interpenetration of Q-M domains by M domains shows that on a micro scale, the distribution of strain was not homogeneous.

(b) It seems that the cleavage is related to the principal stress axes operative during the period of deformation, having formed perpendicular to the maximum compressive stress.

(c) Under stress, the original detrital clay fraction was converted to biotite which grew parallel to the axis of maximum strain when free to do so. In the Q-M domains it was not always able to, and relatively underdeveloped biotite grains with a random orientation formed.

(d) The original clastic quartz grains often have a dimensional preferred orientation also. This is considered to be due to solution at points of high pressure, followed by overgrowths at the less stressed positions (Riecke's Pple., Turner and Verhoogen, 1960, p 617).

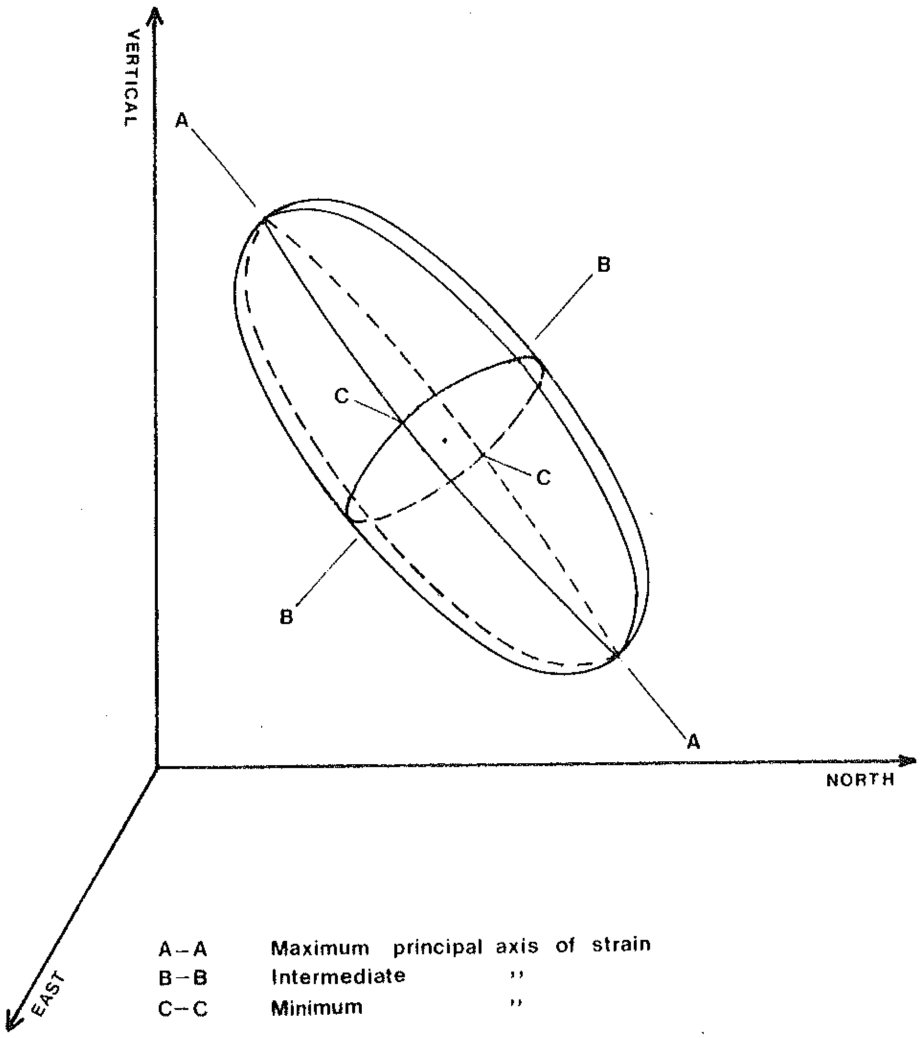
(e) The grain boundaries adjusted in the solid state.

(f) Contrary to Ramsay's ideas (Ramsay 1967, p 177), grain rotation is not thought to be of significance for the development of cleavage in this area. The welded and interpenetrating quartz grains imply that grain solution has occurred on a wide scale. In addition the presence in several slides (106A, 111, 121, 61, 126; Pl. 7i) of detrital muscovite flakes trending perpendicular to the cleavage trace shows that rotation has not occurred (Pl. 7i).

(g) The mineral lineation is determined by a dimensional parallelism of platy crystals and by grains which were elongated by solution and precipitation during the deformation. Growth occurred parallel to the axis of maximum principal strain.

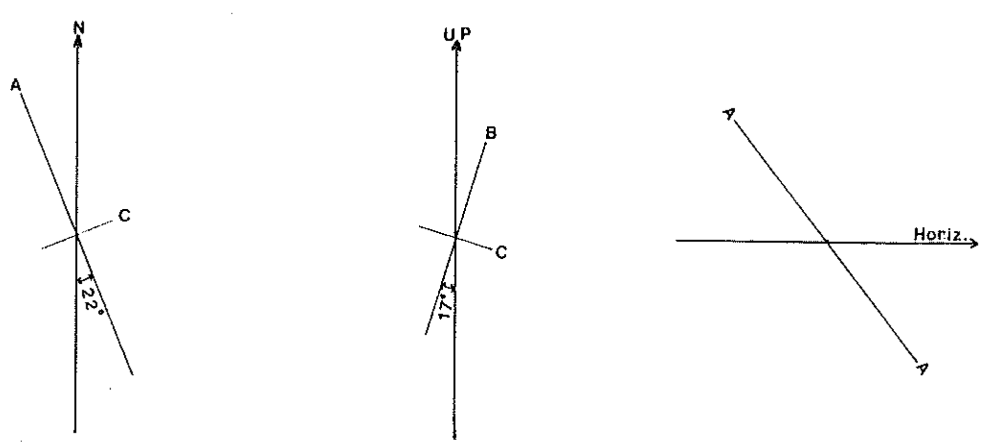
FIG 4

INFERRED STRAIN ELLIPSOID
AUSTRALIA PLAINS



A–A	Maximum principal axis of strain
B–B	Intermediate ,,
C–C	Minimum ,,

Slaty cleavage developed in the A–B plane
Mineral lineation developed along A–A



The relative attitudes of cleavage, the mineral lineation, the inferred strain ellipsoid and the orientation of geographic axes are shown in Fig. 4.

(h) On the basis of these investigations, no evidence for more than one phase of deformation can be found for the Kanmantoo Group. The mineral lineation is not considered to be a product of another deformation acting on the schistosity but, rather, was due to a mineral growth elongation which was related to the stress field.

In summary, this supports the work of Collins and shows that his conclusions are also valid in areas subject to a lower metamorphic grade.

4. SUMMARY AND CONCLUSIONS

1. The boundary between the Tarcowie Siltstone Equivalent? and the overlying Pepuarta Tillite can only be arbitrarily defined.
2. A "Quartzite Facies" of the Pepuarta Tillite has been described and if it is continuous under the syncline then its varying thickness and stratigraphic position pose problems which are not readily soluble.
3. It is not possible to determine whether the contact between the Kanmantoo Group and the Adelaide System is conformable or not.
4. A large normal fault results in the eastern contact between the Kanmantoo Group and the Adelaide System. It has not been recognized by the Mines Department and is regarded as an extension of the Palmer Fault Zone.
5. It is thought that relatively shallow conditions prevailed during the time of deposition of the Kanmantoo Group. However, a steep sided palaeobasin would also account for the observed sedimentary structures.
6. Mapping of the units has disclosed a southerly plunging synclinorium composed of several en echelon folds. This fold pattern explains several apparently puzzling features observed in the field.
7. The slaty cleavage and the mineral lineation are considered to have

formed by mineral grain growth in the solid state, and in preferred directions in response to the strain operative during the deformation phase.

8. Only one deformation event has affected the Kanmantoo Group in this area.

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Andrew J. Drummond

BIBLIOGRAPHY

CITED IN TEXT:

ANDERSON, E. M., 1948: On Lineation and Petrofabric Structure and the Shearing Movement by which they have been produced. Quart. J. Geol. Soc. Vol. 104, p 99-132.

CAMPBELL, J. D., 1958: En Echelon Folding. Econ. Geol. Vol. 53, p 448-472.

COLLINS, A., 1971: Morphology of Slaty Cleavage in the Hill End Trough. Vol. 1, Unpub. Ph. D. Thesis, University of Sydney.

CONYBEARE, C. E. B. and CROOK, K. A. W., 1968: Manual of Sedimentary Structures. Bur. Min. Res. Geol. and Geophys. Bull. 102, Canberra A. C. T.

DAILY, B. and MILNES, A. R., 1972: Revision of the Stratigraphic Nomenclature of the Cambrian Kanmantoo Group, South Australia. Geol. Soc. of Aust. (in press).

DEWEY, J. F., 1965: Nature and Origin of Kinks Bands: Tectonophysics. 1:459-494.

FOLK, R. L., ANDREWS, P. B., LEWIS, D. W., 1970: Detrital Sedimentary Rock Classification and Nomenclature for use in New Zealand. N. Z. Journ. of Geol. and Geophys. Vol. 13, No. 4, p 937-968.

RAMSAY, J. G., 1967: Folding and Fracturing of Rocks. McGraw-Hill, New York.

SELLEY, R. C. 1970: Ancient Sedimentary Environments : A Brief Survey. Chapman and Hall Ltd. London.

SPRIGG, R. C. and CAMPANA, B., 1953: The Age and Facies of the Kanmantoo Group. Aust. J. Sci. 16(1) : p 12-14.

THOMPSON, B. P., 1969: in Handbook of South Australian Geology. (Ed. Parkin, L. W.) Geol, Surv. S. A.

TURNER, F. J. and VERHOOGEN, J., 1960 : Igneous and Metamorphic Petrology. McGraw-Hill, New York.

GENERAL REFERENCES:

BATES, T. F., 1947: Investigation of the Micaceous Minerals in Slate. Amer. Mineralogist. Vol. 32, p 625-636.

CAROZZI, A. V., 1960: Microscopic Sed. Pet. John Wiley and Sons

CLOOS, E., 1946: Lineation, a Critical Review. Geol. Soc. Amer. Mem. Vol. 18.

COMPSTON, W., CRAWFORD, A. R. and BOFINGER, V. M., 1966: Radiometric Estimate of the Duration of Sedimentation in the Adelaide Geosyncline, South Australia. J. Geol. Soc. Aust. 13(1) : p 229-276.

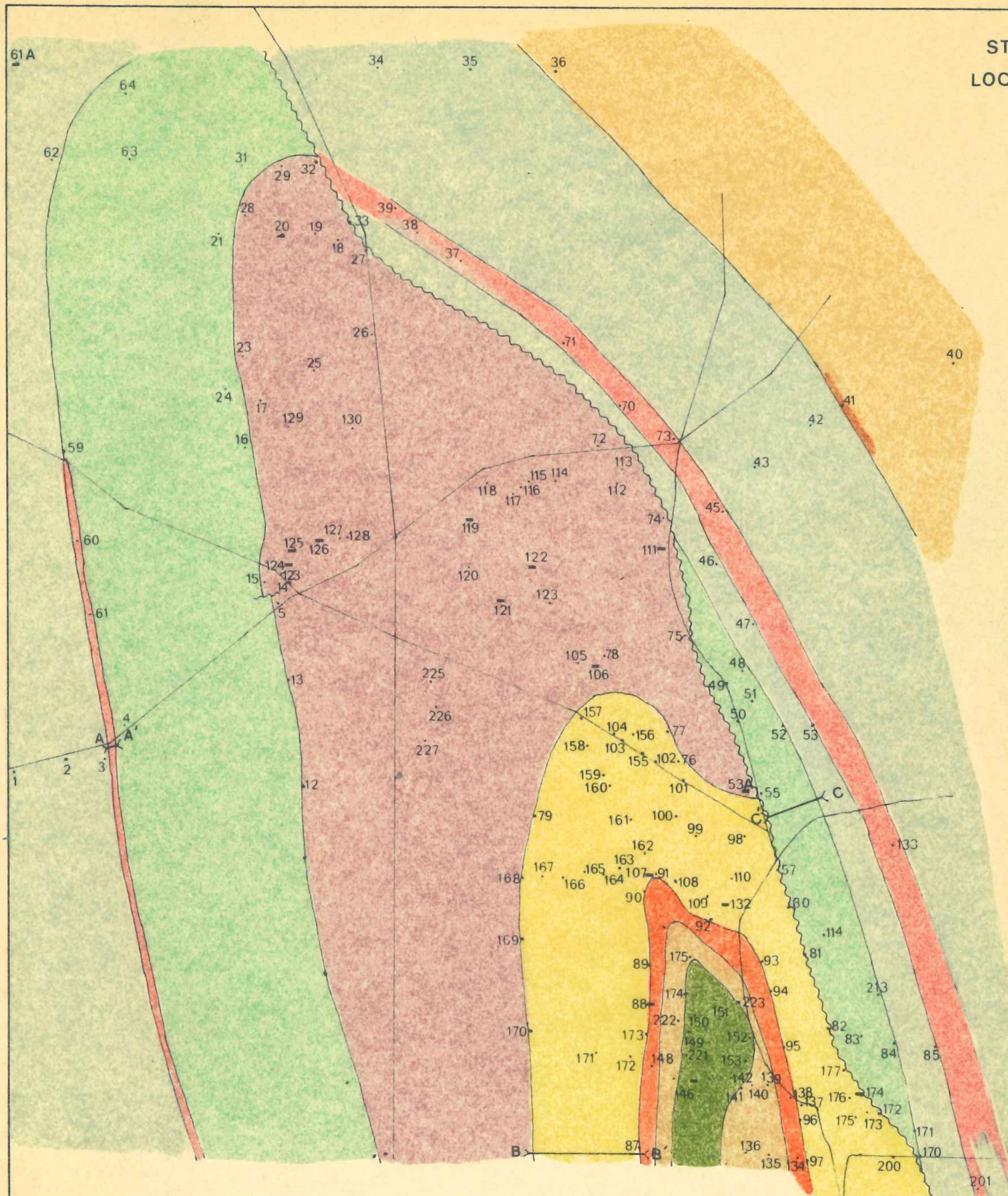
DAILY, B., 1956: The Cambrian in South Australia : El Sistema Cambrico. Pt. 2, p 91-147, XX Int. Geol. Congr. Mexico. (Reprinted 1957, in Bull, Bur. Min. Resources. Geol. and Geophys., Aust. 49, p 91-147).

FAIRBAIRN, H. W., 1936: Elongation in Deformed Rocks. J. Geol. Vol. 44, p 670-680.

FOLK, R. L., 1968: Petrology of Sedimentary Rocks. Hemphill's Austin, Texas.

MENDELSOHN, F., 1959: En Echelon Folding. Econ. Geol. Vol. 54, p 505-515.

WILSON, G., 1946: The Relationship of Slaty Cleavage and Kindred Structures to Tectonics. Proc. Geol. Assoc. Vol. 57, p 263-302.



· 139 Station locality

▬ 93 Collection site for cleavage investigation

A>——<A' Measured section

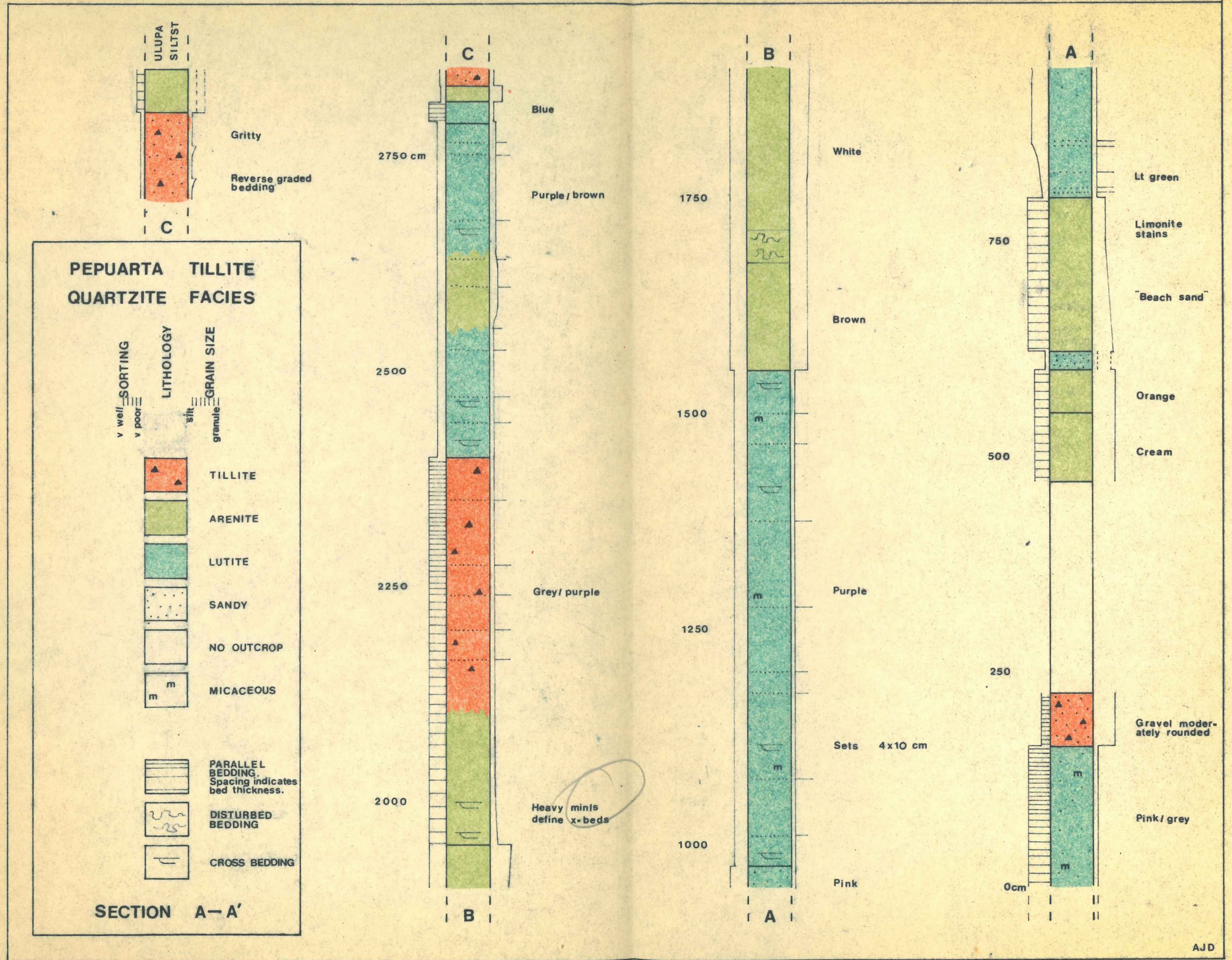
HS 385/047 is collected at Stn. 47

TS 385/136 ,, Stn. 136

Colour code is equivalent to that utilised on the main map

APPENDIX 1A

PETROGRAPHIC DESCRIPTIONS OF HAND SPECIMENS AND T
SECTIONS FROM THE MEASURED STRATIGRAPHIC SECTION
i.e. THROUGH THE QUARTZITE FACIES OF THE
PEPUARTA TILLITE.


ULUPA SILTST
C
Gritty
Reverse graded bedding
C
PEPUARTA TILLITE
QUARTZITE FACIES
SORTING
v well
v poor
LITHOLOGY
GRAIN SIZE
silt
granule
TILLITE
ARENITE
LUTITE
SANDY
NO OUTCROP
MICACEOUS
PARALLEL BEDDING. Spacing indicates bed thickness.
DISTURBED BEDDING
CROSS BEDDING
SECTION A— A'
C
2750 cm
2500
2250
2000
B
Blue
Purple / brown
Grey / purple
Heavy minls define x-beds
B
1750
1500
1250
1000
A
White
Brown
Purple
Sets 4x10 cm
Pink
A
750
500
250
0cm
Lt green
Limonite stains
"Beach sand"
Orange
Cream
Gravel moderately rounded
Pink / grey
AJD

+695cm <u>HS 385/058(695):</u> Pale grey quartzite with weathered orange patches. Interstitial matrix is kaolinized.

<u>TS 385/058(695):</u> Quite homogeneous. Well packed, generally with long grain contacts. Moderately to well sorted. 5% very coarse sand, 20% coarse, 70% medium to fine sand, 5% silt and clay. Sphericity was good before diagenesis; originally grains were well and very well rounded. Many quartz and orthoclase grains have authigenic overgrowths in optical continuity. The grains are bonded mainly by quartz, and to a lesser extent, orthoclase overgrowths.

<u>Composition:</u>

Quartz 45%. Uniformly distributed. 20% coarse, 80% medium to fine sand sizes. Originally moderately spherical and well to very well rounded, but now intergrain penetration and quartz overgrowths are common. Undulose extinction common.

Orthoclase 40%. Uniformly distributed. 30% very coarse to coarse, 70% medium to fine sand. Originally well rounded but both quartz and orthoclase overgrowths and intergrain penetration are prevalent. Generally fresh but some marginal alteration to kaolin.

Other Feldspars 3%. Originally well rounded grains now being kaolinized (weathering?) both marginally and internally. Albite and microcline varieties.

R. F. 5%. Originally well rounded fragments of polycrystalline quartz and orthoclase, and siltstone and granite(?).

Kaolin 7%. Occurs interstitially and as an alteration product of the feldspars. Patchily distributed.

Name:

(a) Moderately sorted sandstone.

(b) Quartz cemented, supermature feldsarenite.

+740cm HS 385/058(740): Poorly sorted, banded yellow sandy mudstone. Banding due to concentrations of sand size grains.

TS 385/058(740): Inhomogeneous as has sandy layers in a mud matrix. Packing moderate, some interpenetration of clastic grains by solution. A preferred orientation is defined on a macro scale by sandy streaks, and on a micro scale by the orientation of elongate clastic grains and the orientation of micas.

Sorting poor but bimodal. Coarse sand 10%, medium and fine 10%, mud 80%.

Grain shapes are affected by pressure and kaolinization.

Matrix bound by silt and clay.

<u>Composition:</u>

Quartz 35%. Sand size (10%) occurs in bands, silt size (25%) evenly distributed throughout the matrix. Elongate clasts have an orientation parallel to bedding. Roundness is affected by pressure, long intergrain contacts usually. Undulose extinction common.

Orthoclase 15%. Sand size (10%) occurs in bands, silt size (5%) evenly distributed throughout the matrix. Initial roundness good but changed by solution and marginal kaolinization.

Plagioclase 2%. An 85. Medium sand size, randomly distributed throughout the sandy layers. It is badly kaolinized (weathering?).

R. F. 2%. Originally moderately to well rounded but generally altered medium to fine sand size grains of polysryctalline quartz and orthoclase, and chert and microcline.

Opaques 6%. Angular black grains of very fine sand to coarse silt predominantly in the sandy layers.

Matrix 40%. Predominantly kaolin. Overall preferred orientation parallels bedding. Formed by alteration of the clay fraction and some of the larger grains.

Name:

(a) Weathered, poorly sorted but bimodal, medium sandstone and mudstone.

(b) Immature, kaolinitic, feldspathic litharenite.

+762cm HS 385/058(762): White medium sand size semi-quartzite, moderately porous.

+870cm HS 385/058(870): Very well indurated white quartzite with a white (kaolin?) interstitial matrix.

TS 385/058(870): Very homogeneous. Very well packed, extensive interpenetration of the clastic grains by solution. Quartz& orthoclase grains have overgrowths generally of the corresponding composition.

Well sorted but bimodal. Meduim and fine sand size 85%, mud 15%, generally interstitial.

All grains anhedral and before packing were well rounded.

Bonded quartz and orthoclase overgrowths and by interstitial kaolin.

Composition:

Quartz 70%. No preferred orientation. Packing has affected rounding and sphericity, both originally good. Few point contacts, generally linear or sutured. Undulose extinction predominant.

Orthoclase 10%. Randomly scattered medium and fine sand size grains. Authigenic orthoclase overgrowths and pressolution have affected grain shapes originally very well rounded. Generally fresh, but some marginal alteration to kaolin.

Plagioclase 4%. Ab 65. Randomly scattered fine sand size grains which were originally only moderately rounded (c.f. quartz and orthoclase). Extensively kaolinized, often recognizable only by relict twinning.

R. F. 6%. Randomly distributed, medium to fine sandstone grains, often extensively kaolinized. Grains of polycrystalline quartzite, orthoclase, and perthite. Grains of siltstone and slate(?).

Clay 10%. Forms a hazy interstitial matrix, generally authigenic.

Name:

(a) Well sorted, bimodal medium siltstone and mudstone.

(b) Submature subfeldsarenite.

+940cm **HS 385/058(940):** A pale brown, weathered mudstone with sandy streaks.

TS 385/058(940): An inhomogeneous rock having sandy streaks in a mud matrix. Packing is poor. The secondary biotite formed from alteration of the clay is parallel to the sandy streaks - bedding and cleavage are coincident. Poorly sorted, Medium and coarse sand 10%, fine and very fine sand 20%, coarse silt size 30%, clay 40%. Roundness of sand grains variable, affected by marginal alteration. Originally moderately to well rounded. Originally bonded by clay, now by secondary biotite.

Composition:

Quartz. 30% of the sand fraction and 100% of the silt fraction. Sand size grains in the silty bands. Little altered, average sphericity = 0.7.

Orthoclase 10%. Confined to the sandy bands.

Medium and fine sand size. Marginal kaolinization affects roundness, originally moderate to well rounded

Perthite 1%.

Plagioclase 3%. Confined to sandy bands, fine to very sand size. Generally extremely altered to kaolin and biotite.

Detrital Micas 1%. A few long flakes of detrital muscovite, up to 0.25mm. Fabric often distorted.

R. F. 6%. Common polycrystalline quartz and orthoclase (medium sand size, well rounded, moderately spherical), a few polycrystalline plagioclase grains and rare siltstone grains (fine sand size, well rounded).

Secondary biotite 40%. The original clay fraction has been converted to biotite which an overall orientation parallel to bedding.

Name:

(a) Poorly sorted, bimodal, sandy mudstone.

(b) Arenaceous subfeldslutite.

+1040cm HS 385/058(1040): A pale pink weathered, slightly micaceous siltstone.

TS 385/058(1040): Fairly homogeneous slide showing occasional sand size grains in a mud matrix. Bedding is evident on a micro scale by some alignment of long axes of sand size clasts, and alignment of clays and micas.

Moderately sorted but bimodal. Medium to very fine sandstone 10%, coarse silt 30%, clay 60%.

Sand and coarse silt grains anhedral, moderately spherical and originally angular to well rounded.

Bonded by clay matrix.

Composition:

Quartz 40%.	Almost all the sand and coarse silt fraction is quartz. Sand grains randomly scattered, silt size uniformly distributed. Slight alignment of long axes parallel to bedding. Sphericity moderate, roundness variable, marginal kaolinization common. Undulose extinction common.
Feldspar.	Rare sand size plagioclase grain undergoing extensive kaolinization.
Biotite 1%.	Oriented parallel to bedding.
Clay.	Imparts a tan colour to the slide, and under crossed polars, a degree of preferred orientation.

Name:

(a) Moderately sorted, bimodal, slightly sandy mudstone.

(b) Quartzlutite

+1950cm <u>HS 385/058(1950)</u>: White, well indurated and well sorted fine quartz sandstone.

+2850cm <u>HS 385/058(2850)</u>: Pale yellowish green (but orange weathering) slightly sandy mudstone.

<u>TS 385/058(2850)</u>: Thick slide because of extreme weathering. Fairly homogeneous, a mudstone with random sand size grains.
Sand size grains 5%, rest mud.
Sand grains anhedral, with variable sphericity and roundness affected by weathering.
Mineral composition unknown due to extreme weathering and thickness of slide.

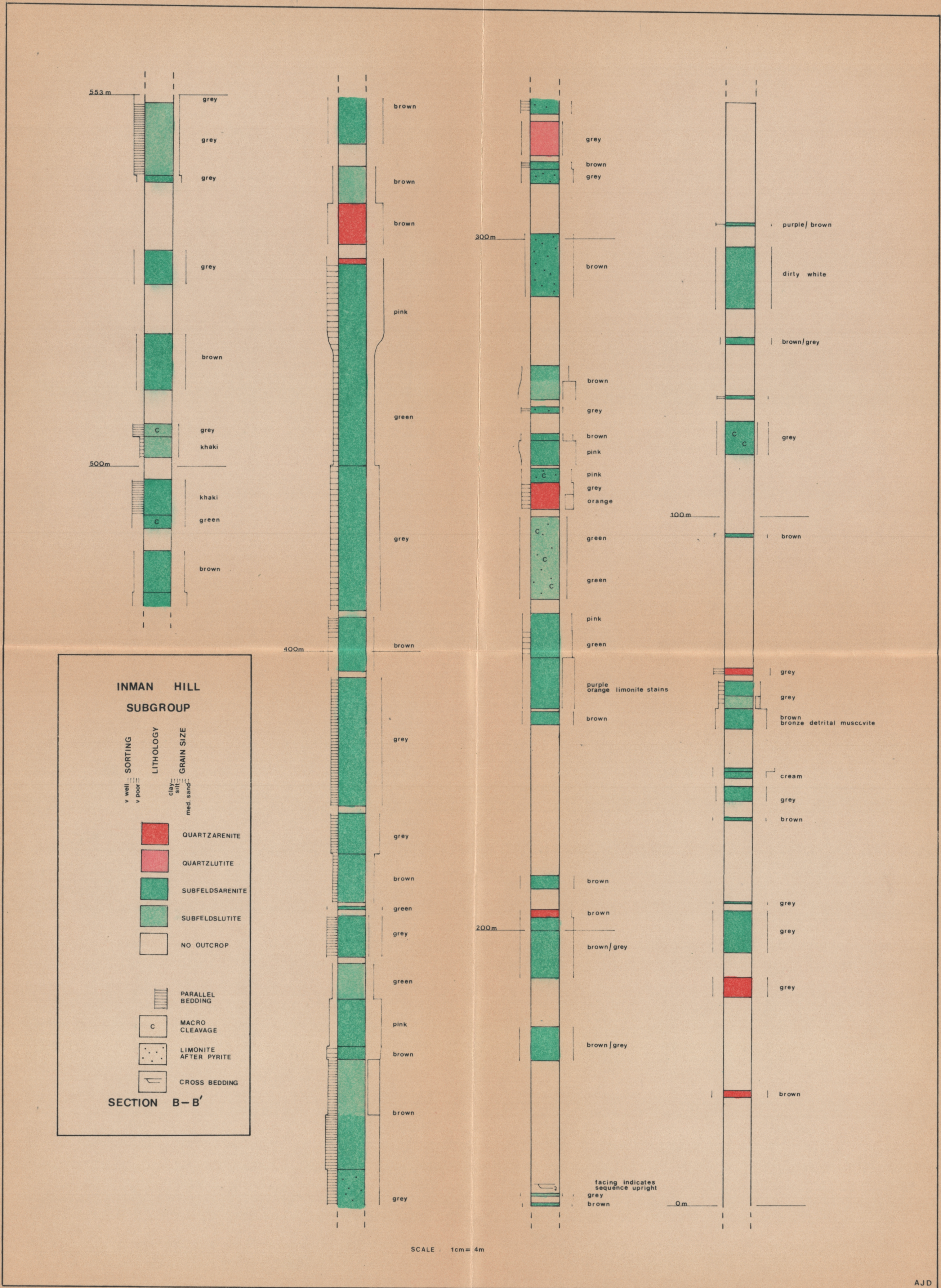
<u>Name:</u>

(a) Moderately sorted, but bimodal, slightly sandy mudstone.

(b) Weathered, clay cemented lutite.

APPENDIX 1B

PETROGRAPHIC DESCRIPTIONS OF HAND SPECIMENS FROM THE MEASURED STRATIGRAPHIC SECTION B-B' i.e. THE INMAN HILL SUBGROUP.


553m
grey
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500m
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300m
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pink
grey
orange
C
green
green
pink
green
purple
orange limonite stains
brown
brown
brown
200m
brown/grey
brown/grey
facing indicates sequence upright
grey
brown
purple/ brown
dirty white
brown/grey
C
grey
100m
brown
grey
grey
brown
bronze detrital muscovite
cream
grey
brown
grey
grey
grey
brown
0m
INMAN HILL
SUBGROUP
SORTING
LITHOLOGY
GRAIN SIZE
v well
v poor
clay
silt
med. sand
QUARTZARENITE
QUARTZLUTITE
SUBFELDSARENITE
SUBFELDSLUTITE
NO OUTCROP
PARALLEL BEDDING
MACRO CLEAVAGE
LIMONITE AFTER PYRITE
CROSS BEDDING
SECTION B– B′
SCALE : 1cm= 4m
AJD

086/015 Pale brown quartzarenite, now a quartzite. Originally a well sorted muddy fine sandstone. Sorting moderate.

086/030 Moderately sorted muddy fine sandstone, now a quartzite. A micaceous subfeldsarenite. Biotite and detrital muscovite common.

086/038 Dark grey coarse hardened quartzite. Originally a moderately sorted fine sandstone; a micaceous subfeldsarenite.

086/044 A medium grey dirty quartzite. Originally a moderately sorted fine sandstone; a micaceous subfeldsarenite.

086/056 A light brown dirty quartzite. Biotite 10%. Originally a well sorted silty fine sandstone; a subfeldsarenite.

086/059 A light grey dirty quartzite. Biotite 10%. Originally a moderately sorted silty fine and very fine sandstone; a subfeldsarenite.

086/062 A cream dirty quartzite. Biotite 5%. Originally a well sorted muddy very fine sandstone; a slightly micaceous subfeldsarenite.

086/063 A weathered pale brown dirty quartzite. Biotite 2%. Originally a well sorted clayey fine and very fine sandstone; a slightly micaceous, limonite stained quartzarenite.

086/070 A pale brown weathered friable dirty quartzite. Detrital muscovite 3%, Originally a moderately sorted, muddy fine sandstone; a muscovite rich subfeldsarenite.

086/073 Light and dark grey banded quartzite. Originally a poorly sorted but bimodal, banded clay and siltstone; a subfeldslutite.

086/074 A pale brown, weathered, friable, banded quartzite. Originally a moderately to poorly sorted, muddy fine and very fine sandstone; a subfeldsarenite.

086/077 A very pale grey quartzite. Biotite 2%. Originally a well sorted slightly clayey medium and fine sandstone; a quartzarenite.

086/097 A pale brown, weathered, friable quartzite with some orange limonite staining. Originally a well sorted slightly muddy, fine and very fine sandstone; a quartzarenite.

086/112 Pale grey, slightly banded dirty quartzite. Originally a moderately sorted but bimodal clayey fine and very fine sandstone; a subfeldsarenite.

086/116 Dark grey dirty quartzite. Originally a moderately sorted muddy fine sandstone; a quartzarenite.

086/125 A brown grey, slightly banded dirty quartzite. Detrital muscovite 2-3%. Originally a poorly sorted muddy fine sandstone; a muscovite rich subfeldsarenite.

086/131 Dirty white, massive weathered quartzite. Originally a moderately to well sorted slightly muddy fine sandstone; a subfeldsarenite.

086/142 Purplish brown, massive,silicified quartzite. Originally a moderately to well sorted slightly muddy fine sandstone; a subfeldsarenite.

086/160 Pale brown, slightly fissile dirty quartzite with orange limonite spots. Biotite 20%. Originally a moderately sorted but bimodal, muddy very fine sandstone; a subfeldsarenite.

086/161 Pale grey, massive, dirty qtzite with orange limonite stains. Biotite 50%. Originally a well sorted but bimodal very fine sandstone and clay; a subfeldsarenite.

086/169 Pale orange, slightly fissile, dirty quartzite. Originally a moderately sorted muddy sandstone; a quartzarenite.

086/182 Pale grey/brown, very dirty quartzite. Originally a well sorted muddy very fine sandstone; a subfeldsarenite.

086/202 Dark brown grey silicified quartzite. Originally was probably a muddy fine sandstone; a subfeldsarenite

086/206 Brown silicified quartzite. Originally a well sorted slightly muddy fine and very fine sandstone; a subfeldsarenite.

086/229 weathered, orange spotted, pale brown dirty quartzite. Originally a moderately sorted, muddy fine and very fine sandstone; a subfeldsarenite.

086/235 Orange limonite spotted, slightly fissile purplish brown, pyritic dirty quartzite. Well developed pyrite cubes up to 2mm, approximately 1%. Originally a moderately sorted, but bimodal clay rich fine and very fine sandstone; a subfeldsarenite.

086/241 Greenish grey dirty chloritic quartzite. Originally a moderately sorted muddy very fine sandstone; a subfeldsarenite.

086/246 Pinkish grey dirty quartzite. Muscovite flakes 1-2%. Originally a moderately sorted muddy very fine sandstone; a subfeldsarenite.

086/248 Greenish grey siltstone with a slightly developed slaty cleavage. Originally a well sorted micaceous siltstone, a subfeldslutite possibly.

086/256 A pale greenish brown slate with detrital muscovite flakes lying on cleavage planes. Originally a well sorted micaceous siltstone, a subfeldslutite possibly.

086/261 Orange/grey, weathered and limonite stained dirty quartzite. Originally a moderately sorted but bimodal, muddy fine and very fine sandstone; a subfeldsarenite.

086/263 Medium grey, slightly banded dirty quartzite. Originally a moderately sorted but banded, bedded clayey fine sandstone; a subfeldsarenite.

086/268 Pinkish brown silicified dirty quartzite. Probably originally a moderately sorted clayey fine sandstone; probably a subfeldsarenite.

086/272 Pale brown silicified(?) pyritic quartzite. Pyrite cubes 2-3% up to 3mm wide. Originally a well sorted slightly muddy fine sandstone; a pyritic subfeldslutite.

086/274 Dark grey massive very dirty quartzite. Originally a moderately sorted but bimodal sandy and silty claystone; a subfeldslutite.

086/277 Light brownish grey very dirty quartzite with a poorly developed slaty cleavage. Originally a well sorted but bimodal clayey fine sandstone; a subfeldsarenite.

086/282 Medium brown, slightly weathered slate with a well developed slaty cleavage. Originally a moderately sorted siltstone; a micaceous quartzlutite.

086/292 Brownish grey, but orange spotted, very dirty quartzite. Originally a poorly sorted muddy sandstone ; a micaceous subfeldsarenite.

086/301 Pinkish brown silicified (?) quartzite. Originally a poorly sorted muddy fine and very fine sandstone; a slightly micaceous subfeldsarenite.

086/303 Pale brown but orange limonite stained quartzite with a poorly developed slaty cleavage. Originally a poorly sorted muddy fine and very fine sandstone; a slightly micaceous subfeldsarenite.

086/308 Medium grey, moderately well indurated, moderately sorted muddy very fine sandstone; a micaceous subfeldsarenite.

086/310 Pale brown but orange limonite stained, weathered, moderately sorted friable muddy fine and very fine sandstone; a micaceous subfeldsarenite.

086/312 A very dark grey massive very impure quartzite. Originally a moderately sorted, slightly sandy claystone; a subfeldslutite.

086/318 Pale grey, weakly banded, dirty quartzite. Originally a moderately sorted, muddy fine and very fine sandstone; a subfeldsarenite.

086/325 Pale brown massive quartzite. Originally a well sorted fine and very fine sandstone; a quartzarenite.

086/326 Pale brown very dirty quartzite. Originally a moderately sorted, muddy very fine sandstone; a subfeldsarenite.

086/334 Pale brownish grey massive quartzite. Originally a well sorted, slightly muddy fine and very fine sandstone; a subfeldsarenite.

086/337 Pale brownish grey banded quartzite. Originally a moderately sorted but bimodal fine and very fine sand and claystone; a subfeldsarenite.

086/341 Pale brown friable, weathered dirty quartzite. Originally a moderately to well sorted slightly muddy fine sandstone; a subfeldsarenite.

086/343 Pale pinkish brown, dirty quartzite. Originally a moderately sorted slightly muddy fine sandstone; a subfeldsarenite.

086/350 Pale greenish brown, very dirty quartzite. Originally a poorly sorted very sandy mudstone; a subfeldslutite.

086/355 Pale and dark grey, banded quartzite. Originally a well sorted laminated clay and fine sandstone; a subfeldsarenite.

086/362 Dark grey, banded dirty quartzite. Originally a well sorted but bimodal fine sand and clay stone; subfeldslutite.

086/363 Pale greenish grey, dirty quartzite. Originally a well sorted slightly clayey fine and very fine sandstone; a subfeldsarenite.

086/366 Dark brownish grey, very dirty quartzite. Originally a poorly sorted sandy mudstone; a subfeldslutite.

086/371 Medium grey dirty quartzite with a poorly developed slaty cleavage. Originally a moderately sorted muddy sandstone; a subfeldsarenite.

086/394 Medium grey dirty quartzite with a moderately developed slaty cleavage. Originally a moderately sorted muddy fine and very fine sandstone; a subfeldsarenite.

086/399 Brownish grey moderately indurated shale with a moderately developed slaty cleavage parallel to bedding. Detrital muscovite flakes lie on bedding planes. Originally a micaceous, clayey coarse siltstone; a subfeldslutite.

086/406 Pale and dark grey banded dirty quartzite with a moderately developed slaty cleavage at 45^{o} to banding. Originally a moderately sorted muddy fine and very fine sandstone; a subfeldsarenite.

086/434 Pale green dirty quartzite with a well developed slaty cleavage. Originally a poorly sorted very fine sandy mudstone; a subfeldslutite.

086/455 Pale pinkish grey massive quartzite. Originally a well sorted fine sandstone; a subfeldsarenite.

086/465 Brownish grey phyllite. Originally a poorly sorted sandy mudstone with detrital muscovite(3%); a subfeldslutite.

086/470 Brownish grey banded dirty quartzite. Originally a moderately sorted muddy fine and very fine sandstone; a subfeldsarenite.

086/488 Light greenish grey micaceous dirty quartzite. Originally a moderately to well sorted muddy very fine sandstone; a subfeldsarenite.

086/491 Light khaki dirty quartzite with a poorly developed slaty cleavage. Originally a well sorted slightly muddy fine and very fine sandstone; a subfeldsarenite.

086/502 Khaki very dirty massive quartzite. Originally a poorly sorted sandy mudstone; a subfeldslutite.

086/505 Dark grey micaceous coarse silt size quartzite. Originally a well sorted very fine sandstone and coarse siltstone; a quartzlutite.

086/528 Pale brown weathered, saccharoidal, banded dirty quartzite; a subfeldsarenite.

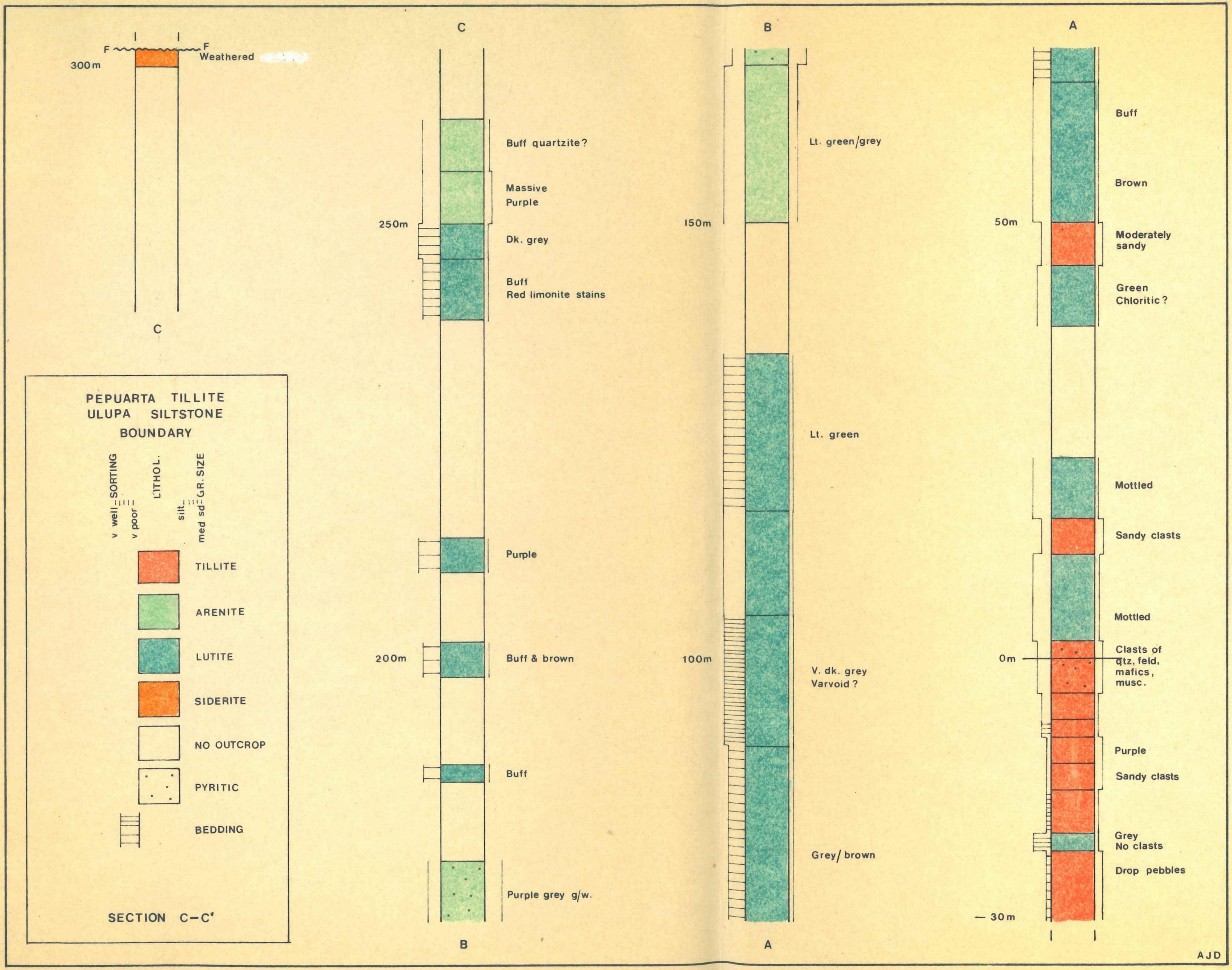
086/541 Dark grey, micaceous, very dirty silt size quartzite. Originally a moderately sorted clayey coarse siltstone; a subfeldslutite.

086/542 Very dark grey, very dirty silt size quartzite. Originally a well sorted clayey coarse siltstone; a subfeldslutite.

086/553 Medium grey dirty silt size quartzite. Originally a well sorted clayey coarse siltstone; a subfeldslutite.

APPENDIX 10

PETROGRAPHIC DESCRIPTIONS OF HAND SPECIMENS AND THIN SECTIONS FROM THE MEASURED STRATIGRAPHIC SECTION C-C' i.e. THROUGH THE PEPUARTA TILLITE/ULUPA SILTSTONE BOUNDARY AND UP TO THE MIDDLE OF THE ULUPA SILTSTONE.


F
F
300m
Weathered
C
PEPUARTA TILLITE
ULUPA SILTSTONE
BOUNDARY
v well SORTING
v poor
LITHOL.
silt GR. SIZE
med sd
TILLITE
ARENITE
LUTITE
SIDERITE
NO OUTCROP
PYRITIC
BEDDING
SECTION C–C'
C
Buff quartzite?
Massive
Purple
250m
Dk. grey
Buff
Red limonite stains
Purple
200m
Buff & brown
Buff
Purple grey g/w.
B
B
Lt. green/grey
150m
Lt. green
100m
V. dk. grey
Varvoid ?
Grey/ brown
A
A
Buff
Brown
50m
Moderately sandy
Green
Chloritic ?
Mottled
Sandy clasts
Mottled
0m
Clasts of qtz, feld, mafics, musc.
Purple
Sandy clasts
Grey
No clasts
Drop pebbles
— 30m
AJD

-20m HS 385/054(-20): Pepuarta Tillite. Grey, micaceous, pyritic slate.

TS 385/054(-20): Homogeneous, well packed slide. Grain contacts are long and often sinuous. Interstitial sites occupied by orthochemical biotite whose orientation, with that of elongate clasts, defines the cleavage.

Grain size: Fine and very fine sand clasts 10-15%; silt size clasts 45%. Remainder is clay and biotite.

Grain shape: All clasts anhedral with moderate sphericity, some grains originally subrounded but now affected by solution, overgrowths and marginal alteration.

Matrix bound, originally by clay, now secondary biotite.

Composition:

Quartz 50%. Fine to very fine sand size 10%, silt size 40%. Larger grains are preferentially oriented parallel to bedding (and coincident cleavage). Sphericity and roundness variable. Silica overgrowths common.

R. F. 2-3%. Grains of fine and very fine sand size gneiss and polycrystalline quartz.

Orthoclase 5%. Randomly distributed fine and very fine sand size grains. Silica overgrowths and marginal alteration to very fine micas both common.

Hornblende «1%. Rare altered very fine sand size grain.

Muscovite <1%. Occasional fine sand size detrital flake lying on bedding planes.

Pyrite 2-3%. Altered to limonite. Random distribution, enhedral grains, very fine sand size.

Biotite. Individual flakes and stringers overall have a preferred orientation defining cleavage. Generally interstitial.

Some clasts have been rotated as fine biotite flakes show a snowball effect.

Name:

(a) Poorly sorted, pyritic, sandy mudstone.

(b) Clay cemented litharenite.

+30m HS 385/054(+30): Ulupa Siltstone. Green grey, manganiferous, slightly pyritic fissile siltstone.

+50m HS 385/054(+50): Ulupa Siltstone. Pale green, but orange mottled (weathering of pyrite?), slightly pyritic, fissile siltstone.

+60m HS385/054(+60): Grey sandy mudstone with some black streaks and with a moderately well developed slaty cleavage.

TS 385/054(+60): A fairly homogeneous slide containing scattered sandy clasts in a mud matrix and with several black iron oxide or manganese stringers.

Well packed; silica overgrowths and interpenetration of clasts common.

A preferred orientation is expressed by (a) parallel orientation of elongate sand grains, (b) alignment of biotite flakes.

Grain size: Poorly sorted, coarse sand 5%, finer sands 25%, silt grains 20%, remainder is clay and secondary biotite.

Grain shapes, sphericity and roundness affected by pressolution.

Matrix bound, originally by clay but now by biotite.

Composition:

Quartz 45%. Evenly distributed. Grains are aligned parallel to both bedding and cleavage . 40% is sand size, 60% silt size. Generally roundness is affected by flattening and pressolution. Unaffected grains are moderately to well rounded.

R. F. 3%. Polycrystalline quartzite and plagioclase up to medium sand size; fine sand size siltstone and rare hornblende.

Orthoclase 1%. Generally fine sand size.

Plagioclase 1%. Very fine sand size, moderately rounded.

Pyrite 3-5%. Limonite pseudomorphs of very fine sand and coarse silt size, euhedral grains.

Other Opaques. Several long (3cm), thin (1mm) stringers of black iron oxides or Mn.

Clay and Biotite 50%. Original clay converted to biotite which forms sub parallel stringers defining cleavage. Also found interstitially.

Name:

(a) Pyritic poorly sorted sandy mudstone.

(b) Pyritic, clay cemented, litharenite.

+120m HS 385/054(120): Ulupa Siltstone. Dark grey, very well indurated, fissile slate. Bedding traces visible on cleavage planes.

+180m HS 385/054(180): Ulupa Siltstone. Dark greyish green, well indurated, very fine grained, very fissile slate.

+225m HS 385/054(225): Ulupa Siltstone. Pinkish grey, but orange mottled, moderately indurated, pyritic coarse siltstone with a moderately developed slaty cleavage.

+240 HS 385/054(240): Ulupa Siltstone. Dark greyish green, well indurated slate.

TS 385/054A(240): A thick slide to show sedimentary structures and the effects of deformation on them.
A cross bedded siltstone, with cross beds rendered visible by the distribution of silt size opaque heavy minerals, possibly ilmenite.
Cleavage development is only moderate, but has smeared, "faulted" and laterally shifted bedding.
Large rafts (up to 10x5mm) have been broken off, transported and rotated during cleavage development.
There appears to have been lateral movement of wedges resulting in the deformation of cross beds.

TS 385/054B(240): Normal thickness slide. Originally 100% terrigeneous material with 55% clay. Clay now converted to very fine biotite.
A most inhomogeneous slide. Almost pure silt chunks and streaks separated

by extremely biotite rich zones in which silt size grains occupy only 20%. Within the silty zones, considerable welding and interpenetration of grains has occurred.

Cleavage is defined by biotite orientation, bedding by heavy minerals.

Sorting is moderate but bimodal.

Shapes of all clastic grains are affected by pressure.

Matrix bound, originally by clay, but now by biotite and interpenetrating silt size grains.

Composition:

Quartz 40%. Distributed in very quartz rich patches but only occupies 20% of the intevening spaces.

Heavy Minerals 2%. Opaque, coarse silt size, angular grains predominantly occurring in bands, defining a cross bedding.

Detrital Biotite, 1%. Occasional, randomly distributed biotite flake, generally of very fine to fine sand size, with no preferred orientation.

Secondary Biotite. Two modes of occurrence:

(a) perpendicular to the slide and generally forms broad bands separating the silty zones and defining cleavage.

(b) lying in the plane of the slide. These probably imply rotation during formation.

Name:

(a) Moderately sorted but bimodal, cross bedded mudstone.

(b) A quartzlutite with a clay matrix.

APPENDIX ID

PETROGRAPHIC DESCRIPTIONS OF HAND SPECIMENS AND THIN SECTIONS OF LITHOLOGIES WHICH ARE EITHER REPRESENTATIVE OR PROBLEMATIC AND WHICH ARE NOT INCLUDED ELSEWHERE.

HS 385/001 Pepuarta Tillite. Pale grey brown, moderately indurated and sorted, slightly fissile, slightly gravelly mudstone. Sand size clasts of quartz, chert and quartzite. Occasional muscovite flakes.

HS 385/002 Ulupa Siltstone. Pale pinkish brown, but weathered, moderately indurated, slightly fissile, pyritic, micaceous,well sorted siltstone. Pyrite 1%, muscovite 1%.

HS 385/002A Pepuarta Tillite. Very weathered, fissile, moderately sorted slightly gravelly mudstone.

TS 385/002A Thick, holey slide because of extreme weathering. Fairly homogeneous, randomly distributed sand grains in a mud matrix. A preferred orientation is expressed by both clay and fine silt orientation and alignment of long axes of sand size grains.

Moderately sorted but bimodal. Coarse sand to coarse silt 10%, fine to medium silt 20%, very fine silt or clay 70%.

All silt and sand size grains are anhedral. Sphericity increases with increasing sand size. Grains angular to sub angular but margins have been dissolved.

Composition:

Quartz 30%. Randomly distributed. Long axes have a lineation parallel to bedding. Silica overgrowths variably present. Quartz often indented by clay.

Chert 1%. Occasional angular grain.

Biotite 1%. Occasional detrital flake, oriented parallel to bedding.

Opaques 2%. Originally iron oxides but now limonitized to an orange stain marginally.

Name:

(a) Moderately sorted bimodal mudstone.

(b) Weathered slightly quartzose lutite.

HS 385/003A Carrickalinga Head Formation. Dark grey, weathered, poorly consolidated, laminated, poorly sorted muddy sandstone.

HS 385/003B Brown Hill Subgroup. Light Brown slate, originally a well sorted siltstone. Slightly micaceous.

HS 385/004 Inman Hill Subgroup. Dark grey, very well indurated quartzite. Originally probably a very fine to fine sandstone.

HS 385/005 Carrickalinga Head Formation. Greyish brown, poorly indurated but weathered, friable, well sorted, slightly micaceous, cross bedded coarse siltstone.

HS 385/009 Carrickalinga Head Formation. Dark charcoal grey silicified siltstone, flinty appearance.

HS 385/018 Carrickalinga Head Formation. Brown and grey weathered slate showing original bedding. Moderately indurated, very well sorted.

HS 385/018A Carrickalinga Head Formation. Pale brown slate with thin green coarse silt bands. Originally a well sorted, bimodal, banded siltstone.

TS 385/018A Fairly inhomogeneous having coarse silt bands separated by a finer silt matrix.

Overall preferred orientation associated with the cleavage. Slightly expressed by compression of quartz grains but predominantly by fine mica and clay orientation.

Grain size: bands of medium to coarse silt size grains (bedding) 10%, very fine silt 20%, clay 50%.

Composition:

Quartz 30%. Slightly stretched metaquartzite parallel to cleavage. Sphericity and roundness both moderate.

Limonite 20%. Occurs as patches with diffuse edges, often elongate parallel to cleavage. In clay fraction but predominantly in silt.

Tourmaline or staurolite. Rare medium silt size grains undergoing marginal alteration.

Clay 50%. Patchily distributed throughout the coarser bands and fills all the intermediate layers Its preferred orientation defines cleavage.

Cleavage is smearing the bedding and a serrated bedding boundary is formed.

Name:

(a) Bimodal, well sorted mudstone.

(b) Brown, bedded lutite.

HS 385/023 Ulupa Siltstone. Pale greenish grey, well indurated, banded and laminated slate. Originally a moderately sorted siltstone with some coarse silt bands.

TS 385/023 Homogeneous on a micro scale. Cleavage is prominent and is expressed by an alignment of elongate grains (probably due to flattening) and by clay orientation.

Medium to fine silt size grains 50%. Clay and limonite stains 50%. Well sorted.

Composition:

Quartz 50%.. Evenly distributed, oriented with long axes parallel to cleavage. Grains are anhedral with uniformly low sphericity (W/L = 0.25).

Tourmaline 1%. Randomly scattered, no preferred orientation. Medium-coarse silt size grains. Marginal alteration to clay. Detrital.

Limonite 20%. Rare euhedral cubic form shows that some, at least, of it is due to alteration of pyrite. Generally seen as black, brown and red blotches of variable size and orientation. Stains also fill cracks developed along cleavage.

Clay. Medium brown. Occurs as elongate patches parallel to cleavage and as an interstitial cement between the quartz grains.

Name:

(a) Brown, well sorted mudstone.

(b) Weathered, pyritic lutite.

HS 385/034 Tarcowie Siltstone Equivalent(?). Dark grey, well indurated fissile siltstone.

HS 385/035 Tarcowie Siltstone Equivalent(?). Dark grey, microcrystalline dolomite with a calcrete capping.

TS 385/035 Grey structureless dolomite. Quite homogeneous, no preferred orientation of the extremely fine crystals (amorphous ?). On weathering, alters to calcrete.

HS 385/036 Pepuarta Tillite. A pale green quartzite. Originally a very well sorted, bedded siltstone.

HS 385/037 Pepuarta Tillite. A very well sorted but bimodal, well indurated white quartzite with some interstitial clay matrix. Quartz grains of fine sand size.

TS 385/037 Very homogeneous consisting of sand size grains with an interstitial matrix.

Very well packed, long sutured grain contacts common. Considerable intergrain penetration. Moderately to well sorted but bimodal. Sand fraction 70%, maximum is medium, mode is fine sand size. Clay and silt as interstitial matrix. All grains anhedral, pressolution has destroyed original roundness and sphericity but generally the coarser grains are the most spherical.

Composition:

Quartz 50%. No preferred orientation. Sutured contacts with other quartz and feldspar grains. Undulose extinction is very common especially near margins. 5% is polycrystalline.

Plagioclase 5%. Ab 55. Evenly distributed, generally of fine sand size. Sutured contacts common. Occasional grain shows undulose extinction.

Orthoclase 15%. Medium sand size 20%, fine to very fine 80%. Polycrystalline grains common. Sutured contacts and undulose extinction both common.

Micas 2%. Biotite occurs interstitially with the clay fraction, not determinable whether detrital or metamorphic.

Opaques 3%. Medium silt size grains and also occurring between quartz and orthoclase grains.

HS 385/039 Pepuarta Tillite. A white, well sorted, but bimodal, fine sand size, quartz sandstone with an interstitial clay matrix.

HS 385/041A Eudunda Arkose Member(?). Khaki, moderately indurated but weathered, slightly fissile, fine sand grain size semi quartzite.

HS 385/041C Eudunda Arkose Member(?). Pale green, well indurated, originally well sorted, fine sand grain size quartzite.

HS 385/042 Tarcowie Siltstone. Pale brownish grey but black speckled (Mn?), moderately indurated siltstone with macro cross bedding. Slaty cleavage is moderately developed.

HS 385/042A Tarcowie Siltstone. Finely laminated, medium grey siltstone.

TS 385/042A Fairly heterogeneous, silty streaks in a claystone. Well packed, some pressolution between the silt size grains. A preferred orientation is given to the slide by the alignment of the clay fraction into streaks and stringers.

Moderately sorted, medium-coarse silt fraction 60%, clay 40%.

Grains are anhedral, shapes are altered by pressure effects. Bonded by the clay matrix.

Composition:

Quartz 50%. Although occurs throughout the slide is preferentially concentrated as lenses and as scour infills.

Fine to coarse silt size, 80% is medium silt. Sphericity is very variable.

Opaques 10%. Probably limonite pseudomorphs after pyrite as some square and rhombohedral sections are seen. Generally ahhedral, randomly distributed, fine to coarse silt size.

Clay 40%. Brownish. Occurs as streaks, stringers, bands and interstitial material. Has a preferred orientation parallel to bedding planes as shown by sedimentary structures hence probably detrital.

Structures: Primary cross beds and infilling of scours defines bedding.

Name:

(a) Brown moderately sorted, cross bedded mudstone.

(b) Pyritic clayey quartzlutite.

HS 385/045 Pepuarta Tillite. Very pale grey weathered quartzite.

HS 385/046 Pepuarta Tillite. Light brown, poorly indurated, gravelly, sandy mudstone with a vague fissility due to cleavage. Larger clasts often well rounded.

TS 385/046 Fairly homogeneous, random sandy grains in a silt matrix.

Well packed, long intergrain contacts, often sutured. Clay filled interstices.

An alignment of secondary micas defines cleavage.

No preferred orientation of sand and silt grains.

Grain size: poorly sorted medium sand size 5%, fine and very fine sand size 10%, silt size 30%, remainder is clay and micas. All detrital grains anhedral, sphericity poor to moderate. Most clasts very angular, occasionally moderately to well rounded

Originally bonded by clay but now by secondary biotite as well.

Composition:

Quartz 40%. Evenly distributed no preferred orientation. Fine and medium sand size 10%, very fine silt size 90%. Variable sphericity. Very angular to subrounded grains (two sources?). Undulose polycrystalline (second cycle?) containing sutured contacts. The quartz often has an opaque surface coating, possibly limonite after pyrite.

Orthoclase 10%. Randomly distributed, generally of fine and very fine sand size. Polycrystalline grains not uncommon. No preferred orientation. Some grains undergoing marginal alteration to clays which align parallel to cleavage. Inclusions not uncommon.

R.F. Several siltstone flakes up to 1.5mm long - appear to be very fine quartz siltstone. Quite angular and elongate parallel to bedding (and cleavage).

Clay 15%. Predominantly as interstitial matrix. Originally more common but was converted to biotite.

Pyrite 5%. Limonite pseudomorphs. Randomly distributed, no preferred orientation. Very fine to coarse silt size. Also forms as rarer opaque coatings around the larger clastic grains, especially quartz.

Micas. Too small to differentiate type, slightly weathered to a brown colour. Define cleavage. Form around clasts also (not pyrite).

Name:

(a) Moderately sorted sandy mudstone.

(b) Pyritic subfeldslutite.

HS 385/047 (55) Pepuarta Tillite. Pale pinkish brown, moderately indurated, moderately sorted, manganiferous sandy mudstone. Slightly micaceous. Contains well rounded medium sand size quartz clasts.

HS 385/053 Inman Hill Subgroup. Weathered mottled quartzite; orange blotches due to limonitization of iron rich heavy minerals (20%). Blotches show an elongation parallel to cleavage.

HS 385/053A Pepuarta Tillite. Slightly weathered, very well indurated, coarse silt size quartzite.

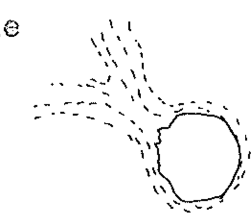
TS 385/053A Homogeneous. Well packed, considerable inter-penetration by solution and welding of grains.

Grain Size: 5% coarse sand, 2% interstitial clay, rest is medium and fine sand, mode is medium. All grains anhedral, grain boundaries affected by pressure.

Composition:

Quartz 95%. No preferred orientation. Sutured intergrain contacts common. Silicate overgrowths over 5% of the grains. Undulose extinction for most grains.

Gaseous and/or crystalline inclusions in 10% of grains. At least one grain, to judge from mica orientations around it, appears to have been rotated and moved laterally.



Feldspar 1%. Principally plagioclase, rarely microcline. Generally altering to clays with a preferred orientation parallel to other clays in the rock.

Opaques 2%. Fine to very fine sand size. Often surrounded by haloes (weathering?).

Clay and mica 2%. Brown interstitial material, also in occasional stringers which define cleavage. Some originates from weathering of an unknown grain type.

Name:

(a) Moderately sorted medium sandstone

(b) Quartzarenite.

HS 385/053B Pepuarta Tillite. Originally a pale grey sandy mud stone now has a well developed slaty cleavage.

TS 385/053B Fairly homogeneous, sand grains in a mud matrix. Moderately packed, interstitial clay and silt, interpenetration of sand grains by solution. Cleavage is defined by (a) orientation of secondary micas (b) orientation of elongated clastic grains.

Grain size: medium sand size 10%, finer sands 20% silt size 10%, 50% clay and very fine secondary micas - poorly sorted.

Clastic grains anhedral, shapes altered by pressure. Bonded by clays (terrigenous) and micas (secondary).

Composition:

Quartz 40%. Elongate grains oriented parallel to cleavage (compression or rotation?).

Silica overgrowths and undulose extinction common. Polycrystalline grains fairly common.

Orthoclase 4%. Generally, polycrystalline grains. Subgrains are of fine sand size, whole grain of medium sand size. Randomly distributed.

Plagioclase 1%. Badly altered hence identification not possible. All grain shapes affected by pressure.

Pyrite 3%. Limonite pseudomorphs. Random distribution and orientation in the clay fraction. Fine and very fine sand size. Euhedral.

Clays and secondary micas. Micas due to metamorphism of clay form sub parallel stringers which pass around clastic grains but not around pyrite (pyrite formed after cleavage deformation?). Snowball effects visible but not common.

R.F. 2%. Occasional fragments of siltstone and microcrystalline granitic material.

Name:

(a) Poorly sorted sand mudstone.

(b) Pyritic subfeldsarenite.

HS 385/053C Inman Hill Subgroup. Pale grey, but orange mottled, banded siltstone.

TS 385/053C Very well packed, interpenetration of grains by solution results in long, often sutured contacts. A preferred orientation (cleavage) results from

(a) alignment of biotite and clay (b) flattening and dissolution of quartz grains.

Grain size: poorly sorted but bimodal. Fine and very fine sand size grains, together with clay. Clastic grains anhedral except for some coarse sand size muscovite flakes, although these are often bent. Sphericity is affected by flattening; rounding by pressolution. Bonded by (a) clay cement (b) biotite associated with cleavage.

Composition:

Quartz 50%. Uniformly distributed, rock is grain supported. Flattening and pressolution result in a preferred orientation. Moderately to well sorted, fine and very fine sand size. Undulose extinction common. Crystalline inclusions in some of the grains.

Orthoclase 5%. Fine and very fine sand size grains. randomly distributed. Sutured and long straight contacts with quartz. Marginal alteration to clay and, possibly, sericite. Undulose extinction common.

Detrital muscovite 2%. Fresh, randomly distributed but with a preferred orientation parallel to bedding (as defined by elongate limonite stains). Medium sand size in length, often bent around quartz grains.

Biotite and clay. Very fine biotite fills interstices where originally was clay. Its orientation defines cleavage. Forms stringers and layers also, often bending around sandy grains. Opaque red stains 15%. Patchily distributed, probably define bedding. Each patch of very fine sand size. Due to weathering of biotite, heavy minerals or possibly pyrite.

Name:

(a) Poorly sorted but bimodal muddy fine sandstone.

(b) Weathered, clay and biotite cemented, sublitharenite.

HS 385/055 Weathered ochre siderite with patchy goethite development and containing some white quartz.

TS 385/055 Brown staining results in slide being almost opaque at mormal thickness, edges show the high refractive index characteristic of carbonates. Contains 5-10% of extremely angular (authigenic?) fine sand size quartz, randomly distributed and oriented. Occasional muscovite flake. Triple points not uncommon in the quartz.

HS 385/061 Pepuarta Tillite. Pale purple, very well indurated banded quartzite.

HS 385/062 Ulupa Siltstone. Green grey banded siltstone with a well developed slaty cleavage.

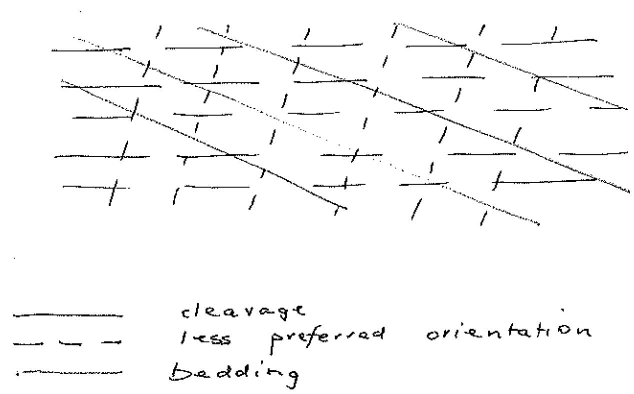
TS 385/062 Fairly inhomogeneous on a micro scale. Bedding is defined by variations in silt size resulting in coarser bands. Within the bands, there is no preferred orientation.

Grain size: fine to very fine silt 60%, medium silt 20%, interstitial clay but now biotite 20%. Individual grain shapes too small to categorize. Originally bonded by clay, now by interlocking silt grains and biotite stringers.

Composition:

Quartz 80%. Comprises nearly all of the silt size grains. Detrital muscovite 1%. Coarse silt size flakes.

Biotite 20%. Defines cleavage. Generally of medium to coarse silt size. Fresh. Has two preferred orientations which locally vary in relative importance. 70% of the flakes have a sub parallel orientation which defines cleavage; 30% are at 75-80° to this direction.



5% of slide is covered by opaque black patches. Not heavy minerals, possibly due to alteration of pyrite. Some patches weather to limonite resulting in an ochreous smear parallel to cleavage.

Name:

(a) Banded, well sorted siltstone.

(b) Green, but patchy, quartzlutite.

HS 385/069 Ulupa Siltstone. Pale brown pyritic siltstone. Limonite after pyrite forms very fine sand size cubes which define a preferred orientation (bedding?).

TS 385/069 Brown weathered matter is 30% of the slide, pyrite 5%, remainder is of terrigenous origin.

Fairly homogeneous. Cleavage is defined by (a) orientation of biotite (b) orientation of blurred weathered matter.

Grain size: fine silt size 80%, fine sand size pyrite 5%, coarse silt size secondary biotite 15%. Clastic grains too small for shape classifications. Originally bonded by interlocking silt grains with an interstitial clay matrix, now aided by biotite stringers.

Composition:

Quartz 80%. All of the silt size particles.

Pyrite 5%. Fairly fresh, with good reflective surfaces. Often euhedral, randomly distributed, no preferred orientation on a micro scale.

Biotite 15%. Defines cleavage. Occurs as stringers and interstitially.

Name:

(a) Brown, weathered, well sorted clayey siltstone.

(b) Pyritic quartzlutite.

HS 385/072 Dark green, with orange weathering spots, crystalline igneous intrusive, probably doleritic.

HS 385/075 Ulupa Siltstone. Dark purple, cross bedded slate, originally a well sorted siltstone. Cross beds are defined by pale purple bands.

HS 385/076 Inman Hill Subgroup. Weathered, micaceous, quartzite.

TS 385/076 Homogeneous slide showing a crystalloblastic texture due to partial recrystallization under high pressures. Extremely well packed, considerable welding and interpenetration of grains by solution. Quartz overgrowths result in elongation. Long straight and sutured intergrain contacts common.

There is a slight orientation parallel to cleavage afforded by (a) compression and elongation of grains (b) stringers of mica.

Grain size: much affected by pressolution, overgrowths etc. but, probably originally a medium to coarse sandstone. All original grain shapes altered.

Bonded by the interlocking grains.

Composition:

Quartz 40%. Medium to coarse sand size. Shapes grossly affected by pressure. Quartz overgrowths common. Undulose extinction for nearly every grain.

Orthoclase 35%. Often polycrystalline, medium to coarse sand size. Generally fresh, but possibly some marginal alteration to biotite in a few cases.

Plagioclase 20%, generally oligoclase. Variably altered to kaolin, often resulting in a cloudy and irregularly mottled appearance. Often intergrown. with quartz, a myrmekitic texture resulting.

Micas 5%. Both biotite and muscovite so locally pressure was such that muscovite grade was attained. Have a sub parallel orientation which defines cleavage. Occur as interstitial patches. Long stringers and as long foliae (3mm) which often bend around the sandy grains.

Name:

(a) Well sorted medium and fine sandstone.

(b) Feldsarenite.

HS 385/077 Inman Hill Subgroup. Dark grey, very well indurated massive quartzite, with biotite approximately 2%.

HS 385/080A Inman Hill Subgroup. A pale grey, well indurated.

weathered, micaceous sandy mudstone with a well developed slaty cleavage.

TS 385/080A Fairly homogeneous with a slight tendency for sand grains to occur in bands. Well packed, showing a considerable amount of welding and interpenetration. Cleavage is defined by biotite orientation. Long axes of clasts are parallel to cleavage (rotation, solution, flattening?).

Size and shapes of grains affected considerably by pressure effects. 30% fine and very fine sand, 20% silt size, 50% clays and secondary micas.

Originally bonded by the clay matrix, now by secondary micas and interpenetrating grains.

Composition:

Quartz 35%. Fine and very fine sand size and silt size grainshapes all affected by pressure. Undulose extinction common.

Orthoclase 10%. Fine and very fine sand size grains patchily altering to sericite and kaolin.

Plagioclase 5%. Very fine sand and coarse silt grains, often altering to sericite and giving a seive like appearance.

Accessories:

Detrital muscovite 1%. Medium sand size foliae, at various angles to cleavage.

Sphene. Occasional coarse silt to very fine sand size grain, quite angular and fresh.

Tourmaline. Rare fine sand size angular grain.
Pyroxene < 1%. Marginal kaolinization common.
Garnet. Rare isotropic green coarse silt size grain.
Micas. Matrix is now all mica, originally probably clay, Its orientation defines the cleavage.

A patchy streaky effect parallel to cleavage is also present possibly due to weathering of iron rich grains.
Name:
(a) Poorly sorted sandy mudstone.
(b) Feldslutite.

HS 385/080B Ulupa Siltstone. Greenish grey, well indurated, weathered siltstone with a well developed slaty cleavage.

TS 385/080B Fairly homogeneous although has a few streaks due to concentrations of biotite along an original clay rich layer.
Considerable welding and interpenetration of clastic grains has occurred. Long straight and sutured contacts result. Long axes of clastic grains are aligned parallel to cleavage as given by biotite orientation.
Grain size: 50% very fine sand and coarse silt. Remainder originally clay. Sorting moderate, but bimodal.
Grain shapes: affected by pressure. Bonded by

micaceous cement and interlocking clastic grains.

Composition:

Quartz 40%. Uniformly distributed. Has a preferred orientation parallel to cleavage given by alignment of long axes. Undulose extinction common, grain shapes affected by pressolution. Inclusions common. Silica overgrowths occasionally.

Orthoclase 10%. Very fine sand size grains. Randomly distributed. Silica overgrowths occasionally present. Often indented by quartz grains. Undulose extinction common. Variably altered to kaolin resulting in a patchy appearance for some grains.

Plagioclase 1%. Randomly scattered, coarse silt size, heavily altered grains. The margins are especially kaolinized.

Accessories. Sphene. A few scattered grains of coarse silt size.

Muscovite. A few detrital flakes up to 0.5mm long, randomly oriented.

Biotite approx. 50%. Two modes of occurrence (a) long continuous, sub parallel stringers defining cleavage (b) occupying interstitial sites, probably originally clay filled. The grains are much finer in this case and do not contribute to the fissility of the rock.

Over the slide is a patchy distribution of dark tan material, probably due to limonite.

Name:

(a) Moderately sorted, bimodal sandy mudstone.

(b) Weathered subfeldslutite.

HS 385/080C Ulupa Siltstone. Weathered, green well indurated siltstone with a well developed slaty cleavage parallel to which are seen colour bands.

TS 385/080C Whole slide clouded by a clayey alteration product due to weathering. Probably nontronite or montmorillonite.

Probably inhomogeneous, banding resulting from differential clay development.

The slide has a preferred orientation defined by a banding. This is parallel to biotite orientation i.e. cleavage.

Composition:

Clay 50%.

Quartz 30%. Very fine to fine silt.

Biotite 20%. Defines cleavage. Locally weathering to form a brownish red stain.

Opaques. Occasional black weathered grain.

Name:

(a) Moderately sorted mudstone.

(b) Weathered quartzlutite.

HS 385/083 Ulupa Siltstone. Dark green slate, originally a well sorted, very finely laminated claystone (varvoid?).

HS 385/084 Pepuarta Tillite. Medium grey, moderately indurated, manganiferous, pyritic, well sorted, slightly gravelly mudstone, possessing a fissility ~~parallel~~ defining slaty cleavage.

HS 385/107 Inman Hill Subgroup. Dark grey, very well indurated, moderately sorted quartzite with a black intersititial matrix. A vague fissility defining cleavage is developed.

HS 385/111 Carrickalinga Head Formation. Medium green, well indurated, very well sorted fine sandstone with a vague fissility defining cleavage.

HS 385/112 Carrickalonga Head Formation. Grey, well indurated, pyritic, very well sorted, very fine sandstone. Pyrite (1%) (limonite pseudomorphs)is of coarse silt size.

HS 385/112A Carrickalinga Head Formation. Pale grey, micaceous pyritic quartzite.

TS 385/112A Very homogeneous. Well packed. Considerable welding of quartz grains and interpenetration by solution resulting in long contacts, sometimes straight, otherwise sutured. Very well sorted, all of very fine sand size. All grain shapes affected by pressure. Bonded by interpenetrating terrigenous grains. Composition:

quartz 90%, orthoclase 3%, plagioclase 2%.

Feldspars randomly distributed, all have properties as above.

Pyrite 2%. Euhedral, cubic limonite pseudomorphs. Up to medium sand size, generally fine and very fine sand size.

Biotite 3%. Randomly scattered foliae. Occasionally form stringers 2-3mm long. Not known whether detrital or secondary.

Name:

(a) Pale brown, very well indurated, well sorted, very fine sandstone.

(b) Pyritic quartzarenite.

HS 385/113 Carrickalinga Head Formation. Pale green grey silt size semi quartzite, well indurated and well sorted.

HS 385/116 Carrickalinga Head Formation. Grey very well sorted slate.

TS 385/116 Very homogeneous. Grains too small to observe packing or grain shape features. Grains of fine and very fine silt size 50%. Remainder originally clay which was the matrix.

Composition:

Silt size grains predominantly quartz with a small amount (1-2%) of material of higher birefringence but too small to identify.

Remainder is fine biotite which has an overall preferred orientation and defines cleavage.

Name:

(a) Pale green, very well sorted siltstone.

(b) Quartzlutite.

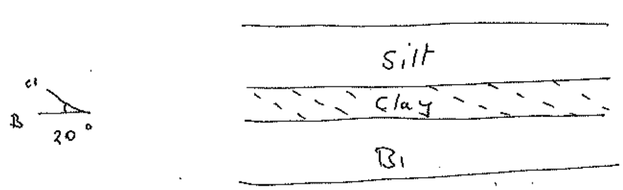
HS 385/115 Carrickalinga Head Formation. Dark grey well indurated semi quartzite with a black interstitial matrix. Has a foliation defining cleavage with biotite (3%) lying on cleavage planes.

HS 385/119 Carrickalinga Head Formation. Dark grey, micaceous, well indurated banded quartzite.

TS 385/119 Fairly inhomogeneous. Thin (1mm) laminae consisting of clay rich streaks in a siltstone which elsewhere had only interstitial clay.

Very well packed. Considerable welding and interpenetration of grains resulting on long contacts, often sutured.

Two orientations in the rock (a) bedding: defined by clay rich (now biotite) layers sandwiched between silty ones (b) within the clay rich layers, mica orientation is oblique and defines cleavage.



Originally medium and coarse silt 65%, clay 35%. All grain shapes affected by pressure. Originally bonded by interstitial clay, now by interlocking silt grains.

Composition:

Quartz 60%. Medium and coarse silt size, generally in bands.

Plagioclase 2%. Coarse silt size, grain shapes affected by pressure.

Orthoclase 3%. Often cloudy due to kaolinization.

Opaques 2%. Random distribution and orientation. Very angular; medium silt size, possibly orthochemical.

Sericite 2%. Occasional patches of sericitized material, possibly originally plagioclase.

Biotite. Originally the clay fraction. Occurs as interstitial patches and as stringers. Defines cleavage.

Name:

(a) Moderately sorted, banded mudstone.

(b) Clayey quartzlutite.

HS 385/121 Carrickalinga Head Formation. Dark green banded slate, very well indurated, Banding is due to segregation of very fine sand size particles. Muscovite is abundant in the coarser bands.

HS 385/124 Carrickalinga Head Formation. Weathered grey micaceous slate.

TS 385/124 Thick slide to observe cross beds.
Matrix fairly homogeneous although less clay rich in some layers. Where less rich is white, where clays dominant, green.
Moderately sorted. Silt size 60%, clay 40%.
Opaques have two modes of occurrence: (a) scattered evenly through the groundmass (b) lying in bands defining cross bedding. See only foresets in the slide. Up to 40mm long. No observable truncation. Opaques are of medium silt size, and are quite angular. Some are altering to limonite.

HS 385/124A Carrickalinga Head Formation. Grey slightly weathered slate. The cleavage forms a vague crenulation on bedding planes. Originally a well sorted siltstone.

HS 385/124B Carrickalinga Head Formation. A well sorted, slightly muddy sandstone. Saccharoidal appearance, massive, 90% fine sand size quartz grains, occasional detrital muscovite flake.

HS 385/127B Carrickalinga Head Formation. A green slate with only a moderate fissility. Bedding transects cleavage at right angles, appearing as slightly coarser light brown laminae.

HS 385/131 Ulupa Siltstone. Very weathered pink/brown slate. Transecting at right angles are finer silty laminae showing very compressed similar folds.

HS 385/131A Carrickalinga Head Formation. Weathered, pale pink, laminated siltstone with a well developed slaty cleavage. Bedding planes defined by bands (3mm thick) of slightly coarser silt.

TS 385/131A Banded mudstone. Banding is due to silt rich (or clay poor) layers. In the siltier layers opaque heavy minerals are common (5%) but only 1% in the clayey layers.

Opaques are very angular and of medium silt size. Besides the opaques the remaining silt grains are quartz. The intervening clay rich layers are weathered and have a green fuzzy appearance.

HS 385/134 Brown Hill Subgroup. Medium grey, but originally black micaceous slate.

TS 385/134 Fairly homogeneous but a few streaks approx. 1mm wide in which clay is much less dominant. When touching, the silt size grains have long contacts, often sutured. Slide has a preferred orientation due to (a) orientation of long axes of silt grains (b) mica orientation. Bedding and cleavage are coincident.

Grain size: Originally 35%silt size, 65% clay, now biotite. Well sorted.

Grains shapes affected by pressure.

Originally matrix supported and bonded by clay.

Composition:

Quartz 30%. Fairly evenly distributed throughout and also concentrated in some thin bands. Undulose extinction common.

Plagioclase 1%. Randomly distributed, moderately spherical, fine to coarse sand size. Generally fresh but occasionally very altered to kaolin.

Opaques 2%. Random distribution and orientation. Very angular, fine silt size. Some are altering resulting in a dark appearance among the surrounding biotite.

Detrital mica 2%. Relatively large flakes of muscovite up to medium sand size. Random orientation, often undergoing marginal alteration to kaolin.

Carbon 1%. Fine stringers of carbonaceous material parallel to bedding.

Biotite 65%. Occurs interstitially and as sub parallel stringers defining cleavage.

Name:

(a) Well sorted but bimodal, banded silty claystone.

(b) Brown, slightly carbonaceous, lutite.

HS 385/135 Brown Hill Subgroup. A pale grey, bleached, pyritic black slate. Has bands of carbonaceous material possibly defining bedding. Well formed cubes of limonite pseudomorphing pyrite are embedded in the slate. Cubes have side length up to 5mm.

HS 385/135A Brown Hill Subgroup. Bleached black slate with some carbonaceous material remaining which is parallel to cleavage. Quartz infilled tension gashes cross cut cleavage.

TS 385/135A Black carbonaceous streaks in a pale grey, translucent weathered matrix. The streaks are parallel to cleavage.

Probably was originally completely black before weathering but now have only a few remnants parallel to cleavage.

There are quartz infilled tension gashes trending at 80° to the cleavage. The biotite which originally defined cleavage is now kaolinized. Cleavage is now defined by quartz infills along cracks and by the carbonaceous stringers.

Associated with the quartz in the cracks is another unknown mineral, grains too small to identify.

Composition:

Kaolin 80%.

Carbon 10%.

Quartz 5%.

Unknown 2%.

Limonite 3%.

HS 385/137 Inman Hill Subgroup. Well banded, weathered, micaceous muddy sandstone.

TS 385/137 Fairly homogeneous, although some biotite streaks in the siltstone.

Well packed. Welding and interpenetration of grains results in long contacts, often sutured.

Slide has an orientation due to (a) alignment of long axes of sand size grains (b) sub parallel alignment of biotite flakes and stringers.

Moderately sorted. Medium sand 5%, fine and very fine sand 35%, silt 40%, remainder originally clay now biotite. Bonded now by interpenetrating grains.

Composition:

Quartz 70%. Evenly distributed. Long axes align parallel to cleavage. Grain size as above.

Grain boundaries affected by pressure. Occasional grain has crystalline inclusions.

Plagioclase 5%. Randomly distributed fine and very fine sand size grains. Sutured contacts common, penetrates into quartz.

Orthoclase 5%. Randomly distributed fine and very fine sand size grains, occasionally coarse silt size. Occasionally perthitic.

R.F. 1%. Few randomly distributed, polycrystalline quartz crystals.

Accessories. Sphene 1%, well rounded.

Biotite 20%. Occurs as interstitial infilling and as sub parallel stringers.

Name:

(a) Moderately sorted muddy sandstone.

(b) Subfeldsarenite.

HS 385/139 Brown Hill Subgroup. Pale grey and orange mottled micaceous slate. Both biotite and muscovite lie on cleavage planes.

HS 385/140 Brown Hill Subgroup. Weathered and bleached medium grey (originally black) carbonaceous slate. Bedding(?) is defined by the orientation of clay.

TS 385/140 Fairly homogeneous slide of a black slate with thick streaks along which quartz has intruded. Cleavage is defined by (a) carbonaceous streaks (b) biotite stringers.

Grain size: Medium silt size 40%, remainder is amorphous carbonaceous matter and authigenic material.

Grain shapes too small to be recognized.

Composition:

Detrital quartz 40%. Medium silt size particles. Evenly distributed. Has an alignment of long axes parallel to cleavage.

Authigenic quartz 5%. Fills long stringers (< 10mm x 1mm) which are parallel to cleavage. Quartz is unstrained and clear.

Limonite 5%. After pyrite? Slight orientation parallel to cleavage and is often assoociated with the quartz stringers.

Carbonaceous matter 3%. Now occurs in stringers parallel to cleavage and helps define cleavage. It seems that during weathering of the black slate only that carbon lying in cleavage planes has yet to be oxidised or removed.

Biotite 20%. Probably originally clay but altered during metamorphism.

There is a very bleached zone along the margins of the quartz infilled stringers, < 1mm wide.

Name:

(a) Well sorted mudstone.

(b) Carbonaceous slate.

HS 385/142 Brown Hill Subgroup. Medium grey, weathered, micaceous slate. Muscovite is very common on cleavage planes.

HS 385/143 Brown Hill Subgroup. Very dark grey, moderately indurated, fissile, micaceous slate.

TS 385/143 Homogeneous slide. Considerable welding of clastic grains and interpenetration by solution. Long contacts common, both sutured and angular. An orientation is expressed by (a) biotite, (b) alignment of long axes of quartz grains. Grain size: Moderately sorted. Very fine sand10%, silt 60%.

Grain shapes affected by pressure but are generally elongate.

Composition:

Quartz 60%. Very fine sand 10%, coarse and medium silt 60%. Fairly evenly distributed, although a quartz rich bands seen (0.5mm). Grain boundaries affected by pressure, undulose extinction common.

Detrital muscovite 2%. Random distribution, having a sub parallel orientation at 20° to cleavage.

Plagioclase 3%. Randomly distributed and oriented, generally of coarse silt size.

Orthoclase 2%. As for plagioclase.

Opaques 5%. Irregular limonitic blotches. Could be due to weathering of either heavy minerals or pyrite.

Biotite. Forms elongate sub parallel stringers and as oriented interstitial patches. Defines cleavage.

Name:

(a) Brown moderately slightly sandy mudstone.

(b) Quartzlutite.

HS 385/147 Brown Hill Subgroup. Pale grey brown, but ochre weathering micaceous mudstone. Biotite 1%.

HS 385/148A Brown Hill Subgroup. Dark grey, weathered, micaceous carbonaceous slate. Muscovite 2%.

HS 385/148B Brown Hill Subgroup. Pale green, but ochre weathering, slightly micaceous slate. Originally a moderately sorted mudstone.

HS 385/149 Brown Hill Subgroup. Light grey brown micaceous siltstone with a slightly developed slaty cleavage.

TS 385/149 Quite homogeneous. Well packed. Welding and interpenetration between grains results in long often sutured contacts.

Moderately sorted but bimodal. Very fine sand size 3%, coarse to medium silt 60%, remainder originally clay. All grain shapes are affected by pressure a and by marginal solution.

Originally bonded by clay, now by biotite and interlocking clastic grains.

Composition:

Quartz 55%. Evenly distributed, properties as above. No preferred orientation. Undulose extinction common.

Plagioclase 1%. Occasional medium silt size grain generally moderately spherical.

Detrital muscovite 2%. Occasional flakes, up to fine sand size. Randomly distributed. Have an overall preferred orientation parallel to cleavage which probably implies that bedding and cleavage are coincident.

Opaques 2%. Fine and very fine silt size grains, very irregular edges. Randomly distributed and oriented. May have altered from pyrite or from a heavy mineral suite.

Name:

(a) Brown, moderately sorted, but bimodal clayey siltstone.

(b) Quartzlutite.

HS 385/152 Brown Hill Subgroup. Dark green grey, but originally black, micaceous slate. Biotite 2%.

HS 385/155 Inman Hill Subgroup. Dark grey, very well indurated slightly micaceous quartzite with a poorly developed slaty cleavage.

TS 385/155 Very well packed. Welding and interpenetration of grains widespread, triple points common.

Slide has a weak preferred orientation, this being due solely to biotite stringers.

Moderately sorted, very fine sand 5%, coarse to medium silt 80%, remainder originally clay.

All grain shapes affected by pressure; all original boundaries altered.

Bonded by interpenetrating sand and silt grains.

Composition:

Quartz 70%. Uniformly distributed. No preferred orientation. Very fine sand 5%, remainder medium to coarse silt. Undulose extinction common. Some grains have very small bubbly inclusions.

Plagioclase 5%. Randomly scattered and oriented. Medium to coarse silt size. Often kaolinized, especially marginally.

Detrital muscovite 3%. Elongate lamellae, up to very fine sand size. Generally oriented parallel to cleavage.

Opaques 5%. Randomly scattered and oriented. Generally medium to coarse silt size. Many euhedral showing cubic cross sections, hence probably limonite after pyrite.

Biotite. Defines cleavage. Has an overall preferred orientation but on a smaller scale is less well aligned.

Name:

(a) Dark grey, moderately sorted, coarse siltstone.

(b) Pyritic quartzlutite.

HS 385/156 Inman Hill Subgroup. Medium grey very well indurated, massive, well sorted micaceous quartzite. Interstitial biotite 25-30%.

HS 385/157 Inman Hill Subgroup. Pale grey but blotchily ochre weathering, massive, very well indurated quartzite.

TS 385/157 Very homogeneous. Extremely well packed, all grains strongly welded. Considerable interpenetration of grains by solution has occurred. Long contacts, often sutured arise.

No preferred orientation at all.

Bonded by interpenetrating grains.

Composition;

Quartz 70%. No preferred orientation. Pressure effects have changed shape of all grains. Undulose extinction common. Occasional grain has many bubbly inclusions resulting in a dirty appearance.

Orthoclase 10%. Evenly distributed. Very fine sand size. Occasionally have overgrowths of orthoclase, not in optical continuity. Microcline 2%.

Plagioclase 5%. Randomly distributed, very fine sand size grains. Grain shapes affected by pressure. Some twinning is slightly bent probably implying strong deformation.

R.F. 10%. Predominantly polycrystalline quartz. Less common polycrystalline orthoclase and plagioclase.

Detrital mica 1%. Relatively long flakes of muscovite up to 0.6mm in length. Foliae often buckled around other grains.

Biotite 4%. Interstitial only, too fine to observe a preferred orientation.

Name:

(a) Very well sorted, very fine sandstone.

(b) Mature lithic feldsarenite.

HS 385/158 Inman Hill Subgroup. Pale grey very well indurated quartzite with a poorly developed slaty cleavage.

TS 385/158 Homogeneous, very well packed slide. There is considerable welding and interpenetration between grains. Long, often sutured, contacts result. Cleavage is defined by the alignment of biotite stringers. Bedding is defined by the occasional sub parallel detrital muscovite flake. Bedding transects cleavage at 85°.

Well sorted 95% very fine sand to coarse silt, 5% interstitial biotite.

Clastic grains are affected by pressure which affects their shape.

Co position:

Quartz 75%. Very fine sand to coarse silt size. No preferred orientation of grains. Quartz overgrowths occasionally present, undulose extinction common.

Orthoclase 10%. Evenly distributed very fine sand to coarse silt size grains sometimes showing simple twinning. Undulose extinction common.

R.F. 5%. Coarse silt size polycrystalline quartz.

Detrital mica 1%. Muscovite foliae, often bent around other clastic grains. Up to fine sand size, generally very fine sand size.

Pyrite 1%. Euhedral limonite,pseudomorphs up to coarse sand size, generally very fine sand size.

Biotite. Grains generally submicroscopic. Occupy interstitial positions and also as stringers which define cleavage.

Name:

(a) Well sorted very fine sandstone and coarse siltstone.

(b) Pyritic subfeldsarenite.

HS 385/160 Inman Hill Subgroup. Light grey with some darker bands, fairly massive, micaceous quartzite with a slight development of slaty cleavage. Quartz 75%, biotite interstitial.

HS 385/173 Inman Hill Subgroup. Pale grey, but orange mottled, banded, very well indurated quartzite.

TS 385/173 A slide of a weathered rock with patchy limonite development. Fairly homogeneous although there is a coarse banding due to varying relative amounts of coarser grains and clay. Well packed, showing a considerable degree of welding and interpenetration by solution.

Two lineations in the slide (a) bedding as given by banding ($<$ 1mm wide) (b) cleavage - shown by an overall preferred orientation of secondary biotite formed from the metamorphism of clay.

Moderately sorted but bimodal, Coarse silt to fine sand 60%, biotite 40%.

The shape of nearly all grains is affected by pressure and the original grain boundaries are lost. Rare grain is unaffected, shows a moderate sphericity but is very well rounded.

Composition:

Quartz 50%. Fairly evenly distributed although less so in some bands which hence define bedding. Generally fine and very fine sand size, coarse silt 10%. Undulose extinction common but not dominant.

Plagioclase 5%. Randomly distributed except in the less sandy layers. Grain boundaries all affected by pressure. Often riddled with inclusions, but quite fresh.

Orthoclase 5%, occasionally microcline. Fine and very fine sand size.

Limonite 5%. Very dark brown, irregularly shaped blotches. Have an overall preferred orientation parallel to cleavage. Due to alteration of biotite,pyrite or heavy minerals ?

Biotite 35%. Generally interstitial but also forms long stringers. Its overall alignment defines cleavage.

Name:

(a) Moderately sorted but bimodal, clayey fine and very fine sandstone.

(b) Weathered subfeldsarenite.

HS 385/174 Greenish grey, weathered micaceous slate, originally a well sorted siltstone.

TS 385/174 Slightly thick slide.

Fairly homogeneous. Where clastic grains touch, is some interpenetration. Glide has an orientation as biotite defines cleavage.

Well sorted but bimodal. Silt size grains 10%, clay and biotite matrix 90%.

Grains are little affected by pressure. Sphericity is low, grains very angular.

Composition:

Quartz 10%. Silt size grains, evenly distributed. Anhedral, no preferred orientation. Occasionally undulose extinction observable.

Detrital muscovite. Rare fine sand size flake, foliae not distorted.

Biotite and clay 90%. Has an overall preferred orientation which defines cleavage.

Name:

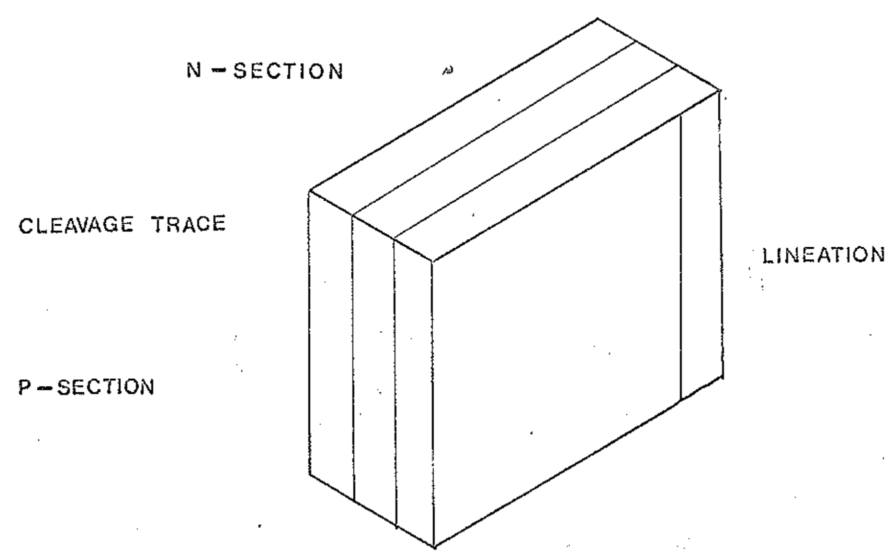
(a) Well sorted bimodal silty claystone.

(b) Weathered quartzlutite.

APPENDIX II

DESCRIPTION OF ORIENTED THIN SECTIONS TO INVESTIGATE THE DEVELOPMENT OF THE SLATY CLEAVAGE AND THE MINERAL LINEATION .

EXPLANATION OF TERMINOLOGY (after Collins, 1971)



Collins found that mineral segregation had occurred in the rocks he studied.

Two principal groups were present, which he named 'domain The first was quartz rich, mica was subordinate, and its flakes occupied interstitial positions. The second was mica rich and its orientation usually was parallel to, and defined, the cleavage.

He named them the 'quartz-mica (Q-M) domains' and the 'mica (M) domains ' respectively.

They are usually quite distinct entities with well defined boundaries and were readily visible in most slides from the Australia Plains area. There they resulted from the deformation of bedding features.

145 Fine and very fine sand size muddy subfeldsarenite.

+145A P Section:

Grain boundaries are affected by pressolution. Domain structure is only slightly developed. In the M domains, biotite grains are subparallel; in the Q-M domains the biotite orientation is more nearly random.

Slaty cleavage and the mineral lineation are defined by slightly elongate Q-M lenses and by subparallel stringers of biotite.

+145B N Section:

The domain structure is moderately developed. Compared with A, the Q-M domains are not as elongate; the biotite grains are generally smaller and they have a less preferred orientation.

The cleavage is not as well defined in B than A.

Summary:

The slaty cleavage is defined principally by the preferred orientation of biotite; secondarily by elongate Q-M domains. The mineral lineation seen in hand specimen is caused by slightly more elongate Q-M domains and longer biotite grains in A than B.

In M domains, the biotite is oriented parallel to domain boundaries; in Q-M domains, biotite has little preferred orientation.

+ 124 A slate.

124A Perpendicular to the cleavage plane, parallel to the strike of cleavage.

124B Perpendicular to the cleavage plane, perpendicular to the strike of cleavage.

In both slides the slaty cleavage is defined by a strong overall preferred orientation of biotite. In A the biotite flakes are longer (mean 0.07mm versus 0.03mm) and have a more preferred orientation than in B.

Hence the mineral lineation probably lies closer to the strike of cleavage than to the pole of it.

+ 122 A sandy mudstone.

122A Perpendicular to the cleavage plane, parallel to the strike of bedding.

122B Perpendicular to the cleavage plane, perpend. to the strike of bedding.

Both A and B show local intense cleavage development which has resulted in the original sandy bedding planes being disrupted into lenses, presumeably by penetration of the slate into the sandy beds.

The mineral lineation can be seen on comparing the slides: in B the biotite grains in the M regions are oVerall more nearly parallel than in A and the size of the average biotite grain is somewhat larger

in Bthan A. Hence it lies closer to B than A.
Cleavage is defined in both A and B by the parallel orientation of biotite stringers and by the elongation of the Q-M domains.

+ 20 A slate.

20A P Section.

20B N Section.

Original bedding is defined by silty bands in what was originally a clay matrix.

In A, few mica flakes are oriented at large angles to the cleavage trace; the flakes are of regular size and shape.

In B, although the majority of the biotite flakes are oriented parallel to the cleavage trace, some do lie at varying angles and a significant proportion lies at right angles.

Cleavage is also defined by the elongation of the original silty layers i.e. the Q-M domains.

The individual flakes on the P section are generally longer and thicker than on S.

An occasional detrital muscovite flake is present.

+ 132 A subfeldsarenite.

132A Perpendicular to the cleavage plane, perpendicular to the strike of cleavage.

132B Perpendicular to the cleavage plane, parallel to the strike of cleavage.

In hand specimen, the cleavage is only moderately well developed. M domains are poorly represented as the biotite was originally only present as interstitial clay. Overall the biotite has a moderately strong preferred orientation which defines cleavage. Occasional sub parallel stringers of biotite anastomose between the sand grains. Both the individual grains and the aggregates of biotite are slightly larger in A than B but a significant mineral lineation is not observable in these slides.

+ 88 Medium and fine sand size subfeldsarenite.

88A Perpendicular to both the cleavage plane and strike of cleavage.

88B Perpendicular to the cleavage plane and parallel to the strike of cleavage.

In A cleavage is defined by biotite which occupies interstitial positions; few long stringers are evident. Few biotite grains lie at a significant angle to the cleavage trace.

In B the biotite appears more evident; anastomosing stringers are common. However, the individual mica flakes have a far more random orientation than in A. This combination is unique in the slides investigated.

In summary, the cleavage is not particularly well developed, being defined by biotite rather than oriented Q-M domains.

A mineral lineation is not observable in these slides probably due to the preponderance of quartz with respect to biotite.

+ 107 Fine and very fine sand size subfeldsarenite.

107A Perpendicular to the cleavage plane and parallel to the strike of cleavage.

107B Perpendicular to both the plane and strike of cleavage.

In both slides, cleavage is defined by sub parallel anastomosing biotite stringers.

In A, a significant proportion of the smaller interstitial biotite grains lie at widely varying angles to cleavage. The individual sand grains also have an overall preferred orientation of their long axes: this is thought to be due to pressure effects rather than rotation.

In B, the mica domains are not as broad, nor as long, as in A. The overall orientation is possibly slightly better. Again there is a slight alignment of the long axes of the sand grains.

As a comparison of the slides does not readily show a mineral lineation, if it is present its direction would lie between the orientations of Aand B.

+ 174 Slate with a small (10%) silt content.

174A N Section.

174B P Section.

The N section has significant variations in size and shape of the biotite grains. The majority of grains are oriented parallel to the cleavage traces. In the P section the average biotite flake is longer than in N and although a significant number are oriented at varying angles to the cleavage trace more lie parallel to it than in the case of N. The quartz grains and their associated beards are elongate parallel to cleavage resulting in a lensoid shape, this being more common and better developed in P than N.

+ 53 Fine and very fine sand size subfeldsarenite.

53A Perpendicular to the cleavage plane, parallel with the strike of bedding.

53B Perpendicular to the cleavage plane, perpendicular to the strike of bedding.

In B, cleavage is almost impossible to distinguish as the basal planes of biotite have an almost random orientation and there is no observable elongation or preferred orientation of the Q-M domains. Biotite flakes average 0.05mm.

In A, the biotite basal planes are sub parallel and hence define cleavage. Grains now average 0.1mm. Larger aggregates anastomose around the sand grains a and around some lensoid Q-M domains which occasionally develop. The individual quartz grains are not regularly inequidimensional however. Hence, on the micro scale, a mineral lineation is defined by the biotite.

+ 119 A banded mudstone.

119A Perpendicular to the basal plane of, and parallel to the strike of, cleavage.

119B Perpendicular to the basal plane and strike of cleavage.

In A, the biotite is predominantly sub parallel to the cleavage trace, with a significant proportion, in the Q-M domains especially, which is oriented at very large angles. These latter flakes are generally the thickest i.e. they have a preferential growth parallel to the maximum principal axis of strain, In B, the biotite flakes again alone define cleavage. The flakes are sub parallel but generally smaller than in A. Long anastomosing stringers are better developed in this slide.

Elongate Q-M domains are not formed in either slide. There is no decisive evidence for a mineral lineation in either slide.

+ 106 A banded sandstone and mudstone.

106A Perpendicular to the cleavage plane and bedding strike, and parallel to the cleavage strike.

+106B Perpendicular to the cleavage plane and strike of cleavage, and parallel to the bedding strike.

In both slides, cleavage is defined by anastomosing biotite stringers. The slides differ in these respects:

(a) the biotite in B forms thicker stringers whose variation in orientation is greater than that in A.

(b) the individual flakes in the Q-M domain are less well oriented in B than A.

(c) the stringers in A are more numerous, but smaller, than in B.

In A, several large (0.1mm) detrital muscovite flakes are present; they are often oriented perpendicular to the cleavage trace and parallel to the bedding observed on a macro scale. This implies that the cleavage is not formed by grain rotation. In summary, the mineral lineation, although not parallel to either section A or B lies closer to A than B.

+111 Originally a cross bedded silt and claystone.

111A Perpendicular to the cleavage plane and parallel to the strike of cleavage.

111B Perpendicular to the plane and strike of cleavage. Both slides still show original sedimentary cross bedding and banding now represented by M and Q-M domains.

Differences in domain shapes between the two slides is thought to be due to the original sedimentary structures rather than due to metamorphic effects.
In B, stringers are poorly developed, the cleavage being defined by moderately parallel individual flakes and small aggregates. Only a small proportion of the flakes lie at greater than 15^{o} to the cleavage trace. In the Q-M domains, the biotite flakes are generally smaller and less elongate with a greater divergence from the cleavage trend, than in the M domains.
There is a slight tendency for the long axes of the silt grains to be oriented sub parallel to cleavage in B than A.
In A, in the Q-M domains there is a greater tendency for the biotite to diverge than in B.
Detrital muscovite flakes are evident, often lying at right angles to cleavage, implying that the cleavage is not due to rotation of grains.
A mineral lineation cannot be recognized from these slides.

+125 Originally a cross bedded silt and claystone.

125A Perpendicular to the plane and strike of cleavage.

125B Perpendicular to the plane and parallel to the strike of cleavage.

In B, the M domains are characterized by stubby biotite grains with a good preferred orientation. In the Q-M domains, grain sizes and shapes are similar but more lie at large angles to the cleavage trace which is not easily recognizable in these domains.

In A, the domain structure is better developed. As the cleavage developed it deformed the sandy layers resulting in thickness variations, locally boudinage structures almost develop. In the Q-M domains the orientation of biotite is nearly random, seemingly having formed wherever there was space to do so. In the M domains, anastomosing stringers are common; biotite flakes are nearly all parallel to the cleavage trace.

Overall there is little difference between the slides.

+ 121 Weathered fine sand size subfeldsarenite.

121A Perpendicular to the cleavage plane and also strike of bedding.

121B Perpendicular to the cleavage plane and parallel to the strike of bedding.

In B, the cleavage is only moderately developed being defined by both small flakes and large aggregates of biotite. The small flakes have a fairly random orientation, the larger stringers are sub parallel.

In A, the cleavage is somewhat better defined than in B in that the small biotite flakes have a sub parallel, rather than random, orientation. The original bedding trends at right angles to cleavage in both slides and is still reflected by relatively large detrital muscovite flakes which have not been rotated during cleavage formation. The mineral lineation as defined by biotite lies closer to the plane of A than B.

+ 61 Originally a silty claystone.

61A Perpendicular to the cleavage plane and also strike of cleavage.

61B Perpendicular to the cleavage plane and parallel to the strike of cleavage.

In A, the cleavage is defined by a sub parallel orientation of biotite grains whose average size is 0.02mm. A large proportion of the basal planes lie at quite large angles to cleavage; many at right angles.

In B, the anastomosing aggregates of biotite are common. The average grain size is now 0.05mm. Few biotite flakes lie at large angles to cleavage in this case.

Again, cleavage is proved not to have formed by grain rotation as detrital muscovite flakes can be seen lying in bedding planes (as defined by coarser layers which trend at right angles to cleavage.

The mineral lineation lies close to the orientation of slide B.

+126 Originally a cross bedded silty claystone.

126A Perpendicular to the plane of, and strike of, cleavage.

126B Perpendicular to the plane of, and parallel to the strike of, cleavage.

As cleavage developed, it tended to disrupt the originally straight boundaries of silty layers producing a saw tooth appearance. This, and the biotite orientation, defines cleavage in both slides. M and Q-M domains result primarily from the initial bedding.

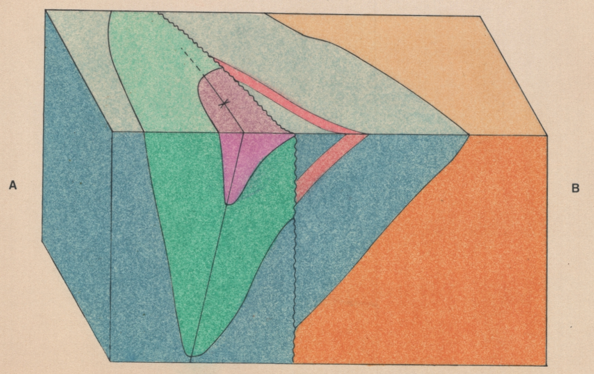
In slide A, the biotite of the Q-M domains is interstitial and although it has a slight overall preferred orientation parallel to the cleavage trace, most flakes lie at significant angles to cleavage. In the M domains, the preferred orientation of the biotite is good with relatively few flakes lying at angles greater than 15° from the cleavage. Many of those that do, lie at right angles.

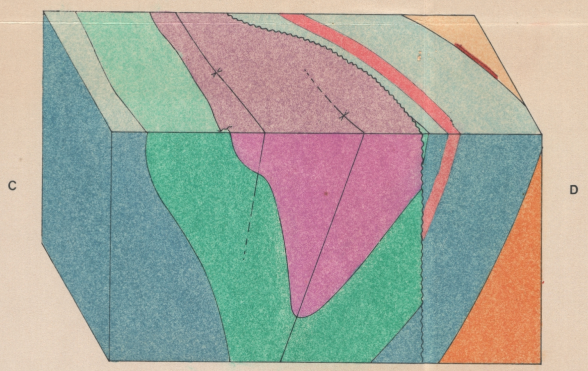
In slide B, more flakes lie parallel to the cleavage trace. The flakes tend to be slightly shorter and often thicker than in A.

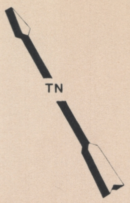
In summary, it is not possible to see a mineral lineation; cleavage is not due to grain rotation as these slides show an elongation and smearing of bedding; cleavage is better defined in the M than Q-M domains as usual.

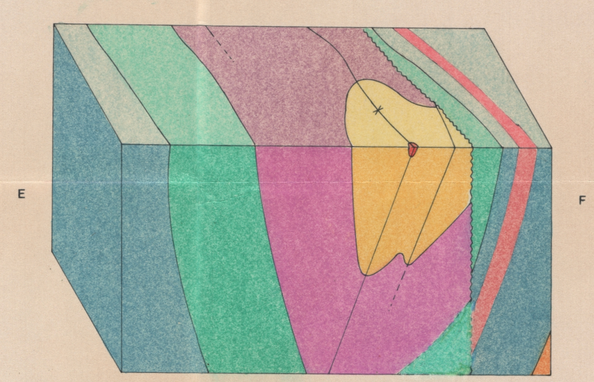
AUSTRALIA PLAINS

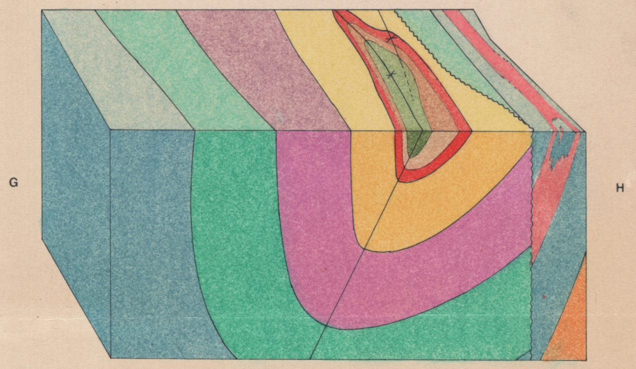
INTERPRETATIVE THREE - DIMENSIONAL REPRESENTATION

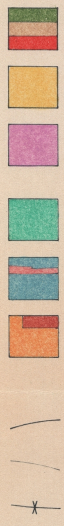












BROWN HILL SUBGROUP

INMAN HILL SUBGROUP

CARRICKALINGA HEAD FMN.

ULUPA SILTSTONE EQUIVALENT

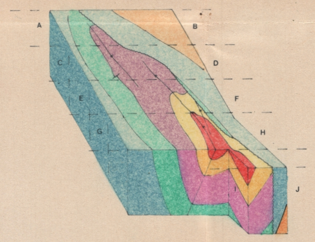
PEPUARTA TILLITE & TARCOWIE SILTSTONE EQUIVALENT?

TAPLEY HILL FORMATION
EUDUNDA ARKOSE MEMBER

Major geological boundaries

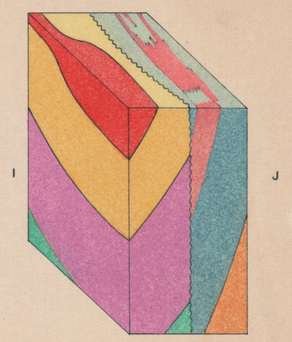
Minor geological boundaries

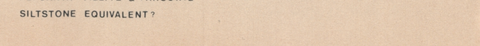
Axial plane trace of syncline



THE POSITIONS OF GEOLOGICAL DATA DRAUGHTED ARE ASSUMED TO BE ACCURATE

THE GEOMORPHIC SURFACE IS SKEWED THROUGH 30° IN A WESTERLY DIRECTION



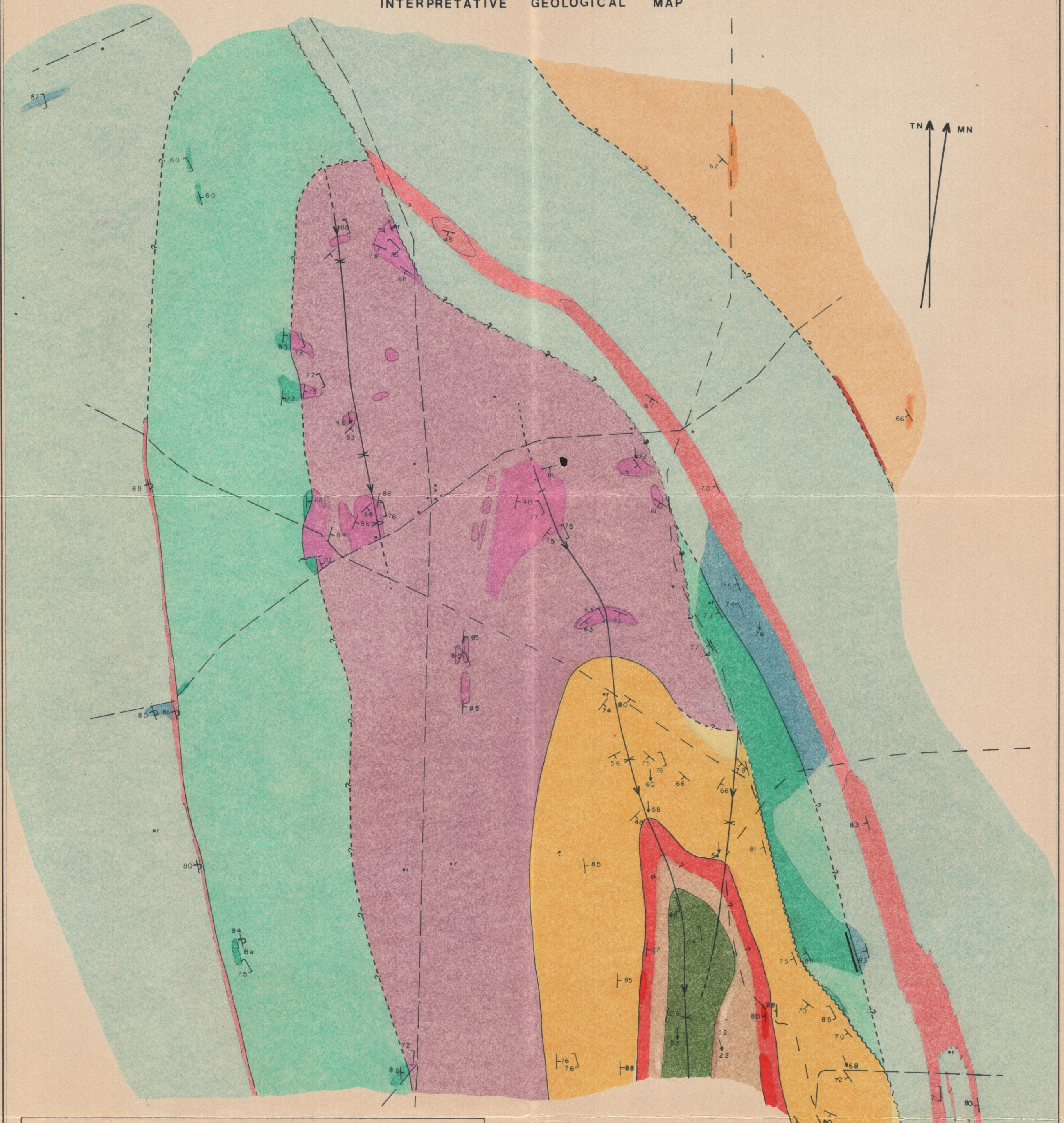


kilometres

AJD

AUSTRALIA PLAINS

INTERPRETATIVE GEOLOGICAL MAP



CAMBRIAN KANMANTOO GROUP

PROTEROZOIC WILPENA GROUP / UMBERATANA GROUP

	Dolerite, lamprophyre
BROWN HILL SUBGROUP	Unit1. Black, well indurated phyllitic slate. Unit2. Karinya Sh. Mem? Bleached, pyritic black slate. Unit3. Brown, green and grey, cross bedded siltstone.
INMAN HILL SUBGROUP	Prominently outcropping, variably cross bedded and banded pyritic spottily weathering feldsarenite with a variably developed slaty cleavage.
CARRICKALINGA HEAD FMN.	Dark greyish green cross bedded lutite with thin arenaceous beds. Occasional feldsarenite bands. Variably developed slaty cleavage.
ULUPA SILTSTONE EQUIVALENT.	Light greyish green occasionally pyritic & cross bedded, variably laminated lutite often with strong cleavage. Passes transitionally into Pepuarta Tillite.
PEPUARTA TILLITE & TARCOWIE SILTST. EQUIVALENT?	Green, pink & brown sandy & occasionally pebbly mudstone grading to mudstone. Clasts of quartz, hornblende, siltstone, granite and gneiss. Slightly pyritic. White cross bedded quartzite facies.
TAPLEY HILL FORMATION Eudunda Arkose Member	Laminated, weathered ochreous siltstone, usually capped by kunkar.

Major geological boundaries. Probable. Inferred.

Minor geological boundaries. Probable. Inferred.

Fault. Probable. Inferred.

Axial plane trace & plunge of syncline & monocline

72 88 Attitude of bedding. Overturned

76 53 Attitude of cleavage and of bedding/cleavage intersection.

Ba Opencut barytes

Road Track

House Ruin

Dark colour shades imply outcrop; pale shades imply float mapping only.

AJD