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# SOUTH AUSTRALIA

GEOLOGICAL SURVEY

## REPORT ON GEOLOGICAL EXCURSION TO THE BARRIER RANGES, N.S.W., MAY, 1971

by

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PALAEONTOLOGIST
PALAEONTOLOGY SECTION

Rept.Bk.No. 72/19

17th February, 1972.

72/19

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Rept.Bk.No.72/19
G.S. No.4791
D.M. No.238/71
Pal. Rept. 20/71

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## ABSTRACT

A short guided excursion to the Barrier Ranges, N.S.W., revealed many points of comparison with the Adelaide Geosyncline. The Poolamacca Group, consisting of a quartzite-carbonate-volcanic sequence, resting with marked angular unconformity on crystalline basement, is generally correlated with the Lower Callanna Beds. Poorly preserved stromatolites from the carbonates (Boco Formation), tentatively identified as ?*Omachtenia* f.indet., occur in dolomitized limestone near Wilangee and in silicified beds at Mt.Woowoolahra.

The Poolamacca Group is unconformably overlain by the predominantly water-laid glacials of the Yancowinna Subgroup, equated with the Yudnamutana Subgroup. Equivalents of the Upper Callanna Beds and Burra Group are not represented in the area. The interglacial Euriowie Subgroup, previously reported to contain stromatolites, was found to be barren of fossils. Slumped carbonate breccias near the western margin of the Euriowie Inlier contain blocks of limestone of possible shallow water origin; otherwise the subgroup lacks evidence of shallow water deposition.

The younger glacials (Teamsters Creek Subgroup) are also primarily water-laid, and conglomerates within them contain clasts with tubular structures here interpreted as highly altered stromatolites. Basement rocks in one part of the Euriowie Inlier show a gradual increase in metamorphic grade from laminated slates in the east to sillimanite schists in the west.

INTRODUCTION

During October, 1970, B.P. Thomson, R.P. Coats, B.G. Forbes, G.W. Krieg, and G.M. Pitt of the Regional Surveys Division undertook a comparative geological excursion in conjunction with members of the New South Wales Geological Survey. The Mount Painter and Olary Provinces, S.A. and the Barrier Ranges, N.S.W., were visited with a view to comparing and correlating Late Precambrian sequences. Their correlations are outlined by Thomson et. al. (1970). In summary, the Poolamacca Group was correlated with the Lower Callanna Beds, the Yancowinna Subgroup with the Yudnamutana Subgroup and the Euriowie Subgroup with the Farina Subgroup. The glacigene beds of the Teamsters Creek Subgroup were equated with the Yerelina Subgroup; the upper part of the Teamsters Creek Subgroup plus the Farnell Subgroup are apparently equivalent to most of the Wilpena Group. Subsequently, Cooper and Tuckwell (1971) have redefined some of the units so that the Torrowangee Group corresponds to the Umberatana Group, its top is the top of the Teamsters Creek Subgroup which has been adjusted to the top of the upper glacials, and thus corresponds to the top of the Yerelina Subgroup. The Farnell Group then becomes equivalent to the Wilpena Group (Table 1).

On the excursion, R.P. Coats discovered that the Boco Formation, a unit of the Poolamacca Group, and correlated with the Wywyana Formation (Thomson et al.1970) is stromatolitic at one locality. A few small specimens were collected and submitted to me at the University of Adelaide, but sectioning showed that they were poorly preserved, and more material was required to make an adequate assessment.

Webby (1970) had recorded abundant stromatolites from a limestone band in the Euriowie Beds (Subgroup) and rare stromatolites in younger beds now considered to be equivalent to the Wilpena Group, in the Sturts Meadows area.

Early in 1971, R.A. Callen revisited some localities in the Barrier Ranges with Paul F. Cooper of the New South Wales Geological Survey. They discovered silicified stromatolites in an isolated outcrop at Mount Woowoolahra, probably equivalent to the Boco Formation. The stromatolites were very poorly visible on the weathered surface of what is now essentially a white quartzite, and specimens submitted to me were not promising.

It was decided that I should visit all the known stromatolite localities in the Barrier Ranges personally, to collect material. The cooperation of the New South Wales Geological Survey was invaluable; I was conducted through the Barrier Ranges by Paul Cooper, who has recently completed mapping of part of the area. This excursion from May 24 to 30, 1971, was successful in locating the reported occurrences, and helped me to gain an impression of the similarities and differences between the sequences of the Flinders and Barrier Ranges.

## FIELD WORK

The itinerany followed is illustrated in Fig.1. After meeting me at Broken Hill on 25th May, Paul Cooper accompanied me, acting as guide. At locality (1), Yanco Glen, the Lady Don Quartzite, basal formation of the Poolamacca Group was observed, apparently resting unconformably upon Willyama basement, in this area consisting of knotted quartz-mica schists. The massive Lady Don Quartzite, in places containing quartzite boulders, dips steeply east, but the actual contact with the basement was obscurred by soil cover.

The Lady Don Quartzite is in turn unconformably overlain by the Torrowangee Group, with the glacigene Yancowinna Subgroup at its base. Rocks belonging to this unit were examined at locality (2), 2km north of Mt Gipps H.S. These beds, consisting of sandstone, siltstone and pebble beds, show some of the features of turbidites. Sandstone beds, up to 10 cm thick, are commonly graded; rounded quartz grains grade from 0.5 mm at the base to 0.2 mm at the top. Siltstone beds frequently contain ripple marks (Fig.2). Pebble beds are diamicitites, consisting of mainly small pebbles in a silty matrix; they overlie laminated siltstones with sharp contacts. The sediments appear to be more strongly metamorphosed than equivalent rocks of the Flinders Ranges. Cleavage is strongly developed in the silty bands and matrix, cleavage surfaces having a phyllitic sheen due to the growth of metamorphic micas.

Locality (3), the Torrowangee Quarry, provides excellent exposures of part of the Wammerra Formation, basal unit of the Euriowie Subgroup, and correlated by Thompson et al. (1970) with the Tindelpina Shale Member of the Tapley Hill Formation. Certain lithological differences are apparent, however. The formation consists of laminated dark grey to black siltstones, but the laminations are not as fine as in the Tapley Hill Formation. Thinly interbedded limestones and dolomites similar to those of the Tindelpina Shale are rare or absent. Large volumes of massive limestone are seen in the quarry face, but they bear unusual relationships to the dark siltstones (Figs.3,4).

The limestones occur as thick pods which intertongue southward with the surrounding sediments. To explain this relationship, some members of the New South Wales Geological Survey had suggested that the limestone pods might represent reefs (Paul Cooper, pers.comm.1971). This view was supported by the presence of intraformational breccias in the upper parts of the quarry face, which were interpreted as reef talus. Others had suggested a tectonic mode of emplacement. An examination of the massive limestones themselves proved fruitless, since they are completely recrystallized to medium grained marbles, preserving no features which might suggest their origin.

Examination of the contacts between the limestone tongues and the surrounding siltstones suggested that base of each pod is erosional, while its upper surface is irregular and transgressively overlain by onlapping silts. Isolated lenticular limestone pods were also seen in outcrop adjacent to the quarry, where massive crystalline limestones are interbedded with bands of sandy limestone and unsorted limestone breccias (Fig.5). I was impressed by the similarity of this sequence to that I had observed near Chintapanna Well, Willouran Ranges (Preiss, 1971c). Like the breccias of the Willouran Ranges, these are best explained as due to slumping. Clasts in the breccias are chiefly angular, and include pale dolomitic limestones, buff dolomites and cherts. Parts of the breccia are silicified. Clasts range in diameter from a few millimetres to 3m. One of the largest blocks, part of which is shown in Fig.6, is a laminated dolomitic limestone containing small polygonal and irregular but clearly defined sparry patches, visible on the weathered surface. Although these resemble birdseye structures (Shinn, 1968) it was not possible in the field to distinguish whether these were primary sedimentary structures or of secondary origin.

Leaving the main road, we travelled north-west from the Torrowangee Quarry through the Yancowinna Subgroup for about 12 km, then followed the unconformity between the Yancowinna Subgroup and the basement southwards to a point 6km east of Wilangee H.S. (Locality 4). Here the Poolamacca Group intervenes between the basement and the glacigene sediments, and it is here that the similarity of sequence between the Mount Painter region and the Barrier Ranges is best seen. The stratigraphic section begins with the basement rocks, in this area characteristically of low metamorphic grade. Similar metasediments were described from Brewery Well not far to the south by Leslie & White (1955). At locality (4), the basement consists of phyllites with well developed cleavage at an acute angle to the bedding, which is preserved as fine dark laminae. Elongated quartz-mica knots are common. The basement is truncated by an irregular erosional surface, overlain by the basal conglomerate of the Poolamacca Group. Quartzite is not well developed in this area, and there was some doubt as to whether the conglomerate ought to be assigned to the Lady Don Quartzite or the overlying Christine Judith Conglomerate.

Overlying the basal clastic sediments is the Boco Formation, consisting here predominantly of white, finely crystalline dolomite containing stromatolitic bioherms. The bioherms are lenticular or tabular, sometimes overlapping one another, but do not intertongue with the surrounding sediment (Figs 7,8). They rest upon a substrate of flaggy, partly cherty dolomites, and must have stood in relief above this substrate and later been compacted into it, since the underlying laminae are depressed around them. Single bioherms are up to 6 m wide, 1.5 m high. Flaggy and lenticular bedded dolomite surrounds the bioherms and must have accumulated after bioherm growth. Chert pods and bands replace parts of bioherms, but bear a cross-cutting relation to the columns. Cooper and Tuckwell (1971) record a maximum thickness of 30 m for the Boco Formation, and a disconformity between it and the overlying amygdaloidal basalts of the Wilangee Volcanics. The volcanics are in turn disconformably overlain by the glacigene Yancowinna Subgroup, here commencing with a massive diamictite with numerous granite boulders, and passing up into shales and siltstones. A brief examination of the area revealed no more than the two stromatolite outcrops shown to me. It is likely that the numerous N.W.-S.E. trending faults in the area were active during deposition, since thicknesses change markedly across these faults. The Boco Formation is absent in some of the fault blocks.

The same route was followed back to the Torrowangee Quarry. At locality (5), north of the quarry, another exposure of Wammerra

Formation was examined. Slumped contorted blocks of limestone containing birdseye-like structures are more prominent than at the quarry. In addition the limestone is strongly laminated at this locality, but it is not clear from field evidence whether folded sturctures of this limestone are of sedimentary or tectonic origin.

The Corona Dolomite is a massive, structureless but strongly fractured white crystalline dolomite occurring alongside the road to Corona H.S. At locality (6), it was observed overlying conglomerates of the Yancowinna Subgroup. The basal diamictite of the latter is in contact with the basement rocks of the Euriowie Inlier. The contact is shown by Rose (1968) as a fault, but at least at this locality, metamorphic convergence has obscured the contact. The basement schists have been retrogressively metamorphosed, and have come to strongly resemble the prograde-metamorphosed schistose matrix of the diamictite. The unconformable contact can be located in the field only approximately by the incoming of erratics.

Locality (7), near Mount Woowoolahra, is an exposure of what is interpreted as silicified Boco Formation, overlying a purple quartzite, possibly a variant of the Lady Don Quartzite! There is no remnant carbonates in the Boco Formation, which is here essentially a white quartzite, but the presence of white chert pods within it (Fig.10), identical to those seen near Wilangee, suggests that silification took place in two stages. Faint traces of broad columnar or pseudo-columnar stromatolites are preserved on weathered surfaces (Fig.11). In this photograph the hammer marks the position where R.A. Callen collected a specimen (sample number 16, Barrier Ranges; my number WP (23)). His other specimens submitted to me are not stromatolites; they may be concretions out of the overlying silcrete.

At (8), near the western margin of the Barrier Ranges 1 km west of Mt. Woowoolahra H.S., the Yancowinna Subgroup directly overlies the eroded surface of the Mundi Mundi Granite, without any intervening Poolamacca Group. Diamictites contain numerous facetted and striated clasts of dark grey cherty quartzites derived from the Willyama Complex nearby.

The Corona Dolomite was again traversed to the north of Corona H.S., where its apparent thickness is greater than at locality 6. Bedding is discernible at neither locality so that truc thicknesses cannot be estimated. The Corona Dolomite is restricted to the northern closure of the Euriowie Inlier.

Rose (1968) showed rocks at locality (9) as of pre-Poolamacca Group age of uncertain stratigraphic position, faulted against Farnell Group. Paul Cooper re-interpreted these beds as highly deformed Farnell Group, and did not postulate a fault in this position. He recognised two periods of deformation in this area, and interpreted the complex structure to be due to northward pressure from the Euriowie Inlier. We did not examine evidence for these ideas, but observed evidence of sedimentary disturbance in the form of slump breccias and large slumped blocks resembling Corona Dolomite. The beds consist mainly of siltstones with laminated dolomitic limestone interbeds, and somewhat resemble the silty carbonates of the Wonoka Formation of the Flinders Ranges. Paul Cooper suggested that these beds lapped transgressively on to uplifted Corona Dolomite, but time did not permit him to demonstrate this to me conclusively.

The Nunduro Conglomerate, the uppermost unit of the upper glacial sequence, the Teamsters Creek Subgroup, was examined at locality (10) where it contains numerous interesting carbonate clasts. Conglomerates form lenticular interbeds in laminated siltstones with rare dropped pebbles. They appear to fill large erosional channels, and are frequently composed of a lithologically limited range of clasts.

One such lens consists of rather tightly packed boulders all of one type of quartzite, and a close examination of the intervening fine clastic matrix was necessary to show that it was not a quartzite bed in situ. Another conglomerate lens contains boulders of quartzites, basement rocks and carbonates. The latter resemble dolomites of the Boco Formation, and may be in part stromatolitic (specimens WP35, WP36). Clasts of creamish-white dolomite containing problematical tubular structures are very common. The tubes have cherty walls and are elliptical in cross-section but it was not obvious from field observations whether or not they are of organic origin, although members of the New South Wales Geological Survey had attributed them to worms. The Nunduro Conglomerate is overlain by the Mantappa Dolomite, which resembles the Nuccaleena

Formation of the Flinders Ranges in lithology and stratigraphic position. It was therefore taken by Cooper and Tuckwell (1971) as the base of the Farnell Group.

Glacigene beds of the Teamsters Creek Subgroup were examined at locality (11), where there are excellent examples of dropstones in laminated siltstones. Erratics up to 50 cm in diameter were observed (Fig.14). Similar siltstones were observed in the Dering Siltstone (underlying the Nundurro Conglomerate) which however contains far fewer dropped erratics. The Dering Siltstone is well exposed at locality (12), informally known as "Boggle Hill". It is dominantly a banded siltstone with graded fine sandy layers up to 3 cm thick (Fig.13). Starved ripple marks (Walker, 1965) caused by sediment impoverished currents, are common and indicate south-easterly palaeocurrent directions (towards 122°). In places they either overlie varve-like laminated siltstones, or occur in sequences from graded coarse silt to starved ripple-marked silt to finely laminated shale draped over the ripples (Fig.12). Such a sequence resembles part of an ideal turbidite sequence as illustrated by Bouma (1962) Micro-ripples of wavelength 2 to 3 mm have axes trending N-S and indicate easterly flowing currents.

The Silver City Highway was followed south to Bijerkerno H.S., where the road to Sturts Meadows H.S. was taken through a poorly exposed section of the Euriowie Subgroup east of the Euriowie Inlier. The lower unit, the Mitchie Well Formation, consists of calcareous green siltstones with interbedded lenses of dark grey sandy banded limestones, generally with angular quartz grains. The overlying Floods Creek Formation consists of cross-bedded rippled fine grained calcareous sandstone interbedded with green calcareous siltstone. South-easterly current direction were noted.

The stromatolites mentioned by Webby (1970) were to be found in a limestone interbed within the Floods Creek Formation near the core of the Sturts Meadows Anticline, just west of the Faraway Hills Tank (locality (13)). Paul Cooper informed me that Dr. Webby had since discounted his other stromatolite occurrences. We searched the whole section from the base of the Teamsters Creek Subgroup to the core of the anticline, and found several thin but continuous silty limestone bands. One of these contained ferruginous laminated concretionary structures which could have been mistaken for bulbous and even "columnar" stromatolites and it is reasonably certain that this is Webby's locality.But they cut across the flat bedding lamination and are clearly secondary structures related to liesegang rings, formed by the diffusion of iron oxides. Moreover, the facies of these sediments is totally unlike that of stromatolite-containing limestones from the Flinders Ranges; in contrast to the latter they are silty lime-mudstones deposited in quiet water, and contain no evidence of shallow water conditions. Therefore the absence of stromatolites was not altogether unexpected.

On the final day of the excursion, we traversed the basement rocks of the Willyama Complex west of Bijerkerno H.S.(locality(14)).The unconformable contact of the Lady Don Quartzite on the basement was seen in Caloola Creek, south of the homestead, while the Willyama Complex itself was examined along a track west of it. Here Rose (1968) had mapped low grade metasediments of uncertain age, occupying a synclinal structure and separated from the higher grade rocks of the Willyama Complex by an uncertain boundary. He termed these the "Bijerkerno Beds." After a traverse through the area it was my impression that such a separation is not warranted, and that there is a gradual increase in metamorphic grade from east to west across that part of the Euriowie Inlier. The rocks exposed near the homestead are low grade metasiltstones and slates, generally dark grey, thinly laminated, and strongly resembling the Tapley Hill Fornation in lithological character. Slaty cleavage is well developed, and steeply dipping; bedding - cleavage relations suggest that the beds are right way up. On the western limb of the syncline, the laminated siltstones become phyllitic, and a few impure metasandstone beds were noted. West of a pegmatite dyke, the phyllites contain chiastolites, and in places show evidence of at least two phases of folding (schistosity is re-folded). They gradually pass into chiastolite schists, which may show metamorphic inverse "graded bedding;" sandy layers with sharp bottoms rhythmically alternate with pelitic schist layers with large andalusite porphyroblasts. Coarse, massive andalusite schists were the first rocks encountered in which bedding is no longer obvious, and these grade westwards into sillimanite schists, the highest grade rocks seen in this area, and probably the oldest. These observations suggest that the basement complex here was originally a continuous dark shale-siltstone-impure sandstone sequence, increasing markedly in metamorphic grade from east to west. A similar conclusion was reached by Branagan (1971), who described sedimentary structures from the low grade rocks of the area.

## GEOLOGICAL INTERPRETATIONS AND COMPARISONS WITH THE ADELAIDE GEOSYNCLINE

As has been pointed out by numerous authors, the Adelaidean sediments of the Barrier Ranges show many similarities to those of the Adelaide Geosyncline, especially parts of the Flinders Ranges and Olary arc. However, some of the differences I observed on this excursion seem equally significant, and may indicate a different palaeogeographic setting from that of the sediments of the Flinders Ranges.

Poolamacca Group. The sequence of basal clastics (Lady Don Quartzite and Christine Judith Conglomerate) - carbonates - volcanics closely resembles the Lower Callana Beds observed near Arkaroola Bore, south of the Mount Painter Block. Although sediments in the Barrier Ranges are in general probably more metamorphosed than those of the Central Flinders Ranges, this basal sequence is less affected than the Lower Callanna Beds of the Arkaroola area, which are of moderate metamorphic grade. Thus although strongly recrystallized, stromatolites are preserved in the Boco Formation. Unfortunately no stromatolites are yet known from the probably equivalent Wywyana Formation. If indeed these two sequences are coeval, this suggests uniform vulcanicity and shelf sedimentation over a large area of the northern part of the Adelaide Geosyncline and north-western N.S.W. Outcrops are too discontinuous to comment on palaeogeography.

No rocks thought to be equivalent to the Upper Callanna Beds and Burra Group are known in the Barrier Ranges, suggesting that the whole area was elevated at this time.

Yancowinna Subgroup: Basal diamictites were observed in several places (Mount Woowoolahra, Corona, Wilangee) which could be interpreted either as tills (i.e. terrestrial moraines) or as subaquatic mudflow deposits (we did not observe any evidence to distinguish between these) but the numerous striated clasts near Mount Woowoolahra are probably glacially derived. Clasts are frequently of local origin. This sediment closely resembles diamictites found in South Australia, e.g. much of the Sturt Tillite, south of Adelaide.

The overlying sequence contains evidence of being water laid, in part by turbidity currents. The sediments are all well bedded (unlike the basal diamictites) and consist of laminated shale, siltstone and sandstone, with numerous dropped erratics. Not all the features of an ideal turbidite (Bouma 1962) occur, but graded sandstone beds alternate with small scale cross bedded siltstones. Thin bands of pebbly diamictite frequently occur at the base of sandstone beds. In other areas, erratics were dropped into laminated silts (from floating ice) without turbidity current action.

These sediments are likely to be marine and deposited in a relatively deep basin. This differs from much of the Yudnamutana Subgroup glacials of the Flinders Ranges. For example, at Depot Creek, diamictites are interbedded with lenticular channel-filling conglomerates, grits and sandstones, probably formed by fluvial reworking of glacial sediments. This suggests possible terrestrial conditions at least in the western part of the Adelaide Geosyncline. E.L. Winterer (1968, pers. comm.), however interpreted the thick sequence east of Hawker to have been deposited in a deep marine basin partly under the action of turbidity currents, and it is possible that this represents a similar environment to that of the Barrier Ranges at this time.

Wammerra Formation - Slump breccias observed at the Torrowangee Quarries recall those of the Willouran Ranges, which are in a broadly similar stratigraphic position. The dark grey shales and siltstones of the Wammerra Formation are not as finely laminated as the Tapley Hill Formation, their probably correlative.

The occurrence of the slump breccia may be related to their position on a small south-plunging anticline with a basement core to the north (Fig.1). If this anticline was elevated during sedimentation it may have provided a local environment suitable for the deposition of shallow water carbonates, while the surrounding sediments (mainly black shale) reflect quiet stagnant conditions in a deeper basin. In particular, if the spar-filled vughs in the limestones are primary birdseyes, this would require littoral conditions. Uplift on the anticline during sedimentation may have caused blocks of these limestones to slump southwards into the deeper basin. The original source probably lay over the basement core and has been removed by erosion. Erosional channels were cut into the black shales, and filled with slump breccia. The southward lensing out of breccias is consistent with a southerly slumping direction. The massive crystalline carbonates seen in the quarries may also have been slumped material, but being composed of pure calcium carbonate, recrystallized to a homogeneous crystalline texture, obliterating any sedimentary structures.

Mitchie Well Formation: This is the lower formation of the Euriowie Subgroup east of the Euriowie Inlier, and consists of thin sandy and silty limestone bands interbedded with calcareous laminated green siltstone. The sandy limestones observed differ from those of the Etina Formation of the Flinders Ranges in having angular quartz grains, much silt admixture(the carbonate of the Etina Formation is mainly clean limestone, mostly sparry cement), and in lacking cross-bedding. These features suggest deposition in quieter water than the Etina Formation.

The Corona Dolomite of the northern Barrier Ranges has to my knowledge no analogue in the Adelaide Geosyncline. It is completely massive and crystalline and reveals no evidence as to its origin.

The Floods Creek Formation, the upper part of the Euriowie Subgroup east of the Euriowie Inlier, consists of calcareous green siltstones with interbedded brown calcareous cross-bedded and ripple marked, sandstones. The south-easterly current directions observed suggest sediment transport away from the Euriowie Inlier. The formation resembles the Tarcowie Siltstone and Amberoona Formation of the Flinders Ranges.

Teamsters Creek Subgroup. The upper glacial sequence (Teamsters Creek Subgroup) is well developed. Whereas in the Adelaide Geosyncline, undisputed glacials at this level are restricted to the Olary Arc and the northernmost Flinders Ranges, they occur throughout the Barrier Ranges. The sequence consists basically of laminated siltstones with dropped erratics of varying size, with occasional thin diamictite interbeds. The presence of sequences of graded sandstone - ripple drift cross-lamination (starved ripples) - laminated shale suggest the action of turbidity currents. The Alberta Conglomerate (Fig.14) and the Dering Siltstone are sediments of this type, but the latter contains far fewer erratics. The overlying Nunduro Conglomerate consists of a series of discontinuous lenses in an essentially similar sequence. The lenses overlie erosional surfaces, and contain rather tightly packed boulders with little matrix. As Cooper and Tuckwell (1971) suggest, these are probably slump breccias. The sedimentary structures suggest that all of the Teamsters Creek Subgroup is water laid, probably marine; sediment was supplied by settling, turbidity currents and ice-rafting. No sediments analogous to the Elatina Formation were observed. Boulders in the Nunduro Conglomerate include dolomitic limestones with chert-walled tubular structures. Laboratory study suggests that these are deformed and recrystallized stromatolites (see Appendix). Although the Torrowangee Group is equivalent to the Umberatana Group and shows many similarities to it, it was probably deposited in deeper water than many of the sediments of the Flinders Ranges. There are no oolitic and stromatolitic limestones such as the Brighton Limestone characteristic of the western margin of the Adelaide Geosyncline. The limestones containing liesegang rings (Webby's "stromatolites") are laminated silty limestones that could have been deposited in relatively deep water. They resemble limestones of the Waukaringa Siltstone observed near Olary. The relatively deep basin in the Broken Hill area at this time was probably divided by the Euriowie Inlier basement ridge; local highs in this area were active during sedimentation and shallow water carbonates accumulated on these; those near the Torrowangee Quarry slumped southwards into deeper water sediments of the Wammerra Formation.

STROMATOLITIC BIOSTRATIGRAPHY

The stromatolites of the Boco Formation give little evidence as to its age. They are poorly preserved and can be assigned only tentatively to the group Omachtenia, which is in any case long-ranging. Its known time range in the USSR is Early Riphean to early Middle Riphean, but O. utschurica Nuzhnov occurs in the Brighton Limestone, Flinders Ranges (Preiss, 1971a) Thus the total known range of Omachtenia is Early to Late Ripean, (1600 ± 50 m.t. to 680 ± 20 m.y.) The Boco Formation almost certainly falls within this time interval, but the stromatolites provide no evidence to resolve whether the base of the Adelaidean dates back to about 1400 m.y. (Thomson, 1966) or only to 800-900m.y. (Cooper and Compston, 1971).

The probable stromatolites in the boulders in the Nunduro Conglomerate are of unknown provenance. The boulders resemble the Boco Formation lithologically, but no such tube-like forms are known from the Boco Formation. These stromatolites are too highly altered to permit identification.

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APPENDIX I

# STROMATOLITES AND PROBLEMATICAL STRUCTURES ON THE BARRIER RANGES

Stromatolites from the Boco Formation near Wilangee, from its probable equivalent at Mount Woowoolahra and from boulders in the Nunduro Conglomerate are described below. The origin of the "birdseye-like" limestones of the Torrowangee Quarries remains problematical. The tubular structures in the Nunduro boulders are probably highly altered stromatolites. The terminology is that outlined in a previous report (Rept.Bk. No.71/91) and in Preiss (1972).

I Boco Formation stromatolites

GROUP OMACHTENIA Nuzhnov, 1967.

Collenia omachtensis Nuzhnov, 1960, p.1422

Omachtenia Nuzhnov, 1967, p.13

Type form: Omachtenia omachtensis (Nuzhnov), from the Omakhtin Suite of the Uchur Basin, S.E. Siberian Platform.

Diagnosis: Cylindrical and subcylindrical unwalled columns, sometimes widening upwards, with numerous cornices and bridges linking several columns. Branching is mianly alph-parallel; columns are usually vertical, sometimes radiating or slightly curved.

Content: O. omachtensis Nuzhnov, O. utschurica Nuzhnov, and O. givunensis Nuzhnov.

Age and Distribution: Early Riphean in the Uchuro-Maya region of the USSR, but in South Australia O. utschurica is probably Late Riphean (Preiss, 1971a).

?Omachtenia f. indet.

Figs. 7,8,15,16,17

Material: Seven specimens from two localities.

Description:

Mode of Occurrence: Figs. 7 and 8 illustrate the better of the two exposures at the Wilangee locality (Fig.1). The stromatolites form discrete lenticular bioherms, generally 1 to 6 m wide and up to 1.5 m high. The separate bioherms are in contact both laterally and vertically, often overlapping earlier bioherms. The bioherms all stood in relief above the surrounding sediment floor. The substrate consists of flaggy, poorly laminated finely crystalline dolomite, containing tabular or lenticular white chert pods. The same sediment continued to accumulate after bioherm growth and is seen lapping up on to the bioherm margins (Fig.8). The stromatolites are largely pseudocolumnar, with columnar and columnar-layered intercalations; only these portions were collected for serial sectioning. Chert pods within the bioherms are broadly conformable, but in detail they cut across the lamination. On casual inspection, vertical pillars of chert give the impression of being strict replacements of stromatolite columns, but sectioning reveals that the pillars cut across continuously laminated stromatolites. At Mount Woowoolahra the whole bed is totally silicified, although the earlier chert pods are still visible (Fig.10) and are distinct from the later silicification. The stromatolites occur in lenticular bioherms similar to those near Wilangee.

Column shape and arrangement: Where truly columnar, the stromatolites consist of sub-cylindrical, vertical columns of more or less constant diameter. They are sub-parallel, except at bioherm margins where some are inclined. Bridging and coalescing occur very frequently at all levels and columns rarely maintain their identity for more than 10 cm in height. Such columns are frequently covered by pseudocolumnar or undulatory stromatolites. Columns vary in width from 1 to 15 cm.

Branching: Branching is rare, except for the initial branching of columns from a laterally-linked stromatolite substrate, (Fig.15). Where branching does occur it is sub-parallel, except near bioherm margins where columns tend to be radially arranged.

Margin structure: Margins of columns are commonly obscured by recrystallization, so that the column-interspace contact is hazy. In places long overhanging peaks are observed (Fig.15) but in other areas column margins appear smooth to bumpy, as far as can be ascertained. No continuous cornices as in Russian specimens of Omachtenia can be observed. Laminae sometimes appear to coat the margins for very short distances, but columns are generally unwalled.

Lamina Shape: The stromatolites are characterized by gently convex lamination. Laminae are smooth, occasionally gently wavy. (Figs.169, 106) The degree of convexity is very uniform for both wide and narrow columns; in specimens from near "Wilangee", 49% of the 105 laminae measured have h/d in the range 0.2-0.3, with only 1% between 0.4 and 0.5. The distribution of lamina convexities for a Mount Woowoolahra specimen is similar: 68% of the 31 measured lie between 0.2 and 0.3 (Fig.16c).

Microstructure: Lamination is rarely well preserved. Where visible, it is indistinctly but continuously banded, with alternating predominantly dolomitic laminae 0.5 to 2.0 mm thick, and thinner, partly calcitic laminae. The dolomitic laminae are very continuous, but pinch and swell slightly along their length. They consist of equigranular hypidiotopic dolomite of grain size ranging from 0.01 to 0.04 mm. The calcitic laminae are much less continuous, and frequently consist only of irregular stringers of sparry calcite separating the dolomitic laminae. Small apophyses of sparry calcite frequently project from them into the dolomitic laminae. The calcitic laminae vary in thickness up to 1.2 mm, and frequently consist of coarse sparry calcite in crystallographic continuity. In places dolomitic laminae alternate with laminae composed mainly of dolomite but containing finely dispersed sparry calcite. Such laminae tend to be as continuous as the dolomitic laminae, and may reach a thickness of 2mm. The totally silicified stromatolites from Mount Woowoolahra have a similar microstructure, but laminae are poorly visible in thin section. Cut slabs show alternating relatively paler and darker grey laminae, which cannot be differentiated in thin section. These specimens consist of a granoblastic quartz mosaic of grain size ranging from 0.02 to 0.15 mm.

Interspaces: The spacing of adjacent columns varies from 0.5 to 5 cm. Interspaces are frequently bridged in the columnar-layered poorly bedded sediments. These consist either of dolomitized micrite or intraformational breccia. Flat, tabular dolomite clasts up to 3 cm long are randomly stacked in the inter-spaces, and are grain-supported at least in part. In places upturned clasts act as high points on which new column growth commences, (Figs.15,17). Intraclasts are entirely dolomitic, while the surrounding matrix consists of dolomite plus void-filling sparry calcite. The original nature of this matrix could not be determined; it may have been lime mud or sparry cement, in each case later dolomitized. The clasts may have been eroded as dolomite.

Secondary Alteration: These sediments are extensively altered, and the original nature of the stromatolitic laminae is not clear. The uniform hypidiotopic equigranular texture of the dolomite suggests that this is formed by replacement of a limestone, but it is uncertain whether or not the sparry calcite is a recrystallized remnant of the original limestone. It is equally possible that the sparry calcite has filled void spaces, which may be either primary (c.f. fenestral structures of modern intertidal and supratidal carbonates) or a secondary porosity due to dolomitization and/or dissolution. When traced into a silicified area, the sparry laminae appear as slightly coarser grained chert (up to 0.15 mm grain size). The silicification is cross-cutting and post-dates the formation of the whole structure. Chert is white, relatively coarse-grained, of grain size 0.02 to 0.05 and of granoblastic texture. Its contact with the carbonate is gradational and slightly sutured; relics of dolomite within the chert suggest that silicification post-dated dolomitization, and probably also the differentiation of the dolomitic and calcitic laminae. This difference is preserved in the chert only as a slight difference in grain size (as above) or as concentrations of carbonate inclusions. The sequence of events could be interpreted as follows:-

(1) Growth of stromatolites with calcitic laminae, possibly with fenestral fabric.

(2) Filling of the interspaces in places with lime mud and partly with flat pebbles which were possibly already dolomitized.

(3) Replacement of calcium carbonate of the stromatolites and interspaces by dolomite.

(4) Filling of void spaces (either primary or secondary) with coarse sparry calcite.

(5) Replacement of parts of the rock by silica.

(6) Metamorphic recrystallization.

Comparisons: These stromatolites are provisionally placed in the group Omachtenia although the preservation does not allow exact comparisons with any particular form. The shape of columns, the predominantly columnar-layered structure and the banded lamination closely resemble Russian representatives of the group. They apparently lack the cornices characteristic of most of these, but long, downward directed peaks are common. The consistently gently domed laminae without sharply deflexed margins most resemble those of O. omachtensis.

Distribution: In the USSR, O. omachtensis and O.utschurica occur in the Lower Riphean Gonam and Omakhtin suites, while O. givunensis occurs in the lowermost Middle Riphean Ennin Suite, all in the Uchuro-Maya Region. In South Australia, O. utschurica occurs in the Brighton Limestone, (Preiss, 1971a). In the Barrier Ranges, ?Omachtenia f. indet. occur in the Boco Formation, probably equivalent to part of the Lower Callanna Beds of South Australia.

Age: Lower Riphean to lowermost Middle Riphean in the U.S.S.R. In South Australia, O. utschurica is Late Adelaidean, probably equivalent to the upper part of the Upper Riphean.

## II Stromatolites from the Nunduro Conglomerate

Boulders of creamish - white dolomite are common in the Nunduro Conglomerate, and some contain probable stromatolites. These are visible only by the alternation of dolomite laminae with fine stringers of sparry calcite (cf. the laminae of specimens from the Boco Formation). On cut slabs the stromatolites are barely visible even when etched, and although column-like structures occur, their margins cannot be discerned. Laminae in these columns are frequently steeply domed to sub-conical and thus differ from the stromatolites of the Boco Formation; the laminated, column-like structures in places are almost in contact, and in places grade into less laminated sediment in which the sparry patches are coarser and more equidimensional. This may represent original interspace sediment. The stromatolites are too poorly preserved to allow reconstruction or comparison. The specimens may have suffered tectonic deformation; indeed some of the curvature of laminae may be due entirely to folding.

III <u>"Birdseye-like" limestones, Torrowangee Quarries</u>

There are both massive and laminated varieties of this rock in the Wammerra Formation of the Torrowangee Quarries. Field occurrence suggest that they all occur as slumped blocks. The massive type consists of randomly oriented irregular polygonal spar-filled vughs, 0.5 to 10 mm in diameter. The vughs are filled with several generations of carbonate: (1) some have an outer drusy rim of dolomite (radiaxially oriented elongated crystals), partly spalled off towards the centre of the vugh; (2) many have a rim of equigranular mosaic calcite; (3) all have a central cavity filled usually with a single large calcite crystal. The host sediment consists of an equigranular mosaic of xenotopic to hypidiotopic dolomite, itself containing some quartz silt and scattered xenotopic calcite crystals.

The laminated varieties have vughs which are elongated and aligned parallel to a lamination in the intervening carbonate. This lamination is of uniform, banded appearance, and sinuously folded, and is possibly stromatolitic, but no direct evidence of this was observed. The folding of laminae is probably sedimentary, but is unlikely to be the original shape of algal laminae. This sediment grades into the massive variety.

The origin of the vughs remains problematical; the textures of the generations of carbonate infilling suggest that the vughs were indeed void spaces; they are not the result of recrystallization. They could be either primary (i.e."birdseye" structures of Shinn, 1968) or secondary, due to solution of carbonate and later infilling by sparry cement. If they are "birdseyes" and the associated laminae are stromatolitic, then these rocks would indicate deposition in very shallow water, possibly in a littoral environment.

Tubular structures from boulders in the Nunduro Conglomerate

Dolomite boulders from the Nunduro Conglomerate at locality (10) contain chert-walled tubular structures (Figs.18,19), not seen anywhere in situ. Thus their relation to the original bedding is not known. In transverse section the tubes are strongly elongated, their longer dimension being up to five times the shorter. In thin section a slight foliation is seen in the dolomite parallel to the direction of elongation, and attenuation of the cherty walls parallel to the foliation shows that the tubes have been tectonically deformed. Cross sections of the tubes commonly measure 0.5 to 1.5 cm by 2 to 4 cm. The carbonate inside and outside the tubes consists of roughly equigranular hypidiotopic dolomite of grain size 0.008 to 0.015 mm, with scattered isolated xenotopic calcite crystals. Contacts of the matrix and the cherty walls are gradational, with the chert containing varying amounts of carbonate interstitial between quartz grains. In rare cases a curved transverse lamination is seen within the tubes.

A specimen collected by R.P. Coats in 1970 (F 182/70) was large enough to allow serial sectioning and three-dimensional reconstruction (Fig. 20). The tubular structures were seen to be only partially silicified, and the reconstruction revealed their branching habit. This, together with the internal convex lamination occasionally observed, suggests that these structures are highly altered columnar branching stromatolites with locally silicified column margins. The suggested original orientation is as shown in Fig. 20. The areas shown by cross-hatching are coarsely recrystallized.

These probable stromatolites are too highly altered to permit identification, and in their unaltered state they could have resembled any of a number of columnar branching forms. They are therefore not of stratigraphic value.

Table 1. Stratigraphic Correlation, Adelaide Geosyncline and Barrier Ranges. Plan No.S9633.

| Barrier Ranges Group | Barrier Ranges Subgroup | Barrier Ranges: West | Barrier Ranges: North | Barrier Ranges: East | Northern Adelaide Geosyncline | Northern Adelaide Geosyncline Subgroup | Northern Adelaide Geosyncline Group |
|---|---|---|---|---|---|---|---|
| FARNELL GROUP | | | | Lintiss Vale Fm<br>Camels Hump Qte. | ? Wonoka Formation | | WILPENA GROUP |
| | | | Fowlers Gap Formation<br>Faraway Hills Quartzite<br>Sturts Meadows Siltstone.<br>Mantappa Dolomite | | Ulupa Siltstone<br>Nuccaleena Formation | | |
| TORROWANGEE GROUP | Teamsters Creek Subgroup | ? | Nunduro Conglomerate<br>— | Dering Siltstone | Pepuarta Tillite<br>Mount Curtis Tillite | Yerelina Subgroup | UMBERATANA GROUP |
| | | Alberta Conglomerate | Alberta Conglomerate | | | | |
| | Euriowie Subgroup | Yowahro Fm<br>Tanyarto Fm<br>Wammerra Fm | Floods Creek Formation<br>Corona Dol | Mitchie Well Fm | Amberoona Formation<br>Tapley Hill Formation<br>Tindelpina Shale Member | Farina Subgroup | |
| | Yancowinna Subgroup | Waukeroo Fm<br>Yangalla Fm<br>Mulcatcha Fm | McDougalls Well Conglomerate<br>— | | Appila Tillite | Yudnamutana Subgroup | |
| | | HIATUS | | | HIATUS | | |
| | | | | | Myrtle Springs Formation<br>Skillogalee Dolomite<br>Copley Quartzite | | BURRA GROUP |
| | | | | | Upper Callana Beds | | CALLANNA BEDS |
| | | | | | HIATUS | | |
| POOLAMACCA GROUP | Wendelpa Subgroup | Wilangee Volcanics<br>Boco Formation | | | Wooltana Volcanics<br>Wywyana Formation | Lower Callanna Beds | |
| | Pintapah Subgroup | Christine Judith Conglomerate<br>Lady Don Quartzite | | | Paralana Quartzite | | |
| | | MAJOR UNCONFORMITY | | | MAJOR UNCONFORMITY | | |
| | | Willyama Complex | | | Mount Painter Complex | | |

... Stromatolites

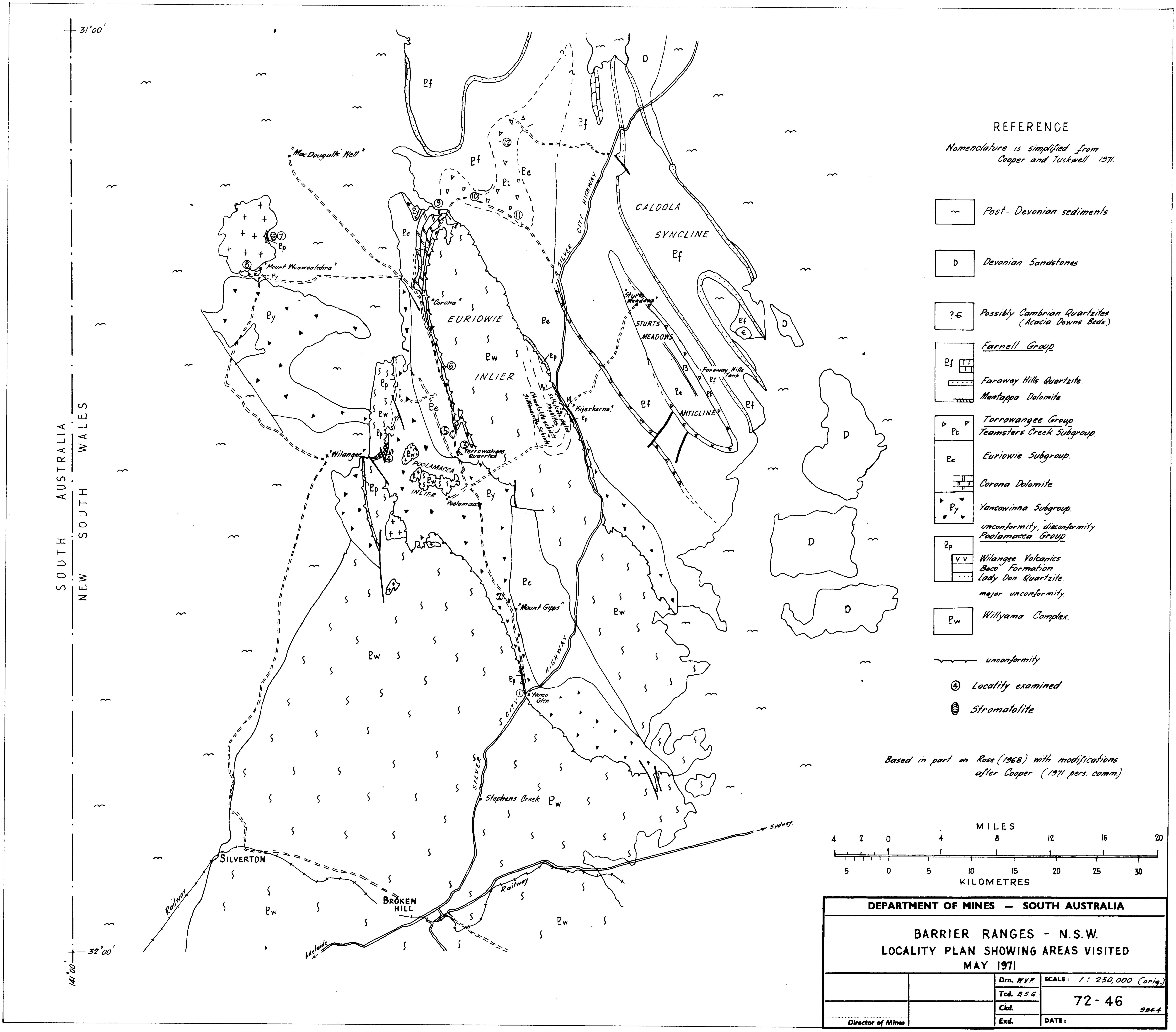
TABLE 1

| DEPARTMENT OF MINES – SOUTH AUSTRALIA | |
|---|---|
| Compiled: W. V. Preiss | Scale: – |
| Drn. B. S. G. Ckd. | Date: 3rd. Feb. '72. |
| ADELAIDE GEOSYNCLINE & BARRIER RANGES STRATIGRAPHIC CORRELATION (after Cooper and Tuckwell, 1971.) | Drg. No. S 9633 |

994·2+4

1M–2.70 A1810

Fig.1 Locality Map, showing geology simplified and modified from Rose (1968), and localities visited. The nomenclature is simplified from Cooper & Tuckwell (1971). Maps produced by Cooper and Tuckwell are yet unpublished. Plan No.72-78.


31°00'
32°00'
141°00'
SOUTH AUSTRALIA
NEW SOUTH WALES
REFERENCE
Nomenclature is simplified from Cooper and Tuckwell 1971.
Post- Devonian sediments
D Devonian Sandstones
?€ Possibly Cambrian Quartzites (Acacia Downs Beds)
Farnell Group
Faraway Hills Quartzite.
Mantappa Dolomite.
Torrowangee Group
Teamsters Creek Subgroup.
Euriowie Subgroup.
Corona Dolomite
Yancowinna Subgroup.
unconformity, disconformity
Poolamacca Group
Wilangee Volcanics
Boco Formation
Lady Don Quartzite.
major unconformity.
Willyama Complex.
unconformity.
Locality examined
Stromatolite
Based in part on Rose (1968) with modifications after Cooper (1971 pers. comm.)
MILES
4 2 0 4 8 12 16 20
5 0 5 10 15 20 25 30
KILOMETRES
"MacDougalls Well"
"Mount Woowoolahra"
"Corona"
EURIOWIE
INLIER
"Wilangee"
POOLAMACCA
INLIER
Poolamacca
"Torrowangee Quarries"
"Bijerkarno"
"Mount Gipps"
Yanco Glen
Stephens Creek
SILVERTON
BROKEN HILL
Railway
Adelaide
Sydney
SILVER CITY HIGHWAY
CALOOLA
SYNCLINE
"Sturts Meadows"
STURTS
MEADOWS
ANTICLINE
Faraway Hills Tank
DEPARTMENT OF MINES — SOUTH AUSTRALIA
BARRIER RANGES - N.S.W.
LOCALITY PLAN SHOWING AREAS VISITED
MAY 1971
Drn. W.V.P.
Tcd. B.S.G.
Ckd.
Exd.
SCALE: 1: 250,000 (orig.)
72 - 46
DATE:
Director of Mines

Neg. No. 22013.

Fig.2. Ripple-drift cross-lamination in siltstone associated with graded sandstones and diamictites, Yancowinna Subgroup, 2km north of Mt. Gipps H.S.

Fig.3. Intertonguing relationship between black siltstones and massive crystalline limestones, of the Wammerra Formation, western face of Torrowangee Quarry. The limestones are interpreted as filling large scour-channels in the siltstones.

Neg. No. 22014.

Fig.4. Similar relationships on the south-eastern face of the quarry. Note: in Figs.3 & 4, the shale-limestone contacts are indicated by the broken line.

Neg. No. 22014.

Fig. 2

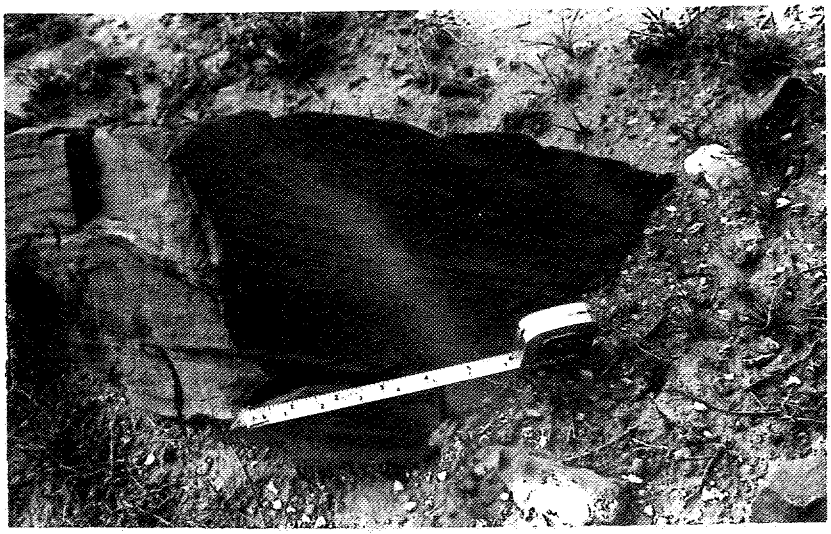


Fig. 3

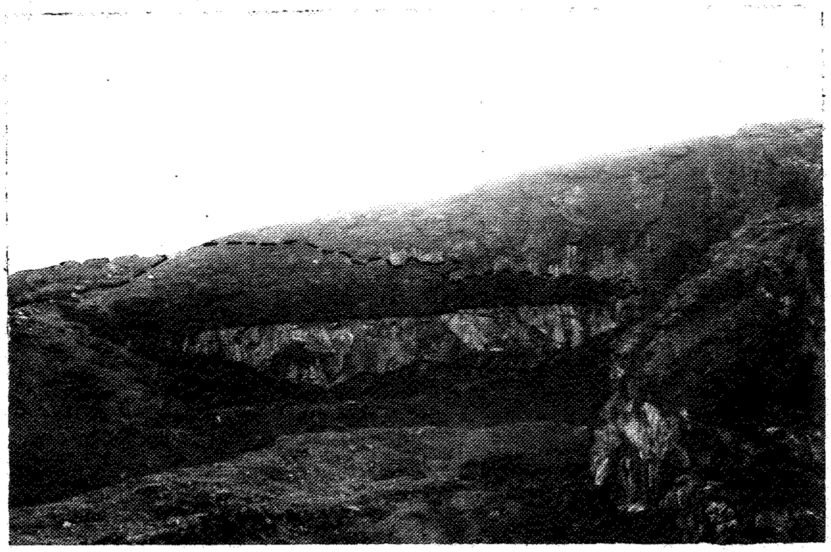


Fig. 4

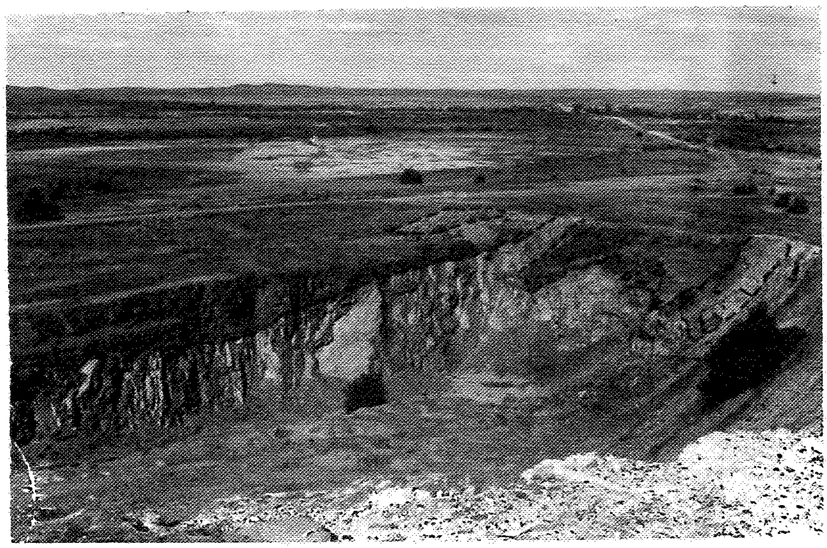


Fig.5. Unsorted limestone breccia, north of the Torrowangee Quarry, containing angular clasts of dolomite, limestone and chert.

Neg. No. 22015

Fig.6. Breccia containing a block of bedded dolomitic limestone with "birdseye-like" calcite-filled voids, aligned parallel to the be dding.

Neg. No. 22015

Fig.7. Small bioherm of pseudo-columnar stromatolites, surround and lapped on to by flaggy dolomite; Boco Formation, 6 Km east of Wilangee H.S.

Neg. No. 22016.

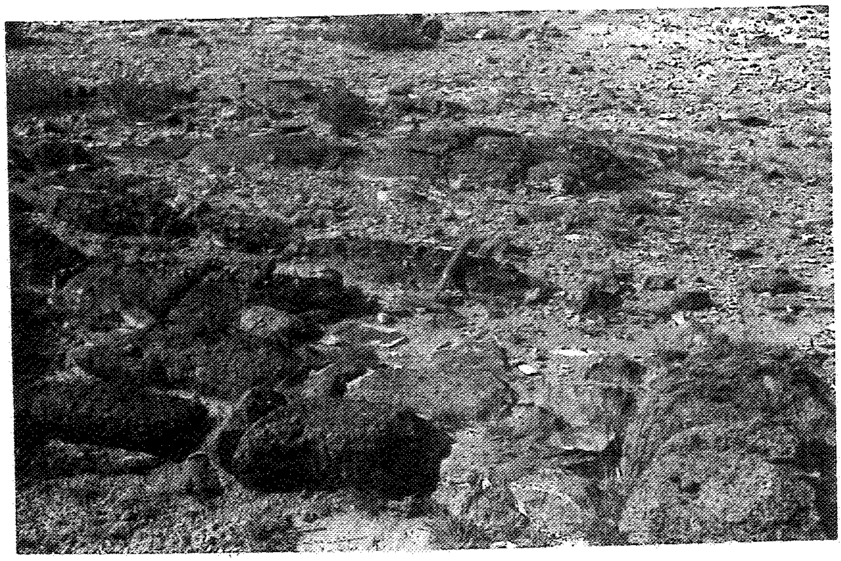


Fig. 5

Fig. 6

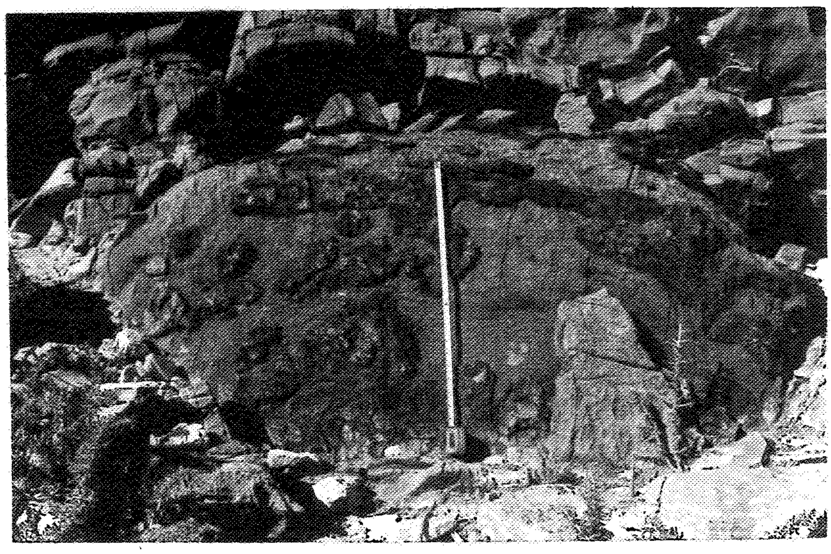


Fig. 7

Fig.8. Composite photograph of a series of juxtaposed bioherms, lapped on to at left and at right by flaggy dolomite. These stromatolites are only locally columnar, elsewhere pseudocolumnar or underlose. The chert lenses weathering out in relief do not faithfully follow the primary structure of the stromatolites, but are broadly concordant with the layering. Locality as for Fig.7.The tape measure is graduated in feet(30cm).

Neg. No. 22017.

Fig.9.Slump breccia limestone, Wammerra Formation, locality (5), north of the Torrowangee Quarries.

Neg. No. 22018.

Fig.10. Silicified rock, probably originally flaggy dolomite of the Boco Formation, near Mt.Woowoolahra. The white chert pods probably predate the main silicification, and correspond to chert pods seen near Wilangee H.S.

Neg. No. 22019.

Fig. 8

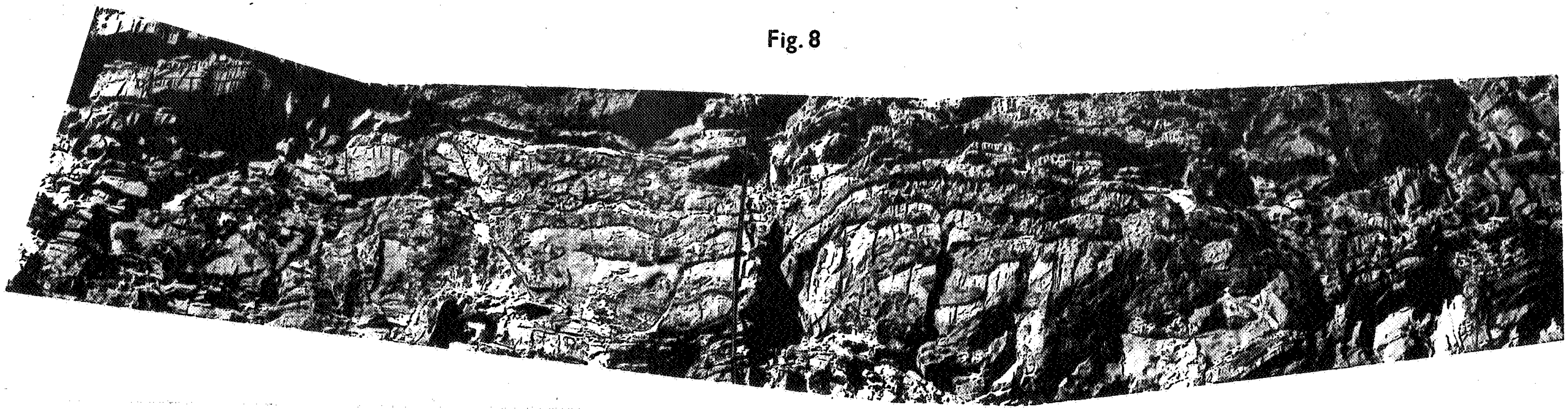


Fig. 9

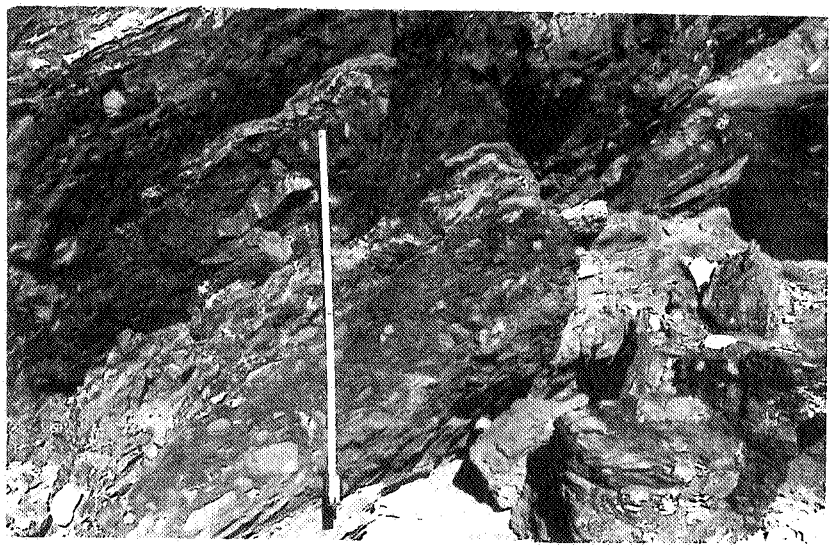


Fig. 10

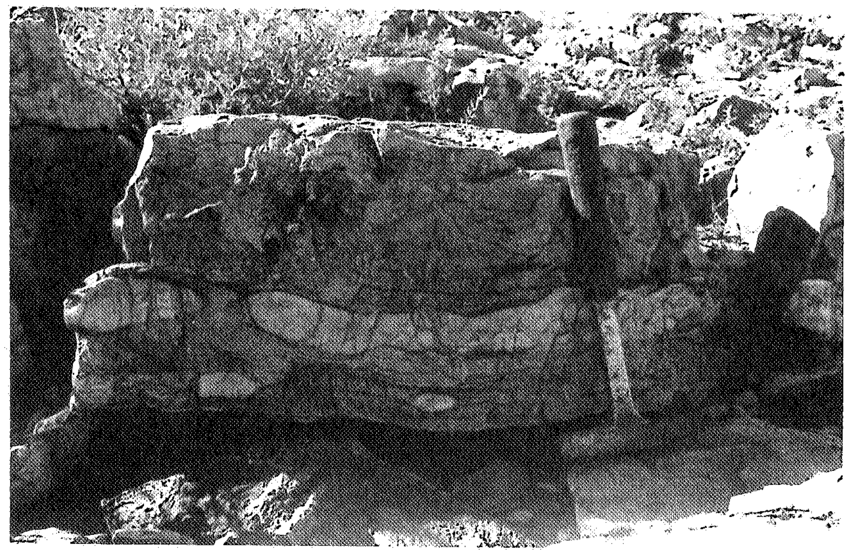


Fig.11. Part of a silicified bioherm, from which R.A. Callen's specimen (WP23) was collected; same locality as for Fig.10.

Neg. No. 22020.

Fig.12. Laminated siltstones with starved ripples draped by laminated shales, "Boggle Hill", locality (12).

Neg. No. 22021.

Fig.13. Laminated siltstone with graded fine sandstone interbeds and ripple-drift cross-lamination, "Boggle Hill", locality (12).

Neg. No. 22021.

Fig.11

Fig.12

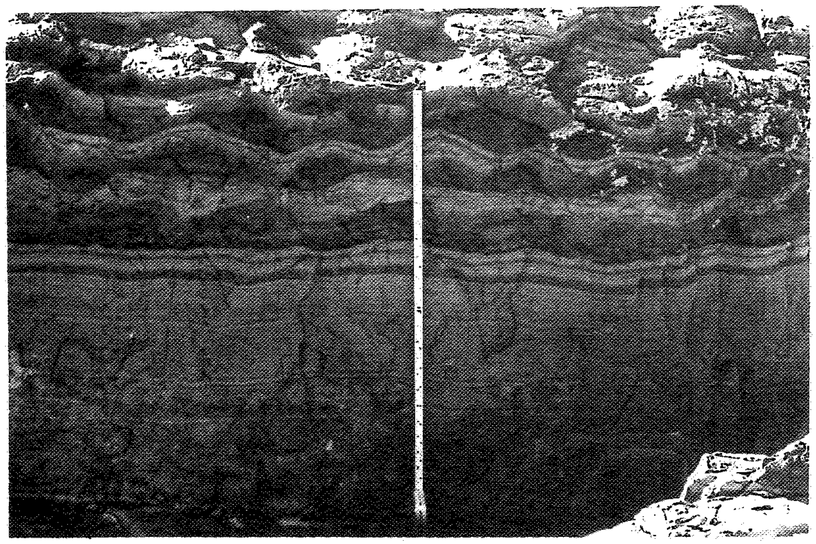


Fig.13

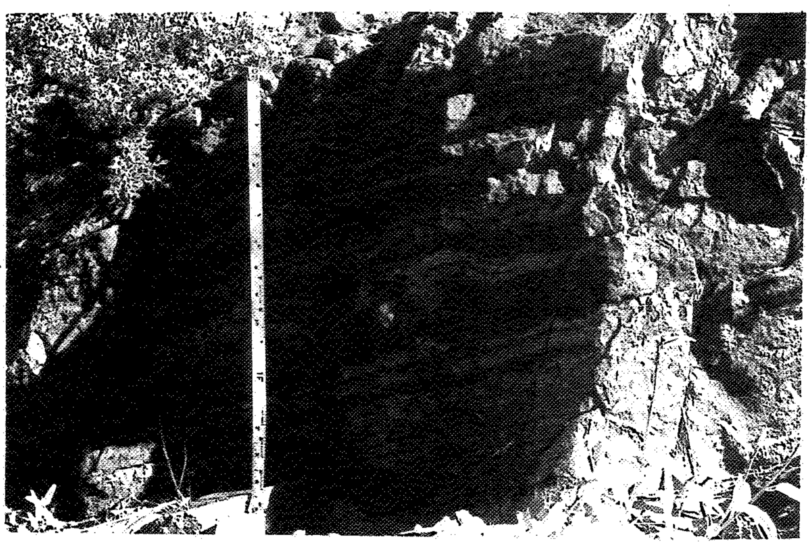


Fig.14. Large dropstone in laminated siltstones, Teamsters Creek Subgroup, locality (11).

Neg. No. 22022.

Fig.15. Reconstructions of ?Omachtenia f.indet., Boco Formation. The stippled areas on cut faces are silicified. (a) to (d) from near Wilangee H.S., and (e) from near Mt. Woowoolahra. Plan No.72-47 MG.

Neg. No. 22023

Fig. 14

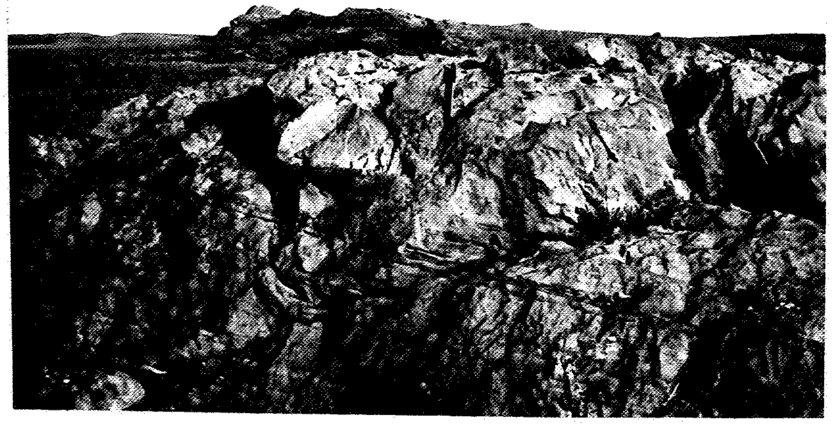


FIG. 15

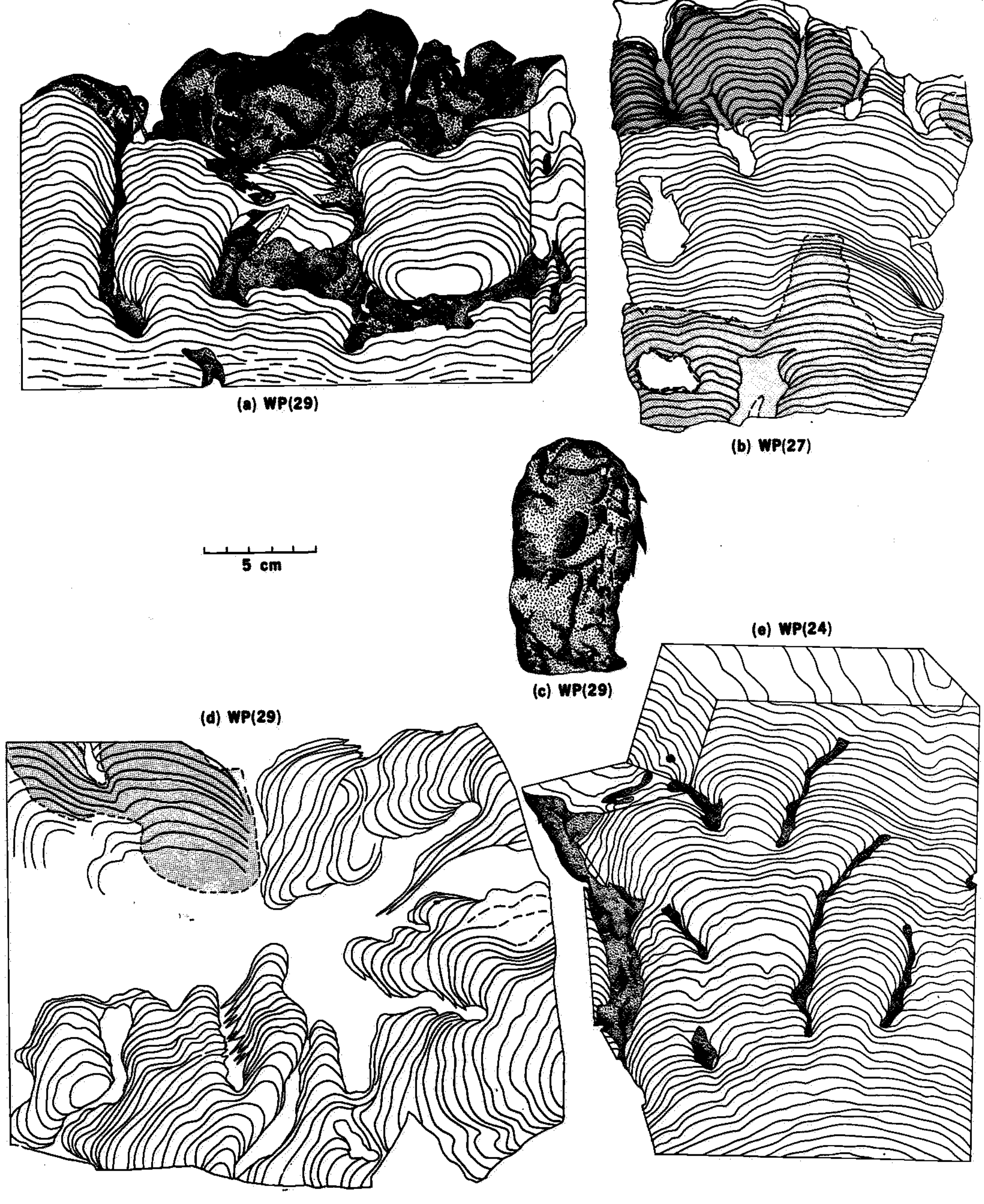


Fig.16 Lamina shapes of ?Omachtenia f.indet.

(a) 6 Km east of Wilangee H.S.
(b) Mt. Woowoolahra.
(c) Histograms of lamina convexity, Wilangee and Mt. Woowoolahra specimens.

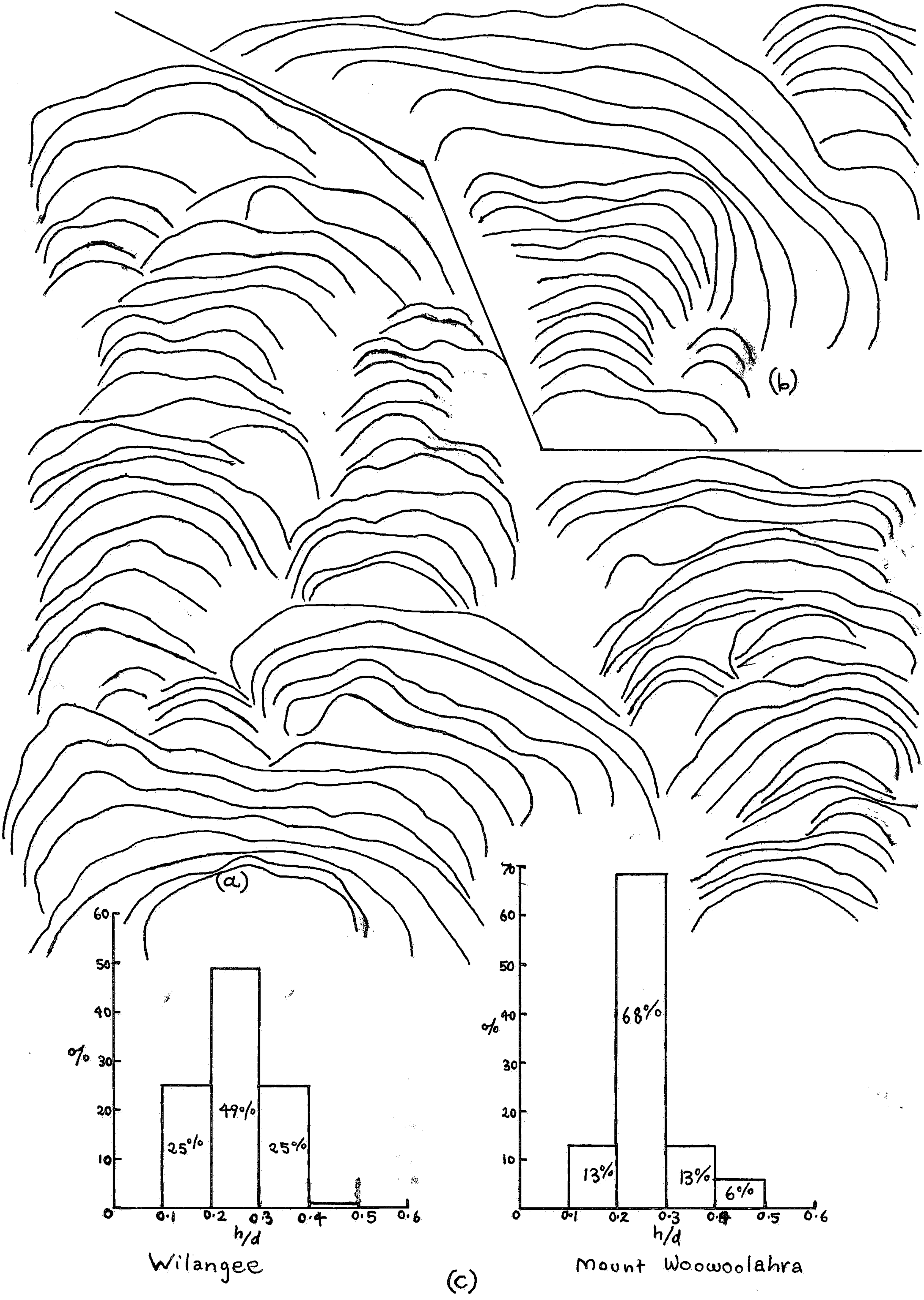

(a)
(b)
60
50
40
%
30
20
10
0
0·1
0·2
0·3
0·4
0·5
0·6
25%
49%
25%
h/d
Wilangee
70
60
50
%
40
30
20
10
0
0·1
0·2
0·3
0·4
0·5
0·6
13%
68%
13%
6%
h/d
Mount Woowoolahra
(c)

Fig.17 Photograph of slab, ?<u>Omachtenia</u> f.indet., 6 Km east of Wilangee H.S.

Neg No 22024.

Fig.18 & 19. Photographs of a boulder with chert-walled tubular structures, Nunduro Conglomerate.

Neg. No. 22025.


Fig. 17

Fig. 18

Fig. 19

Fig.20 Reconstruction of tube-like deformed stromatolites, boulder in the Nunduro Conglomerate. Plan No.S9665 MG.

Fig. 20

F182/70