University of Adelaide

Relationship between Callanna Beds and Adelaidean Cover, and the effect of syn- and post-sedimentary diapirism, Mt. Bayley Range area, Flinders Ranges, South Australia.

by

Leigh McPherson, B.Sc.

November, 1984.

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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, 1984.

National Grid Reference:
1:100,000 series SH549-6538.

This is dedicated to the memory of James Gray
who died in April, 1984.

A very good friend,
he will always be remembered.

FRONTISPIECE

The Puttapa Fault Block
western side of Puttapa Gap

ABSTRACT

Late Precambrian sedimentation in the Mt. Bayley Range area, Northern Flinders Ranges, was largely controlled by tectonism involving the Beltana Diapir. Diapiric uplift caused development of a small syn-sedimentary basin adjacent to the north-western side of the diapir. Sediments deposited within this basin, the Mt. Bayley Trough, exhibit lateral thinning and shallowing of facies and progressive onlapping of the Callanna Beds and breccia constituting the diapir. Conglomerates in the Brachina Formation show a bi-directional inflow of detritus, derived locally from the diapir. Basinal instability, pertaining to pulses of diapiric movement, occur within the Bunyeroo Formation, with the presence of diapiric detritus in non-glacial diamictites and conglomerates, and sedimentary slumping suggesting gravity transport.

Diapiric activity caused the development of local shallowing in a generally transgressive sequence within the Bunyeroo Formation. These diapiric bodies have later pierced the cover as thrust-faulted blocks.

A region to the north of the Mt. Bayley Range presents findings that concur with those of the Mt. Bayley Trough. A sedimentary contact between the diapir and the Bunyeroo Formation exists, with a transgressive rim dolomite unconformably overlying more intensely folded Callanna Beds. This region shows evidence of syn-sedimentary faulting during the deposition of the basal Bunyeroo Formation with resulting facies and thickness changes across faults.

ACKNOWLEDGEMENTS

I wish to thank Dr. Brian Daily for initiating this project at short notice and for the advice and encouragement he has offered. The Electrolytic Zinc Company, through the courtesy of Leigh Schmidt, provided facilities and financial support, without which this study would not have been possible. I am grateful to Nick Lemon of the Department of Geology, University of Adelaide, for his continued interest throughout the project. Evert Bleys and Geoff Trevelyon of the technical staff of the Geology Department, University of Adelaide gave assistance where possible. Mrs. Joan Brumby very kindly typed this thesis.

My family, particularly my parents, deserve recognition for the support they have always given, and for their immense tolerance throughout this year.

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CHAPTER 1 : INTRODUCTION

1.1 AIM OF THESIS

The primary objective of the study was to ascertain the relationship between the Beltana Diapir and the overlying sediments. As such, it was necessary to determine if syn-sedimentary and post-sedimentary diapirism had occurred and, if so, what influence had they exercised upon the cover sediments. A secondary consideration was the role of post-Bunyeroo Formation tectonism within the map area.

1.2 GEOGRAPHICAL SETTING

Location and access

The main study area (95 sq. km.) is situated approximately 15 km. south of Leigh Creek South, on the eastern side of the Main North Highway, 540 km north of Adelaide. Access was via motorbike, with passage through the range possible at Puttapa Gap to the north and Trebilcock Gap to the south. Both passes have roads that lead to Beltana. A supplementary study area (8 sq. km) to the northeast of the Mt. Bayley Range, near the E.Z. Willemite Mine, was also mapped (figure 1).

Physiography

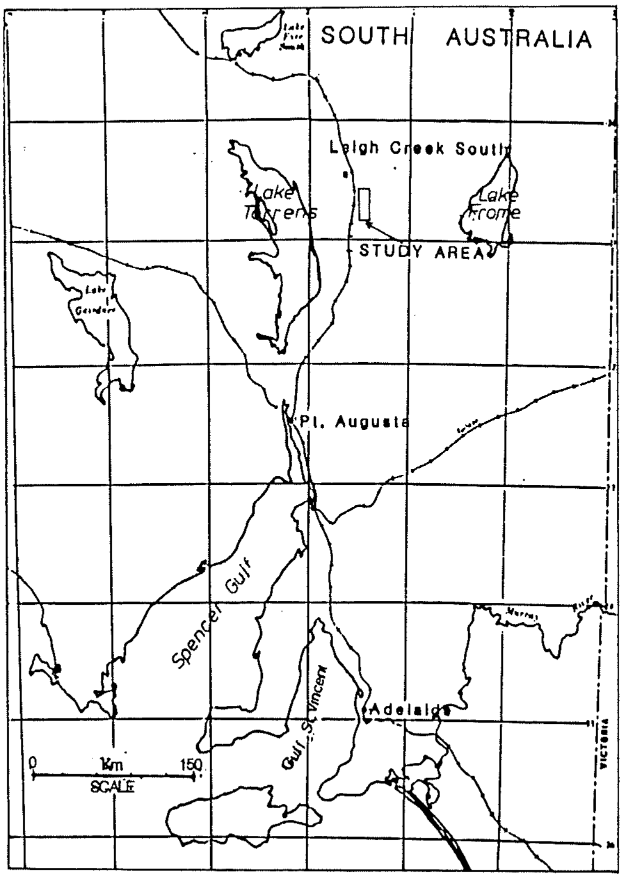
The topography of the region is dominated by the Mt. Bayley Range and the Beltana Diapir. The western face of the range is an imposing flat-iron structure which slopes down to an expansive scree-covered plain (Plate 8).

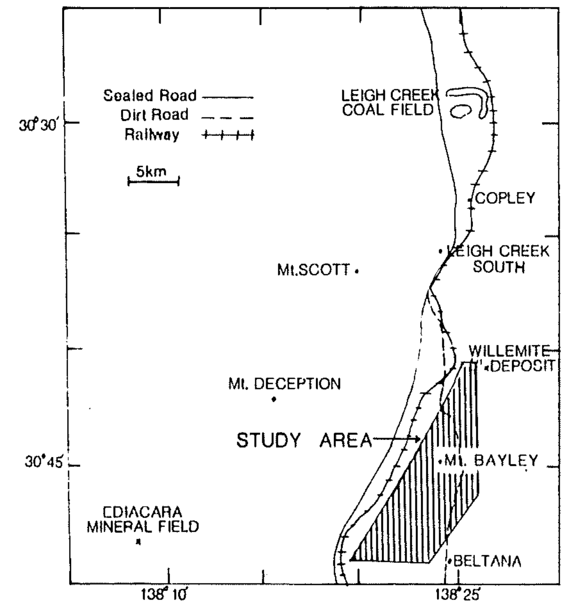
The eastern face of the range is a scarp which drops to a plain covered in a network of ephemeral creeks. The diapir forms a region of low, rugged hills. The Beltana area has an annual rainfall of 180 mm., and a semi-arid climate. Vegetation consists of eucalypts and sheoaks (*Casuarina*) near the creeks, and salt bush (*Rhagodia*) and blue bush (*Kochia cannonii*) on the plains.

1.3 PREVIOUS GEOLOGICAL INVESTIGATIONS

The northern section of the study area is depicted on the Copley map sheet (Parkin and King, 1952), whilst the southern and larger part of the study area appears on the Beltana map sheet (Leeson, 1966). Coats (1973) depicted the complete area on the COPLEY map sheet. The southern sector of the Beltana Diapir has been mapped by Smith (1968) for Carpentaria Exploration, and Daily (1971) prepared a report on the geology of the region near the E.Z. Willemite Mine. No detailed geological work has previously been attempted within this area.

FIGURE 1





LOCALITY MAP OF STUDY AREA

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1.4 REGIONAL GEOLOGICAL SETTING

The Mt. Bayley Range and environs form part of the Adelaide Geosyncline which consists of Late Proterozoic and Early Paleozoic sediments folded and disrupted by the Cambro-Ordovician Delamerian Orogeny. The region, which is in the Northern Flinders Ranges, lies close to the western margin of the Adelaide Geosyncline which is separated from the Stuart Shelf to the west by the Torrens Hinge Zone (Thompson, 1969). The line of the Mt. Deception fault scarp, 18 km. west of Mt. Bayley, marks the western limit of the Flinders Ranges (Leeson, 1970).

A near-complete sequence of Adelaidean sediments is present in the Northern Flinders Ranges, with the basal Adelaidean strata, the Callanna Beds of Willouran age, cropping out as incompletely preserved and partially disrupted sediments in anticlinal cores, fault blocks and diapirs. Coats (1973) recognised fifteen diapiric bodies on COPLEY.

The present topography of the Northern Flinders Ranges is due largely to Cenozoic tectonism within the Delamerian fold belt and post-tectonic erosional etching (Rutland et al. 1981), (Figure 2).

1.5 NEW TECTONIC ELEMENTS

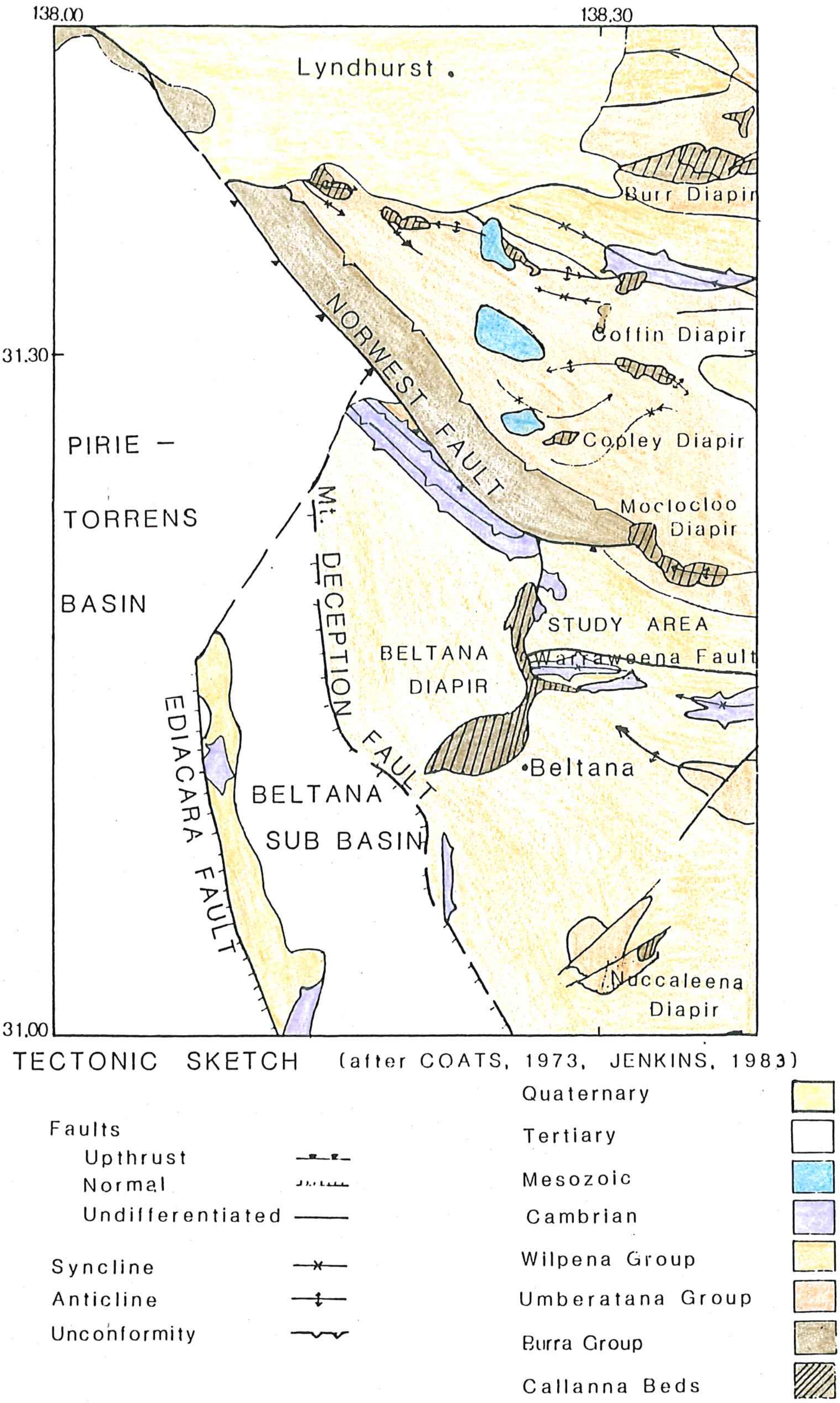
Several new names in this thesis require definition. There are three bodies of Willouran-age strata (Callanna Beds) emplaced within the Bunyeroo Formation on the western side of the Mt. Bayley Range. These are referred to in the thesis as the Puttapa Fault Block, The South Trebilcock Fault Block and the North Trebilcock Fault Block.

The Upper Adelaidean (Marinoan) sediments overlying the Beltana Diapir on the north-western side are collectively defined as the sediments of the Mt. Bayley Trough (see map in Enclosure).

1.6 METHOD OF STUDY

This project involved detailed mapping over a period of six weeks, from early June to early July, and from late August to early September of this year. Regional mapping techniques were generally used, with black and white 1:40,000 and 1:20,000 aerial photographs. The three fault blocks were mapped in much greater detail (50m quadrants in a peg-and-compass programme) due to their complex and chaotic nature. Thin section and acetate peel analyses of rocks were undertaken within the Geology Department, and those rocks referenced in the thesis are retained by the department with an accession number beginning 833/-.

FIGURE 2



REGIONAL GEOLOGY

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CHAPTER 2 : STRATIGRAPHY AND SEDIMENTATION

2.1 INTRODUCTION

Two stratigraphic units constitute the majority of the sediments within the study area. The Callanna Beds sediments (Thompson and Coats, 1964) of Willouran age comprise the main bulk of the Beltana Diapir (Leeson, 1966), and the fault blocks within the Mt. Bayley Trough. Wilpena Group sediments (Dalgarno and Johnson, 1964) of Marinoan age, constitute the cover sediments of the Mt. Bayley Trough and in the supplementary E.Z. Mine study area (Coats, 1973). They unconformably overlie the Callanna Beds in each area (Table 1).

2.2 CALLANNA BEDS*

2.2.1 Introduction

The Callanna Beds encompass a variety of shallow water, clastic sediments and carbonates associated with volcanics. Thompson and Coats (1964) took a sequence defined by Mawson (1927) in the Willouran Ranges as the type section, but Coats (1971) redefined the type section of the Lower Callanna Beds from the Mt. Painter region. The Callanna Beds intrude the upper Adelaidean cover as the Beltana Diapir and comprise the post-Bunyeroo fault blocks. Diapirs in the Adelaide Geosyncline contain blocks of quartzite, siltstone, dolomite and occasional volcanics derived from the Lower Callanna Beds (Coats, 1973).

The basal unit of the Lower Callanna Beds in the Mt. Painter region is the Paralana Quartzite, a clean cross-bedded, partly heavy mineral laminated and pebbly quartzite with minor siltstone and local talus breccia. Conformably overlying this is the Wywyana Formation, 100m of calcitic and dolomitic marble, calc-silicates and minor siltstones. This precedes the Wooltana Volcanics comprised of altered basalts, amygdoloidal in part, with minor rhyolite flows, quartzites, tuffs and calc-silicate metasediments. Above these is the Humanity Seat Formation, a sequence of cross-bedded, black, heavy mineral laminated sandstone with halite casts and purple and blue-grey shale partings, minor red sandstone and massive white quartzite. The Upper Callanna Beds, which rest unconformably on the Humanity Seat Formation, is a sequence of phyllites and conglomerates overlain by dark grey siltstones containing mudcracks, ripple marks and green dolomitic shales.

The depositional environments of the Callanna Beds have been interpreted as fluviatile to shallow marine (largely evaporitic) for the Lower Callanna Beds, and a lower energy, tidal flat to sub-tidal basin environment for the Upper Callanna Beds (Preiss, 1978).

*Thomson & Coats (1967) used the less lithostratigraphic term Callanna Beds since no complete section could be mapped on the structurally complex units (Preiss, 1978). This is used in preference to the more formal Callanna Group.

REGIONAL STRATIGRAPHY

	BELTANA DIAPIR	Mt.BAYLEY TROUGH	EZ MINE AREA
	QUATERNARY COVER	QUATERNARY COVER	QUATERNARY COVER
CAMBRIAN SYSTEM			AJAX LIMESTONE
			PARACHILNA FORMATION
			URATANNA FORMATION
MARINOAN SERIES			POUND QUARTZITE
			WONOKA FORMATION
		BUNYEROO FORMATION	BUNYEROO FORMATION
		ABC RANGE QUARTZITE	
		BRACHINA FORMATION: BAYLEY RANGE MEMBER	
		BRACHINA FORMATION: MOORILLAH MEMBER	
		BRACHINA FORMATION: MOOLOOLOO MEMBER	
		NUCCALEENA FORMATION	
WILLOURAN SERIES	CALLANNA BEDS	CALLANNA BEDS	CALLANNA BEDS

TABLE 1: Columns displaying stratigraphy of each region.

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2.2.2 The Beltana Diapir

The Beltana Diapir is a complex of large, disoriented blocks of quartzite and siltstone set in a matrix of breccia and tightly folded dolomitic siltstone. Some blocks, which measure up to 1 km in length, are large, relatively undeformed, competent masses, whereas the remaining sediments of the diapir are contorted and chaotic having undergone deformation which produces tightly folded siltstone and fractured dolomite. The nature of the outcrops makes it difficult to correlate these sediments with the stratigraphic units of the Mt. Painter region.

There are five main lithotypes within the diapir:

a) A sequence of banded quartzites that pass into blue/grey, thinly laminated siltstones, with pseudomorphs after halite, up to 0.5 sq. cm. Such a sequence occurs immediately east of Puttapa Gap, where pseudomorphs after halite hoppers and cross-bedding in quartzite show the block to be overturned, with the bedding dipping east and facing west.

b) To the north-east of Trebilcock Gap there are several very large blocks of heavy mineral laminated, medium-grained quartzite. These do not contain salt pseudomorphs.

c) The dominant lithology of the diapir is a sequence of blue/purple siltstone interbedded with yellow weathering dolomite. The dolomite contains pseudomorphs after gypsum and shortite. The sequence is largely obscured by scree but appears to consist of siltstone and minor fine-grained sandstone and dolomite. In some cuttings and creek beds the siltstone is tightly folded and exhibits abundant halite pseudomorphs. These sediments are associated with fine red sandstone that exhibits an efflorescence caused by the presence of salts. This is very common in Callanna Beds within the Flinders Ranges (Mount, 1975). (Plates 1 & 4).

d) Coarse and fine-grained dolerites.

e) Conglomerates: Polymitic conglomerates, dominantly quartzitic, with lesser amounts of dolomite and dolerite. Commonly show an in situ brecciation, particularly near fault zones.

2.2.3 The Beltana Diapir: Mode of Emplacement

Leeson (1966) mapped the complex of Willouran lithologies and argued that it was of diapiric origin, naming it the Beltana Diapir.

This determination of a diapiric origin for the complex is based on the disoriented nature of the blocks within the core complex, with blocks up to 2 km long appearing chaotically emplaced within a matrix of dolomitic breccia.

Plate 1.1:

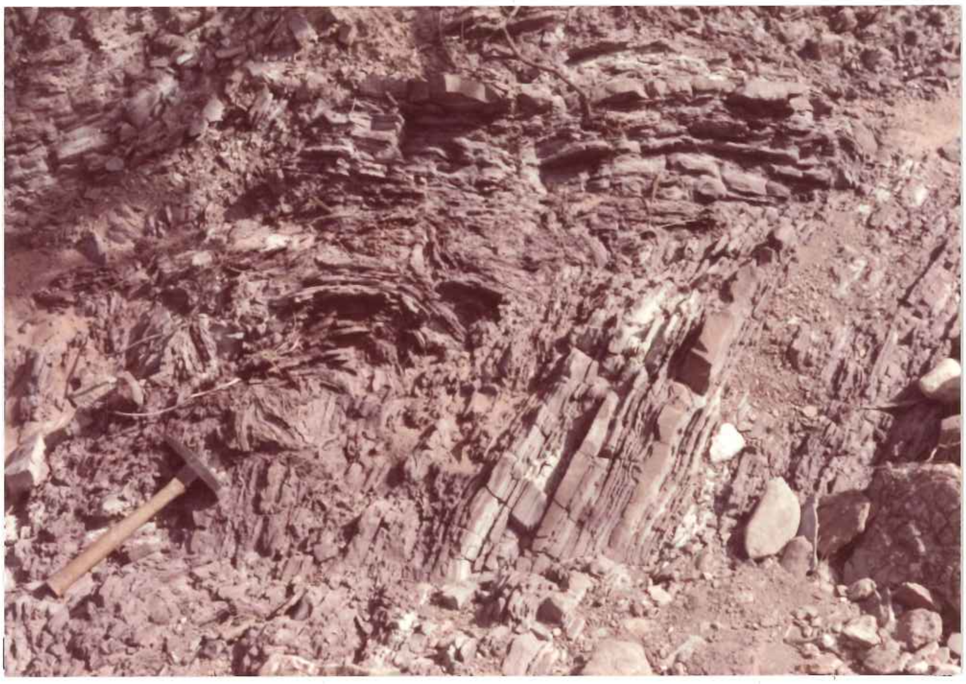
Diapiric flow breccia at Puttapa Gap within Callana Beds.
Matrix flows about dolomite clast.

Plate 1.2:

Tightly folded Callana Beds siltstone.

Plate 1.3:

Halite pseudomorphs on grey/purple siltstone.


As such, Leeson does not attempt to place any of the lithologies in a stratigraphic order as related to the type section of the Callanna Beds.

The diapiric mode of emplacement has been questioned by Smith (1968), who preferred to interpret the complex as a central horst fault-block surrounded by a zone of slump breccia. With this model, the central piercement zone is an emergent penecontemporaneous fault block, partly mantled and fringed by disturbed cover rocks, later deformed and intruded by younger igneous rocks.

With Smith's model, the penecontemporaneous block faulting is invoked as the important factor in the development of the piercement feature. This would largely replace the role formerly attributed to a mechanism analogous to salt diapirism.

Leeson (1969) replied to Smith's model, suggesting that both concepts had significant inadequacies, brought about by the nature of the outcrop within the complex. Nine major conclusions from mapping are listed by Smith, from which he develops his model. Leeson shows that most of these observations can be attributed to diapiric activity as well as the emplacement of a horst block. Smith's model would require a difference to the basement across the horst of the order of 7,500 metres, and one would expect some reflection difference on aeromagnetic contours, none of which are apparent.

The diapiric model proposed by Leeson is the preferred mode of emplacement, in the absence of significant evidence for the alternative by Smith.

2.2.4 The Post-Bunyeroo Fault Blocks

Three blocks containing Callanna Beds lithologies have been emplaced within the Bunyeroo Formation, very close to the top of the ABC Range Quartzite. The mode of emplacement and the structural aspects of the blocks are discussed in Chapter 3. A similar lithological component is evident in the three blocks, with large blocks of quartzite and dolomite set randomly in a matrix of tightly folded siltstones and diapiric breccia.

Puttapa Fault Block

There are two main lithologies within the Puttapa Fault Block. The western half of the block consists of tightly folded purple siltstone. Near the inferred western fault this siltstone is brecciated in situ. The eastern section of the block consists of diapiric breccia, contorted, fractured outcrops of dolomite, and fine red sandstone that exhibits an efflorescence. These sediments outcrop in the creek, with the hill sides scree-covered. The dolomite contains pseudomorphs after gypsum (small rosettes) and shortite, and minor quartzite contains halite pseudomorphs. The diapiric breccia is evident in the railway cutting, with rafts of dolomite set in a red, calcareous silty flow matrix.

South Trebilcock Fault Block

Scree from the western flank of the Mt. Bayley Range covers much of this block. Two main lithologies outcrop, with clean, featureless dolomite occurring on the northern side, and heavy-mineral banded quartzite with minor halite pseudomorphs lying to the south. The outcrops vary in size, up to 100m. long, and 3m. thick. The matrix consists of multi-coloured, red, orange and yellow finely laminated siltstone that has an ochre appearance. Diapiric breccia is found on the southern side of the block, cross-cutting the siltstone bedding, and containing large quartzite clasts set in a grey flow matrix.

North Trebilcock Fault Block

This block forms low-lying hills with very little apparent outcrop. The Callanna Beds quartzite forms a scree, and is a medium-grained, cross-bedded, heavy mineral banded, dark red sandstone with chert and halite pseudomorphs. The dolomite forms discrete, folded and fractured outcrops set in a matrix of intensely weathered red and orange siltstone. Purple siltstone and quartzite lie as clasts in a purple diapiric matrix near the north-western margin of the block. Pseudomorphs are absent from the dolomite, but are present in the quartzite (halite).

2.3 THE WILPENA GROUP

2.3.1 The Mt. Bayley Trough

A succession of Wilpena Group sediments, from the Nuccaleena Formation to the Bunyeroo Formation, occurs on the northwestern side of the Beltana Diapir in the Mt. Bayley Trough (Table 1). The Brachina Formation, which conformably overlies the Nuccaleena Formation, is the major unit of the trough, and it passes into the ABC Range Quartzite, the scarp-forming lithology of the Mt. Bayley Range. The succession youngs to the west, with the Bunyeroo Formation stratigraphically overlying ABC Range Quartzite. Sections measured across the Mt. Bayley Trough, rock thin-section descriptions and photographs referenced in the text are contained in Appendices 1-5.

2.3.2 The Nuccaleena Formation

This unit outcrops on the eastern margin of the Mt. Bayley Trough, 3.5 km. south of Puttapa Gap.

Facies description

The lower member of the Nuccaleena Formation is a cream-weathering, pink, micritic dolomite with a thickness of 2m and is laterally continuous for 2.1 km, and is fault bounded with northeast trending faults at each end. The dolomite is overlain by fine-grained, evenly laminated, purple shales which dip steeply east at 70^{o} to 80^{o}, and are overturned. A gradational boundary exists between the purple shale and the red siltstones of the lower Brachina sequence.

Figure 3a:

Diagramatic representation of the vertical and lateral change in facies within the Mt. Bayley Trough. The position of the sections 1, 2 and 3 are shown on the area map in the enclosure.

A coarsening upward sequence is evident. Laterally, the beds thin and coarsen toward the extremities of the trough that onlap the Beltana Diapir. A bi-directional flow of Callanna Beds detritus, constituting the conglomerate facies is evident.

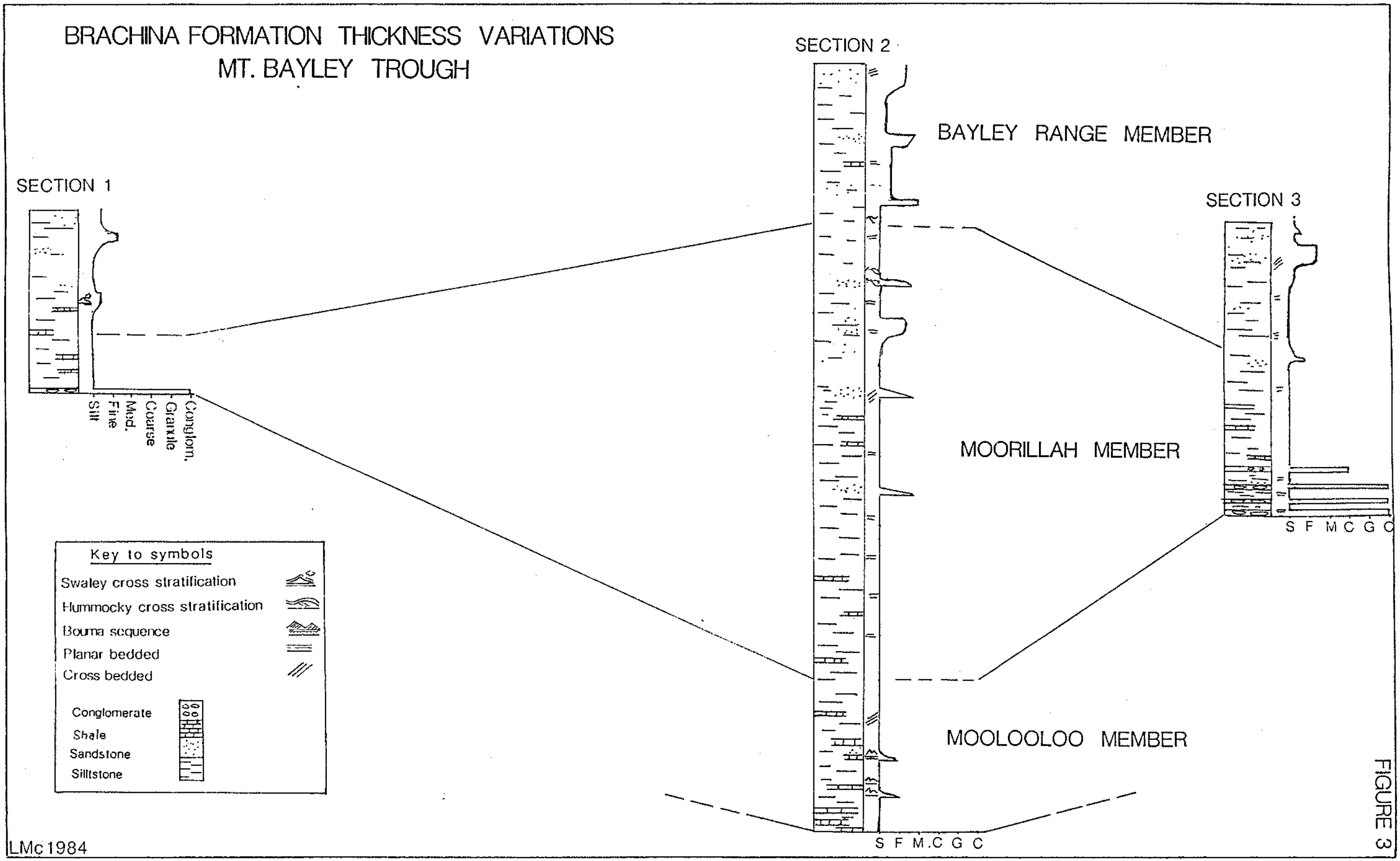

BRACHINA FORMATION THICKNESS VARIATIONS
MT. BAYLEY TROUGH
SECTION 1
Silt
Fine
Med.
Coarse
Granule
Conglom.
SECTION 2
S F M.C G C
SECTION 3
S F M C G C
BAYLEY RANGE MEMBER
MOORILLAH MEMBER
MOOLOOLOO MEMBER
Key to symbols
Swaley cross stratification
Hummocky cross stratification
Bouma sequence
Planar bedded
Cross bedded
Conglomerate
Shale
Sandstone
Siltstone
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FIGURE 3

Depositional environment

The Nuccaleena Formation was deposited under low energy, shallow subtidal conditions. The region was initially clastic deficient, with only carbonates being precipitated, but the purple shales of the upper Nuccaleena Formation were deposited in a very quiet, oxidising environment.

Diapiric detritus is unknown within the Nuccaleena Formation suggesting that it was deposited prior to diapiric activation. It's preservation is fault controlled, and it is presumed that the remainder of the formation beyond the graben was eroded by later exposure, possibly due to uplift of the diapir.

2.3.3 The Brachina Formation

The Brachina Formation, as defined by Leeson (1966), has three members, the Moolooloo, Moorillah, and Bayley Range Members. Three sections taken across the Mt. Bayley Trough (Sections 1, 2 and 3) show significant lateral facies variation that can be attributed to the proximity of the diapir. Thus, there is a decrease in the thickness of the members away from the centre of the trough, with consequent feathering out of the sediments which onlap the edge of the Beltana Diapir. (Figure 3).

2.3.3.1 The Moolooloo Member

Facies description

A transitional boundary from the purple shales of the Nuccaleena Formation to the red siltstone of the lower Moolooloo Member exists at section 3. The red siltstones underlie a sequence of olive-green and grey laminated shales and bedded siltstones. The green, featureless siltstones are occasionally interrupted by interbeds (10-15 cm thick) of siltstones displaying fully developed Bouma sequences (Bouma, 1962). The lower section of each is a graded sequence of coarse- to medium-grained siltstones (A), 6-8 cm thick, overlain in turn, by planar laminated (B), then rippled siltstones (C), which precede laminated siltstones (D), and finally massive mudstones (E), (t.s: 106A & B). As complete T_{ABCDE} sequences are present, the implication is that the site of deposition was very close to the sediment source (Pettijohn, 1975). Three beds containing the T_{ABCDE} sequence lie in a creek bed, approximately 30m apart, at locality.

Depositional environment

The red-purple shale overlying the Nuccaleena Formation was deposited under oxidising conditions. The succeeding olive-green shales and siltstones indicate a change to a reducing environment, the planar laminae suggesting very little current activity, and as such these beds are regarded as having been deposited in an anoxic basin. Occasional storm surges, as shown by the small turbidite sequence, imply intense activity for a short period between prolonged periods of calm. As Bouma sequences are characteristic of deposition Below

Storm Wave Base (Walker, 1981), it seems evident that the Moolooloo Member was deposited in much deeper water than the Nuccaleena Formation.

2.3.3.2 The Moorillah Member

This is the most prominent member of the Brachina Formation. A gradational boundary exists between the green siltstones of the Moolooloo Member and the red shaly siltstones of the Moorillah Member. The latter are finely laminated with interbeds of massive monotonous siltstone. It forms a scree on the eastern slope of the Mt. Bayley Range. A micro-rippling seen as sole marks on loose slabs. It's origin is unknown, yet is common both in the study area and within this member throughout the Flinders Ranges (Jenkins, 1983).

The Moorillah Member floors much of the Mt. Bayley Trough, unconformably overlying the Callanna Beds of the Beltana Diapir.

Conglomerate facies

In several places the basal contact with the Beltana Diapir is a thick band of conglomerate. Four conglomerate lenses, interbedded with siltstones, immediately overlie the contact 1 km south of the Puttapa railway hut ruins. The lenses consist of red, heavy-mineral banded, cross-bedded, subrounded platy quartzite clasts set in a matrix of red siltstone. Similar conglomeratic bands occur 2 km north east of Trebilcock Gap. The lenses show lateral grading, with fining away from the diapir for both sets.

Sandstone facies

Sandstone lenses and bands are evident in the Upper Moorillah Member. East of Trebilcock Gap, red and white sandstone bands (3-5 cm thick) with planar bedding occur in a dominantly siltstone sequence. These sands are moderately sorted, well-rounded and fine- to medium-grained.

Northward of these sands is a sequence of siltstone and interbedded sandstone which displays minor hummocky cross-stratification (HCS). The sandstone beds are 2-4 cm thick, discontinuous, and show a swale-hummock effect. The associated siltstone also shows low-angled cross-bedding (less than 10^{o}). (Plate 2).

Depositional interpretation

The Moorillah Member represents a shallower environment of deposition than that for the underlying Moolooloo Member. HCS is believed to be caused by storm activities similar to that which forms turbidites, but in a more shallow, below-fair-weather wave base environment. Intense storms can create a wave surge that will bring sands in as density currents. Deposition above storm wave base will cause HCS to form, the oscillatory motion of storm waves causing deposition of material over hummocks which were created by the erosional storm event (Harms et al. 1975). The red colouration of the siltstones suggests increased basin

Figure 3b:
Diagramatic representation of the apparent shallowing occurring within the Mt. Bayley Trough, based on the presence of Bouma Sequences, and hummocky and swaley cross stratification.

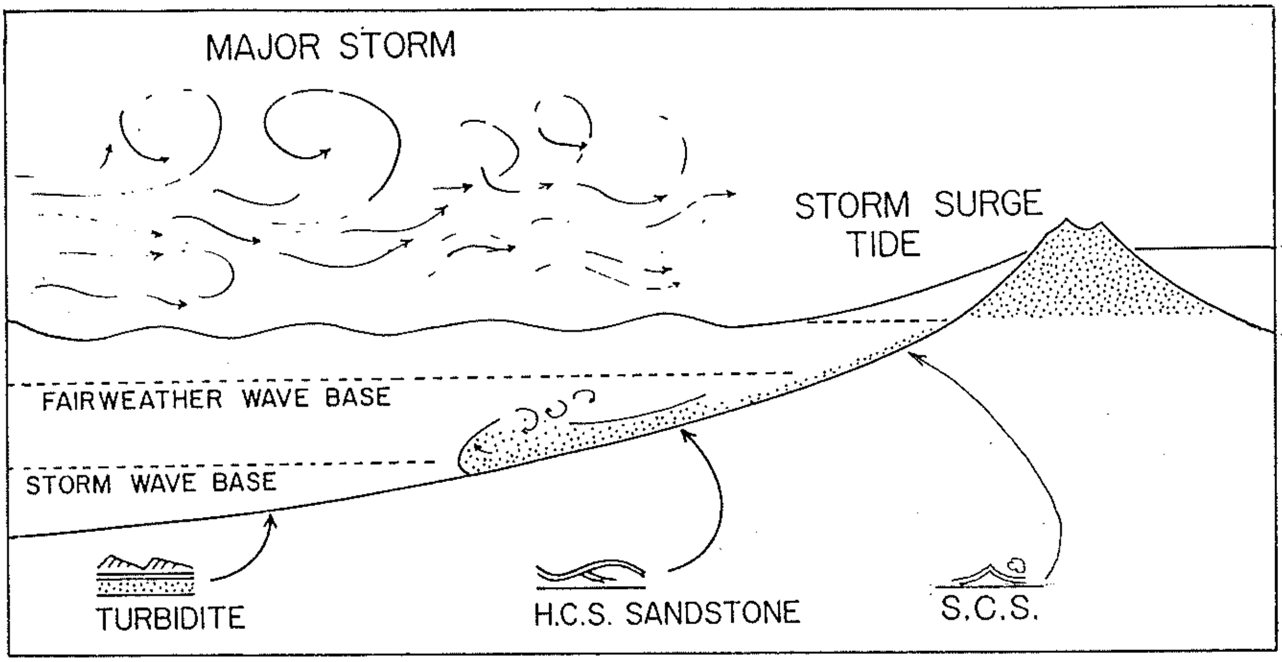

Diagram relates storm event to tidal activity, with the sedimentary features formed defining the depth of deposition. A single storm can develop a density current and form H.S.C. as sand was dropped from a density current into shallow water below fairweather base. If the density current flowed into water below storm wave base a normal turbidite would be deposited. S.C.S. is also a storm dominated structure, but is formed above fair weather wave base. (After Walker, 1981).

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circulation. A bi-directional source of the conglomerates is shown by the lensing and the lateral fining away from the diapir towards the centre of the trough. The conglomerates which were derived from the erosion of the diapir reflect diapiric activity during deposition of the Brachina Formation. There is a general thinning of the siltstone and shale beds laterally, as they progressively onlap the diapir.

2.3.3.3 The Bayley Range Member

Facies description

The red shaly silts of the Moorillah Member pass gradationally into a sequence of drab, olive-green laminated and thinly bedded shales, with minor sandstone lenses which show fine cross-bedding. On the south-eastern side of Trebilcock Gap, the upper seauence of the Bayley Range Member, the green shales exhibit swaley cross stratification (Plate 2.2, figure 3b).

Depositional interpretation

The green shales, similar to those of the Moolooloo Member, were deposited under shallow water conditions. Their green hue is believed to reflect the high organic content of the sediment (Plummer, 1978) at the site of deposition. The presence of SCS suggests deposition above fairweather wave base.

2.3.4 The ABC Range Quartzite

The ABC Range Quartzite (Dalgarno and Johnson, 1964) is the upper unit of the first transgressive-regressive cycle of the Wilpena Group (Rutland et al. 1981), and is considered by Plummer (1978) as the upper member of the Brachina Subgroup, which defines the limits of the first cycle (Plate 2.3).

Facies description

There is an increase in sand content towards the top of the Bayley Range Member, reflecting continual shallowing. It passes gradationally into thick sandstones at the base of the ABC Range Quartzite, which is a massive, clean, white orthoquartzite member. The upper member is a medium-grained, heavy-mineral banded feldspathic sandstone. A green siltstone, 3m to 9m thick, splits the two units. The very top of the ABC Range Quartzite consists of a micro-conglomerate near Puttapa Gap, and a cobble conglomerate south of Trebilcock Gap. The micro-conglomerate has well-rounded, frosted grains of quartz, chert and minor heavy minerals. In the scree on the western side of the Mt. Bayley Range, near Trebilcock Gap, desiccation cracks are present on loose slabs of quartzite.

Depositional interpretation

The facies within the ABC Range Quartzite suggests that the depositional environment was an intertidal sand flat, the coarse detritus coming from a local fluviatile source, as the ABC Range Quartzite shallowed onto the Beltana Diapir at either extremity of the Mt. Bayley Range.

Plate 2.1:

Sandstone and silt displaying hummocks (H.C.S.) within the Moorillah Member.

Plate 2.2:

Swaley cross-stratification: silts sit on shales, Trebilcock Gap, Bayley Range Member.

Plate 2.3:

Massive cross-bedded ABC Range Quartzite, Trebilcock Gap.

2.3.5 The Bunyeroo Formation

The type section of the Bunyeroo Formation (Dalgarno and Johnson, 1964) at Brachina Creek, is a sequence of slightly calcareous purple and green shales. The Bunyeroo Formation in the Mt. Bayley Range consists predominantly of calcareous purple and lesser green siltstones, conglomerates, and minor edgewise dolomitic breccia, dolomicrites, non-glacial diamictites and volcanoclastics.

A significant factor of the Bunyeroo Formation is the almost complete lack of definitive sedimentary features. As such, the expression of facies changes is largely masked, and the interpretation of the depositional environments have differed greatly. Mawson and Signet (1948) concluded that evidence favoured a terrestrial loessal origin, whereas Gostin and Jenkins (1983) have suggested that the Bunyeroo Formation represents a starved basin in a moderately deep marine environment. In the study area sections were taken across the Bunyeroo Formation at Puttapa Gap, Trebilcock Gap, and approximately 3 km south of Puttapa Gap. The facies recognised are as follows:

Red and green siltstone facies

The red siltstones form the dominant lithology of the Bunyeroo Formation. The siltstones are well-sorted, quartzose and show faint bedding. The green siltstones are more localized, appearing in association with micritic dolomites, in pods and lenses (Plates 6.1 & 6.2).

Conglomerate facies

Conglomerates are present at Puttapa Gap and Trebilcock Gap. On the southern side of Puttapa Gap the sub-angular to angular clasts are mud-supported, in an open framework. The conglomerate is up to 25m thick and shows reverse grading in its lower part, grading from pebbles to cobbles. On the south side of Puttapa Gap the mud matrix predominates. On the northern side of Puttapa Gap the conglomerates have less mud matrix, and some are clast supported and show a slight imbrication. The conglomerates are effectively monomictic, with over 95% of the clasts being red, heavy-mineral laminated, platy quartzites. Minor dolomitic clasts are evident. Several of the quartzites contain pseudomorphs after salt, suggesting that the Beltana Diapir was the source (Plates 3.2 & 3.3).

The conglomerates at Trebilcock South form a large lense, 80m long, with an average thickness of 3m and are essentially monomitic. The conglomerates have a closed framework, and the quartzite clasts are generally of cobble size, set in a minor sand matrix. The clasts appear to have come from a Callanna Beds source.

Volcanoclastic facies

A thin band in the lower Bunyeroo Formation (4m) north of Trebilcock Gap, has the appearance of a tuff in thin section. There is a significant amount of microcline (cross-hatched twinning), with lesser amounts of plagioclase and calcite, in a dominantly quartz-rich (65%) rock. The quartz appears to have a dual source. Some are sub-rounded to rounded, others are highly embayed, splintery, showing conchoidal fractures. This suggests that the rock has been derived by mixing of a normal detrital component with volcanic detritus, probably a rhyolitic tuff. Jenkins (1983) has found a similar 'tuff' or volcanoclastic in the eastern Flinders Ranges.

Dolomite facies

At Puttapa and Trebilcock Gaps, dolomite is a significant component of the Bunyeroo Formation. The purple to red dolomites are unbedded, micritic and weather buff yellow to pale red. At Puttapa Gap the dolomicrites closest to the diapir contain pebbles of Callanna detritus, mainly platy quartzites embedded in a dolomitic matrix. The clast-rich dolomites form edgewise conglomerates on the western side of the diapir. There is a transition from pebbly dolomite to a clean dolamicrite away from the diapir. The Trebilcock dolomites are clast-free and clean micritic and red-purple coloured. Green siltstones, deposited in a reducing environment, enclose the dolomite pods and lenses. The Puttapa dolomites are folded into an anticline and syncline which appear to be related to the emplacement of the Puttapa Fault Block. The Trebilcock dolomites are not folded, and exhibit an en echelon arrangement within the siltstone sequence. The Trebilcock dolomites are discontinuous bands, from 2m to 60m long and 0.5m to 1.5m thick. The dolomites at Puttapa are much more extensive, and are up to 20m thick (Plates 5.1 & 5.2).

Diamictite facies

A conspicuous sequence of a diamictite is present in the Puttapa Gap railway cutting. The lithology consists of grey siltstone clasts, generally of small pebble size, set in a red Bunyeroo Formation mudstone matrix. The clasts form up to 35% of the rock, the diamictites being interbedded with siltstones.

Depositional interpretation

There are significant lateral facies changes within the Bunyeroo Formation of the Mt. Bayley Trough that appear associated with diapiric activity.

A notable aspect of the Bunyeroo Formation is the general lack of sedimentary features. Red beds, which constitute the dominant facies, can form in a variety of environments from marine to continental (Von Houton, 1973).

The association of dolomites with red and lesser green siltstones implies a shallow water environment of deposition. The red beds are fine siltstones, and this could explain the lack of sedimentary features. Thompson (1968) has demonstrated that grain size can largely determine the nature of tidal flat deposits. In the Gulf of California, tidal currents move over the flats as broad uniform flows with little tendency to develop channels. Thompson (1975) believes this is due to the fine size of detritus supplied by the Colorado river (fine silt and clay).

Desiccation cracks, which are commonly seen on tidal flats, have not been seen in the Mt. Bayley Trough, but Leeson (1970) states that mudcracks are present in the Bunyeroo Formation in a section immediately south of Beltana.

The dolomites are generally featureless, except where they are conglomeratic or exhibit intraclast breccias as at Puttapa Gap (Plate 5.3).

The pods of dolomite may have been formed in ephemeral carbonate lakes as in the modern Coorong area in South Australia (von der Borch, 1975), or in restricted lagoons marginal to the sea. As such, seaward flowing shallow groundwaters enriched in $Mg(HCO_3)_2$ may have been dominant factors in the hydrology of the ephemeral carbonate lakes or shallow lagoons. During summer, evaporation may have resulted in the lagoons being restricted to lakes in which dolomites could form. Although sulphates and evaporites would normally be associated with such an environment, no such evidence exists at Puttapa Gap, but in a dynamic system these could be washed out. The presence of dolomitic intraclast breccias at Puttapa Gap suggests sub-aerial exposure and desiccation of the dolomites, and minor reworking before re-lithification, as would be anticipated in ephemeral lakes or in a supratidal, intertidal zone. Von der Borch (1975) suggests that such structures are common in the upper part of modern regressive coastal plains. The source of the ions for the dolomite could have been the Beltana Diapir. The volcanics and associated dolerites would have provided sufficient magnesium, but such a theory is conjectural.

The dolomites are spacially associated with the fault blocks, and if diapiric uplift began in Bunyeroo times, a local shallowing would have resulted, thus leading to local regressions (see Chapter 3, p.17).

The dolomites at Puttapa Gap contain quartzite clasts of Callanna Beds origin. They are rounded, platy pebbles, they could have been carried into the supratidal or lagoonal environment during intermittent flooding Several dolomite pods contain imbricated quartzite clasts formed by unidirectional flow in a lower flow regime than the conditions that the other conglomeratic dolomites were deposited in.

On the overturned limb of the Puttapa Syncline (figure 6) there is a thick conglomerate stratigraphically overlain by a slumped siltstone unit and a turbidite derived diamictite, the latter two suggesting slope instability and failure (figures 4a, 4b & 5, and Plates 4a & 4b).

The conglomerate unit thickens from 0.5m north of Puttapa Gap to 17m thick south thereof. At its northern limit the conglomerate is clast supported, with a sand matrix, and is not graded. In contrast to this, the conglomerate which occurs 1700m to the south is generally a massive mud-supported debris flow deposit with poorly sorted, sub-angular clasts in a structureless matrix. This overlies a basal, 3.5m thick conglomerate showing reverse grading, common to mass flow deposits (Fisher, 1971). The southern conglomerates lie on the normal, east limb of the Puttapa syncline, the overturned limb having been cut out by a thrust fault. The conglomerates reflect instability in the upper limits of the depositional slope adjacent to the then contemporary shoreline.

Overlying the conglomerate is a siltstone unit that contains sedimentary slump features. The slumped and contorted beds lie between normal conformable siltstones (Plate 3.1).

The diamictites are conspicuous in the railway cutting, forming a 14m sequence of interbedded diamictites and purple siltstone. This reflects intermittent turbidite pulses, followed by normal quiescent phases of siltstone deposition. There is a general decrease in clast to matrix ratio within the diamictite/siltstone sequence. The grey siltstone clasts which predominate, appear to have been derived from the Callanna Beds within the Beltana Diapir.

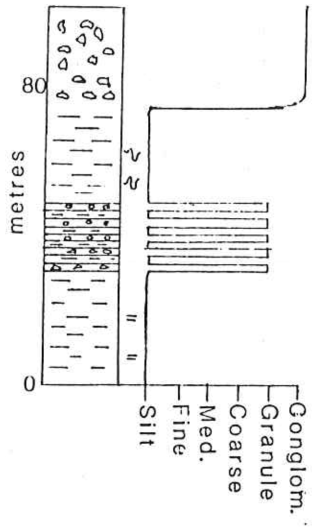
Figure 4a:
Columns showing the overturned sequence at Puttapa Gap.

Figure 4b:
Representation of the order of deposition caused by diapiric movement, with sediments destabilized and shed down the slope.

Figure 5:
Diagram of the reverse drag fold within Bunyeroo Formation siltstone on the overturned limb of the Puttapa Syncline, in the railway cutting.

FIGURE 4

4 A



Overturned sequence on the western limb of the Puttapa Syncline. The correct sequence is shown schematically in figure 4B with the mass debris flow conglomerate deposited first, overlain by silts and diamictites.

√ Slumps
= Planar bedding

4 B

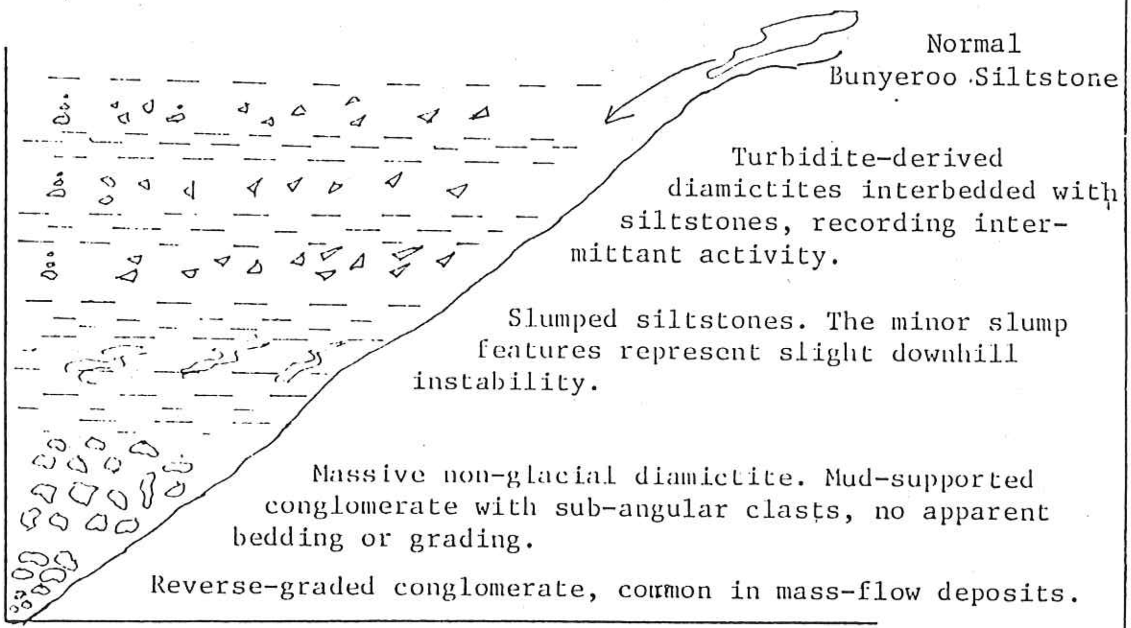
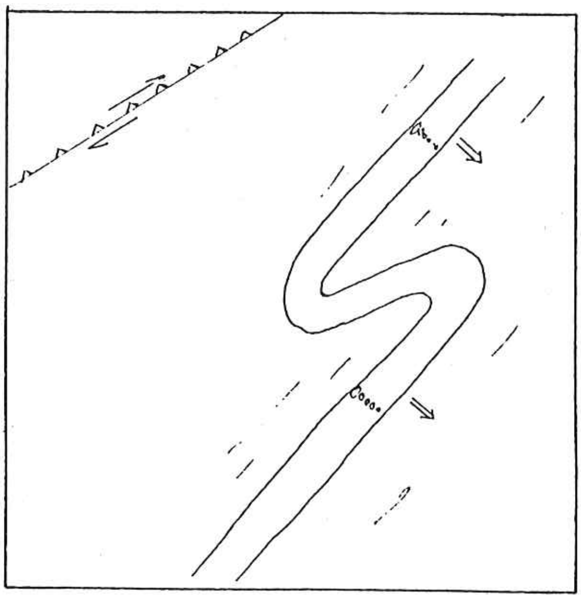


FIGURE 5



Drag fold within siltstone. Facing, shown by arrows (grainsize) shows fold to be overturned.

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Plate 3.1:

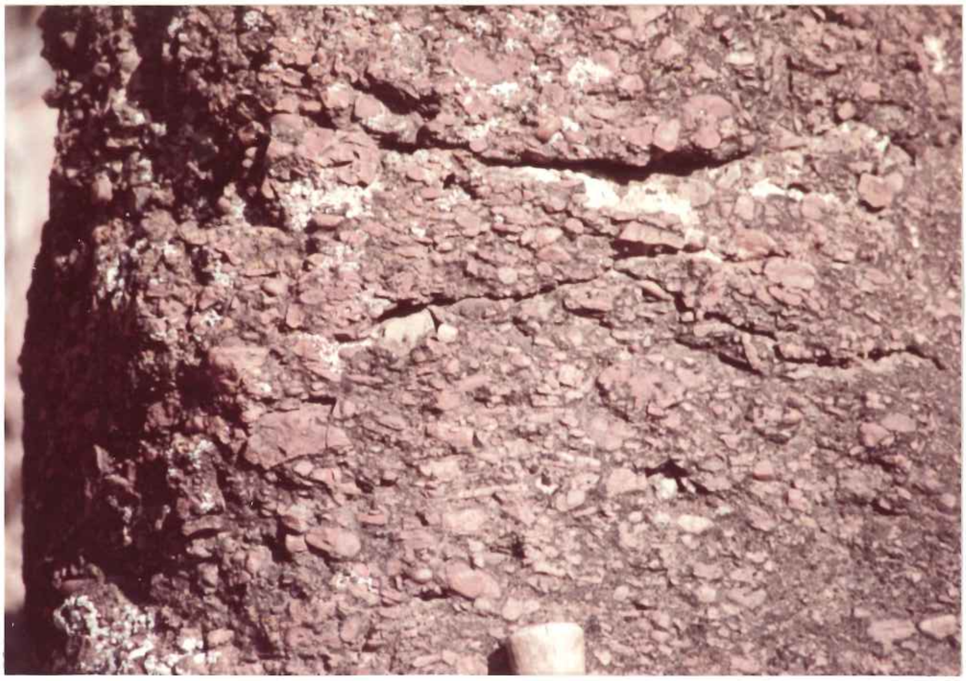
Sedimentary slump features - Puttapa Gap.

Plate 3.2:

Closed framework conglomerates, north of Puttapa Gap.

Plate 3.3:

Open framework conglomerate (debris flow diamictite deposit) south of Puttapa Gap.



CHAPTER 3 : POST-BUNYEROO FAULT BLOCKS

3.1 INTRODUCTION

Leeson (1966) and Coats (1973) have mapped two blocks of Callanna Beds sediments emplaced within the Bunyeroo Formation near Trebilcock Gap as diapiric intrusions, and Coats (1973) mapped a third such block near Puttapa Gap as part of the Beltana Diapir. The lithologies of the bodies are discussed in Chapter 2.

The present topographical disposition of the three fault blocks make the accurate determination of their mode of emplacement difficult. The blocks sit within the largely scree-covered western flank of the Mt. Bayley Range. In order to resolve their mode of emplacement, the blocks were mapped using 50m x 50m quadrants in a north-south grid system.

There are three possible means by which the blocks could have been emplaced in the Bunyeroo Formation.

a) Diapirically intruded. Diapiric breccia has been found in all three blocks, and at Puttapa Gap and Trebilcock North marginal breccias occur.

b) Block faulting.

c) Sedimentary deposition. The apparent random assortment and placement of large blocks could have been caused by gravity mass transport from the Beltana Diapir.

3.2 THE PUTTAPA FAULT BLOCK

This block is present near the western entrance to Puttapa Gap. It forms small hills on the southern and northern sides of the main road, and is believed to be faulted against the Beltana Diapir on its northern extremity but Quaternary cover masks a potential contact. A cutting on the disused narrow-gauge railway provides an excellent section through the block. On the eastern side of the block Callanna Beds are faulted against a folded sequence of the ABC Range Quartzite and Bunyeroo Formation siltstone and conglomerate. The western block margin is faulted against a folded sequence of Bunyeroo Formation siltstone, dolomicrite and pebbly dolomite units.

A low angle reverse fault forms the eastern contact between the Puttapa Fault Block and the Bunyeroo Formation. The fault trends northeast at 34^{o}, the fault plane dipping west at 22^{o}, and the Callanna Beds rest on the upthrown side, which lies against the overturned west limb of a south plunging syncline (figures 6 & 8A).

The evidence for the fault contact is:

a) The shallowing of the Bunyeroo Formation bedding from 45^{o} west to 24^{o}W on approaching the fault zone (in the railway cutting).

b) The presence of a crush zone in the silts of the Bunyeroo Formation close to the contact, such that the siltstones have lost all structure due to intense brecciation (Plate 7.1).

c) Fault breccia overlies the fault contact within the Callanna Beds. These siltstones are intensely weathered, but in situ brecciation of clasts is evident.

d) The western limb of the syncline is overturned against the fault. The eastern and normal limb dips west at 40^{o} near the railway line, but north of this the beds steepen up and overturn near the nose of the fold, causing the western limb to dip east and face west. The beds of the ABC Range Quartzite overturn sympathetically with the Bunyeroo Formation siltstones. This is the result of uplift of the fault block, comprised of Callanna Beds, causing drag folding to develop within the Bunyeroo Formation. A reverse drag fold on the western limb is evident in the railway cutting, below the fault (figure 5).

e) On the southern side of the road the thrust fault lies between a thick sequence of Bunyeroo Formation conglomerate and Callanna Beds quartzite and dolomite. Callanna Beds on the fault contact exhibit in situ brecciation of clasts, representing a fault breccia.

The western contact is less positive because of the Quaternary overburden, but purple siltstones and dolomites are intensely brecciated, the breccias lying against a syncline and anticline developed in the Bunyeroo Formation to the west of the fault.

No northern and southern contacts are evident due to Quaternary cover.

3.3 THE SOUTH TREBILCOCK FAULT BLOCK

One kilometre south of Trebilcock Gap, this block of Callanna Beds with an approximate area of 1.8 sq. km., is conspicuous by the confused nature of its topography. No actual fault trace is evident, as in Puttapa railway cutting, but there is significant evidence to support faulting (figures 7 & 8B).

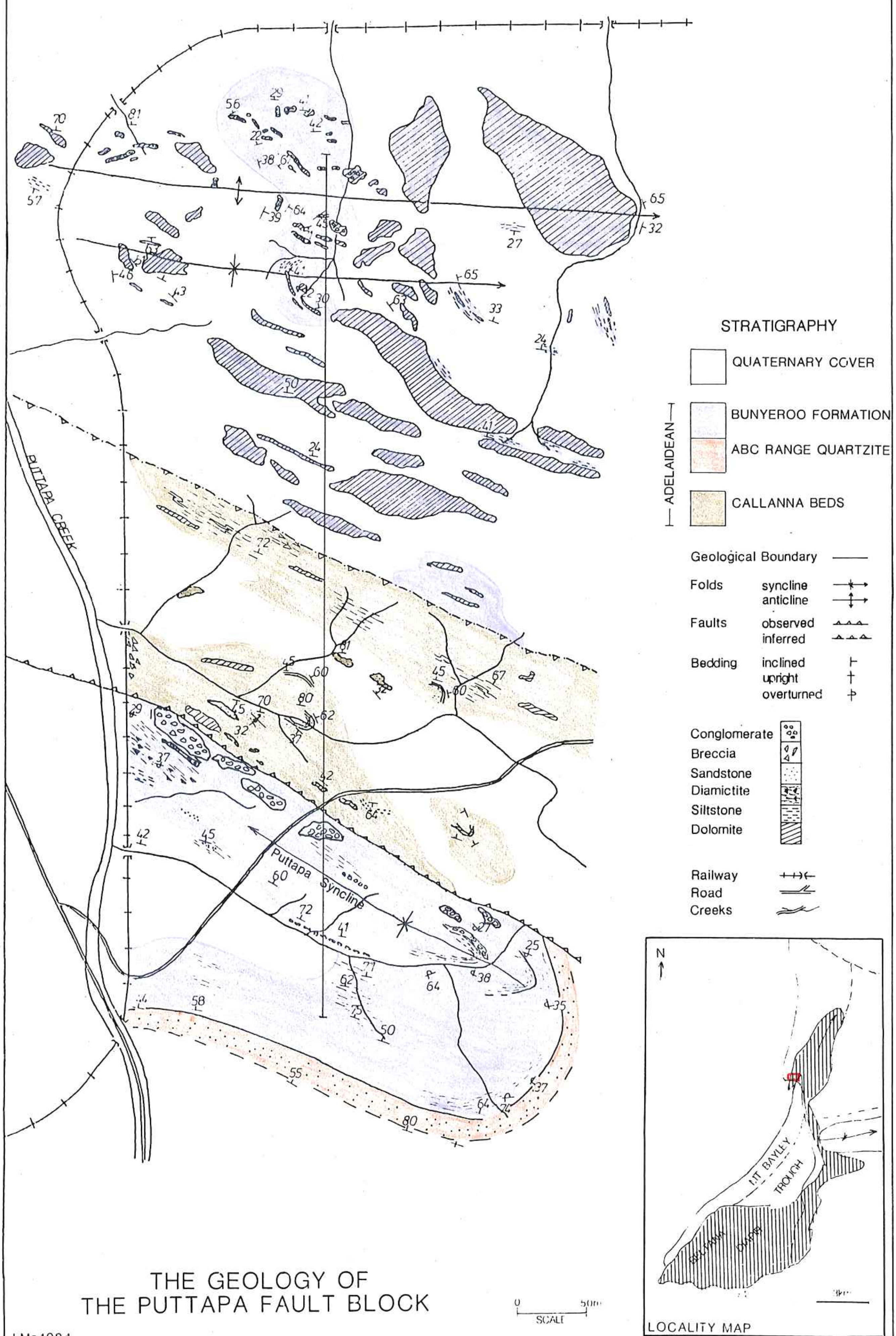
a) The eastern contact of the block is largely covered by Quaternary scree, but where outcrop is present there is a shallowing of dip of the Bunyeroo Formation siltstones from 55^{o}W to 36^{o}W towards an inferred contact.

b) A section of mottled, structureless, weathered Bunyeroo Formation siltstone underlies the inferred eastern contact, and this crush zone may represent a fault breccia.

c) At the southern end of the eastern contact, a large block of east trending Callanna Beds, quartzite strikes into the west-dipping ABC Range Quartzite. Slickensides are developed on the bedding faces (Plate 7.3).

d) The Bunyeroo Formation siltstones on the western side of the Callanna Beds Block are steeply overturned, dipping east on the eastern limb of

FIGURE 6



THE GEOLOGY OF
THE PUTTAPA FAULT BLOCK

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a south plunging syncline. A syncline and parallel anticline have developed along this contact, as drag folds, the axial plane of these folds trending approximately 28^{o} (Plate 7.2; figure 8c).

e) Minor faults are evident within the Bunyeroo Formation that are interpreted as small splay faults off the inferred western contact. These faults have caused a minor re-orientation of the bedding.

The southern and northern contacts are again scree covered, and the creeks further along strike contain Bunyeroo Formation outcrop. The scree aprons blanket the west side of the Mt. Bayley Range, and outcrop is generally restricted to the creeks.

3.4 THE NORTHERN TREBILCOCK FAULT BLOCK

Two kilometres north of Trebilcock Gap, the Quaternary cover ensures that very little substantial evidence as to the mode of emplacement of the 'fault block' is present. The contacts are uncertain but can be inferred by changes in lithology.

a) The Bunyeroo Formation siltstones on the western side of the block are steeply overturned, dipping east and facing is shown by reverse grading.

b) A deeply weathered section overlies the area where the eastern contact is inferred. This may represent a brecciation of siltstone as seen at the other fault blocks.

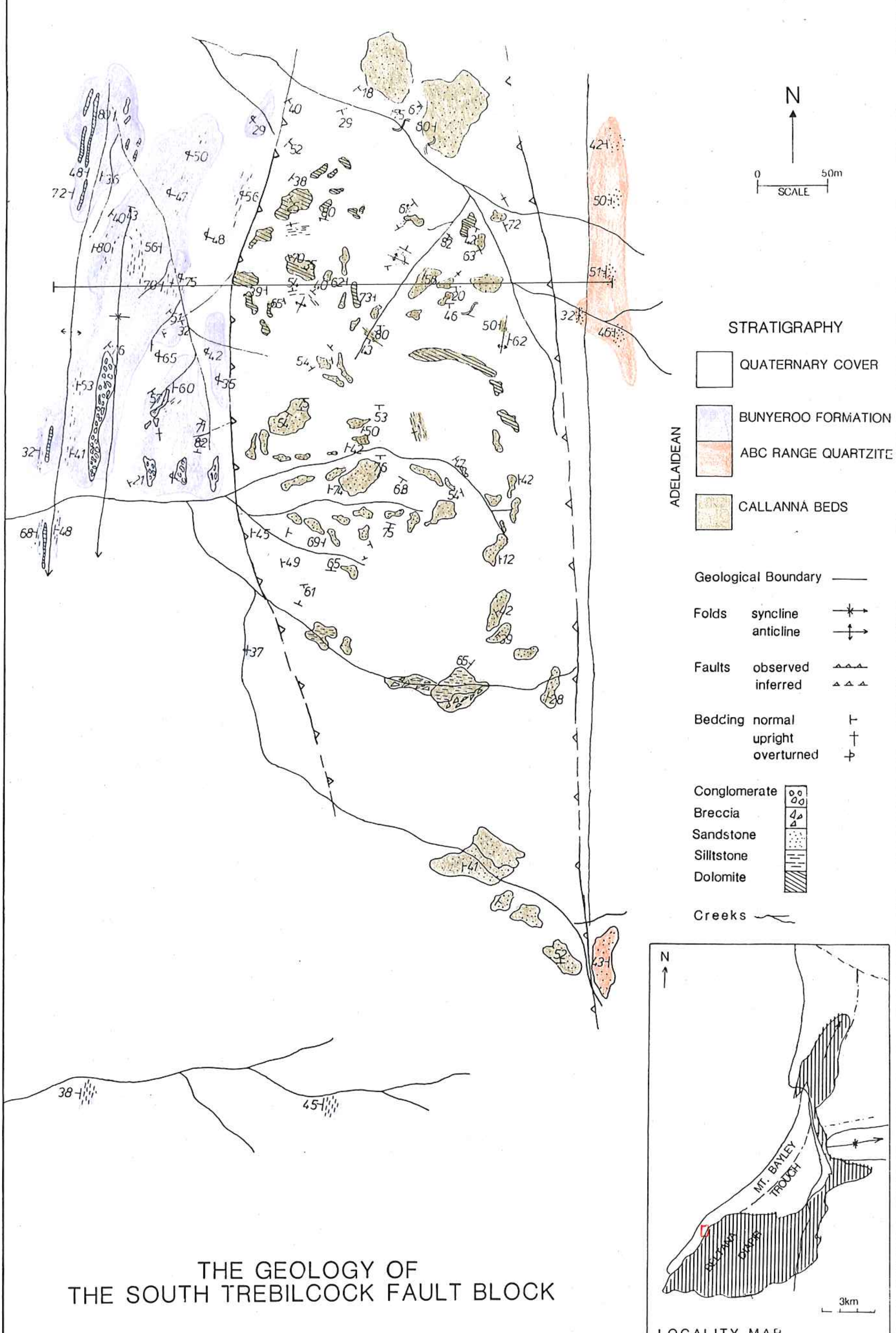
3.5 DISCUSSION

The data presented supports the theory of fault emplaced blocks in preference to the other alternatives. The blocks are all geometrically sub-rectangular, a characteristic common to fault blocks, whereas diapiric bodies usually have a more rounded intrusive form.

The three fault blocks exhibit a similar orientation. The Puttapa fault on the eastern contact trends at 34^{o}, and the Trebilcock folds have an axial direction of approximately 28^{o}. This north-east trend shows a regional association to the major inferred fault system on the eastern side of the Beltana Diapir (Leeson, 1966; Smith, 1968), and to a series of splay faults off the Norwest Fault (Coats, 1973), which lies 7 km north of Puttapa Gap.

The apparent regional relationship, with diapirism and block faulting showing the same trend, could suggest the presence of a north-east fracture system, possibly a minifestation of basement faulting. It is common for diapirs and faulted blocks to use the same zone of weakness (the same fractures) for movement. Dalgarno and Johnson (1968), show that diapiric intrusions within the Flinders Ranges follow well-defined trends that are an indication of a basement fault system.

FIGURE 7



THE GEOLOGY OF
THE SOUTH TREBILCOCK FAULT BLOCK

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Figure 8a:

A west-east section taken across the Puttapa Fault Block. The overturned limb of the Puttapa Syncline is evident against the eastern side of the fault block.

Figure 8b:

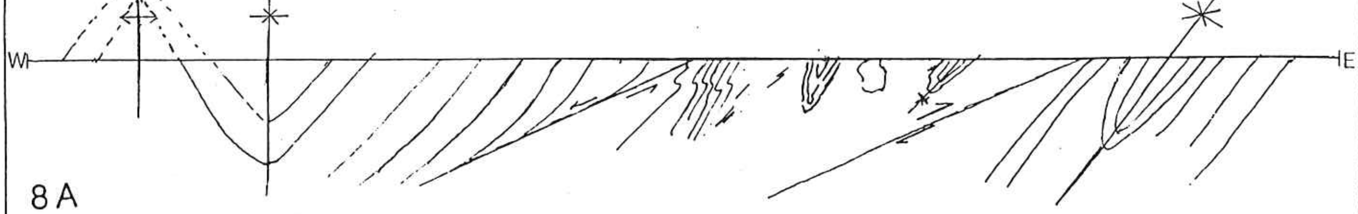
A west-east section across the South Trebilcock Fault Block. The syncline on the western side of the block is overturned on the eastern limb, and the ABC Range Quartzite and Bunyeroo Formation siltstones show a westward shallowing of dip, towards the fault block.

Figure 8c:

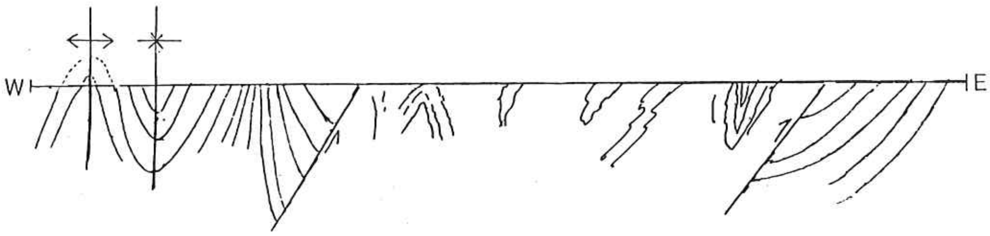
A stereographic net plot of the poles of the bedding of the folds within the Bunyeroo Formation, associated with the western side of the South Trebilcock Fault Block. A definite north-east trend of the bedding is evident.

FIGURE 8

Colours.

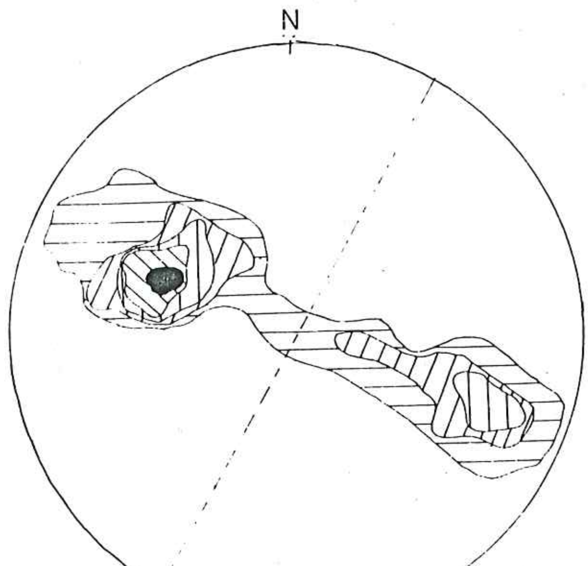


8A



8B

8C



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The presence of diapiric breccia generally associated with block margins, suggests a diapiric association with the faulted blocks. It is possible that the Callanna Beds may have been diapirically intruded along a north-east fracture zone, and at a late stage of uplift the diapiric bodies pierced the surface as faulted blocks. This association of diapirism and thrust faulting has been suggested by Morgan et al. (1968), and Chapman (1974) has shown that slope instability can lead to diapirically induced bodies developing as thrust faults.

This proposed model of diapiric uplift followed by faulting, leading to the emplacement of bodies as fault blocks, allows for the discrete nature of the three blocks along inferred fractures. Such diapiric activity would allow for the facies changes that occur within the Bunyeroo Formation and show a spacial association to the blocks. Uplift during Bunyeroo deposition would cause local shallowing, with the related change in facies. The actual piercing of the surface (the thrust faulting) is essentially of post-Bunyeroo age, possibly of Delamerian origin.

CHAPTER 4 : THE E.Z. MINE AREA: GEOLOGY AND COMPARISON

The northern area is in the vicinity of the E.Z. Willemite Mine, approximately 5 km northeast of Puttapa Gap. It is structurally more complex than the Mt. Bayley Trough, with the sediments folded by a north-plunging, regional anticline, and significantly faulted by a series of north and north-east trending faults that splay off the Norwest Fault, which lies 2 km north of the diapir.

Wilpena Group sediments overlie the Callanna Beds of the northernmost part of the Beltana Diapir. The western limb of the anticline contains a complete succession, 1600m thick, from the Bunyeroo Formation, through the Wonoka Formation and Pound Quartzite into the Cambrian Uratanna and Parachilna Formations, and is overlain by the Ajax Limestone. On the eastern limb of the anticline much of this sequence has been eliminated by faulting (figure 9).

The transgressive basal Wilpena Group lithology is the Bunyeroo Formation, the lower section being a conglomeratic dolomite, which unconformably overlies the Callanna Beds (Daily, 1971). This pebbly dolomite contains clasts primarily derived from the Callanna Beds, with salt pseudomorphs present in quartzite(Plate 6.3). The pebbles are lithologically the same as those present in the Puttapa Gap dolomites, and the mass flow conglomerate (see pgs. 10,13). The contact is sedimentary as with the basal conglomerate of the Moorillah Member in the Mt. Bayley Trough. The presence of the dolomites suggests a shallowing of facies onto the diapir, from the typical sub-littoral environment of the Bunyeroo Formation to a supratidal or lagoonal environment in which dolomites can form.

Minor growth faulting appears to have occurred within the Bunyeroo Formation sediments. On the western limb of the anticline the dolomite and overlying siltstones thicken substantially across a fault, suggesting contemporaneous faulting and sedimentation.

The dolomites on the eastern side of the anticline are much thinner and contain a much greater detrital (conglomerate) content. Westward there is a substantial reduction in the clast content. This could imply that the eastern limb dolomites were deposited in a shallower environment, closer to the shoreline.

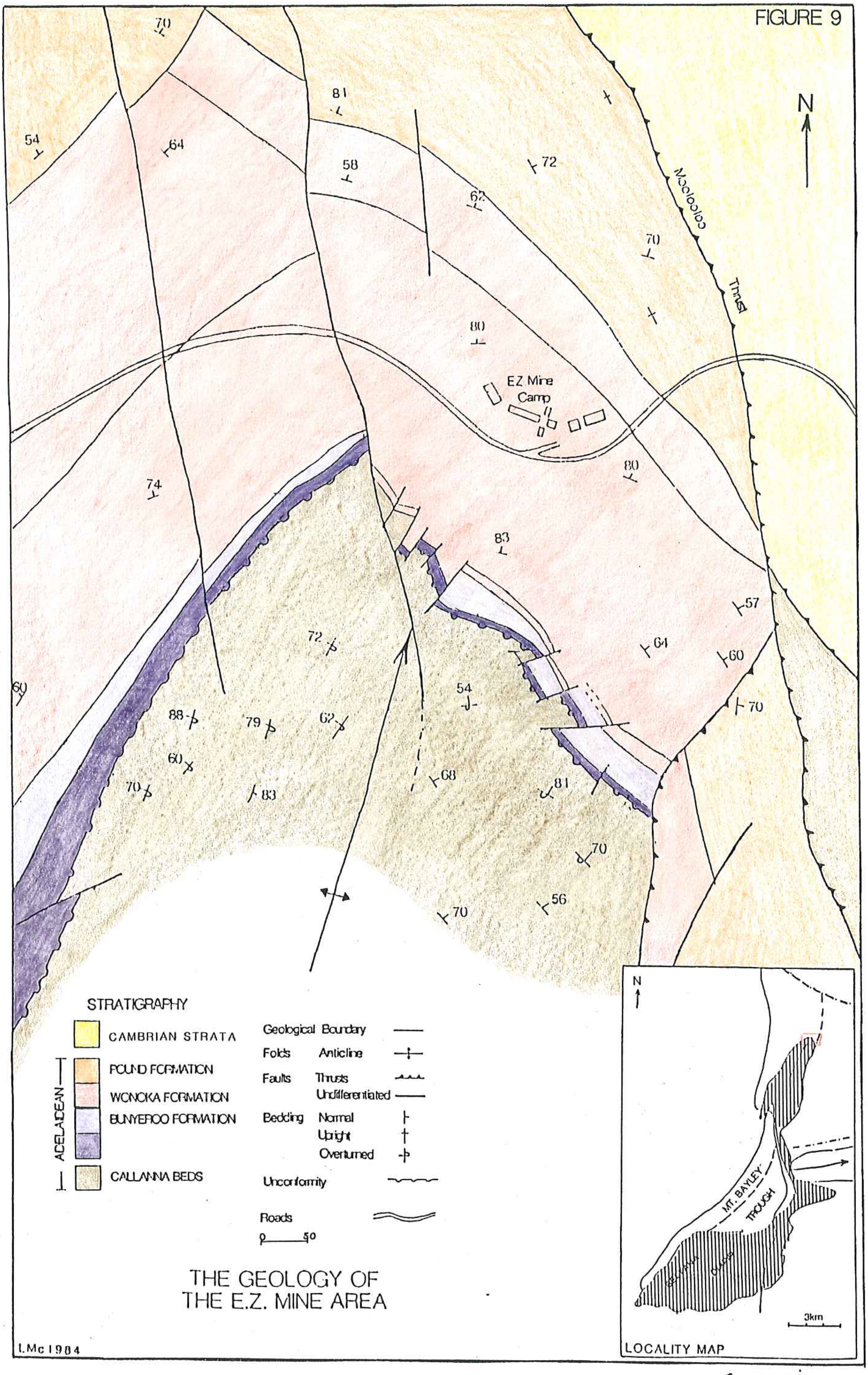

FIGURE 9

THE GEOLOGY OF THE E.Z. MINE AREA

CHAPTER 5 : DISCUSSION

The Wilpena Group sediments of the Mt. Bayley Range area were deposited in the Adelaide Geosyncline in Marinoan times under shallow marine conditions. The Wilpena Group, which constitutes the Marinoan post-glacial sequence, records two major transgressive cycles. The first cycle, defined by Plummer (1978) as the Brachina subgroup, forms the lower Wilpena Group, from the Nuccaleena Formation to the top of the ABC Range Quartzite. The Bunyeroo Formation marks the beginning of the second cycle, which terminates with the Pound Quartzite at the top of the Adelaidean.

In the study area the Marinoan deposits were significantly modified by movement and erosion of the Beltana Diapir. Tectonism resulted in the development of the Mt. Bayley Trough, within which local facies changes occurred, associated with progressive onlap of the diapir.

This resulted in a lateral thinning and coarsening of facies within the trough, with the shallowest deposits formed along the shorelines of the trough. This is exemplified by the following features.

In the deepest parts of the Mt. Bayley Trough, purple siltstones of the Moolooloo Member of the Brachina Formation rest conformably on the Nuccaleena Formation. These change facies laterally into a basal conglomerate, which onlaps the Beltana Diapir.

Likewise, Moorillah Member conglomerate lenses within the Brachina Formation are conspicuous where they approach and onlap the diapir.

In each case, the conglomerate clasts were derived from the erosion and reworking of the Callanna Beds.

In addition, supratidal dolomites are evident in the basal Bunyeroo Formation. In the E.Z. Mine area a similar shallowing is evident at this time, with the development of a basal Bunyeroo Formation dolomite, which unconformably overlies the Callanna Beds of the diapir. Reworked Callanna Beds clasts there constitute a significant component of the rimming dolomites.

Periodic movements of the Beltana Diapir caused instability within the Mt. Bayley Trough, which resulted in sedimentary slumping, debris-flow conglomerates and turbidite-derived diamictites, as seen at Puttapa Gap, being deposited down slope from the shoreline.

Thus the Beltana Diapir was an island lying within a shallow seaway, with local shore and shelf environments developing along its unstable margins. In this setting, the sediments of the Mt. Bayley Trough were deposited. This sedimentary relationship between the Beltana Diapir and the Adelaidean cover sediments is reinforced by the nature of the rim dolomite in the E.Z. Mine area.

Although this relationship is primarily sedimentary, syn-sedimentary tectonism is believed to have produced the Mt. Bayley Trough, probably as a consequence of upward movements of the Beltana Diapir. Such syn-sedimentary synclinal structures are well known and conspicuous adjacent to uprising diapiric bodies. Although faulting is absent along the Mt. Bayley Trough-Beltana Diapir contact, local steepening and overturning of Brachina Formation sediments provides good evidence of growth folding during the course of cover sedimentation.

Three anomalous bodies of Callanna Beds lie within the Bunyeroo Formation. These diapically intruded the overlying sediments during the deposition of the Bunyeroo Formation, the uplift causing shallower environments of deposition to develop. Supratidal dolomites formed in response to the localised shallowing. These diapiric bodies later pierced the cover as thrust-faulted blocks, along a regional north-east fracture system, a trend that is reflected in the faulting in the E.Z. Mine area.

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APPENDICES

APPENDIX 1

BUNYEROO FORMATION SECTIONS

The descriptions of the sections below are of those taken across the Bunyeroo Formation. Three sections, denoted section 1, 2, and 3, were also taken across the Brachina Formation, and are desribed within the main text, in Figure 3A, following page 6. As such, the Bunyeroo Formation sections begin with section 4. The position of the sections are shown on the main map, within the enclosure.

SECTION 4: 300 metres north of Trebilcock Gap

0m-30m: Medium grained sandstone, with magnesite weathering, leaving a black weathered face. Is generally a buff-coloured sandstone. ABC Range Quartzite lithology.

30m-100: Scree slope with ABC Range Quartzite rubble and red siltstones, typical Bunyeroo Formation siltstone.

100.0-100.25: Green, mottled siltstone, in a discontinuous band.

100.25-103.5: Alternating bands of green and red siltstones.

103,5-108.2: Volcanoclastic lense. Red silts with clasts in a tuffaceous texture.

108.2-166.0: Red siltstones and shales. Minor bedding (fine laminations) are occasionally evident. The shales are generally fractured (pencil shales).

166.0-166.5: Micritic dolomite, fresh face pink, weathered brown.

166.5-167.0: Pebbly conglomerate band with carbonate matrix.

167.0-168.0 Red shale

168.0-172.0: Volcano clastic band.

172.0-201.0: Red siltstones with thin interbeds of medium grained carbonate (3cm thick).

202.0-215.0: Green siltstones with minor pebble lenses in carbonate matrix.

215.0-215.6: Weathered light brown, featureless, micritic dolomite.

215.6-222.9: Green siltstones.

222.9-223.5: Micritic dolomite.

223.5-236.0: Green siltstones.

236.0-237.1: Micritic dolomite.

237.1-240.0: Green siltstone.

SECTION 5: Trebilcock North Fault Block and adjacent Bunyeroo Formation.

0.0-15.0m: ABC Range Quartzite sandstone with magnesite weathering. Is a medium grained, quartzt-rich, light brown sandstone.

15.0-29.4: Scree with green silts, possibly Bunyeroo Formation siltstone.

29.4-30.2: Callanna Beds dolomite, tightly folded, with chert nodules present.

30.2-95.0: Float of Callanna Beds debris, red, cross-bedded quartzites with halite casts (pseudomorphs). Underlying rock is an unconslidated grey siltstone.

95.0-98.0: Dolomite blocks.

98.0-116.0: Callanna Beds debris scree.

116.0-117.0: Black, weathered, cherty dolomite, tightly folded.

117.0-126.0: Scree.

126.0-140.0: Bedded sandstone with halite pseudomorphs. Upright, tightly folded quartzite with occasional ripple marks. Heavy mineral cross-laminated sandstone.

140.0-142.0: Folded dolomite.

142.0-165.0: Chaotically bedded siltstones, red sandstone and chert.

165.0-175.0: Scree.

175.0-192.0: Bedded grey siltstones, red sandstone and chert.

195.0-220.0: Scree.

220.0-223.0: Red dolomicrite.

223.0-231.0: Scree, containing Callanna Beds debris.

231.0-237.0: Blocks of red, weathered dolomites with large component of chert, and sub-angular quartzite clasts of granule and pebble size. I Interbedded with tightly folded grey siltstones and sandstones.

237.0-280.0: Interbedded grey sandstones and siltstones. Have a folded, mottled appearence.

280.0-324.0: Have scree with Callanna beds debris and red siltstone, possibly Bunyeroo Formation silts.

324.0-335.4: Bunyeroo Formation silstones present. Red siltstones with minor pebble bands that show reverse grading. The beds dip east, and are assumed to be overturned, on the basis of the reverse grading.

335.4-338.2: Red siltstones that have small clasts and appear mica rich. Are similar to the volcanoclatic facies present to the south.

338.2-340.2: Intermittant layers of yellow sandy siltstone, overturned.

340.2-368.0: Scree (talus) of red silts.

368.0-370.0: Clean, pink micritic dolomite. Overlain by small band of conglomerate pebbles.

370.0-385.0: Talus of red siltstone.

385.0-385.2: Clean, pink micritic dolomite.

385.2-388.0: Red silt talus.

388.0-389.0: Dolomite.

389.0-394.0: Red silt talus.

394.0-396.2: Dolomite.

396.0-408.0: Green siltstone.

408.0-408.4: Green sandy siltstone.

408.4-429.0: Green siltstone talus.

429.0-429.5: Dolomite (Pink micritic dolomite).

429.5-452.0: Quaternary cover sediments.

452.0-476.4: Yellow, light green pencil siltstones, with intermittant sandy bands.

476.4-476.9: Micritic, clean dolomite.

476.9-499.0: Green siltstone and shales.

499.0-500.2: Dolomite pod, approximately 6m long.

500.2-521.5: Talus of green pencil shales.

521.5-521.8: Dolomite pod.

521.8-527.0: Talus of silts.

The section then passed into a region of Quarternary cover sediments.

SECTION 6: PUTTAPA GAP RAILWAY CUTTING

0.0m-5.4: Weatherd buff orange, medium grained, cross-bedded sandstone (ABC).

5.4-14.4: Scree-no apparent outcrop.

14.4-25.6: Brown sandy siltstone, minor folding.

25.6-35.4: Beds of coarse sandstone with well rounded quartz grains, alternating with brown sandy silt layers.

35.4-60.0: No outcrop (scree).

60.0-62.0: Light brown silts and shales, Bunyeroo Formation.

62.0-130.0: Alluvium cover.

130.0-146.3: Light green, brown weathered finely laminated siltstone.

146.3-154.2: Red laminated siltstones.

154.2-176.5: Diamictite bands interbedded with red siltstone layers.

176,5-251.0: Red, brown laminated siltstones that contain sedimentary slump features.

251.0-257.5: Green silts, contain an overturned (reverse) drag fold.

257.5-259.6: Featureless, crushed red siltstone.

259.6-261.0: Massive, orange coloured carbonated rock. Unconformably overlies the silts. Is the contact between the Bunyeroo Formation and the Callanna Beds, which are thrust over the top of the Bunyeroo Formation

261.0-284.5: Grey, blue, brecciated, heavily weathered silts.Contains dolomite clasts, about which folded brecciated silts flow.

284.5-302.5: Cemented diapiric flow breecia, show flow banding in matrix about large dolomite clasts and rafts, some measuring up to 10m x 3m .

302.0-420.0: Alluvium scree.

420.0-420.5: Callanna Beds dolomite, contain gypsum pseudomorphs.

420.5-473.0: Diapiric breccia.

473.0-644.0: No outcrop apparent.

644.0-662.5: Brecciated purple siltstone

662.5-685.0: Steeply bedded silts and sands. Have been intensely weathered to pink mottled colour. Are overlain by alluvium, covering Bunyeroo Formation and Callanna Beds contact.

APPENDIX ii

SUPPLEMENTARY PLATES

Plate 4.1:

Salt pseudomorphs:

1. Rosettes of gypsum on dolomite
2. Shortite pseudomorphs on dolomite
3. Halite pseudomorphs on quartzite
4. Quartzite clast from Puttapa Conglomerate with halite casts.

Plate 4.2:

The effleurescence characteristic of some Callanna Beds sandstones.

Plate 4.3:

Fractured dolomite: Common to Beltana Diapir.


0 1 2 3
cm

Plate 5.1:

Massive pink weathered dolomite, western side of Puttapa Fault Block.

Plate 5.2:
Pebbly dolomite, Callanna Beds Quartzite clasts present as detritus
Puttapa Gap.

Plate 5.3:

Rip-up dolomite clasts within a dolomite matrix. Have re-lithification
after very little sorting or rounding.

Plate 6.1:

Typical Bunyeroo Formation. Broken purple and minor green shale.

Plate 6.2:

Clean dolomite lense enveloped by green shale.

Plate 6.3:

Pebbly rim dolomite - E.Z. Mine Area.

Plate 7.1:

Thrust fault, east contact of Puttapa Fault Block Callanna Beds (with large dolomite clast) overlie fractured and crushed Bunyeroo Formation Siltstone.

Plate 7.2:

Nose of south-plunging syncline, western contact, South Trebilcock Fault Block, on Bunyeroo Formation.

Plate 7.3:

Slickensided quartzite, eastern contact of South Trebilcock Fault Block with ABC Range Quartzite.

APPENDIX iii

ACETATE PEELS

Carbonate Staining Technique

A carbonate staining technique (Dickson,]965) was used to identify the carbonate mineralogy of selected hand specimens using acetate peels . The acetate peels that were achieved contributed little to the overall geology. This is because of the intense dolomitization of the carbonates, all the dolomites excepting those that contained Callanna Beds quartzite clasts, were micritic in nature, and as such the peels contributed very little information. Several of the peels are with the selection of sample to be retained by the department, and are discussed in appendix iv.

Method

1. Prepare solutions of:
   a. 0.2 g Alizarin Red S (A.R.S.) per 100 ml 1.5% HCl
   b. 2.0 g Potassium ferricyanide (P.F) per 100 ml 1.5% HCl
2. Mix A.R.S. : P.F. in ratio 3:2.
3. Clean sample briefly in 1.5% HCl.
4. a. Immerse hand specimen in mixture for 1.5-2 minutes.
5. Rinse in distilled water.
6. Make acetate peel from hand specimen.

Result

Calcite - very pale-red depending on optical orientation.
Ferroan calcite - very pale-red and pale to dark blue. Two superimposed give mauve-purple-royal blue.
Dölomite - no colour.
Ferroan dolomite- Pale-deep turquoise depending on ferroan content.

APPENDIX iv

ROCK SAMPLE TYPES AND LOCATIONS

This is a list of those samples retained by the Geology Department. All samples are prefixed 833, followed by the specific identification number. This listing contains the rock sample number, a brief description of the rock type, the rock unit the sample came from, and the locality at which it was collected. Thin sections (TS) of some of the rocks have been cut, and these are listed, the descriptions of some being in appendix v. Several acetate peels (AC) are with the collection, and these are briefly described.

833/001: Callanna Beds; Cross-bedded sandstone with halite pseudomorph, Section 3.
833/002: Bunyeroo Formation; Conglomerate, Puttapa Gap.
833/008: ABC Range Quartzite; Buff-coloured, medium grained sandstone Section 3.
833/022: Bunyeroo Formation; Mass flow debris conglomerate, South Puttapa Gap.
833/028: ABC Range Quatzite; Bedded quartzite with micro conglomerate. Puttapa Gap
833/030: Bunyeroo Formation; Volcano clastic, north of Trebilcock Gap.
833/034: Callanna Beds; Quartzite with halite pseudomorphs. Trebilcock North Fault block.
833/035: ABC Range Quartzite; Gray, medium grained quartzite, Puttapa Gap.
833/037: Callann Beds (TS) siltstone, North Trebilcock Fault Block.
833/039: Callanna Beds: Grey sandstone, North Trebilcock Fault Block.
833/042: Bunyeroo Formation; Pink, micritic dolomite, Section 5.
833/44A: Brachina Formation; Moolooloo Member siltstone Section 2.
833/44B: Brachina Formation (TS), Large Callanna Beds cobble from within a Moorillah member conglomerate. Section 3.
833/052: Callanna Beds (TS), Quartzite, heavy mineral cross-bedding. Section 3.
833/057: Bunyeroo Formation; Pebble conglomerate, South of Puttapa Gap.
833/058: Callanna Beds; Diapiric Breccia, Puttapa railway cutting.
833/062: Brachina Formation (TS). Typical Moorillah siltstone, Section 2
833/64c: Bunyaroo Formation (TS). Volcanoclastic, section 5.
833/071: Callanna Beds; Weathered, honey-combed, calcareous sitlstone. Puttapa Gap.
833/072: Callanna Beds: Dolomite with chert, North Trebilcock Fault block
833/72A: Bunyeroo Formation. Typical red siltstone, Puttapa Gap.
833/073: Bunyeroo Formation. Diamictite, Puttapa Gap.
833/076: Bunyeroo Formation. Finely bedded, brown sandy silt Puttapa Gap.
833/080: Callanna Beds; Dolerite, east of Puttapa Gap.
833/088: Brachina Formation; Medium grained sandstone, red and white bands, Moorillah member, section 1.
833/094: Brachina Formation; Sandy siltstone, Moorillah member, section 1.
833/095: Brachina Formation (TS), siltstone, section 3.
833/98A: Brachina Formation, heavy mineral -rich sandy silt, Moorillah member, section 1. (TS)
833/98c: Bunyeroo Formation; Volcano clastic, section 4.

833/106A: Brachina Formation (TS), Mooloolooo member siltstone, minor Bouma sequences, section 2.

833/106B: Brachina Formation (TS), Moolooloo member siltstone, minor Bouma sequence, continuation of 106A.

833/107: Callanna Beds, pink siltstone, Trebilcock south fault block. (TS)

833/108: Callanna Beds, Dolomite with gypsum pseudomorphs (TS), Puttapa Fault block.

833/110: Nuccalleena Formation. Dolomite, base of section 2.

833/111: Bunyeroo Formation; (AP), conglomeratic dolomite (Callanna clasts in dolomitic matrix, western side of Puttapa Gap.

833/112: Bunyeroo Formation (AP); Dolomicrite, Near Trebilcock north fault block.

833/113: Nuccaleena Formation (AP); Dolomite

APPENDIX v

ROCK THIN SECTION DESCRIPTIONS

Thin section 833/108

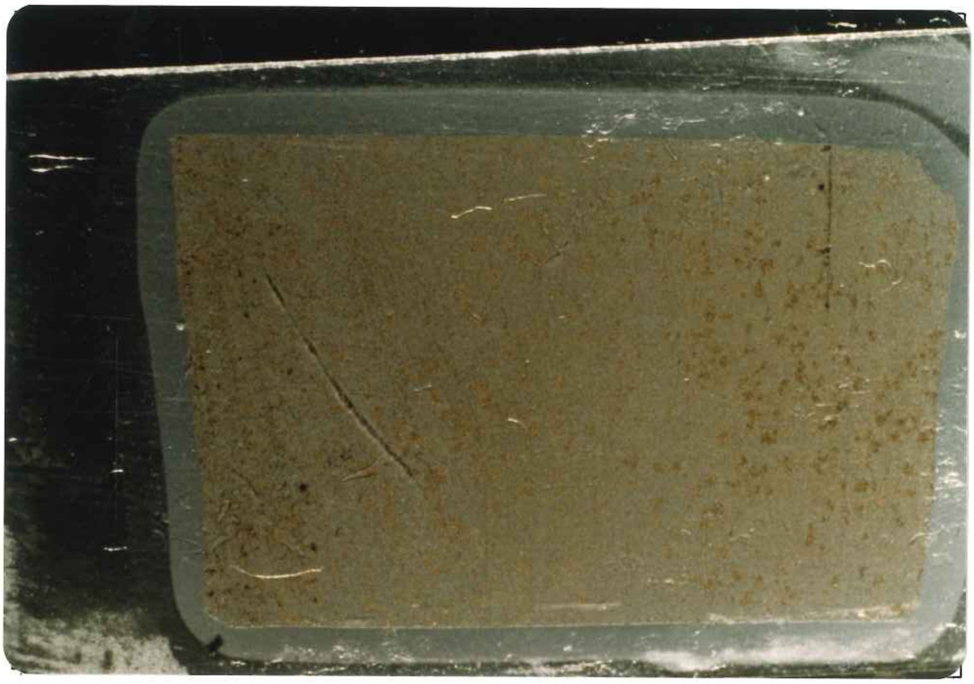
Is a Callanna Beds dolomite from the Puttapa Fault block with silica replacing gypsum. These pseudomorphs form small rosettes in thin section, in hand specimen the pseudomorphs occur as clusters of nodules. The weathered light brown dolomite is a pink micritic dolomite in fresh sample.

833/62

Brachina Formation, Moorillah member siltstone.
Macro description; A dark mauve brown colour, fine-grained and finely bedded.
In thin section the dominant mineral constituent is quartz (70%), which are fine, well rounded and sorted grains. Other major mineral components are clays (20%) and minor iron oxides. A coarsening in the silt grain size is associated with mild cross-bedding. Is typical of lower Moorillah member siltstone unit.

833/10B

Callanna Beds sandstone. Macro: Large, re-coloured cobble. Associated with a conglomerate band in the lower Moorillah member. Is dominantly quartzitic, with 60% quartz grains present, with intense iron staining. Shows distinct cross-bedding, with the concentration of heavy minerals (zircon, tourmaline), 10%, allowing the expression of the distinct cross bedding, which appears to be Herringbone.
A granule of silt is present within the fine grained sandstone, consisting of quartz and mica. The quartz grains are generally sub-rounded.



Thin section slides 833/106A and 833/106B

These slides were cut form the same sample, the lower slide (106B) being from the lower part od the sample. Is a Moolooloo Member siltstone, and contains a small Bouma sequence, representing deposition from a storm generated current. 106B contains a graded silt sequence, which passes intp planar laminated silts, which are overlain by rippled siltstones, which precede laminated and massive fine silts.

The sample is grey/brown in colour, a fine to coarse grained siltstone, consisting dominantly of sub-rounded and sub-angular quartz grains. The cross-laminations are enhanced by the preferred lie of the heavy mineral constituents.

833/64c

Bunyeroo Formation Volcanoclastic

Plate shows hand specimen and thin section photos. The rock contains volcanoclastic and detrital clastic material. Sub rounded quartz grains form 25% of the rock, a significant detrital clastic contribution. 20% of the rock is calcite, and in the hand specimen the larger granule is calcitic. The calcite generally occurs intersticially. Volcanoclastic quartz forms 30% of the rock, and the whole rock contains 60% SiO_2, very high for a rock of tuffaceous origin. The purple colouration is caused by the presence of iron oxides, which occur as fine needles and laths. A minor amount of microcline (5%) also occurs, showing characteristic twinning. Many of the minerals had been altered to a volcanic glass. The presece of detrital quartz grains mixed with volcanically derived quartz grains support a volcanoclastic over a tuffaceous origin.


0 1 2 3
cm

833/44B

Brachina Formation, Moorillah member conglomerate.

Macro description: sub-elongate clasts in a silty matrix.

Clasts: 50%, Heavy mineral laminated fine sandstone with minor mica (muscovite)

25%. Sandstone with grains of feldspar, quartz, carbonate and some opaques.

20%, Dolomite clasts

05%, Minor opaques

The conglomerate contains clasts of Callanna Beds origin that have been derived from the Beltana Diapir.

833/26

ABC Range Quartzite

Moderately well sorted micro-conglomerate of coarse grained sands, overlying a fine grained matrix. The micro conglomerate has an almost closed framework, with very little matrix material. The micro conglomerate is dominantly quartz, the matrix consists of quartzite and feldspar with minor opaques.

833/26

833/44 II

833/22

Bunyeroo Formation

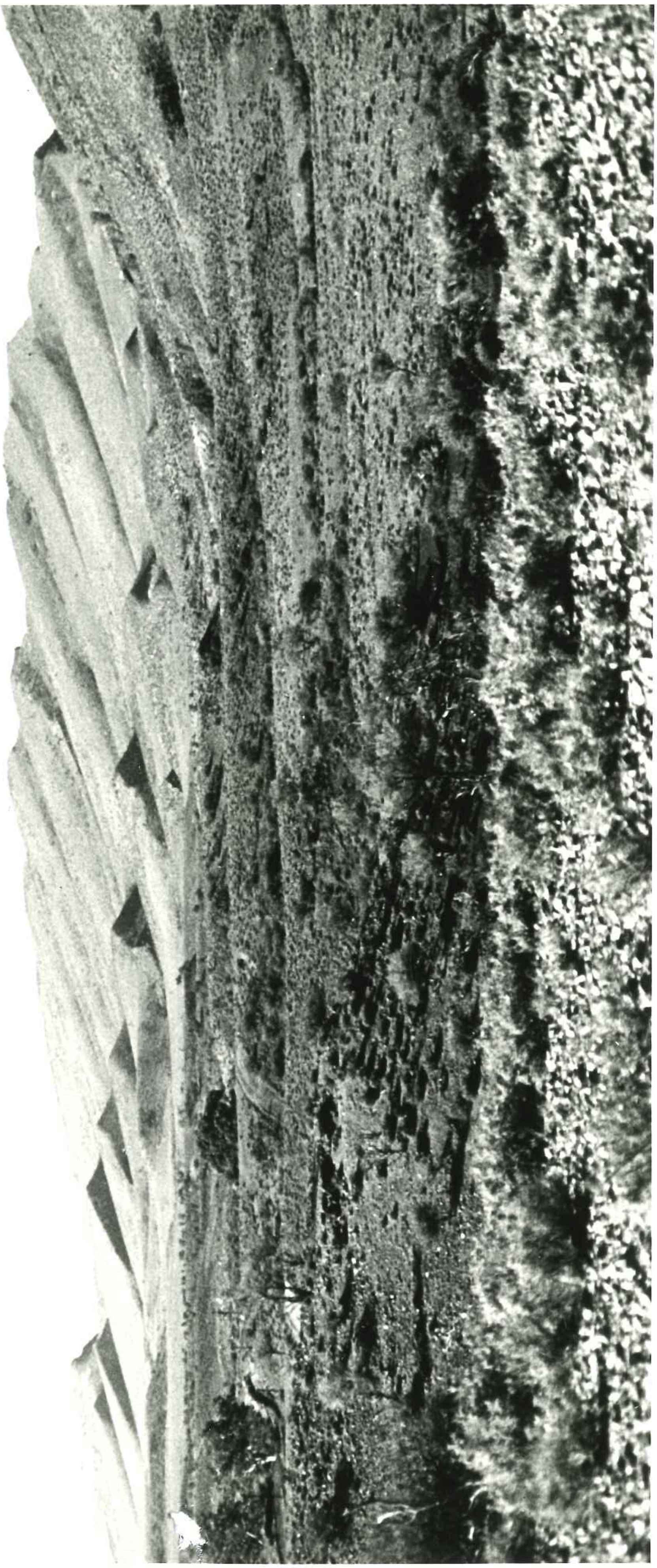
Mass debris flow conglomerate

Macro: Sub angular clasts showing no apparent bedding, set in a red silt matrix.

Clasts: Largely a monomictic conglomerate, with heavy mineral laminated quartzose siltstones and sandstone. Minor dolomites and chert are present.

Matrix: This is a dark red mud matrix, the colouration due to the large amounts iron oxides within the silt. Quartz and mica form the dominant minerals, with minor clay evident.

The conglomerate clasts found are of Callanna Beds origin, similar to those found in the Moorillah member of th Brachina Formation.



THE GEOLOGY OF
THE MT. BAYLEY RANGE AREA
NORTHERN FLINDERS RANGES SOUTH AUSTRALIA