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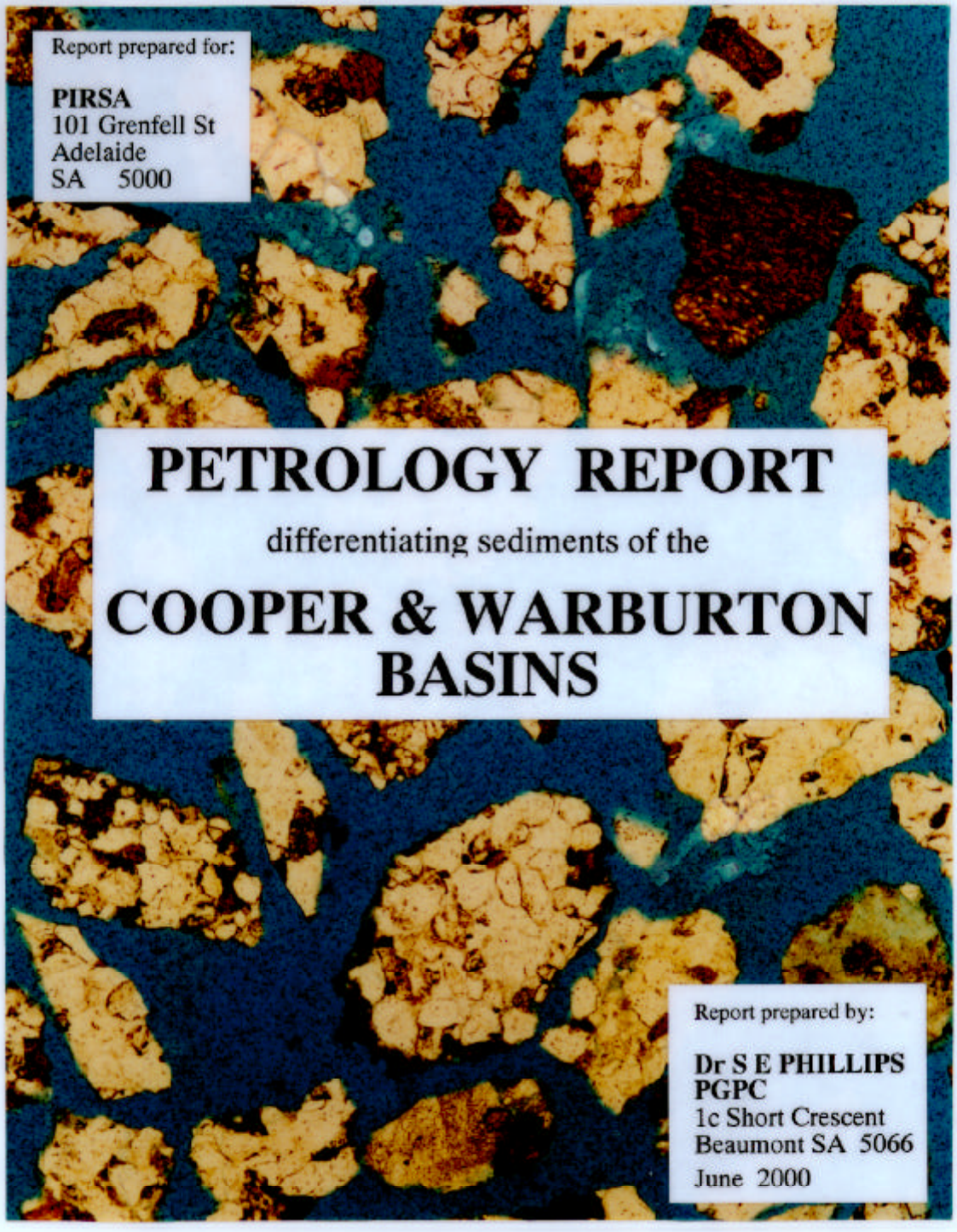

Report prepared for:

PIRSA
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PETROLOGY REPORT

differentiating sediments of the

COOPER & WARBURTON BASINS

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Front cover:
Photomicrograph of cuttings from Turban-1, depth 7990-8000ft. Plane light. Horizontal field of view 3.25mm.

1. SUMMARY

Primary Industries and Resources SA submitted 50 thin sections of cuttings to PGPC for brief petrological description. Samples were selected by the late Dr David Gravestock from the Cooper and Warburton Basins. Four samples from Tarragon-1 included chips of igneous origin and therefore have been described by Dr Doug Mason of Mason Geoscience Pty Ltd. The study was designed to further characterise the nature and distribution of an altered zone recognised at the top of the Warburton Basin and to discriminate between sediments of the Cooper and Warburton Basins.

Results from the thin section descriptions are summarised in Table 1. Obviously it is very difficult to be certain of the stratigraphic unit based solely on lithology, especially when lithology has been determined from cuttings where there can be significant down hole contamination. This problem is compounded for the Merrimelia Formation where core descriptions indicate there has been significant reworking of a variety of lithic fragments from the underlying Warburton Basin. For example it is impossible to distinguish illitic shale reworked into the Merrimelia Formation from illitic shale *in situ* near the top of the Dullingari Group based on cuttings. Identification of possible diamictite in the Merrimelia Formation is also tentative. Given these problems the Merrimelia Formation has been recognised where there is a lack of metamorphic alteration or a lack of carbonaceous material. The latter is abundant in the Patchawarra Formation and metamorphism would indicate the sediment belonged to the Warburton Basin.

Descriptions of sediments from the Dullingari Group indicate that the altered zone at the top of the Warburton Basin is characterised by an illitic shale with healed fractures and rare spherulitic carbonate spar. The shale is typically colourless in plane transmitted light due to the abundance of illite. Fractures of various widths are healed with polycrystalline quartz, carbonate spar and kaolin. There may be multiple generations of healed fractures with the earliest type occurring prior to significant mechanical compaction. Where this shale is thought to be relatively fresh in Toolache-39 & -50 there are remnants of slatey cleavage, an increase in the abundance of muscovite and rarely authigenic crystals of epidote. The latter are indicative of low grade metamorphic alteration of possible greenschist facies. Identification of the alteration zone in siltstones and sandstones is relatively difficult. Differentiation of the Lycosa Formation from the Dullingari Group was not possible from the cuttings.

Those sediments that lack evidence of metamorphic alteration and contain minor fresh feldspars and/or grains of glaucony could represent the ?Innamincka Formation. Glauconitic mudstone in Toolachee-28, shale in Bagundi-2 and fine grained sublitharenites and quartzarenites from Turban-1 and Napowie-1 respectively may all be part of this classification. The oxidised very fine to fine grained sublitharenite from Turban-1 is the most obvious example of the 'Red Beds'. At Bagundi-2 the ?Innamincka Formation is overlain by the ?Patchawarra Formation and underlain by the Dullingari Group.

Mooracoochie Volcanics of acid porphyry are apparent at the base of Tarragon-1. Fragments of igneous origin in the overlying sediment could have been reworked.

TABLE 1 SUMMARY OF LITHOLOGY & POSSIBLE STRATIGRAPHIC UNITS

WELL Depth (ft)	LITHOLOGY	PIRSA Stratigraphic Unit	PGPC Stratigraphic Unit	ZONE
Bagundi-2				
7240-7250	shale & greywacke	?Merrimelia	?Patchawarra	
7270-7280	illitic shale	?Merrimelia	?unknown/Dullingari	
7340-7350	illitic shale + fractures	?Ordovician	Dullingari	
7350-7360	shale to silty shale + fractures	?Mooracoochie	Dullingari	
Mataranka-1				
7440-7450	silty carbonaceous mudstone & coal	?Patchawarra	Patchawarra	
7450-7460	illitic shale or ?diamictite	?Patchawarra	Merrimelia	
7460-7470	illitic shale + fractures	?Merrimelia	?Merrimelia/ ?Dullingari	
7510-7520	silty shale + fractures	?Lycosa	Dullingari/Lycosa	fresh
7670-7680	silty shale + fractures	?Lycosa	Dullingari/Lycosa	fresh
Napowie-1				
10770-10780	fine illitic sandstone	?Kalladeina	?unknown/Dullingari	
10860-10870	fine illitic sandstone	?Kalladeina	?unknown/Dullingari	
10930-10940	fine quartzarenite	?Kalladeina	?unknown/Dullingari	
Strzelecki-15				
6440-50	illitic shale + fractures	?Merrimelia	Dullingari	altered
6520-6530	illitic shale + fractures	?Merrimelia	Dullingari	
Suta-1				
10400-10410	sandstone greywacke	?Merrimelia	?Merrimelia	
10490-10500	v fine illitic sandstone	?Lycosa	?Dullingari/Lycosa	
10573	v fine illitic sandstone/siltstone	?Lycosa	?Dullingari/Lycosa	
Tarragon-1				
7790-7800	illitic sandy shale	?Mooracoochie	?unknown/not volcanic	
7760-7770	illitic sandy shale	?Mooracoochie	?unknown/not volcanic	
7930-7940	acid porphyry	?Mooracoochie	Mooracoochie	
8080-8090	acid porphyry	?Mooracoochie	Mooracoochie	
Tirrawarra-60				
9890-9900	illitic shale to sandy shale & siltstone	?Merrimelia	?Merrimelia	
9940-9950	illitic shale to sandy shale	?Merrimelia	?Merrimelia	
10010-10020	v fine to fine illitic sandstone	?Merrimelia	?unknown	
10160-10170	medium quartzarenite	?Merrimelia	Merrimelia	
10290-10300	illitic shale to sandy shale	?Merrimelia	?Merrimelia	
10340-10350	siltstone & illitic shale	?Merrimelia	?Merrimelia	
Toolachee-1				
6950-6960	medium to coarse quartzarenite	?Merrimelia	?Merrimelia	
6990-7000	siltstone to v fine quartzarenite	?Merrimelia	?Merrimelia	
7020-7030	siltstone to v fine sandstone	?Merrimelia	?Merrimelia	
7040-7050	fine sublitharenite	?Merrimelia	?Merrimelia	
7070-7080	illitic shale + fractures	?Merrimelia	?Dullingari	
Toolachee-28				
7520-7530	illitic shale, siltstone & sandstone	?Merrimelia	?Dullingari	
7570-7580	illitic shale & sandstone + fractures	?Merrimelia	Dullingari	altered
7620-7630	fine illitic sandstone	?Merrimelia	Dullingari	
7670-7680	?illitic shale to sandy shale or glauconitic mudstone	?Merrimelia	?Dullingari/unknown	
Toolachee-39				
8200-8210	illitic shale, siltstone & v fine sandstone	?Merrimelia	Dullingari	
8250-8260	illitic shale to sandy shale + fracture	?Merrimelia	Dullingari	altered
8290-8300	blackish silty shale	?Merrimelia	Dullingari	fresh
8320-8332	blackish silty shale + fractures	?Merrimelia	Dullingari	fresh
Tootachee-50				
7700-7710	carbonaceous shale & illitic shale	?Merrimelia	contact Patchawarra/Dullingari	
7730-7740	illitic sandy shale	?Merrimelia	Dullingari	
7740-7750	illitic shale & sandy shale	?Merrimelia	Dullingari	fresh
7790-7800	illitic sandy shale	?Merrimelia	Dullingari	fresh
7850-7860	illitic shale + fractures	?Merrimelia	Dullingari	fresh
Turban-1				
7860-7870	siltstone	?Merrimelia	unknown	
7900-7910	silty mudstone or ?diamictite	?Merrimelia	?Merrimelia	
7950-7960	mudstone, siltstone, v fine sublitharenite	?Merrimelia	unknown	
7990-8000	oxidised v fine to fine sublitharenite	?Merrimelia	?Innamincka	
8050-8060	v fine to fine sublitharenite	?Merrimelia	unknown	

2. INTRODUCTION

Primary Industries and Resources SA submitted 50 thin sections of cuttings samples to PGPC for brief petrological description from the Cooper and Warburton Basins. Samples were selected by the late Dr David Gravestock from the wells Bagundi-2, Mataranka-1, Napowie-1, Strzelecki-15, Suta-1, Tarragon-1, Tirrawarra-60, Toolachee-1, Toolachee-28, Toolachee-39, Toolachee-50 and Turban-1. Four samples from Tarragon-1 included chips of igneous origin and therefore have been described by Dr Doug Mason of Mason Geoscience Pty Ltd. Results from Dr Mason have been integrated into this report but all interpretation remains the responsibility of PGPC. The study was designed to further characterise the nature and distribution of an altered zone recognised at the top of the Warburton Basin and to discriminate between sediments of the Cooper and Warburton Basins. The client supplied all the thin sections and wireline logs of each well.

3. METHODS

Thin section

Thin sections were systematically scanned to determine lithology, composition, porosity and textural relationships. All percentages given in thin section descriptions are visual estimates, not point counts. Rock classifications are based on the work of Folk (1974) for clastics.

4. PETROLOGY

4.1 Bagundi-2, cuttings, depth 7240-7250ft, ?Merrimelia Formation

Sample number: 431780

Thin section description

Lithologies present:
Chips are comprised of single grains of coarse sand, coarse sandstone, fine greywacke (30%), siltstone (1%) and shale (19%). Based on the wireline logs the coarse grains of sand and coarse sandstone (49%) are probably downhole contaminants.

Sandstone (greywacke)

Sedimentary structures	stringers of organic matter
Avg grain size	fine sand
Range	silt to coarse sand
Sorting	poor
Roundness/sphericity	subangular / moderate
Texture	matrix supported with tangential & sutured grain contacts
Porosity	none apparent
Composition	detrital monocrystalline & polycrystalline quartz, lithics of deformed shale & chert, muscovite flakes, accessory tourmaline, matrix of randomly oriented illitic clay & organic matter, authigenic patchy Fe rich anhedral carbonate spar, blocky pyrite replacing organic matter, pyrite framboids & rare anhedral ?anatase. One chip contains fine sand size deformed grains of bright green glaucony

Shale

Sedimentary structures	weak alignment of organic matter may indicate laminae
Composition	rare silt size quartz in anhedral brown clay matrix with stringers & patches of organic matter, patchy Fe rich carbonate

Comments:
This depth interval probably consists of interbedded shale and greywacke. Organic matter in these lithologies suggests this could be the Patchawarra Formation.

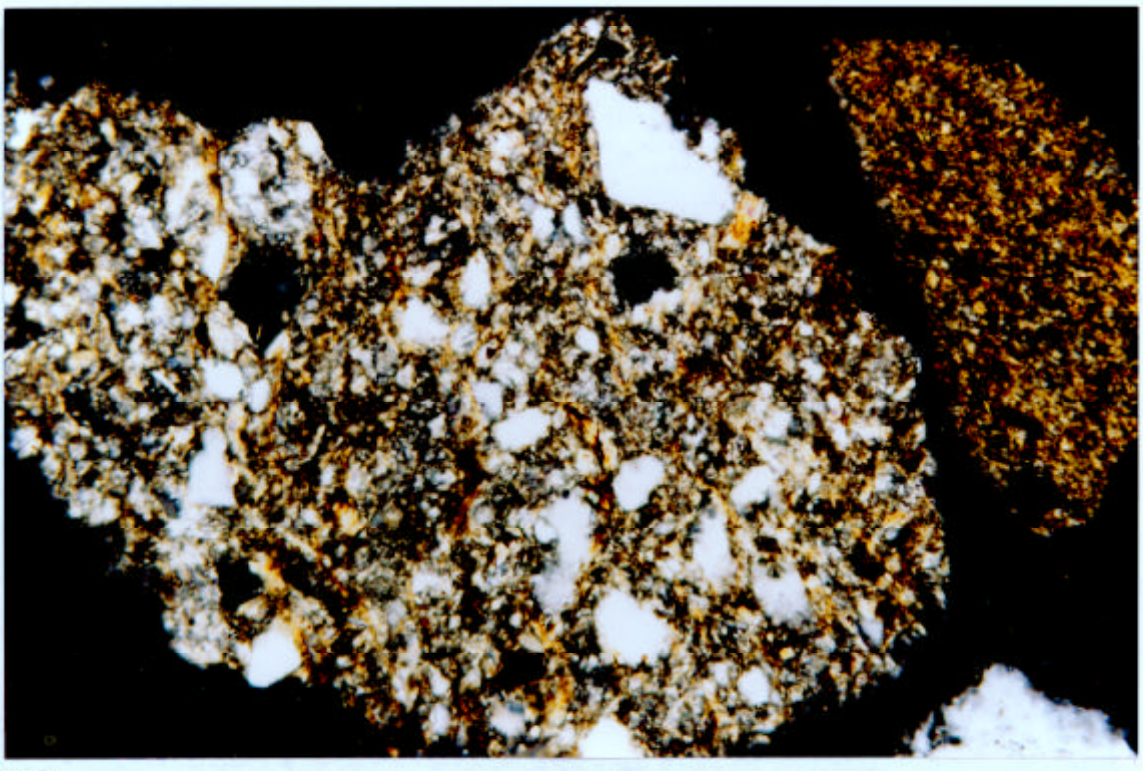

Figure 1
Chips of greywacke and shale are apparent in this field of view. This example of greywacke is more matrix rich than most other chips but it does illustrate the poor sorting. Bagundi-2, cuttings, depth 7240-7250ft. Plane light. Horizontal field of view 1.30mm.

4.2 Bagundi-2, cuttings, depth 7270-7280ft, ?Merrimelia Formation

Sample number:431781

Thin section description

Lithologies present:
Illitic shale (82%), greywacke (5%), quartzarenite (1%), siltstone (1%), single grains of very coarse polycrystalline & monocrystalline quartz (10%), Fe rich carbonate (trace), glauconitic carbonate replaced by blocky pyrite (trace) and opaques (trace) are apparent. The gamma ray log suggests this depth interval should be characterised by shale. Chips of greywacke, quartzarenite and very coarse grained quartz are considered down hole contaminants.

Illitic shale

Sedimentary structures	none apparent
Composition	silt size quartz, mica flakes, accessory zircon & tourmaline, rare coarse silt size rounded grains of bright green glaucony float in a matrix of anhedral randomly oriented illitic clay, minor anhedral Fe carbonate blotches scattered throughout the shale, rarely these blotches have a spherulitic habit and appear to have been recrystallised to spar, traces of pyrite on the margins of carbonate blotches, possible anhedral minute crystals of anatase

Comments:
The shale lacks organic matter that was apparent at 7240-7250ft. Spherulitic habit in the carbonate and presence of anatase may indicate this shale is representative of the Dullingari Group rather than Merrimelia Formation.

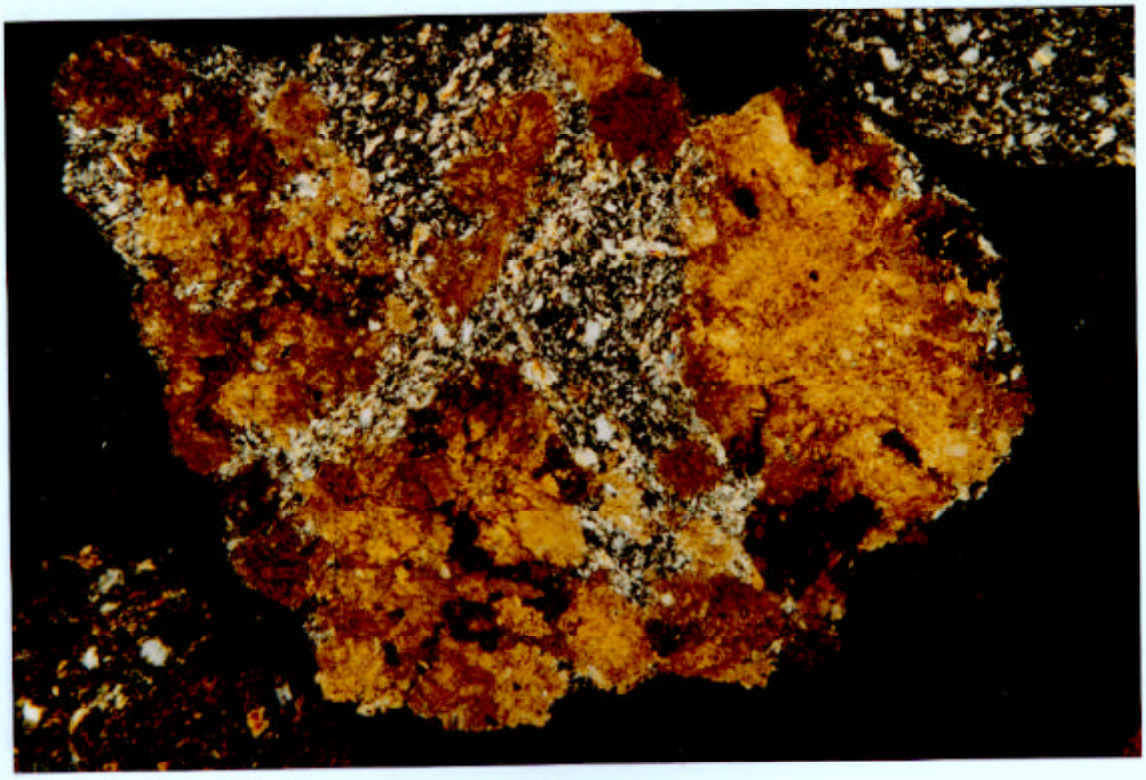

Figure 2
In this illitic shale chip spherulitic carbonate has Fe staining that may indicate the presence of siderite. Bagundi-2, cuttings, depth 7270-7280ft. Crossed nicols. Horizontal field of view 1.30mm.

4.3 Bagundi-2, cuttings, depth 7340-7350ft, ?Ordovician

Sample number:431782

Thin section description

Lithologies present:
Cuttings consist of illitic shale (94%), siltstone (trace), very fine to medium grained sandstone (2%), single grains (3%) of coarse quartz, kaolin, Fe stained carbonate spar and opaques. The dominance of shale indicates this lithology should be representative of this depth interval.

Illitic shale

Sedimentary structures	rare fractures approximately 0.20mm wide filled with Fe stained carbonate & then polycrystalline quartz
Avg. grain size	clay to silt
Sorting	poor
Composition	silt size monocrystalline quartz, muscovite & accessory tourmaline &?epidote float in an illitic matrix, illite laths are aligned tangentially to grain margins, patchy micritic Fe rich carbonate is scattered throughout the matrix & there are rare grains replaced by blocky pyrite & anhedral anatase

Comments:
Rare healed fractures in the shale may indicate it is part of the Dullingari Group.

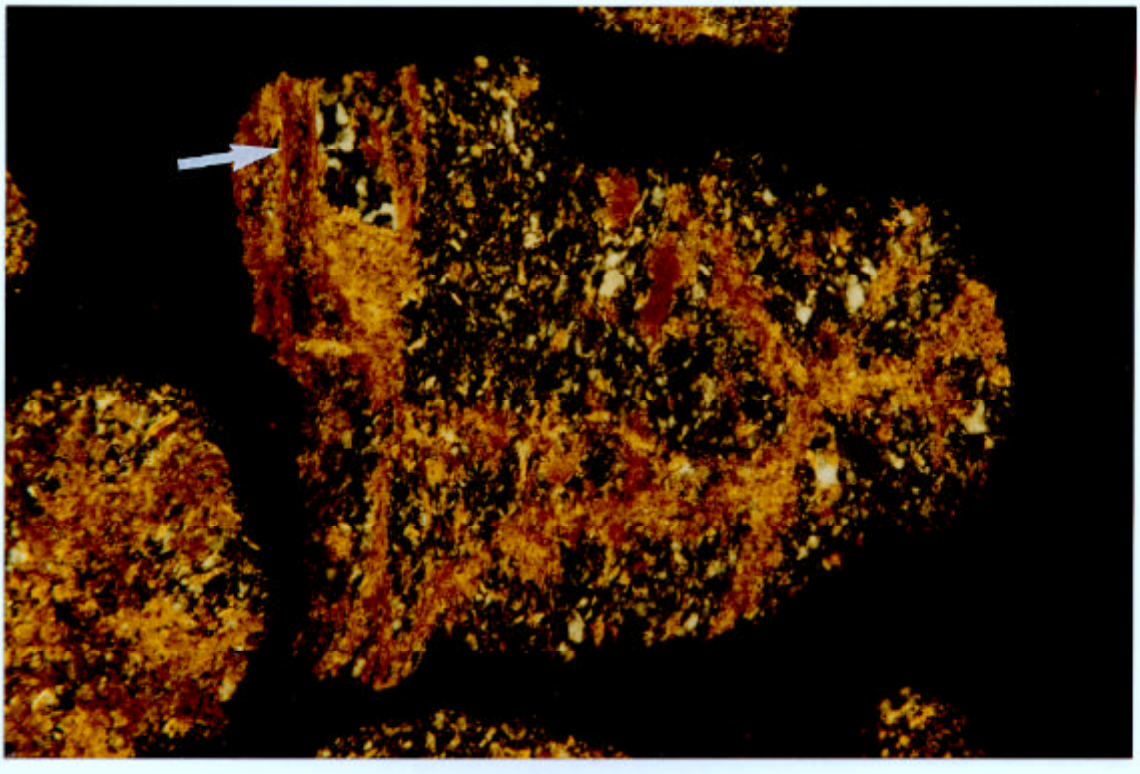

Figure 3
On the margin of the larger shale chip there is part of a healed fracture (arrow). Fe rich carbonate similar to that in the adjacent shale appears to predate a final fracture fill of polycrystalline quartz. Bagundi-2, cuttings, depth 7340-7350ft. Crossed nicols. Horizontal field of view 1.30mm.

4.4 Bagundi-2, cuttings, depth 7350-7360ft, ?Mooracoochie Volcanics

Sample number:431783

Thin section description

Lithologies present:
Cuttings consist of chips of shale to silty shale (98%), very fine grained sandstone (1%), siltstone (trace), glauconitic mudstone (trace), Fe stained carbonate spar (1%) and opaques (trace). The dominance of shale and silty shale in these cuttings suggests this lithology is representative of this depth interval.

Silty shale

Sedimentary structures	silty laminae may be present in the shale, fractures approximately 0.20mm wide healed with blocky Fe rich carbonate spar & a later phase of kaolin
Avg. grain size	clay to silt
Sorting	poor
Composition	varying amounts of silt to very fine grained monocrystalline quartz, muscovite, chloritised biotite, traces of corroded feldspar & accessory tourmaline, rutile, zircon & opaques float in an illitic matrix, patches of dusty micrite are scattered throughout the matrix & there are rare patches of clear blocky spar

Comments:
This shale is very similar in composition to the overlying Dullingari Group. There is no evidence of Mooracoochie Volcanics.

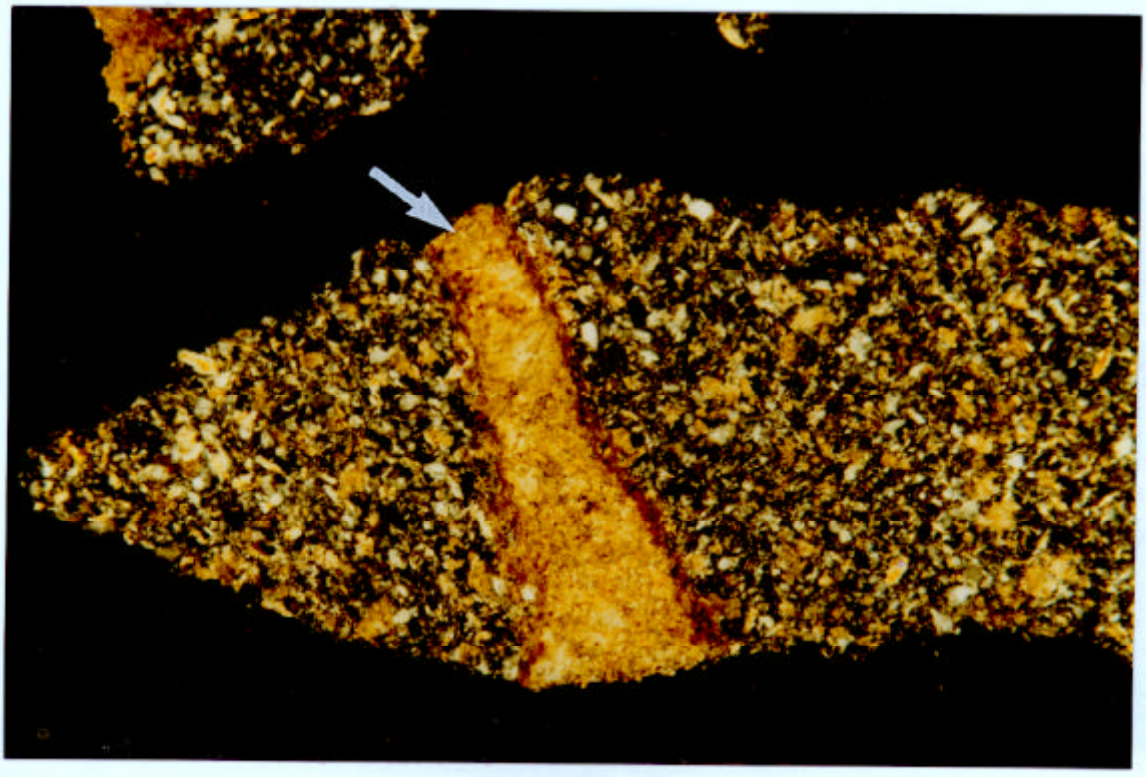

Figure 4
Fe stained carbonate spar has healed this fracture (arrow). Patchy micritic carbonate is apparent in the adjacent shale. Bagundi-2, cuttings, depth 7350-7360ft. Crossed nicols. Horizontal field of view 1.30mm.

4.5 Mataranka-1, cuttings, depth 7440-7450ft, ?Patchawarra Formation

Sample number: 431785

Thin section description

Lithologies present:
Cuttings of partially pyritised carbonaceous material (?coal, 40%), Fe rich anhedral to subhedral carbonate spar (3%), siltstone (3%), silty carbonaceous mudstone (50%), shale with fractures healed by polycrystalline quartz (trace), very fine grained siderite cemented sandstone (2%), medium grained quartz, carbonate & kaolin cemented quartzarenite (trace) and fine grained poorly sorted sandstone (1%). Based on the logs from this depth interval it would appear that the chips of sandstone are downhole contaminants. The silty carbonaceous mudstone is probably interbedded with pyritised coal and possibly siltstone. Shale with quartz healed fractures may represent lithics reworked from the Dullingari Group.

Mudstone

Sedimentary structures	laminae are outlined by the alignment of carbonaceous material
Avg. grain size	clay to silt
Sorting	poor
Composition	silt to very fine sand size grains of monocrystalline quartz & minor muscovite flakes float in a matrix of anhedral brown clay & fragments of carbonaceous material, extensive replacement of the matrix by micritic Fe rich carbonate (?siderite) that has been partially oxidised

Comments:
This depth interval may represent the Patchawarra Formation given the abundance of coal in this unit.

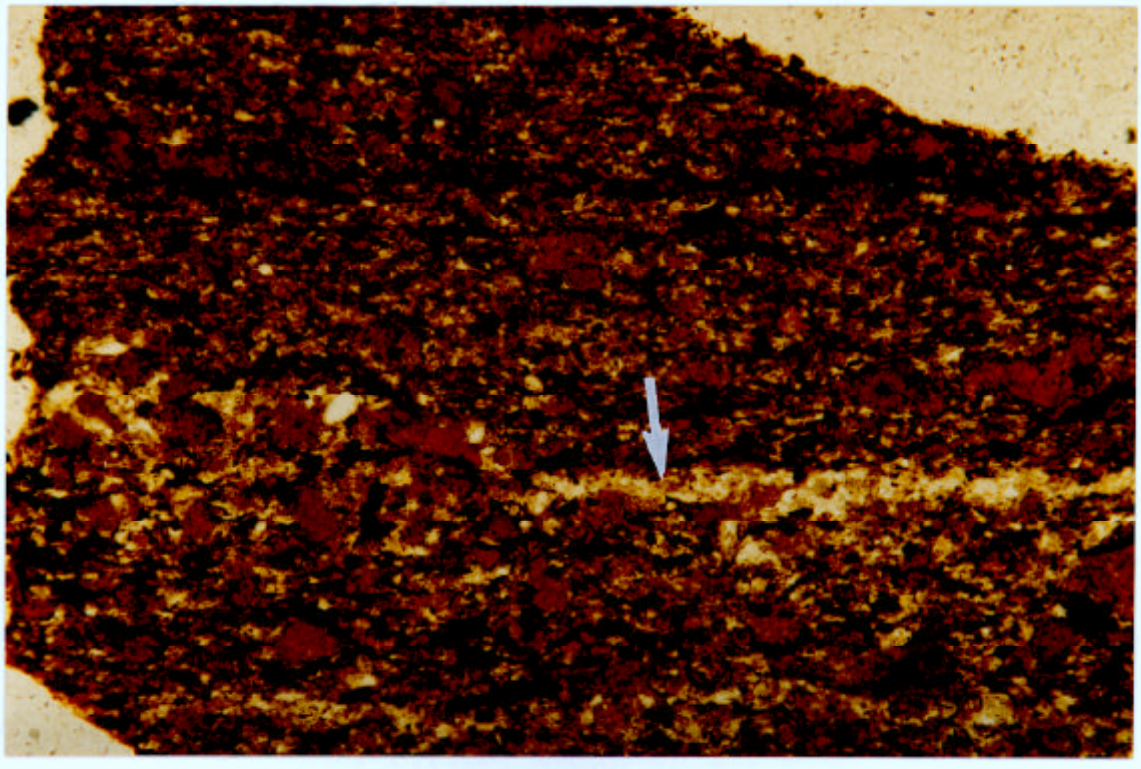

Figure 5
A silty laminae (arrow) is apparent in this chip of carbonaceous (opaque) mudstone. Partial oxidation of the micritic Fe rich carbonate in one laminae has resulted in a reddish colour. Mataranka-1, cuttings, depth 7440-7450ft. Plane light. Horizontal field of view 1.30mm.

4.6 Mataranka-1, cuttings, depth 7450-7460ft, ?Patchawarra Formation

Sample number:431786

Thin section description

Lithologies present:
Chips consist of carbonaceous mudstone (20%), carbonaceous material (20%), illitic shale (30%), ?diamictite (25%), medium grained kaolin & quartz cemented quartzarenite (1%), Fe rich carbonate spar (2%), coarse grains of monocrystalline & polycrystalline quartz (1%) and greywacke (trace). Illitic shale typical of the Dullingari Group probably represents clasts in the ?diamictite. Polycrystalline quartz & a later phase of subhedral kaolin booklets heal thin fractures 0.05 to 0.20mm wide in the illitic shale

?Diamictite

Sedimentary structures	clasts of illitic shale have deformed thin clay stringers in the ?diamictite
Avg. grain size	clay to very fine sand
Sorting	very poor
Composition	silt to medium sand size grains of monocrystalline quartz, lithics of illitic shale & quartzite, & muscovite flakes float in an anhedral pale brown matrix, stringers of slightly darker clay are evident in the matrix, authigenic subhedral to euhedral crystals of Fe rich carbonate spar are scattered throughout the matrix, kaolin booklets have replaced micas & possibly feldspars, silt size grains replaced by ?anatase, rare patches of blocky pyrite

Comments:
If this interval is composed of ?diamictite then it represents the Merrimelia Formation rather than the Patchawarra Formation. If the interpretation of ?diamictite is incorrect then the illitic shale was derived from the Dullingari Group. In either scenario this is not the Patchawarra Formation.

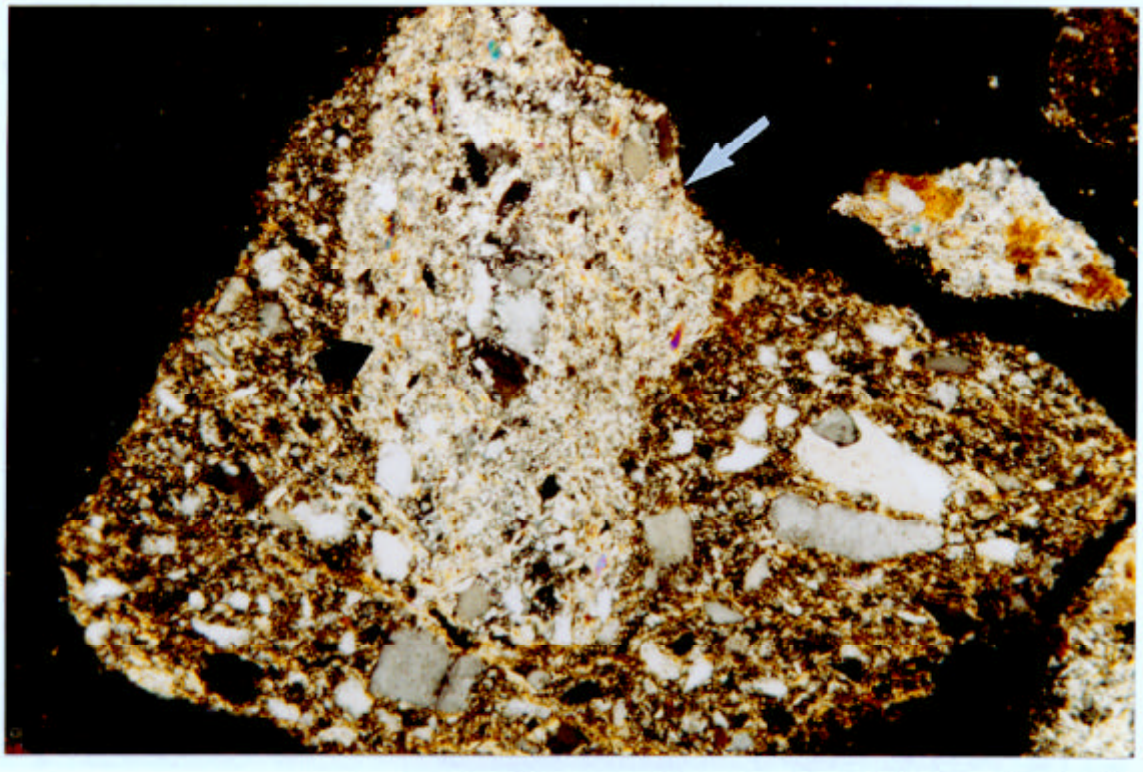

Figure 6
Clast of illitic shale (arrow) imbedded in ?diamictite. Note the alignment of elongate quartz grains in the ?diamictite at right angles to the orientation of the illitic shale clast. Mataranka-1, cuttings, depth 7450-7460ft. Crossed nicols. Horizontal field of view 1.30mm.

4.7 Mataranka-1, cuttings, depth 7460-7470ft, ?Merrimelia Formation

Sample number: 431787

Thin section description

Lithologies present:
Cuttings consist of various lithologies including illitic shale (80%), carbonaceous material (2%), carbonaceous mudstone (4%), single grains of very coarse to granule size monocrystalline & polycrystalline quartz (2%), carbonate cemented greywacke (trace), ?diamictite (1%), fine to medium grained quartz and kaolin cemented quartzarenite (trace), and Fe rich carbonate spar that is rarely spherulitic (10%). Illitic shale and Fe rich carbonate spar are probably representative of this depth interval.

Shale

Sedimentary structures	fractures of variable thickness are healed with polycrystalline quartz
Avg. grain size	clay to silt
Sorting	poor
Composition	silt to fine sand size grains of monocrystalline & polycrystalline quartz, muscovite flakes & accessory zircon, tourmaline & rutile float in an illitic matrix, authigenic minerals are dominated by spherulitic carbonate spar & lesser patches of micritic Fe rich carbonate, minor blocky pyrite has replaced the spherulitic spar, rare grains have been replaced by kaolin

Comments:
The dominant lithology is illitic shale typical of the alteration zone in the Dullingari Group. However, it is possible that the illitic shale has been reworked into the Merrimelia Formation. The very coarse to granule size grains of quartz may represent other clasts within the Merrimelia Formation.

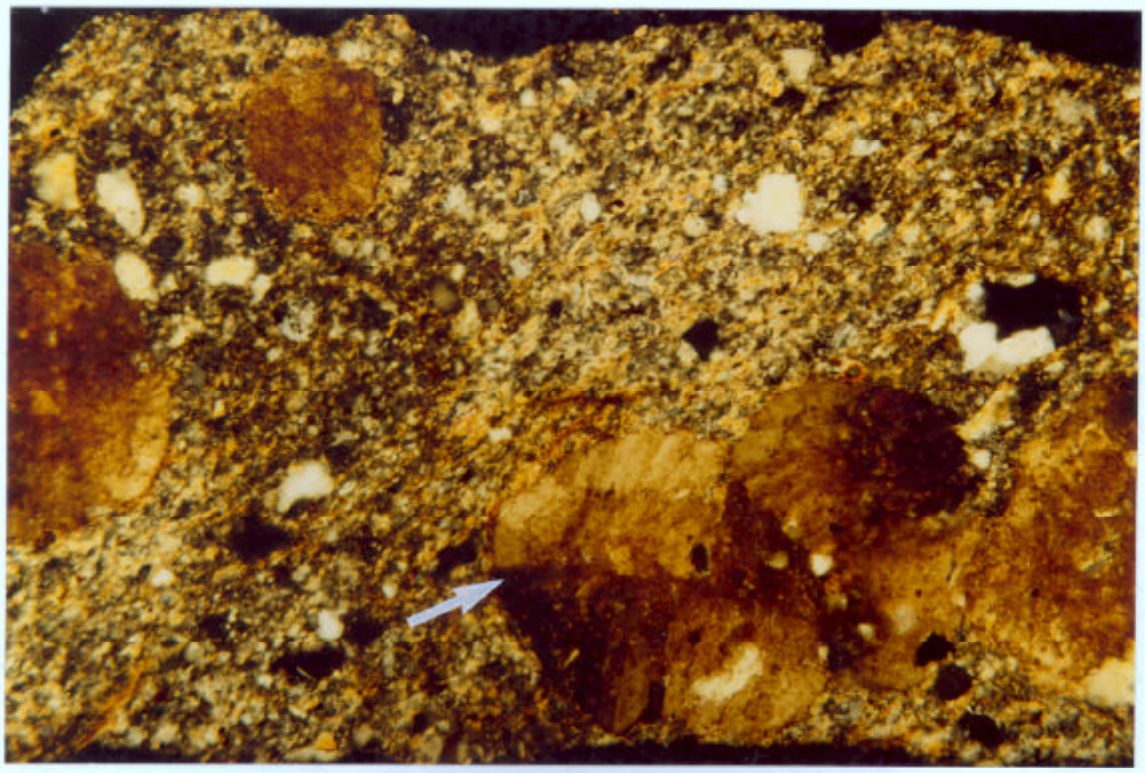

Figure 7
Spherulitic carbonate spar (arrow) is abundant in the illitic shale. Note the poor sorting in the shale with silt to fine sand size monocrystalline and polycrystalline quartz. Mataranka-1, cuttings, depth 7460-7470ft. Crossed nicols. Horizontal field of view 1.30mm.

4.8 Mataranka-1, cuttings, depth 7510-7520ft, ?Lycosa Formation

Sample number: 431792

Thin section description

Lithologies present:

Cuttings include examples of carbonaceous mudstone (2%), carbonaceous material (2%), illitic shale (25%), Fe rich carbonate spar (10%), medium to very coarse sand size grains of monocrystalline and polycrystalline quartz (4%), crenulated silty shale (56%), fine grained carbonate cemented sandstone (trace), micaceous siltstone (trace) and glauconitic very fine grained greywacke (trace). The wide variety of lithologies present may be attributed to downhole contamination. There is no evidence that the sandstone chips have undergone low grade metamorphic alteration, therefore they were probably derived from the Patchawarra or Merrimelia Formations along with the carbonaceous mudstone and carbonaceous material. Illitic shale with healed fractures and spherulitic Fe rich carbonate is characteristic of the alteration zone in the Dullingari Group. Many of the grains/chips of polycrystalline quartz could represent remnants of healed fractures in the Dullingari Group or clasts in the Merrimelia Formation. Since there is only one chip of micaceous siltstone and one of glauconitic very fine grained greywacke it is unlikely that they are representative of this depth interval. Therefore chips of silty shale are probably the most likely lithology at this depth.

Silty Shale

Sedimentary structures	healed fractures include examples of quartz where crystal size systematically increases towards the centre of the fracture and there are traces of opaque material (?reservoir bitumen) trapped between crystals before the final quartz cement, rare chips have the crenulated nature of examples from 7670-80'
Avg. grain size	clay to silt
Sorting	poor
Composition	silt to very fine sand size grains of monocrystalline quartz, rare muscovite flakes & accessory tourmaline float in anhedral brownish clay matrix, authigenic minerals of dusty grain replacing spar, grain replacing illite and blocky pyrite are evident

Comments:

It is possible that at least some of the lithologies present have been reworked from the Dullingari Group into the Merrimelia Formation. However, the dominance of silty shale suggests this depth interval is characterised by relatively fresh Dullingari Group. In addition, there may be a thin interval of altered shale as indicated by the illitic shale present.

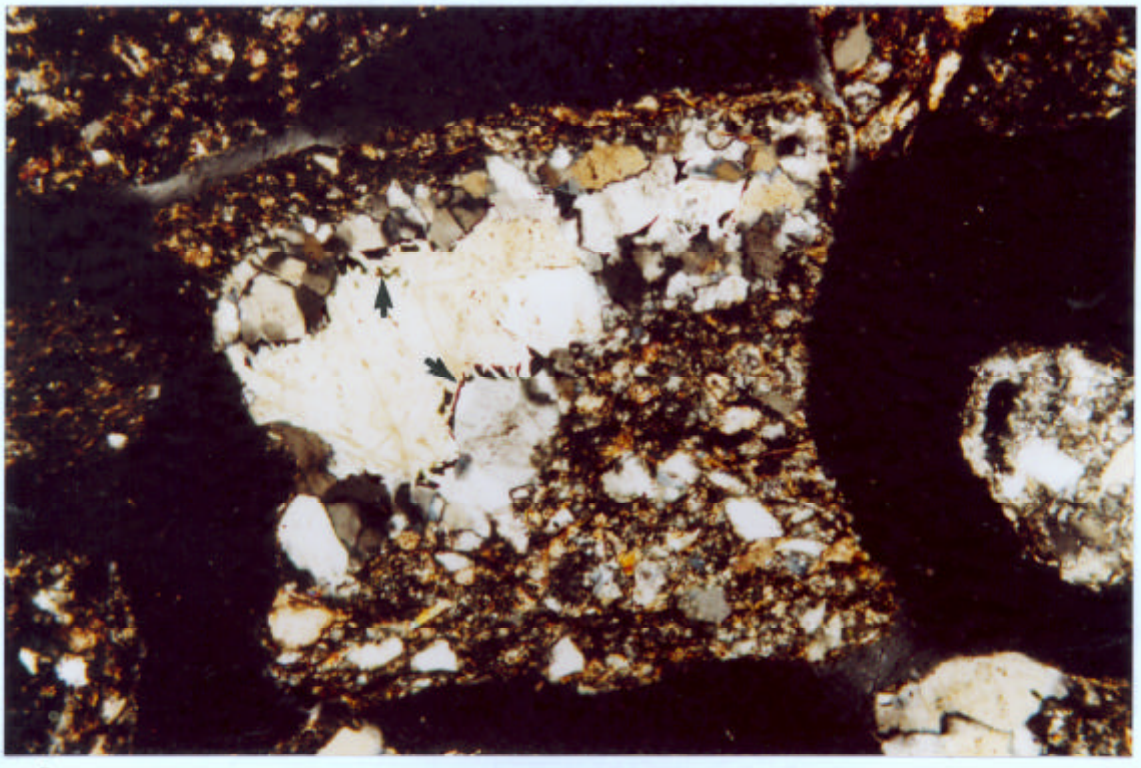

Figure 8

A fracture in this silty shale has been healed by quartz in which crystal size increases towards the middle of the fracture. Note the opaque material (arrows) trapped between crystals. Mataranka-1, cuttings, depth 7510-7520ft. Crossed nicols. Horizontal field of view 1.30mm.

4.9 Mataranka-1, cuttings, depth 7670-7680ft, Lycosa Formation

Sample number: 431788

Thin section description

Lithologies present:
Cuttings consist of silty shale (95%), illitic shale (2%), pyritised carbonaceous material (trace), single grains of polycrystalline quartz (2%) and Fe rich carbonate microspar (trace). Silty shale is thought to be representative of this depth interval. The polycrystalline quartz has probably been derived from fractures in the silty shale.

Silty Shale

Sedimentary structures	distinctive crenulated nature of shale is probably due to the development of slatey cleavage, numerous fractures are healed by a variety of cements these include polycrystalline quartz, polycrystalline quartz partially replaced by clear carbonate spar, Fe rich carbonate spar, Fe rich spar replaced by pyrite & pyrite
Avg. grain size	clay
Range in grain size	clay to very fine sand
Sorting	poor
Composition	abundant silt size grains of monocrystalline quartz, rare fresh plagioclase, muscovite flakes & accessory tourmaline surrounded by a matrix of greenish-brown anhedral clay with crenulated stringers of opaque material, authigenic minerals of Fe rich micritic carbonate form minute patches within the matrix & there are minute blocky crystals of pyrite & grains replaced by illite

Comments:
The crenulated nature of the shale and abundance of healed fractures are consistent with this depth interval representing the Lycosa Formation.

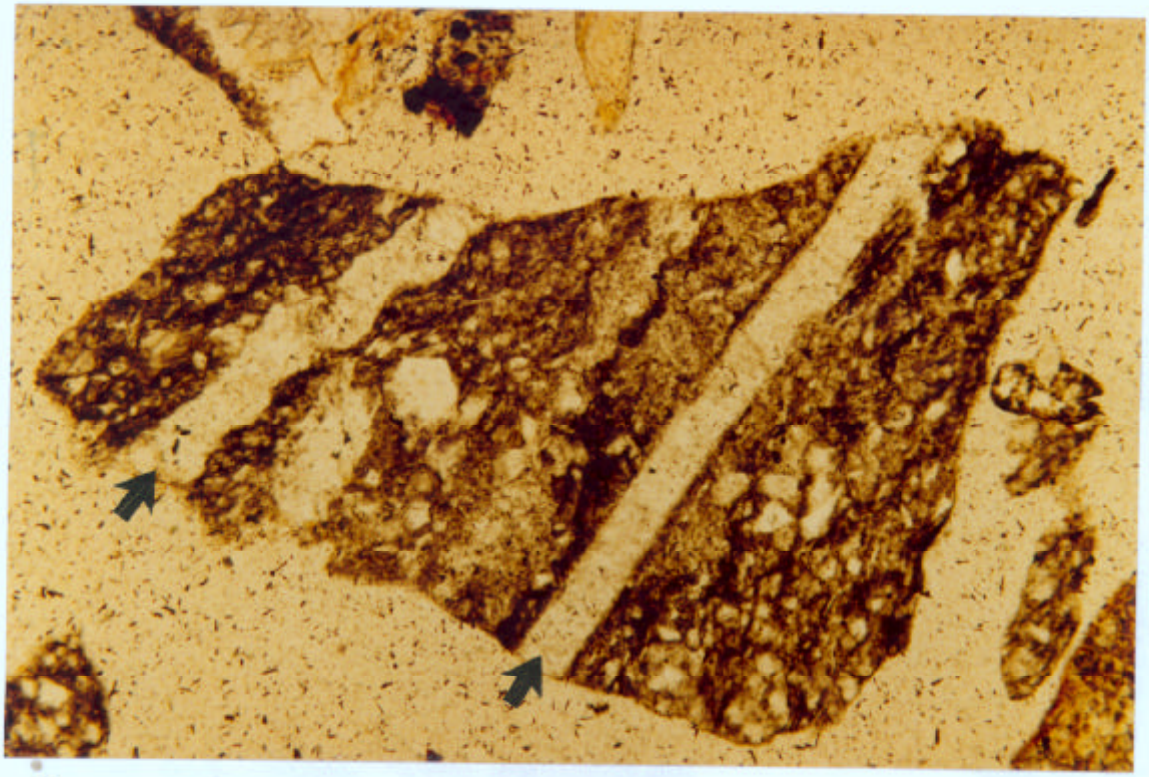

Figure 9
In this chip of silty shale there are two fractures (arrows) healed by polycrystalline quartz. One fracture has a crenulated outline suggesting it predated significant compaction and the other fracture has a straight outline possibly because it postdated deformation. Mataranka-1, cuttings, depth 7670-7680ft. Plane light. Horizontal field of view 1.30mm.

4.10 Napowie-1, cuttings, depth 10770-10780ft, ?Kalladeina Formation

Sample number: 431795

Thin section description

Lithologies present:

Cuttings consist of fine to medium grained illitic sandstone (75%), carbonate cemented sandstone (trace), siltstone (3%), carbonaceous shale (7%), greywacke (7%), illitic shale (trace), blocky pyrite (6%), rare Fe rich carbonate spar (trace), and single grains of coarse monocrystalline & polycrystalline quartz & chert (1%). One chip of laminated ?phosphate contains grains that have been replaced by vermiform kaolin. There is probably a gradation between the chips of illitic sandstone and the greywacke. The dominant lithology in cuttings from this depth is the illitic sandstone, which could be described as a protoquartzite.

Illitic Sandstone (protoquartzite)

Sedimentary structures	none apparent in individual chips but variations in sorting between chips may indicate bedding
Avg. grain size	fine sand
Range in grain size	very fine to medium grained sand
Sorting	poor to well sorted
Roundness/sphericity	subangular to subrounded/ low sphericity
Texture	grain supported
Porosity	none apparent but there could be micropores
Composition	framework grains are dominated by monocrystalline quartz with minor to trace amounts of polycrystalline quartz, lithics of shale & chert, muscovite flakes & accessory tourmaline, rutile & zircon, matrix is present in variable amounts & is composed of illitic clay with a patchy distribution & trapped between quartz overgrowths, rare crystals of clear subhedral to euhedral carbonate spar cement the quartz & rare patches of anhedral dusty spar are evident in the matrix, grains have been replaced by illite, rare ?anatase rims & replaces grains, there are rare grains of bright green glaucony & grains replaced by kaolin are apparent

Comments:

This protoquartzite is very similar in texture and composition to other examples of illitic sandstone described from the Dullingari Group. It is unlikely to be representative of the Tirrawarra Sandstone because of the dominance of illite (rather than kaolin) and presence of fresh glaucony.

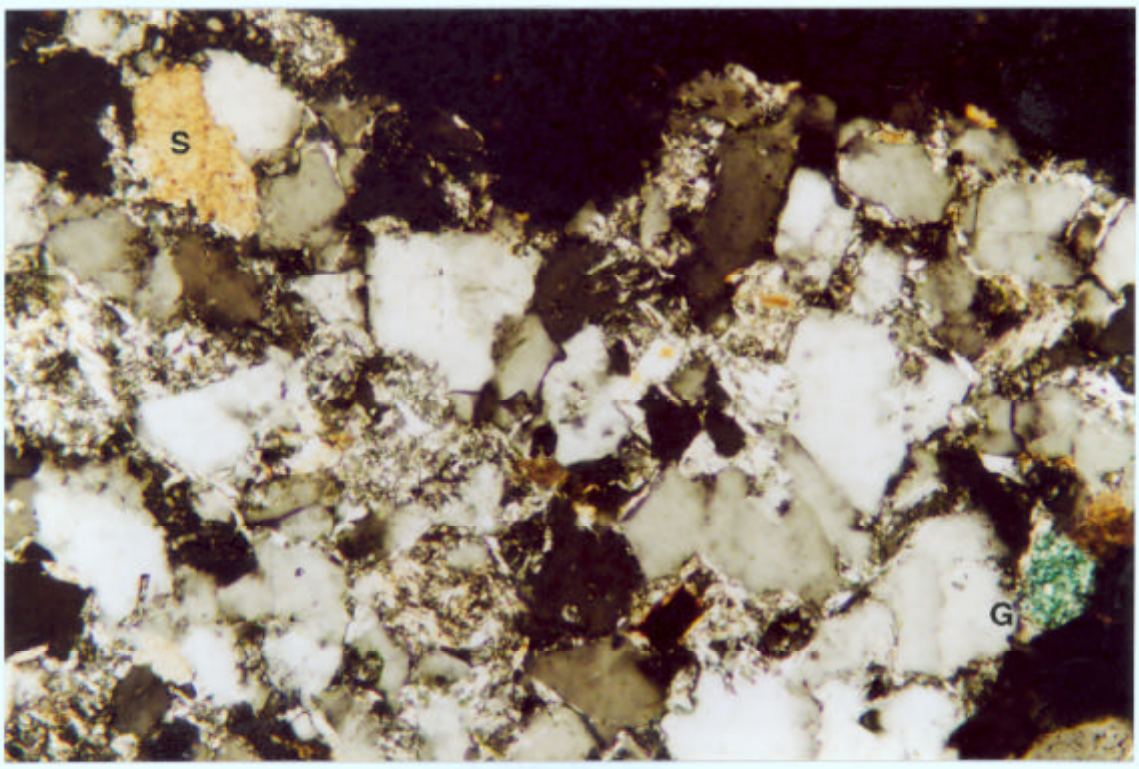

Figure 10

Illite forms the matrix and has replaced grains in this chip of very fine grained protoquartzite. Note the bright green grain of fresh glaucony (G) and patchy carbonate spar (S). Napowie-1, cuttings, depth 10770-10780ft. Crossed nicols. Horizontal field of view 0.65mm.

4.11 Napowie-1, cuttings, depth 10860-10870ft, ?Kalladeina Formation

Sample number:431796

Thin section description

Lithologies present:
Chips of greywacke (1%), illitic sandstone (85%), carbonate cemented very fine grained sandstone (3%), medium grained kaolin & quartz cemented sandstone (1%), carbonaceous shale (5%), shale (2%), siltstone (trace), Fe rich spar (1%), pyrite cemented sands (trace) and single grains of coarse to very coarse monocrystalline quartz & opaques (1%) are apparent. The illitic sandstone that appears to be representative of this depth interval has significantly more carbonate cement and less illite than cuttings from 10770-10780ft.

Illitic Sandstone (protoquartzite)

Sedimentary structures	changes in grain size & sorting between chips indicate there is bedding present
Avg. grain size	fine sand
Range in grain size	very fine to medium grained sand
Sorting	poor to moderately well
Roundness/sphericity	subangular to subrounded/ low to moderate
Texture	grain supported
Porosity	none apparent
Composition	framework grains of monocrystalline quartz are dominant with minor polycrystalline quartz, rare corroded K-feldspars (?microcline), shale lithics, muscovite & altered biotite flakes & accessory zircon & tourmaline, matrix is characterised by illitic clay, authigenic minerals are dominated by anhedral to subhedral blocky clear carbonate spar, quartz overgrowths are well developed in cleaner sands, rare grains of bright green glaucony, minor grains replaced by illite, rare grain replacing ?anatase

Comments:
There is nothing distinctive about this sandstone to identify it as Kalladeina Formation.

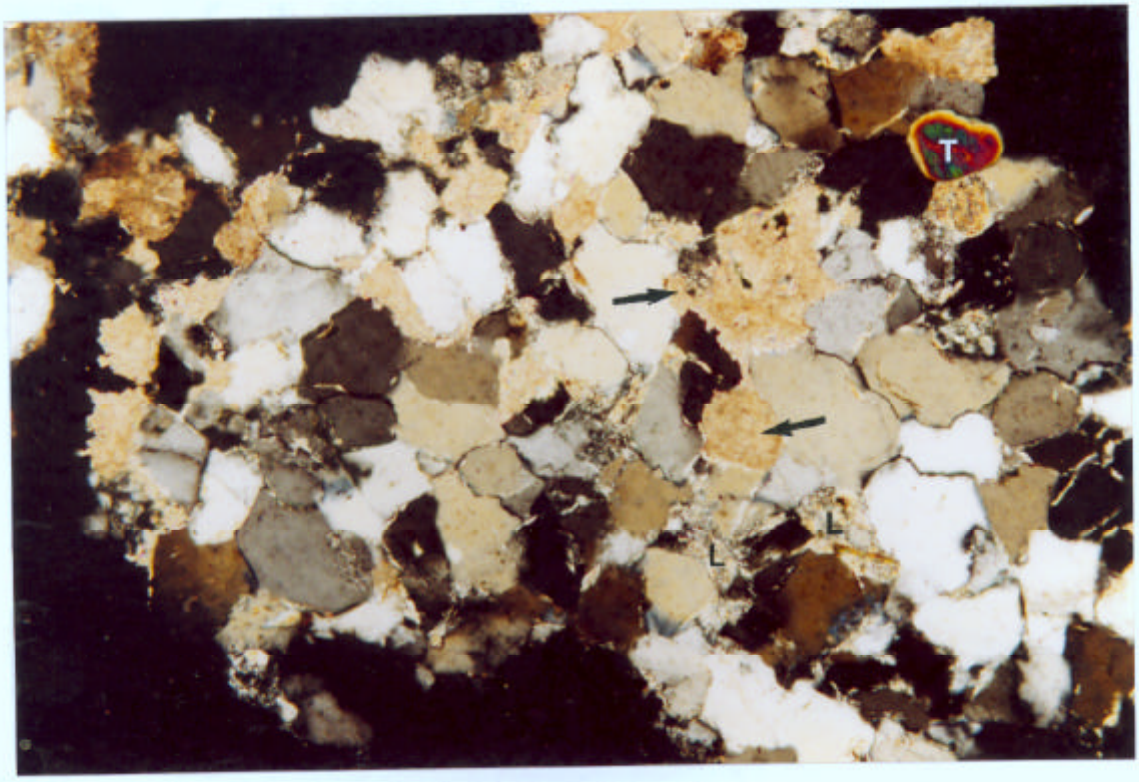

Figure 11
Typical chip of fine grained illitic sandstone illustrating the presence of shale lithics (L), accessory tourmaline (T) and abundance of carbonate cement (arrows). Napowie-1, cuttings, depth 10860-10870ft. Crossed nicols. Horizontal field of view 1.30mm.

4.12 Napowie-1, cuttings, depth 10930-10940ft, ?Kalladeina Formation

Sample number: 431797

Thin section description

Lithologies present:
Chips consist of fine grained sandstone (60%), illitic sandstone (30%), siltstone (5%), carbonaceous shale (2%), pyritised carbonaceous material (trace), Fe rich carbonate spar (trace), kaolin & quartz cemented poorly sorted coarse grained quartzarenite (trace), greywacke (2%) and single grains of coarse monocrystalline quartz (trace). The dominance of fine grained sandstone probably indicates that it is representative of this depth interval. The fine grained sandstone has less illite and more quartz cement than cuttings from 10860-70'.

Sandstone (Quartzarenite)

Sedimentary structures	variations in grain size & sorting may indicate bedding
Avg. grain size	fine sand
Range in grain size	silt to medium sand
Sorting	moderately well
Roundness/sphericity	subangular to subrounded/ moderate sphericity
Texture	grain supported
Porosity	none apparent
Composition	framework grains are dominated by monocrystalline quartz, with rare polycrystalline quartz, chert & shale lithics, fresh microcline, muscovite & biotite flakes, accessory tourmaline, rutile & zircon, illite is trapped as a dust rim within quartz overgrowths & has replaced grains, clear blocky carbonate spar appears to postdate the quartz, rare grains of bright green wormy glaucony

Comments:
There is nothing to distinguish this fine grained sandstone as Kalladeina Formation.

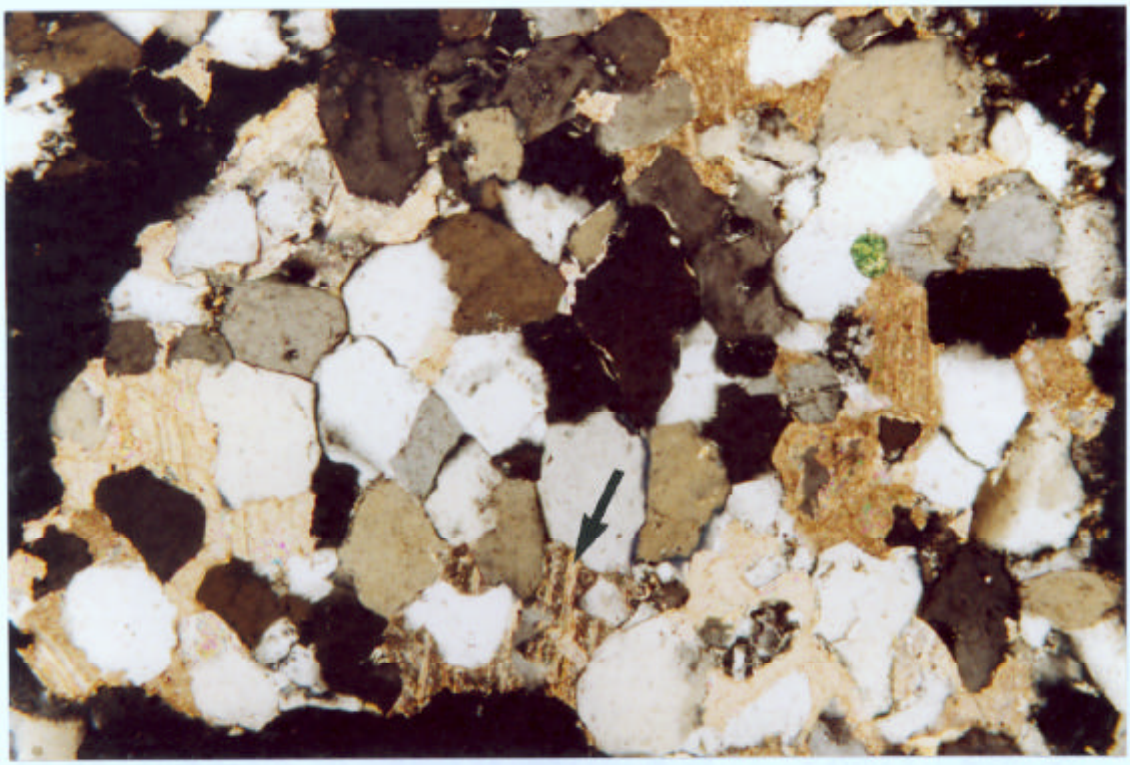

Figure 12
Typical chip of fine grained well sorted quartzarenite. Straight grain contacts indicate the abundance of quartz overgrowths. Twinning in the carbonate spar (arrow) suggests this is a burial cement. Note the bright green grain of glaucony. Napowie-1, cuttings, depth 10930-10940ft. Crossed nicols. Horizontal field of view 1.30mm.

4.13 Strzelecki-15, cuttings, depth 6440-6450ft, ?Merrimelia Formation

Sample number: 431798

Thin section description

Lithologies present:
Chips consist of illitic shale (75%), siltstone (2%), illitic sandstone & carbonate cemented sandstone (7%), kaolin & quartz cemented sandstone (2%), carbonaceous shale (3%), Fe rich microspar (2%), carbonaceous material (2%), greywacke (trace) and coarse to granule size grains of polycrystalline & rare monocrystalline quartz (6%). Illitic shale is thought to be characteristic of this depth interval. Fractures in the shale are healed with polycrystalline quartz & Fe rich carbonate spar therefore chips of these compositions may also be representative of this interval. Carbonaceous material, carbonaceous shale and kaolin + quartz cemented sandstone probably represents down hole contaminants from the Patchawarra Formation.

Illitic Shale

Sedimentary structures	variations in the percentage of silt in the shale may be attributed to bedding, fractures are typically healed with polycrystalline quartz & a later phase of Fe rich carbonate spar
Avg. grain size	clay
Range in grain size	clay to very fine sand
Sorting	poor
Composition	detrital grains of monocrystalline quartz & rare muscovite flakes & accessory zircon, tourmaline, rutile & opaques float in a matrix of illitic clay, authigenic minerals are dominated by irregular patches of Fe rich spar, rare framboidal pyrite & grains replaced by kaolin

Comments:
Illitic shale from this depth interval is typical of the altered zone in the Dullingari Group because of the illitic nature and healed fractures. However, it is also possible that this lithology may have been reworked as clasts into the Merrimelia Formation.

Figure 13
Chip of illitic shale cross-cut by a fracture healed with polycrystalline quartz. This fracture appears to parallel the orientation of bedding in the shale. Strzelecki-15, cuttings, depth 6440-6450ft. Crossed nicols. Horizontal field of view 1.30mm.

4.14 Strzelecki-15, cuttings, depth 6520-6530ft, ?Merrimelia Formation

Sample number: 431799

Thin section description

Lithologies present:
Chips consist of illitic shale (87%), carbonaceous shale (trace), medium grained illitic sandstone (2%), polycrystalline quartz + Fe rich spar (7%), carbonaceous material (trace), Fe rich micrite and oxidised spar (3%). The illitic shale that dominates chips from this depth interval contains significantly more Fe rich carbonate than illitic shale at 6440-50'. Chips of polycrystalline quartz + Fe rich spar probably represent healed fractures within the illitic shale.

Illitic Shale

Sedimentary structures	fractures are healed by dusty carbonate, Fe rich carbonate, polycrystalline quartz & traces of kaolin
Avg. grain size	clay
Range in grain size	clay to fine sand
Sorting	poor
Composition	silt to fine sand size grains of monocrystalline quartz, muscovite flakes & accessory minerals of tourmaline float in a matrix of illitic clay, scattered throughout the matrix there are irregular patches of Fe rich carbonate & dusty carbonate, rare pyrite framboids

Comments:
Illitic shale thought to represent this depth interval is typical of the Dullingari Group.

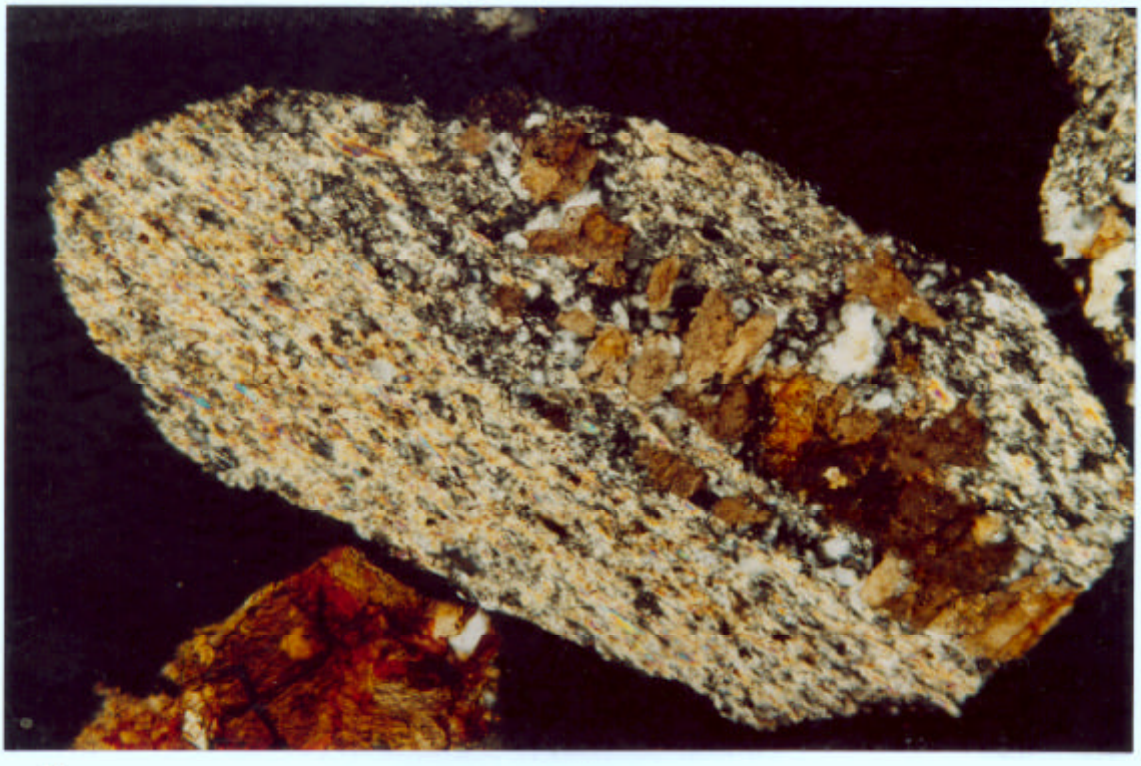

Figure 14
The healed fracture in this chip of illitic shale contains polycrystalline quartz that has been partially replaced by Fe rich carbonate spar. Note the fracture appears to be oriented parallel to bedding. Strzelecki-15, cuttings, depth 6520-6530ft. Crossed nicols. Horizontal field of view 1.30mm.

4.15 Suta-1, cuttings, depth 10400-10410ft, ?Merrimelia Formation

Sample number:431800

Thin section description

Lithologies present:
Cuttings consist of illitic shale (10%), carbonaceous material (6%), carbonaceous silty mudstone (3%), fine to coarse grained well sorted quartzarenite (30%), poorly sorted carbonate cemented sandstone (35%), very fine grained illitic sandstone/ protoquartzite (5%), greywacke (10%), and single grains of polycrystalline quartz and chert (trace). Given the relative proportions of these chips it is difficult to be certain which lithology is representative of this depth interval. The carbonaceous material, carbonaceous silty mudstone and well sorted quartzarenites have probably been derived from the overlying ?Patchawarra Formation. Illitic shale and very fine grained illitic sandstone (protoquartzite) are characteristic of the Dullingari Group and may have been reworked into the Merrimelia Formation. There is a gradation between the poorly sorted carbonate cemented sandstone and greywacke. These lithologies are probably representative of this depth interval.

Sandstone/greywacke

Sedimentary structures	none apparent
Avg. grain size	medium sand
Range in grain size	silt to very coarse sand
Sorting	poor
Roundness/sphericity	medium - coarse grains are rounded with low sphericity
Texture	matrix supported
Porosity	none apparent
Composition	detrital grains are dominated by monocrystalline quartz with rare polycrystalline quartz, sericitised feldspar, quartzite & shale lithics that float in an anhedral grey clay size matrix, authigenic minerals are dominated by Fe rich carbonate spar that has replaced the matrix & embayed framework grains, rare grains have been replaced by kaolin

Comments:
This depth interval could be a ?diamictite from the Merrimelia Formation.

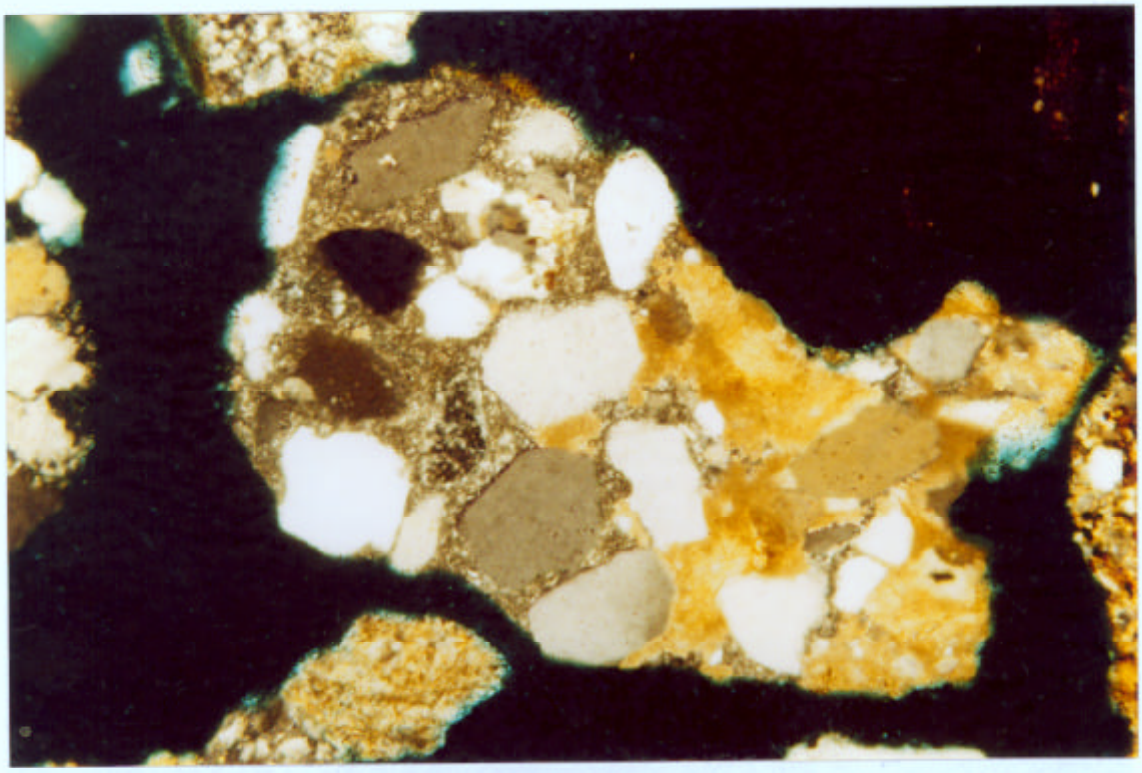

Figure 15
The chip of ?diamictite in the centre of this field of view appears to have detrital grains floating in matrix. Part of the chip has been replaced by anhedral dusty carbonate spar. Suta-1, cuttings, depth 10400-10410ft. Crossed nicols. Horizontal field of view 1.30mm.

4.16 Suta-1, cuttings, depth 10490-10500ft, ?Lycosa Formation

Sample number:431801

Thin section description

Lithologies present:
Chips from this depth interval consist of illitic sandstone (45%), carbonaceous material (15%), carbonaceous & phosphatic mudstone rarely with vermiform kaolin (20%), shale (6%), silty shale (4%), Fe rich carbonate microspar (3%), poorly sorted carbonate cemented sandstone (trace), greywacke (2%), kaolin + quartz cemented quartzarenite (trace), siltstone (2%), ?weathered granite (1%) and single grains of coarse sand size polycrystalline & monocrystalline quartz (1%). It is extremely difficult to identify which of these lithologies is representative of this depth interval. Based on the gamma ray log it might be a shale or mudstone but the chips present of shale/mudstone are not characteristic of the Dullingari Group. It is also possible that the gamma log has been elevated by the abundance of illite in the illitic sandstone.

Illitic Sandstone (protoquartzite)

Sedimentary structures	none apparent
Avg. grain size	very fine sand
Range in grain size	silt to medium sand
Sorting	well to moderately well
Roundness/sphericity	subrounded / low
Texture	grain supported
Porosity	none apparent
Composition	monocrystalline quartz is the dominant framework grain with minor fresh & corroded microcline, shale lithics, muscovite flakes & accessory rutile, tourmaline & zircon, illitic matrix is a minor component but there has been abundant replacement of grains by illite, quartz overgrowths are the major cement & there are rare patches of authigenic clear carbonate spar & blocky pyrite

Comments:
If this illitic sandstone is representative of this depth interval then it is probably the Dullingari Group. However, the illitic sandstone could have been reworked during deposition of the Merrimelia Formation. Possible identification of weathered granite may support the latter hypothesis but this might also be interpreted as a downhole contaminant from the Merrimelia Formation.

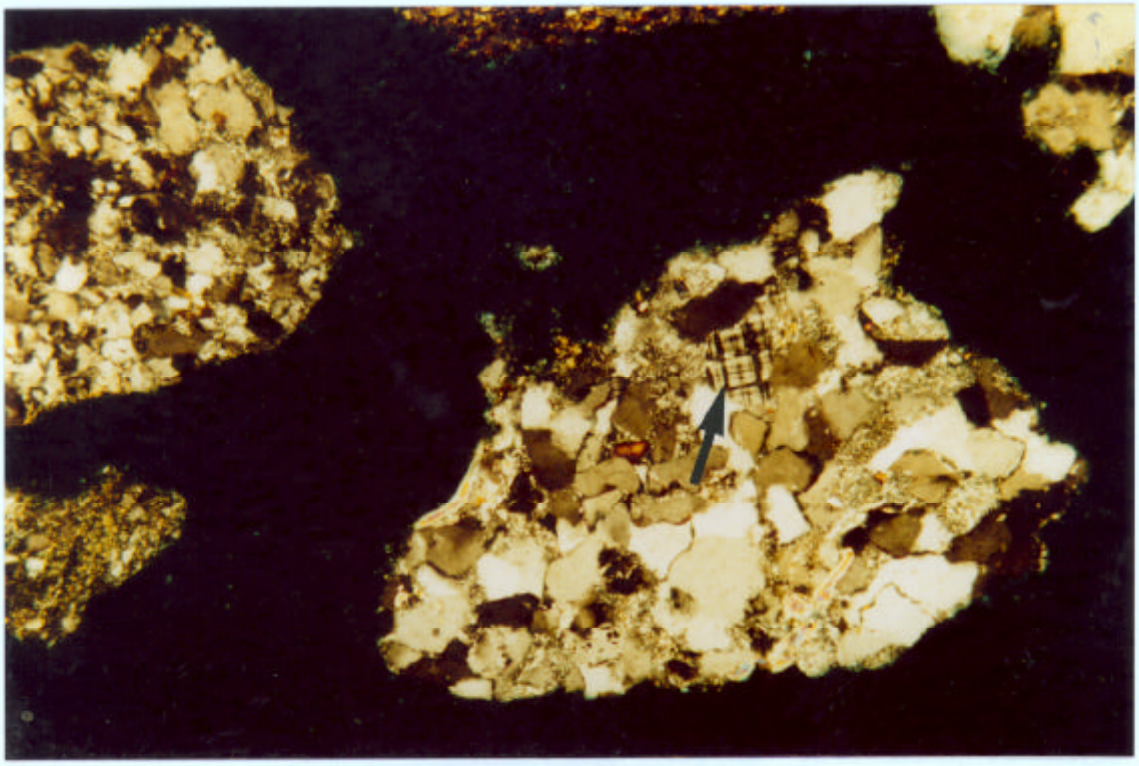

Figure 16
Typical chips of very fine grained illitic sandstone and siltstone. Note the fresh feldspar (arrow) in the sandstone. Suta-1, cuttings, depth 10490-10500ft. Crossed nicols. Horizontal field of view 1.30mm.

4.17 Suta-1, cuttings, depth 10573ft, ? Lycosa Formation

Sample number: 431802

Thin section description

Lithologies present:
Chips consist of carbonaccous material (10%), silt to very fine grained illitic sandstone/siltstone (56%), medium grained sandstone (15%), carbonaceous mudstone (10%), shale (3%), illitic shale with quartz healed fractures (trace), greywacke/diamictite containing lithics of ?weathered granite (trace), Fe rich carbonate cemented sandstone (2%), ?weathered granite (1%) and single grains of monocrystalline quartz (2%). In addition, there are a high percentage of chips that appear to have been crushed, these have not been taken into account in the visual estimates given above. The dominant lithology is a gradation between silt to very fine grained illitic sandstone and siltstone.

Illitic Sandstone/siltstone

Sedimentary structures	changes in grain size suggest the presence of bedding
Avg. grain size	silt/very fine sand
Range in grain size	silt to fine grained
Sorting	moderate
Roundness/sphericity	subangular/ low
Texture	grain supported
Porosity	none apparent
Composition	framework grains are dominated by monocrystalline quartz with minor muscovite & accessory tourmaline, rutile & zircon, these grains are surrounded by abundant illitic matrix, where matrix is absent in the sandstone there are quartz overgrowths, rare patches of authigenic carbonate spar have replaced the matrix & there are traces of grain replacing ?anatase

Comments:
This illitic sandstone/siltstone could be characteristic of the Dullingari Group.

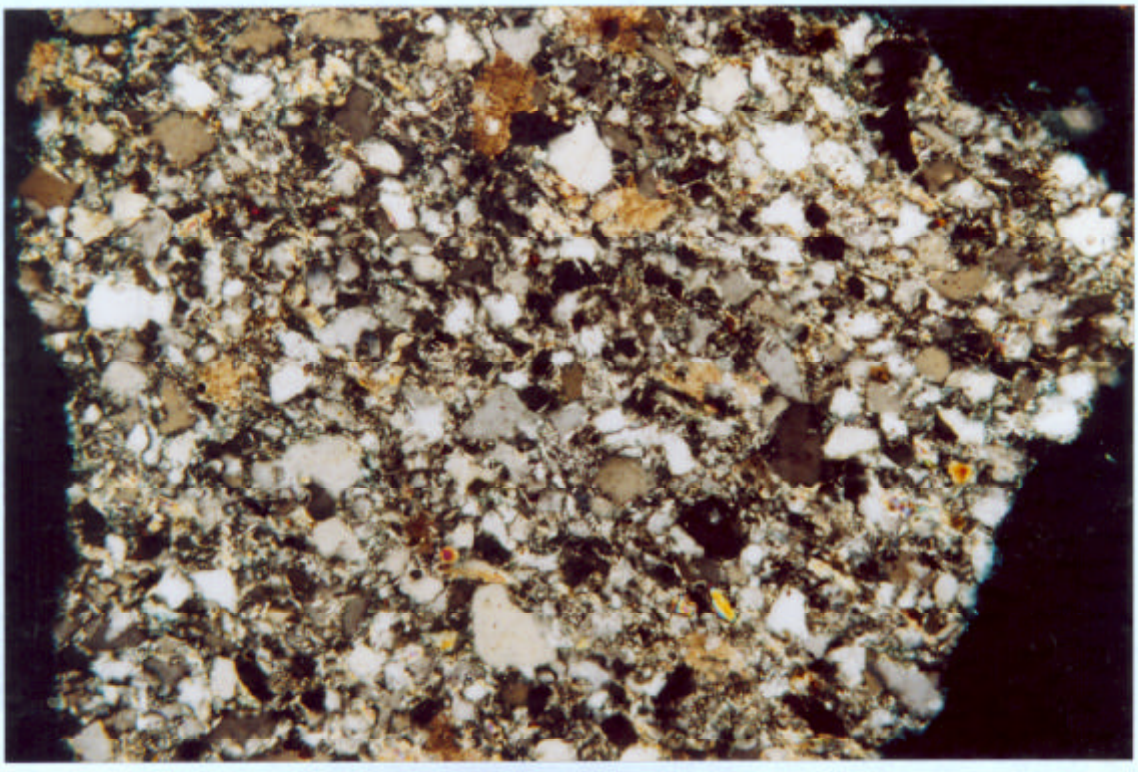

Figure 17
Typical chip of illitic siltstone with rare patches of dusty carbonate spar. Suta-1, cuttings, depth 10573ft. Crossed nicols. Horizontal field of view 1.30mm.

4.18 Tarragon-1, cuttings, depth 7790-7800ft, ?Mooracoochie Volcanics

Sample number:431803

Thin section description

Lithologies present:
Chips consist of illitic sandy shale (44%), medium to coarse grained quartzarenite (5%), ?igneous fragments (10%), radiating bladed crystals of carbonate spar (trace), opaque material (?scale, trace), single grains of very coarse sand size monocrystalline & polycrystalline quartz & chert (40%). It is possible that many of the single grains of quartz & chert have been derived from the overlying sands. Chips of quartzarenite are probably down hole contaminants.

Illitic sandy shale

Most chips are dominated by a very fine-grained matrix of weakly sutured quartz and tiny illite flecks through which are scattered small angular quartz crystal fragments and minor ragged alteration siderite. The illite and siderite appear to represent low-grade alteration possibly of diagenetic origin. Uncommon subhedral to subrounded larger grains of unstrained quartz appear to represent volcanic quartz grains. In some chips of sandy nature, larger rounded crystal fragments of quartz and fine-grained quartz-altered felsic volcanogenic rock are closely packed and cemented by angular siderite crystals.

?Igneous fragments

The ?igneous fragments consist of polycrystalline quartz and feldspar phenocrysts in a microcrystalline quartz groundmass with minor ?hornblende, anatase & zircon. There has been minor replacement of feldspars by illite.

Comments:
The illitic sandy shale does not represent an altered volcanic rock, therefore the igneous material present at this depth has probably been reworked from the underlying Mooracoochie Volcanics. The illitic sandy shale is almost a greywacke in composition and may represent the ?Dullingari Group.

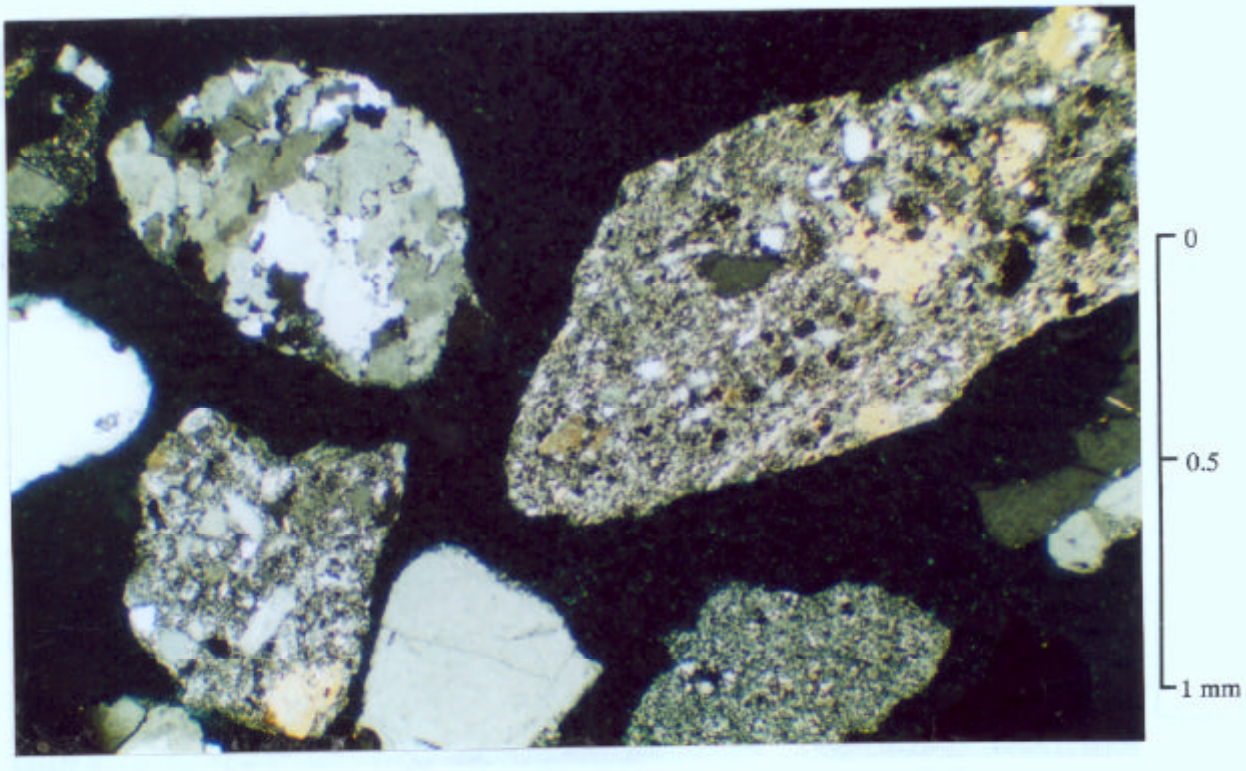

Figure 18
This view illustrates two chips of illitic sandy shale (upper right, lower left), a chip of polycrystalline quartz (upper left), and chips of unstrained quartz fragments (white, bottom, centre left). Tarragon-1, cuttings, depth 7790-7800ft. Crossed nicols. Magnification x5.

4.19 Tarragon-1, cuttings, depth 7860-7870ft, ?Mooracoochie Volcanics

Sample number:431804

Thin section description

Lithologies present:
Cuttings consist of chips of illitic sandy shale (80%), carbonate cemented sandstone (trace), ?igneous & volcanic fragments (2%), clear carbonate spar (trace) and single grains of coarse monocrystalline & polycrystalline quartz & chert (17%). The illitic sandy shale ranges in composition from shale to greywacke therefore many of the single grains may be derived from this lithology. Dominance of illitic sandy shale chips suggests this lithology may be representative of this depth interval.

Illitic sandy shale

Most chips are composed of abundant very fine-grained massive illite, through which are scattered tiny angular quartz grains. Some chips contain larger sand-sized particles of rounded quartz grains and fine-grained devitrified siliceous volcanic fragments. Some of the larger quartz grains display shadowy extinction suggestive of a metamorphic origin, but some are perfectly strain-free and display subrounded and partly resorbed textures suggestive of a volcanic origin. Angular interstitial siderite crystals form a cement in some of the sandy chips, and the illite and siderite are considered to be of diagenetic origin. Also present in some of the sandy chips are cryptocrystalline dark yellowish brown patches of hydrated iron oxide (goethite), possibly of weathering origin.

Quartz grains

Most quartz grains display shadowy strain extinction suggestive of a metamorphic origin, but some are perfectly strain-free and may be of volcanic origin.

Comments:
The dominance of illitic sandy shale indicates this is not the Mooracoochie Volcanics but lithics from this formation have been reworked into this interval.

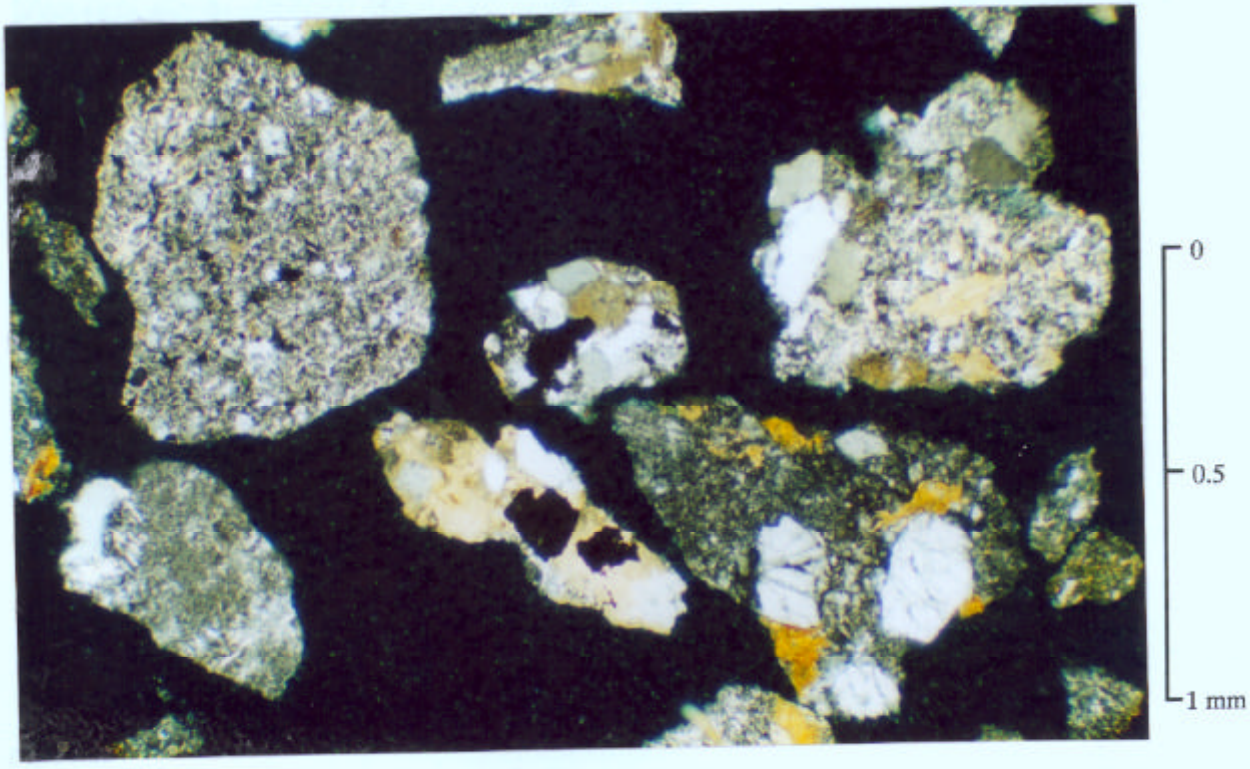

Figure 19
This view illustrates the illitic sandy shale fragments which dominate this sample. Tarragon-1, cuttings, depth 7860-7870ft. Crossed nicols. Magnification x5.

4.20 Tarragon-1, cuttings, depth 7930-7940ft, ?Mooracoochie Volcanics

Sample number:431805

Thin section description

Lithologies present:
Chips consist of ?volcanic fragments (90%), shale (trace), illitic very fine grained sandstone (trace), carbonate spar (trace) and single grains of monocrystalline and polycrystalline quartz (9%).

Siderite-illite altered quartz-plagioclase-biotite-hornblende porphyry

The chips represent a massive coarsely porphyritic igneous rock, originally composed of large euhedral to rounded quartz crystals, lesser plagioclase crystals, minor dark brown biotite plates, uncommon spongy dark green hornblende crystals and accessory small zircon crystals, in a uniformly fine-grained ?devitrified mosaic of quartz and feldspar. The rock has the appearance of a volcanic or subvolcanic rock of acid bulk composition. Some chips contain ragged siderite crystals and aggregates of alteration origin (?diagenetic), and minor illite occurs as fine randomly oriented flecks concentrated in local patches. A small number of chips contain cryptocrystalline yellow-brown ferruginous alteration patches (goethite) of probable weathering origin.

Quartz grains

Fragments of clear unstrained quartz are identical to the quartz crystals in the porphyry chips, and have been derived from them by comminution.

Comments:
Preservation of plagioclase in the volcanics suggests this is relatively fresh Mooracoochie Volcanics.

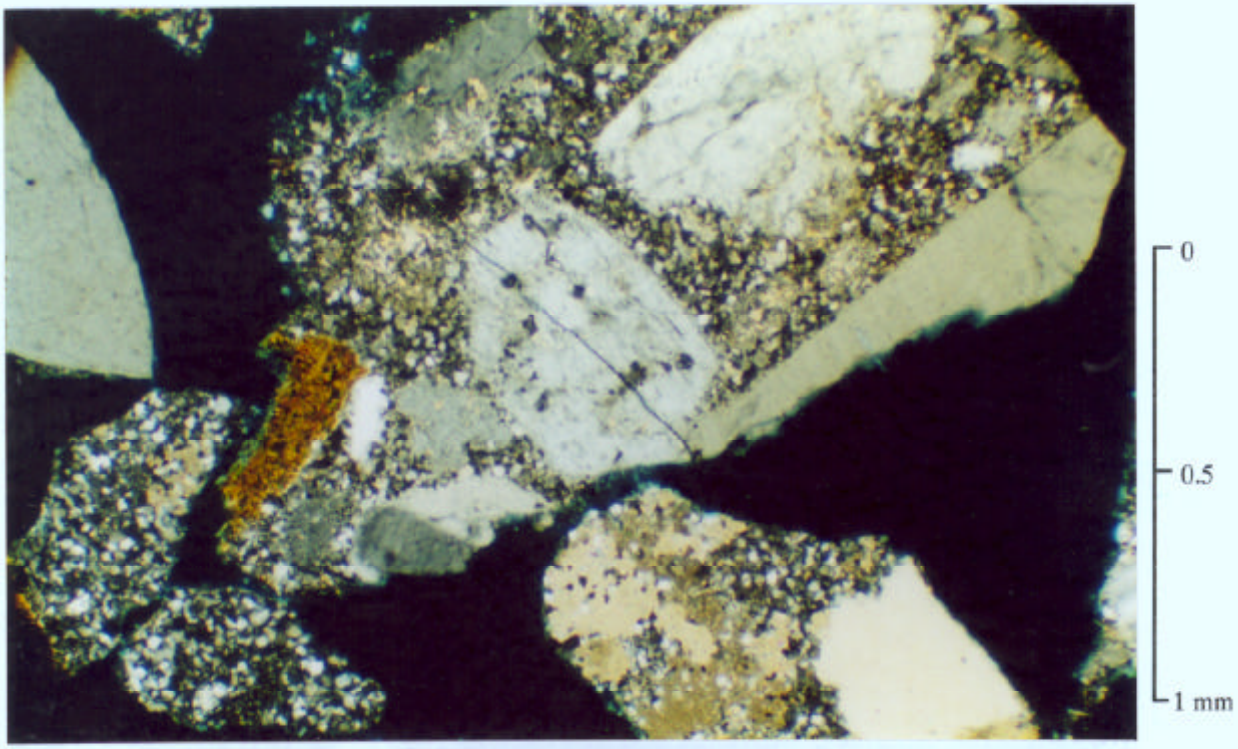

Figure 20
Chips of porphyry retain their primary porphyritic texture, with crystals of plagioclase (greys), quartz (mainly white) and biotite (brown flake, at left margin of large chip) in a uniformly fine-grained felsic groundmass. Mild alteration has generated ragged patches of siderite (bright pastel colours, bottom right chip) and traces of illitic clay. Tarragon-1, cuttings, depth 7930-7940ft. Crossed nicols. Magnification x5.

4.21 Tarragon-1, cuttings, depth 8080-8090ft, ?Mooracoochie Volcanics

Sample number:431806

Thin section description

Lithologies present:
Chips of porphyry (94%), medium grained quartzarenite (trace), carbonate spar (trace), illitic shale (trace) and single grains of plagioclase & monocrystalline quartz (5%).

Siderite-illite altered plagioclase-quartz-hornblende-biotite porphyry

The chips are composed of abundant blocky twinned plagioclase crystals, less common large clear quartz crystals and subrounded grains, minor brown biotite plates, spongy pleochroic dark brownish green crystals of hornblende, and rare stumpy zircon crystals, in a uniformly fine-grained massive felsic groundmass of quartz, feldspar and uncommon tiny stumpy apatite crystals. The rock has the appearance of a volcanic or subvolcanic rock of acid bulk composition. The lower abundance of quartz crystals and higher abundance of plagioclase crystals compared with Tarragon-1, 7930-7940' indicates compositional variation in the rock.

Rare small epidote grains, of low-grade alteration origin, occur in some incipiently altered hornblende crystals. Some chips contain ragged alteration patches of siderite, and less commonly of fine-grained massive illitic clay, both of low-grade (possibly diagenetic) alteration origin.

Quartz grains

Quartz grains of two types are distinguished. Some have the clear unstrained character of the large quartz crystals in the acid porphyry, from which they have been derived. Some other quartz grains display the shadowy strain extinction and sutured textures of metamorphic quartz.

Comments:
This depth interval is characterised by relatively fresh Mooracoochie Volcanics

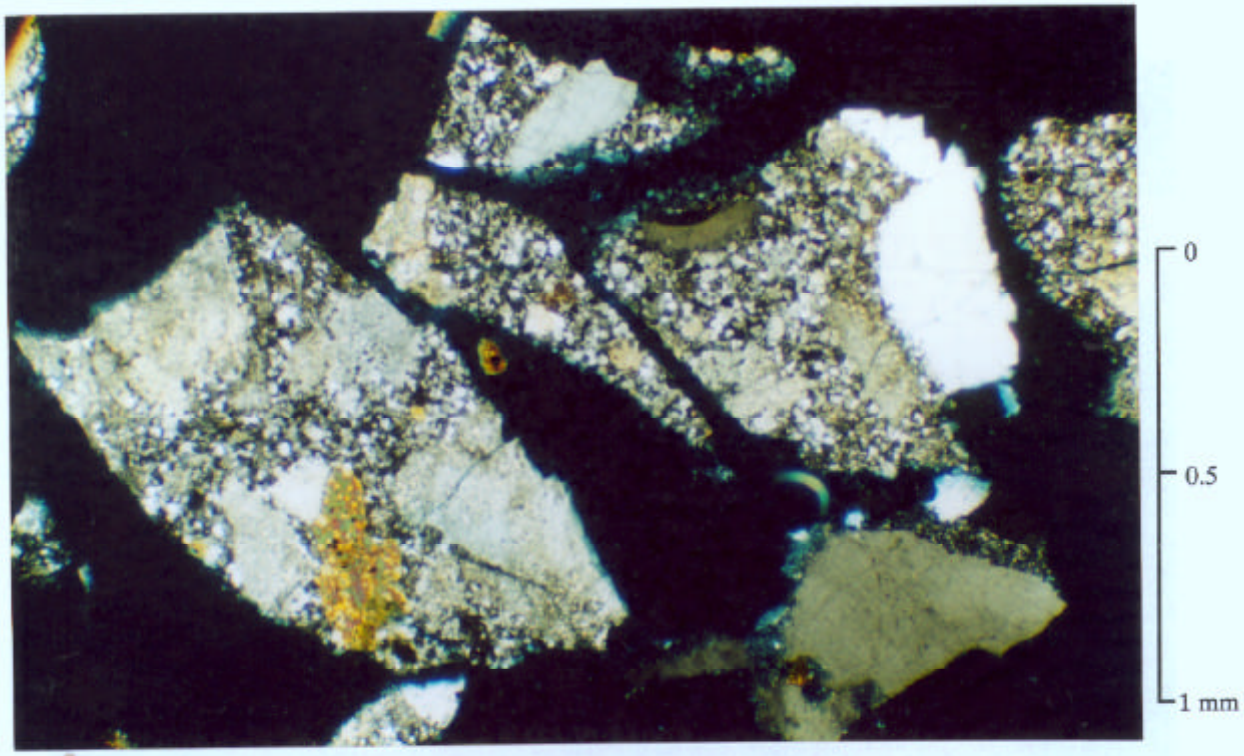

Figure 21
Chips of porphyry contain crystals of plagioclase and quartz (greys to white), and uncommon hornblende (mottled yellow-green colour, lower left), in a uniformly fine-grained felsic groundmass. Tarragon-1, cuttings, depth 8080-8090ft. Crossed nicols. Magnification x5.

4.22 Tirrawarra-60, cuttings, depth 9890-9900ft, ?Merrimelia Formation

Sample number: 431807

Thin section description

Lithologies present:
Cuttings are composed of illitic/micritic shale (35%), oxidised shale to silty shale (2%), carbonaceous shale (trace), carbonaceous material (coal, 1%), ?porphyry (trace), siltstone (25%), fine to medium grained quartzarenite (35%), carbonate cemented sandstone (trace), carbonate spar (trace), micrite (trace) and single grains of monocrystalline & polycrystalline quartz (1%). Based on the logs this depth interval is probably represented by the chips of siltstone and illitic/micritic shale. Carbonaceous shale and coal and possibly the clean quartzarenite may be down hole contaminants from the Patchawarra Formation and Tirrawarra Sandstone. Oxidised shale and ?porphyry could have been reworked from the Warburton Basin.

Siltstone

Sedimentary structures	none apparent
Avg. grain size	silt
Range in grain size	silt to fine sand
Sorting	moderately well
Composition	monocrystalline quartz is the dominant framework grain with minor muscovite flakes & rare shale lithics & accessory rutile, tourmaline & sphene, minor illitic matrix, extensive replacement by dusty patches of micritic carbonate & spar, traces of blocky pyrite

Illitic/micritic shale to sandy shale

Sedimentary structures	probably interbedded with siltstone
Avg. grain size	clay
Range in grain size	clay to medium sand
Sorting	poor
Composition	rounded silt to sand size grains of monocrystalline & polycrystalline quartz float in an illitic matrix, extensive replacement of the matrix by patches of micritic carbonate, rare grains replaced by kaolin booklets

Comments:
If the illitic/micritic sandy shale is a diamictite then there is no doubt that this depth interval is the Merrimelia Formation.

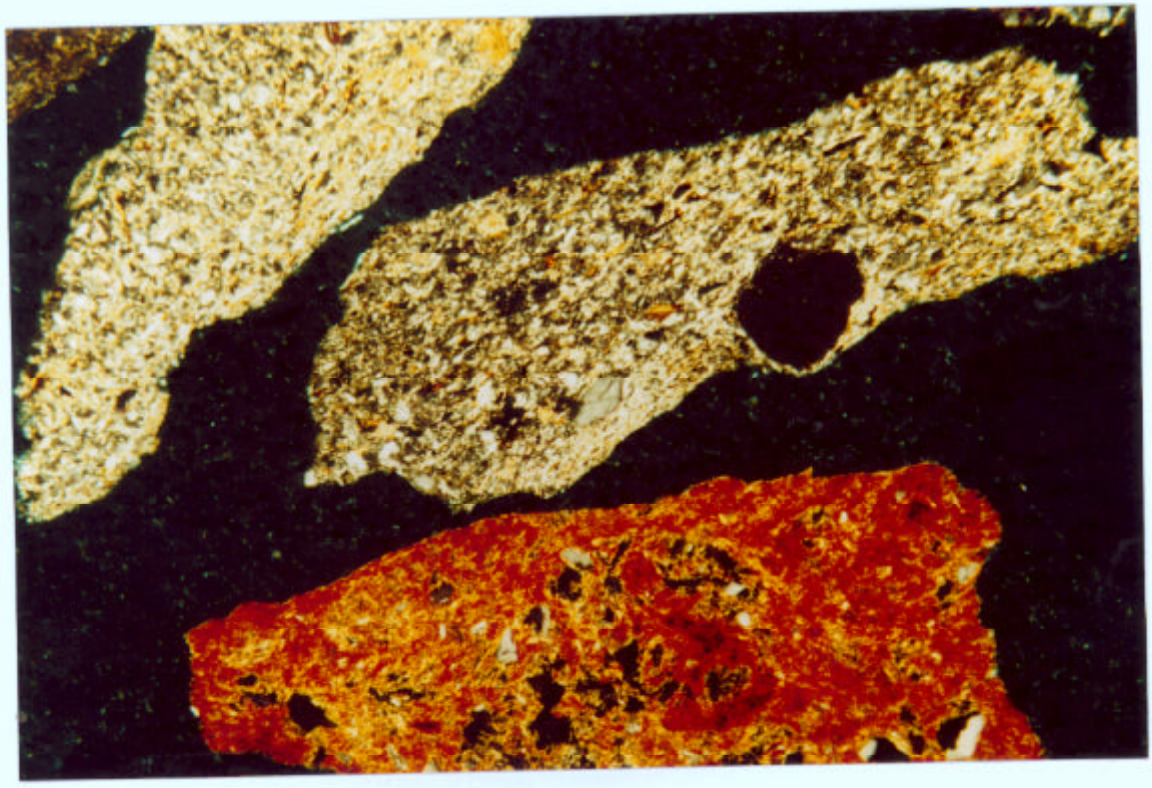

Figure 22
Two chips of poorly sorted illitic shale contrast with a chip of oxidised (?hematite) shale. Tirrawarra-60, cuttings, depth 9890-9900ft. Crossed nicols. Horizontal field of view 1.30mm.

4.23 Tirrawarra-60, cuttings, depth 9940-9950ft, ?Merrimelia Formation

Sample number:431808

Thin section description

Lithologies present:
Chips of illitic/micritic shale to sandy shale (60%), greywacke (1%), fine to medium grained quartzarenite (25%), carbonaceous material (coal, 3%), carbonaceous mudstone (trace), oxidised shale (trace), shale (5%), siltstone (4%), micrite (trace) and single grains of monocrystalline & polycrystalline quartz (1%) are apparent. The dominance of illitic/micritic shale is consistent with the gamma ray log for this depth interval. Varying amounts of sand are present in the shale.

Illitic/micritic shale to sandy shale

Sedimentary structures	bedding may be apparent from variations in the proportion of sand in the shale
Avg. grain size	clay
Range in grain size	clay to medium grained sand
Sorting	poor
Composition	silt to sand size subrounded grains of monocrystalline & rare polycrystalline quartz, rare siltstone & chert lithics, muscovite flakes & accessory zircon float in an illitic matrix, minor replacement of matrix by irregular patches of micritic carbonate & rare blocky pyrite, rare grains replaced by kaolin

Comments:
Chips of illitic/micritic shale are dominant and the examples that contain sand grains suggest that this clay may represent a diamictite of the Merrimelia Formation.

Figure 23
Chips of illitic/micritic shale and sandy illitic/micritic shale are dominant at this depth interval. Tirrawarra-60, cuttings, depth 9940-9950ft. Crossed nicols. Horizontal field of view 1.30mm.

4.24 Tirrawarra-60, cuttings, depth 10010-10020ft, ?Merrimelia Formation

Sample number: 431809

Thin section description

Lithologies present:
Chips consist of siltstone (10%), very fine to fine grained carbonate cemented sandstone (30%), fine grained ?sublitharenite (trace), very fine grained illitic sandstone (30%), carbonaceous material (?coal, 5%), carbonaceous mudstone (2%), oxidised laminated shale (1%), illitic sandy shale to greywacke (20%), ?altered porphyry (trace) and single grains of chert, monocrystalline & polycrystalline quartz (1%). Very fine grained illitic sandstone commonly has a patchy carbonate cement and therefore may be equivalent to the chips of very fine grained carbonate cemented sandstone. Dominance of very fine to fine grained sandstone in these cuttings may indicate this lithology is representative of this depth interval.

Sandstone

Sedimentary structures	none apparent but variations in grain size & sorting may indicate bedding
Avg. grain size	very fine to fine sand
Range in grain size	silt to medium sand
Sorting	poor to moderate
Roundness/sphericity	subangular/ low to moderate
Texture	grain supported
Porosity	none apparent
Composition	framework grains are dominated by monocrystalline quartz with minor to rare polycrystalline quartz, lithics of shale & ?porphyry & accessory sphene & tourmaline, trace to minor amounts of illitic matrix are apparent, where matrix is absent silicification has cemented grains, rare grains replaced by kaolin, extensive replacement of matrix & grains by clear blocky carbonate spar

Comments:
There is nothing distinctive about this sandstone to confidently assign it to a particular formation. It is similar in composition to the illitic sandstones described from the Dullingari Group but there is no evidence of low grade metamorphic alteration.

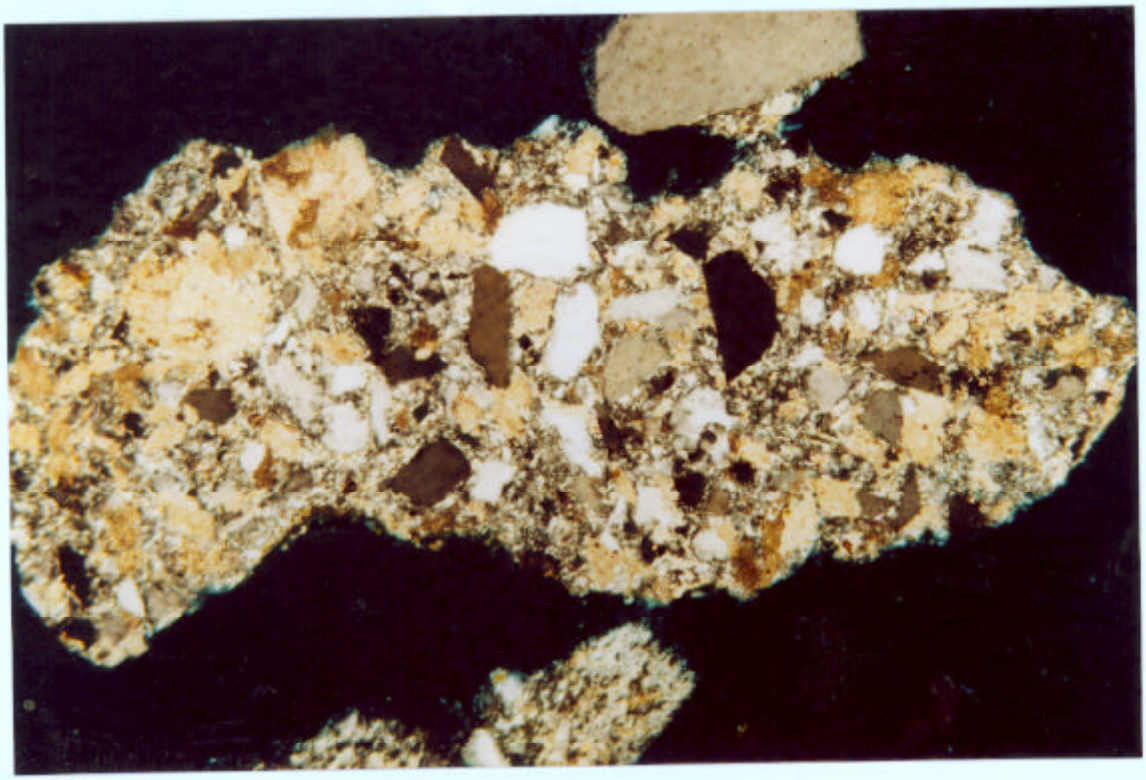

Figure 24
Typical chip of poorly sorted very fine grained illitic sandstone with patchy carbonate cement. Tirrawarra-60, cuttings, depth 10010-10020ft. Crossed nicols. Horizontal field of view 1.30mm.

4.25 Tirrawarra-60, cuttings, depth 10160-10170ft, ?Merrimelia Formation

Sample number: 431810

Thin section description

Lithologies present:
Chips consist of medium grained quartzarenite (60%), silt to very fine grained illitic sandstone (20%), carbonate spar (rarely spherulitic, trace), shale (5%), carbonaceous material (1%), carbonaceous mudstone (3%), ?phosphatic mudstone (trace), oxidised shale (trace), ?volcanics (trace), illitic sandy shale (trace) and single grains of monocrystalline & polycrystalline quartz & chert (10%). The dominance of chips of medium grained quartzarenite suggests this lithology is representative of this depth interval.

Quartzarenite

Sedimentary structures	none apparent
Avg. grain size	medium sand
Range in grain size	silt to coarse sand
Sorting	moderately well
Roundness/sphericity	subrounded/ low to moderate
Texture	grain supported
Porosity	primary intergranular, rare intragranular & micropores
Composition	monocrystalline quartz is the dominant framework grain with minor to trace amounts of polycrystalline quartz, lithics of shale, ?porphyry & chert, muscovite flakes, traces of illitic matrix trapped between syntaxial quartz overgrowths, patches of blocky carbonate spar, rare grains replaced by illite, others replaced by chlorite, siderite scalenohedra precipitated after the chlorite, kaolin has replaced grains & filled pores

Comments:
This quartzarenite does not appear to have undergone any low grade metamorphic alteration therefore it probably belongs to the Merrimelia Formation.

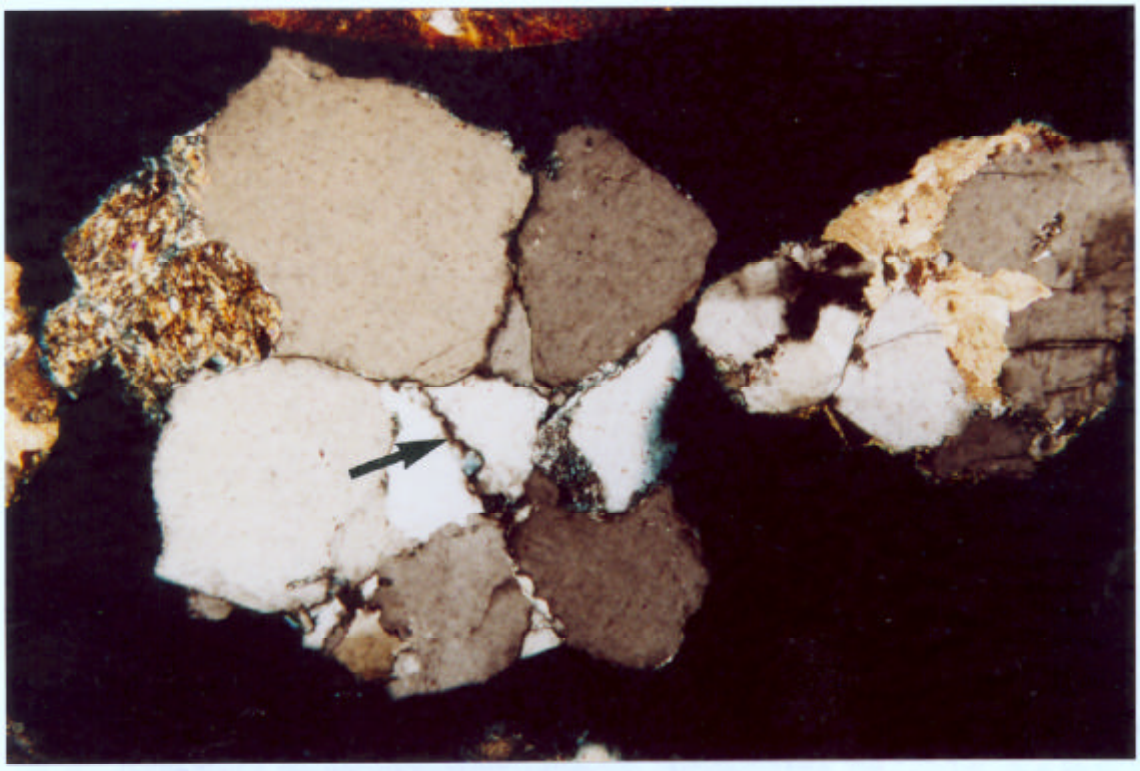

Figure 25
Grain contacts in these chips of medium grained quartzarenite are typically tangential. The only suturing occurs between quartz overgrowths (arrow). Carbonate spar postdates the quartz overgrowths. Tirrawarra-60, cuttings, depth 10160-10170ft. Crossed nicols. Horizontal field of view 1.30mm.

4.26 Tirrawarra-60, cuttings, depth 10290-10300ft, ?Merrimelia Formation

Sample number: 431811

Thin section description

Lithologies present:
Cuttings consist of fine to medium grained quartzarenite (25%), carbonate cemented sandstone (trace), carbonaceous material (coal, 8%), carbonaceous mudstone (trace), illitic siltstone to very fine grained sandstone (10%), oxidised shale (1%), illitic shale interbedded with sandy shale (55%), ?diamictite (trace), ?volcanics (trace) and single grains of well rounded coarse monocrystalline & polycrystalline quartz (trace). Given the log signature over this depth interval and the relative proportion of chips, the illitic shale to sandy shale should be characteristic.

Illitic shale

Sedimentary structures	laminae of silt to sandy shale
Avg. grain size	clay
Range in grain size	clay to fine sand
Sorting	moderate
Composition	matrix of pale brown illitic shale in which floats rare grains of angular monocrystalline quartz, muscovite flakes, rutile, minute opaques & patches of dusty micrite to microspar

Comments:
Lack of cleavage development in the shale indicates it has probably not been deformed by low grade metamorphism therefore this interval may be part of the Merrimelia Formation.

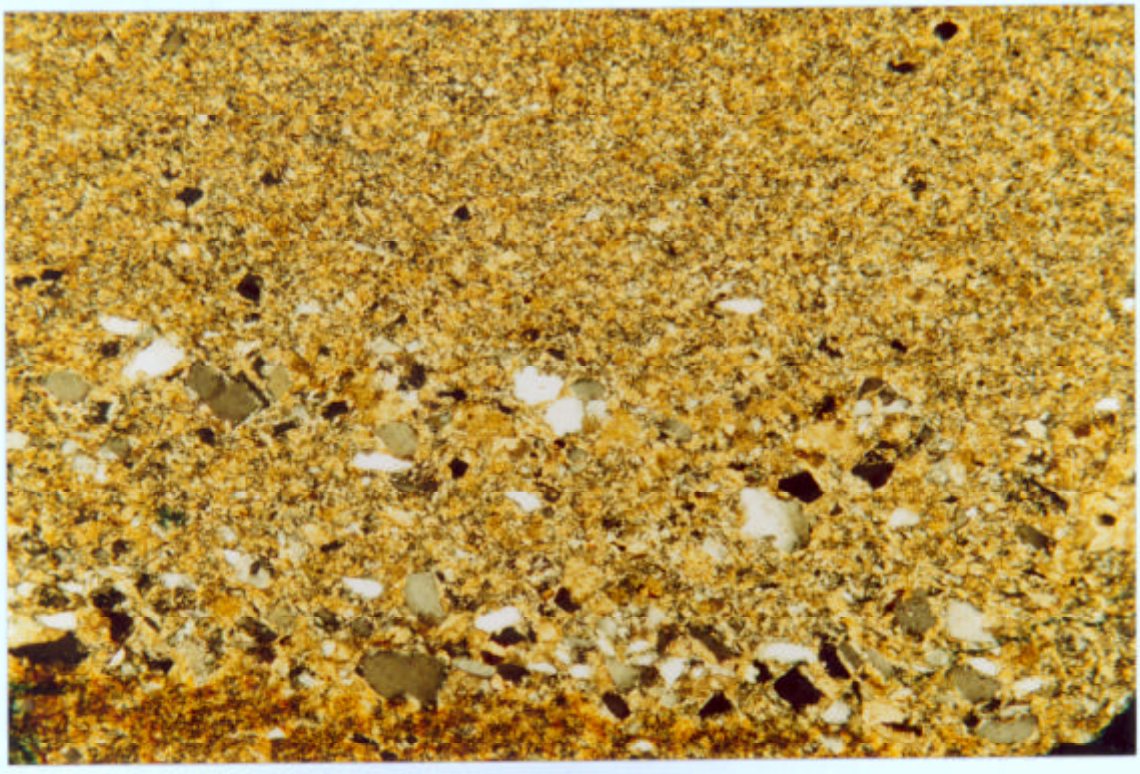

Figure 26
Planar silty laminae are apparent in the illitic shale that is thought to characterise this depth interval. Tirrawarra-60, cuttings, depth 10290-10300ft. Crossed nicols. Horizontal field of view 1.30mm.

4.27 Tirrawarra-60, cuttings, depth 10340-10350ft, ?Merrimelia Formation

Sample number: 431812

Thin section description

Lithologies present:
Chips of siltstone (30%), fine to medium grained illitic sandstone (20%), carbonaceous material & mudstone (7%), ?volcanics (1%), shale & illitic sandy shale (30%), oxidised shale (trace), carbonate cemented sandstone (10%), carbonate spar (trace) and single grains of monocrystalline & polycrystalline quartz & chert (1%) are apparent. It is difficult to be certain which lithology is representative of this depth interval from the visual estimates of relative abundance. Based on the logs it is probably the chips of siltstone and shale that are representative.

Siltstone

Sedimentary structures	planar laminae outlined by subtle changes in grain size, may be interbedded with shale
Avg. grain size	silt
Range in grain size	fine silt to very fine sand
Sorting	moderately well
Composition	framework grains are dominated by monocrystalline quartz with rare muscovite flakes & accessory tourmaline, zircon, rutile & opaques, traces of illitic matrix, micrite & microspar form patches scattered throughout the siltstone, minor quartz cement, rare grains partially replaced by illite

Shale

Sedimentary structures	none apparent
Avg. grain size	clay
Sorting	moderate
Composition	pale brown illitic clay in which floats rare silt size quartz, muscovite flakes & accessory opaques, partial replacement of matrix by micritic carbonate

Comments:
There is nothing distinctive about the siltstone/shale to differentiate this unit therefore it could be Merrimelia Formation.

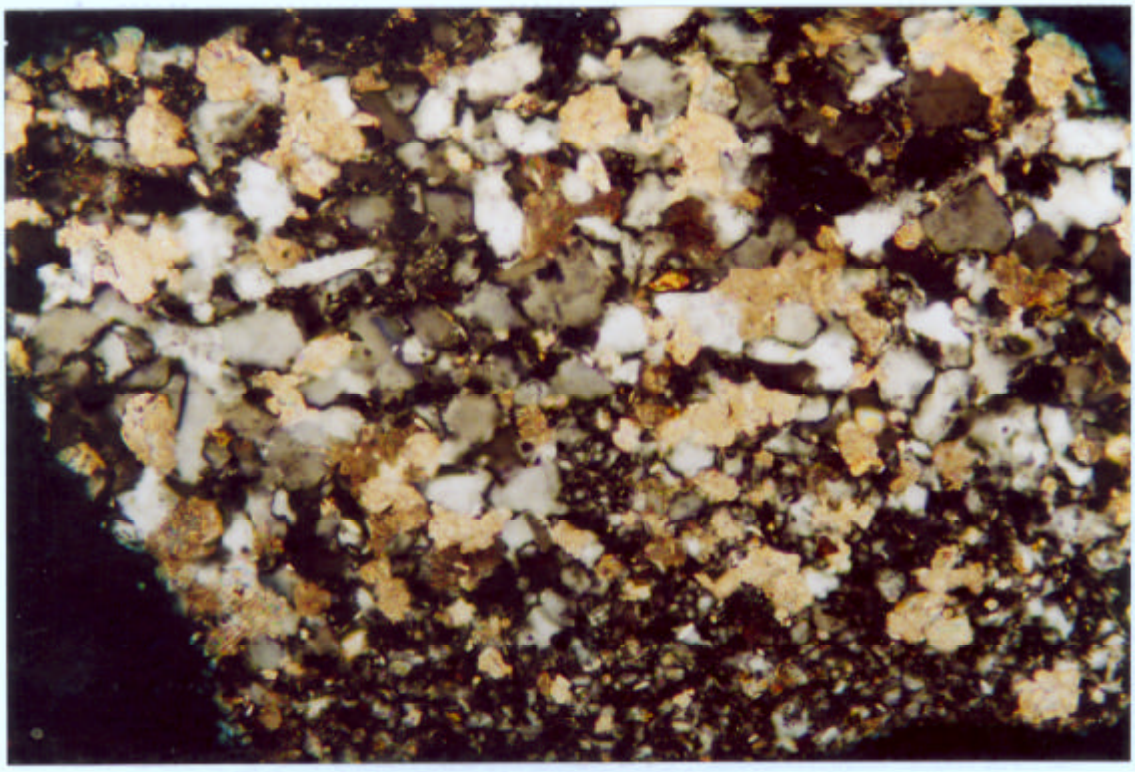

Figure 27
This chip of siltstone displays a gradation from very fine silt to coarse silt/very fine sand. Patches of carbonate microspar partially replace the siltstone. Tirrawarra-60, cuttings, depth 10340-10350ft. Crossed nicols. Horizontal field of view 0.65mm.

4.28 Toolachee-1, cuttings, depth 6950-6960ft, ?Merrimelia Formation

Sample number:431813

Thin section description

Lithologies present:
Chips consist of shale (35%), siltstone (10%), carbonaceous mudstone (30%), carbonaceous material (7%), poorly sorted very fine grained sandstone (10%), carbonate spar (trace), Fe rich microspar (trace), oxidised shale (1%), glauconitic mudstone with pyrite filled foram (1%), medium grained quartzarenite (trace) and very coarse sand size grains of quartz (5%). The logs indicate these cuttings should be dominated by a medium to coarse grained sandstone with minor siltstone and carbonaceous material. It would appear that the sandstone is poorly cemented and only one chip plus single grains remain of the sandstone. This description of sandstone is based on this assumption.

Sandstone (quartzarenite)

Sedimentary structures	within the sandstone there are none apparent
Avg. grain size	medium to coarse sand
Range in grain size	very fine to very coarse sand
Sorting	moderate
Roundness/sphericity	subrounded to rounded/ low to moderate
Texture	grain supported
Porosity	primary intergranular, micropores
Composition	monocrystalline quartz with minor polycrystalline quartz & lithics of quartzite, cemented by rare quartz overgrowths & blocky pyrite, rare grains replaced by kaolin booklets, traces of dusty carbonate spar postdate the quartz

Comments:
If the chips of glauconitic mudstone and oxidised shale are lithics in this sandstone that have been reworked from the Innamincka Red Beds then this interval could represent the Merrimelia Formation. Otherwise, there is nothing distinctive about the quartzarenite to identify the formation.

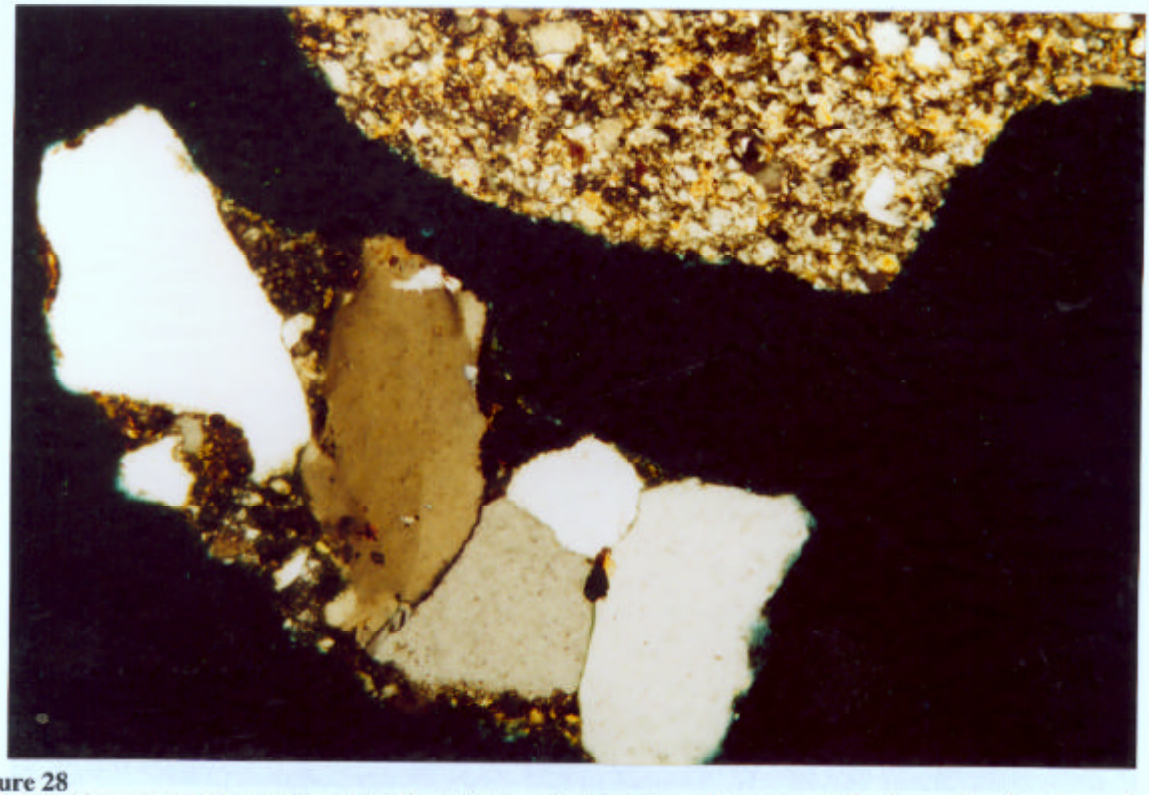

Figure 28
This field of view illustrates a chip of medium grained quartzarenite with authigenic pyrite & kaolin, and a chip of siltstone. Toolachee-1, cuttings, depth 6950-6960ft. Crossed nicols. Horizontal field of view 1.30mm.

4.29 Toolachee-1, cuttings, depth 6990-7000ft, ?Merrimelia Formation

Sample number:431814

Thin section description

Lithologies present:
Cuttings consist of shale (40%), carbonaceous material & shale (5%), siltstone (20%), glauconitic mudstone (3%), very fine grained glauconitic greywacke (1%), single grains of coarse quartz (10%), siltstone to very fine grained carbonate cemented quartzarenite (10%), very fine to fine grained poorly sorted muddy sandstone (10%), and Fe rich microspar (trace). Based on the logs this interval is probably represented by the siltstone to very fine grained sandstones. Carbonaceous material in the poorly sorted muddy sandstone probably indicates this is a down hole contaminant associated with the carbonaceous shale and coal.

Siltstone/ sandstone

Sedimentary structures	siltstones are interbedded with shales
Avg. grain size	silt to very fine sand
Range in grain size	clay to fine sand
Sorting	poor to moderately well
Porosity	clean sandstones have intergranular & grain size pores
Composition	monocrystalline quartz is the dominant framework grain with minor polycrystalline quartz, shale lithics, muscovite flakes & rare accessory tourmaline, zircon & rutile, authigenic minerals are dominated by syntaxial quartz overgrowths & patches of dusty carbonate spar & Fe rich micrite, rare grains replaced by illite

Comments:
There is nothing distinctive about this siltstone/sandstone to differentiate the formation. Lack of metamorphic deformation/alteration favours interpretation of this depth interval as Merrimelia Formation.

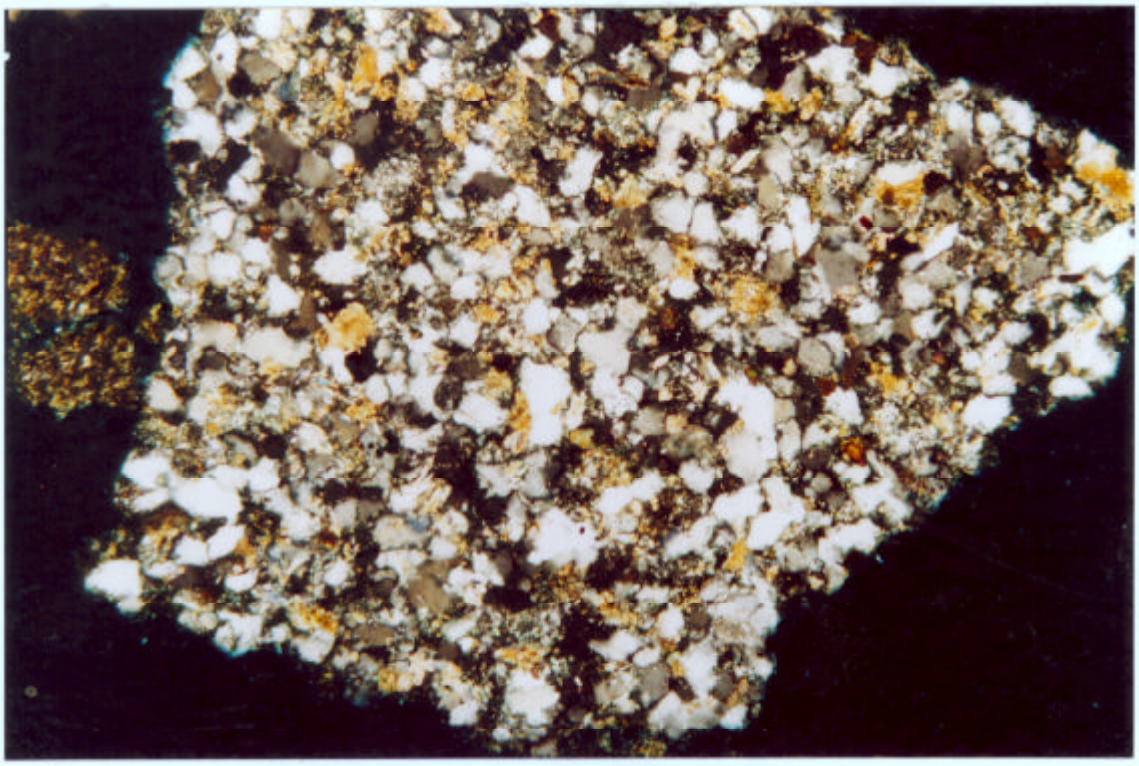

Figure 29
Typical chip of silt to very fine grained sandstone with patches of authigenic carbonate. Toolachee-1, cuttings, depth 6990-7000ft. Crossed nicols. Horizontal field of view 1.30mm.

4.30 Toolachee-1, cuttings, depth 7020-7030ft, ?Merrimelia Formation

Sample number:431815

Thin section description

Lithologies present:
Chips consist of shale (16%), sandy shale (5%), carbonaceous shale (22%), carbonaceous material (16%), siltstone (12%), very fine to medium grained kaolin & quartz cemented quartzarenite (12%), poorly sorted very fine grained sandstone (10%), carbonate replaced volcanics (trace) and single grains of monocrystalline & polycrystalline quartz & chert (6%). It is extremely difficult to know which lithology is representative of this depth interval. Carbonaceous material, carbonaceous shale and possibly the shale are all thought to be down hole contaminants. Based on the logs there is unlikely to be a medium grained quartzarenite present but the beds could be very thin and thus not recorded by the logs. If this quartzarenite was a contaminant from the overlying clean sands it is surprising that it was not more abundant in the cuttings from 6990-7000'. However, fragments of carbonaceous material in the medium grained sands do suggest this lithology is a contaminant. Siltstone and poorly sorted very fine grained sandstone were also apparent in cuttings from higher in the sequence but appear to be consistent with the log signature at this depth.

Siltstone/sandstone

Sedimentary structures	probably bedding
Avg. grain size	silt to very fine sand
Range in grain size	silt to coarse sand
Sorting	poor
Roundness/sphericity	subrounded/ low to moderate
Texture	grain supported
Porosity	intergranular, grain size dissolution & micropores
Composition	framework grains are dominated by monocrystalline quartz with minor polycrystalline quartz, shale & sandy shale lithics, muscovite flakes & accessory zircon, minor illitic clay matrix in siltstone, authigenic minerals are dominated by syntaxial quartz overgrowths with minor grain replacing & pore filling kaolin booklets, & patchy carbonate spar

Comments:
This interval probably represents the Merrimelia Formation because there is no indication of low grade metamorphic alteration.

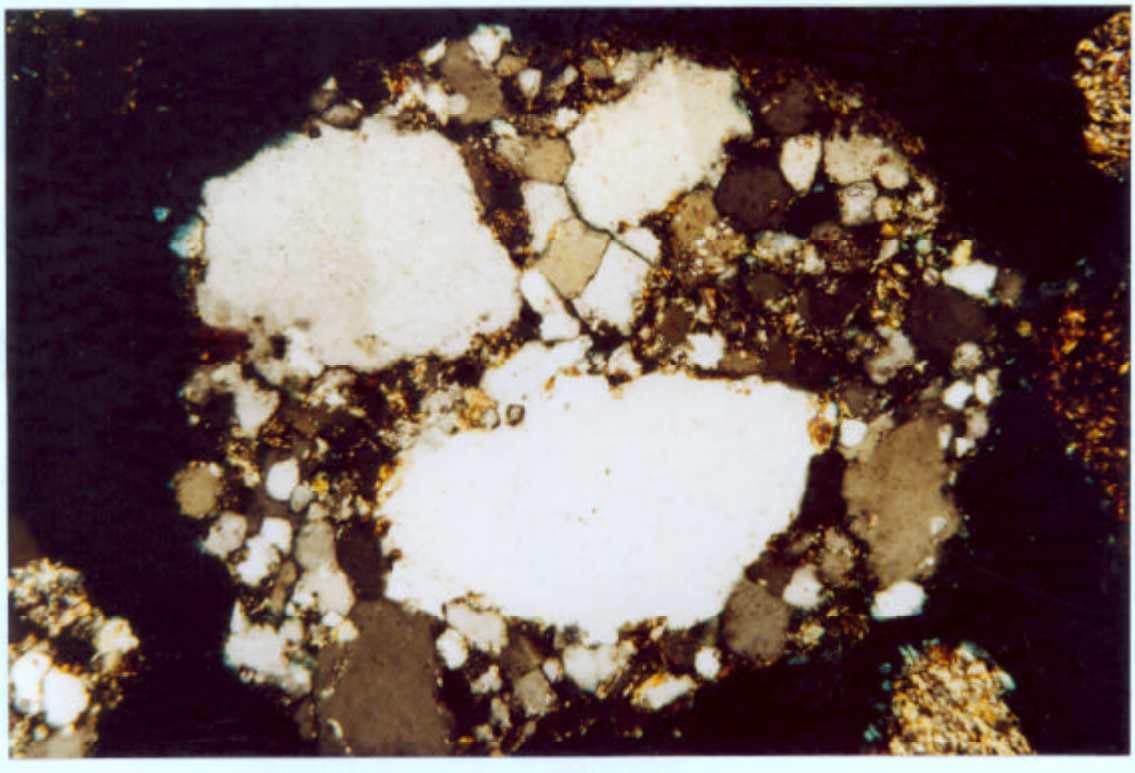

Figure 30
Poorly sorted sandstone may be representative of this depth interval. Toolachee-1, cuttings, depth 7020-7030ft. Crossed nicols. Horizontal field of view 1.30mm.

4.31 Toolachee-1, cuttings, depth 7040-7050ft, ?Merrimelia Formation

Sample number:431816

Thin section description

Lithologies present:
Chips of carbonaceous shale (18%), shale (16%), carbonaceous material (17%), very fine to medium grained poor to moderately sorted sandstone (35%), siltstone (5%), glauconitic mudstone with fresh feldspars (6%), carbonate spar (trace) and coarse grains of monocrystalline & polycrystalline quartz (2%) are apparent. It is extremely difficult to identify with confidence the lithology representative of this depth interval. Relative proportions of the different lithologies suggest the sandstone may be characteristic and this is consistent with the log signature. Medium grained sandstones are probably down hole contaminants because they contain traces of carbonaceous material.

Sandstone (sublitharenite)

Sedimentary structures	variations in grain size & sorting indicate bedding
Avg. grain size	fine sand
Range in grain size	silt to coarse sand
Sorting	poor to moderate
Roundness/sphericity	subangular to subrounded/ low
Texture	grain supported
Porosity	micropores
Composition	monocrystalline quartz is the dominant framework grain with minor deformed shale & chert lithics, rare muscovite flakes & accessory tourmaline & zircon, rare detrital illite is trapped along grain margins, authigenic minerals are dominated by syntaxial quartz overgrowths with minor scalenohedral carbonate spar & traces of grain replacing illite & kaolin

Comments:
Probably the sublitharenite represents the Merrimelia Formation. Chips of glauconitic mudstone could have been reworked from the Innamincka Red Beds.

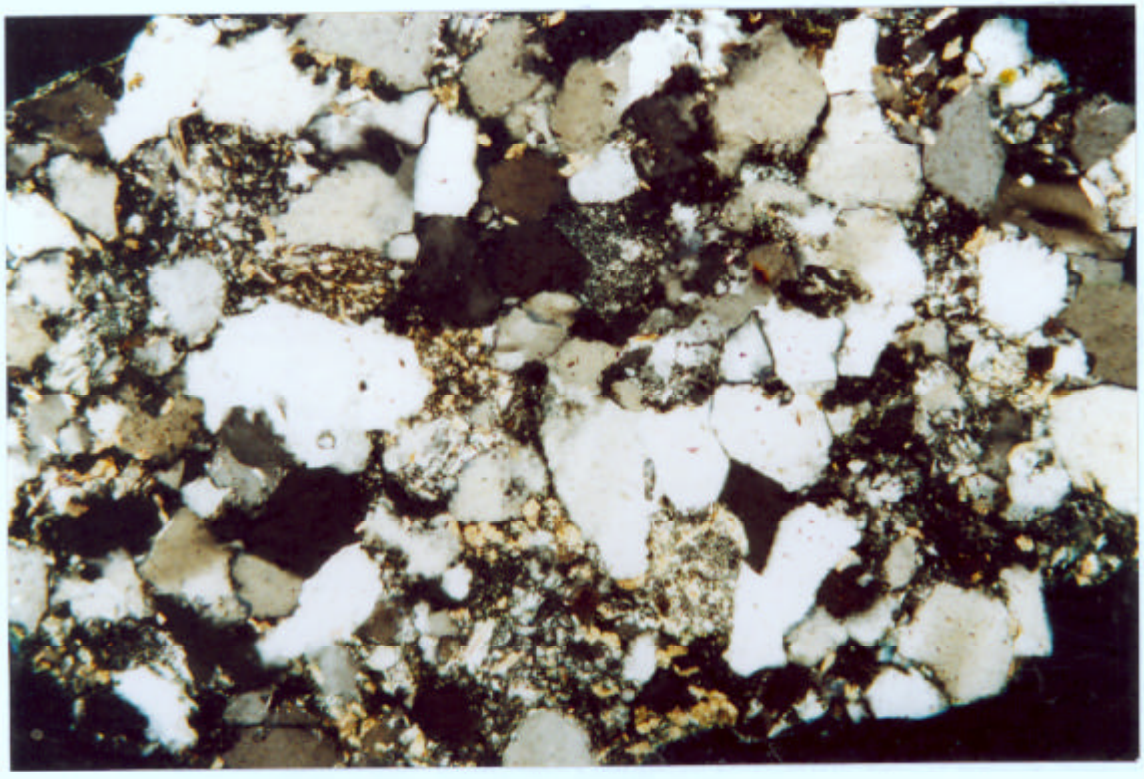

Figure 31
Lithics within this chip of fine grained, moderately sorted sublitharenite are difficult to identify because of extensive alteration by kaolin and illite. Toolachee-1, cuttings, depth 7040-7050ft. Crossed nicols. Horizontal field of view 1.30mm.

4.32 Toolachee-1, cuttings, depth 7070-7080ft, ?Merrimelia Formation

Sample number:431817

Thin section description

Lithologies present:
Chips consist of illitic shale (34%), shale (10%), carbonaceous shale (14%), carbonaceous material (10%), very fine grained sandstone (11%), medium grained quartzarenite (2%), Fe rich carbonate spar (5%), glauconitic mudstone (9%), siltstone (trace) and single grains of coarse quartz (4%). Illitic shale is the dominant lithology at this depth. It contains Fe rich carbonate spar and the chips of this composition may have been derived from the illitic shale.

Illitic shale

Sedimentary structures	bands of Fe rich carbonate spar, fractures healed by polycrystalline quartz
Avg. grain size	clay
Range in grain size	clay to very fine sand
Sorting	poor
Composition	silt to very fine sand size grains of monocrystalline & polycrystalline quartz, & rare muscovite flakes & tourmaline & zircon float in an illitic clay matrix, patches of dusty micrite are scattered throughout the matrix & there are rare pyrite framboids & traces of ?anatase

Comments:
The illitic shale that is characteristic of this depth interval is very similar to the altered zone of the Dullingari Group. It is possible that there has been extensive reworking by the Merrimelia Formation from the underlying Dullingari Group. A more conclusive answer may be obtained by studying core number 5 taken from deeper in this sequence.

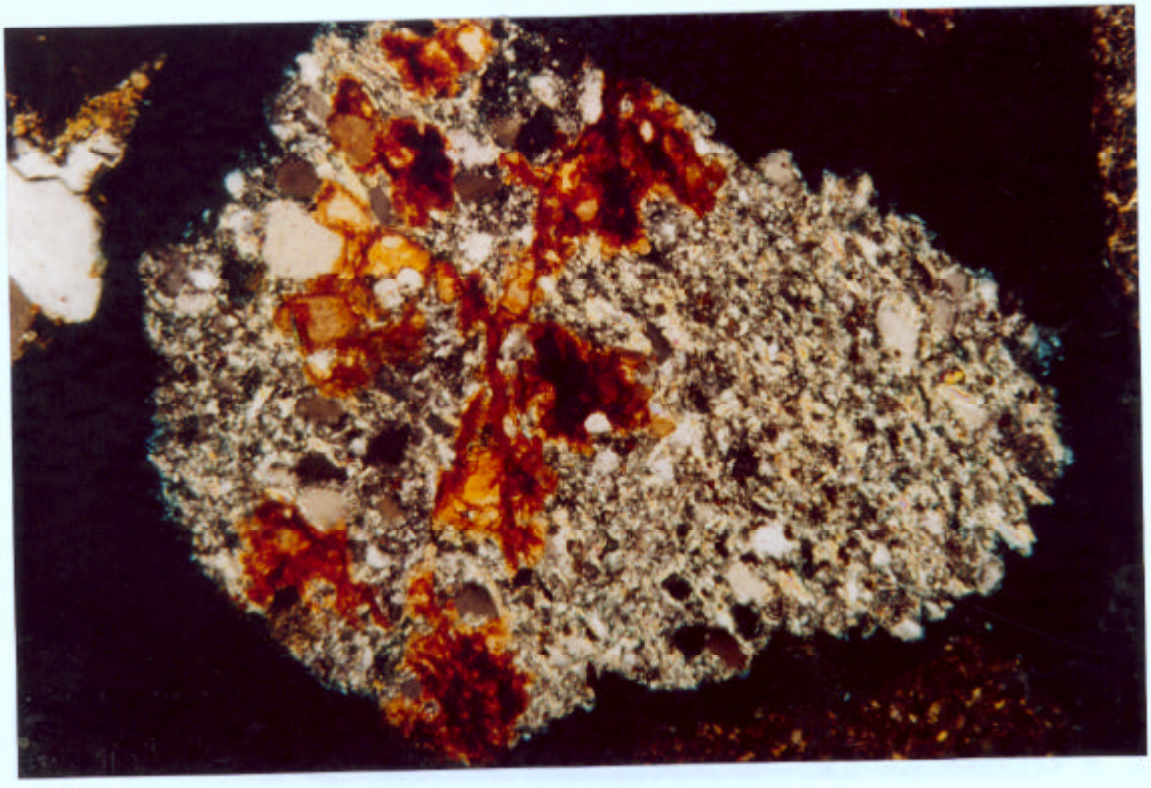

Figure 32
In a laminae of silt to very fine sand within this chip of illitic shale, Fe rich carbonate spar has been oxidised to ?hematite (reddish brown). Toolachee-1, cuttings, depth 7070-7080ft. Crossed nicols. Horizontal field of view 1.30mm.

4.33 Toolachee-28, cuttings, depth 7520-7530ft, ?Merrimelia Formation

Sample number: 431818

Thin section description

Lithologies present:
Chips consist of illitic sandstone (33%), illitic shale & illitic sandy shale (14%), carbonaceous shale (25%), shale (3%), siltstone (6%), Fe carbonate spar (3%), carbonaceous material (5%) and medium grained quartzarenite (10%). Based on the logs the carbonaceous shale and coal are down hole contaminants. The medium grained quartzarenite may also be an artifact at this depth. This interval is probably characterised by the illitic sandstone, siltstone and illitic shale to illitic sandy shale.

Illitic Sandstone

Sedimentary structures	sandstone may grade or be interbedded with illitic sandy shale & illitic shale
Avg. grain size	very fine to fine sand
Range in grain size	silt to medium sand
Sorting	moderate
Roundness/sphericity	subangular to subrounded/ low to moderate
Texture	grain supported
Porosity	micropores, rare intergranular
Composition	monocrystalline quartz is the dominant framework grain with minor polycrystalline quartz, lithics of shale & chert, rare muscovite & accessory zircon & tourmaline, detrital matrix is illitic in composition, authigenic minerals are dominated by quartz overgrowths, with minor grain replacing kaolin & illite, rare carbonate spar, blocky pyrite (rarely massive) & ?anatase

Comments:
Illitic shale and the illitic sandstone are similar to those of the Dullingari Group. The illitic sandstone could be described as a protoquartzite.

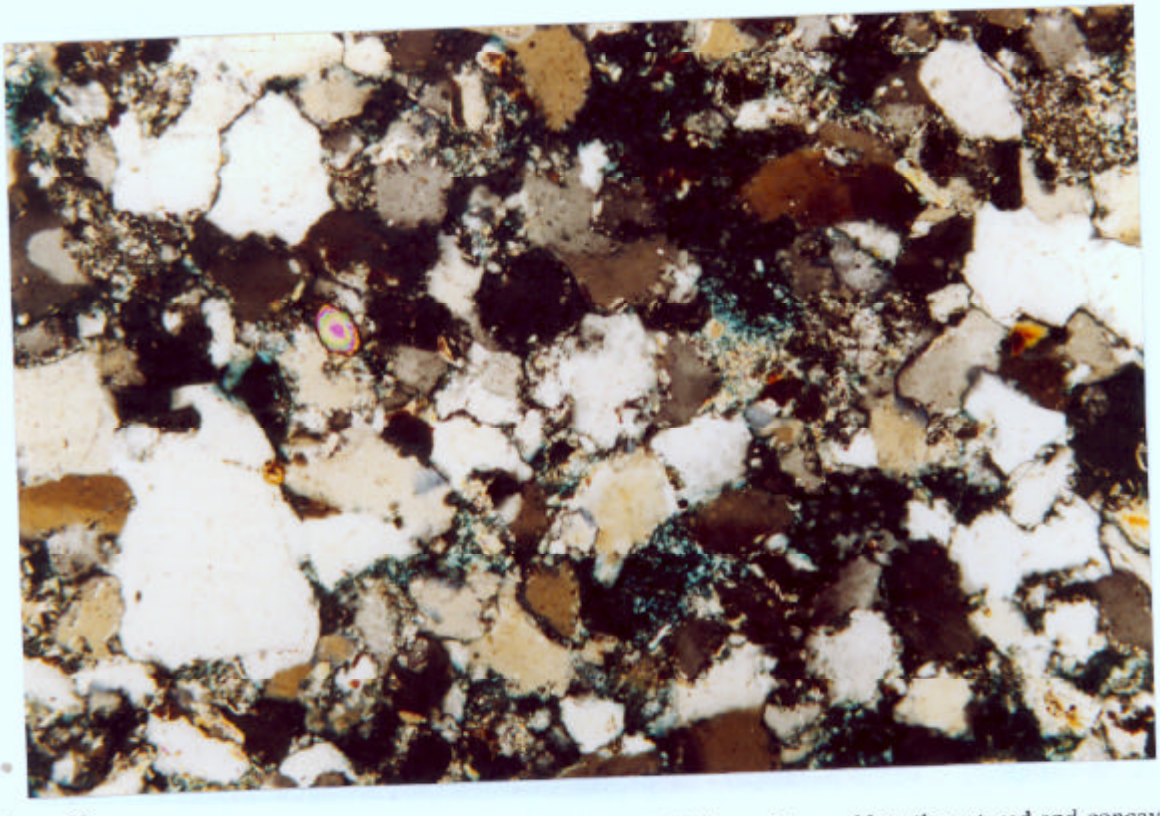

Figure 33
Typical chip of moderately sorted very fine to fine grained illitic sandstone. Note the sutured and concavo-convex nature of grain contacts. Toolachee-28, cuttings, depth 7520-30ft. Crossed nicols. Horizontal field of view 1.30mm.

4.34 Toolachee-28, cuttings, depth 7570-7580ft, ?Merrimelia Formation

Sample number: 431819

Thin section description

Lithologies present:
Chips consist of illitic shale with variable amounts of carbonate spar (40%), sandy illitic shale (5%), carbonaceous shale (3%), carbonate cemented illitic fine grained sandstone (23%), carbonate spar (21%), carbonaceous material (2%), glauconitic mudstone (1%), siltstone (2%) and single grains of quartz (2%). The dominance of illitic shale and carbonate spar plus carbonate cemented sandstone indicate these lithologies are representative of this depth interval.

Illitic Sandstone

Sedimentary structures	probably interbedded with the illitic shale
Avg. grain size	fine sand
Range in grain size	silt to coarse sand
Sorting	moderate
Roundness/sphericity	subangular/ low
Texture	grain supported
Porosity	micropores
Composition	monocrystalline & polycrystalline quartz, lithics of shale & micaceous schist, muscovite flakes & accessory rutile, zircon & tourmaline, remnants of illitic matrix, abundant dusty Fe rich spar replacing framework grains & matrix, grain replacing kaolin predates the carbonate, rare ?anatase

Illitic Shale

Sedimentary structures	probably interbedded with the sandstone, fractures healed by carbonate spar
Avg. grain size	clay
Sorting	poor to well
Composition	rare grains of silt to fine sand size quartz, muscovite & tourmaline float in a matrix of illitic clay, abundant replacement of matrix by patches of dusty Fe rich carbonate spar which is rarely spherulitic, traces of blocky pyrite

Comments:
The illitic shale and sandstone are characteristic of the altered zone in the Dullingari Group rather than the Merrimelia Formation.

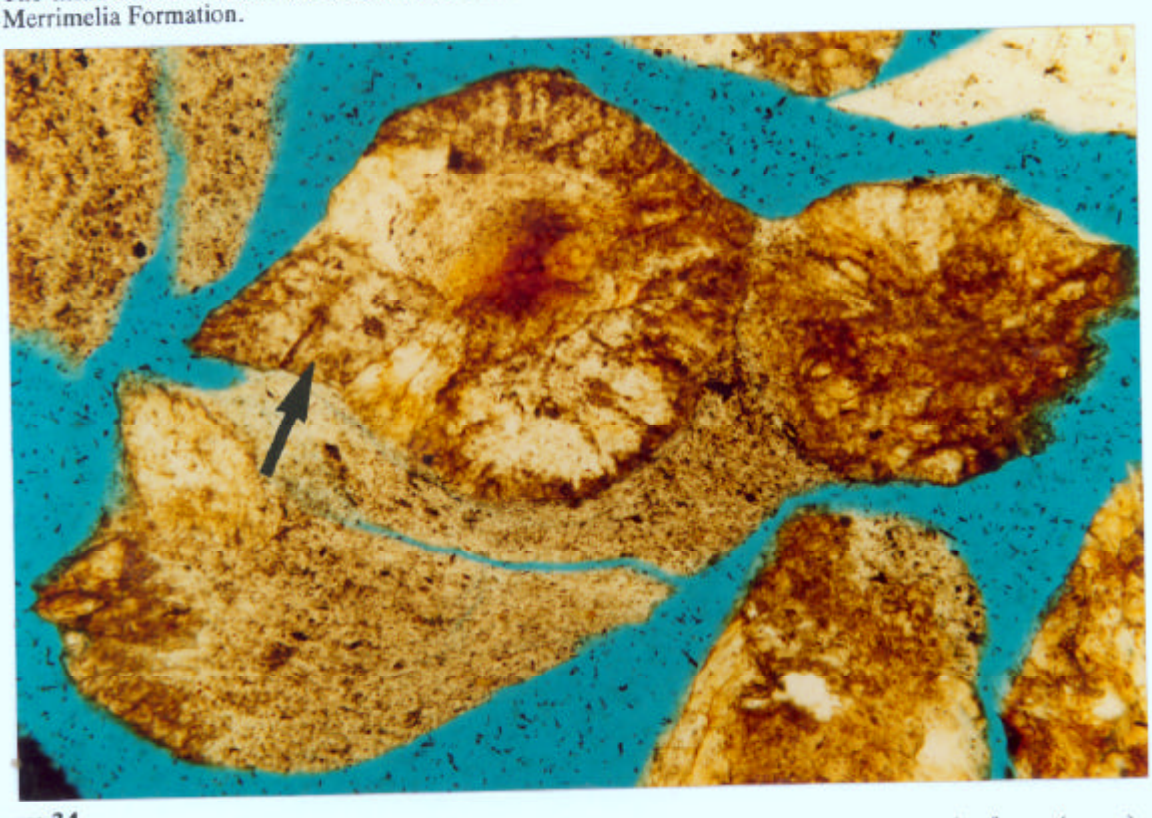

Figure 34
This chip illustrates spherulitic Fe rich carbonate spar in the illitic shale. Note the rhomb of spar (arrow) on the margin of the spherulite that may indicate later recrystallisation or replacement. Toolachee-28, cuttings, depth 7570-7580ft. Plane light. Horizontal field of view 1.30mm.

4.35 Toolachee-28, cuttings, depth 7620-7630ft, ?Merrimelia Formation

Sample number: 431820

Thin section description

Lithologies present:
Chips of illitic shale (20%), illitic sandy shale (13%), carbonate cemented fine grained illitic sandstone (22%), carbonate spar (16%), glauconitic mudstone (trace), carbonaceous material (2%), carbonaceous shale (2%) and single grains of coarse sand (24%) are apparent. Commonly the single grains of coarse quartz have traces of illite along the margins suggesting these grains have been derived from the illitic sandy shale or the illitic sandstone. Illitic sandstone is probably representative of this depth interval given its relative abundance in the cuttings and the log signature.

Illitic Sandstone

Sedimentary structures	none apparent
Avg. grain size	fine sand
Range in grain size	silt to coarse sand
Sorting	poor
Roundness/sphericity	subangular/ low
Texture	grain supported
Porosity	micropores
Composition	monocrystalline quartz is the dominant framework grain with minor polycrystalline quartz, lithics of micaceous schist, quartzite & shale, muscovite flakes & accessory tourmaline & zircon, variable amounts of illitic clay matrix, patchy cement of Fe rich spar replacing framework grains & matrix, grains replaced by illite & rare kaolin

Comments:
Illitic sandstone is probably characteristic of the Dullingari Group.

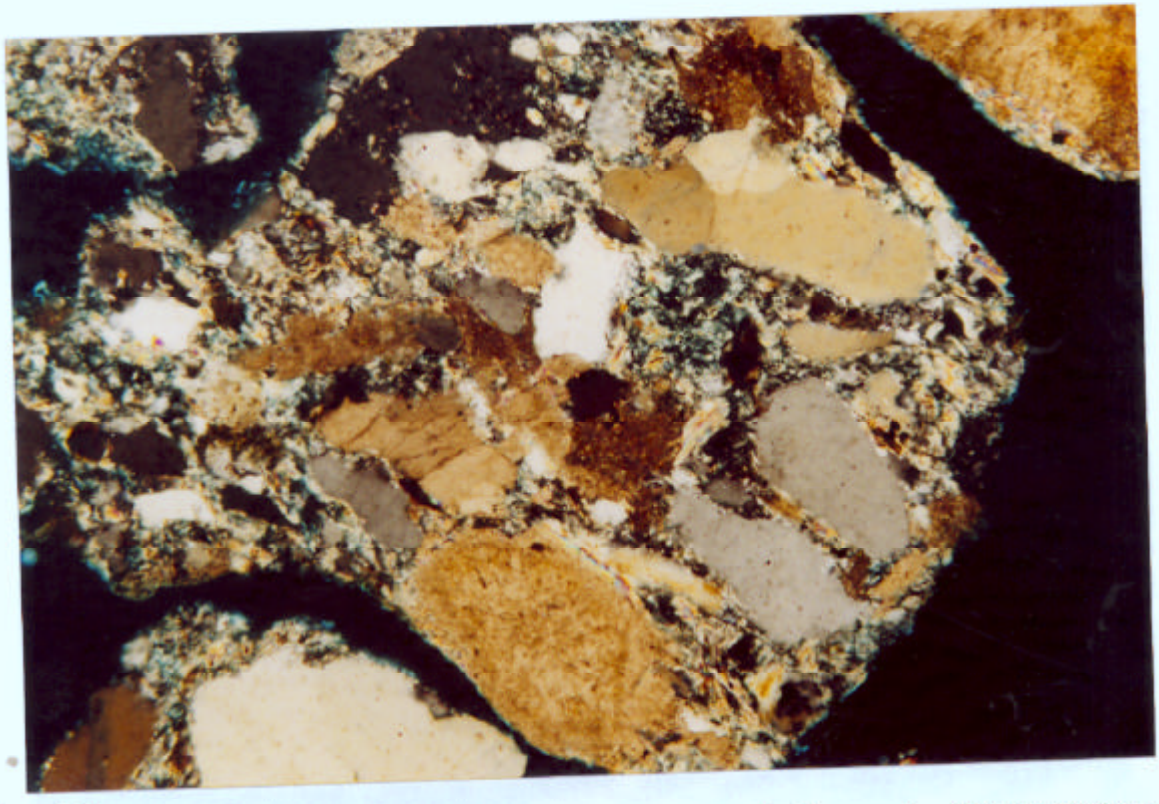

Figure 35
Poorly sorted illitic sandstone with grains up to medium sand in size in this example. Note the replacement of grains & matrix by carbonate spar. Toolachee-28, cuttings, depth 7620-7630ft. Crossed nicols. Horizontal field of view 1.30mm.

4.36 Toolachee-28, cuttings, depth 7670-7680ft, ?Merrimelia Formation

Sample number: 431821

Thin section description

Lithologies present:
Chips consist of illitic shale (14%), illitic sandy shale (8%), carbonaceous shale (10%), shale (7%), glauconitic mudstone to sandy mudstone (18%), siltstone (4%), illitic sandstone (6%), medium grained quartzarenite (3%), carbonate cemented sandstone (6%), carbonaceous material (8%), carbonate spar (4%), blocky pyrite replacing ?mudstone (2%) and single grains of quartz (9%). The variety of lithologies present are indicative of considerable contamination at this depth and it is impossible to be certain which lithology is representative. The relative abundance of glauconitic mudstone to sandy mudstone is difficult to explain given that this probably represents a down hole contaminant. Given that the other illitic lithologies (shale & sandstone) have already been described above it was considered that a description of the glauconitic mudstone would be of more value.

Glauconitic mudstone to sandy mudstone

Sedimentary structures	silty/sandy laminae
Avg. grain size	clay
Range in grain size	clay to fine sand
Sorting	poor to moderate
Composition	silt to fine sand size subangular grains of monocrystalline & polycrystalline quartz, fresh & corroded K-feldspar, muscovite & altered biotite flakes & accessory rutile, zircon & tourmaline float in a matrix of brown anhedral clay with traces of ?carbonaceous material, authigenic grains of rounded bright green glaucony also float in the matrix & there has been minor replacement by framboidal pyrite, traces of clear carbonate spar selectively replace feldspars, dusty altered grains could be oxidised glaucony or ?devitrified glass

Comments:
Although glauconitic mudstone may not be representative of this depth it is not part of the Merrimelia Formation.

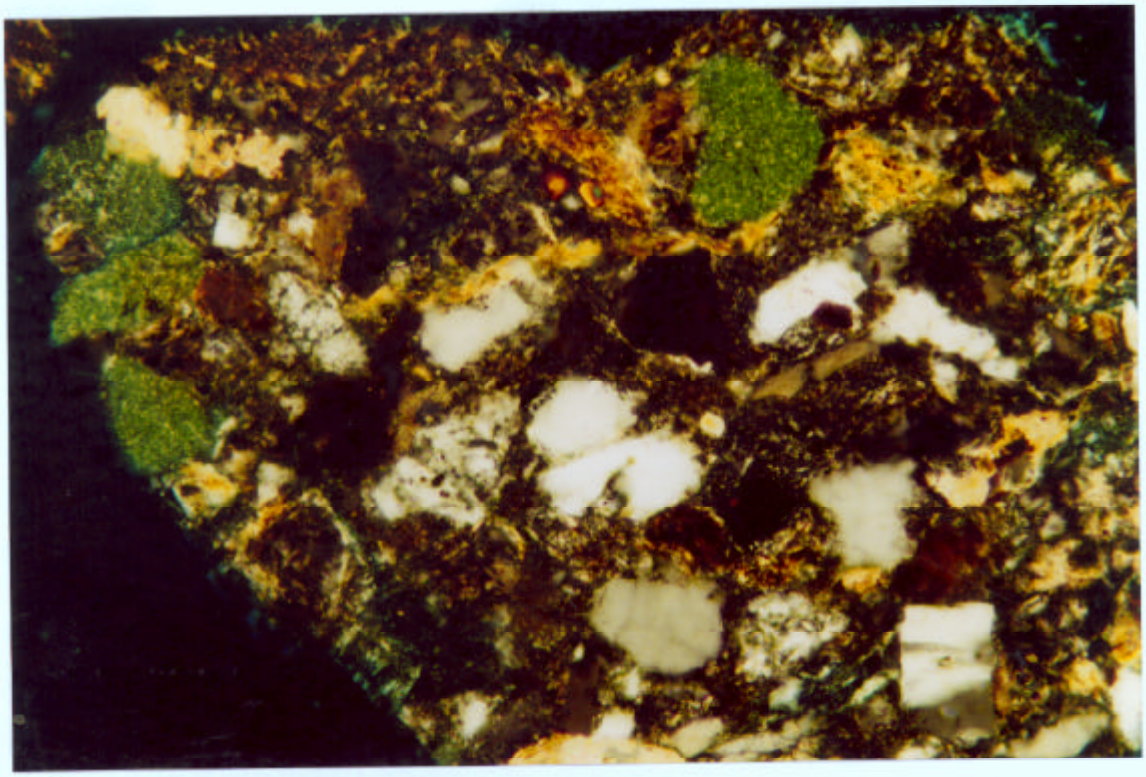

Figure 36
Typical chip of glauconitic sandy mudstone. Note the carbonate spar replacing grains. Toolachee-28, cuttings, depth 7670-7680ft. Crossed nicols. Horizontal field of view 0.65mm.

4.37 Toolachee-39, cuttings, depth 8200-8210ft, ?Merrimelia Formation

Sample number: 431822

Thin section description

Lithologies present:
Chips consist of carbonaceous material (7%), carbonaceous shale (25%), illitic shale to illitic sandy shale (15%), illitic siltstone (3%), fine grained illitic sandstone (30%), medium grained quartzarenite (8%), carbonate spar (3%) and single grains of quartz (8%). Carbonaceous shale, coal and medium grained quartzarenite are probably downhole contaminants from the Patchawarra Formation. This depth interval may be characterised by the illitic shale, illitic siltstone and fine grained sandstone.

Illitic Sandstone

Sedimentary structures	stringers of ?organic matter
Avg. grain size	very fine to fine sand
Sorting	poor
Roundness/sphericity	subangular/ low
Texture	grain supported
Porosity	none apparent
Composition	framework grains of monocrystalline & polycrystalline quartz, shale lithics, muscovite flakes & accessory tourmaline, variable amounts of illitic clay matrix, authigenic minerals of carbonate spar, traces of pyrite & ?anatase

Illitic Shale

Sedimentary structures	none apparent but probably interbedded with illitic sandy shale
Avg. grain size	clay
Sorting	moderate
Composition	silt to fine sand size grains of monocrystalline & polycrystalline quartz , muscovite & accessory rutile float in a matrix of illitic clay, scattered patches of dusty microspar have replaced the matrix

Comments:
The illitic shale and sandstone are probably characteristic of the Dullingari Group. Unless there has been extensive reworking this is not the Merrimelia Formation.

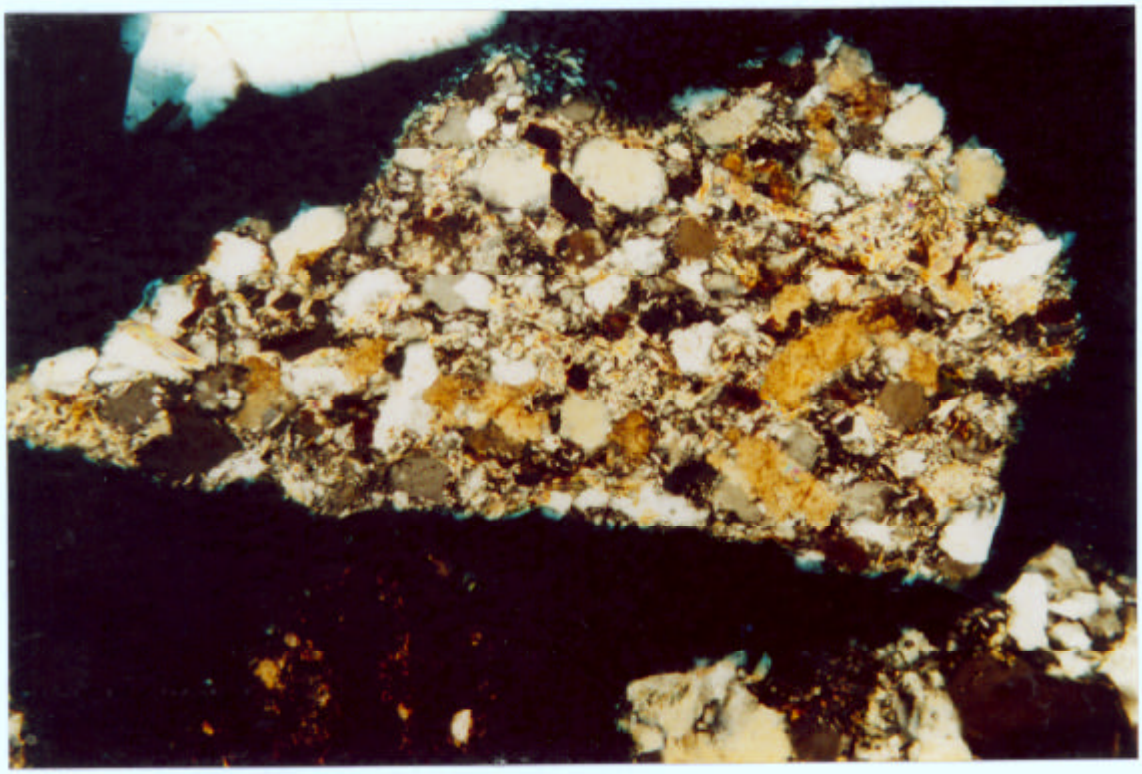

Figure 37
Chip of very fine grained illitic sandstone typical of this depth interval. Note the carbonate spar that has replaced grains & the matrix. Toolachee-39, cuttings, depth 8200-8210ft. Crossed nicols. Horizontal field of view 1.30mm.

4.38 Toolachee-39, cuttings, depth 8250-8260ft, ?Merrimelia Formation

Sample number: 431823

Thin section description

Lithologies present:
Chips of illitic shale & illitic sandy shale (65%), shale (4%), carbonaceous shale (5%), coal (4%), carbonate cemented fine sandstone (trace), fine grained illitic sandstone (8%), medium grained quartzarenite (1%), carbonate spar (6%), glauconitic mudstone (trace), siltstone (trace) and single grains of quartz up to granules in size (6%) are apparent. The dominance of illitic shale and illitic sandy shale suggest these chips are representative of this depth interval.

Illitic Shale to illitic sandy shale

Sedimentary structures	sandy laminae within the shale, fracture healed with carbonate spar
Avg. grain size	clay
Range in grain size	clay to coarse sand
Sorting	poor
Composition	silt to coarse sand size grains of monocrystalline & polycrystalline quartz, muscovite flakes & accessory rutile float in a matrix of illitic clay, partial replacement of matrix by patchy carbonate spar & spherulitic spar, rare silt size anhedral patches of ?anatase

Comments:
This illitic shale is typical of the Dullingari Group.

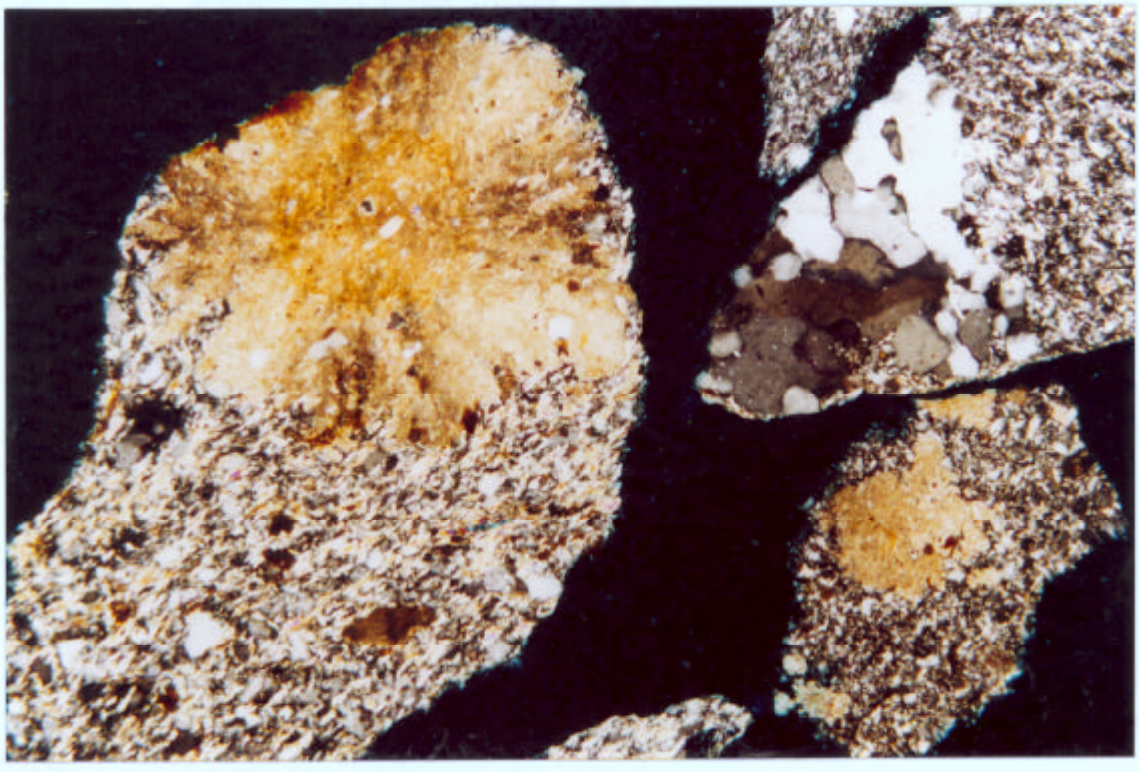

Figure 38
Two chips of illitic shale are apparent. One contains a patch of spherulitic spar which is common in this shale and the other has part of a coarse polycrystalline quartz grain. Toolachee-39, cuttings, depth 8250-8260ft. Crossed nicols. Horizontal field of view 1.30mm.

4.39 Toolachee-39, cuttings, depth 8290-8300ft, ?Merrimelia Formation

Sample number: 431824

Thin section description

Lithologies present:
Chips consist of illitic shale (27%), carbonaceous shale (7%), carbonaceous material (4%), blackish coloured silty shale (45%), siltstone (3%), illitic sandstone (10%), medium grained quartzarenite (trace), carbonate spar (2%) and carbonate cemented sandstone (1%). The relative abundance of blackish coloured silty shale suggests this lithology may be representative of this depth.

Silty shale

Sedimentary structures	slatey cleavage is outlined by a concentration of ?graphite, sands are segregated into lenses within the shale possibly as remnants of bedding
Avg. grain size	clay
Sorting	poor
Composition	silt to fine sand size grains of monocrystalline & polycrystalline quartz, muscovite flakes & accessory tourmaline & rutile, crenulated contacts with a matrix of illitic clay & anhedral opaque material that may be ?graphite, authigenic minerals of patchy carbonate spar both dusty & Fe rich

Comments:
Rare chips of illitic shale contain remnants of the blackish coloured silty shale. This may indicate that the illitic shale is an alteration product of the blackish coloured silty shale. This is not the Merrimelia Formation.

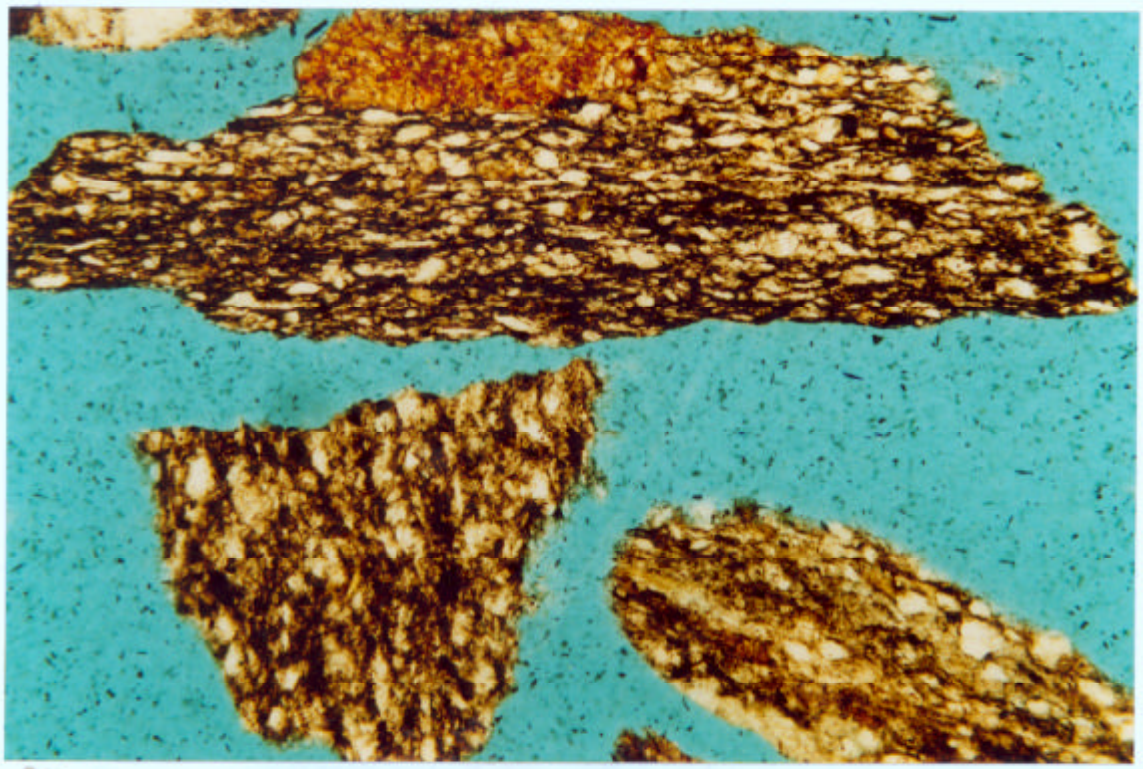

Figure 39
Typical chips of blackish coloured silty shale. Slatey cleavage is well developed in the larger chip which has a patch of Fe rich carbonate spar. The other chips do not display the cleavage as clearly, possibly because of crushing during sampling and/or minor alteration. Toolachee-39, cuttings, depth 8290-8300ft. Plane light. Horizontal field of view 1.30mm.

4.40 Toolachee-39, cuttings, depth 8320-8332ft, ?Merrimelia Formation

Sample number: 431825

Thin section description

Lithologies present:
Chips of blackish coloured silty shale (64%), illitic shale (23%), illitic sandstone (5%), carbonaceous material (2%), carbonaceous shale (4%), medium grained quartzarenite (trace) and single grains of quartz (1%) are apparent. Blackish coloured silty shale is the dominant lithology at this depth but it contains lenses of illitic sand.

Silty shale

Sedimentary structures	slatey cleavage, lenses of illitic sand in the blackish coloured silty shale, fractures 0.05 to 0.35mm wide healed by polycrystalline quartz & Fe rich carbonate spar
Avg. grain size	clay
Range in grain size	clay to fine sand
Sorting	poor to moderate
Composition	grains of monocrystalline & polycrystalline quartz, muscovite flakes & accessory tourmaline are surrounded by anhedral blackish material (?graphite) & minor illite, authigenic carbonate spar & blocky pyrite concentrate in the sandy lenses, rare grains replaced by illite

Comments:
This depth interval is not the Merrimelia Formation because the shale has undergone low grade metamorphism. It appears to be a zone of Dullingari Group that has not been extensively altered to illite, even though it has been penetrated by fractures.

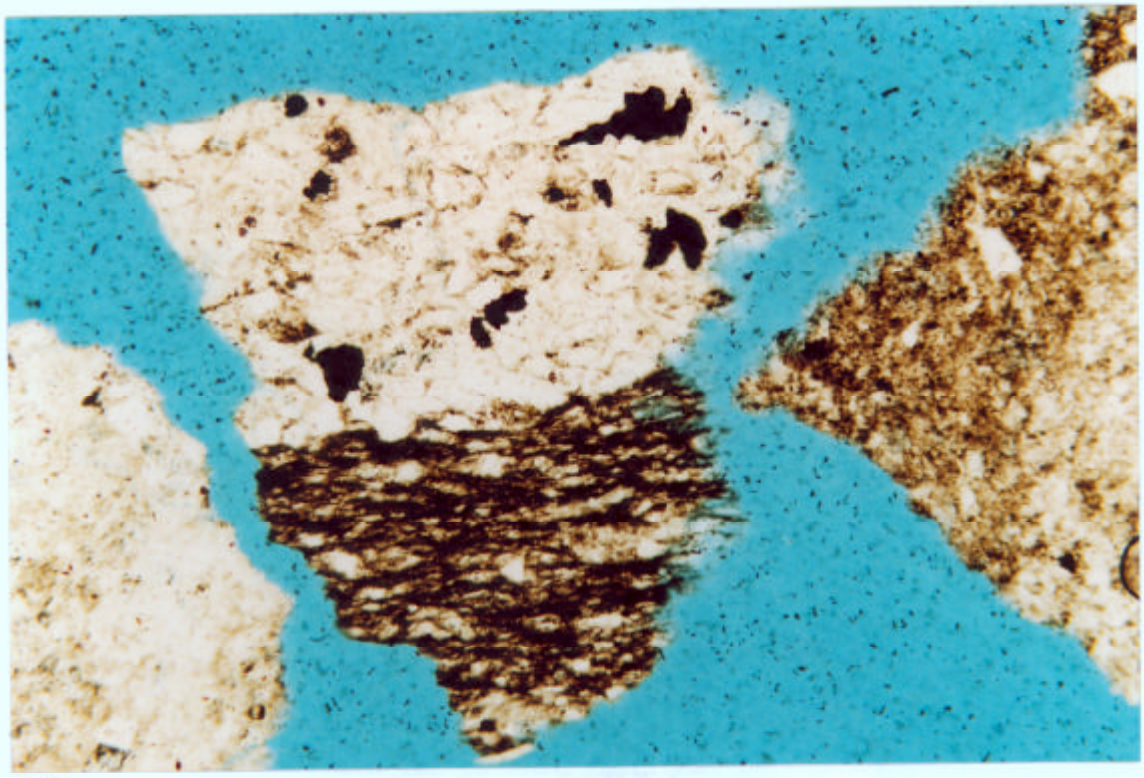

Figure 40
This chip shows a sharp contact between illitic sand with minor blocky pyrite cement (opaque) and blackish silty shale that is dominant at this depth. Toolachee-39, cuttings, depth 8320-8332ft. Plane light. Horizontal field of view 1.30mm.

4.41 Toolachee-50, cuttings, depth 7700-7710ft, ?Merrimelia Formation

Sample number: 431826

Thin section description

Lithologies present:
Chips consist of carbonaceous shale (48%), carbonaceous material (3%), illitic shale (30%), siltstone (4%), poorly sorted fine grained sandstone (9%), carbonate spar (2%), pyritic very fine grained sandstone (trace), fine grained well sorted quartzarenite (3%) and single grains of quartz (trace). It is difficult to know which shale is representative of this depth interval. A slight spike on the sonic log may suggest the carbonaceous shale is the dominant lithology but the lower resistivity near the base of this interval would be typical of the illitic shale.

Carbonaceous Shale to sandy shale

Sedimentary structures	stringers of organic matter & silty/sandy laminae
Avg. grain size	clay
Range in grain size	clay to very fine sand
Sorting	poor
Composition	grains of quartz, & muscovite & biotite flakes float in reddish brown anhedral clay with stringers & fragments of organic matter, minor replacement by Fe rich micrite & microspar

Illitic Shale

Sedimentary structures	none apparent
Avg. grain size	clay
Range in grain size	clay to silt
Sorting	moderate
Composition	silt size grains of quartz float in an illitic matrix, minor patches of carbonate microspar scattered throughout the matrix, rare opaque material could be organic matter

Comments:
The carbonaceous shale is typical of the Patchawarra Formation and the illitic shale of the Dullingari Group. This may be the contact between these two formations, or it may be the contact between the Patchawarra and the Merrimelia Formation which is dominantly composed of reworked Dullingari Group.

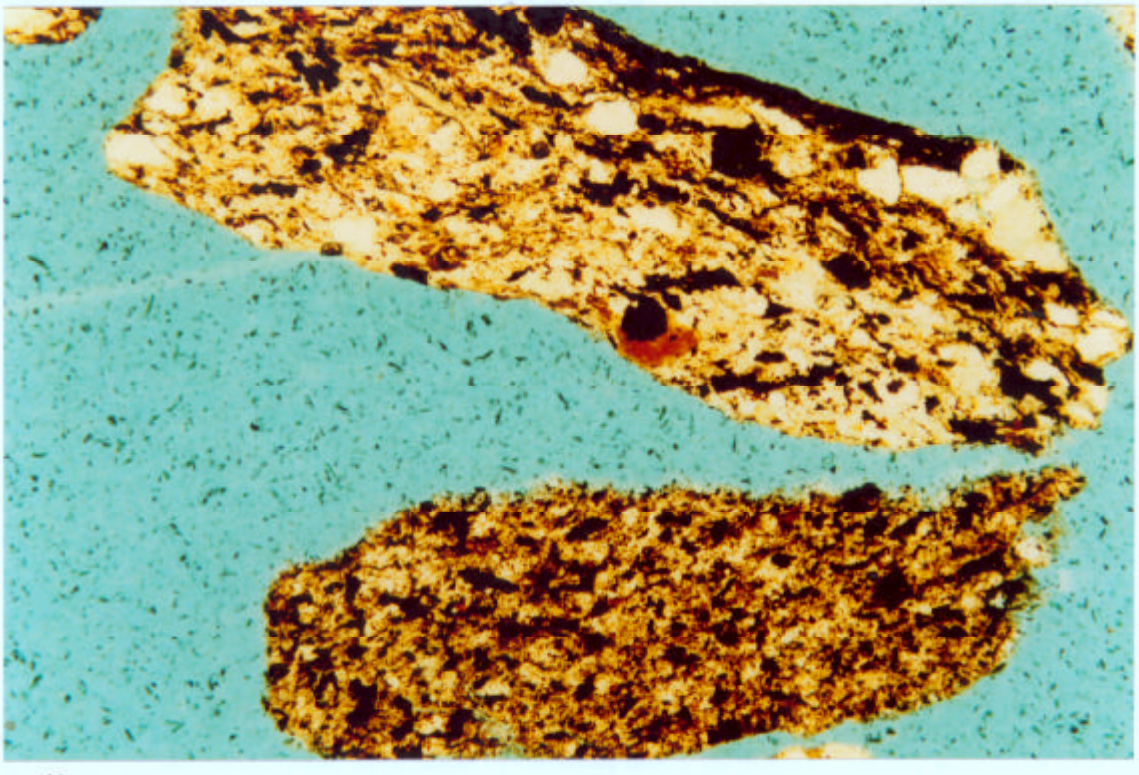

Figure 41
Angular opaque material represents the organic matter in these two chips of carbonaceous shale. Silt and fine sand size grains of quartz (white) are relatively abundant in the upper chip. Toolachee-50, cuttings, depth 7700-7710ft. Plane light. Horizontal field of view 1.30mm.

4.42 Toolachee-50, cuttings, depth 7730-7740ft, ?Merrimelia Formation

Sample number: 431827

Thin section description

Lithologies present:
Chips consist of carbonaceous shale to rare sandy shale (42%), carbonaceous material (4%), illitic shale to sandy shale (35%), siltstone (trace), fine to medium grained sandstone (10%), Fe rich microspar (rarely oxidised, 3%) and single grains of quartz (5%). Based on the relative abundances of the different lithologies it is difficult to be certain whether the carbonaceous shale or the illitic shale is representative of this depth. In the illitic shale category there is a significant percentage of sandy shale that would be consistent with gamma ray log signature at this depth.

Illitic sandy shale

Sedimentary structures	sandy shale may be interbedded with shale
Avg. grain size	clay
Range in grain size	clay to coarse sand
Sorting	poor
Composition	subangular grains of monocrystalline & polycrystalline quartz, muscovite flakes & rare accessory tourmaline, float in a matrix of illitic clay with traces of anhedral opaque material (?graphite) & possibly ?quartz, dusty carbonate spar has partially replaced grains & matrix, rare blocky pyrite postdates the carbonate, rare grains replaced by kaolin or illite

Comments:
The high percentage of polycrystalline quartz grains in this sandy shale is unusual and it is possible that these grains had an igneous provenance. The illitic sandy shale is similar to that of the Dullingari Group.

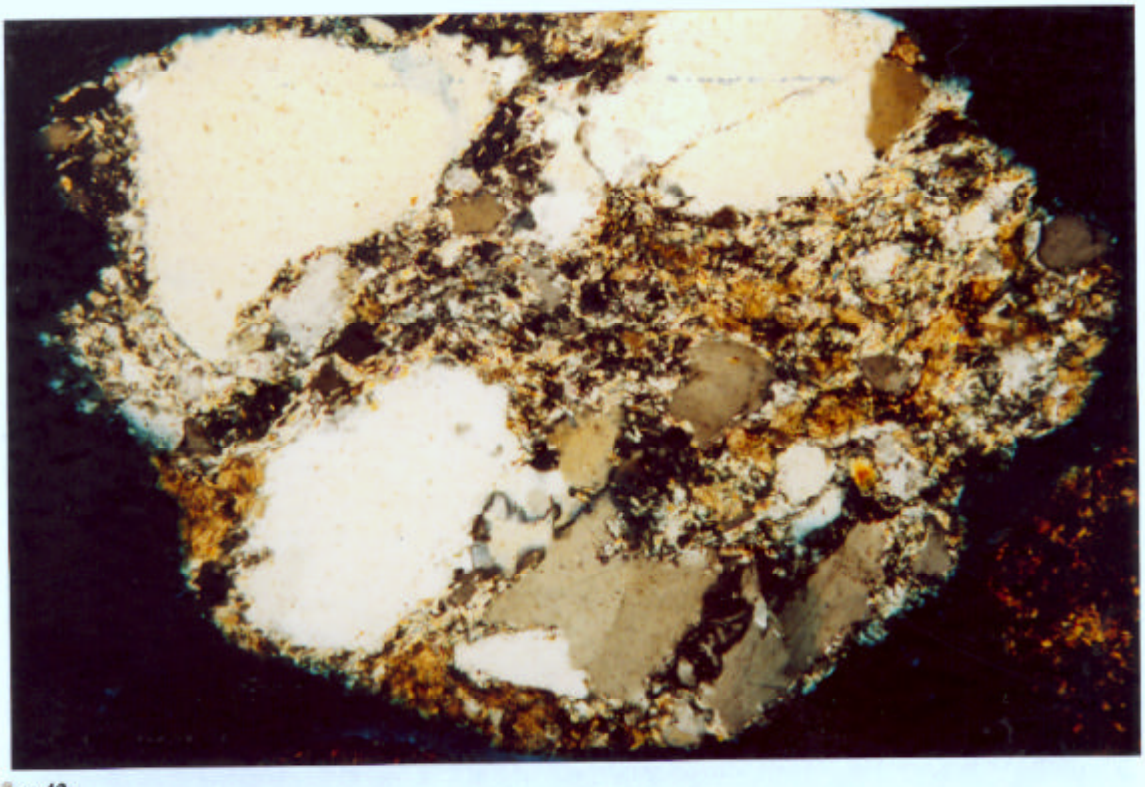

Figure 42
Extensive alteration to illite and replacement by carbonate makes the origin of this chip difficult to ascertain. It has been described as an illitic sandy shale but may have had an igneous origin, or at least many of the quartz grains may have been derived from this provenance. Toolachee-50, cuttings, depth 7730-7740ft. Crossed nicols. Horizontal field of view 1.30mm.

4.43 Toolachee-50, cuttings, depth 7740-7750ft, ?Merrimelia Formation

Sample number: 431828

Thin section description

Lithologies present:
Chips consist of illitic shale to sandy shale (60%), carbonaceous shale (28%), carbonaceous material (1%), siltstone (4%), Fe rich spar (3%), poorly sorted very fine grained sandstone (trace), medium grained quartzarenite (trace) and single grains of quartz (4%). The illitic shale to sandy shale would appear to be the dominant lithology at this depth. Within this lithology 36% is composed of illitic sandy shale. However, the log signature suggests the illitic shale should be most abundant. Muscovite flakes in the shale and sandy shale are more abundant than previous examples of this lithology and may have influenced the log signature.

Illitic sandy shale

Sedimentary structures	none apparent
Avg. grain size	clay
Range in grain size	clay to coarse sand
Sorting	poor
Composition	monocrystalline & polycrystalline quartz are present in approximately equal proportions, other detrital grains of fresh muscovite & accessory tourmaline float in an illitic clay matrix with minor quartz & possibly ?graphite, illite has also replaced grains & there are irregular shaped patches of dusty carbonate spar & traces of blocky pyrite & ?anatase

Comments:
The illitic shale and illitic sandy shale that dominate this depth are more characteristic of the Dullingari Group than the Merrimelia Formation.

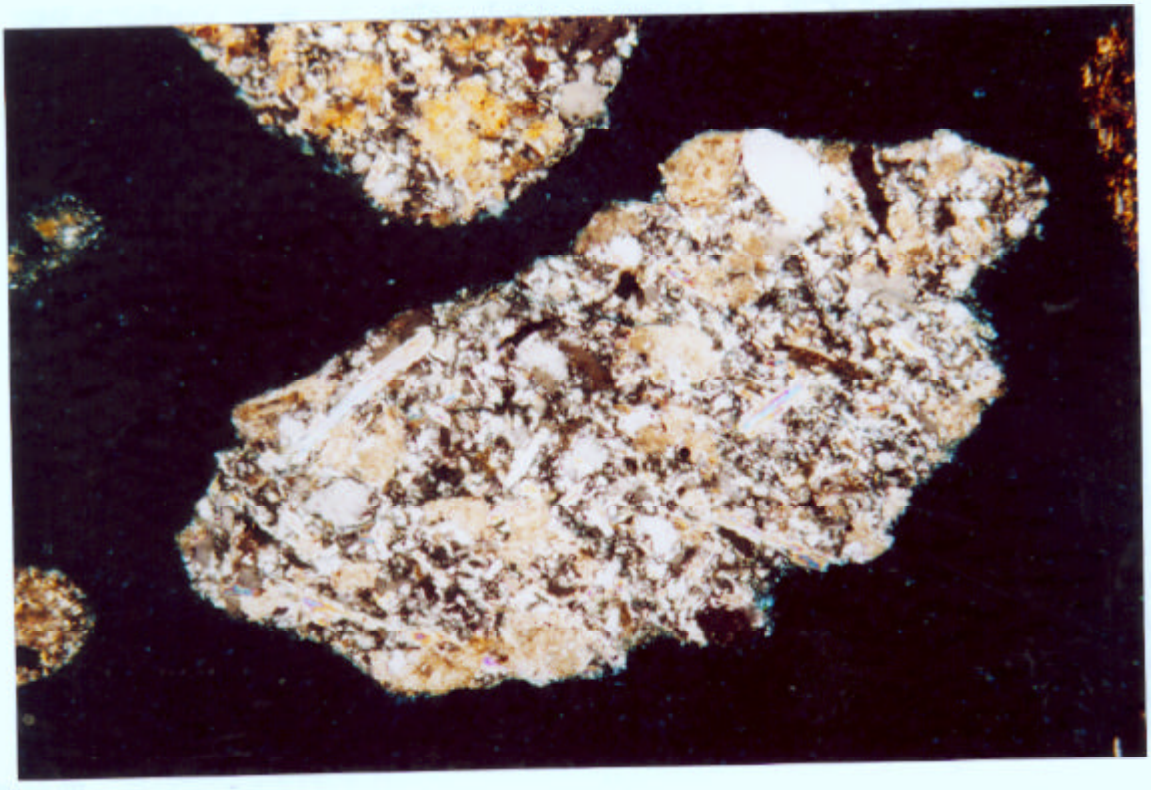

Figure 43
Typical chip of illitic sandy shale with fresh muscovite flakes and minor replacement by carbonate spar. Toolachee-50, cuttings, depth 7740-7750ft. Crossed nicols. Horizontal field of view 1.30mm.

4.44 Toolachee-50, cuttings, depth 7790-7800ft, ?Merrimelia Formation

Sample number: 431829

Thin section description

Lithologies present:
Cuttings of illitic sandy shale (73%), illitic shale (15%), carbonaceous shale (3%), carbonaceous material (1%), carbonate spar (3%) and single grains of quartz (4%) are apparent. The abundance of illitic sandy shale suggests this lithology is representative of this depth interval. The illitic sandy shale may grade to a greywacke in composition.

Illitic sandy shale

Sedimentary structures	none apparent
Avg. grain size	clay
Range in grain size	clay to coarse sand
Sorting	poor
Composition	subangular grains of monocrystalline & polycrystalline quartz, muscovite flakes & accessory tourmaline are enclosed by an illitic matrix, irregular patches of dusty carbonate spar have replaced the matrix, grains have been replaced by illite & rarely by kaolin booklets, traces of anhedral ?anatase

Comments:
The illitic sandy shale dominant at this depth is thought to be representative of the Dullingari Group.

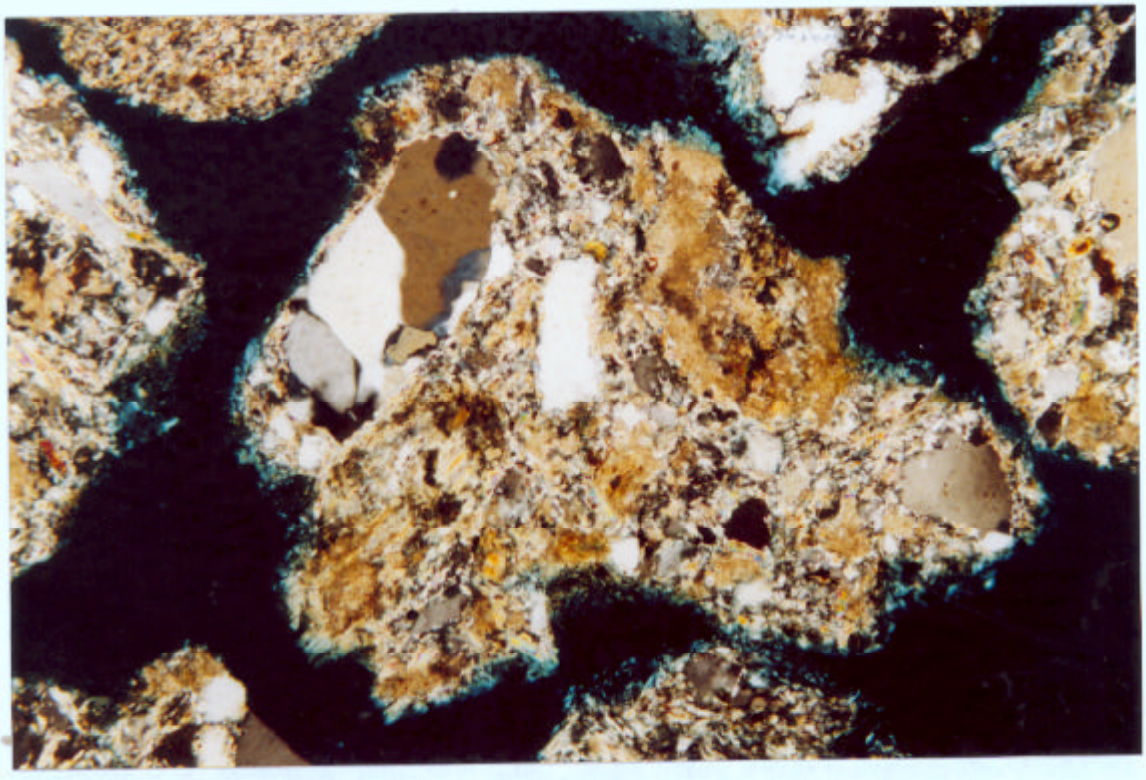

Figure 44
Quartz grains in the illitic sandy shale are commonly polycrystalline with straight crystal boundaries typical of an igneous provenance. Toolachee-50, cuttings, depth 7790-7800ft. Crossed nicols. Horizontal field of view 1.30mm.

4.45 Toolachee-50, cuttings, depth 7850-7860ft, ?Merrimelia Formation

Sample number: 431830

Thin section description

Lithologies present:
Chips of illitic shale (73%), illitic sandy shale (20%), carbonate spar (1%), carbonaceous material (1%), carbonaceous shale (1%), siltstone (1%), fine grained quartzarenite (1%) and single grains of quartz (trace) are apparent. Dominance of chips of illitic shale indicates this lithology is probably representative of this depth interval. In the chips of illitic shale, illitic sandy shale and siltstone at this depth there is minor authigenic epidote that is probably of low grade metamorphic origin (greenschist facies).

Illitic Shale

Sedimentary structures	fractures healed with carbonate spar
Avg. grain size	clay
Range in grain size	clay to silt
Sorting	moderate
Composition	rare angular silt size grains of monocrystalline & polycrystalline quartz float in an illitic clay matrix, traces of authigenic carbonate spar are rimmed by anatase, elsewhere dusty micrite has a patchy distribution & anatase forms silt size anhedral grains, minor silt size epidote in the matrix & rare minute blocky opaques (?pyrite)

Comments:
This depth interval is represented by the Dullingari Group rather than the Merrimelia Formation because there is evidence of low grade metamorphic alteration.

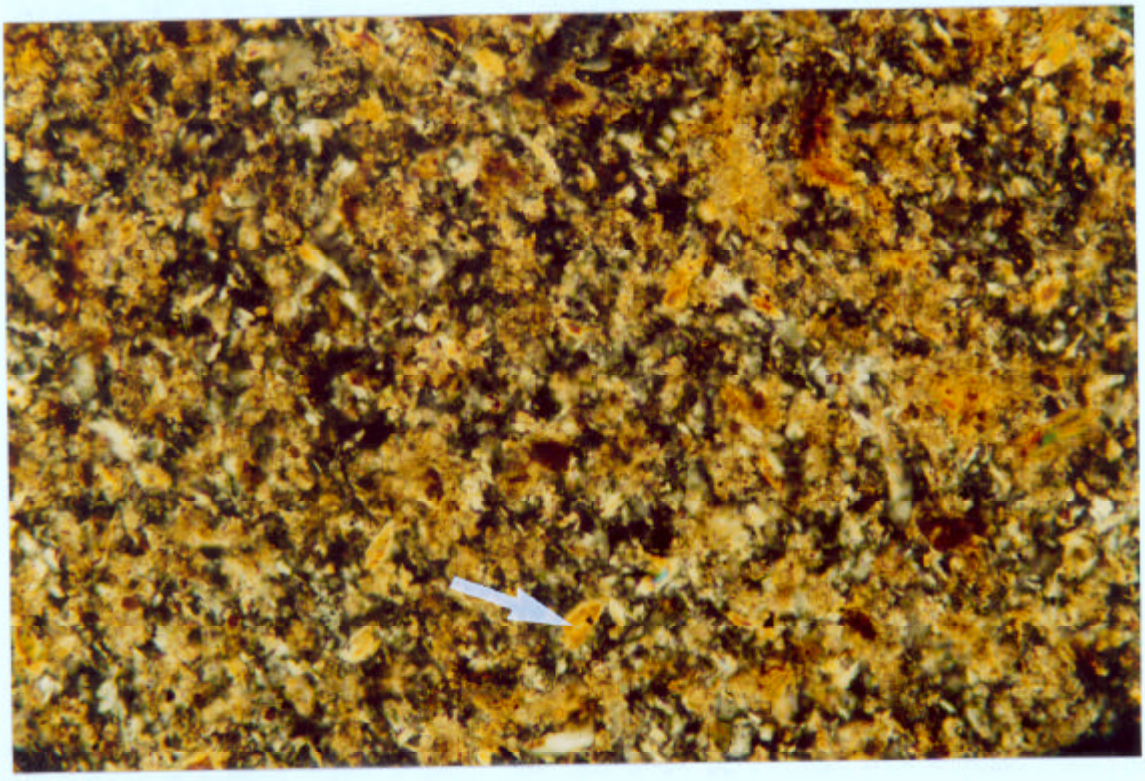

Figure 45
Illitic shale typical of the Dullingari Group contains minute anhedral yellow crystals of epidote (arrow). Toolachee-50, cuttings, depth 7850-7860ft. Crossed nicols. Horizontal field of view 0.65mm.

4.46 Turban-1, cuttings, depth 7860-7870ft, ?Merrimelia Formation

Sample number: 431831

Thin section description

Lithologies present:
Chips consist of kaolin & quartz cemented medium grained sandstone (32%), siltstone (trace), illitic shale (6%), illitic sandy shale to greywacke (5%), carbonate spar (trace), oxidised shale (trace), glauconitic mudstone (trace), carbonaceous shale (4%), carbonaceous material (1%) and single grains of coarse monocrystalline and polycrystalline quartz and chert (52%). Most of the cuttings have been derived from a disaggregated coarse grained quartz rich sandstone and a medium grained sandstone. However, it would appear from the logs that these chips should be down hole contaminants if the difference between drillers and loggers depths (12') is correct. Illitic sandy shale to greywacke occurs as lithics within the sandstone (?sublitharenite) and therefore is also a contaminant. Rare chips of siltstone may be characteristic of this depth interval.

Siltstone

Sedimentary structures	none apparent
Avg. grain size	silt
Sorting	moderate
Composition	framework grains of monocrystalline & polycrystalline quartz, muscovite flakes & accessory zircon & rutile, minor illitic clay matrix, authigenic Fe rich spar has a patchy distribution, rare rounded epidote & anhedral anatase

Comments:
Epidote in the siltstone suggests a low grade metamorphic origin for this lithology if the epidote is authigenic in origin. However, the siltstone could have been reworked as a lithic into the Merrimelia Formation. Quartz & kaolin cemented sandstone chips that dominate these cuttings were derived from the Cooper Basin.

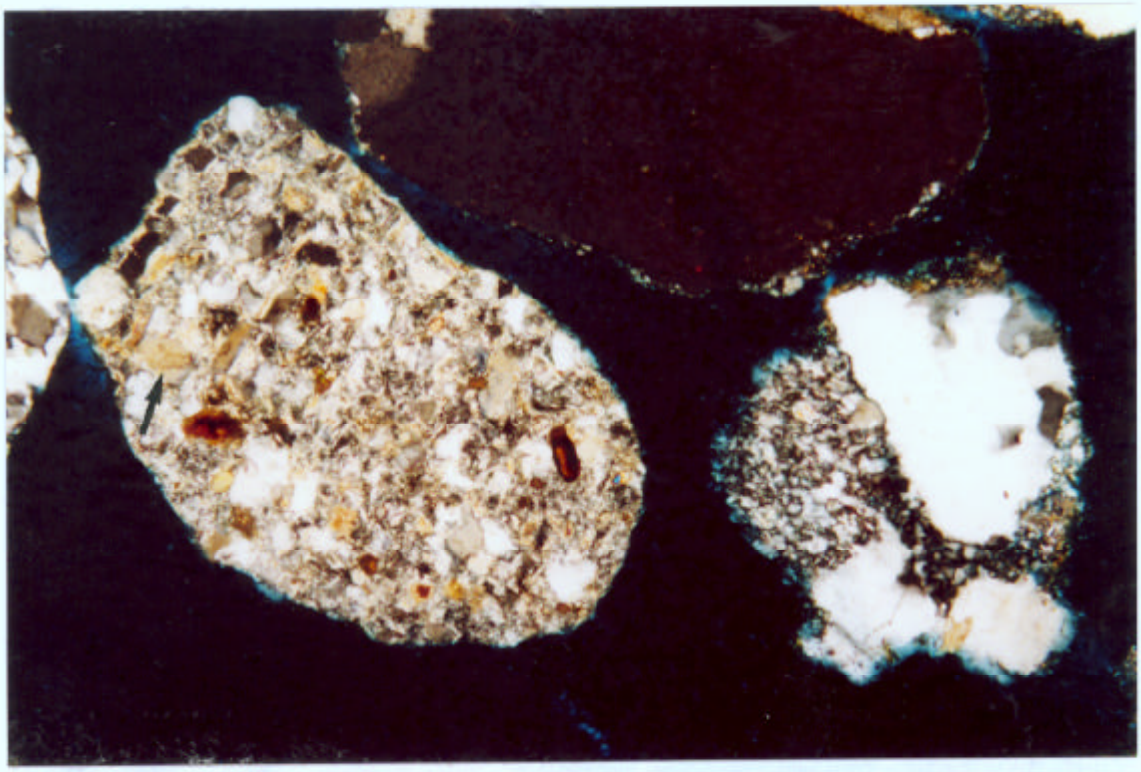

Figure 46
The chip of illitic siltstone contains accessory rutile (dark brown) and a rounded grain of epidote (arrow) that could be either detrital or authigenic. The adjacent chip of medium grained sandstone is composed of monocrystalline & polycrystalline quartz plus a quartz rich lithic with pore filling kaolin & traces of carbonate spar. Turban-1, cuttings, depth 7860-7870ft. Crossed nicols. Horizontal field of view 1.30mm.

4.47 Turban-1, cuttings, depth 7900-7910ft, ?Merrimelia Formation

Sample number: 431832

Thin section description

Lithologies present:
Chips of carbonaceous shale (6%), carbonaceous material (7%), illitic shale (3%), silty mudstone (?diamictite, 32%), carbonate & quartz cemented sandstone (32%), greywacke (3%), oxidised sandstone (1%), carbonate spar (trace) and single grains of quartz (15%) are evident. Based on the logs the silty mudstone (?diamictite) should be characteristic of this depth interval.

Silty mudstone (?diamictite)

Sedimentary structures	none apparent
Avg. grain size	clay
Range in grain size	clay to medium sand
Sorting	moderate
Composition	rare silt to medium sand size grains of monocrystalline & polycrystalline quartz, illitic shale lithics & silt size opaques & tourmaline float in a matrix of pale brown anhedral clay, minor patches of dusty Fe rich micrite have replaced the matrix, rare grains replaced by kaolin

Comments:
There is no evidence of low grade metamorphic alteration in the silty mudstone therefore it probably is part of the Merrimelia Formation (possibly as a diamictite).

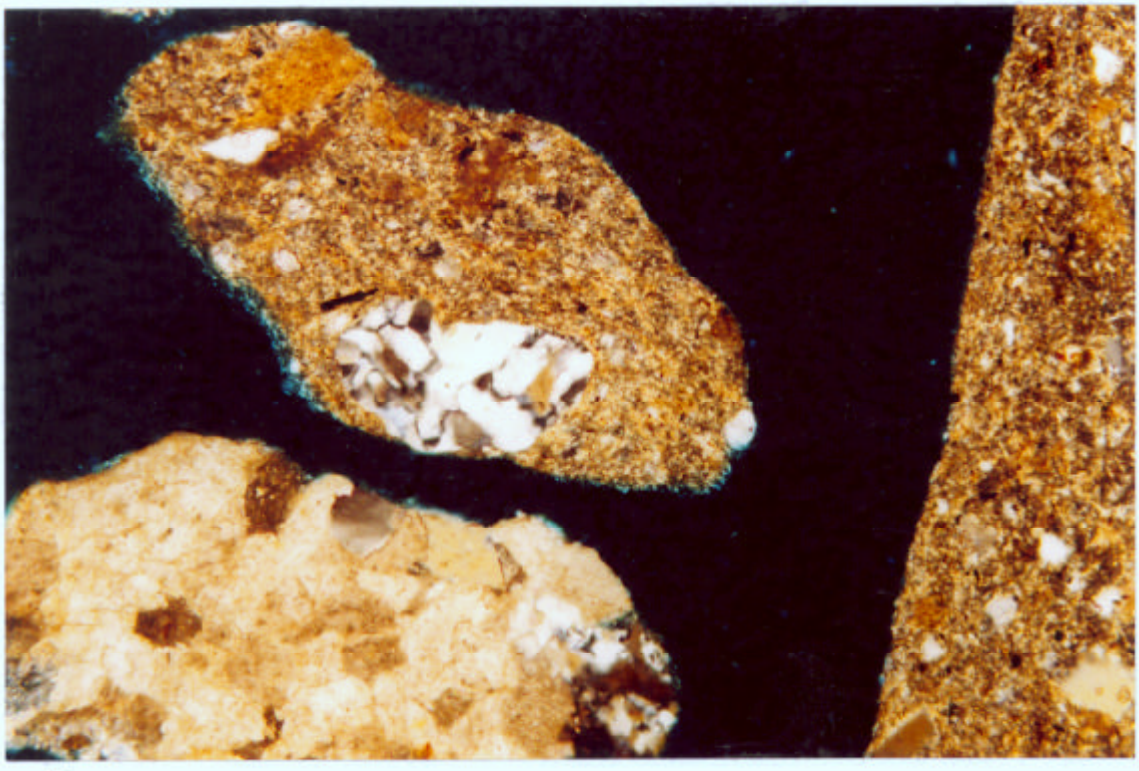

Figure 47
Two chips of silty mudstone illustrate that silt in the mudstone chips is angular whilst sand size grains are subrounded. The adjacent chip consists of carbonate cemented sandstone. Turban-1, cuttings, depth 7900-7910ft. Crossed nicols. Horizontal field of view 1.30mm.

4.48 Turban-1, cuttings, depth 7950-7960ft, ?Merrimelia Formation

Sample number: 431833

Thin section description

Lithologies present:
Chips consist of siltstone (6%) to fine grained sandstone (36%), illitic shale (3%), carbonaceous material (1%), mudstone to silty mudstone (34%), oxidised shale (trace), carbonate spar (trace), medium grained sandstone (7%) and single grains of quartz (6%). This depth interval is probably a mixture of the siltstone to fine grained sandstone and the mudstone to silty mudstone.

Siltstone to fine grained sandstone (sublitharenite)

Sedimentary structures	none apparent
Avg. grain size	silt to very fine sand
Range in grain size	silt to medium sand
Sorting	moderate to well
Roundness/sphericity	subangular to subrounded/ low
Texture	grain supported
Porosity	none apparent
Composition	framework grains of monocrystalline & polycrystalline quartz, shale lithics, muscovite flakes & accessory zircon, tourmaline & sphene, trace amounts of illitic clay trapped between grains & replacing grains, minor Fe rich carbonate spar, syntaxial quartz overgrowths, rare rounded grains of bright green glaucony, isolated grains replaced by kaolin

Mudstone to silty mudstone

Sedimentary structures	rare silty laminae
Avg. grain size	clay
Range in grain size	clay to coarse sand
Sorting	poor
Composition	pale brown anhedral clay is dominant with abundant patches of dusty micrite, rare chips have silt to sand size grains of quartz, minute opaques & bright green glaucony floating in the matrix

Comments:
Grains of glaucony in both the siltstone/fine sandstone and silty mudstone are not characteristic of the Merrimelia Formation. There is no indication of metamorphic alteration that would suggest this is the Dullingari Group.

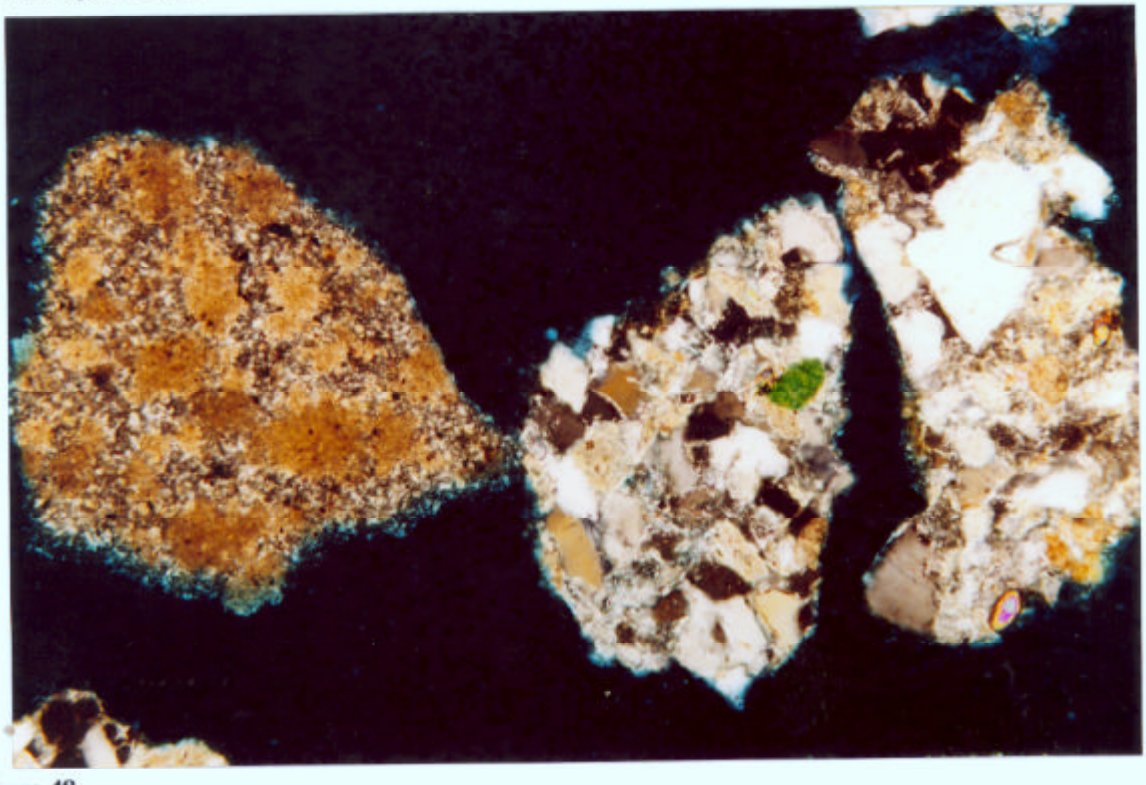

Figure 48
The central chip of very fine grained illitic sandstone contains a grain of bright green glaucony. Note the abundance of shale lithics in the sandstone chips and the patches of micritic carbonate in the mudstone chip. Turban-1, cuttings, depth 7950-7960ft. Crossed nicols. Horizontal field of view 1.30mm.

4.49 Turban-1, cuttings, depth 7990-8000ft, ?Merrimelia Formation

Sample number: 431834

Thin section description

Lithologies present:
Chips of very fine to fine grained sandstone (sublitharenite) containing minor oxidation (65%), very fine to fine grained sandstone (sublitharenite, 16%), medium grained quartzarenite (1%), siltstone (7%), carbonaceous material (2%), carbonaceous shale (trace), mudstone & silty mudstone (4%) and single grains of quartz (4%). Very fine to fine grained oxidised sandstone is thought to be representative of this depth interval. Sandstone of a similar grain size that lacks oxidation may be a down hole contaminant.

Sandstone (sublitharenite)

Sedimentary structures	none apparent
Avg. grain size	very fine to fine sand
Range in grain size	silt to medium sand
Sorting	moderately well
Roundness/sphericity	subrounded/ low to moderate
Texture	grain supported
Porosity	rare secondary grain size and intragranular pores
Composition	framework grains of monocrystalline & polycrystalline quartz, shale & possibly volcanic lithics and accessory tourmaline & zircon are cemented by quartz overgrowths, traces of illite rim grains, varying amounts of replacement of these rims by Fe rich oxide (hematite) & replacement of shale lithics, rare grains of bright green fresh glaucony, rare grain replacing carbonate spar

Comments:
Oxidation plus rare grains of glaucony might suggest this depth interval is representative of the Innamincka Red Beds.

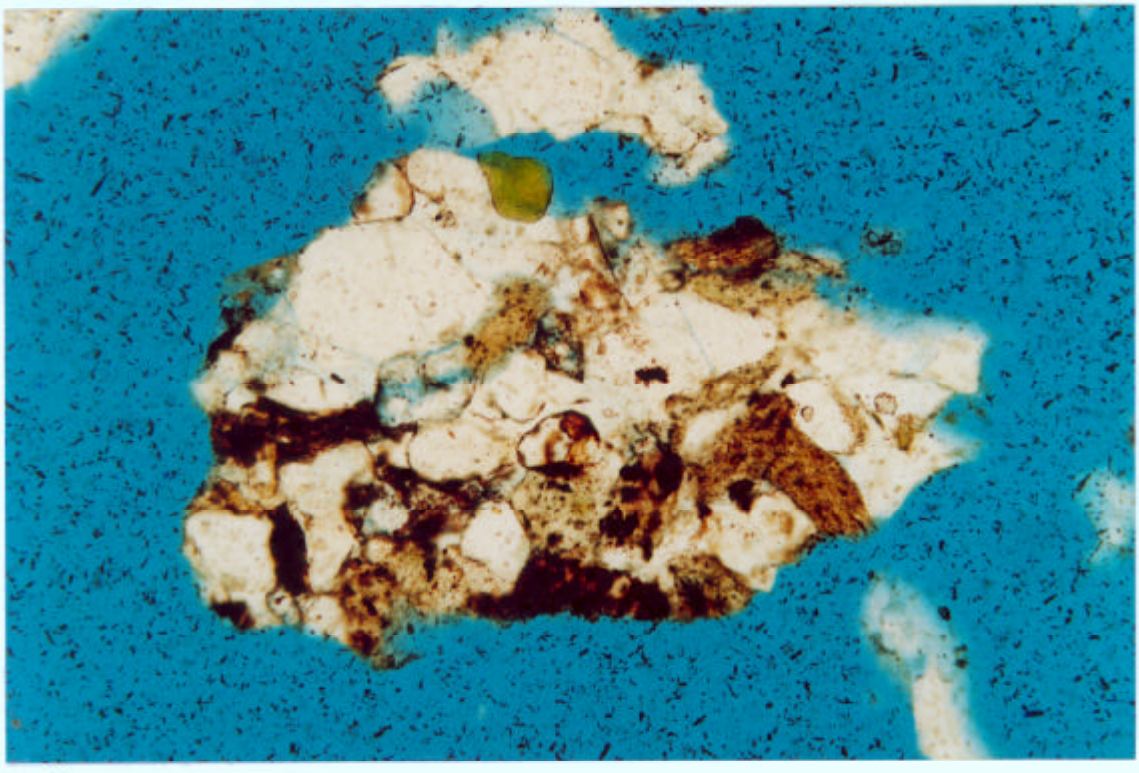

Figure 49
Fine grained sublitharenite has been partially oxidised. Oxide rims grains & has replaced shale lithics, a bright green grain of glaucony remains unaltered. Turban-1, cuttings, depth 7990-8000ft. Plane light. Horizontal field of view 1.30mm.

4.50 Turban-1, cuttings, depth 8050-8060ft, ?Merrimelia Formation

Sample number: 431835

Thin section description

Lithologies present:
Chips of siltstone (2%), fine grained sublitharenite (79%), oxidised siltstone to fine grained sublitharenite (6%), medium grained quartzarenite (3%), silty mudstone (6%) and single grains of quartz (3%) are evident. The relative abundance of fine grained sublitharenite indicates this lithology is dominant at this depth.

Sandstone (sublitharenite)

Sedimentary structures	none apparent
Avg. grain size	very fine to fine sand
Range in grain size	silt to medium sand
Sorting	moderately well
Roundness/sphericity	subrounded/ low to moderate
Texture	grain supported with minor sutured contacts
Porosity	rare grain size pores & honeycomb pores
Composition	framework grains of monocrystalline & polycrystalline quartz, minor shale & possibly volcanic lithics, rare fresh & corroded feldspars with pericline & tartan twinning, muscovite & biotite flakes & accessory zircon & tourmaline, traces of illitic clay matrix, cemented by syntaxial quartz overgrowths, minor carbonate spar, rare grains altered to goethite, bright green grains of glaucony, traces of sphene/anatase

Comments:
There is no obvious evidence of low grade metamorphic alteration in this sublitharenite. The presence of glaucony suggests it is not the Merrimelia Formation.

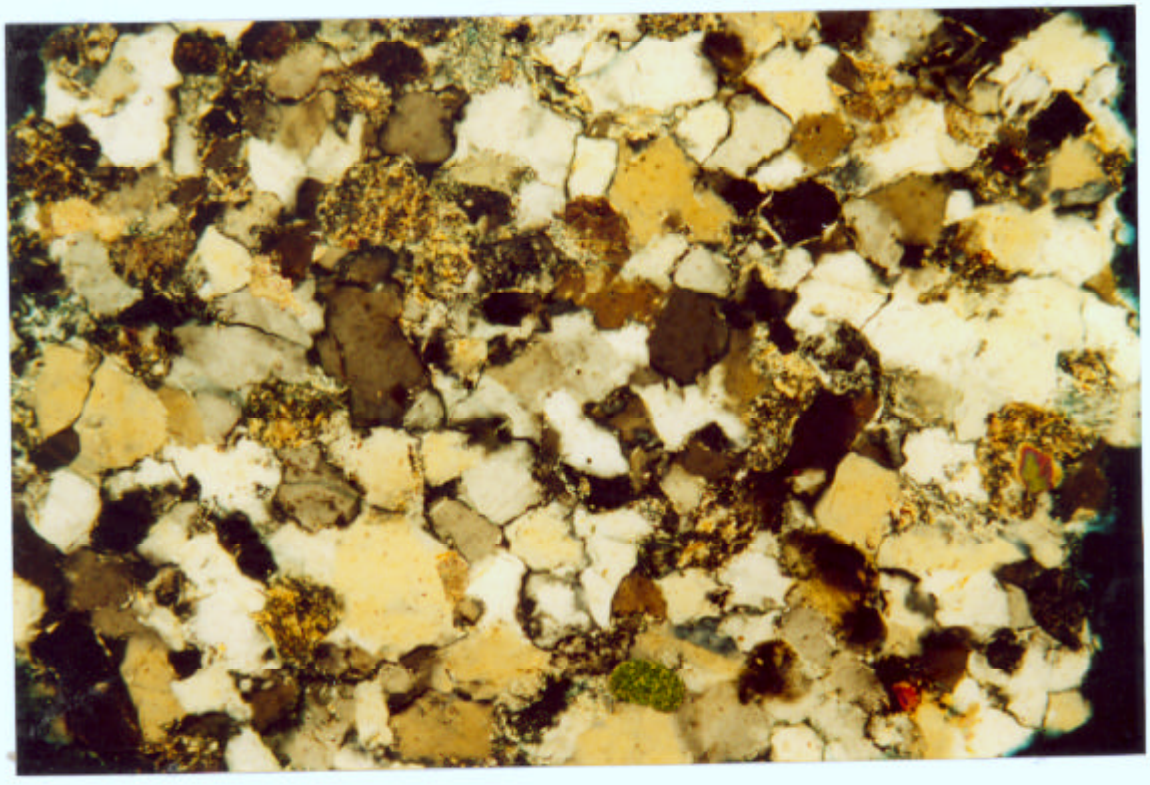

Figure 50
Typical chip of very fine grained, moderately well sorted, texturally mature and mineralogically submature sublitharenite. Dusty grains are lithics and there is a well rounded grain of glaucony present. Turban-1, cuttings, depth 8050-8060ft. Crossed nicols. Horizontal field of view 1.30mm.

5. GLOSSARY OF TERMS

Framboid
A cluster of pyrite crystals with a spheroidal outline.

Glaucony
A term used to describe green minerals without any genetic connotations. If the green minerals can be identified, a specific mineral name is given.

Glauconite
An Fe-rich dioctahedral illite. The term is also used to refer to a family of Fe-rich dioctahedral clays with varying ratios of expanded (smectite) and non-expanded layers.

Greywacke
A type of sandstone marked by large angular detrital quartz and feldspars and variable quantities of lithics, set in a dominantly clay matrix which on low grade metamorphism can be converted to chlorite and sericite and partially replaced by carbonate.

Microporosity
Porosity directly associated with clay minerals.

Neomorphism
All transformations between a mineral and the same mineral, or another of the same general composition.

Orthoquartzite
Clastic sedimentary rock composed of silica cemented quartz sand.

Porphyritic
A textural term applied to igneous rocks in which there are two distinct grain sizes present.

Porphyry
A term used for all rocks containing conspicuous phenocrysts in a fine grained or aphanaitic groundmass. The resulting texture is porphyritic.

Protoquartzite
A sandstone intermediate between orthoquartzite and subgreywacke.

Subgreywacke
Similar to a greywacke but this sandstone has less feldspar and more quartz. The latter is better rounded than in a greywacke.

Vacuole
Gas or liquid filled inclusion.

6. REFERENCE

FOLK, R.L. (1974) *Petrology of sedimentary rocks.* Hemphill, 182p.