Orthoganal fracture set in Lycosa 1

FRACTURE ANALYSIS of the EASTERN WARBURTON BASIN (Early Palaeozoic) South Australia

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Silica and siderite filled fractures in Pando 1

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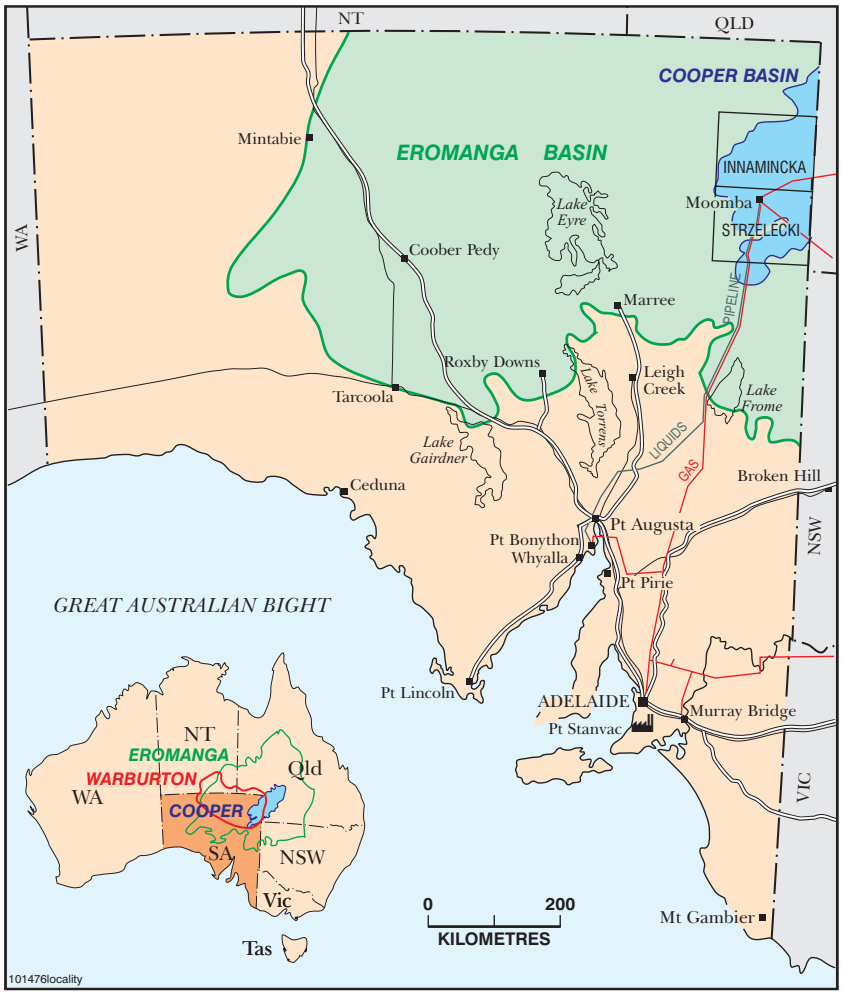


Frontispiece: Locality map.

EXECUTIVE SUMMARY

Cambro-Ordovician Warburton Basin strata and intrusive granites are conventionally regarded as economic basement beneath the Cooper-Eromanga oil and gas province in northeast South Australia and southwest Queensland. This study, the first of its kind, has identified and mapped a regional fracture system through upper levels of the Warburton Basin and because the fractures contain oil and gas from Cooper Basin source rocks, effective secondary hydrocarbon migration into fractured 'basement' traps is confirmed. Oil has flowed in commercial volumes from fractured Cambrian tuffs in Sturt 6 and 7, gas has been tested in Moolalla 1 and Lycosa 1 in Ordovician sandstone and fractured siltstone lithologies respectively (Baily, 1991a, Taylor *et al*., 1991).

Considerable information has been gathered from a detailed core study of 91 wells in conjunction with the use of dipmeters, formation micro-scanner (FMS) logs from 27 wells. Absolute orientation data are obtained from measurements of cores and logs from 23 wells and additional relative orientation data are collected from 24 wells. Two systems of orthogonal fracture sets have been identified for the first time across local structures, and extend beneath the Cooper Basin in South Australia. System I has a pair of orthogonal fractures, striking NNE-SSW (20-200°) and ESE-WNW (110-290°). This system is similar in direction to low frequency lineaments NNE8 and WNW9 (Boucher, 1998b). System II has a pair of orthogonal fracture sets, striking NE-SW (60-240°) and NW-SE (150-330°). The NE-SW strike orientation is similar to lineament NE1 (Boucher, 1998b). Open fractures in Lycosa 1 have azimuths striking WNW and NW within systems I and II, and dip SW. Open, steeply dipping SW fractures are interpreted from FMS in the production zone over the interval 8653-8670 feet, and incompletely filled fractures are observed in core 1. Open fractures striking NNE and NW are interpreted from FMS in Malgoona 4. Based on data from Lycosa 1, Gidgealpa 5 and Tilparee A1, system I is possibly younger than system II. The results indicate that an optimum well trajectory designed to maximise intersection with open natural fractures should be 200-210° and 240-250°, and possibly 270-290°. The deviation angle should be approximately 30° from horizontal in the fracture zone due to the high angle and subvertical fracture dips.

A semi-quantitative estimate of fracture density has been determined for 91 wells and summarised in the form of an interpretive map. The greatest fracture density is located in major fault zones or structural culminations as expected. Generally speaking, fractures are mainly developed within brittle rather than ductile rock types if they are frequently interbedded. Open fractures or incompletely filled fractures are associated with brittle dolomite such as in Gidgealpa 1, 5, 7, and also in brittle sandstones such as in Beanbush 1, Meranji 2, Jennet 1, Merrimelia 6, 7, or brittle ignimbrite and tuffaceous sandstone such as in Boxwood 1, Gidgealpa 4, and Sturt 7, 8. These fractures are mostly at a high angle. Microfractures have been found and are believed to connect secondary porosity in ignimbrite of Sturt 7, 8. Fracture fairways exist in brittle sandstone, dolomite and volcanics, and any rock types with the above suggested orientations of the two systems of orthogonal fracture sets.

INTRODUCTION

Fractured reservoirs

The eastern Warburton Basin unconformably underlies the Cooper and Eromanga Basins in northern South Australia. Since the discovery of gas in Gidgealpa 2 in the Cooper Basin in 1963, the Warburton Basin has been regarded as economic basement and thus not explored seriously. Its Early Palaeozoic age, limited drilling, poor seismic data below thick Permian coal beds, and tectonic deformation make the Warburton Basin a high-risk exploration target. Although, to now, more than 600 wells have partly intersected the Warburton Basin, most of them are "ratholes" with less than 40 m of penetration. Four wells (gas in Lycosa 1 and Moolalla 1, and oil in Sturt 6 and 7) (Fig. 1) have produced commercial volumes of hydrocarbons which are considered to have migrated from Cooper Basin source rocks (Taylor *et al*., 1991). The reservoir rocks comprise: fractured siltstone (Lycosa 1), sandstone and siltstone with fracture-enhanced matrix porosity (Moolalla 1), and tuff with fracture porosity (Sturt 6 and 7) (Taylor *et al.*, 1991). The fractured siltstone in Lycosa 1 has a maximum gas flow of 5.0 MMCFD (million cubic feet per day) (0.14 Mm^3/d), while the fracture enhanced sandstone reservoir in Moolalla 1 has maximum gas flow of 9.6 MMCFD (0.27 Mm^3/d) (Taylor *et al*., 1991). The fractured tuff flowed at a rate of 1250 BOPD in Sturt 6 (Baily, 1991b). In Sturt 7, a small oil recovery from DST 4 (17.8 bbls oil + 0.7 bbls oil cut mud) demonstrated that the fractured volcanics contain oil (Nugent, 1991) and the well was subsequently completed using artificial lift. These Warburton Basin reservoirs are likely related to fractures or in fault contact with mature Permian source rocks. The relatively high porosity but very low permeability values in Warburton Basin sandstone, volcanics and dolomite (Taylor *et al*., 1991; ACS Laboratories report in Sun and Gravestock, 1999) highlight the importance of having open fractures to connect the pore spaces.

This is the first detailed study of fracture systems in Warburton Basin cores. It aims to characterise fractured reservoirs and to delineate fracture patterns in order to predict the orientation of open fractures and thus potential reservoirs. A similar study has been carried out in the Palm Valley gas field (Berry *et al.*, 1996 and references therein), where fracture analysis was based on study of outcrops, several unoriented cores and one oriented core. Palm Valley is a relatively simple anticline, and bedding dip angles are low. However, the Warburton Basin is orders of magnitude larger, lacks outcrop and has a large number of predominantly random cores. With a range of dips, commonly exceeding 30°, a major task is to determine the orientations of bedding, fractures and other vector properties based on integration of a minimal amount of directional data.

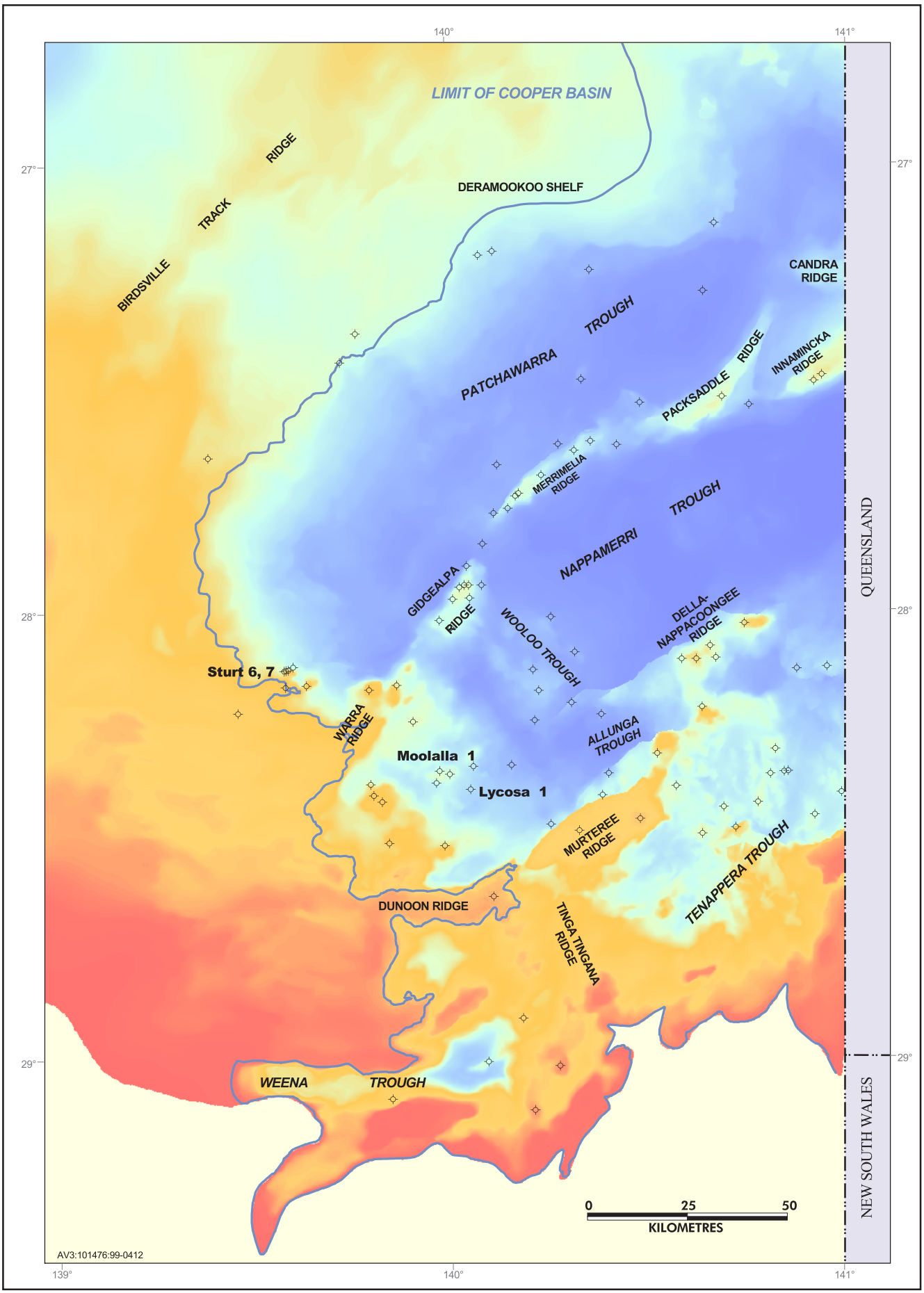


Fig. 1 *Well location map, showing studied wells including economic wells Lycosa 1, Sturt 6, 7 and Moolalla 1, and major structural trends.*

Data and methods

The study concentrates on the eastern Warburton Basin underlying the Cooper Basin (STRZELECKI and INNAMINCKA 1:250 000 map sheets).

Fractures in cores provide relative spatial information on fracture development. About 199 cores from 93 wells, which cover more than 98% of cores in the basin, have been studied in detail (Fig. 1). After washing and scrubbing cores clean, I have measured orientations of structural attributes particularly fractures and fault planes from cores. This stage of work resulted in about 135 measured orientation values at different depths from 22 oriented wells and 24 unoriented wells (Appendix 1, 2). The remaining wells studied have only core slabs, in most cases there are only 1/3 or less of the original core left. For these wells, I recorded fracture dip angles, types, chronology and fills (Appendix 3). 80% of the cores examined have been video recorded, and various kinds of fractures and fault planes have been photographed. In this study, I exclude granite (Big Lake Suite) intersected in wells such as McLeod 1, Moomba 1, and some metamorphic rocks of Willyama Supergroup, such as those cored in Mulga 1. Depths used in this study are in feet, normally KB driller depths.

Constraints

There are many wells with dipmeters recorded over Warburton Basin intervals, but in many cases, there are only unprocessed logs available at PIRSA, thus only 23 interpreted dipmeters are used for this study. Most of these dipmeter logs are old (pre-1980), cannot pick high angle data, and some are not suitable for meaningful interpretation due to random orientations of dip azimuths.

No azimuth data of deviated drilling axes are recorded in the studied Warburton Basin wells except Lycosa 1, although younger wells mostly after 1992 have azimuth data of deviation. Therefore, correction for deviation can be done only in Lycosa 1. Fortunately, most deviation angles are less than 5 degrees except Dullingari 1 (max. 32°), Merrimelia 2 (max. 10°) and Lycosa 1 (max. 17.9°). This error is not significant considering error in measurements by hand. Most strikes and dips calculated from seismic surveys are from the overlying Cooper Basin, rather than the Warburton Basin. In most cases, bedding dips change dramatically between the Warburton Basin and the overlying Cooper Basin. This reduces the accuracy of interpretation of bedding dip azimuth from seismic data. Lacking dipmeters, the orientations of open fractures from Gidgealpa 4, Meranji 4 and Jennet 1 have been assumed relatively or by considering the bedding dips of the adjacent wells or the regional fracture patterns.

Stratigraphy and tectonic history

The Cambro-Ordovician Warburton Basin unconformably underlies the Cooper and Eromanga Basins. Stratigraphy of the Warburton Basin has been discussed in Sun (1996, 1998), and is simplified in Fig. 2 which also shows the overlying Cooper Basin. The Warburton Basin has a complex tectonic history, which is largely speculative owing to a lack of reliable data and detailed study. Early work interpreted thrust fault-repeated sections in the Gidgealpa area (Daily, 1964; Carroll, 1990) and also in the

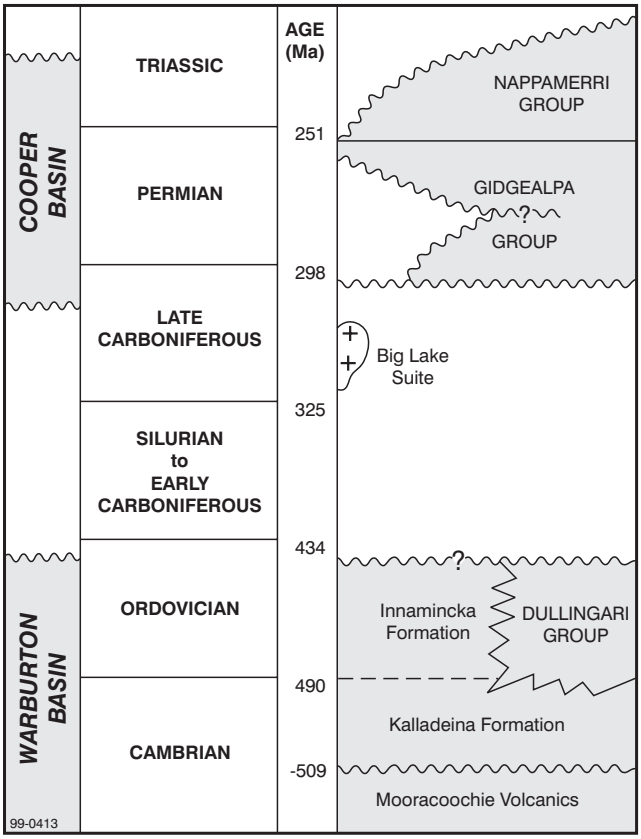


Fig. 2 *Simplified stratigraphic column of the Warburton and Cooper Basins*

Merrimelia, Wantana, Packsaddle and Innamincka areas (Sun, 1996, 1997), indicating a convergent tectonic regime. Compression has been attributed to several orogenic movements: Benambran Orogeny (Gatehouse, 1986), a late stage of the Delamerian Orogeny *(*arc setting of Roberts *et al.*, 1990), and the much younger Alice Springs Orogeny (Gravestock and Flint, 1995).

Using seismic sequence stratigraphic and biostratigraphic data, Sun (1996, 1997) has demonstrated mild compressive NW-SE fault reactivation as young as early Mesozoic in the Packsaddle area, while other seismic interpretations (e.g. Kuang, 1985), suggest Mesozoic wrench fault activity and Tertiary east-west compression. Wopfner (1985) suggested that a general state of compression existed during the Permian and early Triassic, and in the late Cretaceous and Tertiary.

FRACTURE CHARACTERISATION

Identification and classification

This report discusses only natural fractures and excludes those induced by drilling, coring and handling. It is the most difficult task to distinguish natural fractures from induced fractures when both types are open in cores. A comprehensive review of the physical characteristics of natural and induced fractures and how to distinguish them have been discussed by Kulander *et al*. (1990). One kind of induced fracture is petal fractures that have been observed in Coonatie 1, and Dullingari 1 (Fig. 3).

Numerous natural fractures have been identified from cores, wireline logs, and from indirect evidence during drilling. Poor core recovery and broken pieces in cores 25-29 in Gidgealpa 1 and core 16 in Gidgealpa 7 imply the presence of highly fractured zones in both wells. In Coongie 1, minor losses of drilling fluid may be caused by fractures or a breccia at 11150-11304', which is permeable but contains salt water (Pemberton, 1970). In Toolachee 51, a gas anomaly was encountered 34' into Warburton Basin siltstone, which was interpreted as a fractured zone that was also responsible for constant mud losses. DST 1 tested this zone, but flowed gas at a rate too small to measure, the gas peak over the zone was 600U (85/12/3/tr) (Ostler, 1996). In Gahnia 1, gas peaks of 60-320 units were recorded from siltstone of the Warburton Basin, which was assumed to be related to fracturing (Baily, 1996). In Cherri 1, cycle skipping on sonic over 4569-79' was suggested to indicate fracturing (Pexa Oil N.L., 1970).

A geological classification of natural fractures has been suggested by Nelson (1985), and is followed herein.

1. tectonic fractures – associated with local tectonic events.
2. regional fractures – developed over large areas of the earth's crust with relatively little change in orientation, show no evidence of offset across the fracture plane, and always perpendicular to major bedding surfaces.
3. contractional fractures – tension or extension fractures resulting from a general bulk volume reduction through the rock.
4. surface-related fractures – developed during unloading, release of stored stress and strain, creation of free surfaces or unsupported boundaries and weathering in general.

Basically, most fractures examined in this study are either tectonic or regional except a few possible contractional fractures in rhyodacite in Gidgealpa 2, 3 and 11, and numerous fractures in basalt from Murteree A1. Here, I have concentrated on tectonic and regional fractures, which most likely contribute to the generation of fracture porosity.

Fig. 3 *Petal fractures (induced) in sandstone from Dullingari 1, core 28, at 9669'2". (Photo 046695)*

Generally speaking, the majority of studied natural fractures are only observed in Warburton Basin strata, in other words, they were caused by pre-Cooper Basin events. In several wells including Pelketa 1 (Fig. 4), Big Lake 52 and Gidgealpa 8, angular clasts with pre-existing and filled-fractures from Warburton Basin strata were redeposited in basal conglomerates of the immediately overlying Cooper Basin succession. Few fractures have been observed in the overlying Cooper Basin strata in most of the studied wells except Gidgealpa 5 in which vertical joints have been recorded in the Merrimelia Formation.

However, natural fractures do exist in the immediately overlying Cooper Basin strata though they do not commonly propagate above the Permian Tirrawarra Sandstone. An exception is in the Telopea field where Triassic sedimentary rocks overlie the Mooracoochie Volcanics of the Warburton Basin directly, and have been fractured. From FMS data, Hillis *et al*. (1997) interpreted natural fractures from the lower Patchawarra Formation and the Big Lake Suite of Moomba 73.

Fracture plane morphology and porosity

According to Nelson (1985, p.29), morphology of the fracture planes is an important attribute of fracture porosity and permeability. Four basic types of natural fracture plane morphology include:

1. open fractures,
2. deformed fractures: (a) gouge-filled fractures,
   (b) slickensided fractures,
3. mineral-filled fractures,
4. vuggy fractures.

These four basic types are all present, and some representatives are illustrated in Figs. 5-8. Porosity and permeability in the studied wells mainly exist in open fractures, partially open fractures or incompletely mineral-filled, slickensided, and rarely vuggy fractures.

Moolalla 1, Sturt 6 and Lycosa 1 exhibit fracture porosity, but no porosity values (as functions of the computed aperture (fracture width), Schlumberger, 1997) have been computed. Cuttings thin sections of these wells show some microfractures, but cuttings generally break along rather than across open fractures. Various microfractures are found in these and other wells, and are illustrated mainly from core samples in Figure 9.

Lithological control

Mechanically, different rock materials react to stress differently. In more brittle rocks such as dolomite and quartz-arenite, fractures are more irregular and intensive. Examples include well fractured dolomite in Gidgealpa 5 (Fig. 5a), fractured limestone (bioclastic wackestone and packstone) (Fig. 10a), severely fractured quartz-arenite in Mudrangie 1 (Fig. 10b), and ignimbrite in Sturt 7, 8 (Nugent, 1991). In softer rock such as mudstone and shale, as in Pelketa 1, short conjugate fractures are better developed in mudstone than siltstone layers (Fig. 10c). Weathered mudstone has irregular and short fractures, in contrast to fresh siltstone and shale which have long and regular fractures, as shown in Narcoonowie 1 (Fig. 10d). Mudstone in the altered zone at the top of the Warburton Basin (Boucher, 1998a) may thus form a top seal to fractures in the underlying fresh sequence (Gravestock *et al*., 1998).

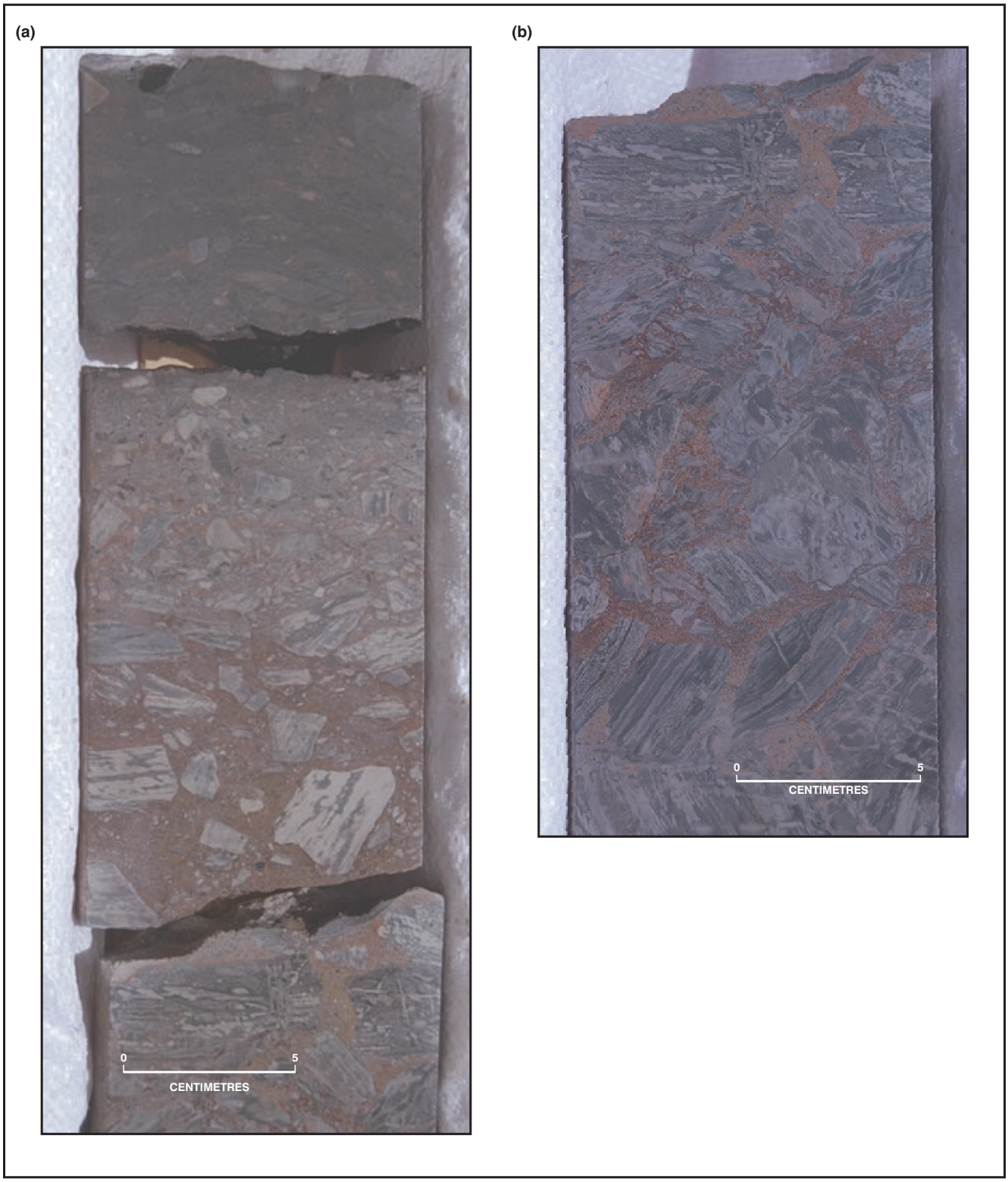


Fig. 4 *(a) Permian basal conglomerate above the Warburton Basin unconformity in Pelketa 1, 7093'10"–7094'.*
(b) Detail of clasts containing pre-existing fractures within Warburton Basin siltstone and shale. *(Photo 046696, 046697)*

Associated structural features

Many microstructures are observed in the studied cores. There are few normal microfaults whereas folds, reverse and thrust faults are common (Appendix 3), indicating deformation in a compressive tectonic regime. Most are unoriented and orientations of slickenside surfaces, lineations and fault planes can only be determined in a small number of wells with dipmeters. These structures are described briefly.

Folds

Microfolds are observed in several cores in Warburton wells, such as in Wantana 1. A microfold is associated with numerous short fractures (Fig.11a). In Dullingari 1, cleavage is developed along an axial plane, and some subparallel fractures also occur (Fig. 11b).

Fig. 5 *(a) Core photo, showing open fractures connecting vuggy porosity in dolomite, Gidgealpa 5, 8118'.*
(b) Open fracture in ignimbrite from Boxwood 1, 6154.5'.
(c) Core photo, showing open fracture and other filled fractures along normal microfaults, Gidgealpa 4, 7226'8-9".
(d) Open fracture in core, Meranji 2, 10920'. *(Photo 046698, 046699, 046700 and 046701).*

Thrust faults

Thrust faults are observed in Packsaddle 1, (Fig. 11c). There is a thrust fault plane at 12605' in Gidgealpa 1 (Fig. 11d), at an angle of about 35°, and its azimuth is similar to that of the bedding plane, which is 67° (NE). Restoration across the fault is illustrated in Figure 11e.

Reverse faults

A reverse fault is observed in cored *Nuia*-rich limestone in Wantana 1 (Fig. 11f), and has less than 1 cm displacement. There is a reverse fault dipping about 65° to the core axis in Boxwood 1 at 6154.5' (Fig. 5b), but its azimuth is not certain as there is no definite bedding in ignimbrite. In Lycosa 1, a low-angle fault has displaced bedding at 8794' in a reverse mode (Fig. 11g).

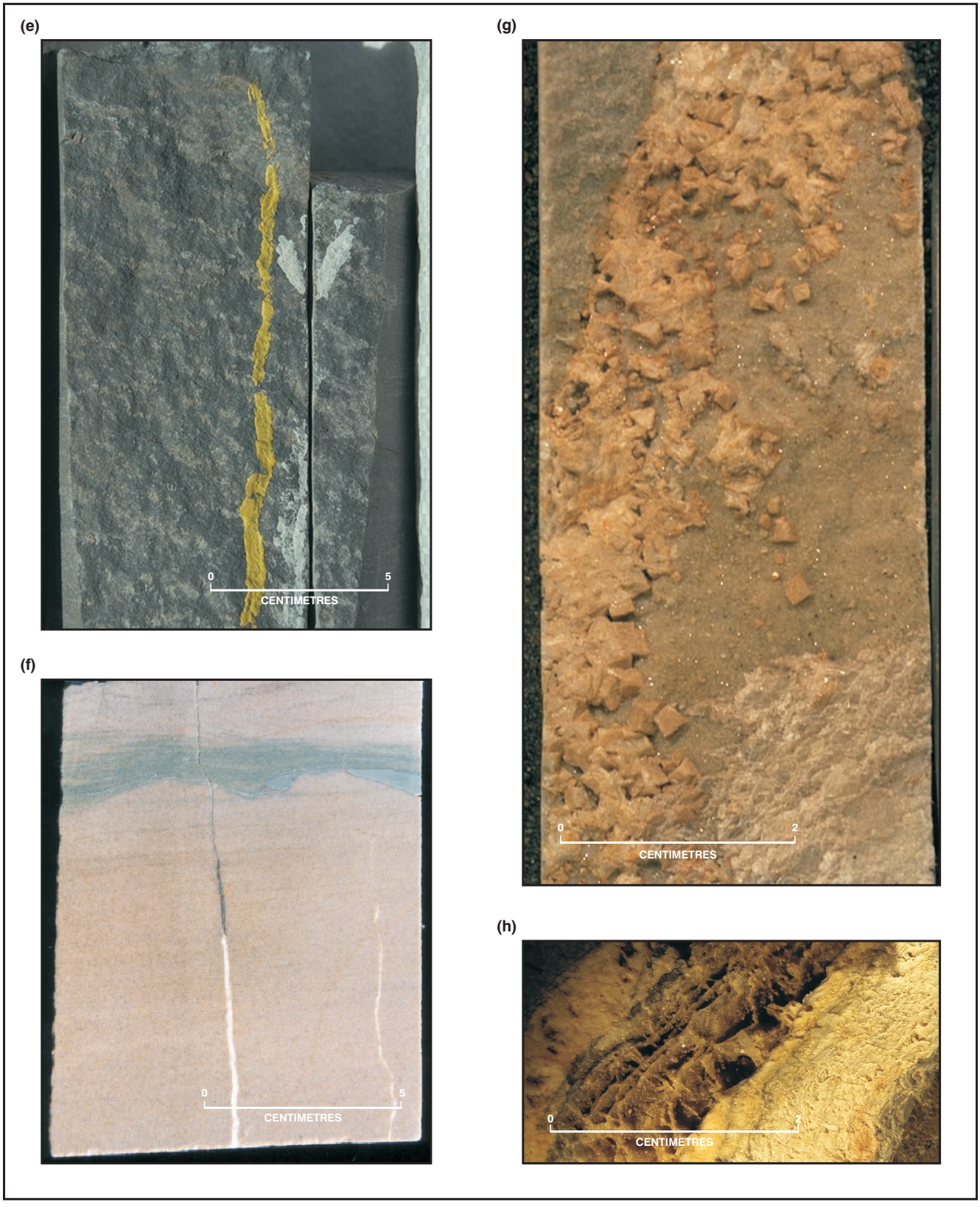


Fig. 5 *(e) Open fracture in core, Beanbush 1, 12130'6", showing fracture plane surface with very subtle mineral fill.*
(f) Open to completely, calcite filled fractures in Merrimelia 6, core 5, 7442'.
(g) View of fracture plane, incompletely filled early with fine quartz crystals (transparent) and late coarse calcite crystals, Merrimelia 2, 9017'
(h) Remnant fracture porosity in Lycosa 1, at 8803', where matrix porosity of 6.2 per cent and permeability of 0.019 millidarcies were measured. *(Photo 046702, 046703, 046704 and 046705)*

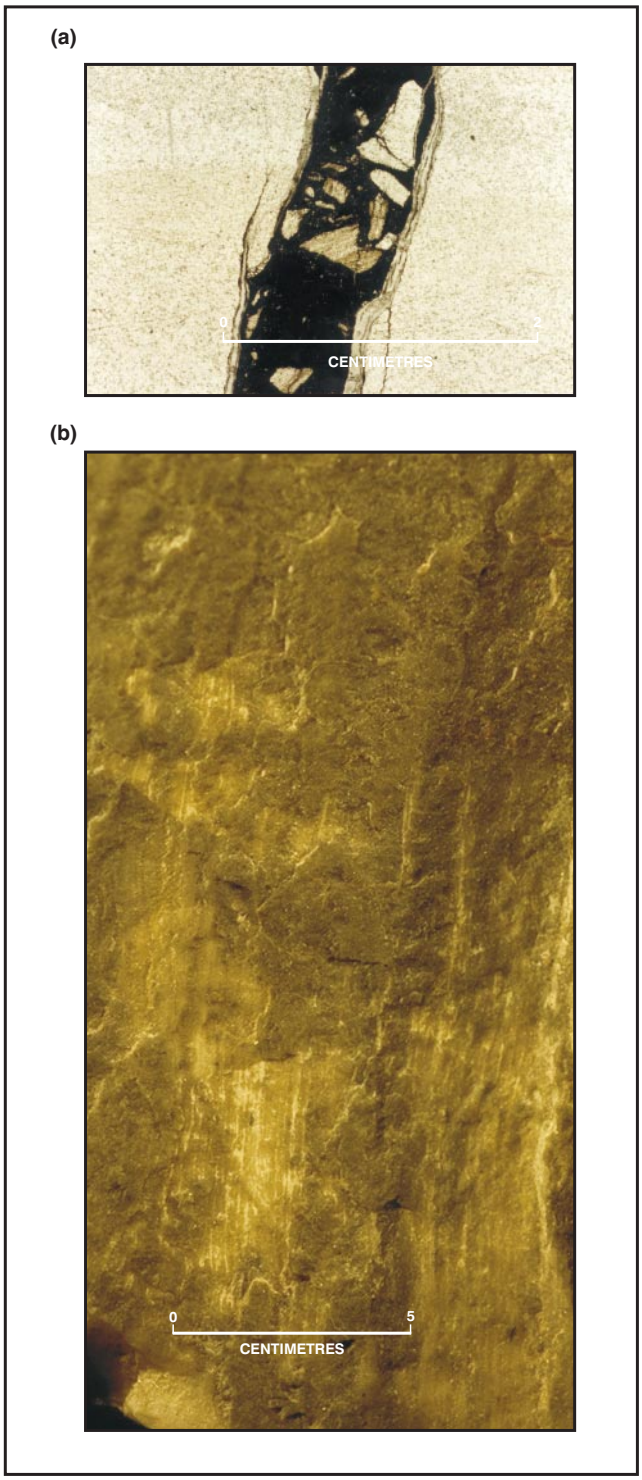


Fig. 6 *(a) Gouge filled fracture in fine-grained sandstone, showing gouge with clasts derived from fractured walls or surrounding sandstone Innamincka 1, 7199'. (b) Detail of slickensided fracture plane combined with calcite fill. Lycosa 1, 8802'.* *(Photo 046706, 046707)*

Normal faults

A normal microfault in Gidgealpa 4 (Fig. 5c), is open and partially open. In Coongie 1, normal microfaults are found in thin section, and fractures have been filled with calcite (Fig. 11h).

Fault zone, gouge fill, shale smear

There is a major fault zone and associated gouge fill in limestone of Gidgealpa 7 (Fig. 11i). Carroll (1990) interpreted a thrust fault in this well but below this depth. There is another major fault zones and associated gouge fill in volcanics of Gidgealpa 8. Relatively smaller-scaled fault zones associated with little cataclasis and shale smear have been found in several wells such as Boxwood 1, Murteree 1 and Snake Hole 1 (Appendix 3).

Slickensides

Many slickensides are observed along bedding, fracture or fault planes. Those along fault planes have good lineations indicating movement of faults. In wells Lycosa 1, Gidgealpa 1, Snake Hole 1, Pelketa 1, slickenside surfaces are mainly SE dipping. Slickenside lineation is predominantly SE-NW, and subordinately NE-SW, such as in Lycosa 1 (Figs. 6b; 11l).

Stylolites

There are basically two kinds of stylolites; one is the common horizontal type due to burial compaction from loading, the other is vertical such as in Gidgealpa 1 (Fig. 11j) due to lateral compressional stress. Most of the stylolites are found in limestone rocks, seldom in siliciclastics, which is unusual since a number of sandstones in the overlying Cooper Basin do possess styolites.

Conjugate fractures

Conjugate fractures are common, such as observed in cores of Nappacoongee 1, Lycosa 1 (Fig.11l), Mudlalee 1, Tinga Tingana 1, Pelketa and Wantana 1. They have also been interpreted from dipmeters of Mudlalee 1, 2, Coochilara 1 and Strzelecki 3.

Chronology and fills

Chronology of fractures and fracture fills in each individual well is determined by crosscut relationships and recorded in Appendix 3. Although limited coring and intersection of fractures prevent positive fracture chronology determined by crosscutting of fractures in most wells, two general patterns are recognised: (1) High angle, fine fractures cross-cut low angle fault planes associated with fault breccia. They possibly also postdate high angle coarse fractures filled with calcite such as in Lycosa 1 and Gidgealpa 5. (2) At least four phases of fracture fill are found in several wells. Typical examples are in Murteree 1 and Tilparee A1 (Fig. 12a), Narcoonowie 1 (Fig. 12b), Gidgealpa 5 (Fig. 10a) and Gidgealpa 7 (Fig. 12c). Tilparee A1 is a typical example. Tilparee A1, particularly measured in core 3, 7019' 1" has the following relative orientation data (Table 1): (1) Fine fracture or joint, with dip angle of 85-90°, and dipping to the NW (300° dip azimuth); (2) fault plane, with dip angle of 60°, parallel to bedding (arbitrarily assigned to the north); (3) with dip angle of 70-90°, dipping SW (240°); (4) with dip angle of 60-80°, and dipping to the SE (140°). Table 1 also shows four generations of fracture and vein systems in ascending order.

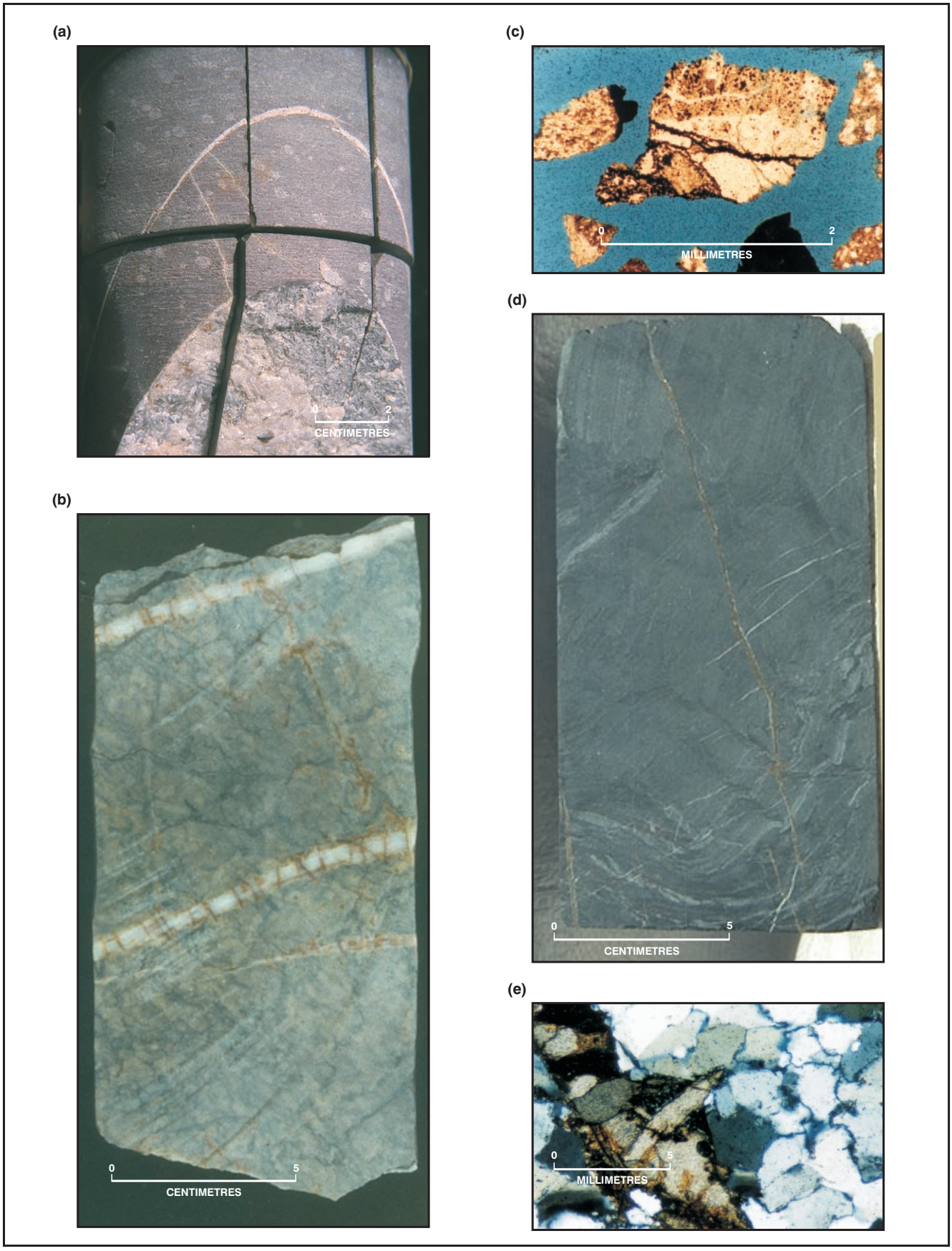


Fig. 7 *(a) Calcite filled fracture in Gidgealpa 2, core 9, 7275', showing a broken fracture plane.*
(b) Silica-filled fractures crossed orthogonally by short vertical fractures filled with ferroan carbonate. Pando 1, 5812'.
(c) Cuttings thin section, showing pyrite filled fracture in siltstone, Lycosa 1, 8670-8680'.
(d) Core photo, from Tilparee A1, 7019', showing pyrite and quartz filled fractures.
(e) Photomicrograph, showing siderite and kaolinite filled fracture in Daralingie 1, 7426', cross-polarised light.
(Photo 046708, 046709, 046710, 046711 and 046712)

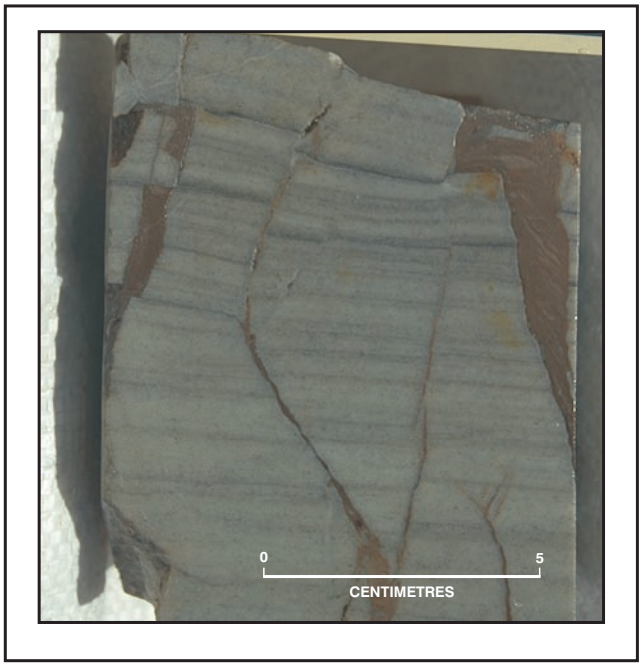


Fig. 8 *Vuggy fractures in Coonatie 1, core slab, 10400'6". (Photo 046713)*

Table 1 *Four generations of fracture fill in Tilparee A1 (bedding arbitrarily north).*

Type	Dip azimuth	Dip angle	Colour code	Comments	Generation (ascending)	Fills
bedding	0	60-70	green	bedding, against folding	-	-
frac (1)	300	85-90	blue	high angle, fracture	1	quartz
frac (2)	0	60	yellow	parallel to bedding, ? fault plane	2	quartz
frac (3)	240	70-90	brown	vein 2 (1-2 mm)	3	pyrite, quartz
frac (4)	140	60-80	black	vein 1, (1-8 mm) associated with slickensides	4	quartz, pyrite

The four generations of fracture fill and mineralogy is more or less consistent with the fracture fill phases recognised by Rezaee (1997). He studied fracture filling cements of core samples from 5 wells by analysing their petrography, electron microprobe, fluid inclusions and oxygen and carbon stable isotopes. He deduced that the fracture fill phases in ascending order are: quartz in the form of chalcedony, pyrite, mega-quartz, siderite and ankerite, and kaolinite. However, he did not come across calcite and dolomite cement in his data. Rezaee (1997) also concluded, quite incorrectly in the face of evidence to the contrary, that the Warburton Basin 'cannot be a fractured reservoir'. Phillips (1997) found that the carbonate spar and dusty micrite postdate kaolinite in Narcoonowie 1. Calcite and dolomite fracture filling cements occur in many other wells especially in the region where the Kalladeina Formation subcrops, basically extending from the eastern flank of the Birdsville Track Ridge to the eastern flank of GMI Ridge. For example, subvertical fractures filled with calcite are common in various rock types in Coongie 1, (as only middle slabs of cores are available in Coongie 1, the orientations of these fractures cannot be determined). Low angle fractures filled with calcite are also observed in Daer 1 and other wells. At least four phases of calcite fill can be observed in Gidgealpa 5 (Fig. 10a) in ascending order: (1) coarse calcite vein fill (1cm width max.) and minor gouge fill, dip angle 65°, (2) fine (1-3mm max.), filled with calcite, 65°, surrounded by stylolite, (3) fine fracture (1mm), filled with calcite, steep to subvertical, 60°-85°, (4) slickenside fracture surface, undulating, slightly steeper than bedding.

CASE STUDY - FRACTURED RESERVOIR IN LYCOSA 1

Three drillstem tests in Lycosa 1 had some decline in flow with a maximum rate of 5.0 MMCFD (0.14 Mm^3/d) (Baily, 1990a; Taylor *et al*., 1991). Mean porosity calculated from the neutron-density log is 3-4 per cent within the pay zones. These indicate that Lycosa 1 has the behaviour of a fractured reservoir. The aim is to understand which fractures contributed in producing gas.

Among the Warburton Basin discovery wells, only Lycosa 1 has a relatively complete data set including dipmeter, FMS logs, and 6.7 m core (core 1, 8792-8814') which was cut immediately below the gross pay zone. A comprehensive account of this well is provided by Taylor *et al*. (1991). However, a detailed fracture study via integration of core and logs is given here. The composite log is shown on Figure 18.

Core data

At least five types of fracture have been measured in core 1, as listed below and can be more or less seen in core slabs (Fig. 13).

1. high angle, 78-80°, SE dipping, at 8793': dip azimuth 115-120°, hairline width, filled with calcite. At 8810', the fracture has displaced bedding plane slightly, and is associated with tension gashes and slickensides. At 8802', it is associated with slickensides as well, after being filled with calcite.
2. high angle, 60-70°, SW dipping, at 8793': dip azimuth 217-240°, hairline width, partially filled by calcite, and possibly partially filled with brown clay (?drilling mud) and white quartz at 8794';
3. Low angle fractures dipping south, displaced bedding, thus could be part of a fault system; they have similar azimuths to mineralisation and brecciated zone over the intervals of 8795-8796', and other common low angle calcite filled fractures.
4. High angle veins, up to 25 mm calcite fill at 8802'6"–8803'5", and possibly the same cement in a veinlet at 8798' (2-5 mm), more or less parallel to bedding.
5. Some nearly vertical fractures filled by calcite, curved (changing dip direction) at 8803'5" (SE), 8806-8807' (SW).

All fractures measured from, Lycosa 1 (Fig. 13) are divided into three groups and illustrated in stereonet and rose plots (Fig. 14) including (1) high angle fractures; (2) slickensided fractures; (3) other structure-related fractures. The dip azimuths and dip angles of major fractures, bedding and fault plane (after being corrected for deviation) fractures are summarised in Table 2 for the depth 8793' and illustrated in Fig. 11k and Fig. 15. They have not been picked via FMS data over the cored interval by Schlumberger (Fig. 14e).

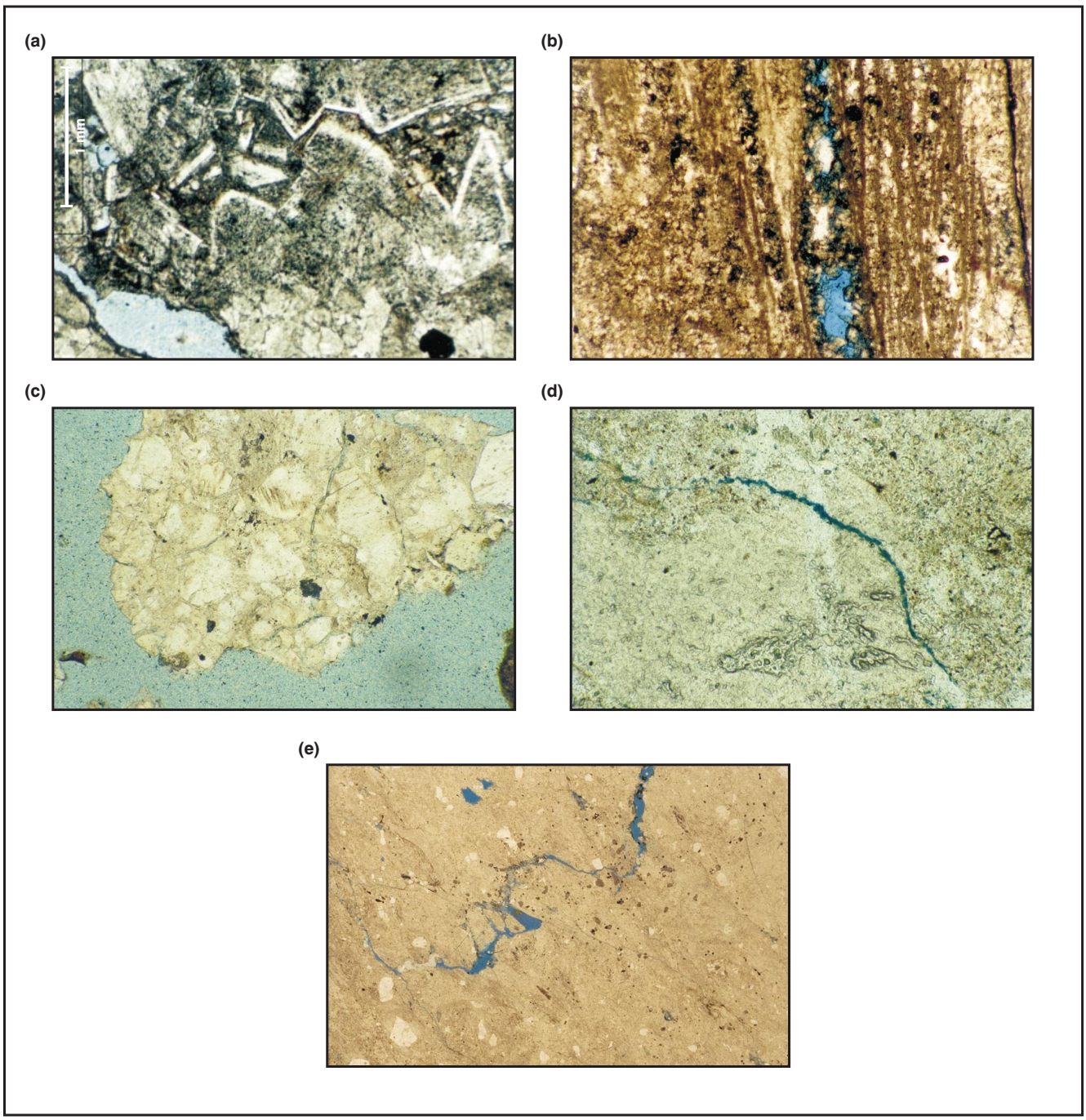


Fig 9 *(a) Vuggy dolomite from Gidgealpa 1, 12950', showing open microfracture connecting vuggy and intercrystalline pores. Plane light.*
(b) Incompletely filled fracture in Lycosa 1, 8798'. Plane light. Width of view 1.65 mm.
(c) Open microfracture in Moolalla 1, 8600-8610'. Plane light. Width of view 1.65 mm.
(d) Possible open fracture in Sturt 8, 6382.87'. Plane light. Width of view 1.65 mm.
(e) Possible open fracture in Boxwood 1, 6160'. Plane light. Width of view 1.65 mm. *(Photo 046714, 046715, 046717, 046716 and 046718)*

Chronology of fractures and fills

Four generations (I-IV) of fracture systems are recognised. First, as mentioned in Table 2, high angle fractures (SE and SW dipping) cross-cut the fault plane at 8793' and 8794'. Second, a high angle fracture (NNW dipping, subparallel to bedding, filled by calcite) has offset fault plane at 8798' and 8803'. Therefore, fault plane fracture is earlier than the latter two fractures. No direct crosscut relationship of the two later fractures can be observed. Movement on the NNW dipping fracture is evidenced by having a slickensided surface at 8803'. At 8802', a SE dipping slickensided fracture seems to crosscut a NNW dipping slickensided fracture (Fig. 11l; Fig. 13).

Thus, at least four generations can be determined: (1) relatively low angle fault plane, associated with mineralised zone and breccia, (2) calcite-filled fracture subparallel to the bedding (NNE dip), (3) slickenside surface developed on the fracture orientation ranging from NNE to NNW, (4) SE dipping slickensided fracture. The high angle fractures (SE and SW dipping) therefore occur between generation 1 and 4.

Since high angle fractures (SE and SW dipping) belong to the system I orthogonal fracture set whereas SE and NW slickenside fractures belong to system II orthogonal fracture

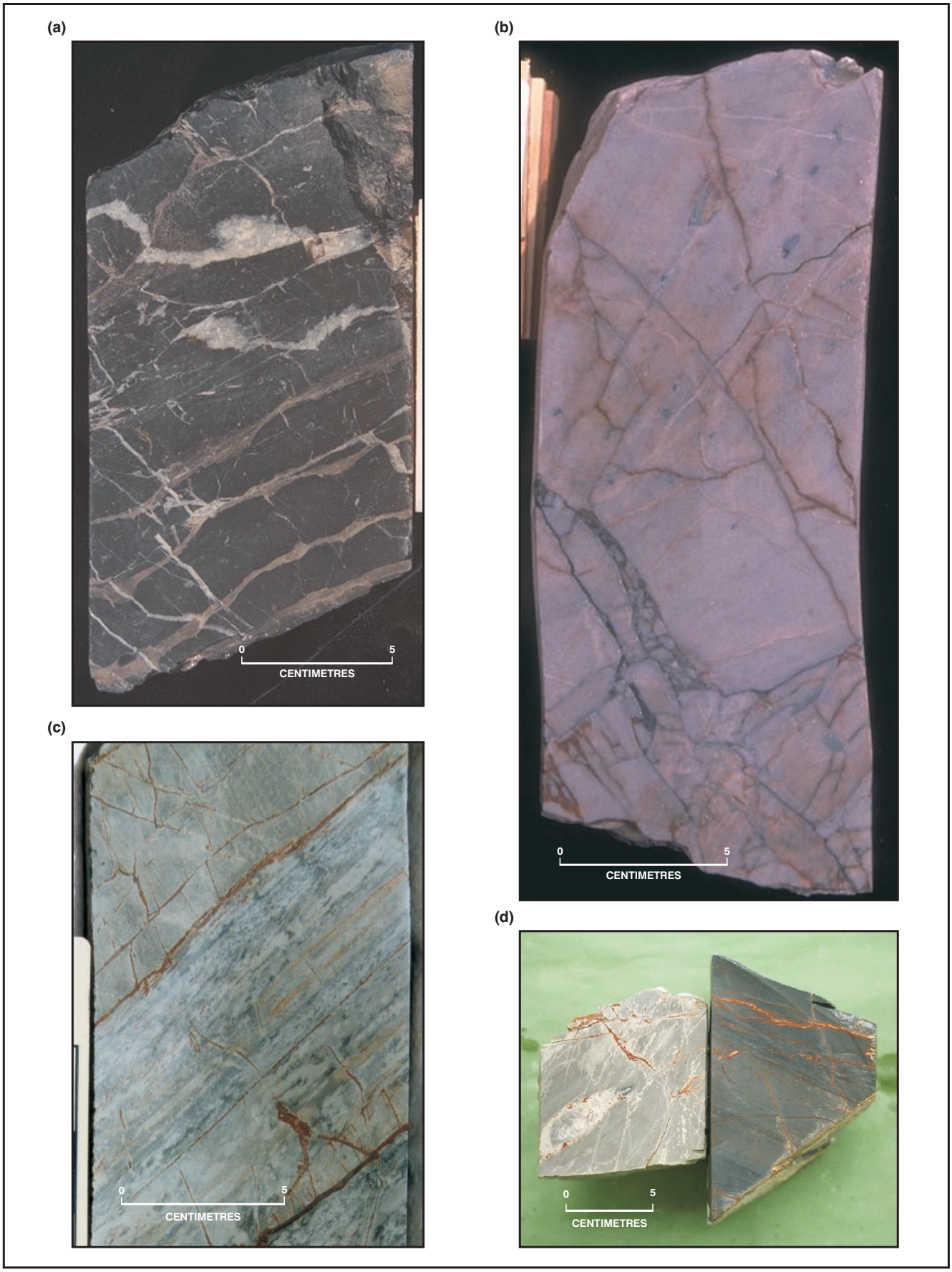


Fig. 10 *(a) At least three phases of fractures and fills in limestone, Gidgealpa 5, 7944'4"–7".*
(b) Numerous fractures and brecciation in quartz-arenite in Mudrangie 1 .
(c) In Pelketa 1, short conjugate fractures are more numerous in softer mudstone rather than siltstone layers.
(d) Fractures in weathered mudstone and fresh siltstone and shale, Narcoonowie 1. *(Photo 046719, 046720, 046722 and 046723)*

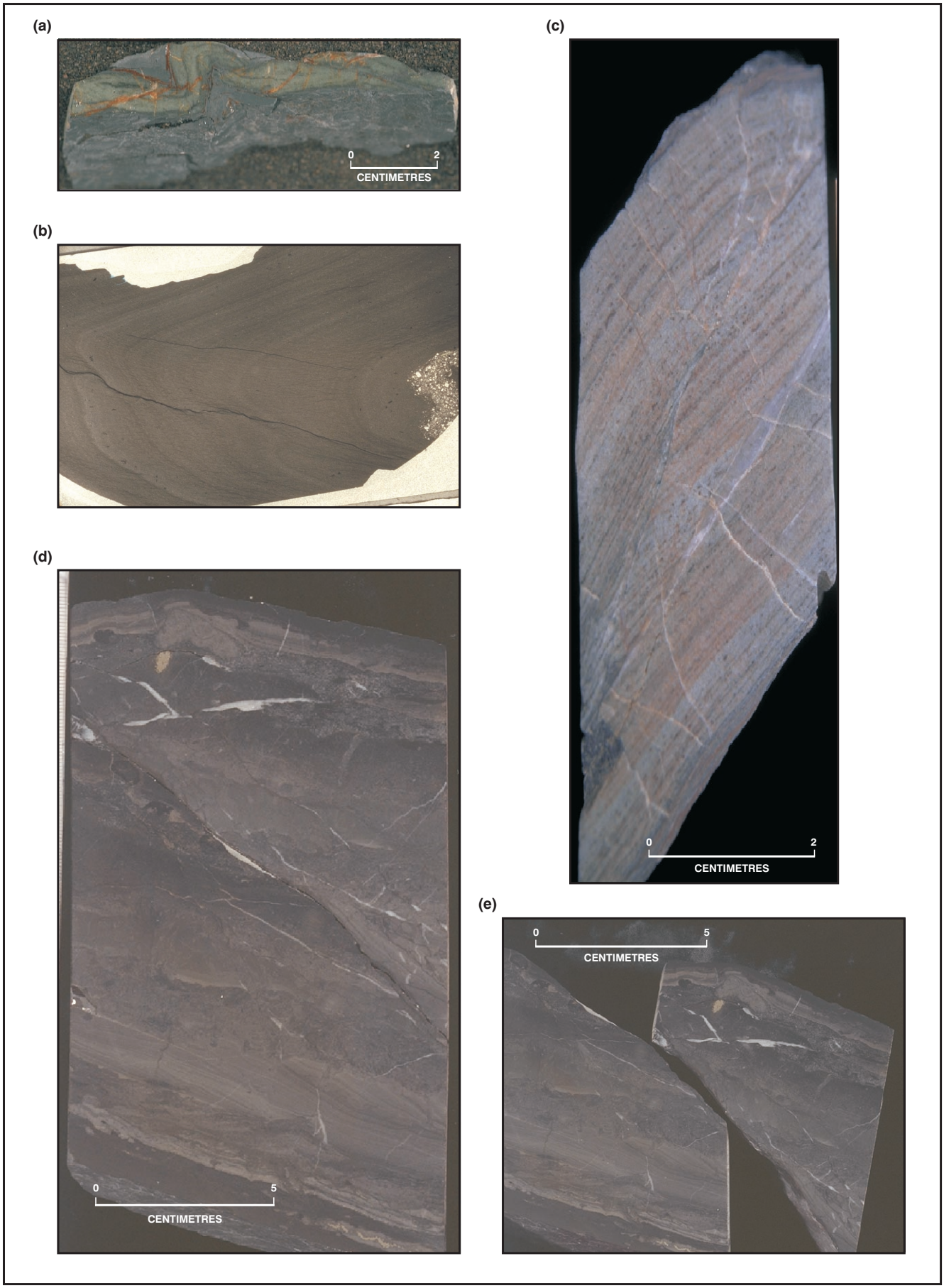
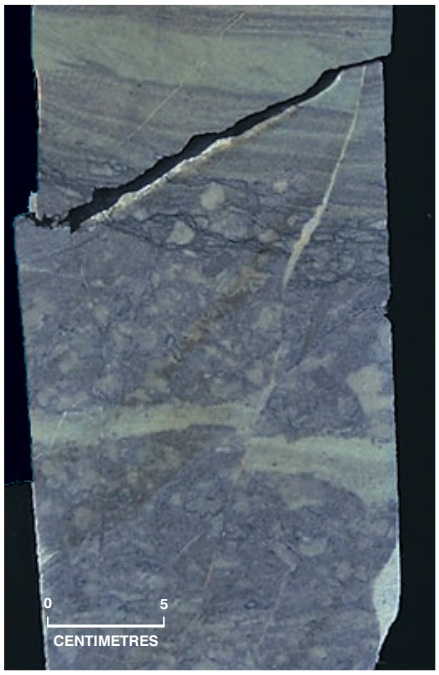


Fig. 11 *(a) Microfold and numerous fractures in Wantana 1.*
(b) Microfold and associated cleavage in Dullingari 1, width of view 36 mm.
(c) Thrust fault in Packsaddle 1.
(d) Thrust fault in Gidgealpa 1.
(e) Restoration of thrust fault in Gidgealpa 1, 12605.5'. *(Photo 046724, 046725, 046726, 046727 and 046728)*

(f)



(g)

(h)

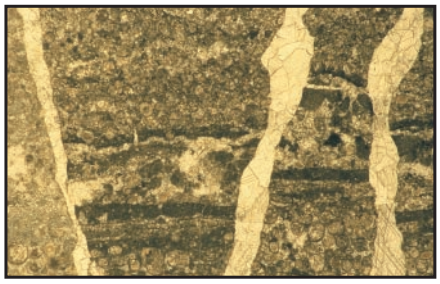


Table 2 *Lycosa 1 directional and fill data for depth 8793'.*

Type	Dip azimuth	Dip angle	Colour code	Comments	Generation (ascending)	Fills
bedding	328.3°	20.8°	green	bedding		-
frac (1)	194.5°	81.5°	blue	high angle fracture	2	partially calcite
frac (1)	96.3°	82.7°	orange	high angle fracture	2	calcite
frac (2)	197.0°	79.2°	orange	high angle fracture	2	partially calcite
frac (1)	215.4°	76.4°	blue	high angle fracture	2	partially calcite
frac (2)	101.1°	84.0°	orange	high angle fracture	2	calcite
frac (3)	171.0°	20.3°	red	opposite bedding, fault plane	1	?dolomite

set, it is important to know which fracture set occurred first. Because the NW-SW oriented slickenside lineation is more dominant than others, the SE dipping slickensided fracture plane is interpreted to be the younger event.

Formation Micro Scanner (FMS) interpretation

Rayner and Chin (1990) have interpreted FMS images from Lycosa 1. A total of 47 fractures were identified in the logged interval which is 8549' to 8850', with moderate scatter (Rayner and Chin, 1990, Figure 2), dominated by azimuths: 14°, 163°, 214°, 270-289°. Compared with the fractures interpreted from FMS over the cored interval in Lycosa 1, my measurements have much higher resolution, recognising SW fractures which they did not. Rayner and Chin pointed out that "The shear energy profile [from the array sonic log] indicates that the fractures over the interval 8670 – 8651' extend away from the borehole and have the most potential for production". Although SW dipping fractures such as over the interval 8650-8662' (Fig. 16) were interpreted by Rayner and Chin as having a low confidence in interpretation because the microresistivity effect may be related to conductive minerals rather than open fractures, they concluded that most of these fractures are open and dip steeply towards the southwest. The average dip azimuth over this interval is similar to the high angle SW dipping, partially open fracture observed in core at depth 8793' (Table 2, Fig. 15). I have added representative, high-angle fractures interpreted from FMS to those measured from cores, and they are plotted on a stereonet. As can be seen, the open fractures dip SW (Fig. 37).

Dipmeter interpretation

I interpreted only the MSD 4 ft x 2 ft – 35 degree x 2 which is a non-optimum option (Fig. 17), bad for detection of high angle dips. As a result, dip azimuth is right, but dip angle value is usually too low. Most dip azimuths range

Fig. 11 *(f) Reverse fault in Wantana 1, 9628', with 8-9 mm displacement.*
(g) Lycosa 1, a low-angle reverse fault displaced bedding at 8794'.
(h) Coongie 1, micro-normal fault.
(Photo 046729, 046730 and 046731)

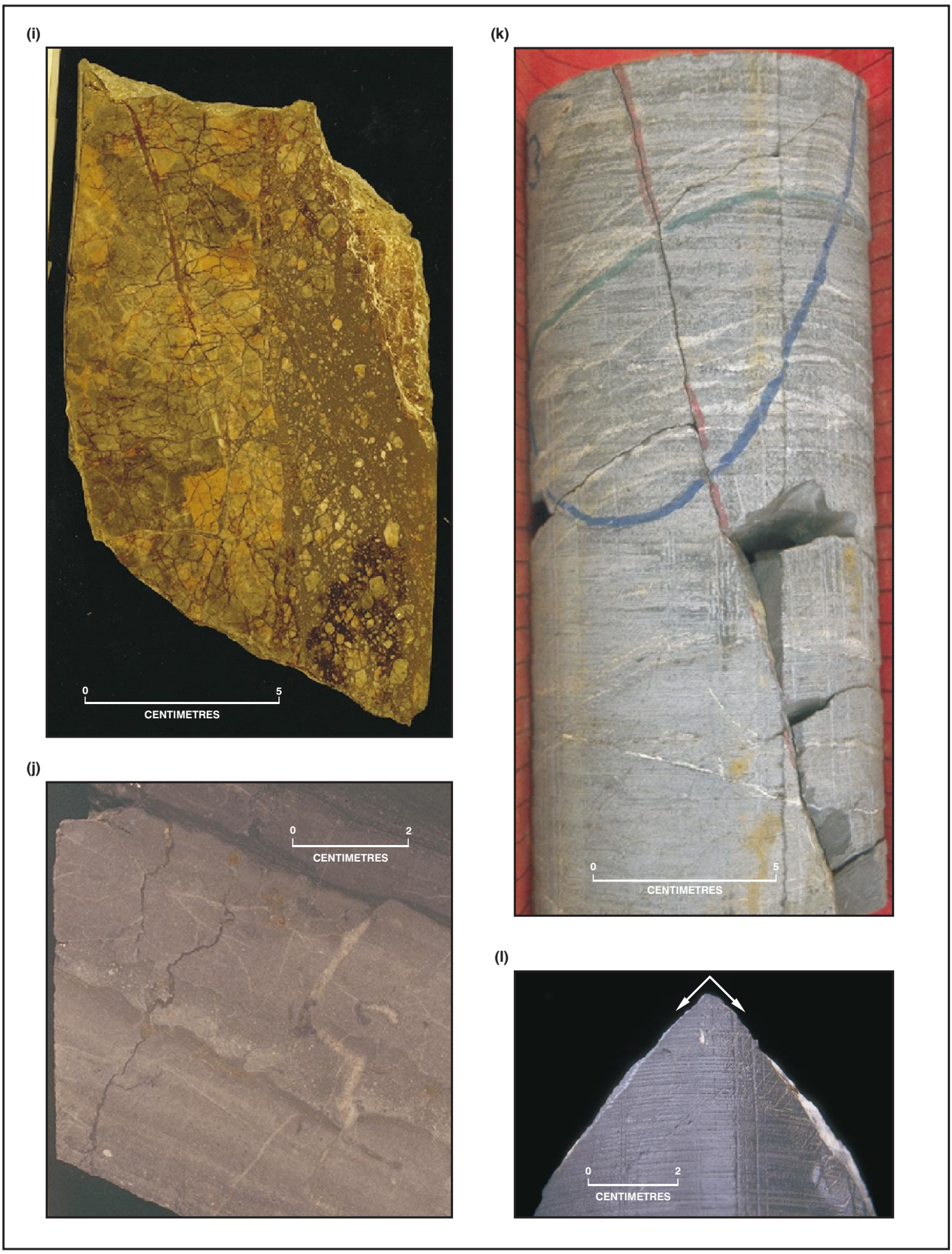


Fig. 11 *(i) Gidgealpa 7, 9069', showing a fault zone breccia and associated gouge fill.*
(j) Gidgealpa 1, 11678', showing vertical stylolites.
(k) Lycosa 1, 8793', showing an orthogonal set of fractures dipping towards SW (blue) and SE (red) respectively, the SW dipping fracture is still partially open.
(l) Lycosa 1, showing a conjugate set of fractures with slickensides on fracture planes, one dips SE, the other dips N to NNW (similar to bedding), apparently SE fracture crosscut the latter at 8802'. *(Photo 046732, 046733, 046324 and 046734)*

from N (0°) to NNE (18°), dip angles range from 34° to 60° over the interval 8330 to 8940', except 8840-70': NNE (30°), dip angle 65-70°.

All the dipmeter recordings are listed in Table 3 and compared with FMS interpretation against corresponding gas shows and log calculated or test calculated pay.

Slickensides

Several slickensides are observed in core 1, at 8803', 8810', 8813' and 8814' (Figs. 14, 15). Slickensides are also observed in cuttings samples which display calcite mineralisation over intervals with relatively low gamma values. Vague slickensides occur on the subhorizontal fracture just above 8797'.

Fracture density

Spacing between fractures along the core axis is not even, varying from 2.5 to 15 cm (Fig. 13). Very high fracture density (greater than 10 fractures per inch) occurs over the interval 8794-8796', in which numerous filled fractures are associated with cataclasis zone containing metallic and ore minerals (e.g. galena, Taylor *et al*., 1991).

Creation of porosity

Open fractures (Figs. 9b; 11k), fracture surfaces parallel to slickensides (Fig. 6b), and remnant pores due to incomplete fill of original open fractures (Fig. 5h) all contribute to fracture porosity. Vuggy porosity, which more or less relates to calcite dissolution generated along cleavage of calcite crystals is also observed (Fig. 11k). Several calcite-rich intervals recognised by their low gamma log values, correspond to high gas shows, e.g. the intervals 8650-8666' and 8682-8680' with two gas peaks (Fig. 18). This indicates the possibility that calcite-rich intervals have better reservoir quality either due to incompletely filled pores or secondary dissolution. Alternatively, they correspond to open fractures due to parallel reactivation or slickensided after calcite fill such as in the interval 8650-60', where SW dipping open fractures dominate. Open space parallel to slickenside surfaces may be generated during several reactivation events of compressional tectonism. The dominant NW-SE orientation of the slickenside lineation further supports this assumption.

Fractures which contribute to production

Most fractures in core 1 are filled by calcite, dolomite or clay, this is why no gas was circulated over the interval. Only one partially open fracture is measured from core 1 at 8793', and dips steeply SW. This category of fracture may

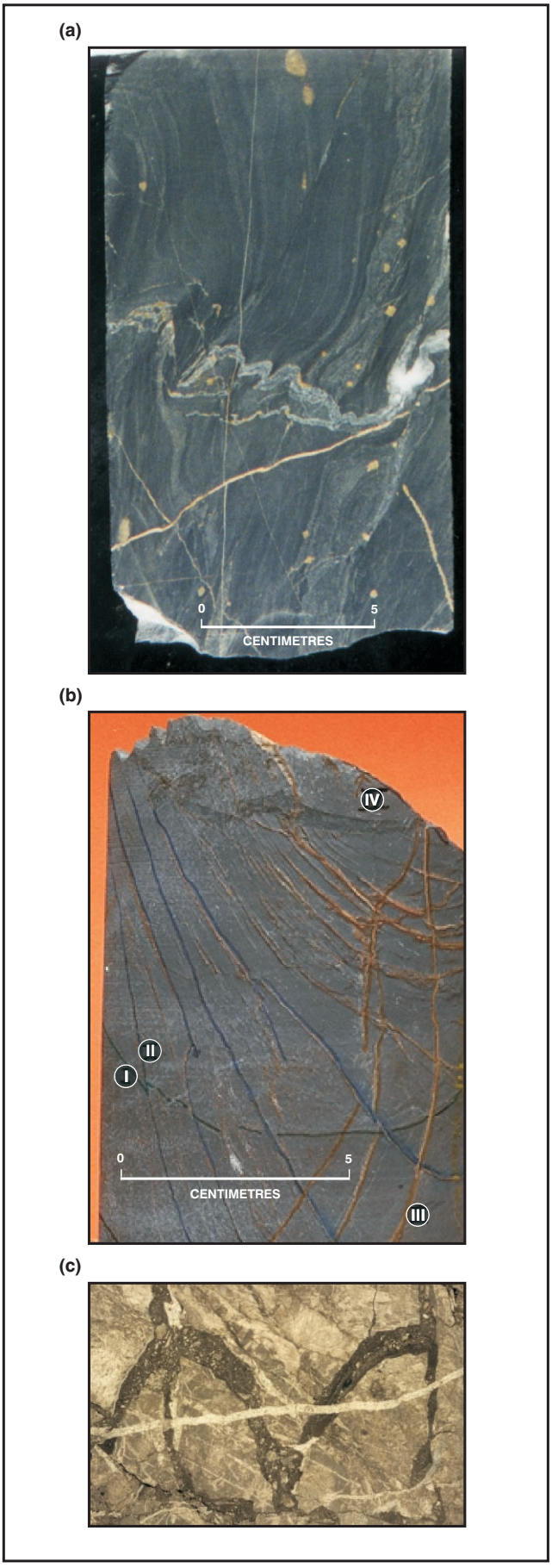


Fig. 12 *(a) Pyrite filled fracture has cut and displaced silica-filled fracture in Tilparee A1, 7021.65'.*
(b) Narcoonowie 1, core 2, 6542'5", showing crosscut relationship as marked by numbers in ascending chronology (I-IV).
(c) Photomicrograph, Gidgealpa 7, 9062', showing calcite filled fracture and vertical stylolite crosscutting gouge-filled fracture.
(Photo 046735, 046736 and 046737)

Table 3 *Dipmeter, FMS fracture analysis with corresponding gas show and pay zone as shown on composite log.*

Depth (feet)	Azimuth (dipmeter)	Dip angle	Interpretation confidence	FMS depth (feet)	Gas show depth (feet)	Pay zone net pay (feet)
8300-01	S (181)	8°	Not good (NG)		8314	No pay
8318	SW (240)	6°	NG		8345-6	
8470	NW (336)	6°	NG			
8484	SW (202)	4°	NG			
8525	SW (210)	18°	G (Good)		8500, 8514	8514-8594: 17.5 Net pay
8560	NW (300)	34°	G			
8562	W (270)	32°	G	8562: near vertical, open fracture in NW and SE sectors. 8578: low planarity, open fracture in SE and NW.	8572	
8600	NW (330)	30°	G			8594-8610:
8605	SE (120)	2°	G		8602-06	1.5 Net pay
8606	SE (160)	1°	G	8611-8661: SW dipping fractures.		8610-8634: 0.5 net pay
8653	SW (260)	38°	NG	8653-8670: SW dipping open fracture (WCR)		8634-8672: 30.5 net pay
8663	E-ENE (73)	30°	NG	8657: W dipping fracture low confid.		
8670	SW (240)	20°	NG	8678.5: healed fracture	8688-8689	
8786	SE (157)	36°	NSG	8710: mineralised, non-planar fracture In S and W sectors. 8732: mineralised fracture 8734: numerous small fracture in SW sector. 8779: sub-ver., open fracture in E sector. 8792: sub-ver. open fracture in N sector.	8729, 8732-34; 8740 8784	8672-8800: 59.0 net pay
8805	NW (330)	18°	G	8831: south dipping mineralised fractures. 8839: NNE dipping bed.	no gas circulated below 8800’	
8910	NW (345)	64°	NG			
8918	NW (333)	47°	NG			
8936	NW (348)	56°	G			

contribute to production. Supporting evidence comes from the FMS, where this fracture type dominates the interval 8622 to 8661’ within which there is a good gas show (Rayner and Chin, 1990). Fractures steeply dipping SE may be a conjugate set because they have similar dipping angles and fracture apertures and also either partially or completely filled by calcite (Fig. 11l). However, I am not sure why dip angles of the SW dipping fractures observed in core 1 are above 75°, being much higher angle than those recorded by either dipmeter or from FMS interpretation (Rayner and Chin, 1990), and despite correction for hole deviation.

In conclusion, detailed measurements of fractures in core 1 of Lycosa 1 and FMS interpretation indicate open or partially open fractures tend to be high angle and SW dipping. Rayner and Chin (1990) also pointed out that the shear energy profile indicates that the fractures over the interval 8670 – 8653’ extend away from the borehole and have the most potential for production. With similar dip azimuths, slickensided fractures associated with pre-existing calcite fill also contribute to production. Taylor *et al*. (1991) interpreted faults dipping SW and NE from seismic sections, and these faults were propagated into the overlying Permian Patchawarra Formation. If their interpretation is right, these faults including SW dipping fractures have been reactivated in the Permian and may re-open older fractures.

FRACTURE MAPPING

Orientation

Core measurement

I have measured dips of bedding planes, fractures and fault planes from cylindrical surfaces of cleaned, normally facing cores by using a flexible ruler. Azimuths of dips were measured from a face cut perpendicular to core axis by tracing their strikes in plan view (Fig. 19a, b). If a vertical fracture occurred (90°), I recorded its strike azimuth. I initially arbitrarily assumed bedding dip to north, with other fractures measured relative to the bedding. If there is no bedding plane such as in volcanics and weathered mudstone, I used a predominant fracture to north. I entered these orientation data into a StereoNett program created by Dr Johannes Duyster in Germany. After determination of orientations of bedding planes from dipmeters, I rotated bedding planes or predominant fractures with similar dip angle as recorded in dipmeter, and others into corrected orientations. A lower hemisphere stereonet projection has been used.

Dipmeter and FMS log interpretation

There are 33 wells with both dipmeters and cores within Warburton Basin intervals, but only 23 wells have both full-diameter cores for measurement and available

Fig. 13 *Core 1, Lycosa 1, 8792-8814', showing main fractures on slab surface; fracture density is not even, and varies from low over the intervals 8799-8801' and 8807-8809'10", high to very high over the interval 8794-8797'. Density variations are marked to the left of the core intervals.*

dipmeters (remaining cores have been slabbed). There are seven wells with FMS: Dullingari 44, Gidgealpa 47, Lycosa 1, Malgoona 4, Merrimelia 29, Moomba 73 and 75, but only Lycosa 1 has core material. Only three wells — Lycosa 1, Malgoona 4 and Yalchirrie 1 — have interpreted FMS logs available for this study.

Dipmeter is very useful at picking unconformities between the Warburton and Cooper or Eromanga Basins, and is normally recognised by abrupt change of azimuth or dip. The angular unconformity between the Dullingari Group and overlying Late Permian Toolachee Formation has been recognised in both core and dipmeter in Strzelecki 3 (Fig. 20).

Dipmeters are fairly good at picking dips of bedding planes or structural dips, but they are not sensitive for detecting high angle bedding planes or fractures because of non-optimal processing algorithms, even in relatively modern data as in Lycosa 1 (Fig. 17). In the cases where dipmeters pick several fractures, I analysed how many groups of orientations, compare with dip azimuth of fracture sets observed in core, and decided which represents bedding dips or fracture dips. One example is in Mudlalee 1, although only the centre core slab is available for study, bedding dips are higher than fractures (Fig. 21), fracture set 1 has opposite orientation from the bedding, and fracture set 2 is at an oblique angle to the bedding.

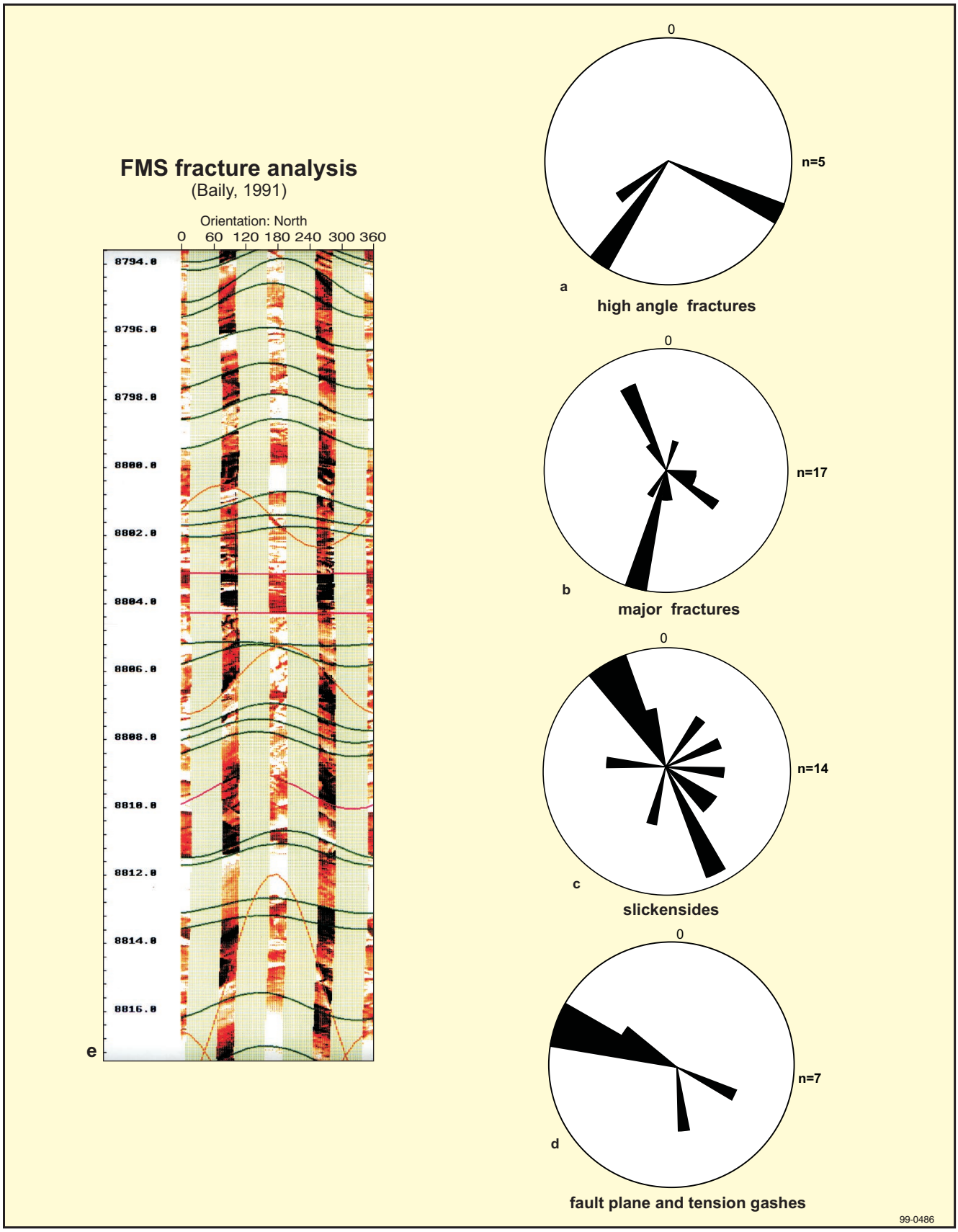
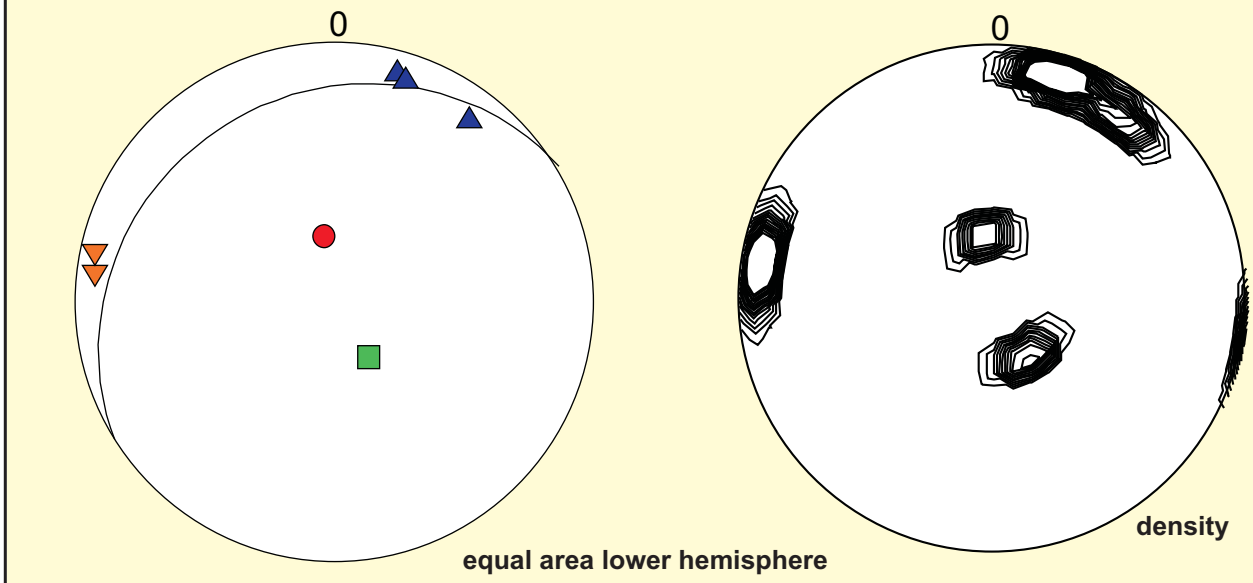


Fig. 14 *Rose diagrams of fractures in core 1, Lycosa 1:*
(a) high angle fractures; (b) main fractures; (c) slickensided fractures and lineations; (d) fault planes and tension gashes.
(e) FMS over interval of core 1, Lycosa 1 showing fractures (red and orange) interpreted by Schlumberger. Bedding is shown in green.



dip azimuth	dip angle	type	symbols
328	20	bedding	
194	81	fracture 1	
96	82	fracture 2	
197	79	fracture 1	
215	76	fracture 1	
101	84	fracture 2	
171	20	microfault plane	

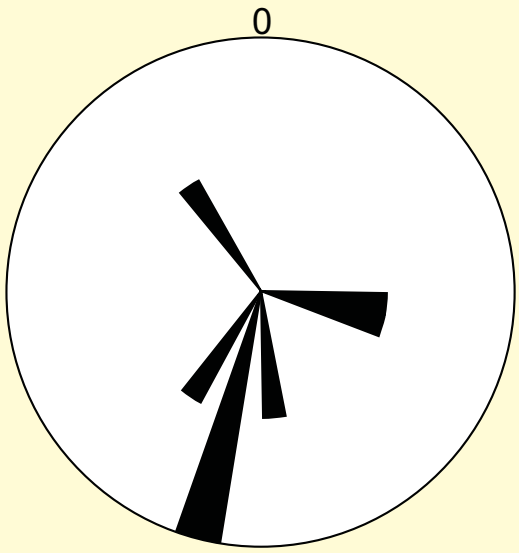


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Fig. 15 *Stereographic projections of poles to and great circle for bedding, density and rose diagram of fractures measured from core 1, 8793', Lycosa 1.*

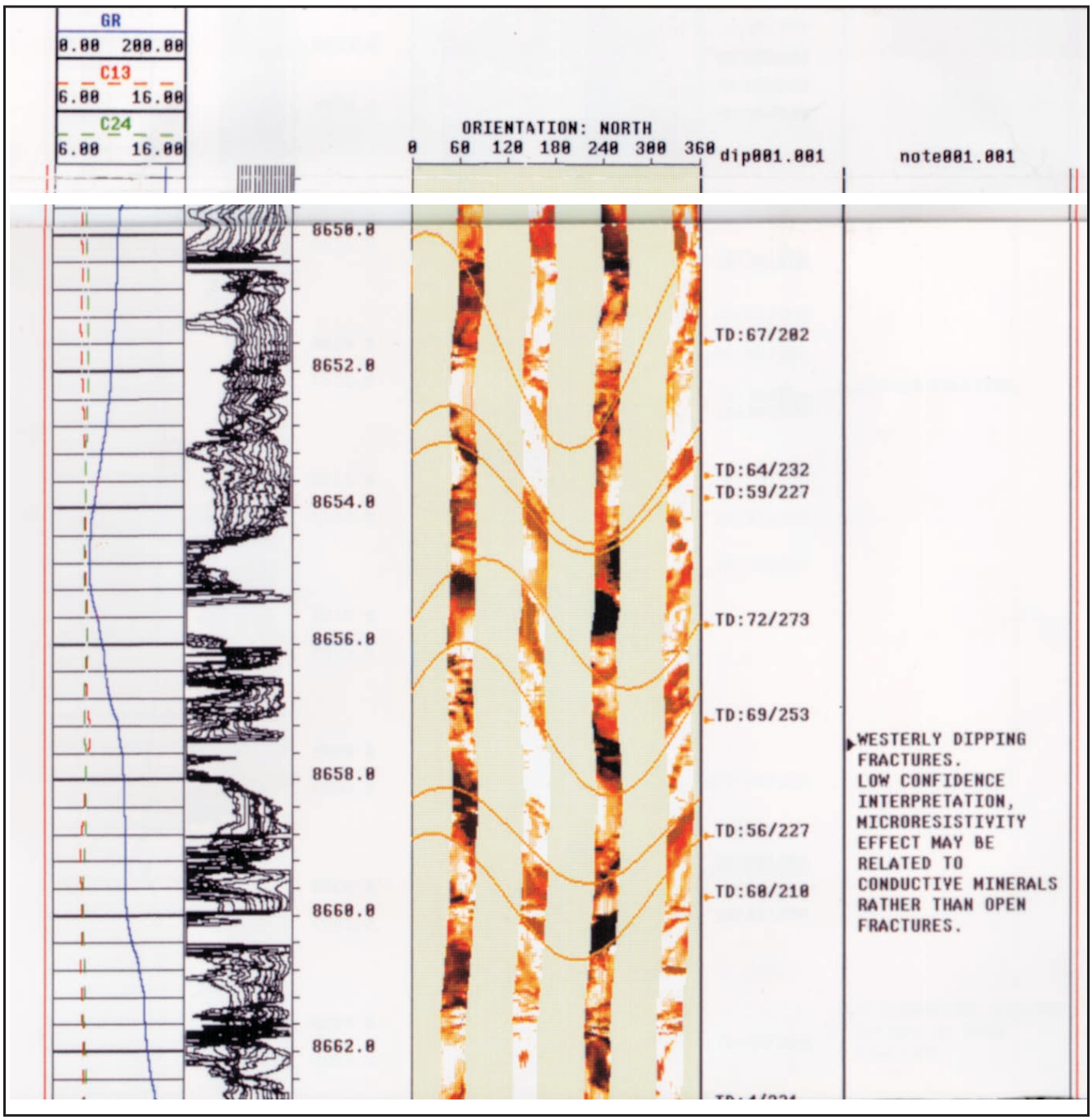


Fig. 16 *FMS (fracture analysis) in Lycosa 1, showing SW dipping open fractures (orange). (From Rayner and Chin, 1990).*

The wells listed in Table 4 have only core slabs except Coochilara 1 and Mudlalee 2 which lack cores. Their dipmeters can be interpreted by recognising conjugate fracture sets which cannot be confused with subvertical bedding dips as mentioned above for Mudlalee 1. With confidence, they can contribute to absolute orientation data (Figs. 23-24). The azimuths are averaged from dipmeter values, and are listed in the order of decreasing frequency of occurrence (Table 4).

Table 4 *Dip and strike azimuths of fractures interpreted from dipmeters.*

Well name	Dip azimuth	Strike azimuth
Coochilara 1	157°, 335°	67°, 245°
Mudlalee 1	240°, 330°	150°, 60°
Mudlalee 2	73°, 215°, 297°	163°, 125°, 27°
Strzelecki 3	52°, 335°	142°, 65°

Absolute orientations

From almost 100 measured depths in 22 wells, Table 5 lists absolute strike orientations of mostly high angle fractures. Low angle fractures have also been measured (Appendix 1, 2). Warburton Basin intervals in most wells have only one or two cores, each core is normally 10 feet long. However some old wells such as Gidgealpa 1, 2, 3, 4, 5, 7, 8, 9, 11, Merrimelia 1, 2, Innamincka 1, Coongie 1 and Kalladeina 1 have many cores. Therefore, for those wells, the measurements near top of Warburton Basin strata have been chosen because they are more likely to trap Cooper Basin hydrocarbons. A difference of orientation with depth is prominent in Gidgealpa 1 (Fig. 22), probably due to footwall and hanging wall deformation differences in a compressive fault system.

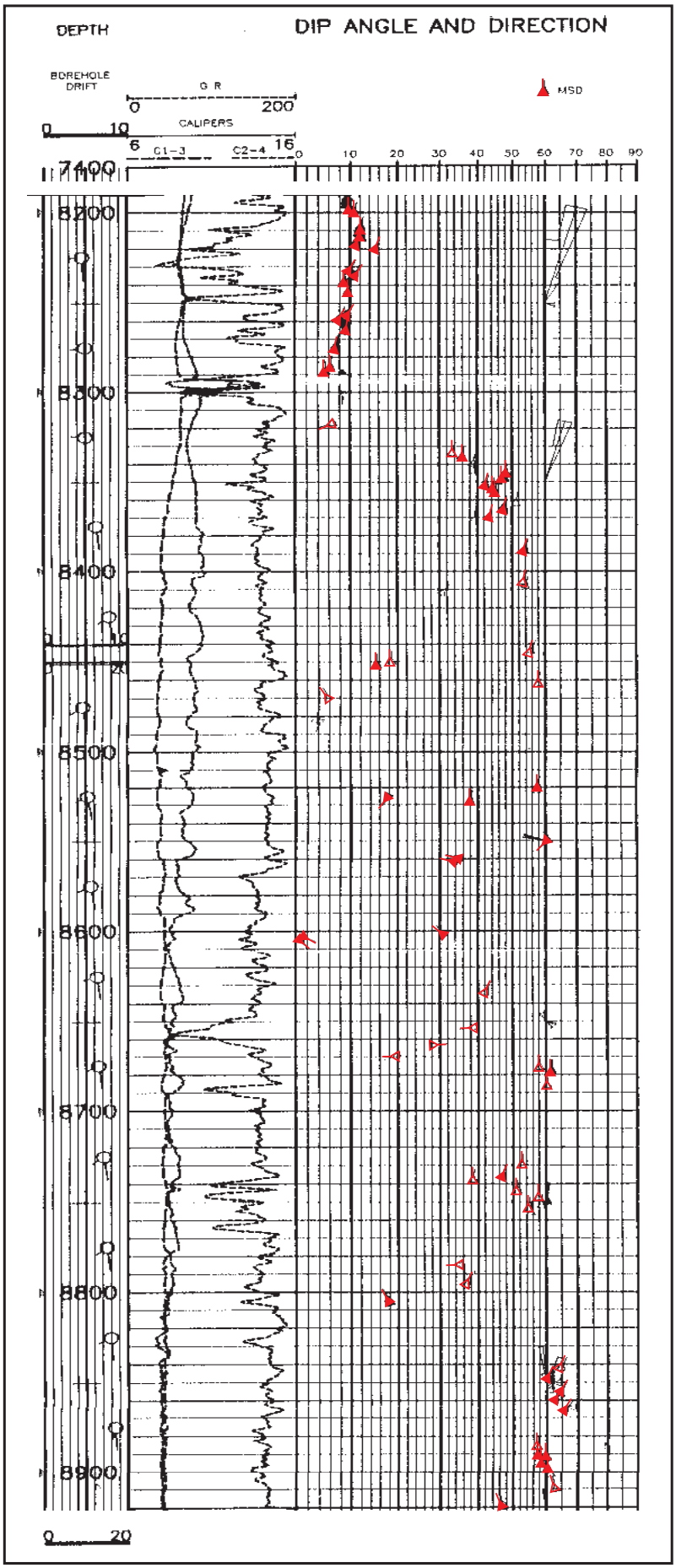


Fig. 17 *Dipmeter in Lycosa 1.*

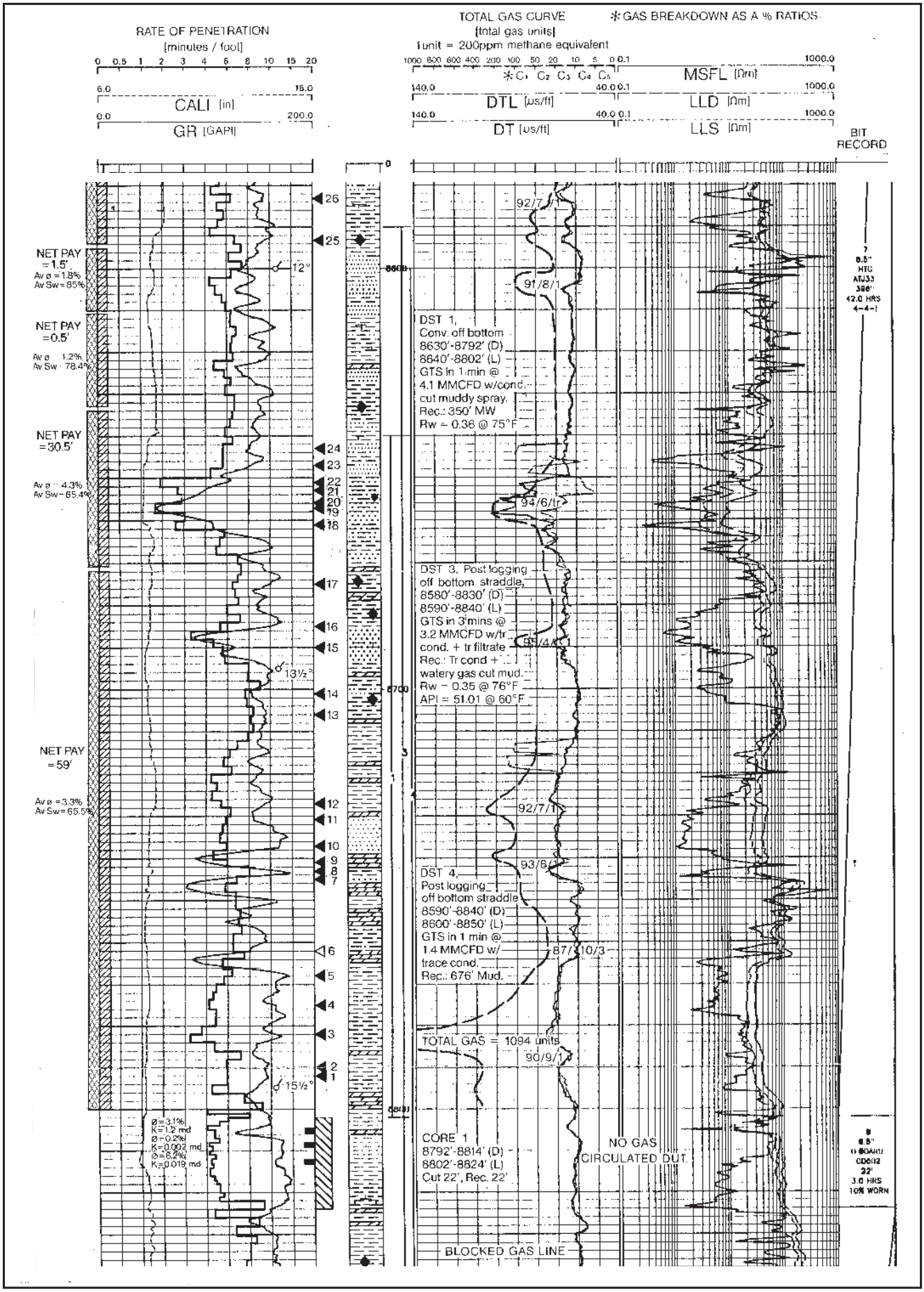


Fig. 18 *Composite log in Lycosa 1*

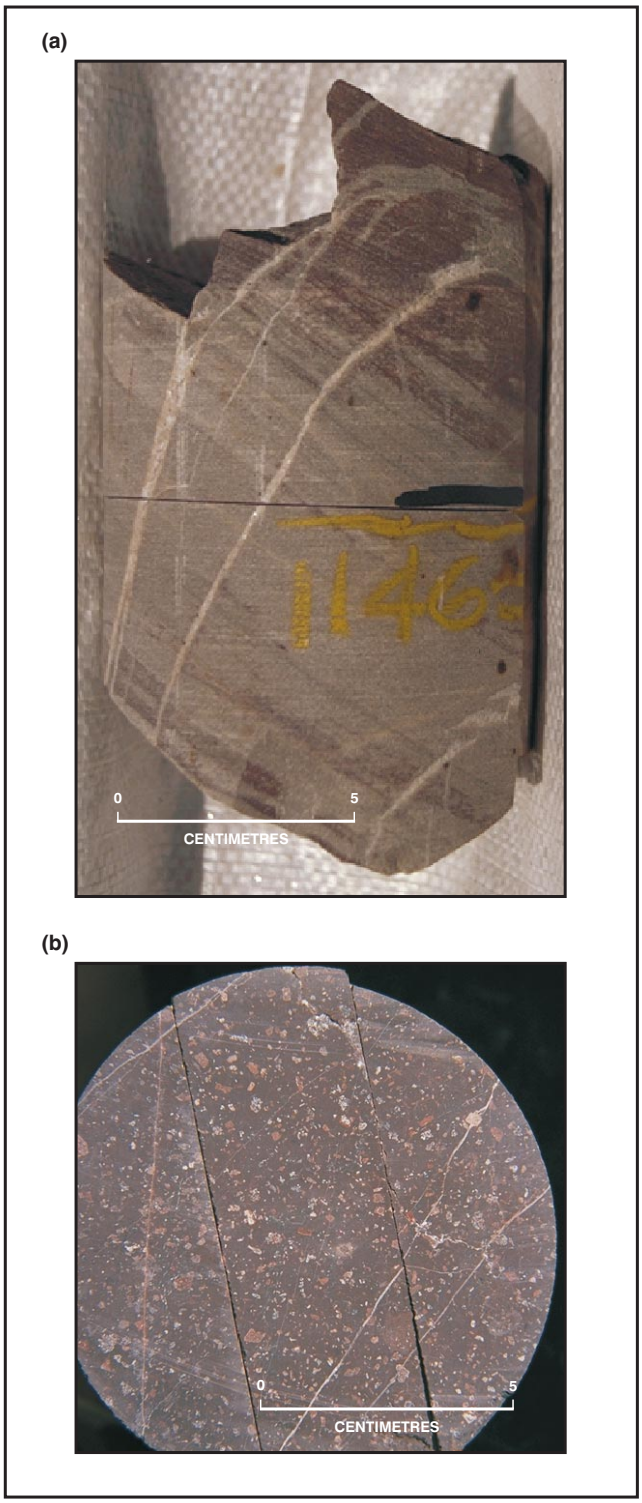


Fig. 19 *Fracture orientations in cores,*
(a) circumferential surface in Innamincka 1,
(b) right angle to core axis, Gidgealpa 3. *(Photos 046738, 046739)*

Since major regional structural trends in the Cooper Basin are inherited from those which deformed the Warburton Basin (Sun, 1997 and references therein), Warburton Basin fracture systems are grouped in the five major structural domains which control Cooper Basin architecture. They are further partitioned into seven strike subdivisions to show similarity from well to well within a subdivision.

Table 5 *Absolute orientations of mean strike direction of fractures, including those interpreted from FMS by Hillis et al., 1997 (*) and in (Rayner and Chin, 1990; Chin, 1991) ([1]) (o = open fractures, po = partially open fractures).*

	STRIKE SUBDIVISION						
	1	2	3	4	5	6	7
Sturt-Malgoona-Nealyon-Jennet Structural Domain							
Malgoona 4 (o)[1]		018°		060°		150°	
Gidgealpa-Merrimelia-Packsaddle-Innamincka Structural Domain							
Gidgealpa 1	001°	018°	046°	060°	107°	150°	
Snake Hole 1	007°				104°		
					126°		
Gidgealpa 2				087°	120°	150°	
						162°	
Gidgealpa 3		026°	046°	074°	120°		176°
Gidgealpa 5		021°		054°			
				063°	133°		
Gidgealpa 7		025°		059°	136°	150°	
Merrimelia 6						147°	171°
Merrimelia 7		026°					173°
Mudrangie 1		030°	041°	060°		150°	
Wantana 1				079°	115°		
Packsaddle 3		021°		064°		150°	
						140°	
Innamincka 1				079°	135°	150°	
Boxwood-Daralingie-Lycosa-Moomba Structural Domain							
Boxwood 1	006°		050°	085°	102°		
Lycosa 1		020°		063°	110°(po); 127°(o)[1];	140°(o)[1]	
						162°(o)[1]	
Yalcumma 1			072°	082°			
Moomba 2		020°					
Moomba 73*						147°	
Della-Nappacoongee-Dullingari Structural Domain							
Della 1					112°	141°	
Dullingari 1					117°	144°	
Tilparee-Pelketa-Toolachee-Munkarie Structural Domain							
Murteree 1		021°				156°	
Munkarie 1	008°		068°		090°		
Pelketa 1			046°		108°		179°

The strike data in 23 wells (Table 5) chosen for final interpretation are from high angle fractures and averaged into 45 mean strike directions from many measurements. They are illustrated in Fig. 23. From these seven subdivisions, four groups of fractures can be further separated (Fig. 24; Appendix 4). The four groups have average strike azimuths of 22°, 61°, 114°, 148°, which can be approximated as four strike directions: 20°, 60°, 110°, 150°. As shown in Table 5, in the Gidgealpa-Merrimelia-Packsaddle-Innamincka domain, NW-SE strikes are dominated by azimuth 150-330°, subsidiary NW-SE strikes can be averaged as 110°. NNE strikes can be averaged as 020°. NE strikes can be averaged as 60°. These major strike directions can be seen in other domains as shown in Table 5 and Fig. 23. For example, in Lycosa 1, 020° and 110° are orthogonal directions, one dipping SW and the other dipping SE (Fig. 11k). I interpret the NE striking 060° and 150° pair as a second orthogonal set. These two sets are more or less found in all the structural domains although some fractures may not have been intersected during drilling or have no core or other logs to record them. These two systems are simplified and superimposed on the Z time structural map (Fig. 25). Relatively few wells, Munkarie 1, Pelketa 1, Wantana 1, Yalcumma 1, Boxwood 1 and Gidgealpa 2 have fractures close to E-W striking fractures.

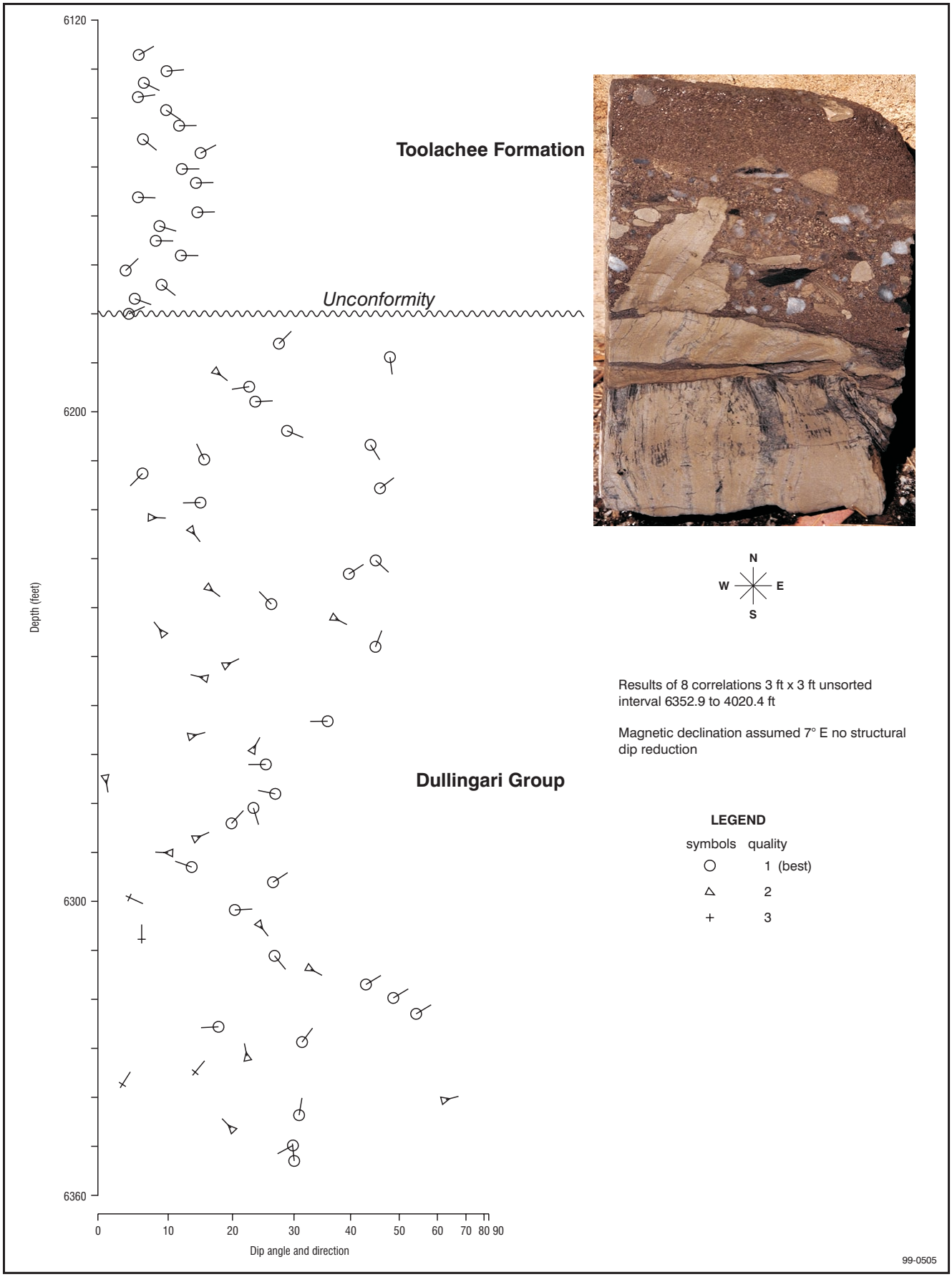


Fig. 20 *Strzelecki 3 dipmeter and core illustrations of angular unconformity between Toolachee Formation (Permian) and Dullingari Group (Ordovician).* *(Photo 046740)*

Table 6 *Absolute dip azimuths and dip angles (e.g. 120/60) of steep fractures, including those interpreted from FMS by Hillis et al., 1997 (*) and in (Rayner and Chin, 1990; Chin, 1991) ([1])*

Sturt-Malgoona-Nealyon-Jennet Structural Domain				
Malgoona 4(o)[1]	240/65(o)[1]	288/55(o)[1]	330/80(o)[1]	
Gidgealpa-Merrimelia-Packsaddle-Innamincka Structural Domain				
Gidgealpa 1	136/55	197/35	239/80	271/55
Snake Hole 1	14/89 or 194/89	36/80	277/83	
Gidgealpa 2	72/50, 177/80, 210/70, 240/68			
Gidgealpa 3	116/78, 136/73, 164/82, 210/85, 266/85			
Gidgealpa 5	144/55, 291/60, 333/50			
Gidgealpa 7	226/85, 240/78, 295/43, 329/73			
Merrimelia 6	237/87, 261/87			
Merrimelia 7	83/75, 296/80			
Mudrangie 1	120/48, 240/80, 311/45, 330/60			
Wantana 1	169/60, 205/50			
Packsaddle 3	63/70, 230/80, 291/61, 334/85			
Innamincka 1	45/70, 240/70, 349/68			
Boxwood-Daralingie-Lycosa-Moomba Structural Domain				
Boxwood 1	175/63, 192/55, 276/80, 320/60			
Lycosa 1	110/84, 200/78(op), 230/67(o)[1], 333/65[1], 217/62(o)[1], 252/67(o)[1]			
Yalcumma 1	172/70, 342/58			
Moomba 2	290/85			
Moomba 73 *	57 or 237			
Della-Nappacoongee-Dullingari Structural Domain				
Della 1	202/77, 231/80			
Dullingari 1	54/55			
Tilparee-Pelketa-Toolachee-Munkarie Structural Domain				
Murteree 1	111/85, 246/70, 306/60			
Munkarie 1	98/72, 158/75, 180/80			
Pelketa 1	89/45, 136/52, 198/60			

Dip azimuths of absolute orientations are presented in Fig. 26 and listed in Table 6. Several major groups of dip azimuths include in order of decreasing frequency: SW, SE, NW and NE.

Relative orientations

The majority of cores are from wells that are not orientated down-hole in the Warburton Basin. In 24 wells, bedding is arbitrarily assumed to dip north, with other fractures measured relative to the bedding (Appendix 1, 2). Because the two orthogonal fracture systems transcend local structures, and more or less have the same orientations as low frequency lineaments, they are interpreted as regional fractures. With guidance of the regional fracture pattern, relatively oriented high angle fractures can be rotated into sensible strike directions by their angular relationships. In this way the relatively-oriented high angle fractures from an additional 17 wells can fit within two orthogonal fracture systems. However, there are two possible solutions (Table 7, Figs. 27, 28 and 29).

A choice can be made between the two possibilities by considering the regional fracture patterns recognised in the nearby wells. Since the regional fractures in the Warburton Basin have been superposed by local tectonic fractures (see discussion), local structural features such as thrust faults, slickensided surfaces and lineation directions can constrain the more likely possibility on a case by case basis (Table 8). Absolute and relative orientations of fractures can then be combined to present a fracture strike map (Fig. 29).

Orientations of open and partially open fractures

From FMS interpretation, Chin (1991) identified 181 natural fractures in the Mooracoochie Volcanics in Malgoona 4, of which 167 are open (or conductive). He also found that the fractures have mean azimuth 288.6°, dip 55.9°, and the most intensely fractured intervals are 7225-7230 and 7278-7285 feet, in which fractures have aperture: max: 0.1 mm, mean: 0.063 mm; density of open fractures 7/foot. However, there are at least three dominant azimuths with 167 conductive fractures (Chin, 1991, Fig. 5), whose mean values are 290°/55, 240°/65, 330°/80 It is illogical to calculate a mean azimuth and dip for these fractures and hence Figure 29 displays all three directions for

Fig. 21 *Mudlalee 1 core, illustration of fracture sets.*
(Photo 046741)

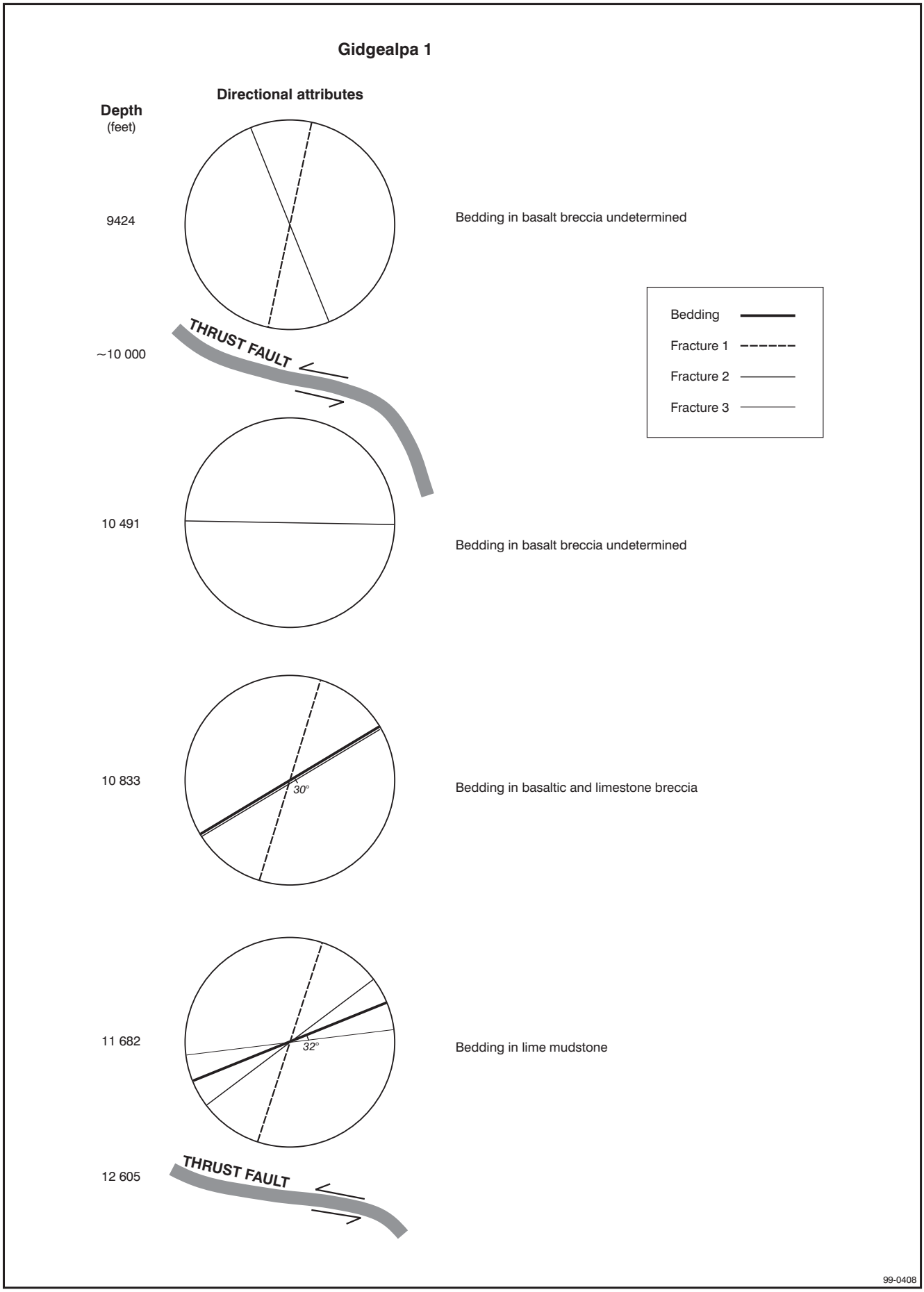
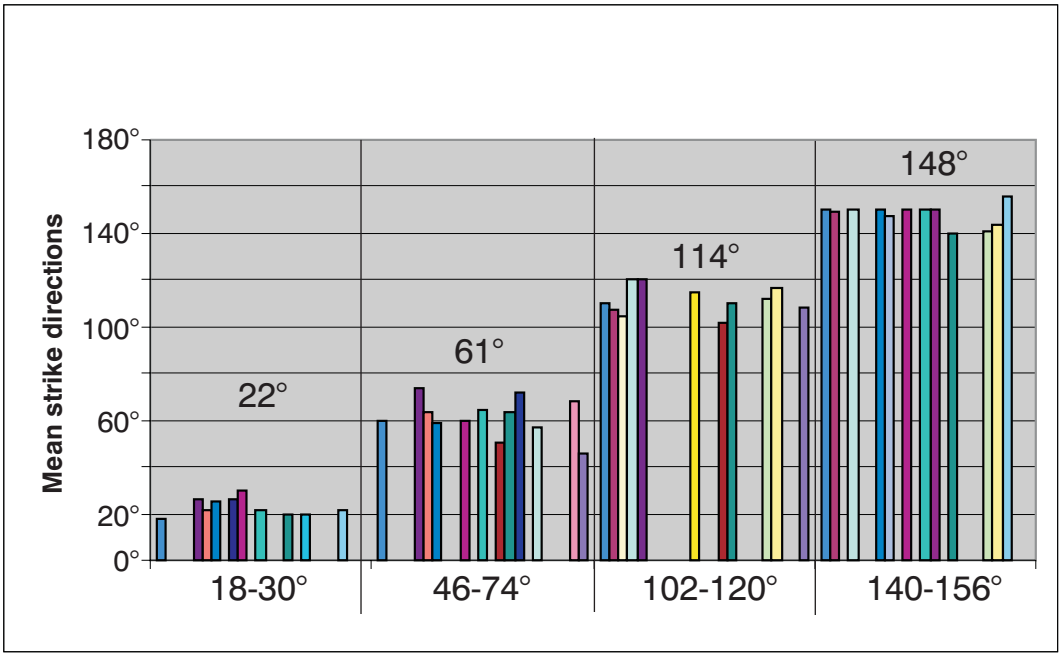


Fig. 22 *Variation of fracture orientation with depth in Gidgealpa 1*

Fig. 23 *Map of Cooper Basin showing absolute orientations of strike directions*

(a)



(b)

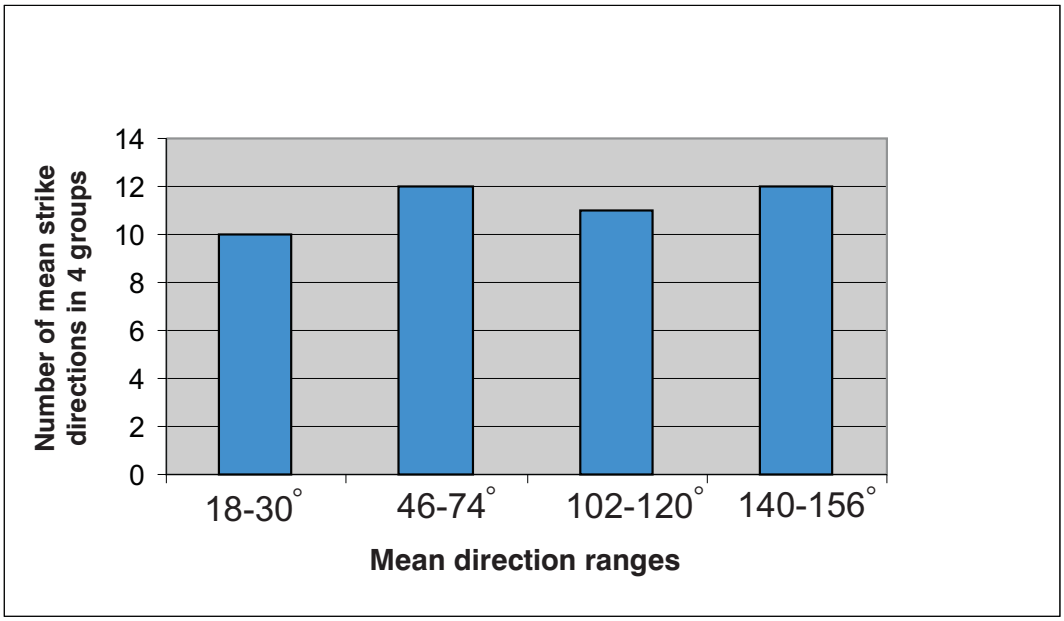


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Fig. 24 *Four groups of strike direction stand out from mean high angle fracture strike direction as shown in two histograms (n=45):*
(a) mean strike direction plot, with four average directions: 22°, 61°, 114°, 148°;
(b) frequency of mean strike direction in four groups.

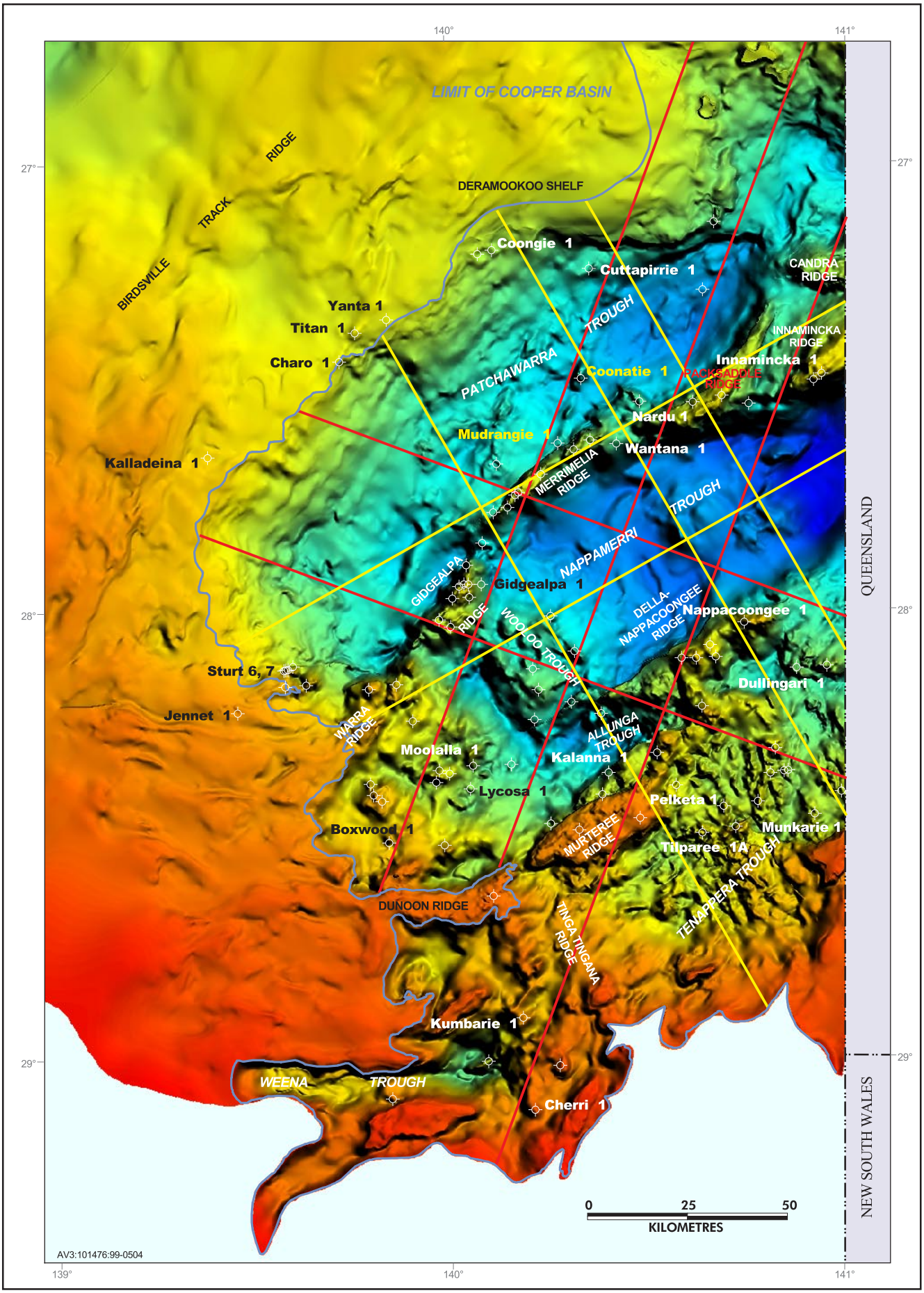

Fig. 25 *Map of Cooper Basin showing two sets of orthogonal fractures which are independent of local structure when laid over the 'Z' horizon structural map.*

Table 7 *Strike orientations of fractures rotated in azimuth to fit within regional fracture systems*

Well name	Possibility 1	Possibility 2
Big Lake 52	20°, 150°	60°, 110°
Brumby 1	20°, 110°	60°, 150°
Cherri 1	20°, 150°	60°, 110°
Coonatie 1	20°, 60°	110°, 150°
Daralingie 1	20°, 150°	60°, 110°
Della 2	20°, 60°	110°, 150°
Jennet 1	20°, 110°	60°, 150°
Kalanna 1	20°, 110°	60°, 150°
Kumbarie 1	20°, 60°	110°, 150°
Lowanna 1	20°, 150°	60°, 110°
Nappacoongee 1	20°, 60°	110°, 150°
Narcoonowie 1 (upper core)	20°, 60°	110°, 150°
Narcoonowie 1 (lower core)	20°, 150°	60°, 110°
Nealyon 1	20°, 60°	110°, 150°
Packsaddle 1	20°, 60°, 150°	60°, 110°, 150°
Tilparee A1	20°, 150°	60°, 110°
Toolachee 1	20°, 110°	60°, 150°
Toolachee 9	20°, 60°	110°, 150°

Table 8 *Case by case selection of more likely fracture strike orientation.*

Well name	More likely fracture strike orientations	Brief reasons
Big Lake 52	20°, 150°	shear plane (~1500) due to strike slip faulting zone, also relate to to those from Mudlalee 1 and 2 and Moomba 2
Brumby 1	60°, 150°	NE trending anticline related fractures.
Cherri 1	20°, 150°	N-S aligned small anticline
Coonatie 1	20°, 60°	Similar to adjacent Mudrangie 1
Daralingie 1	60°, 110°	NE trending anticline related fractures. Similar to Lycosa 1.
Della 2	110°, 150°	Similar to adjacent Della 1
Jennet 1	60°, 150°	Slickenside lineation dipping NW (3400), high angle fault dipping NW or SE, more NW.
Kalanna 1	60°, 150°	NE-SW trending fault zone
Kumbarie 1	20°, 60°	NE trending anticline related fractures.
Lowanna 1	20°, 150°	Close to Big Lake 52
Nappacoongee 1	110°, 150°	Similar to Della 1
Narcoonowie 1	110°, 150°	NE-SW trending anticline, NW flank
6543' (10 differ.)	60°, 110°	Similar to Pelketa 1
Nealyon 1	20°, 60°	Similar to Malgoona 4 and Jennet 1
Packsaddle 1	20°, 60°, 150°	NE trending anticline related fractures, especially thrust faults (~150°).
Tilparee 1A	60°, 110°	E to NE trending small anticline
Toolachee 1	20°, 110°	Large N-S trending anticline
Toolachee 9	20°, 60°	N-S bounding fault

this well. There is insufficient material to determine whether or not all three fracture sets are open (no core was cut).

Four of the wells shown in Table 9 have open or partially open fractures with known absolute orientations. They represent three of the five structural domains. One of the remainder, Gidgealpa 4, has open fractures along a normal microfault. Although this well is not oriented down the hole, and also has fractures with a single orientation, we can assume that its bedding plane dips SE (i.e. 130°) like many other nearby wells in the Gidgealpa North Dome. If this is the case, then the open fracture will dip towards the SW (236°) whose strike will be NW-SE (nearly 150°) similar to common bedding strikes of several nearby wells such as Gidgealpa 2 and 3. Open fractures are also found in Beanbush 1 (Fig. 5e) and Meranji 2 (Fig. 5d), with high angles ranging from 80° to subvertical. Unfortunately these wells lack dipmeters and have no fracture patterns to help find their orientations. If we assume the bedding in Meranji 2 dips NW (330°), the subvertical fracture (dip angle 85°) will dip towards SW (215°) as shown in Table 9 (Appendix 2).

There are some possibly induced open fractures, which need further examination to be certain of their nature. Numerous irregular open fractures are observed in Jennet 1 (Fig. 31), also at some depths in Merrimelia 2. In Jennet 1, possible open fractures are observed in coarse-grained sandstone. Because it is an unoriented well, the dip azimuth of the fractures will be 230° (average) if one assumes that they belong to System II regional fractures striking 60° and 150°.

Fracture density

The productivity of a fractured zone is directly proportional to the number of fractures intersected by a wellbore. Where fracture distribution is even, I have recorded average distance or spacing between the fractures along the borehole; if not, I have measured both minimum and maximum distance between adjacent fractures along the borehole. I have used average distance to calculate the number of the fractures per foot along the borehole which is similar to raw fracture density (the number of fractures per foot or meter selected along the borehole, Schlumberger, 1997). Usually there are one or two fractures which intersect the circular face of a plane cut perpendicular to the core axis except in heavily fractured wells which can have more than 10 small fractures. Examples are cores from Murteree C1, Mureree A1, Pelketa 1, core 25 in Gidgealpa 5 and Kalanna 1 (Fig. 32). Therefore, for typical wells I calculate the number of fractures along the core axis. For heavily fractured cores, I take account of fractures which intersect a plane perpendicular to the core axis as well. These quantitative spacing data are recorded in excel format (Appendix 3). For mapping, I classified the fracture density of all the studied wells into five grades: very high (>25/1'), high (>=7/1'), moderate (>2/1'), low (<1/1'), nil (0 fractures, in normally about 10 feet of core). The five grades for 91 wells are listed in Table 10 together with their main lithologies. They are illustrated in Figs 32-35. For those wells which have long intersections such as Gidgealpa 1, Innamincka 1, I have taken an average and shown the main lithology especially near the top of the Warburton Basin for the density map (Fig. 36). In such wells with many cores, fracture density varies with depth and lithology, such as in Merrimelia 2 (Table 11). Fracture density is often unevenly distributed within a single 10 or 20 feet length of core, such as in Lycosa 1 (Fig. 13) and Wancoocha 1. Normally, very high fracture density occurs in brecciated zones which are probably caused by faulting. In Lycosa 1, a severely fractured and brecciated zone is observed over the interval of 8794'5". The low angle microfaults and mineralised breccia zone all indicate faulting. At this stage, I have not attempted to compare the fracture densities of the two separate orthogonal sets.

Table 9 *Orientations, aperture, lithology of open and partially open fractures*

Well, Depth (feet)	open (o), partially open (po)	lithology	aperture (max. mm)	Azimuth (mean)	dip (average)
Lycosa 1					
8793	po	siltstone and shale	0.1	202°	78°
86271	o	as above	no data	217°	62°
Malgoona 4+					
7278-7285	o	acid volcanics	0.1	288°	55°
				240°	65°
				330°	80°
Merrimelia 6					
7441.5-7442	po	sandstone	0.2	249°	87°
Merrimelia 7					
7445.33	po	sandstone	broken	83°	75°
7451	po	as above	0.2-0.3	296°	80°
Gidgealpa 4*					
7226.67	o and po	tuffaceous sandstone	0.2	236°	75°
Meranji 2*					
10920	o	fine sandstone	0.1	215°	85°
Jennet 1*					
5525	o	coarse sandstone	0.35	230°	65°
Beanbush 1					
	o	fine sandstone	0.1	no data	85°

* assumed from relative orientation data,
\+ from FMS interpretation

Table 10 *Fracture density and main lithology from 91 studied wells*

Well	Fracture density	Main lithology
Beanbush 1	low	siltstone, fine-grained sandstone.
Big Lake 52	high	siltstone and shale
Bookabourdie 1	high	siltstone and fine-grained sandstone
Boxwood 1	moderate	ignimbrite; siltstone and shale
Brumby 1	high	siltstone and mudstone
Burke 1	moderate	siltstone, sandstone
Charo 1	nil	grainy limestone
Cherri 1	high vertically	slate
Coonatie 1	moderate to high (not even)	siltstone, fine-grained sandstone, shale
Coongie 1	low (siltstone and shale to high (grainy limestone)	shale, siltstone, sandstone, grainy limestone
Cuttapirrie 1	high	rhyodacite
Daer 1	low-moderate (not even)	grainy and minor marly limestone
Daralingie 1	moderate to high (not even)	sandstone and siltstone (low); quartzite (high)
Daralingie 2	high	fine-grained sandstone, siltstone, shale
Daralingie 10	moderate to partly high (breccia)	protoquartzite, breccia
Della 1	moderate, not even	siltstone
Della 2	very high	siltstone and shale (weathered)
Della 4	low	sandstone
Della 5A	very high	siltstone and shale (weathered)
Dullingari 1	moderate to high	siltstone and shale, minor fine-grained sandstone
Dunoon 1	nil	siltstone, fine-grained sandstone
Gidgealpa 1	moderate to partly high (breccia)	marly limestone, grainy limestone, dolomite
Gidgealpa 2	high	tuffaceous sandstone, tuff, rhyodacite
Gidgealpa 3	moderate to high	tuffaceous conglomerate, tuff, rhyodacite
Gidgealpa 4	high to very high (breccia)	tuffaceous sandstone, tuff, ?rhyodacite
Gidgealpa 5	very high to moderate	marly and grainy limestone, dolomite (veryhigh), tuffaceous sandstone and rhyodacite (moderate)
Gidgealpa 7	high to very high (breccia)	marley limestone, grainy limestone, dolomite, tuffaceous sandstone
Gidgealpa 8	very high (breccia) to partly high	fault breccia, tuff
Gidgealpa 11	low	ignimbrite, tuff
Gurra 1	high	phyllite
Innamincka 1	low (mudstone) moderate to high (sandstone)	green siltstone, vf sandstone; red mudstone and siltstone.
Innamincka 4	low	siltstone and very fine sandstone.
Jennet 1	high	sandstone and minor siltstone.
Kalanna 1	high to very high	mudstone and shale
Kalladeina 1	low to partly moderate	siltstone, shale, marly and grainy limestone, rhyodacite
Kumbarie 1	high	weathered mudstone; siltstone and shale
Lowanna 1	high	siltstone and shale
Lycosa 1	to very high	siltstone and shale
Malgoona 4	high and partly moderate	?ignimbrite
McKinlay 1	moderate, not even	siltstone and shale
Merrimelia 1	low (mudstone), moderate (sandstone)	
Merrimelia 2	low (mudstone), moderate (sandstone), high (breccia zone)	
Merrimelia 3	high at top (8210'), nil in lower part (8964-76')	sandstone, siltstone and mudstone
Merrimelia 5	nil	mudstone
Merrimelia 6	low to moderate	fine-grained sandstone
Merrimelia 7	moderate	fine-grained sandstone
Meranji 2	low	siltstone, fine-grained sandstone

Minkie 1	low	fine-grained sandstone
Moomba 2	high	weathered sandstone, siltstone
Moomba 3	low to moderate	hornfels
Moomba 7	low to moderate	sandstone
Moomba South 1	high to very high (breccia)	hornfels
Mudrangie 1	high to very high (breccia)	quartzite
Mudlalee 1	moderate	balsalt; siltstone and shale
Munkarie 1	high	grey mudstone and shale
Murteree 1	moderate to high	dk siltstone and shale
Murteree A1	veryhigh	basalt
Murteree C1	very high	weathered siltstone and mudstone
Nappacoongee 1	high to very high (breccia)	shale, f. sandstone
Narcoonowie 1	very high	weathered mudstone; mudstone and shale
Nealyon 1	high	siltstone and shale
Packsaddle 1	high	siltstone and f. sandstone, sandy limestone
Packsaddle 3	moderate to high	shale and f. sandstone
Pando 1	moderate to high	sandstone
Pando 2	high (breccia)	weathered shale; sandstone
Pando North 1	moderate	mudstone and siltstone
Pelketa 1	high to very high	weathered siltstone and shale
Pinna 1	low, partly moderate	mudstone and siltstone
Snake Hole 1	not even, moderate to high	siltstone, red mudstone
Spencer 1	nil to low	conglomerate of volcanics
Spencer 2	moderate to high	rhyolite
Strzelecki 1	hight to very high (short fractures)	pyritic shale
Sturt 7	low but high partly	tuff (low); ignimbrite (moderate)
Stuart 8	low to moderate	tuff (low); ignimbrite (moderate)
Taloola 1	low	ignimbrite
Tilparee A-1	high	pyritic shale
Tinga Tingana 1	moderate to partly high	quartzite; shale
Tirrawarra 1	nil to low	sandstone, siltstone
Titan 1	moderate to high (breccia)	siltstone and shale, grainy limestone
Toolachee 1	high and partly very high	pyritic shale and siltstone
Toolachee 2	moderate	sandstone; shale
Toolachee 4	moderate	arkosic sandstone
Toolachee 9	high	arkosic sandstone
Toolachee East 2	high	weathered siltstone and shale
Walkillie 1	moderate	rhyolite
Wancoocha 1	not even, high in upper part, (breccia), low in lower part (siltstone and shale)	weathered siltstone and shale
Wantana 1	moderate to high	siltstone and shale, grainy limestone
Weena 1	nil	pebbly sandstone
Wirrarie 1	nil	sandstone, siltstone
Yalcumma 1	not even, moderate to partly high	siltstone and shale
Yanpurra 1	nil	siltstone and shale

Table 11 *Fracture density change with depth in Merrimelia 2. Core recovery is 100%, except core 11 (92%) and cores 7, 15, 17 (85%).*

Top depth (feet)	Bottom depth (feet)	Core	Number of fractures	Main lithologies
7900.00	7916.70	2	26	Bioturbated red-brown, micaceous mudstone; x-laminated sandstone which is well fractured through along the core axis.
8339.00	8349.00	3	4	Similar lithology to the above, but more green pebbles.
8572.00	8603.00	4	>8	Similar to the above, sandstone with irregular lamination.
8630.00	8644.00	5	7	Cross-laminated sst, truncated bed. Green shale clasts.
8695.00	8715.00	6	5	Orthoquartzite and shale with vague low angle lamination. A possibly induced fracture (open).
9117.00	9127.00	7	18	Sandstone with thin soapy green shale layers, numerous fractures filled by quartz and calcite. Red sheet-like micaceous shale with fractures.
9627.00	9637.00	8	2	Low angle planar cross laminated sst. Red mudstone.
10139.00	10149.00	9	0	Bioturbated mudstone and siltstone, sandstone with. rip-up clasts.
10636.00	10646.00	10	1	Slightly silty, convolute bed; siltstone, cross lamination. Red brown mudstone.
11110.00	11119.50	11	0	Brown laminated siltstone and sandstone. Well-bioturbated mudstone.
11513.50	11523.50	12	2	Red micaceous shale, and fine sandstone, planar lamination; rip-up clasts of green mudstone.
12071.00	12081.00	13	0	Red bioturbated mudstone and siltstone.
12123.00	12138.00	14	1	Lateral accretion foreset, calcareous. Trough cross-lamination; flat-pebbles, some still fit. Red shale breccia.
12673.00	12680.00	15	1	Red-brown mudstone, bioturbation. Slightly laminated.
12765.00	12781.00	16	3	Bioturbated mudstone, rip-up intraclasts (green), minor x-laminated siltstone.
13004.00	13011.00	17	2	Brown to purple sandstone, granules along bedding; truncated “trough” cross-lamination.

Fig. 26 *Map of Cooper Basin showing absolute orientations of dip azimuths.*

Fig. 27 Map of Cooper Basin showing those relative orientation data which fit within system I or II, or both orthogonal sets (possibility 1).

Fig. 28 *Map of Cooper Basin showing those relative orientation data which fit within system I or II, or both orthogonal sets (possibility 2).*

Fig. 29 *Map of Cooper Basin showing combination of absolute and relative data (strike only).*

Fig. 30 *Map of Cooper Basin showing absolute strike orientations of steep fractures (circled) to low frequency lineaments (LFL), NNE8, WNW9 and NE1 identified by Boucher (1998).*

A fracture density map with lithologies has been constructed (Fig. 36). The fracture density depends first on structural style and severity of deformation, secondly on lithology, thickness and pattern of interbeds. The density distribution is consistent with the severity of structural deformation. Fractures are most severely developed along fault zones, such as in Kalanna 1 which has high to very high fracture density. Kalanna 1 lies on a NE-SW fault zone, and is a fault dependent trap with the Merrimelia-Tirrawarra-Patchawarra section truncated against Warburton strata along the fault (Morgeneier, 1985). Most wells with grade 5 fracture density are associated with faulting and gouge fill fault zones such as Lycosa 1, Gidgealpa 4, 5, 8, some of Gidgealpa 1 and 7, Della 5A, Murteree C1. Fractures are also more severe on the crests of structural culminations such as in the vicinity of Strzelecki 1, Pelketa 1, Murteree A1 and the Gidgealpa area (Appendix 3). Most of these culminations are bounded by faults at Z horizon depth. Wells without fractures such as Dunoon 1, Weena 1, Wirrarie 1 and Charo 1 are situated away from fault zones and off the crests of fault-related anticlines. They are almost flat-lying, and probably only suffered uplift within a large block such as Dunoon 1 or mild and broad folding such as in Charo 1. In severely faulted and uplifted areas, fractures are well developed and independent of lithology, which ranges from siltstone and shale to carbonate, sandstone or volcanics.

Within the Gidgealpa-Merrimelia-Packsaddle-Innamincka structural domain, fracture density varies markedly for two reasons. The first is due to structural control, strata which have been overthrusted have higher bedding dips and higher fracture density than those in underlying flat-lying and gently dipping beds. From seismic interpretation, we know that Gidgealpa 1, 7, Wantana 1 and Packsaddle 1 are located on overthrust slices, they are relatively steeply dipping and have high to very high fracture density. The second, is controlled by lithology, in the flat-lying or gently dipping thick Innamincka Red Beds as found in most Merrimelia wells, fracture density tends to be moderate to high in siltstone and sandstone, but nil to low in the interbedded bioturbated mudstone and micaceous shale. Generally speaking, steeply dipping strata have higher fracture density than flat-lying beds. Thicker beds have less fractures than thinner beds which have undergone the same structural history.

Fig. 31 *Core photo in Jennet 1, showing possible open fractures in brittle coarse sandstone.*

DISCUSSION

Major fracture types and orientations

Three main types of natural fractures are identified in the Warburton Basin, namely regional, tectonic and contractional. Possible contractional fractures have been recognised in the volcanics, varying from the acid Mooracoochie Volcanics such as in Gidgealpa 2 and 3 to basalt of Murteree A1. Since such fractures are sinuous, irregular and discontinuous, their orientations cannot be mapped.

Regional, high angle fractures are the most significant, forming two systems of orthogonal pairs. They cross local structures, and extend beneath the Cooper Basin in South Australia. They can be used as a guide to interpret fractures in cores from unoriented wells. System I has a pair of orthogonal fractures, striking NNE-SSW (20-200°) and ESE-WNW (110-290°). System II has a pair of orthogonal fracture sets, striking NE-SW (60-240°) and NW-SE (150-330°). System I is similar in direction to low frequency lineaments NNE8 (approximately 20°) and WNW9 (approximately 290°) referred to the Tethyan primary and orthogonal lineament network by Boucher (1998b). One of the system II fractures is similar in direction to low frequency lineament NE1 (approximately 60°), but the other is not recognised in lineament data (Fig. 30). The high degree of directional similarity indicates that these lineaments are basically related to deep-seated fracture systems in the Warburton Basin. According to Boucher (1998b), intersections of the WNW and NNE lineaments of the Tethyan primary and orthogonal lineament network are not prospective for petroleum but provide prospective mineral targets. He also found that most of the larger gas fields occur in 'shadow zones', 1-10 km from the NW and NE trending lineaments. However, in the Warburton Basin,

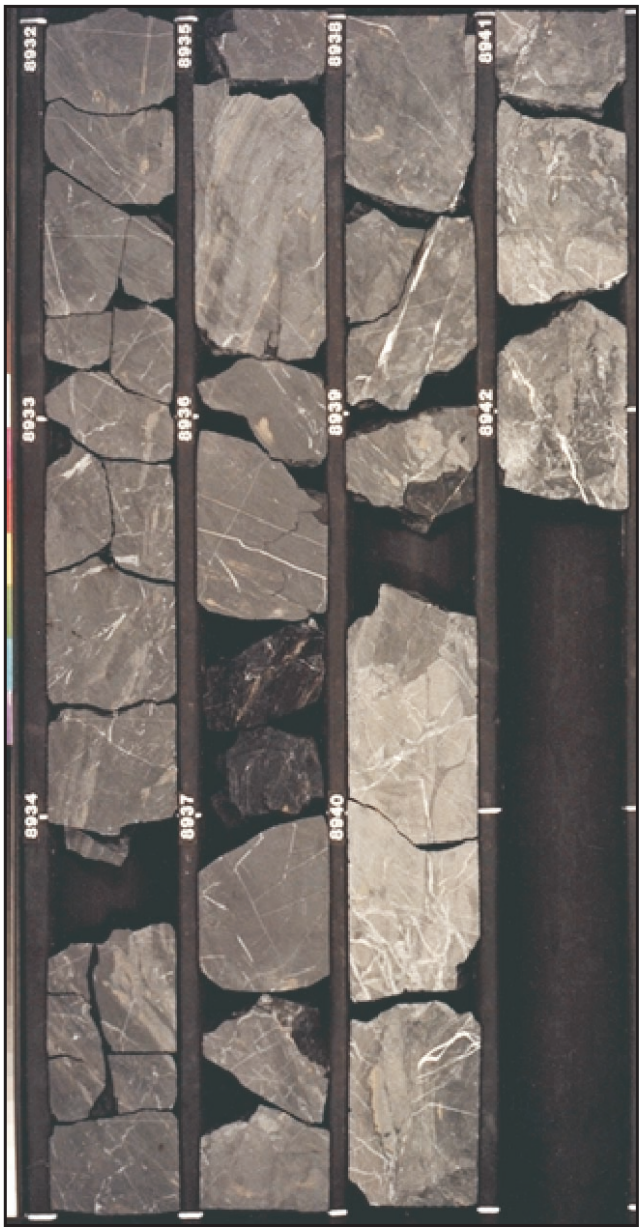

Fig. 32 *Core photo in Kalanna 1, showing high to very high grades of fracture density.*

WNW 9 is parallel to the strike direction of productive open fractures in Lycosa 1.

Similarly oriented orthogonal natural fracture sets have been recognised independently from FMS data by Hillis *et al*. (1997, p.13) in the lower Patchawarra Formation of the Cooper Basin. However, in the Big Lake Suite granodiorite of Moomba 73, Hillis *et al*. (1997) interpreted only northwest striking fractures. Fractures in Big Lake Suite cores have not been studied here.

Origin of fractures

In a recent publication on naturally fractured reservoirs, Aguilera (1997, p.26) stated that various reasons have been offered to explain the existence of regional fractures. These include: (1) Regional uplift (Price, 1966), (2) Fatigue due to low level cyclic stress differentials, (3) Formation of fractures soon after sedimentation, due to prolongation of fractures in the beds below. The first explanation is the best

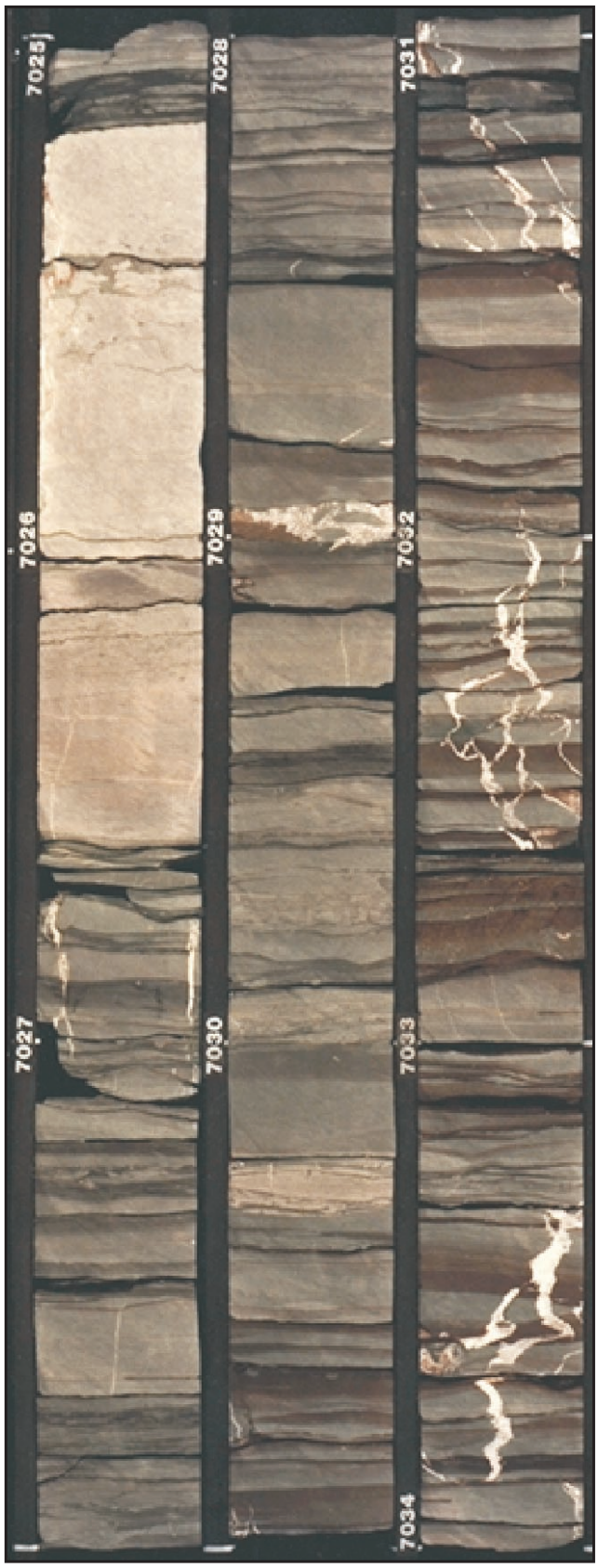

Fig. 33 *Core photo in Titan 1, showing moderate grade of fracture density.*

but it cannot explain the occurrence of two superposed patterns (four fractures) (Stearns and Friedman, 1972). Although no single explanation has proven conclusive, regional fracture systems produce hydrocarbons in

numerous fields, they are second in importance only to tectonic fractures in hydrocarbon production. Excellent fractured reservoirs occur when tectonic fracture systems are superposed over a strong regional system (Nelson, 1985, p.19). Some of these reservoirs include the Austin chalk, the Big Sandy field of eastern Kentucky and West Virginia which produces from Devonian shale (Bagwal and Ryan, 1976), the Altamont-Blue Bell field of Utah which produces from fractured sandstone (Baker, 1972). Regional fracture systems have also been called "systematic joints" by many authors (see Nelson, 1985 for references) because they are consistently distributed over a large area with orientation variations of only 15-20°, and fracture spacing ranging from just under 1 ft to over 20 ft vertically along the borehole axis. Warburton Basin regional fractures have all these characteristics, thus have reservoir potential.

The regional fractures in the Warburton Basin may be caused by regional uplift, and the two systems may have been caused by two different regional stress fields, due possibly to the Benambran and Alice Springs Orogenies. The Bebambran Orogeny was responsible for mid-Palaeozoic convergent tectonism on the eastern part of the Australian continent (E-W compression) while the Alice Springs Orogeny was responsible for convergent tectonism in Central Australia (N-S compression). Timing of system I and II is difficult to determine, it is possible that system I postdates II. As observed in Gidgealpa 5 (7942') regional fracture system I (200º) displaced system II (240º); a similar case exists in Lycosa 1. It is interesting that younger fractures have much finer apertures (about 0.1-0.3 mm) than older fractures (about 10-20 mm). One of the regional fracture systems, 20-200° and 110-290° in the basin is almost parallel to NNE (G8, GD) and WNW (RD5, RD6) lineaments with less than 5° discrepancy. Sprigg (1961) believed that the lineaments were due to crustal fracture. They have been interpreted as fundamental lineaments controlling morphology of the Warburton Basin, which influenced distribution of oil and gas fields of the overlying Cooper and Eromanga Basins (Campbell and O'Driscoll, 1989). These authors also stated that the Warburton Basin was framed by the NNE and WNW continental lineaments. Interestingly, Price (1974) suggested that the two orthogonal orientations of most regional fracture sets parallel the long and short axes of any sedimentary basin due to the loading and unloading history of the rock. Supporting studies have been reported in Narr and Currie (1982) and Das Gupta and Currie (1983). If the regional fractures in the Warburton Basin are superposed over these crustal fracture lineaments, they are expected to be inherited by the Cooper Basin.

The tectonic fractures in the Warburton Basin include mainly fold and fault related fractures. Friedman (1969) used the orientation of microscopic fractures from oriented cores in the Saticoy Field of California to determine the orientation and dip of a nearby fault. There are not enough data to determine a relationship between faulting and fracturing. Only for those fractures along the fault planes or associated with small-scale thrust faults and reverse faults, can the orientation of fault movement be determined (Table 12). For other fractures associated with structural features, I can only decide their nature but not their orientations. The fractures related to folding include those associated with microfolds such as seen in Wantana 1 and Dullingari 1 (Figs. 11a, b). The fractures due to microfaults include reverse faults in Lycosa 1 (Fig. 11g) and

Table 12 *Orientations of fault-related tectonic fractures.*

Well depth (feet)	Type	Dip azimuth (degree)	Dip angle (degree)	Slickensides, tension gashes	Slickensided lineation Direction (degree)
Lycosa 1					
8793	reverse fault	171	20	no	-
8802	fracture	32	26	yes	96 (older)
	fracture	129	80	yes	133
(younger)					
8810	reverse fault	158	84	yes	146
Wantana 1					
9634'3"	reverse fault	169	60	no	-
Gidgealpa 1					
12605'	thrust fault	67	32	yes	~67
~10000'	thrust fault	155	37	no core	no core
Gidgealpa 19					
7400'	thrust fault	150	20	no core	-
Gidgealpa 7					
9069	thrust fault, associated with fault breccia	SE	no data	no data	no data
Packsaddle 1*					
10386'	thrust fault, fracture	150	60	no	
Gidgealpa 1					
11682'	slickensided surface	233	50	yes	143
Gidgealpa 5					
8391'	slickensided surface	4	65	yes	no data
7946'	slickensided surface	193	25	yes	223
8793'	? fault plane, fracture	40	5	yes	no data
Packsaddle 3					
7217'4"	slickensided surface	63	70	yes	231
Snake Hole 1					
9315'6"	slickensided surface	277	80	yes	277
Jennet 1*					
5525	slickensided surface	330	65	yes	160
Pelketa 1					
7097'6"	slickensided surface	124	40	yes	108

* assumed from relative orientation and seismic interpretation

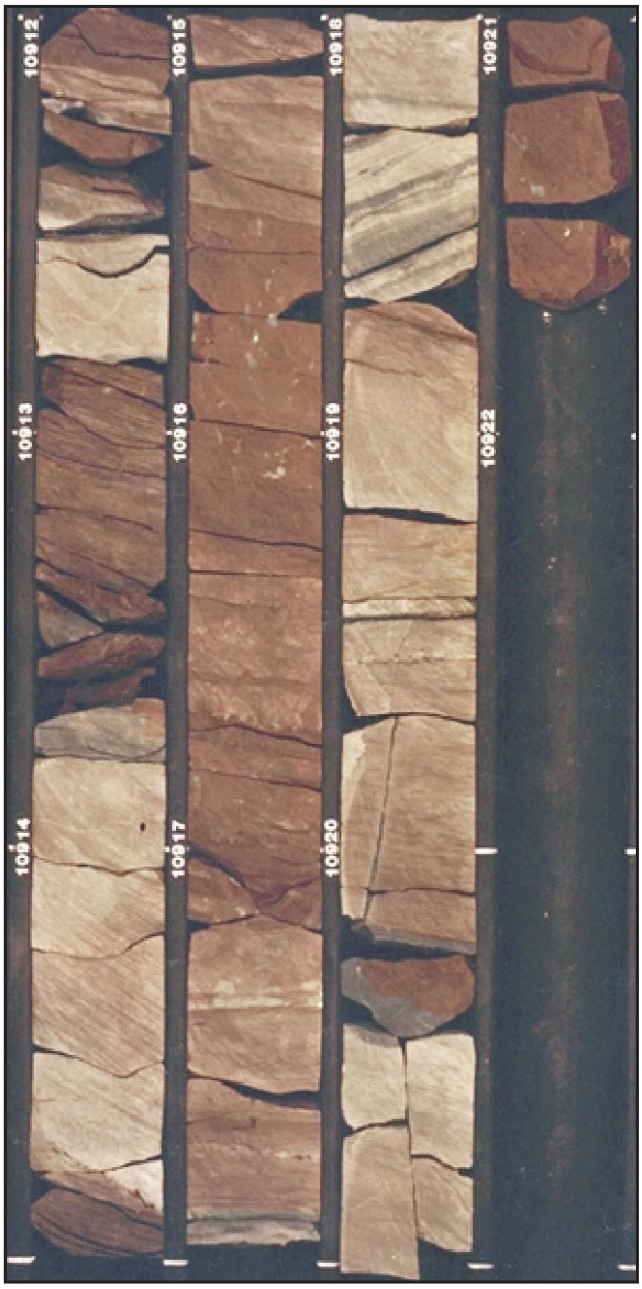

Fig. 34 *Core photo in Meranji 2, showing low grade of fracture density.*

Wantana 1 (Fig. 11f), thrust faults in Packsaddle 1 and Gidgealpa 1 (Figs. 11c, d); and normal faults in Gidgealpa 4 (Fig. 5c). A conjugate set of fractures in Lycosa 1 (Fig. 11l) possibly relates to faulting. The orientation of thrust faults and reverse faults can be determined from dipmeters and core measurement in several wells. (Table 12).

Slickensided fractures are common, and more or less superposed over regional fractures as indicated by associated thrust or reverse faults and fault breccias. Thrust faults and slickensided surfaces (Table 12) are dominantly SE dipping, and slickenside lineations are dominantly NW-SE. They indicate a NW-SE compressional regime. The GMI Ridge is believed to have overprinted the pre-existing Warburton Basin thrust belt. The GMI Ridge trends in a curve 50-60° (NE); thrust faults or reverse faults associated with it should dip 140°, 150°, 160°, depending on which compartment the faults are located in along the ridge. Amazingly, Gidgealpa 1, 5, 7, 19, fit about 140-150° dip angles; while Wantana 1 fit 169°, and Packsaddle should be 150°. Furthermore, 150° striking fractures have been measured from many wells around this domain. Therefore, the tectonic fractures are believed to overprint regional fracture system II by thrust and reverse faulting and slickensides.

The contractional fractures in the volcanics are probably due to thermal contraction, caused by volume reduction during cooling of lava. The classic example of natural thermally induced fractures is columnar jointing in fine-grained igneous rocks (Peck and Minakami, 1968). Sustained flow of oil and water of up to 1,000 bbl/day was achieved from such contractional fractures in the Tertiary basalt flows at West Rozel Field, Salt Lake, Utah (Nelson, 1985, p.24). The Jena Basalt in Murteree A1 is severely fractured, but the fractures have been mineral filled. If they were not filled, excellent fracture porosity and permeability would have had existed and may still be present at undiscovered locations.

Fracture fairway

Steeply dipping regional fractures cross the Warburton Basin and are interpreted to constitute two orthogonal sets which strike NNE/WNW and NE/NW. These directions remain the same in different structural domains at least on the drilled anticlines. Based on FMS interpretation the gas-productive open fracture system in Lycosa 1 strikes WNW and NW (Fig. 37) which leads to a conclusion that all open fractures in the region will similarly strike these two directions. However, FMS interpretation in Malgoona 4 (approx. 53 km from Lycosa) indicates a NNE-SSW open fracture strike direction in addition to the above two strike directions. Three directions of open fractures in Malgoona 4 seem unlikely and needs further study to clarify if some of them are alternatively caused by conductive minerals.

Although the regional fracture pattern does not vary across different local structural zones, the choice of which fractures are open probably does. The preferred orientation of open fractures is controlled by several factors, which include:

- superposition by tectonic structures
- reactivation through geological history
- younger tectonic movements
- present day stress state

As mentioned in the discussion on the origin of fractures, tectonic fractures are believed to be superposed over regional fracture system II as a result of thrusting and reverse faulting, and also over regional fracture system I as evidenced by slickensides. Therefore, they have potential for fluid communication after tectonic movement.

Natural fractures found in the Cooper Basin may be caused by reactivation of the old Warburton Basin thrust belt, as old faults were propagated along the crests of the GMI Ridge as observed in seismic sections (Sun, 1997). Since compression has caused reactivation several times after the Late Carboniferous, filled fractures may be re-opened due to reactivation of relatively weak zones. Furthermore, the two sets of regional fractures in the Warburton Basin are very close to two lineament networks which occur within the Cooper Basin area and recognised by Campbell and O'Driscoll (1989) and Boucher (1998b). This

further supports the commonly held opinion that the Cooper Basin structures are inherited and reactivated from underlying Warburton Basin structures.

Mesozoic wrench fault activity and Tertiary east-west compression have generated large scale strike-slip faults and folds. These structures drape over the thrust belt and fault zones of the Warburton Basin. As a result, these deformations probably created new fractures, others may have re-opened previously filled fractures of the Warburton Basin. NW-SE striking fractures of system II may be related to strike-slip wrench faults along the GMI Ridge.

From borehole breakouts Hillis *et al*. (1997) interpreted the maximum horizontal stress to be oriented approximately east-west in the Nappamerri Trough area. Any steep-dipping, east-west striking, pre-existing fractures in the Trough should thus be open and potentially productive. It is possible that natural fractures can be re-opened if they are parallel to such maximum *in situ* stress direction. Relatively few wells, Munkarie 1, Pelketa 1, Wantana 1, Yalcumma 1, Boxwood 1 and Gidgealpa 2 have close to E-W striking fractures. It is worth knowing that the interpreted maximum horizontal stress is not exactly east-west, but slightly WNW (see Hillis *et al.,* 1997, Fig. 2.2). Furthermore, in Moomba and Wantana and other areas, it varies from WNW to NW. Therefore, it is possible that WNW (110-290°) striking regional fractures could re-open due to in situ stress. This is probably the case in Lycosa 1, in which the SW dipping fractures striking WNW (110-290°) were probably previously filled by calcite but re-opened later.

Considering all the factors, the preferred orientation of open fractures probably will include in decreasing order of likelihood order: WNW trending regional fractures of system I, NW oriented fractures of system II, and possibly NNE trending fractures of system I.

Although most fractures from the studied wells are either filled with minerals or deformed with gouge-fill or slickensides, some open fractures and many partially open fractures are observed both from cores and FMS. Although more than 90 wells in the Warburton Basin have hydrocarbon shows (Sun and Gravestock, 1999), they were not tested with fractures in mind, and were not optimally drilled. With few exceptions Cooper Basin wells are not designed to test naturally fractured reservoirs either. This is similar to the situation pointed out by Aguilera (1997) as a reason why many naturally fractured petroleum reservoirs around the world have not become profitable discoveries. Many have been abandoned because of 1) incorrect pressure extrapolations, 2) poor completions, and/or 3) failure to intersect the natural fractures. For example, three vertical wells were drilled in the Dilly field's Austin Chalk unsuccessfully. As a result the lease was dropped in 1979. More recently two horizontal wells were drilled in the same general area and were successful. Another example where a vertical and a second, slightly deviated well failed to yield commercial production is in the Palm Valley gas field, Amadeus Basin. A third well was drilled as a highly deviated well from the same borehole, it produced 137 MMSCFD from naturally fractured reservoir (Fig. 38). The successful gas producer Lycosa 1 is an unusual deviated well (max. 17.9°), and its success may be due in part to the unintentional deviation.

The Palm Valley gas field fracture systems are localised, mainly tectonic fractures related to a doubly plunging anticline (Berry *et al*., 1996) whereas the fracture systems in the Warburton Basin are regional, but superposed by tectonic fractures in many localised structures essentially related to thrust and reverse faults or fault-related anticlines.

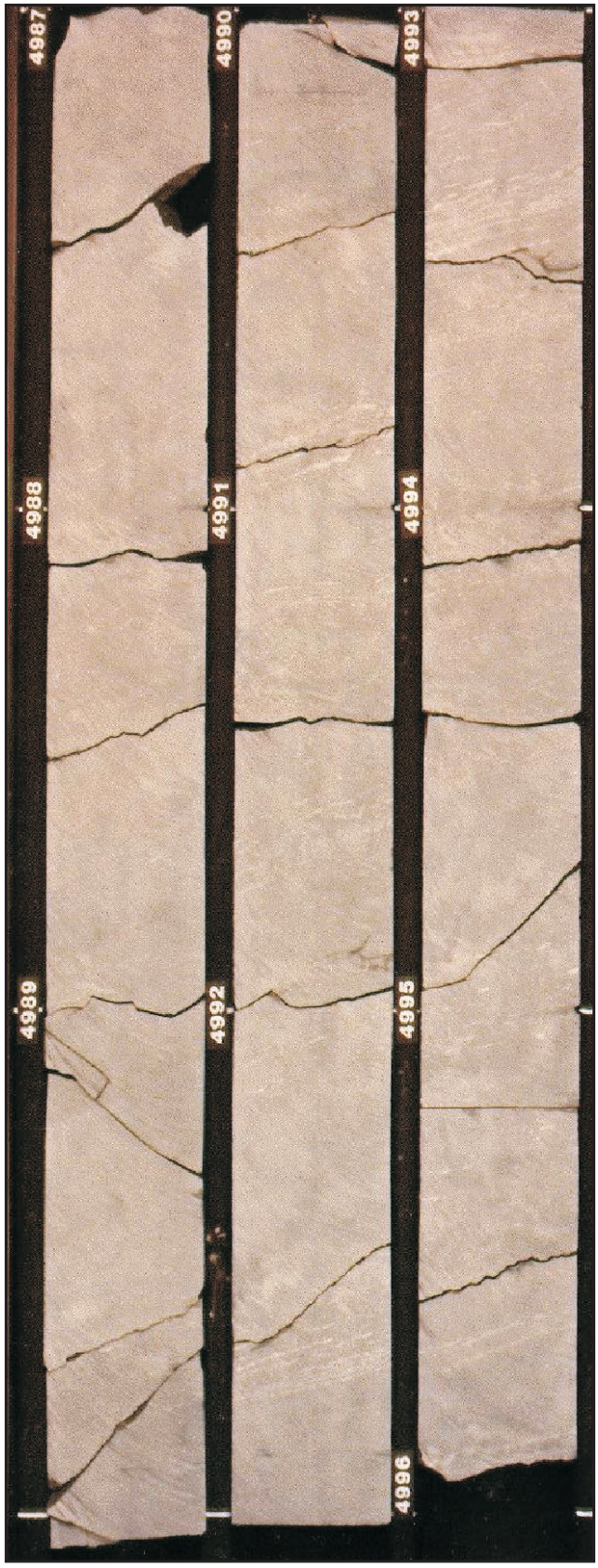

Fig. 35 *Core photo in Dunoon 1, showing nil grade of fracture density.*

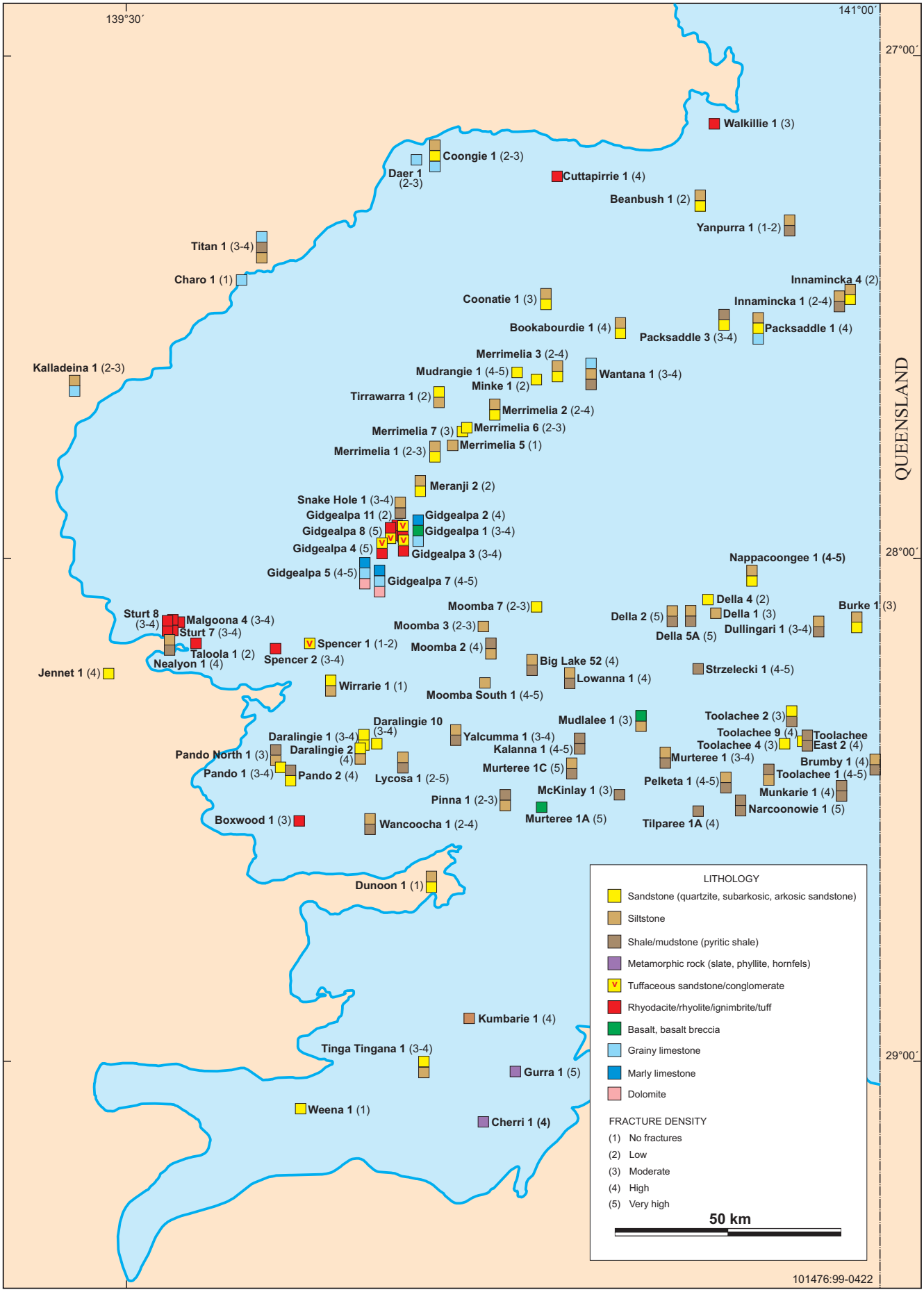

Fig. 36 *Fracture density map of the Cooper Basin with main lithologies.*

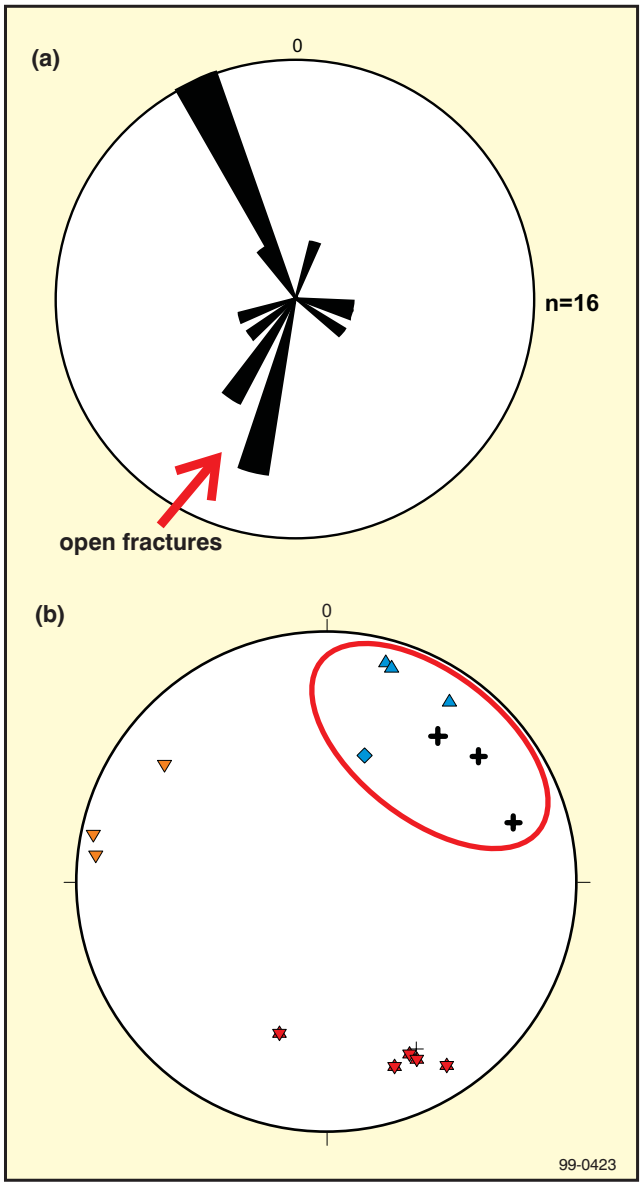

Fig. 37 *High angle fractures in Lycosa 1, including those interpreted from FMS (symbol +),*
(a) rose diagram,
(b) lower hemisphere, stereographic projections of poles to, open fractures are within red circle and dip SW.

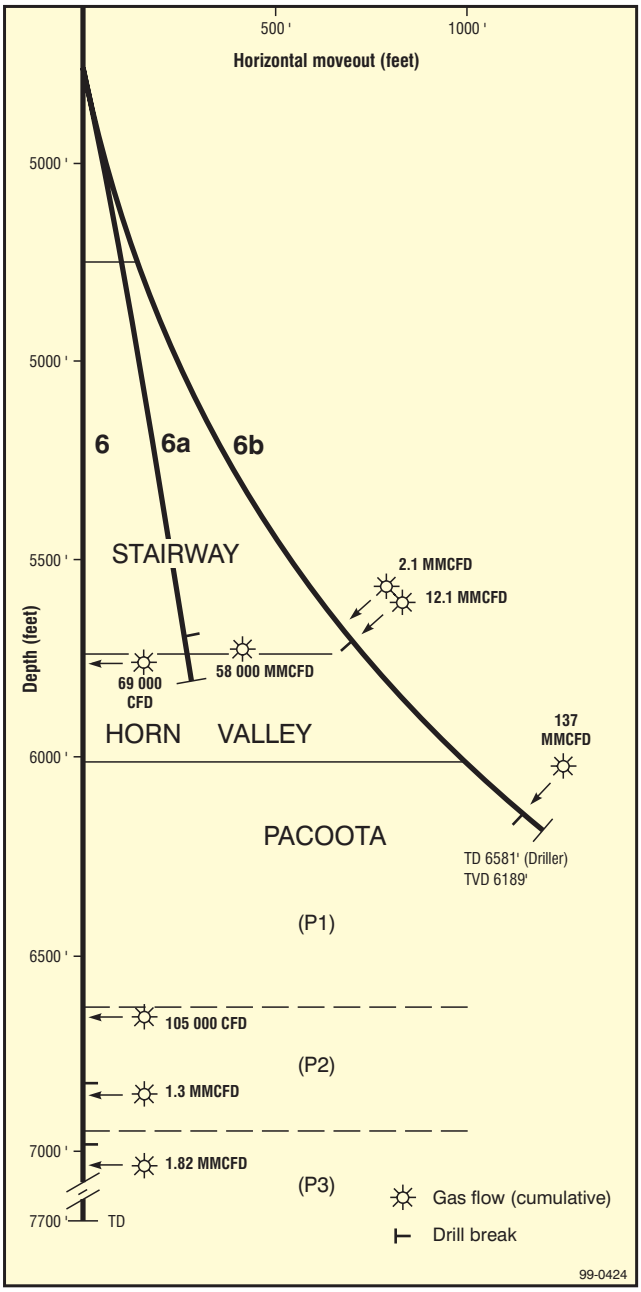

Fig. 38 *Well deviation plot – Palm Valley 6, 6a, 6b – showing location of drill breaks and cumulative gas flows. (from Aguilera, 1997).*

CONCLUSIONS AND RECOMMENDATIONS

This study is the first of its kind to characterise and analyse fracture systems in the Warburton Basin from 199 cores and wireline logs of 93 wells beneath the Cooper Basin in South Australia. Of the 93 wells, about 22 are oriented and 3 wells have FMS data, among them, Lycosa 1 has been studied intensively because it has produced gas from a fractured reservoir with the most complete data sets.

Natural fractures can be classified into contractional, regional and tectonic types. The Contractional fractures have been recognised in acid and basic volcanics. The regional high angle fractures comprise two systems of orthogonal pairs. They extend beneath and probably through the Cooper Basin in South Australia, and cross local structures. System I has a pair of orthogonal fractures, striking NNE-SSW and ESE-WNW. System II has a pair of orthogonal fracture sets, striking NE-SW and NW-SE. System I is similar in direction to low frequency lineaments NNE8 and WNW9 identified by Boucher (1998b). They are fairly close to NNE (G8, GD) and WNW (RDS, RD6) lineaments. The similarity of the regional fracture systems in the Warburton Basin and these lineaments suggests that the lineaments are related to the deep-seated fracture systems. The regional fracture pattern is useful for interpreting fractures measured from unoriented wells.

The tectonic fractures in the Warburton Basin include fractures related to mainly folds, thrust and reverse faults, and minor normal faults. From a few oriented wells, fault planes of thrust and reverse faults along the GMI Ridge dip SE, slickensides are very common and have majority orientation NW-SE. These features confirm a compressive tectonic regime interpreted from seismic and borehole breakout data. The tectonic fractures are superposed on the regional fractures.

Lithological control on fractures includes the following points. Thinly-interbedded siltstone and shale have more fractures than adjacent thick bedded sandstone mainly in the Dullingari Group. Thinly bedded brittle rocks of the Innamincka Formation including sandstone and siltstone are fractured whereas the adjacent thick ductile beds such as bioturbated micaceous mudstone are hardly fractured. Brittle dolomite and grainy limestone are also fractured and brecciated more than marly limestone of the Kalladeina Formation. Fine-grained tuff has fewer fractures than the adjacent welded ignimbrite of the Mooracoochie Volcanics.

Fracture density is not even in many wells, but varies with vertical depth. Density is controlled by structural style and structural intensity, less importantly by lithology. The greatest fracture density is associated with fault breccia, and located at fault zones or structural culminations. They are possibly caused by mainly thrust, reverse and strike-slip faults. Because this report mainly concentrates on hand specimens and some thin sections of about 20% of core specimens, it is possible that microfractures will be under-estimated. Further microscopic study is recommended.

More than 90 wells in the Warburton Basin have hydrocarbon shows, including some with drilling evidence indicating the existence of fractured reservoirs. This further encourages discovery at Warburton Basin depths. Future wells should be drilled at least 400 feet vertically into the Warburton Basin contacting Cooper Basin source rocks, and wells should be deviated approximately 30° from horizontal in the fracture zone to intersect open fractures. Proper testing for hydrocarbons in the Warburton Basin is recommended. Wireline logs should include dipmeter or FMS, especially where bedding dips are suspected to be significant.

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FRACTURE ANALYSIS OF THE EASTERN WARBURTON BASIN (EARLY PALAEOZOIC), SOUTH AUSTRALIA

Disk contains data files for Appendix 1, 2 , 3 and 4

Appendix 1

Stereon1.xls is an Excel file containing measurement data

Appendix 2

Contains StereoNett TXT files.

Nodmeter directory contains 61 files for Stereonet, rose, density and text data files for those without dipmeters.
Dipmeter directory contains 185 files for Stereonet, rose, density and text data files for those with dipmeters.

The software required to view these files is free for non-commercial use and available from the following website

http://homepage.ruhr-uni-bochum.de/Johannes.P.Duyster/stereo

Appendix 3

Fracture 1 : Excel file - basic data for wells with dipmeters
Fracture 2 : Excel file - basic data for wells without dipmeters

Appendix 4

Excel file : 45 mean high angle fracture strike data of absolute measurement and plots

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	**Well**	**depth**	**KIND**	**No.**	**Marks**	**Azimu**		**Dip**	**assumed**	**reasons**	**dipmeter**	**Comment**	**chronology**	**fill**	**Deviation**	**Dev Azi**	**Dipmeter**	**file names**
2									**dip azi.**		**log**						**picks (WCR)**	
3	**Boxwood 1**	6332	bedding	1	green	0	**63**	60-65			**6220-6250**	bedding						
4			frac(1)	2	red	170	60				**24-30NW326**	fracture						
5			frac(2)	3	blue	126	80				**? factures, fault**	fracture						
6			frac(3)	4	green	42	**55**	50-60			**6280-6326**	fracture						
7			frac(4)	5	green	25	**63**	60-65			**20-32SE137-170**	fracture						
8																		
9		6339	bedding		green	0	**47**	45-50				bedding						
10					purple	105		low			**?bedding**	low angle fracture						
11			fault plane		no plastic			70			**36 SWS195**	fault plane, can be discontinuous						
12			fracture				**12**	10-15			**? Fracture**	oblique to the fault plane, low angle fracture		brownish, ?				
13		6338	bedding		no plastic		**47**	45-50										
14			fault plane				**80**	70-90				similar fault, but steeper,						
15			slickenside				**30**					along fault plane, crosscut bedding plane		calcite + chlorite?				
16		6155-6154'6"	bedding		no plastic							ignimbrite, possible bedding 10-15dg						
17			fault plane		no plastic		**63**	60-70				60 dg to 70, shear plane?		filled by kaolinite				
18																		
19																		
20	**Daralingie 1**	c2, 7420'	bedding	1	green	0	**67**	65-70			**missing**	bedding, quartzose sandstone						
21			frac(1)	2	blue	224		65				high angle fracture		brownish, ?				
22			frac(2)	3	red	285		70				high angle fracture		0.1-0.2mm, yellow, ? still open				
23			frac(3)	4	red	315		25										
24																		
25	**Della 1**	7123	bedding	1	green	0	42				**CDM**							
26			frac(1)	2	yellow	60	80				**SE 20dg**	high angle fracture		0.05mm, black?				
27			frac (2)	3	yellow	60	72					high angle fracture						
28		7124	bedding	1	green	0	55					lineation of bedding, not sure						
29			frac(1)	2	yellow	88	88					high angle fracture						
30			frac (2)	3	yellow	90	82					high angle fracture						
31																		
32	**Dullingari 1**	9210'6"	bedding	1	green	0	**60**	60	27	should be opposite		bedding						
33			frac(1)	2	blue	46	**81**	81		deviated direction		high angle fracture,		0.2mm, ? Dolo.				
34			frac(2)	3	purple	236-56	**87**	85-90		S27W, 1dg.		? Induced curved, open frac, changing dip						
35		9198'-2"	bedding	1	green	0	**60**	60	27	should be opposite								
36			frac(1)	2	brown	180	**20**	20		deviated direction				0.2-1mm, ? Dol.				
37			frac(2)	3	black	27	**55**	55		S27W, 1dg.		? Induced,		< 0.1mm				
38		9198'-2"	bedding	1	green	0		?										
39			frac(1)	2	blue	162		?										
40		9669'2"	bedding									sandstone, bedding, not sure						
41			frac(1)	1	blue	0	**85**	80-90										
42			frac(2)	2	yellow	163	**62**	62										
43			frac(3)	3	purple	122	**61**	60-62				? stylolite, possible bedding						
44			frac(4)	4	orange	113	**43**	43										
45			frac(5)	5	yellow	326		30-35				veinlet						
46		9802'4	bedding	1	green	0						not apparent						
47		not exact	frac(1)	2	brown	90		83						pyrite				
48		cut 90	frac(2)	3	orange	297		30										
49		10143'-5"	bedding	1	green	0		?				not recorded						
50			frac(1)	2	orange	334		?				not recorded						
51			frac(2)	3	blue	190		60										
52																		
53	**Gidgealpa 1**	12605	bedding	1	no plastic	0		25				bedding						
54			thrust fault	2				30-35				thrust fault plane						
55			fracture	3				60				fracture		0.2-0.5mm, calcite				
56		11682	bedding	1	green	0	**32**	30-35							7 max			
57			frac(1)	2	purple	173		55				important		3mm, calcite				
58			frac (2)	3	red	210		70				not important						
59			frac (3)	4	red	195		50				hairline, 0.2mm		0.2mm, calcite				
60			frac (4)	5	yellow	130		45				very fine, vague fracture						
61			slicke. surf	6	yellow	165		50				slickenside surface						
62			slickenside	7	black	75-255						slickenside lineation						
63																		
64		10833	bedding	1	green	0		30										
65			frac(1)	2	purple	180		80				fracture, displaced bedding		0.8mm, calcite				
66			frac (2)	3	brown	138		35				microfault replacement		0.2mm, calcite				
67																		
68		-10491	bedding		green	0						no apparent bedding						
69			frac(1)	1	purple	0		55				coarser fracture	2 cut 1	quartz				
70			frac (2)	2	brown	135		55				fracture		quartz				
71																		
72		9424'8"	bedding	1	green	0	**32**	30-35				bedding not sure;						
73			frac(1)	2	purple	280		65				coarse fracture		2mm, calcite				
74			frac (2)	3	blue	246		60				fracture		1mm, calcite				
75																		
76	**Gidgealpa 2**	6890'3"	bedding	1	green	0		25				bedding?						
77			frac(1)	2	blue	138		70				fracture,		0.1mm; hematite?				
78			frac(2)	3	blue	105		80				fracture,						
79																		
80		6898' 3/4"	bedding	1	green	not sure		low angle				bedding?						
81			frac(1)	2	brown	0	**50**	40-60				fracture,		? Brown , hematite				
82			frac(2)	3	orange	211	40	40				fracture,		lining, hematite,				
83			frac(3)	4	red	120	**21**	20-22				fracture,		sider or hemat.				
84																		
85		6910'	bedding	1	green	0	25	25				bedding?						
86			frac(1)	2	blue	168	68	68				fracture,		0.5mm; ? Kaolinite				
87			frac(3)	4	blue	162	70	70				fracture,						
88			frac(4)	5	blue	178	60	60				fracture,		0.2mm; brown, ? Clay				
89																		
90		7275'	bedding	1	green	0	20	20				bedding?		calcite				
91			frac(1)	2	blue	157	60	60				fracture,		calcite				
92																		
93		7276	bedding	1	green	0	30	30				? Bedding						
94			frac(1)	2	blue	238	65	65				fracture,		0.5-0.8mm;calcite				
95			frac(?1)	3	blue	219	70	70				fracture,		0.2-0.3mm;calcite				
96			frac(2)	4	blue	51	60	60				fracture,		0.2mm; calcite				
97			frac(3)	5	red	234	60	60				fracture,		calcite				
98		7917	fra(1)	1	red	0	35	35	280	dmeter:N80W:37		fracture,		0.2-0.3mm;calcite				g279176.txt
99			frac(2)	2	blue	238	70	70				fracture,		0.8mm; calcite				previous mea.
100																		
101		7917'6"	fra(1)	1	orange	0	40	40				fracture		0.1mm, calcite				
102			frac(2)	2	brown	146	72	72				fracture		0.4mm, calcite				
103			frac(3)	3	blue	248	85	85				fracture		0.1mm, calcite				
104																		
105	**Gidgealpa 3**	9736'3.5"	fra(1)	1	blue	0	**82**	80-85				fracture		calcite(1.5mm), pyrite+gre.clay				
106			frac(2)	2	red	115		85				fracture		3mm, calcite+ breccia				
107			frac(3)	3	brown	145		85				fracture		<0.1mm, calcite				
108			? Frac(3)	4	brown	127		85				fracture		0.1mm, calcite				
109			? Frac(3)	5	brown	140		85				fracture		0.1mm, calcite				
110																		
111		10156'	frac(1)	1	blue	0		77				fracture		0.8mm, calcite				
112			frac(2)	2	red	200		89				fracture		0.2mm, calcite				
113																		
114		10156'10"	frac(1)	1	blue	0		80	124	10144':S56E:26		fracture		0.8mm, calcite, breccia				
115			frac(2)	2	brown	357	**78**	78-79		but angle too low		fracture, possibly the same as the above		0.4mm, calcite				
116			frac(3)	3	red	146		82				fracture		0.2mm, calcite				
117			frac(4)	4	red	253		79				fracture		0.1mm, calcite				
118																		
119		10597'	fract(1)	3	brown	0		50	136	10624':S44E:21		fracture		0.15mm, calcite				
120			fract(2)	1	blue	130		85				fracture		0.2mm, calcite				
121			fract(3)	2	blue	130		85				the same as the above		0.1mm, calcite				
122																		
123		10599'	frac(1)	1	blue	0		80				fracture		0.7mm, calcite				
124			fract(2)	2	blue	8		75				? the same as the above		0.4mm, calcite				
125			fract(3)	3	blue	8		73				? the same as the above		<0.1mm, calcite				
126			frac(4)	4	blue	20		60				? the same as the above		0.5mm, calcite				
127			frac(5)	5	brown	340		85				offset by blue		0.1-0.2mm, calcite				
128		10929' 7.5"	frac(1)	1	brown	0	**82**	80-85				offset blue by (0.5-0.9mm)		calcite				
129			frac(2)	2	blue	290		66				relatively straight, most sinuous, ? Unloading fr?		c0.1-0.2mm, calcite				
130			frac(3)	3	red	295		80				from 0.2mm to 1.2mm (partially)		calcite				
131																		
132		10934'	frac(1)	1	blue	0		20				sinuous						
133			fract(2)	2	brown	21		30				fracture						
134																		
135		11423	bedding	1	green	0		35				bedding						
136			frac(1)	2	blue	118		80				fracture		calcite				
137			frac(1)	3	blue	101		85				fracture		calcite				
138																		
139	**Gidgealpa 5**	c23, 7630'	bedding	1	green	0	**17**	15-20				bedding						
140					blue	250		76				fine fracture		calcite				
141																		
142		c24, 7942'	bedding	1	green	0		45										
143			frac(3)	2	yellow	132		50				fracture		calcite				
144			frac(3)	4	yellow	140		60				the same as the above		calcite				
145			frac(4)	5	blue	280		55				displace the above		calcite				
146																		
147		7946'	bedding	1	green	0	**37**	35-40				bedding, emphasised by stylolite, cal.mud			not much			
148																		
149			frac(1)	2	purple	225		65				coarse fracture, upto 10mm	cut by fra(2)	calcite, min. cataclasts of surrou. ls	< 5dg			
150			frac(2)	3	green	0	**37**	35-40				medium fracture, upto 3mm		calcite				
151	**bedding dip**		frac(3)	4	yellow	110		65				fine fracture, up to 1mm; para. tension crack	cut by fra(2)	calcite				
152	**S14W**											v-shaped tension gashes between "mud" layers, filled by 'mud' and breccia; obliquely cut by frac(1)						
153			frac(4)	5	yellow	315		65				fine fracture, up to 1mm; obliq tension crack	cut by fra(2)	calcite, connected with stylolite seam				
154			slickenside	6	black	15 NE-SW	**37**	35-40				along undulated bedding plane or stylolite	cut every thing					
155		7946'																
156		new measure	bedding	1	green	0		25				bedding, bioclastic packstone						
157			frac(1)	2	blue	235		65				fracture,		up to 4mm, calcite & m. matrix				
158			frac(2)	3	black	30		30				fracture, displace the above		up to 2mm, calcite + m. matrix				
159			frac(3)	4	red	300		60				fine fracture, between the above vein fill & m. bed.		0.2mm, calcite				
160			frac(3)	5	red	98		60				fine fracture, between the above vein fill & m. bed.		0.1mm, calcite				
161			slickenside	6	black	30		25				slickenside lineation from adjacent						
162																		
163		c25, 8122'3"	bedding	1	green	0		30				possible, due to dolomitization						
164			frac(1)	2	blue	205		70				fine fracture						
165			frac(1)	3	blue	210		68				fine fracture						
166			frac(2)	4	yellow	280		70				irregular, ? Induced						
167			frac(3)	5	brown	320	**57**	55-60				projected from 1" below also irregular		? Open,				
168														? Microspar+py.				
169		c26, 8391'6"	bedding	1	green	0		22				bedding						
170			frac(1)	2	brown	160		65				slickenside surface, 0.1mm		hematite				
171																		
172		c27, 8708'	bedding	1	green	0		55				lava banding?						
173			frac(1)	2	purple	170		80				coarse fracture		calcite				
174			frac(1)	3	purple	165		65				coarse fracture		calcite				
175			frac(2)	4	orange	280		85				in fine sst		calcite				
176			frac(3)	5	brown	240	**76**	75-78				fine fracture	brown cut purple	calcite				
177																		
178		c27, 8793'	bedding	1	green	0		35				bedding						
179			frac(1)	2	orange	217		67				fracture						
180			frac(2)	3	blue	115	**79**	78-80				fracture						
181			frac(3)	4		S or SE ~ 190	**5**	0-10				fracture or fault pla., + slicken.						
182		second	frac(1)	2	blue	220		65				fracture						
183		measure	fra(2)	3	yellow	240	**67**	60-70				should = frac(1), blue		? Dolom, pyrite				
184																		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
185	**Gidgealpa 7**	10573	bedding	1	green	0	**23**	20-25				bedding, not exact (cut not 90 to axis)						
186			fract	2	red	233		40				fracture		0.2mm, calcite				
187	**S31E**	9995	bedding	1	green	0		20				bedding						
188			fract	2	red	85		85				fracture		1mm, calcite				
189		8074 (a)	bedding (b)	1	green	0		10				bedding (a)						
190			fract(1a)	2	red	90	**45**	40-50				?hair line fracture						
191			fract(2a)	3	blue	123		70				hairline fracture		calcite				
192		8074(b)	bedding (a)	1	green	0		10				bedding (b)						
193			fract(1b)	2	red	155	**43**	40-50				?hair line fracture						
194			fract(2b)	3	blue	180		70				hairline fract, up 3cm becomes 80		calcite				
195		7709	bedding	1	green	0		10?										
196			fract	2	red	160	**73**	70-75				calcite filled fracture		0.1-0.2mm, cal				
197																		
198	**Inammincka 1**	71993"	bedding	1	green	0	**17**	15-20				bedding						
199			frac(1)	2	blue	107		85				fracture						
200																		
201		11424'	bedding	1	green	0		?30				bedding						
202			fract1)	2	blue	73		76				fracture		1.5mm				
203			fract(1)?	3	blue	68		80				fracture		1mm				
204			frac(2)	4	blue	105		80				fracture		1.4mm				
205																		
206		11444'	bedding	1	green	0	**31**	30-32				bedding						
207			fract1)	2	blue	218		50				fracture						
208			frac(2)	3	blue	180		68				fracture						
209			frac(3)	4	blue	150		30				fracture						
210		11458	bedding	1	green	0		31				bedding? With heavies lining up						
211			frac(1)	1	blue	235		80				fracture		2mm; calcite				
212																		
213		11462	bedding	1	green	0		30				bedding						
214			frac(1)	2	blue	108		60				fracture		calcite; 0.6mm				
215			frac(2)	3	blue	90		88				fracture		Calcite; 0.2mm				
216																		
217		11465	bedding	1	green	0		33				bedding,						
218			frac(1)	2	blue	220		60				fracture		1.2mm, calcite				
219			frac(2)	3	blue	260		60				fracture		5-7mm, calcite				
220																		
221		11467'6"	bedding	1	green	0		30				bedding,						
222			frac(1)	2	blue	256		86				fracture		1.5mm,				
223			frac(2)	2	brown	141		55				fracture		1mm, calcite				
224																		
225		11553	bedding	1	green	0		36				bedding,						
226			frac(1)	2	blue	70		69				fracture		0.7mm				
227			frac(2)	3	blue	72		65				fracture		0.4mm				
228																		
229		11561'2"	bedding	1	green	0		22				bedding						
230			frac(1)	2	blue	133		78				fracture		0.5mm, calcite				
231																		
232		12070'7"	bedding	1	green	0		38				bedding						
233			frac(1)	2	blue	223		45				fracture		0.6-0.7mm, calcite				
234			frac(2)	3	blue	104		54				fracture		1mm, calcite + catac.				
235																		
236	**Lycosa 1**	8793'	bedding	1	green	0		35	339	8803.54		bedding, siltstone and shale			15.4	176		
237			frac(1)	2	orange	217		67		339 / 17.5		fracture		calcite				
238	**logger 10' deeper**		frac(2)	3	blue	115		80		dev. 176 / 15.4		fracture		partially calcite				
239	**than driller**	second	frac(1)	4	blue	220		65				fracture		partially calcite				
240	**so core measurements**	measure	fra(2)	5	yellow	240	**65**	60-70: 65				should = frac(1), blue		? dolom, pyrite				
241	**should add 10'**		frac(3)	6	orange	120		80				= red, fine fract., open; cut blue.		calcite				
242			fault plane	7	red	180		5				fracture or fault pla., + slicken.			15.4	176		
243		8798	bedding	1	green	0	**57**	55-60		8811		bedding, siltstone and shale						
244			frac(1)	2	black	207	**12**	10-15		10 / 41.8		fine, low-angled calcite veinlet	1	calcite				
245			fra(2)	3	black	0 to 6	**67**	60-70		dev. 177 / 15.6		coarse, high angle, calcite and ?siderite vein	2	2-5mm				
246																		
247		8799' - 4"	bedding	1	no plastic	0		60		as above		bedding, siltstone and shale			15.4	176		
248			frac(1)	1	no plastic	~ 0	**77**	75-80				open fracture, ? Induced, disconti.						
249																		
250		8801	bedding	1	green	0	**52**	50-55		as above		bedding, siltstone and shale			15.6	177		
251			frac(1)	2	purple	180	**17**	15-20				v. fine, low-angled, cut frac(1)		? siderite				
252			fra(2)	3	purple	302		?				v fine, 0.1mm;		? siderite				
253			frac(3)	4	red	110		60				displace bedding; 0.1-0.8mm,		calcite				
254																		
255		8802 - 3"	bedding	1	simple	0		55		as above		bedding, siltstone and shale			15.6	177		
256			frac(1)	2	plastic	116		70				slickenside and calcite, up to 1cm		calcite				
257			slickenside	3		100-280						slickenside lineation						
258			frac(2)	4		10		40				up to 1mm						
259			slickenside	5		120-300						slickenside lineation						
260		8803	bedding	1	no plastic	0		not mesure		as above		bedding, siltstone and shale			15.7	177		
261			frac(1)	2	no plastic	~ 0		not mesure				calcite vein, up to 2.5cm, intercrystal. Pore		calcite				
262			slickenside	3	no plastic	not measure		not mesure										
263																		
264		8805	frac(1)	1	no plastic	120		80				high angle fracture		calcite	15.7	177		
265		8806	bedding	1	no plastic	0	**57**	55-60		as above		bedding, siltstone and shale			15.8	177		
266			frac(1)	2	no plastic	~ 0		~90				up to 1mm		calcite				
267			frac(2)	3	no plastic	~ 180						low-angle fracture, filled by up to 0.5mm		? siderite				
268																		
269		8806' 5"	bedding	1	green	0		55		8816.31		bedding			15.8	177		
270			frac(1)	2	yellow	37	**12**	10-20		6 / 61.9		fracture	1					
271			frac(2)	3	blue	330		80		dev. 177 / 15.8		fracture	2					
272			fra(3)	4	red	197	**15**	10-20				slickenside surface	3					
273			lineation	5	purple	65-248						slickenside lineation						
274																		
275		8806' 5"	bedding	1	green	0		60		8816.31		bedding, siltstone and shale			15.8	177		
276			frac(1)	2	blue	335	**82**	80-85		6 / 61.9		fracture	2					
277			frac(2)	3	yellow	42		15		dev. 177 / 15.8		low-angle, fracture filled by yellow, ? dolo.	1					
278			frac(3)	4	purple	200		30				open						
279																		
280		8807' 6"	bedding	1	no plastic	0		60				bedding, siltstone and shale			15.8	177		
281			frac(1)	2	no plastic	~ 180		40				low-angle fracture						
282		8808' 7"	bedding	1	no plastic	0		60				bedding, siltstone and shale						
283			frac(1)	2	no plastic	~ 180		25				low-angle fracture						
284		8809' 5"	bedding	1	no plastic	0		50				bedding, siltstone and shale			15.9	176		
285			frac(1)	2	no plastic	~ 180		25				low-angle fracture						
286																		
287		8810	bedding	1	green	0		60		8819.81		bedding, siltstone and shale			15.9	176		
288		correct	frac(1)	2	red	338		40		357 / 70.4		x-cut tension gashes						
289			frac(2)	3	green	160	**69**	68-70		dev. 176 / 15.9		slickenside surface						
290			lineation		green	310-130						lineation of slickenside						
291																		
292		8810'2"	bedding	1	green	0	**63**	60-65		as above		bedding, siltstone and shale			15.9	176		
293			frac(1)	2	red	322	**25**	? 20-30				tension gashes						
294			frac(2)	3	blue	155	**77**	75-80				?slickenside surface						
295			frac(3)	4	purple	321	**22**	20-30				slickenside cut by blue slickenside						
296			frac(4)	5	red	335		20				?tension gashes connected with blue slicen.						
297																		
298		8810'2"	bedding	1	green	0		60		as above		bedding, siltstone and shale			15.9	176		
299		second	frac(1)	2	red	322	**25**	? 20-30				tension gashes: short to long, gentle to step-like						
300		measure.	frac(1)	3	red	321	**25**	?20-30				tension gashes						
301			frac(1)	4	red	330	**25**	?20-30				tension gashes, up to 4mm						
302			frac(2)	5	blue	156		70				slickenside surface, vague						
303																		
304		8811' ?7-11"	bedding	1	green	0		50		8821.31		bedding, siltstone and shale			15.9	176		
305		not present	frac(1)	2	red	333	**87**	85-90		355 / 56		calcite veinlet 1-6mm		calcite				
306		core slab	frac(2)	3	red	335	**82**	80-85		dev. 176 / 15.9		slickenside surface						
307																		
308		8811' 7"	bedding	1	green	0		40		as above		bedding, siltstone and shale			15.9	176		
309			frac(1)	2	purple	339	**82**	80-85				calcite veinlet: 1-6mm		calcite				
310			frac(2)	3	purple	341		80				slickenside surface						
311			lineation	4	black	335-155						slickenside lineation						
312																		
313	**Merrimelia 6**	7441'6"-7442	bedding	1	green	0	**13**	12-15				bedding, quartzose sandstone.						
314			frac(1)	2	black	130	**87**	85-90						filled by calcite				
315			frac(2)	3	red	106	**87**	85-90						filled by calcite				
316			frac(3)	4	red	270		?				No dip recorded		filled by calcite				
317	**Merrimelia 7**	7445'4"	bedding	1	green	0		14										
318			frac(1)	2	black	234		70				? Induced fracture		? Clay				
319			frac(2)	3	black	258		80				parallel to the above						
320			frac(3)	4	black	240		80				parallel to the above						
321		7445	bedding	1	green	0		15										
322			frac(1)	2	black	247		80				filled by 2 kinds of crystals		two kinds of crystals				
323			frac(2)	3	black	67		75				strike as same as the above, but dip opposite						
324												not sure from plastic						
325		7451	bedding	1	green	0		25										
326			frac(1)	2	black	165	**80**	75-85						0.2-0.3mm; crystals				
327			frac(2)	3	black	140		80						0.3mm; clay?				
328																		
329	**Moomba 2**	c3, 9847'	bedding	1	green	0		?20				possible bedding						
330			frac(1)	2	blue	20	**85**	80-90				high angle fracture, 0.4mm (open)		partially filled with silica+calcite				
331	**20 W**		frac(2)	3	red	horizontal		0				@ ? Fault plane		0.6mm or > filled				
332		9837										65-70, fracture filled						
333		8914						30				open or partially filled, random breccia, but still		filled with yellow, ?				
334												fit like after cracking.						
335																		
336																		
337	**Mudrangie 1**	10448'6"	bedding	1	green	330		40				bedding						
338			fracture	2	blue	240		80				fracture, high angle		0.1-0.3mm	brown?			
339			fracture	3	orange	178		30				fracture		0.1-0.3mm	brown?			
340			fracture	4	orange	36		40				fracture		0.1-0.3mm	brown?			
341			fracture	5	brown	13		35				fracture		0.1-0.3mm	brown?			
342		10449	bedding	1	green	330		42				bedding						
343			fracture	2	blue	120		48				fracture, high angle		<0.3mm	brown?			
344			fracture	3	orange	311		45				fracture		<0.3mm	brown?			
345																		
346																		
347	**Munkarie 1**	c2,7692'-6"	bedding	1	green	0		80	188	dominated SW		bedding					useless	
348			frac(1)	2	blue	352		80				high angle fracture		pyrite + ?			see WCR	
349	2°	? 80	frac(2)	3	brown	330		70				high angle fracture						
350	directional	due to folding	frac(3)	4	yellow	270		72				high angle fracture						
351			frac(4)	5	yellow (s)	330		80				short, discontinuous						
352																		
353																		
354	**Murteree 1**	c4, 722	bedding	1	green	0		50-55				bedding						
355			frac(1)	2	blue	210		60				fracture		calcite				
356			frac(2)	3	brown	150		70				very fine	frac (3) cut	pyrite				
357			frac(3)	4	yellow	15		85				fracture	by fract(1)	calcite				
358																		
359	**Nappacoongie 1**	6706	bedding	1	green	0		75				bedding not sure						
360			frac(1)	2	orange	270		73										
361			frac(2)	3	orange	31		63										
362			frac(3)	4	brown	133		90										
363																		
364	**Packsaddle 3**	7233	bedding	1	green	0		50	240			bedding						
365			frac(1)	2	brown	358		80				slickenside dipping surface						
366			slic. line.	3	brown	27-207		80				slickenside lineation						
367																		
368																		
369		7209'4"	bedding	1	green	0		50	243			bedding						
370			frac(1)	2	blue	91		85				fracture		0.1-0.2mm, ? siderite				
371																		
372		7217'4"	bedding	1	green	0		40	243			bedding						
373			frac(1)	2	brown	180		70				slickenside dipping surface						
374			slic. line.	3	brown	348-168		70				slickenside lineation						
375		7217'4"	bedding	1	green	0		46				bedding						
376			frac(1)	2	blue	94		35				fracture		0.9mm, authi. Qtz, (1mm)				
377																		
378																		
379		7227	bedding	1	green	0		51	208			bedding						
380			frac(1)	2	blue	85		50				fracture						
381			?frac(1)	3	blue	82		65				fracture		0.5mm, hemetite or sider?				
382																		
383	**Pelketa**	7102	bedding	1	green	0		45				bedding						
384			frac(1)	2	brown	355		45				fracture		<2mm, siderite				
385			frac(2)	3	blue	332		40				fracture		0.8mm, siderite				
386																		
387		7105	bedding	1	green	0		35-40				bedding						
388			frac(1)	2	brown	358		40				fracture		1mm, siderite				
389			frac(2)	3	blue	214		25				fracture		0.4mm, siderite				
390																		
391		7107'4"-9"	bedding	1	green	0		40			(WCR): 40-45 to E	bedding						
392			frac(1)	2	brown	3		34				fracture		0.9mm, siderite				
393			frac(2)	3	brown	228		20				branches of fracture 1						
394			frac(3)	4	brown	14		?				fracture		0.2mm, siderite				
395																		
396		7105'-7"-7106	bedding	1	green	0		30				bedding						
397			frac(1)	2	brown	306		80				fracture		0.2mm, ? + siderite "stitches"				
398			frac(2)	3	brown	108		60				fracture		0.3mm, ? + siderite "stitches"				
399			frac(3)	4	brown	46		52				branches of fracture 2		0.3mm, ? + siderite "stitches"				
400																		
401		7097'6"	bedding	1	green	0		40				bedding						
402			frac(1)	2	brown	358		40				fracture		0.4-1mm, siderite				
403			frac(2)	3	brown	34		40				slickenside surface		0.2-0.8mm, siderite				
404			frac(3)	4	brown	18-198		40				slickenside lineation						
405																		
406	**Pinna 1**	c3, 8565'	bedding	1	green	0		68				bedding						
407			frac(1)	2	brown	340		80				high angle fracture						
408			frac(2)	3	brown	160		70				frac (1) & (2) ? same phase						
409																		
410	**Snake Hole 1**	9313'10"	bedding	1	green	0		0	294	294 / 13		bedding						
411			frac(1)	2	purple	345		85		new file: 9313r		fracture		calcite & green clay				
412			frac (2)	3	yellow			90				fracture, strike 350-170; no dip		calcite (0.6mm)				
413		9315-6"	bedding	1	green	0		0				bedding						
414			slickenside	2	orange	343		80				NW and SE (if bedding is N), green clay at surface						
415																		
416		9317	frac (2)									fracture, not traced		calcite	5.5			
417		9326	bedding									interpreted from dipmeter						
418	**Toolachee 9**	7802	bedding	1	green	0	**63**	60-65				bedding						
419			frac(1)	2	orange	210		30				fracture						
420			frac(2)	3	purple	318		80				fracture						
421			frac(3)	4	brown	0	**81**	80-82				fracture						
422	**Wantana 1**	9634'3"	bedding	1	green	0		20				bedding						
423			frac(1)	2	blue	150		60				fracture						
424			frac(2)	3	blue	180		50				branched from frac(1)						
425			frac(3)	4	yellow	0		40										
426			frac(4)	5	red	180		25										
427		5cm below	frac(5)	6	brown	167		60				calcite-filled fracture						
428	**Yalcumma 1**	9790'5"	bedding	1	green	0		70	150	dominated in		bedding					HDT	
429			frac (1)	2	yellow	22		70		dipmeter		fracture		white, ?kaolinite, displaced bedding				
430			frac (2)	3	black	192		60				fracture		?				
431			frac (2)	4	black	192		55				fracture, 2mm below						
432			lineation	5	red	0		70				slickenside lineation along bedding						

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
433												after filled with white ? minerals.						

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
434																		
435	**No dipmeters**																	
436	**Big Lake 52**	9487'8"	bedding	1	green	0		70				bedding, siltstone						
437			frac(1)	2	purple	180		50				hair line, shear quartz vein		brown, ?				
438			frac(2)	3	orange			90				strike parallel to bedding						
439			frac(3)	4								155-335 strike, dip not sure; displace bedding						
440			frac(4)	5								18-198 strike, same as frac(3), both displaced by frac(1) and (2)						
441																		
442	**Brumby 1**	7710	bedding	1	green	0		25										
443			frac(1)	2	blue	265		55										
444			frac(2)	3	blue	0		45										
445		7709	bedding	1	green	0		25										
446			frac(1)	2	blue	343		40										
447			frac(2)	3	blue	180		60										
448	**Cherri 1**	4592	bedding	1	green	0	**47**	45-50										
449			frac(1)	2	purple	175	**83**	80-85				reliable		0.2mm				
450		4588	bedding	1	green	0		50										
451			frac(1)	2	purple	260	**79**	78-80										
452			frac(2)	3	brown	210		65										
453		4582	bedding	1	green	0		50										
454			frac(1)	2	red	160		75										
455			frac(2)	3	red	160		65				veinlet, coarser than the above						
456												slowly acid reactive						
457	**Daer 1**	10634'4"	bedding	1	green	0		20				bedding, grainstone						
458			frac(1)	2	blue	314		80				high angle fracture		0.8mm, calcite				
459			frac(1)	3	blue	304		72				high angle fracture		0.2mm, calcite				
460			frac(1)	4	blue	300		60				high angle fracture		0.6mm, calcite				
461																		
462		10636'8"-10637'	bedding	1	green	0		25				bedding, grainstone						
463			frac(1)	2	blue	272		10				low angle fracture		2mm, calcite				
464			slickenside	3	blue	318		31				slickenside surface		0.8mm, calcite				
465			lineation		brown	95-275						slickenside lineation						
466																		
467	**Della 2**	7219	bedding						270	domal, flanking W		not measured						
468		2cm	frac(1)	1	purple	0		40				assume to N		0.2mm				
469		below	frac (2)	2	yellow	340		85				meshwork		0.1mm				
470		the next	frac(3)	3	orange	227		65				fracture		0.1mm				
471		measurement	frac(4)	4	brown	168		80				veinlet		2mm				
472		7219	frac(1)	1	purple	0		50				assume to N						
473			frac (2)	2	yellow	120		85				fracture						
474			frac(3)	3	brown	163		70				fracture						
475																		
476	**Gidgealpa 8**	7117'5"	frac(1)	1	brown	0		40				fracture assumed to N		0.8mm, siderite				
477			frac (2)	2	brown	18		60				fracture		2mm, siderite				
478																		
479		7117'10"-7118'	frac(1)	1	brown	0		60				fracture assumed to N		1-5mm, calcite				
480			frac (2)	2	brown	24		55				fracture		0.3mm, siderite?				
481																		
482		7151	frac(1)	1	blue	0		80				dominated fracture assumed to N, breccia		> 2mm, calcite				
483			frac (2)	2	brown	39-219		90				almost vertical fracture		> 1mm, calcite				
484												below which, v. broad calcite veinlet (4cm)						
485												tut siderite filled fracture.						
486																		
487																		
488	**Inammincka 4**	6976	bedding	1	green	0		20										
489			frac(1)	2	blue	286		85				0.6mm						
490																		
491	**Jennet 1**	c1, 5525'	bedding	1	green	0		65				bedding						
492			frac(1)	2	blue	90	**67**	65-70				high angle fracture		open, fine frac, predate slickenside?				
493			frac(2)	3	yellow	70		60				possibly equal blue		open, fine frac, predate slickenside?				
494		2" below	slickenside	4	orange	0		65				slickenside strike on the bedding surf.						
495			lineation	5	orange	10-190		65				slickenside lineation						
496																		
497		5232'2-7"										vuggy fractures						
498																		
499	**Kalanna 1**	8937'3"	bedding	1	green	0		70	315	W. flank of major		possible bedding, muds.		pyrite lam.	4			
500			frac(1)	2	blue	274		65		NE-SW Kal. Fault		fracture, subpara to 300^{o} (blue)		calcite, 0.3mm				
501			frac(2)	3	orange	355		50		Coaxial P-Z dome/fault trap		fracture, displaced fra(1)		clay seam, v. fine, 0.08mm				
502																		
503	**Kumbarie 1**	5400'4"	bedding	1	green	0		60				bedding						
504			frac(1)	2	blue	356		78				high angle fracture		0.5mm, open, siderite "stitches"				
505			frac(2)	3	brown	200		33				fracture		0.2mm, transparent crystal, non-				
506														calcite, further by siderite				
507			frac(3)	4	orange	346		25				fracture, conjugate with frac(2)?		0.1mm, transparent crystal, non-				
508														calcite, further by siderite				
509			frac(4)	5								abundant, small, fine fractures, branched?						
510																		
511		5524'10"	bedding	1	green	0		70				bedding						
512			frac(1)	2	red	170		65				fracture		1.3mm, dolomite				
513			frac(2)	3	blue	200		35				fracture		0.6mm, ?				
514		5534	bedding	1	green	0		55				possible bedding between sst and shale.						
515			frac(1)	2	blue	33		30				fracture		2.1mm, ?				
516			frac(2)	3	blue	172		35				fine fracture, cut by the above		0.1mm				
517	**Lowanna 1**	9802'3"	bedding	1	green	0	**53**	50-55										
518			frac(1)	2	red	210		25				veinlet fill		2-3mm, calcite				
519			frac(2)	3	purple	240	**57**	55-58						0.1, calcite				
520			frac(3)	4	orange	120		60						.1-<1mm, calcite				
521		9801'3"	bedding	1	green	0		55										
522			frac(1)	2	purple	280		50						calcite				
523			frac(1)	3	purple	290		65				dominated fracture		calcite				
524			frac(1)	4	purple	284	**80**	75-90						calcite				
525			frac(2)	5	orange	230		70										
526			frac(3)	6	red	170		18				calcite and breccia zone		calcite				
527			frac(4)	7	purple	134		70				hairline, minor fault displacement						
528												? branch from frac(1)						
529	**Meranji 2**	10920	bedding	1	green	0		20				bedding						
530			fracture	2	black	245		85				open fracture						
531																		
532																		
533																		
534	**Narcoonowie 1**	6542'5"	bedding	1	green	0	**43**	42-45	330	NW flank of anticline		bedding, siltstone and shale						
535			fra(1)	2	blue	335	**67**	65-70				fracture	1	siderite or dolomite				
536			fra(2)	3	yellow	horizontal		0				fracture	after 1?	siderite or dolomite				
537			fra(3)	4	black	260		80				fracture	3	siderite or dolomite				
538			frac(4)	5	brown	205		40				coarse frac, or vein	2					
539	**opposite side**		fra(1)		blue	30	**67**	65-70					1					
540			fra(3)		black	310		80					3					
541																		
542		6540	bedding	1	green	0		40	330			bedding, siltstone and shale						
543			fra(1)	2	blue	57		70				high angle fracture						
544			fra(2)	3	brown	150	**43**	45-50				? Conjugate, coarser fract.						
545			frac(3)	4	yellow	horizontal		0				horizontal fracture						
546																		
547		6543	bedding	1	green	0	**43**	40-50	330			bedding, siltstone and shale						
548			fra(1)	2	blue	330	**70**	60-80				high angle fracture		dolomite				
549			fra(2)	3	brown	270		70				coarser fracture		dolomite				
550		6112'10"	frac(1)	1	blue	0		60	330			moderately steep fracture		breccia, filled with dolomite				
551			frac(2)	2	brown	101		60				displaced blue fracture		dolomite				
552			frac(3)	3	yellow	240		65				displaced blue and brown		dolomite				
553	**Nealyon 1**	6333	bedding	1	green	0	**13**	10-15				siltstone						
554			frac(1)	2	brown	210		85						1mm, filled with calcite				
555			frac(2)	3	blue	172		70						0.1-0.2mm; calcite				
556																		
557	**Packsaddle 1**	10366	bedding		green	0		75	135	dipping SE		bedding, quartzose sst						
558			frac(1)	1	black	30		50		in seismic		fracture		0.1mm				
559			frac(2)	2	yellow	335		65		section		fracture		< 0.1mm				
560		1cm below	frac(3)	3	black	70		30						up to 0.9mm				
561		10357'5"	bedding		green	0	**35**	30-40	135			bedding, siltstone / fine sst.						
562			frac(1)	1	brown	0		60				thrust fault						
563			frac(2)	2	yellow	0		65				fracture		filled by calcite				
564																		
565		10388	bedding	1	green	0		40	135			bedding, calcareous siltstone						
566			frac(1)	2	blue	60	**75**	70-80				cross-cut every other fractures		calcite				
567			frac(2)	3	brown	190		10				majority fracture 10 dg dip		0.5mm, calcite				
568			frac(3)	4	black	105		20				fracture		up to 0.8mm, calcite				
569		10390	bedding	1	green	0		45				bedding, calcareous siltstone						
570			frac(1)	2	blue	110	**85**	80-90				may be opposite due to almost vertical						
571			frac(2)	3	brown	190		45										
572			frac(3)	4	black	0		40										
573																		
574	**Strzelecki-1**	6806-16'	bedding	1	green	0		70				bedding (from Daily's collection)						
575		not exact	fracture	2	blue	90		23				fracture		pyrite + white, ?				
576		6806-6915	bedding	1	green	0		70				bedding (from Daily's collection)						
577			fracture	2	purple	225	**37**	35-40				fracture		pyrite + white, ?				
578																		
579	**Sturt 7**	6376'6"	bedding	1	green	0	**27**	25-30	45	fault block anticline								
580			frac(1)	2	blue	194		60		towards NE		reliable						
581		6376'6"	bedding	1	green	0		25										
582			frac(1)	2	blue	203		50				more reliable						
583		6363	bedding	1	purple	0		50				flow band of volcanics						
584			frac(1)	2	brown	142		70										
585		6381	bedding	1	green	0		30										
586			frac(1)	2	red	285		70										
587			frac(2)	3	blue	81		70				similar to other 60dg						
588	**Tilparee A1**	c3, 7019' 1"	bedding	1	green	0	**65**	60-70	160	S flank of E-NE		bedding, against folding	1					
589		down to	frac(1)	2	blue	300	**87**	85-90				high angle fracture	2	white, ?				
590		younger	frac(2)	3	yellow	0		60				parallel to bedding, ? fault plane	3	brown, ?				
591			frac(3)	4	brown	240	**80**	70-90				v2, veinlet (1-2mm)	4	pyrite				
592			frac(4)	5	black	140	**70**	60-80				v1, veinlet (1-8mm), asso. slickenside	5	quartz+ pyrite				
593																		
594		c3, 7013'	bedding	1	green	0		80				bedding						
595			frac(1)	2	yellow	20	**77**	75-80				high angle fracture (fine)						
596			frac(2)	3	brown	45-50		40				lower angle fracture						
597			frac(3)	4	brown	150		70				v11" below, steps & slickenside						
598			lineation	5	orange	135-NW						lineation of slickenside, 1" below						
599																		
600	**Toolachee 1**	7221'	bedding	1	green	0		60	90	N-S trending anticline		bedding, siltstone and shale						
601			frac (1)	2	blue	0		55		? E flank		fracture		pyrite				
602			frac(2)	3	brown	105		65				fracture		pyrite				
603			frac(3)	4	yellow	107		80				fracture		? open				
604			frac(4)	5	red	135		10				fracture, ?diss. Seam						
605																		
606																		
607	**Gidgealpa 4**	7226'8-10"	bedding	1		0		3	315	western flank of	IRB							
608						106		79		gentle NE-SW								
609										trending anticline								
610																		
611	**Meranji 2**										IRB							

Appendix 2
Text files on CD

Well	core	round?	dipmeter log	depth (t) ft	depth (t) m	depth (b) ft	depth (b) m	Rec ft	?deviation	bedding dip angle	Sedi. structure	slickenside	stylolite	vein (1)	filled by	vein (2)	filled by	fractures (1)	filled?	fractures (2)	filled?	fractures (3)	filled?	chronology	fracture intensity	Comments	Structure (WCR)	WCR
Boxwood 1	2	y	CDM	6151.0	1874.8	6161.0	1877.9	10.00		no recording	brecciated, fractured ignimbrite, angularly uncon.														moderate	Mooracoochie ignimbrite, possible along shear plane.	Boxwood structure, The Gidgealpa Fm dips at appro.	6153'6" and below, mottled green, recrystalised
ENV 879			down to 6340								below Merrimelia sst at about 6152' (my), 6157'(WCR)															Some kaolinite filled along the plane. At 6155-6154'6".	7 dg. Merrimelia Fm at 30 while Pre-Permian 30-50.	sediment. Shear planes 70, 85dg. Slickenside
logger=driller										6220-6250																Fold, microfold. Up to 0.4 x 0.8cm vug,		on some of surfaces. A definite structural
										24-30NW326																numerous microfractures.		dip : 30 (6151-6153 1/2'). 6153'3"up: Merr. Fm
										? factures, fault																		
										6280-6326																		
										20-32SE137-170																		
										?bedding																		
	3	y		6332.0	1930.0	6342.0	1933.0	10.00		36 SWS195	dark green laminated to thin-bedded mudstone and	6334'5"														Bedding measured: 50, 55, 40, 45. Slickenside,		Light grey-green shale, dip 30 (6332-6334');
										? Fracture	shale, slump. Daily (WCR): dip:40dg; abundant worm	6340'5"-6341														at 6339', fault (? compressive block faulting, high		to 50 (6334-6342).
											castings parallel to bedding.	30dg, >4mm														angle, 70). Vertical fractures along faultplane, cut across		Shearing, on shear plane para to bedding.
												calcite, chlor														bedding, low angle; bedding above the fault: 40-50dg.		another at 70 to the horizontal. White clay
												metamor?														Fault reappear at 6332'6"		calcareous in part with green mineral
												X-cut bedding																chlorite?) along shear planes.
Coongie 1	4	slab	CDM	8615.0	2625.9	8626.5	2629.4	10.67	< 2	8 NNW330	siltstone, shale, minor sandstone.							? 80 (8625')	0.3mm; calc.	75-80,?					low to moderate	tend to be in v.f. sst, but not orange-red sst.	N-S trending structural lineation extending from the	DST No.3 (10020-250') minor losses of drilling fluid.
		1/3	to 11790						max: 4 1/2																		Gidgealpa area, to be a Cambrian hinge-line.	? Due to fracture or breccia? 11150-11304':
	5	middle	dominated	9838.0	2998.6	9849.0	3002.0	10.30	at 10400	16 NNW359	siltstone, shale, minor sandstone.							? 80-90 (9839')	0.2mm, cal.	high angle					low	high angle fracture.	On a faulted domal structure (seismically delineated).	permeable but salt water.
			by NNW																	9847.0	<0.2mm						Dipmeter indicates well sited slightly N-W of the	
			& NNE; 4-16,22																		calcite						structural culmination, Cambrian dipping gently	
	6		few SE, 10-16	10069.0	3069.0	10079.0	3072.1	7.75		18 N30E	dolomitised peritidalite		y	10076; 4mm; 2 fra	calcite			10073.0	1.6mm, calc						high	high angle fractures, filled with calcite	in this direction. Upper Cambrian 4dg NW to NNW	
			few SW, 26											? 75				10074: 85?	0.5mm / 2mm	10075: 2 frac.	calcite						Although gentle folding, normal faulting common.	
																		stop at stylolite	calcite	75-80;	6mm / 1.9mm							
	7			10157.0	3095.9	10177.0	3101.9	14.50		no reading	dolomitised algaliminite		abundant	10164', 2 frac.	<2mm, cal			10157': 70?	1.5mm, calc.	10169'; 2 frac,	calcite	10171; numerous			moderate	high angle fractures, filled with calcite		
			10570: SW, 26											? 80-90						high angle		fine fractures						
	8			10991.0	3350.1	10997.0	3351.9	1.00		11/ SE120	black micac. siltstone.		y												moderate			
			11300-400'																									
	9		NW or SE	11236.0	3424.7	11251.0	3429.3	13.00		no reading	massive to thin bedded, vug pore at 11246'		y												moderate	2-3 fracs at 11248'10", ? r. angle to bedding. 0.8mm		
			11500-11750																							11238'4"-11240': high angle frac., 1.8mm.		
			6-38: NE10-40																							numerous fine fracture, same high angle.		
														11939'3"; 20dg?	calcite;													
	10			11931.0	3636.6	11941.0	3639.6	10.00		no reading	ignimbrite lined up.				1.6cm										low	11938', numerous hairline fracture filled with calcite.		
Cuttapirrie 1			CDM	10095	3077.0	10100	3078.5	3.0	7 Max.		rhyodacite or crystal tuff														1cm in	Fractures completely or partially filled by calcite,	NW flank of Ptachawarra Trough, its anticline is	Welded tuff, two relict cleavages at right angle.
			9870'								below dipmeter interval.														width	partially filled, 1mm, 70dg at 10095'.	elongate parallel to NE trend.	No bedding. One well deve. Joint set at 25 dg to
																										0.5-1mm, 70, calcite.	Small antithetic faults distrub the regional	core axis, calcite along the planes.
only cuttings										234dg: 9845'	only cuttings																southerly dip.	
										single	bioclastic, peloidal packstone.																	
										structural dip																		
										20-38dg																		
										210-250 azim																		
Daralingie 1	4	y	CDM	7420.0	2261.6	7431.0	2265.0	3.05	missing	65°	vague cross bedding, possibly thin-bedding	65dg		0.5-1mm	brownish			50-70°	brown,						2-5cm in brec.zone	at 7420', frac 1 and frac 2	Daralingie NE-SW trending anticline. Off the crest,	X-Ray: bedding 90°, but very tentative.
Env 837			down to							to 70°	thin ribbons of finer-grained sst			at 7451 ft	? clay			at 7420'	? clay						1' : 7420-7424'.	are connected		Orthoquartzite (7423'), 99% quartz.
logger = driller			7430'																							except at 7431', frac 1 round the		Core description: 75o, colour banding.
																										core. Brecciation at 7431',		Three fracture sets, two > 70°, one 15°.
																										brittle crash at 7426'.		
																										Induced fracture still open, curved.		
																									1/1', but more	Fracture, brown fill, (35dg), ? Siderite.		Merrimelia Fm, conglomerate, sst.
																									as meshwork			
	3			7170.0	2185.4	7220.0	2200.7	15.24			Almost horizontal, severely bioturbated sst/silt.	7212'						80°· < 1mm	brownish, ?	40° <1mm	brownish,				20cm	Bedding, undetermined due to biotur.		high and low angle partings: 75
											Conglomerate may belong to Merrimelia Fm,	65 dg.							siderite		? Siderite					possibly < 20dg.		10o, occass. frac. with slickensides.
											containing angular to rounded quartzite = Dara-1,							10-30° at								network-like fractures, filled by		brown waxy modules, ? Manganese.
											core 4 quartzite, bioturbated sst, red pebbles of ?							7190'								brownish (?). Frac(1), 80° but by		0° bedding (conformed by X-ray at 7190')
											and ? volcanics (see Chris TS 7193').															frac(2), 40°, but both discontinuous.		
Daralingie 2	8	only slab	CDM	7910.0	2411.0	7924.0	2415.2			60° (WCR)	fragmental core, disturbed by poor handling, not	along shaly													3-5cm	Bedding, 80, ssst and glauconitic at top;	Southern flank of the Daral. anticline. 2 miles S, Sw.	dip appro. 60dg; interbedded phyllite and
900			6312-7912'							mainly SE	reliable for study. However, sst, siltstone /shale,	layers														85-90 at 7910'; fractures: 1 . Filled by sider., kaol	Top of Permian, 200 feet lower than Dara. 1.	quartzitic sst; phyllite at 7922 dip: 60.
										? 163 / 30	gradually more weathered near top.															20-30 dg; some siderite crystalline "seeds" .	Tria to Permian 9-12 dg, azimuth from SE to SW .	
										at 7890'	Therefore, possibly belongs to WB. Glauconitic sst															2. Filled by white (?)		
										? Fracture	seems to be porous															siderite also fills parall-bedding, original porous?		
										NE																Steep bedding of shaly layers, 80-90 dg,		
																										at 7912' (80); at 7910' (85-90); fracture 20-30,		
																										filled by siderite and kaolinite in between crystals.		
Daralingie 10	2	Y	HDT	7215.0	2199.1	7224.0	2201.9	5.30	1- 1/2°	50-60°	Quartzite, fine, glauconitic, mud drape.														not even	Bedding, 50-60 dg (6); 60-65 (2) upper part, such	Flank of anticline.	quartzite, phyllite, sandstone:
5725			7190-7301'							n = 6 (> 7218')	from 7218' upwards: shattered due to weathering?														moderate to high	as 7218'. Deformed sst lense plus breccia;		10% dull yellow mineral fluorescence
3' (log > driller)										60-65 (< 7218')	fractures and vuggy poro. filled by siderite rhombs.														high (6/1")	upwards to 7215'. Glauconitic sst + mud drapes.		dip 50°. HDT decides 46-66 NNW.
										46-66 NNW	deformed sandstone lenses, breccia upward to															Above 7218', shattered, fracture, vuggy pore filled		
											7215', from which upwards belongs to Permian?																	
Della 1	6	y	CDM	7122.0	2170.8	7132.0	2173.8	3.00	3		only 3' recovery (7122-7125'); brown-red silt.	yes												both fractures cut	10-17cm, 1cm (not	Two sets fractures cut "lineation", 1. 30-55	angular unconformity with overlying Merr. Fm of glacigene	7072' top of WB; bedding 60-70;
			SE 20dg						7036'		with some "microstromatolite", steep lining (40-50) of	angle to												"lineation", 2. Stop	even); width < 1-2cm	filled by 0.1mm black, ? 2. 80-90, filled 0.05mm	conglomerate; possibly Devonian uplift. Also during	fracture abundant, irregular from hori. to ver.
			142 / 20								minerals due to deformation ("lineation").	"lineation"												before 1, but 1:30		? Bk. 1 = slickenside surface, right angle to 2.	Permian, Della structure.	
			at 7140'																					displace 2:70		carbonate filled in thin section.		
Dullingari 1	26	Y	CDM	9191.0	2801.4	9211.0	2807.5	20.00	Max 32	9050.0	Cm' laminated siltstone and shale, light grey green.														moderate		A seismically delineated fold, well defined anticline;	Dark grey shale and interbedded siltstone. Small slump
ENV 258			6700-11550						at 11,100	60dg (WCR)	slump, microfolds.																10x5milessq, trending NW-SE, 500' closure of P.	and micro-crossbedding. Dip: 60 (reliable)
			Below 8425						deviated to																		D-1 drilled on the apex of this structure.	
			not reliable						NW at 9050	dip to SE																		
			(WCR)																								Below 8425' CDM curves not suitable for dip calculations.	
	27	y		9496.0	2894.4	9506.0	2897.4	10.00	4-6dg	44dg (WCR)	Greenish, laminated siltstone and shale.														moderate		60 dg in upper part of WB, 45dg in the lower part	Dark grey shale, silty, fine irregular dolomite veins
																											WCR, Appendix III, part E by Opik and Jones:	frequent, occasional patches of pyrite. Dip: 44 (reliable)
																											the sequence of Permian conglomerate unconformably	
	28	y		9668.0	2946.8	9678.0	2949.9	10.00	8-12dg	46dg(WCR)	greenish sandstone, siltstone and shale.														not even, 3/1" at one place	Fractures.	above Ordovican shale as analogous with the sequence	Shale, fractured, vein filling by dolomite. Fractures
																											known from Bacchus Marsh, Victoria.	at 90 angle to dip and strike. Dip: 46. 9803 1/2 to 9812:
																												Conglomerate in matrix of sandstone, numerous fine
	29	y		9802.0	2987.6	9812.0	2990.7	10.00	13dg	53dg(WCR)	Conglomerate in matrix of sandstone, including														moderate			unoriented fractures. Dip: not apparent.
		frag.									shale clasts.																	dark grey shale, fine irregular fractures.
																												Dip: 53.
	30	y		10143.0	3091.6	10153.0	3094.6	2.00	22dg		Dark grey shale, pyritic, dolomitic. Lineation														moderate			Dark grey shale, pyritic, dolomitic. Dip: high but amount
		frag.																										interdeterminate due to broken nature.
	31	y		10890.0	3319.3	10908.0	3324.8	4.00	30dg	24dg(WCR)	Dark grey shale, pyritic, dolomitic. Lineation														high	pyrite filled fractures, severe		Fissile, very hard, silty, slightly carbonaceous(?),
		frag.																										Thin veinlets (probably fracture fillings of pyrite etc.).
																												Dip: 24-26 (unreliable). Pyritic slate, pyrite filled fractures.
Gidgealpa 1	30	y	CDM	13106.0	3994.7	13114.0	3997.1	8.00	7 max		massive to slightly graded bedding in ash-size beds			up to 1mm, 65-9	calcite			25-28	calcite						only top	basalt breccia and calcite-rich cement	down the flank of a strong NE-SW anticline. "P' seismic	31-33 dg reliable
			d. to 13100											top of core				ash-size bed							& bottom		700' closure. The anticline asymmetrical, west limb	
	29	y		12950.0	3947.2	12960.0	3950.2	2.0			massive, complete dolomitisation		yes					hairline	?clay						intensive,	indeterminate, vugs and brecciation	steeper than eastern one.	indeterminate, bright pale blue fluores.
		breccia																up to 0.1mm	mud invasion?						1mm-cm	saddle dolomite partially filled vug;	From 10,000 to 11300 dip above is SE but below: N-E	Red clay filled fracture, ?mud invasion
																										fractures abundant, well connected network	? Due to thrust fault causing repeated section.	
	28	breccia		12800.0	3901.4	12804.0	3902.7	0.0			no recovery														not core	brecciation		
	27	breccia		12773.0	3893.2	12783.0	3896.3	2.0			brecciated														not core			dull gold fluorescence rounded vugs &
																												fractures. Doubtful oil staining;
																												heavy mud invasion in vugs and fractures.
	26			12750.0	3886.2	12770.0	3892.3	0.0		12692	no recovery														not core			
	25			12740.0	3883.2	12750.0	3886.2	0.0		S7E:49	no recovery														not core			
	24			12605.0	3842.0	12615.0	3845.1	10.0		12597	thin-bedded siltstone, shale and bioclastic ps, ws.	common		50-70	calcite										2-5cm	30-45dg, 2 sets of fractures filled by calcite		bedding 32 dg reliable, two systems of
										N67E:42																slickenside along thrust fault by		weak fractures at 10-60 dg to core axis.
																										which calcite veinlets were sheared		Filled by calcite, no displacement of beds
				12605.0							bedding, 25dg							60; 0.2-0.5mm,	calcite							Thrust fault 30-35dg, parallel to bedding.		but slickensideing common.
	23			12239.0	3730.4	12251.0	3734.1	11.50		12258	thin-bedded ws, ps, rs, basaltic tuff-rich layers	common	yes	40-50; 1-2mm	calcite			45-60; 0.3-6mm	calcite						5-10cm	50-80 dg (due to compaction), two sets of		50 dg reliable, irregular fractures, filled
										N48E:66			dissol. seam													calcite-filled veinlet and fractures.		by calcite.
				12244.0						12218	? Bedding, along dissolution seam, 70dg							30-40 (1-2mm)	calcite							Calcite-filled fracture right angle to seam ? bedding		
										N55E:62																		
	22			12021.0	3664.0	12031.0	3667.0	10.00		12074	lamination, faded ripples, thin-beds.	~~ bedding													2-5cm	36-43 dg, fracture filled by calcite or		30-32 dg reliable, prominent fracture
										N78E:57																dolomite, 0.1mm , 75 dg, opposite bedding		system 65 dg to core axis.
																										fault, 45-50 dg.slickenside parrel to bedding		
	21			11675.0	3558.5	11719.0	3572.0	40.50		11715	thin-bedded lm ms and ws, ps; nodular, ribbon,		yes	50-60; 2-6mm	calcite			60-80; 0.3-1mm	calcite					h. angle, calcite-filled	not even, 2-5cm	30-45 dg, slickenside surface = calcite		30-37 dg, occasional fractures in 3 systems:
										N68E:59	breccia, turbidites etc.		vertical											fracture, tension	below 11679'	fracture surface (60dg, 1mm), parallel to		1. parallel to bedding (? Cleavage)
																								gash; then stylolit.	~ 20cm	calcite veinlet (6mm).		2. 45 dg to core axis
																												3. 65 to core axis.
				11683'6"							bedding: 30dg, dilate filled by calcite, 30-40-50 dg.														2-3 / 1"			
											from 0.3mm to 1cm, opposite bedding or 90 to it.																	
				11684.0						11565	bedding: 25-30 dg; calcite veinlet opposite bedding.			35-40; 0.3-4mm	calcite										4-5"	fault displacement 1.3cm; vertical stylolite postdate calcite veinlet		
										N69E:42																		
				11691.5'							turbidite bedding (20), almost vertical displacement.															bed, 20dg; calcite filled fracture along microfaultplane		
																										almost 90dg, haireline to corner fill (5mm).		
	20			11391.0	3472.0	11407.0	3476.9	16.00		11390	thin-bedded lm ms and ws, ps; nodular, ribbon.			60-65; >1mm	calcite			65; 0.01	calcite						5-8cm, most of them	30 dg, faultplane displacing bedding,		25-30 dg, occasionally slickensides.
										N69E:39								opposite to beddi							are fine, hairline one	parallel to calcite frac (65; 0.01mm), oppo.		
																										bedding.		
	19			11366.0	3464.4	11391.0	3472.0	13.50		11329	massive amygodal basalt & minor ls interbeds			35; 1cm											12cm or 6cm	bedding undeterminate; one calcite vein (1cm)		30-35 dg from minor limestone beds
										N60E:37																one fracture, up to 1mm (55dg).		at 11367'.
	18			11068.0	3373.5	11078.0	3376.6	10.0		11119	brecciated basalt + minor limestone			1.7-2cm	calcite			60-70; 3mm,	calcite						10 - 12cm	two sets of calcite fractures: para. To bed		50-55 dg; calcite veins common; some
										N37E:49								1. along bedding								and one opposite to bedding		up to 1" wide and parallel to bedding;
																		2. opposite bedd.										
	17			10828.0	3300.4	10838.0	3303.4	10.0		10858	thinly bedded tuffaceous limestone		yes													45-50 dg; well fractured, filled by calcite, two sets.		45 dg reliable; two major sets of fractures:
										N59E:35																65; >1mm; 60, 1-1.5mm;		filled by calcite: parallel to bedding
																												normal to bedding. Other no pref. Orient.
	16			10488.0	3196.7	10498.0	3199.8	8.5		10516	basaltic breccia, bedding indeterminate			60; 1mm	dolomite			50; 0.6-0.7mm	dolomite							bedding dip undeterminable;		dip indeterminate due to lack of bedding.
										S44E:56																two sets of dolomite-filled fractures		
	15			10280.0	3133.3	10290.0	3136.4	10.0			laminated siltstone and shale with slump.			55.0	calcite										5cm or more	bedding dip 65 at 10284', slump-fold, 70;		45-65 dg, everage 55dg, bottom 5 feet
																										calcite-filled microfaults (2mm displaceme)		of core fractured & shattered; two systems
																										& fracture fill, plus breccia and good fracture.		one parallel to, other normal to bedding,
																										irregular fracture network at breccia horizon		displacements up to 1cm on fractured lam
											bedding about 50 dg.															Breccia and gauge zone, push-up, 50dg, hairline.		
	14			9989.0	3044.6	9999.0	3047.7	10.0		9963	finely laminated siltstone and shale			45; 0.5mm	calcite			75; 0.3mm	calcite						10cm (not continu.)	30-40 bedding, two sets of calcite filled fract.		30 reliable; irregular fractures (displa. 1/2")
										S19E:48																		
	13			9798.0	2986.4	9808.0	2989.5	10.0			interbedded siltstone and shale			75; 1.3mm	calcite			70-90; 0.12mm	calcite						5-12cm (uneven)	bedding 30-40; calcite-filled fract.		30dg, reliable; few irregular fracture, with
																										one opposite to bedding, 70 dg.;		displacement up to 1". Filled by calcite.
																										brecciation, filled by calcite.		
	12			9415.0	2869.7	9425.0	2872.7	10.0		9422	basaltic breccia and limestone; similar to c18,19.		yes					65-80; 0.5-1mm	calcite						< 1m	bedding 25-35; calcite-filled fract.		reliable 30dg; small, irregular fract, with
										S88E:44																		displacement 1/4 - 1/2.
	11			9140.0	2785.9	9150.0	2788.9	11.0		9199	ribbon, nodular limestone and lime mudstone/shale.							75; 0.8mm	calcite						not even	bedding, 30-35; calcite fracture, 75dg, 0.8mm.		27-30 reliable;
										S59E:34																		
Gidgealpa 2	6	y	CDM	6880.00	2097.0	6895.00	2101.6	15.00		6802	feldspathic pebbly sandstone, some with x-beds.																high on the Gidgealpa structure, while Gidgealpa 1	
		1/8 miss	8656							N4E:17	? Sedimentary or														2.54cm or more	60-70dg;, fracture filled by brownish Fe?	was drilled well down the flank of the structure (anticline).	
	7	y	NE dominant	6895.00	2101.6	6915.00	2107.7	20.00		6922	greenish breccia and tuffaceous layers															slickenside, filled by siderite nodules or ?	18 to 20 dg (reliable dip at 6890') by CDM.30 at 7275'.	
		1/8 miss	but SE, SW							N72E:19	6995.5': minor cross-bed, dune migration truncation															from 6899 1/2' upwards white in colour, similar to c6	Between 6922-7578, dip 19-30, reliable, E to NE.	
										7094	?sandwave beds in hydroclastites.															greenish to brown, siderite nodules near 6963'.	Below 7578, dip very erratic, very unreliable.	
	8			7206.00	2196.4	7216.00	2199.4	10.00		N21E:22	top, red tuff and breccia																	
																										random fractures: 60-85 dg. Breccia at top, > 2mm		
	9			7275.0	2217.4	7285.0	2220.5	10.00		7283	laminated fine tuff.															calcite filled fractures (0.5-1.2mm) at 7284'		
	10			7449.0	2270.5	7455.0	2272.3	0.00		N68E:41	No recovery																	
										7401																		
	11			7455.0	2272.3	7462.0	2274.4	2.00		N66E:53	basalt															calcite (0.1mm) fracture, 90dg.		
	12			7914.0	2412.2	7924.0	2415.2	10.00		7933	rhyodacite lava															calcite-filled fracture(7914'), 0.3-0.4mm, 90dg.		
										N80W:37																flow lineation, ? 37dg.		
								8299.00		7987																		
								S37E		S30W:22																		
	13			8683.0	2646.6	8692.0	2649.3			no survey																calcite fracture, 60-75dg, filled by ?clay.		
	14			9011.0	2746.6	9020.0	2749.3			no survey																		
Gidgealpa 3			CDM																						moderate to high		located on eastern flank of N-E trending structure.	
	7		d. to 10932	8068.0	2459.1	8076.0	2461.6	6.80		8066																		
			SE dominant							S83E:31																		
	8			8524.0	2598.1	8530.0	2599.9	0.45																				
	9			8572.0	2612.7	8582.0	2615.8	6.40		8577																		
										S31E:67																		
	10			9151.0	2789.2	9161.0	2792.3	9.00		9178																		
										S62E:55																		
	11			9735.0	2967.2	9745.0	2970.3	9.50		9734																		
										N81E:24																		
	12			10151.0	3094.0	10161.5	3097.2	10.50		10144																		
										S56E:26																		
	13			10591.0	3228.1	10599.0	3230.6	8.00		10624																		
										S44E:21																		
	14			10927.0	3330.5	10934.0	3332.7	5.00		10929																		
										S86E:22																		
Gidgealpa 5	27	y	CDM	8708.0	2654.2	8723.0	2658.8	15.00	? <5(DIG)	8581	rhyodacite, lava, some flowing band and thin beds.			0.7cm	quartz			70-90; 0.5cm	calcite					qtz cut by cal.	low to moderate	no bedding, some thin banks, breccia;	Southwest plunging nose of the Gidgealpa structure.	no bedding; veins subvertical, and at 60 to
			SW dominant							S30W:10																quartz vein, cut by calcite-filled veinlet and fract.	CDM shows dips: 25-35 in Cambrian limestone;	core axis. Haematite veins, fine qtz veins.
																										red lava banding (0.8cm wide). V. f. cal. Fract.	15 in volcanics. Average 30 west of south.	
	26			8384.0	2555.4	8399.0	2560.0	15.00		8332'	light green tuffaceous breccia, sst.	yes													low	low angle dip; slickenside surface filled by		dip 15dg. Occasional subvertical fractures.
										S24W: 20		haematite														haematite? From 60-80 dg., up to 3mm.		
	25			8114.0	2473.1	8126.0	2476.8	12.00		8136'	complete dolomitisation, dense recrystalline,	possible						three kinks	dolomite, cal						2-5cm	possible bedding at 8122', 30dg.		dip indeterminate, subvertical, horizon
										S28W: 23	no obvious bedding.															oblique fracture possibly open, cut vugs;		fractures, 60 to the core axis, and occa. Conn
																										horizontal fractures more intensive, filled by cal.		vugs, whose length is up to 2", line with dol.
	24			7941.0	2420.4	7951.0	2423.5	10.00		7961'	Thin-bedded to nodular lime ws, ms, ps, floatstone.	common	yes	65; up to 1cm	calcite			50-75; up to 1mm	frac(3) calcite					frac(1) displaced	8 / 1"	bedding 35dg, four sets of fractures, stylolite		dip slightly irregular, between 25-35dg.
										S13W:20		emphasise	paral to frac(2	frac (1)				40; up to 3mm	fra(2) calcite					by frac(2), or (4);	not even	parallel to frac(2), amplitude outline boundary		generally slickenside, pyrite veins,
												muddy layer						60-85; fine	frac(4), calcite					frac (3) finer than frac	< 1" spacing	between frac(2) and matrix; undulated surface		large and small calcite veins.
																								possibly same phase.		parallel to mud layer and finally by slickenside.		minor erosional surface
	23			7609.0	2319.2	7630.0	2325.6	19.75		7596'	Cooper Basin thin-bedded, lam. siltstone / shale.														only at bottom	calcite filled fine fracture set at 7630'.		dip 15-20, microfaults.
										N39E:6	conglomerate with pebbles and cobbles of limestone														moderate			SW plunging nose of Gidgealpa structure
																												25-35 dg, but in volcanics 15 dg.
Gidgealpa 7	17	y	CDM	10567.0	3220.8	10582.0	3225.4	15.00		10548'	well bedded, lamination at top; but massive in							45-50; 0.2mm	calcite						1-1.5cm	20-25 dg; pebbly volcaniclastic sst, breccia;	SE sector of the Gidgealpa structure.	20dg; occasional calcite
			10580.0							S31E:30	breccia or conglomerate at bottom.															calcite-filled fractures.	Dip direction is constant, from 10 to 30, S30E (average)	filled fracture.
	16	breccia.	S31E	10120.0	3084.6	10125.0	3086.1	5.00		10110'	vuggy dolomite, no apparent bedding. Brecciated															no bedding, ?fenestral vugs;fine, hair-line fractures.	but, in Permian section, 2-3 dg, not reliable, x-bedding.	no bedding; very heavily fractured.
										S47E:29																		
	15	y		9985.0	3043.4	9997.0	3047.1	12.00		9985'	nodular limestone within silty mudstone / shale.	y	y					75-85; 1mm	calcite						1-1.5'	20-30 dg; oblique calcite-filled fractures;		20-30 dg; sub-vertical frac filled by calcite
										S39E:33		60; 70														slickensides intercalated with calcite.		along which slickensides developed.
	14	y		9674.0	2948.6	9685.0	2952.0	11.00		9666'	rhythmite of turbidite sets.	common														20-30 dg; 30 average, slump: 20-30;		28-30dg; graded bedding & current ripples;
										S11E:33																slickenside common; calcite-filled fractures.		slickenside along dip; thin calcite fractures.
	13	y		9348.0	2849.3	9358.0	2852.3	10.00		9303'	Bioclastic oncolite; diameter of oncoid up to 2cm.														high plus brecciation	undeterminate because of massive oncolite;		30 dg; horizontal fract (top 2 feet), vertical vein
										N56W:6	Original intergranular pore, fenestrae, shelter filled															stylites emphasised by haematite; calcite-filled		
											by sparry calcite, some dolomitised.															veinlet; 4.5mm; 75-80; horizontal slickensides		
																										numerous horizontal calcite-filled(?open) fractures.		
	12	y		9059.0	2761.2	9074.0	2765.8	15.00		no reading	massive intraclastic ps, gs, brecciated.		y	70-75; 2.5-3cm	calcite			60-70; 1-4mm	calcite					cal. Vein; stylo	well fractured	limestone breccia, ? fault breccia; plane: 70-5;		indeterminated dip; fracture - breccia (top
															haematite										gouge	3 phases of cross-cut relationship:		1 foot strongly); massive.
																										1. Calcite vein; 2. Brecciation filled by haematite		
																										3. stylolite; 4. Filled by kaolinite.		
											Stylolite at 8798'6", a-b = 6.5 (straight line), =11.5cm	8793-4'	high relief													different lithologies (high relief); calcite-filled vein		and partially filled by calcite . Stylolitic.
											(curved line), reduction = 5cm.															fractures.		

	10	y		8413.0	2564.3	8433.0	2570.4	20.00		8410' S11E:17	ribbon limestone and lime ms, shale (carbonate turbidite); nodular bedding. Thin bed of basalt, flat-pe. pebbles of shale at contact, thermal dyke forced?							0; 2mm 80-90; hairline; opposite bedding.	calcite calcite						low	< 10 dg; high angle calcite-filled fractures.		7-10 dg, reliable; fracture healed with calcite and pyrite, paralleling core axis.
	9	y		8072.0	2460.3	8082.0	2463.4	10.00		8056' S 8E:13	Ribbon ls and lm ms; former more than latter.														30.48cm	more ribbon limestone than lm ms. tension cracks between or within nodules. deformed ribbons have been pushed up like TP. microfaults, and fractures filled by calcite.		10 dg; mm's lamination and nodular.
	8	y		7701.00	2347.3	7711.0	2350.3	10.00		7713' S11E:10	lm ms / shale more than ribbon ls.		vertical	65-70; 0.1-2mm	calcite			70; 0.4mm	calcite						5cm below 7708' 2-3cm above it.	10 dg approximately; vertical stylolite in ribbon ls; calcite-filled fractures in high angles.		10 reliable, frac 30-90 to bedding, or parallel to core axis.
Innamincka 1		y	DIP LOG to 12635							SE (dmeter) dominated															moderate to high		E-NE trending anticline, no possible to interpret Palaeozoic structure from Inn. 1. Occasional fracturing occurs below 10,000', with a badly disturbed and distorted section blow 11396. The shatter zone includes vertical shears with apparently considerable displacement. Both fractures and shears may be filled with calcite and or soft, red, silty mudstone. Average apparent dip is 25, varying from 18 to 37.	
	17			7194.0	2192.7	7207.0	2196.7	10.90			7199'3": bedding: 15-20														high			
	18			7477.0	2279.0	7490.0	2283.0	10.00			7477: 32 dg														moderate			
	19			7917.0	2413.1	7933.0	2418.0	7.40																	moderate			
	20			7995.0	2436.9	8016.0	2443.3	9.40																	moderate			
	21			8216.0	2504.2	8239.0	2511.2	21.80			8225: 25dg (B1 facies)														moderate			
	22			8392.0	2557.9	8415.0	2564.9	22.80		34 S20E	8407': 30dg														moderate			
	23			8879.0	2706.3	8899.0	2712.4	19.60		31 S15W	8895: 30dg														moderate			
	24			9397.0	2864.2	9414.0	2869.4	17.00		30 S6E															moderate			
	25			9887.0	3013.6	9909.0	3020.3	22.00		36 S26E	9891': 30dg														moderate			
	26			10358.0	3157.1	10381.0	3164.1	19.50		39 S18E	10361: 25														moderate			
	27			10881.0	3316.5	10897.0	3321.4	14.80		39 S13E	10888' : 30dg,														moderate	fracture 70dg, 85 not continuous, filled by calcite		
	28			11396.0	3473.5	11399.0	3474.4	3.00		32 S4E															moderate			
	29			11399.0	3474.4	11423.5	3481.9	24.50			11399' : 30dg														moderate			
	30			11423.0	3481.7	11455.0	3491.5	31.50																	high			
	31			11455.0	3491.5	11505.0	3506.7	14.50		32 S8E or 111	Laminated sandstone.														moderate	well fractured, filled by calcite.		
	32			11506.0	3507.0	11544.0	3518.6	38.00																	moderate			
	33			11544.0	3518.6	11567.0	3525.6	23.00		39 S10E															moderate			
	34			12067.0	3678.0	12088.0	3684.4	14.50		34 S21E															moderate			
	35			12576.0	3833.2	12586.0	3836.2	10.00		35 S24E															high			
Lycosa 1 Env 7290 10' > driller	1	Y	MSD 8942.0 CSB 8942.0 DUADIP 8900.0	8792.0	2679.8	8814.0	2686.5	22.00	Y 15° max. 17.9	x-ray 40°(WCR) at 8793' 35°(N)	thin-bedded, starved ripples, fine-grained sand lobes.	at 8797' 8796'6"		2cm at 8803'	calcite-rich	1mm	quartz?	at 8793' 67-68° (210° SW) para to vein 1	partially calcite hairline	at 8793' 78-80° (120°SE) para to vein 2 hairline	? open partial filled by calcite see 8794'	network patches or micro en echlon at 8796' 90° to bedding	? quartz	1 by 2	1" ever, but not even	1 displaced beddings, fault plane? at 8796ft Mineralisation zone: vein: 5mm filled by ? calcite; breccia (3.5cm) at 8796 ft, with metals including Fe.	Small and reverse fault on the northern flank, throw of fault increase with depth, max. throw of 80'. North to NW regional dip. Reverse-faulted anticline 5km south of Big Lake Fault	8514 (FTP of WB), metasiltstone, calcite filled fracture en echlon calcite filled fractures, slickensides; dolomite banding. Open fractures at 8803'5" (not true).
Malgoona 4 cuttings only				7178.0		7457.0					volcanics, some flow banding. (WCR)														high 7 / 1' from FMS	Good fractures shown in FMS etc.	Southern flank of Patchawarra Trough, West lobe of a fault.	acid volcanics consisting of crystals of quartz, white feldspar, minor pink feldspar. 181 natural fractures identified by FMS, 167 are open due to conductive, dip towards WNW, dip 50 ave. the most intensely fractured intervals: 7225-7230, 7278-7285., fracture aperture: max: 0.1mm; densities: 7/ft DST 3 indicates 100 bbl fluid/day range but produces water.
Merrimelia 1 ENV 471	13	N	CDM 6434-9985 NW12-15 (9950-60)	9958.0	3035.2	9977.0	3041.0	19.00	~8400 increase to >1 to 4		Grey sandstone, with minor red mudstone/siltstone. Horizontal to x-lamination; some shale pebbles.														a few in siltstone and sst	a few fractures in siltstone and sandstone	NW flank of NE-SW trending closed anticline the well located near SW extremity of the structure, 300' structurally below the highest point on SE	Maroon shale, fissile, siltstone. Dip 10: 20 between 9971-73'.
	14			10317.0	3144.6	10332.0	3149.2	15.00			Grey-orange sandstone, with flat pebbles. small scale x-lamination.														low in mudstone			light grey sandstone, shale (maroon). 10-15 dip.
Merrimelia 2 ENV 496		slab (M.) < 1/3 2 pieces	CDM down to8266						1-3 7-10 below ?12,000		Thin bedded, laminated siltstone, sandstone; bioturbated red-brown mudstone.	along red shale	n	e.g. 9018:	qtz, calcite										low to moderate high in brecciation	In general, calcite filled fracture high angle, opposite azimuth to the bedding or x-lam.direction.	NE-SW trending anticline with no surface expression possible east flanking normal fault.	Dipmeter in the red bed (7650-7780): 7-12 to SE. Angular u/c at 7650' (WB top). 7650-11520: 15-30; but 11520-13011: 30-40 which may be caused by faulting or u/c.
	2		S47E: 7dg at 7917'	7900.00	2407.9	7916.70	2413.0	16.70		20dg: 7907'2"	bioturbated red-brown, micaceous mudstone; x-lam. sst. drapes of heavies ? 2-4mm faint lam.								yellow, ?						1cm or less vertically 26 fractures	well fractured, all the way through.		shale (7900-7910'); sst (7901-7911': qtz filled fracture common. 7911-7916.7':shale green and red; cut and fill ripple marks common. 10dg reliable.
	3		S46E: 11dg at 8257'	8339.00	2541.7	8349.00	2544.8	10.00			similar as above. With more green pebbles.								half filled by qtz, m. cal.						2 fractures	two fractures.		sst and shale, 7-10 dg reliable .
	4			8572.00	2612.7	8603.00	2622.2	31.00		30dg: 8597'	similar to the above. Sst with irregular lami. Green mudstone.							? 65-70	qtz+calc. 0.1- 1mm						> 8 fractures	more than 8 fractures, more between 8572-76' Microfault displaced 1-1.5mm.		Orthoquartzite above 8587', below which red shale. two sets fractures at appro. 80 dg to core axis; healed by gypsum; well developed 8577-8579'; 8580-8530; 8596-99.5'. 3-6 dg reliable.
	5			8630.00	2630.4	8644.00	2634.7	14.00			X-laminated sst, truncated bed. Green shale clasts. 4cm high relief along which green mud clasts.							fracture, high ang.	tiny qtz cryst.	Displace: 2-3mm	0.5-0.6mm				7 fractures	fracture, 0.5mm, filled by clay or quartz, > 5 hard		Orthoquartzite and shale; 4 dg fairly reliable
	6			8695.00	2650.2	8715.00	2656.3	20.00			vague low angle lamination; sst opaque along lam. Green mud clasts (rounded, flakes). 3.2cm long.							2mm, high angle 70-90, 1- 1.5mm	cal. rhombs + ? dolomite	open, ? 60dg ? Induced 70-80?	N				5 fractures	5 fractures, filled by calcite, 1: 1mm, 2. 2mm 3. Open, ? Induced.		Orthoquartzite and shale. 7-10 dg reliable. 8703-8715: prominent fracture set at 80 to axis and parallel to bedding
	7			9117.00	2778.9	9127.00	2781.9	8.50			Sandstone with thin soaping green shale layers. Red sheet-like micaceous shale.							? 90 cut bedding		veins & fracture, high angle	qtz calcite				18 fractures	14" long fracture or vein (2-4mm), filled by qtz, cal. plus breccia zone with 2cm wide vein filled by qtz		Orthoquartzite interbedded shale; vertical fracture healed with qtz. Shale with slickenside.
	8			9627.00	2934.3	9637.00	2937.4	10.00			Low angle planar cross laminated sst. Red ms. Mud drape along x-laminae. Siltstone / shale.							70-80	? Green clay						2 fractures	Slickenside in green mudstone, breccia zone Two high angle fractures.		Thinly interbedded shale and sandstone. 15 reliable
	9			10139.00	3090.4	10149.00	3093.4	10.00			Bioturbated mudstone /silt. X-lam. Sst. Rip-up clasts															no fractures. Good trace fossils (photoed).		Interbedded sst, siltstone. Small "cut & fill"; 7 dg re
	10			10636.00	3241.9	10646.00	3244.9	10.00			Slightly silty, convoluate bed; siltstone, x-lam. Red brown mudstone.														one fracture	Fractured and brecciated zone, slickenside; filled by calcite.	NE-SW trending elongated anticline, no surface expres. "P" horizon 3 culminations; reverse fault west flanks.	Sst, shale, limestone. Fracture common, healed by calcite, qtz and gypsum. 10-13 reliable.
	11			11110.00	3386.3	11119.50	3389.2	8.75			Brown lamin. Siltstone / sst. Well-bioturbated ms.															no fractures.	west flanking fault, normal fault. U/C between Lower	Shale, sandstone; limestone at 11112.25'. 5-10dg.
	12			11513.50	3509.3	11523.50	3512.4	10.00			Red micaceous shale, and fine sst, planar lami. Rip-up clasts of green mudstone. De-water; synaer.														one fracture	Fracture	Triassic and the red bed which is 7-12 dg. 7650-7780' Dipmeter indicates that increase dip from 7650 to 11520.	Interbedded sh and sst. 10-15 reliable. Irre. Fract. Calcite veins.
	13			12071.00	3679.2	12081.00	3682.3	10.00			Red bioturbated mudstone /silt. X-lam. Sst. Small granules and intraclasts (orange); green ms.														no fracture	? No fractures.	From 11520 to 12080 core dips increase from 15 to 30, and to 30-40 at 13011 (core 17). This may be caused by faulting or unconformity which cannot be overlooked.	Shale, siltstone / sst. Pegmatite sills and dykes. Slickenside, thermally metamorphosed. Cal. veins common, vertical fractures. 30 dg reliable.
	14			12123.00	3695.1	12138.00	3699.7	15.00			Lateral accretion forset? Calcareous. Trough X-lam. Flat-pebbles, some still fit. Red shale breccia?							fracture, high ang.	calcite						1 fracture	one fracture, filled with calcite.	Permian structure near crestal area of an anticline, the growth may be associated with a west flanking	Sandstone, shale; microfaults common; right angle to bedding with calcite. Cut and fill; 30-35 reliable.
	15			12673.00	3862.7	12680.00	3864.9	6.00			Red-brown mudstone, bioturbation. Slightly cross lamination.	yes						? >70,	calcite						1 fracture	One fracture, ? 70 dg, filled with calcite.	fault. During Permian and Permo-Carboniferous times, the central culmination of the structure was rising or	dip 20dg; sst / silts, slickensides; 3 sets fractures two at high angle to bedding, one 60-70 to c. axis.
	16			12765.00	3890.8	12781.00	3895.6	16.00			Bioturbated mudstone, rip-up intraclasts (green), minor x-laminated siltstone.	yes						> 70	0.2-0.5mm calcite						3 fractures	three fractures, ? 70dg, filled with calcite. Breccia zone; slickenside.	stood as a positive physiographic element. At the end of Permian, the Merrimelia structure tilt to	Quartzite, siltstone, shale. 20 fairly reliable Fracture set 75 to core axis, calcite veins heal.
	17			13004.00	3963.6	13011.00	3965.8	6.00			Slightly brown to purple sst, granules along bedding truncated "trough" x -lamination.	yes mica. gre. sh.							calcite						2 fractures	Bedding: 20-25 dg; calcite-filled fracture.	the north, this probably initiated by movement along faults.	Sandstone, siltstone, shale; silty shale nodules. 30-40 dg fairly reliable.
Merrimelia 3 ENV 508	17		CDM 6350-8900	8964.0	2732.2	8981.0	2737.4	16.00			red to green, cross-laminated siltstone, sandstone, escaping trail.	yes													not even none to 2-5cm near 8210	In core 16, well-fractured interval near 8210', ? 45 dg, filled by siderite? (>1mm).	Seismically delineated structure. Faulting possible within the Permian itself.	Interbedded sandstone, shale and siltstone. Dip: 10 (reliable) to east or southeast.
	16		at 8146 S34E: 24	8210.0	2502.4	8215.0	2503.9	5.00			Faint-horizontal laminated sandstone. Green micaceous shale within the sst.			3-4mm	breccia					45 dg; < 1mm	siderite							Light grey sandstone, very fine grained, interbedded shale. Dip: 10 (fairly reliable) to east or southeast.
		below 8146	115-177 / 7-46																									
Merrimelia 4 ENV 284	3	slab 1/3	CDM 6100-8535' SE azim 110-170 dip 6-26	8495.0	2589.3	8511.0	2594.2	16.00			Cross laminated sandstone, red siltstone, shale. ? Brush mark and ? Trilobite trail	yes		7mm				0.2mm	hematite	0.7mm meshwork	haematite	small fracture 0.1mm	siderite		1-1.5' lightly to moderately	14 scattered fractures and veinlets, filled by haematite and siderite.	Little difference between Pre-Permian and base of Permian. A small reverse fault at 8380 within Permo-Carboniferous at 8380', striking NE-SW, up thrown block being to the NW side.	Red brown sandstone, shale, interbedded silt/sst/sh. Dip 4-7 reliable. (?) Trilobite tracks present. 8401 SE, 9dg.
Merrimelia 6 ENV 4554	5	y	GEODIP CDM HDT 7424'	7432.0	2265.3	7442.5	2268.5	10.50			Light green, grey, fine-grained sandstone, low-angle x-lamination, bedding plane has brush mark trace fossil. Flat-pebbles of green shales.														1-3 fractures	Two calcite veinlet through 7440-42'6". Partially filled by crystals.	NE-SW Merrimelia horst structure.Growth fault step off the flanks of the structure.	Maroon shale, green shale clasts, white to buff quartzite shallow dip appro. 2-5dg.
Merrimelia 7 ENV 4910	5		GEODIP	7442.0	2268.3	7452.0	2271.4	9.30			Light grey, green, fine-grained sandstone, forset cross bedding and truncations, faint low angle to horizontal lamination. Minor muddy layers. 7442-7444, dark grey siltstone, mudstone (minor red).			7444-4"; fracture											not even 13 fractures.	Partially filled fractures, see plastics for detail. 6 fractures.	Downdip to the SW of Merr. 6 which on crestal culmi. of Merr. High NE-SW trending dome.	Claystone, sandstone, Vein 70dg to horizontal. Bedding is sub-horizontal to 30. Core photo
Taloola 1 7147	1	y	SHDT 4170-6305'	6294.0	1918.4	6309.0	1923.0	11.0			green (shard) lining between quartz dominated layer slightly welded.							28;0.5-0.8mm 1		80.0 2				2 displace 1	a few through	Two sets of fractures, not significant. Possibly filled by silica.	NE-SW trending anticlinal dome located on the NE end of the Nealyon-Taloola high on western flank of Patchawarra Trough, 6 km east of Nealyon 1.	Subhorizontal hairline fractures with dolomite after desert rose minor haematite; silica healed.
Moomba 2 Env 632	3	y	CDM W 20° at 9836' 9770-90 SE / 72-77° SE mainly	9837.0	2998.3	9858.0	3004.7	21.00	?Y	x-ray 58°(WCR)	thin-bedded, thin ribbons of ? ms			0.5cm at 9852 ft 2cm at 9846 ft 2cm at 9847 ft ? 90° to bedding	silica silica silica	cross-cut v 1-2° to vein 1 at 9846'	calcite	90° to vein 1 form network at 9837 ft para or 10° to bedding small angle	calcite brownish	50-60° to bedding	calcite				high	high angle fractures intraclasts or folded ribbons at 9837'	broad low relief closed anticline, NE-SW trending	Dolomitic siltstone. Fractures numerous, dominant at 80 to 90dg. They are filled by white clay, calcite, and minor silica and traces of lignite. Two white veins of silica with minor dolomite cut the core at 9846 (60dg) and 9853' (dip 40) and 4" band of white silica at 9852'. Possible dip varied from 40 to 55, good at 9849':55-60.
	2		CDM 31°, 36° / NW 22° / NWW	9245.0	2817.9	9274.0	2826.7	29.00		x-ray 20-35° (WCR)	thin-bedded, thin ribbons of ? ms			similar as above												fractures and breccias		Dolomitic siltstone. Numerous small fractures and faults. Filled with white earthy argillaceous minerals, green chlorite (?) and minor calcite. Slickensides on fault plane.
	1		71° / S SE / 24-38°	8906.0	2714.5	8921.0	2719.1	15.00		x-ray 40°(WCR)	severely fractured, more deformed, bedding hardly recognisable, probably the same as below within weathered zone	9248'						? para to bedding	? calcite or clay	right angle or less to bedding								Dolomitic siltstone, highly fractured, with sets at angles of 40, 50, 70, filled with carbonates, clay material, qtz.
Moomba 7	6	y	CDM to 9952' 9920': NE16 9805': NE9 9630 (Cooper) S9 to SSE	9950.0	3032.8	9955.0	3034.3	3.0	no data		Horizontally-laminated sandstone, medium to coarse WCR, petrological report: 0.75-0.3mm qtz grain; called it orthoquartzite.														5-8"	Bedding possibly 20-25dg. Induced fractures (parabolic? 30-40); 2 sets of fractures at 9953'; 1. 0dg, 2. 90dg; 2 cut 1.; 3. 76dg, filled by clay (?), all hairline, and open. At 9951', 45 open; 45 dg; so they are probably all induced.	4.8km NE of Moomba 1, near crest of SE end of N closure of the Moomba feature. Gidgealpa Fm S-dip. WB succession (218ft): 9-20dg NE.	Orthoquatzite, structural dip 20dg.
Mudlalee 1 867	3	n	CDM d. to 6822' 6800-6810 NW dominant 0-40 azim. dip angle 10-26	6810.0 one piece of 1/3 core circum-pherential at 6828'	2075.7	6829.0	2081.5			60-70° from 1/3 core at 6828'	Grey to dark grey laminated mudstone /shale at bottom half; basalt at top half with sharp contact.	N		1.5mm wide opposite direction to bedding	quartz + ? Fe-dol. (brown + white)	wavy, parallel to conjugate set	dk grey to bk 2mm	conjugate (better in basalt) 20 - 45° = Vein 1	brownish =? Vein 1						3-5"	At least 2 sets of fractures, low angle, high conjugate, one steeper than the other in core slab. minor vuggy porosity.	Anticline	sandstone and shale; bedding: 70° 2 parting directions: 40-50° qtz & pyrite fill fractures
Munkarie 1 3308	2		GEODIP HRD 3700-7690'	7692.0 only 6" recovery	2344.5	7694.0	2345.1	0.50	2° directional survey	? 80 from core due to folding	dk grey mudstone, with needles of ? spicules, slumping or microfolding.	N						high angle, fine 80, parallel to bedding 1/10 to 1/2mm	pyrite + ?	high angle, fine 1/10mm	open				2-3"	high angle dipping (? structural fold) due to slumping or fracture, paral. to ? bedding, both 80. Other fract. connecting but not straight. dipmeter only show: 10W, 40S, 80E	northwest trending anticlinal nose downthrown side of a major NW trending fault. Situated on western to south wes- flank of the structure.	homogenous shale, dense, hard, dark grey shale with minor quartz veining and minor pyrite. 7692'6"-7694' no recovery due to barrel jammed.
Murteree 1 1511	4	N	CDM 5500-7220'	7224.0	2201.9	7231.0	2204.0		3° 7224'	45-55°	Dark grey to black, laminated siltstone and shale.	no		quartz vein 1cm wide with brecciated core at 7229'5"	quartz									? younger order: yellow, blue, brown, a fault plane is earliest.	moderate to high 1-4"	Several reverse fault planes observed, dip angles to the core edge: (4). Broken core in the interval ? caused by fault. 2 sets of conjugate and tension gashes. At least three kinds of joints: blue, brown and yellow (plastic trace of core slab) Fault plane may be thrust or reverse faults because of displacement of beddings (2 phases).	Downthrown side of fault, flank of Murteree A1 on the crest of anticline structure.	Argillite, freq, mm wide fracture; frequent qtz filled conjugate fracture planes. Bedding: 45-60°. fracture plane parallel to bedding, but in opposite direction to bedding at 60dg.
Nappacoongee 1 16 > Driller	9	N slab BMR owes some	CDM "possible" compare with core (WCR)	9864.0	3006.5	9874.0	3009.6	10.00			shale							? 40; 0.1mm	pyrite	? 50; 0.8mm	calcite				0.45-.76m	0.8mm, calcite-filled fractures, approx. 50dg, only 4 fractures. a few breccias filled by calcite at top.	Nappacoongee anticline is asymmatric with steep flank to NW. Seismic data indicates that normal fault within the steep dip in the Pre-Permian section. Down thrown side of the fault is to the **NW**. Nappacoongee 1 near the crest of s seismically located	shale, very sharp fracture. 15-20° to core axis. dip: 15-20°, unreliable.
	8			8619.0	2627.1	8636.0	2632.3	9.00		8600.0 18SEE	fragmental cores, shale																anticline with no surface expression. rejuvinated during Cooper The Nappacoongee 900 feet higher than the highest closing contour at the Gidgealpa field. It is 800' high	shale, dip 25-32 reliable. Mean 28. Fracture set at 15-30 to core axis, healed by dolomite and occasionally calcite.
	7			8418.0	2565.8	8422.0	2567.0	1.00			grey shale																to Dullingari 1 and 1400 feet high to Merrimelia 2. Innamincka structure is the only drilled feature to the North, with greater structural relief.	Shale, silty, dolomitic; a fracture set at 30° to core axis No apparent dip.
	6			7663.0	2335.7	7697.0	2346.0	34.00			Massive grey fine-grained sandstone and siltstone. Lots of breccias. TS (7664'), ? Spicules.														1cm(l), 3-4cm (w)	majority fractures < 40dg, brecciation + veinlet (0.5mm) + brecciated zone: 6-7cm	Dip increas below the u/c, reached a max. of 36.5 dg (by X-ray analysis) in core 7, at 8420. Between c7-c9, dips flattened. In core 8, 32 dg; at 9870, core 9: 16. CDM considered by Schlumberger to have a correlation class of three, or "possible". This is becaused massive nature and unchanging lithology and fracture patterns in Pre-Permian section.	shale and siltstone; sharp fract; an foliation at 30° to core axis, and poss. right angle to apparent bedding. Lineation; possible bedding: micaceous layer. Dip 20 fairly reliable at 7696-7697'
	5			7371.0	2246.7	7377.0	2248.5	4.00			Grey to green, micaceous fine sst, more greenish. TS (MESA)																	Interbedded shale and siltstone. Dip: 12-15° relia. silt balls, flute casts and worm casts common. A near vertical fracture set healed with dolomite, qtz and pyrite is present.
	4			6997.0	2132.7	7031.0	2143.0	30.00			Grey to brownish siltstone, pseudo nodular sst, lobes. well fractured; displaced bedding (2-4mm). Lamination cm's.														1-2cm 5cm, not even	displacement (2-4mm), 2 sets of fractures at least; majority, 50, (0.5mm), filled by calcite. Brown one , ? pyrite; one been displaced by other fractures, fine, 0.3mm, filled by calcite.		siltstone shale; worm casts, load casts, slumping. two intersecting frac: 20-30° to core axis. bedding at 20°.
	3			6692.0	2039.7	6712.0	2045.8	20.00			light grey siltstone, massive; fine lam. (not clear).lineation, almost vertical, = Della 1													2 displace 1		One half or less core, two fractures: 45, 70. 1 parallel to bedding or parting surface, <1mm 2, high angle, 1-2mm; some filled with ? Dolomite.		highly fract. siltstone; dip 60-70° (possible bedding)
Packsaddle 3	1.0	y	y	7201.0	2194.9	7251.0	2210.1	39.50	1 1/2 0-7	15-45 SW 17-40 NE 25-45 SE one of them	Light grey sandstone interbedded with carbonaceous shale. Flat-shale-pebble beds common, shale clasts with green edge, some turn green which are similar to those in top part of IRB or "Mudrangie Sst". Siderite emphased bedding. Truncation of x-lam.	7217'8", 7232' 7233'						70dg	brown, ?7224'	85.0 7233'	orange, pink, ?	2 fract. 85, 72 7239'	black, ?		moderate not even, 3"	bedding measured from cores: 35, 50, 60; fractures from 70 - 85 dg. Measured at 7218, 19' At 7222': fractured plus breccia, siderite concentration. At 7235': fracture filled by black, plus yellow (?dolomite). Slickenside from place to place.	Within the largest NE-SW trending structural complexes. Fault-bounded anticline. Adjacent to thick sequences of Permian. Dipmeter inter.: random high angle dips too high for sedimentary dips, probably minor fracture planes suggesting NNE-SSW flexture.	White sandstone, low angle cross-bedding, green shale galls and thin clay-filled stringers. Dip approx. 45 at 7209'2"- 7210'. 7210-7210'6": shale, slickenside surface, ?fault, parallel to bedding. Below, sandstone interbedded with dark shale, siltstone, dip: 45-57. 7201-7209'2" Merrmelia conglomerate.
Pelketa 1				7095'8"		7114.0					weathered, interbedded, former silicified siltstone and shale. High angle breccia below horizontal Patch awarra Formation.														high to very high 1-5cm vertical, 1-6cm hori.	Fractures include, parallel to bedding, obliquely high angle to bedding, ? conjugate sets within shale beds. Siderite filled in thin section.	anticline	interbedded metasediments (shale and siltstone); bedding dip: 60dg to core axis. Numerous fractures cut core at variable angles.
Pando 1 Env 585	5	N	CDM (missing)	5807.0	1770.0	5822.0	1774.5	14.00	?	?paral to vein 1	bioturbated sst, deformed by tectonics small burrows similar to Dara. 1, but plus big ones.			5812 ft mm's,	qtz milky white			cross-cut vein	? clay siderite?						moderate to high 2"	quartz filled vein cut by siderite-filled veinlets. core 4 may belong to Permian, at least from	Crest of anticline or small horst block, bounded by N fault and S lineament. Pando Nt in N., Pando 2 in S.	core5:dip 20-30 unreliable; fracture set and shear, 10-25 to core axis. Qtz vein
6 feet < driller	4			5689.0	1734.0	5703.0	1738.3	10.00			Conglomerate, pebbly sst, and smashed pieces of core from bioturbated sst. Some pebbles are quartzite = Daralingie 1 quartzite Conglomerate belong to Cooper Basin, ? fluvial depo.							brownish ? 70°							4 / 1" in one place	solid congl. at 5689'.	top fo Permian, 529' higher than Spencer 1 1006' higher than the highest well in Gidgeal.	possible indicate bedding.5813-16, poss. faulting, deformed. C6: 10-40 to core axis: filled by siderite and silica; no dip.
core 6 missing	6			6235.0	1900.4	6240.0	1902.0	2.00			no core left															missing		sandstone, buff to occasionally brown. Fine to med grained, siliceous, quartzitic, occasionally haematic 1. fracture set 10 to 40 to core axis 2. right angle to it. Healed with siderite and silica. No apparent dip.
Pinna 1 3945	3		y only to 8100'	8460.0	2578.6	8470.0	2581.7	9.00		horizontal & discontinuous at 8467'3"	Dark grey to black siltstone/mudstone, with slumping, folds, slightly metamorphosed to chloritic or graphite. With clasts of yellow (neritic limestone, black (?).Green lamination is within dark grey to black siltstone/ mudstone.	calcite		conjugate: 65-70° 8465' fine, 0.2-0.8mm,	brownish, ?			nearly horizontal to 5°. 8468'7"-10"							1-2' but locally 2/1"	Fault displacement at 8466', displaced about 1-1.5cm, almost horizontal. Fractures or joints are not distinct, but apprarently are two types:	NE trending "half anticline", fault bounded to the SE. Faulting of Permian sediments against the metased. of Warburton Basin may provide a good seal. Drilled on NW side of the bounding fault.	metasiltstone and occasional interbed of andesite Bedding although often indistinct, appear at about 70dg. Two poorly developed sets of fractures both about 70dg, one paralle to bedding, the other at an angle

																											1. Conjugate set: 65° and 70°.		of 40 dg to bedding.
																											2. Nearly horizontal to 5° can be		
																											connected to wavy, oblique, even		
Snake Hole 1	**1**	y	**CYBERDIP**	9212.0	2807.8	9322.0	2841.3	7.00	6 3/4	**6-8**	thinly bedded siltstone, v.f sst and red mudstone,	y		asso. Fract 1	calcite	en-echelon		345 / 85	calcite	strike: 350-170;	calcite				low in mudstone	well fractured from 9316 upwards and below	Snake Hole Prospect parallels the Gidgealpa Nth	Dip: 0; with microfault zone between 9315-9316'6"
									5 1/2	**from dipmeter**	cross-laminated at 9315'. Microfolding or slumping	9315-7'	n					9317"			90	0.6mm			3 / 1" in fault zone	9312'9"; fault breccia (1cm wide) at 9315-7"	dome on the NW side. Gidgealpa Nth dome is	with calcite infilling on fault plane.
6' > logger									below 9300'		at 9319'. Vertical bioturbation at 9312'.	soapy green								9313'10"					microfaulting, displacement up to 2.5mm;	NE-SW oriented anticlinal trend.	Interbedded metasiltstone.
												shale													slickenside along soapy green clay along the	The pre-Permian strata have been uplifted along	
																									fault zone. Bedding at 9316 is about 0-3.	a complex, NE trending fault system. Merrimelia	
																									High angle calcite filled fractures at 9312'9"-9314'5"	Fm onlap to the structure. Asymmetry of the	
																									Discontinuous calcite-filled fracture, similar to	uplifted basement block is indicated by thinning	
																									en echelon.	of sediments from SE, whereas sediments on	
																										NW flank are markedly thicker. The block thus	
																										had a steep NW face and a more gentle SE face.	
																										The prospect three way dip closure, truncated on	
																										on the SE flank by the uplifted basement block.	
Spencer 1	**3**	slab		**6736.0**	2053.1	**6738.0**	2053.7			**20 SWS201**	Dark red-brown cobbles of rhyodacite within red													**nil to low**	Slabs except a piece at bottom rounded (no bedding)	structural nose along GMI, southern end.	Tuff, agglomerate, with minor shale. Apparent dip: 20dg.
		bottom		6733.00	2052.2	6747.00	2056.5	14.00		**at core 3**	siltstone/mudstone (e.g. 6738' has 1cm red mudstone).														Rhyodacite cobbles at bottom have fractures,	located downdip .	
		rounded								**but 9 NE 31**	At top, sst pebbbles or cobbles (>7cm in diameter)																
										at u/c (6626)	and breccias of truncated rhyodacite or welded tuff.																
										12 NW332																	
										at 6675																	
Tinga Tingana 1	**10**	N	**CDM**	7547.0	2300.3	7552.0	2301.8	4.50	1.1 max.		thinly bedded, light brown quartzite,														two conjugate fractures	Near crest of the Tinga Tingana anticline, about 3-1/2	7547-7551.5': orthoquartzite, minor shale. Dip 70-80
Env 889		up to	**down to**								with minor micaceous; shale.														filled by silica, near 7552'	miles long, up to 2 miles wide. Vertical closure:200'.	reliable. A fracture set 15-20 dg to horizontal.
		7512'	**7512'**																						7548'; 45° or less to the core edge.		Slickensides on these fracture planes, infilled with
			not much																								calcite or occasionally a green clay.
			difference																								
	9		from above	7427.0	2263.7	7436.0	2266.5	12.00	?	**near 80° or**	under 7427', sandstone and shale											.		Dip nearly vertical.	Permian definitely extends to 6123', it may extend to	7424-27': conglomerate; 7427-7436': shale, siltstone,
										more	above 7427', conglomerate, with pebbles of												.			7432'. Chris' new data 6056' is Tirrawarra.	nearly 80 dg, reliable.calcite veins and slickenside
											rhyodacite, sandstone and ?																from 10 - 30 dg to horizontal.
Toolachee 9	**2**	no, 1/2	**CDM**	7802.0	2378.0	7806.0	2379.3	1.5	1 1/4		Two units: bottom - grey coarse sandstone, similar													high	80-85 dip of bedding. Quartz veinlet, 1-3mm.	Eastern edge of Toolachee structure on the upthrown	Grey, medium-grained, micaceous quartzite.
ENV 3731			**7790.0**						at 7600		to that of Pandieburra, with muscovite, no app.													5 / 1"	? become stylolite.	side of the major N-S bounding fault which separates	Fine fractures present, causing minor disturbance
4' > driller											bedding. upper: dark grey to black gradded-bedding															Toolachee 9 from Toolachee East 1.	and microbrecciation of quartz framework grains.
																												Petrology: Minor quartz veins, find joints/fracture.
																												Well-compacted and indurated sericitic, mica, quartzite
Yalcumma 1	**1**	y	**HDT**	9783.5	2982.0	9794.5	2985.4	10.50			grey to dark grey siltstone and shale, good burrows													moderate to high	Steeply dipping bedding, cross-cut by calcite	Fault closed anticline in southern part of Nappamerri	Steeply dipping interbedded quartzite and metasiltstones.
3946											on muddy bedding planes, deformed bedding.													10 / 1'	filled fractures.	Trough, Northerly trending anticline	Quartzite, white to pale frey-green, very hard, silt to
											at southern Nappamerri Trough area.															anticline, intersects only 'V' and 'Z', implying faulting	fine sst. Metasiltstone: light grey very hard.
																										contemporaneous with uplift in early Permian.. A slight	
																										thickening of V to Z interval on downthrown side of fault.	
Wantana 1		y	**HDT**	9628.00	2934.6	9636.00	2937.1	7.50	3 max		bioturbated fine sst; shale with siltstone layers;							60; 0.2mm-2mm	calcite					1"	Very tight microfold, thrust fault with 0.8-0.9mm	SE flank of the Merrimelia Anticline of NE trend.	Dip 30dg. Qtz veins (to2mm) - random.
			9640'								laminated siltstone and fine sandstone.													but 5 / 1" in sst. + fault	displacement, 70-75dg. Two sets of fractures,	NW and SE flanks are faulted with smaller faults	subphylitic shale, convoluted or compacted struct.
17 > driller											Top by sandy limestone, laminated, rip-up clasts														high angle one displaced by low angle one.	cutting across the main structure.	WB TOP: 9537'
											and intraclastic grainstone full of Nuia debris.														Bedding: 20-22 dg. If bedding: N, thrust fault SE.		

Well	Formation	core	round?		depth (t)		depth (b)	Rec ft	?deviation	bedding	Sedi. structure	slickenside	stylolite	vein (1)	filled by	vein (2)	filled by	fractures (1)	filled?	fractures (2)	filled?	fractures (3)	filled?	chronology	fracture	Comments	Structure (WCR)	WCR
				ft	m	ft	m			dip angle															intensity			
Beanbush 1	IRB	**5**	**y**	12126.0	3696.0	12138.0	3699.7	11.7			Laminated and cross-laminated siltstone, fine														3 / 12'	Open subvertical fracture at 12130'6", aperture: 0.1mm		
											sandstone, minor red mudstone.															80-85 degree		
Big Lake 52	Dullingiari	**2**	y	9462.0	2884.0	9520.0	2901.7	42'8"			Thin-bedded, grey, siltstone and shale.	para. bedding		quartz vein	4mm; qtz			35 dg (1mm)	? Siderite					qtz vein cut by	high	strongly fractured and sheared, slickenside 65-70.	domal anticline	Steeply dipping slate and quartzite with quartz veins.
> 12' than driller											Steeply dipping bedding below almost horizontally	at 2892.5m						displace 7mm						siderite	10 / 7"	see plastics; dip: 50-55, siderite cemented		
											bedded Cooper conglomerate (Merrimelia Fm).	75dg														veinlet (2.5mm) (fault displacement); finer (0.5mm)		
																										also displaced. Quartz vein (3mm) twisted at		
																										9491', ? right-lateral. Fracture breccia.		
Bookabourdie 1	Innam. Red	**4**	Y	9700.0	2956.6	9710.0	2959.6		6°	subhorizontal	light brown, grey, greenish siltstone/sst, below							85-90°	grey to white	conjugate	light grey			fractures in differer	high, 5/1" or 1-2"	fracturing and brecciation, slickenside, ? Fault	anticlinal dome striking NE. Basement uplifted along	High angle fracture,
6237									9700'	but deformed	9710'; cross lamination & bioturbation at 9706'							at 9707'	?	40°				intervals, not	not even	zone. To fragile to measure. 85-90° at 9707'	NW-SE trending Permian faults as compressional	brecciation: 9702-3'.
										at 9705'6"-	some part calcite rich; above 9710': red ms									at 9702'6"			possible to decide.	fault zone?	conjugate, 40 at 9702'6"	and wrench tectonics.	
										9706', slump																		
										or folding																		
Brumby	Dullingari	**4**	y	7703.0	2347.9	7713.0	2350.9	10.0	3/02/2004		Dark grey, thin-bedded, siltstone, with abundant	common													5"	Fractures, 20 (5) - 30 (1)	drilled close to the crest of a broad anticline, trends NE	Banded siltstone (phyllite), low-grade metamorphic.
									7703		spicules.	bedding plane																Fracture planes at 50 dg.
																												structural dip: 30.
Burke 1	Dullingari	**7**	**y**	8375.0	2552.7	8385.0	2555.7	10.0	2 3/4		Light grey siltstone, sandstone, slumping.														3-5"	Weathered former sandstone to siltstone, shale.	Burke feature is closure adjacent to the Dullingari	Siltstone and shale, light grey, slightly
											? weathered zone															Patches of siderite within sericite shale. fractures.	structure; Burke 1 just off the crest of the Burke feature,	fossiliferous (sponge? Spicules).
																										Fra(1). nearly horizontal to 20dg; Frac(2) 60 to 90.	which is part of a larger closure which	
																											forms the Dullingari-Burke feature.	
Charo 1	Kalladeina	**1**	y	7309.0	2227.8	7319.0	2230.8	4.95			Oncolitic packstone, grainstone, thin beds, storm		abundant												nil	No fractures. Abundant stylolites, every 4-6cm.	NW flank of the Patchawarra Trough.	Massive limestone with minor siltstone
											beds (thin).			intercalations.											no fractures	5 dg bedding and emphasised by stylolite.	N-S elongated, low relief anticline, prevailing SE regional	Lithic fragments (<1cm) meta sandstone
																											dip. A fault in Cambrian sequence.	within limestone at 7313.8'.
Cherri 1	Dullingari	**3**	y	4581.0	1396.3	4596.0	1400.9	14.00	2 max.		Laminated mudstone / shale, marked by white (?)	minor		75; 2mm	minor calcite			80-85; 0.2mm	pyrite	65; 0.2-3mm			? Siderite	bedding (white)	almost across	Possible bedding alignment possibly emphasised	locates flank of westerly culmination of N-S aligned	45 bedding, shale and minor siltstone;
											and pyrite, possible due to metamorphism (DIG)				? Kaolinite									cut by 2, by	through all core	or pure due to metamorphism; at least two or	small anticline; locates also at the southern extremity	rare white siliceous vein appro. 80dg.
											Very black, graphite or carbon. ? schist or slate			1				2		3				coarser pyrite	vertically; but half	three sets of fractures and veinlets.	of a magnetic and gravity high. Cycle skipping on sonic	micromicaceous, fissile, finely carbonaceous
																									(parallel to bedding	horizontally across		over 4569-79' indicates fracturing. Marked decrease in	
																									then by 3 (65).	core (8cm) in		sonic travel time indicates considerable movement	
																										diameter.		prior to the deposition of the Permian.
Coonatie 1	"Mudr. Sst"	**8**	Y	10395.0	3168.4	10405.0	3171.4		0-5°		light grey fine sst, with cross-bed, cross-lamina.			at 10401':	brownish			85-90°	auth. Qtz,	para. Bedding	brownish	60-65°	1mm-1cm	**3 cut 2**	not even	some faint fractures: more or less	North of GMI, a Permian downwarp, this low is bounded	numerous small
1697											rounded green shale pebbles; interbedded with			2-4cm	breccia				min. calcite		Fe- clay?		brownish		4 / 1" in fractured	parallel to bedding and also connect	to the South by normal down to north faulting	faults & joints in
											dark greenish siltstone / shale.			80-85 dg				? Former			4mm		Fe - clay		zone and vuggy	vertically, dish-structure like,		core
																		Slickenside							moderate in	not cross-cut whole core, 5-25°		
																									other	discontinuous. High angle cut by horizontal or low angle		
Daer 1	Kalladeina	**1**	y	10630.0	3240.0	10640.0	3243.1	8.00			nodular skeletal wackestone, thin bedded packstone,														low to moderate	Bedding measured: 15, 20, 25; fractures:	The structure located on NW flank of Pat. Trough. NE	Bedded dolomitic limestone, intrasparite.
											oncolitic grainstone, dolomitised														2 / 1'	10, 2mm, calcite filled; 75, calcite, 0.4mm.	-SW aligned folding with W.B. sequ. But extensive	The core to bedding angle averages: 70 dg.
																									1 / 1-2'	scond phase fracture, 80, calcite, fill, fract. 0.15mm;	NNW-SSE normal faulting on EW sides of structure.	Minor calcite veining. Most prominent set of
																										stopped below slickenside. High amplitute stylolite,	Changing of structural style: W of Daer structure, the	calcite veins averages 60 dg to core axis.
																										> 25 dg. At 10637'7", 1cm calcite vein + catac.	western flank of the Patchawarra Trough trends N-E;	Calcite veinlets form stockworks at 10631'7"-
																										slickenside along surface, similar to thermal fluid.	to the east, the margin defined by an EW fault system	10631'11" and 10636'-10636'5".
																										Stopped at slickenside.	4km WSW of Coongie 1.	Also good porosity equivalent to Coongie 1,
																												but water wet.
Della 2	Dullingari	**7**	y	7212.0	2198.2	7222.0	2201.3	10.00	1 1/4		weathered, slightly deformed rock, originally silt/sh.			1-3mm; 70-80	Fe? Siderite			1. 25-35;	Fe, or sideri.	2. meshwork			Fe clay	Vein 1displace	1-5mm ; < 1cm wid.	thoroughly fractured; weathered, altered	Angular u/c with overlying Merrime. Fm at 7148'.	low meta., fractures 40-50, filled by silica, pyrite.
									at 7212'		no bedding; well fractured and brecciated partially.			gauge up to 3mm	kaolinite			0.1-0.3mm	= lining in	80-90:0.1mm				frac(1) which repl		3 phases of fracture, vein, veinlet displaced frac		distinct parting at 40, bedding poss. 70.
																			vein 1	irregular				frac (2)		1-displc frac2. Weathered crust (Dr Luo, per. comm.)		fracture 40-50.
																										Filled by siderite or ankerite in thin section.		
Della 4	Dullingari	**6**	y	7063.00	2152.8	7073.00	2155.9	4.50			relatively well-sorted sandstone (0.1-1mm), no bedding.							50-60	? Siderite						30cm	Irregular fractures, siderite patches (2-3cm interv)	near axis of N-E trending Della structure, north of Della 1	
											A mud clast about 2cm long.							not regular								at 7065', possible induced fracture, open to	structurally equal to Della, higher than Della 2 and 3.	
																										filled by brownish clay, grey mud(drilling?).		
Della 5A	Dullingari	**4**	y	6409.0	1953.5	6446.0	1964.7	37.00	3 1/2		light grey siltstone, but it is badly	abundant						gauge, 2mm	Fe +	meshwork			Fe clay or		5mm (length)	Weathered, altered zone, brecciation, slightly	Crest of the Della structure, between productive Della 1,	Dip horizontal at 6407', below it, badly broken
									above		weathered and altered zone, fractured and brecciated.	high angle						25dg,	trace dol.	high angle			siderite		< 1cm (width)	foliation; angular unconformity below horizontal	2, and SW of Della 4.	core 4, mudstone breccia; high angle foliation
		3		6349.0	1935.2	6409.0	1953.5		core interv.		slightly foliated, common slickensides.	85-90						lining + filling	(reactive)	=low angle						? Merrimelia Fm.	It is development well to test if gas was escaping from	slickensides. Minor crystalline fracutre filling.
											similar to Della 2, but more strongly deformed, more	very polished								connected						Veinlet cut meshwork (2), some shining	Della 5.	Trace calcite on fractures.
											brecciation, broken core at bottom, u/c Cooper at top	lineation								breccias						surface has sericite		
												new mineral														a few low angle gauge		
												formed on																
												curved surfa.																
Dunoon 1	? Dullingari	**1**	Y	4987.0	1520.0	4997.0	1523.1		1 to 1+1/4		grey, mm to cm laminated siltstone and v. f. sst.														nil	No fractures at all.	58 km SSW of Moomba; on an E-W trending anticline	Metasandstone, grey green, very fine, well sorted,
6047											271 feet thick of W.B.														no fractures		located in SW of the Murteree Horst.	angularity, quartzitic, chloritic, v. hard, horizontal beds.
7' > driller																												
Gurra 1	W. GP	**2**	y	4684.0	1427.7	4686.0	1428.3	1.3	Max: 2		Phyllite, possibly orignally shale and siltstone			0; upto 7mm	calcite			80-85; 1mm	calcite						5cm	Well-fractured, horizontal and vertical, filled by calcite.	SW margin of Cooper, small anticline; fracture and	Core 1 phyllite shale, between 4529-4533';
			half						at TD		crenulation, vertical graphite alignment.																indurated WB succession, recovered low salinity water.	numerous fractures from very fine to 1.5",
		1	y	4528.0	1380.1	4535.0	1382.3	6.0			Horizontal and vertical calcite veinlet, brecciation.																	Similar to Cherri 1, with low grade dg of metamorphism	filled by milky quartz, slightly vuggy.
			half								formal shale, shining lineation.																		core 2, dip 20; core 1, 10-15 dg.
Gidgealpa 4	Mooracoochie	**9**		7190.0	2191.5	7257.0	2211.9				tuffaceous sandstone, breccia of porphyritic latite?														4-15 /1'	severely fractured, brecciated	Western flank of gentle NE-SW anticline, u/c on crest	tuff, green-yellowish. Small veins of apparently
											ignimbrite in core 11.																	of carbonate in the upper section.
		10		7402.0	2256.1	7494.0	2284.2	11.00																					tuff, varicoloured, with abundant green specks,
																												unreliable traces of bedding, 15dg.
		11		7773.0	2369.2	7703.0	2347.9	9.66																				
																												tuff, variouloured, buff-brown, sandy in places.
Gidgealpa 8	Mooracoochie		y						3 3/4		tuff, fault breccia, still jig-saw fit.														not even		Western flank of gentle NE-SW anticline, slightly higher	
		6		7079.0	2157.7	7145.0	2177.8	46.0			Warburton Basin top at about 7089'.																	than Gidgealpa 4. Volcanics with ? 20 dip angle.	
				7089 WB																									tuff, extensive veining. Fractures with slickensides.
																												dip over the upper nine feet is irregular within 20dg.
		7		7149.0	2179.0	7157.0	2181.5	8.0																	1-2cm /vert.	highly fractured, brecciated.		
																									2-5cm / hor.	highly fractured, brecciated.		
Gidgealpa 11	Mooracoochie	**3**		6852.0	2088.5	6885.0	2098.5	30.5			ignimbrite, tuff.														low	sparse fractures, due to ? Contractional	norther part of Gidgealpa structure.	
Jennet 1	metasst, sit	**1**	y	5525.0	1684.0	5535.0	1687.1		1°		Coarse to fine porous sst with brownish ms layer,														3 / 1'	brittle fracturing, some open, ?	crest of a domal anticline develpoed upon	Steeply dipping metasandstone, minor metasiltstone.
7028										steep dip	cross lamination at 5525-5526'. (phyllite WCR)	many													vertically	induced fractures at 5232'2"-5"	a major NE-SW trending horst block	Common fracturing, nil visual porosity, no shows.
										60-65° at	most porous at cross-lamination portion.	such as												3.4cm	slicenside at 5525'5", fracture displ.	plunging basinward towards the NE.	Slickensides, phyllite at 5525'6".
										5525'		5525'														bedding.	Pre-Z, high angle fault along its NW & SE	
												5528' (WCR)															displacement along NW more significant	
Kalanna 1	Dullingari	**1**		8933.0	2722.8	8943.0	2725.8		4°		dark grey to black mudstone, bedding	N		40-50°	calcite			70°	calcite	20, 30°,	calcite				high	Possible fault plane (40-50°)	At Z, NE-SW Kalanna fault zone is defined by a series	silt, sst, fractures filled by calcitic
									8930'		unrecognisable, because of folding. Some sandy			1-3mm						? Para bedding					2-5 cm	along which parallel veins.	of subparallel intersecting and anastomosing faults that	brecciated;
											layers sheared in between mudstone, e.g.														or 2 / 1"		cut the scarp into a number of wedge slices of varying	
											at 8940'.																throw.	
Innamincka 4	IRB	**1**	y	6976.0	2126.3	6986.0	2129.3	7.50	1 3/4	a few	Green to red siltstone, mudstone, v.f. sst.			6976' - 5"	calcite	6977'9"	not calcite	6982'1-8". 2 frac	calcite	6976'-3" : 80	calcite	6981'6"-6983'	calcite		low	6978'2"-6978'8"-9" fracture filled by calcite.	on the upthrown side of the basement fault,	Interbedded sandstone and siltstone.
											thin beds, flat pebbles of rip-up greeb shale clasts.			see measured		fracture	?	1. 0.1mm; 2. 0.6mm		0.6mm							Patchawarra Fm pinched out at the flanks.	
											minor x-lamination. Skolithos.																	
																												Vertical fracture with quartz infill at 5981 to 5982.
																												no obvious bedding dip.
Kumbarie 1	? Dullingari	**2**									weathered, light grey mudstone,														1-2cm, hor/ver.	N-E trending anticlinal accumulation, on a N-S trending	N-E trending anticlinal accumulation, on a N-S trending	Light grey sandstone, siltstone with shany lustre
											whole core broken														or > 10 /1'	ridge.	ridge.	very siliceous with common slickensides highly
																												fractured with healed fractures, cleavage planes.
		3	y	5376.0		5392.0		7.9			dark siltstone and shale, 5526' has sandstone layer.														2-3cm			shale with minor siltstone. Fractures healed partly
																												by white anhydrite or gypsum. Siltstone band:
Lowanna 1	Dullingari	**1**	y	9800.0	2987.0	9803.0	2988.0	2"7"	3 1/2		Green-grey siltstone, shale, laminae.														1-2cm	Well fractured, filled by calcite.	N margin of the Allunga Trough, SE of Big Lake trend.	Dolomitic siltstone, green-grey, very silicified.
									at 9800'		cm laminated very fine sandstone, shale.															0.1mm-4mm at bottom.	Dormal form is caused by prominent NE-SW folds	Grading to quartzite, very hard, minor argillaceous.
Logger > driller																										Dip: 50-65? Measured, see plastics.	extending SW from Della-Nappacoongee trends with	moderalte fault brecciation in part and thin fracturing
16'																											less prominent - folds oriented NW-SE. The Permian	throughout. Off white to dark grey calcareous fil.
																											and Mesozoic Fms are simply draped over the underlying	Very small flame structure.
Meranji 2	IRB	**1**	y	10912.0		10922.0					x-laminated fine sandstone, siltstone and														3 / 10'	high angle open fractures, aperture 0.15mm	anticlinal dome	metasandstone and metasiltstone.
											minor red shale.														low			
Merrimelia 5	Innamincka	**5**	y	8969.0	2733.8	8989.0	2739.8	20.00	4 1/2	nil	Red mudstone and minor fine-grained sandstone,														nil		NE-SW anticline, southern flank of this structure.	Red shale, ssub-fissile, silty, slightly micaceous.
ENV 1525											siltstone, x-lamination, slump, nodular structures.																	Red sandstone, very siliceous. Dip: 10.
											Faint bioturbation															No obvious fractures.		
Minkie 1	Innamincka	**1**	y	7840.0	2389.6	7847.0	2391.8	7.00	3		Light grey x-laminated fine-grained sandstone,														3 / 7'		NE of Merrimelia structure (NE trending uplifted	Sandstone with shale clasts; laminated siltstone.
8 > driller											with green shale pebbles, siderite nodules and patches.																horst block. Located in the Merrimelia North high,	Shale clasts generally angular, smooth texture,
																										3 fractures and a meshwork.	irregular and splays east from normal NE trend.	fissile, commonly aligned parallel to bedding.
																											"Z" seismic mapping: basement has been faulted	
													40-50°														by major NE trending faults on the sides of Merrimelia	
																											High, throws up to 900'. Reactivation bounding faults	
																											in pre-Toolachee caused uplift, erosion Permian in crest.	
Moomba 3	?	**8**	slab	9506.0	2897.4	9508.0	2898.0	2.0	No data		Green, ?hornfel, pyrite-rich.									fine, hairline			brown, ?clay		a few fractures		5.6km NNW of Moomba 2; correlated with Moomba 2.	x-ray core shows 18dg, fractures 20-30dg;
																											Moomba structure, it 119' lower than Moomba 1.	pyrite fill. Sandstone, siltstone, shale.
																										a few horizonal fractures filled by brown (?clay).		
Moomba South 1	?	**2**	y	9858.0	3004.7	9876.5	3010.4	17.80	3 1/2		massive metasst, siltstone, ? hornfel. Bedding not														1-10 mm		to the south of the Moomba structure, a broad, low	Meta sst, siltstone, sst.
5487											recognisable, well fracture but irregular network.																v. high angle to vertical lamination due to flowing	relief composite anticlinal structure with subsidiary	
											dk brown to grey. Contact with granite?															band? Brecciation forced by thermal fluid?	culminations at the 'P' horizon.	
																											fractures are intensive (1-10mm), filled by siderite.	The Moomba South prospect is a NE-SW trending	
																											Cuttings from 10240' granite; 10130: siltstone	elongate dome.	
Mudrangie 1	"Mudr. Sst"	**11**	Y	10455.0	3186.7	10452.0	3185.8			40-60°	light grey, medium to fine, well sorted quartzite,			45-50°	brownish			50-52°	brownish	50-60°	brownish	90°	brownish	1 and 2 cut by 3	high		northern (downthrown) side of the fault of Merrimelia stru.	Bedding: 40°
1577											lamination, greenish muddy siltstone and mud.			at 10450: 5mm	?				? Fe clay		? Fe clay		? Fe clay	in some core not s	> 4 /1"	severely fractured, brecciated,	southmost of 3 en echelon structures,	low-grade metom.
											Greenish pebbles of shale or mudstone are															thick vein filled by breccia and	trending NE-SW,	two planes: 60°
											lined-up along the bedding plane of quartzite.														2-5" spacing	brownish ? Fe rich clay.		fault brecciated
											some visible fragments of black ? lithics along																	
											the bedding of the sst.																	
Murteree A1	? Kalladeina	**2**	2/3	5155.0	1571.2	5165.0	1574.3		1/4°		amygdales in basalt, brecciation called originai							50o	brownish, ?	60.0				f(1) cut f(2)	1 cm		large anticlinal feature.	andesite,
2156			top						5051'		basalt in water, displaced by later (frac(1)).							seems cut f(2)							or 8 / 1"	Numerous fractures, series of		70-75° fracture planes abundant
			1/3																							displacement surfaces.		rare bedding 30-35° suggesting
			missing																							fine fractures, several phases (> 2).		a tuffaceous nature in part.
																										Fill of amygdale & veinlets are white		
Murteree C1	Dullingari	**2**	2/3	7427.0	2263.7	7437.0	2266.8		3-1/4°	y, 62°	Light grey, siltstone and mudstone, cm's layering,	6x4cm².		breccia of				80°	brownish	20°		60°		need work out	1cm or > 10/1"	Down thrown side of SW-NE trending fault, forming	Low grade metamorphic (phyllite).
2186	"altered"		missing						at 7344'	at 7430'	? = bedding, 60°; because of alteration,			mother rock &								= silickenside			severely fractured & brecciated.	N flank of the horst.	Occassional thin layers of quartz
			outside							most	hard to decide.			qtz (vein qtz?) +												slickenside (steep). Fracture filled		pebbles up to two inches
										changing from				brownish clay.												by brownish (?clay). Different		delineating bedding at appro. 70°
										60 to 90°.																shape of greenish granules along		Fracture planes frequent at
																											(?bedding) lineation.		approximately 70°, along bedding
																												and at 90° opposite to
																												bedding planes. Detrital andersite.
																												highly fractured, metasiltstone or phyllite.
McKinlay 1	Dullingari	**3**	Y	5130.0	1563.6	5140.0	1566.7		1°	50-60	Dark grey to black siltstone/shale, mm's lamination			50-55 (6), 1-5mm				fine, 2-20° (6)	calcite or						2 /1"		subsidiary structure on the larger Murteree Horst.	Prominent NE-SW trending Horst
										N = 6	(brecciation / veinlet); pyrite lamination and			branches of 1-20 °				40° (1)	kaolinite						not even	microfaulting & veining of at least		flanked by major faults.
											nodules (1x5cm) along bedding.															two phases of filling, brown ? dolo		Basement structure is one of a
																										or siderite, calcite or kaolinite.		network of faults.
																												Domed anticline of McKinlay.
																												Phyllitic metasiltstone, foliation,
																												possibly represent bedding.
Narcoonowie 1	? Dullingari	**2**	Y	6540.0	1993.4	6550.0	1996.4		N/R		grey, dark grey mudstone, shale, siltstone			brown: 40-70°	dolomite			blue: 65-70°	dolomite	yellow: horizon	? Dolomite	black: fine:	?	fra (blue) by	2cm or less		NE-SW trending anticline, fault bounded on	Dark grey phyllitic silstone, dip: 45 to core. Fractures:
Env									not recorded		from 6545' downwards: light grey, medium to									asso. stylolite		80° to vertical		fra (brown)		bedding: 45°, fra (blue): 70°;	the NW flank. Narcoonowie 1 was drilled on the apex of t	60 to core, 45 to core; filled by thin quartz veins.
4' > driller											coarse sandstone with slumps, thin interbeds of													fra (blow):		fra (brown): 40-70°, two direction;	structure or very close to the highest closing contour.	phyllitic sheen on some surfaces
											mudstone and siltstone.													by fra (fine, ?black).		fra (yellow): nearly horizontal and		6545' and downwards: metasst. V fine veins of pyrite
																											associated with stylolites; fra (black)		and quartz filled thin fractures.
		1	y	6106.0	1861.1	6116.0	1864.2		N/R		6112 & below: pale grey to creamy claystone,			yellow: 65°	dolomite			blue: 60°		brown: ?								extremely fractured, at 6113' Dull gold fluorescence
									2.5 above		brecciated, patches of siderite after silica.			6112' 10"												altered zone, pale grey due to		in a small subhorizontal fracture. Phyllitic sheen
									6000'		? Burrowed at 6112.8'.																alteration to clay? Fra (brown): ?		on some surfaces cement in fracture is dolomite.
											at 6112' 10" contact with Permian conglomerate																filled with quartz in wide fracture, kaolinite and siderite		
											? Merrmelia Fm, with reworked angular these																in thin section of 6110'.		
											claystones or other.																		
																											cement in fracture is dolomite.		
Nealyon 1	? Dullingari	**1**	y	6327.0	1928.5	6337.0	1931.5	9.25	3 1/4		grey to dk grey, laminated and bioturbated siltstone,	minor						73; (0.1-0.2mm)	calcite						2-5cm; 2-3cm (w)		Domal syncline, compressional anticlinal feature.	Steeply dipping metasandstone with very
									5972'		shale, low-angle bedding, lamination. Some severely																Intensively fractured, filled by calcite, fine,	Convergent wrenching in early Permian, reactivated	minor metasiltstone. Calcite vein and veinlets
									5 1/4		bioturbated portion (resembles IRB).																0.1-0.2mm wide, but 2-4mm in veinlet	prior to the Toolachee Fm. Regional tilt to the north east	Fracture filled by calcite, interstitial chlorite
									6326																		+ breccia at 6327'.	during the Late Triassic. Glacial scour u/c in seismic.	pyrite.
Packsaddle 1	Kalladeina	**9**	n	10357.0	3156.8	10396.0	3168.7	39.0			horizontally laminated siltstone and sandstone.	along		10383' 9",	0.8cm			opp. Bedding(50)	calcite	low-angle, 10	0.1-1.1mm	opp. bedding	< 0.1mm		1.5-2.5cm, except		S. flank of Packsaddle anticline. Dips in cores 1-8 is	Siliceous siltstone shale and sandstone,
			fragment								with breccia of limestone (Nuia grainstone, sandy).	bedding		Nuia-tri. gs	calcite			20-30; 0.1-0.8mm		or paral to	calcite	at 10388			10367-369': 4cm,	thrust fault (10384 and 10357'5"); ? Para. to bedding,	generally flat to 5dg. A major u/c between Permian and	Fracturing common in siltstone at high
			1/4															10388'6"		bedding.	meshwork	nearly vertical			or more.	Dip measured at bottom, 45dg. 5 sets of fractures.	pre-Permian.	angles to the bedding.
																						fine (v.fine),				Bedding in shale, 50-60, slump in middle (1.8cm)		The dips: 20-80, average: 50.
																						crosscut every				bedding : 90. Possibly belong to tension gashes,		

																						fractures					forth fracture is about 60-70, adjacent to thrust fault		
																											Detail description see measurement and 3 pages.		
Pandieburra 1	? Dullingari		N								Sandstone, interbedded with little shale/mudstone;							swarm (reverse)							moderate		locates on the intersection of two major anticlinal trends	felspathic sandstone with shaly partings.
											tabular pebbles of shale/mudstone.							thus thrust fault								Calcite filled fracture in massive	(one: E-W, the other SW-NE)	
											Dirty sst (my ts description)															sandstone with wavy lamination or		
																										crenuation, 50^{0} to core axis.		
																										Yellowish (?) filled fractures.		
Pando 2	?Pando	**2**	N	5993.0	1826.7	6020.0	1834.9	27.00		? horizontal	Light grey, thin-bedded to massive sandstone with	yes		two 1.5mm veins	qtz?		fracture	brown, ? Siderite							1"-5"		10 miles W-SW of Daralingie gas field. Fault trending	bedding average 10; 3 sets fractures: 80, 45, 50 to
Env 1031											green flat pebbles of shale or mudstone,	along shaly		x to bedding			20-30	then kaolinite								Broken cores ? due to well fracturing.	NE-SW. Pando 2 on S or downthrown side of this fault.	the horizontal. Clay along fracture planes.
11`> driller											truncation of cross-bedding, along which mud drapes.	layer		10 dg to c. edge												Similar to core 4, Pando 1.	on a culmination within a graben. Structural dip in	Orthoquartzite, siltstone, shale.
											Shale shows variation of weathering, top the most.															Moderate to high, brecciation.	Gidgealpa Fm is 5-7, but average 10 in pre-Permian.	
Pando North 1	? Pando	**4**	N	6449.8	1965.9	6460.0	1969.0	4.33	1 1/2^{0}		thin-bedded siltstone and mudstone; starved ripples,			2-4.5mm	calcite			para to N	calcite	40^{0} to N	calcite	120 to N	calcite	1 by 2 by 3	moderate		Locates 2 miles N of Pando 1 anticline on the northern	Argillite, green, silty in part, micromicaceous. Poorly
Env 1483									at core 4		accretional cross-lamination; slump-fold, step-like;			? para to N				or fold plane								plunge of the feature. Vertical closure is over 400' on	developed slaty cleavage at high angle to core.
									Max. 2 1/4^{0}		cm's graded; bedding of fine-grained															structural nose, about 300' at Pando North location.	One dolomite-filled fracture at top of core.
									at 5320'		sand lobes; ? tiny burrows.																	
Spencer 2	Mooraco.	**2**	y	6429.0	1959.6	6432.0	1960.5	2.50			rhyolite with flow bands. Phenocrysts (1-2mm) and														moderate to high		on the crest of the Spencer structure ridge. The	arkosic quartzite, some indications of
											groundmass. High angle to vertical fractures, 80,															orange-brown rhyolite, flowing structures,	basement at Spencer consists of a brittle-fractured	possible relic of bedding 30dg.
											< 0.2mm, filled by brown, ? Silica.															similar to those in Spencer 1; high-angle to	Early Palaeozoic metamorphics.	
																										vertical fractures, 80, <0.2mm, filled by silica?	The block is bounded by a prominent fault to W and N	
																											with more complex trends to NE and S.	
Strzelecki 1	Dullingari	**5**	Y	6805.0	2074.2	6815.0	2077.2		1 1/2^{0}		possibly laminated dark grey siltstone / shale,	N		50-60^{0}	y, by qtz?	70-90^{0}	y, by qtz?	discontinuous							high to v. high	Severely folded, less fractured,	angular unconformity with Cooper.	sh, metamorphosed to slate;
1575									5635'		because of severely folding. Numerous short fractures,															only two veins with similar fill, poss.	on crest of N-trending anticline.	bedding: 70^{0}; parting plane at 45^{0}
											only few long fractures.															quartz, dip change from 50 to 90^{0}.	On nose of structure.	
Sturt 6	Moorac.	**N/C**									only cuttings, thin sections: rhyodacite														no data		northern flank of an E-W aligned anticlinal structure,	
7312																												Sturt / Sturt East structure.	
Sturt 7	Moorac.	**1**	y	6336.0	1931.2	6394.0	1948.9		4 3/4		below 6356': low-angle banded green banded ?	common	n	90; 3-11mm	siderite			70; 0.5-1mm	siderite						30 to 60cm	Green flowing(?) band about 5-30 dg; fracture	Fault block on anticline flank.	Green banding of serpentine?
7303									6520'		ignimbrite been fractured; from 6456' (1cm siltstone)														not even	filled by calcite and siderite, 50 dg, opposite		dips: 10 to 30 at 6358'. Slickensides with
											above: dk brown to black breccia, dominated by dk															it; possibly second phase stop before first.		lineation. At 6355'6"-6367'6" volcanics with
											brown to grey volcanic fragments (reworking) without															From 6356' upwards: reworked volcanics.		slickensides and infilled settling structures.
											fractures.																		from 6336' upwards: reworked volcanics.
Sturt 8	Moorac.	**2**	y	6328.0	1928.8	6388.0	1947.1				below 6364', yellow-green ignimbrite = Taloola 1;														low to high	a few fractures, slickensides are in ignimbrite,	anticline	6345'9" - 6350': 10% very dull even to patch
											between 6364' to u/c (about 6348.7'or 6352 WCR):														1-2"	none in ? reworked tuff and above u/c.		yell/grn fluorescence, no crush cut.
											red-brown tuff or tuffaceous breccia.														1-2 / 1'	Intensity: 2m at bottom, <1m top part.		6352-6354': 30% even fluo.
											Above u/c, elongate greenish angular breccia of vol.															A slickenside at contact between ignimbrite and ? Tuff		6354-69': trace, even to patchy fluo.
											(Wenlong has photo).																	below 6368'6" -rhyolite, 6352'-thin basal coal.
																													6352-54' reworked tuff, 30% Fluo; 6354-69'
																													rhyolite tuff, 30% fluo; 6369-6356, rhyolitic lava,
Tilparee A-1	? Dullingari	**3**		7012.0	2137.3	7022.0	2140.3		Y	70-80	Black pyritic shale with starved ripple lobes of	Y		75-80: 1-8mm	qtz + Pyri.	80: 1-2mm	pyrite	fine, 60-70	brownish,	blue, fine, 85-9	white, ?			fine (f(2)) by f(1)	8 / 1'	Quartz veinlet + pyrite common.	On southern flank of a fairly small E-NE trending	dipping, horizontal to 80o. Foliation and pyrite
1905									7013-7013'9"		silt or very fine-grained sandstone.	7013-7013'9"		at 7018'; 7017'5";		cut by			? Fault plane				by v(2)by v(1)		Dip of bedding changes a lot.	anticlinal structure, at least 2 phases of fractures and	
									70		Folding & faulting, bedding steep.					v(1)									lineation of slickenside and steps	slickensides.	
									same as v(1)		Strongly fractured, at least 2 phases; slickensided.															could be down or upthrown		
Tirrawarra 1	"Mudr. Sst"	**8**	Y	10220.0	3115.1	10226.0	3116.9			5-17^{0}	light grey, fine-grained sst, with green clasts of	70-85		? At 10220'											only 1 slickensided	sst, no fractures, except a slickensided surface.	Large N-S trending anticline, dip 5-10 dg of 10220-6';	White quartzite, dip: 5-10^{0}
1416											shale (cm), interbedded with 2cm green			to 10221;	80-85-90^{0}										surface	bedding increase dip upwards;	10066-76': 30 dg.	
											siltstone or mudstone.																possibly due to progradation of		
																											forsets (because thickening of		
																											laminae from 1mm to 1-2cm;		
																											at 10220' back to subhorizontal).		
Titan 1	Kalladeina		y	7025.00	2141.2	7035.00	2144.3	9.00			laminated siltstone and shale, interbedded with thin														4 frac. at 7033'6"	Bedding measured: 5-10. Calcite filled fracture,	crest of low relief dome, aligned NE-SW in western	Shale, limestone, metasandstone, veining.
											beds of bioclastic packstone and oolitic grainstone.														7029. breccia	curved, 80; 0.2-2mm. Breccia at 7029', with calcite	part of the Patchawarra Central Block.	
																									7025, calcite fill+	vein fill.		
																									green shale			
Toolachee 1	Dullingari	**6**	Y	7224.0	2201.9	7227.0	2202.8				Thin-bedded, lamination of siltstone / shale,							80-90^{0}, fine,	y, white ?	50-60^{0}, coarse	y, by brown	Low angle			high to v. high	dip changes a lot due to sedimentary	SW closure of southern part of a large anticline	sh/sil, fissile, pyritic; fractured,
1090											dark grey to black; slumping: dip changes							discontinuous.			quartz?	displacing			(partly)	slumping. Brecciated between	(N-S trending), gravity low, SW flank of Tennappera.	slightly metamorphosed
											from 20-90^{0}.											bedding.				7162-7164', especially 7162'. Well fractured.		bedding: 70^{0} reliable, at 7222-7227: cleavage
		5		7159.0	2182.1	7178.0	2187.9															similar to				Combination of slickensides and quartz, lineation		80-90 degree.
																						Lycosa 1.				along fault plane or microdisplaced surface.		
Toolachee 2	? Dullingari	**3**	Y	7195	2193.0	7202.0	2195.2			60-70	Grey shale with microfolds, at 7202', above which			quartz vein	cut by v(1)			two lineation	brown,						moderate	Similar to Nacoonowie, but more	crest of northern part of N-S trending structure.	crest of the northern structure
										shaly portion	coarse feldspathic sst, massive.			= f(1), 7196'8"	stylolite			parting (40-55)	dolo. Or sider						sandstone within mudstone		E-W trending.
										65^{0} (WCR)				associated with				(N=4)	lite or calcite							Stylolite.		
														quartz fill															
Toolachee 4	? Dullingari	**3**	y	7280.0	2218.9	7311.0	2228.4				Almost massive sst, seems from 7299', coal bed														moderate	irregular fractures, filled by siderite, near top	northernmost culmination of the structure, fault controlled	sandstone, poorly sorted, composed of quartz and
1906											horizontal bedding, Cooper sequence.															at 7296', many siderite nodules.	in the east.	dark lithic fragments below 7362,. Merr.(7312-7362)
											Possibly at 7311'6" to 7312'1", bedding: 75-80;															Sandstone is coarse, pebbly, some with truncated		Fm, including this core 3, sst, light grey, pebbles.
											decided by apparent boundary between graded bedding															quartz veinlets.		Anticline structure.
Toolachee East 2	? Dullingari		Y	8333	2539.9	8343.0	2542.9		1+3/4	40-45	Weathered rock, light grey, brownish, dk grey	N						55-60	brownish, ?	swarm or netw	brownish				2-3 /1"	Well fractured and slickensides; major frac (f(1)),	near crestal location of a drag fold on the downthrown	mestsiltstone, dip: 45dg. Trace pyrite, fissile.
										N=7	lining may indicate original bedding, also paral.							? Cleavage or		displaced by f(	?					but displaced f(2), F(1) may be reverse fault plane or	side of a major fault.	
											with pebbles (see ts). Clay ? Kaolinite							fault plane		30-40						cleavage reverse displacement.		
																		disp. Bedding &										
Walkillie 1	Mooracoochie	**1**	y	9012.0	2746.9	9016.00	2748.1	3.00			rhyolite	? 80						70;	calcite	80;			calcite			1cm	well fractured, causing broken core. At least two	N-S elongate low relief anticline at southern end of N-NE	Potassic rhyolite;
			2/3 left																							sets of fractures, and one possible slickenside.	- S-SW oriented horst trend. N fault (E-W) denotes N	
																											edge of Patchawarra Trough.	
Wancoocha 1	Dullingari	**3**	slab	6510.0	1984.2	6525.0	1988.8	15.0			Dark green, laminated siltstone and shale, bedding	yes	n												6506 upwards	Irregular fractures and brecciation, filled by calcite and	19.2km south of Daralingie structure on the N flank	60-65dg bedding shale or siltstone.
											45-50 (appro.); slumping and fold, and normal faults	6501'													kaolinite. Similar to Boxwood 1 and Pando Nth 1.	of a large NE trending anticline.	Fractures about 45-55dg, secondary mineralisation
											at 6501' (cm's displacement); with some white and														but 1-1.5m below it.	Bedding apparently > 70 dg.		along fracture faces.
											yellow (silty or v. f. sst laminae). Balck lineation																	At 6510-15': siltstone lamination 60 reliable.
											along graphite lining (oblique) similar to Lycosa 1.																	Bedding dip: 0-70; slickenside along bedding
Wirrarie 1	Dullingari	**3**	y	7242.0	2207.4	7258.0	2212.2	15.0	1 max.		Massive green-grey fine to medium sst, interbedded																Sst and interbedded siltstone with slump	on crest of small anticline; 'P' horizon, lowest closing	dip: 0 - 70. Sandstone, siltstone, shale.
											with dark green siltstone. Lamination and slump in															bedding: 35-50, but slumping (65-90);	contour 3x2 miles; vertical closure is 120'.	pale grey, very fine-grained, moderately well
											siltstone (7254-7256')															no fracture at all.		sorted, slightly micaceous. Shale, subfissile
Weena 1	? IRB	**5**									bioturbated sandstone, "pipe" (> 15cm long) rock.														nil		north plunging nose on the southern flank of E-W	quartz-mica-schist with minor quartzite bands
											granule-sized (>1.2mm) sandstone. Red micaceous														no fractures.		elongate trending graben. Close to the south by a fault	no dip determinable.
											layers.																downthrown on its northern side.	micaceous shale, dip: 20-30; quartzite.
Yanpurra 1			slab						3 1/2		micaceous siltstone and shale. Minor sandstone.														nil to low	no fracture, or only one.	North extension of the Packsaddle anticline on a North	Siltstone and sandstone.

Well	mean strike azimuths			
Malgoona 4	18	60	110	150
Gidgealpa 1			107	149
Snake Hole 1			104	
Gidgealpa 2			120	150
Gidgealpa 3	26	74	120	
Gidgealpa 5	21	63		
Gidgealpa 7	25	59		150
Merrimelia 6				147
Merrimelia 7	26			
Mudrangie 1	30	60		150
Wantana 1			115	
Packsaddle 3	21	64		150
Innamincka 1				150
Boxwood 1		50	102	
Lycosa 1	20	63	110	140
Yulcumma 1		72		
Moomba 2	20			
Moomba 73		57		
Della 1			112	141
Dullingari 1			117	144
Murteree 1	21			156
Munkarie 1		68		
Pelketa 1		46	108	
sum	**228**		**1225**	**1777**
aver.	**22**	**61**	**114**	**148**
min	**18**	**46**	**102**	**140**
max	**30**	**74**	**135**	**156**

range	frequency
18-30	10
46-74	12
102-120	11
140-156	12
	total: 45