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DEVILFISH-1
WELL COMPLETION REPORT
GIPPSLAND BASIN
VIC/P21

VOLUME 2
INTERPRETATIVE DATA

SOUTHERN TEAM/PETROLEUM
ENGINEERING/DRILLING
OPERATIONS

JULY 1990

Keywords : Exploration, reservoir, seal, source, stratigraphy, structure, hydrocarbons, petrophysics, palynology, palaeontology, geochemistry, synthetic seismogram

SHELL COMPANY OF AUSTRALIA
1 SPRING STREET, MELBOURNE, VIC. 3000

90/288

SDA 958

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1. INTRODUCTION

Gippsland Basin Permit VIC/P21 was awarded to a consortium of Shell (50%, operator), and Western Mining Corporation (50%) on the 23 July, 1987, for a period of six years. Devilfish-1 fulfilled the Year 3 drilling commitment. Prior to the well spudding, WMC farmed out 25% equity in the permit to T.C.P.L. Resources Limited. Devilfish-1 was spudded on 10th April, 1990. The well was located on S.P. 160 on seismic line GS88A-05 in 73m of water. All depths are quoted in metres below derrick floor, unless otherwise stated.

The primary objective of Devilfish-1 was to test barrier sandstones in a downthrown fault trap at Top Latrobe Group level, bounded by the Foster Fault (Fig. 1). Minor independent dip closure was mapped, but the trap primarily relied on the juxtaposition of reservoir sands in the downthrown block, against a thick marine shale (SDA 904). Additional targets were anticipated in intra-Latrobe and Golden Beach Group sandstones. Devilfish-1 was plugged and abandoned without encountering significant hydrocarbon shows.

2. REGIONAL GEOLOGY

The stratigraphy of the offshore Gippsland Basin is summarised in Figure 2.

The Early Cretaceous Strzelecki Group represents the initial rift infill sequence, and its deposition can be correlated with the onset of the development of the Southern Australian rift system. The Group consists of non-marine greywackes, shales and minor coals, and is regarded as economic basement.

The Cenomanian to Late Campanian Golden Beach Group overlies Strzelecki Group sediments with an angular unconformity (marking the onset of opening of the Southern Ocean), and represents a second phase of rift infill, associated with the development of the Tasman Sea rift. Where penetrated, sediments comprise dominantly immature non-marine sandstones, siltstone, shales and minor coals deposited in alluvial fan, braided stream, lacustrine and upper coastal plain environments. Basaltic volcanics are both stratigraphically and areally widespread. Continued subsidence, though with much-reduced extension, resulted in growth on earlier faults during deposition of the Golden Beach Group. This was followed by a pronounced phase of tectonism and associated volcanism during the Campanian, which produced the major throws now seen on intra-Golden Beach Group faults. This "Intra-Campanian Unconformity" can be correlated with the onset of drift in the Tasman Sea (ca. 76 MA BP), and marks the cessation of Golden Beach Group deposition.

From Late Campanian to Late Eocene the Latrobe Group was deposited as a non-marine to coastal sequence of sandstones, siltstones, shales and extensive coals under the progressive influence of the opening Tasman Sea. As marine conditions encroached from southeast to northwest, a diachronous succession of laterally equivalent sedimentary facies was deposited comprising alluvial, upper coastal plain, lower coastal plain, estuarine, back barrier/lagoonal, coastal barrier, shoreface and offshore marine deposits. Slow subsidence characterised Latrobe Group deposition with continued movement on earlier faults. The major basin-bounding faults continued to exert a major influence of sedimentary patterns. Early to Late Eocene tectonic uplift of the northeastern part of the basin, in association with a series of sea level falls, led to submarine channelling of the Top Latrobe surface. Late Eocene deposition is recorded by a thin condensed glauconitic sandy siltstone sequence known as the Gurnard Formation, which marks the top of the Latrobe Group.

Convergent wrenching due to Southern Ocean spreading, and strike slip movement along Tasman Sea fracture zones occurred during the later part of Latrobe Group deposition. In the Late Eocene, this phase of activity terminated Latrobe Group deposition in the offshore basin and was responsible for strike slip and reverse reactivation of many earlier normal faults and the formation/enhancement of the major anticlinal features in the basin. Thermal subsidence from the Oligocene to Recent resulted in the deposition to calcareous siltstones and marls of the Lakes Entrance Formation overlain by a marine, eastwards prograding sequence of bryozoan limestones and marls of the Gippsland Limestone.

3. STRATIGRAPHY

The stratigraphic sequence in Devilfish-1 is summarised in Figure 3 and Enclosure 1. Formation tops and ages are based on lithological, palynological (Appendix 1) and palaeontological (Appendix 2) data from cuttings and sidewall samples, together with wireline log characteristics. All depths are quoted in metres below derrick floor.

3.1 Gippsland Limestone (SEGL): 101-1461m (1360m)

The Gippsland Limestone consists of interbedded calcarenite, calcilutite, calcareous claystone and marl. The calcarenites and calcilutites are pale grey to olive-grey, and argillaceous, with traces of pyrite, glauconite and carbonaceous material. These lithologic units contain locally abundant fossils, predominantly foraminifera and echinoderms. Calcarenite and calcilutite dominate the section from 101-703m. Below 703m, the Gippsland Limestone comprises interbedded calcareous claystone and marl. The calcareous claystone is olive-grey, and very soft to sticky, with minor amounts of pyrite, glauconite and foraminifera. Marl occurs as interbeds throughout this interval, but is most abundant above 1275m. The marl is light greenish grey, sticky and amorphous, with common foraminifera.

The carbonate depositional environment appears to have been upper continental slope to shelf edge, with continual shallowing of water depth from approximately 300-400m to 100-200m.

3.2 Lakes Entrance Formation (SELE) : 1461-1645m (184m)

The Lakes Entrance Formation consists dominantly of calcareous claystone, however the unit becomes slightly silty and sandy at the base. The calcareous claystone is olive-grey, sticky and amorphous, and contains trace to locally abundant amounts of pyrite, glauconite foraminifera, molluscs and bivalves.

The Lakes Entrance Formation was probably deposited in an upper slope environment (water depths of 200-400m).

3.3 Latrobe Group (LA) : 1645-2058m (413m)

The Latrobe Group has been subdivided on the basis of palynological biozones.

3.3.1 N. asperus Biozone (LANA) : 1645-1795m (150m)

The N. asperus biozone consists of unconsolidated sandstones. The sandstones show two major coarsening upwards cycles, with grainsize varying from very fine to very coarse. The sandstones are transparent, quartzose, generally very well rounded, spherical, and have good to excellent visual porosity. These sandstones have been deposited in coastal barrier environments.

The section from 1770 to 1785m consists of a fine grained, silty sandstone which has been oxidised, as indicated by the red-brown colour. The sandstone is partially micrite cemented, contains shell fragments and patches of glauconite. This unit was probably deposited in a marine environment which subsequently deveoped as a hard ground, prior to deposition of the overlying barriers. The interval from 1785 to 1795m comprises interbedded sandstones and carbonaceous siltstones deposited in a back barrier setting.

3.3.2 P. asperopolus Biozone (LAPA) : 1795-1807m (12m)

This biozone consists of interbedded sandstones, carbonaceous siltstone, and minor coal deposited in a back barrier environment.

3.3.3 M. diversus Biozone (LAMD) : 1807-1822m (15m)

This biozone consists of interbedded sandstones, siltstones and trace coal. The sandstones are white-buff, medium grained, subrounded to subangular with minor pyrite. The siltstone is light brown and slightly carbonaceous and the coal is slightly silty, dark brown-black and sub-vitreous. This section was deposited in a back barrier environment.

3.3.4 L. balmei Biozone (LALB) : 1822-1977m (155m)

Back barrier-lagoonal deposition dominated during this biozone, although small, transgressive barriers have also been observed. The sediments consist of interbedded sandstones, siltstones and coals. Generally the sandstones are clear-light grey, clayey, fine-coarse grained, moderately well sorted, subrounded to subangular, subspherical, quartzose (but with trace lithics), unconsolidated and have fair to moderate visual porosity. The siltstones are dark brown-buff, slightly micaceous, contain carbonaceous laminae, and are firm to hard. The coals are black, slightly vitreous, sub-fissile and hard.

3.3.5 T. longus Biozone (LALO) : 1977-2058m (81m)

The T. longus biozone consists dominantly of mineralogically and texturally immature litharenites, with subordinate amounts of siltstone and claystone. The sandstones are clayey, greenish-grey, fine to coarse grained, poorly sorted, angular and subspherical. The framework grains are commonly chlorite schists, micas and phyllites. The samples were predominantly disaggregated, but some aggregates were seen. These sandstones are interpreted to have been deposited in an alluvial environment with little transport from source. It is likely that this section was shed from the basin margin fault scarp, with Palaeozoic metasediments of the Bassian Rise the likely source.

4. SEISMIC MARKERS AND STRUCTURE

A velocity survey was conducted at Devilfish-1 upon completion of drilling (Appendix 3, Volume 1). The synthetic seismogram (Encl. 2) for Devilfish-1 was used to relate the main seismic markers to the well results as shown below. A good match with seismic at the well location was achieved. Drill depths to marker horizons were in close agreement with the predicted depths (Fig. 4), except for the Top Golden Beach Group seismic marker. A seismic re-interpretation now places this horizon just below or at Total Depth (Fig. 5), which is consistent with palynological data.

TABLE 1: ACTUAL DEPTH TO MARKERS

SEISMIC HORIZON	TWO-WAY TIME (secs)	DEPTH (m bdf)	DEPTH (m SS)
NEAR TOP LAKES ENTRANCE		1461	1433
TOP LATROBE GROUP		1645	1617

The Devilfish structure is a downthrown fault trap, mapped at Top Latrobe Group, with some independent rollover (Fig. 5). A much larger trap would be present if the marine shale (within the Latrobe Group) seen in Pike-1 was laterally juxtaposed against the reservoir section in the downthrown block. The dipmeter data confirms the depth mapping at Top Latrobe level with north-easterly dips. The marine shale present in Pike-1 between 1988-2019m was encountered in Devilfish-1, although here it was only 15m thick and in sidewall sample is a fine grained sandstone. Petrologically the sample consisted of a fossilferous micrite and a carbonate cemented sandstone (Appendix 5). The marine shale has thinned considerably and become sandy towards the basin margin. It is therefore unlikely that it would provide an effective lateral seal in a juxtaposition trap.

5. HYDROCARBON SHOWS

No significant hydrocarbon shows were encountered in Devilfish-1. Mud gas levels were low throughout the entire section with background levels in the order of 0-0.2% methane. Minor gas increases were recorded in association with coal and some carbonaceous shales, with the maximum gas reading (2.0% C_1, 0.15% C_2, 0.01% C_3) at 1960m associated with coal.

Petrophysical evaluation indicates the objective Latrobe Group section to be entirely water bearing (see Appendix 3).

6. RESERVOIRS, SEALS AND SOURCE ROCKS

Reservoirs

Reservoir quality of the N. asperus biozone barrier sandstones (1645-1770m) is excellent, with log-derived porosities in the range 20-30% and average approximately 24%. These sandstones are generally medium to coarse grained, well sorted, with good visual porosity.

Sandstones in the P. asperopolus to L. balmei bizones (1795-1977m) are dominantly quartzose, fine to medium grained, with fair to moderate visual porosity. These sandstones were deposited in back-barrier/lagoonal to coastal barrier settings. Log-derived porosities are in the range 20-30%, and average approximately 22%.

Within the T. longus biozone (1977-2058m), the litharenites are minerallogically and texturally immature. Log analyses indicate these sands have porosities in the range 10-20% (average 15%).

Seals

Top seal for the primary objective Top Latrobe Group barrier sands is the Lakes Entrance Formation. Here calcareous claystones form an effective regional seal. Lateral seal was predicted to occur by juxtaposition of reservoir sands in the downthrown block against a thick marine shale (as seen in Pike-1) in the upthrown block. This marine shale section is condensed at the Devilfish-1 location and is only some 15m thick. In addition, the unit is a silty sandstone, and is unlikely to have provided an effective lateral seal.

Secondary targets in Devilfish-1 were intra-Latrobe Group sandstones, however the well penetrated a relatively sandy back barrier sequence with a high net:gross (73%). Favourable sand-shale juxtaposition at the bounding fault is therefore considered unlikely.

Source Rocks (Appendix 4)

Source rocks were encountered in carbonaceous shales and coals from the back barrier facies in the Latrobe Group.

7. CONCLUSIONS AND CONTRIBUTIONS TO GEOLOGY

(a) The seismic markers mapped can be related directly to the well data, however the Top Golden Beach Group marker is now thought to occur at or just below Total Depth of Devilfish-1.

(b) Drill depths to the seismic markers are in close agreement with the predicted depths.

(c) The lithological and stratigraphic sequences encountered in Devilfish-1 were for the most part as anticipated from the regional facies distribution mapping and well control (Pike-1). The two N. asperus biozone coastal barriers were encountered at the Top Latrobe Group. The marine shale seen in Pike-1 was penetrated in Devilfish-1, however it was considerably thinner and sandy. The well reached Total Depth in T. longus biozone litharenites interpreted to be sourced from Palaeozoic basement.

(d) Reservoir quality of the Latrobe Group sandstones is generally good to excellent, however the T. longus biozone has poor to moderate porosities. Porosity is reduced due to the textural and mineralogical immaturity of the sandstones.

(e) No significant hydrocarbon shows were encountered. The complete absence of shows implies that lack of hydrocarbon charge is a major cause of failure. The validity of the juxtaposition trap is also in question.

REFERENCE

SDA 904: Exploration Well Proposal Devilfish-A, Gippsland Basin Permit VIC/P22

Appendix 1

Palynology

PALYNOLOGICAL ANALYSIS, DEVILFISH-1

GIPPSLAND BASIN

by

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Palaeontological report prepared 2 June 1990 for
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INTRODUCTION

SUMMARY OF RESULTS

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INTRODUCTION

Sighteen sidewall core samples, representing the interval 1775.0 to 2035.0m in Devilfish-1, were processed and examined for spore-pollen and dinoflagellates.

With the exception of SWCs at 1775.0 and 1783.00m, yields and preservation were medium to high and most age-determinations of moderate to good confidence. Conversely virtually all palynofloras have been contaminated with caved Oligo-Miocene dinoflagellates and these may have concealed any marine influence in the lower-yielding Paleocene samples.

Palynological determinations and interpreted lithological units are summarized below. Interpretative and basic data are given in Tables 1 and 2 respectively. Check lists of all species recorded are attached. Electric log data were unavailable.

SUMMARY

AGE	UNIT	DEPTH (m)	S-P ZONE	ENVIRONMENT
?Late Eocene	LATROBE GROUP	1783.0	?Mid. N. asperus	Marine
Early Eocene	"	1812.0-1814.5	Low. M. diversus	Marginal marine
Paleocene	"	1834.0	Upper L. balmei	"
		1853.0-1882.5	Upper L. balmei	Fluvio-lacustrine
"	"	1895.0	Upper L. balmei	Marginal marine
"	"	1949.5	Lower L. balmei	Lacustrine
"	"	1975.0	Lower L. balmei	Marginal marine
Maastrich-tian	"	1983.0-2020.0	Upper T. longus	Fluvio-lacustrine

GEOLOGICAL COMMENTS

1. Assuming that dinoflagellates in quartzose sandstone at 1783.0m are _in situ_, coarse clastics at Top of Latrobe may be as young as Late Eocene, Middle _N. asperus_ Zone.

2. Otherwise Devilfish-1 contains a continuous sequence of zones from Maastrichtian Upper _T. longus_ to the Early Eocene Lower _M. diversus_ Zone between 1812.0-2020.0m.

   This section is likely to consist of a stacked sequence of thin [onlapping] units separated by unconformities representing long periods of erosion or non-deposition.

3. Uncertainty exists about the position of the Upper/Lower _L. balmei_ Zone boundary [see Biostratigraphy]:

   Based on the first appearances [see Biostratigraphy Section 3] this boundary could occur between 1931.5-1949.5m. Conversely, palaeoecological evidence indicate that the same interval is part of a well-defined cyclothem represented by the interval 1983.0 to 1904.2m. A second Paleocene cyclothem is recorded by samples at and between 1895.0 and 1853.0m [see Palaeoenvironments].

   Overall the _L. balmei_ Zone unit is thin - maximum 168.5m - relative to thicknesses recorded elsewhere in the basin and, as with the less than 50m thick Lower _M. diversus_ Zone unit, the data are consistent with thinning of sediments as these onlap the margin of the basin.

4. Irrespective of dating problems, it is clear that the Devilfish-1 includes units that are seldom sampled in the Gippsland Basin. These occur between:

   (i) 1814.5-1834.0m.

   This unit of silty claystones and siltstones which includes the Lower _M. diversus_/Upper _L. balmei_ Zone boundary, is likely to have been deposited during the early part of the _A. hyperacantha_ Zone, marine transgression (see Partridge (1976)

   If correct, then the claystones are a correlative of the [54.2-53.5 Ma] transgressive phase of cycle TA2.4 (see Haq _et al._, 1987). Therefore a major condensed section could lie within or immediately above this unit. The _A._

hyperacantha Zone marine transgression could be a useful datum point for correlating this well with e.g. Pike-1.

(ii) 1949.5-1983.0m.

The Danian/Maastrichtian boundary occurs between 1975.0 and 1983.0m in this unit of carbonaceous claystones. Palynofloras are different in terms of species composition and species abundance to Lower L. balmei and Upper T. longus Zone palynofloras recovered from wells further to the east in the central deep.

These differences may relate to changes in the source vegetation, subtle facies differences or to a slight age difference in the top of the Upper T. longus Zone across the basin. It is noted that the sandstone sampled at 2020.0m yielded a typical Upper T. longus Zone palynoflora.

5. On present indications, Devilfish-1 terminated in undifferentiated Latrobe Group coarse clastics rather than in the Golden Beach Formation. The sparse palynoflora recovered from the basal SWC at 2035.0m included a significant percentage of recycled Lower Cretaceous and Permo-Triassic palynomorphs, consistent with the mixed lithology.

PALAEOENVIRONMENTS

As with the majority of wells located on the margins of the central deep, Devilfish-1 shows the effects of the progressive encroachment of the Tasman Sea from the south-east.

The earliest marine influence recorded is the earliest Danian, T. evittii Zone marine transgression at 1975.0m (see Partridge, ibid).

The short-lived nature of this event is demonstrated by the occurrence of a Sphagnum swamp at 1949.5m and freshwater swampy conditions supporting abundant conifers at 1904.2m. Similarly, marginal marine conditions at the wellsite during the Upper Paleocene, A. homomorphum Zone marine transgression [1985.0 and ?1882.0m] were succeeded by a freshwater lake then a Phyllocladidites mawsonii swamp forest - represented by the light grey claystone containing abundant freshwater dinocysts at 1855.0m and a coal at 1853.0m respectively. Both cyclothems have close analogues in hydroseral developments in the modern Gippsland Lakes.

On present indications, the shoreline migrated across the wellsite during the earliest Eocene A. hyperacantha Zone although Devilfish-1 is located slightly to the west of the general position of the Lower M. diversus Zone shoreline (Partridge, ibid.).

BIOSTRATIGRAPHY

Zone and age-determinations have been made using criteria proposed by Stover & Partridge (1973), Helby et al. (1987) and unpublished observations made on Gippsland Basin wells drilled by Esso Australia Ltd. The informal subdivision of the T. longus Zone proposed by Macphail (1983b: see Helby et al., ibid p.58) is followed here. Zone names have not been altered to conform with nomenclatural changes to nominate species such as Tricolpites longus [now Forcipites longus: see Dettman & Jarzen, 1988].

It is noted that published criteria for subdividing the L. balmei Zone are unreliable although first appearances and extinctions defining the zone overall are not. For example, species whose first appearance **are** diagnostic of Upper L. balmei Zone age, e.g. Cyathidites gigantis and Proteacidites incurvatus, appear only towards the top of the zone whilst others which are usually restricted to this zonule have been recorded within the Lower L. balmei Zone, e.g. Malvacipollis subtilis and Verrucosisporites kopukuensis. It is noted that M. subtilis occurs in the what is otherwise a reliable Lower L. balmei Zone palynoflora at 1949.5m in Devilfish-1.

Similarly the typically Lower L. balmei Zone species Proteacidites angulatus and Tetracolporites verrucosus are known to range into the Upper L. balmei Zone. Conversely other species appear to terminate within the Upper zonule and therefore could be used to define a third or 'middle' subdivision, e.g. Beaupreadites orbiculatus, Integricorpus antipodus ms and Jaxtacolpus pieratus ms given adequate geological control.

For present purposes, it is suggested that the Upper/Lower L. balmei Zone boundary be treated as provisional unless supported by unequivocal geological and dinoflagellate data.

Upper *Tricolpites longus* Zone 1983.0-2020.0m Maastrichtian

The four SWCs in this interval are characterized by several to many specimens of *Stereisporites punctatus* and frequent to abundant *Gambierina rudata*, both diagnostic of the Upper *T. longus* Zone.

All palynofloras contain species which range no higher than the Upper Cretaceous, e.g. *Proteacidites reticuloconcavus*, and *Triporopollenites sectilis*, but two [2002.5m, 2008.0m] are unusual in that *Nothofagidites* spp. and *Tricolporites lilliei* are more frequent than is usually the case for this zone.

The lower boundary of the zone is provisionally placed at 2020.0m, a sample yielding abundant *Tetracolporites verrucosus* and *Triporopollenites sectilis* as well as *Stereisporites punctatus*. The upper boundary is tightly defined by the association of *S. punctatus* and *Quadraplanus brossus*.

The palynoflora at 2035.0m contains *Tetracolporites verrucosus* and therefore is no older than uppermost *T. lilliei* Zone but the yield is too low to make a more confident age-determination. This sample and that at 2020.0m yielded reworked Lower Cretaceous and Permo-Triassic species.

Lower *Lygistepollenites balmei* Zone 1949.5-1975.0m Paleocene

The SWC at 1975.0m zone contained the index species of the lowermost Danian *T. evittii* Zone, *Trithyrodinium evittii* and *Palaeoperidinium pyrophorum*, and is assigned to this zone with a good degree of confidence.

Nevertheless the palynoflora also includes dinoflagellates which usually appear higher within the Lower *L. balmei* Zone, e.g. *Palaeocystodinium australinum* and *Glaphryacysta retiintexta*.

Multiple specimens of *Nothofagidites* and *Tetracolporites verrucosus* at 1975.0m are consistent with a Lower *L. balmei* Zone age but otherwise the spore-pollen component of both samples are more typical of the Upper *T. longus* Zone. E.g. *Asteropollis asteroides* and *Proteacidites reticuloconcavus* are present at 1975.0m and *Gambierina rudata* is frequent-common in this sample and at 1949.5.

These anomalies could be due to mixing of different aged sediments within a condensed unit. Alternatively the interval may represent a time period that is transitional between the Maastrichtian and Danian and rarely sampled in the Gippsland Basin.

The latter explanation is supported by the occurrence at 1975.0m of a highly distinctive Gambierina species [G. corpusculus ms] not previously recorded in the Gippsland Basin. Gambierina-dominated palynofloras in a similar stratigraphic position in Tarwhine-1 and Torsk-1 (Macphail, 1982, 1989).

The upper boundary is provisionally picked at 1949.0m, based on frequent Tetracolporites verrucosus, Stereisporites punctatus and Proteacidites angulatus and scarcity of Lygistepollenites balmei relative to Paleocene palynofloras upsection. As noted above, Malvacipollis subtilis occurs at 1949.5m.

Upper Lygistepollenites balmei Zone 1834.0-1895.0m Paleocene

Palynofloras between 1931.5 and 1834.0m are dominated by long-ranging gymnosperm and angiosperm species and spores, in particular Lygistepollenites balmei, Phyllocladidites mawsonii and Podocarpidites, Nothofagidites endurus, Haloragacidites harrisii, and Gleicheniidites.

Two alternative picks for the lower boundary are possible:

(a) 1931.5m, based on the first occurrence of Cupanieidites orthoteichus.

(b) 1895.0m, based on occurrences of the dinoflagellate Apectodinium homomorphum, index species of the correlative of the upper Upper L. balmei Zone, the A. homomorphum Zone.

As noted previously, the first appearance of this species may not necessarily be a reliable indicator of an Upper L. balmei Zone age and it is possible the single specimen recorded in this sparse palynoflora is caved. This is almost certainly the case with dinoflagellates in the sample since most are Oligocene spp. Conversely Apectodinium homomorphum is a reliable index species.

Given palaeoenvironmental evidence that the interval 1904.5-1975.0m represents a single regressive event, the higher, i.e.conservative, boundary of 1895.0m is picked.

Other species first appearing between 1824.0-1931.5m are: *Tetracolporites multistrixus* at 1904.2m; *Triporopollenites heleosus*; *Triporopollenites ambiguus* at 1882.5m [associated with *Beaupreadites orbiculatus* and frequent *Proteacidites grandis*] and *Proteacidites annularis* and *P. incurvatus* at 1855.0m [associated with *Jaxtacolpus pieratus*]. The palynoflora at 1855.0m is dominated by a freshwater dinocyst, provisionally identified as *Saeptodinium* spp.

The upper boundary is tightly defined by the association of *Amosopollis cruciformis*, *Australopollis obscurus*, *Banksieaeidites elongatus*, *B lunatus* ms, *Camarozonosporites bullatus*, *Cyathidites gigantis*, *Gambierina rudata*, abundant *Lygistepollenites balmei*, *Malvacipollis diversus*, *Nothofagidites endurus*, *Polycolpites langstonii* and *Proteacidites annularis*. Isolated specimens of *Kenleyia* spp. are present in the same palynoflora.

Apectodinium hyperacantha shows that this assemblage was deposited during the *A. hyperacantha* marine transgression. Similar Upper *L. balmei*/*A. hyperacantha* Zone palynofloras are present in a number of central deep wells close to shelf edge and as far west as Kahawai-1.

Lower *Malvacipollis diversus* 1812.0-1814.5m Early Eocene

The two samples assigned to this zone are dominated by *Araucariacites*, undescribed *Proteacidites* spp. and [1814.5m] abundant specimens of the marine dinoflagellate *Kenleyia*, in particular *K. lophophora*.

The zone determination is based on the relative abundance of *Proteacidites grandis* and the dominance of *Kenleyia lophophora*: although both species range from the Upper Paleocene and through the Early Eocene (see Cookson & Eisenack, 1967), both are only abundant in the Lower *M. diversus* and *A. hyperacantha* Zones respectively. Species ranging no higher than the Upper *L. balmei* Zone or lower than the Middle *M. diversus* Zone are absent [3 strew mounts worked].

The sample at 1812.0m is no older than Lower *M. diversus*, based on *Cordosphaeridium inodes*.

Middle *Nothofagidites asperus* Zone? 1783.0m Late Eocene?

The SWC at 1783.0m yielded two specimens of the typically Late Eocene dinoflagellate *Gippslandica extensa* athough it is by no means certain that these are contemporary with the sediment. Other palynomorphs in this very sparse assemblage include Nothofagidites emarcidus-heterus and the Upper Cretaceous-Paleocene species Gambierina rudata.

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TABLE 1: SUMMARY OF INTERPRETATIVE PALYNOLOGICAL DATA

SWC	DEPTH (m)	ZONE S-P	ZONE DINO	CONF. RTG.	COMMENT
25	1775.0	Indet.	–	–	
24	1783.0	M. N.a.	–	2	No confidence
22	1812.0	L. M.d.	–	2	Not older
21	1814.5	L. M.d.	A. hyp.	2	Kenleyia spp.
20	1824.0	U. L.b.	A. hyp	0	
18	1853.0	U. L.b.	–	1	P. annularis
17	1855.0	U. L.b.	–	1	P. annularis
16	1882.5	U. L.b.	–	2	T. ambiguus
15	1895.0	U. L.b.	–	1	A. homomorpha
14	1904.2	L. b.	–	–	
10	1931.5	L. b.	–	–	C. orthoteichus
09	1949.5	L. L.b.	–	1	T. verrucosus
06	1975.0	L. L.b.	T. evt.	0	T. evittii
05	1983.0	U. T.l.	–	0	Q. brossus S. punctatus
04	2002.5	U. T.l.	–	1	S. punctatus
03	2008.0	U. T.l.	–	1	S. punctatus
02	2020.0	U. T.l.	–	1	S. punctatus
01	2035.0	No older than uppermost T. lilliei Zone			

TABLE 2: SUMMARY OF BASIC PALYNOLOGICAL DATA

SWC	DEPTH (m)	YIELD S-P	YIELD DINO	DIVERSITY S-P	DIVERSITY DINO	PRES.	LITH.*
25	1775.0	negl	-	low	-	poor	?
24	1783.0	negl	low	low	low	poor	ss.
22	1812.0	med.	low	med.	low	poor	clayst.?
21	1814.5	high	high	high	med.	poor	clayst.
20	1824.0	high	low	high	low	mod.	clayst.
18	1853.0	low	low#	low	low	poor	coal
17	1855.0	high	high	high	low	poor	clayst.
16	1882.5	med.	low#	med.	low	good	ss.
15	1895.0	high	low	high	low	good	ss.
14	1904.2	high	-	low	-	poor	siltst.
10	1931.5	med.	low#	med.	low	mod.	ss.
09	1949.5	high	low#	med.	low	mod.	clayst.
06	1975.0	med.	med.	high	med.	good	ss/clay
05	1983.0	med.	low#	med.	low	mod.	clayst.
04	2002.5	high	low#	med.	low	mod.	clayst.
03	2008.0	high	low#	high	low	poor	clayst.
02	2020.0	high	low#	med.	low	good	ss.
01	2035.0	low	low#	low	low	poor	ss.

Caved Oligocene-Miocene species.

* Lithological descriptions [main rock type.qualifier] taken from hand-written sidewall core sample description sheets

Well Name SHELL DEVILFISH-1 Basin GIPPSLAND Sheet No. 1 of 3.

SAMPLE TYPE OR NO. *	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
FOSSIL NAMES / DEPTHS (m)	1775.0	1783.0	1812.0	1814.5	1834.0	1853.0	1855.0	1882.5	1895.0	1904.2	1931.5	1949.5	1975.0	1983.0	2002.5	2008.0	2020.0	2035.0
SPORE-POLLEN																		
Aequitriradites spinulosus R																•		•
Anacolosidites acutullus				•														
Amosopollis cruciformis					•	•				•	•			•		•	•	
Araucariacites australis	•		•	•	•	•	•	•	•	•	•	•	•	•		•	•	•
Arecipites spp.								•	•									
Asteropollis asteroides R													•					
Australopollis obscurus					•		•				•	•	•	•			•	•
Baculatisporites comaumensis R				•				•					•			•		•
B. disconformis			•		•	•	•		•		•			•			•	
Banksieaeidites elongatus				•	•													
B. lunatus ms					•													
Basopollis mutabilis ms									•									
B. otwayensis ms				•	•								•		•			
Beaupreaidites elegansiformis							•											
B. orbiculatus					•		•	•										
Biretisporites spp. R																•		
Camarozonosporites australiensis				•									•					
C. bullatus					•													
C. dumus ms												•	•					
C. heskermensis													•					
Clavifera triplex				•			•									•		
Concavissimisporites penolaensis R																		•
Cupanieidites orthoteichus				•	•						•							•
Cyathidites australis/minor	•				•		•	•	•		•	•			•		•	
C. gigantis				•	•													
C. splendens			•	•			•	•	•			•	•	•				
Dicotetradites clavatus			•	•					•	•	•		•	•	•	•		
Dictyotosporites speciosus R			•															
Dilwynites granulatus			•	•	•		•		•	•	•		•					
D. tuberculatus		•		•												•		
Elphredripites notensis					•													
Ericipites scabratus			•				•											
Foraminisporis asymmetricus R																•		
Foveosporites canalis					•													•
Foveotriletes balteus					•													
F. parviretus							•							•		•		
Foveogleicheniidites spp.					•													
Gambierina corpusculus ms													•					
G. edwardsii					•		•		•				•			•		
G. rudata		•			•		•		•	•	•	•	•	•	•	•	•	
Gleicheniidites spp.			•	•	•	•	•	•	•	•	•	•	•	•		•		•
Haloragacidites harrisii	•	•	•	•	•	•	•	•	•	•								
Herkosporites elliotii							•		•		•	•		•				
Ilexpollenites anguloclavatus				•	•		•						•					
Ischyosporites gremius			•														•	
I. irregularis ms			•								•							
Kraeuselisporites linearis													•					
Laevigatosporites spp.	•		•	•	•	•	•	•	•	•	•	•	•	•		•		
Latrobosporites amplus													•	•	•	•	•	
L. crassus					•		•	•	•		•	•	•					
Liliacidites sernatus ms										•								
Liliacidites spp.				•		•	•		•					•	•	•	•	
Lycopodiacidites asperatus													•	•		•		
L. variverrucatus ms												•						
Lygistepollenites balmei					•	•	•	•	•	•	•	•	•	•	•	•	•	

* C=CORE S=SIDEWALL CORE
T=CUTTINGS J=JUNK BASKET

R = REWORKED SP.
C = CONTAMINANT

Well Name SHELL DEVILFISH-1 Basin GIPPSLAND Sheet No. 2 of 3

SAMPLE TYPE OR NO. *	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
FOSSIL NAMES / DEPTHS (m)	1775.0	1783.0	1812.0	1814.5	1834.0	1853.0	1855.0	1882.5	1895.0	1904.5	1931.5	1949.5	1975.0	1983.0	2002.5	2008.0	2020.0	2035.0
Lygistepollenites florinii			•		•		•		•	•	•		•		•	•		
Malvacipollis diversus				•	•				•									
M. robustus ms				•														
M. subtilis s.l.			•	•	•		•					•						
Microalitidites palaeogenicus							•											
Microcachrydites antarcticus			•		•	•	•		•	•	•		•				•	•
Monosulcites gemmatus ms			•															
Myrtaceidites parvus-mesonesus				•														
Nothofagidites asperus			•															
N. brachyspinulosus			•	•	•		•	•	•		•	•	•					
N. deminutus							•											
N. emarcidus-heterus		•	•	•	•		•		•									
N. endurus					•	•	•	•	•	•	•	•	•		•	•	•	
N. flemingii			•	•	•													
Peninsulapollis gillii					•		•			•	•	•	•	•	•	•	•	
P. truswellii													•					
Phimopollenites pannosus R															•			
Parvisaccites catastus									•		•							
Periporopollenites demarcatus			•		•		•								•		•	
P. polyoratus s.l.			•	•					•	•	•							
Peromonolites bacculatus ms									•									
P. densus					•				•		•							
Phyllocladidites mawsonii	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
P. reticulosaccatus						•	•	•	•	•	•	•	•			•		
P. verrucosus							•	•				•						
Podocarpidites exiguus								•	•		•							
Podocarpidites spp.	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Podosporites microsaccatus			•		•	•		•	•	•	•	•	•	•		•	•	
P. parvus			•															
Polycolpites langstonii					•				•									
Proteacidites adenanthoides			•	•			•		•		•		•					
P. ademonosus ms											•					•	•	
P. angulatus										•		•		•				
P. annularis			•	•	•	•	•											
P. clinei ms														•	•			
P. grandis			•	•	•			•										
P. incurvatus			•		•		•											
P. latrobensis var.									•									
P. obscurus s.l.				•														
P. otwayensis ms															•	•		
P. palisadus														•		•		
P. rectus				•			•											
P. retiformis													•	•				
P. reticuloconcavus ms													•	•	•	•	•	
P. reticuloscabratus			•	•														
P. vulgaris ms					•													
Pseudowinterapollis cranwellae							•									•		
Quadraplanus brossus														•				
Retistephanocolpites nixonii ms									•									
Retitriletes australoclavatidites					•			•			•		•		•	•		
Retitriletes spp.					•		•					•						•
Rousea georgensis																•		
Rugulatisporites mallatus				•	•										•			
Schizocolpus marlinensis			•															
Stereisporites australis f. crassa			•		•													
S. antiquisporites			•		•				•		•	•	•	•	•	•		

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R = REWORKED SP.
C = CONTAMINANT

Well Name SHELL DEVILFISH-1 Basin GIPPSLAND Sheet No. 3 of 3

FOSSIL NAMES / DEPTHS (m)	1775.0	1783.0	1812.0	1814.5	1834.0	1853.0	1855.0	1882.5	1895.0	1904.2	1931.5	1949.5	1975.0	1983.0	2002.5	2008.0	2020.0	2035.0
SAMPLE TYPE OR NO. *	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Stereisporites (Tripunctisporis) punctatus ms					•		•	•	•		•	•	•	•	•	•	•	
Stereisporites regium																•	•	
Stereisporites spp.				•		•			•				•			•		•
Tetracolporites multistrixus ms			•	•	•	•	•			•						•		
T. textus ms			•				•											
T. verrucosus												•	•				•	•
Tricolpites confessus								•						•	•	•		
T. phillipsii			•	•	•			•	•	•		•	•					
T. reticulatus Cookson					•											•		
T. waipawaensis Couper														•	•			
Tricolpites indet./undescribed				•	•		•		•		•	•	•	•	•	•	•	
Tricolporites lilliei														•	•	•	•	
T. marginatus ms																		
T. moultonii ms			•	•														
T. scabratus				•														
T. sphaerica s.l.			•	•														
Tricolporites spp. indet./undescribed				•	•	•	•		•	•	•	•	•	•	•	•	•	
trilete spores indet./undescribed			•	•	•				•		•		•		•			
Triletes tuberculiformis					•				•			•						
Triporopollenites ambiguus								•										
T. sectilis															•	•	•	
Triporopollenites spp. indet./undescribed			•	•					•	•			•					
Triporoletes reticulatus																•		
Uvatisporites spp.						•						•						
Verrucatosporites alienus					•													
Verrucosisporites kopukuensis			•	•	•		•	•	•									
Jaxta olpus pieratus																		
PERMO-TRIASSIC SPP. R					•													•
DINOFLAGELLATES																		
Areosphaeridium diktyoplokus C													•					
A. capricornum C											•							
Apectodinium homomorphum									•									
A. hyperacantha					•													
Ceratopsis medcalfii									•									
Cordosphaeridium inodes			•															
Gippslandica extensa																		
Glaphyracysta retiintexta		•											•					
Hemiplacophora semilunifera C?									•									
Hystrichosphaeridium tuberiferum																		
Kenleyia lophophora				•	•													
Kenleyia spp.			•	•	•			•										
cf Muratodinium fimbriatum				•														
Operculodinium centrocarpum C		•	•		•			•	•		•		•			•	•	
Palaeocystodinium australinum													•					
Palaeoperidinium pyrophorum ms													•					
Paralecaniella indentata		•										•	•					
Protoellipsodinium simplex ms C											•							
Saeptodinium spp.							•	•										
Senagalium dilwynense					•													
Spinidinium cf essoi		•	•	•	•		•		•									
Spiniferites spp.		•		•				•	•				•				•	
Trithyrodinium evittii													•					
INDET./UNDESCRIBED DINOFLAGELLATES C?		•		•	•	•	•	•	•		•	•	•	•	•		•	

* C=CORE S=SIDEWALL CORE
T=CUTTINGS J=JUNK BASKET

R = REWORKED SP.
C = CONTAMINANT

Appendix 2

Micropaleontology

Appendix 2

MICROPALAEONTOLOGICAL ANALYSIS

DEVILFISH-1, GIPPSLAND BASIN

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CONTENTS

1. SUMMARY

Devilfish-1 was drilled in offshore petroleum permit Vic P/21, Gippsland Basin to a depth of 2058mKB. Sidewall cores from 1300m to 1642m have been examined for foraminifera and calcareous nannoplankton. A summary of the biostratigraphic breakdown of the respective microfossil groups and environmental sub-division is given below:-

Planktonic Foraminiferal Subdivision

1300m-1450m	:	Zone G	upper Early Miocene
*1642m	:	Indeterminate	

Calcareous Nannoplankton Subdivision

1300m	:	Zones NN5 & NN4	lower Middle-upper Early Miocene
1450m	:	Zones NN3 & NN2	lower Early Miocene
*1642m	:	Indeterminate	

Environment of Deposition

1300m	:	outer neritic
1450m	:	outer neritic-upper bathyal
*1642m	:	indeterminate

* sidewall core contaminated with Early and Middle Miocene assemblages.

II. INTRODUCTION

A total of 3 sidewall cores have been scrutinized for foraminifera and calcareous nannoplankton from the interval 1300m to 1642m in Devilfish-1. Fossil assemblages identified in the well section are provided in Appendix No. 2.

III. BIOSTRATIGRAPHIC ANALYSIS

The planktonic foraminiferal letter zonal scheme of Taylor (in prep.) and the NN calcareous nannoplankton zonal scheme of Martini (1971) are used for biostratigraphic subdivision.

(A) Planktonic Foraminiferal Subdivision

1. **1300m-1450m : Zone G (upper Early Miocene)**

   The samples in the interval are assigned to Zone G on the basis of the occurrence of *Globigerinoides trilobus* without *Globigerinoides sicanus*.

2. **1642m : Indeterminate**

   The sidewall core sample at 1642m lacks *in-situ* planktonic foraminifera.

(B) Calcareous Nannoplankton Subdivision

1. **1300m : Zones NN5 & NN4 (lower Middle-upper Early Miocene)**

   The occurrence of *Sphenolithus heteromorphous* in the sample indicates assignment to Zones NN5 and NN4.

2. **1450m : Zones NN3 & NN2 (lower Early Miocene)**

   The sidewall core sample is assigned to Zones NN3 and NN2 on the basis of the occurrence of *Sphenolithus belemnos*.

3. **1642m : Indeterminate**

   The sample lacks *in-situ* calcareous nannoplankton.

IV. ENVIRONMENT OF DEPOSITION

1. 1300m : Outer neritic

The rich foraminiferal fauna at 1300m comprises approximately 80% planktonics. The diverse benthonic fauna includes Sphaeroidina bulloides (frequent), Globocassidulina subglobosa (frequent), Cassidulina delicata (few) and Trifarina bradyi (frequent). Deposition in an outer neritic environment is envisaged.

2. 1450m : Outer neritic-upper bathyal

The sample at 1450m is interpreted to have been deposited in an upper bathyal to outer neritic environment on the basis of containing a rich foraminiferal fauna which comprises mainly planktonics (greater than 80% planktonics) and includes the following bathymetrically-diagnostic taxa: Siphouvigerina proboscidea (few), Hyperammina (rare) and Pullenia bulloides (rare).

3. 1642m : Indeterminate

The sand-prone sample at 1642m contains a low yielding foraminiferal fauna which is interpreted to represent only contaminants from the carbonate section.

V. REFERENCES

MARTINI, E., 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. In: FARINACCI, A., (Ed). Proc. Second Planktonic Conf., Roma. : 739-785.

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APPENDIX NO. 1 : SUMMARY OF MICROPALAEONTOLOGICAL DATA, DEVILFISH-1

SAMPLE (mKB)	FORAM YIELD	FORAM PRESERV.	FORAM DIVERSITY	NANNO YIELD	NANNO PRESERV.	NANNO DIVERSITY
SWC30, 1300	high	moderate	high	high	moderate	mod/high
SWC29, 1450	high	moderate	mod/high	high	moderate	mod/high
*SWC27, 1642	low	poor	mod/low	mod/high	mod/poor	mod/high

* sidewall core sample contaminated with calcareous microfossils from the carbonate section in the well.

APPENDIX NO. 2 : Micropalaeontological distribution chart, Devilfish-1 (foraminifera)

SAMPLE TYPE OR NO.	SWC	SWC	SWC
FOSSIL NAMES / DEPTHS	1300m	1450m	1642m
BENTHONIC FORAMINIFERA			
Sphaeroidina bulloides	0	/	c/
Globocassidulina subglobosa	0/	/	c•
Cibicides aff. vortex	/	•	
Fissurina spp.	0	/	
Cibicides aff. mediocris	•		
Cassidulina delicata	/	/	c•
Lagena apiculata	/		
Nodosaria spp.	0	/	c•
Anomalinoides macroglabra	0	/	c/
Gaudryina spp.	•	•	
Lagena spp.	/		
Buliminella spp.	•		
Lenticulina spp.	/	•	
Pullenia quinqueloba	/		c•
Textularia semicarinata	•		c•
Quadrimorphina spp.	•		
Brizalina spp.	0	●	
Quinqueloculina spp.	0		
Trifarina bradyi	0	/	c•
Lagenonodosaria scalaris	•		
Ammodiscus spp.	•		
Cibicides spp.	0	●	c/
Dentalina spp.	/	/	
Gyroidina aff. allanii	/	•	
Lagena aff. paucicostata	•	•	
Siphonina australis	•		
Spiroloculina spp.	•		
Hanzawaia spp.	/		
Ramulina spp.	•	•	
Karreria maoria	•		
Lagena sulcata	/		
Gyroidina subzelandica	•	/	
Cibicides mediocris	/	/	
Bulimina pupula		0	c•
Siphouvigerina proboscidea		/	
Hyperammina spp.		•	
Pullenia bulloides		•	
PLANKTONIC FORAMINIFERA			
Globorotalia miozea miozea	/		
Globorotalia praescitula	●	/	c/
Globigerinoides trilobus	0	■	c/
Globigerina woodi woodi	0	0	c/
Globigerina praebulloides	0	0	c/
Globorotalia mayeri	●	/	c•
Globoquadrina dehiscens s.s.	/		c•
Juvenile planktonics	0	●	c/
Globigerina woodi connecta		●	
Globigerina venezuelana		•	
Globorotalia bella		•	
Globorotalia spp.		/	
Orbulina universa			c/
Globigerinoides sicanus			c/
Globigerina spp.			c/

• Single   0 Few   ■ Dominant   C Contamination

/ Rare   ● Common   B Barren   Ns Not studied

APPENDIX NO. 2 : Micropalaeontological distribution chart, Devilfish-1 (nannoplankton & other skeletal material)

SAMPLE TYPE OR NO.	SWC	SWC	SWC
FOSSIL NAMES / DEPTHS	1300m	1450m	1642m
CALCAREOUS NANNOPLANKTON			
Cyclicargolithus floridanus	■	■	c■
Helicosphaera kamptneri	/	/	c
Coccolithus miopelagicus	0	0	c/
Coccolithus eupelagicus	0	●	c0
Sphenolithus moriformis	■	●	c0
Braarudosphaera bigelowii	■	●	c0
Pontosphaera multipora	0		c/
Micrantholithus fornicatus	0	•	c/
Discoaster spp.	•		
Discoaster deflandre	0	●	c0
Reticulofenestra minutula	•		c/
Dictyococcites productus	/	/	c0
Sphenolithus abies	/	•	c0
Helicosphaera euphratis	•	•	
Calcidiscus macintyrei	/		c/
Sphenolithus heteromorphous	•		c0
Reticulofenestra minuta	0	0	c0
Sphenolithus belemnos		0	
Micrantholithus spp.		•	
Reticulofenestra aff. pseudoumbilica		/	
Sphenolithus aff. delphix		•	
Pontosphaera spp.		/	c•
Reticulofenestra haqii		•	
Reticulofenestra pseudoumbilica			c0
OTHER SKELETAL MATERIAL			
Ostracods	0	/	•
Echinoid debris	/	•	
Bryozoan fragments	•		

• Single   0 Few   ■ Dominant   C Contamination
/ Rare   ● Common   B Barren   Ns Not studied

Appendix 3

Petrophysical Analysis

Appendix 3

APPENDIX 3

PETROPHYSICAL ANALYSIS

WIRELINE LOGS (all depths are logging depths in metres below derrick floor)

The following wireline logs were run:

Date	Hole Size	Run	Interval	Type
17/4/90	12-1/4"	1	893-390m	DLL/BCSL/LDL/GR/SP/A MS
	20" csg	1	390-92m	GR
22/04/89	8-1/2"	1	2038-1590m	DLL/LSSL/LDL/CNL/NGS/ MSFL/CAL/AMS
	8-1/2"	1	1590-1091m	DLL/LSSL/LDL/GR/CAL/AMS
	9-5/8" csg	1	1091-850m	GR
	8-1/2"	2	2036-1590m	SHDT/GR
	8-1/2" csg	3	2025-527m	WST (50 levels)
	8-1/2"	4	2035-1300m	CST/GR (30 fired, 27 rec.)

EVALUATION

General

Petrophysical evaluation indicates the objective Latrobe Group to be entirely water-bearing. No significant above-background mud gas readings nor hydrocarbon shows were recorded.

Factors Affecting Log Evaluation

- All recorded logs were of good quality presenting no difficulties in evaluation.

- The 12 1/4 inch open-hole section between 1100 and 893m was not logged as the super-combo tool could not pass below 898m. The section was subsequently logged (GR) through 9 5/8 inch casing.

Petrophysical Parameters

- Values of 2.098 for the cementation exponent m, 1.84 for the saturation exponent n and 2.66 g/cc for the matrix density were used in the evaluation of the Latrobe sandstones. These parameters were derived from Basker-1 Latrobe core analyses.

- No core-derived values for the parameters A, m, n and RHO_{ma} were available for the lithologically distinct, deeper Latrobe Group; see Table 1 for a petrophysical parameter summary.

- In the absence of Qv data in both sections, the shaley sand Indonesia equation was used for calculation of hydrocarbon saturations.

- Resistivity of the formation water was derived using the Rwa technique over clean, low resistivity sands. Relative constant values of 0.05-0.07 ohmm (40000-50000 ppm Nacl equivalent) for Rw were derived.

TABLE 1 : PETROPHYSICAL PARAMETERS

	INTERVAL (m BDF)		
	1645-1770	1770-1965	1965-2008
Hole size (inches)	8.5	8.5	8.5
GR_{ma} (API)	13	13	25
GR_{sh} (API)	120	120	120
R_m (OHMM)	0.16	0.16	0.145
R_{mc} (OHMM)	0.31	0.31	0.28
R_w (OHMM)	0.05	0.07	0.06
R_{sh} (OHMM)	5.0	7.0	6.0
A	1.0	1.0	1.0
m	2.098	2.098	2.0
n	1.83	1.83	2.0
RHO_{ma} (g/cc)	2.66	2.66	2.65
RHO_{mud} (g/cc)	1.12	1.12	1.12
RHO_{mf} (g/cc)	1.00	1.00	1.00

EVALUATION PROCEDURE

The following steps were used in the petrophysical evaluation of Devilfish-1:

Preliminary Lithology Calculation

- Correct CGR/GR for borehole effects

- Calculate fraction of shale (V_{SH} from GR)

- Apply cutoffs for sst/sh definition

  sst : $V_{SH} \leq 50\%$
  sh : $V_{SH} \geq 50\%$

- Correct LDL for borehole effects

- Apply cutoff for coal definition coal

  coal : Density $\leq$ 2.1 g/cc

Preliminary Rwa Calculation over Clean, Water-bearing Sandstones.

- Correct DLL/DLS/MSFL for borehole effects

- Calculate diameter of invasion and true resistivity

- Correct LDL for borehole effects

- Calculate porosity from density

- Calculate Rwa from porosity and true resistivity

Calculation of Hydrocarbon Saturation Latrobe Group

- Hydrocarbon saturation calculated using Indonesia shaley sand equation:

$$S_h = 1 - R_T^{-1/n} * \left[\frac{V_{sh}^{(1-Vsh/2)}}{R_{sh}^{1/2}} + \frac{POR^{m/2}}{(A*Rw)^{1/2}} \right]^{-2/n}$$

EVALUATION SUMMARY

No net hydrocarbon zones above the porosity and hydrocarbon saturation cutoffs (10% and 50% respectively) were calculated from log data. No significant mud gas readings nor shows in samples were recorded. Results of the analysis are tabulated below:

TABLE 2 : EVALUATION SUMMARY

INTERVAL (mBDF)

	1645-1965m	1965-2008m
Gross Thickness (m)	320	43
Net sst (m)	234	12
Average Porosity (%)	22.7	14.6
Net sst/gross	73	28
S_h Average	6	8

PE604490

This is an enclosure indicator page.
The enclosure PE604490 is enclosed within the container PE905928 at this location in this document.

The enclosure PE604490 has the following characteristics:

```
     ITEM_BARCODE = PE604490
CONTAINER_BARCODE = PE905928
             NAME = Petrophysical Evaluation
            BASIN = GIPPSLAND BASIN
           PERMIT = VIC/P21
             TYPE = WELL
          SUBTYPE = WELL_LOG
      DESCRIPTION = Petrophysical Evaluation (enclosure
                    from WCR vol.2 appendix
                    3--Petrophysical Analysis) for
                    Devilfish-1
          REMARKS =
     DATE_CREATED = 31/05/90
    DATE_RECEIVED =
             W_NO = W1026
        WELL_NAME = DEVILFISH-1
       CONTRACTOR =
    CLIENT_OP_CO = SHELL AUSTRALIA
```

(Inserted by DNRE - Vic Govt Mines Dept)

Appendix 4

Geochemical Analysis

Appendix 4

PETROLEUM GEOCHEMISTRY

DEVILFISH 1

DATA REPORT

Prepared for :

The Shell Company of Australia Ltd

June 1990

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DATA REPORT

DEVILFISH 1

Ten sidewall core samples were submitted for geochemical analysis.

Total organic carbon and Rock-Eval pyrolysis determinations were performed on four samples from 1834.0m to 2002.5m.

Vitrinite reflectance measurement and coal maceral description was undertaken for six samples from 1814.5m to 2008.0m.

TABLE 1

ROCK-EVAL PYROLYSIS DATA (one run)

WELLNAME = DEVILFISH 1

DATE OF JOB = MAY 1990

DEPTH(m)	TMAX	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
1834.0	425	0.23	1.50	0.09	1.73	16.67	0.13	0.14	0.93	161	9
1855.0	429	0.28	5.03	0.25	5.31	20.12	0.05	0.44	1.75	287	14
1945.5	430	0.07	1.08	0.12	1.15	9.00	0.06	0.10	0.70	154	17
2002.5	441	0.04	0.57	0.30	0.61	1.90	0.07	0.05	0.35	162	85

TMAX = Max. temperature S2
S1 = Volatile hydrocarbons (HC)
S2 = HC generating potential
S1+S2 = Potential yield
S3 = Organic carbon dioxide
PI = Production index
PC = Pyrolysable carbon
TOC = Total organic carbon
HI = Hydrogen index
OI = Oxygen Index
nd = no data

K.K. No.	Depth (m)	$\bar{R}_v max$	Range	N	Description Including Liptinite (Exinite) Fluorescence
v2522	1814.5 SWC 21	0.46	0.36-0.59	25	Common phytoplankton, yellow to orange, sparse liptodetrinite, yellow to dull orange, sparse sporinite, orange to dull orange, rare cutinite dull orange, rare bituminite, brown. (Calcareous siltstone. Dom abundant, L=V=I. All maceral groups common. Oil drops rare, yellow. Bitumen rare, orange. Fossil fragments abundant. Iron oxide and pyrite abundant.)
v2523	1853.0 SWC 18	0.62	0.56-0.70	26	Abundant sporinite and liptodetrinite, yellow to orange, sparse resinite, orange to brown, rare suberinite and exsudatinite, dull orange to brown. (Coal, V>I>L. Vitrite=duroclarite=clarodurite>vitrinertite. Maceral group composition (mmf) of coal. Vitrinite 52.0% Inertinite 40.0% Liptinite 8.0% Dom absent. Vitrinite fluorescence major, brown. Pyrite rare.)
v2524	1904.2 SWC 14	0.46	0.34-0.52	25	Abundant phytoplankton, yellow to orange, abundant sporinite, yellow to dull orange, common liptodetrinite, yellow to dull orange, sparse suberinite, dull orange to brown. (Siltstone>>shaly coal. Shaly coal common, V>>L. Vitrite=clarite. Dom major, V>L>>I. Vitrite major, liptinite abundant, inertinite sparse. Vitrinite fluorescence abundant brown. Mineral fluorescence major, dull green to yellow. Fossil fragments rare. Iron oxides and pyrite abundant.)
v2525	1955.0 SWC 8	0.57	0.49-0.63	28	Abundant sporinite, resinite and liptodetrinite, yellow to brown, sparse cutinite, yellow to brown. (Coal. V>I>L. Duroclarite>vitrite>vitrinertite>clarodurite. Maceral group composition (mmf) of coal: Vitrinite 70.0% Inertinite 25.0% Liptinite 5.0% Dom absent. Vitrinite fluorescence dominant, brown. Mineral fluorescence rare, yellow to brown. Pyrite abundant.)
v2526	1983.0 SWC 5	0.47	0.37-0.63	27	Sparse phytoplankton and liptodetrinite, yellow to orange, rare sporinite, orange, rare resinite, yellow to orange. (Calcareous siltstone>>sandstone. Dom abundant, I>V>L. Inertinite abundant, vitrinite common, liptinite sparse. Oil drops sparse yellow. Mineral fluorescence dominant green to yellow. Iron oxides and pyrite abundant.)

K.K. No.	Depth (m)	$\bar{R}_v max$	Range	N	Description Including Liptinite (Exinite) Fluorescence
v2527	2008.0 SWC 3	0.44	0.37-0.52	28	Common sporinite, yellow to dull orange, sparse liptodetrinite and phytoplankton yellow to orange, rare cutinite and resinite, orange, rare suberinite and bituminite, brown. (Siltstone. Dom major, V=I>L. Vitrinite and inertinite abundant, liptinite common. Oil drops sparse yellow. Bitumen sparse, orange. Vitrinite fluorescence abundant brown. Mineral fluorescence dominant, green to yellow. Fossil fragments rare. Iron oxide and pyrite abundant.)

THEORY AND METHODS

This section details a series of geochemical methods which are commonly used in ou laboratory, including those used to obtain the data presented in this report. Wher applicable, the discussion is accompanied by a summary of the general theory used t interpret the data generated by each method.

1. SEDIMENTARY GAS ANALYSIS

a) Headspace Analysis

Headspace analysis is carried out using sealed containers (usually tinned cans) c wet cuttings. The containers are approximately three quarters filled with th cuttings and water to leave an appreciable headspace into which volatile hydrocarbon contained in the cuttings diffuse.

After covering about 1cm2 of the container lid with silicone and allowing th silicone to dry, the procedure involves placing a small hole in the lid through th silicone, then sampling an aliquot of the headspace gas with a gas injection syringe and finally gas chromatographing this sample of gas under the following conditions instrument = Shimadzu GC-8APF; column = 6' x 1/8" Chromosorb 102; column temperatur = 110 Deg. C; carrier gas = nitrogen at 23mls/min; injector temperature = 120 Deg C.; analysis cycle = C1-C4 components are flushed from the column in the forwar direction and then the C5-C7 compounds are removed from the column by backflushing.

The integrated areas of peaks representing each of the C1-C7 components of th headspace gas are compared to the areas of corresponding components of a standard ga of known composition. The calculated amount of each component in the sample gas i adjusted for the total headspace volume and reported as ppm (parts of gas per millio parts of sediment by volume).

Data from headspace analysis is commonly used to identify the zone of oil generatio by plotting gas wetness (C2-C4/C1-C4) expressed as a % against sediment burial depth Gas containing appreciable quantities of C2-C4 components, termed wet gas (Fuex 1977), is generally considered to be gas associated with oil generation. I addition, the ratio of isomeric butanes can sometimes be used for assessment o sediment maturity (Alexander et. al., 1981). The amount of gas in sediments can b used to identify zones of significant gas generation and out-of-place gas (LeTran et al., 1975).

b) Cuttings Gas Analysis

This analysis is the same as Headspace Analysis with the exception that instead o analysing the gas in the container headspace, a known volume of the wet cuttings ar transferred to the blender bowl of a Kenwood electronic blender with the lid modifie to incorporate a septum, water at 75 Deg. C is added to leave a headspace of 160ml and the mixture is blended at maximum speed for 2 minutes. Following a 2 minut settling period 1ml of the blending bowl headspace gas is analysed as described i section 1a.

It is recommended that for the most meaningful gas data both headspace and cutting gas analysis are carried out. In such cases we provide tabulations of the headspace gas, and combined headspace/cuttings gas data. Normally, the combined data is use for plotting purposes.

2. SAMPLE PREPARATION

a) Cuttings

Cuttings samples are inspected by our qualified geological staff and then wate washed according to the drilling mud content and lithology. In special cases (e.g diesel contamination) it is necessary to lightly solvent wash samples. Afte washing, the samples are air dried, either sieved or picked free of cavings, ar crushed to 0.1mm using a ring pulveriser.

b) Sidewall Cores

Sidewall samples are freed of mud cake and any other visible contaminants, and ar also inspected for lithologic homogeneity. For homogeneous samples, the minimu amount of material required for the requested analyses is air dried and handcrushe to 0.1mm. For non-homogeneous samples, the whole sample is air dried and handcrushe to 0.1mm.

c) Conventional Core and Outcrop Samples

These sample types are firstly inspected for visible contaminants, and wher applicable, are freed of these contaminants to the best of our ability. Commonly the surface of conventional core and outcrop samples are lightly solvent washed. Th samples are then crushed to approximately 1/8" chips using a jaw crusher, air dried and finally further crushed to 0.1mm using a ring pulveriser.

d) Petroleum/Aqueous Mixtures

The most common sample type in this category are RFT tests containing oil, water an mud. The mixture is placed in a separation funnel and allowed to stand for severa hours which enables the petroleum and water/mud fractions to separate. The nea petroleum is isolated by removal of the lower layer (water/mud) from the funnel. T remove the last traces of water and mud, the neat petroleum is centrifuged a moderate speed.

When the volume of petroleum accounts for only a very small part of the sample th method above is unsatisfactory and the petroleum is solvent extracted from th mixture with dichloromethane. The petroleum is recovered by careful evaporation o the solvent from the organic layer.

TOTAL ORGANIC CARBON DETERMINATION

The total organic carbon value (TOC) is determined on the unextracted sedimen sample. The value is determined by treating a known weight of sediment with ho dilute HCl for 1 hour to remove carbonate minerals, and then heating the residue t 1700 Deg. C (Leco Induction Furnace CS-044) in an atmosphere of pure oxygen. Th carbon dioxide produced is transferred to an infra-red detector which has bee calibrated with a series of standards, and the microprocessor of the Leco unit the automatically calculates the % TOC in the sample. To ensure reliable data a standar is run after every 10 samples, regular sample repeats are carried out, and at leas one blank determination is carried out for each batch of samples.

The following scales are normally used for source rock classification based on % TO data:

Classification	Clastics	Carbonates
Poor	0.00 - 0.50	0.00 - 0.25
Fair	0.50 - 1.00	0.25 - 0.50
Good	1.00 - 2.00	0.50 - 1.00
Very Good	2.00 - 4.00	1.00 - 2.00
Excellent	> 4.00	> 2.00

4. ROCK-EVAL PYROLYSIS

Although a preliminary source rock classification is made using TOC data a mor accurate assessment accounting for organic source type and maturity is made b pyrolysis analysis. Two types of Rock-Eval pyrolysis services are offered: "one run which involves pyrolysis of the crushed but otherwise untreated sediment and "tw run" which involves pyrolysis of both the crushed, untreated sediment and sedimen which has been rendered free of carbonate minerals by treatment with hot dilute HCl The two run service offers considerably more reliable S3 data.

The method involves accurately weighing approximately 100mg of the sample into sintered steel crucible and subjecting it to the following pyrolysis cycle:

Stage (i) - Sample purged with helium for 3.5 minutes in unheated part o pyrolysis furnace;

Stage (ii) - Sample heated at 300 Deg. C for 3 minutes to liberate fre petroleum (S1 peak);

Stage (iii) - Sample heated from 300 Deg. C to 550 Deg. C at 25 Deg C/minute to produce petroleum from kerogen (S2 peak). Th furnace is maintained at 550 Deg. C for one minute. Carbo dioxide produced during this pyrolysis up to 390 Deg. C i the case of "one run" and 550 Deg. C for "two run" i absorbed on a molecular sieve trap;

Stage (iv) - During the cool down period the carbon dioxide produce during pyrolysis is measured (S3 peak).

The units used for Rock-Eval data are as follows:

S1, S2, S3 = kg/tonne or mg/g of rock

Tmax = Deg. C

Hydrogen Index = $\frac{S2}{TOC} \times \frac{100}{1}$

Oxygen Index = $\frac{S3}{TOC} \times \frac{100}{1}$

Rock-Eval data is most commonly used in the following manner:

(i) S1 - indicates the level of oil and or/gas already generated b the sample according to the following scale:

S1 (mg/g or kg/tonne)	Classification
0.00 - 0.20	Poor
0.20 - 0.40	Fair
0.40 - 0.80	Good
0.80 - 1.60	Very Good
> 1.60	Excellent

(ii) S1+S2 - referred to as the genetic potential this parameter is use for source rock classification according to the followin criteria:

S1+S2 (mg/g or kg/tonne)	Classification
0.00 - 1.00	Poor
1.00 - 2.00	Marginal
2.00 - 6.00	Moderate
6.00 - 10.00	Good
10.00 - 20.00	Very Good
> 20.00	Excellent

(iii) S1/(S1+S2)- this parameter is the production index (PI) which is measure of the level of maturity of the sample. For oi prone sediments, values less than 0.1 are indicative o immaturity, the values increase from 0.1 to 0.4 over the oi window and values greater than 0.4 represent over maturity For gas prone sediments, the PI data shows a relativel smaller change with increasing maturity.

(iv) Tmax - the temperature corresponding to the S2 maxima. Thi temperature increases with increasingly mature sediments Values less than 430 Deg. C are indicative of immaturit while values from 430/435 to 460 Deg. C represent th maturity range of the oil window. Tmax values greater tha 460 Deg. C are indicative of over maturity.

(v) HI, OI - the hydrogen ((S2 x 100)/TOC) and oxygen ((S3 x 100)/TOC indices when plotted against one another provide informatio about the type of kerogen contained in the sample and th maturity of the sample. Both parameters decrease in valu with increasing maturity. Samples with large HI and low O are dominantly oil prone and conversely samples with low H and large OI are at best gas prone.

5. EXTRACTION OF SEDIMENT SAMPLES

Crushed sediment (maximum of 250g) and 300mls of purified dichloromethane are place in a 500ml conical flask and are then blended for ten minutes with a Janke and Kunke Ultra-Turrax T45/2G high efficiency disperser. After a ten minute settling perio the solvent is separated from the sediment using a large Buchner filtration system The extract is recovered by careful evaporation of the solvent on a steam bath an weighed. The weight of extract is used to calculate % EOM and ppm EOM using th following formulae:

$$\% \text{ EOM} = \frac{\text{Wt EOM}}{\text{Wt Sediment Extracted (g)}} \times \frac{100}{1}$$

$$\text{ppm EOM} = \frac{\text{Wt EOM (mg)}}{\text{Wt Sediment Extracted (kg)}}$$

The following scale is used to classify the source rock richness of samples based c C12+ extractables:

Classification	ppm Total Extract
Poor	0 - 500
Fair	500 - 1000
Good	1000 - 2000
Very Good	2000 - 4000
Excellent	> 4000

6. SEPARATION OF PETROLEUM INTO CONSTITUENT FRACTIONS

Sediment extracts and crude oil or condensate samples are separated into saturate aromatic and NSO (asphaltenes plus resins) fractions by medium pressure liqui chromatography (MPLC). That part of the petroleum which is soluble in pentane i applied to the MPLC system via a sample loop and is then pumped using pentane to partially activated silicic acid pre-column which prevents further movement of th non-hydrocarbon compounds. The hydrocarbon components are pumped further to a Merc Si60 column where the saturate fraction is obtained by forward flushing and th aromatic fraction is recovered by reverse flushing. This separation procedure i monitored using a refractive index detector. To complete the separation the pre column is removed from the MPLC system and flushed with dichloromethane: methano (1:10). This non-hydrocarbon fraction is combined with the pentane insolubl material which is not applied to the MPLC system, and is labelled as the NS fraction. The neat fractions are recovered by careful removal of the solvent b distillation and are weighed.

The weight of each fraction is used to calculate the % of each fraction in th sediment according to the following formulas:

$$\% \text{ Fraction} = \frac{\text{Wt Fraction}}{\text{Wt all Fractions}} \times \frac{100}{1}$$

$$\text{ppm Fraction} = \frac{\text{Wt Fraction (mg)}}{\text{Wt Sediment Extracted (kg)}}$$

The ppm hydrocarbon (saturates and aromatics) and ppm saturate values can be used t classify source rock richness and oil source potential respectively according to th following criteria:

Classification	ppm Hydrocarbon	ppm Saturates
Poor	0 - 300	0 - 200
Fair	300 - 600	200 - 400
Good	600 - 1200	400 - 800
Very Good	1200 - 2400	800 - 1600
Excellent	> 2400	> 1600

The composition of the extracts can also provide information about their levels o maturity and/or source type (LeTran et. al., 1974; Philippi, 1974). Generally marine extracts have relatively low concentrations of saturated and NSO compounds a low levels of maturity, but these concentrations increase with increased maturation Terrestrially derived organic matter often has a low level of saturates and larg amount of aromatic and NSO compounds irrespective of the level of maturity.

N.B. If requested by a client the NSO fraction is separated into asphaltenes an resins by conventional methods.

EXTRACTABLE/TOTAL ORGANIC CARBON RATIOS

The ratios of EOM(mg)/TOC(g) and SAT(mg)/TOC(g) are determined from the appropriat data. The EOM(mg)/TOC(g) ratio can be used as a maturation indicator, especially i the parameter is plotted against depth for a given sedimentary sequence. In a absolute sense it is less reliable as a maturation indicator, although previous worl (Tissot et. al., 1971; LeTran et. al., 1974) suggests that the following criteria ca be used to determine maturity with this parameter.

< 50	Low maturity
50 - 100	Moderate maturity
> 100	High maturity

The ratios of EOM(mg)/TOC(g) and SAT(mg)/TOC(g) can be used collectively to provid information about source type. For example, if SOM(mg)/TOC(g) is > 100, suggesting high level of maturity, but the SAT(mg)/TOC(g) < 20 it is very likely that th organic matter is gas prone. Conversely, the same EOM(mg)/TOC(g) value with SAT(mg)/TOC(g) value > 40 suggests oil prone source type.

PYROLYSIS GAS CHROMATOGRAPHY

Pyrolysis-gas chromatography (PGC) incorporates a Chemical Data System Pyroprope 15 flash pyrolysis unit interfaced with a capillary gas chromatograph. A sample (5-10mg) of extracted sediment is placed in a quartz tube inside the element coil of th pyrolysis probe and is then heated to 610 Deg. C in a few milliseconds, and i maintained at this temperature for 20 seconds. Products generated from the pyrolysi are swept onto the bonded phase capillary column of the gas chromatograph and ar chromatographed from -20 Deg. C (isothermal for two minutes) to 280 Deg. C at 4 Deg C/minute. The product distribution is dominated by the nature of the kerogen fror which it is derived.

9. C12+ GAS CHROMATOGRAPHY

C12+ gas chromatography is commonly carried out on the saturate fraction but ir certain instances is carried out on neat oil, condensate or extract. The analysis i carried out under the following conditions: instrument = Shimadzu GC-9A; column = 50m x 0.2mm ID OV101 vitreous silica; column temperature = programmed from 60 Deg. (

to 280 Deg. C at 4 Deg. C/min; injection system = Grob splitless using a 30 secon dump time and split ratio of 25:1, carrier gas = hydrogen at 2mls/min; sample = 1u of 0.5% soln in pentane.

The following information is commonly obtained from C12+ gas chromatographi analysis:

(a) n-Alkane Distribution - The C12-C31 n-alkane distribution is determined fro the area under peaks representing each of these n-alkanes. This distributic can yield information about both the level of maturity and the source typ (LeTran et. al., 1974).

(b) Carbon Preference Index - Two values are determined:

$$CPI\ (1) = \frac{(C23 + C25 + C27 + C29)\ Wt\% + (C25 + C27 + C29 + C31)\ Wt\%}{2 \times (C24 + C26 + C28 + C30)\ Wt\%}$$

$$CPI\ (2) = \frac{(C23 + C25 + C27)\ Wt\% + (C25 + C27 + C29)\ Wt\%}{2 \times (C24 + C26 + C28)\ Wt\%}$$

The CPI is believed to be a function of both the level of maturity (Cooper an Bray, 1963; Scalan and Smith, 1970) and the source type (Tissot and Welte 1978). Marine extracts tend to have values close to 1.0 irrespective o maturity whereas values for terrestrial extracts decrease with maturity fro values as high as 20 but do not usually reach a value of 1.0

(c) (C21+C22)/(C28+C29) - This parameter provides information about the source o the organic matter (Philippi, 1974). Generally, terrestrial source materia gives values <1.2 whereas a aquatic source material results in values >1.5.

(d) Pristane/Phytane Ratio - This value was determined from the areas of peak representing these compounds. The ratio renders information about th depositional environment according to the following scale (Powell and McKirdy 1975):

< 3.0	Relatively reducing depositional environment
3.0-4.5	Reducing/oxidizing depositional environment
>4.5	Relatively oxidizing depositional environment

(e) Pristane/n-C17 Ratio - This ratio was determined from the areas of peak representing these compounds. The value can provide information about both th depositional environment and the level of maturation (Lijmbach, 1975). Ver immature crude oil has a pristane/n-C17 ratio >1.0, irrespective of th depositional environment. However, the following classification can be applie to mature crude oil:

<0.5	Open water depositional environment
0.5-1.0	Mixed depositional environment
>1.0	Peat-swamp depositional environment

In the case of sediment extracts these values are significantly higher and th following classification is used:

<1.0	Open water depositional environment
1.0-1.5	Mixed depositional environment
>1.5	Peat-swamp depositional environment

(f) Phytane/n-C18 Ratio - This ratio was determined from the areas of peak representing these compounds. The value usually only provides informatic about the level of maturity of petroleum. The value decreases with increase maturation.

(g) Relative Amounts of n-Alkanes and Naphthenes - Since n-alkanes and naphthene are the two dominant classes of compounds in the saturate fraction, a semi quantitative estimate of the relative amounts of these compounds can be mad from saturate GLC's. This information can be used to assess the degree o maturation and/or the source type of the petroleum (Philippi, 1974; Tissot an Welte, 1978). Very immature petroleum has only small proportions of n-alkanes but as maturity increases the relative amount of n-alkanes increases. I addition, terrestrial petroleum has a greater proportion of high molecula weight naphthenes than petroleum comprising aquatic source material.

10. API/SPECIFIC GRAVITY

A specific gravity (SG) bottle was accurately weighed, then filled with crude oil a 60 Deg. F and finally reweighed. The weight difference was divided by the weight o an equal volume of water at 60 Deg. F to obtain the specific gravity. The followin formula was then used to calcuate the API gravity:

$$\text{API Gravity} = \left[\frac{141.5}{\text{SG (60 Deg. F)}}\right] - 131.5$$

The reported gravity value is the average of duplicate determinations.

11. SULPHUR DETERMINATION

The % sulphur by weight is determined by dissolving 0.5g of the petroleum in 50mls kerosene and then analysing this mixture with an inductively coupled plasma (ICP instrument which has been calibrated with a series of sulphur standards.

This parameter is influenced by the nature of the source material from which a crude is derived, the depositional environment of the source rocks, and reservoir alteration processed such as bacterial alteration.

12. C1-C31 WHOLE SAMPLE GAS CHROMATOGRAPHY

This method of analysis is normally only applied to oil or condensate samples. The technique provides a "picture" of the sample which shows good resolution of the low. medium and high molecular weight components. Whole sample GC data is considered to be more useful than C12+ saturate fraction GC data for oil or condensate samples.

The analysis is carried out under the same conditions as for the C12+ GC analysis with the following exceptions: column temperature = programmed from -20 Deg. C to 280 Deg. C at 4 Deg. C/min (uses cryogenic mode); injection is carried out in split mode: sample = 0.1 μl of neat petroleum.

C1-C31 analysis data can be used to obtain the same information as that obtained fr C12+ GC but further provides detailed compositional data on the C1-C11 fraction a enables calculation of the distillation range of the sample.

13. MOLECULAR SIEVE EXTRACTION

This technique is used to isolate the branched/cyclic alkanes from the satura fraction for gas chromatography/mass spectometry analysis. A mixture of saturate 5A molecular sieves: purified benzene in the proportions 1:5:12 by weight is plac in a 100ml round bottom flask and refluxed for 24 hours. After cooling, the seiv are filtered from the liquid phase and are washed with 4 x 10ml aliquots of benzen The liquid phase plus washing are freed of benzene by distillation yielding t branched/cyclic compounds.

14. COMPUTERIZED GAS CHROMATOGRAPHY/MASS SPECTOMETRY (GC/MS)

Gas chromatography/mass spectrometry employs a capillary column gas chromatogra linked in series with a mass spectrometer and data system (GC/MS/DS). As molecule are eluted from the capillary column they are bled into the analyser tube of the mas spectrometer where they are bombarded with high energy electrons and consequentl fragment to form several ions each with molecular weights less than that of th parent molecule. The fragmentation pattern is characteristic of the particula molecular type. The spectrum of these ions (referred to as a mass spectrum) i recorded approximately once every second and all of the mass spectra recorded durin a GC/MS/DS analysis are memorised by the data system. Since any given class c molecules will breakdown in the analyser type to give one or more characteristic ic fragments of known molecular weight, after a GC/MS/DS analysis it is possible t examine the distribution of compounds within a given class by having the data syste reproduce a mass fragmentogram (plot of ion concentration against gas chromatograph retention time) representative of the particular class.

GC/MS/DS analyses can be carried out using one of the two following modes c operation:

(i) Acquire mode - in which all ions in each mass spectrum are memorised by th data system;

(ii) Selective ion monitoring (SIM) mode - in which only selected ions of interes are memorised by the data system.

At present the sterane/triterpane/bicyclane fraction of petroleum is considered mos useful for GC/MS/DS analysis and therefore we commonly use the second of the abov mentioned modes of operation and run the following twenty-two ions which ar pertinent to the sterane/triterpane/bicuclane fraction.

Ion	Molecular Type
177	Demethylated triterpanes
191	Normal triterpanes
205	Methyl triterpanes
163	Specific dethylated triterpanes
356	Parent ion - C26 triterpanes
370	Parent ion - C27 triterpanes
384	Parent ion - C28 triterpanes
398	Parent ion - C29 triterpanes

412	Parent ion - C30 triterpanes
426	Parent ion - C31 triterpanes
183	Isoprenoids
217	Normal steranes
218	Normal steranes
231	4-methylsteranes
259	Diasteranes
358	Parent ion - C26 steranes
372	Parent ion - C27 steranes
386	Parent ion - C28 steranes
400	Parent ion - C29 steranes
414	Parent ion - C30 steranes

GC/MS/DS analysis of the sterane/triterpane/bicyclane fraction can often provid information about the maturity and source type of petroleum and whether it has bee affected by micro-organisms. This technique is also often useful for oil:oil an oil:source rock correlation. The following sections indicate which parameters ar used to obtain this information and summarize the theory behind their use.

Maturity

(i) Based on Steranes

(a) The biologically produced $\alpha\alpha\alpha$ (20R) sterioisomer is converted in sedimen to a mixture of the $\alpha\alpha\alpha$ (20R) and $\alpha\alpha\alpha$ (20S) compounds. The ratio o

$$C29 \frac{\alpha\alpha\alpha\ (20S)}{\alpha\alpha\alpha\ (20R) + \alpha\alpha\alpha\ (20S)}$$

expressed as a percentage is about 25% at the onset of oil generation and increases almost linearily to a value of abou 50% at the peak of oil generation.

(ii) Based on Triterpanes

(a) The C31, C32, C33, C34 and C35 hopanes have the biological configuration at C22. On mild thermal maturation equilibration occurs t produce a 60/40 mixture of S/R. This equilibration occurs before th onset of oil generation.

(b) The conversion of the biological $17\beta,21\beta$ hopanes to the correspondin $17\alpha,21\beta$ and $17\beta,21\alpha$ compounds is also maturation dependant. Fo C30 triterpanes the ratio of $\frac{17\beta,21\alpha}{17\alpha,21\beta}$ decreases steadily from value of about 0.4 at the onset of oil generation to a value of about 0. at peak oil generation.

(c) Two of the C27 triterpanes can also be used as maturity indicators. Th ratio of 18 α(H) trisnorhopane to 17 α(H) trisnorhopane increase exponentially with increasing maturity from a value of approximately 0. at the onset of oil generation to approximately 1.0 at peak oi generation.

(d) It is our experience that the ratio of the C27 18α(H) + C27 17α (H triterpanes to C30 $17\alpha,21\beta$ triterpane is maturity dependent. The rati decreased from values around 1.0 at the onset of oil generation to a valu of approximately 0.4 at peak oil generation. With increasing maturity a levels greater than that equivalent to peak oil generation the rati increases steadily to values greater than 3.0.

Source Type

(i) Based on Steranes
Algal organic matter contains steranes in which the C27 compounds are mor abundant than the C29 compounds. General aquatic organic matter ha approximately equivalent amounts of the C27 and C29 compounds while organi matter rich in land-plants usually has a lot more of the C29 steranes.

(ii) Based on Triterpanes
The triterpane components in petroleum can be derived from both bacteria ar higher plants. The common bacterial products are the C27-C35 hopanes ar moretanes whereas the higher plant triterpanes are compounds other than hopane or moretanes and are commonly C30 compounds.

(iii) Based on Diasteranes
The diasteranes are not produced biologically but are formed during earl diagenesis from sterane precursors. The diasterane ratios

$$\frac{C27(20R)}{C29(20R)} \quad \text{and} \quad \frac{C27(20R+20S)}{C29(20R+20S)}$$

should reflect the nature of the organi matter in the same manner as that outlined above for the steranes.

Biodegradation

It has been observed that in severely biodegraded petroleum the series of norma hopanes are converted to a series of A ring demethylated hopanes and the C29 (20R sterane is selectively removed. For altered crudes which have not been degraded t this extent the severity of biodegradation can often be gauged by studying th isoprenoid and aromatic fractions. However, this type of investigation extend beyond a standard GC/MS/DS analysis.

Correlation

Our present approach to oil:oil or oil:source rock correlation problems is a follows:

(i) Compare the distribution of compounds in the 123, 177, 191, 205, 217, 218, 23 and 259 mass fragmentograms for an oil or sediment extract to the distributio of compounds in the respective fragmentograms for the other oil(s) or sedimen extract(s). It is necessary in this type of comparison to make allowance fo small variations due to possible maturity differences.

(ii) Examine the fragmentograms for peaks or sets of peaks which may represen compounds that are specific to the geological system under investigation Normal steranes, diasteranes and bacterial hopanes cannot be used for thi purpose because they are present in virtually all crude oils and sedimen extracts. However, compounds like higher plant triterpanes, bisnorhopane an botryococcane can often prove very useful for this purpose.

15. CARBON ISOTOPE ANALYSIS

The measurement is carried out on one or more of the following mixtures; topped oil saturate fraction; aromatic fraction; NSO fraction. The organic matter is combuste at 860 Deg. C in oxygen and the carbon dioxide formed is purified and transferred t an isotope mass spectrometer. The carbon isotope ratio is measured relative to standard gas of known isotopic composition. In our case the standard gas is prepare from the NBS No. 22 oil. However, since the isotopic relationship between NBS No. 2 oil and the international reference PDB limestone are known, the values are adjuste to be relative to PDB limestone.

Although carbon isotope data has been commonly used for oil:oil and oil:source roc correlation its most significant application is the identification of the source c gas according to the following criteria (Fuex, 1977):

$\delta 13C$ (PDB)	Gas Type
-85 to -58	Biogenic methane
-58 to -40	Wet gas/associated with oil
-40 to -25	Thermal methane

16. VITRINITE REFLECTANCE MEASUREMENT

Vitrinite is a coal maceral which responds to increasing levels of thermal maturity This response can be measured by the percent of light reflected off a polishe surface of a vitrinite particle immersed in oil. Reflectance measurements are mad on a number (40 if possible) of vitrinite particles in each sample, in order t establish a range and mean for reflectance values. Immature rocks have lo reflectance values (0.2% Ro to 0.6% Ro), with mature values ranging from 0.6% Ro t 1.2% Ro. Very mature values are between 1.2 % Ro and 1.8% Ro, while severely altere rocks have reflectances above 1.8% Ro.

Vitrinite reflectance results are best obtained from coals or rocks deposited i environments receiving large influxes of terrestrially-derived organic matter Unfortunately, these environments are not conducive to the accumulation of larg quantities of oil-prone organic mater. Also vitrinite reflectance cannot b performed on rocks older than Devonian Age, due to the absence of land plants in th older geological time periods.

17. VISUAL KEROGEN

Visual kerogen assessment is carried out by the coal petrologist and/or th palynologist. In the case of the petrologist the assessment is made in reflecte light using the plug prepared for vitrinite reflectance measurement, and reports th relative amounts of alginite, exinite, vitrinite and inertinite particles..

Visual study of kerogen by the palynologist is carried out in transmitted light an can indicate the relative abundance, size and state of preservation of the variou recognizable kerogen types and hence indicates the source character of a sedimentar rock. In addition, the colour of the kerogen is related to the thermal maturity o the sediments and is often used as a maturation indicator.

The preparation of slides for visual kerogen assessment by the palynologist firstl involves concentration of the organic matter by removal of the rock matrix usin hydrochloric and hydrofluoric acid treatment and heavy liquid separation. Th organic concentrate is then mounted on a glass slide using Petropoxy.

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APPENDIX 1

SIGNIFICANCE OF SELECTED PARAMETERS FROM GC/MS ANALYSIS

	Parameter	Ion(s)
1.	18α(H)-hopane/17α(H)-hopane (Ts/Tm)	191
2.	C30 hopane/C30 moretane	191
3.	C31 22S hopane/C31 22R hopane	191
4.	C32 22S hopane/C32 22R hopane	191
5.	C29 20S ααα sterane/C29 20R ααα steranes	217
6.	C29 20S ααα /C29 20R ααα + C29 20S ααα	217
7.	$\frac{\text{C29 } \alpha\alpha\alpha \text{ steranes}}{\text{C29 } \alpha\alpha\alpha \text{ steranes + C29 } \alpha\beta\beta \text{ steranes}}$	217
8.	C27/C29 diasteranes	259
9.	C27/C29 steranes	217
10.	18α (H)-oleanane/C30 hopane	191
11.	$\frac{\text{C29 diasteranes}}{\text{C29 } \alpha\alpha\alpha \text{ steranes + C29 } \alpha\beta\beta \text{ steranes}}$	217
12.	$\frac{\text{C30 (hopanes + moretanes)}}{\text{C29 (steranes + diasteranes)}}$	191/217
13.	C15 drimane/C16 homodrimane	123
14.	Rearranged drimanes/normal drimanes	123
15.	C15 alkylcyclohexane/C16 homodrimane	83/123

nd = not detectable

Significance of selected parameters from GC-MS analysis

1. 18 α (H)-hopane/17 α (H)-hopane (Ts/Tm)

   Maturity indicator. The ratio of 18 α (H) trisnorhopane to 17 α (H) trisnorhopane increases exponentially with increasing maturity from approximately 0.2 at the onset to approximately 1.0 at the peak of oil generation, i.e. Tm decreases with maturity. This parameter is not reliable in very immature samples.

2. C30 hopane/C30 moretane

   Maturity indicator. The conversion of C30 17 β, 21 β hopane to 17 β, 21 α moretane is maturity dependent. Values increase from approx. 2.5 at the onset of oil generation to approx. 10. Once the hopane/moretane ratio has reached 10, no further changes occur. A value of 10 is believed to represent a maturity stage just after the onset of oil generation, hopane/moretane ratios are therefore mainly useful as indicators of immaturity in a qualitative sense.

3.&4. C31 and C32 22S/22R hopanes

   Maturity indicator. An equilibrium between the biological R- and the geological S- configuration occurs on mild termal maturation. A ratio of S:R = 60:40, i.e. a value of 1.5 characterise this equilibrium which occurs before the onset of oil generation.

5. C29 20S ααα /C29 20R ααα steranes

   Maturity indicator. Upon maturation, the biologically produced 20R stereoisomer is converted into a mixture of 20R and 20S compounds. An equilibrium between the two forms is reached at approximately 55% 20R and 45% 20S compounds. VR equivalents are approximately 0.45% for a 20S/20R value of 0.2 and 0.8% for a 20S/20R value of 0.75. This parameter is most useful between maturity ranges equivalent to 0.4% to 1.0% VR.

6. C29 20Sααα /C29 20R ααα + C29 20Sααα

<u>Maturity</u> indicator. Different way of expressing the conversion from the biological 20R to the geological 20S configuration (see parameter 5). Expressed as a percentage, a value of about 25% indicates the onset of oil generation and of about 50% the peak of oil generation.

7. C29 αββ/C29 ααα + C29 αββ steranes

<u>Maturity</u> indicator. The form is produced biologically, it converts gradually into a mixture of αα (normal steranes) and ββ (isosteranes) compounds upon maturation. Equilibrium is reached at about 65% ββ compounds, which is equivalent to approximately 0.9% VR.

8.&9. C27/C29 diasteranes and steranes

<u>Source</u> indicator. It has been suggested that marine phytoplankton is characterised by a dominance of C27 steranes and diasteranes whereas a preponderance of C29 compounds indicates strong terrestrial contributions. (C28 compounds are nearly always the lowest of the three sterane groups. High proportions of C28 compounds could indicate a contribution from of lacustrine algae). Values smaller than 0.85 for C27/C29 diasterane and sterane ratios are believed to be indicative for terrestrial organic matter, values between 0.85 to 1.43 for mixed organic material, and values greater than 1.43 for an input of predominantly marine organic matter.

As it has shown recently that apparently also pelagic marine sediments can contain a predominance of C29 steranes, the above rules have to be applied with caution. Any simplistic interpretation of C27/C29 steranes and diasteranes can be dangerous and the interpretation of these data should be consistent with other geological evidence.

10. 18 α (H) - oleanane/C30 hopane

<u>Source</u> indicator. Oleanane is a triterpenoid compound which has often been reported from deltaic sediments of late Cretaceous to Tertiary age. It is thought to be derived from certain angiosperms which developed in the late Cretaceous. If the 18 (H)-oleanane/C30 hopane ratio is below 10%, no significant proportions of oleanane are present. At higher values, it can be used as indicator for a reducing environment during deposition of land plant-derived organic matter.

11. C29 diasteranes/C29 ααα steranes + C29 αββ steranes

<u>Source</u> indicator. Parameter used to characterise the oxidity of depositional environments. High values (up to 10) indicate oxic conditions, low values (down to 0.1) indicate reducing environments.

12. C30 (hopanes + moretanes)/C29 (steranes + diasteranes)

<u>Source</u> indicator. Triterpanes are believed to be of prokariotic (bacterial) origin, whereas steranes are derived from eukariotic organisms. This ratio reflects the preservation of primary organic matter derived from eukariots relative to growth and preservation of bacteria in the sediment after deposition (prokariots).

13. C15 drimane/C16 homodrimane

Drimanes and homodrimanes are ubiquitous compounds most likely derived from microbial activity in sediments. The C15 drimane/C16 homodrimane ratio is a useful parameter for <u>correlation</u> purposes in the low molecular weight region, e.g. for condensates which lack most conventional biomarkers. Drimanes are also useful for an assessment of the level of biodegradation as the removal of C14 to C16 bicyclics characterises an extensive level of biodegration.

14. Rearranged/normal drimanes

Like parameter 13, for <u>correlation</u> purposes in samples without conventional biomarkers, and to assess level of biodegradation.

15. C15 alkylcyclohexane/C16 homodrimane

Like parameters 13 and 14, useful for <u>correlation</u> purposes. Mainly used for condensates and light oils.

Appendix 5

Petrography

Appendix 5

AMDEL
CORE
SERVICES

PETROLOGY REPORT

DEVILFISH #1

GIPPSLAND BASIN

Dr S E PHILLIPS

Amdel Core Services
PO Box 109
Eastwood
SA 5063

May 1990

INDEX

1. SUMMARY

The Shell Company of Australia Ltd requested petrological descriptions of 5 sidewall core samples from Devilfish #1, in the Gippsland Basin. The main aim was to provide accurate lithological descriptions, and where possible to identify depositional environments and diagenetic alteration.

Lithologically only sidewall cores 1 and 2 (2035m and 2020m) are similar. They are poorly sorted, very fine to coarse grained, texturally immature to submature litharenites. Rock fragments are predominantly from metamorphic and sedimentary environments and comprise 35 to 40% of the total rock composition. Sidewall core 6 (depth 1975m) is a very poorly sorted, coarse silt to granule sized, chloritic quartzarenite. Two lithologies are evident in sidewall core 25 (depth 1775m); well sorted, fine grained carbonate cemented sandstone and fossiliferous micrite/microspar. The boundary between these two lithologies is sharp and the sandstone is oxidised at the contact. Sidewall core 26 (depth 1650m) is a poorly sorted, sandy mudstone which displays textural inversion.

Interpretations of depositional environments are highly speculative. The deepest litharenites (sidewall cores 1 and 2) would appear to be alluvial/fluvial deposits. There is a suggestion of coarsening upwards between the two samples. Sidewall core 6 had a very different sediment source but appears to be a scree, deposited in a shallow marine environment. A shoreline sequence is evident in sidewall core 25, with possible exposure of sediments in the intervening period. Textural inversion in sidewall core 26 makes identification of the depositional environment very difficult. One possibility is that a barrier bar sand has been mixed with lagoonal mud.

Diagenetic alteration of all samples is very similar and has occurred in both the eogenetic and mesogenetic environments. The main diagenetic events are as follows;

- oxidation
- mechanical compaction
- alteration of feldspars
- alteration of biotites to chlorite and precipitation of authigenic chlorite
- precipitation and recrystallization of carbonate cements
- precipitation of pyrite

2. INTRODUCTION

This report contains petrological descriptions of 5 sidewall core samples from Devilfish #1, in the Gippsland Basin (VIC/P21). The Shell Company of Australia Ltd requested these descriptions in order to ascertain sediment lithology, depositional environments and diagenetic alteration of the sidewall core. In particular, they were interested to know if the deepest samples were from basement. The following samples from Devilfish #1, were received by Amdel Core Services on 5th May 1990;

SWC No.	DEPTH(m)
1	2035
2	2020
6	1975
25	1775
26	1650

3. METHODS

Sidewall core were described in hand specimen, and all references to colour are based on the Rock-Color Chart produced by the GSA (1984). Blue dye was used in the araldite prior to thin section preparation, to facilitate descriptions of porosity and permeability. Thin sections were systematically scanned to determine lithology, composition, porosity and textural relationships. All percentages given in brief descriptions are based on visual estimates, not point counts.

4. CORE PETROLOGY

4.1 Devilfish #1, swc, 1 depth 2035m

Hand specimen description
Sample received consisted of approximately 1cm of full diameter sidewall core, with a thick coating of drilling mud. It was a moderately consolidated, fine to coarse grained, light grey (N7), poorly sorted, sandstone. There was no reaction to 10% HCl. More quartz rich layers are interbedded with opaque stringers (possibly organic) and a moderate yellowish brown (10YR 5/4) clay layer. Fine to medium grained quartz and opaques occur in the clay layer. Minor amounts of glaucony (green particles), iron staining and opaques were also noted.

Thin section description
The sample is a poorly sorted, mineralogically and texturally immature litharenite with distinctive beds in which opaque material (?organic) and clays are evident. There is a gradation in grain size from coarse relatively clean litharenite to finer grain sizes (Figs 1a & b) in those beds where clays and opaques concentrate. Boundaries between beds are irregular and in places relatively sharp. Fractures through the sample are probably due to sidewall collection.

Framework grains consist of quartz, lithics, feldspar, tourmaline and micas. Quartz grains vary in size from coarse silt to very coarse sand. Typically larger grains are subrounded to subangular and finer grains are more angular. Quartz is both monocrystalline and polycrystalline, with straight to slightly undulose extinction, and rare fluid and mineral inclusions (rutile needles). Abundant lithic fragments of chlorite schist, chert, siltstone, and shale are evident. These clasts are up to 4.5mm in diameter and moderately well rounded. Shale clasts are distinctly elongate and contain numerous minute opaque crystals. Chert fragments of micro- and mega-quartz have highly sutured contacts between crystals. There are rare patches of anhedral carbonate spar in the siltstones which contain abundant illite and opaques. Feldspars are 0.1mm in diameter, subangular, and have twinning characteristic of microcline and plagioclase. There are also rare non-twinned feldspars. Rare tourmaline occurs as subhedral silt sized crystals. The majority of micas are bent and highly altered. There are rare examples of fresh muscovite up to 0.6mm in length.

The clay rich bed is orangy red in colour (which suggests oxidation) and has a globular texture. Floating within the clay there are quartz grains and lithic fragments. One large lithic fragment (4.5 mm in diameter) is an intraclast from the cleaner litharenite. There is a gradual transition from the clay rich bed into beds where an opaque material forms the matrix. The opaque material coats framework grains in crenulated stringers with anhedral to angular outlines. There are minor amounts of iron staining associated with the opaque material. Elsewhere, matrix consists dominantly of illite with minor amounts of iron staining. Within the matrix there are several authigenic minerals including fibrous chlorite, anhedral to subhedral rhombs of carbonate microspar, and an opaque material. Chlorite is also evident where it has replaced micas. K-feldspars have been partially replaced by illite and opaques.

Texturally the sample is grain supported with predominantly tangential contacts between grains. Many of the lithic fragments and micas have been distorted by mechanical compaction to the extent that it is difficult to differentiate these fragments and grains from the matrix. The only porosity evident is that due to fracturing, probably during sidewall collection.

Composition based on visual estimates

Framework grains	%
Quartz	30
Feldspar	tr
Mica	2
Lithics	35
Tourmaline	tr
Matrix	
Clay	15
Organic matter	5
Fe staining	2
Authigenic minerals and cements	
Chlorite	5
Opaques	1
Carbonate	tr
Porosity	
Secondary fracturing	5

Interpretation
The abundance and type of lithic fragments in this bedded litharenite, indicate short distances of sediment transport, dominantly from low grade metamorphic and sedimentary terrains. Rounding of lithics can probably be attributed to the soft nature of clasts rather than long distances of transport.

Deposition was relatively rapid with intervening quiescent periods when clays and ?organic matter accumulated. The red colour of the clays suggests periods of exposure and oxidation. Two methods of sediment transport are evident from the grain size distribution, namely saltation and traction load. Graded bedding indicates changes in current activity from traction to saltation. Based on these facts a possible fluvial/alluvial depositional environment can be invoked to explain these characteristics. Poor sorting tends to favour the alluvial interpretation.

Diagenetic alteration of the litharenite is minimal and predominantly mesogenetic (burial diagenesis) and eogenetic (near-surface). The following events have been recognised, although the paragenetic sequence is uncertain;

a) Mechanical compaction has deformed lithic fragments which makes any estimation of the relative proportion of matrix very difficult.

b) Chlorite has formed as the alteration product of biotites and as an authigenic precipitate. Weathering of biotites to chlorite may have occurred prior to deposition in a surficial environment. Authigenic chlorite is probably the result of burial diagenesis or low grade metamorphism, rather than precipitation in a shallow marine environment when Fe rich river water enters the sea.

c) Alteration of feldspars may have provided some of the illite in the matrix.

d) Minor amounts of carbonate are also considered to be a late precipitate during burial diagenesis. This event may be related to neomorphic carbonate cements evident in other sidewall core.

4.2 Devilfish #1, swc 2, depth 2020m.

Hand specimen description
Sample received was a poorly consolidated and highly disturbed remnant of a sidewall core. It was fine to coarse grained (average fine), poorly sorted, light grey (N7), litharenite. Quartz grains were subangular with moderate to poor sphericity. No sedimentary structures were observed. There was a moderate reaction with 10% HCl, suggesting the presence of carbonate. Minor proportions of opaques and glaucony were also observed.

Thin section description
The sample is a fine to coarse grained, poorly sorted litharenite with very coarse grained lithic fragments and a carbonate cement (Figs 2a & b). The rock is texturally and mineralogically submature. Many quartz grains are fractured, possibly due to sidewall collection. The sample consists of fragments of sidewall core, some with drilling mud adhering to the rim.

Framework grains of quartz, feldspar, lithics, and micas were recognised. Quartz grains vary from angular to well rounded and there is no relationship between grain shape and grain size. Quartz is both monocrystalline and polycrystalline, has straight to undulose extinction and rare fluid inclusions. Lithics of fine grained micaceous schist, shale, siltstone and chert have been recognised. One clast of micaceous schist is crossed by a fracture healed with quartz. Kinks within the fracture correspond to those in the schist. Micas (muscovite and biotite) and feldspars are relatively rare in the sample.

Matrix is typified by illite rimming framework grains and filling intergranular pores. Opaques concentrate in the illite and carbonate appears to have partially replaced some of the illite.

Patches of anhedral to euhedral carbonate spar forms a cement which embays and replaces quartz grains. In places this cement is poikilitic and there is iron staining associated with the carbonate. The displacive influence of carbonate spar is clearly demonstrated by the splaying of mica flakes (Fig. 3). There are chips which have a microspar, rather than spar cement and framework grains typically float in the carbonate cement. Carbonate forms a minor cement in one granule sized polycrystalline quartz grain. Since grain boundaries in this composite quartz grain are straight and concavo-convex it would appear to have a quartz cement. Fibrous chlorite replaces grains and lithic fragments, fills pores and a fracture. It also occurs as pseudohexagonal booklets similar to kaolin in the same fracture.

Texturally, the litharenite is submature, with most fragments of sidewall core being grain supported. Lithics and micas are only slightly deformed which indicates that there has been very little compaction. Disruption, due to sidewall collection, is so extensive that it is difficult to recognise any porosity.

Composition based on visual estimate

Framework grains	%
Quartz	15
Feldspar	tr
Mica	tr
Lithics	40
Matrix	
Clay	10

Authigenic minerals and cements	
Carbonate	30
Chlorite	3
Opaques	tr
Porosity	?

Interpretation
Sediment provenance is broadly similar to that of sidewall core 1, with a predominance of shale clasts indicating a metamorphic source. However, there are differences between the samples. A slight decrease in the proportion of micas in this sample could indicate longer distances of transport. This possibility is contradicted by the fact that shale clasts are generally slightly larger in size than those in sidewall core 1. Furthermore, there is an increase in the number of composite or polycrystalline quartz grains in this sample (probably derived from quartzites).

Lack of bedding makes it very difficult to interpret the depositional environment. However, poor sorting, the very coarse grain size of lithic fragments and the similarity of sediment provenance to sidewall core no.1 suggest this is an alluvial deposit. This interpretation should be confirmed from the relevant wireline logs.

Diagenetic events are also similar to that of sidewall core no. 1. The most significant difference is the degree of cementation by carbonates which have both a displacive and replacive role. Spar formation is typical of burial environments (mesogenetic) and thus this carbonate cement is thought to have formed late in the diagenetic sequence. Minor fracturing prior to the introduction of chlorite is also evident.

4.3 <u>Devilfish #1, swc 6, depth 1975m</u>

Hand specimen description
Sample received consisted of approximately 0.5cm of full diameter sidewall core, with a thick coating of drilling mud. It was highly disturbed, very fine to coarse grained (average fine), poorly sorted, olive black (5Y 2/1), ?quartzarenite. Quartz grains are subangular to subrounded and moderately spherical. Minor amounts of iron staining, pyrite and glaucony were noted. There were no sedimentary structures, nor reaction to 10% HCl.

Thin section description
The sample is very poorly sorted, grain size varies from coarse silt to granule sized quartz, texturally the rock is submature, but it is mineralogically mature (Figs 4a & b). Lithologically the sample is described as a chloritic quartzarenite. Many grains are fractured, probably due to sidewall collection.

Framework grains are dominantly quartz, with trace amounts of mica, lithics, plagioclase, zircon, sphene and tourmaline. Quartz grains are subrounded to subangular and moderately spherical. Monocrystalline quartz is dominant with rare polycrystalline varieties, extinction is generally undulose on coarser grains and straight on finer grains. There are rare mineral inclusions of zircon and mica (biotite being replaced by pyrite) and Boehm lamellae in some of the quartz grains. Lithic fragments are rare and tend to be silt sized, making identification of provenance very difficult. However, siltstones have been observed. Zircon and sphene occur as rounded silt sized grains that are only present in trace amounts. Biotite and muscovite are both present, flakes are up to 0.5mm in length and the biotite commonly is partially altered to chlorite. Some tourmaline crystals are zoned, they are very fine to fine grained in size, and probably detrital in origin.

Anhedral reddish brown clay forms the main type of matrix, rimming grains and filling pores. It is possible that some of this material is drilling mud or that chlorites have been oxidized. Trace amounts of illite and opaque material is present in the matrix.

There are two types of glaucony present; glauconite and chlorite. Rare pellets of glauconite are very bright green, whereas the chlorite is duller in colour and more fibrous. Chlorite fills pores and replaces micas. Stringers and single cubes of pyrite are often associated with the chlorite and Fe staining in the matrix. Pyrite also partially replaces quartz grains. Opaque material forms discontinuous layers through the rock. Slight reddening along the margins suggests this opaque material may be hematite.

Texturally the sample is grain supported, with tangential contacts between grains. Micas are bent and glauconite pellets deformed due to mechanical compaction. There is little evidence of porosity except for fractures induced during sidewall collection. Minor amounts of secondary porosity due to dissolution of labile grains is also evident.

Composition based on visual estimates

Framework grains	%
Quartz	60
Feldspar	tr
Mica	3
Glauconite	tr
Lithics	tr
Heavy minerals	1
Matrix	
Clay	15
Fe staining	2
Authigenic minerals and cements	
Chlorite	15
Pyrite	3

Interpretation

Sediment provenance is markedly different in this sample to that of sidewall cores 1 and 2. Volcanic and igneous sediment provenance would appear to be the most likely based on the nature of quartz grains and heavy minerals present. It is unlikely that the sediment was transported long distances because of the presence of both muscovite and biotite in the sample.

Extremely poor sorting in this sample indicates very rapid deposition, possibly as a scree. However, the presence of glaucony pellets also implies a shallow marine depositional environment. The latter suggestion is supported by the presence of pyrite and chlorite. Currents and wave action were minimal in this marine environment otherwise the sands would be better sorted.

Diagenetic alteration of the quartzarenite is restricted to mechanical compaction, chloritization of biotites and the precipitation of authigenic chlorite and pyrite. The latter indicates a mildly reducing environment.

4.4 Devilfish #1, swc 25, depth 1775m.

Hand specimen description

Sample received consisted of soft, poorly consolidated fragments of sidewall core. It was a highly disturbed, very fine to fine grained, well sorted, moderate brown (5YR 3/4) sandstone. Grains are subrounded with good sphericity. No sedimentary structures were observed. There were minor amounts of iron staining, pyrite, glaucony and ?feldspar. A moderate reaction to 10% HCl suggests the presence of carbonate.

Thin section description

Two different lithologies are evident in this sample, namely fossiliferous micrite and carbonate cemented sandstone. The contact between these lithologies is sharp and there is a significant degree of oxidation in the sandstone at the contact.

a) Carbonate cemented sandstone
The sandstone is well sorted, very fine to fine quartz sand which is mineralogically and texturally mature. Many of the quartz grains are fractured, probably due to sidewall collection. Framework grains are dominantly quartz, mica, tourmaline, chert, glaucony pellets and feldspars. Quartz grains are subangular and moderately spherical. Monocrystalline quartz is dominant with rare examples of polycrystalline grains, extinction is straight to slightly undulose and there are rare mineral (rutile needles) and fluid inclusions. Muscovite and biotite are both present, much of the biotite has been oxidized and altered to chlorite, whilst muscovite remains relatively unaltered. Tourmaline occurs as zoned, silt sized, subangular grains. Feldspars are commonly potassic varieties, silt to fine sand sized and generally appear to be highly altered, although there are examples of relatively fresh grains.

Cement consists dominantly of carbonate spar and micrite, with traces of chlorite. Quartz grains are embayed by spar which is typically anhedral. In many areas micrite has been oxidised to form a reddish brown cement.

The majority of micas are bent due to mechanical compaction. Where the carbonate cement is almost absent there is well preserved intergranular porosity, with only traces of drilling mud in the pores (Figs 5a & b). Quartz grains in these zones have predominantly point contacts and very rarely tangential contacts. Elsewhere quartz floats in the carbonate cement. The sandstone has a grain supported fabric.

b) Fossiliferous micrite/microspar
The limestone is bedded, with cement varing from anhedral micrite to microspar. Shell fragments, intact foraminifera tests, silt sized quartz, mica and chert floats within the cement. Shell fragments are elongate and commonly up to 0.1 mm in length, with some examples having micrite coatings. These fragments show some preferential alignment. Foram tests are dominantly globigerinas, filled with anhedral spar and rarely pyrite. Walls of the tests have a radial fabric and there are some tests with chambers that do not contain cement thus retaining minor intragranular porosity. Micritic cement concentrates in a laminae adjacent to the sandstone and has a sharp contact with a microspar/spar cement (Figs 6a & b). Patches of pyrite framboids, chlorite and glaucony pellets occur in the microspar/spar cement and there are rare examples of subhedral to euhedral neomorphic rhombohedral spar, suggesting that the cement has been recrystallized. Surrounding some shell fragments there are blocky circumgranular cements of spar. Texturally, the sample is matrix supported.

Composition based on visual estimates

	Micrite	Sandstone
Framework grains	%	%
Quartz	tr	50
Feldspar	-	1
Mica	tr	5
Glauconite	tr	1
Lithics	tr	tr
Fossils	20	-
Others - tourmaline	-	tr
Authigenic minerals and cements		
Carbonate	75	35
Chlorite	-	2
Pyrite	3	-
Porosity		
Primary	1-	up to 10

Interpretation
Based on the characteristics of framework grains in the sandstone, it would appear that sediments have been derived from granitic and sedimentary environments. Multiple sources of sediment are also implied by the fact that both altered and unaltered feldspars are present. Minor amounts of feldspar and mica indicate that only moderate distances of sediment transport or low to moderate energy regimes were operative.

Grain size distribution in the sandstone indicates that saltation is the most likely method of transport. Current or tidal activity was probably responsible for the well sorted nature of this sand. However, the angularity of grains suggests either early deposition inhibited rounding, or that these are lower energy deposits as indicated by the mineralogy. The fact that this sandstone has been oxidized is probably the result of surficial exposure and weathering. Much of the iron staining is associated with the micritic cement, which was probably siderite. It is possible that the sandstone was a beach rock since it is associated with fossiliferous micrite.

The fossiliferous micrite was probably deposited in a shallow water marine environment, because shell fragments are aligned (implying current activity), and glauconite pellets and pyrite framboids are present. Benthonic forams in the micrite are not diagnostic of water depths since these are bottom dwelling organisms.

Diagenetic alteration of the micrite started with the boring and micritization of shell fragments which is likely to occur in a shallow marine environment. Micritization was followed by the precipitation of circumgranular cements in the meteoric phreatic regime. Fossil tests were probably filled with spar at this time and an early phase of pyrite may have precipitated as mildly reducing conditions prevailed. Later, during burial diagenesis (mesogenetic), sparry carbonate precipitated and there was partial recrystallization of the micrite. This phase of recrystallization was confined to parts of the micrite away from the sandstone contact.

In the sandstone, diagenetic alteration involved the oxidation of micrite and biotite, chloritization of biotite, mechanical compaction and precipitation of sparry carbonate. The latter probably occurred in the mesogenetic environment and may be related to the precipitation and recrystallization phase evident in the fossiliferous micrite.

4.5 Devilfish #1, swc 26, depth 1650m

Hand specimen description
Sample received consisted of soft, poorly consolidated fragments of sidewall core. The largest fragment was approximately 2cm long and 0.75cm in diameter. The sample was highly disturbed and contaminated with drilling mud. It was a poorly sorted, coarse to very fine grained, dark yellowish brown (10 YR 4/2), muddy sand. Quartz grains are subrounded to well rounded with moderate sphericity. No sedimentary structures were observed. There were minor amounts of iron staining and a moderate reaction to 10% HCl.

Thin section description
The sample is poor to moderately sorted, with very coarse to very fine grained quartz sand in a mudstone. Textural inversion is indicated in this sandy mudstone by contrasts in sorting and grain shape (Figs 7a & b). Very coarse to medium sized quartz grains are well rounded and generally have high sphericity. The fact that these grains are floating in a mud illustrates textural inversion. Some quartz grains are fractured, and since the fractures have not been healed this is probably due to sidewall collection. The sandy mudstone has been reduced to large chips during sampling and many chips are very disturbed.

Framework grains are dominantly quartz, feldspar, mica, tourmaline and glaucony pellets. Quartz grains are both monocrystalline and polycrystalline, with predominantly undulose extinction and rare fluid inclusions. Microcline and plagioclase are very fine sand sized and relatively fresh, in contrast to medium sized grains of K-feldspar which have been altered by micrite along preferred crystallographic axes. Micas are relatively rare, oxidized and chloritised which suggests the original mica was biotite. Only one grain of subhedral tourmaline, 0.2mm in diameter was observed. Rare glaucony (glauconite) pellets are silt sized, well rounded and have oxidised rims.

Orangy red clay which appears to be slightly platy in character (possibly illite), forms the dominant matrix in this sample. Matrix also consists of very dark reddish to opaque material which has a cellular structure in places and is therefore possibly organic. This material forms large irregular shaped anhedral patches and rarely has a globular appearance.

Euhedral isolated rhombs of carbonate spar, 0.1mm in diameter, float within the matrix. There are minor patches of poikilitic, twinned spar.

The fabric of this sandstone is matrix supported, with quartz grains floating in the clay. There is no evidence of porosity nor mechanical compaction.

Composition based on visual estimates

Framework grains	%
Quartz	25
Feldspar	1
Mica	tr
Glauconite	tr
Others - tourmaline	tr
Matrix	
Clay	35
?Organic matter	10
Authigenic minerals and cements	

Carbonate	25
Chlorite	tr

Interpretation
Textural inversion makes interpretation of the depositional environment particularly difficult in this sample. There has been mixing of sediments from at least two different environments as illustrated by differences in the degree of feldspar alteration and grain size. Glaucony pellets are usually indicative of shallow marine environments but the pellets have been oxidised, probably due to exposure, and this may indicate reworking from a different environment. Alternatively the whole sediment may have been exposed hence the red colour of the clays and oxidation of pellets.

Differences in grain size and sorting could be explained by the following scenario. Coarse, well rounded quartz grains could be derived from beach or barrier bar sands. Mixing of these grains with a lagoonal mud would produce the textural inversion noted in this sample. It is possible that organic matter might have accumulated in the lagoon.

Diagenetic alteration of the sandy mudstone includes the oxidation of clays and glaucony pellets, chloritisation of biotites and the precipitation of carbonate cements. Isolated euhedral rhombs of carbonate spar, which float in the mud, may be dolomitic in composition. Anhedral poikilitic spar may form a second type of carbonate cement. Both these ?phases of carbonate cementation are probably related to burial diagenesis as seen in other samples.

5. CONCLUSIONS

Lithologically the 5 sidewall cores from Devilfish #1, are highly variable; ranging from litharenites, quartzarenites, and sandy mudstones to fossiliferous micrite/microspar. Generally, the sands are minerallogically mature but texturally immature. Framework grains consist of quartz, feldspars, lithic fragments, mica, heavy minerals and glaucony. Only sidewall cores 1 and 2 (2035m and 2020m) have similar lithologies. They are poorly sorted, very fine to coarse grained, texturally immature to submature litharenites. Rock fragments are predominantly from metamorphic and sedimentary environments and comprise 35 to 40% of the total rock composition. Sidewall core 6 (depth 1975m) is a very poorly sorted, coarse silt to granule sized, chloritic quartzarenite. Two lithologies are evident in sidewall core 25 (depth 1775m); well sorted, fine grained, carbonate cemented sandstone and fossiliferous micrite/microspar. The boundary between these two lithologies is sharp and the sandstone is oxidised at the contact. Sidewall core 26 (depth 1650m) is a poorly sorted, sandy mudstone which displays textural inversion.

Any conclusions concerning the depositional environments of these sidewall core samples are restricted in value by the limited section of the sediment column which they represent. Furthermore, without the advantage of information gained from wireline logs and intervening sections, the possible depositional environments suggested in this report are very tentative. The deepest litharenites (sidewall cores 1 and 2) would appear to be alluvial/fluvial deposits. There is a suggestion of coarsening upwards between the two samples. Sidewall core 6 had a very different sediment source but appears to be a scree deposited in a shallow marine environment. A shoreline sequence is evident in sidewall core 25, with a possible change from beach to open water, and exposure of sediments in the intervening period. Textural inversion in sidewall core 26 makes identification of the depositional environment very difficult. One possibility is that a barrier bar sand has been mixed with lagoonal mud.

Diagenetic alteration of all samples is very similar and has occurred in both the eogenetic and mesogenetic environments. The main diagenetic events are as follows;

- oxidation
- mechanical compaction
- alteration of feldspars
- alteration of biotites to chlorite and precipitation of authigenic chlorite
- precipitation and recrystallization of carbonate cements
- precipitation of pyrite

It should be noted that although these diagenetic events have been identified it is difficult to discern the paragenetic sequence.

Estimates of porosity are always very difficult from sidewall core due to the amount of disruption during sampling. Most of the samples appear to have very poor porosity and permeability. In sidewall core 25, which is a well sorted, fine grained sandstone, good intergranular porosity was evident. Even in this example other parts of the sandstone are carbonate cemented.

Further work is required to assess the significance of the ?organic matter in sidewall core 26. A better understanding of the diagenetic sequence could also be obtained by the identification of the carbonate species responsible for cementation.

PE905941

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CLIENT_OP_CO =	SHELL AUSTRALIA

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6. FIGURES AND CAPTIONS

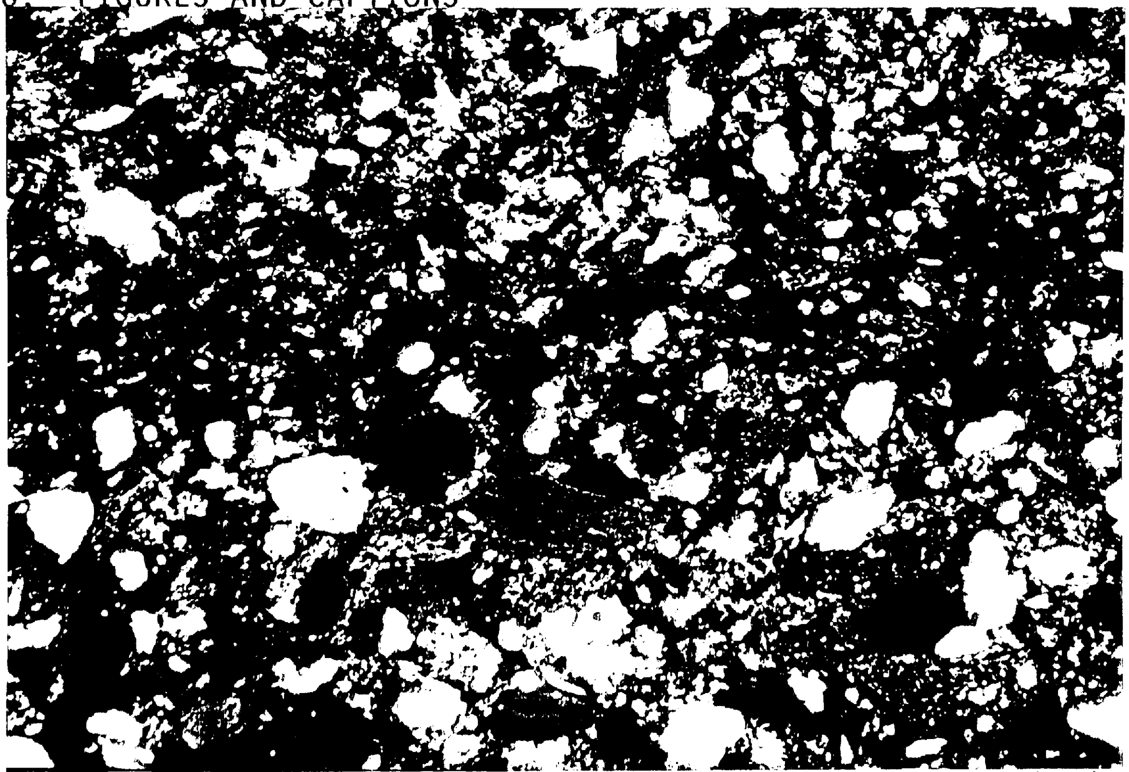

FIGURE 1a. Thin section micrograph of a litharenite with abundant shale clasts which are deformed to produce an illite matrix. There is a change in quartz grain size either side of the discontinuous opaque laminae. Devilfish #1, sidewall core 1, depth 2035m. Crossed nicols. Field of view 2.72mm.

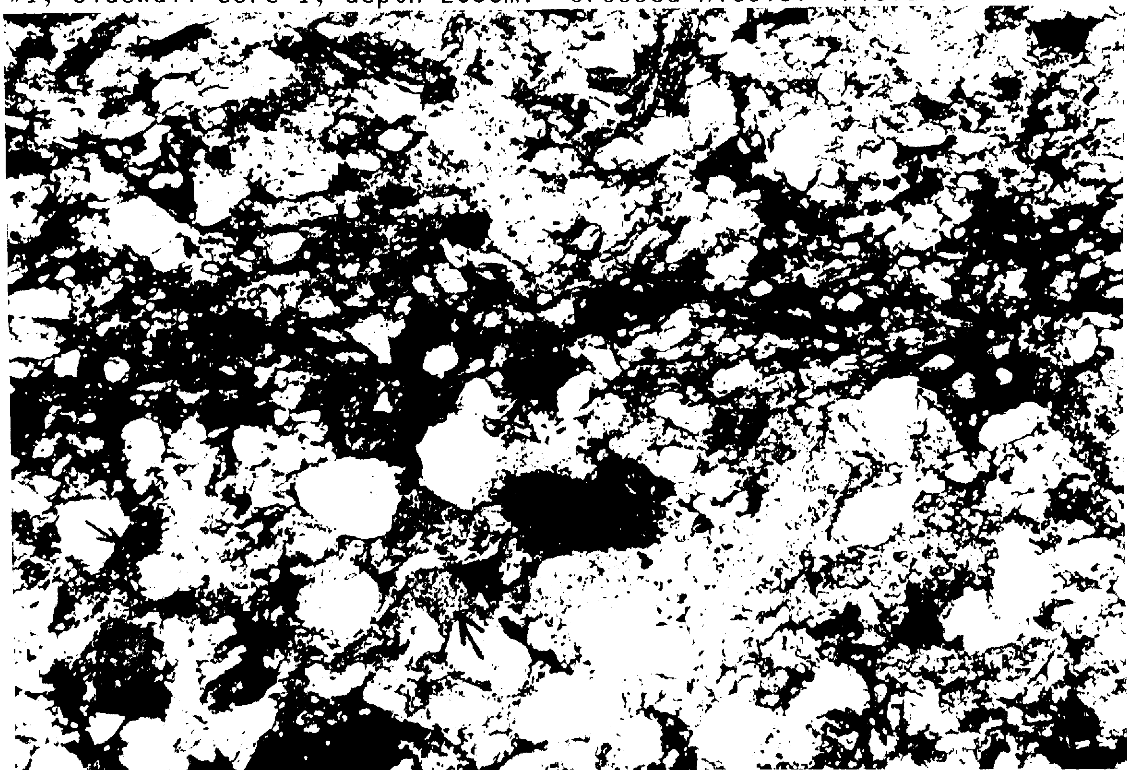

FIGURE 1b. Same field of view as Figure 1a in plane light. Highlights the deformed lithics (arrows) and opaque laminae. The latter could be a dissolution seam.

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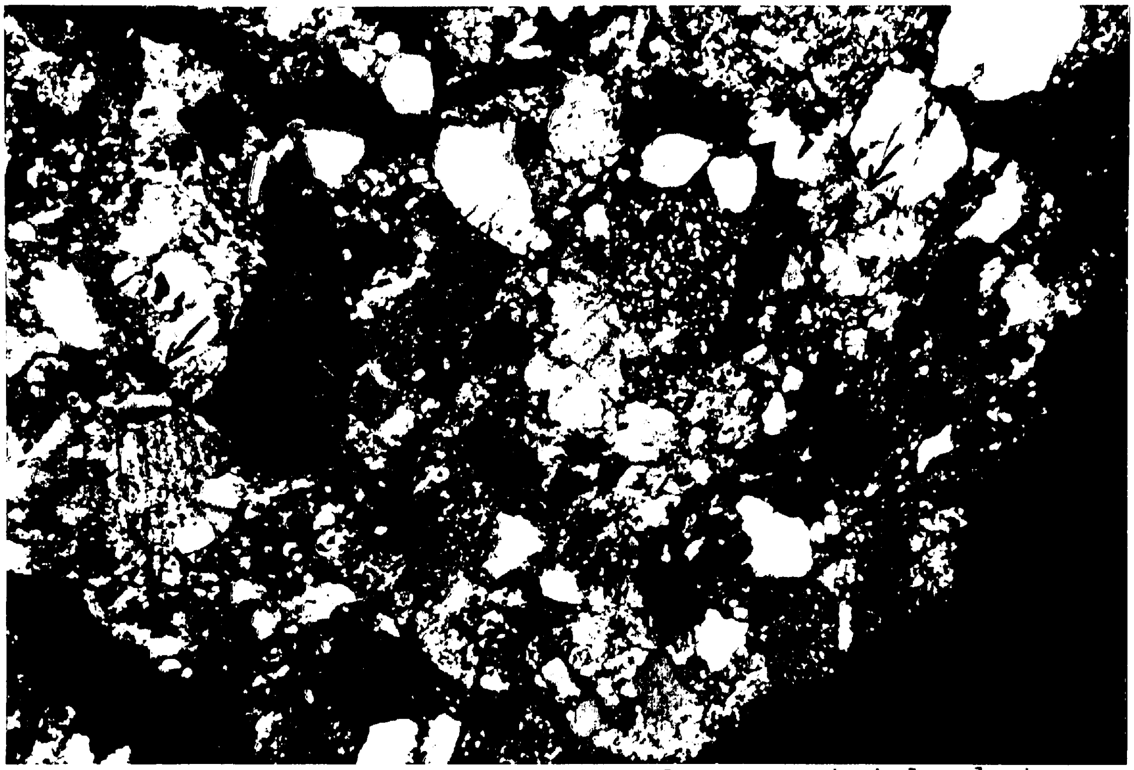

FIGURE 2a. Litharenite with abundant siltstone and shale clasts cemented by sparry carbonate (arrows). Quartz grains are subangular to subrounded. Fractures are probably the result of sidewall collection. Devilfish #1, sidewall core 2, depth 2020m. Crossed nicols. Field of view 2.72mm.

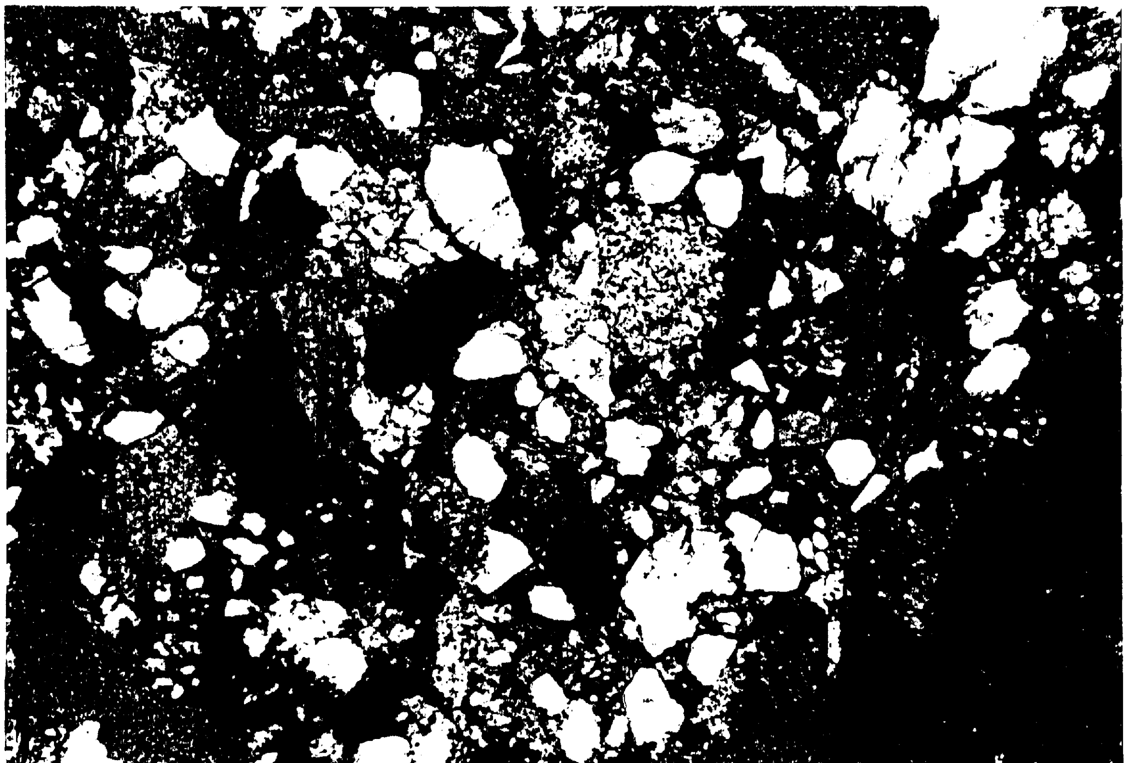

FIGURE 2b. Same field of view as Figure 2b in plane light.

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CONTRACTOR =	AMDEL CORE SERVICES PTY LTD
CLIENT_OP_CO =	SHELL AUSTRALIA

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Figure 3. The displacive influence of carbonate cement is demonstrated by this splayed biotite. Chlorite (pale green) has selectively replaced some flakes of the biotite. Opaques concentrating along these flakes are probably reaction products of this alteration. Blue dye highlights fracturing caused by sidewall collection. Devilfish #1, sidewall core 2, depth 2020m. Plane light. Field of view 0.45mm.

PE905944

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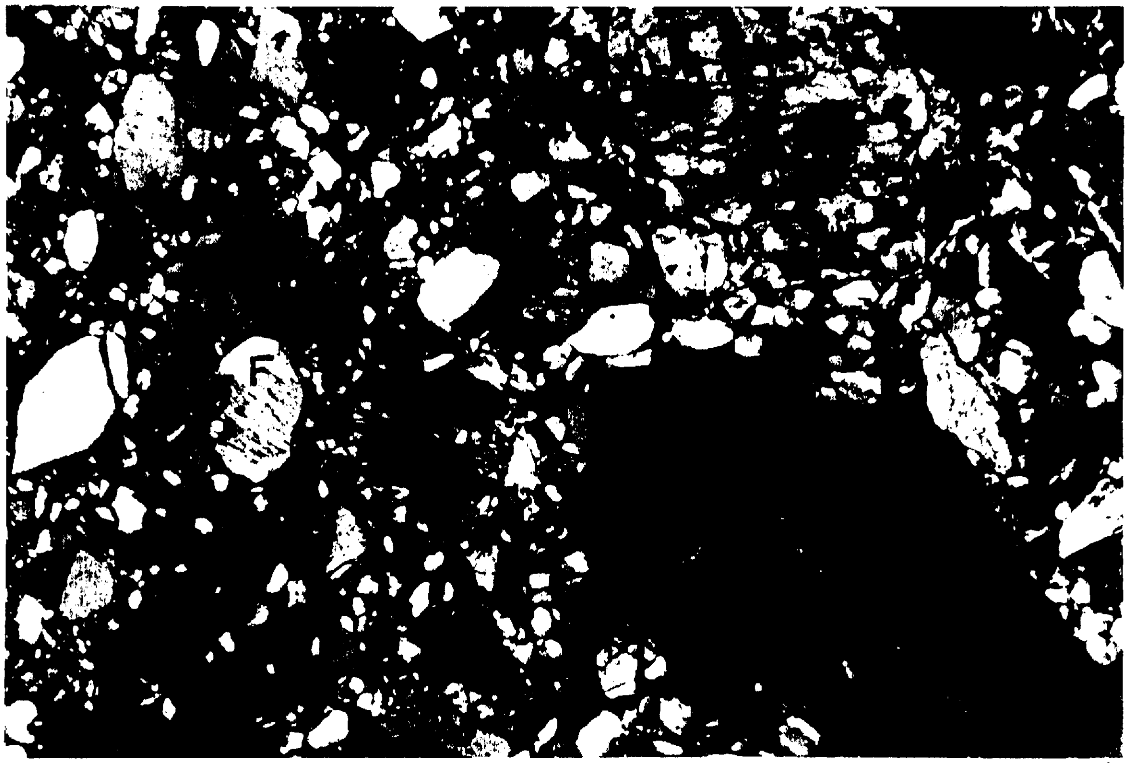

FIGURE 4a. Thin section micrograph of poorly sorted chloritic quartzarenite with opaques concentrating in the chlorite cement (bright yellow). A large biotite inclusion (arrow) in the granule sized quartz grain is being replaced by pyrite. Most framework grains are quartz with rare feldspars (F). Devilfish #1, sidewall core 6, depth 1975m. Crossed nicols. Field of view 2.72mm.

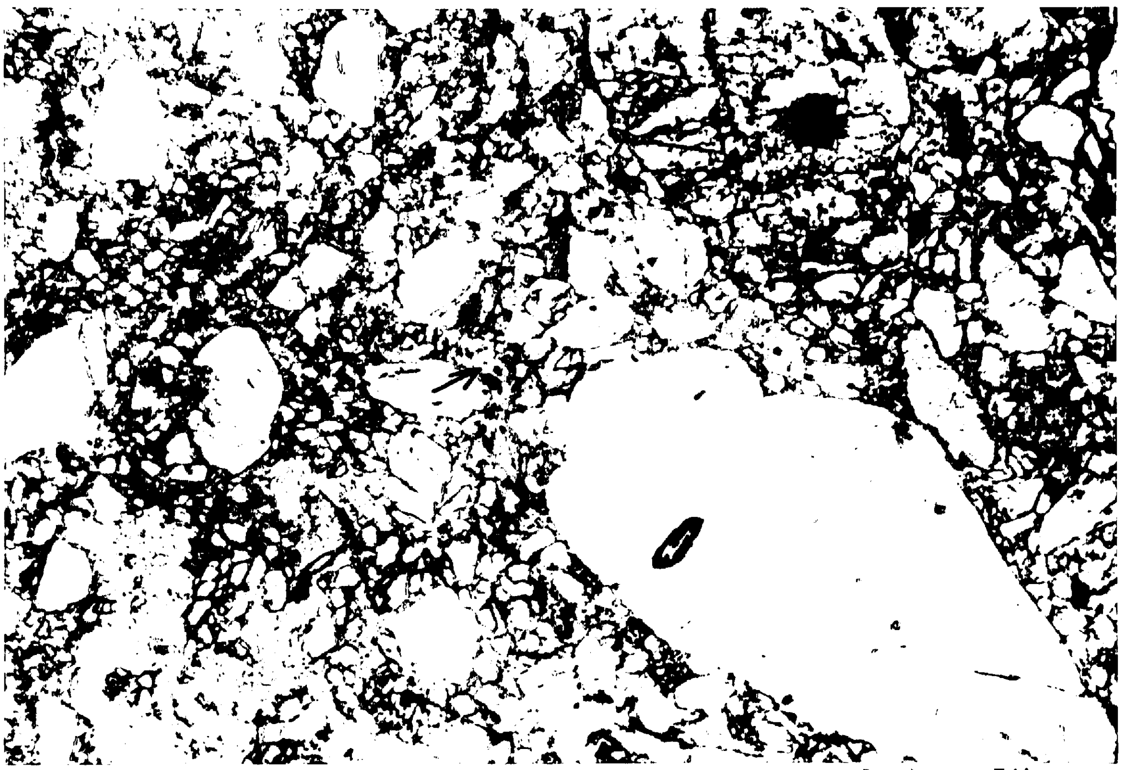

FIGURE 4b. Same field of view as Figure 4a in plane light. Fibrous chlorite cement is apparent as pale green colour (arrow).

PE905945

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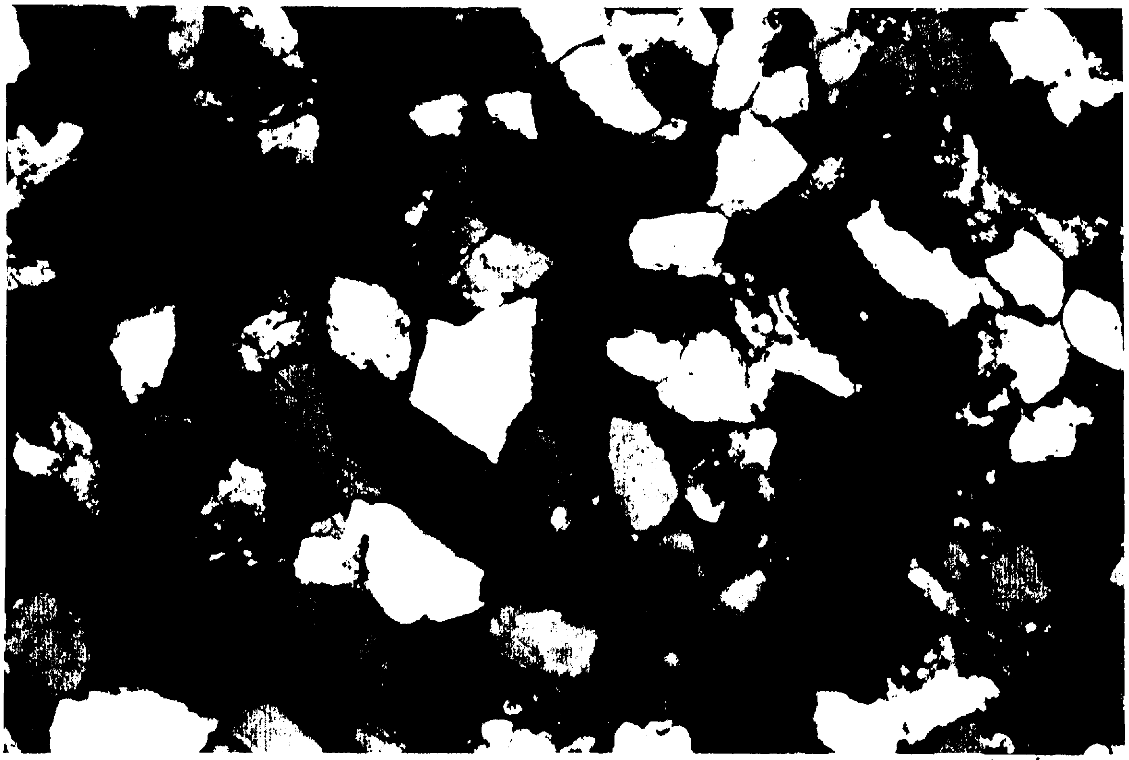

FIGURE 5a. Only rare patches of sparry carbonate, cement (arrows) this portion of a well sorted, subangular quartz sand. There are rare grains of feldspar (F), glauconite (G) and large opaque grains of oxidized biotite present in the sample. Devilfish #1, sidewall core 25, depth 1775m. Crossed nicols. Field of view 0.88mm.

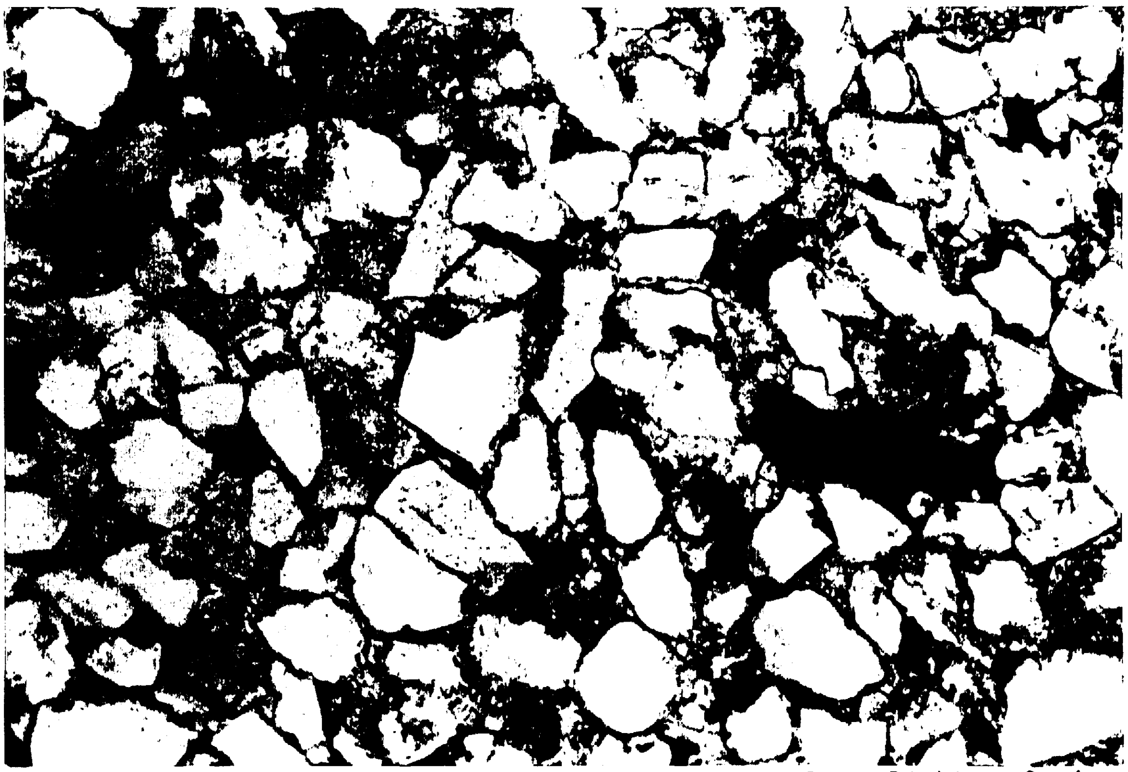

FIGURE 5b. Same field of view as Figure 5a in plane light. Grain contacts are typically only at points and rarely tangential. Good intergranular porosity is evident with only traces of drilling mud (opaque) partially rimming some pores.

PE905946

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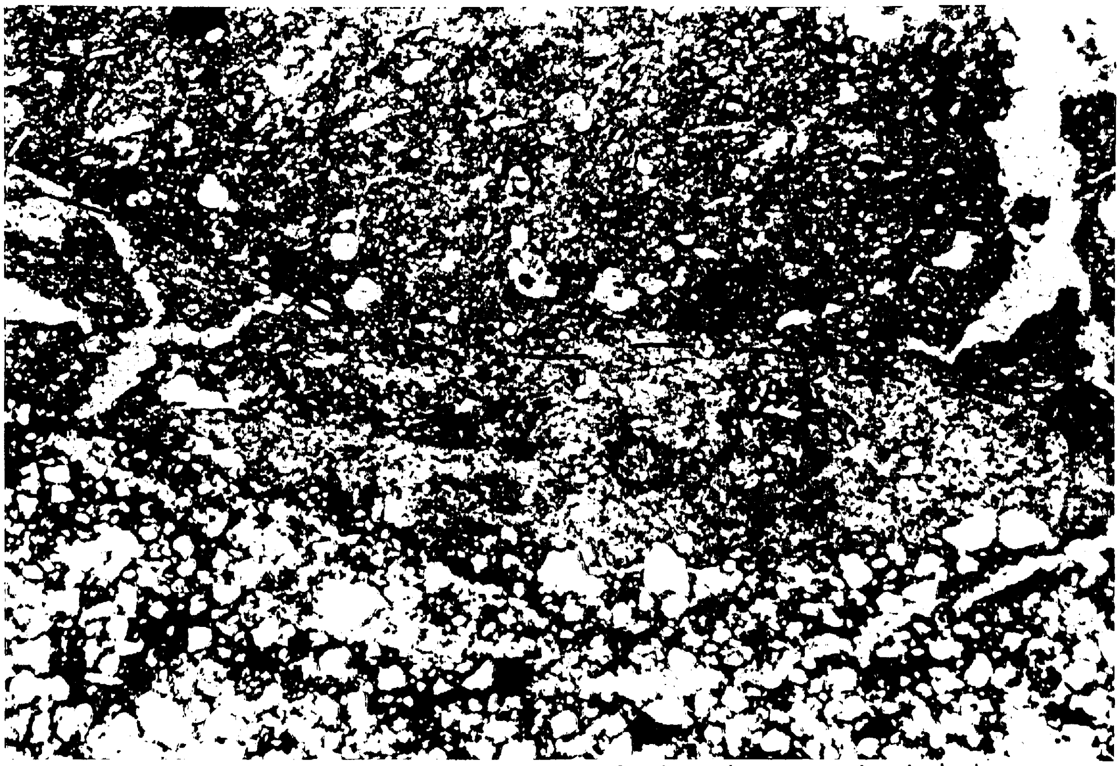


FIGURE 6a. Thin section micrograph of the sharp contact between a carbonate cemented sandstone and a fossiliferous micrite. The dashed line marks the boundary between the micrite (less fossils) and microspar. Devilfish #1 sidewall core 25, depth 1775m. Plane light. Field of view 2.72mm.

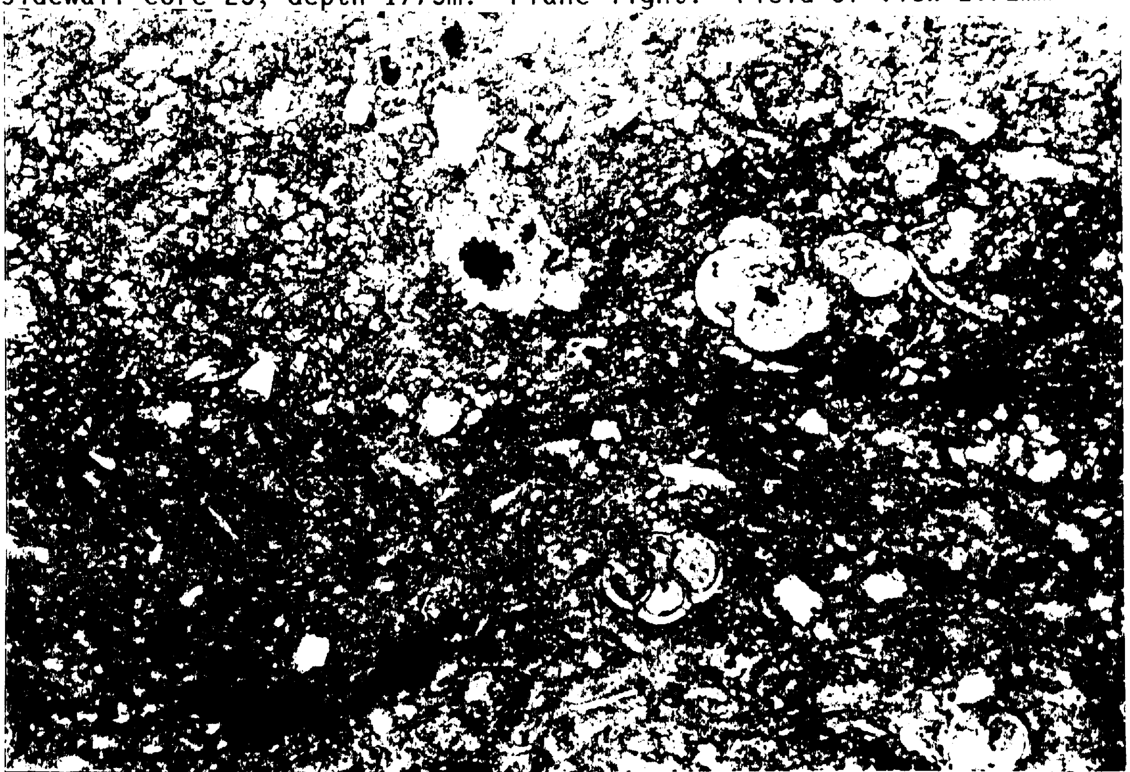


FIGURE 6b. Closer view of the spar and pyrite filled foraminifera at the boundary between the micrite (less fossils) and microspar. The pale green particle in the microspar is glauconite. Minor intragranular porosity is evident within one foram test in the micrite. Devilfish #1, sidewall core 25, depth 1775m. Plane light. Field of view 0.88mm.

PE905947

This is an enclosure indicator page.
The enclosure PE905947 is enclosed within the container PE905928 at this location in this document.

The enclosure PE905947 has the following characteristics:

ITEM_BARCODE =	PE905947
CONTAINER_BARCODE =	PE905928
NAME =	Thin Section Micrograph
BASIN =	GIPPSLAND BASIN
PERMIT =	VIC/P21
TYPE =	WELL
SUBTYPE =	PHOTOMICROGRAPH
DESCRIPTION =	Thin Section Micrographs 7a & 7b (from appendix 5 of WCR vol.2) for Devilfish-1
REMARKS =	this page contains 2 photos
DATE_CREATED =	
DATE_RECEIVED =	13/09/90
W_NO =	W1026
WELL_NAME =	DEVILFISH-1
CONTRACTOR =	AMDEL CORE SERVICES PTY LTD
CLIENT_OP_CO =	SHELL AUSTRALIA

(Inserted by DNRE - Vic Govt Mines Dept)

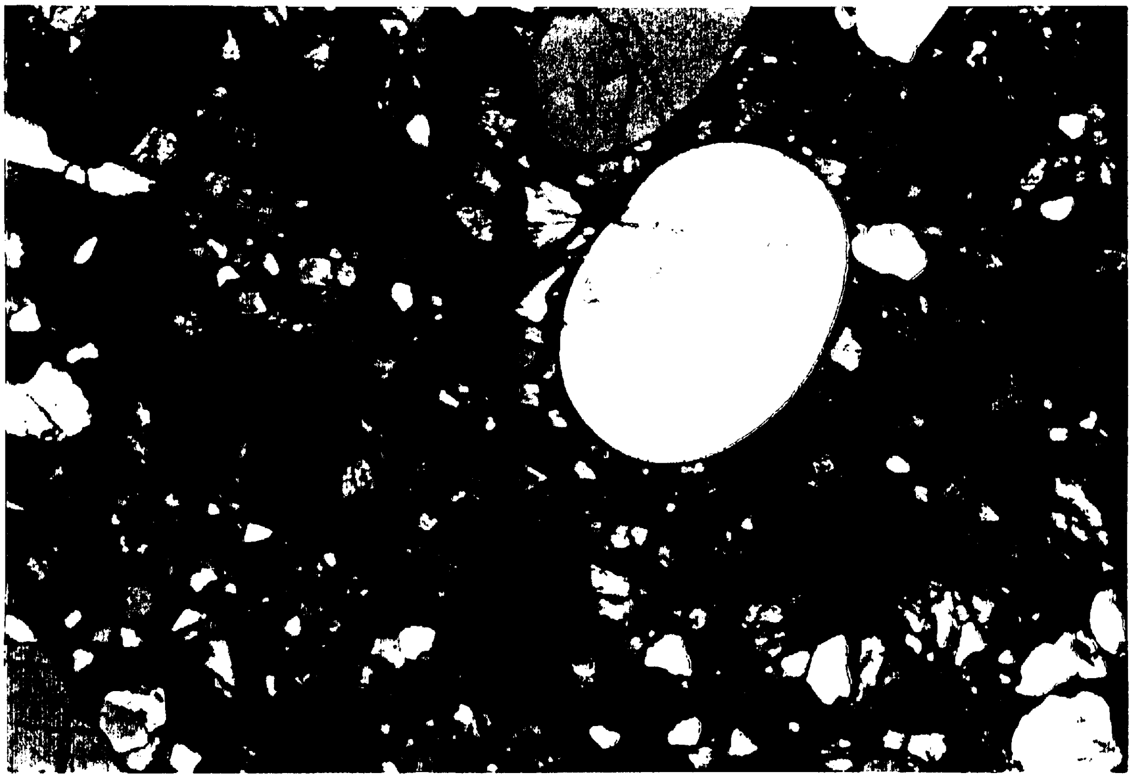


FIGURE 7a. Poorly sorted, sandy mudstone which demonstrates textural inversion. Coarse, well rounded quartz grains and numerous subhedral rhombohedra of carbonate float within a silty mud. There are large patches of opaque material throughout the slide which are possibly organic. Devilfish #1, sidewall core 26, depth 1650m. Crossed polars. Field of view 2.72mm.

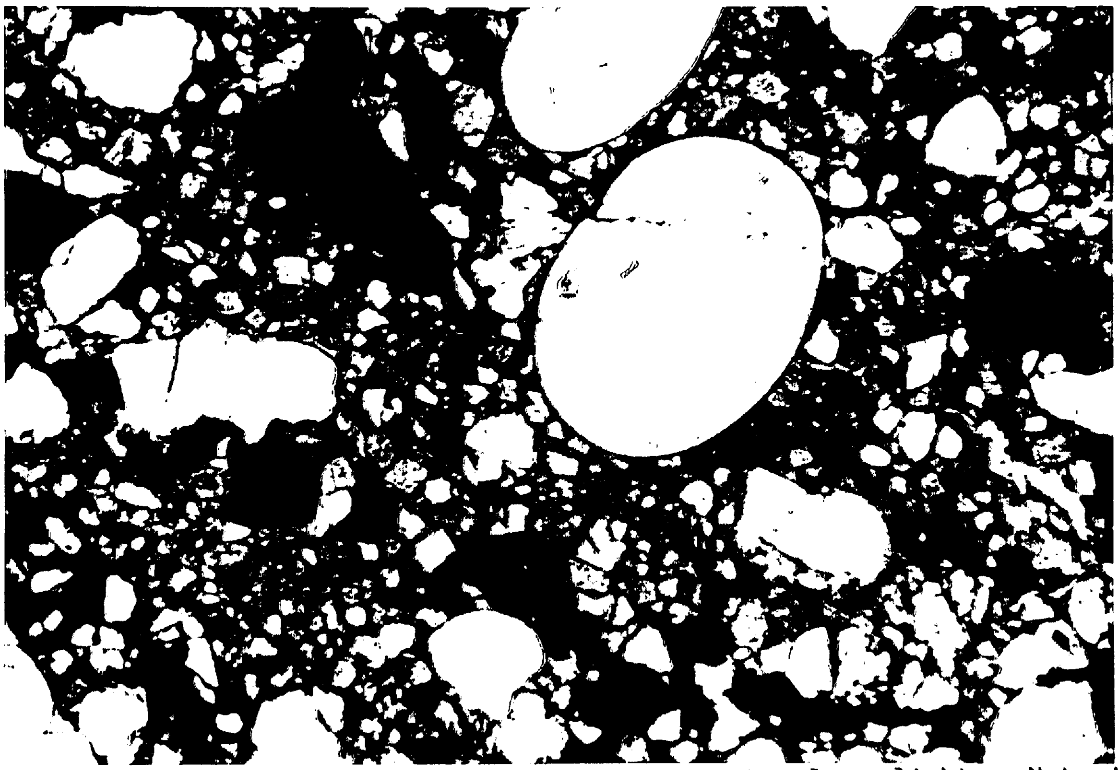
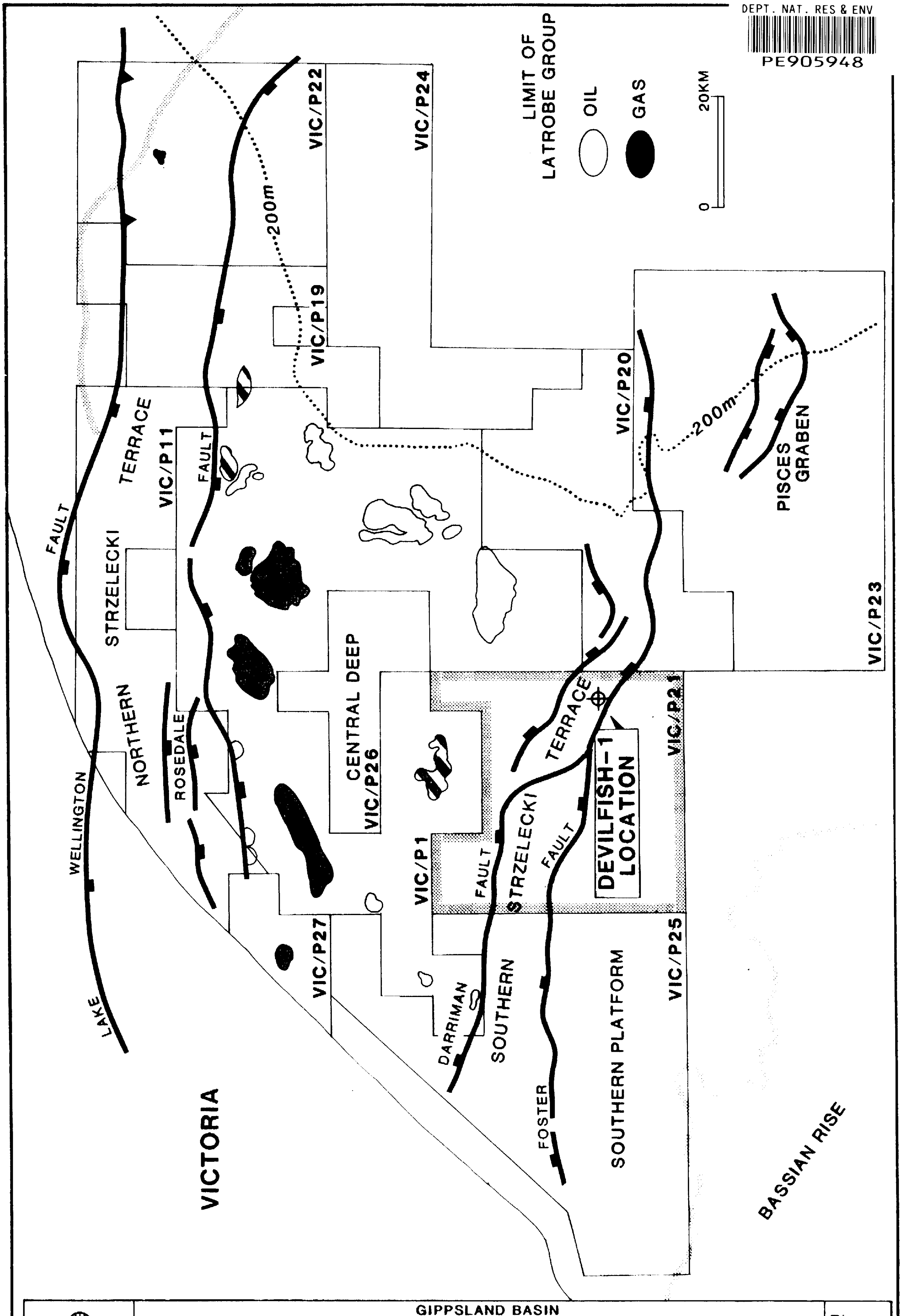


FIGURE 7b. Same field of view as Figure 7a in plane light. Note the red-brown colour of the clay matrix which suggests it has been oxidized. The distribution of opaque material is also more obvious.

Figures . . . .



SHELL-AUSTRALIA E&P OIL AND GAS	GIPPSLAND BASIN			Figure
	LOCATION MAP - DEVILFISH-1			1
	Author: EXO	Report No.: SDA 958	Date: MARCH 1989	Drawing No.: 25212

PE905948

This is an enclosure indicator page.
The enclosure PE905948 is enclosed within the container PE905928 at this location in this document.

The enclosure PE905948 has the following characteristics:

ITEM_BARCODE =	PE905948
CONTAINER_BARCODE =	PE905928
NAME =	Location Map
BASIN =	GIPPSLAND BASIN
PERMIT =	VIC/P21
TYPE =	WELL
SUBTYPE =	MAP
DESCRIPTION =	Location Map (figure 1 of WCR vol.2) for Devilfish-1
REMARKS =	
DATE_CREATED =	31/03/89
DATE_RECEIVED =	13/09/90
W_NO =	W1026
WELL_NAME =	DEVILFISH-1
CONTRACTOR =	AMDEL CORE SERVICES PTY LTD
CLIENT_OP_CO =	SHELL AUSTRALIA

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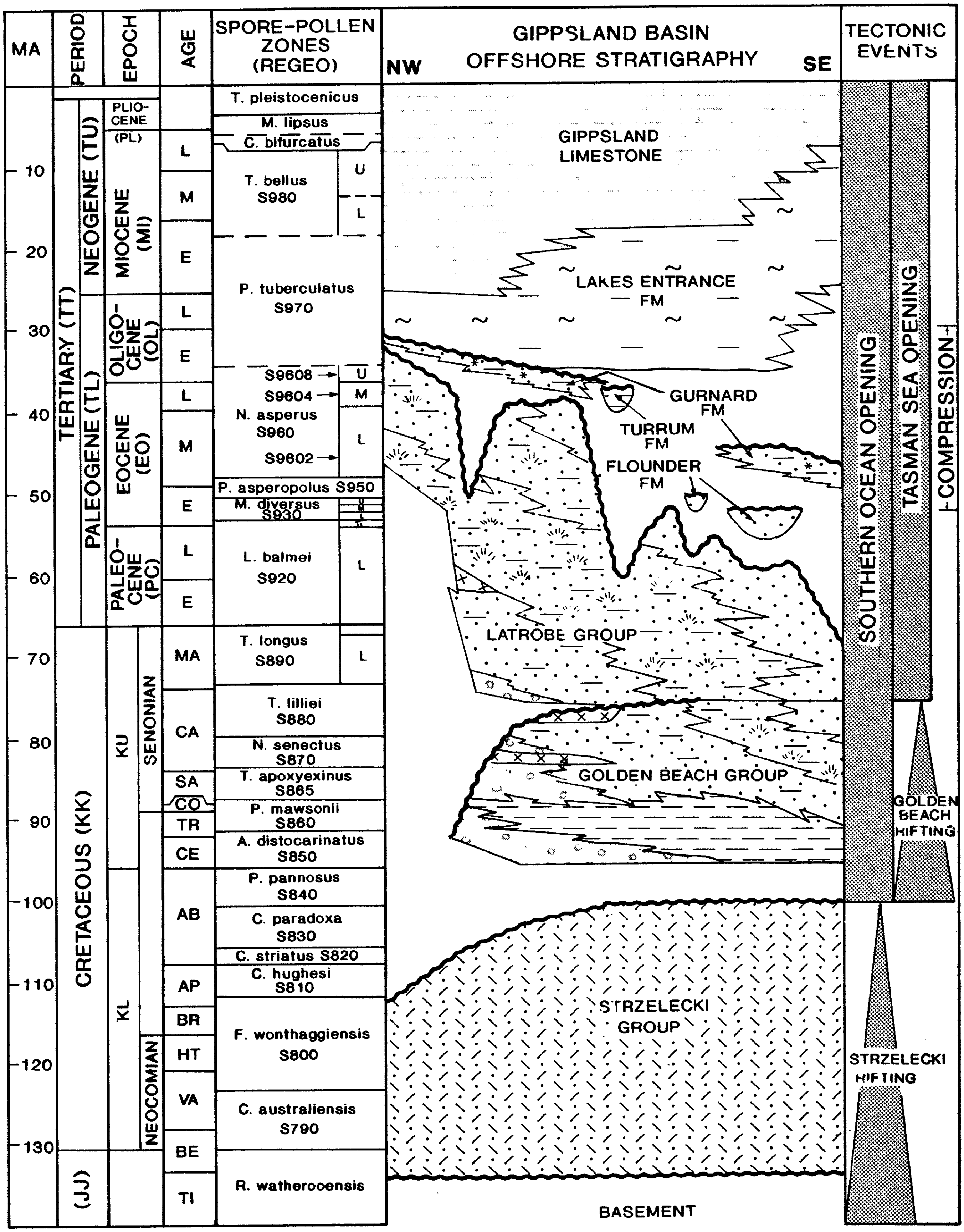


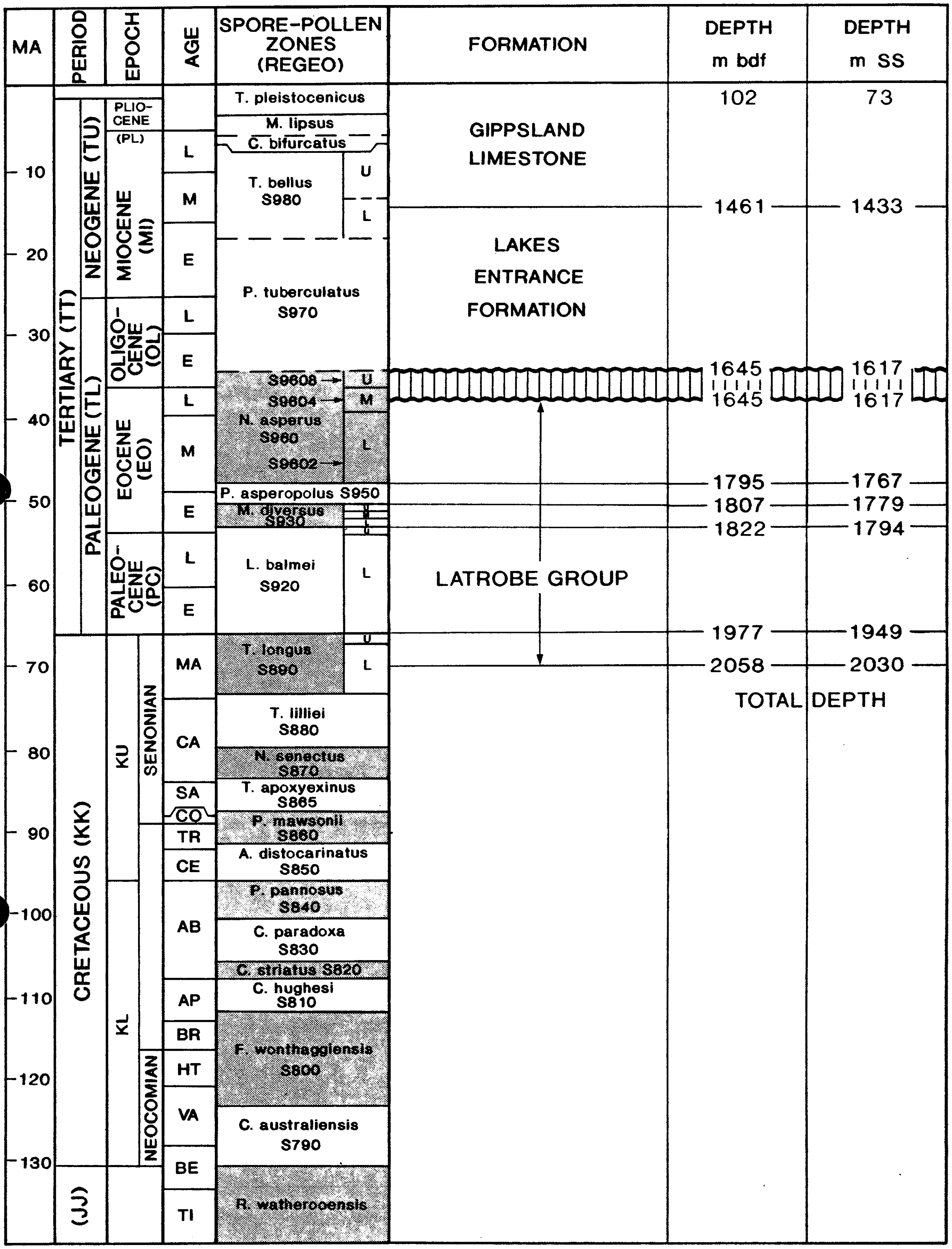
SHELL-AUSTRALIA
E.& P. OIL AND GAS

GIPPSLAND BASIN

OFFSHORE STRATIGRAPHY

Figure 2

Author: EXO | Report No.: SDA 958 | Date: JAN.1990 | Drawing No.: 25630



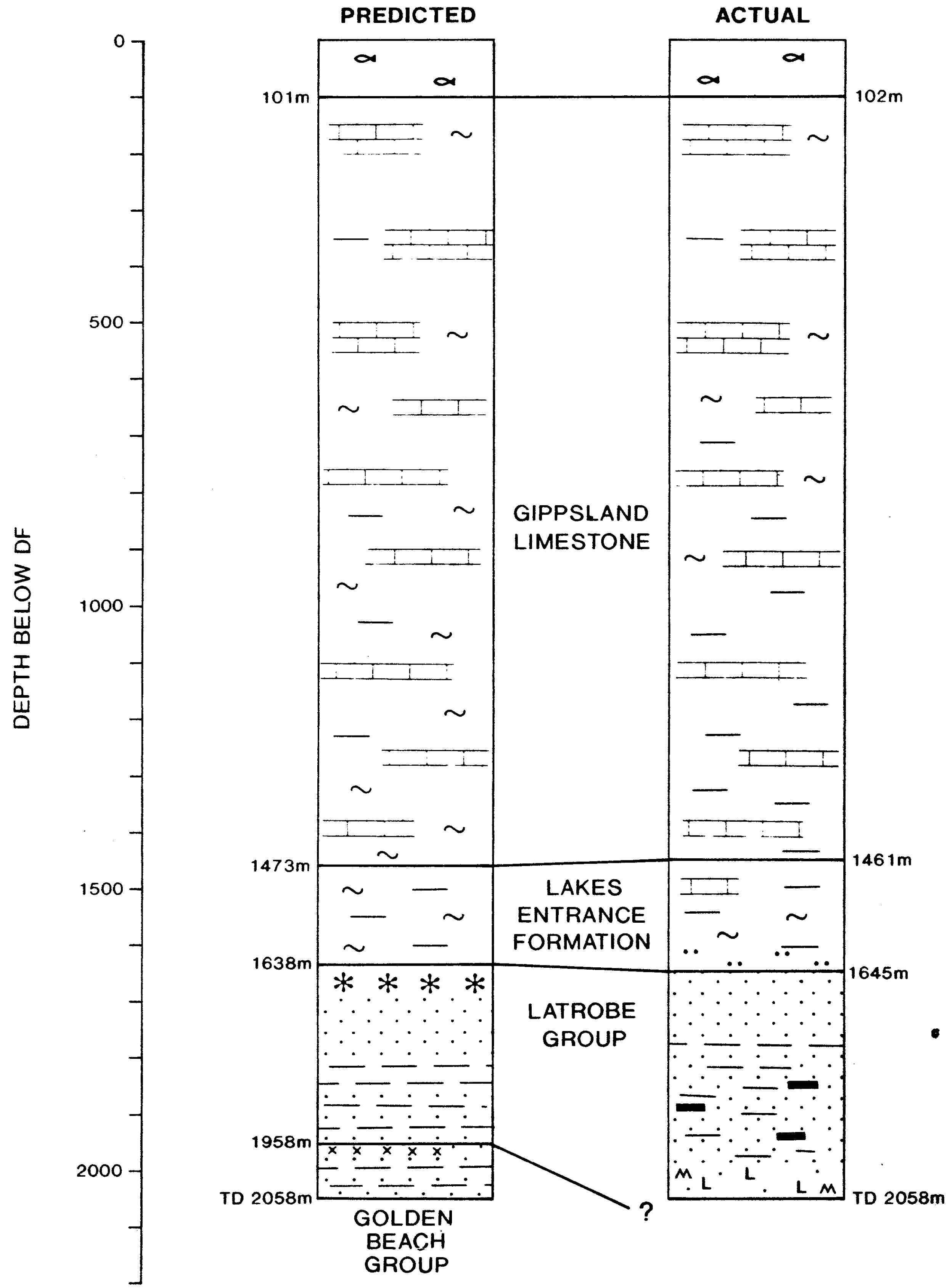
SHELL-AUSTRALIA
E.& P. OIL AND GAS

GIPPSLAND BASIN

DEVILFISH-1 STRATIGRAPHIC TABLE

Figure 3

Author: EXO | Report No.: SDA 958 | Date: JUNE 1990 | Drawing No.: 26201

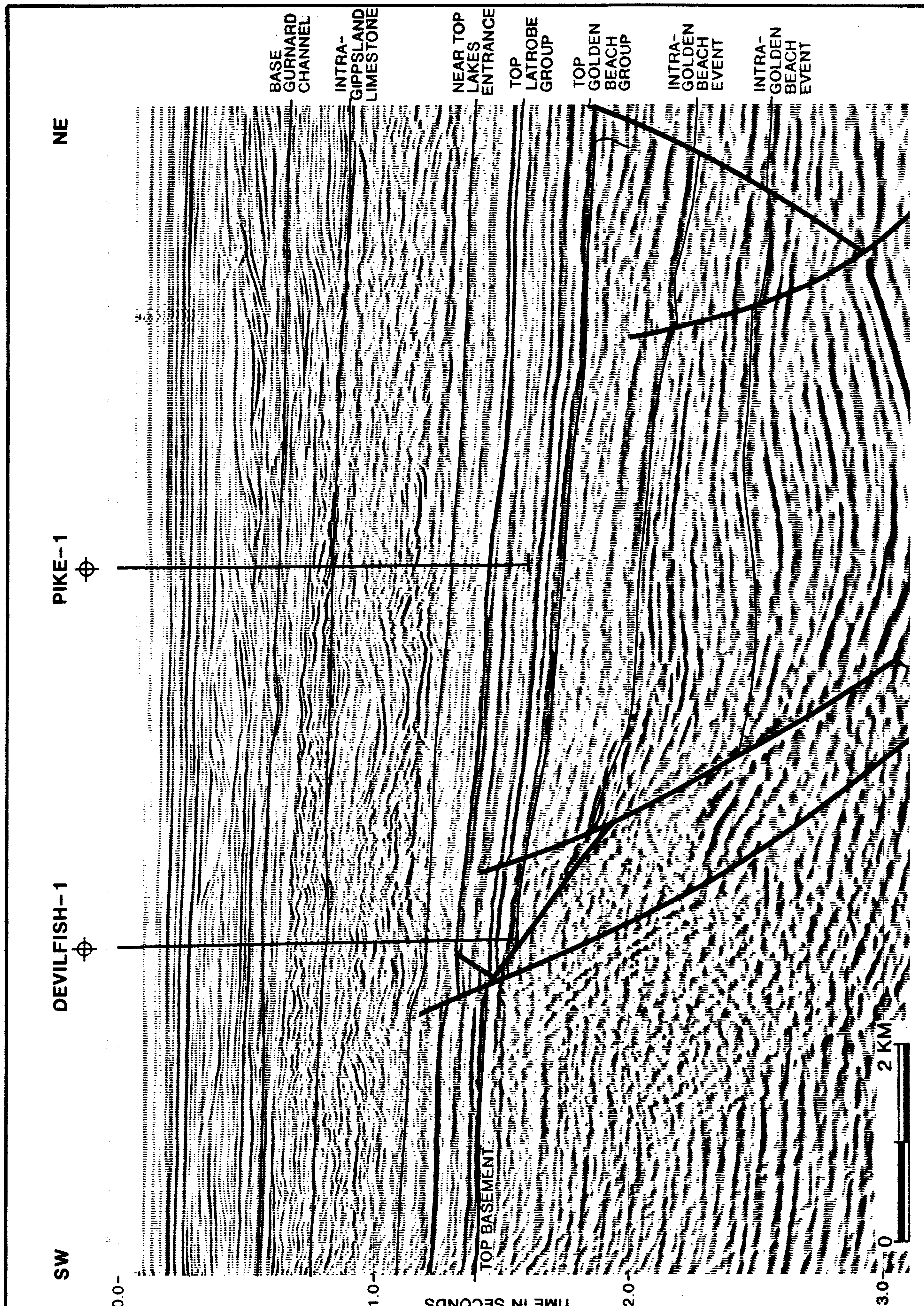


SHELL-AUSTRALIA
E.& P. OIL AND GAS

GIPPSLAND BASIN

DEVILFISH-1 PREDICTED Vs ACTUAL STRATIGRAPHY

Author: EXO	Report No.: SDA 958	Date: JUNE 1990	Drawing No.: 26189	Figure 4



SHELL-AUSTRALIA E.& P. OIL AND GAS	GIPPSLAND BASIN		Figure 5
	INTERPRETED SEISMIC LINE GS88A-05		
Author: EXO	Report No.: SDA 958	Date: JULY 1990	Drawing No.: 26265

Enclosures

Enclosures . . .

PE604491

This is an enclosure indicator page.
The enclosure PE604491 is enclosed within the container PE905928 at this location in this document.

The enclosure PE604491 has the following characteristics:

ITEM_BARCODE =	PE604491
CONTAINER_BARCODE =	PE905928
NAME =	Composite Well Log
BASIN =	GIPPSLAND BASIN
PERMIT =	VIC/P21
TYPE =	WELL
SUBTYPE =	COMPOSITE_LOG
DESCRIPTION =	Composite Well Log (enclosure 1 from WCR vol.2) for Devilfish-1
REMARKS =	
DATE_CREATED =	1/05/90
DATE_RECEIVED =	
W_NO =	W1026
WELL_NAME =	DEVILFISH-1
CONTRACTOR =	
CLIENT_OP_CO =	SHELL AUSTRALIA

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PE905949

This is an enclosure indicator page.
The enclosure PE905949 is enclosed within the container PE905928 at this location in this document.

The enclosure PE905949 has the following characteristics:

ITEM_BARCODE =	PE905949
CONTAINER_BARCODE =	PE905928
NAME =	Synthetic Seismogram
BASIN =	GIPPSLAND BASIN
PERMIT =	VIC/P21
TYPE =	WELL
SUBTYPE =	SYNTH_SEISMOGRAM
DESCRIPTION =	Synthetic Seismogram (enclosure 2 from WCR vol.2) for Devilfish-1
REMARKS =	
DATE_CREATED =	31/07/90
DATE_RECEIVED =	
W_NO =	W1026
WELL_NAME =	DEVILFISH-1
CONTRACTOR =	
CLIENT_OP_CO =	SHELL AUSTRALIA

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