DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

Rept.Bk.No. 79/115

BYILKAOORA NO. 1
WELL COMPLETION REPORT

REPORT No. 1 of the
OFFICER BASIN STUDY GROUP

GEOLOGICAL SURVEY

by

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and

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D.M. No. 651/78

PREFACE

The Department of Mines and Energy late in 1978 formed the Officer Basin Study Group, by temporary secondment of geologists from two Divisions of the Geological Survey. The Study Group, under the direction of the Supervising Geologist, Fossil Fuels Division, was charged with the tasks of:-

(a) performing appropriate geological mapping and stratigraphic drilling in the Officer Basin;
(b) reviewing all previous geological data from the region; and
(c) producing an integrated assessment of the basin's petroleum potential.

Formation of this Study Group was a response to the discovery of excellent source-rock potential, including traces of hydrocarbons, in the SADME Wilkinson No. 1 stratigraphic well drilled during 1978.

The Study Group's work to date includes detailed geological mapping in the Mt. Johns area, northeastern Officer Basin; drilling of Byilkaoora No. 1; and a helicopter geological survey in the southwestern Officer Basin.

This report is the first of a series by Study Group personnel: B.C. Youngs (Group Co-ordinator, from the Fossil Fuels Division), M.C. Benbow and G.M. Pitt (from the Regional Geology Division).

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DEPARTMENT OF MINES AND ENERGY
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ABSTRACT

SADME Byilkaoora No. 1 was drilled on the north-eastern margin of the Officer Basin, in the Mt. Johns Range, with the principal objective of coring a complete stratigraphic section of the Observatory Hill Beds. Good hydrocarbon source-rock potential had been determined for this sequence in SADME Wilkinson No. 1, 300 km to the south of Byilkaoora.

This objective was accomplished. Byilkaoora No. 1 penetrated an ?Early Cambrian sequence of Trainor Hill Sandstone, Mt. Johns Conglomerate, Observatory Hill Beds and Davies Bore Beds, and the underlying Rodda Beds of Adelaidean age, to a total depth of 496.7 m.

Significant hydrocarbon shows were discovered in the Observatory Hill Beds, where a range of oil types bled from calcite veins and vugs in a carbonaceous carbonate/siltstone sequence. Ubiquitous sulphides in this sequence include chalcopyrite and sphalerite. A thick accumulation of evaporite-related sediments contains calcite pseudomorphs after minerals including shortite and trona.

As a consequence of Byilkaoora No. 1, Cambrian sediments in the eastern Officer Basin have assumed an increased significance in hydrocarbon, evaporite and metallic mineral search.

INTRODUCTION

In 1978 SADME Wilkinson No. 1, drilled on the south-eastern margin of the Officer Basin, intersected a sequence of carbonates with excellent source-rock potential for hydrocarbons (McKirdy, 1978; Kantsler, 1978). These carbonates are part of the Observatory Hill Beds, considered Early Cambrian in age at Wilkinson No. 1 (Muir in Gatehouse, 1979(b)). Byilkaoora No. 1 was intended to penetrate a complete section of the Observatory Hill Beds in the northeastern

Officer Basin, by spudding within outcrops of the overlying Trainor Hill Sandstone and drilling to "basement". By fully coring the well with strict control on mud properties to avoid hydrocarbon contamination, the petroleum-generating potential of the Observatory Hill Beds could be assessed in this area.

The well was sited on the southeastern margin of the Mt. Johns range, 5 km north of Marla Bore and 0.5 km west of the Stuart Highway and Alice Springs-Tarcoola railway line. Previous mapping showed the proposed well site to be on a shallowly west-plunging synclinal axis.

The aim of this report is to present preliminary results from the drilling of Byilkaoora No. 1 and from concurrent geological mapping in that area. Evaluation and analysis is proceeding and, when completed, will be integrated with the Final Report of the Officer Basin Study Group.

DRILLING SUMMARY

Byilkaoora No. 1 was spudded on 18th May 1979 and reached the total depth of 496.7 m on 20th July 1979.

Cuttings were taken at 3 metre intervals during rotary drilling from surface to 13.1 m. Continuous NQ wireline coring commenced at 13.1 m and continued to total depth, with overall core recovery of 483.6 m (100%).

Drilling procedure and completion details are discussed in Appendix 7.

WELL HISTORY

Well Data

Well Name and Number

South Australian Department of Mines and
Energy Byilkaoora No. 1.
D.M.E. Bore No. 5643000SW00030.

Location

Latitude $27^{\circ}17'00''$

Longitude $133^{\circ}30'30''$ (A.M.G.)

Site was 0.5 km west of the Stuart Highway.

Access

Access was gained by a track from the Stuart Highway, 5 km north of Marla Bore.

Map Reference

1:250 000 WINTINNA

1:100 000 Marla (5643).

Elevation

334.41 m. Natural surface

335.15 m. Top of casing (capped)

334.58 peg

335.0 Approx. platform level

Total Depth

496.7 metres.

Date Drilling Commenced:	18th May 1979
Date Drilling Completed:	20th July 1979
Actual Drilling Time :	38 days
Date Well Completed :	21st July 1979
Date Rig Released :	22nd July 1979.

Status: Completed with well head and standpipe (see Appendix 7). Well will be bailed about December 1979 to check for possible oil accumulation.

Drilling Data

Name and address of Drilling Contractor

South Australian Department of Mines and Energy Mechanical and Drilling Branch, Dalgleish Street, Thebarton, S.A., 5031.

Drilling Rig

Make : Mindrill

Type : 10 L

Rated capacity : 500 m using NQ rod; 800 m using BQ rod.

Motor : Lombardine, 4 cylinder Diesel, 48HP @ 3000 RPM.

Mast

Make : Mindrill

Type : Swivel

Rated Capacity : -

Pump

Make : John Bean Triplex

Type : Model 435

Size : 2 3/4" stroke, 2 3/4" bore

Motor : Pedders, model TH2

Power Rating : 16.4HP, 400 psi continuous, 800 psi discontinuous.

Hole Dimensions

158.75 mm	0 - 4.8 m
114.30 mm	4.8 - 13.1 m
107.95 mm	13.1 - 54.7 m
75.8 mm	54.7 - 496.7 m

Casing and Cementing Details

Size	Weight	Grade	Depth
127 mm			0 - 4.84 m
80 mm		NOM bore steel pipe	0 - 12.80 m
80 mm		NB steel pipe	0 - 54.72 m
	cemented hole after losing circulation at 121.50 m. lost circulation again at 150.00 m.		
80 mm			48.72 m left in hole
32 mm		NOM bore steel pipe	0 -201.55 m
32 mm	annulus cemented between		137.24-201.15 m
		and	0.00- 1.50 m
	Stand pipe cemented at surface for future access for testing purposes.		0.00- 1.50 m

Bit Record

No. bits used	Size	Type	Make
1	158.75mm (6¼")	3 cone rock bit	Regular V2 Varel.
1	114.30mm (4½")	" " " "	" VH2 "
1	107.95mm (4¼")	" " " "	" V2 "
2	NQ75.8mm (4¼")	Reamer Shells diamond set.	Mindrill.
2	" "	Core bits multi-step diamond set.	Diamond and Boart.
5	" "	Core bits multi-step diamond set.	Mindrill.
1	" "	Core bits over case.	Craelius (DIAMY).

Drilling Fluids Used

Great care was taken in using only those drilling fluids compatible with source rock analytical work. In addition only water was used from 130.0 m to 496.7 m (TD).

Surface to 13.1 m.	Romud Super-Gel Bentonite Mix 25 kg per 200 Galls. 1 Sack used.
13.1 m to 54.7 m	Opened Hole from 75.8 mm to 107.95 mm DIA 3 Sacks Super-Gel used.
13.1 m to 496.7 m	Coring NQ. Straight Water - No Additives.

Circulation was completely lost at 121.5 m and thereafter the hole was drilled with no returns to surface (see Appendix 7).

Water Supply

Drilling water was obtained from a nearby claypan.

Formation Sampling

Cuttings	Cuttings were collected at 3 metre intervals from surface to 13.1 m during rotary drilling.
Coring	Continuous coring commenced at 13.1 m and continued to T.D. of 496.7 m.
Water Sampling	None collected while drilling; sample will be taken when well is bailed out.

Electrical Logging

(Appendix 9)

Log	Depth (m) From	To
Gamma	0.6	464.4
Neutron	1.4	465.0
SP	55.6	465.2
Point Resistivity	55.6	465.2
6ft. lateral	55.6	465.2
Density	0.8	465.2

Penetration Rate

The penetration rate for every run drilled (3 metres) was recorded by the driller.

Velocity, Deviation Surveys

No deviation surveys.

Well velocity survey performed: see Appendix 8.

REGIONAL GEOLOGICAL SETTING

Byilkaoora No. 1 was sited on the southeastern margin of the Mt. Johns Range, in the northeastern corner of the Officer Basin. This basin, underlying the Great Victoria Desert in South Australia, extends from the Mt. Johns area southward to underlie the Eucla and Arckaringa basins and westward into Western Australia.

Jackson and van de Graaff (in prep.) suggest that the term Officer Basin should be restricted to the structural downwarp in northwestern South Australia and eastern W.A. that contains late Proterozoic to pre-Permian rock sequences. There has been some debate in previous literature concerning the definition and therefore the extent and nature of the Officer Basin, but the suggestion of Jackson and van de Graaff is tentatively accepted for the purposes of this report. Thus the Adelaidean

Rodda Beds here are included as Officer Basin sediments.

Regional studies of the Officer Basin are contained in Krieg (1969), Krieg and Jackson (1973), Krieg, Jackson and van de Graaff (1976) and Jackson and van de Graaff (in prep.). Geophysical work in the South Australian Officer Basin is summarised in Milton (1979). A review study of the South Australian part of the Officer Basin, of which study Byilkaoora No. 1 drilling was a part, is being undertaken by the Officer Basin Study Group of the S.A. Dept. of Mines and Energy. A final report from that Group should be available about mid-1980.

Background literature to the Officer Basin in the Mt. Johns area is listed and discussed by Krieg (1973), who compiled results of mapping the EVERARD 1:250 000 geological sheet and described a formal stratigraphy for the area. The following summary is taken from Krieg (1973).

Proterozoic crystalline basement to the basin is exposed in the north as the Musgrave Block, and at Ammaroodinna Hill, 35 km south-southwest of Byilkaoora No. 1, as the Ammaroodinna Inlier (Krieg, 1973). Rocks exposed in the inlier include schistose and gneissic metamorphics and pegmatoids, for which Webb (1972) obtained a metamorphic Rb/Sr age of 1000-1050 Ma.

Upper Proterozoic (Adelaidean) sediments include diamictites, basic volcanics and metasiltstones which may reasonably be correlated with rocks of the Adelaide Geosyncline. In part of the area around the Mt. Johns Range these appear conformable with the overlying Cambrian succession defined by Krieg (1973) as the "Marla Sequence". Within this succession he recognised correlatives of the Observatory Hill Beds, originally defined by Wopfner (1969) in the Emu area, 250 km southwest of Mt. Johns.

In this report, the term "Observatory Hill Beds" is applied to the largely-carbonate sequences of assumed Early Cambrian age in the Officer Basin area and includes both dolomite/siltstone sequences in Murnaroo No. 1 and evaporite sequences in Wilkinson No. 1 (Gatehouse, 1979 a,b). The Observatory Hill Beds near Mt. Johns are overlain by the Trainor Hill Sandstone; conglomeratic interbeds occur in parts of both those formations and are strongly developed near their bases. These conglomerates were defined by Krieg (1973) as the Mt. Johns Conglomerate; he recognised a southward fining from conglomerate to claystone between Mt. Johns and Mt. Byilkaoora (Fig. 1).

The "Marla Sequence" is disconformably overlain by the (?) Ordovician "Munda Sequence", consisting of the Mt. Chandler Sandstone, Indulkana Shale, Blue Hills Sandstone and Cartu Beds, in ascending order. The Indulkana Shale has yielded a whole-rock Rb-Sr age of 460 ± 15 Ma (Webb, 1978) similar to the Arenigian age attributed to the Horn Valley Siltstone of the Amadeus Basin (Wells *et al.*, 1970).

Recent geological mapping has modified the stratigraphy discussed above (Fig. 2):

(1) beds of Mt. Johns Conglomerate occurring at the base of the assumed Cambrian sequence are redefined informally as the "Davies Bore Conglomerate"; the term "Mt. Johns Conglomerate" is reserved for the conglomerate (proximal) to claystone (distal) facies interbedded within the Trainor Hill Sandstone.

(2) "Upper" and "lower" members are recognised informally in the Trainor Hill Sandstone, separated by a major bed of Mt. Johns Conglomerate.

The Mt. Johns Range itself is formed by bold outcrops of Trainor Hill Sandstone, Mt. Chandler Sandstone and Blue Hills

Sandstone. The Indulkana Shale crops out very poorly and is usually obscured by sandstone scree. The Observatory Hill Beds crop out near the base of the eastern face of the range, and occur in extensive shallow subcrop beneath piedmont plains extending east of the range. Rare outcrops of the Observatory Hill Beds in this area and south of the range are veneered by basal (Mesozoic) sands of the Great Artesian (Eromanga) Basin and surficial Cainozoic units.

WELL STRATIGRAPHY

Introduction

Byilkaoora No. 1 intersected all rock units comprising the 'Marla Sequence' of Krieg (1973). Drilling commenced in a thin veneer of Quaternary drift overlying the lower part of the "upper member" of the Trainor Hill Sandstone (Figs 2, 3).

A synopsis of the sequence intersected is:-

1. Quaternary: red sands and sandstone rubble (surface to 6.7 m).
2. Trainor Hill Sandstone, "upper member": white, kaolinitic cross-bedded sandstones (6.7 m - 49.2 m).
3. Mt. Johns Conglomerate, distal facies: red, laminated dolomitic claystone with minor conglomerate at the base (49.2 m - 98.8 m).
4. Trainor Hill Sandstone, "lower member": red, arkosic sandstone and red laminated, interbedded siltstone and claystone (98.8 m - 155.8 m).
5. Observatory Hill Beds: laminated red to green-grey and grey claystone, grey dolomitic and calcareous claystone and siltstone, grey dolomite and limestone (155.8 m - 379.4 m); five informal, local members recognised.

6. "Davies Bore Conglomerate": conglomerate with a dolomitic, sandy matrix (379.4 m - 486.0 m).
7. Rodda Beds (Adelaidean): laminated non-calcareous indurated siltstone (486.0 m - 496.7 m).

These rock units are identifiable on gamma-ray logs (Appendix 9).

Description of units

Unnamed (Quaternary) Depth Interval Surface to 6.7 m

A thin veneer of unconsolidated red alluvial Quaternary sands, gravelly to rubbly toward the base, overlies weathered Trainor Hill Sandstone, of assumed Cambrian age. The sands are moderately well sorted, fine to medium grained and subangular to rounded.

Trainor Hill Sandstone Depth Interval 6.7-49.2 m

"Upper Member"

The lower part of this member is composed of cross-bedded, medium and even grained white sandstones with minor very thin beds and laminae of white clay. It is kaolinitic (generally less than 15%) with fair porosity. The kaolin most likely represents altered feldspar, and the rock might once have been an arkosic arenite. Quartz grains are subangular to subrounded, and most are surrounded or partially surrounded by optically continuous overgrowths of secondary quartz, which infills interstices (e.g. Sample 5643 RS10, Appendix 4).

Mt. Johns Conglomerate Depth Interval 49.2-98.8 m

Distal Facies

Red-brown dolomitic claystones-siltstones and fine-grained clayey sandstones represent a distal facies of the Mt. Johns Conglomerate and show a sharp contact with the overlying and underlying members of the Trainor Hill Sandstone. They are indistinctly laminated (perpendicular to the core axis) with

TABLE 1

SUMMARY OF STRATIGRAPHY IN BYILKAOORA 1

AGE	FORMATION	DEPTH, TOP OF UNIT (m)	THICKNESS (m)
Quaternary	surficial sand, talus	0.0	6.7
	Trainor Hill Sandstone, "upper member"	6.7	42.5
	Mt. Johns Conglomerate, distal facies	49.2	49.6
?Early to Middle Cambrian	Trainor Hill Sandstone, "lower member"	98.8	57.0
	Observatory Hill Beds	155.8	223.6
	member 5	155.8	44.7
	member 4	200.5	58.5
	member 3	259.0	63.5
	member 2	322.5	53.5
	member 1	376.0	3.4
	"Davies Bore Conglomerate"	379.4	106.6
Adelaidean	Rodda Beds	486.0	10.7+

some biotite-rich laminae. Thin-section examinations show that they are variably dolomitic (up to 40-45%) and that most of the clay is composed of sericite and chlorite. Green reduction mottles are conspicuous, ranging from 1 cm to 5 cm in size. Thin laminated beds of white to green dolomite are also present.

Towards its base, the unit becomes sandy and conglomeratic with clasts from granule to pebble size. The clasts are generally angular to subangular but some are rounded, including red siltstone (reworked from underlying units), fine-grained sandstone and granitoid lithologies. The matrix is composed of angular to subangular lithic grains, feldspar, sericite, chlorite and carbonate (up to 20%). Black alteration-veining cuts both matrix and clasts.

The base of this unit is defined at the base of the conglomerate. Although the contact is clearly discordant and erosional, deposition of the conglomerate occurred before lithification of the underlying sands, which are penetrated by a clast from the conglomerate.

<u>Trainor Hill Sandstone</u> <u>Depth Interval</u> 98.8-155.8 m

<u>"Lower Member"</u>

This unit is composed of fine to medium-grained, orange to red-brown arkosic arenites and interbedded red-brown claystones. The sandstones, although very well sorted, are chemically immature, containing a high proportion of feldspar (up to 30%), lithic grains including fine-grained metasediments (up to 30%), and both biotite and muscovite (up to 30%). There are rare small pebble- to granule-sized red clay clasts. The visual porosity of these sandstones is fair.

The claystones are non-calcareous, light to deep red-brown, laminated, and interbedded with silt and very fine sand. Some of the laminae and interbeds are highly micaceous with both muscovite and biotite. Sericite and chlorite form the bulk of the rock.

Detrital grains in both the sandstones and claystones display a very thin surface film of reddish brown iron oxide or iron-oxide-stained clay. Quartz and feldspar overgrowths are superimposed on the iron oxide films, filling some of the interstices. The matrix of the claystone is heavily stained by iron oxides.

The sequence is cross-bedded, with large-scale foresets suggested by varying apparent dips in the drill core, with sharply discordant breaks accompanied by marked colour changes between beds. Neutron and gamma logs (Appendix 9) indicate that the unit consists of six upward-fining cycles. Soft-sediment slump structures are not uncommon in the claystones.

The base of this unit is defined at 155.8 m depth at the base of the lowermost prominent sandstone.

Observatory Hill Beds Depth Interval 155.8-379.4 m

The Observatory Hill Beds are composed of laminated, partly dolomitic claystones and siltstones, with limestones and dolomites, and a basal intraformational breccia. Between 203 m and 330 m depth, oil bleeds from partly sealed fractures and vugs (Appendix 2). A variety of evaporite minerals including trona and shortite throughout much of the sequence has been replaced by calcite pseudomorphs. Five informal local members are recognised.

Member 5 (silty claystone) Depth interval 155.8-200.5 m

The red-brown to brown and green laminated claystones and silty to very fine sandy claystones of this member are similar to those of the "lower member" of the Trainor Hill Sandstone.

The bulk of the rock consists of sericite and chlorite. Between 158.8 m and 179.0 m depth the claystone is non-calcareous and red-brown in colour. Colours below vary from alternating green and brown to grey-green. Over the interval 179.0 m - 200.5 m, the claystone contains flaser-like interlaminations and interlaminated cross-beds of siltstone and very fine-grained sandstone which become increasingly more calcareous with depth. The thicker interlaminations often have sharp bases and graded tops. Slump structures and disrupted or injected sand features are common.

The contact with the member below is transitional.

Member 4 (clayey and calcareous dolomite)

Depth Interval 200.5-259.0 m

This member is composed of interbedded and interlaminated argillaceous dolomite, calcareous dolomite, silty limestone, calcareous claystone and claystone. Its colour varies from green-grey and grey-green to dark grey, brown and dark red-brown. The clay fraction consists of sericite and chlorite. Detrital grains vary from clay size to very fine sand, consisting of angular to subangular quartz, feldspar and mica. Regular, wavy laminae are conspicuous and are probably of cryptalgal origin.

Small scale sedimentary slump structures and 'injection veins' of very fine sands into the formation occur throughout. Layering has been destroyed, possibly by bioturbation at 226.9 - 228.1 m. Several ?trilobite fragments occur at 200.6 m and 201.9 m. Rare chert nodules occur throughout.

Pyrite and calcite veining, often subvertical and subhorizontal, and pyrite - and calcite-lined vugs occur irregularly throughout. Calcite veins are concentrated within the most calcareous lithologies. Strong gamma-ray log "peaks", of uncertain origin, are evident between depths of 224.5 m and 258.5 m (Appendix 9).

Oil Shows:

The uppermost hydrocarbon traces in Byilkaoora No. 1 occur between 202.5 m - 202.9 m in an organic rich (? algal) laminated section.

Other intervals with hydrocarbon traces are:

203.5 m: a steeply dipping calcite vein, enclosing bituminous oil.

203.5 - 206.3 m: strong hydrocarbon odour.

218.0 - 220.3 m: calcite and pyrite veins with pyrite-lined vugs that bleed dark brown, viscous oil.

226.9 - 228.1 m: calcite veins bleeding a small amount of viscous oil.

<u>Member 3</u> (clayey and calcareous dolomite with pseudomorphs after evaporite minerals)

<u>Depth interval</u> 259.0-322.5 m

This unit is characterised by a matrix lithology of variably clayey and cherty carbonates, with embedded sub-spherical, 'feathery' rosette and cuniform crystals and crystal aggregates which consist of calcite, probably replacing evaporitic minerals such as shortite and trona (A. White, C. Cuff, pers. comm.). The sediments are well laminated, with cherty layers, chert breccia, chert nodules and wavy laminae that may be of cryptalgal origin. Soft-sediment deformation structures, which occur irregularly throughout, brecciate and fold the layering. Chert layers often have sphalerite associated with them, and occasionally contain shortite or halite pseudomorphs.

The gamma-ray log through Member 3 displays several large "peaks", the origins of which have not yet been identified (Appendix 9).

Oil Shows:

259.2 m: millimetre-size vugs bleeding light oil.
261.2-261.5 m: " " " " " " "
276.7-284.6 m: " " " " " " "
298.2-322.5 m: " " " " " " "

Member 2 (clayey and calcareous dolomite)

Depth interval 322.5-376.0 m

This member is a silty to very fine sandy carbonate rock generally with poorly defined 'wispy' lamination or a complete lack of visible structuring. This is possibly due to bioturbation or to major soft-sediment deformation. Greyish-red-brown colours predominate, and rare cherty concretions and layers occur in the uppermost part. A fine-grained sandstone bed at 356 m - 357 m depth divides the upper, calcareous portion of this member from the lower, apparently non-calcareous portion. Both upper and lower parts are visually similar and are flecked throughout with (?)carbonate pseudomorphs of evaporite minerals of crystal morphology different from those in Member 3.

Oil Shows

A single occurrence of bleeding oil was recorded at 329.8 m.

Member 1 (indurated, argillaceous dolomite)

Depth interval 376.0-379.4 m

This unit consists of a grey-pink, silty, indurated dolomite with sedimentary intraformational breccia at the base.

The base of the unit is affected also by tectonic brecciation which has jointed the rock and veined the sedimentary breccia with a black, carbonaceous clay.

The base is placed at 379.4 m depth, where a major change in matrix lithology occurs: the matrix is grey and dolomitic in Member 1, but is sandy, silty and dolomitic in the conglomerate beneath.

"Davies Bore Conglomerate" (conglomerate with carbonate matrix)

Depth interval 379.4-486.0 m

The lithology of this unit is remarkably uniform, with well rounded elongate clasts averaging 0.1-4.0 cm and ranging up to 10 cm in size. Clasts are of granitoids or grey-green and pink-brown dolomitic siltstones. Clasts are commonly oriented sub-perpendicular to the core axis. Occasional preferred orientations at some 70° to the core axis over intervals up to 0.5 m are ascribed to imbrication. "Shadow" effects are observed in the form of a thicker, framework-free, carbonate-matrix zone beneath many clasts that show a ferruginous skin on top. The matrix is silty to sandy, and dolomitic. Calcite veins traverse both matrix and clasts.

This rock unit shows little character on gamma-ray logs (Appendix 9).

Rodda Beds (indurated siltstone) Depth Interval 486.0-496.7 m

Indurated, dark grey, non-calcareous, laminated siltstones beneath the "Davies Bore Conglomerate" are correlated with the Rodda Beds (Krieg, 1973). Laminations are almost perpendicular to the core axis, suggesting at least local conformity with the overlying sequence.

The Rodda Beds were not logged geophysically.

SUMMARY OF 1979 GEOLOGICAL MAPPING IN THE NORTHEASTERN OFFICER BASIN

(1) Mt. Johns Range area

The base of the "Davies Bore Conglomerate", previously regarded as part of the Mt. Johns Conglomerate (Krieg, 1973), has been mapped about the northern margin of the Mt. Johns Range.

The contact with the underlying Rodda Beds is sharp and shows no angular discordance.

Much of the "Davies Bore Conglomerate" consists of arkosic arenites, moderately well sorted and with fresh angular feldspars. Interbedded green and red siltstones (calcareous in part) and sandy to silty limestones and dolomites occur.

Current directions (from two observations) are southeasterly in the northern part of the Mt. Johns Range. Supporting this proposed current direction is a gradual coarsening of the sequence to the west, where conglomerates contain well rounded boulders up to 0.5 m in diameter; however other conglomerates recently mapped northeast of Mt. Johns Bore (Fig. 1) may be a separate tongue in the "Davies Bore Conglomerate" showing easterly provenance.

The "Davies Bore Conglomerate" intertongues with laminated claystone, siltstone and limestone of the Observatory Hill Beds in the northeastern part of the Mt. Johns Range.

The Observatory Hill Beds crop out poorly, generally being obscured by Pleistocene-Holocene cover. Chert nodules and laminae appear to be confined to the upper half of the sequence in this area. (The chert is also observed incorporated and resilicified in nearby Tertiary silcrete).

Overlying the Observatory Hill Beds is the lower part of the Trainor Hill Sandstone. The contact is transitional, especially in the southeastern part of the Range.

The Trainor Hill Sandstone can be divided into two members. The "lower member" is composed of red, cross-bedded arkosic arenites with shale intraclasts and red siltstone and claystone interbeds, which are best developed in the southeastern part of the Range.

Overlying the "lower member" of the Trainor Hill Sandstone, with possible disconformity, is the Mt. Johns Conglomerate which in the northern part of the Range consists of red siliceous sandstone with conspicuous well-rounded pebbles and cobbles. Near Byilkaoora No. 1 is developed a distal facies, of red dolomitic claystone with rare pebble and granule interbeds.

Overlying the Mt. Johns Conglomerate, the "upper member" of the Trainor Hill Sandstone consists of white cross-bedded kaolinitic sandstones. Minor conglomerate interbeds become more conspicuous towards the north, where the sandstones become red and arkosic. At the southern end of the Range a palaeosol is preserved in the uppermost part of the Mt. Johns Conglomerate.

Overlying the "upper member" of the Trainor Hill Sandstone with possible disconformity is a thin, presently unnamed sequence of white and green dolomitic or calcareous claystone, and kaolinitic sandstone and conglomerate. At Mt Byilkaoora dark calcareous sandstones to sandy limestones form prominent outcrops.

The Mount Chandler Sandstone overlies this unnamed sequence with apparent conformity.

(2) Wallatinna area

Limited mapping south of "Wallatinna" outstation (20 km southwest of Marla Bore: Fig. 1) revealed extensive but generally poor outcrops of Observatory Hill Beds, usually in scarp-foot situations, overlain by silicified, poorly sorted, pebbly kaolinitic sandstones representing basal sands of the Great Artesian (Eromanga) Basin sequence.

Several localities warrant specific comment:

(a) Granite conglomerate and/or brecciated granitoid rocks in spoil from a well at Wallatinna Waterhole, 5 km south of "Wallatinna", may represent shallow "basement"; but it seems more likely by the mapped local distribution of the Observatory Hill Beds that such spoil represents lithified talus, derived from a granitic terrain and overlying the Amaroodinna crystalline basement inlier, correlative with the "Davies Bore Conglomerate".

(b) 5 km southeast of Wallatinna Waterhole outcrops of silicified limestone also expose dark silty limestone with subspherical vugs. These resemble the subspherical dolomite rosettes in Member 3 (evaporite/limestone) of the Observatory Hill Beds in Byilkaoora No. 1.

(c) Immediately southeast of "Wallatinna" outstation interlayered claystone and sandstone beds are overlain by a silicified sandstone which occurs in a broad synclinal keel. The sandstone/claystone beds dip up to 40° and display vergence folds parasitic to the syncline. They are considered to represent a transition from the Observatory Hill Beds into the Trainor Hill Sandstone.

(d) Exposed along a boundary fence 5 km southeast of "Wallatinna" are silicified sandstones correlated with the Trainor Hill Sandstone. Underlying siltstones/claystones resemble Unit 5 of the Observatory Hill Beds in Byilkaoora No. 1. Five kilometres farther south outcrops display poorly preserved but in situ brecciated chert interlayers, and chert nodules can be found in scree in the vicinity. These features are typical of Members 3 and 2 in Byilkaoora No. 1.

The major preliminary conclusions from geological mapping in the area are:-

(i) that a broad subdivision of the Observatory Hill Beds outcrop in this area may be correlated with members identified in Byilkaoora No. 1; and

(ii) that the structural complexities south of "Wallatinna" shown on the EVERARD 1:250 000 sheet have been confirmed. Fold structures with a 1-3 km amplitude, jointing, and parasitic vergence folds are present, and 0°-40° dips have been recorded.

DISCUSSION

Byilkaoora No. 1 penetrated a carbonate sequence containing the first discovered petroleum in the Officer Basin. Oil bleeding from partly open calcite veins and from vugs ranges in character from heavy, viscous black oil to pale brown oil with light ends that rapidly evaporate on exposure and deposit a brown stain. Preliminary results from oil and source-rock analysis performed by this Department (Appendix 2) suggests that the oils are variably biodegraded but probably originated from the same facies of the Observatory Hill Beds that were drilled in Byilkaoora No. 1.

Total organic carbon (TOC) contents of spot samples analysed to date range up to about 0.96% (Appendix 2). This compares with an average TOC for carbonates of about 0.20%.

The presence of calcite pseudomorphs after trona and shortite indicates that the Observatory Hill Beds in the northeasternmost part of the Officer Basin may have been deposited in a saline- or playa-lake (i.e. non-marine) environment. By contrast, the Observatory Hill Beds in Wilkinson No. 1 (300 km south of Byilkaoora No. 1) include a thick sequence of almost pure halite (Gatehouse, 1979 b), and may be interpreted as sabkha (i.e. marginal marine) deposits.

There are similarities between the Observatory Hill Beds and "Davies Bore Conglomerate" of the northeastern Officer Basin and the Eocene Green River and Wasatch Formations of Wyoming, U.S.A. A playa-lake model has been proposed by Eugster and Hardie (1975) for the Wilkins Peak Member of the Green River Formation. The Wilkins Peak Member consists of a sequence of dolomitic mudstone, oil shale and calcareous sandstone, with trona and shortite mineralization. Such a model includes marginal fanglomerate deposition which at Byilkaoora may be represented by the "Davies Bore Conglomerate".

Tectonic instability during the Early Cambrian is suggested by the freshness and angularity of detrital feldspar in the "Davies Bore Conglomerate", preserved through rapid erosion and deposition. Whitehead (Appendix 4) suggests similarly rapid deposition of at least part of the Observatory Hill Beds, observing the unoxidised state of much organic matter. Inferred earth movements may have been associated with terminal phases of the Petermann Ranges Orogeny or with the Indulkanan folding (e.g. Austin and Williams, 1978).

Current drilling of SADME Marla No. 1B, 25 km south-east of Byilkaoora No. 1, and detailed re-examination of all previous geological data from the Officer Basin should elucidate environments of Cambrian deposition in the region. Until such studies are completed, adopted working hypotheses regarding the occurrence of hydrocarbons are:

(a) Byilkaoora oils probably were generated within the same carbonate facies as those drilled;

(b) The oils may be of local origin, or may have migrated upward, along the synclinal axis on which Byilkaoora No. 1 was drilled, from the deeper portions of the northeastern Officer Basin.

Further analytical data from Byilkaoora No. 1 will become available in the near future. They may be obtained upon request to the Fossil Fuels Division but will be compiled and interpreted in subsequent reports of the Officer Basin Study Group.

SUMMARY

Hydrocarbon potential of the eastern Officer Basin

The drilling of Byilkaoora No. 1 has considerably upgraded the hydrocarbon potential of the eastern Officer Basin through the intersection of a carbonate sequence that bleeds oil over an aggregate thickness of some 50 m. The carbonate sequence is correlated with the Early Cambrian Observatory Hill Beds intersected in Wilkinson No. 1, for which an excellent source rock potential was determined.

The Observatory Hill Beds and adjacent reservoir sections have never been drilled in a petroleum-trap situation. Until they are so tested, the eastern Officer Basin remains essentially unexplored.

Evaporitic and metallic mineralization

Byilkaoora No. 1 discovered evaporite-related sediments containing pseudomorphs after economically significant evaporite minerals, with ubiquitous pyrite and scattered syngenetic chalcopyrite and sphalerite. These discoveries supplement lesser base-metal anomalies recorded from other stratigraphic wells within the Officer Basin, and establish a new province for evaporitic- and metallic-mineral search.

Stratigraphic Significance

Byilkaoora No. 1 penetrated all rock units comprising the "Marla Sequence", and the underlying Rodda Beds. All rock units within the sequence are essentially conformable; in particular, the contact between the Observatory Hill Beds and the lower member of the Trainor Hill Sandstone is gradational, and the claystones in both are closely related. These facts were not previously appreciated.

Five local members were recognised in the Observatory Hill Beds, much of which contains sulphide-bearing, non-marine evaporitic and related sediments. A playa-lake origin is postulated. The "Davies Bore Conglomerate" contains sulphide throughout and is interpreted as a fanglomerate. Much of the sequence appears to have been deposited during a period of relative aridity.

Future Work

At the time of writing this report, the Officer Basin Study Group is drilling Marla No. 1B, 25 km south of Byilkaoora No. 1, to a planned depth of 750 m or prior "basement". Marla 1B will fully core a carbonate sequence assumed correlative with the Observatory Hill Beds at Byilkaoora, and thus extend knowledge of this potentially important rock sequence.

MCB:GMP:ZV

M.C. BENBOW

G.M. PITT
OFFICER BASIN STUDY GROUP

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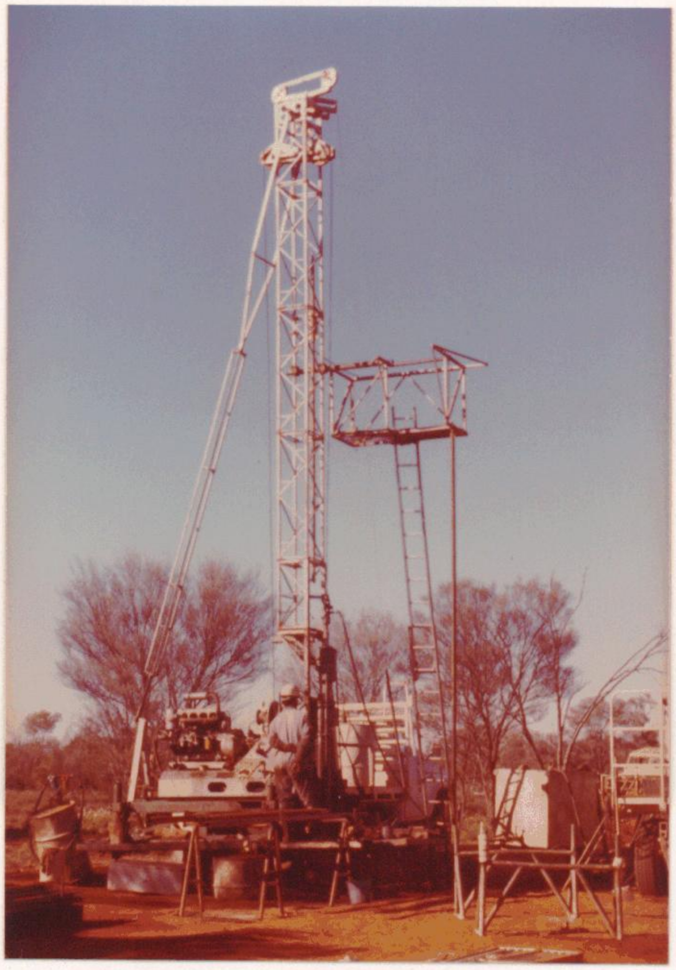


PLATE 1 Mindrill 10L diamond drill rig onsite at Byilkaoora 1. (Transparency No. 14751; Neg. No. 30876).

PLATE 2 NQ drillcore from 219.75 m depth, showing oil bleeding from calcite veins and a calcite and pyrite-lined vug. (Transparency No. 14752; Neg. No. 30877).

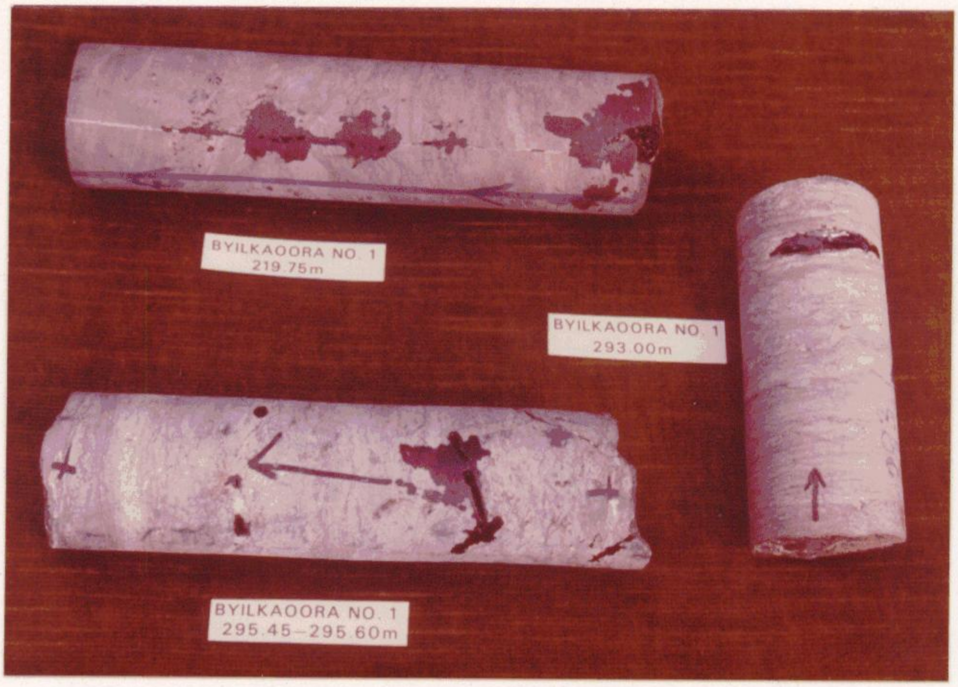


PLATE 3 Selection of core segments, showing "bleeding" oil in dolomite. (Core is 48 mm diameter, arrow points downwards).
Transparency No. 14753; Neg. No. 30878

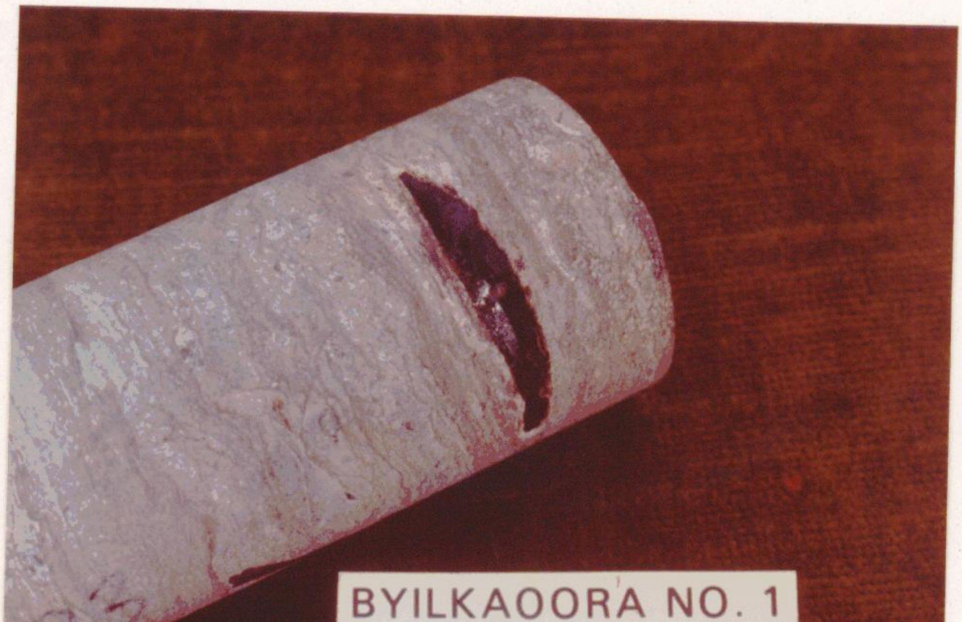


PLATE 4 Core segment showing oil biodegraded to a bitumen within a vug in dolomite rock. (Core is 48 mm diameter, arrow point downwards).
Transparency No. 14754; Neg. No. 30879.

PLATE 5 Slabbed core, showing bladed calcite pseudomorphs after trona or shortite (upper piece). Fine laminations are possibly cryptalgal. Lower piece displays subspherical dolomite rosettes (white circular dots on cut surface) (Slabs are 45 mm across; Transparency No. 14755; Neg. No. 30880).

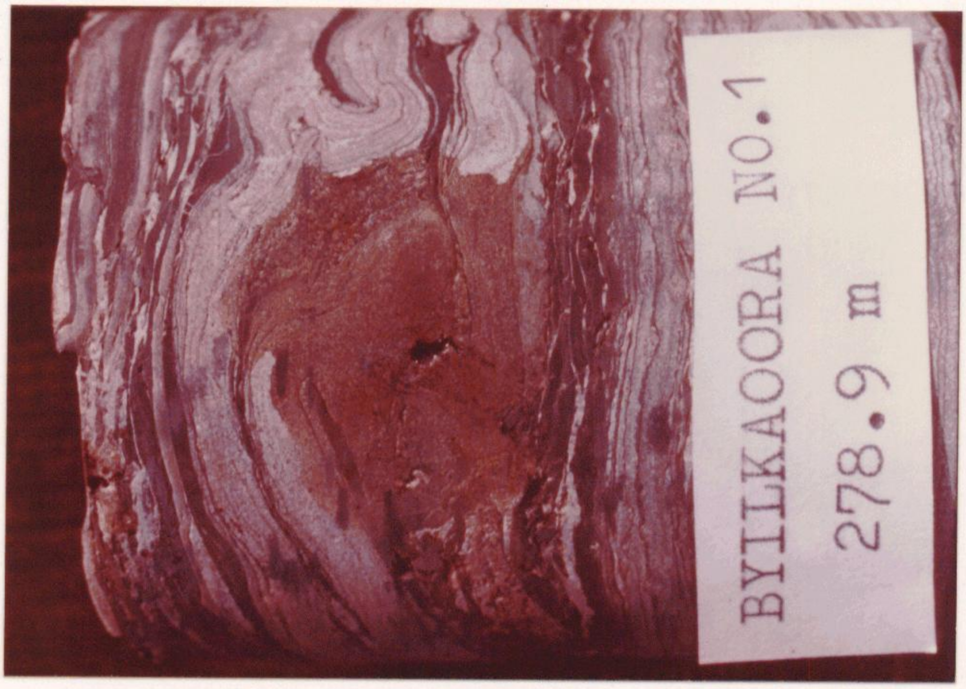


PLATE 6 Dolomite and interlaminated carbonaceous claystone showing contorted ?cryptalgal laminations. Oil (brown stain) bleeds from a low-pressure space within the contorted layering. (Core is 48 mm diameter; Transparency No. 14756; Neg. No. 30881.

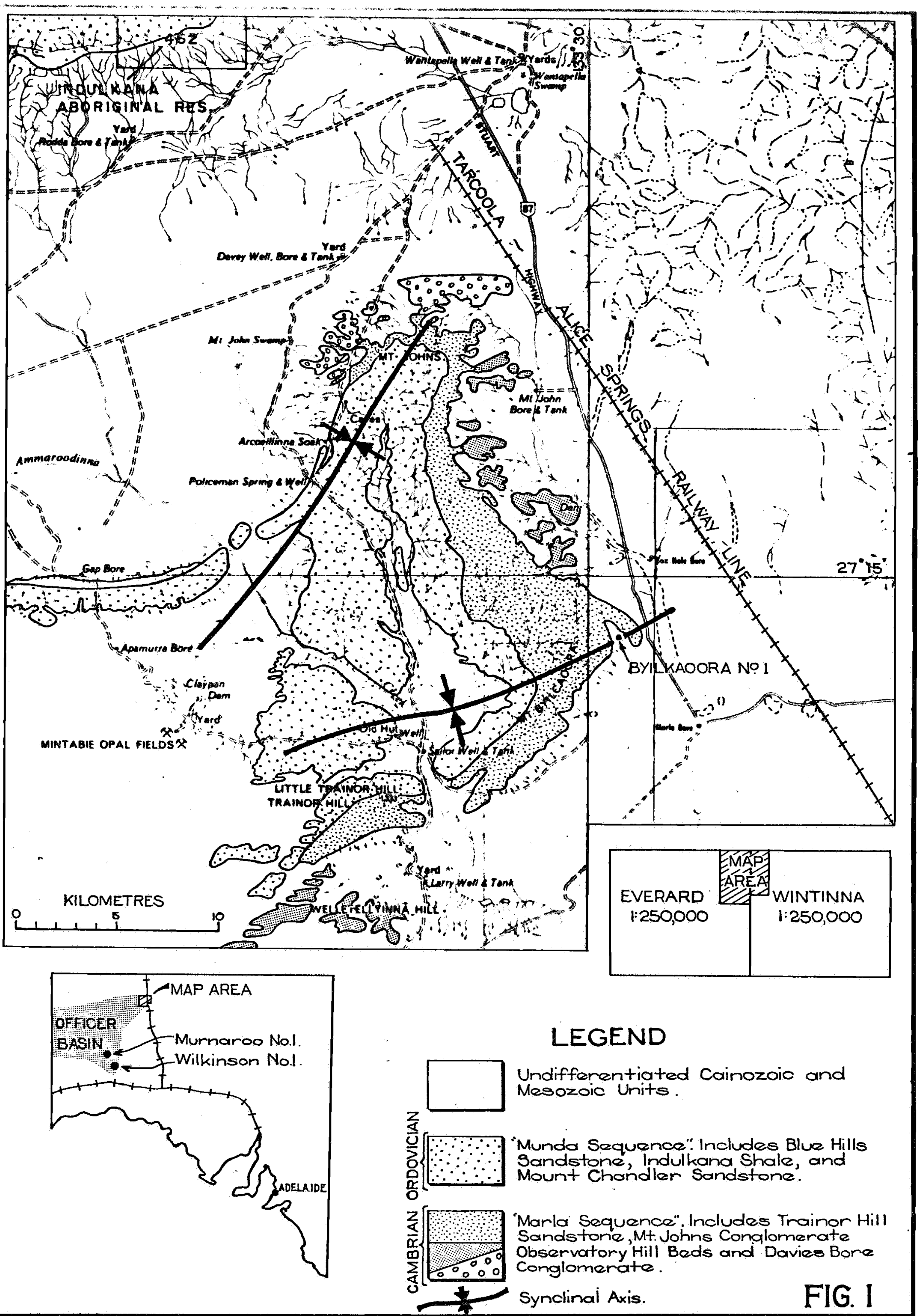


FIG. 1

GEOLOGICAL SURVEY BRANCH	DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE: 1:250,000
COMPILED: M.Benbow	BYILKAOORA NO.1 GEOLOGICAL AND TOPOGRAPHICAL LOCATION	DATE: August '79
DRN: J.W. CKD:		PLAN NUMBER S14243

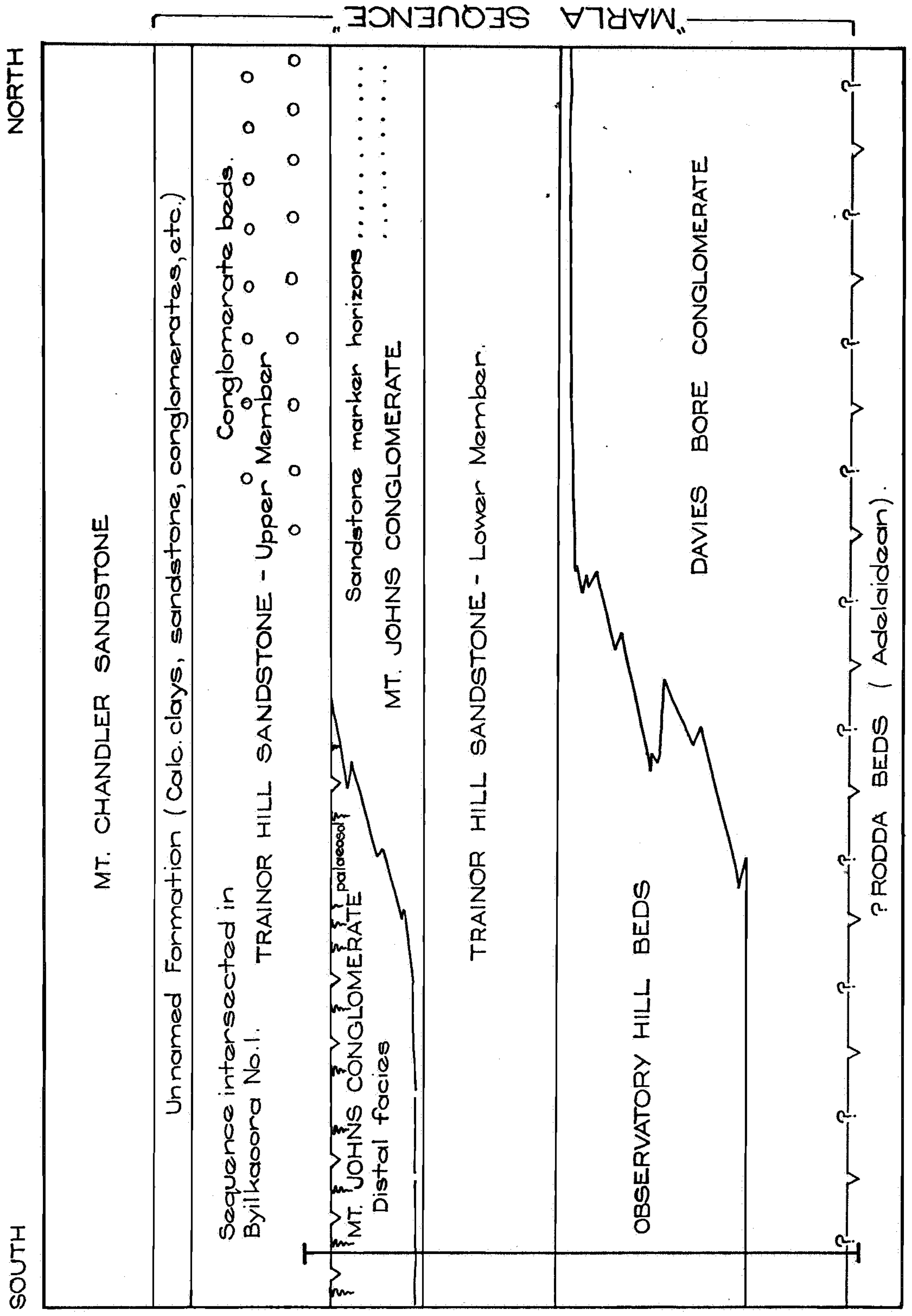


FIG. 2

GEOLOGICAL SURVEY BRANCH.

COMPILED: M. Benbow

DRN: J.W. CKD: GFR

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

MARLA SEQUENCE
STRATIGRAPHIC AND FACIES RELATIONSHIPS
MT. JOHNS RANGE

SCALE:

DATE: August '79

PLAN NUMBER
S14244

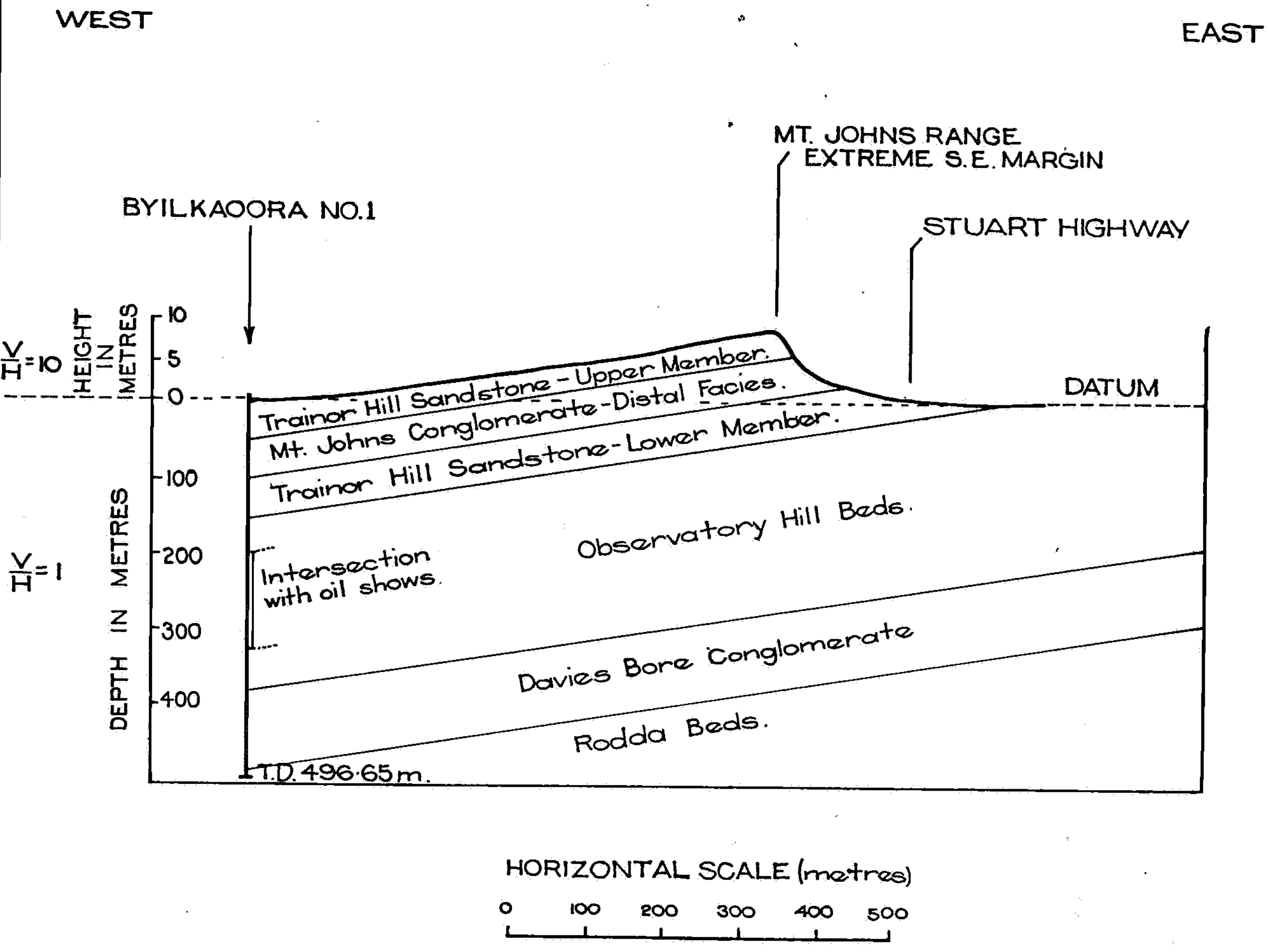


FIG. 3

GEOLOGICAL SURVEY BRANCH.

COMPILED: M. Benbow

DRN:

CKD:

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

CROSS SECTION SHOWING RELATIONSHIP OF BYILKAOORA NO. I AND OUTCROPPING FORMATIONS ON S.E. MARGIN OF MT. JOHNS RANGE

SCALE:

DATE: August '79

PLAN NUMBER
S14245

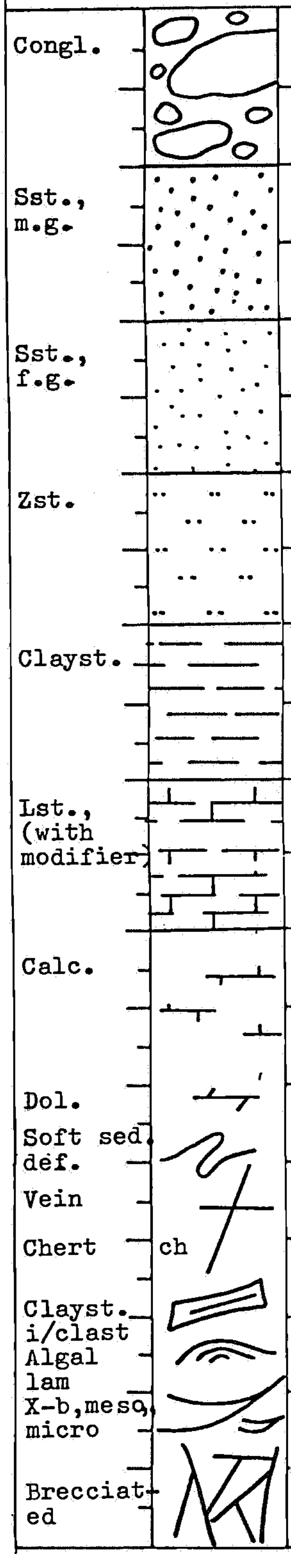
APPENDIX 1

CORE DESCRIPTION SHEETS

ABBREVIATIONS USED IN CORE DESCRIPTIONS

WELL BYILKAOORA 1
LOCATION
LAT.
LONG.

GRAPHIC LOG | DESCRIPTION



H/C :Hydrocarbon shows on drill core
wo weak petroliferous odour
so strong petroliferous odour
bl-obleeding oil
bit bituminous material in vug
carbonac? possible carbonaceous matter

Pal. :Fossils and biogenic structures (laboratory determinations excepted

a	algal, cryptalgal structures
mf	macrofossil (fragments)
t/bite	trilobite
bio	bioturbation

Col. :Predominant colour

lt.	light	r	red
med.	medium	gn	green
dk.	dark	gy	grey
wh	white	br	brown
or	orange	bl	black
y	yellow	mot	mottled
pi	pink		

Access. :Accessory features

(?)	pseudomorphs after evaporite minerals
s/e	scattered, irregular crystal aggregates
o/e	subcircular crystals
a/e	stubby but acicular, sharply facetted crystals
f/e	'feathery' crystal aggregates

Lithology descriptions:

congl	conglomerate
sst	sandstone
zst, zty	siltstone, silty
clayst	claystone
lst	limestone
v.f.g.	very fine grained
f.g.	fine grained
m.g.	medium grained
c.g.	coarse grained
layg/layd	layering/layered
lams/lamd	laminations/laminated
i/lams-i/lamd	interlaminations/interlaminated
i/layd	interlaminated
i/clasts	intraclasts
x-b	cross-bedding, cross-bedded
soft sed. def.	soft sediment deformation

carb	carbonate	fsp	feldspar
calc	calcareous	cc	calcite, calcitic
dol	dolomite/dolomitic	py	pyrite, pyritic
micac	micaceous	ccv	calcite, calcitic vein
kaol	kaolinitic	pyv	pyrite, pyritic vein
bi	biotite, biotitic	pyd	disseminated pyrite
qz	quartz		

LOGGED BY

DATE

PETROLEUM GEOLOGY SECTION

SHEET 1 OF 27 DRG. NO. S14313a

1639

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1

LOCATION 5 km, 320°T, Marla Bore,

LAT. 27° 17' 00"S WINTINNA

LONG. 133°31' 30"E (AN G, provisional)

ELEVATION GR.

R.T.

DATUM

Core size: NQ

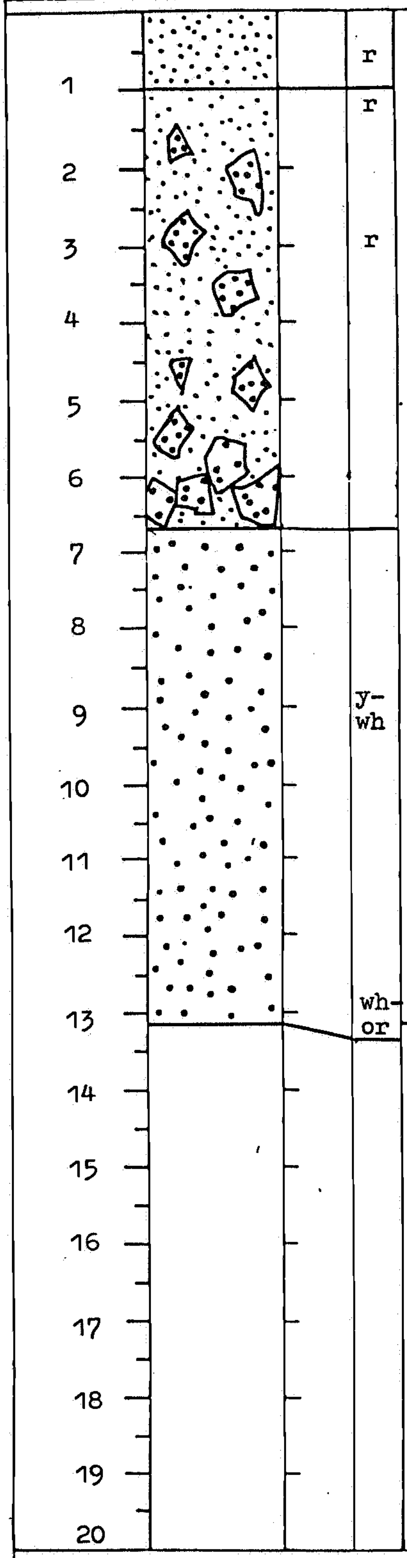
DEPTH 0-13.12m

DATE DRILLED 18-5-79

RECOVERY cuttings m %

FORMATION Trainor Hill Sandstone

DEPTH (METRES)	GRAPHIC LOG	H/C, Pal.	Col	Access.	DESCRIPTION :CUTTINGS



0-1 Sand, m.g., mod. sort., red, unconsol., (Quaternary sands).

1-3 Sand, A.A.; rubble of pebble size: ferrug. and kaol f.g. sst., (Quaternary sand and talus).

3-6.75 A.A.

6.75-9.0 Sst., f.g., kaol., y. ferrug. staining, wh. interstitial kaol.

9.0-13.12 A.A., some dk. ferrug.

Coring commences at 13.12m.

LOGGED BY M.C.B.

DATE 19-5-79

PETROLEUM GEOLOGY SECTION

SHEET 2 OF 27

DRG. NO. S14313b

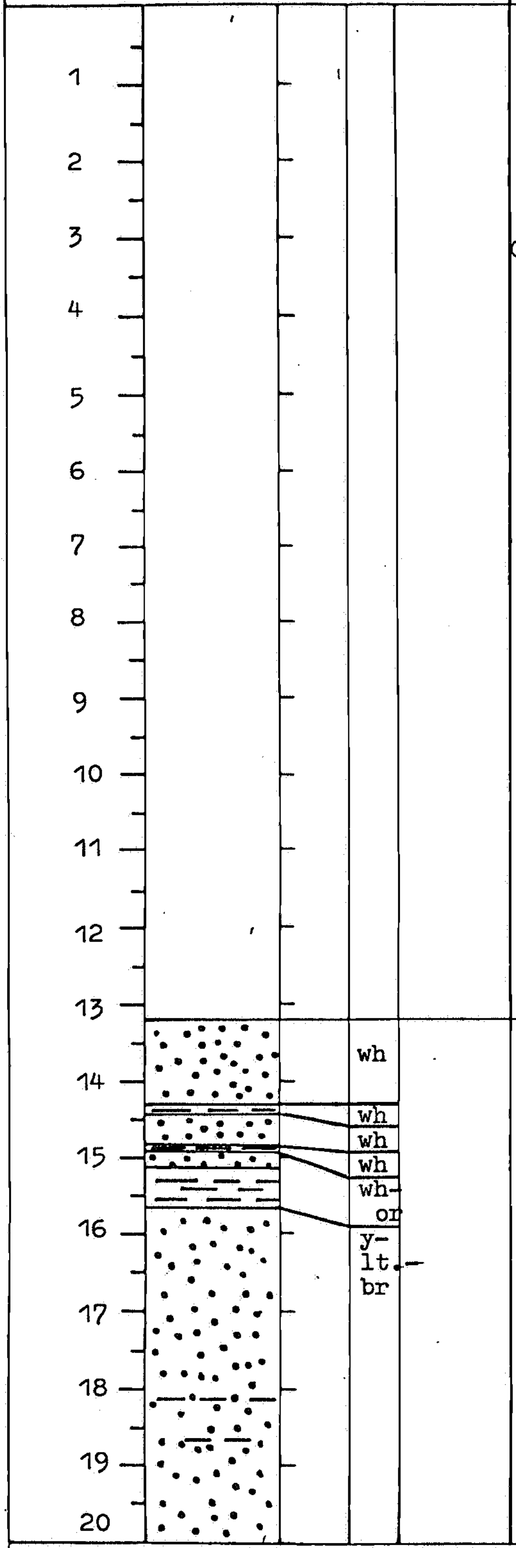
DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1
LOCATION 5 km, 320°T, Marla Bore,
LAT. 27°17' 00"S WINTINNA
LONG. 133°31' 30"E (ANG, provisional)
ELEVATION GR. DATUM
R.T.

Core size: NQ
DEPTH. 13.12-20 m
DATE DRILLED 18-5-79
RECOVERY 6.88 m 100 %
FORMATION Trainor Hill Sandstone

DEPTH (METRES)	GRAPHIC LOG	H/C, Pal.	Col.	Access.	DESCRIPTION



Cuttings: 0-13.12m.

13.12-14.3 Sst., m.-f.g., mod.-well sorted, mod. por.-perm., 10% interstitial kaol., wh. clay i/clasts; wh.-off wh.
14.3-14.4 Clayst., f.g. sandy, wh.
14.4-14.8 Sst., as for 13.12-14.4m.
14.8-14.85 Clayst., as for 14.3-14.4m.
14.85-15.1 Sst., m.g., mod.-poor sort., 10-20% kaol., wh.-y.
15.1-15.7 Clayst., lt. or.-gy.
15.7-22.15 Sst., f.-m.g., well sort., less than 5% kaol., both interstitial and forming whispy wh. lams.; y.-wh. to lt. br.-gy.

LOGGED BY M.C.B.
G.M.P.
DATE 20-5-79
18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 3 OF 27 DRG. NO. S14313c

1639

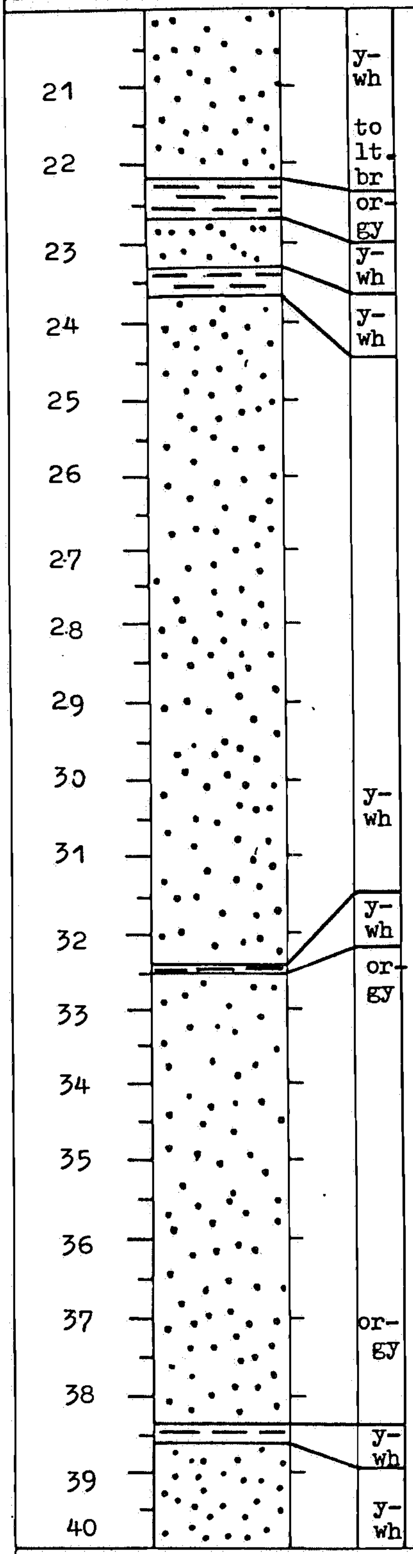
DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1
LOCATION 5 km, 320°T, Marla Bore, WINTINNA
LAT. 27° 17' 00"S
LONG. 133°31' 30"E (ANG, provisional)
ELEVATION GR.
R.T.
DATUM

CORE size: NQ
DEPTH 20-40 m
DATE DRILLED 19-5-79
RECOVERY 20 m 100 %
FORMATION Trainor Hill Sandstone

DEPTH (METRES) | GRAPHIC LOG | H/G, Pal. | Col | Access. | DESCRIPTION



22.15-22.7	Clayst., lt.or.-gy., 5-10% f.g. qz. grains.
22.7-23.3	Sst.,f.g., mod.-well sort., kaol. var. 5-20%, wh. whispy clay lam. foresets dip 15-20°;y.-wh.
23.3-23.7	Clayst.,y.-wh.(kaol.).
23.7-32.4	Sst., f.g.,gen. well sort.; 5-10% wh. clay and clay-rich lams., rare c.g. sst. and clay beds, rare wh. clay i/clasts; y.-wh.
32.4-32.5	Clayst.-v.f.g.sst., y.-wh.
32.5-38.4	Sst., f.-m.g., mod.-well sort., kaol., or.-gy.
38.4-38.6	Clayst., y.-wh., sharp contact at top and base.
38.6-48.0	Sst.,m.-f.g., mod. sort., kaol.,wh.-lt.y., wh. kaol. lams.

LOGGED BY M.C.B.
DATE 21-5-79

PETROLEUM GEOLOGY SECTION

SHEET 4 OF 27 DRG. NO. S14313d

1639

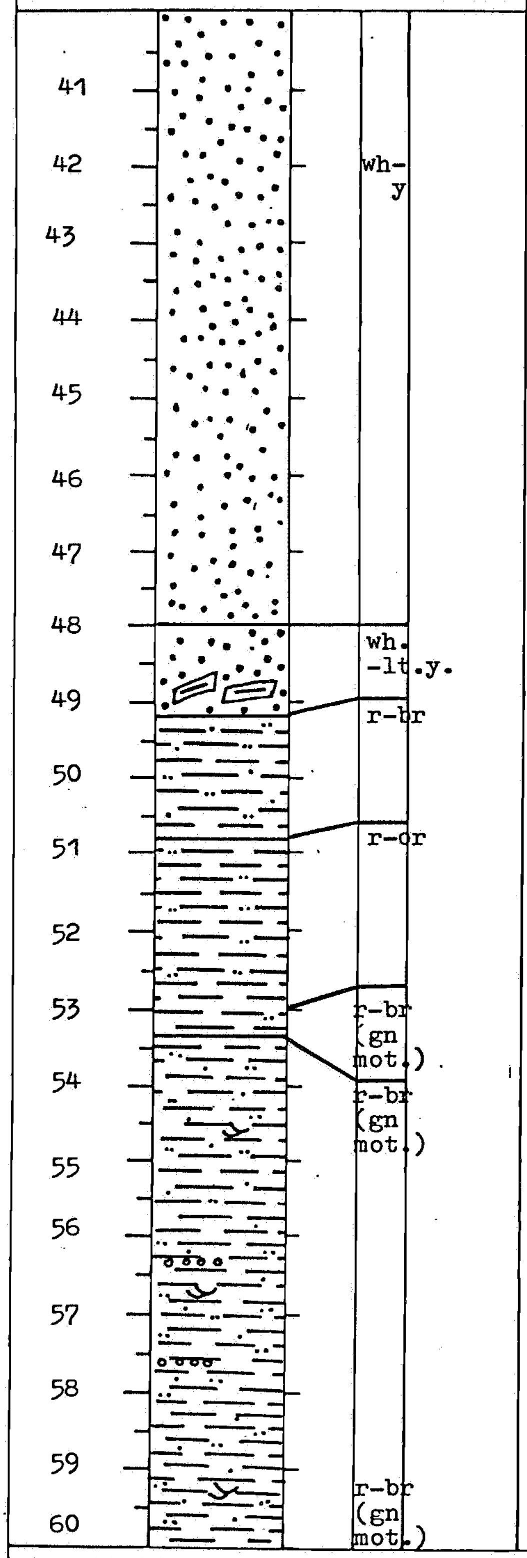
DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1
LOCATION 5 km,320° T,Marla Bore,WINTINNA
LAT. 27° 17' 00"S
LONG. 133° 31' 30"
(ANG, provisional)
ELEVATION GR.
R.T.
DATUM

Core size: NQ
DEPTH 40-60 m
DATE DRILLED 21-5-79
RECOVERY 20 m 100 %
FORMATION Trainor Hill Sandstone

DEPTH (METRES)	GRAPHIC LOG	H/C, Pal.	Col.	Acces.	DESCRIPTION



48.0-49.2 Sst.,kaol.,m.-f.g.,mod. sort.,wh.-lt.y.,wh. kaol. lams.,red clay intraclasts up to 2 cms. rare, grad. base.

49.2- 50.8Clayst.,zty-v.f.g. sandy,mica-rich lams.,lt.-dk. red-br.

50.8-53.4 Clayst.,v.f.g.sandy-zty.,v.f.g.mica-rich lams., lt.red-lt.or.,grades down to clayst.,v.f.g. micac.,red-br.,at base,with 1-5 cm gn. reduct. mottles

53.4-65.5 Clayst.,v.f.g.sandy to zty.,v.f.g.micac.,red-br., mottled with lt.red-br.to gn. thru/out.,structureless to lamd. to v.f. x-b. lams.,some soft sed. def.,10-15 cm litharenite beds at 56.4 and 57.6m,with grains/clasts of gn. mafics,clay,qz. and fsp.

LOGGED BY M.C.B.
G.M.P.
DATE 24-5-79
18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 5 OF 27 DRG. NO. S14313e

1639

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1

LOCATION 5 km, 320°T, Marla Bore, WINTINNA

LAT. 27° 17' 00"S

LONG. 133°31' 30"E (ANG, provisional)

ELEVATION GR.

R.T.

DATUM

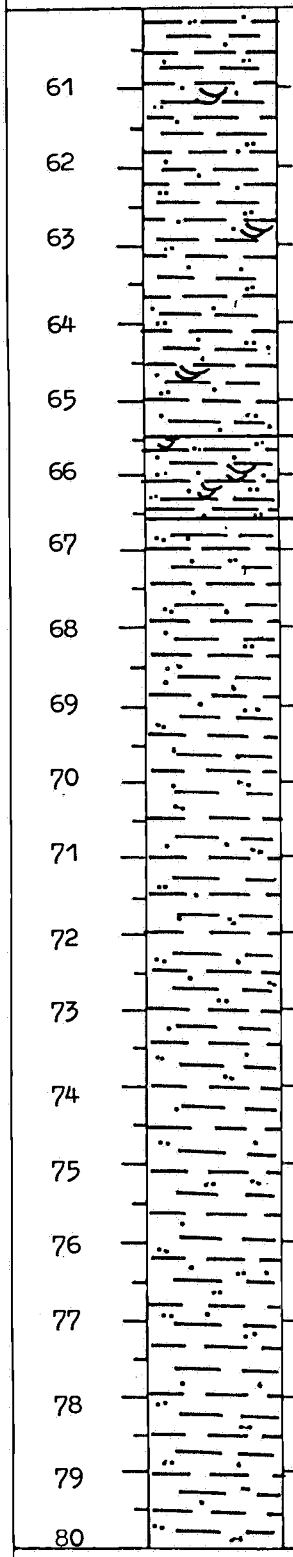
Core size: NQ

DEPTH 60-80m

DATE DRILLED 22-5-79

RECOVERY 20 m. 100 %

FORMATION Trainor Hill Sandstone



DEPTH (METRES)	H/C, Pal.	Col.	Acces.	DESCRIPTION
63		r-br (gn mot)		
66		red (gn mot.)		65.5-66.6 <u>Siltst.-clayst</u>.,i/layd. and i/lamd. with f.-m.g. <u>sst</u>.;predom. red,some gn. layers,lt.gn. mottling,some areas of soft sed. disruption.
67		r-br (gn mot.)	s/e	66.6-91.2 <u>Siltst.-clayst</u>.,with v.f.g.sandy micac.lams.; <u>lamd. to thinly</u> layd.,structureless at places, lt.-dk. red-br.,lt.gn. mottles and i/layers thru/out,irreg. calc. and/or kaol.i/layers at places, scattered flecks of ?carb. thru/out.
72		r-br (gn mot.)	s/e	
79		r-br (gn mot.)	s/e	

LOGGED BY M.C.B.
G.M.P.

DATE. 24-5-79
18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 6 OF 27

DRG. NO. S 14313f

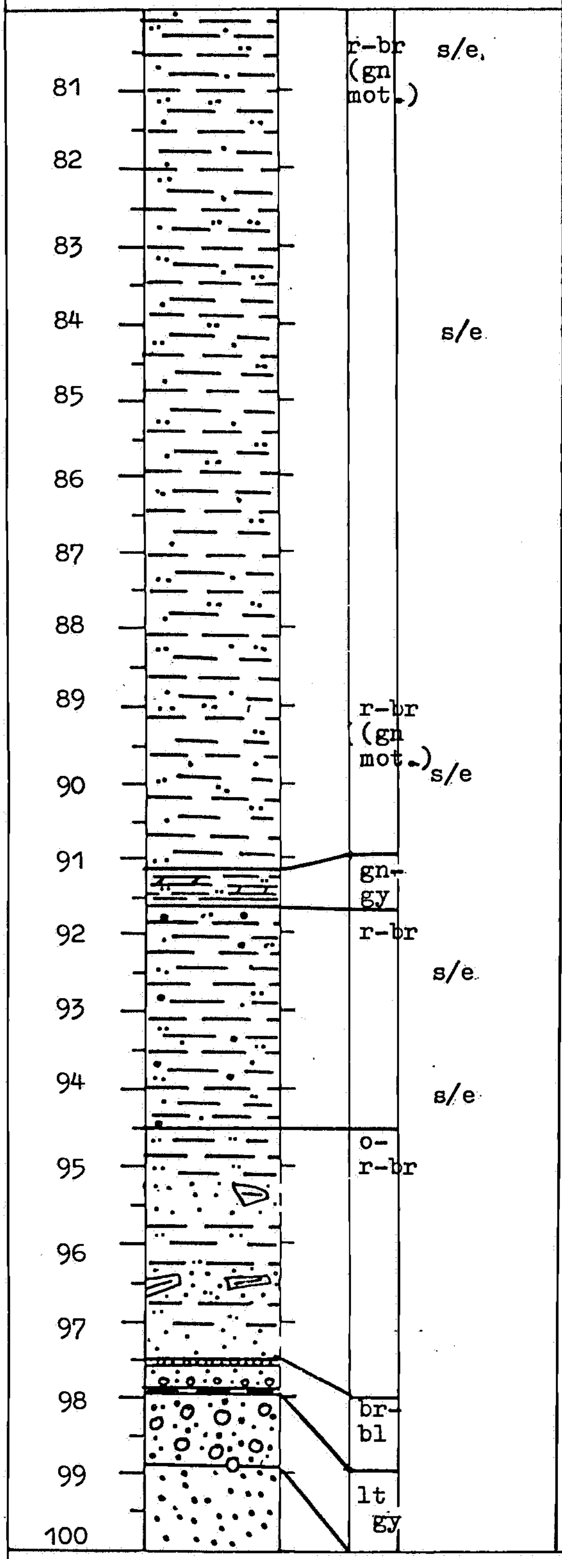
1639

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOCRA 1
Core size: NQ
LOCATION 5 km, 320°T, Marla Bore, WINTINNA
DEPTH 80-100m
LAT. 27° 17' 00"S
DATE DRILLED 24-5-79
LONG. 133° 31' 30"E (ANG, provisional)
RECOVERY 20 m 100 %
ELEVATION GR.
R.T.
DATUM
FORMATION Trainor Hill Sandstone

DEPTH (METRES)	GRAPHIC LOG	H/C, Pal.	Col	Access.	DESCRIPTION



91.2-91.6 Siltst.-clayst., gn.-gy.; i/layd. with 1-20 mm beds of dolomite/dol.siltst., off-wh., f.g., lams. irreg. and anastomosing.

91.6-94.5 Clayst.-siltst., var. sandy-gritty, lt.-dk. red-br.; m.g. wh. ?carb. flecks (?evaporitic); i/lams. of clayey v.f.g. sand, whispy, irreg., off-wh.; o.1-1.0 cm gn. mottles.

94.5-97.5 A.A.; i/layd. with sst., f.-m.g., lt.or. to lt. red-br., clayey, with red-br. clay i/clasts and whispy clay x-b i/lams. Sharp contact at base.

97.5-97.55 Sandst., f.-m.g., grading to granule congl. (single 5 cm graded bed), all clasts pale, bleached, matrix iron-cemented, sl.-mod. perm., sharp base.

97.55-97.9 Sandst., zty., v.f.-v.c.g., v.ferrug., dk.br. to bl.; o/lies pebble congl., poorly graded, off wh. to dk. br., includes qz.-fsp. basement clasts.

97.9-97.93 Siltst., v.ferrug., 3 cm bed.

97.93-98.8 Congl., clasts up to 3 cm; matrix m.g. sand, off-wh. to lt.br.; v. porous; sharp, discordant base, clast penetrates sand unit below.

LOGGED BY M.C.B.
G.M.P.
DATE. 25-5-79
18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 7 OF 27
DRG. NO. S 14313g

1639

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1

LOCATION 5 km, 320°T Marla Bore, WINTINNA

LAT. 27° 17' .00"S

LONG. 133°31' 30"E (ANG, provisional)

ELEVATION GR.

R.T.

DATUM

Core size: NQ

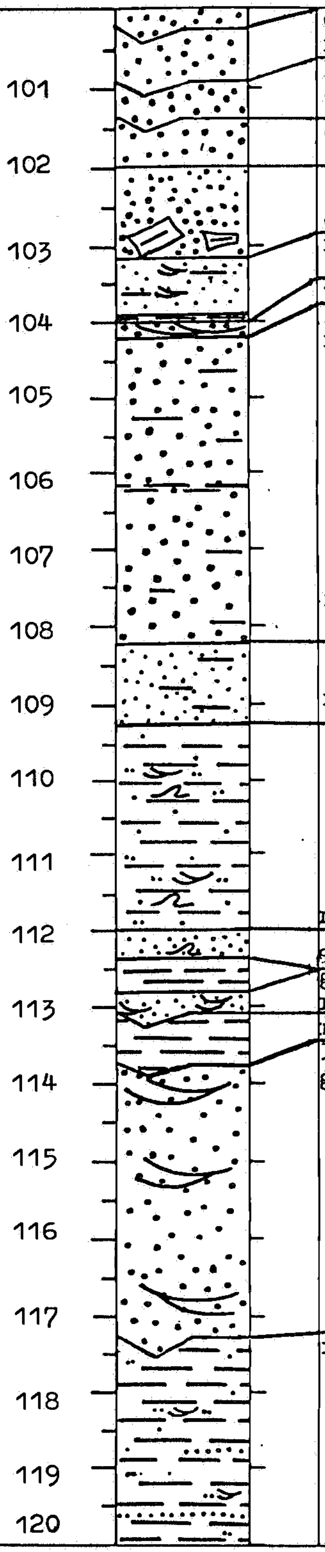
DEPTH 100-120m

DATE DRILLED 26-5-79

RECOVERY 20 m 100 %

FORMATION Trainor Hill Sandstone

DEPTH (METRES)	GRAPHIC LOG	H/C Pal.	Col.	Acces.



Col.: dk r-or; lt or; or; or; r-br; wh; or-; r-br; r-br; r-br; r-br; gy-br; gy-; r-br; r-br; lt gy-br; r-br

DESCRIPTION

98.8-99.8	Sst., m.g., even gr., sl.-mod. perm., sl. kaol., col. grades lt. red-or. at top to lt. red-br. at base, non-layd., non-calc.
99.8-100.2	Sst., f.-m.g., even gr., mod. perm., sl. kaol., lt. red-or., circular pits at top due to irreg. lithif., sharp colour change at discordant base.
100.2-100.9	Sst., f.-m.g., even gr., dk. red-or., non-layd., non-calc., sharp col. change at discord. base.
100.9-101.3	Sst., m.g., sl. perm., kaol., micac., off-wh. to lt. or., rare red clay i/clasts, non-layd., non-calc., sharp col. change at discord. base.
101.3-102.0	Sst., f.-m.g., por.-perm., clean, non-calc., v. faint layg., non-lithif. pits on core surface.
102.0-103.2	Sst., f.-m.g., clean to sl. kaol., lt. or. to lt. red; coarsens towards base, becoming por.-perm., layg. v. faint to absent, 2-3 cm red clay clasts, sharp base.
103.2-103.9	Sst., v.f.g., non-perm., micac., lt.-med. red-br.; with clayey, micac., i/lamd. x-bs., dk. red-br.; non-calc.
103.9-103.95	Clayst., zty., red-br., 5 cm i/bed.
103.95-104.2	Sst., m.g., faintly layd., apparent dip of 20-30° (prob. x-b. foresets), off-wh.
104.2-108.1	Sst., f.-m.g., mod. por.-perm., lt. or.-red to dk. red br.,; with clayey, micac., red-br., x-b. i/lams., and clayst. i/bed at 106.2.
108.1-108.2	Clayst., red-br., non-calc.,; with siltst-v.f.g. sst. i/lams., lt. gy., 10 cm bed, sharp top, base.
108.2-109.2	Sst., v.f.g., micac., lt. red-br.; with i/lamd. x-bs. of clay, red-br.; non-calc.; sst predom.
109.2-112.0	Clayst., red-br., f.g. micac., i/lamd. with lesser v. lt. red-br. v.f.g. sst. and zst. x-bs. (micac.); soft sed. deform. structs.
112.0-112.3	Sst., f.-v.f.g., gy.-br.; dk. col. millimetric parallel lams. v. rich in c.g. mica (?bi.); sharp base showing soft sed. deform.
112.3-112.8	Clayst., red-br., v.f.g. micac.
112.8-113.05	Sst., f.-v.f.g., gy. to red-br., fine x-bs with mica-rich lams.; sharp base, cut into unit below.
113.05-113.8	Clayst., red to red-br., sharp base, cut into unit below.
113.8-117.3	Sst., m.-f.g., sl. kaol., v. micac., sl.-non-por.-perm., lt. gy. to v. lt. red-or.; minor coarser gn. beds, rare micac. lams.; prob. reps. 3-4 x-b sets; sharp base, strongly x-cut into u/lying clay; non-calc.
117.3-121.3	Clayst., red-br. to dk. red-br., lamd., soft sed def. structs.; f.g. micac.; rare millimetric gn. mottles; lesser i/lamd. and i/bed. v.f.g. sst. and zst. (micac., lt. red-br. and finely x-b.); two 5-10cm off-wh. sst. i/beds.; v. sharp x-cut base.

LOGGED BY M.C.B.
G.M.P.

DATE 27-5-79
18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 8 OF 27

DRG. NO. S 14313h

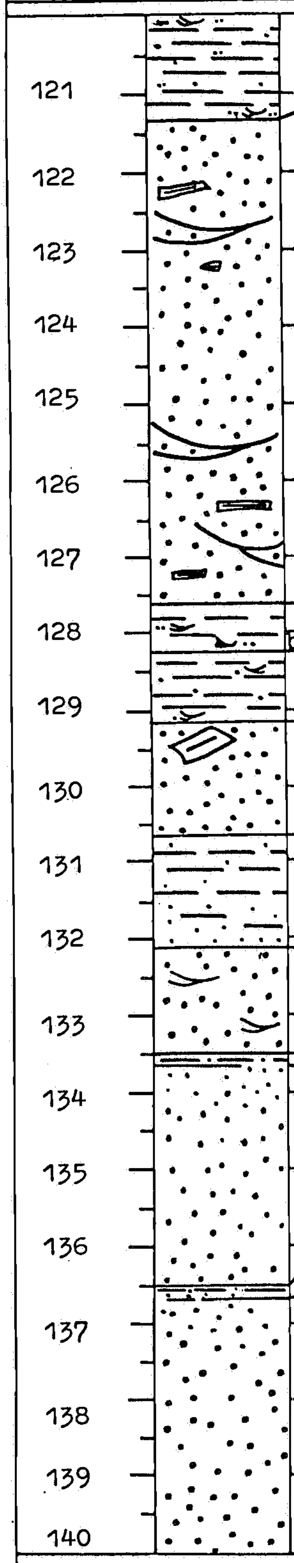
1639

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1.
LOCATION 5 km, 320°, Marla Bore,
LAT. 27°17' 00"S WINTINNA
LONG. 133°31' 30"E (ANG, provisional)
ELEVATION GR. DATUM
R.T.

Core size: NQ
DEPTH 120-140m
DATE DRILLED 28-5-79
RECOVERY 20 m 100 %
FORMATION Trainor Hill Sandstone



DEPTH (METRES)	H/C, Pal.	Col	Access.	DESCRIPTION
121.3-127.65		lt gy-br lt gy-br		Sst., f.-m.g.,kaol., micac., vuggy, v.lt.gy.-or.; prob. reps. lge.-scale x-l. sets; tabular red-br. clayst. i/clasts orient. // to bedding; variably sl. calc.
127.65-128.25	bio	r-br		Clayst., red-br., v.f.g. micac.; zty.-v.f.g. sandy x-b. lams., v.micac., lt. red-br.; poss. bioturb. (worm tubes or rootlets) on bedding surface at 128.20m.
128.25-129.1		r-br		Clayst., red to red-br., v.f.g. micac.; sst., v.f.g., lt.red-br., non-calc., fi. x-b., with small clayst. i/clasts and micac. i/lams.
129.1-130.7		or-gy		Sst., f.-m.g., lt.or-gy., v.sl.calc. at places lge. red-br. clayst. i/clast near top; sharp top and base.
130.7-132.1		dk r-br		Clayst., dk.red-br., 5-10 cm bed, grades down to sst., v.f.g.; gy-br, v. mica-rich lams., non-calc.
132.1-133.5		wh-br		Sst., f.-m.g., off-wh. to lt.br., kaol., v. micac., x-b. lams. at places, irreg. subvert. joints.
133.5-133.65		r-br		Clayst., red-br., zty., v.f.g. micac., sharp top, grad. base, forms graded bed with unit below.
133.65-136.5		wh-br		Sst., f.-m.g., as for 132.1-133.5 m.
136.5-136.7		lt r-br		Clayst., lt. red-br., zty., lamd., 'vein' of f.-m.g. sand injects vertically with some assoc. alteration; grad. contact with sst. below.
136.7-142.25		lt gy- lt r-br		Sst., f.-m.g., lt.gy. to v.lt.red-br., sl. kaol., unlayd. to v. fi. lamd. with f.g. micac. lams., sl. por-perm.,non-calc.,sharp base.

LOGGED BY G.M.P.

DATE. 3-6-79

PETROLEUM GEOLOGY SECTION

SHEET 9 OF 27 DRG. NO. S14313i

1639

47

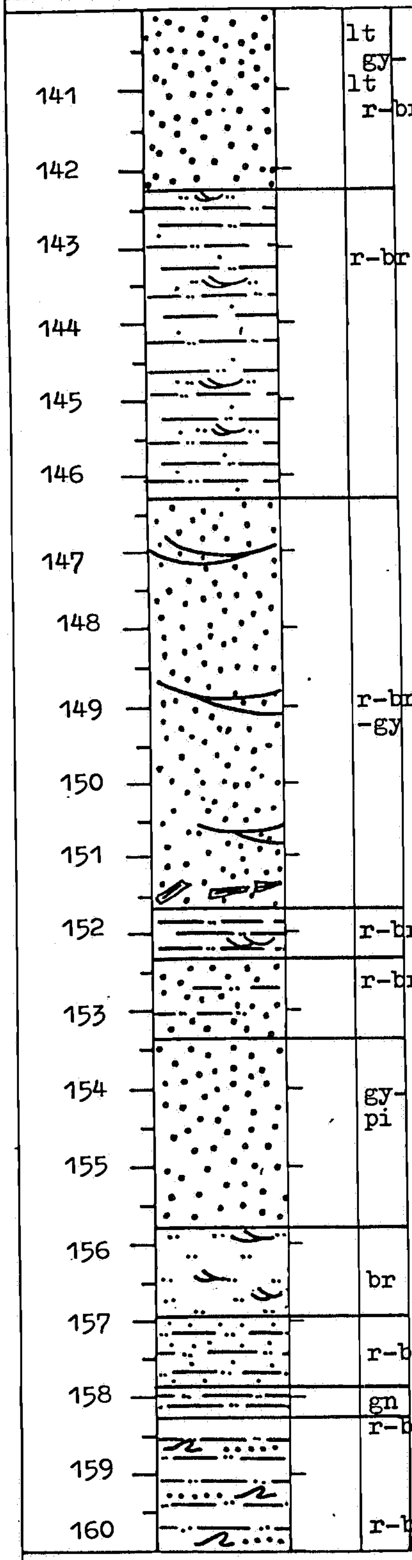
DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1
LOCATION 5 km, 320°T, Marla Bore, SWINTINNA
LAT. 27° 17' 00"S
LONG. 133°31' 30"E (AN G, provisional)
ELEVATION GR.
R.T.
DATUM

Core size: NQ
DEPTH 140-160 m
DATE DRILLED 29-5-79
RECOVERY 20 m 100 %
FORMATION Trainor Hill Sandstone, Observatory Hill Beds

DEPTH (METRES) | GRAPHIC LOG | H/C, Pal. | Col. | Acce ss. | DESCRIPTION



142.25-146.35	Clayst.-zst., red-br., zst.-v.f.g. sst. x-b. i/lams., soft sed. deform., some gn. clayst.-zst. i/beds; sharp base.
146.35-151.7	Sst., m.g., clean, mod. well sort., sl. por.-perm., sl. kaol., v.lt.red-br. to gy.; faintly but well layd., prob. lge. x-b. sets; subvert.-irreg. joints; basal 20 cm contains small tabular clay i/clasts; sharp base.
151.7-152.4	Clayst., zty., micac., parallel and x-b. lamd. sharp base, red-br.
152.4-153.4	Sst., m.g., porous, m.-dk.red-br., micac.; wit v.f.g. sandy-zty., micac., red clay i/beds.
153.4-155.8	Sst., m.g., por., sl. perm., gy.-pink, sl. kaol., non-calc., gen. no layering.

Base of Trainor Hill Sandstone at 155.80 m ; defined herein as the base of lowermost f.-m.g. sandstone.

155.8-156.9	Zst., br., micac., x-b.lamd.
156.9-157.9	Clayst., zst., sst., v.f.g., i/bedded and x-b. i/lamd., red-br., v.f.g. mica, non-calc.
157.9-158.3	Clayst.-zst., lt. gn. to dk.gn.-br., micac.
158.3-161.4	Clayst., red-br., v.f.g. micac., non-calc.; i/layd. with lesser sst., f.-m.g., kaol., forming i/beds which are slumped, disrupted, or injected up/down into the clayst.; graded f.g. sst. bed, with sharp base and grad. top, at the base of the unit.

LOGGED BY G.M.P.
DATE 3-6-79

PETROLEUM GEOLOGY SECTION

SHEET 10 OF 27 DRG. NO. S 14313 j

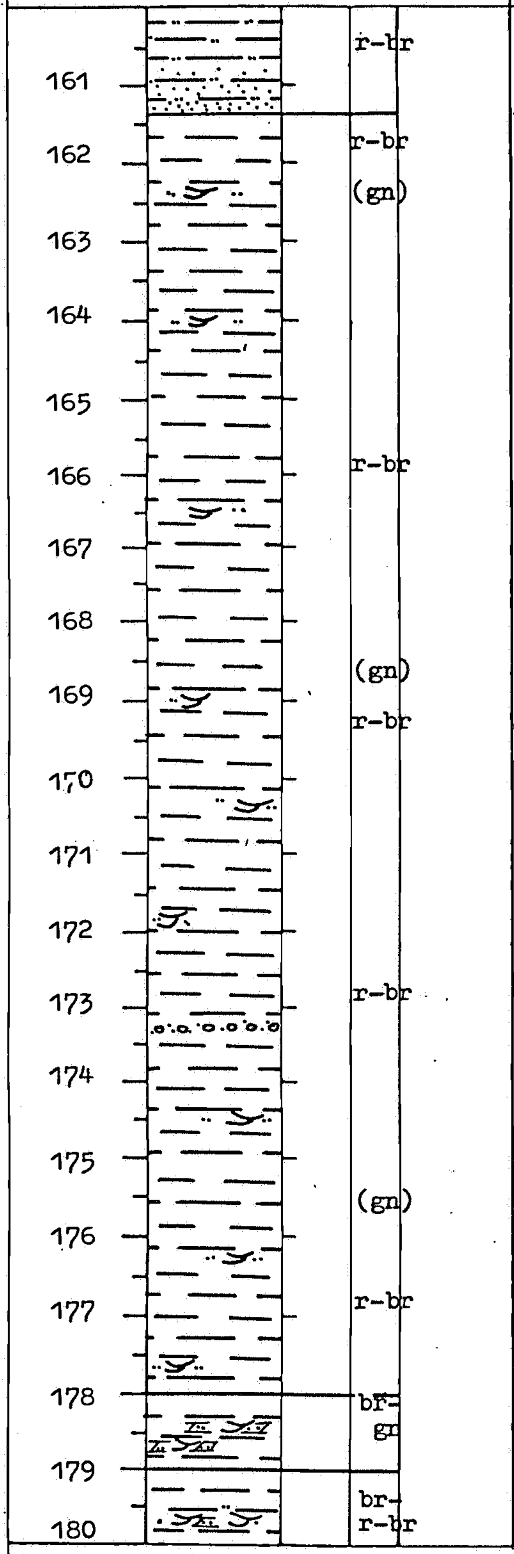
1639

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1
LOCATION 5 km, 320°T, Marla Bore,
LAT. 27° 17' 00"S WINTINNA
LONG. 133°31' 30"E (ANG, provisional)
ELEVATION GR.
R.T.
DATUM

CORE size: NQ
DEPTH 160-180 m
DATE DRILLED 30-5-79
RECOVERY 20 m 100 %
FORMATION Observatory Hill Beds



DESCRIPTION	
161.4-178.0	Clayst., predom. red-br. lesser gn. beds and lt.gn. mottles; occas. v.f.g. sandy-zty., i/lamd. x-bs.; non-calc.; granule cgl.,partly i/clastic and with rare carbonate clasts, single 10 cm bed at 173.3-173.4 m.
178.0-179.0	Clayst., br.-gn., lamd., non-calc.; with v.fi. i/lam. x-bs. of zt. to v.f.g. sst.,calc.
179.0-188.9	Clayst., br. to red-br., lamd. to massive, lt.gn. mottles; i/lamd. with zst.-sst.,v.f.g., v.fi. x-bs., micac., calc. (clayst. is non-cal

LOGGED BY G.M.P.

DATE 3-6-79
18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 11 OF 27 DRG. NO. S14313k

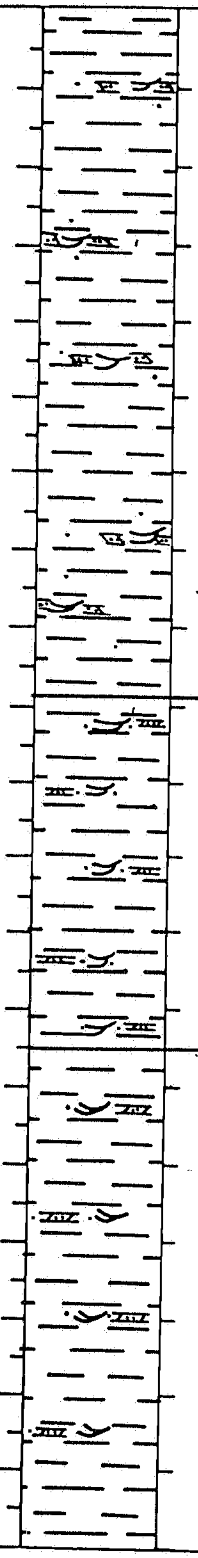
1639

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAORA 1
LOCATION 5 km, 320°T, Marla Bore, WINTINNA
LAT. 27° 17' 00"S
LONG. 133°31' 30"E (ANG, provisional)
ELEVATION GR.
R.T.
DATUM

CORE size: NQ
DEPTH 180-200 m
DATE DRILLED 31-5-79
RECOVERY 20 m 100 %
FORMATION Observatory Hill Beds



DEPTH (METRES)	GRAPHIC LOG	H/C, Pal.	Col.	Access.	DESCRIPTION
181			br-r-br		
182					
183			lt gn mott.		
184					
185					
186					
187			br-r-br		
188					
189			gn/br		188.9-193.5 <u></u>A.A., alternating gn. and br. beds on 0.1-5 cm scale.
190					
191					
192			gn/br		
193					
194			gn		193.5-200.5 A.A., gn. only.
195					
196			gn		
197					
198					
199					
200			gn		

LOGGED BY G.M.P.

DATE 3-6-79
18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 12 OF 27

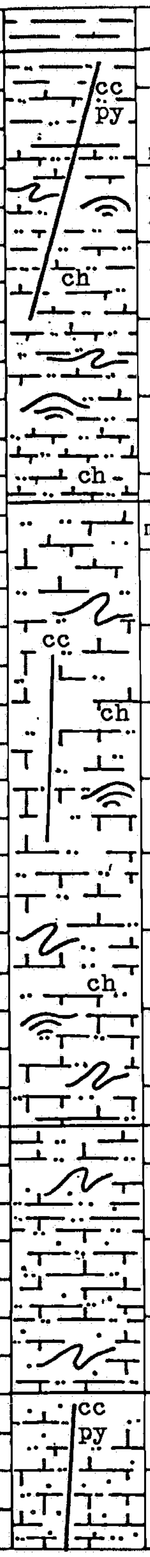
DRG. NO. S143131

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAORA 1
LOCATION 5 km, 320°T, Marla Bore, WINTINNA
LAT. 27° 17' 00"S
LONG. 133°31' 30"E (ANG, provisional)
ELEVATION GR.
R.T.
DATUM

CORE SIZE: NQ.
DEPTH 200-220 m
DATE DRILLED 1-6-79
RECOVERY 20 m 100 %
FORMATION Observatory Hill Beds

DEPTH (METRES)	GRAPHIC LOG	H/C, Pal.	Col	Access.	DESCRIPTION
201 202 203 204 205 206		mf a wo wo bit so so a	gn-gy gn-gy	ccv pyv	200.5-206.3 Clayst.-zst.,gn.-gy., becoming calc. and grading to zty. lst.,layd. to lamd.; v.calc. v.f.g sandy to zty. x-b. i/lams. and i/beds, which often form disrupt. beds due to soft sed. def. with a pyic. cc-rich 'mash'at 200.60 and 201.40 m; cc., cc.-py., and py. veins, subvert. and sub-horiz.; regular, wavy lam. thru/out prob. of cryptalgal origin, ??t/bite cast at 201.90 m, grooved fossil frag. (? t/bite) at 200.55m; h/c odour, weak, at 202.50-202.90 m, h/c odour from wavy submil. organic-rich (?algal) lams. thru/out, steep dipping cc. vein encl. bituminous h/c at 203.50 m; h/c odour, strong, down from 203.5m, chert nodules. Fluorescence assoc. only with vug of visible h/c. Poss. t/bite cast at 201.90 m.
207 208 209 210 211 212 213 214		mf a a	gy to gn-gy	pyd s/e pyd pyd s/e pyd ?pyd	206.3-214.5 Zst., v.calc., or zty.lst., m.-dk.gy. to gn.-gy., layd to lamd.; much soft sed. disruption, slumping and sst.-zst veining; v. calc. and dissem. v.f.g. py. thru/out; rare subvert. cc veins; prob. cryptalgal lam.; scattered chert nodules; some zones 'speckled' with possible evap. minerals. Poss. acicular fossil fragments at 206.85 m.
215 216 217			br br		214.5-218.0 Zst.-sst.,v.f.g., v.calc.,or zty.lst., lt.-med. br.; minor clayst., non-calc., med.-dk. br.,possibly pyic.; coarser fraction of the zty. lst. forms lter. col. whispy lams. and beds, and outline areas of soft sed. def. no discern. h/c odour.
218 219 220		bl-o	br	pyv cc-pyv	218.0-225.4 A.A., sl.incr. content of v.f.g. sst.,v.lt. br.-gy., at the expense of non-calc. clay; subvert. cc. and cc-py veins at 218.0-220.3m, with py-lined vugs which bleed dk. br. semi-viscous oil:lge. vug, 15×5 mm at 219.55 m, no assoc. h/c odour.

LOGGED BY G.M.P.

DATE 3-6-79
18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 13 OF 27 DRG. NO. S 14313m

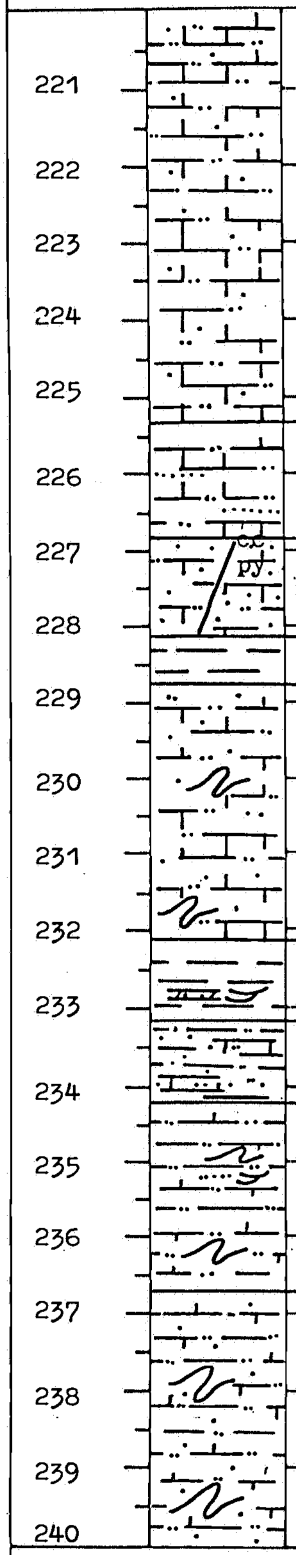
1639

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1
LOCATION 5 km, 320°T, Marla Bore, WINTINNA
LAT. 27° 17' 00"S
LONG. 133°31' 30"E (ANG, provisional)
ELEVATION GR.
R.T.
DATUM

CORE SIZE: NQ
DEPTH 220-240 m
DATE DRILLED 4-6-79
RECOVERY 20 m 100 %
FORMATION Observatory Hill Beds



H/C, Pal.	Col.	Access.	DESCRIPTION	
	br-gy			
	gn-gy	pyd	225.4-226.9	Zst., calc. or zty.lst., gn.-gy., lamd. to thin bedded with i/layers of sst., v.f.g., lt. gy.; minor microfaulting; rare dissem. py., v.f.g.
bl-c bit	gn-gy	pyd cc-pyv	226.9-228.1	Zst.-sst.,v.f.g., calc., or zty.-v.f.g. sandy lst., all layg. destroyed by bioturb. or soft sed. def.; rare py., dissem.,v.f.g., py. on joint faces; cc. veins bleeding minor viscous oil to bituminous h/c.
		s/e	228.1-228.7	Clayst.,br., micac., non-calc.; prob. mudcracks; irreg. calc. spotting, prob. evap. origin.
	gy-gn/br		228.7-232.1	Zst, calc.,or zty.lst., dk.gy.-gn. to gy.-br., sst., v.f.g., calc.,i/beds, micac.; disrupted layg.,zst.-v.f.g.sst. injection veins.
	r-br		232.1-233.2	Clayst.-zst., red-br., non-calc.,micac., i/lamd. with x-bs. of zst.-sst.,v.f.g., lt. red-br. to off-wh., v. calc.
	lt r-br		233.2-234.2	Clayst.-sst.,v.f.g., lt.red-br., with i/layers of red-br. clay i/clasts; the v.f.g. sst. i/lams. and i/layers are lighter col. and calc., remainder is non-calc.
	gy-br		234.2-236.7	Zst.-clayst., gy.-br., with sst.,v.f.g., lt. gy.-br.,calc., as x-b. i/lams. and i/layers up to 5 mm thick; small-scale soft sed. def. structs., v.f.g.sst. injection veins.
	gy-br (gn)		236.7-240.0	Zst.-clayst., predom. gy.-br., lesser gn., calc., micac.; with x-b. i/lams. and i/layers of zst.-sst.,v.f.g., v. calc.; soft sed. def. with two assoc. patches of chert breccia and disrupted fine beds,lams., etc.

LOGGED BY G.M.P.
DATE 8-6-79
18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 14 OF 27 DRG. NO. S 14313n

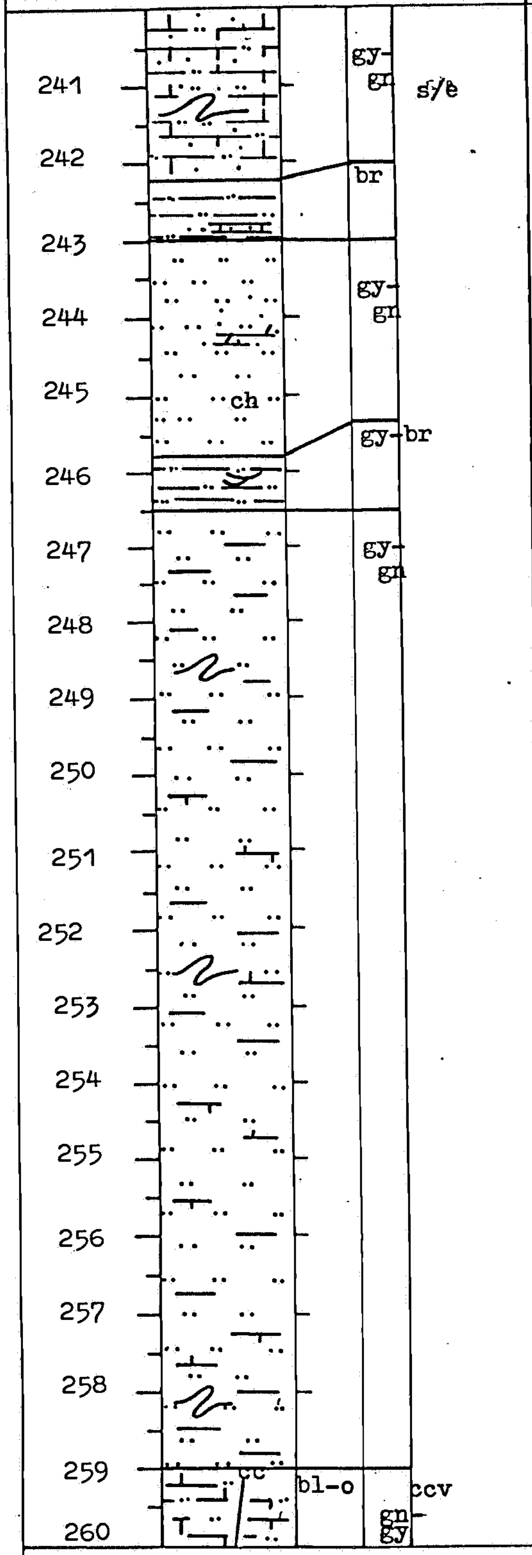
DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1.
LOCATION 5 km, 320°T, Marla Bore,
LAT. 27° 17' 00"S WINTINNA
LONG. 133°31' 30"E (ANG, provisional)
ELEVATION GR.
R.T.
DATUM

CORE SIZE: NQ
DEPTH 240-260 m
DATE DRILLED 5-6-79
RECOVERY 20. m 100 %
FORMATION Observatory Hill Beds

DEPTH (METRES) | GRAPHIC LOG | H/C, Pal. | Col | Access.



DESCRIPTION	
240.0-242.2	Lst., zty.-v.f.g.sandy (calc. v.f.g. sst.-zst.), dk.gy. to gy.gn.; rare cherty i/clasts; some soft sed. def. and v.f.g. sst. injectipn veins; some homogeneous zty. lst. patches are spotted with evap.-originated mineral.
242.2-243.0	Zst.-clayst., br., micac.,non-calc., lamd.; with i/layers and lams. of v.f.g. sst., off-wh., calc.
243.0-245.8	Zst., lt. gy.-gn., micac., non-calc.; rare chert nodules //to bedding; lamd. to unstructured; zst-v.f.g.sst.,v.lt.gy., v.calc., two 10 cm beds at 243.8 and244.8 m.
245.8-246.5	Zst.-claysst., gy.-br., micac.,lamd.;zst.-v.f.g.sst. x-b.lams., lt. red-br.; non-calc.
246.5-259.0	Zst., zst.-clayst., lt.-dk. gy.-gn., micac., var. mod. calc. to non-calc.;lamd. to thinly i/bedded with zst.-sst.,v.f.g., calc., lt. gy., lams. are graded; soft sed disruption struct., disrupted bedding, clastic injectinn veins, etc.

LOGGED BY G.M.P.
DATE 8-6-79
18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 15 OF 27 DRG. NO. S 14313o

1639

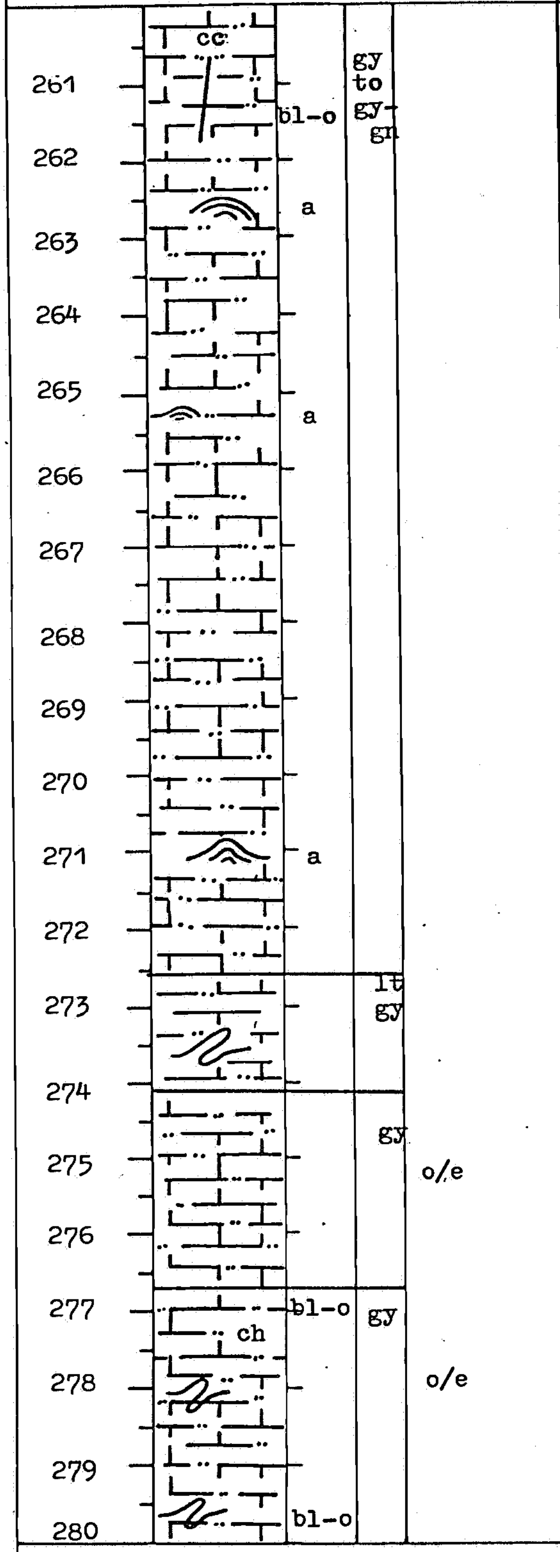
DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAQORA 1
LOCATION 5 km, 320°T, Marla Bore, WINTINNA
LAT. 27°17' 00"S
LONG. 133°31' 30"E (ANG,provisional)
ELEVATION GR.
R.T.
DATUM

CORESIZE : NQ
DEPTH 260-280 m.
DATE DRILLED 6-6-79
RECOVERY 20 m 100 %
FORMATION Observatory Hill Beds

DEPTH (METRES) | GRAPHIC LOG | H/C, Pal. | Col. | Access.



	DESCRIPTION
259.0-272.6	Lst.,zty.(calc. zst.-v.f.g.sst.), gy. to gy.-gn., gen. well lamd., 'chert breccia' layer; convoluted to wavy v.lt.gy. to off-wh. lams. are prob of cryptalgal origin; subhoriz. and subvert. cc. veins with millimetric vugs bleeding light oil at 259.15 and 261.20-261.50 m.
272.6-274.1	Lst.,zty.(calc. zst.), lt. gy.-off-wh., v. hard/Indurated,well lamd. tothin layd., soft sed. def. structs.
274.1-276.7	Lst.,zty.(calc. zst.), gy., lamd. to structureless; spotted with numerous millimetric sub-circular xls. (?evap. min.); cherty nodules.
276.7-284.6	Lst.,zty.(calc. zst.), lt.-dk. gy. , massive/unlayd. to lamd.(?cryptalgal); cherty layers,disrupted beds and nodules; spotted thru/out with subcircular, acicular and 'feathery' xls,all now ?cc., prob. replacing orig. evap. minerals; soft sed. def. of the zone results in convoluted textures formed from distortion of the original radiating xl. fabrics; low density oil bleeds from millimetric vugs over whole length of unit.

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DATE 8-6-79
18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 16 OF 27
DRG. NO. S 14313p

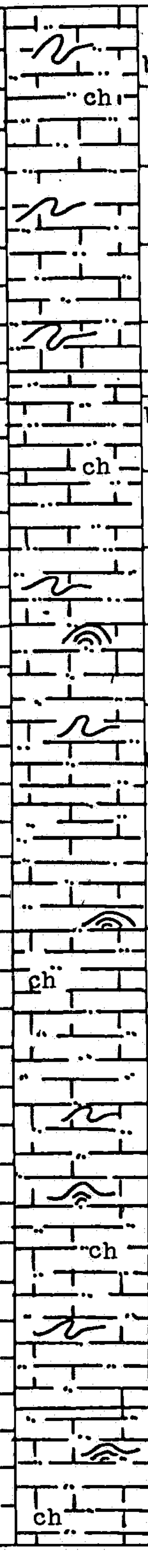
1639

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1
LOCATION 5 km, 320°T, Marla Bore,
LAT. 27°17' 00"S WINTINNA
LONG. 133°31' 30"E (ANG, provisional)
ELEVATION GR. DATUM
R.T.

CORE SIZE: NQ
DEPTH 280-300 m
DATE DRILLED 7-5-79
RECOVERY 20 m 100 %
FORMATION Observatory Hill Beds



DEPTH (METRES)	H/C, Pal.	Col	Access.	DESCRIPTION
			o/e	
281	bl-c	gy		284.6-298.2 Lst., zty. (calc. zst.), m.-dk. gy., lamd. to thin layd.; chert nodules; soft sed. def. structs., with some areas completely disrupted; some areas spotted with millimetric subcircular xls dispersed through matrix.
282				
283				
284			o/e	
285	bl-c		a,f/e	
286		gy		
287				
288	a			
289	bl-c			
290			a,f/e	
291				
292	a			
293	bl-c	gy		
294				
295	a			
296				
297	bl-c		a,f/e	298.2-316.6 Lst., zty., lt.-dk. gy., well lamd. (cryptalgal) beds alternate with massive, unstructured beds of calc. zst./zty. lst. which contain numerous stubby, euhedral xls. of cc. prob. replacing an earlier evap. mineral; scattered chert nodules; oil bleeds from millimetric vugs thru/out.
298	a	gy	a/e	
299	bl-c			
300				

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DATE. 8-6-79
18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 17 OF 27 DRG. NO. S14313q

1639

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1
LOCATION 5 km, 320°T, Marla Bore;
LAT. 27°17' 00"S WINTINNA
LONG. 133°31' 00"E (AN G, provisional)
ELEVATION GR.
R.T.
DATUM

CORE SIZE : NQ
DEPTH 300-320 m
DATE DRILLED 8-6-79
RECOVERY 20 m 100 %
FORMATION Observatory Hill Beds

DEPTH (METRES)	GRAPHIC LOG	H/C pal	Col	Access.	DESCRIPTION
		a	gy	o/e	
301		bl-o			
302					
303					
304			gy		
305				o/e	
		a			
306					
307					
308		bl-o			
309					
310					
311		a	gy	o/e	
312					
313					
		bl-o			
314					
315		a			
316				o/e	316.6-322.5 Lst.,zty., gy.,alt. beds lamd. and massive; lams. prob. cryptalgal in part; acicular, radiating, 'feathery' aggregates of carbonate prob. cc. after an earlier evap. mineral; oil bleeds from scattered vugs, 1-(rarely)10 mm dia.
317		bl-o	gy	f/e	
318		a			
319		bl-o			
				f/e	
320		a			

LOGGED BY G.M.P.

DATE 10-6-79
18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 18 OF 27 DRG. NO. S 14313r

1639

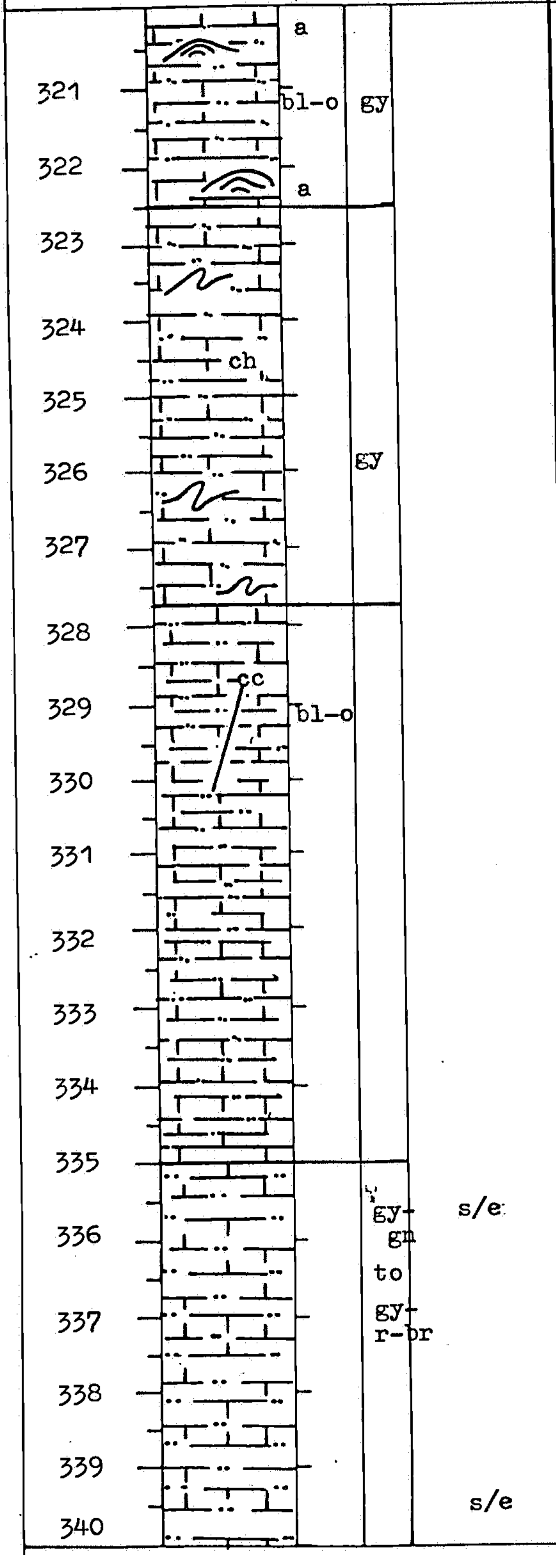
DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1
LOCATION 5 km, 320°T, Marla Bore, WINTINNA
LAT. 27° 17' .00"S
LONG. 133°31' .30"E (ANG, provisional)
ELEVATION GR.
R.T.
DATUM

CORE SIZE: NQ.
DEPTH 320-340 m
DATE DRILLED 11-6-79
RECOVERY 20 m 100%
FORMATION Observatory Hill Beds

DEPTH (METRES)	GRAPHIC LOG	H/C, Pal.	Col	Access.	DESCRIPTION



322.5-327.8 Lst., zty.-v.f.g. sandy, lamd. to thin bedded, med. gy., rare cherty layers and concretions, whispy to lenticular layering, soft sed. disruption.

327.8-335.0 Lst., zty.-v.f.g. sandy, oil bleeds from cc. vein and vug at 329.8 m.

335.0-356.0 Zst., calc., gy.-gn. to greyish red-br., flecked thru/out with acicular xls. and xl. aggregates which react to acid, prob. cc.; no bedding structs. preserved due to soft sed. def. and/or bioturbation, leaving whispy, irregular patches which are coarser-grained (zty.-v.f.g. sandy) and v.f.g. micac.

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DATE 18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 19 OF 27 DRG. NO. S 14313 s

1639

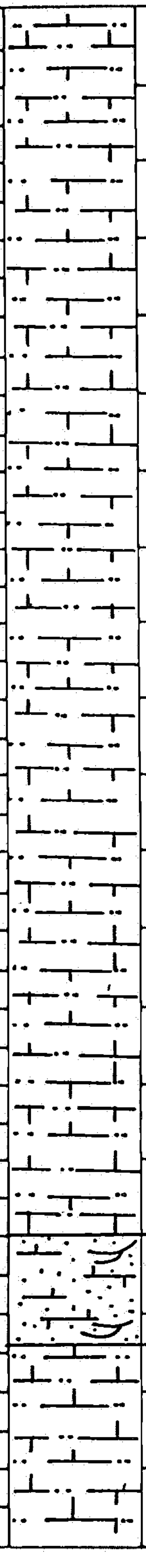
DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

1

WELL BYILKAOORA 1
LOCATION 5 km, 320°T, Marla Bore, WINTINNA
LAT. 27° 17' 00"S
LONG. 133°31' 30"E (AN G, provisional)
ELEVATION GR.
R.T.
DATUM

CORE SIZE: NQ
DEPTH 340-360 m
DATE DRILLED 12-6-79
RECOVERY 20. m 100. %
FORMATION Observatory Hill Beds



DEPTH (METRES)	H/C, Pal.	Col.	Access.	DESCRIPTION
341			s/e	
342				
343		gy-gn		
344		to		
345		gy-r-br		
346			s/e	
347				
348				
349				
350				
351				
352			s/e	
353				
354				
355			s/e	
356		br-gy		356.0-357.4 Sst., f.-v.f.g., br.-gy., even gr., calc., micac., finely x-b.
357				357.4-369.0 Zst., calc., br., flecked thru/out with acicular xls. and xl. aggregates ; no planar bedding structs., prob. due to soft sed. def. or bioturbation; v.f.g. micac.
358		br	s/e	
359				
360			s/e	

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DATE. 18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 20 OF 27
DRG. NO. S 14311

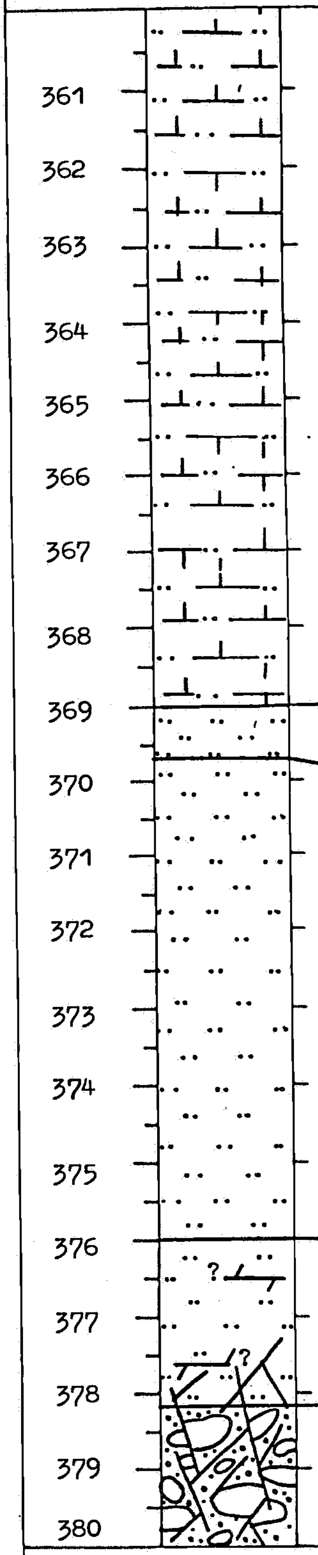
1639

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1
LOCATION 5 km, 320°T, Marla Bore, WINTINNA
LAT. 27° 17' 00"S
LONG. 133°31' 30"E (ANG, provisional)
ELEVATION GR. DATUM
R.T.

CORE Size: NQ
DEPTH 360-380 m.
DATE DRILLED 14-6-79
RECOVERY 20 m. 100 %
FORMATION Observatory Hill Beds, 'Davies Bore Conglomerate' (informal name)



H/C Pal	Col.	Access.	DESCRIPTION
	br	s/e s/e s/e	
	gn-gy		369.0-369.7 Zst., lt. gn.-gy., micac., non-calc., poorly layd. to unlayd.
	br	s/e s/e	369.7-376.0 Zst., br., flecked with wh. acicular xls. and xl aggregates: i.e., appears lithologically identical to units at 335.0-356.0 and 357.4-369.0 m, however the present unit appears to be completely non-calc. (both flecking and zst. matrix), flecking is sl. more irregular and sparse.
	gy-buff	? ccv	376.0-378.0 Zst., gy.-buff, v. hard and indurated, sheared and jointed partic. near 378 m, no acid react., ?dolomitic; ?cc. vein.

Contact between Observatory Hill Beds and 'Davies Bore Conglomerate' gradational and herein defined at 378.0-378.2 m.

378.2-379.4 Conglomerate, intraformational or breccia: matrix dk., zty.-clayey, calc. in part, traces of sulphide; joint and shear faces covered with black powder -

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DATE. 18-6-79

PETROLEUM GEOLOGY SECTION

SHEET 21 OF 27
DRG. NO. S 14313 u

1639

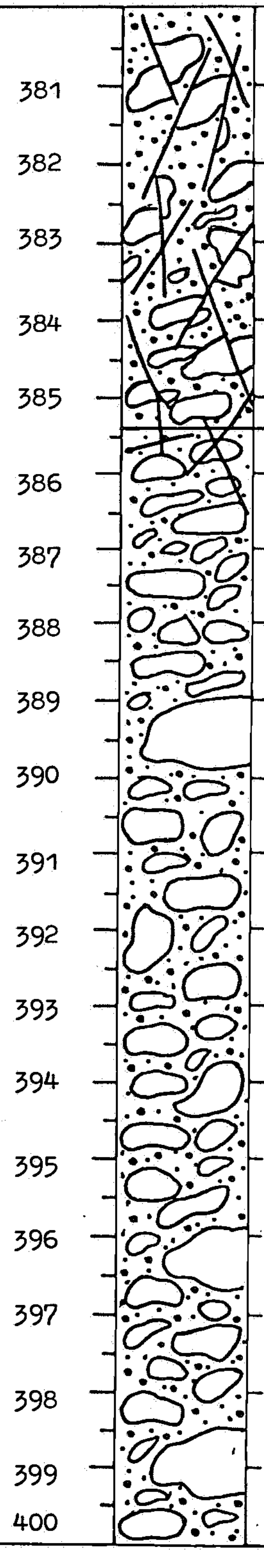
DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1
LOCATION 5 km, 320°T, Marla Bore, WINTINNA
LAT. 27° 17' 00"S
LONG. 133°31' 30"E (ANG, provisional)
ELEVATION GR.
R.T.
DATUM

CORE SIZE: NQ
DEPTH 380-400 m
DATE DRILLED 14-18/6/79
RECOVERY 20 m 100 %
FORMATION 'Davies Bore Conglomerate' (informal name)

DEPTH (METRES)	GRAPHIC LOG	H/C, Pal.		Access.	DESCRIPTION
				pyd ?carbonac	379.4-385.4 **Conglomerate**, breccaated, dk. gy., bl. veining as above; matrix zty.-clayey, calc. in part; includes clasts of gn. and pi. dol.-zst.; minor trace of sulphide.
				pyd	
					385.4-465.5 **Conglomerate**, indurated; clasts of granitoid (xline. bmt.) lithotypes up to 10 cm and greater, and of zsts. and dol.-zsts. (? adelaidean) from 0.1-4 cm, well rounded and elongate, with preferred orient. subperpendicular to core axis ; matrix zty. to sandy prob. with lge. content of Adelaidean material, contains high propn. of carbonate which noticeably lines clasts and forms veins traversing whole rock; rare sandy and zty. i/beds often reddish; cp. and cc.-py vugs at 436.5 and 463.1 m; This whole section forms a single unit , which cannot be at present subdivided meaningfully, although geophysical logs, such as Resistivity, suggest subunits may be recognised.



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M.C.B.
DATE. 3-7-79
20-6-79

PETROLEUM GEOLOGY SECTION

SHEET 22 OF 27 DRG. NO. S 14313 v

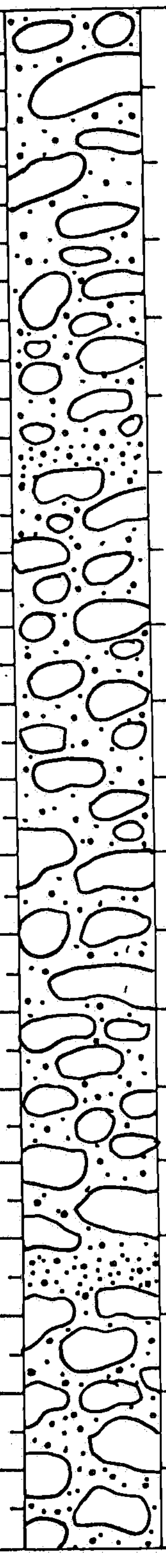
1639

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1
LOCATION 5 km, 320°T, Marla Bore,
LAT. 27° 17' 00"S WINTINNA
LONG. 133°31' 31"E (ANG, provisional)
ELEVATION GR. DATUM
R.T.

CORE SIZE : NQ
DEPTH 400-420 m
DATE DRILLED 19-20/6/79
RECOVERY 20 m 100 %
FORMATION 'Davies Bore Conglomerate' (informal name)

DEPTH (METRES)	GRAPHIC LOG	H/C Pal.	Col.	Access.	DESCRIPTION
401–420					As above ; see Sheet 21.

LOGGED BY M.C.B.
G.M.P.
DATE 20-6-79
3-7-79

PETROLEUM GEOLOGY SECTION

SHEET 23 OF 27 DRG. NO. S 14313 W

1639

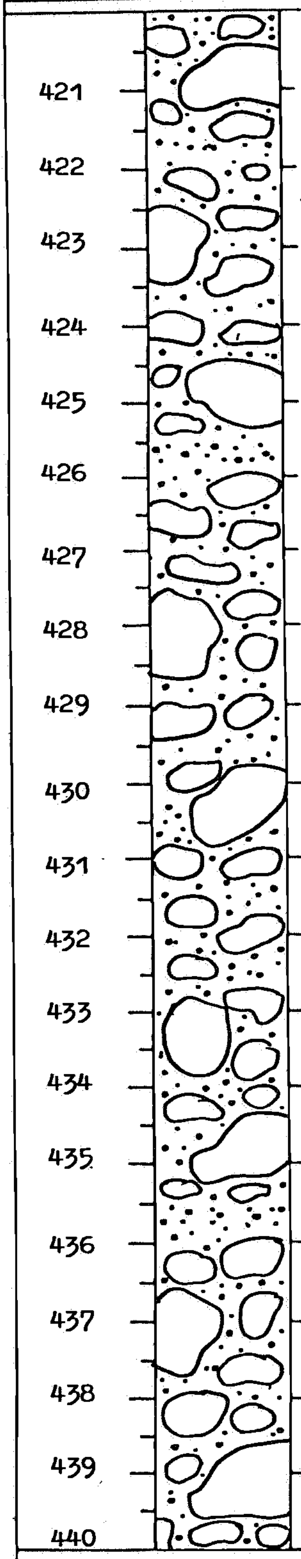
DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1
LOCATION 5 km, 320°T, Marla Bore, WINTINNA
LAT. 27° 17' 00"S
LONG. 133° 31' 30"E (ANG, provisional)
ELEVATION GR.
R.T.

CORE SIZE: NQ
DEPTH 420-440 m
DATE DRILLED 20-21/6/79
RECOVERY 20 m 100 %
FORMATION 'Davies Bore Conglomerate' (informal name)

DEPTH (METRES)	GRAPHIC LOG	H/C, Pal.		Access.	DESCRIPTION



As above ; see Sheet 21

Rare cc.-lined vugs at 436.5 m.

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G.M.P.

DATE. 21-6-79
3-7-79

PETROLEUM GEOLOGY SECTION

SHEET 24 OF 27 DRG. NO. S 14313 x

1639

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1

LOCATION 5 km, 320°T, Marla Bore, WINTINNA

LAT. 27° 17' 00"S

LONG. 133°31' 30"E (ANG,provisional)

ELEVATION GR.

R.T.

DATUM

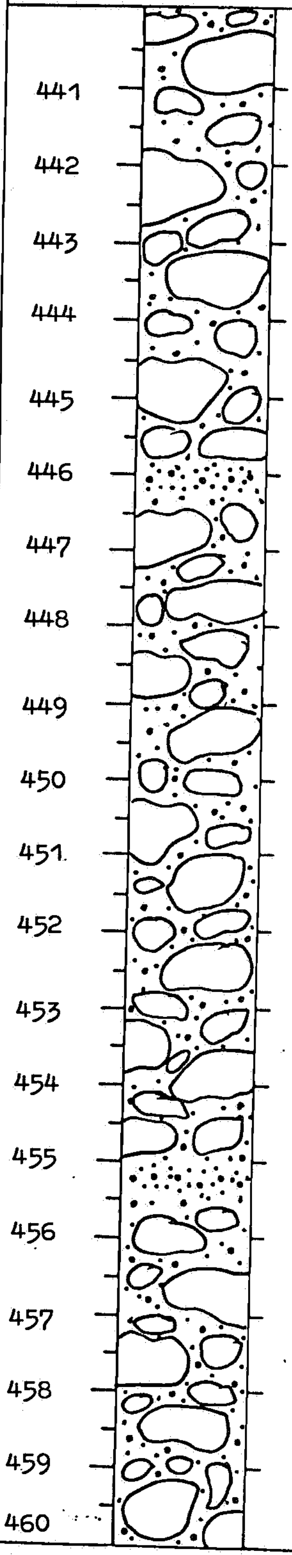
CORE SIZE: NQ

DEPTH 440-460 m

DATE DRILLED 21-23/6/79

RECOVERY 20 m 100 %

FORMATION 'Davies Bore Conglomerate' (informal name)

DEPTH (METRES)	GRAPHIC LOG	H/C, Pal.		Access.	DESCRIPTION
441–460					As above ; see Sheet 21.

LOGGED BY M.C.B.
G.M.P.

DATE. 24-6-79
3-7-79

PETROLEUM GEOLOGY SECTION

SHEET 25 OF 27

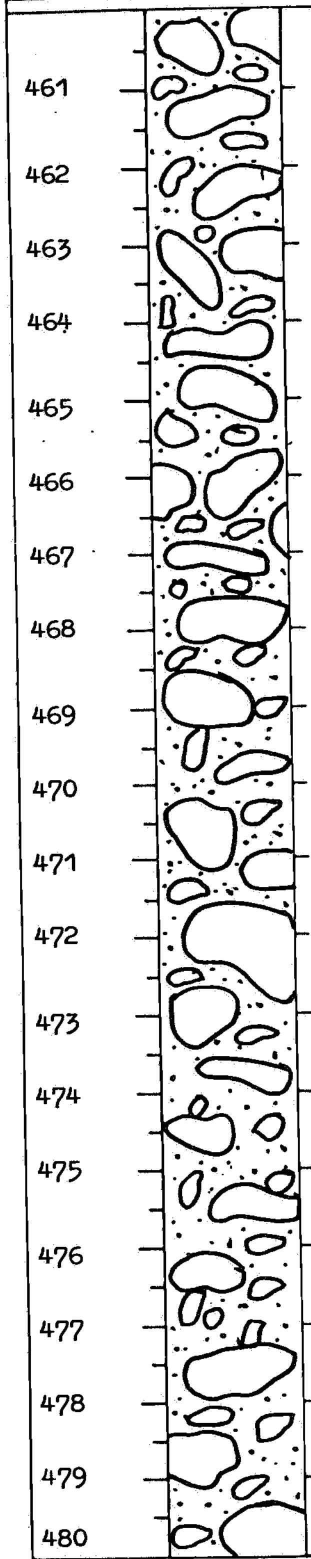
DRG. NO. S 14313 y

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1
LOCATION 5 km, 320°T, Marla Bore WINTINNA
LAT. 27° 17' 00"S
LONG. 133°31' 30"E (ANG, provisional)
ELEVATION GR.
R.T.
DATUM
CORE SIZE: NQ
DEPTH 460-480 m
DATE DRILLED
RECOVERY 20 m 100 %
FORMATION Davies Bore Conglomerate (informal name)

DEPTH (METRES)	GRAPHIC LOG	H/C, Pal.	Access.	DESCRIPTION



As above; see Sheet 21.

Cc. matrix with py., vug lined with c.g. cc. and m.g. py. at 463.1 m.

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G.M.P.

DATE 23/6/79
3/7/79

PETROLEUM GEOLOGY SECTION

SHEET 26 OF 27 DRG. NO. S14313z

1639

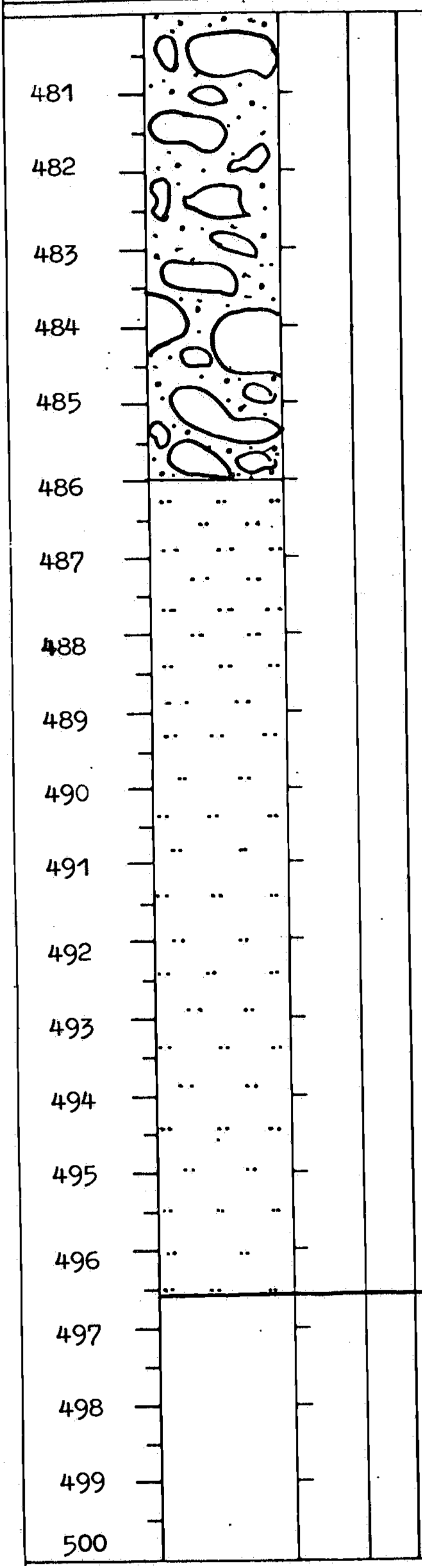
DEPARTMENT OF MINES — SOUTH AUSTRALIA

CORE DESCRIPTION

WELL BYILKAOORA 1
LOCATION 5 km, 320°T, Marla Bore WINTINNA
LAT. 27° 17' 00"S
LONG. 133°31' 30"E (ANG, provisional)
ELEVATION GR. DATUM
R.T.

CORESIZE : NQ
DEPTH 480-500 m
DATE DRILLED
RECOVERY 20 m 100 %
FORMATION Davies Bore Conglomerate, (informal name); Rodda Beds.

DEPTH (METRES)	GRAPHIC LOG	H/C, Pal.	Access.	DESCRIPTION



As above; see Sheet 21.

486.0 Sharp contact between overlying conglomerate and underlying siltstone.

486.0-496.65+ Siltstone, laminated, indurated, dark grey, non-calc., lams. are perpendic. to core axis, as is the contact with the overlying conglomerate. Correlated with the upper Adelaidean Rodda Beds.

T.D. 496.65m.

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G.M.P.

DATE

PETROLEUM GEOLOGY SECTION

SHEET 27 OF 27

DRG. NO. S14313aa

1639

APPENDIX 2

OIL AND SOURCE ROCK ANALYSES, BILKAOORA NO. 1

By

D.M. McKirdy

INTRODUCTION

Between the depths of 202 m and 320 m, Byilkaoora No. 1 penetrated a sequence of silty carbonates, with evaporite pseudomorphs, showing vugular and fracture porosity, the latter being partly healed with calcite. Core recovered from this interval displays abundant evidence of hydrocarbons, viz. petroliferous odour, pale yellow fluorescence on minor joints and fractures, oil bleeding from fractures and vugs, and heavy black reservoir bitumen infilling larger vugs. Initially, four samples of oil-bearing core, together with three short lengths of dark, non-reservoir rock, were selected for routine geochemical analysis. All samples came from the (?)Early Cambrian Observatory Hill Beds, shown by McKirdy (1979) to have excellent source potential for oil in SADME stratigraphic well, Wilkinson No. 1, drilled in 1978 about 300 km SSW of Byilkaoora.

The purpose of the first round of organic geochemical analyses reported here was threefold:

(1) to establish the type (or types) of oil present;

(2) to ascertain the maturation state and hydrocarbon-generating potential of fine-grained sediments in the section, and

(3) to determine whether or not the oil(s) had originated from source beds within the Observatory Hill Beds.

SAMPLING AND METHODS

The four oils chosen for analysis (Table 1) range in appearance from light oil, with a pale stain, actively bleeding from a fracture in the core (sample 2280), through progressively darker (? heavier) oils (samples 2279 and 2281), to black, viscous oils in a large vug (sample 2278). Each oil was isolated by a 5 minute ultrasonic washing of the core in benzene/methanol (3:2), followed by rotary evaporation of the solvent. The oil was then fractionated in the same manner as a source-rock extract (see below).

The half cores selected for source-rock analysis (Table 2) are from Member 3 and represent three quite distinct lithofacies:

278.66-278.70 m	grey silty dolomitic mudstone, with feathery crystals of calcite after (?) trona (between oil samples 2279 and 2280).
278.86-278.91 m	medium grey micritic dolomite (immediately below oil sample 2280).
289.77-289.80 m	dark brown argillite, with aggregates of medium-grained calcite and some dolomite (about 11 m below oil sample 2280).

These cores lacked visible porosity and were free of oil staining. Sixteen additional half-core samples subsequently were taken for source-rock analysis. Preliminary results (total organic carbon, TOC, values only) are given in Table 3. The analytical procedures used were the same as those previously described by McKirdy (1979), except that liquid chromatography of the asphaltene-free oil and extractable organic matter (EOM) was performed on a silica/alumina (4:1) column. The identification of the C_{15}, C_{16} and C_{18} isoprenoid alkanes in gas chromatograms of the saturates is based only on comparison of their retention times with published values and so should be regarded as tentative.

All analytical work was carried out by AMDEL under the technical supervision of D.M. McKirdy, Fossil Fuels Branch, SADME (see attached Progress Report 19, Source Rock Studies, S.A. Sedimentary Basins).

CONTAMINATION

Following problems with contaminated drill core from SADME Wilkinson No. 1 (McKirdy, 1979), the use of diesel (as a mud additive) and Delvac (core barrel lubricant) was discontinued. All lubricants and mud additives used during the drilling of Byilkaoora were screened for hydrocarbons, and deemed acceptable, prior to spudding of the well.

RESULTS AND DISCUSSION

Oils

Analysis of the oils (approx. C_{15+} fraction) by liquid chromatography (Table 1) reveals a wide spread in their composition. Saturated hydrocarbons (alkanes) decrease from 58.7% in sample 2279 to 24.9% in sample 2278, corresponding to an increase in aromatic hydrocarbons from 12.5% to 33.2%. This decrease in the ratio of saturates to aromatics parallels the variation in physical appearance mentioned previously, from pale (?"light") oil, to dark viscous (?"heavy") oil. (Note: insufficient sample was available to allow measurement of API gravities). It also corresponds to a progressive increase in the proportion of branched and cyclic alkanes, as shown by gas chromatograms of the respective saturates (total alkane) fractions (Figs 1a-d).

The alkane chromatogram of sample 2279 (Fig. 1a) features n-alkanes (range = C_{14} to C_{31}; maximum = C_{19}), isoprenoid alkanes (C_{15}, C_{16}, C18 (norpristane), C_{19} (pristane) and C_{20} (phytane); maximum = phytane), and several prominent but as yet unidentified ~C_{20}+ compounds (marked with asterisk in Figs 1a-d), with a relatively subdued asymmetric naphthene hump peaking at about the n-C_{26} position. Norpristane, pristane and phytane are present in much greater concentration than the adjacent n-alkanes.

In samples 2280 and 2281 (Figs 1b and 1c, respectively), the n-alkanes become progressively more depleted (cf. pr/n-C_{17} value increases: Table 1), and the naphthene hump more prominent. In sample 2278 (Fig. 1d), the n-alkanes appear to be completely missing, the isoprenoids and "asterisked" compounds are greatly reduced in concentration, and the chromatogram is dominated by the naphthene hump, an unresolved complex mixture of mainly cyclic alkanes.

The above gas chromatographic (Figs 1a-d) and compositional data (Table 1) are interpreted as indicating that the oils belong to the same genetic family, but have undergone differing degrees of biodegradation (c.f. Milner et al., 1977). The extent of biodegradation appears to be governed by the accessibility of the invading meteoric waters (and the bacteria which they carry) to the pore space in which the oil occurs. Thus least altered oil (sample 2279, Fig. 1a) is found in tight fracture porosity, whereas the most altered oil (sample 2278, Fig. 1d) occurs in open vuggy porosity.

Source rocks

The TOC content of the three samples analysed (Table 2) is above average. EOM yield exceeds 500 ppm and 100 mg/g C in each case, being lower in the micritic dolomite (sample 2283) than in the mudstone (sample 2282) and argillite (sample 2284).

The hydrocarbon content (saturates plus aromatics) of the EOM falls in the range 45-54%. The hydrocarbon yield is particularly high (100-105 mg/g C) for the two clastic samples. All samples contain in excess of 50 mg of hydrocarbons per gram of organic carbon, indicating good to excellent source potential for oil (Powell, 1978; Fig. 2). Figure 2 shows that the Byilkaoora sequence between 278 m and 290 m contains mature, oil-prone source beds.

Gas chromatograms of the alkane fractions of the sediment extracts (Fig. 3a-c) are remarkably similar, except for differences in the concentration of the isoprenoid and "asterisked" alkanes, relative to the n-alkanes. This feature is illustrated by the Pr/n-C_{17} values (Table 2), viz. 2284 (1.57) > 2283 (1.20) > 2282 (0.83).

Oil - source correlation

Comparison of the alkane chromatogram of the least-altered oil (Fig. 1a) with those of the rock extracts, particularly sample 2284 (Fig. 3c), the most prolific potential source bed analysed, reveals an excellent match. This suggests that the oil originated within those facies which were drilled at Byilkaoora.

FURTHER WORK

Routine source-rock analysis of the core samples listed in Table 3 is proceeding. In addition, samples from among these listed in Tables 1-3 have been selected for the following analytical work:

1) reflected-light microscopy of the disper sed organic matter
2) isolation of the insoluble organic matter (kerogen) and determination of its elemental and stable carbon isotopic composition.
3) detailed gas chromatography - mass spectrometry (GC-MS) of oil - source-rock EOM pairs.

The results of this additional work will be reported in future Departmental publications.

REFERENCES CITED

McKirdy, D.M., 1979. Source rock analyses, Wilkinson No. 1. Appendix to S. Aust. Dept. Mines and Energy report 79/88 (unpublished).

Milner, C.W.D., Rogers, M.A., and Evans, C.R., 1977. Petroleum transformations in reservoirs. J. geochem. Explor., 7: 101-153.

Powell, T.G., 1978. An assessment of the hydrocarbon source rock potential of the Canadian Arctic Islands. Geol. Surv. Canada Paper, 78-12.

TABLE 1: OIL ANALYTICAL DATA BYILKAOORA 1

Analytical No.	Depth (m)	Composition*				Alkane Parameters**	
		Sat.	Arom. (%)	ONS	Asph.	Pr/n-C_{17}	Pr/Ph
A 2278/79	277.00-277.05	24.9	33.2	41.6	0.2	n.d.	0.77
A 2279/79	278.55-278.60	58.7	12.5	28.3	0.5	2.22	0.89
A 2280/79	278.77-278.82	53.4	13.8	32.3	0.5	2.28	0.94
A 2281/79	317.10-317.12	37.2	22.5	31.4	8.9	3.17	0.85

Analysts: H.W. Sears and N. Burns

*Isolation procedure involved loss of light ends; fraction analysed approximates to C_{15+}

**Pr = pristane, Ph = phytane, n-C_{17} = n-heptadecane, n.d. = not determined

All samples from Observatory Hill Beds, Member 3.

TABLE 2: SOURCE ROCK ANALYTICAL DATA, BYILKAOORA 1

ANALYTICAL NO.	DEPTH (m)	TOC (%)	EOM YIELD		EOM COMPOSITION				ALKANE PARAMETERS*	
			ppm	mg/g C	Sat.	Arom. (% EOM)	ONS	Asph.	Pr/n-C_{17}	Pr/Ph
A 2282/79	278.66-278.70	0.50	1128	226	31.7	14.7	45.4	8.2	0.83	0.97
A 2283/79	278.86-278.91	0.45	508	113	31.4	13.9	45.8	8.9	1.20	0.92
A 2284/79	289.77-289.80	0.96	1806	188	41.4	12.0	38.7	7.9	1.57	0.98

Analysts: H.W. Sears and N. Burns

*Pr = pristane, Ph = phytane, n-C_{17} = n-heptadecane

All samples from Observatory Hill Beds, Member 3.

TABLE 3: TOTAL ORGANIC CARBON, OBSERVATORY HILL BEDS

BYILKAOORA 1

Sample No.	Member	Depth (m)	TOC (%)
5643 RS 59	Member 5	200.30	0.66
60	Member 4	207.45	0.04
61		211.60	0.18
62		212.50	0.03
63		225.90	0.21
64		240.90	0.03
65		252.75	0.09
66	Member 3	262.95	0.56
67		279.50	0.32
68		285.00	0.70
69		293.40	0.10
70		296.25	0.38
71		306.15	0.64
72		312.30	0.33
73		313.30	0.42
74		316.50	0.48

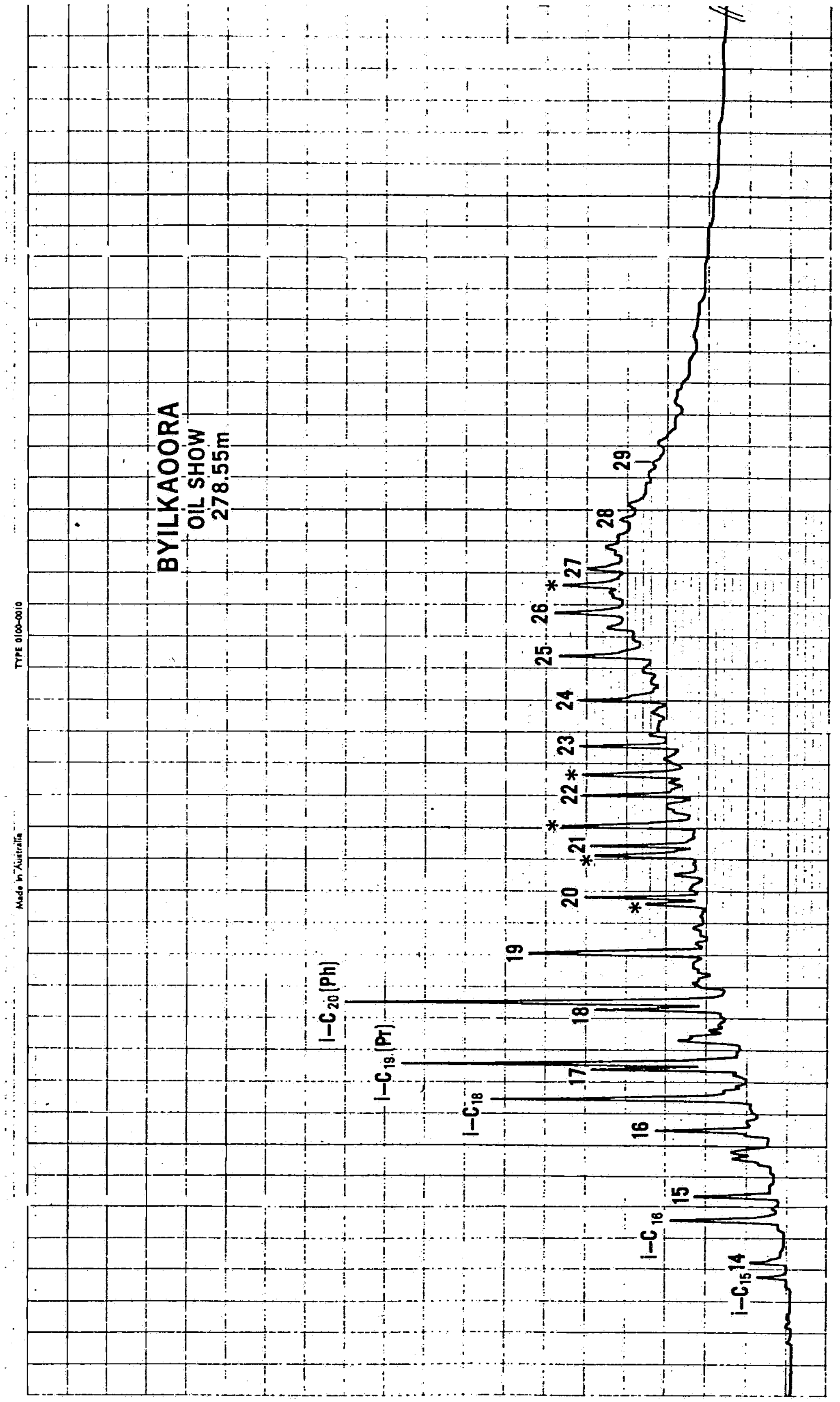


Fig.1a

		DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE
COMPILED		Gas chromatograms of Alkanes from selected oil shows, Observatory Hill Beds, Byilkaoora 1	DATE 27-7-71
DRN	CKD		PLAN NUMBER S-14316

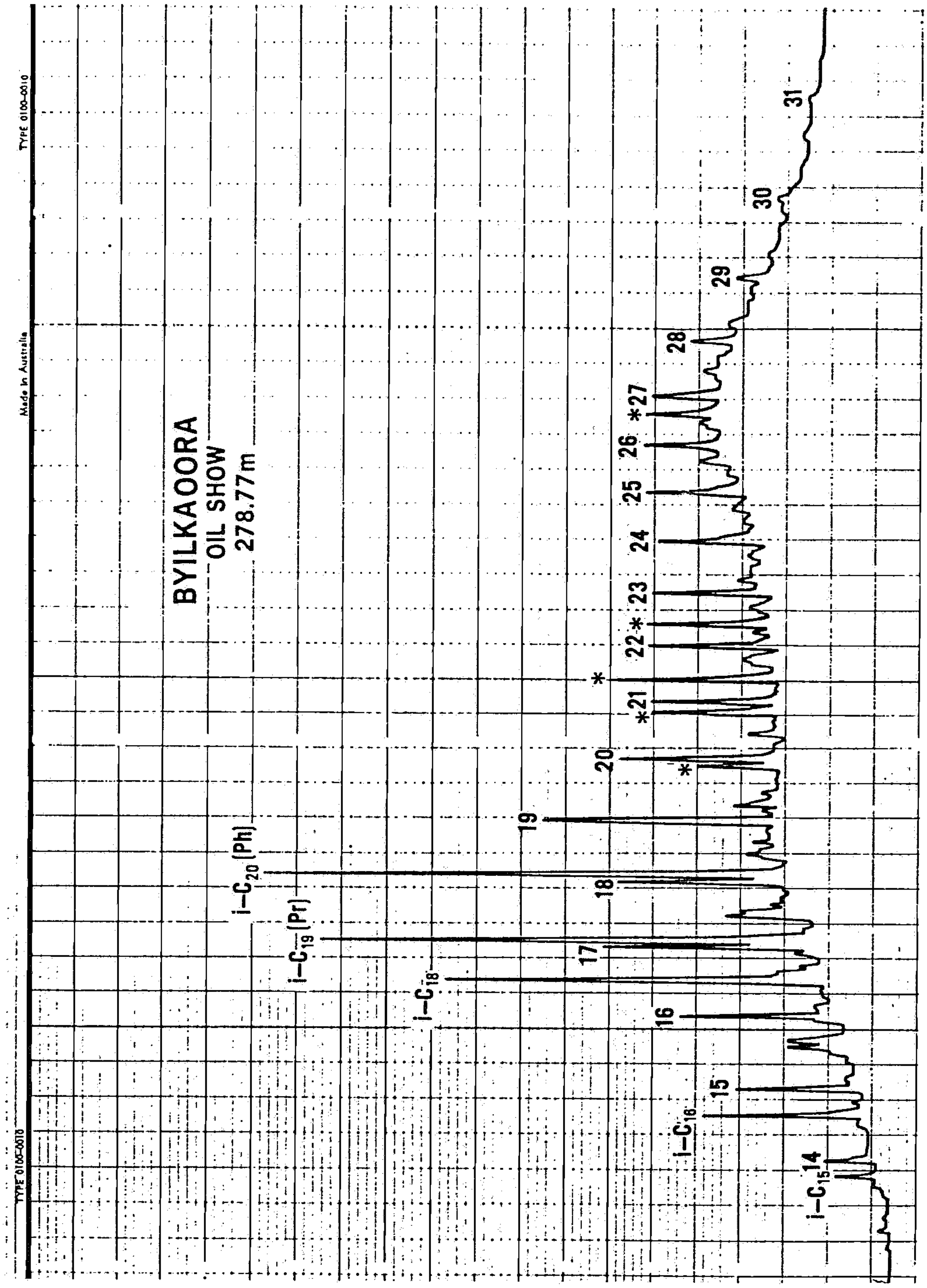


Fig.1b

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

Gas chromatograms of Alkanes
from selected oil shows,
Observatory Hill Beds, Byilkaoora 1

COMPILED

DRN

CKD

SCALE

DATE 21-7-77

PLAN NUMBER
S-14317

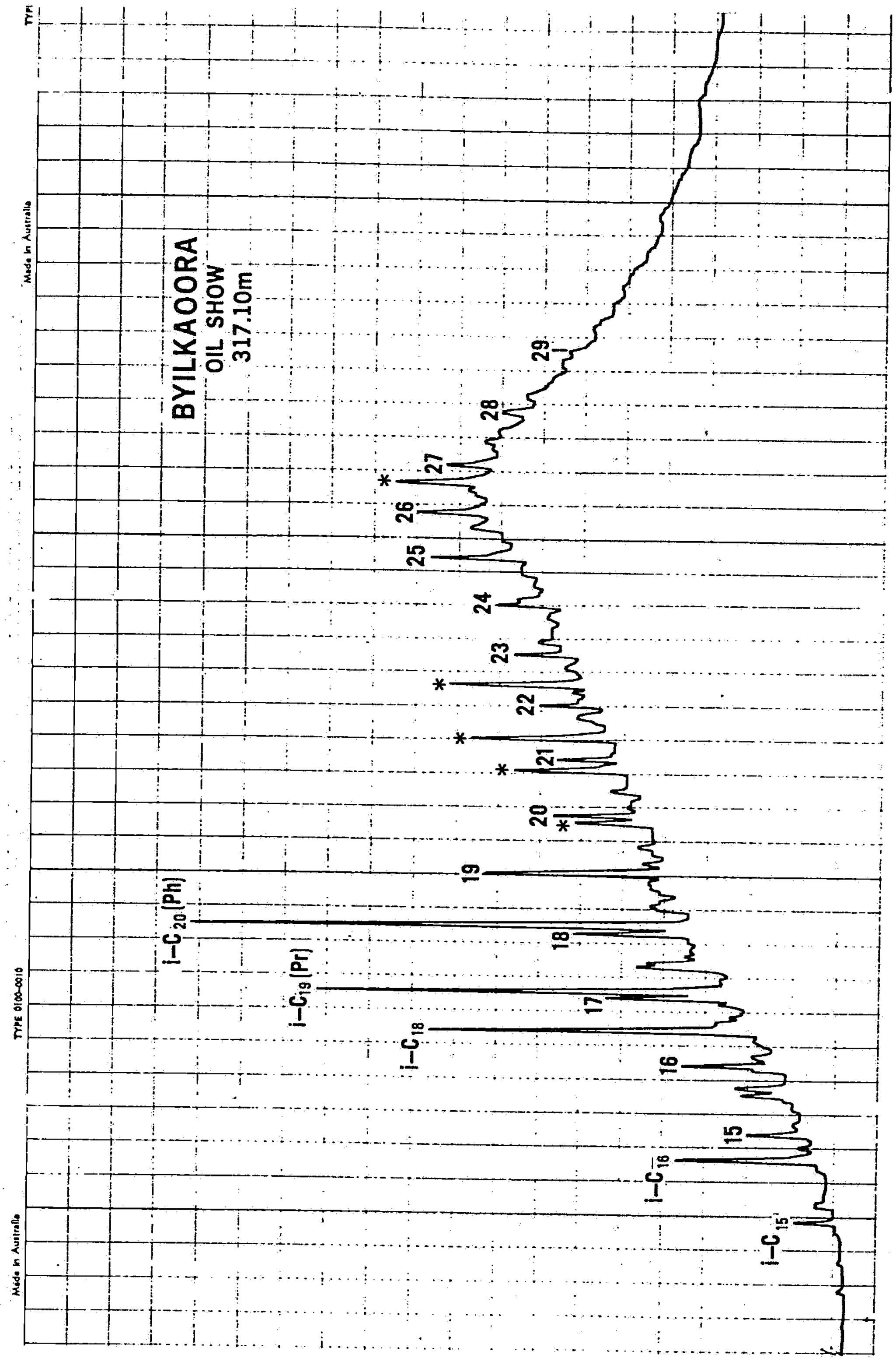


Fig.1c

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

COMPILED

DRN

CKD

Gas chromatograms of Alkanes
from selected oil shows,
Observatory Hill Beds, Byilkaoora 1

SCALE

DATE 29-9-77

PLAN NUMBER

S-14318

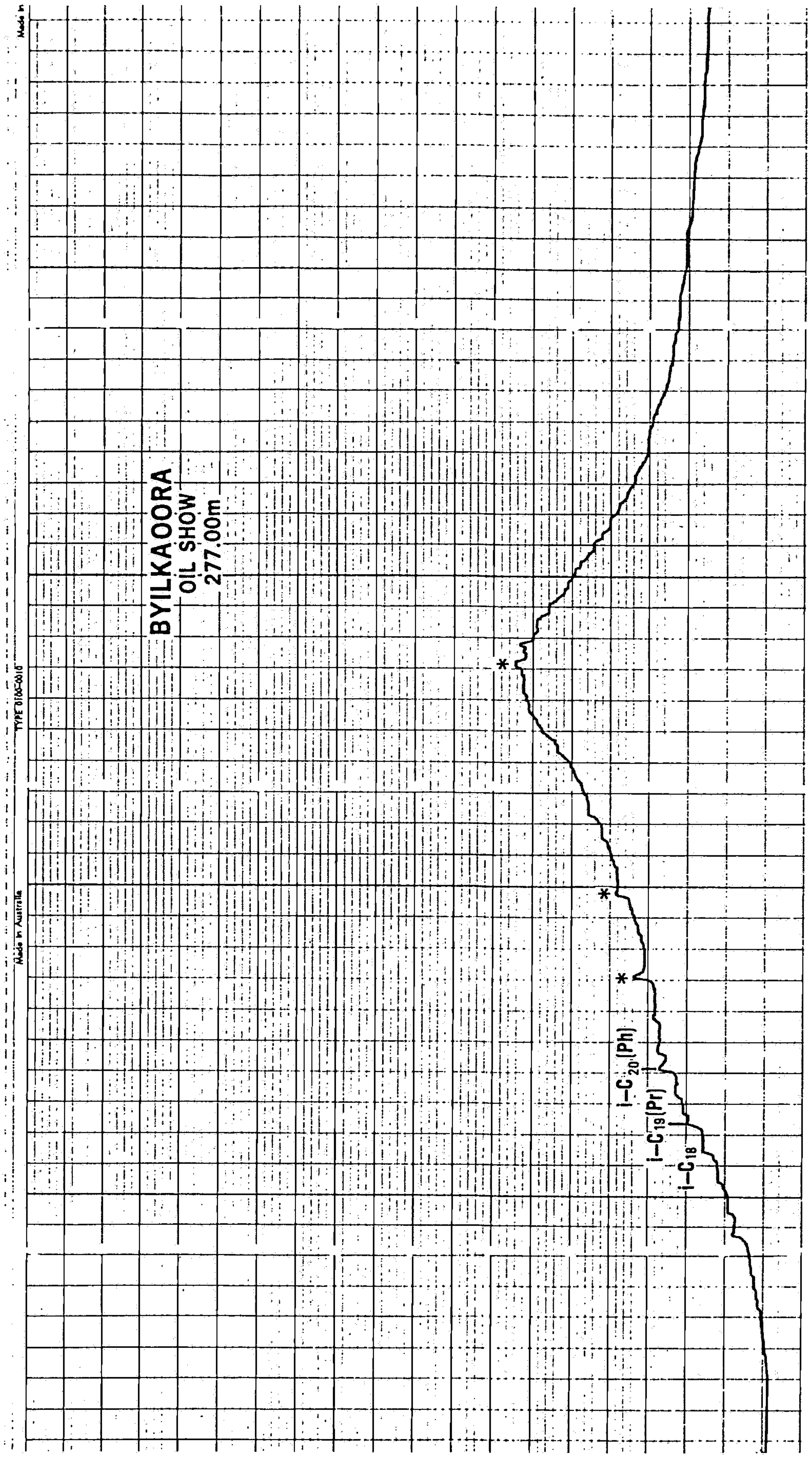


Fig.1d

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

Gas chromatograms of Alkanes
from selected oil shows,
Observatory Hill Beds, Byilkaoora 1

SCALE

DATE [illegible]

PLAN NUMBER
S-14319

COMPILED

DRN

CKD

MATURATION STATE AND HYDROCARBON POTENTIAL

A. IMMATURE

A′ overlaps with D_4

B. MARGINALLY MATURE

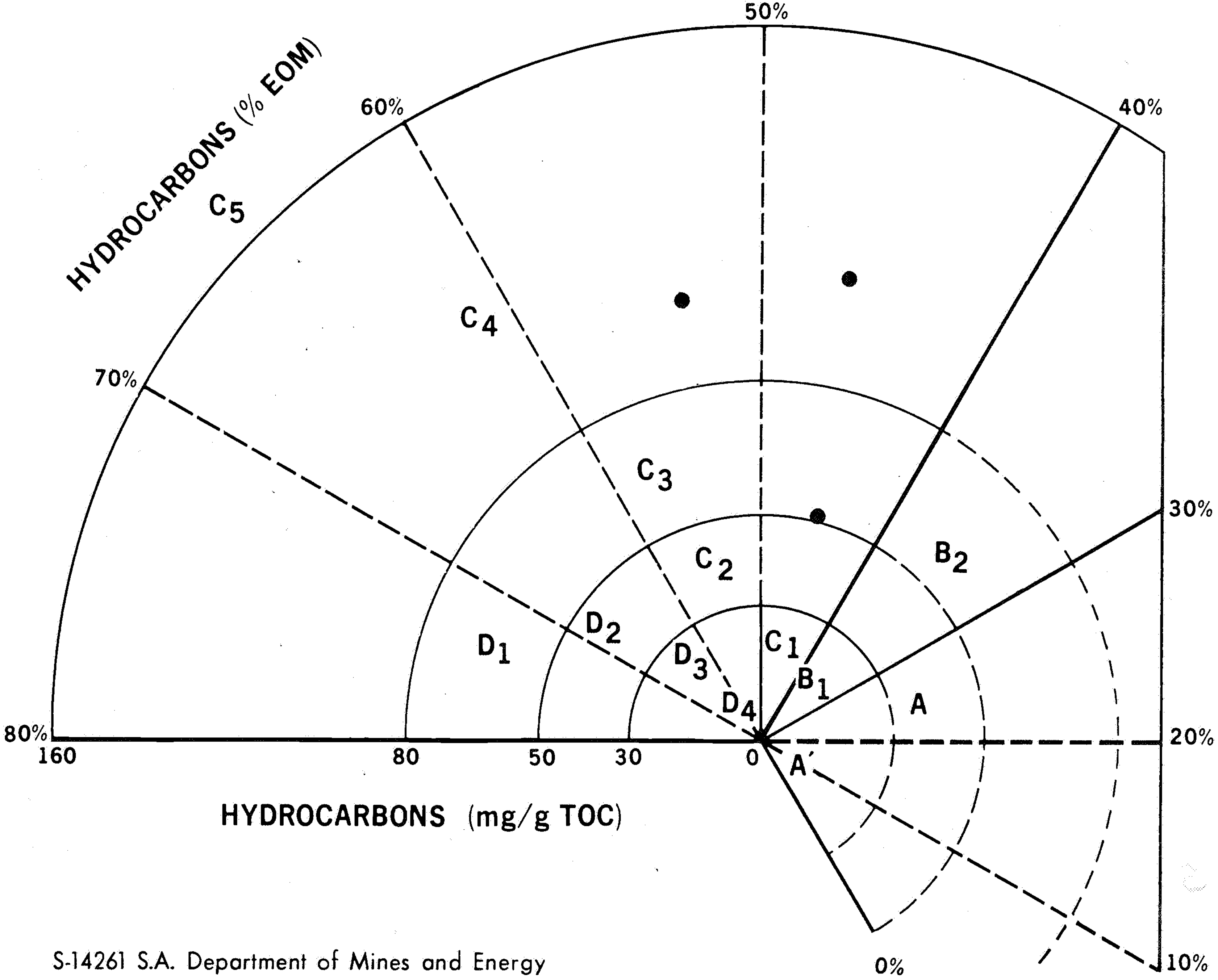
Dry gas....................................B_1
Gas possibly heavy oil............B_2

C. MATURE

Gas only....................................C_1
Gas condensate; minor oil.......C_2
Intermediate oil source..........C_3
Prolific oil source.....................C_4
Staining......................................C_5

D. OVERMATURE

Light oil and gas......................D_1
Gas condensate; minor oil........D_2
Gas condensate; wet gas.........D_3
Dry gas (overlaps with A′)......D_4



BYILKAOORA 1

● —Observatory Hill Beds

Fig.2

S-14261 S.A. Department of Mines and Energy

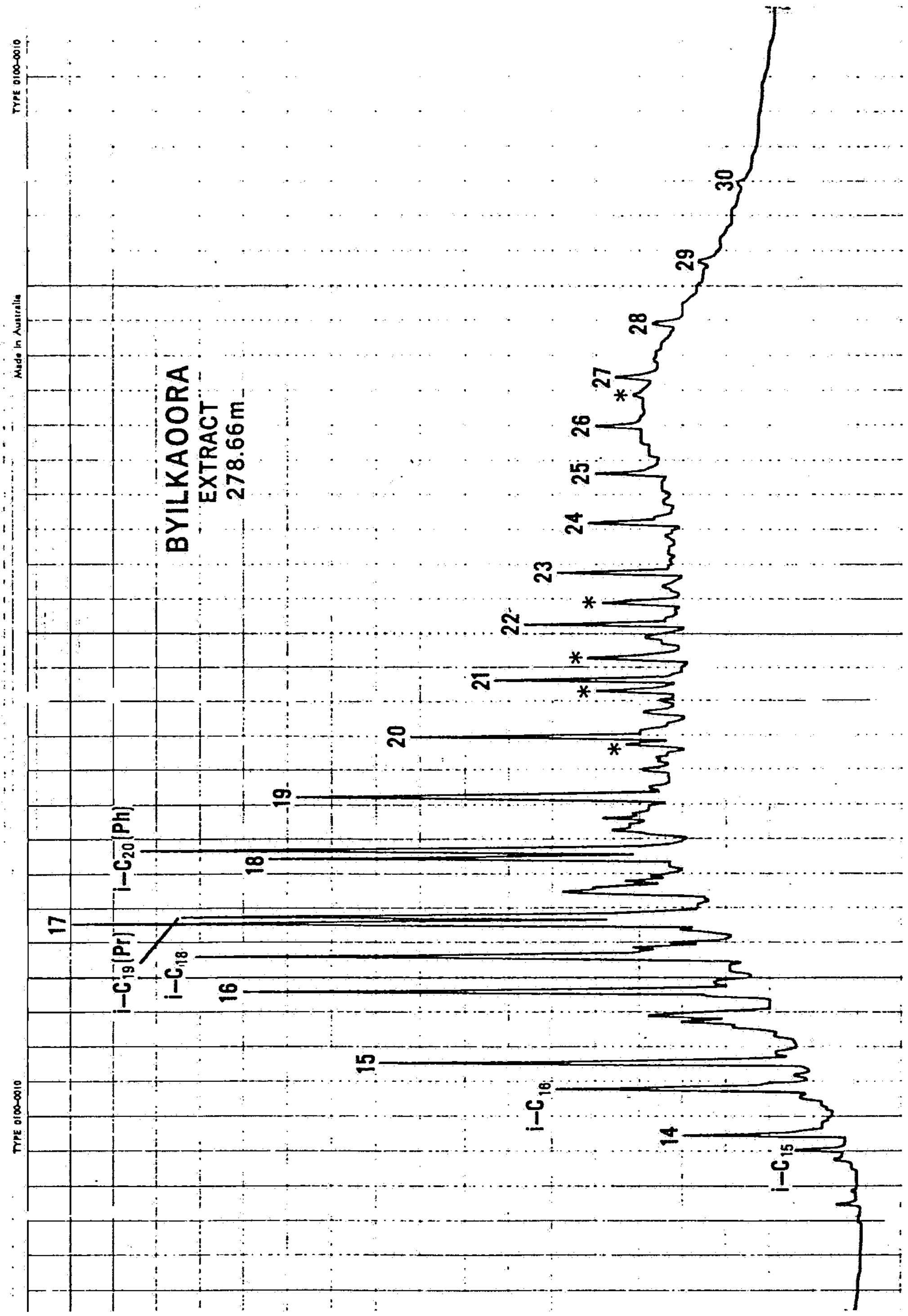


Fig.3a

	DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE
COMPILED	Gas chromatograms of Alkanes from selected oil shows, Observatory Hill Beds, Byilkaoora 1	DATE 29-9-77
DRN / CKD		PLAN NUMBER S-14322

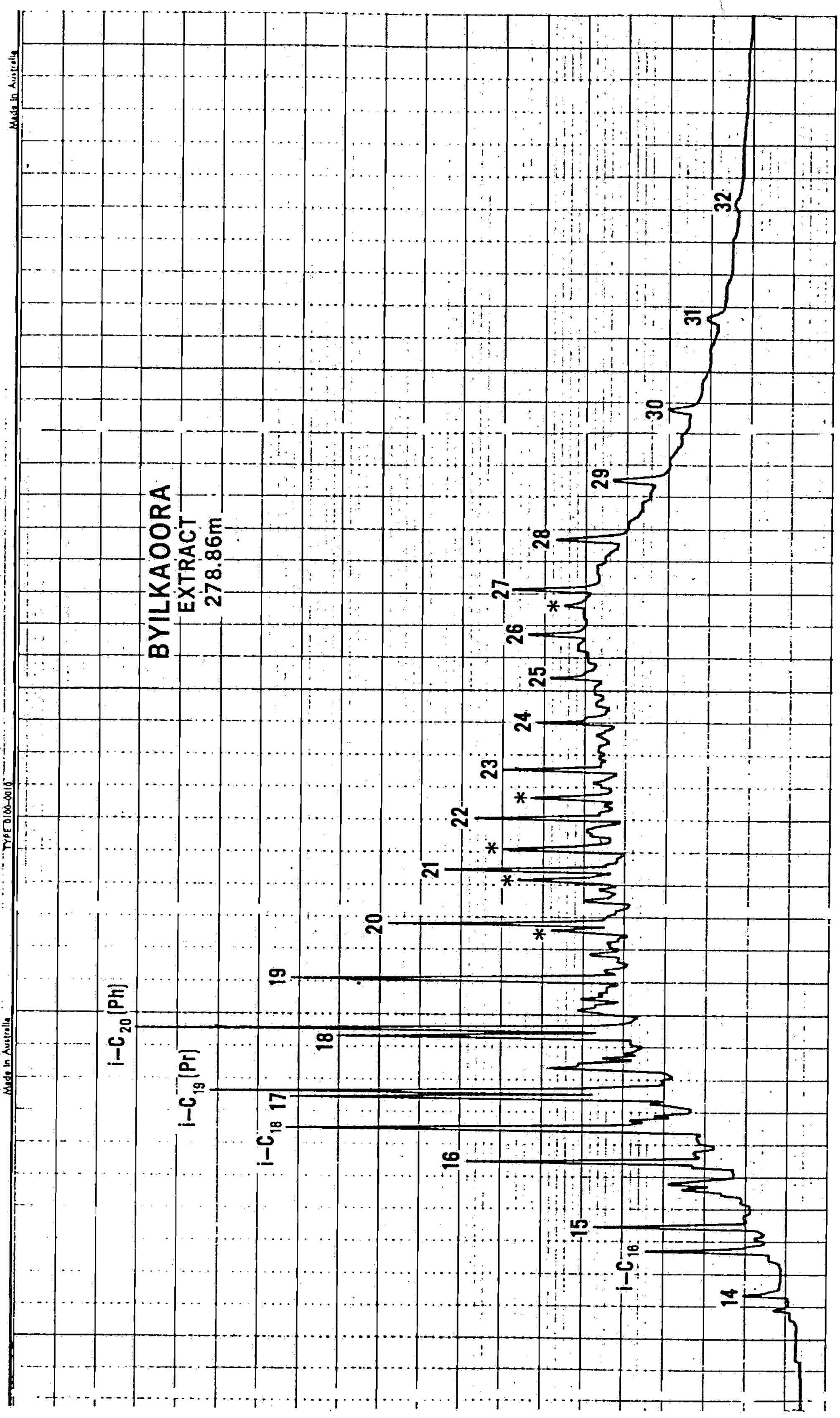


Fig.3b

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

SCALE

COMPILED

DATE 20-7-77

DRN

CKD

Gas chromatograms of Alkanes
from selected oil shows,
Observatory Hill Beds, Byilkaoora 1

PLAN NUMBER
S-14321

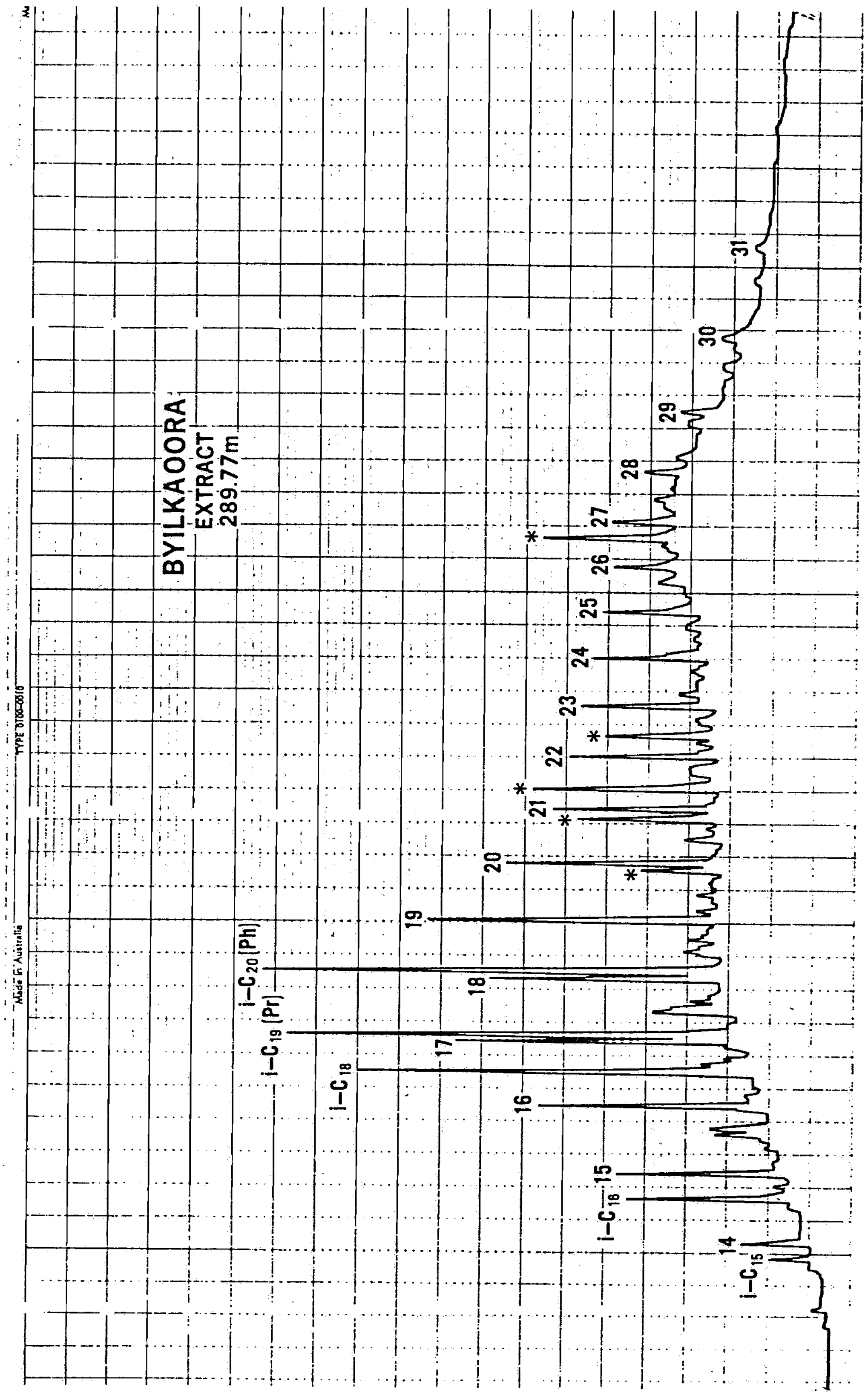


Fig.3c

	DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE
COMPILED	Gas chromatograms of Alkanes from selected oil shows, Observatory Hill Beds, Byilkaoora 1	DATE 21-7-77
DRN · CKD		PLAN NUMBER S-14320

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(B5236/79, part)

26 July 1979

Director-General,
Department of Mines & Energy,
Post Office Box 151,
EASTWOOD, 5063.

Attention: Dr D.M. McKirdy

SOURCE-ROCK STUDIES -
S.A. SEDIMENTARY BASINS

PROGRESS REPORT NO. 19

Investigation and Report by: H. Sears

Manager, Geological Services Division: Dr Keith J. Henley

Keith Henley
for Norton Jackson,
Managing Director.

meo

OILS

SAMPLE NO: A 2278/79

WELL: Byilkaoora 1.

SAMPLE IDENTIFICATION:

DEPTH: 277.00 - 277.05 m

TYPE OF SAMPLE: Oil Seep.

Analysis of fraction boiling above 210°C

Asphaltenes	0.2	% (wt)
Saturates	24.9	%
Aromatics	33.2	%
Resins	32.1	%
Loss on column	9.5	%

n-Alkane distribution of saturates:-

n-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{2}
Rel abundance	Saturates wholly naphthenic no n-alkanes showing on chromatogram										

n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{3}
Rel abundance											

Pristane/phytane ratio

Pristane/C_{17} ratio

OILS

SAMPLE NO: 2279/79

WELL: Byilkaoora 1.

SAMPLE IDENTIFICATION:

DEPTH: 278.55 - 278.74m

TYPE OF SAMPLE: Oil Seep

Analysis of fraction boiling above 210°C

Asphaltenes	0.5	% (wt)
Saturates	58.7	%
Aromatics	12.5	%
Resins	23.8	%
Loss on column	4.5	%

n-Alkane distribution of saturates:-

n-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{2}
Rel abundance	-	2.9	5.7	7.5	10.5	8.9	12.6	8.6	7.2	7.2	6.7

n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{3}
Rel abundance	6.0	6.0	5.0	2.9	1.4	0.9	-	-	-	-	-

Pristane/phytane ratio	0.89
Pristane/C_{17} ratio	2.22

OILS

SAMPLE NO:	2280/79
WELL:	Byilkaoora 1.
SAMPLE IDENTIFICATION:	
DEPTH:	278.77 - 279.00 m
TYPE OF SAMPLE:	Oil Seep

Analysis of fraction boiling above 210°C

Asphaltenes	0.5	% (wt)
Saturates	53.4	%
Aromatics	13.8	%
Resins	20.9	%
Loss on column	11.4	%

n-Alkane distribution of saturates:-

n-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}
Rel abundance	-	2.7	6.3	8.1	10.6	8.7	11.7	7.9	6.4	6.2	5.9

n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{34}
Rel abundance	5.0	4.7	4.0	4.1	2.7	1.8	1.6	1.6	-	-	-

Pristane/phytane ratio	0.94
Pristane/C_{17} ratio	2.28

OILS

SAMPLE NO: 2281/79

WELL: Byilkaoora 1.

SAMPLE IDENTIFICATION:

DEPTH: 317.00 - 317.20 m

TYPE OF SAMPLE: Oil Seep

Analysis of fraction boiling above 210°C

Asphaltenes	8.9	% (wt)
Saturates	37.2	%
Aromatics	22.5	%
Resins	23.2	%
Loss on column	8.2	%

n-Alkane distribution of saturates:-

n-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}
Rel abundance	-	1.7	4.9	7.6	10.4	10.1	14.9	8.0	5.2	4.9	5.2

n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{34}
Rel abundance	5.2	7.3	5.9	4.5	2.8	1.4	-	-	-	-	-

Pristane/phytane ratio 0.85

Pristane/C_{17} ratio 3.17

SOURCE ROCK

SAMPLE NO. A 2282/79

WELL: Byilkaoora 1.

SAMPLE IDENTIFICATION:

DEPTH: 278.66 - 278.70 m

TYPE OF SAMPLE: Core sample

Total organic carbon (TOC)	0.50	%
Weight of sample extracted	43.35	gm
Extracted organic matter (EOM)	1 128	ppm
EOM as fraction of TOC	226	mg/g
Weight of EOM mg	48.9	

Analysis of extracted organic matter:-

Asphaltenes	8.2	% (wt)
Saturates	31.7	%
Aromatics	14.7	%
Resins	26.8	%
Loss on column	18.6	%

n-Alkane distribution of saturates:-

N-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}
Rel abund.	-	4.3	11.7	14.4	17.7	11.6	10.4	7.6	5.6	4.6	3.5
n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{34}
Rel abund.	2.5	2.0	1.5	1.3	0.8	0.5	-	-	-	-	-

Pristane/phytane ratio 0.97

Pristane/C_{17} ratio 0.83

SOURCE ROCK

SAMPLE NO.	A 2283/79
WELL:	Byilkaoora 1.
SAMPLE IDENTIFICATION:	
DEPTH:	278.86 - 278.91 m
TYPE OF SAMPLE:	Core sample

Total organic carbon (TOC)	0.45	%
Weight of sample extracted	77.8	gm
Extracted organic matter (EOM)	508	ppm
EOM as fraction of TOC	113	mg/g
Weight of EOM mg	39.5	

Analysis of extracted organic matter:-

Asphaltenes	8.9	% (wt)
Saturates	31.4	%
Aromatics	13.9	%
Resins	23.5	%
Loss on column	22.3	%

n-Alkane distribution of saturates:-

N-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}
Rel abund.	-	1.7	5.8	9.2	14.0	11.0	12.2	8.8	6.7	5.3	4.3
n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{34}
Rel abund.	2.8	2.1	2.3	3.7	3.0	2.6	2.1	1.5	-	-	-

Pristane/phytane ratio	0.92
Pristane/C_{17} ratio	1.20

SOURCE ROCK

SAMPLE NO. A 2284/79

WELL: Byilkaoora 1.

SAMPLE IDENTIFICATION:

DEPTH: 289.77 - 289.80m,

TYPE OF SAMPLE: Core sample

Total organic carbon (TOC)	0.96	%
Weight of sample extracted	23.15	gm
Extracted organic matter (EOM)	1 806	ppm
EOM as fraction of TOC	188	mg/g
Weight of EOM mg	41.8	

Analysis of extracted organic matter:-

Asphaltenes	7.9	% (wt)
Saturates	41.4	%
Aromatics	12.0	%
Resins	33.3	%
Loss on column	5.4	%
	41.8	

n-Alkane distribution of saturates:-

N-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}
Rel abund.	-	2.9	6.7	9.1	11.6	9.7	11.6	8.8	6.7	6.0	5.4
n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{34}
Rel abund.	4.8	4.0	2.7	2.8	2.1	2.2	1.7	1.2	-	-	-

Pristane/phytane ratio 0.98

Pristane/C_{17} ratio 1.57

APPENDIX 3

SOURCE ROCK EVALUATION AND MACERAL DESCRIPTION OF FOUR CORE SAMPLES FROM BYILKAOORA No. 1

Shell Research

Technical Service Report August 1979
RKTR 0150.79

SOURCE ROCK EVALUATION AND MACERAL DESCRIPTION OF FOUR CORE SAMPLES FROM WELL BYILKAOORA-1, AUSTRALIA

by

J.M.A. BUISKOOL TOXOPEUS & J.B.v. LIESHOUT

In co-operation with:

P.J. van der Vet
I.J. Immerzeel
H.P.C. Postma

Investigation
9.12.264

KONINKLIJKE/SHELL
EXPLORATIE EN PRODUKTIE LABORATORIUM
RIJSWIJK, THE NETHERLANDS

CONTENTS

I INTRODUCTION

A source rock evaluation has been carried out on four core samples from Cambrian sediments penetrated by well Byilkaoora-1, Australia.

The purpose of the investigation was:

1. to detect the presence (or absence) of source rocks in the samples,
2. to determine the quality of the organic matter, as well as its distribution,
3. to establish the degree of organic metamorphism.

A source rock is identified by measuring the amount of temperature reactive ("live") organic matter present, that is the amount of organic matter that yields hydrocarbons upon pyrolysis. The method excludes any inert ("dead") organic matter (highly carbonised material) such as inertinites (micrinite, fusinite, sclerotinite, ...).

Typically, source rocks contain up to 1% of inert organic matter in addition to pyrolysable organic material. However, occasionally the amount of inert organic matter may be very high. This points to either a postmature source rock, i.e. a source rock that already has generated its oil and gas, or a rock that has never been a source rock, as it was deposited with highly carbonised (or oxidised) organic matter.

In case postmature source rocks are suspected to be present in a series of samples, the total organic carbon content is measured. Rocks containing less than about 0.5%C (by weight) are considered unlikely to have been commercial oil source rocks.

The quality of a source rock depends also on the type of organic matter present. Five categories of organic matter can be distinguished, viz.: humic, mainly humic, mixed, mainly kerogenous, kerogenous. This classification is based on the hydrogen content of the organic matter. The classification is in agreement with the composition of the organic matter as observed microscopically. Organic matter of the types humic to mixed is usually land plant derived and generally indicates organic matter with increasing quantities of liptinites and/or "structureless organic matter".

Source rocks with organic matter of mixed to kerogenous type generate predominantly oil at a relatively low level of carbonisation. Organic matter of humic type generates gas only. Strata with organic matter of mainly humic quality generate either gas, or gas and oil. This depends on the concentration and the distribution of the "hydrogen-rich" organic constituents (such as SOM -structureless organic matter- , liptinites) in the sample. In the case that the routine typing of the organic matter based on hydrogen content yields a mainly humic source rock type, microscopical analyses must be carried out to estimate the oil or gas potential of the sample.

II. EVALUATION OF SOURCE ROCK PROPERTIES

A. By means of chemical analyses

The source rock indications, which are a measure of the amount of pyrolysable organic matter, are given on the geochemical log and are detailed in Table I.

The source rock indications have been determined on the original samples and in certain cases also after extraction with organic solvents. A systematically lower value after extraction is due to the presence of extractable hydrocarbons. These may consist of trapped oil, migrated oil, oil generated in situ by a source rock, or e.g. gasoil used in the drilling fluid.

In general, samples with source rock indications of 30 or less do not represent (immature or mature) source rocks. Values between 30 and 100 generally indicate marginal source rocks; this may depend also on the thickness of the source rock interval. Marginal source rocks may either develop laterally (downdip) into genuine source rocks or disappear completely.

Intervals or samples with high source rock indications are investigated under a low magnification microscope to ensure that the high values indicate genuine source rock properties and are not due to contaminants of an organic nature such as lost circulation material.

The type of the organic matter in the source rock interval is determined by pyrolysis gaschromatography. The results are included in Table I as well as on the geochemical log.

For a number of samples, the total organic carbon content, measured (normally) on the insoluble organic residue, and expressed in weight percentage, is also given in Table I and on the geochemical log.

In addition to the concentration and type of (live) organic matter, the source rock quality is also characterised by the distribution of the organic constituents in the sediments. The type(s) of maceral(s)(1) can be used to further qualify the source rock, especially when mainly humic quality is found. For this purpose a microscopic study on polished rock fragments is carried out.

By means of microscopical analyses

Assessing a source rock microscopically in order to obtain information about the source rock quality, it is not only important to determine the maceral composition, but also to indicate their distribution. For oil source rocks it is considered to be of importance that the organic matter is loadbearing to facilitate expulsion of generated products. Therefore, lenses and layers of organic matter will be more favourable for oil expulsion than diffusely or intergranularly distributed organic matter. Gas generation and

(1)maceral: an organic constituent which can be recognised under the microscope (with objectives 25x to 50x) expulsion is considered to be less influenced by the distribution of the organic matter.

A general maceral description of the source rocks (carried out with the aid of incident light microscopy using normal -tungsten- and ultra violet irradiation) considers two main types of organic matter: a primary and a secondary organic matter.

Four main groups of primary organic matter (vitrinite, structureless organic matter -SOM-, liptinite and inertinite) are distinguished.

The vitrinite is present as vitrinite I (i.e. telocollinite, telinite) or as a hydrogen-richer vitrinite II. The vitrinite II is in most cases a vitrinite (desmocollinite) bacterially transformed during or just after sedimentation. Most detrital vitrinite particles can be identified as vitrinite II.

The SOM is distributed as a dense mass, in layers and lenses, diffusely and intergranularly. The origin of the SOM is not fully clear; it may be algal and/or bacterial. During or just after sedimentation, the original algal matter may be partly or fully transformed by anaerobic bacteria. SOM may also originate from bacterial transformation of vitrinite material. These anaerobic bacterial transformation processes are manifest by the presence of (high quantities of) framboidal pyrite concentrated in the SOM and around the vitrinite II particles.

To the liptinites belong sporinite, cutinite, resinite and liptodetrinite (/microplankton). Liptodetrinite is formed by slight mechanical breakdown, as well as by slight synsedimentary bacterial transformation of liptinites such as spores, cuticles, etc... .

These small detrital particles show still some of the original optical properties of the liptinites from which they were derived. However, the exact origin can not be determined anymore. Because liptodetrinite and microplankton show similar optical properties, no distinction could be made betweem them.

The primary inertinites such as fusinite and sclerotinite are not considered further, because they do not generate oil or commercial quantities of gas.

The following secondary macerals are distinguished: expulsion products (exsudatinites) and inertinites (micrinite, macrinite).

Exsudatinite and micrinite are formed from the primary macerals SOM and liptinites during increased burial (maturation, coalification). In general micrinisation of lipid materials in source rocks is a temperature sensitive process indicating a hydrogen disproportionation which leads among others to an immobile fine grained residue, viz. micrinite. This maceral is sometimes called "rank"-micrinite as it reflects the degree of thermal exposure. However, weathering (oxydation / bacterial "rotting" / forest fires / ...) could also induce this micrinisation process, especially if one is dealing with organic-rich surface samples. The term "oxy"-micrinite is sometimes used to designate this type of process. It should be noted that although exsudatinites and micrinite were formed from SOM and liptinites, the exact maturity level at which they are generated is strongly variable, depending on the type of the macerals, the preservation of the macerals (oxidation, bacterial transformation), and perhaps the surrounding macerals or type of sediments.

The maceral description is made in a semi-quantitative way using terms as abundant, present, few and rare. The estimated quantities of structureless organic matter (SOM) still contain the following percentages inorganic matter:
SOM_{dense}, layers, lenses : 60 to 90% inorganic
$SOM_{diffuse}$, intergranular: 90 to 99% inorganic. The semi-quantitative data do not warrant addition to arrive at a total organic matter content. This should be arrived at by chemical analysis.

In fact, when assessing a source rock, four factors should be taken into account:

- the total amount of organic matter,
- the type of the organic matter,
- the distribution of the organic matter,
- the degree of organic metamorphism.

These four factors are considered when determining source rock quality. As an absolute quality ranking system of source rocks has not yet been completed, tentative results are given. Comparison between the microscopic results from one well gives a relative ranking of the source rock quality.

It should also be realised that all microscopic observations are made on spot samples rather than on semi-continuous series of samples. Sampling of course is attempted to be representative.

The maceral description results in a qualitative conclusion about the generation capacity of the source material of the described samples. So far no appropriate system exists to correlate the amount and type of maceral assemblage found with the amount of hydrocarbons that will be generated and expelled. Therefore, final conclusions about the overall quantity and quality of the source rock interval are based on the usual recognition and typing tools, taking into account the above qualities.

II MACERAL DESCRIPTION

For a better understanding of the source rock evaluation it was felt necessary to carry out maceral analysis. A semi-quantitative maceral analysis of the four core samples (278.66, 278.86, 289.8 and 315.02m) is given in Tables II - V (see also Plates 1 and 2).

The type of the organic matter in all samples is structureless organic matter (SOM), and is therefore considered favourable for oil and gas generation.

The distribution of the organic matter in samples 278.66, 278.86 and 315.02 is partly diffusely and intergranularly and partly loadbearing, and is therefore regarded favourable for gas expulsion together with (very) marginal amounts of oil. The distribution of the organic matter in sample 289.8 is predominantly loadbearing and is regarded favourable for oil (and gas) expulsion.

All samples show completely micrinised SOM, indicating a high degree of conversion of the organic matter.

III RESULTS

The source rock indication values of samples 278.66, 278.86 and 315.02 are insignificant. Sample 289.8 gives a source rock indication value of 60 units (after extraction).

Typing of the organic matter was not possible, because of the high degree of micrinisation of the SOM, but originally - at a low degree of carbonisation - the quality of the organic matter must have been "kerogenous".

The organic carbon content of the samples ranges between 0.3 and 1.3 % C. Assuming for immature oil source rocks CR/CT values of 0.4, a factor 2 to 3 implies CR/CT ratios close to 1, which indicates postmaturity. Therefore it can be assumed that the postmature samples would represent samples in the immature stage with 0.6 to 3.9 % organic carbon.

It should be noted that microscope observations of sample 278.86 (with 0.3%C) revealed more SOM in this sample than in sample 278.66 (with 0.6%C); the overall distribution of the organic matter seems irregular.

IV CONCLUSIONS

Four core samples (278.66, 278.86, 289.8 and 315.02m) from apparently Cambrian sediments penetrated by well Byilkaoora-1, have been investigated for the presence of source rocks and maceral content.

The results indicate that sample 289.8 contains organic matter in a sufficient concentration to qualify as source rock for gas and as postmature source rock for oil. Samples 278.66, 278.86 and 315.02 contain organic matter in a concentration which qualifies as marginal source rock for gas and as non to very marginal, postmature source rock for oil.

TABLE I WELL: BYILKAOORA-1

DEPTH M	TYPE OF SAMPLE	SOURCE ROCK INDICATION BEFORE EXTR.	SOURCE ROCK INDICATION AFTER EXTR.	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %W
278.70	R	35	25		.6
278.90	R	20	-		.3
289.80	R	75	60		1.3
315	R	20	-		.4
289.80	R	75	60		1.3

TYPE OF SAMPLE C = CUTTINGS, R = CORE, S = SIDEWALL SAMPLE

CONTAMINATION : W = WALNUT FRAGMENTS OR SOME SIMILAR PRODUCT, E = CELLOPHANE SHREDS, F = FIBRES, P = PLASTIC OR PAINT AND C = CONTAMINATED BUT KIND NOT SPECIFIED

A DASH (-) INDICATES TEST NOT MADE, ASTERISKS INDICATE THE ORGANIC CARBON CONTENT IS THE AVERAGE FOR THE SAMPLES CONCERNED

OBSERVATION

Country AUSTRALIA
Well/Location BYILKAOORA-1

Analist BTX/LHT
d.d. 22-6-79

sample nr. depth (ft/m)	sample type	age	formation
278.66 m	c		

Organic																									Inorganic			
S.O.M.						Vitrinite						Liptinite									Inertinite					Pyrite		
						vit-I										algae												
dense	layers	lenses	diffuse	intergranular	patches	telocollinite	telinite	vitrinite-II	layers	lenses	detrital	sporinite	cutinite	resinite	liptodetrinite	botryococcus	tasmanites	other	microplankton	exsudatinite	sclerotinite	fusinite	macrinite	micrinite	undefined	framboidal	aggregates	crystals
		F	+	+																R				F	OF		F	F

acc. Haan

Sedimentary Facies	Metamorphic Facies

Point Count Method (%)

c ; core
ct ; cutting
sws ; side wall sample
s ; surface sample

● ; abundant
\+ ; present
F ; few
R ; rare
ox ; oxidised

INTERPRETATION

Main maceral(s) : Structureless organic matter present, distributed diffusely and intergranularly. Few lenses of SOM.

Rare expulsion products in coarse grained mineral matter.

Minor maceral(s) :

TABLE: II

OBSERVATION

Country AUSTRALIA
Well / Location BYILKAOORA-1

Analist BTX/LHT
d.d. 22-6-79

sample nr. depth (ft/m)	sample type	age	formation
278.86 m	c		

Organic																												Inorganic			
S.O.M.						Vitrinite						Liptinite									Inertinite					Pyrite		
						vit-I										algae												
dense	layers	lenses	diffuse	intergranular	patches	telocollinite	telinite	vitrinite-II	layers	lenses	detrital	sporinite	cutinite	resinite	liptodetrinite	botryococcus	tasmanites	other	microplankton	exsudatinite	sclerotinite	fusinite	macrinite	micrinite	undefined	framboidal	aggregates	crystals
R	R	F	+	+																F				+	O	F	R	F

acc. Haan

Sedimentary Facies	Metamorphic Facies

Point Count Method (%)

c ; core
ct ; cutting
sws ; side wall sample
s ; surface sample

● ; abundant
\+ ; present
F ; few
R ; rare
ox ; oxidised

INTERPRETATION

Main maceral(s) : Structureless organic matter present, distributed diffusely and intergranularly. Rare SOM distributed as a dense mass and in layers. Few lenses of SOM. The SOM is completely micrinised.

Minor maceral(s) : Few expulsion products in coarse grained mineral matter.

TABLE: III

OBSERVATION

Country AUSTRALIA
Well/Location BYILKAOORA-1

Analist BTX/LHT
d.d. 22-6-79

sample nr. depth(ft/m)	sample type	age	formation
289.8 m	c		

Point Count Method (%)

Organic																									Inorganic			
S.O.M.						Vitrinite						Liptinite									Inertinite					Pyrite		
						vit-I										algae												
dense	layers	lenses	diffuse	intergranular	patches	telocollinite	telinite	vitrinite-II	layers	lenses	detrital	sporinite	cutinite	resinite	liptodetrinite	botryococcus	tasmanites	other	microplankton	exsudatinite	sclerotinite	fusinite	macrinite	micrinite	undefined	framboidal	aggregates	crystals
O	+	+	+	+																+				O	O	R	R	R

acc. Haan

Sedimentary Facies	Metamorphic Facies

c ;core
ct ;cutting
sws ;side wall sample
s ;surface sample

● ;abundant
+ ;present
F ;few
R ;rare
ox ;oxidised

INTERPRETATION

Main maceral(s) : Abundant structureless organic matter, distributed as a dense mass. SOM present in layers, lenses, diffusely and intergranularly. The SOM is completely micrinised.

Minor maceral(s) : Expulsion products present in coarse grained mineral matter.

TABLE: IV

OBSERVATION

Country AUSTRALIA
Well/Location BYILKAOORA-1

Analist BTX/LHT
d.d. 22-6-79

sample nr. depth(ft/m)	sample type	age	formation
315.02 m	c		

Organic																									Inorganic			
S.O.M.						Vitrinite						Liptinite									Inertinite					Pyrite		
						vit-I										algae												
dense	layers	lenses	diffuse	intergranular	patches	telocollinite	telinite	vitrinite-II	layers	lenses	detrital	sporinite	cutinite	resinite	liptodetrinite	botryococcus	tasmanites	other	microplankton	exsudatinite	sclerotinite	fusinite	macrinite	micrinite	undefined	framboidal	aggregates	crystals
	R	F	+	+																+				+	O	F	R	F

Point Count Method (%)

acc. Haan

Sedimentary Facies	Metamorphic Facies

c core
ct cutting
sws side wall sample
s surface sample

● ; abundant
\+ ; present
F ; few
R ; rare
ox ; oxidised

INTERPRETATION

Main maceral(s) :

Minor maceral(s) :

Structureless organic matter present, distributed diffusely and intergranularly. Rare layers of SOM. Few SOM lenses.

The SOM is completely micrinised.

Expulsion products present in coarse grained mineral matter.

TABLE: V

APPENDIX 4

PETROGRAPHY

S. Whitehead, AMDEL

Note: Many petrological samples have been taken coincident with, or adjacent to metals analysis, hydrocarbon analysis and proposed biostratigraphic sample sites.

Sample No.	Depth (m)	Stratigraphic Unit
5643RS10	16.95	Trainor Hill Sandstone, upper member.
5643RS11	53.00	Mt. Johns Conglomerate, distal facies.
5643RS12	57.53	as above.
5643RS13	65.55	as above.
5643RS14	93.31	as above.
5643RS15	94.94	as above.
5643RS16	97.97	as above.
5643RS17	98.60	as above.
5643RS18	98.93	Trainor Hill Sandstone, lower member
5643RS19	111.00	as above.
5643RS20	112.00	as above.
5643RS21	38.60	Trainor Hill Sandstone, upper member.
5643RS22	92.50	Mt. John Conglomerate, distal facies.
5643RS23	100.15	Trainor Hill Sandstone, lower member.
5643RS24	167.70	Observatory Hill Beds, Member 5.
5643RS25	189.10	as above.
5643RS26	200.35	as above.
5643RS27	201.45	Observatory Hill Beds, Member 4.
5643RS28	207.40	as above.
5643RS29	211.60	as above.
5643RS30	213.65	as above.
5643RS31	225.50	as above.
5643RS32	225.50	as above.
5643RS33	225.15	as above.
5643RS34	240.80	as above.
5643RS35	252.85	as above.
5643RS36	259.45	Observatory Hill Beds, Member 3.
5643RS37	272.45	as above.
5643RS38	273.20	as above.
5643RS39	278.50	as above.
5643RS40	279.55	as above.
5643RS41	285.30	as above.
5643RS42	289.00	as above.
5643RS43	293.45	as above.
5643RS44	295.05	as above.
5643RS45	306.28	as above.
5643RS46	313.25	as above.
5643RS47	316.55	as above.
5643RS48	317.15	as above.
5643RS49	327.95	Observatory Hill Beds, Member 2.
5643RS50	335.45	as above.
5643RS51	370.40	Observatory Hill Beds, Member 1.
5643RS52	376.60	as above.
5643RS53	385.40	Davies Bore Conglomerate.
5643RS54	385.45	as above.
5643RS55	393.00	as above.
5643RS56	440.60	as above.
5643RS57	463.10	as above.

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9 July 1979

Director-General,
Department of Mines & Energy,
PO Box 151,
<u>EASTWOOD,</u> SA 5063.

<u>Attention:</u> Mr M. Benbow

<u>REPORT GS 4926/79</u>

YOUR REFERENCE:	Application dated 31 May 1979
MATERIAL:	11 drill core samples
LOCALITY:	Byilkaoora No. 1 drillhole
IDENTIFICATION:	Samples 5643 RS 10 - 20
DATE RECEIVED:	6 June 1979
WORK REQUIRED:	Petrographic description with special reference to possible volcanic-lithic grains and to green alteration

Investigation and Report by: Sylvia Whitehead

Manager, Geological Services Division: Dr Keith J. Henley

Keith Henley.

for Norton Jackson
Managing Director

jd/14

SUMMARY OF SPECIMENS

Sample and TS No.	
5643 RS 10 TS41718	Quartzite in which some grains, possibly feldspar have been replaced by clay and/or leached.
5643 RS 11 TS41719	Deformed, weakly metamorphosed, ferruginous siltstone and shale with some bleached zones from which ferric oxide has been removed.
5643 RS 12 TS41720	Laminated ferruginous shale in contact with poorly sorted, dolomitic sandstone containing some feldspar and lithic grains. No grains of definite volcanic origin were found but some are too fine-grained for the origin to be determined.
5643 RS 13 TS41721	Argillaceous and dolomitic sandstone composed of poorly sorted material. It could also be classified as diamictite. There are a few grains of basalt.
5643 RS 14 TS41722	Ferruginous, sandy, dolomitic siltstone with scattered zones in which the ferric oxide has been bleached.
5643 RS 15 TS41723	Ferruginous, argillaceous, dolomitic sandstone and siltstone. This contains a higher proportion of lithic grains most of which were derived from fine-grained metasediment (metasiltstone). Very few were derived from volcanic rock.
5643 RS 16 TS41724	Conglomerate composed of material derived mainly from coarse-grained granitic or gneissic rocks and from fine-grained metasediments. The matrix is heavily stained by iron oxide.
5643 RS 17 TS41725	Conglomerate containing pebbles of sheared quartz-feldspar gneiss and granitic rock in a ferruginous, sandstone matrix.
5643 RS 18 TS41726	Feldspathic and lithic sandstone composed of well-sorted but immature detrital material. Lithic grains include a few derived from acid volcanic rock.

5643 RS 19 TS41727	Ferruginous, micaceous siltstone.
5643 RS 20 TS41728	Ferruginous, micaceous siltstone, fine-grained sandstone and shale.

DESCRIPTION OF SEDIMENTS FROM DDH BYILKAOORA NO. 1

Sample: 5643 RS 10; TS41718; Depth 16.95 - 17 m

Hand Specimen:

A pale pinkish cream-coloured sandstone with a uniform grain size. It contains numerous small leached voids and some containing white clay which has probably resulted from the alteration of some mineral grains possibly feldspar.

Thin Section:

A visual estimate of the minerals is as follows:

	%
Quartz	80-90
Grains replaced by clay or leached	10-15
Lithic grains	trace
Muscovite	trace
Zircon	trace
Leucoxene	trace

This is composed of well-sorted quartz grains most of which are between 0.2 and 0.4 mm. in size and there is a moderate proportion of elongate grains which are subparallel probably to the direction of bedding. There are a few lithic grains mainly composed of fine-grained quartz and only one or two grains of acid volcanic rock. Heavy mineral grains are mainly zircon and leucoxene and the sediment once contained some other grains possibly of feldspar, some of which have been replaced by clay and some have been leached leaving voids. Relict textures show that the quartz grains were subangular to sub-rounded.

The detrital grains are closely packed and there has been minor interpenetration. Most of the quartz grains are now surrounded or partly surrounded by overgrowths of secondary quartz in optical continuity with the detrital grain and these overgrowths have intergrown to fill many interstices. A few interstices contain clay, some of which could have been derived from altered feldspar grains.

Conclusion:

Weathered and leached quartzite which probably once contained some feldspar.

Sample: 5643 RS 11; TS41719; Depth 53.0 - 53.04 m

Hand Specimen:

A reddish-brown, fine-grained rock with a few pale-greenish grey patches. Some of these are isolated and some occur along small fractures. There are traces of dark manganese oxide also along a few joints or fractures.

Staining with cobaltinitrite shows traces of potash feldspar along a few joints or veins.

Thin Section:

A visual estimate of the minerals is as follows:

	%
Sericite and chlorite heavily stained by iron oxide	85-90
Muscovite	5-10
Quartz	2-3
Biotite	trace
Potash feldspar	trace
Opaque oxide	1-2

Much of this sample is composed of sericite and lesser chlorite which are very heavily stained by reddish-brown iron oxide and, because these minerals are very fine-grained and the optical properties are largely obscured by the iron oxide, it is not possible to determine the relative proportions of these two minerals. However, in the bleached areas which have similar textures but lack the iron oxide staining, it can be seen that sericite or illite is more abundant than chlorite. The unstained areas also show that there are two directions of foliation resulting in a finely crenulated appearance. In the darker, heavily stained zones there are very numerous, small oval spots about 0.05 mm in size which are not as intensely stained by iron oxide as the remainder of the rock but no definite conclusion as to the reason for this could be found. They may, in same way, be related to the finely crenulated structure of the rock. These zones of ferruginous shale contain some detrital mica flakes 0.05 to 0.1 mm long and a few very small quartz grains.

There are some zones of siltstone containing angular quartz grains 0.02 to 0.04 mm in size, moderately abundant detrital mica flakes up to 0.1 mm long and a few very small heavy mineral grains mainly leucoxene in a matrix of sericite or clay stained by reddish-brown iron oxide. Layers or zones of ferruginous shale have been fractured and invaded by the siltstone and in some of the larger patches of siltstone there are small, angular fragments of shale. There are also a few very small, very irregular and discontinuous veins along which there are small amounts of potash feldspar and traces of non-opaque oxide.

In the area sectioned there is one pale-coloured, oval spot from which ferric oxide has been bleached or leached and there are similar pale-coloured zones spreading out from a relatively recent, open fracture. No definite evidence could be found in the thin section to explain these zones of bleacing but there shape and distribution suggests that they are of relatively recent origin (after metamorphism and deformation) and are presumably due to the action of some reducing agent which changes the ferric iron to the more soluble ferrous state.

Conclusion:

Deformed, weakly metamorphosed, ferruginous shale and siltstone with some pale-coloured, bleached zones from which ferric oxide has been removed.

Sample: 5643 RS 12; TS41720; Depth 57.53 - 57.62 m

Hand Specimen:

Portion of this sample is fine-grained, finely laminated, dark reddish-brown shale and this is in contact with paler-coloured, coarser-grained sediment which appears to have been disturbed. Fine bedding in the shale also shows some evidence of contorted folding.

Staining with cobaltinitrite shows that the coarser-grained sediment contains some grains of potash feldspar.

Thin Section:

This was cut mainly from the coarser-grained portion of the rock. It contains the following minerals.

	%	
Dolomite	35-40	
Quartz	25-30	
Potash feldspar	10-15	
Detrital mica	2-3	(varies)
Lithic grains	1-2	
Tourmaline	trace	
Iron oxide-stained sericite or clay	15-20	

This is a rather mixed sediment showing some evidence of disturbance in that there are thin wisps or fragments of dark reddish-brown ferruginous shale and siltstone scattered through a predominantly coarser-grained sediment and some of the thin wisps or fragments of shale show rather complex folding. Larger fragments of ferruginous shale are very similar to portions of the sample from 53.00 m and the description will not be repeated.

The coarser-grained sediment in contact with the shale and also enclosing the fragments of shale contains poorly sorted quartz and potash feldspar grains which vary in size from about 0.05 mm up to 1 mm and there are a few larger grains composed of intergrown, coarse-grained quartz and potash feldspar possibly derived from granitic or gneissic rock. There are also a few lithic grains of varying composition, colour and texture and these include some of fine-grained metasediment probably mainly metasiltstone, a few of microcrystalline quartz, a few chloritic grains and some grains composed of fine-grained mica or chlorite and quartz which do not show any definite texture and the origin of these cannot be determined. No grains were found showing unquestionable evidence of volcanic origin but it is possible that some of the fine-grained, chloritic or micaceous grains could have been derived from volcanic rock. The sediment also contains a few detrital mica flakes including both muscovite and biotite and a few heavy mineral grains mainly tourmaline and leucoxene.

The matrix now contains a large proportion of dolomite crystals up to 0.1 mm in size but there are also varying amounts of iron oxide-stained sericite or chlorite and some of this could have been replaced or partly replaced by the dolomite.

Conclusion:

Laminated, ferruginous shale in contact with dolomitic sandstone composed of poorly sorted detrital material in a fine-grained matrix now cemented by dolomite. No grains were found which could be recognized as having a definit volcanic origin but some are too small and too fine-grained for their origin to be determined.

Sample: 5643 RS 13; TS41721; Depth 65.55 - 65.59 m

Hand Specimen:

A pale greyish-green rock containing some sand-sized quartz grains.

Thin Section:

A visual estimate of the minerals is as follows:

	%
Quartz	35-40
Potash feldspar	5-10
Lithic grains	2-3
Chlorite and sericite	30-35
Detrital mica	1-2
Dolomite	15-20
Zircon	trace

This sediment is composed of poorly sorted quartz, feldspar and lithic grains which vary in size from less than 0.1 mm to about 1.5 mm and there are also some fragments of shale of varying size, the largest being about 6 mm long. These shale fragments probably represent disrupted layers of sediment of similar age to the sandstone but it is not certain whether they represent reworked fragments of bottom sediment or fragments of layers which were disrupted soon after the sediment accumulated.

Most of the larger quartz and feldspar grains are well rounded or subrounded but there are a few angular or subangular microcline grains. Lithic grains include some composed of intergrown quartz and feldspar, some of fine-grained chloritic rock of undetermined origin, some of fine-grained metasediment and a few of partly altered basic igneous rock which was either basalt or fine-grained dolerite. Basalt is probably more likely.

These detrital grains are very loosely packed and are generally not touching or barely touching. They are cemented by a turbid matrix which contains varying proportions of dull greenish chlorite, sericite and dolomite. There are a few small detrital mica flakes and traces of very fine-grained leucoxene and/or other opaque or semi-opaque material.

Conclusion:

Argillaceous and dolomitic sandstone composed of poorly sorted detrital material most of which was probably derived from moderately coarse-grained granitic or gneissic rocks but some grains were derived from basaltic rock.

Sample: 5643 RS 14; TS41711; Depth 93.31 - 93.37 m

Hand Specimen:

A dark reddish-brown, fine-grained rock with scattered oval, pale greyish-green patches varying in size from less than 1 mm to about 5 mm. These pale-coloured patches have sharp boundaries and are similar to the bleached zones noted in the sample from 53.00 - 53.04 m.

Thin Section:

A visual estimate of the minerals is as follows:

	%
Iron oxide-stained sericite and chlorite	40-45
Dolomite	35-40
Quartz	10-15
Potash feldspar	1-2
Lithic grains	5-10
Detrital mica	trace
Tourmaline	trace
Leucoxene	trace

The matrix of this rock is composed of sericite and chlorite heavily stained by reddish-brown iron oxide and this contains scattered crystals and crystalline aggregates of dolomite which vary in size from about 0.01 mm up to about 0.15 mm. There are a few detrital flakes of muscovite and biotite, a few very small heavy mineral grains and numerous scattered wisps and/or fragments of material so heavily stained by reddish-brown iron oxide as to be almost opaque. These could be described as fragments of ferruginous shale and they were probably derived from thin layers of shale interbedded with the more silty sediment. Scattered through this dolomitic and ferruginous matrix there are some poorly sorted detrital quartz, feldspar and lithic grains varying in size from less than 0.1 mm up to about 0.8 mm and the concentration of these detrital grains varies in a rather irregular manner which does not show any relationship to bedding and there are a few zones or pockets up to about 5 mm in size containing moderately high concentrations of these detrital grains. Lithic grains found in this thin section are mainly of fine-grained metasediment predominantly metasiltstone, a few composed of muscovite and biotite with and without quartz which are probably fragments of schist and some of turbid, very fine-grained rock the origin of which cannot be determined from available evidence. No definite volcanic-lithic grains were found but it is possible that some of those composed of fine-grained material could have been derived from volcanic rock.

There are a few oval, bleached zones in the section and these differ from the surrounding rock only in the absence of reddish-brown ferric oxide staining. In these bleached zones all ferric oxide has been removed from the matrix and only traces of ferric oxide are preserved within a few of the larger lithic and feldspar grains and occasionally there are also traces of ferric oxide still coating one or two of the quartz grains. As noted in the hand specimen the boundary between iron oxide-stained sediment and bleached sediment is generally sharply defined and in some places cuts across lithic grains part of which will remain stained while portion has been bleache As in the sample from 53.00 - 53.04 m no definite evidence could be found in the thin section to show why certain zones are bleached and others are not.

Conclusion:

Ferruginous, sandy, dolomitic siltstone with scattered zones in which the ferric oxide has been bleached.

Sample: 5643 RS 15; TS41723; Depth 94.94 - 95.00 m

Hand Specimen:

A predominantly reddish-brown sediment with some layers a few millimetres thick of siltstone stained a darker reddish-brown alternating with paler-coloured layers also a few millimetres thick of sandstone. Boundaries between the layers are rather irregular and not always clearly defined.

Thin Section:

The proportions of constituent minerals vary in different layers and a general estimate is given below:

	%
Quartz	20-25
Lithic grains	15-20
Potash feldspar	2-3
Detrital mica	2-3
Iron oxide-stained sericite and chlorite	25-30
Dolomite	20-25
Apatite	trace
Opaque oxide	trace

The paler-coloured, sandy layers contain moderately well-sorted quartz, feldspar and lithic grains in a matrix of reddish-brown argillaceous material and dolomite and these layers alternate with layers of siltstone containing a much higher proportion of sericite and chlorite very heavily stained by reddish-brown iron oxide and relatively few, much smaller detrital quartz grains. In most of the sandstone layers a large proportion of the detrital quartz and feldspar have a common grain size of about 0.1 to 0.4 mm but there are also a few scattered larger grains up to 1 mm in size and an occasional lithic fragment up to 4 mm in size.

One notable feature of this sample is that lithic grains occur in higher concentration than in samples from shallower depths and in general they are slightly larger than the detrital quartz and feldspar grains. Fragments of fine-grained metasediment predominate, in particular metasiltstone, and most of these are elongate and well-rounded. Other lithic grains include some composed of moderately coarse-grained quartz and feldspar, some of sericitic schist and some of turbid, fine-grained chloritic material, the origin of which cannot be determined. There are one or two grains which were probably derived from volcanic rock but they are very subordinate to lithic grains derived from metasediment.

Detrital quartz, feldspar and lithic grains are loosely packed and in general they are not touching. The surrounding matrix contains varying proportions of heavily stained sericite and/or chlorite containing some fine-grained detrital mica, a few opaque oxide grains and varying proportions of dolomite crystals. In general, the matrix in the sandstone layers is very similar to the material forming the bulk of the iron oxide-stained siltstone layers.

Conclusion:

Ferruginous, argillaceous and dolomitic sandstone interbedded with ferruginous and dolomitic siltstone. This sample contains a higher proportion of lithic grains than those from shallower depths and most of these were derived from fine-grained metasediment in particular from metasiltstone.

Sample: 5643 RS 16; TS41724; Depth 97.97 - 98.00 m

Hand Specimen:

A conglomeratic rock with some large grains and pebbles up to 1 to 2 cm in size in a reddish ferruginous matrix.

Thin Section:

A visual estimate of the minerals is as follows:

	%
Quartz	30-35
Lithic grains and fragments	20-25
Potash feldspar	10-15
Detrital mica	1-2
Iron oxide-stained sericite and chlorite	25-30
Opaque oxide/leucoxene	trace

This is a poorly sorted sediment containing some large grains and pebbles up to several millimetres in size in a matrix composed largely of sand-sized detrital grains with interstitial iron oxide-stained argillaceous material, now mainly sericite and/or chlorite.

The larger fragments and grains wereall derived from moderately coarse-grained granitic or gneissic rock composed predominantly of quartz, potash feldspar and plagioclase but most of the plagioclase has been extensively altered and sericitized. There are a few large fragments of strained and recrystallized quartz which could have been derived either from a deformed quartz vein or deformed quartzite and there are a few fragments 2 to 3 mm long of finer-grained quartzite and other metasediment. There is one fragment of gneissic rock. Most of these larger fragments are subangular to subrounded and elongate fragments tend to be subparallel probably to the direction of bedding.

The matrix contains quartz grains up to about 0.5 mm in size, some potash feldspar grains and lithic grains, a large proportion of which were derived from fine-grained metasediment as in the sample from 94.94 - 95.00 m. There are some lithic grains of indeterminate origin and there are one or two which were probably derived from basic volcanic rock. The matrix also contains a few detrital muscovite flakes and a few heavy mineral grains mainly opaque oxide and leucoxene with a trace of zircon. Detrital grains in the matrix are loosely packed and are cemented by reddish-brown, iron oxide-stained chlorite or sericite. Some of the detrital grains have a thin, surface coating of iron oxide and some zones in the rock are more heavily stained by iron oxide than others.

Conclusion:

Conglomerate composed of detrital material derived mainly from coarse-grained granitic and/or gneissic rocks and from fine-grained metasediments.

Sample: 5643 RS 17; TS41725; Depth 98.60 - 98.64 m

Hand Specimen:

A conglomerate containing some large pebbles at least 2 to 3 cm in size in a brown, iron oxide-stained matrix containing some sand-sized detrital grains.

Thin Section:

As the composition varies, a visual estimate of the minerals present would have little meaning.

Portions of two of the large pebbles are included in the thin section, one of these is of a sheared, coarse-grained, quartz-feldspar gneiss and the other is of coarse-grained quartz-feldspar rock which has also been subjected to some form of tectonic stress before it was eroded and the fragments included in this sediment.

The matrix contains poorly sorted grains of quartz, potash feldspar and lithic grains varying in size from about 0.2 mm up to 4 mm and most of the quartz and feldspar grains are angular or subangular. Lithic grains were derived mainly from fine-grained metasediment and these tend to be elongate and rounded probably because they were softer than the quartz and feldspar grains. A few lithic grains composed of fine-grained material are of indeterminate origin but none were found which could be recognized as having been definitely derived from volcanic rock. There are a few heavy mineral grains mainly opaque oxide and a few grains which have been extensively replaced by iron oxide. These detrital grains are closely packed and are cemented by iron oxide-stained chlorite and/or sericite similar to that forming a matrix in other sediments.

Conclusion:

Conglomerate containing pebbles of sheared quartz-feldspar gneiss and granitic rock in a sandstone matrix stained by iron oxide. Most of the lithic grains in the matrix were derived from fine-grained metasediment and no volcanic-lithic grains were recognized.

Sample: 5643 RS 18; TS41726; Depth 98.93 - 99.00 m

Hand Specimen:

A salmon-pink sandstone or quartzite containing some some grains which have been replaced by white clay and some small voids.

Thin Section:

A visual estimate of the minerals is as follows:

	%
Quartz	45-50
Detrital feldspar	25-30
Lithic grains	20-25
Detrital mica	trace
Opaque oxide/leucoxene	trace
Tourmaline	trace

The sediment is composed of very well sorted quartz, feldspar and lithic grains most of which are between 0.1 and 0.2 mm in size and subangular to subrounded. Feldspar grains are predominantly potash feldspar and some of these show twinning typical of microcline. Lithic grains are of variable composition and include some of fine-grained metasediment, some sericitic fragments of undetermined origin and a few orange-stained grains which were clearly derived from acid volcanic rock. There are a few heavy mineral grains mainly opaque oxide or leucoxene and a few detrital muscovite flakes.

The detrital grains are closely packed and some are welded but in general there has been little or no interpenetration of grains. Many of the detrital grains are coated with a very thin film of iron oxide which is the cause of the orange to pink colour of the rock and this film of iron oxide is included within thin overgrowths of both quartz and feldspar which surround some of the detrital grains. Some interstices have been filled by secondary quartz in places intergrown with the secondary feldspar overgrowths and some interstices contain portions of deformed softer lithic grains which have been squeezed into these interstices. A few interstices have been filled by reddish-brown iron oxide.

Conclusion:

Feldspathic and lithic sandstone composed of well-sorted but not very mature detrital material. Lithic grains include many of fine-grained metasediment and some derived from acid volcanic rock.

Sample: 5643 RS 19; TS41727; Depth 111.00 - 111.04 m

Hand Specimen:

A reddish-brown, fine-grained rock with very indistinct bedding defined by slight variations in colour.

Thin Section:

A visual estimate of the minerals is as follows:

	%
Quartz and feldspar	30-35
Detrital mica including muscovite and biotite	25-30
Iron oxide-stained sericite and chlorite	35-40
Opaque oxide grains	trace

This sediment varies slightly in composition and grain size in layers most of which are between 1 and 2 mm thick with a few up to 5 mm and there are a few very thin layers which are heavily stained by iron oxide. Most of the layers contain angular quartz and feldspar grains varying in size from about 0.02 mm to about 0.08 mm and abundant detrital mica flakes 0.1 to 0.3 mm long which include both muscovite and biotite. There are a few heavy mineral grains and in a few places there is evidence suggesting that the rock originally contained a few lithic grains but these tend to merge with matrix sericite and chlorite. The mica flakes show a preferred orientation parallel to the bedding and some elongate fragments of quartz and feldspar are also orientated in this direction. One or two small grains composed of a bright green, fine-grained micaceous mineral were found but the origin of these is unknown.

Relative proportions of quartz, feldspar and mica vary slightly in the different layers and the paler-coloured layers contain slightly higher concentrations of quartz and feldspar. Many of the detrital grains have a very thin, surface film of reddish-brown iron oxide or iron oxide-stained clay and they are surrounded and cemented by the matrix of sericite or clay which is so heavily stained by iron oxide that its optical properties cannot be determined. In general, the finer-grained layers containing less detrital quartz and feldspar are more heavily stained by iron oxide.

Conclusion:

Ferruginous, micaceous siltstone.

amdel

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20 August 1979

In reply quote: GS 1/2/0

Your Ref: 12.06.0532

Director-General,
Department of Mines & Energy,
PO Box 151,
EASTWOOD, SA 5063.

Attention: Mr G. Pitt

REPORT GS 216/80

YOUR REFERENCE:	Application dated 11 July 1979
MATERIAL:	37 drill core samples
LOCALITY:	DDH Byilkaoora 1, 5 km, 320°T Marla Bore
IDENTIFICATION:	Samples 5643 RS 21-57
DATE RECEIVED:	12 July 1979
WORK REQUIRED:	Petrographic description with comments on environment of deposition and degree of metamorphism

Investigation and Report by: Sylvia Whitehead

Manager, Geological Services Division: Dr Keith J. Henley

Keith Henley

for Norton Jackson
Managing Director

ilot Plant: Osman Place
Thebarton S.A.
Telephone 43 8053
ranch Laboratory: Perth

jd/55

Sample: 5643 RS ~~2~~20; TS41728; Depth 112.00 - 112.02 m

Hand Specimen:

A reddish-brown, fine-grained sediment with layering on a scale of about 1 to 3 mm defined by variations in colour.

Thin Section:

A visual estimate of the minerals is as follows:

	%
Detrital quartz and feldspar	35-40
Detrital mica	20-25
Lithic grains	1-2?
Iron oxide-stained chlorite and sericite	35-40
Leucoxene	trace

This is similar to the sample from 111.00 - 111.04 m but is slightly coarser-grained and variations in grain size with bedding are more conspicuous.

Coarser-grained layers which vary in thickness from about 0.4 mm to about 2 mm contain angular quartz and potash feldspar grains 0.05 to 0.2 mm in size and numerous detrital flakes of muscovite and biotite generally between 0.2 and 0.6 mm long in a matrix of iron oxide-stained argillaceous material. There are a few lithic grains most of which are too small for their origin to be determined but there are at least one or two which could have been derived from basic volcanic rock. A few of the quartz and feldspar grains have become welded and a few show overgrowths of secondary quartz and feldspar which have filled interstices in small areas but these overgrowths are not common.

The darker layers contain lower concentrations of detrital quartz and feldspar and correspondinly higher concentrations of iron oxide-stained chlorite and/or sericite which, in some layers is almost opaque and its optical properties cannot be determined.

Conclusion:

Ferruginous, micaceous siltstone, fine-grained sandstone and shale.

SUMMARY OF SPECIMENS

Sample and TS No.	
DDH BYILKAOORA 1	
5643 RS 21 38.60 m TS41876	White claystone composed of kaolin and 'sericite'.
5643 RS 22 92.50 m TS418.77	Sandy, ferruginous shale and siltstone showing patchy bleaching.
5643 RS 23 100.15 m TS41878	Feldspathic sandstone composed of very well-sorted but not very mature, iron oxide-stained, detrital material. Minor lithic grains have been derived from a variety of rock types. It is cemented mainly by overgrowths on quartz and feldspar grains.
5643 RS 24 167.70 m TS41879	Ferruginous shale and siltstone with thin layers of fine-grained, feldspathic sandstone. There was some disturbance to the bedding early in the history of this sediment.
5643 RS 25 189.10 m TS41880	Micaceous and slightly silty shale and siltstone with patchy iron oxide staining.
5643 RS 26 200.35 m TS41881	Pyritic and dolomitic siltstone with small concretions (nodules) composed mainly of carbonate with lesser pyrite.
5643 RS 27 201.45 m TS41882	Interbedded calcitic and pyritic dolomite, dolomitic shale and pyritic chert with some deformed bands and veins of calcite. There is a trace of chalcopyrite Evidence of algal origin is inconclusive.
5643 RS 28 207.40 m TS41883	Dolomitic and pyritic shale with some thin layers of silty dolomite.
5643 RS 29 211.60 m TS41884	Finely laminated dolomite and limestone with minor amounts of argillaceous and silty material and a trace of pyrite. There is a trace of carbonaceous staining.

5643 RS 30 213.65 m TS41885	Pyritic and dolomitic shale with a few thin silty layers. There were minor disturbances to the bedding early in the history of the sediment (soft-sediment deformation).
5643 RS 31 225.50 m RS41886	Silty and argillaceous limestone interbedded with calcareous and dolomitic shale and siltstone. There is a patch of chert and small patches of orange-stained chalcedonic quartz. (The red mineral is orange-stained, spherulitic and colloform chalcedony)
5643 RS 32 225.80 m TS41887	Silty limestone and pyritic shale with thin layers of disturbed material containing chert, chalcedony and carbonate minerals and possibly some pseudomorphs after evaporite minerals (e.g., gypsum). The orange-red material is spherulitic chalcedonic quartz stained orange. Some has formed around carbonate and minute opaque spheres.
5643 RS 33 225.15 m TS41888	Thinly bedded dolomitic and calcareous siltstone and shale with some layers 1 to 3 mm thick showing graded bedding. It may once have contained some organic or carbonaceous material and small joints are stained by organic material.
5643 RS 34 240.80 m TS41889	A complex mixture of shale, siltstone and minor silty limestone in which some silty matetial has invaded shale. It could have been bioturbated but there is no conclusive proof of this.
5643 RS 35 TS41890 252.85 m	Mainly siltstone with minor shale and a layer of fine-grained sandstone. The bedding was disturbed while soft but the structures do not suggest bioturbation.
5643 RS 36 259.45 m TS41891	Silty dolomite and limestone grading locally to dolomitic siltstone interbedded with thin layers of shale. There are two bands of chert and layers containing fragments or patches of chert associated with calcite, silty material and some sulphide mainly sphalerite.
5643 RS 37 272.45 m TS41892	Pyritic, dolomitic siltstone with a zone containing patches of calcite which probably replaced an earlier mineral. This could have been an evaporite mineral (halite?) but the evidence on which this suggestion is based is very inconclusive. There may also have been some organic material.
5643 RS 38 273.20 m TS 41893	Very fine-grained, slightly silty, calcitic dolomite with a few thin layers of shale.

5643 RS 39 278.50 m TS41894	Disrupted bands and fragments or patches of chert in moderately coarse-grained calcite and dolomite with some silty shale. Relict textures strongly suggest that some of the chert once contained a few crystals of halite. There is a trace of sulphide including sphalerite.
5643 RS 40 279.55 TS41895	Calcareous (or calcitic), pyritic shale with a few small pockets of fine sand. It may once have contained minor halite (replaced by fine-grained quartz and pyrite).
5643 RS 41 285.30 m TS41896	Argillaceous and calcareous or calcitic dolomite with a lenticular layer of carbonate-bearing chert. There are veins and patches of migratory calcite and minor sulphide.
5643 RS 42 289.00 m TS41897	Argillaceous, dolomitic and pyritic 'limestone' with a matrix of dark-stained and pyritic argillite through which there are numerous moderately large crystals and aggregates of calcite and dolomite. Calcite has partially replaced an evaporite mineral but relict textures are not sufficently well preserved for this to be identified.
5643 RS 43 293.45 m TS41898	Argillaceous, dolomitic and pyritic 'limestone' essentially very similar to the sample from 289.00 m. Aggregates of dolomite are better defined, of uniform size (1 mm) and almost spherical. Calcite forms irregularly-shaped aggregates.
5643 RS 44 295.05 m TS41899	Calcite pseudomorphs after a coarsely crystalline evaporite mindral in a matrix of fine-grained argillaceous dolomite. The prence of slightly curved, elongate or prismatic pseudomorphs suggests former gypsum but the possibility of other evaporite minerals cannot be excluded.
5643 RS 45 306.28 m TS41900	Pyritic argillite containing calcite pseudomorphs very probably after an evaporite mineral but the crystal form is not preserved and this cannot be identified. These are smaller and in lesser concentration than in samples from 289.00 m - 295.05 m. There is minor dolomite.
5643 RS 46 313.25 m TS41901	Argillaceous and calcitic dolomite with a few thin layers of shale. There is minor pyrite.
5643 RS 47 316.55 m TS41902	Calcitic dolomite containing a lower proportion of argillaceous material than at 313.25 m. There are a few very thin layers of pyritic shale.

5643 RS 48 317.15 m TS41903	Dolomitic shale containing abundant calcite pseudomorphs after crystals of an evaporite mineral very probably gypsum. There are some small globules of dark viscous oil.
5643 RS 49 327.95 m TS41904	Calcitic, silty and sandy dolomite with thin layers and lenticles of chert. There is a trace of dark organic material as small particles and concentrated along stylolitic seams. There is a trace of sphalerite associated with the chert (compare samples 5643 RS 36 and 39 at 259.45 m and 278.50 m).
5643 RS 50 335.45 m TS41905	Sandy dolomite (or fine-grained, dolomitic sandstone) containing calcite pseudomorphs after crystals of an evaporite mineral probably gypsum.
5643 RS 51 370.40 m TS41906	Sandy, dolomitic argillite (or argillaceous dolomite) very heavily stained by iron oxide. There are numerous irregular aggregates of coarser-grained, clear dolomite which have either crystallized in voids or replaced an evaporite mineral. The sediment contains many rounded lithic grains derived from siltstone and shale.
5643 RS 52 376.60 m TS 41907	Intraformational breccia composed of dolomite.
5643 RS 53 385.40 m TS41908	Conglomerate which has suffered additional fracturing and movement. Most of the clasts are of feldspathic and micaceous sediment varying from siltstone to poorly sorted, coarse sandstone. There is one of coarse-grained adamellite or metamorphic rock. Interstices contain large quartz and feldspar grains, dolomite and carbonaceous material.
5643 RS 54 385.45 m TS41909	Conglomerate composed mainly of pebbles of sedimentary rock with a silty and dolomitic matrix stained by iron oxide. Small fractures formed after consolidation of the rock contain carbonaceous material.
5643 RS 55 393.00 m TS41910	Conglomerate composed mainly of clasts of sedimentary rock and a few large quartz and feldspar grains cemented by dolomite. The rock has been fractured and numerous small fractures contain calcite and minor sulphide. Other fine fractures contain carbonaceous material.

5643 RS.56 440.40 m TS41911	Conglomerate composed mainly of clasts of sedimentary rock and some coarse-grained microcline and quartz cemented by dolomite.
5643 RS57 463.10 m TS41912	Conglomerate composed mainly of clasts of sedimentary rock cemented by dolomite with a small vug lined with calcite crystals.

GENERAL COMMENTS

At the base of this sequence there is a conglomerate which was deposited in a high energy environment probably close to shore and it is composed mainly of rounded and subrounded clasts of sedimentary rock varying from dolomitic, micaceous and feldspathic siltstone to feldspathic, micaceous sandstones and coarser-grained arkosic rocks. There are very few clasts of other rock types but there are a few large detrital quartz and feldspar grains. This conglomerate had only small amounts of argillaceous or silty matrix probably indicating strong wave or current action. It is cemented mainly by dolomite which, in one sample, could have replaced some argillaceous material heavily stained by ferric oxide. There has been practically no interpenetration of grains and pebbles during compaction of this conglomerate and there has been only minor deformation of some of the softer clasts. There has, however, been some fracturing in places after lithification of the rock. Some fine fractures contain migratory carbonaceous or organic material and some contain calcite associated with minor amounts of sulphide. The presence of carbonaceous material and some sulphide show that, although oxidizing conditions may have prevailed during deposition of some of the conglomerate, reducing conditions probably prevailed at the time of migration of the organic material and sulphide.

Overlying the conglomerate there is a dolomitic intraformational conglomerate followed by a series of sandy, silty and argillaceous dolomites and calcitic dolomites interbedded with thin layers of shale. Most of these sediments are slightly pyritic and some contain small amounts of carbonaceous or organic material and most of the argillaceous material shows brownish, probably organic staining. Some of the layers in this sediment once containd evaporite minerals which have been replaced mainly by calcite with trace amounts of microcrystalline quartz. In many of the samples the shape of these calcite pseudomorphs is not sufficiently well preserved to enable identification of the former evaporite mineral but in a few samples there is strong evidence to suggest that some of the larger calcite pseudomorphs were once gypsum. Trace amounts of dark, viscous oil were found associated with some of the calcite pseudomorphs after evaporite minerals. These sediments were probably deposited in very shallow water under low energy conditions possibly in lagoons and in some of the samples there is evidence of soft-sediment deformation. The presence of sulphides and carbonaceous material suggests generally reducing conditions and therefore it is possible that the sediments accumulated fairly rapidly ensuring that organic material was buried before it was oxidized.

At and above 285.30 m there are a few layers and lenticles of microcrystallin quartz or chert interbedded with thin layers of siltstones and shales, silty dolomites and silty limestones and these sediments also are slightly pyritic indicating reducing conditions during diagenesis and they contain trace amounts of carbonaceous material. Fine-grained clastic detritus appears to have been slightly more abundant and dolomitic shales and siltstones predominate but there are some layers of very fine-grained dolomite and very fine-grained limestone. The cherts are peculiar in that they do not generally form continuous layers but are lenticular and some consist mainly of small fragments or patches of microcrystalline quartz or chert. The chert bands and fragments contain small carbonate crystals and in at least three of the chert bands examined there are scattered small crystals of sphalerite. At 225.80 m (sample 5643 RS 32) the chert occurs as yellow to orange-stained patches or fragments which appear to have been corroded and partly replaced by carbonate and it is associated with numerous fragments of spherulitic and colloform chalcedonic quartz which is heavily stained a bright orange-red. The cause of this bright orange staining is unknown but these spherulitic patches of orange chalcedony contain, or have formed around tiny spheres of opaque material. Identification of this opaque material would require investigation by other means than thin section. Some of the yellow-stained chert contains small calcite pseudomorphs which may have been crystals of gypsum, and in another sample a band of chert has some coarser-grained quartz which could have replaced halite crystals. It is therefored suggested that this chert was deposited under very shallow water or near surface conditions in which some evaporite minerals were also crystallizing. The very bright orange colour of the chalcedonic quartz remains to be explained and also the reason for the persistent presence of trace amounts of sphalerite associated with the chert.

The series of pyritic siltstones and shales, dolomites and limestones with thin bands and patches of chert and chalcedony are overlain by a series of shales and siltstones with some thin layers of feldspathic sandstone composed of well-sorted but generally immature sediment. These were probably deposited under moderately shallow water conditions and the fact that most of the argillaceous material is heavily stained by reddish-brown iron oxide suggests that reducing conditions no longer prevailed. There is some evidence of soft sediment deformation. The argillaceous material in these sediments has recrystallized mainly to sericite associated with lesser chlorite and in many samples this shows a preferred orientation which is generally parallel to the bedding. This recrystallization may have occurred under conditions of load metamorphism. There is no evidence of recrystallization of quartz but there are some overgrowths of secondary quartz and feldspar on detrital grains in sandstone layers. This could have occurred under conditions of diagenesis or load metamorphism. In some of the samples of red-stained siltstone and shale there are irregular, bleached patches.

DESCRIPTION OF CORE FROM DDH BYILKAOORA NO. 1

Sample: 5643 RS 21; TS41876, Depth 38.60 m

Hand Specimen:

A soft, almost white rock composed of clay minerals. There is no definite evidence of bedding and only a minute trace of iron oxide staining in a few spots which may be remnants in a bleached rock.

Thin Section:

The rock is composed almost entirely of clay minerals including kaolin and "sericite" with a trace of quartz, a trace of leucoxene and one or two detrital flakes of altered mica.

Very fine-grained, turbid sericite predominates throughout most of the area sectioned and this shows some evidence of preferred orientation which may be parallel to the direction of bedding but this could not be confirmed. It is intergrown with varying but lesser amounts of micaceous kaolin, some of which may have replaced small detrital grains. The kaolin occurs in vein-like patches and streaks which do not form any regular pattern and are probably not related to bedding. There are a few very small grains of leucoxene and in one area a small tourmaline crystal less than 0.05 mm long was found. There are a few small patches of quartz generally less than 0.1 mm in size which have very irregular, ragged and embayed boundaries and shapes which suggest that the quartz crystallized in small voids but the reason for this is obscure.

The rock shows evidence of extensive fracturing and in a few areas the rock is stained by ochreous iron oxide generally adjacent to fractures.

Conclusion:

On the evidence of composition, grain size and texture this is classified as a claystone and it shows very little evidence from which to determine its origin.

Sample: 5643 RS 22; TS41877; Depth 92.50 m

Hand Specimen;

A mottled dark red and grey, fine-grained rock with some pale coloured grains up to about 1 mm in size scattered through parts of the rock. The dark red iron oxide staining varies in intensity but it does not generally follow the bedding.

Thin Section:

A visual estimate of the constituents is as follows:

	%	
Iron oxide-stained sericite and chlorite	65-70	
Detrital quartz	10-15	
Dolomite	10-15	(varies)
Potash feldspar grains	2-3	
Lithic grains	2-3	
Mica	1-2	
Tourmaline	minute trace	
Leucoxene	trace	

In this sediment there are poorly sorted quartz, feldspar and lithic grains varying in size from 0.2 mm up to 2 mm scattered through a much finer-grained matrix consisting mainly of sericite and chlorite with minor amounts of silt-sized detrital quartz and feldspar. The coarser-grained detrital material is not concentrated into layers but occurs scattered in varying concentrations which do not show any particular pattern.

Quartz and feldspar grains are mainly subangular and subrounded with a few angular grains and very few well rounded grains. Lithic grains vary in composition and include some of metasiltstone, some of dolomite, a few which were probably derived from volcanic rock, a few of chert, a few of metamorphic rock or feldspathic quartzite and one which may be an altered dolerite or similar basic igneous rock. In general, these larger detrital grains are not touching.

The matrix is composed of very fine-grained sericite and chlorite showing some evidence of preferred orientation and it contains minor amounts of fine-grained, probably detrital mica, some very small, dark wisps now heavily stained by iron oxide, a trace of leucoxene and a few small grains or crystals of tourmaline. In some zones this matrix contains silt-sized quartz grains and it also contains varying amounts of very fine-grained dolomite. Some parts of the matrix are heavily stained by red iron oxide and in other parts the chlorite and sericite show very little staining but there is still dark red iron oxide staining many of the fine wisps of material and staining crystals and aggregates of dolomite. The general impression in thin section is that these pale-coloured areas have been bleached but no evidence to suggest the cause of this bleaching was found. Some boundaries between red stained areas and bleached areas are sharply defined, others are diffuse and they show no recognizable pattern in this section.

Conclusion:

Sandy, ferruginous shale and siltstone. It shows patchy bleaching but no evidence to suggest the reason for this bleaching.

Sample: 5643 RS 23; TS41878; Depth 100.15 m

Hand Specimen:

A salmon-pink sandstone with a uniform grain size and no definite evidence of bedding. It contains some small grains which have been replaced by white clay.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Quartz	65-70
Feldspar (mainly potash feldspar)	15-20
Lithic grains	10-15
Detrital muscovite	trace
Leucoxene	trace
Tourmaline	minute trace
Zircon	minute trace

The sandstone is composed of very well-sorted quartz, feldspar and lithic grains most of which are between 0.15 and 0.3 mm in size but there are some elongate grains about 0.4 mm long. Most of the quartz and feldspar grains were originally subangular with some subrounded grains and some angular grains but the boundaries have been modified by overgrowths. Some grains have possibly corroded boundaries with very small embayments only a few microns deep and less than 50 microns across. Other grains have smooth boundaries and all of the grains have a very thin, surface film of brown iron oxide. This film is included within secondary overgrowths where these are present and it is the cause of the orange-pink colour of the rock. It is not possible to determine from the thin section the cause of these small embayments in some of the quartz grains.

Lithic grains vary in composition and include some composed of sericite or of sericite and fine-grained quartz which could have been derived from metasediment, a few which were probably derived from acid volcanic rock and some turbid and altered grains of unknown origin. Heavy mineral grains are mainly leucoxene with traces of tourmaline and zircon.

The detrital grains are not very closely packed and, although some of the quartz and feldspar grains in contact have been welded there is very little interpenetration, however, some of the softer lithic grains have been deformed to accommodate adjacent, harder mineral grains. The rock is cemented mainly by overgrowths of potash feldspar and quartz on the detrital grains and these are intergrown to fill some interstices but the rock also has some interstitial voids. In one area a few interstices contain trace amounts of a clear, pale blue mineral which cannot be positively identified as it occurs in only extremely small amounts. No trace of it could be found in the hand specimen. It has a moderately low refractive index (higher than quartz) and very low birefringence to almost isotropic. It may be a copper-bearing mineral but there are other possibilities.

Conclusion:

Feldspathic sandstone composed of very well-sorted but not very mature sediment. It has minor lithic grains derived from a variety of rock types and very few heavy mineral grains.

Sample: 5643 RS 24; TS41879; Depth 167.70 m

Hand Specimen:

A reddish-brown, fine-grained rock with a few thin, grey layers generally only about 1 to 2 mm thick and these contain slightly coarser-grained sediment.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Iron oxide-stained sericite and chlorite	65-70
Detrital quartz	10-15
Detrital feldspar	5-10
Detrital mica (muscovite and biotite)	10-15
Chlorite	trace
Tourmaline	trace
Opaque oxide and leucoxene	trace
Calcite	minute trace (local)

This is a thinly bedded sediment with alternating layers of reddish-brown, iron oxide-stained shale and siltstone and a few thin layers of sandstone composed mainly of quartz and feldspar grains with a few lithic grains.

The layers of shale are composed mainly of sericite and chlorite but these are so heavily stained by reddish-brown iron oxide that it is not possible to determine the relative amounts of these two minerals. There is some evidence of preferred orientation probably mainly of sericite parallel to the bedding and most of these layers of shale contain a few scattered, silt-sized grains of quartz and feldspar and also some flakes of mica. The siltstone layers contain angular and subangular quartz and feldspar grains 0.02 to 0.05 mm in size with a few larger grains up to 0.1 mm mixed with detrital mica flakes which vary from 0.1 to 0.3 mm long. There are also a few detrital flakes of chlorite and a few heavy mineral grains mainly leucoxene and tourmaline. These siltstone layers have a matrix of iron oxide-stained sericite and chlorite similar to that forming the bulk of the shale layers. The thin section contains one coarser-grained layer which varies in thickness from 1 to 2 mm and contains closely packed quartz and feldspar grains 0.1 to 0.2 mm in size and a few lithic grains composed mainly of sericite or sericite and feldspar. In this layer the detrital grains are cemented mainly by secondary overgrowths of quartz and feldspar on the detrital grains and there is also a little interstitial calcite.

There has been some disturbance to this sediment early in its history probably soon after it was deposited and this has resulted in the mobilization of some of the coarser-grained material which, in a few places, has invaded shale layers. There is also a larger, cross-cutting vein or intrusion of ferruginous silt cutting both shale and siltstone layers.

There are some elongate patches of secondary, opaque iron oxide which has been deposited along a few small fractures and/or bedding planes and this has replaced or obscured the argillaceous material.

Conclusion:

Ferruginous shale, siltstone and fine-grained, feldspathic sandstone. There was some disturbance to the bedding early in the history of this sediment.

Sample: 5643 RS 25; TS41880; Depth 189.10 m

Hand Specimen:
A finely laminated, fine-grained sediment showing patchy brownish-red and dull green staining.

Thin Section:
A visual estimate of the constituents is as follows:

	%
Chlorite and sericite	>80
Detrital mica	10-15
Detrital quartz and feldspar	2-3

This sediment is now composed predominately of orientated sericite intergrown with very fine-grained chlorite and it contains detrital flakes of muscovite, biotite and chlorite averaging about 0.05 mm long. There are a few scattered detrital quartz and feldspar grains varying in size from about 0.01 to about 0.1 mm but most of them are less than 0.05 mm. In general, they are not concentrated in any particular layer but scattered sporadically through the shale, however, there is one band 1 to 2 mm thick containing a higher concentration of these detrital quartz and feldspar grains and also a higher concentration of detrital mica. This band could be classified as siltstone. There are a few very small dark grains which are possibly leucoxene but no other accessory minerals were found.

Much of the shale is heavily-stained by reddish-brown iron oxide which obscures the optical properties of the sericite and chlorite and in these brown-stained zones there are small spots 0.1 to 0.3 mm in size which have been bleached and are now a dull green. The coaser-grained silstone band is also a dull green colour and there is a gradual transition to brown-stained zones in this area. However, in this bleached siltstone band many of the biotite flakes are still heavily stained by iron oxide.

Conclusion:
Siltstone and micaceous and silty shale with patchy iron oxide-staining. In some zones the rock has been bleached and is now a dull green.

Sample: 5643 RS 26; TS41881; Depth 200.35 m.

Hand Specimen:

A dark grey, fine-grained sediment with some small nodules generally 1 to 2 mm in size.

Thin Section:

A visual estimate of the constituents is as follows:

	%	
Detrital quartz and feldspar	10-15	
Detrital mica	15-20	
Sericite and chlorite	55-60	
Dolomite	5-10	(varies)
Carbonate concretions	3-5	
Pyrite	2-3	
Carbonaceous material?	trace	

This is a laminated siltstone and shale composed mainly of orientated sericite with lesser chlorite and varying proportions of very small, detrital quartz and feldspar grains and muscovite and biotite flakes. Thin bands also show varying concentrations of brown staining some of which could be organic staining. Most of the siltstone layers contain minute crystals and spherical grains of pyrite only a few microns in size and some larger crystals and framboidal or microspherular grains 0.02 to 0.04 mm in size. Some of the bands contain small dolomite crystals less than 0.05 mm in size and these occur in varying concentrations

The nodules noted in the hand specimen are lenticular to oval concretionary bodies composed mainly of turbid carbonate which was found to have a refractive index higher than that of dolomite and it is therefore probably an iron-bearing carbonate either ankerite or a sideritic carbonate. These carbonate concretions vary in size from about 2 to 4 mm long and 1 to 2 mm thick and most of them contain some pyrite as well as carbonate and in a few, this pyrite is concentrated in a zone about 0.5 mm from the surface of the concretion. At one end of one of the concretions there is a larger mass of pyrite 1.5 mm in size. Most of the concretions are concentrated in a very fine-grained layer and thin laminations in siltstone and shale layers curve around these concretions suggesting that they were formed before complete compaction of the rock.

Conclusion:

Pyritic and dolomitic siltstone and shale with small concretions (nodules) composed of carbonate with lesser pyrite.

Sample: 5643 RS 27; TS41882; Depth 201.45 m.

Hand Specimen:

A finely laminated, pale grey and darker grey, very fine-grained sediment with irregular markings, some of which could be interpreted as of algal origin. One thin dark band is very hard and is probably chert. There are some small carbonate veins and there are a few small patches of yellow sulphide, the colour of which suggests chalcopyrite.

Thin Section:

A visual estimate of the constituents is as follows:

	%	
Dolomite	40-50	
Calcite	30-35	
Chert	5-10	
Shale	5-10	(varies)
Pyrite	2-3	
Chalcopyrite?	trace	

This is a finely laminated sediment in which there are layers composed mainly of dolomite with lesser interstitial calcite and minor brown-stained argillaceous material, two layers 2 to 3 mm thick composed mainly of chert with minor amounts of carbonate and pyrite, some thin layers composed predominantly of calcite and some layers of dark-stained shale containing varying amounts of dolomite, calcite and fine-grained pyrite. The shale bands also contain some lenticular patches of dolomite and calcite a few millimetres in size. There is one band of brown-stained shale containing up to about 50% of fine-grained dolomite and a little very fine-grained pyrite. One band of dolomite containing up to about 40% of interstitial calcite has at least 5% of finely disseminated pyrite and a few larger aggregates 0.3 to 0.5 mm in size of sulphide which had migrated and recrystallized and this could be, or could contain, chalcopyrite but examination of a polished section would be necessary to confirm this.

Bedding in this rock is not regular or parallel and the chert bands in particular show variations in thickness and one is lenticular. The structures in thin section show that the sediment was disturbed probably soon after it was deposited and there were very small intrusions of carbonate and silty material into shale. There is a mass of sparry calcite adjacent to one of the cherty bands and this shows rather complex markings defined by staining in the calcite. These are not sufficiently conclusive to show whether or not they were of algal origin and this mass of calcite grades into a vein of coarse-grained, sparry calcite.

Conclusion:

Interbedded calcitic and pyritic dolomite, dolomitic shale and pyritic chert with some deformed bands and veins of calcite. There is a trace of possible chalcopyrite which has migrated and recrystallized but the dominant sulphide is pyrite.

There is no conclusive evidence of algal material.

Sample: 5643 RS 28; TS41883; Depth 207.40 m

Hand Specimen:

A greenish-grey, fine-grained sediment which tends to split along some planes parallel to the bedding.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Sericite and chlorite	60-65
Dolomite	25-30
Pyrite	5-10? (difficult to estimate)

The rock is very fine-grained and is composed largely of orientated sericite intergrown with lesser amounts of extremely fine-grained chlorite and it contains scattered, small crystals of dolomite 0.01 to 0.03 mm in size which occur in varying concentrations. In part of the section there are a few thin layers mainly 0.2 to 0.4 mm thick composed mainly of dolomite with a few very small detrital quartz and feldspar grains and these could be classified as thin layers of silty dolomite.

The rock contains scattered, small crystals of pyrite which vary in size from 0.01 to about 0.03 mm and there are some only a few microns in size. They occur in varying concentrations in different bands and in some parts of the rock this variation in the concentration of pyrite is the only indication of bedding. There are a few places in which pyrite has migrated and recrystallized but generally over only very small distances. There is one oval mass of dolomite 1.5 mm long containing at least 10% of pyrite and this could be incipient concretion. Other sulphides which may be associated with the pyrite cannot be identified in thin section and would require examination of a polished section.

Conclusion:

Dolomitic and pyritic shale with some thin layers of silty dolomite.

Sample: 5643 RS 29; TS41884; Depth 211.60 m

Hand Specimen:

A thinly bedded, pale grey and darker grey, fine-grained sediment. The layering is essentially straight and parallel but there are some small-scale irregularities and slightly wavy patches.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Dolomite	45-50
Calcite	45-50
Argillaceous material	3-5?
Detrital quartz, feldspar and mica	1-2
Dark staining (?organic or carbonaceous)	trace
Pyrite	trace

In this sample there are some layers 0.5 to 2 mm thick composed predominantly of dolomite, some composed almost entirely of calcite and other layers containing varying proportions of both dolomite and calcite. There is one thicker band of dolomite containing up to 20% calcite and a few scattered silt-sized grains of quartz and feldspar and some very fine-grained, brownish staining which could be partly argillaceous material and partly organic staining. There are also a few very tiny wisps of black opaque material. Some layers contain a few small grains of pyrite.

Banding due to variations in the concentration of dolomite and calcite are fairly sharply defined and in places there are thin laminations only 0.2 to 0.4 mm thick containing varying concentrations of calcite and dolomite. In some of these bands there is a gradation from dolomite to calcite with a sharply defined (upper ?) boundary of calcite and one of these has a rather wavy or scalloped appearance with a thin line of dark staining about 0.05 mm from the boundary of the layer. Whether or not this could be interpreted as indicating algal markings is a matter for speculation.

In one thicker, calcite-rich band there is some evidence of disturbance and possible intraformational breccia. There are a few poorly defined, elongate fragments of finely banded calcite and dolomite 2 to 3 mm long and also scattered patches or fragments of fine-grained feldspathic sandstone or siltstone. In another part of section there is a lenticular patch of coarser-grained silt or fine-grained sand about 5 mm long at the boundary between bands containing different proportions of calcite and dolomite.

Conclusion:

Finely laminated dolomite and limestone with minor amounts of silty and argillaceous material and a trace of pyrite.

Sample: 5643 RS 30; TS41885; Depth 213.65 m

Hand Specimen:

A dark greenish-grey, fine-grained sediment with a few very thin paler-coloured layers. The rock tends to split along some planes parallel to the bedding giving smooth surfaces.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Sericite and chlorite	60-65
Dolomite	25-30
Pyrite	3-5
Quartz and feldspar	1-2
Calcite	1-2
Detrital mica	trace
Tourmaline	trace
Zircon	trace
Leucoxene	trace

Most of the rock is composed largely of extremely fine-grained sericite which shows preferred orientation parallel to the bedding and it is intergrown with lesser but varying amounts of very fine-grained chlorite. There are a few thin layers composed almost entirely of sericite and some of the indistinct layering is due to variations in these proportions of sericite to chlorite. Some dolomite crystals are scattered in varying proportions throughout the mass of sericite and chlorite and most of the layers also contain scattered, very small crystals of pyrite generally about 10 microns in size. Some of this pyrite is concentrated in groups of tiny grains and these may be partly dispersed framboids. Trace amounts of calcite occur in some interstices and along grain boundaries but there are many layers which do not contain any calcite.

There are few thin layers generally between 0.5 and 1 mm thick which contain silt-sized detrital quartz and feldspar and a few mica flakes and heavy mineral grains in a matrix of dolomite which is slightly coarser-grained than in the remainder of the rock. These silty layers are not of uniform thickness, they have uneven and wavy boundaries and in a few places have invaded some adjacent layers of shale. There are some other patches of disturbed sediment where silt, shale and dolomite form a rather confused mass and clearly parts of this sediment have been mobilized early in its history possibly during de-watering.

Conclusion:

Pyritic and dolomitic shale with some thin silty layers. There have been minor disturbances to the sediment early in its history.

Sample: 5643 RS 31; TS41886; Depth 225.50 m

Hand Specimen:

Finely laminated, pale grey and darker grey, fine-grained sediment which is curved around a disturbed zone containing some coarser-grained, sparry carbonate and also some small patches of orange-red material found in thin section to be mainly chalcedony and chert.

Thin Section:

A visual estimate of the constituents is as follows:

	%	
Calcite	35-40	(varies)
Sericite and chlorite	30-35	
Dolomite	15-20	
Detrital quartz and feldspar	2-3	
Chert	3-5	
Chalcedonic quartz	3-5	
Detrital mica	1-2	
Pyrite	trace	(more locally)

This is a finely laminated and locally disturbed sediment in which the layers contain varying proportions of calcite, argillaceous material or sericite and chlorite, silt-sized detrital material and dolomite. Some of the layers containing higher concentrations of calcite could be classified as silty limestone and these generally contain minor dolomite, small patches of argillaceous material and traces of pyrite. There are a few thin layers containing high concentrations of sericite and chlorite with lesser calcite, minor detrital mica, very few detrital quartz and feldspar grains and 1 to 2% of pyrite. These layers would be classified as pyritic and calcareous shale.

In one of the shale layers there is a disturbed zone containing irregular and possibly nodular patches of chert lightly stained pale orange and containing varying amounts of very fine-grained carbonate. One patch of this chert is heavily stained reddish orange and this may be the reddish material referred to in the description submitted with the samples. In this mass of chert there are some irregular veins and vein-like patches containing sparry calcite, dolomite and a few radiating aggregates of orange-stained chalcedonic quartz. The vein is partly lined with a thin colloform layer of orange-stained chalcedony and, scattered through the chert there are a few isolated, small bodies of orange-stained chalcedony some of which have a radiating structure. These small bodies of chalcedony vary in size up to about 1 mm, some are narrow and elongate and others of irregular shape. Their origin remains obscure but at least some of the chalcedonic material probably filled small voids in this disturbed zone. In a few of these aggregates of secondary chalcedony and quartz crystallization of orange-stained chalcedony was followed by crystallization of a layer of clear, coarser-grained quartz which lacks the orange-staining and these layers of chalcedony and quartz have apparently spread out from small elongate fractures or voids.

The finely laminated silty limestone and shale curve around this disturbed mass containing chert and migratory carbonate and chalcedonic quartz and there is no conclusive evidence to show whether or not algae were involved. The cause of the orange-staining is not known.

Conclusion:

Silty and argillaceous limestone interbedded with calcareous and dolomitic shale and siltstone containing traces of pyrite. A disturbed zone contains a patch of chert and some orange-stained chalcedony.

Sample: 5643 RS 32; TS41887; Depth 225.80 m

Hand Specimen:

Finely laminated, pale grey and darker grey, fine-grained sediment with some irregular and disturbed paler-coloured bands in which there are very small aggregates or patches of material coloured orange-red. This was found in thin section to be orange-stained chalcedony.

Thin Section:

As the composition varies in different layers a quantitative estimate of the different minerals would have little meaning.

At one end (bottom?) of the sediment there are some layers 2 to 3 mm thick of shale and silty shale showing graded bedding in that at the base of some of the layers there is a little silt-sized detrital quartz and feldspar, a little calcite and a few crystals of pyrite. At the top of this zone there is a rather disturbed and ragged boundary showing small intrusions of silt into the shale and a thin, disturbed layer of dark-stained shale which has been more extensively disturbed. Above this is a mixed layer containing calcite and dolomite with numerous elongate rods and irregular patches of varying size, some of which are composed of chert and some of bright orange to red-stained chalcedony. The general appearance suggests that there were some broken fragments of thin chert layers and other very thin layers or fragments which have been replaced by the orange-stained chalcedony. Some patches of chalcedony contain tiny, opaque spherulitic grains and a few crystals of carbonate near the centre and the orange-stained chalcedony has grown out from these, possibly replacing adjacent rock. The chert fragments are not as heavily stained orange as the radiating chalcedonic quartz and they have very irregular shapes. Some contain a few microspherular grains of opaque material (possibly pyrite or oxidized pyrite?) and their relationship to the enclosing, turbid dolomite and calcite is rather chaotic. The general impression is that this was a disturbed zone containing thin, elongate and irregular fragments of chert and possibly some other material which has been replaced by the orange-stained radiating chalcedonic quartz.

Above (?) this layer containing chert and chalcedonic quartz there are some bands of silty and argillaceous limestone with streaks of dark staining which could be organic, and trace amounts of pyrite. There is also some pyritic shale containing only minor calcite and dolomite. Following this is another disturbed layer 1 to 2 mm thick containing small, angular patches of orange-stained chert intermixed with some dolomite and irregular and elongate patches of calcite. These fragments of chert vary in size from about 0.05 mm to 0.5 mm and most of them appear angular. There is, however, a larger mass of orange-stained chert 1.5 to 2 mm in size which contains some irregular and elongate crystals now composed of calcite and these appear to be pseudomorphs of calcite after elongate or prismatic crystals and a few of these were intergrown or twinned crystals. They could have been gypsum but this suggestion should be regarded as very tentative. In this band all of the orange to reddish-stained fragments are of chert and there are no patches of radiating chalcedony noted in the other band containing red fragments.

Above this band containing fragments of chert there are thin layers of silty limestone and shale and another layer of shale which along only part of its length contains some fragments of orange-stained chert associated with dolomite and calcite and these chert fragments do show some spherulites and radiating aggregates of chalcedonic quartz.

Conclusion:

The sample is mainly interbedded silty limestone and shale with some probably disturbed layers containing small fragments of orange-stained chert and chalcedony the significance of which is difficult to interpret. There is however some evidence in the form of calcite pseudomorphs which suggest that at least one of these chert layers may have contained evaporite minerals such as gypsum.

No definite evidence of algal material was found but there is some carbonaceous or organic staining and algal material is a possibility.

The cause of the orange staining in chert and chalcedony is unknown. The colour is brighter than would be expected from iron oxide staining.

Sample: 5643 RS 34; TS41889; Depth 240.80 m

Hand Specimen:

A dark grey, fine-grained sediment with some paler-grey patches and also some thin irregular and intersecting veins or patches containing paler-coloured sediment. Some of these are about parallel to the bedding and some cut across the bedding at a high angle.

Thin Section:

This sediment is a complex mixture of shale and siltstone with small patches of silty limestone and, as it is the structures which are of significance, quantitative estimate of the minerals present will not be attempted.

The section has a background of pale brownish-coloured shale composed largely of orientated sericite probably intergrown with some chlorite and it contains minor amounts of silt-sized detrital quartz, minor detrital mica and traces of calcite. When the section is examined between crossed nicols the sericite shows preferred orientation which is approximately parallel throughout the area sectioned but there are small areas where the direction is slightly different. This background of shale has been invaded by siltstone containing at least 25% of angular quartz and feldspar grains most of which are less than 0.05 mm in size but there are a few elongate quartz grains up to 0.2 mm long. Some of the feldspar grains are stained pale orange by iron oxide. There are also moderately abundant detrital mica flakes 0.05 to 0.4 mm long including both muscovite and biotite and there are grains and shreds or wisps of dark opaque material some of which could be carbonaceous matter but this is difficult to confirm. These detrital grains are scattered through a matrix composed of very fine-grained sericite and chlorite stained by minute dark particles probably now mainly iron oxide. Some of this siltstone forms irregular and ragged patches almost entirely surrounded by shale and some forms a near-vertical vein or intrusion varying in width from about 3 to 6 mm and the shale in contact with this has very ragged but fairly sharply defined boundaries. The sides of this intrusion of vein are very irregular and cannot be matched. This intrusive siltstone is continuous with a layer of siltstone which contains some patches of shale with rather diffuse boundaries.

As well as the dark siltstone patches the shale also contains some irregular patches and possibly intrusions of silty limestone (stained pink with alizarin red-S) which appear to be unrelated to the dark, possibly carbonaceous siltstone.

There are a few very small, irregular fractures or veins which have developed after compaction of the rock and these are finely contorted. Material on the edge of the small veins has been replaced by very fine-grained, yellowish green secondary mica and clearly some solutions have moved along these very small fractures or veins.

Conclusion:

The sample is a complex mixture of shale, siltstone and minor sandy limestone in which the silty material has invaded shale. The structures could be due to the activity of organisms but this is very difficult to prove as the pattern is irregular with no very special features.

Sample: 5643 RS 33; TS41888; Depth 235.15 m

Hand Specimen:

A greyish-purple, fine-grained sediment in which part of the sample is finely laminated and contains some thin, paler-coloured layers 1 to 2 mm thick some of which are slightly lenticular.

Thin Section:

A visual estimate of the constituents is as follows:

	%	
Heavily stained argillaceous material (possibly sericite and chlorite)	35-40	
Detrital quartz and feldspar	25-30	
Detrital mica	10-15	
Dolomite	10-15	(more in some layers
Calcite	3-5	(more in some layers

Most of the sample is a finely laminated sediment with layers of siltstone and shale and a few showing graded bedding with siltstone at the bottom grading up to dark-stained, possibly carbonaceous shale which is now at least partly stained by iron oxide. There is also a thick layer of dolomitic and argillaceous siltstone.

The siltstone layers contain detrital quartz and feldspar grains 0.02 to 0.04 mm in size and some detrital flakes of mica both muscovite and biotite 0.05 to 0.1 mm long and also some dark-stained grains and wisps of indeterminate material. The siltstone layers also contain dolomite and calcite in varying proportions generally with a grain size of 0.02 to 0.3 mm and the calcite tends to occur in interstices between the other grains and crystals. In some of these layers dolomite is the most abundant carbonate and in others both calcite and dolomite are present in about equal proportion There are a few layers which contain minor dolomite and no calcite. The shale layers are composed of dark-stained argillaceous material and detrital mica with very minor silt-sized quartz and feldspar grains and a little dolomite. The presence of shreds of dark material suggests that they may have contained carbonaceous material which has been partly oxidized but this suggestion is tentative as some of the dark shreds could be flakes of weathered biotite heavily stained by iron oxide. There is one area 1.5 mm long where some coarser-grained silt appears to have invaded a shale layer but this is only of very limited extent.

There is a small microfault cutting the bedding at a moderate angle and displacement along this has varied from about 0.5 to 1 mm. In places this small fracture is marked by dark staining and in some of the coarser-grained layers it disappears.

Conclusion:

Thinly bedded dolomitic and calcareous siltstone and shale with a few thin layers showing graded bedding. It may once have contained organic or carbonaceous material.

Sample: 5643 RS 35; TS41890; Depth 252.85 m

Hand Specimen:

A dark grey, fine-grained rock which shows very little evidence of bedding.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Chlorite and argillaceous material	45-50
Detrital quartz and feldspar	35-40
Detrital mica	10-15
Lithic grains	trace
Leucoxene	trace
Apatite	trace
Tourmaline	minute trace
Calcite	minute trace

This sample is predominantly argillaceous and micaceous siltstone with one poorly defined zone containing fine sand.

When the section is examined under very low magnification the overall structure can be seen and in part of the section there is a zone of finely laminated siltstone with some very thin layers containing higher concentrations of silt-sized detrital quartz and feldspar alternating with thin layers containing higher concentrations of sericite or chlorite and argillaceous material. This zone is about 12 mm in size and it has been folded and disrupted. The finely laminated zone is cut off by a small intrusion of silty material and from the manner in which this has occurred it is more likely to have been caused by movement within the sediments after they were deposited either by slumping or some other cause than by the activity of organisms. In the zone or band containing fine sand-sized detrital grains there are a few elongate fragments of shale.

The section was then examined under higher magnification and the zones of siltstone were found to contain angular grains of quartz and feldspar (mainly plagioclase) less than 0.05 mm in size, some detrital mica flakes and a few very small heavy mineral grains mainly leucoxene with minute traces of tourmaline and apatite in a turbid matrix which is probably mainly sericite and chlorite. In the finely laminated zone many of the detrital mica flakes are parallel to the bedding but where there has been some disturbance to the bedding the direction in which most of the mica flakes are orientated varies and there are some complex structures where silty material has invaded disrupted layers of finer-grained sediment.

The coarser-grained zone contains angular and a few subangular grains of quartz and feldspar 0.05 to 0.2 mm in size and a few lithic grains which are composed of varying proportions of sericite and fine-grained quartz or feldspar, a few composed entirely of sericite and a few of microcrystalline quartz. These grains are too small for their origin to be determined and none were found which are of unquestionable volcanic origin. This zone contains detrital mica flakes up to 0.6 mm long including both muscovite and biotite and a few heavy mineral grains including leucoxene, tourmaline and apatite some of which are rounded. These sand-sized detrital grains are moderately closely packed but have a matrix of turbid argillaceous material. A few of the quartz and feldspar grains which are in contact have become welded but in general they are separated by the argillaceous material. This sandy band does not have any sharply defined boundaries and, as noted above, it contains some elongate fragments or patches a few millimetre long of turbid shale. These fragments do not have sharply defined boundaries but tend to merge with the argillaceous matrix and almost certainly they were soft at the time this sandy layer accumulated.

Conclusion:

Siltstone and minor shale with one band of fine-grained sandstone. The bedding was disturbed early in its history either by slumping or during compaction. The structures do not suggest bioturbation.

Sample: 5643 RS 36; TS41891; Depth 259.45 m

Hand Specimen:

A finely banded, grey, fine-grained sediment in which most of the bedding is horizontal (assuming the drill hole is vertical). There are two to three bands containing pale coloured patches of hard siliceous material found in thin section to be chert and the bedding associated with these appears slightly disturbed. When the sample is closely examined low magnification a few small grains of sulphide can be seen including some yellowish sphalerite and this is associated with a small carbonate vein.

Thin Section:

A visual estimate of the constituents is as follows:

	%	
Silty dolomite and limestone grading locally to dolomitic siltstone	65-70	
Shale	5-10	
Chert	20-25	
Opaque sulphide and sphalerite	trace-1	(more locally)
Migratory calcite	1-2	

Part of the sample is composed of silty and calcareous dolomite which contains varying proportions of silt-sized, detrital quartz and feldspar, minor detrital mica, some turbid argillaceous material and varying proportions of dolomite and calcite. In general, dolomite is more abundant than calcite (as shown by staining with alizarin red-S) and much of this could be classified as calcareous and silty dolomite but in a few poorly defined bands where calcite is more abundant it could be classified as silty limestone. A few layers containing higher concentratio of detrital quartz and feldspar could be described as dolomitic siltstone but this is a very minor constituent. This silty dolomite and limestone is interbedded with thin bands of shale generally less than 1 mm thick and these shale bands have been disrupted in places and have very irregular and ragged boundaries against the silty carbonate sediment.

There is one layer at least 6 mm thick composed almost entirely of chert which, in places, has numerous minute spherules about 10 microns in size marked by dark staining. Similar microspherules are not uncommon in cherts but their origin is uncertain. This chert band contains minor amounts of carbonate minerals and some clear patches which now contain coarser-grained quartz. Some of these clear patches and relict textures have straight boundaries suggesting that this band may once have contained some crystals up to at least 0.5 mm in size but these are not sufficiently well developed or well preserved for this former mineral to be identified. Carbonate or evaporite minerals are possibilities but this suggestion should be taken with caution. One of these zones bounded by straight edges is lined with a layer of small, projecting quartz crystals and is now filled with a moderately large crystal of calcite associated with a little opaque material. There is another discontinuous or lenticular band of similar chert which contains a slightly higher concentration of scattered, carbonate crystals and some extremely fine-grained, microspherular pyrite. This band shows an angular fracture which has been invaded by calcite and a little opaque material. An adjacent band contains irregular and angular patches or fragments of chert 0.5 to 2 mm in size with a few longer fragments up to 5 mm surrounded and separated by a mixture of calcite and dolomite containing some argillaceous material and also some silty detrital material. This band also has a few irregular aggregates and crystals up to 0.5 mm in size of sphalerite intergrown with the calcite and chert and some small aggregates of opaque sulphide, the identity of which cannot be determined from the thin section. Some of these patches of chert have a few almost straight edges but there is not sufficient textural evidence to show whether the chert may have replaced some earlier crystals or whether they are disrupted fragments of a chert layer which has been invaded and partly replaced by the silty carbonate. Certainly some of the boundaries between chert and silty carbonate appear ragged and corroded and some sharply defined fractures in the chert have been filled by calcite. There is one elongate mass of chert 6 mm long and 1 to 2 mm thick which is composed of tiny, radiating aggregates of extremely fine-grained, chalcedonic quartz.

The rock is cut by a calcite vein about 0.5 to 1 mm thick and this vein contains a little opaque material.

Conclusion:

This is mainly silty dolomite and limestone grading locally to dolomitic siltstone interbedded with thin layers of shale. There are a few bands of chert and some bands containing fragments of chert mixed with calcite, silty material and some sulphide mainly sphalerite.

Sample: 5643 RS 37; TS41892; Depth 272.45 m

Hand Specimen:

A grey, fine-grained sediment with indistinct banding on a scale of about 2 to 10 mm. Near one end of the sample there is a zone containing small, irregular patches of white calcite most of which are a few millimetres in size and some of these contain a little very fine-grained sulphide.

Thin Section:

A visual estimate of the constituents is as follows:

	%	
Detrital quartz and feldspar	30-35	
Detrital mica	5-10	
Argillaceous matrix (seritice and chlorite)	35-40	
Dolomite	15-20	
Calcite	2-3	(more locally)
Sulphide	trace-1	
Leucoxene	trace	
Zircon	minute trace	
Tourmaline	minute trace	

Most of the sample is a dolomitic siltstone containing moderately well sorted, angular quartz and feldspar grains and some detrital mica flakes in a very turbid, argillaceous matrix which contains varying amounts of dolomite. There is some variation in the grain size of quartz and feldspar in different layers in that some have grains which are mainly 0.02 to 0.03 mm and a few bands have grains which average 0.05 mm. A few of the feldspar grains show twinning typical of plagioclase and there are one or two very small lithic grains composed mainly of sericite. The proportion of dolomite varies in different layers and it is absent from some. Small crystals of sulphide, probably mainly pyrite, 0.01 to 0.03 mm in size occur in varying proportions in the different layers but are generally present only in trace amounts. There are a few small, elongate patches or fragments of shale.

In a zone about 20 mm thick there are numerous patches of moderately coarse-grained, sparry calcite most of which are less than 5 mm long but there is one irregular patch or aggregate which is semi-continuous for about 15 mm. These have a variety of shapes which in general show no resemblance to any particular crystal of mineral but along one layer where calcite is less abundant there are two patches or aggregates of finer-grained calcite 1 and 2 mm in size which have almost square cross sections. Both of these are stained by dark brownish (organic?) material which is concentrated in very thin, parallel lines and these also contain minor amounts of very fine-grained sulphide probably pyrite. The almost square cross section of these suggest the possibility that they could be pseudomorphs after halite but the presence of the thin, parallel lines of dark brown staining cannot be explained from available evidence. In this band there is another area 1 mm long containing some similar dark brown-stained material in interstices between small carbonate (dolomite?) crystals. The other patches of calcite were carefully searched for evidence of pseudomorphous forms and although there are a few straight edges suggesting former crystals, none of the aggregates have sufficiently well-preserved shapes for any former mineral to be identified. These patches of calcite contain a few very small aggregates of sulphide, most of which is probably pyrite.

Conclusion:

Dolomitic and pyritic siltstone with a band containing patches of calcite. This calcite has probably replaced an earlier mineral which could have been an evaporite mineral (halite?) but the evidence on which this suggestion is based is very inconclusive.

Sample: 5643 RS 38; TS41893; Depth 273.20 m

Hand Specimen:

A pale grey, fine-grained sediment with a few very thin, dark grey layers. There is some variation in colour in different layers which vary in thickness from about 2 mm up to 15 mm and the rock tends to split along a few planes parallel to the bedding revealing flat surfaces on which there are a few flakes of mica. These correspond to thin bands of shale in the sample.

Thin Section:

A visual estimate of the constituents is as follows:

	%	
Dolomite	50-60	
Calcite (stained with alizarin red-S)	30-35	
Detrital quartz and feldspar	3-5	
Detrital mica	1-2	(varies)
Argillaceous material	1-2	
Sulphide probably pyrite	trace	
Leucoxene	trace	

Most of this rock is composed of very small crystals of carbonate 0.01 to 0.03 mm in size with a few larger crystals up to 0.05 mm and the proportions of calcite to dolomite suggested above were determined by staining the section with alizarin red-S. A refractive index test on some material removed from the hand specimen also showed that it contains dolomite. In general, the calcite and dolomite have a uniform grain size and are intergrown with minor amounts of turbid, argillaceous material. There are a few small detrital quartz and feldspar grains up to 0.05 mm in size and a few detrital mica flakes. The bedding noted in the hand specimen is due mainly to slight variations in the concentration of detrital quartz and feldspar grains and there are also slight variations in the size of these grains. There are a few very thin layers less than 1 mm thick which contain higher concentrations of slightly coarser-grained quartz and feldspar and there are a few thin layers of shale composed predominantly of sericite, chlorite and detrital mica. There are a few small aggregates of very fine-grained sulphide probably pyrite and this occurs in higher concentration in one of the thin shale layers.

There are a few veins of calcite along some bedding planes and there is a very thin, irregular, cross-cutting fracture which, in places, coincides with a small stylolitic seam marked by a concentration of dark staining possibly of organic material.

Conclusion:

Very fine-grained, slightly silty, calcitic dolomite with a few thin layers of shale.

Sample: 5643 RS 39; TS41894; Depth 278.50 m

Hand Specimen:

A medium-grained, grey rock containing moderately abundant carbonate and some small, almost spherical grains or crystals with patches of dark matrix. There are also a few elongate or lath-like patches of carbonate. When the rock was examined under low magnification a small patch of honey-coloured mineral was found and this proved to be sphalerite when examined separately in a temporary oil mount.

Some material was removed from the small spherical grains or crystals and also from the lath-like crystals or aggregates and examined in refractive index liquids in temporary mounts. This was all found to be dolomite.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Calcite	40-45
Dolomite	25-30
Chert	10-15
Siltstone and shale	15-20
Opaque material	trace
Sphalerite	minute trace

Part of the sample consists of loosely intergrown crystals of calcite 0.5 to 2 mm in size and some smaller crystals and aggregates of dolomite with a matrix of turbid argillaceous material containing some fine-grained, detrital mica and in a few places, some silt-sized detrital quartz and feldspar. This argillaceous material shows patchy brown staining possibly organic staining and it contains minor amounts of extremely fine-grained opaque material, some of which is probably pyrite and some may be carbonaceous material. The calcite and dolomite have crystallized in irregular patches through this matrix of shale and siltstone and in general the dolomite is finer-grained than the calcite. A few of the larger calcite crystals completely enclose isolated crystals and also a few circular aggregates of dolomite up to about 0.5 mm in size and there are some similar, almost spherical aggregates of dolomite scattered through parts of the silty shale. These tend to have been plucked out during preparation of the section and therefore their identity was checked as described under the hand specimen description. Some interstices between calcite crystals contain fine-grained to microcrystalline quartz.

Towards one end of the sample there are elongate and irregular masses and/or fragments of chert generally between 2 and 5 mm long but there is one band or portion of a band over 10 mm long. Some of these patches or chert are certainly fragments of a disrupted layer but many of the patches have finely irregular boundaries against calcite and the general appearance of having been corroded and in places invaded by calcite. Interstices between these fragments contain coarse-grained calcite and lesser amounts of dolomite with a few turbid, stained patches suggesting that there may once have been some silty shale.

The larger, discontinuous band of chert is of particular interest in that it contains at least four areas of coaser-grained quartz 0.5 to 1 mm in size which are bounded by former crystal faces and clearly this quartz has replace an earlier mineral or has crystallized in an open void.

These former crystals have been slightly deformed but still retain a roughly square (and triangular) section and some evidence suggesting that these may have been hopper-faced, cubic crystals typical of halite. The largest of these pseudomorphs is lined with projecting quartz crystals and a few dolomite crystals and has an interior filled by calcite. There are also a few other vein-like patches of coarser-grained quartz and calcite invading this band of chert and there are a few small crystals of dolomite. Some of the chert contains a trace of opaque sulphide and one elongate fragment or patch of chert contains a crystal of sphalerite 0.3 in size. A little very fine-grained opaque material (sulphide?) occurs along the boundary of some of the chert and in places this resembles a stylolitic seam.

Conclusion:

Bands and fragments of chert in moderately coarse-grained, dolomitic limestone with some silty shale. Relict textures in some of the chert strongly suggest that it may once have contained a few crystals of halite now replaced by coarser-grained quartz with a little calcite and dolomite. The chert also contains traces of sulphide including sphalerite.

The almost spherical crystals and aggregates and lath-like aggregates referred to in the notes are now composed of dolomite.

Sample: 5643 RS 40; TS41895; Depth 279.55 m

Hand Specimen:

A dark greenish-grey, fine-grained rock with very little evidence of bedding.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Sericite and chlorite	60-65
Calcite	25-30
Detrital quartz and feldspar	10-15
Opaque material including pyrite	1-2

This is an extremely fine-grained rock containing a large proportion of turbid and brownish-stained sericite and lesser chlorite and when the section is examined between crossed nicols this sericitic material can be seen to have a preferred orientation. Small crystals of calcite varying in size from a few microns to 0.03 mm are scattered fairly uniformly throughout the recrystallized argillaceous material and, in places, there are a few larger calcite crystals up to 0.2 mm in size. There are a few silt-sized detrital quartz and feldspar grains and also a few small, generally altered detrital mica flakes. Some very fine-grained opaque material including at least some pyrite occurs as elongate grains and aggregates many of them less than 0.05 mm long but there are some elongate shreds or wisps up to 0.2 mm long. Some of these may be carbonaceous material or may have been carbonaceous material replaced by pyrite but examination of a polished section would be required to confirm this. The sediment contains a few small patches or pockets generally less than 1 mm in size containing a little coarser-grained detrital quartz with grains averaging about 0.1 mm in size and these do not show any relationship to bedding.

There are a few small patches of secondary, fine-grained to microcrystalline quartz about 0.15 to 0.2 mm in size and some of these have shapes which, with imagination, could be interpreted as having once been small crystals of halite. Some very small grains of pyrite are invariably associated with this quartz.

Conclusion:

Calcareous (or calcitic), pyritic shale with a few small pockets of fine sand. It may once have contained minor halite which has been replaced by fine-grained quartz and pyrite but the evidence is not absolutely conclusive.

Sample: 5643 RS 41; TS41896; Depth 285.30 m

Hand Specimen:

A grey, fine-grained sediment with a lenticular band or mass of hard chert which varies in thickness from 5 to 10 mm. Banding in the adjacent sediment curves around this mass of chert and some medium-grained, white carbonate (calcite) can be seen along part of the boundary between chert and the other sediment. There are a few very small patches of soft, black opaque material probably carbonaceous matter.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Chert band	30-35
Dolomite	50-55
Calcite	5-10
Argillaceous material and silt	3-5?
Opaque material	1-2

The sediment contains a large proportion of dolomite crystals 0.02 to 0.04 mm in size and in some layers there are lesser amounts of calcite in interstices between the dolomite crystals. These carbonate minerals are associated with generally minor amounts of turbid, argillaceous material probably mainly sericite and chlorite with a few detrital flakes of altered mica and some elongate shreds or wisps of opaque material probably now largely very fine-grained pyrite but these may represent former small particles of carbonaceous matter. The argillaceous material in some of the layers contains very minute grains of pyrite only a few microns in size. There are a few angular grains of quartz and feldspar up to 0.05 mm in size. The composition varies, however, in that there are a few thin layers less than 1 mm thick composed entirely or almost entirely of dolomite and adjacent to the chert band there are disrupted fragments of a thicker layer composed almost entirely of dolomite. Further away from the chert layer there is a band in which there is a higher concentration of coarser-grained calcite and some small patches of microcrystalline quartz.

The lenticular mass of chert noted in the hand specimen is composed largely of microcrystalline or cryptocrystalline silica and it contains a sprinkling of very small crystals of carbonate at least some of which are calcite but, as the others are enclosed by the silica their reaction to staining with alizarin red-S cannot be determined. The concentration of these carbonate minerals varies in different parts of the chert band and in places probably reaches about 20%. In one area there is a small vein of dolomite in the chert and this grades into an irregular patch of dolomite 2 x 3 mm in size which also contains a little coarser-grained quartz and calcite. There are no recognizable relict textures in this patch of dolomite and quartz. The boundary between chert and the other sediment is sharply defined, slightly irregular and marked by a film of dark brownish material which could be carbonaceous or organic matter. There is a band or vein of medium-grained calcite along most of the boundary between chert and the enclosing rock and adjacent to this and also partly enclosed by the calcite there are fragments of a band of dolomite.

No conclusive evidence of former evaporite minerals was found but in one of the bands of dolomite there are a few aggregates of secondary quartz about 0.3 mm in size and one of these has a square cross-section which could be interpreted as suggesting former halite but this is by no means proof that the band once contained halite.

Conclusion:

Argillaceous and calcareous or calcitic dolomite associated with a lenticular band of carbonate-bearing chert. There are veins and patches of migratory calcite.

Sample: 5643 RS 42; TS41897; Depth 289.00 m

Hand Specimen:

The rock contains an abundance of pale grey to almost white crystals and aggregates of medium-grained carbonate generally between 1 and 3 mm in size with a matrix of dark greenish-grey, very fine-grained material.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Stained sericite and chlorite (argillite)	40-45
Calcite	35-40
Dolomite	15-20
Detrital quartz	1-2
Detrital mica	trace
Pyrite	1-2?

This rock has a matrix or background of brown-stained, very fine-grained argillaceous material which is probably mainly sericite with lesser chlorite and the colour may be due to organic staining. This contains at least 1 to 2% and possibly more of very minute crystals and spheres of pyrite a few microns in size and in places it contains trace amounts of very fine-grained, detrital quartz and mica. This matrix could be described as pyritic argillite or shale.

Aggregates of medium-grained calcite and some of dolomite are scattered apparently at random through this argillaceous matrix and they vary in size but are mainly between 0.5 mm and 3 mm. In general, the aggregates of calcite are larger than those of dolomite and there are a few isolated dolomite crystals 0.2 to 0.4 mm in size scattered through the argillaceous matrix. In general, the calcite and dolomite are not intergrown but a few of the larger crystals of calcite enclose one or two small crystals of dolomite.

The aggregates of calcite and dolomite were very carefully searched but no definite evidence was found to show that these carbonate minerals replaced evaporite minerals and, although there are a few elongate or lath-shaped crystals of calcite it would be unwise to attach too much significance to this. It is possible, and may even be probable, that calcite replaced some crystals of evaportite mineral but the shapes are certainly not sufficiently clear for this to be identified. Most of the straight edges to these aggregates of calcite are the normal crystal faces of calcite. The aggregates of dolomite do not show any evidence of significant external shape. Possibly of greater significance is the presence of one, lath-like or almost rectangular patch of secondary, microcrystalline quartz about 0.6 mm long which is probably a pseudomorph after an almost rectangula elongate crystal. This has been replaced by the quartz associated with a little carbonate and the possibility that it could have been a crystal of a mineral like gypsum must be considered.

Conclusion:

Argillaceous, dolomitic and pyritic "limestone" with an abundant matrix of dark-stained and pyritic argillite through which there are numerous crystals and aggregates of both calcite and dolomite. The calcite has probably replaced an evaporite mineral but relict textures are not sufficiently well preserved for this to be identified.

Sample: 5643 RS 43; TS41898; Depth 293.45 m

Hand Specimen:

This is similar to the sample from 289.00 m and it contains abundant crystals and aggregates of calcite in a matrix of dark-stained argillaceous material. The sample was carefully examined under low magnification but no definite crystal shapes could be identified. The crystals and aggregates of carbonate vary in size from 1 mm to 4 mm and they comprise at least 50 to 60% of the rock. Many of the smaller aggregates are almost spherical and these were found to be dolomite.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Pyritic argillite	40-45
Calcite	40-45
Dolomite	10-15

This is essentially very similar to the sample from 289.00 m and a full description would involve needless repetition. It differs, however, in that the argillaceous matrix is not as intensely stained and may contain a slightly lower proportion of very fine-grained pyrite.

The dolomite aggregates are more clearly defined than in sample RS 42 and these are of uniform size generally about 1 mm and are equidimensional being almost spherical or almost square in shape. The dolomite comprising these aggregates is very turbid and there are traces of calcite around the edges of some these dolomite aggregates.

The aggregates of calcite are very similar to those in the sample from 289.00 m and in general they do not show any recognizable external shapes. There are a few which are roughly rectangular and could have been prismatic or elongate crystals but the external boundaries are irregular and not well-preserved. Some calcite crystals give an approximately triangular cross section but this is insufficient evidence to suggest that they replaced shortite. There are in fact very few straight boundaries to these aggregate of calcite and it would be virtually impossible to prove the identity of the mineral which the calcite has very probably replaced.

Conclusion:

Argillaceous, dolomitic and pyritic limestone essentially very similar to the sample from 289.00 m. Aggregates of dolomite are better defined, of uniform size (1 mm) and generally almost spherical. Calcite aggregates are of irregular shape and it would be virtually impossible to determine the identity of the mineral it has replaced.

Sample: 5643 RS 44; TS41899; Depth 295.05 m

Hand Specimen:

This is similar to the previous two samples in that it has a dark greenish-grey, fine-grey matrix with very numerous crystals and aggregates of white carbonate but it differs in that the aggregates of carbonate are elongate to prismatic and some of them are up to 10 mm long. Some are about horizontal and some form slightly curved crystals and aggregates in varying directions.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Calcite	45-50
Dolomite	30-35
Argillaceous material	15-20
Microcrystalline quartz and chert	3-5
Opaque material probably pyrite	trace

This differs from the two previous samples (5643 RS 42 and 43) in that the fine-grained matrix is composed of argillaceous material containing abundant crystals of dolomite 0.05 to 0.1 mm in size which are distributed more or less uniformly throughout this matrix and do not occur as aggregates of any particular shape. Many of the dolomite crystals have a turbid central zone with a clear outer zone and in general they occur as separate, well-developed crystals. The argillaceous material contains some very fine-grained opaque material which is probably mainly pyrite but there a few tiny, elongate shreds which may have been carbonaceous material. In a few places, this matrix has been invaded and partly replaced by microcrystalline quartz or chert and in general these form roughly spherical or equidimensional patches 1 to 2 mm in size which are now composed largely of microcrystalline quartz containing scattered small crystals of dolomite. Boundaries between these partly silicified zones and the argillaceous portions of the matrix are gradational. There are also a few clear patches of microcrystalline quartz which has very probably filled small voids left by the removal of small crystals or portions of crystals of the evaporite minerals. Some of these are associated with the calcite pseudomorphs and some are isolated.

The calcite aggregates differ from those in the previous two specimens in that pseudomorphous shapes are much better preserved and show that the calcite replaced elongate or prismatic crystals varying in length to over 6 mm and generally 0.5 to 1 mm thick. Some of these crystals may have formed slightly radiating aggregates and some were apparently almost parallel to the bedding. Some of these elongate or prismatic pseudomorphs are curved and this fact tends to suggest that the mineral which was replaced may have been gypsum as it is not uncommon for elongate crystals of gypsum to be slightly curved. However, this should not be regarded as conclusive proof and the possibility of other evaporite minerals cannot be excluded. In one area calcite replacing several of these crystals is in optical continuity over a distance of over 10 mm but this is not common. Along the edges and at the ends of a few of these calcite pseudomorphs there are small patches of microcrystalline quartz which have possibly filled gaps left by the replacing calcite.

Conclusion:

Calcite pseudomorphs after a coarsely crystalline evaporite mineral are scattered abundantly through a matrix of very fine-grained, argillaceous dolomite. The presence of some slightly curved, elongate pseudomorphs suggests that the mineral replaced may have been gypsum but the possibility of other evaporite minerals cannot be entirely excluded.

Sample: 5643 RS 45; TS41900; Depth 306.28 m

Hand Specimen:

The sample has a dark grey, very fine-grained matrix containing scattered crystals and patches of white carbonate which are smaller and not as abundant as in the previous three specimens. Most of the patches of calcite in this sample are only about 1 to 2 mm in size.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Sericite and lesser chlorite	65-70
Calcite	25-30
Dolomite	trace-1
Detrital quartz and feldspar	1-2
Detrital mica	1-2
Pyrite	trace-1

The matrix of this rock is mainly recrystallized argillaceous material which is probably mainly sericite with minor chlorite and the sericite shows well-developed preferred orientation probably about parallel to the bedding but the orientation of this sericite varies in direction in contact with, or in small zones adjacent to the calcite aggregates. This argillaceous matrix is slightly stained and it contains a sprinkling of extremely small pyrite grains most of which are less than 0.01 mm in size but there are a few slightly larger crystals and aggregates of pyrite. There are a few detrital mica flakes and in one zone or band there is a low concentration of silt-sized, detrital quartz. A few isolated dolomite crystals generally less than 0.05 mm in size are present in parts of the matrix but most of the dolomite in this sample is associated with calcite.

Crystals and aggregates of calcite generally about .1 mm in size are scattered throughout the argillaceous matrix and some of these are bounded by straight edges. There is, however, no consistent shape and, although a few of the calcite aggregates are approximately triangular and a few are slightly elongate most of them have no particular shape and it is not possible to determine the identity of the mineral which the calcite has almost certainly replaced. Small patches of fine-grained dolomite are intergrown with some of the calcite and a few small dolomite crystals are included within some of the larger calcite crystals. There are also a few small, elongate aggregates of dolomite 1 to 2 mm long and these contain minor amounts of pyrite.

This rock is now cut by a network of very small, open fractures generally only about 10 microns wide, most of which are parallel to the incipient schistostiy as defined by the orientation of sericite and they also surround many of the aggregates of calcite and form a network connecting most of the aggregates of calcite. These fractures are probably of recent origin but it is not possible to determine the exact time of their formation. Adjacent to some of these fractures the rock shows a slight greenish staining suggesting that they may have carried solutions.

Conclusion:

Pyritic argillite containing calcite pseudomorphs probably after an evaporite mineral but this cannot be identified. There is minor dolomite.

Sample: 5643 RS 46; TS41901; Depth 313.25 m

Hand Specimen:

A finely laminated, pale grey and darker grey, fine-grained sediment which tends to split along some planes parallel to the bedding. These were found to be mainly thin layers of shale.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Dolomite	45-50
Calcite	25-30
Sericite and chlorite	20-25
Detrital quartz and feldspar	1-2
Detrital mica	trace
Pyrite	trace
Leucoxene	trace

Most of the layers in this sample are composed mainly of fine-grained dolomite and calcite with a common grain size of 0.02 to 0.04 mm and in general the calcite and dolomite are fairly uniformly distributed and closely intergrown. There are, however, many interstices which contain brown-stained argillaceous material mainly sericite and chlorite which show preferred orientation parallel to the bedding. This argillaceous material contains a few small detrital mica flakes and in some layers it also contains a few very small detrital quartz and feldspar grains. There are traces of very fine-grained opaque material, some of which is pyrite and some may be carbonaceous matter and a few layers contain scattered, larger crystals of pyrite up to 0.1 mm in size. Interbedded with these carbonate-rich layers there are a few thin layers (less than 1 mm) of shale composed predominantly of orientated sericite and lesser chlorite with only minor amounts of dolomite and a trace of pyrite.

Conclusion:

Argillaceous and calcitic dolomite with a few thin layers of shale. The sediment contains minor pyrite.

Sample: 5643 RS 47; TS41902; Depth 316.55 m

Hand Specimen:

A laminated, pale grey, fine-grained sediment with a few thin, darker grey layers. The bedding is straight and parallel.

Thin Section:

A visual estimate of the constituents is as follows:

	%	
Dolomite	50-60	
Calcite	30-35	
Sericite and chlorite	5-10?	(difficult to estimate)
Detrital quartz and feldspar	1-2	
Detrital mica	trace	
Pyrite	trace	
Leucoxene	trace	

This is very similar to the sample from 313.25 m and is composed mainly of fine-grained dolomite and calcite with a common grain size of 0.02 to 0.04 mm with a few slightly larger, rhombohedral crystals of dolomite 0.05 mm in size. These carbonate minerals are slightly turbid and probably contain small amounts of argillaceous material as impurity but this is obscured by the optical properties of the carbonate and it cannot be quantitatively estimated with any degree of accuracy. This sample contains a lower proportion of argillaceous material in interstices between the carbonate minerals and only a few scattered detrital grains of quartz, feldspar and mica. There are very small grains (a few microns in size) of pyrite and small, elongate aggregates or wisps of opaque material probabl mainly very fine-grained pyrite which may have replaced carbonaceous matter.

There are a few very thin (0.2 to 0.4 mm) layers of pyritic shale with some brownish, probably organic staining and there is one thin layer less than 0.5 mm thick composed almost entirely of dolomite and calcite without argillaceous material. There is one discontinuous, diagonal fracture marked by brown staining and containing trace amounts of migratory calcite and dolomite.

Conclusion:

Calcitic dolomite containing a lower proportion of argillaceous material than the sample from 313.25 m. There are a few very thin layers of shale.

Sample: 5643 RS 48; TS41903; Depth 317.15 m

Hand Specimen:

This sample contains an abundance of white carbonate pseudomorphs after elongate crystals 2 to 5 mm long, some of which are arranged in sheaf-like or radiating aggregates and some are intergrown with no particular pattern. A number of these prismatic pseudomorphs are curved suggesting that the former mineral is more likely to have been gypsum than any of the other evaporite minerals. Some patches of calcite, however, do not show definite shapes and it is possible that other minerals were originally present. The matrix is dark brownish-green and very fine-grained.

On the outer surface of the drill core sample there is a small spot 1 x 2 mm in size of very dark brown, viscous oil and when the sample was cut a few other very small patches of dark, viscous oil were found mainly in the calcite aggregates. Most of these are less than 0.5 mm in size.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Calcite pseudomorphs	65-70
Matrix of dolomitic shale	30-35
Secondary microcrystalline quartz	2-3
Oil globules	trace

The section contains abundant calcite pseudomorphs in a thinly bedded matrix of dolomitic shale with a few very thin layers of dolomite.

Almost all of the calcite pseudomorphs are elongate or prismatic crystals varying in length from 2 to 12 mm and in places they have formed radiating aggregates and in other places they show parallel growth. Many of these elongate crystals have slightly curved faces and in general the morphology is typical of that of gypsum. No crystals which can be recognized as having been derived from another mineral were seen in the thin section but this does not exclude the possibility that other evaporite minerals may have been present. Along one side of the section there is a mass of calcite at least 12 mm deep (across the bedding) which does not show any definite external shape. In some places a whole group of these crystals has been replaced by optically continuous calcite up to about 6 mm in size. In one area some of the crystals have been only partly replaced by calcite and the remaining portions have been replaced by microcrystalline quartz associated with minor amounts of fine-grained dolomite.

In the larger aggregates of these calcite pseudomorphs interstices contain masses of intergrown dolomite crystals 0.02 to 0.5 mm in size which are turbid and show patchy, pale brown, probably organic staining (oil staining?) and in a few interstices there are very tiny patches of opaque and almost opaque material. These masses of interstitial dolomite also contain minor amounts of stained argillaceous material and in some aggregates of calcite pseudomorphs the interstitial spaces contain higher concentrations of brown-stained argillaceous material and less dolomite.

Between some of the aggregates of calcite pseudomorphs there are zones of thinly bedded sediment consisting of some layers of dolomitic shale and some of dolomite 0.2 to 1 mm thick. The dolomitic shale contains some minute grains and crystals of pyrite and also a few patches of rather diffuse, brown staining which could be oil staining. This finely bedded sediment is gently folded and this could be interpreted as doming over a clustre of pseudomorphs after gypsum crystals. In parts of this sediment there are small patches of microcrytalline quartz which have probably formed in small voids where there has been some differential movement of parts of the sediment. There are a few very small fractures which have been filled by calcite and there are now a few very fine, open fractures most of them about parallel to the bedding.

Preservation of oil is difficult in a thin section but there are one or two small, opaque globules about 0.1 mm in size with slight, diffuse brown staining and these are probably oil globules. They occur in sediment in interstices between calcite pseudomorphs.

Conclusion:

Dolomitic shale containing abundant calcite pseudomorphs after crystals of an evaporite mineral which was very probably gypsum. The sample contains some very small globules of dark, viscous oil.

Sample: 5643 RS 49; TS41904; Depth 327.95 m

Hand Specimen:

A thinly bedded, pale grey sediment with a few very thin, darker grey layers. The bedding is not all straight and parallel and in one zone it curves around a lenticular patch of chert and this cherty zone contains two honey-yellow crystals which, when examined in a temporary oil mount were found to be sphalerite.

Note: There appears to be a persistent association of trace amounts of sphalerite with layers and lenticles of chert in the samples from this drill hole (compare samples 5643 RS 36 and RS 39 at 259.45 m and 278.50 m).

Thin Section:

A visual estimate of the constituents is as follows:

	%	
Dolomite	50-55	
Calcite	20-25	
Argillaceous material	15-20?	(difficult to estimate)
Detrital quartz and feldspar	2-3	(more in some layer
Detrital mica	trace	
Secondary microcrystalline quartz and chert	5-10	
Opaque material	trace	
Detrital tourmaline	minute trace	
Sphalerite	minute trace	

Most of the layers in this sample contain abundant, rhombohedral crystals of dolomite 0.05 to 0.15 mm in size with a few larger crystals in places and interstices between these dolomite crystals contain generally finer-grained calcite, small amounts of brownish-stained argillaceous material and variable but generally minor amounts of microcrystalline quartz. In some layers there are detrital quartz and a few feldspar grains up to 0.1 mm in size and one or two detrital tourmaline grains up to 0.1 mm in size were found. There are a few detrital flakes of mica but these are not common. Some of the layering noted in the hand specimen is due to variations in staining probably by argillaceous material occurring in interstices and also possibly included within some of the dolomite and there are also variations in the relative proportions of calcite and dolomite although dolomite predominates. There are a few opaque grains or patches about 0.05 mm in size, some of which have a round or oval shape and are surrounded by diffuse, brown staining or grade into brown-stained material and these are probably some form of organic matter. There is also a stylolitic seam approximately parallel to the bedding which is marked by a concentration of this opaque and dark brown material which is probably mainly organic matter. There are probably trace amounts of very fine-grained pyrite in some of the opaque aggregates and in places there are clusters of minute opaque grains less than 10 microns in size.

There are a few layers of chert 1 to 2 mm thick and also a few lenticular patches of chert which may be discontinuous layers. This chert contains scattered, small crystals of dolomite in varying amounts and some of the boundaries of these chert layers are rather diffuse where they grade into adjacent calcitic dolomite. Four small crystals of sphalerite 0.1 to 0.4 mm in size were found scattered along one of the chert layers and in a lenticular patch or band of chert there is another small crystal of sphalerite 0.2 mm in size and a porous mass of opaque material 1 mm long.

In one layer of calcitic dolomite there are a few almost spherical, concretionary-like bodies 1 to 1.5 mm in size containing coarser-grained dolomite and interstitial quartz.

Conclusion:

Calcitic, silty and sandy dolomite with thin layers and lenticles of chert. There is a trace of dark organic material occurring as small particles and also concentrated along stylolitic seams parallel to the bedding.

There are traces of sphalerite in some of the chert bands and lenticles and probably traces of other sulphide.

Note: There is a persistent association of traces of sphalerite with chert bands and lenticles in the sediments from this drill hole, see samples 5643 RS 36 and RS 39 at 259.45 m and 278.50 m.

Sample: 5643 RS 50; TS41905; Depth 335.45 m

Hand Specimen:

A pale grey, fine-grained sediment with some scattered patches of white calcite similar to the calcite pseudomorphs noted in other samples and some of these occur as groups of elongate or prismatic crystals with the general shape and habit similar to that of gypsum. They are not as large (up to 5 mm) as in some samples and they are not as concentrated. The rock also contains some disseminated, very fine-grained pyrite and a few zones contain higher concentrations of this pyrite.

Thin Section:

A visual estimate of the constituents is as follows:

	%	
Calcite pseudomorphs	15-20	
Dolomite	20-25	
Detrital quartz	20-25	
Detrital feldspar	10-15?	
Detrital mica	3-5	
Lithic grains	trace	
Argillaceous material	15-20	(difficult to estimate)
Pyrite	1-2	
Other opaque material	trace	
Leucoxene	trace	
Zircon	trace	
Tourmaline	trace	

This sediment is coarser-grained than the samples from shallower depths and it contains angular and subangular and a few rounded grains of quartz and feldspar and also a few lithic grains generally between 0.05 and 0.2 mm in size but there are a few much larger quartz and feldspar grains 0.5 to 0.8 mm in size and lithic grains up to 1.5 mm in size. Most of the smaller grains are angular or subangular but there are a few rounded grains and the larger grains greater than 0.5 mm tend to be subrounded to well rounded. These larger grains are scattered sporadically through the finer-grained sediment and are also loosely concentrated along a few poorly defined layers. The feldspar grains include both potash feldspar and plagioclase and the lithic grains include many rounded grains of siltstone and shale, some larger, rounded grains of granitic and/or gneissic rock, one rounded grain which is possibly altered fine-grained dolerite and a few small grains which may have been derived from acid volcanic rock. There are a few detrital lithic grains which appear weathered and are stained pale orange and it is possible that these were derived from volcanic rock. The sediment contains minor amounts of detrital mica flakes including both muscovite and biotite and a few heavy mineral grains mainly leucoxene, tourmaline and zircon up to 0.05 mm in size. One or two small orange, almost isotropic grains with a moderate refractive index were found and it is possible but not confirmed that these could be collophane. These detrital grains are loosely packed and have a matrix composed of varying proportions of argillaceous material and extremely fine-grained (mainly micritic) dolomite with some scattered, larger crystals of dolomite 0.05 mm in size. Some very small crystals and fine-grained aggregates of sulphide, probably pyrite, are scattered throughout most of the matrix but the concentration varies and there are a few larger aggregates of pyrite up to 1 mm long which contain some inclusions of detrital mineral grains. There are a few opaque grains grading into, or associated with, dark brown staining and it is possible that these are traces of organic material.

There is no clearly defined bedding in this rock although there is one poorly defined layer in which there is a concentration of the larger lithic (granitic or gneissic) grains. In other places there are irregular patches of micritic dolomite and of sandstone and the general appearance suggests some soft-sediment deformation.

The calcite pseudomorphs vary from about 1 to 5 mm in length and some of these show crystal shapes and evidence of aggregates with parallel growth and also some with radiating crystals which are similar in habit to crystals of gypsum. There are other patches of calcite which have very irregular boundaries with no recognizable shape.

Conclusion:

Classification of this rock is difficult as it could be either a fine-grained, dolomitic sandstone or a sandy dolomite depending on the relative proportions of dolomite to detrital grains and this varies in an irregular manner. It contains some calcite pseudomorphs after crystals of an evaporite mineral which was most likely gypsum.

Sample: 5643 RS 51; TS41906; Depth 370.40 m .

Hand Specimen:

A dark brownish-purple, fine-grained sediment containing a few scattered larger, generally rounded grains 1 to 2 mm in size. There are numerous irregular patches of medium-grained, white carbonate which do not have any regular shape.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Detrital quartz	10-15
Detrital feldspar	10-15
Lithic grains	5-10
Detrital mica	3-5
Iron oxide-stained, argillaceous and dolomitic matrix	35-40
Clear dolomite	20-25

The sediment contains detrital quartz, feldspar and lithic grains and also mica flakes in a very fine-grained matrix of argillaceous material and dolomite which is so heavily stained by reddish-brown iron oxide that it is not possible to determine by microscopic examination the relative proportions of argillaceous material to dolomite. The rock shows poorly defined bedding in that there are some bands 2 to 4 mm thick containing mainly silt-sized detrital quartz, feldspar and lithic grains, some layers which have detrital grains 0.1 to 0.5 mm in size and some very poorly defined zones or bands in which there is there is a higher portion of iron oxide-stained matrix. In some of the silty layers the detrital material is moderately well-sorted but in some of the coarser-grained layers the detrital material is poorly sorted and there are a few, generally rounded grains 0.5 to 2 mm in size. Feldspar grains include both plagioclase and potash feldspar including microcline and a few of the larger lithic grains are composed of quartz and coarse-grained feldspar. A large proportion of the lithic grains are rounded fragments of siltstone and shale and it is not certain whether these represent reworked fragments of disturbed bottom sediments or were derived from exposed sedimentary rocks. Coarser-grained layers in this sample contain higher concentrations of these siltstone and shale lithic grains and most of these siltstone lithic grains are elongate and well rounded. They are, however, of similar size to the other detrital grains in any particular layer. Mica flakes and elongate detrital grains tend to be orientated parallel to the bedding but there are numerous exceptions to this and there is some evidence of soft-sediment deformation.

The matrix is dark reddish-brown with some almost opaque patches and is so heavily stained that finer details cannot be determined. There are some patchy variations in the intensity of the iron oxide-staining but no definite evidence to suggest the reason for this.

The rock now contains a network of very irregular, vein-like patches of moderately coarse-grained, clear dolomite which either filled open voids or replaced an evaporite mineral. No definite pattern could be found in these patches of dolomite and they have very irregular and ragged boundaries with small extensions or protuberances. It is, however, not impossible that the sediment could have contained irregular aggregates or masses of halite which were dissolved and replaced by the dolomite.

Conclusion:

Sandy, dolomitic argillite or argillaceous dolomite which is very heavily stained by iron oxide. It has numerous irregular aggregates of clear, coarser-grained dolomite which has either crystallized in voids or replaced an evaporite mineral.

Some layers contain concentrations of rounded lithic grains derived from siltstone and shale.

Sample: 5643 RS 52; TS41907; Depth 376.60 m

Hand Specimen:

A slightly brownish-grey, fine-grained sediment some of which shows more or less regular banding but there is a zone 2 to 3 cm thick containing many elongate and irregular framgents and this has the general appearance of an intraformational breccia.

Thin Section:

A visual estimate of the constituents is as follows:

	%
Dolomite	>90
Quartz and feldspar	2-3
Argillaceous material	2-3?
Opaque grains	trace
Leucoxene	trace
Calcite	trace

The laminated portion of the rock is composed mainly of very fine-grained dolomite varying in grain size from micritic to about 0.05 mm and some layers contain small amounts of silt-sized detrital quartz and feldspar and a few small mica flakes. Variations in colour in the different layers are due mainly to small amounts of dark-stained argillaceous material and some contain a few very small opaque grains which are probably pyrite.

The other portion of the sample contains elongate fragments of layers of silty dolomite which vary in length from about 1 to 6 mm and also vary in thickness up to about 2 mm. Most of these fragments are angular without rounded ends and some of them are banded. They are packed fairly closely and the boundaries of some are no longer clearly defined. Interstic contain silt-sized detrital quartz and feldspar cemented by fine-grained dolomite and generally there are also a few very small opaque grains in this silty material. In one area there is a slightly darker zone containing a few quartz and lithic grains up to 0.8 mm in size and also a few small spherulites of secondary quartz up to 0.4 mm in size.

There are a few stylolitic seams, some of which follow the boundaries of fragments and these are marked by concentrations of very dark brown to opaque material, most of which is probably carbonaceous or organic material. There is a trace of calcite associated with some clear, coarser-grained dolomite which has very probably filled a leached void.

Conclusion:

Intraformational breccia composed mainly of dolomite.

Sample: 5643 RS 53; TS41908; Depth 385.40 m

Hand Specimen:

A fragmental rock in which there are clasts up to at least 10 mm in size of a variety of rock types including some moderately coarse-grained sandstones and feldspathic fragments generally closely packed and separated by concentrations of dark to almost black material much of which is carbonaceous matter.

Thin Section:

This sample contains closely packed lithic fragments and a few large quartz and feldspar grains cemented by dolomite. There has been some additional fracturing and movement of fractured fragments and there are now concentrations of carbonaceous material along many of the fractures and in many interstices.

Many of the larger clasts are of fine-grained sedimentary rock mainly micaceous and slightly dolomitic and feldspathic, fine-grained sandstone and siltstone but there are a few of coarser-grained feldspathic sandstone composed mainly of angular detrital grains and there is one clast composed of poorly sorted, angular quartz and feldspar grains 0.1 to 1 mm in size and in this clast feldspar grains (mainly plagioclase) are more abundant than quartz. Interstices in the clast contain chlorite. There is one moderately large clast about 5 mm in size of coarse-grained rock composed of intergrown quartz, plagioclase and microcline with minor chloritized biotite which could have been derived from adamellite or from a coarse-grained metamorphic rock. Some of these clasts are subrounded and some are angular but there is some evidence to suggest that the boundaries of some have been modified after they accumulated in this rock. In general they are closely packed with a few large quartz and feldspar grains up to 1 mm in size in interstices. The rock is cemented mainly by dolomite.

Some of the clasts have been fractured *in situ* and the fractures have been invaded by dolomite and silty material and in places also by carbonaceous material which is present along many grain boundaries and in some interstices. Some portions of fractured clasts have been displaced relative to one another.

Conclusion:

A sedimentary conglomerate containing clasts derived mainly from micaceous and feldspathic sediments varying from siltstone to coarse-grained sandstone and a few clasts from other sources together with some large quartz and feldspar grains. The rock has suffered additional fracturing and is cemented by dolomite with some carbonaceous material in interstices and along grain boundaries.

Sample: 5643 RS 54; TS41909; Depth 385.45 m .

Hand Specimen:

A fragmental or conglomeratic rock containing pebbles and grains varying in size from less than 1 mm to over 20 mm and also varying in colour from grey through greenish-grey to dull pink. The matrix is stained dull pink to red and there are numerous, fine films of black carbonaceous material along grain boundaries and also along small fractures, some of which cut the clasts.

Thin Section:

This contains rounded and subangular lithic fragments and a number of large quartz and feldspar grains cemented by a matrix of silty dolomite in which much of the dolomite is stained reddish-brown by iron oxide.

The lithic clasts are mainly feldspathic sediments and are very similar to those in the sample from 376.60 m in that they include siltstone, fine-grained sandstone and some coarser-grained, poorly-sorted sediment of angular quartz and feldspar grains up to 1 mm in size. Some of these clasts are well rounded and some are subrounded to subangular. There is one well rounded clast which is probably altered dolerite 2 mm in size.

The lithic clasts are moderately closely packed and interstices contain some large quartz and microcline grains up to 1.5 mm in size and also a few lithic grains of similar size. These are cemented by very turbid silty and argillaceous dolomite which is heavily stained by reddish-brown iron oxide and there are also a few larger dolomite crystals which have a central zone heavily stained by iron oxide. This suggests that the matrix was heavily stained by ferric oxide before the dolomite crystallized and the staining is not a result of partial alteration of the dolomite. A few interstices contain sparrry calcite and a few contain small crystals and aggregates of pyrite, some of which is closely associated with the calcite.

There are some small, generally straight and in places intersecting fractures which cut some of the clasts and also coincide with a few boundaries of clasts. Most of these are only about 0.05 mm wide and they contain concentrations of black to very dark brown organic or carbonaceous material. They have formed after consolidation and lithification of the rock.

Conclusion:

Conglomerate composed mainly of pebbles of sedimentary rock with a silty and dolomitic matrix heavily stained by iron oxide. Numerous small fractures formed after consolidation of the rock contain carbonaceous material.

Sample: 5643 RS 55; TS41910; Depth 393.00 m

Hand Specimen:

A fragmental or conglomeratic rock containing predominantly brownish-coloured clasts cemented by a matrix containing some carbonate. There are also numerous, small veins of white carbonate and some disseminated, fine-grained sulphide.

Thin Section:

The rock contains angular and rounded clasts of sedimentary rock similar to those in the two previous samples from 385.40 and 385.45 m and these vary in size from less than 1 mm to over 20 mm. Interstices between the larger clasts contain some moderately large grains of quartz and feldspar and also lithic grains of similar size up to 2 mm and some of these smaller lithic grains are well rounded. The rock has been cemented by medium-grained dolomite which does not show the turbidity and iron oxide staining noted in the sample from 385.45 m.

There has been some deformation resulting in the fracturing of some of the larger clasts and also the fracturing and deformation of some of the quartz and feldspar grains which are present in interstices between the larger clasts. There are numerous small, discontinuous fractures or veins containing small amounts of calcite and a few small crystals and aggregates of sulphide and there are also very fine fractures which contain carbonaceous material. In some places the calcite veins cut the small fractures containing carbonaceous material but in general it is very difficult to determine the exact relationship between the fractures containing carbonaceous material and those containing calcite. Many of the very small calcite veins are almost parallel.

Conclusion:

Conglomerate composed largely of clasts of sedimentary rock and a few large mineral grains cemented by dolomite. There has been some fracturing and there are numerous small veins containing calcite and pyrite and others containing carbonaceous material.

Sample: 5643 RS 56; TS41911; Depth 440.40 m

Hand Specimen:

A dull reddish-grey conglomeratic rock with grains and pebbles of very variable size, some of them over 2 cm in a matrix containing carbonate.

Thin Section:

Most of the pebbles are of sedimentary rock and similar to those in the previous specimens of conglomerate and therefore a full description would entail needless repetition. There are, however, two rounded clasts composed of moderately coarse-grained microcline intergrown with minor quartz and plagioclase which were probably derived from some form of granitic rock. Elongate pebbles tend to be orientated in an approximately horizontal direction. Interstices between the larger clasts contain large grains of microcline and quartz averaging about 1 mm in size and a few lithic grains of similar size cemented by some turbid, argillaceous or silty material and dolomite. Some of the feldspar grains in this rock are stained as if by weathering and this may have occurred before they were incorporated in this sediment.

Conclusion:

Conglomerate composed mainly of fragments of sedimentary rock but with a few derived from a granitic type of rock. It is cemented by dolomite.

Sample: 5643 RS 57; TS41912; Depth 463.10 m

Hand Specimen:

A conglomerate containing round pebbles varying greatly in size with one almost spherical pebble about 4 cm in diameter. The pebbles also vary greatly in composition, grain size and colour - some are very fine-grained, some medium to coarse-grained.

Thin Section:

All of the pebbles and lithic grains included in the area sectioned are of sedimentary rock and they vary from very fine-grained siltstone and silty dolomite to coarse-grained arkose. Many are well rounded, some subrounde and some subangular and the elongate pebbles show some evidence of preferre orientation parallel to the bedding. Interstices between the large pebbles contain large grains of microcline and quartz up to 1 mm in size and some lithic grains of similar size.

The rock is cemented by turbid, iron oxide-stained, very fine-grained dolomite which grades into, or has been replaced by, coarser-grained, clear dolomite with crystals varying up to 1 mm in size. The vug noted in the hand specimen is lined firstly by projecting dolomite crystals about 0.5 mm in size which are overlain by larger calcite crystals up to 1.5 mm long which project into the vug.

Conclusion:

Conglomerate composed mainly of clasts of sedimentary rock cemented by dolomite with a vug lined by calcite.

APPENDIX 5

GEOCHEMICAL ANALYSES

AMDEL

Sample No.	Depth (m)	Stratigraphic Unit
5643RS26 (A2368/79)	200.35	Observatory Hill Beds, Member 5.
5643RS28 (A2369/79)	207.40	as above, Member 4.
5643RS29 (A2370/79)	211.60	as above.
5643RS30 (A2371/79)	213.65	as above.
5643RS32 (A2372/79)	225.80	as above.
5643RS34 (A2373/79)	240.80	as above.
5643RS35 (A2374/79)	252.85	as above.
5643RS36 (A2375/79)	259.45	Observatory Hill Beds, Member 3.
5643RS40 (A2376/79)	279.55	as above.
5643RS41 (A2377/79)	285.30	as above.
5643RS45 (A2378/79)	306.28	as above.
5643RS46 (A2379/79)	313.25	as above.
5643RS55 (A2380/79)	393.00	"Davies Bore Conglomerate".
5643RS56 (A2381/79)	440.40	as above.
5643RS57 (A2382/79)	463.10	as above.

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NATA CERTIFICATE

AC 1/2/0 - 213/80

27 July 1979,

The Director General,
Department of Mines & Energy,
P.O. Box 151,
EASTWOOD S.A. 5063

REPORT AC 213/80

YOUR REFERENCE:	12.06.0532. Application dated 11 July 1979,
IDENTIFICATION:	Sample No A2368/79 - A2382/79.
LOCATION:	SADME Byilkaoora.
DATE RECEIVED:	12 July 1979.

Enquiries quoting AC 213/80 to the Manager please

D. K. Rowley
Manager
Analytical Chemistry Division

for R L Bruce

for Norton Jackson
Managing Director

dg

Pilot Plant: Osman Place
Thebarton S.A.
Telephone 43 8053
Branch Laboratory: Perth

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

REPORT AC 213/80

x = not detected at the limits quoted

Results in ppm unless otherwise stated. Detection limits in brackets.

Sample No.	Ba (200)	Co (5)	Cr (20)	Ce (300)	Mn (10)	Mo (3)	Ni (5)	Sr (50)	Ti (100)	V (10)
A2368/79	x	80	200	x	500	200	50	x	2500	200
69	300	20	200	x	500	x	50	150	3000	200
70	5000	5	60	x	500	60	15	800	1000	100
71	300	20	200	x	700	x	50	150	2000	150
72	300	10	150	x	300	30	20	250	1000	200
73	200	15	150	x	500	x	40	250	1000	150
4	600	15	250	x	200	x	50	50	7000	250
75	400	10	150	x	300	80	20	150	1500	200
76	400	10	200	x	100	15	50	300	1500	200
77	200	5	80	x	100	15	15	250	1000	100
78	400	10	150	x	80	50	30	200	1000	200
79	x	x	60	x	300	10	20	300	1000	80
80	400	15	250	x	1000	x	40	100	3000	100
81	500	15	150	x	700	x	30	100	3000	100
A2382/79	300	25	200	x	700	x	40	150	3000	100

Results are semi-quantitative. Elements apparently present in concentrations of economic interest should be redetermined by an appropriate accurate analytical technique.

REPORT AC 213/79

x = not detected at the limits quoted

Results in ppm unless otherwise stated. Detection limits in brackets.

Sample No.	W (50)	Zr (10)	Ag (0·1)	As (50)	Bi (1)	Cd (3)	Cu (1)	Ga (1)	Ge (3)	In (10)
A2368/79	x	100	10·	x	x	x	2000	25	x	x
69	x	100	1·5	x	x	x	50	25	x	x
70	x	30	0·6	x	x	x	20	7	x	x
71	x	100	0·2	x	x	x	20	25	x	x
72	x	30	0·8	50	x	x	15	20	1	x
73	x	100	0·2	x	x	x	3	25	x	x
74	x	250	0·2	x	x	x	20	25	x	x
75	x	60	0·4	x	x	x	30	20	x	x
76	x	50	x	x	x	x	20	10	x	x
77	x	50	0·5	x	x	x	10	10	x	x
78	x	50	0·1	100	x	x	20	10	x	x
79	x	30	0·1	x	x	x	15	7	x	x
80	x	250	0·1	x	x	x	4	20	x	x
81	x	200	0·1	x	x	x	4	20	x	x
A2382/79	x	200	x	x	x	x	50	15	x	x

Results are semi-quantitative. Elements apparently present in concentrations of [illegible] interest should be redetermined by an appropriate accurate analytical technique.

FORM 91B THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

REPORT AC 213/79

x = not detected at the limits quoted

Results in ppm unless otherwise stated. Detection limits in brackets.

Sample No.	Pb (1)	Sb (30)	Sn (1)	Zn (20)	Au (3)	P (100)	Te (20)	Tl (1)	Li (1)	Na (50)
A2368/79	50	x	2	x	x	600	x	10	100	10000
69	50	x	1	x	x	300	x	x	150	10000
70	40	x	1	x	x	x	x	x	30	3000
71	30	x	1	20	x	500	x	x	300	10000
72	30	x	1	20	x	x	x	x	100	5000
73	25	x	1	20	x	400	x	x	100	10000
74	110	x	2	x	x	700	x	x	200	>10000
75	50	x	1	100	x	200	x	x	150	10000
76	25	x	x	30	x	300	x	x	600	10000
77	30	x	2	x	x	x	x	x	150	3000
78	20	x	x	20	x	300	x	x	700	7000
79	20	x	x	x	x	400	x	x	300	5000
80	20	x	2	40	x	800	x	x	50	10000
81	20	x	2	30	x	500	x	x	50	>10000
A2382/79	20	x	1	300	x	800	x	x	50	10000

Results are semi-quantitative. Elements apparently present in concentrations of economic interest should be redetermined by an appropriate accurate analytical technique.

APPENDIX 6

BRIEF DESCRIPTIONS AND PRELIMINARY INTERPRETATIONS OF ACETATE PEELS, 201.35-325.60 m

by

Bridget C. Youngs

Officer Basin Study Group

Sample depth (m)	Stratigraphic Unit
201.35-201.45	Observatory Hill Beds, Member 4.
205.90-206.00	as above.
211.30-211.50	as above.
212.00-212.10	as above.
214.50-214.60	as above.
226.50-226.70	as above.
240.10-240.30	as above.
257.60-257.80	as above.
261.55-262.00	Observatory Hill Beds, Member 3.
286.15-286.25	as above.
288.40-288.50	as above.
294.00-294.10	as above.
295.00-295.20	as above.
297.60-297.80	as above.
325.50-325.60	Observatory Hill Beds, Member 2.

The carbonates for acetate peeling were prepared using the method of Davies and Till (1968, Journal of Sedimentary Petrology, volume 38, p. 234-237). Alizarin Red-S and Potassium Ferricyanide stains were used and acetate drafting sheets (available commercially) were used to make dry peels.

201.35-201.45: Stromatolite and Algal-Peloidal Packstone (?Grainstone)

This peel is composed of two distinct lithologies:

(i) basal bed is an algal-peloidal packstone with a mainly chert matrix, some recrystallised micrite is also in the matrix. Chert was an early diagenetic feature and only partially replaced micrite/filled pores; coarse ferroan calcite cement filled remaining pores later (Plate 10). Some algal plates may have micrite envelopes. Possibly also a few micritised intraclasts and ?fossil fragments.

(ii) overlain by an algal mat which is silty, calcite and ferroan dolomite micrite. Some coarse, secondary calcite runs parallel to bedding and also vertically. Few algal layers are recrystallised to microsparite. One chert nodule is a secondary replacement feature: is aligned parallel to bedding and grades laterally into a carbonate layer.

205.90-206.00: Micrite with one Algal Mat Layer

Silty calcite micrite in undisturbed layers with some thin, slightly ferroan dolomite laminations. No apparent recrystallisation.

One 10 mm algal mat - silty, mainly ferroan dolomite with ferroan calcite recrystallisation patches throughout.

211.30-211.50: Cherty, Algal Wackestone

Silty algal laminations (some oncolitic) throughout but highly disrupted-intraclastic in centre. The majority of the intraclasts were most probably originally algal plates (Plate 9), some of which were later altered to chert. The chert replacement has been pervasive and occurred in patches with irregular margins. There are rare angular (2-3 mm) chert intraclasts in the flat laminations overlying the intraclastic zone. Evidence of recrystallisation throughout and also secondary sparry calcite cement in patches.

212.00-212.10: Cherty Intraclast and Algal Packstone

Algal plates range from a few to 20 mm in length. Sharp, angular ends to the silty, slightly ferroan calcite plates. Chert intraclasts average 5 to 10 mm but some reach 30 mm. Larger ones are long, platy and may originally have been algal. Smaller intraclasts tend to be subrounded. The larger plates appear to form the framework for some oncolitic growth around them. The matrix is a silty calcite micrite, with patches of pervasive chert replacement and also secondary ferroan calcite replacement.

214.50-214.60: Dolomite

Fine grained dolomite rock with some patches and streaks (parallel to bedding) of ferroan calcite microspar.

226.50-226.70: Dolomitic Intraclast Wackestone

A predominantly flat-laminated, dolomitic rock displaying distinct graded layers. Each layer has a base of dolomitic, subrounded to rounded, <0.5 mm intraclasts and grades up through finely crystalline dolomite to the next unit.

240.10-240.30: Chert Intraclast Mudstone and Micrite-Chert Interbeds

This peel is composed of two distinct lithologies:

(i) basal bed is a slightly silty, flat-laminated calcite micrite with regular interbeds of chert. Chert beds show both irregular and sharp boundaries with the micrite. There is some secondary calcite veining of the cherts but not of the micrites. One vertical chert vein runs 40 mm into a micrite bed and is in turn cut by a calcite vein.

(ii) top bed is a chert intraclast mudstone composed of ill-sorted, angular to subrounded, 3-15 mm, chert intraclasts in a dolomite mudstone. The intraclasts were possibly derived from the bed below.

257.60-257.80: Dolomite

Fine, equi-granular dolomitic mudstone which contains a vertical calcite vein (2 mm wide) and two unidentified features -

(a) a large (30 mm x 20 mm) mass of chert and carbonate intraclastic material which appears to have been injected into the underlying beds when they were semi-lithified; and

(b) a vertical, ?dewatering feature 60 mm high and filled with coarser peloidal material. The latter feature occurs in non-silty mudstone and the bed appears to have been eroded before the deposition of a more silty bed above. The large balloon-like feature ((a)) is restricted to the siltier bed.

261.55-262.00: Interbedded silty Micrite and Chert

Regular, flat-laminated beds of silty, calcite micrite with rare small intraclasts of chert. Interbedded with chert beds and nodules (5-10 mm vertical thickness). Chert appears to be contemporaneous or early diagenetic and to have developed along bedding planes, occasionally incorporating small fragments of micrite. Some nodules show vague colour banding. Later sedimentary boudinage during compaction encouraged the formation of nodules and lenses (Plate 8).

276.50-276.70: Silty Micrite (Mudstone)

Regular, graded laminations of silty, calcite micrite and microsparite. Top 80 mm contains ?algal laminations which were deformed while soft and are now microspar. Remainder of peel in silty micrite with one chert bed and a few cherty intraclasts.

286.15-286.25: Dolomite with abundant Calcite Pseudomorphs after Evaporite Minerals

Originally a fine grained dolomite mudstone, silty and calcareous in parts. Blocky calcite (average 2-3 mm) has replaced most of the bladed-rosette evaporite minerals (Plate 7). A few evaporite blades appear to have been replaced by micrite - they are now "micrite ghosts".

288.40-288.50: Chert Intraclast Wackestone

Chert intraclasts are platy to elongate, sub-parallel to the bedding and average 10 to 30 mm. They are in a slightly ferroan calcite and dolomite, silty mudstone.

294.00-294.10: Algal Micrite with Intraclasts and ?Ooids

Predominantly an algal-laminated slightly ferroan calcite mudstone with layers and patches of ferroan dolomite. Contains intraclasts of chert and micrite, rare chert nodules and, at the base of the peel, "ghosts" of ?ooids.

295.00-295.20: Dolomite with Abundant Calcite Pseudomorphs after Evaporite Minerals

Similar to 286.15 (Plate 7). Calcite replacement of evaporite minerals as above but in this sample there are dark silty margins to the blades. "Ghosts" of blades occur at ends of and between calcite areas. Intraclasts and peloids occur as "ghosts" at 294.80.

297.60-297.80: Dolomitic Algal Micrite and Silty Calcite Micrite

This peel is composed of two distinct beds:

(i) the basal bed is a silty, calcite micrite with regular thin beds of calcite microsparite. Rare calcite pseudomorphs after bladed and blocky evaporite minerals.
(ii) the top bed is dolomitic algal micrite, with some layers and algal plates of (recrystallised) microsparite.

325.50-325.60: Micrite and Chert Interbeds

Flat-laminated, silty, calcite and dolomite, interbedded with chert. Cherts are up to 5 mm thick and distinct from micrites. Few chert intraclasts in the micrite beds. ?Burrow at the base of the peel, filled with sparry calcite. The peel indicates this is a porous rock.

Conclusions

The interval 201.35 to 325.60 m in Byilkaoora 1 is characterised by fine-grained silty carbonates, intraclasts, algal mats and chert. No ooids, fossils, peloids, columnar stromatolites or large areas of sparry cement have been positively identified. Pseudomorphs after evaporite minerals occur between 260 and 320 m.

The features observed in this suite of peels show that the rocks were deposited in shallow waters into which there were regular influxes of terrestrially-derived silts. Energy levels in the basin were never high but varied regularly between quiet (flat-laminated micrites) to agitated and possible subaerial exposure (intraclast packstones). The abundance of algal mats, lack of recognisable fossil fragments and occurrence of evaporites suggest that salinities were high. These carbonates may have been deposited in a shallow marine to supratidal environment (lagoon to sabkha) or a non-marine playa lake: at this preliminary stage no positive interpretation can be made.

2.8.79 B.C. Youngs

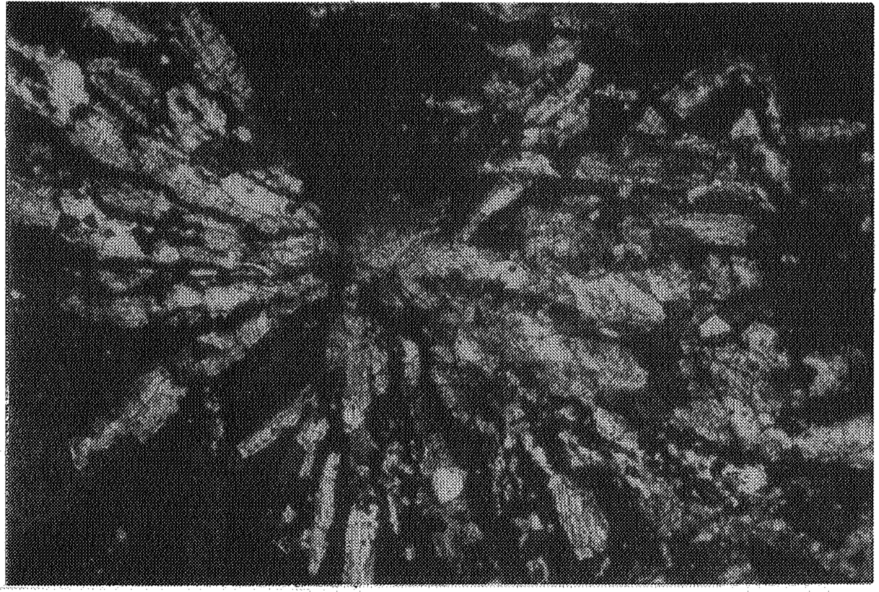


PLATE 7 "Rosette" of blades, composed of coarse calcite crystals, in a ferroan dolomite mudstone. The calcite has replaced an evaporite mineral. x 12. 286.20 m. (Neg. No. 30882).

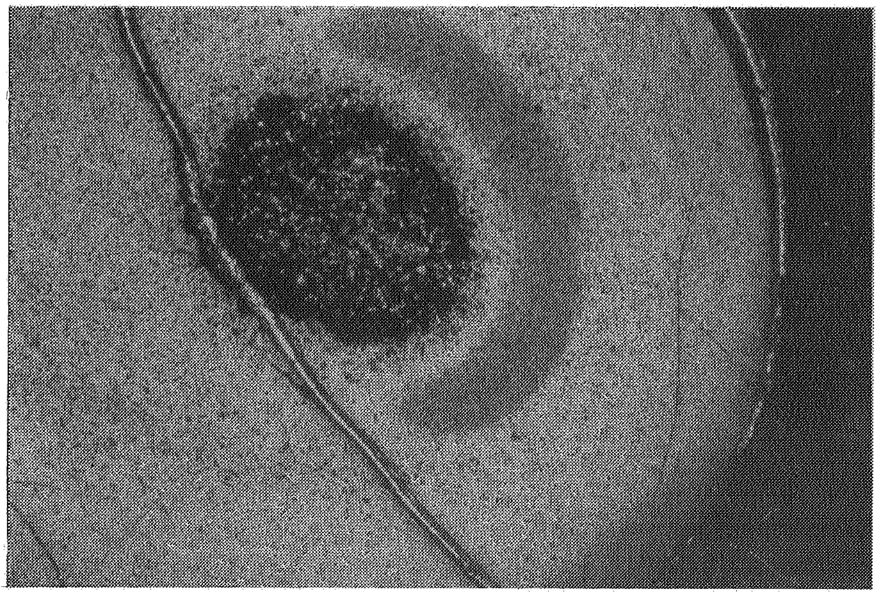


PLATE 8 Part of a chert nodule showing concentric banding and a calcite vein cutting the chert. Silty calcite mudstone matrix at right. x 12. 261.80 m. (Neg. No. 30883).

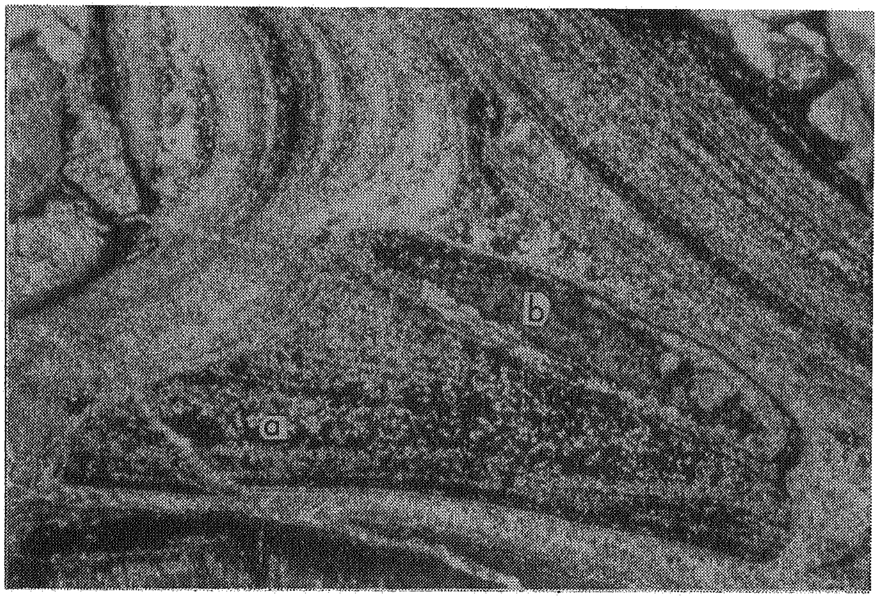


PLATE 9 Oncolitic growth around algal plate (a) ?fossil fragment (b). x 12. 211.30 m.
(Neg. No. 30884)

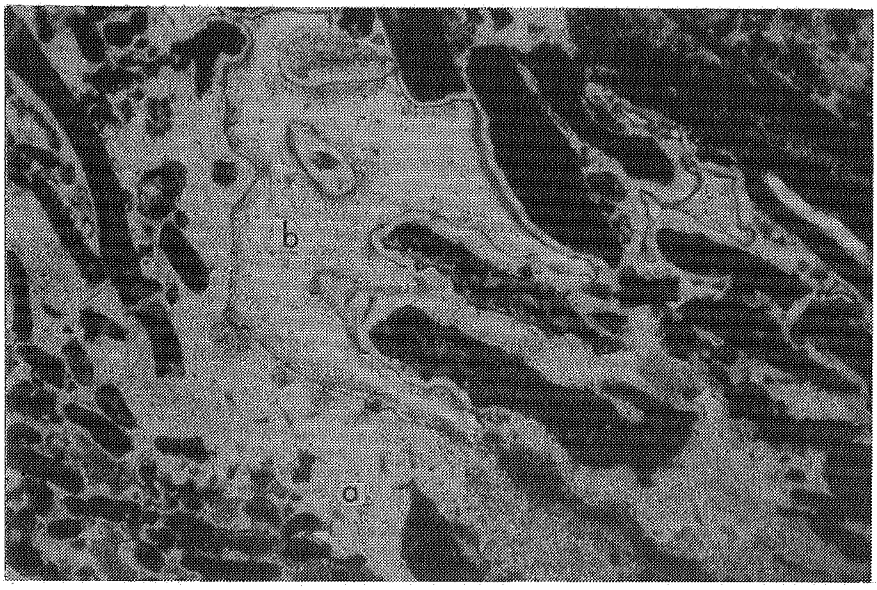


PLATE 10 Algal plate wackestone showing chert fill (a) clinging to allochems and a later coarse ferroan dolomite cement in the centre (b). Material at bottom left is peloidal. x 12. 201.35 m.
(Neg. No. 30885)

APPENDIX 7

DRILLERS' COMPLETION REPORT

M. Obst

Driller D. White drilled the upper section and driller F. Costello drilled the lower section with the Mindrill 10L diamond drill, Department of Mines and Energy No. DD6.

Construction details of the well were, commenced from surface with a 158.75 mm tricone roller bit to 4.84M and installed 4.84M of 127 mm steel casing; continued drilling with 114.30 mm tricone roller bit to 13.12M obtaining sludge samples at 3.00M intervals; installed 12.80M of 80 mm NOM bore steel pipe Q series thread and continued drilling NQ wire line 75.8 mm, core diameter 47.6 mm to 59.55M; lost complete water fluid circulation to surface at 42.00M; withdrew the 80 mm steel pipe as casing and reamed hole out to 107.95 mm, from 12.80M to 54.72M and installed 54.72M of 80M N.E. steel pipe to regain water returns; continued drilling NQ wire line from 59.55M to the completed depth of 496.65M; lost water fluid returns at 121.50M; cemented hole several times to regain circulation which was only partially successful; lost complete water returns at 150.00M when it was decided to drill ahead without returns to surface. The well was geophysically logged to 465M. Attempt was made to withdraw the 80 mm NB pipe; this was unsuccessful; too tight, back screwed recovered 6.00M leaving 48.72M in hole. Following geological inspection of the core samples it was decided to case bore to 201.55M with 32 mm NOM bore steel pipe, with annulus cemented from 137.24M to 201.15M and surface to 1.50M with 32 mm valve on pipe; open hole from 201.15 m to bottom, plus a stand pipe cemented at surface for future access for testing purposes as required.

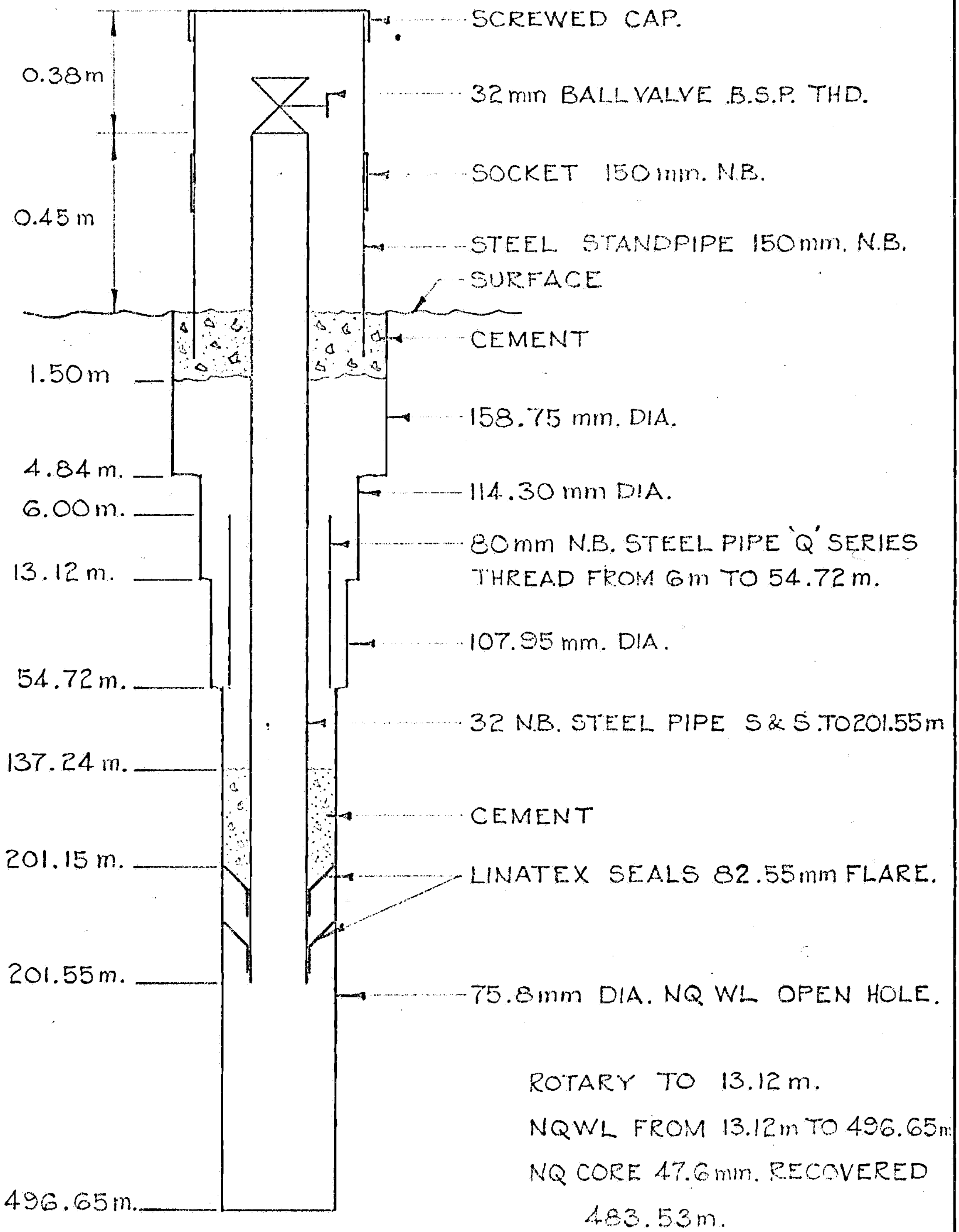
A sketch drawing of the completed bore is attached.

Geologist M. Benbow & G. Pitt were on site during drilling operations, alternating visits between them.

Details of the bore are as follows:-

Bore No.	From	To	Rotary	NQ Cored	Core Rcd.	Angle	Bore Serial No.
Byilkaoora 1	0 M	496.65M	13.12M	483.53M	483.53M	90°	624/79

Total metreage drilled 496.65M - Rotary drilled 13.12M - NQ wire line coring 483.53M - core recovered 483.53M.



ROTARY TO 13.12 m.
NQWL FROM 13.12 m TO 496.65 m
NQ CORE 47.6 mm. RECOVERED
483.53 m.

	DEPARTMENT OF MINES–SOUTH AUSTRALIA	Scale: N.T.S.
Compiled: M.O.	BYILKAOORA No.1 BORE SERIAL No. 624/79 ANGLE 90° DEPTH 496.65.	Date: 9 - 8 - 79
Drn. R.B Ckd.		Drg. No. SK-870

500—11.76 H1081 O

APPENDIX 8

WELL VELOCITY SURVEY

By

B.J. Taylor

SADME Geophysics Division

BYILKAOORA NO. 1

REPORT ON WELL VELOCITY SURVEY

Formation velocities and overall average velocities were determined from nineteen geophone positions in the Byilkaoora No. 1 well.

Average formation velocity of the Mt. Johns Conglomerate was measured as being much higher than that of the deeper lower member of the Trainor Hill Sandstone, causing a velocity inversion. However, it is considered that these velocities may change where these formations are deeper within the basin.

PROCEDURE

A well velocity survey was conducted in the Byilkaoora No. 1 well on the 24th June, 1967. A down-hole geophone on loan from the Bureau of Mineral Resources, Geology and Geophysics, was used in conjunction with a 6000 feet Failing logging unit. Seismic times were recorded on a 12 channel SIE P 19 portable seismograph system with photographic recording.

Shot holes, approximately 1 m deep, were offset to the west, initially at 80 m, then reducing in 5 m steps to 10 m as the geophone was raised in the hole. This helped maintain a consistent measured velocity in the upper material, as constant blasting in one area tends to aerate the soil and sand around the hole and lower its velocity.

The down-hole geophone was lowered without difficulty to what was then the bottom of the hole (464.9 m) and records were taken with the down-hole geophone at the bottom, at 450 m and at 25 m intervals up the hole to the base of the casing (52 m). A refraction geophone was placed near the top of the well. Times from this geophone gave a check that the times measured from the down-hole geophone related to energy passing through rock formations and not the steel logging cable.

RESULTS

The observed times were corrected, as shown on the attached computation sheet, to vertical times from the down-hole geophone to surface. A correction to an elevation datum was not made. Curves of corrected vertical times, slant times and average velocity are shown on drawing no. S14224, along with a generalised geological log and average formation velocities.

Generally, although the time breaks were easily identified and timed, the amount of explosive charge (280 grams) could have been doubled to achieve sharper breaks.

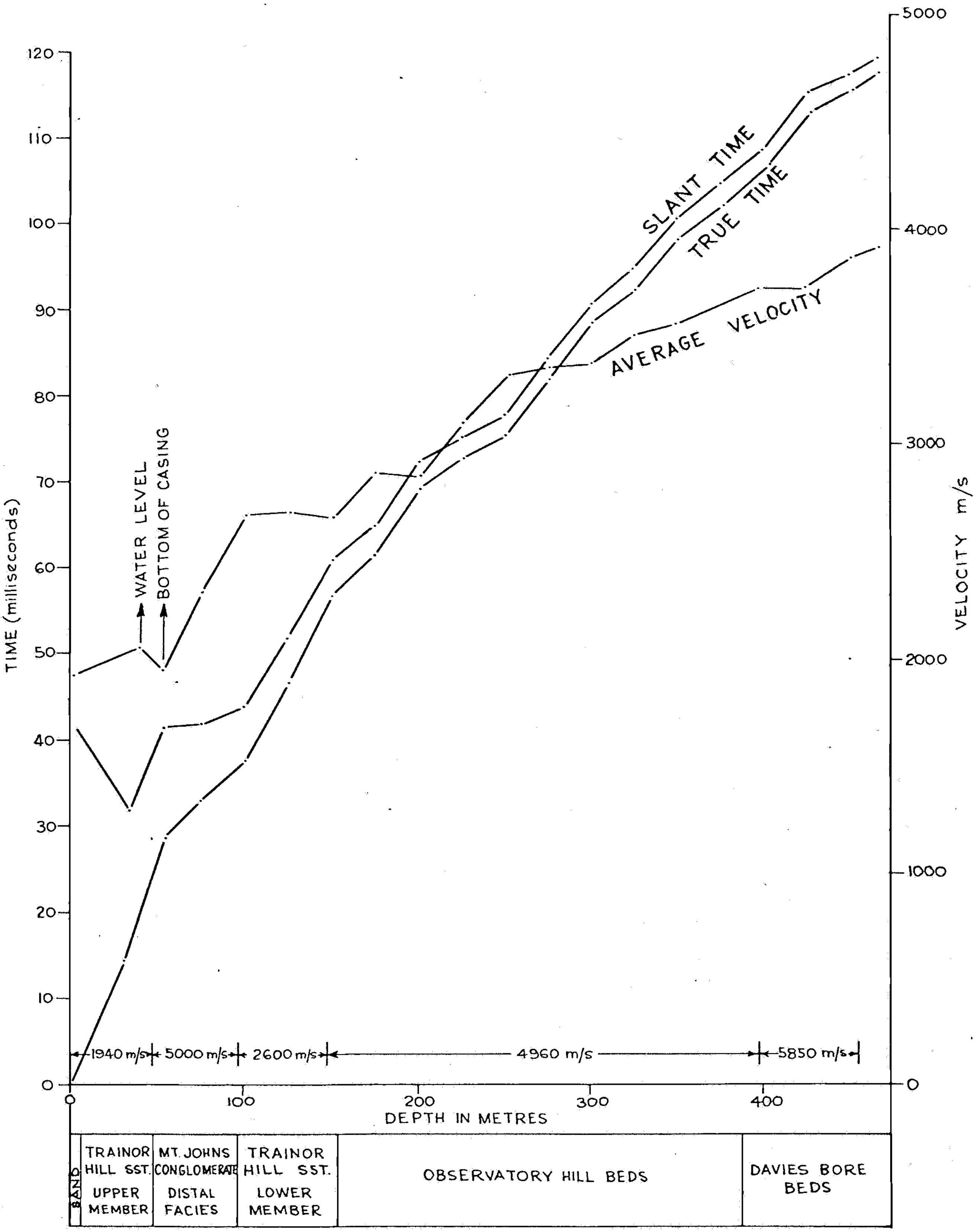
Results show a general increase in average velocity with depth but it is not a constant increase. The average formation velocity of the Mt. Johns Conglomerate is 5000 m/s which is much higher than the average formation velocity of the lower member of the underlying Trainor Hill Sandstone (2600 m/s). The average formation velocities of the remaining beds increase with depth.

CONCLUSION

It is considered that the formations logged in the hole are at too shallow a depth for the average formation velocities measured to extrapolate to the same formations when they are at greater depths within the basin.

B.J. TAYLOR

SUPERVISING TECHNICAL OFFICER



DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

COMPILED B Taylor

DRN A F

CKD

BYILKAOORA 1 WELL COMPLETION REPORT
WELL VELOCITY SURVEY

SCALE -

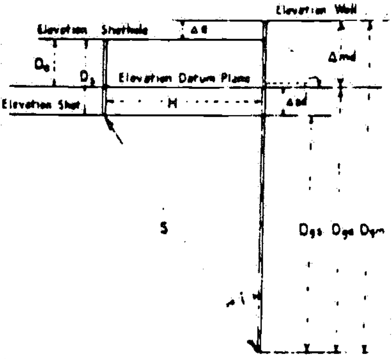
DATE 3 - 9 - 79

PLAN NUMBER

S 14224

Shothole Information.- Elevation, Distance & Direction from Well	Department of Mines Well	Elevation (Derrick Floor)	Total Depth	LOCATION
≈1m BELOW SURFACE WEST OF HOLE AT DISTANCES SHOWN IN COLUMN 'H'	BYILKAOORA N° 1		464·9 m	Coordinates Section, Township, Range County Area or Field

Record Number	Shothole Number	D_{gm}	D_s	t_{us}	t_r	T Reading	T Polarity	T Grade	D_{gs}	H	cotan i	cos i	T_{gs}	Δsd	$\frac{\Delta sd}{V}$	T_{gd}	T_{gd} Average	D_{gd}	ΔD_{gd}	ΔT_{gd}	V_i Interval Velocity	V_a Average Velocity
1		464·9				120				80		·9855				118·26						3912
2		450				118				80		·9846				116·18					7173	3873
3		425				116				80		·9827				113·99					11418	3728
4		400				109				75		·9829				107·14					3648	3733
5		375				105				75		·9806				102·96					5991	3642
6		350				101				75		·9778				98·76					5949	3544
7		325				95				75		·9744				92·57					4039	3511
8		300				91				65		·9773				88·93					6880	3373
9		275				84·5				65		·9732				82·24					3732	3344
10		250				78				65		·9678				75·49					3703	3312
11		225				75·5				60		·9662				72·95					9841	3084
12		200				72·5				60		·9578				69·44					7127	2880
13		175				65				60		·9459				61·48					3142	2846
14		150				61				60		·9285				56·64					5160	2648
15		125				52				60		·9015				46·88					2561	2666
16		100				44				60		·8575				37·37					2733	2650
17		75				42				60		·7809				32·80					5069	2287
18		55				42				60		·6757				28·38					4527	1938
19		30				32				60		·4472				14·31					1422	2096
11	B	225m				77				60		·9662										



D_{gm} = Geophone depth measured from well elevation
D_{gs} = " " " " shot "
D_{gd} = " " " " datum "
D_s = Depth of shot
D_e = Shothole elevation to datum plane
H = Horizontal distance from well to shotpoint
S = Straight line travel path from shot to well geophone
t_{us} = Uphole time at shotpoint
T = Observed time from shotpoint to well geophone
t_r " " " to reference geophone
Δe = Difference in elevation between well & shotpoint
Δsd = " " " shot & datum plane
$\Delta sd = D_s - D_e$
$D_{gs} = D_{gm} - D_s \pm \Delta e$; $\tan i = \frac{H}{D_{gs}}$
$T_{gs} = \cos i\ T$ = Vert travel time from shot elev to geophone
$T_{gd} = T_{gs} \pm \frac{\Delta sd}{V}$ " " " " datum plane " "
$D_{gd} = D_{gm} - \Delta md$
V_i = Interval velocity = $\frac{\Delta D_{gd}}{\Delta T_{gd}}$
V_a = Average " $\frac{D_{gd}}{T_{gd}}$

Surveyed by ....

Date ....

Weathering Date

WATER LEVEL 28 m

Casing Record 52 m

BJS

Well Velocity Calculation Form

APPENDIX 9

GEOPHYSICAL LOGS

1. Gamma
2. Neutron
3. SP
4. PR
5. Density
6. 6 ft. Lateral
7. Gamm-Neutron/lithological correlation

SOUTH AUSTRALIAN DEPARTMENT OF MINES # 1988

CLIENT: Dept. of MINES & ENERGY. AREA: MARLAR BORE BORE: Byilkaoora.

TYPE OF LOG		DENSITY.	DEPTH DRILLER	465.50 metres.
LOC:- Latitude			DEPTH LOGGER	465.4 metres.
Longitude			FIRST READING	465.2 metres.
ELEVATION:- GL			LAST READING	0.8 metres.
Log			CASING LOGGER	55.6 metres.
LOGGER	UNIT	B. TRAEGER	"6,000G"	CASING DRILLER	3" I.D. STEEL PIPE @ 52 metres.
DATE		24-6-79	MUD: Type	NIL.
PROBE		No2. GAMMA.	Rm @	@

REMARKS :-

SOUTH AUSTRALIAN DEPARTMENT OF MINES # 1989

CLIENT: DEPT. of MINES & ENERGY. AREA: MARLAR BORE BORE: Byilkaoora.

TYPE OF LOG	GAMMA NEUTRON.	DEPTH DRILLER	465.5 metres.
LOC:- Latitude		DEPTH LOGGER	465.4 metres.
Longitude		FIRST READING	464.4 metres 465 metres
ELEVATION:- GL		LAST READING	0.6 metres 1.4 metres.
Log		CASING LOGGER	55.6 metres.
LOGGER | UNIT	B. TRAEGER | "6,000G"	CASING DRILLER	3" I.D. STEEL PIPE 52 metres.
DATE	24-6-79	MUD Type	NIL.
PROBE	No.2. GAMMA. No.1. NEUTRON.	Rm @	

REMARKS:

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SOUTH AUSTRALIAN DEPARTMENT OF MINES # 1985

CLIENT: Dept. of Mines & Energy. AREA: Marlar Bore. BORE: Byilkaoora.

TYPE OF LOG	6Ft. LATERAL.	DEPTH DRILLER	465.5 metres.
LOC:- Latitude		DEPTH LOGGER	465.4 metres.
Longitude		FIRST READING	465.2 metres.
ELEVATION:- G.L.		LAST READING	55.6 metres.
Log		CASING LOGGER	55.6 metres.
LOGGER | UNIT	B. TRAEGER | "6,000ft."	CASING DRILLER	3" I.D. STEEL PIPE (I) 52 metres.
DATE	24-6-79	MUD Type	NIL.
PROBE	Flexible resis. probe.	Rm (Ω)	

REMARKS:

SOUTH AUSTRALIAN DEPARTMENT OF MINES # 1986

CLIENT: Dept. of Mines & Energy. AREA: Marlar Bore BORE: Byilkaoora.

TYPE OF LOG	S.P. & P.R.	DEPTH DRILLER	465.50 metres.
LOC.:- Latitude		DEPTH LOGGER	465.4 metres.
Longitude		FIRST READING	465.2 metres 465.2 metres.
ELEVATION:- G L		LAST READING	55.6 metres 55.6 metres.
Log		CASING LOGGER	55.6 metres.
LOGGER / UNIT	B. TRAEGER / "6,000Ω."	CASING DRILLER	3" I.D. Steel pipe @ 52 metres.
DATE	24-6-79	MUD: Type	NIL.
PROBE	Flexible resis. probe.	Rm @ °C	@

REMARKS:

DEPARTMENT OF MINES AND ENERGY — SOUTH AUSTRALIA

BYILKAOORA 1

COMPARISON BETWEEN GAMMA/NEUTRON & LITHOLOGICAL LOGS

○	Conglomerate	▤	Claystone
⁘	Sandstone (medium-coarse grained)	▦	Limestone, dolomite (proportions unspecified)
⁚	Sandstone (fine grained)	▱	Siltstone-claystone clasts
··	Siltstone	◒	Oil in vugs and veins

FOR LOGGING DATA SEE ORIGINAL GEOPHYSICAL LOGS

DRAWING № 79-571