LAKES OIL N.L.

ACN 004 247 214

BOUNDARY CREEK No.1
AND
BOUNDARY CREEK No.1A

STRATIGRAPHIC CORE HOLE

WELL COMPLETION REPORT

BY

J.N. MULREADY & D.R. HORNER

LAKES OIL N.L.
LEVEL 11,
500 COLLINS
STREET,
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DECEMBER, 2002

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914415 003

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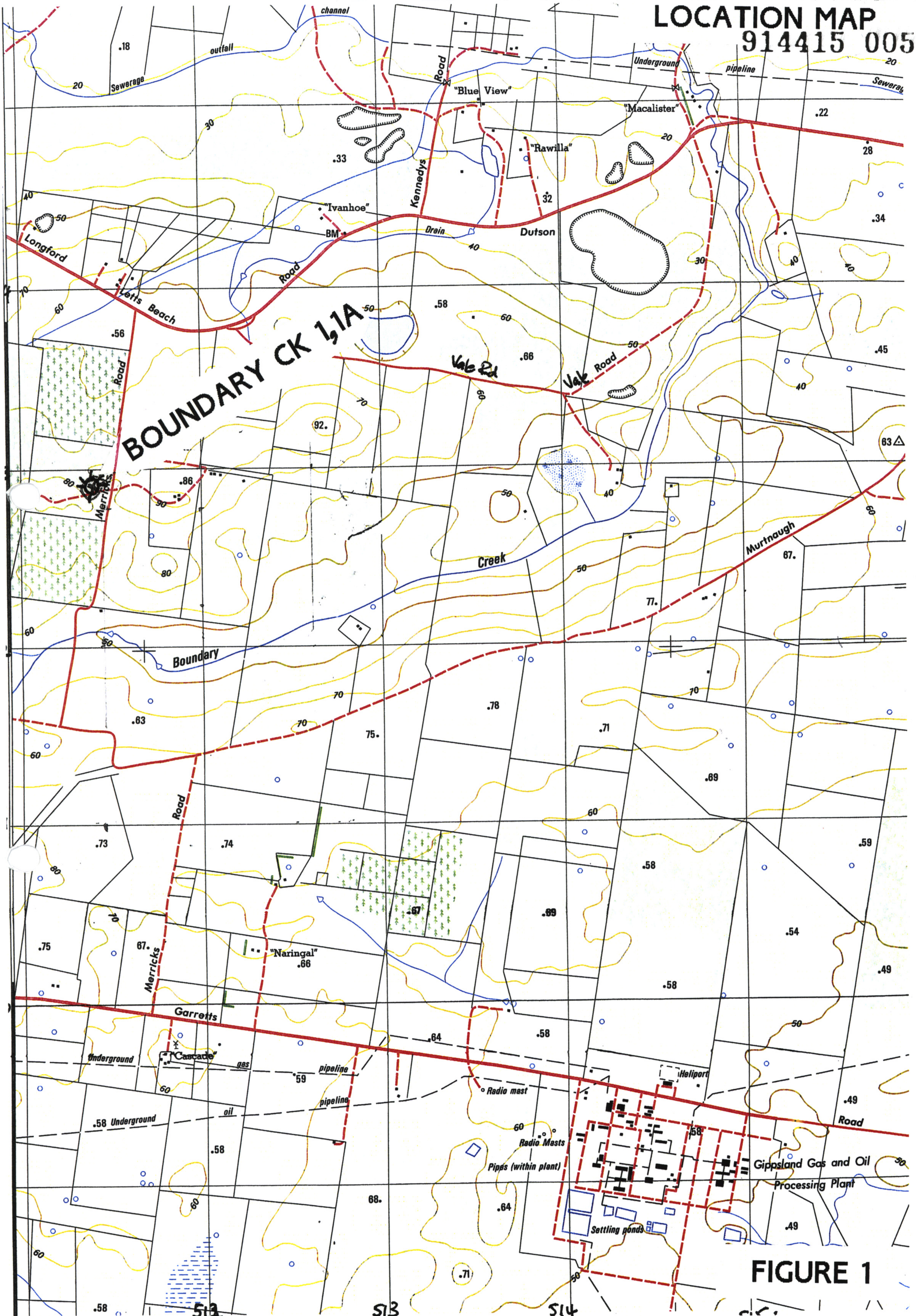

FIGURE 1

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1.0 SUMMARY

Boundary Creek No.1 stratigraphic core hole was located in PEP 157 adjacent to Merricks Road, Longford, approximately 11 kilometers south southeast of Sale. The purpose of the well was to follow up on Lakes Oil's previous stratigraphic work in the Longford area, Gippsland, with a view to providing stratigraphic and reservoir information regarding the Strzelecki Formation at this location. Control was provided by 1985 vintage seismic (the nearest line is Hartogen Rosedale Survey 1985 Line 2 approximately 1 km to the south), with well control provided by the Strzelecki Formation intersection in the Tanjil Pt Addis-1 well 3 km to the southwest.

Boundary Creek No.1 was spudded on the 12th of August, 2001 employing a Gardner Denver 1500 rig. A 254 mm (10") conductor was set at 3.5 meters. 238 mm (9.375") hole was drilled to 60 meters, and 178 mm (7") casing set at 59.75 meters.

152 mm (6") hole was drilled to 218 meters, where the rig was shut down, as it had been intended to core the Latrobe Fm/Strzelecki Fm boundary and this opportunity had now been missed.

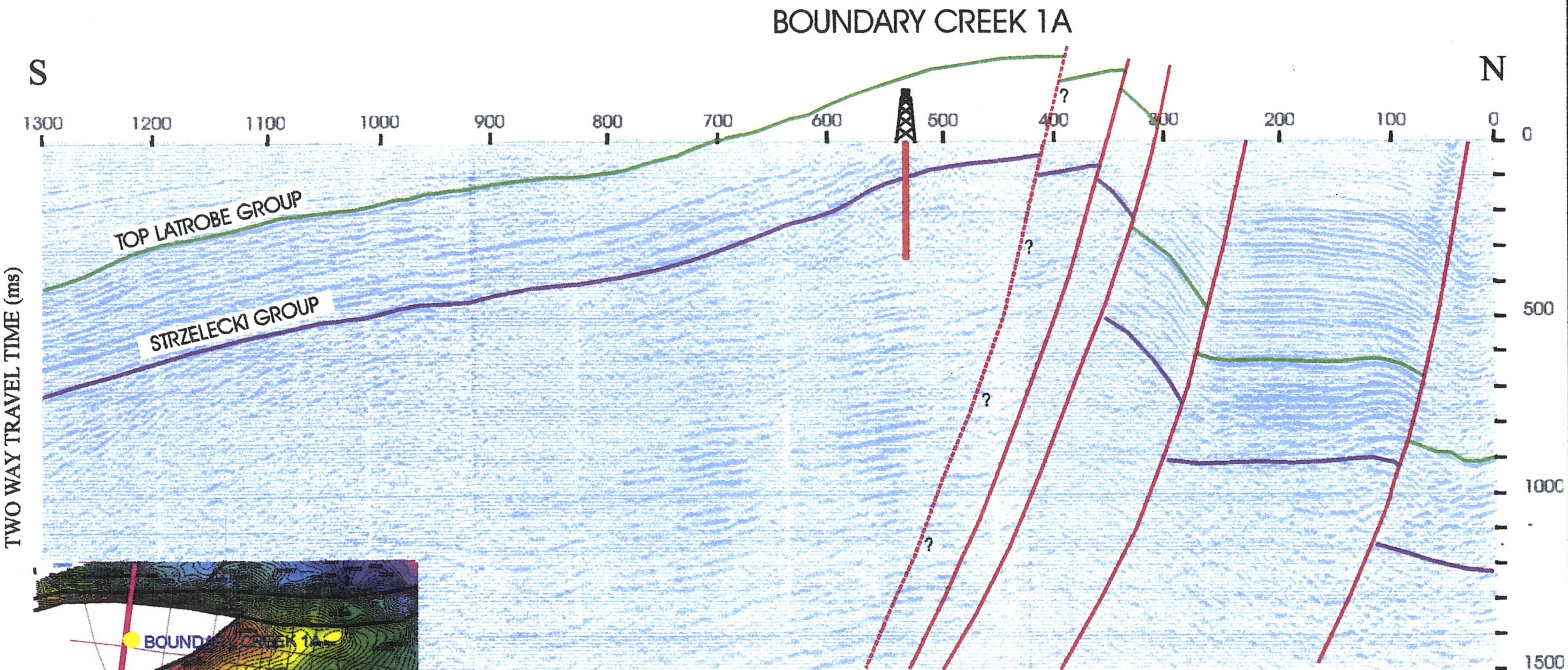
The Gardner Denver rig then drilled a 3 meter offset well (Boundary Creek No.1A) to a depth of approximately 60 meters, and 178 mm (7") casing was set at 59.75 meters. 152 mm (6") hole was then drilled to 195 meters where 127 mm (5") water well casing was set. The Gardner Denver rig was then moved off location to be replaced by a Bourne coring rig.

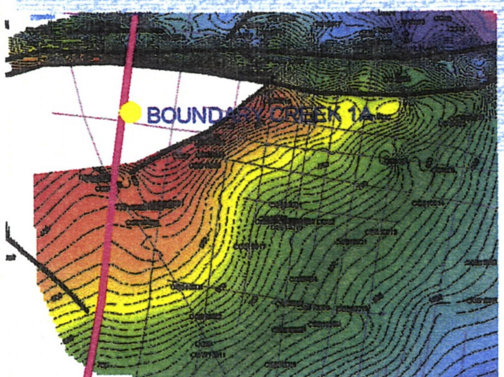
On the 28th of August, 2001, with the Bourne rig onsite, the BOP installation began. After installing and pressure testing the BOP's, a coring assembly was run in hole. Cement was tagged at 192 meters. After coring out cement and 30 centimeters of new hole, the casing dropped 15 centimeters. After the casing was retrieved and secured, it was re-cemented with cement returns to surface.

The coring assembly was subsequenly run in hole and coring recommenced. Coring continued with several minor problems (see section 2.3 - Drilling Data) to 366.5 meters (T.D.) which the well reached on the 21st of September, 2001. A Gamma Ray and CCL log was run from T.D. to surface, after which the hole was plugged with a cement plug from T.D. up to 30 meters into the 5 inch casing. Finally a short plug was run at surface.

The primary objective of the well was achieved, with both reservoir and palynological data from the Strzelecki Formation being obtained. Of particular significance was the good reservoir quality encountered within this unit, and the presence of formation gas, (up to 10 units whilst coring and up to 109 units from trips).

No oil fluorescence was noted.





BOUNDARY CREEK 1
SEISMIC SECTION
HARTOGEN ROSEDALE SEISMIC SURVEY 1985 LINE 2

Figure 2

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2.0 WELL HISTORY

2.1 GENERAL DATA

2.1.1 Well Name and Number	Boundary Creek No.1 & 1A
2.1.2 Location	511423 E 5772873 N
2.1.3 Elevations	G.L. 75.0 m A.S.L. R.T. 76.0 m A.S.L. Latitude: 38° 11' 30.7: S Longitude: 147° 07' 49.6: E
2.1.4 Petroleum Tenement	PEP 157
2.1.5 Name of Operator	LAKES OIL N.L. A.C.N. 004 247 214 11TH Level, 500 Collins Street, Melbourne Vic. 3000
2.1.6 Other Participants	None.
2.1.7 Date Drilling Commenced	12th August, 2001.
2.1.8 Date Drilling Completed	21st September, 2001.
2.1.9 Date Rig Released	24th September, 2001.
2.1.10 Drilling Time to T.D.	44 days.
2.1.11 Total Depth	366.5 meters.
2.1.12 Status	Plugged and Abandoned.

Boundary Creek 1, 1A Time vs Depth

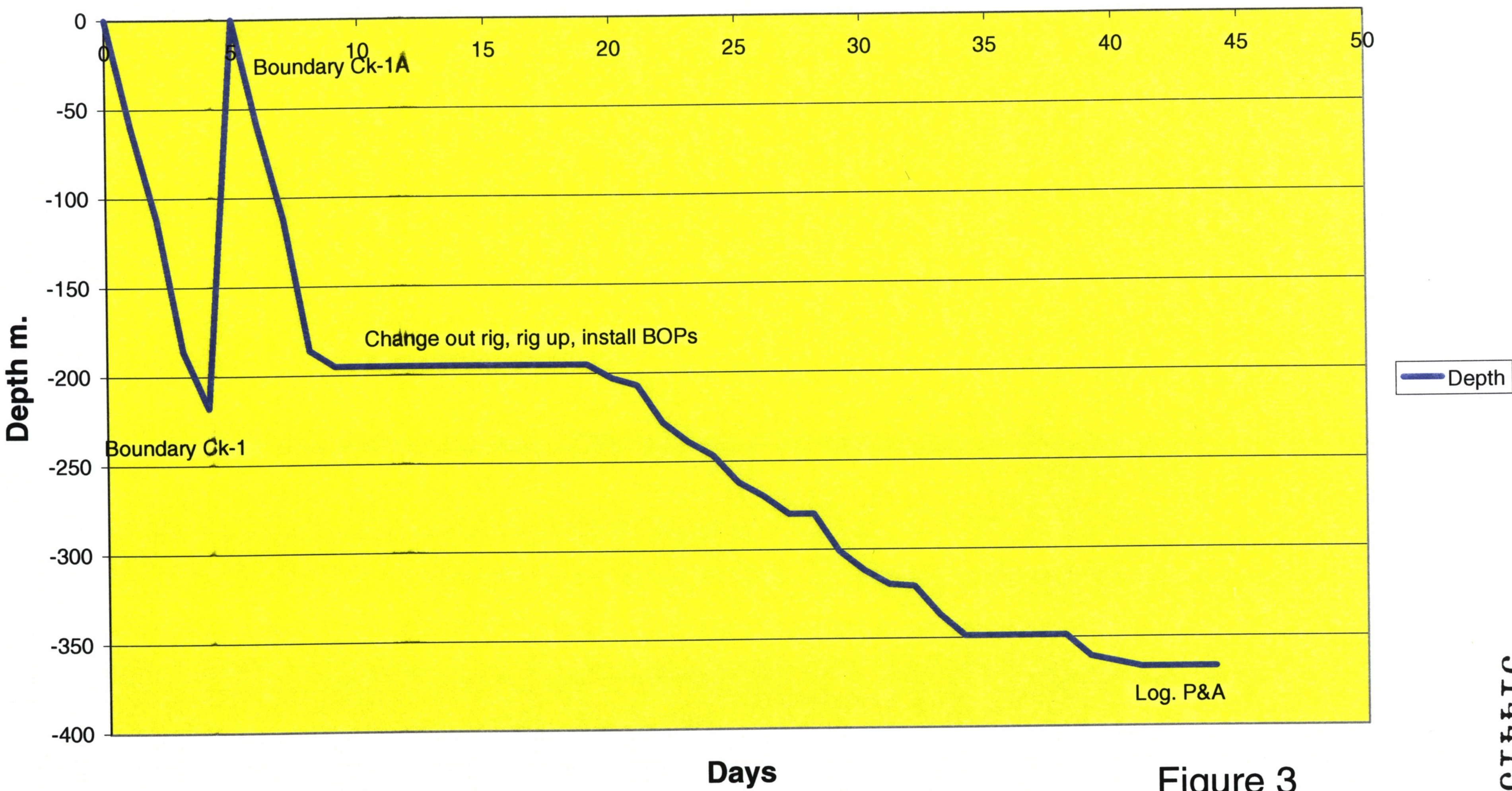

Figure 3

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2.2 RIG DATA (Rig 1)

2.2.0	Drilling Contractor	Drilltech Pty Ltd Drilling Depot Rd Morwell Victoria 3168
2.2.1	Rig	Gardner Denver Mayhew model 1500W.
2.2.2	Rig Carrier	Truck Mounted.
2.2.3	Weight Indicator	Martin Decker Hydraulic Pressure
2.2.4	Power	Truck Engine
2.2.5	Rotary	Mayhew Model RT10.
2.2.6	Blocks	Two ST-15 single sheave 15 ton.
2.2.7	Pumps	Gardner Denver FD-FXX 5"X8".
2.2.8	Kelly	3.5" square X 26' 6".
2.2.9	Sump pump	Not applicable.
2.2.10	Transfer Pump	Not applicable.
2.2.11	Tubulars	Not applicable.
2.2.12	Fishing Tools	None on Site.
2.2.13	Handling Tools	BJ type 15W.
2.2.14	Stablizer	None used.
2.2.15	Spare Parts	As reasonably required to conduct operations for programmed well.
2.2.16	Personnel	Driller plus 2 crew.

Rig Operated Daylight Hours Only.

RIG DATA (Rig 2)

2.2.17	Rig	Bournedrill THD25VP.
2.2.18	Rig Carrier	Truck Mounted.
2.2.19	Weight Indicator	Hydraulic Pressure.
2.2.20	Power	Truck Engine.
2.2.21	Rotary	Top Drive.
2.2.22	Pumps	Duplex 5"X 6" double action.
2.2.23	Tubulars	PQ pipe
2.2.24	Fishing Tools	None on Site.
2.2.25	Handling Tools	Hydraulic 48" Rigid wrench.
2.2.26	Stabilizer	Not applicable.
2.2.27	Spare Parts	As reasonably required for carrying out the well programme.
2.2.28	Personnel	Driller plus 2 crew.
2.2.29	Rig Operated Daylight Hours Only.	

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2.3 DRILLING DATA

2.3.1 The following is the daily operations summary for Boundary Creek No.1 & 1A. It has been compiled from the daily drilling reports. Onsite drilling supervision and wellsite geology services for Lakes Oil N.L. was provided by J. Mulready. The rig operated daylight hours only.

DATE	DRILLING OPERATIONS
12-08-2001	Set 10 inch casing at 3.5 m Drilled 9.3/8 inch hole to 60 m, set 7 inch casing at 59.75 m Drilled out cement
13-08-2001	Drilled from 60 to 112 m.
14-08-2001	Drilled from 112-132 m. POH to change bit RIH drilled from 132 to 186 m
15-08-2001	Drilled from 186 - 218 m.
16-08-2001 to 26-08-2001	Rig to redrill approx 3 m lateral offset well (Boundary Creek 1A) to depth of approx 60 metres and set 7 inch casing, then drill 6 inch hole to 195 m and set 5 inch water well casing. Gardner Denver rig will then move off location to be replaced by Bourne after BOP installed.
27-08-2001	Bourne Coring Drill on site, cellar in place, BOP partly installed. Driller ill, no progress to p.m. 27.8.01 Expect replacement driller a.m. tomorrow.
28-08-2001	Completed rigging up, including installation of BOP. Tested BOP. RIH, tagged top cement at approx 192 m.
29-08-2001	Cored out cement, cored 30 cm., then casing dropped 15 cm., indicating inadequate cement job. POH recovered 30 cm core – soft clay with boulders. Retrieved and secured casing. Re-cemented with accelerant – returns to surface.
30-08-2001	Pulled pipe free. RIH tagged cement at 180 m. Cored cement to 196.5 m. Hydraulic slips failed, rig shut down, p.m. 30.8.01
31-08-2001	Repaired rig, cored to 203 m.
01-09-2001	RIH, cored to 207.3 m. Variable recovery, between 0 and 100%. Core barrel parted, rig shut down. Replacement core barrel to be on-site tomorrow.
02-09-2001	Coring resumed 8.15 a.m. in steady rain. Cored 207.3 to 227.7 m., mostly 100% recovery.
03-09-2001	Cored 227.7 m. - 239.1 m. Gas show of 15 units, background gas 0-3 units. Dropped core barrel. Unable to latch on and retrieve. POH, changed bit, RIH retrieved most of core. Cored ahead.
04-09-2001	After experiencing circulation problems POH, circulation ports blocked. Changed bit. RIH, cored 239.1 –247 m. Gas show of 15 units whilst circulating at start up, background gas 0-3 units.
05-09-2001	RIH cored to 259

	Experiencing problems with retrieving core. Cored to 262 m. Cable parted whilst attempting to retrieve core. POH recovered core. Background gas 0-3 units
06-09-2001	Cored to 270.2 m Background gas 4-12 units. Circulation gas 29 units
07-09-2001	Cored to 280 m Background gas 4-12 units.
08-09-2001	Rig shut down for Sunday break.
09-09-2001	Cored to 301 metres Background gas 2-9 units.
10-09-2001	Cored to 312 metres POH to change bit. Background gas 2-5 units.
11-09-2001	RIH to commence coring at 312 m Dropped core barrel whilst trying to retrieve core from first run. Top of barrel had unscrewed. POH retrieved core barrel. RIH resumed coring. Cored to 320 m.
12-09-2001	RIH to commence coring at 320 m Drill string parted. POH, replaced one rod. RIH attempted to latch on to fish. Unsuccessful. POH RIH latched on to fish, restored circulation. Resumed coring. Cored to 321 m.
13-09-2001	RIH commenced coring at 321 m. Cored to 336.5 m at 6 p.m. 13th. Background gas 0-2 units.
14-09-2001	RIH commenced coring at 336.5 mm. Cored to 348.6 m at 6 p.m. 14th. Background gas 0-3 units.
15-09-2001	RIH pipe parted. POH attached fishing tool, RIH to retrieve fish. POH with fish, RIH to retrieve base of last core to 348.6 POH. Pipe bent, unable to resume coring. Rig shut down pending arrival of new pipe.
16-09-2001	Rig shut down pending arrival of new pipe.
17-09-2001	New pipe arrived on site
18-09-2001	RIH Wednesday 19th, restored circulation, reamed to bottom. Maximum gas whilst reaming 31 units (0.78%).
19-09-2001	Cored to 361.1 m. Gas whilst coring 1-2 units.
20-09-2001	RIH cored to 364.1 m Gas 1-3 units increasing to 8 units. POH to change bit.
21-09-2001	RIH with new bit, circulate bottoms up. Two trip-gas peaks of 56 & 109 units. Mud weight 8.6 lb/gall. Cored from 364.1 m to 366.5 m. Hole caving. Pipe backed off, POH made up fish, RIH & retrieved fish. POH
22-09-2001	RIH with drill bit, circulate bottoms up, circulate hole clean.

	Gas peaks of 60 units. POH. Ran Gamma Ray & CCL log. Set up to run abandonment plugs.
23-09-2001	RIH. Mixed 35 sacks of cement and 3% bentonite. Ran plug from TD across casing shoe. WOC RIH. Tagged top of cement at 220m, c.f. calculated rise to 140m. Mixed an additional 35 sacks of cement with 3% bentonite. Ran plug from 220m across casing shoe a.m. 24th. WOC
24-09-2001	Ran surface plug. Rig released.

2.3.2 Hole sizes and depths:

9.375" (238mm) Spud to 60 meters.
6" (152mm) 60 to 195 meters.
HQ Pipe 195 to 366.5 meters.

2.3.3 Casing and cementing:

SURFACE:

SIZE:	9.625" / 244 mm
Weight:	54.5 lb/ft/79.8 kg/m
Grade:	K55
Shoe setting depth:	59.75 m

INTERMEDIATE:

SIZE:	7" / 178 mm
Weight:	23 lb/ft/33.7 kg/m
Grade:	K55
Shoe setting depth:	195 m

2.3.4. Deviation Surveys:
None taken.

2.3.5 Drilling Fluid:

(A) Spud - 60 meters: Type: Freshwater/Gel spud mud.

(B) 60 - 366.5 meters KCl/Polymer/PHPA.

2.3.6 Water Supply:

Water was trucked to site from Sale.

2.3.7 Perforations:

None.

2.3.8 Plugging and Cementing:

Plug 1.	366.5 (T.D.) to 220 m	35 sx cmt
Plug 2.	220 to < 140 m	
Plug 3	Surface plug	

2.4 LOGGING AND TESTING

2.4.1 Wellsite Geologist:
J. Mulready.

2.4.2 Mudlogging:
Hot wire hydrocarbon detection, depth and drill rate monitoring were provided by Denis Sisely.

2.4.3 Ditch Cutting Samples:
Cuttings were collected at 3 meter intervals from spud to 218m (Boundary Creek No.1). These being 1 set 500 gm unwashed calico bag, and 1 set washed samplex tray. Unwashed cutting samples were submitted to the DNRE Core Store at Werribee.

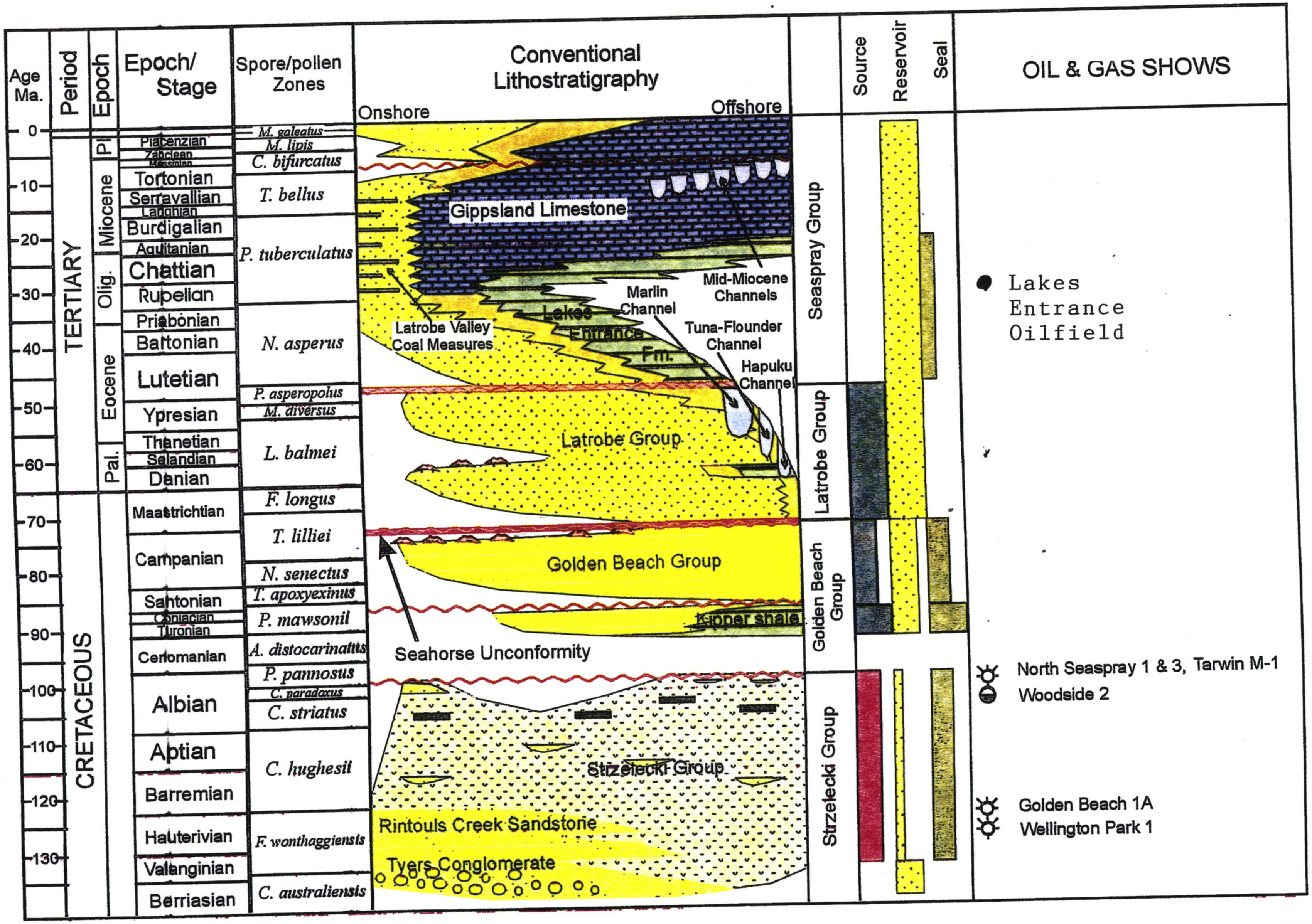
2.4.4 Coring: (Boundary Creek No. 1A)
Continuous core was taken from 195 meters to 366.5 meters (T.D.).

2.4.5 Sidewall Cores:
None taken.

2.4.6 Testing:
No tests were conducted.

2.4.7 Wireline Logs:
A Gamma Ray and CCL log was run from 366.5 m (T.D.) to 195m in open hole and from 195m to surface through casing.

2.4.8 Velocity Survey:
No velocity survey was conducted.



LITHOSTRATIGRAPHY
GIPPSLAND BASIN

TABLE 1

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3.0 GEOLOGY

3.1 REGIONAL GEOLOGY

The Gippsland Basin is an early Cretaceous to Cainozoic basin occupying approximately 46,000 square kilometers of the southeastern margin of the Australian continent. The basin is flanked on the north, west and south-west by Palaeozoic rocks and confined between the structural uplifts of the Victorian Highlands in the north and the Bassian Rise in the south. The eastern margin of the basin is open to the Tasman sea. The Gippsland Basin is an east-west trending half graben feature with 70% of its area beneath Bass Strait and 30% onshore.

With the exception of occasional wildcat drilling in the boom of the 1980's, exploration of the onshore Gippsland Basin has been largely ignored since the 1970's.

The early exploration activities in the onshore part were aimed primarily at the Early Cretaceous Strzelecki Group and, later on after successful drilling offshore, at the top of the LaTrobe Group "coarse clastics", but a lack of understanding of the stratigraphy and the mechanism of hydrocarbon generation, migration and timing of structures, along with the poor quality of the seismic and well log data, resulted in a downgrading of the hydrocarbon potential of the onshore area.

3.2 PERMIT PEP 137 (now PEP 157)

Lakes Oil N.L. acquired the PEP 137 permit in April 1999, following the drilling by Roma Petroleum N.L. of the McCreesh-1 well, an unsuccessful test of the top LaTrobe Group sands. PEP 137 covered an area of 1,680 square kilometers within the onshore Gippsland Basin. The permit extends over the northern part of the Seaspray Depression, the southern portion of the Lake Wellington Depression and part of the Baragwanath Anticline. Eleven exploration wells have been drilled in the permit between 1962 and 2002, with Lakes Oil N.L. having tested gas at the North Seaspray-3, Trifon-1 and Gangell-1 wells. North Seaspray-3 was a follow up to Woodside/Lakes Oil North Seaspray-1 well, which also flowed gas from the top of the Strzelecki Formation.

3.3 EXPLORATION HISTORY

Hydrocarbon exploration commenced in the onshore region of the basin in 1924 when the Lake Bunga well encountered traces of oil, leading to the discovery and development of the Lakes Entrance oil field. The oil accumulation is found in a stratigraphic trap within a glauconitic sand member of the Oligocene Lakes Entrance Formation. The field produced a total of 10,000 bbls of 15.7 API gravity oil before production ceased in 1956. Aside from the Lakes Entrance oil accumulation, wet gas flowed to the surface during testing from the Strzelecki sandstones at North Seaspray 1 and 3, Gangell-1 and Trifon-1.

'Modern' petroleum exploration in the permit commenced in the early 1960's and continued into the early 1970's, conducted mainly by Woodside and Arco, with eight wells being drilled within the permit. This exploration originally had as its main objective the Strzelecki Group with emphasis moving to the LaTrobe Group later in this period. Few of these wells, except for North Seaspray-1, are thought to be located within closure at the Top LaTrobe Group level.

Several shallow bores have been drilled in the vicinity of PEP 157 by Victoria Electricity, Coal and Water Resources authorities; however, none of these bores encountered LaTrobe Group reservoirs at a significant depth or within closure.

During 1985, Hartogen Energy Ltd drilled Burong-1 to test the Top LaTrobe at the crest of a northeast trending asymmetrical anticline which is fault controlled to the northwest. While the LaTrobe section contained excellent reservoir rock, no significant shows were recorded within this unit.

Recently, Lakes Oil has drilled eight wells within their onshore Gippsland permits; PetroTech-1 targeted greensands of the Lakes Entrance Formation but was not tested; Hunters Lane-1 produced oil from the same formation but at a non-economic rate; Baudin-1 and Investigator-1, which both targeted Lower LaTrobe Formation sands, were unsuccessful, probably due to lack of seal. Within PEP157 the North Seaspray-3, Trifon-1 and Gangell-1 wells were drilled between 2000 and 2001, all targeting Strzelecki Formation sands.

3.4 TECTONIC HISTORY

The Gippsland Basin is a rift basin, which originated in the Late Jurassic to Early Cretaceous and consists of alternating half graben structures along its east-west trend. It is characterised by a deep central basin, flanked by northern and southern terraces. In the onshore area, the Late Cretaceous movements were accompanied by volcanism. Several phases of positive structural inversion occurred in the Gippsland Basin from Mid-Oligocene to the present time, creating the major hydrocarbon bearing structures seen in the offshore region. The main phase occurred during the Late Miocene, which resulted in inversion of existing features and the creation of anticlinal structures.

3.5 STRUCTURAL ELEMENTS

The onshore area can be tectonically sub-divided into six major areas:

(A) Lakes Entrance Platform (Northern Platform): This lies immediately south of the Eastern Highlands, where the Palaeozoic Basement gently slopes southwards and is unconformably overlapped by Oligocene - Miocene marine sediments and thin Pliocene - Quartenary continental deposits.

(B) LaTrobe Valley Depression: This lies between the Palaeozoic Eastern Highlands to the north and the Early Cretaceous Balook Block to the south. Over 700 meters of continental LaTrobe Valley sediments are present in this area.

(C) Lake Wellington Depression: This lies to the south of the Lakes Entrance Platform, where over 1200 meters of Eocene to Pliocene sediments unconformably overlie the Early Cretaceous rocks. This trough is offset from the LaTrobe Valley Depression to the west, by left lateral displacement on the Yinnar Transfer Fault Zone which occurred during the Tertiary. The boundary also closely coincides with the western limit of marine Tertiary sediments. To the east it merges with the Strzelecki Terrace.

Baragwanath Anticline: This is the eastern extension of the outcropping Balook High. It is an Early Cretaceous block, which was elevated during Late Miocene time as a result of the renewed lateral strike slip wrenching along the Boundary Fault Systems. It separates the Lake Wellington Depression to the north from the Seaspray Depression to the south. On the crest of the structure, thin Miocene strata are succeeded unconformably by a veneer of Pliocene-Pleistocence sediments. On the flanks of the structure, however, the Miocene sediments wedge out towards the crest by onlap at the base and erosion at the top of the sequence.

(D) Seaspray Depression: This is the onshore extension of the Central Deep. It occupies the southern onshore part of the basin, where the most complete stratigraphic section is present. The permit occupies the northeastern end of the Seaspray Depression.

(E) South Terrace: Wilson's Promontory is an erosional remnant of a broad shallow basement platform bounding the Gippsland Basin on its southern side. The Southern Terrace represents the edge of this platform. The Chitts Creek Conglomerate onlaps the South Terrace as a mirror image to the Tyers Conglomerate on the North Terrace.

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3.6 REASONS FOR DRILLING

Boundary Creek No.1 was drilled to provide stratigraphic and reservoir information on the Strzelecki Formation at this location.

3.7 STRATIGRAPHIC PROGNOSIS

The stratigraphic prognosis was made utilising the sparse nearby well data and the available seismic coverage.
A comparison between prognosed and actual formation tops is given below:

FORMATION	PROGNOSED (MkB)	ACTUAL (mKB)	ACTUAL (mSS)	DIFFERENCE (m)
LaTrobe Group	Surface	Surface	+70	0
Strzelecki Formation	300	197	-122	103 High
Total Depth	400	366.5	-291.5	23.5 High

3.8 STRATIGRPAHY

<u>LATROBE FORMATION</u> (Spud - 210 meters)

1 - 29 meters
SANDSTONE: (100%) white to clear to pale yellow, very coarse grained, occasionally pebbly, unconsolidated, quartzose, minor white clay matrix, subangular to rounded. Grading with depth to:
SANDSTONE: (100%) dominantly clear, fine to medium grained, rarely coarse grained pebbly, unconsolidated, quartzose with suspected argillaceous matrix.

29 - 57 meters
COAL: (100%) brown, soft-firm, subfissile, silty, scattered minor fine to medium quartz grains.

57 - 105 meters
SST: (95%) white, clear, occasionally milky, translucent, coarse to very coarse grained, well sorted, subangular to subrounded, loose quartz grains, rare white clay adhering to grains, clean, with minor interbedded SILTSTONE: (5%) grey, argillaceous, arenaceous.

105 - 133 meters
SANDSTONE: (50%) white to clear, light grey, medium to very coarse grained, occasionally pebbly subangular to subrounded, loose quartz grains. Interbedded with
CLAYSTONE: (50%)light brown to white, light grey, soft, kaolinitic, trace coal.

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133 - 197 meters
SANDSTONE: (90%) white to light grey, dominantly coarse to very coarse grained and pebbly, subrounded, loose quartz grains. Interbedded with minor
COAL: (5%) black, firm, trace light brown soft clay. With minor interbedded
CLAYSTONE: (5%) light brown, soft, argillaceous.

STRZELECKI FORMATION (197- 366.5+ meters)

197 - 245 meters
SANDSTONE: (70%) light to medium grey, fine to medium grained, well sorted, subrounded, consisting of quartz, feldspar, mica and coal fragments in an argillaceous matrix, trace pyrite. Common white subvertical striations and in part common sub-vertical fracturing, good porosity in part. With minor clasts of:
SHALE: (20%) light medium to dark grey, firm, moderately to very carbonaceous, micaceous in part. With thin interbeds of light brown to cream tuff(?) and occasional interlaminated tight
SANDSTONE: (10%) light to medium dark grey, fine grained, well sorted, subrounded, composed of quartz, feldspar, mica and coal fragments in an argillaceous matrix.

245 - 252 meters
Finely interbedded and interlaminated sandstone and shale
SANDSTONE: light to medium dark grey, firm, composed of very fine to fine grained subangular felspar and quartz grains in an argillaceous matrix, no visual porosity.
SHALE: medium grey, firm, arenaceous grading to very fine grained sandstone.
Dip 0-12 deg

252 - 277 meters
SANDSTONE: (50%) light grey, carbonaceous, fine to medium grained, well sorted, subangular to subrounded, composed of feldspar, light grey quartz, mica and abundant coal fragments in an argillaceous matrix, no visual porosity.
SHALE: (40%) medium grey, firm, slightly micaceous, common partings with shiny slickensides, silty, arenaceous in part with interlaminations of
SANDSTONE: (10%) light grey, very fine to fine grained, well sorted, subrounded, composed of white feldspar grey quartz, mica and common coal fragments in an argillaceous matrix.

277 - 324 meters
SANDSTONE: (50%) light grey, carbonaceous, fine to medium grained, well sorted, subangular to subrounded, composed of feldspar, light grey quartz, mica and abundant coal fragments in an argillaceous matrix, poor to fair visual porosity throughout. Interbedded with
SHALE: light to medium grey, firm, silty, slightly micaceous, slightly to occasionally very carbonaceous.
Dip 0-10 deg.

324 - 366.5 meters
SANDSTONE: (70%) light grey, fine grained, well sorted, subrounded, composed of white feldspar, grey to clear quartz and abundant carbonaceous specks in an argillaceous matrix, no visual porosity.
SHALE: medium grey, firm, with occasional high angle fractures, occasional silty and sandy interlaminates and fine interbeds.
Dip 10-20 deg.

3.9 HYDROCARBON SHOWS

Modest gas shows were encountered within the Strzelecki Formation from 228 m to total depth. More significant trip-gas shows (up to 60 units on the hot-wire gas detector) were observed when resuming drilling after the overnight shut-in.

4.0 DISCUSSION AND CONCLUSIONS

Following the drilling of the Trifon-1 and Gangell-1 wells in the general North seaspray area in 1999-2000, it became apparent that there was only limited core material available for investigation of Strzelecki Formation petrology and reservoir characteristics.

Boundary Creek corehole was located near the northern boundary of the Seaspray depression, at a location where the depth to the top Strzelecki was shallowest, allowing ready access for coring. Seismic indicates this is a regional high at the top Strzelecki unconformity level, and also corresponds with a Latrobe Group structural high located just south of the Rosedale Fault, with eroded Lower Latrobe Group outcropping at surface.

The results of the well may be summarised as follows:

- Palynological dating indicates the Strzelecki section is from the *C. paradoxa zone*, i.e. the upper portion of the unit, Refer Appendix III.
- Structural dip, generally in the range 10-20 degrees is consistent with regional data from dipmeters and seismic, suggesting an east to south east structural dip.
- The results of a SEM study undertaken by Geotrack Intl. (Appendix II) indicates the Strzelecki Formation sediments are particularly prone to problems associated with swelling clays (smectite, chlorite).
- The results of core analysis were surprisingly good (Appendix I), believed to be related in part to depth of burial, a higher quartz content due to close proximity to the Rosedale Fault, which forms the northern boundary of the half graben, (with a possible higher basement sourced input), and weathering effects at the Lower Cretaceous - Tertiary unconformity.

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5.0 COMPLETION

Boundary Creek No.1A was plugged and abandoned.

TABLE 2 : BOUNDARY CREEK No. 1A : STRATIGRAPHIC TABLE

AGE	FORMATION	DEPTH RT	ELEVATION	THICKNESS
E. Oligocene - Eocene	LaTrobe Group	1	+74	196
Early Cretaceous	Strzelecki Fm	197	-122	169.5+
	Total Depth	366.5	-291.5	

- all depth are in meters.

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CORE ANALYSES

914415 026

CORE LABORATORIES AUSTRALIA PTY. LTD.

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TO	:	**LAKES OIL**			
ATTN	:	**JACK MULREADY**			
FAX	:	**(03) 9629 1624**	**DATE**	:	**27 September 2001**
PAGES	:	**5** (including cover page)	**COPY**	:	
FROM	:	**DARRYL BEER**			
SUBJECT	:	**BOUNDARY CREEK 1A PLUGS**			

Jack,

Please find attached the preliminary porosity, permeability and grain density data for the majority of the Boundary Creek #1A plugs. I have also attached a porosity versus permeability cross-plot that Dennis said you may be interested in.

Now that analyses are complete, please advise if you want the plugs returned, and the delivery address you want them sent to.

Please contact us if you have any queries, or require further information.

Best regards,

Darryl

POROSITY, PERMEABILITY AND GRAIN DENSITY
(Ambient)

SAMPLE NUMBER	DEPTH (m)	800psig NOB PRESSURE			GRAIN DENSITY (g/cc)	COMMENTS
		PERMEABILITY		POROSITY (%)		
		Kinf (md)	Kair (md)			
1	210.60	80.1	88.2	30.7	2.56	
2	214.20	154	165	26.4	2.64	
3	218.30	137	148	26.5	2.63	
4	220.90	88.2	98.1	28.0	2.66	
5	224.60	57.0	62.4	28.0	2.63	
6	224.90	95.0	102	29.6	2.64	
7	227.10	838	⊦ 886 ↑	29.7	2.67	
8	227.65	448	461	28.6	2.67	
9	231.85	688	704	27.5	2.66	
10	233.60	602	616	30.9	2.65	
11	234.30	701	723	30.5	2.66	
12	234.65	711	740	30.2	2.65	
13	236.30	208	248	32.4	2.67	fractured
63	243.90	15.3	18.4	35.1	2.68	
14	245.05	5.00	6.58	33.3	2.68	
15	245.35	11.1	13.9	34.9	2.67	
16	252.25	0.733	1.05	30.6	2.68	
17	254.25	101	106	29.6	2.66	
18	255.15	55.2	59.4	28.2	2.65	
19	256.90	4.46	5.47	25.0	2.63	
20	259.20	95.3	99.4	27.0	2.69	
21	259.77	43.6	47.1	27.5	2.63	
22	260.55	33.0	36.5	26.7	2.62	
23	262.10	10.3	11.9	25.8	2.60	
24	262.55	63.0	67.9	27.1	2.63	
25	264.55	94.4	102	28.7	2.62	
26	265.45	136	147	30.6	2.64	
27	268.66	16.8	19.3	27.2	2.63	
28	269.60	36.8	40.2	22.9	2.65	
29	272.40	8.60	10.2	27.5	2.64	
30	278.20	13.8	14.9	28.2	2.64	
31	279.55	43.6	47.9	29.1	2.63	
32	281.25	41.3	44.9	27.8	2.64	

COMPANY : LAKES OIL
WELL : BOUNDARY CREEK #1A

POROSITY, PERMEABILITY AND GRAIN DENSITY
(Ambient)

SAMPLE NUMBER	DEPTH (m)	800psig NOB PRESSURE PERMEABILITY Kinf (md)	800psig NOB PRESSURE PERMEABILITY Kair (md)	POROSITY (%)	GRAIN DENSITY (g/cc)	COMMENTS
33	282.20	99.1	106	29.8	2.64	
34	283.90	26.0	29.0	29.8	2.66	
35	285.25	61.1	65.6	31.9	2.67	
36	297.86	0.936	1.20	27.1	2.64	
37	298.74	15.6	17.6	28.8	2.64	
38	299.76	16.1	18.4	28.1	2.64	
39	301.18	7.12	8.15	27.0	2.65	
40	303.55	0.055	0.085	28.1	2.70	
41	305.85	0.111	0.161	26.1	2.66	
42	308.85	4.72	5.79	26.7	2.62	
43	310.04	0.831	0.988	27.0	2.66	
44	311.38	29.5	31.8	26.7	2.63	
45	313.03	0.497	0.563	27.8	2.70	
46	315.03	5.03	5.58	28.3	2.67	
47	316.55	8.13	8.56	26.4	2.66	
48	318.55	6.09	7.29	22.9	2.58	
49	319.03	0.025	0.039	25.5	2.65	
50	320.54	0.037	0.055	26.5	2.66	
51	326.40	0.544	0.704	28.8	2.67	
52	327.28	0.133	0.185	26.7	2.65	
53	328.29	4.33	4.82	28.2	2.73	
54	328.88	13.2	14.9	24.4	2.59	
55	329.40	3.36	3.92	26.8	2.66	
56	331.10	25.3	28.0	26.2	2.64	
64	331.72	88.1	92.8	27.8	2.67	
57	331.93	13.8	15.2	26.2	2.65	
58	333.20	1.42	1.78	26.7	2.65	
59	333.81	2.86	3.43	26.8	2.66	
60	336.15	1.94	2.44	24.6	2.66	
61	338.13	10.1	10.7	24.5	2.66	
65	338.82	143	168	25.7	2.54	
62	340.03	7.58	8.15	25.2	2.69	
66	341.23	42.6	47.0	25.2	2.67	not cylindrical

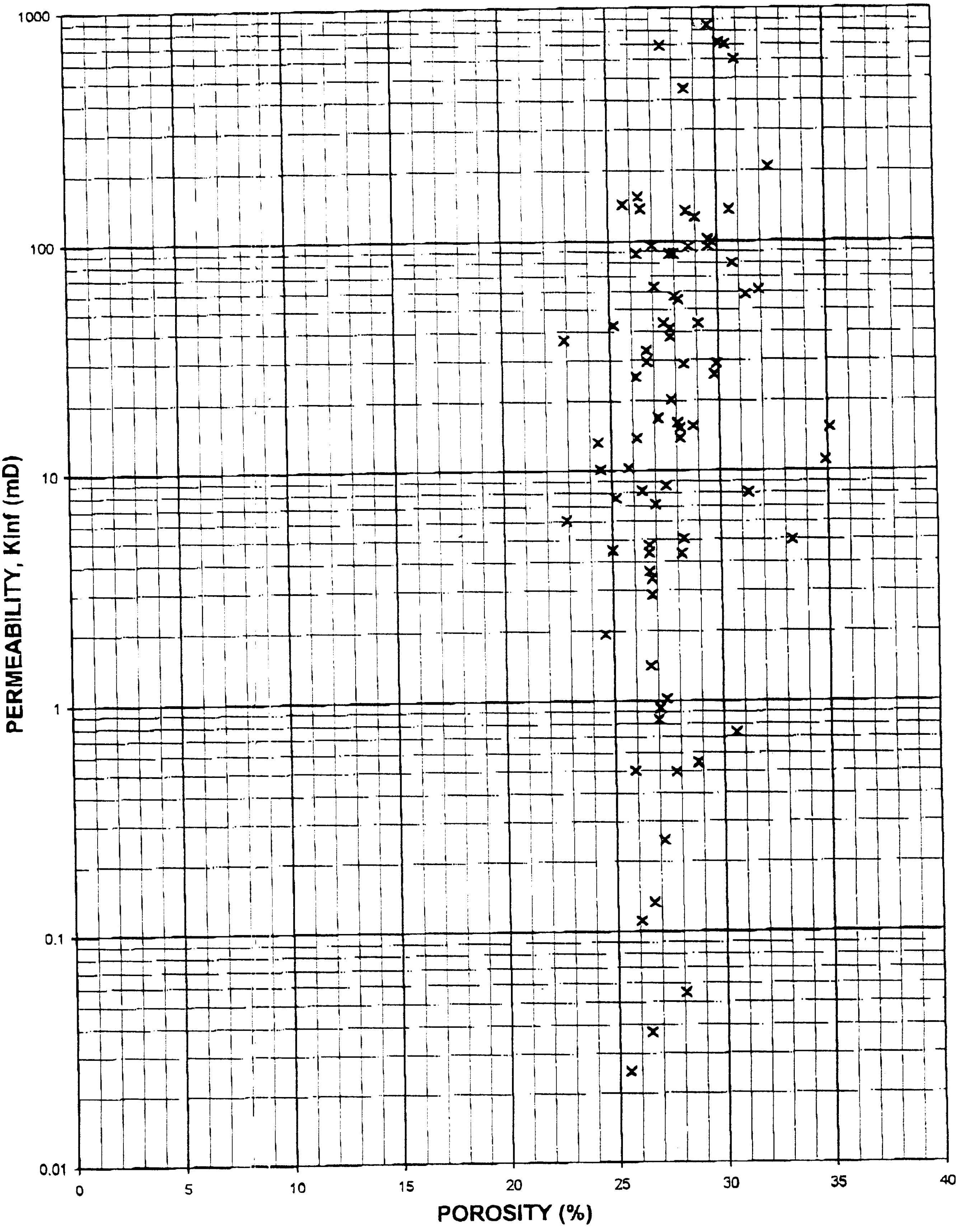
COMPANY : LAKES OIL
WELL : BOUNDARY CREEK #1A

POROSITY, PERMEABILITY AND GRAIN DENSITY
(Ambient)

SAMPLE NUMBER	DEPTH (m)	800psig NOB PRESSURE			GRAIN DENSITY (g/cc)	COMMENTS
		PERMEABILITY		POROSITY (%)		
		Kinf (md)	Kair (md)			
67	342.02	0.501	0.661	25.9	2.67	
68	342.95	4.37	5.09	26.7	2.70	
69	344.90	28.8	30.4	28.4	2.68	
70	345.41	37.9	40.2	27.8	2.68	
71	346.15	20.2	22.0	27.8	2.68	
72	348.30	3.61	4.12	26.7	2.70	
73	352.10	0.248	0.354	27.2	2.68	
74	353.30	15.3	17.0	28.2	2.70	
75	353.84	1.02	1.33	27.4	2.70	
76	356.05	88.2	92.4	26.3	2.66	
77	357.10	134	139	28.6	2.69	
78	357.87	126	133	29.0	2.70	
79	358.71	29.1	30.9	29.9	2.78	
80	361.90	58.3	63.6	31.3	2.68	
81	362.89	8.01	9.74	31.3	2.68	

COMPANY : LAKES OIL
WELL : BOUNDARY CREEK #1A

POROSITY VS PERMEABILITY (AT AMBIENT)



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2

PETROGRAPHY AND MATURITY STUDY

GEOTRACK

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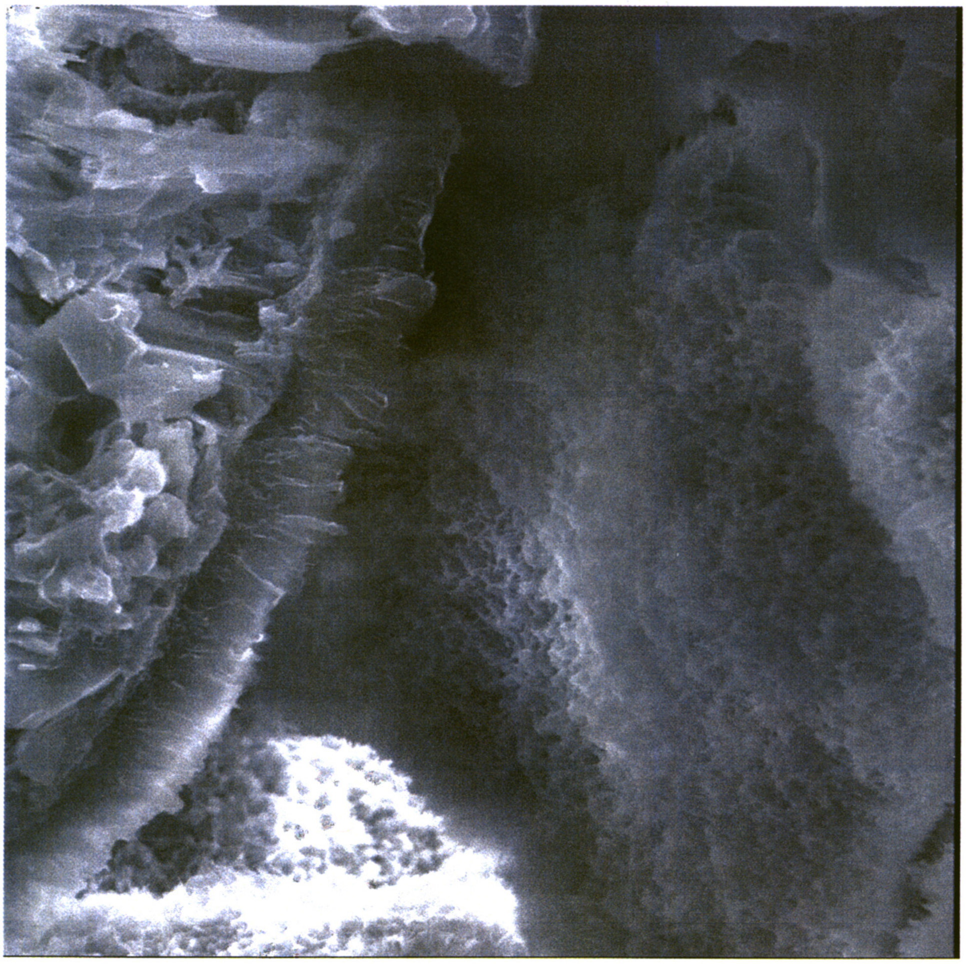
Boundary Creek-1 well, Gippsland Basin

A petrographic and maturity study of Strzelecki Group samples

Geotrack Report #825



An exclusive report prepared for
Lakes Oil N.L.

Report prepared by: I. R. Duddy
Vitrinite Reflectance: Dr. Alan. C. Cook

FINAL REPORT
April 2002

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Boundary Creek-1 well, Gippsland Basin

A petrographic and maturity study of Strzelecki Group sampes

CONTENTS

GEOTRACK REPORT #825

Boundary Creek-1 well, Gippsland Basin

A petrographic and maturity study of Strzelecki Group samples

Geotrack Report #825

Introduction

Polished thin sections were made from three conventional core samples from the **Boundary Creek-1 well** and subjected to optical microscopy. A fresh broken surface of one sample was inspected using the Scanning Electron Microscope. Vitrinite reflectance was determined on coal in one sample. Details of these samples are given in Table 1.

Table 1: Samples from Boundary Creek-1

Sample No	Depth (m)	Unit	Procedure
GC825-1	233.55	Strzelecki Grp	Optical and Scanning Electron microscopy
GC825-2	238.00	Strzelecki Grp	Vitrinite Reflectance
GC825-3[*3]	279.05	Strzelecki Grp	Vitrinite Reflectance
GC825-4	285.20	Strzelecki Grp	Optical microscopy
GC825-5	357.80	Strzelecki Grp	Optical microscopy

[*3] back-up sample not processed

Report structure

A summary of the qualitative petrographic observations derived from the three samples is provided in the following section. The observations are illustrated in each case by a number of optical photomicrographs together with digital SEM images in the case of sample GC825-1. Detailed point counting has not been carried-out, but general comments are provided on the relative abundance of the major components comprising each sample and the nature of any visible porosity.

In addition, general information on the tectonic setting, sedimentary environments, volcanogenic provenance and diagenetic mineral history of the Strzelecki and Otway Groups extracted and updated from Duddy (1983) are presented in an Appendix.

Summary of observations

1. A measured vitrinite reflectance level in sample GC825-2 is 0.38% ($R_o$max), although the analyst considers the true maturity level may be closer to 0.45% due to the canneloid nature of the coal sample (see Table 2).

2. Optical petrography indicates that all three Strzelecki Group samples are composed dominantly of volcanogenic rock fragments (>50%), with lesser amounts of low low-grade metamorphic and sediment rock fragments, feldspar (plagioclase and K-feldspar) and quartz. Geochronological studies indicate that the volcanism was contemporaneous, or near contemporaneous, with deposition throughout the Early Cretaceous deposition of the Strzelecki Group.

3. Detrital grains in all samples are coated with diagenetic iron-rich clay. X-ray chemical analysis, SEM observations, extreme water sensitivity (observed during thin section preparation) and previous work on these sediments show these clays to be mixture of swelling chlorite and smectite, precipitated soon after deposition of the sands due to breakdown of labile volcanic components, especially volcanic glass.

4. Kaolinite is present, but relatively rare and appears to be largely present in altered detrital grains rather than as a pore mineral. Carbonate cement is present as both a replacement of detrital grains and as a minor pore fill.

5. Primary porosity is present in all samples and is visibly higher in sample GC825-1 which has a higher percentage of detrital quartz and K-Feldspar interpreted to have been derived from a Paleozoic basement provenance.

6. There is a clear (qualitative observations) variation in both quartz abundance and grainsize between samples, with sample GC825-1 having the highest quartz content and a coarser grain size than samples GC825-4 and –5. Sample GC825-5 has the highest abundance of volcanic rock fragments together with a high abundance of free crystals of volcanic plagioclase. These plagioclase crystals appear to be fresh and not albitised.

7. K-feldspar invariably shows some degree of alteration, with SEM observations indicating partial dissolution and re-precipitation with associated secondary porosity is common.

8. The presence of primary porosity, swelling diagenetic clay coatings and fresh volcanic plagioclase in the sandstones all suggest that the section encountered in Boundary Greek-1 is very close to the very top of the Strzelecki Group, a section normally represented by the latest Albian P. pannosus spore pollen zone in the region. Further, the low VR level of associated coal indicates that the section has not been deeply buried since the Cretaceous.

[redacted]

Table 2. Vitrinite reflectance data and organic maceral description

GC825 KK # Ref #.	Depth (m) /Type	$\bar{R}_{v}max$	Range	N	BOUNDARY CREEK BOREHOLE Sample description including liptinite fluorescence, maceral abundances, mineral fluorescence
					STRZELECKI GROUP - E CRETACEOUS
T8213	238.0	0.38	0.28-0.50	32	Abundant sporinite yellow to orange, common cutinite yellow to orange, common resinite greenish yellow to bright yellow, common liptodetrinite yellow to orange. (Canneloid shaly coal. Clarite>fusite. V>I>>L. Composition of maceral groups (mf): vitrinite - 49.3.0%, inertinite - 42.2.0%, liptinite - 8.50%. Iron oxides common. Pyrite rare.)
825-2	$\bar{R}_{I}max$	0.78	0.53-1.36	15	

The canneloid coal type is unusual for the Strzelecki Group but the abundance of semifusinite and fusinite is typical of these coals. A high proportion of the vitrinite is transitional to suberinite and the higher values are more representative of the level of maturation. An adjusted value of about 0.45% is likely to be representative for this horizon.
ACC 21/05/2002

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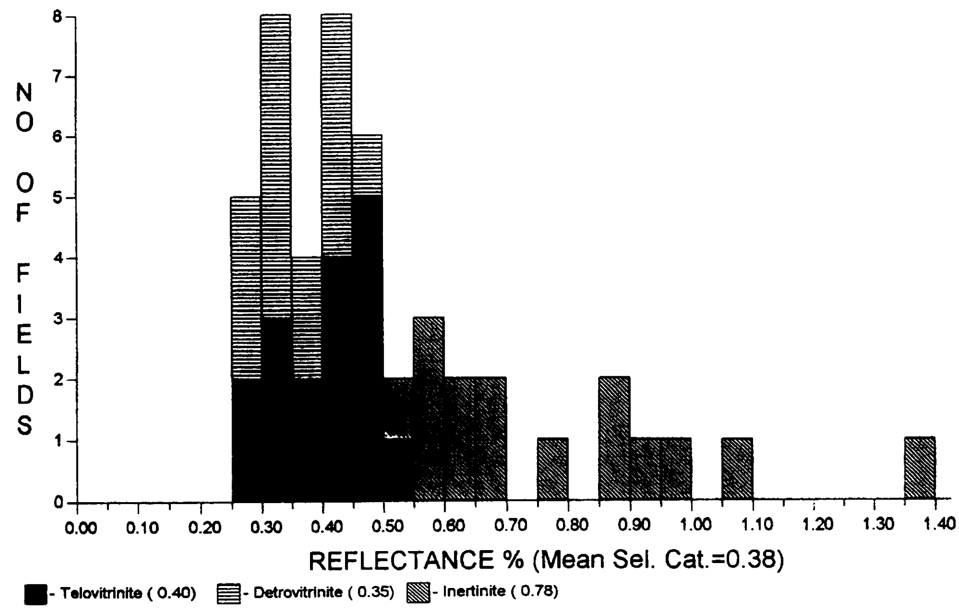
#825-2, Strzelecki Gp.,238.0 m, core (T8213)



Category	No. of Readings	Mean	Standard Deviation
Telovitrinite	17	0.40	0.069
Detrovitrinite	15	0.35	0.060
Inertinite	15	0.78	0.231
Total:	47	0.50	0.235

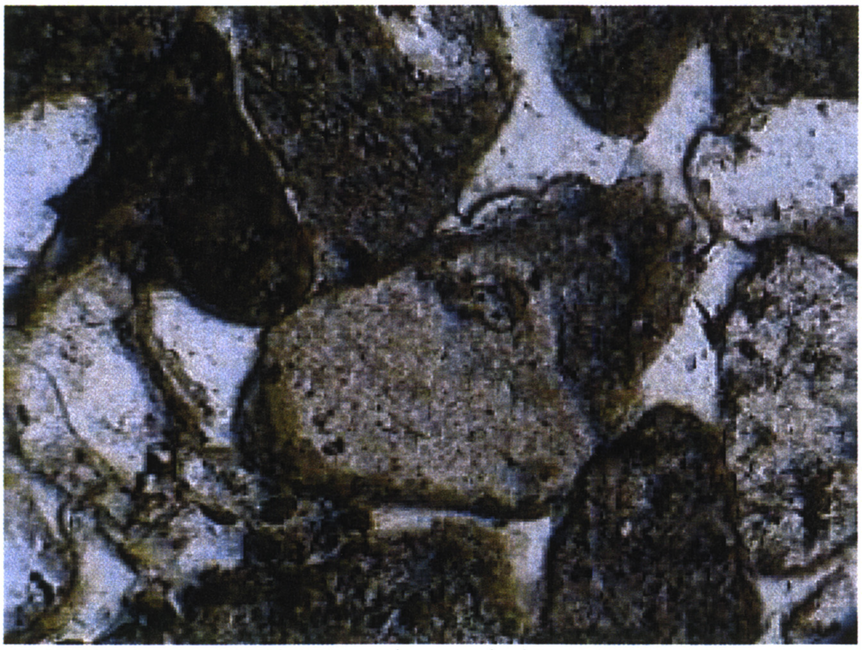
Selected categories: Telovitrinite, Detrovitrinite,

No. of readings:	32
Mean of selected categories:	0.38
Standard deviation of selected categories:	0.069

Optical and scanning electron microscopy observations

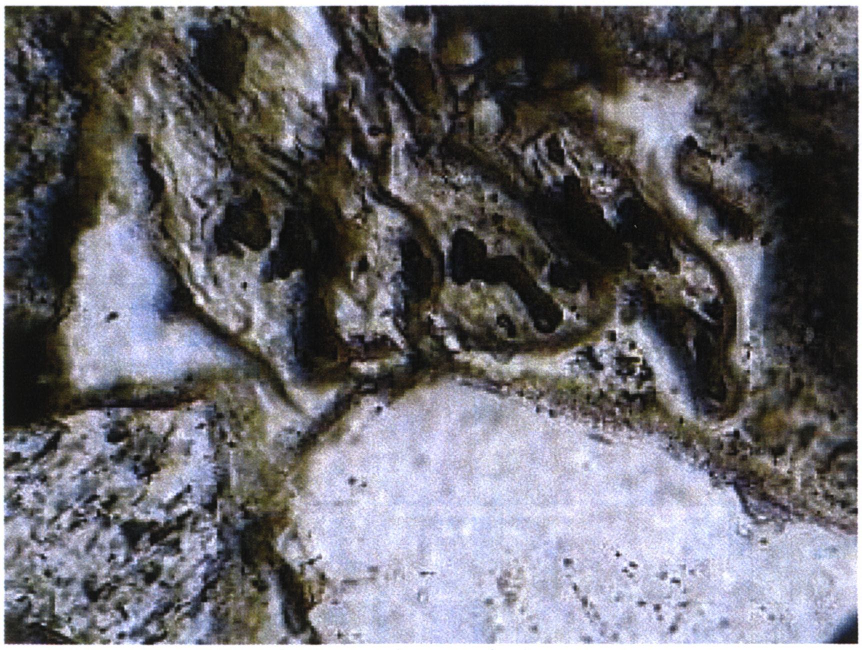
Digital photomicrographs with descriptive captions are presented for each sample in the following section. In addition, scanning electron microscope images are provided for sample GC825-1.

In addition to these photographs and descriptions, general information on the tectonic setting, sedimentary environments, volcanogenic provenance and diagenetic mineral history of the Strzelecki and Otway Groups extracted and updated from Duddy (1983) are presented in an Appendix.



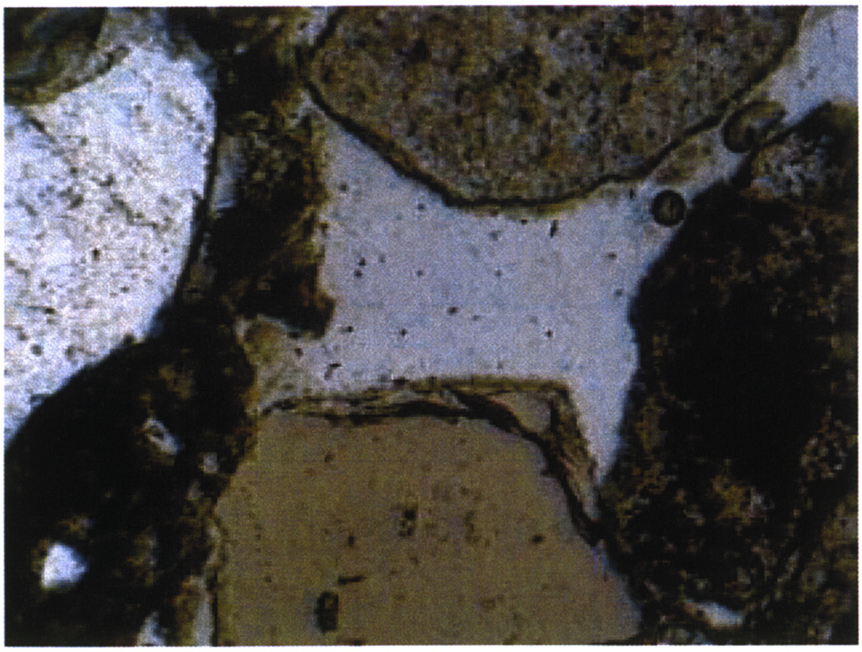
GC825-1A: Boundary Creek Bore hole, 233.55 m
(Plane Light. Width of field of view = 780 μm).

Strzelecki Group sandstone. General view: Majority of grains are volcano-lithics, quartz. Note visible primary porosity and swelling chlorite - smectite grain coating cement on all detrital grains



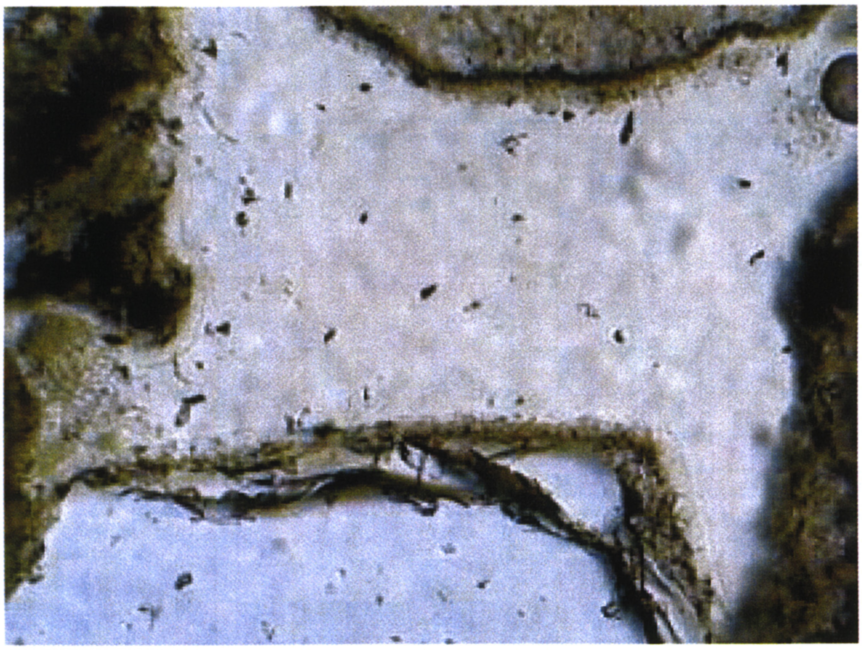
GC825-1B: Boundary Creek Bore hole, 233.55 m
(Plane Light. Width of field of view = 390 μm).

Strzelecki Group sandstone. Altered volcanic glass fragment (chlorite, Fe-oxide possible zeolite), granitic quartz. Primary porosity clearly visible with swelling chlorite - smectite clays coating detrital grains



GC825-1C: Boundary Creek Bore hole, 233.55 m
(Partially crossed polars. Width of field of view = 780 μm).

Strzelecki Group sandstone. Large primary pore, detrital granitic quartz and dark coloured lithic fragments.



GC825-1D: Boundary Creek Bore hole, 233.55 m
(Plane Light. Width of field of view = 390 μm).

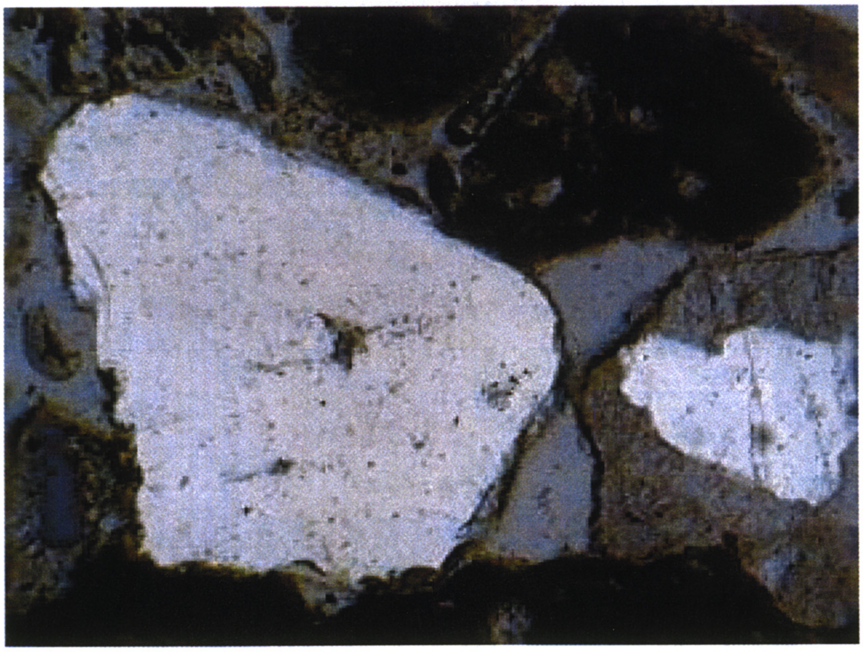
Strzelecki Group sandstone. Close up of large primary pore in GC825-1C. Note early diagenetic swelling chlorite – smectite grain coating growing into primary pore.

GC825-1E: Boundary Creek Bore hole, 233.55 m
(Plane Light. Width of field of view = 390 μm).

Strzelecki Group sandstone. Probable detrital grain with early diagenetic swelling chlorite – smectite grain coating now replaced by calcite. Original grain may have been volcanic glass or perhaps olivine or pyroxene dissolved after precipitation of clay coat. Note dominance of lithic grains.

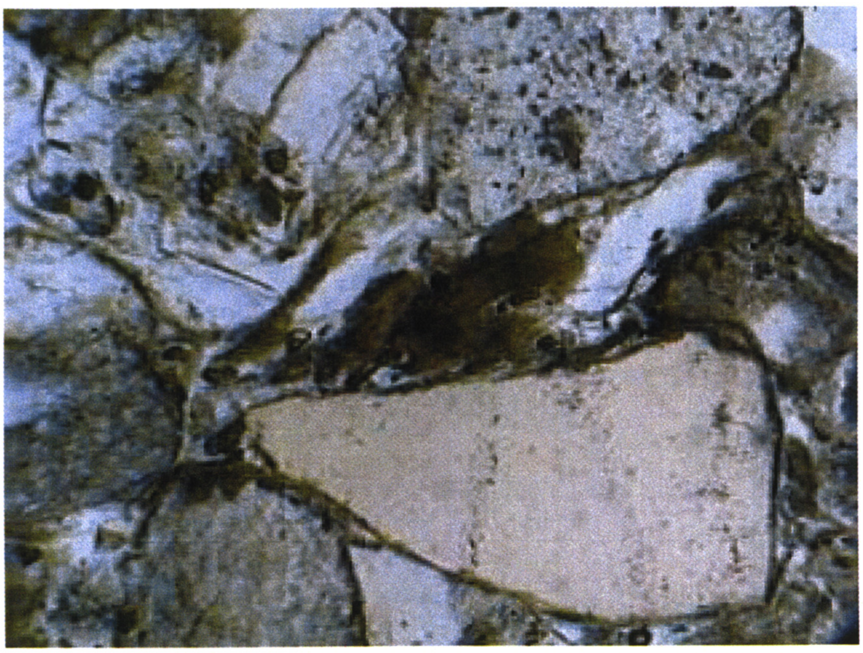
GC825-1F: Boundary Creek Bore hole, 233.55 m
(Plane Light. Width of field of view = 390 μm).

Strzelecki Group sandstone. Obvious volcanic rock fragment showing chloritised ferro-magnesian minerals and feldspar laths.



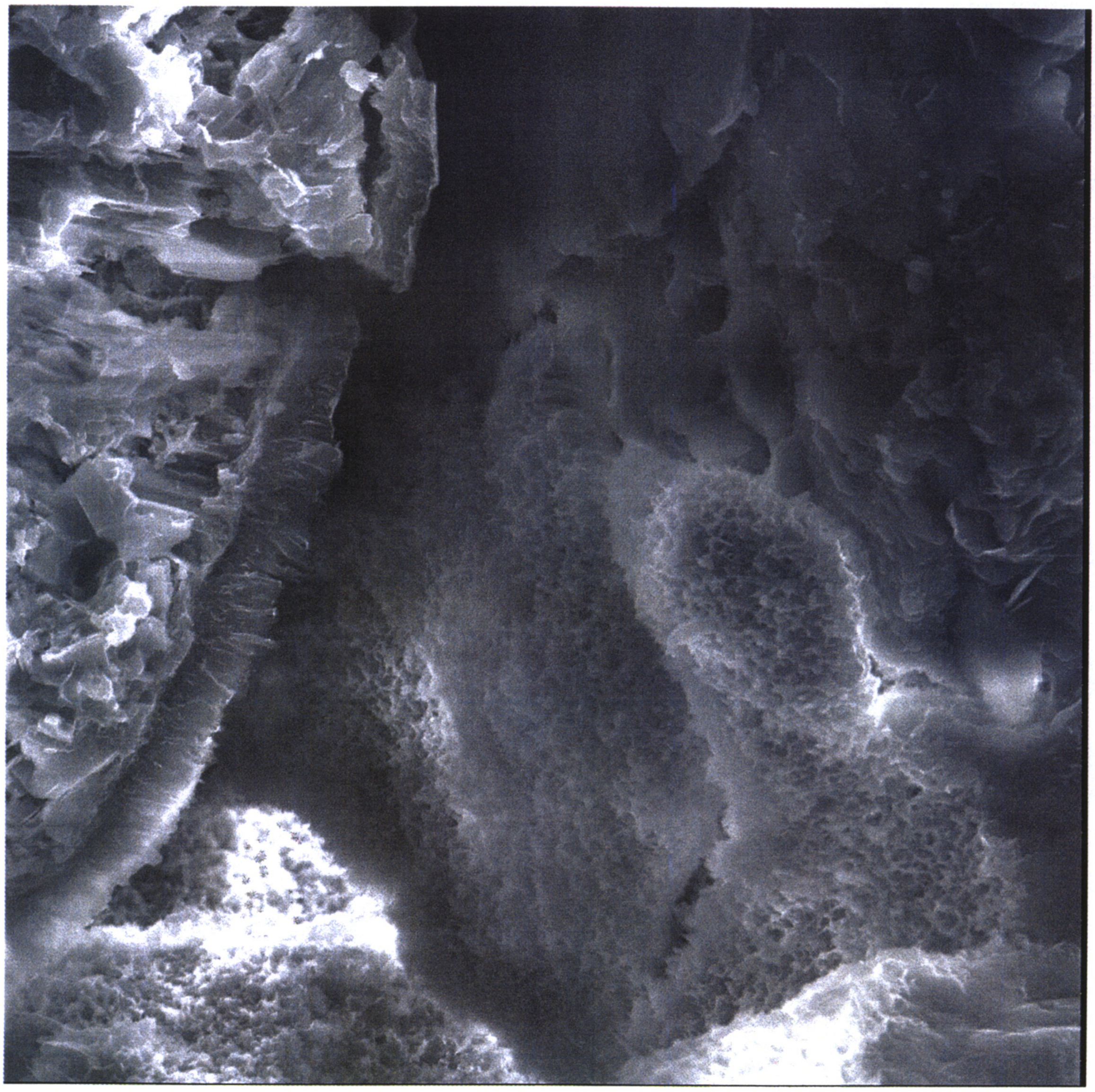
GC825-1G: Boundary Creek Bore hole, 233.55 m
(Plane Light. Width of field of view = 390 μm).

Strzelecki Group sandstone. Granitic quartz and quartz-feldspar grain and dark-coloured metasedimentary fragment, all suggesting a dominant Paleozoic basement provenance, although only a few millimetres thick in this sample.



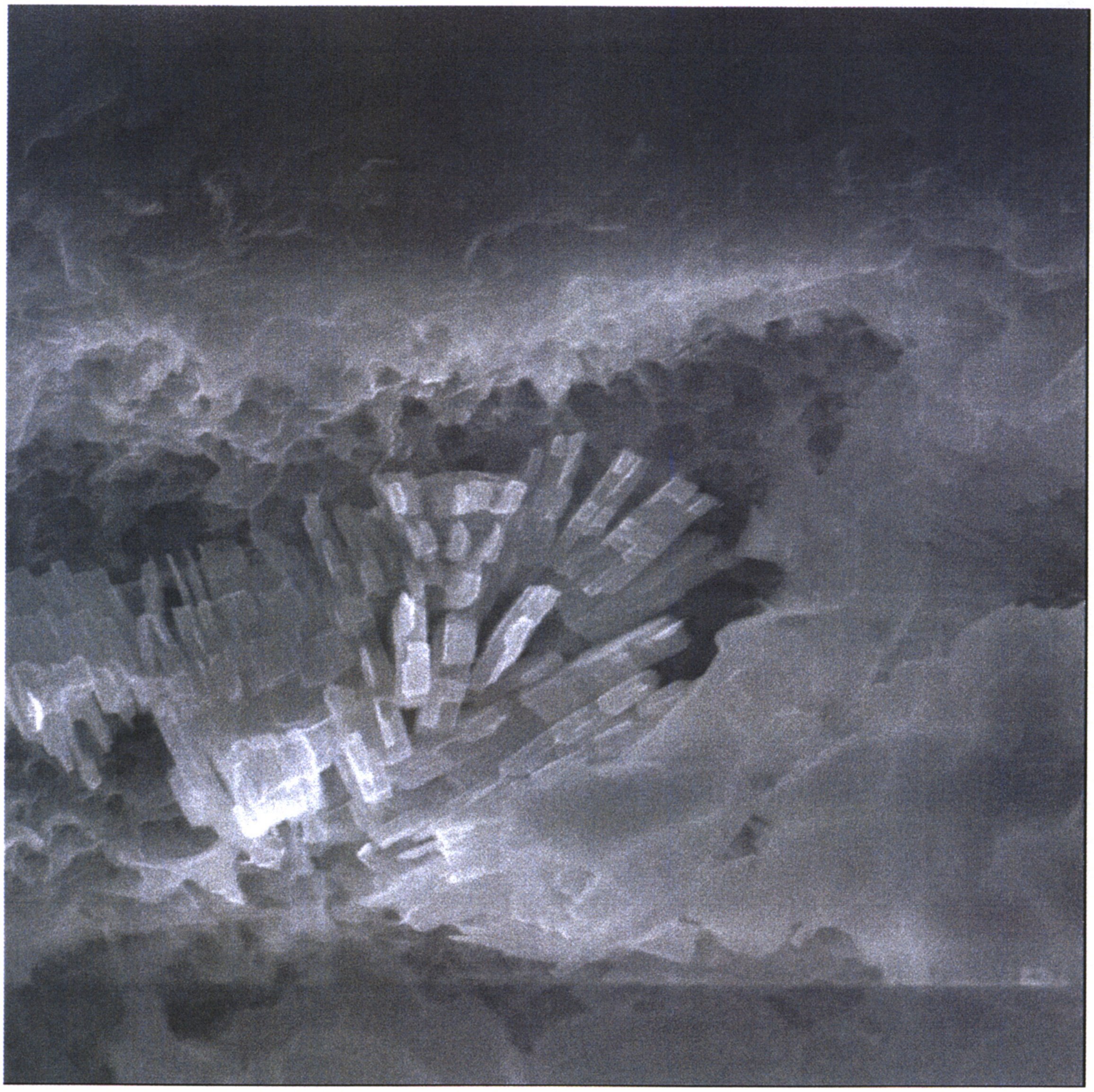
GC825-1H: Boundary Creek Bore hole, 233.55 m
(Plane Light. Width of field of view = 390 μm).

Strzelecki Group sandstone. Another general view with both granitic quartz and metasediment lithic fragments (bottom) and volcanogenic fragments (top).



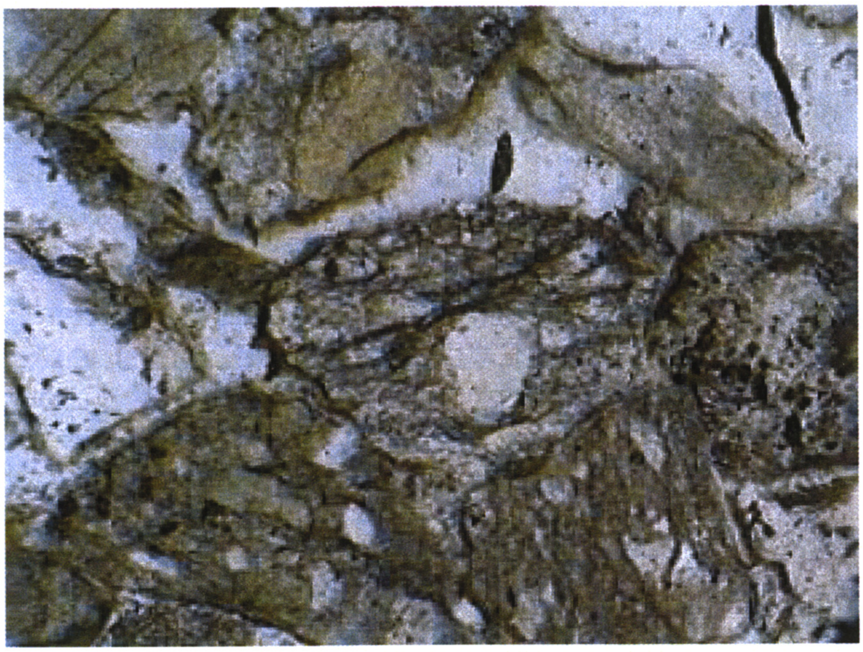
GC825-1: Boundary Creek Bore hole, 233.55 m
Scanning Electron Microscope image. Width of field of view = 90 μm).

Image of primary pore space in Strzelecki Group sandstone showing typical textures of early diagenetic swelling chlorite – smectite grain coating growing into primary pore. Clay coating is ~ 10 μm thick.
Detrital grain on left consists of partially dissolved K-feldspar with diagenetic generation of 2° porosity.



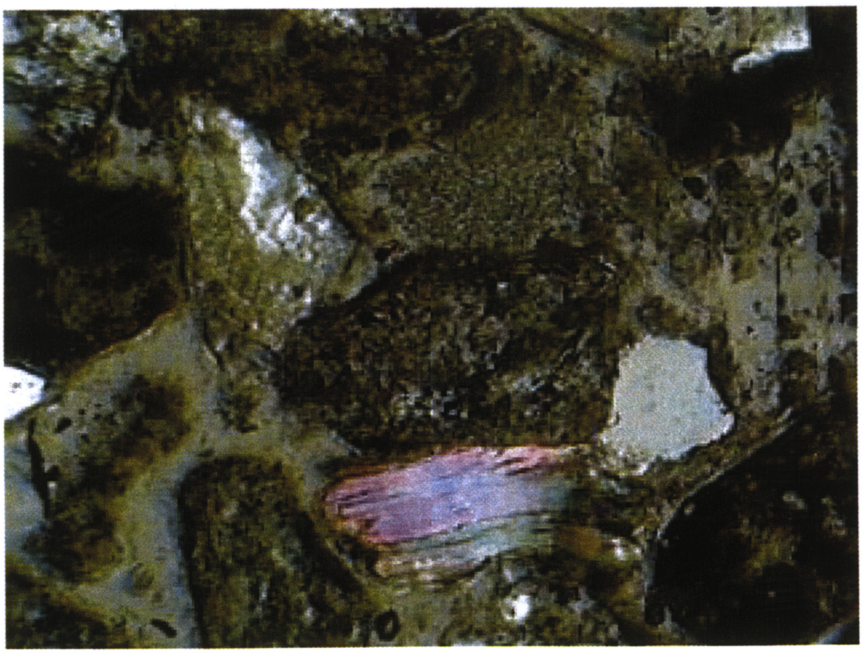
GC825-1: Boundary Creek Bore hole, 233.55 m
Scanning Electron Microscope image. Width of field of view = 90 μm).

Image of primary pore space in Strzelecki Group sandstone showing surface of early diagenetic swelling chlorite – smectite grain coating growing into primary pore, with subsequent development of diagenetic kaolinite books, partially occluding primary porosity. Kaolinite is generally rare as a pore mineral in this sample.



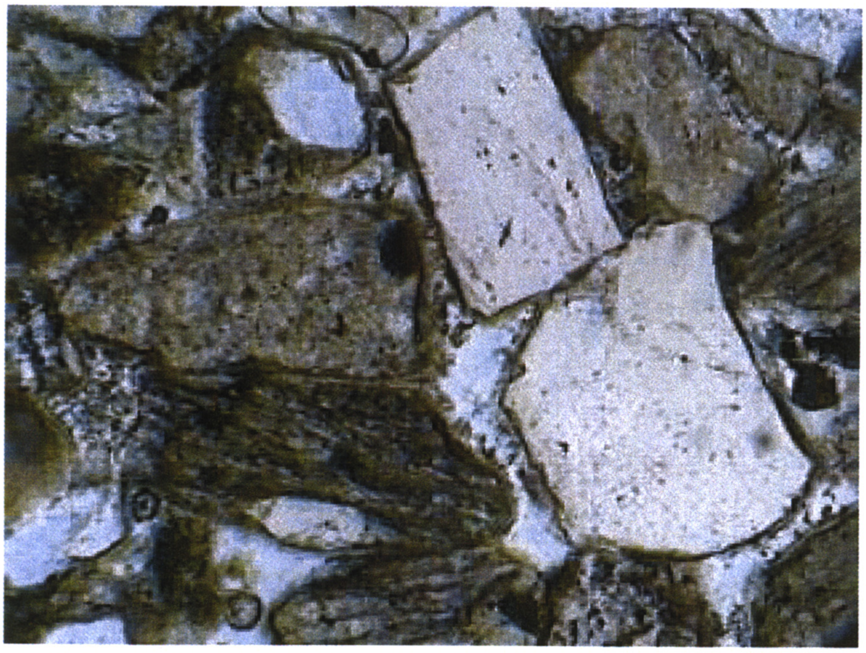
GC825-4A: Boundary Creek Bore hole, 285.20 m
(Plane Light. Width of field of view = 780 μm).

Strzelecki Group sandstone. General view: Majority of grains are meta-sedimentary lithics (meta-siltstones). Primary porosity is well developed but diagenetic swelling chlorite - smectite cement coats all detrital grains



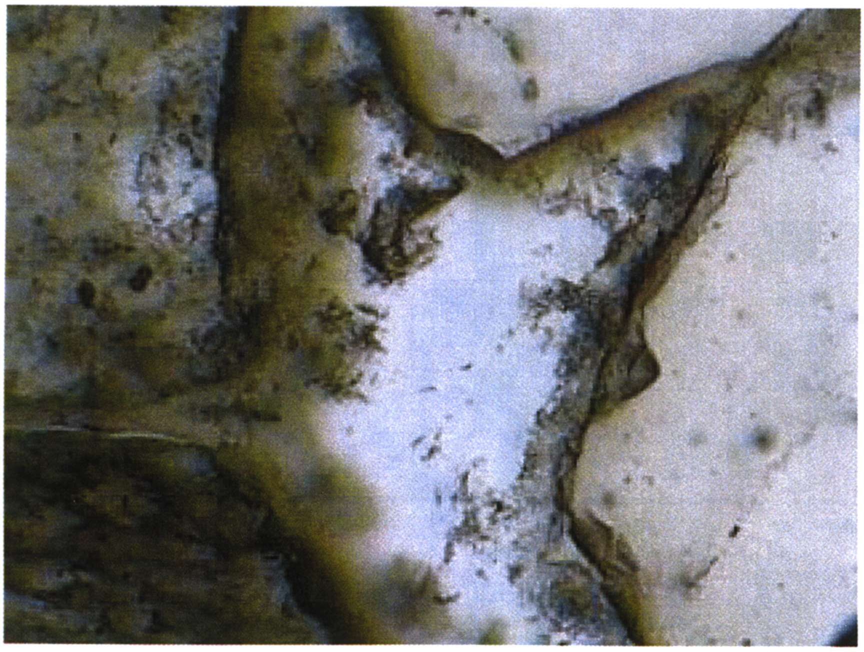
GC825-4B: Boundary Creek Bore hole, 285.20 m
(Partially crossed polars). Width of field of view = 780 μm).

Strzelecki Group sandstone. Dominance of lithic detrital grains is clear. Muscovite grain is bent indicating some degree of compaction but primary porosity is well developed.



GC825-4C: Boundary Creek Bore hole, 285.20 m
(Plane Light. Width of field of view = 780 μm).

Strzelecki Group sandstone. Detrital quartz grains and meta-sedimentary lithics with well developed primary porosity and diagenetic swelling chlorite - smectite grain coating cement.



GC825-4D: Boundary Creek Bore hole, 285.20 m
(Plane Light. Width of field of view = 190 μm).

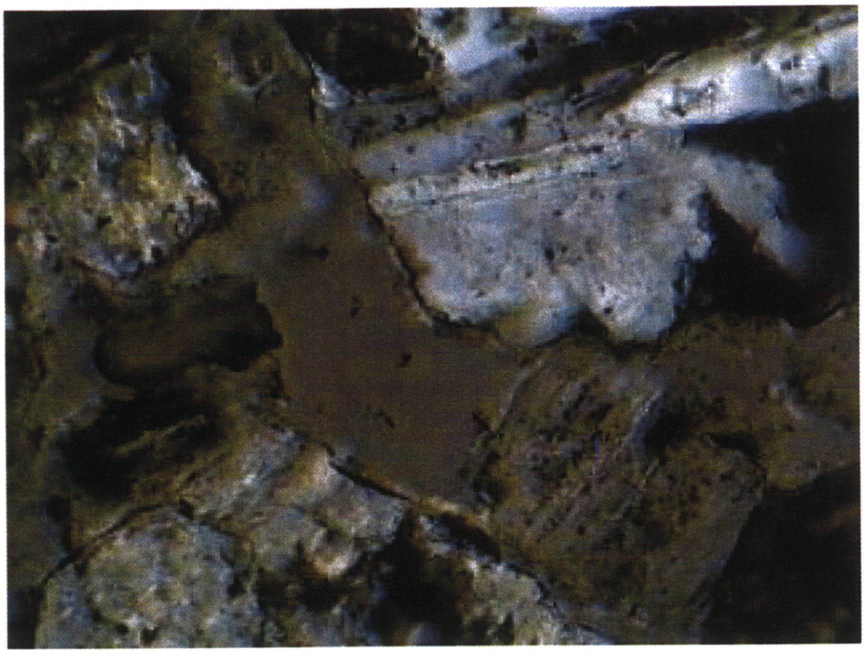
Strzelecki Group sandstone. Close-up of primary pore and diagenetic swelling chlorite - smectite grain coating cement from image GC825-4C. Detrital quartz grains right, lithic grains left.

GC825-4E: Boundary Creek Bore hole, 285.20 m
(Plane Light. Width of field of view = 780 μm).

Strzelecki Group sandstone. General view of largely quartz detrital grains with partially altered (expanded flakes) detrital biotite in centre of field.

GC825-4F: Boundary Creek Bore hole, 285.20 m
(Plane Light. Width of field of view = 780 μm).

Strzelecki Group sandstone. Altered (sericitised) detrital K-feldspar (bottom), palgioclase (top) chloritised volcanic glass (below right) all swelling chlorite coating. Primary porosity well preserved.



GC825-4G: Boundary Creek Bore hole, 285.20 m
(Partially crossed polars. Width of field of view = 390 μm).

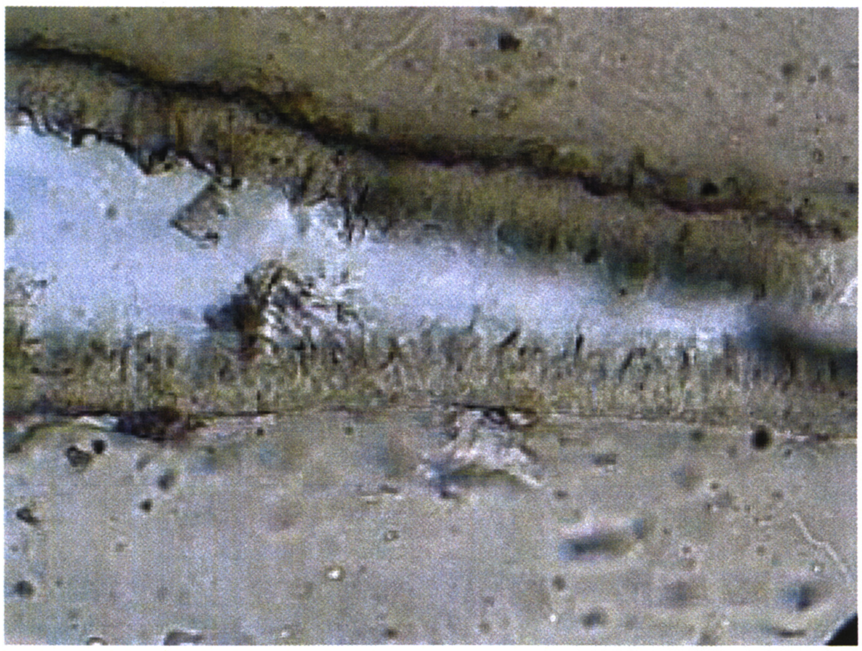
Strzelecki Group sandstone. Close-up of GC825-4F showing sericitised detrital K-feldspar below and twinned plagioclase, above.

GC825-4H: Boundary Creek Bore hole, 285.20 m
(Plane light. Width of field of view = 390 μm).

Strzelecki Group sandstone. Relatively fresh detrital biotite (either volcanic or derived from Paleozoic granodiorite) and VRF. Chlorite grain coating and primary porosity both well developed.

GC825-4I: Boundary Creek Bore hole, 285.20 m
(Partially crossed polars. Width of field of view = 190 μm).

Strzelecki Group sandstone. Close-up of detrital grain diagenetic swelling chlorite - smectite grain coating replaced by diagenetic kaolinite.



GC825-4J: Boundary Creek Bore hole, 285.20 m
(Plane light. Width of field of view = 50 μm).

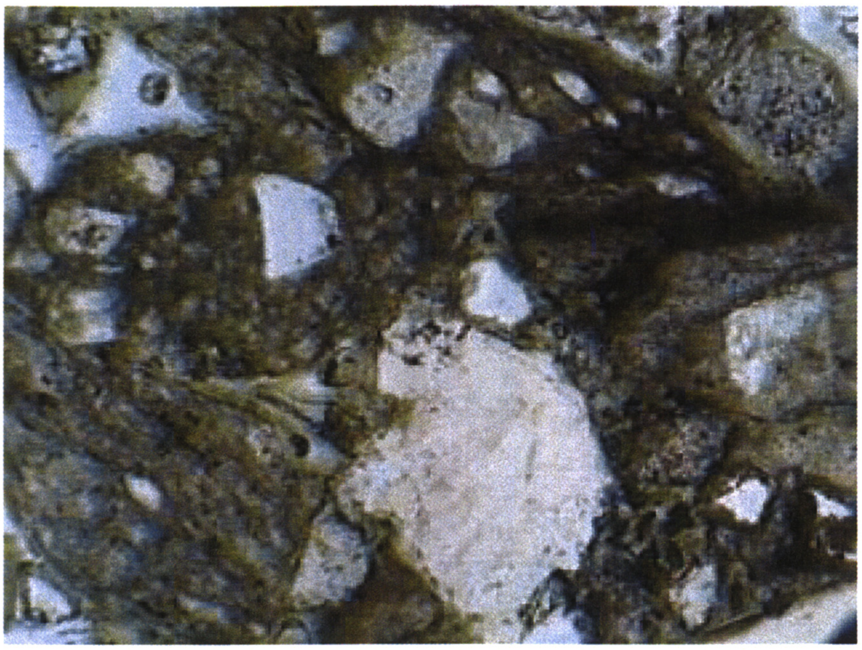
Strzelecki Group sandstone. Detail of diagenetic swelling chlorite grain coating cement on detrital quartz grains growing into primary pore.

GC825-5A: Boundary Creek Bore hole, 357.80 m
(Crossed polars. Width of field of view = 780 μm).

Strzelecki Group sandstone. Volcanic plagioclase and volcanic lithic grains.

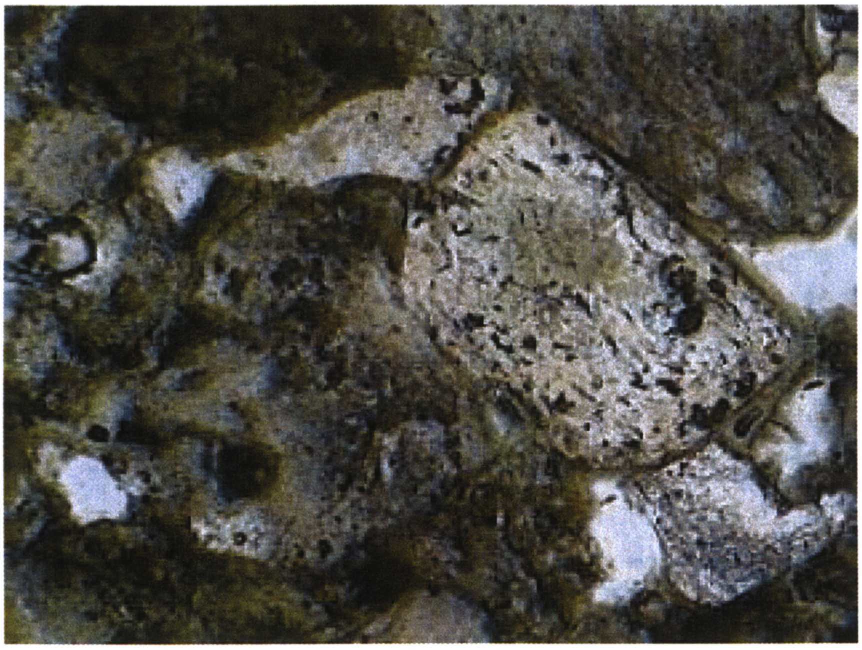
GC825-5B: Boundary Creek Bore hole, 357.80 m
(Plane light. Width of field of view = 780 μm).

Strzelecki Group sandstone. Same view as in image GC825-5A in plane light. Primary porosity is clearly visible with diagenetic swelling chlorite - smectite cement coats well developed on all detrital grains.



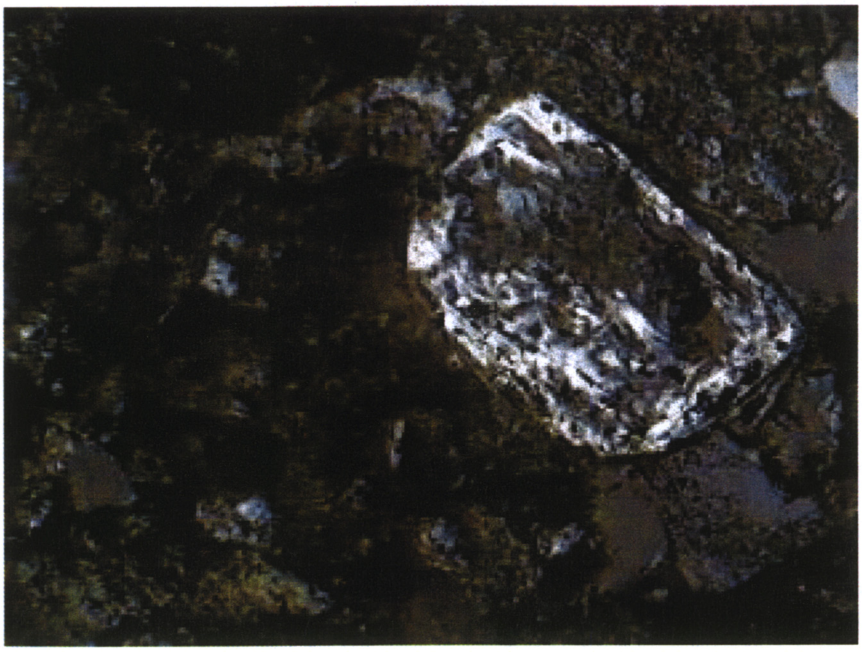
GC825-5C: Boundary Creek Bore hole, 357.80 m
(Plane light. Width of field of view = 780 μm).

Strzelecki Group sandstone. View shows mainly lithic fragments (mostly siltstone) with diagenetic swelling chlorite - smectite coatings, a highly compacted texture and low primary.



GC825-5D: Boundary Creek Bore hole, 357.80 m
(Plane light. Width of field of view = 780 μm).

Strzelecki Group sandstone. View shows a highly altered K-feldspar detrital grain and lithic fragments (mostly siltstone) with diagenetic swelling chlorite - smectite coatings.

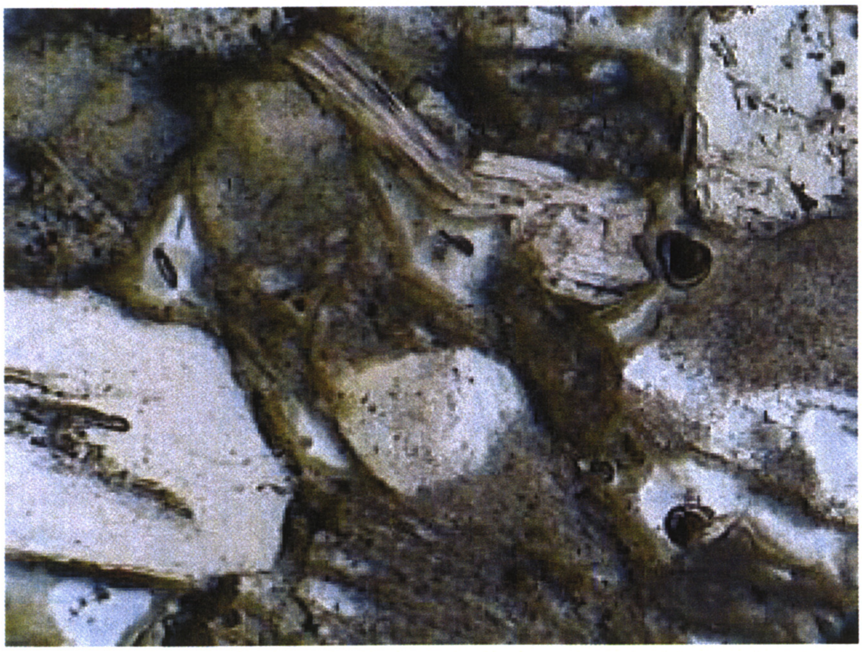


GC825-5E: Boundary Creek Bore hole, 357.80 m
(Crossed polars. Width of field of view = 780 μm).

Strzelecki Group sandstone. Same view as GC825-D emphasing alteration of K-feldspar detrital grain.

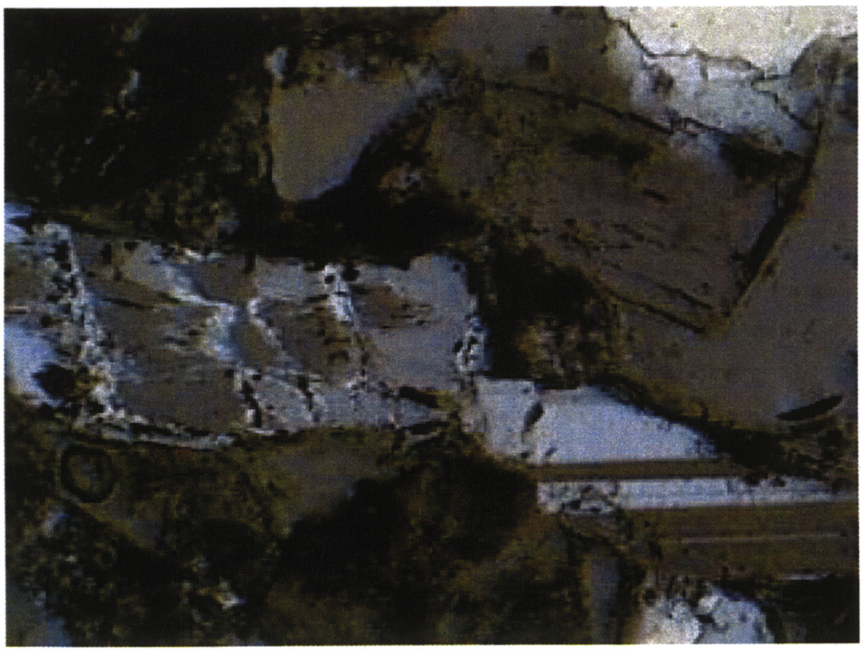
GC825-5G: Boundary Creek Bore hole, 357.80 m
(Plane Light. Width of field of view = 780 μm).

Strzelecki Group sandstone. Volcanic lithic grains and plagioclase, diagenetic swelling chlorite - smectite coatings. Primary porosity relatively low.



GC825-5H: Boundary Creek Bore hole, 357.80 m
(Plane Light. Width of field of view = 780 µm).

Strzelecki Group sandstone. Muscovite detrital grain deformed by compaction, diagenetic swelling chlorite - smectite coatings. Primary porosity relatively low.



GC825-5I: Boundary Creek Bore hole, 357.80 m
(Partially crossed polars. Width of field of view = 780 µm).

Strzelecki Group sandstone. Twinned volcanic plagioclase and altered K-Feldspar (possibly or granitic origin).

GC825-5J: Boundary Creek Bore hole, 357.80 m
(Plane light. Width of field of view = 190 μm).

Strzelecki Group sandstone. Large primary pore with well-developed diagenetic swelling chlorite - smectite cement coating the detrital grains.

GC825-5K: Boundary Creek Bore hole, 357.80 m
(Crossed polars. Width of field of view = 780 μm).

Strzelecki Group sandstone. Volcanic lithic grains and plagioclase.

APPENDIX

THE STRZELECKI AND OTWAY GROUPS OF SOUTHERN AUSTRALIA

(Extracted largely from Duddy ,1983, with additions)

1. INTRODUCTION

1.1 Summary of tectonic setting and geological history

The fluviatile Strzelecki and Otway Groups (Figure 1) were deposited in continental rift grabens that stretched some 1000 km along the southern coast of Australia during the Early Cretaceous. In the main depositional areas, of the Otway, Gippsland and Bass Basins, the Strzelecki and Otway Groups are at least 3 to 6 km thick and are comprised of at least 100,000 cubic kilometres of detritus predominantly derived from contemporaneous volcanism.

From the Late Jurassic to about the end of the Aptian quartzose terrigenous detritus derived from the northern margin dominated the sedimentary section. This gave rise to the Tyers Group in the Gippsland Basin and the Pretty Hill Sandstone in the Otway Basin, deposited predominantly as alluvial fan deposits close to the northern basin margin. Contemporaneous volcanism did occur during this period, however, and mixing of quarztose detritus with volcanogenic detritus lead to deposition of the Geltwood Beach Formation in the Otway Basin. Similar mixed provenance sediments presumably occur in the Gippsland Basin, but subdivision of the Strzelecki Group on this basis has not been carried out. Tosolini et al (1999) have recently proposed a subdivision of the lower Strzelecki Group, principally a reassessment of the Tyers Group and other marginal sediments, but the various units described are considered here to be different fluvial sedimentary environments and not correable lithostratigraphic units.

The Early Cretaceous volcanoes are considered to have been situated in the Main Rift between Australia and Antarctica and in the Bass and Gippsland Basins between the Australian mainland and Tasmania. Presumably they were sufficiently distant from the presently accessible depositional areas so that airfall tuffs or in situ volcanic flows are generally absent from the known sequence. However, in the Woolsthorpe-Hawkesdale area of the Otway Basin, basic lavas at the base of the Eumeralla Formation, previously considered to be a part of the late Jurassic Casterton Formation, are now known to be Early Cretaceous in age, ?Aptian (Mitchell et al 1997). This provides the first record from South Eastern Australia of in-situ volcanic flows associated with the Eumeralla Formation volcanogenic sediments.

The dominant drainage direction within the main rift basins during the Early Cretaceous is not well understood. Paleocurrent directions within the Otway and Strzelecki Groups indicate both generally E to W and W to E flow, although there is a general feeling that the dominant flow direction may have been from east to west from Gippsland and Bass into the Otway and through to the Duntroon and Great Australian Bight Basin's in South Australia. This does not mean the volcanogenic sediment itself was derived from an eastern source terrain (i.e. an eastern margin volcanic arc). Indeed, the detailed petrology of the volcanogenic sediments, the distribution of fluvial lithologies and a lack of along rift grain-size variation strongly points to localized volcanic input throughout the depositional basins, and not a single eastern margin volcanic arc provenance (Duddy, 1983; 1997).

Unfortunately, lack of detailed age information from the sediments (from palaeontology) prevents any rigorous assessment of changes in regional water flow direction through time.

The Otway Group in the Bass Basin is not well known but it appears to be similar in most respects to the deposits in the major basins. Similarly the Early Cretaceous sediments of the Murray Basin have been shown to contain detritus from contemporaneous volcanicity.

At the end of the Early Cretaceous cessation of Strzelecki and Otway Group deposition was concomitant with the initial separation of Australia and Antarctica. This separation at about 95 Ma was associated with deformation which gave rise to the initial uplift of the Otway and Strzelecki Ranges, largely as broad domal anticlines, but with local complexity introduced due to differential re-activation of an approximately orthogonal set of Early Cretaceous normal and transfer fault zones. Typically, 1 to 2 km of the Strzelecki and Otway Group, comprising dominantly the upper andesine-heulandite mineral alteration zone, was eroded during rapid uplift at this time. Locally, as a Cape Otway in the Otway Basin, up to ~6 km of Otway Group section was uplift and eroded.

In the newly formed Late Cretaceous basins to the west of the Otway Ranges and to the south-east of the Strzelecki ranges, deposition continued almost without break but became dominantly marine and quartzose. In the intervening Torquay sub-Basin and Bass Basin, deposition also became quartzose, but remained non-marine until late in the Eocene.

Separation of Australia and Antarctica during the Late Cretaceous and Early Tertiary was extremely slow, with rapid spreading not beginning until the Eocene (about 45 to 55 Ma). The onset of rapid spreading may also have been associated with deformation, and local uplift and erosion in both the Otway and Gippsland Basins. Similarly, an Oligocene unconformity at the top of the Nirranda Group in the Otway Basin and between the Latrobe Group and Seaspray Groups in the Gippsland Basin, also indicates a regional denudation episode.

The present outcrop regions of the Otway and Strzelecki Groups have not had any significant burial by younger sediments since the 95 Ma uplift and thus preserve the diagenetic mineralogical relationships produced during the Early Cretaceous burial phase. The Otway Ranges were again uplifted in the Late Miocene-Pliocene (post-Heytesbury Group) with rejuvenation of the main structures and the production of a series of steep dipping monoclines reflected in the present day topography. Similar re-activation may have occurred in the Gippsland Basin.

1.2 The Early Cretaceous depositional system: General comments

The Early Cretaceous rift grabens were dominated by large-scale multi-channel streams cutting extensive floodplains. These streams deposited thick vertically stacked channel sandstones in sheet-like bodies and a spectrum of overbank mudstones and fine-grained sandstones. The channel sandstones display fining upward cycles with numerous erosional breaks indicating repeated flood cycles. The channel deposits have internal features consistent with braided stream channels but the overall system has a large proportion of floodplain, previously considered characteristic of meandering stream units (Figure 2).

It is considered that multiple channel streams developed under temperate conditions due to an oversupply of pyroclastic derived sediment and high seasonal rainfall.

Alluvial fans input terrigenous quartzose detritus throughout the Early Cretaceous, but they are best developed in the Neocomian, when the supply of volcanogenic detritus was insufficient to significantly mask the terrigenous input. Nevertheless, quartzose sediments of Pretty Hill Sandstone (Crayfish Group) alluvial fans are best developed in half grabens close to the northern margin of the Otway Basin with similar aged alluvial fan deposits making up the Tyers Group near the northern margin of the Gippsland Basin.

In the later part of the Early Cretaceous, thin quartzose sandstones derived from a northern margin provenance occur within the largely volcanogenic Eumeralla Formation. One unit regionally well-developed in the Otway Basin is referred to the Heathfield Sandstone member.

Thus, quartzose sandstones with enhanced hydrocarbon reservoir potential can be expected to occur within the volcanogenic sediments of the Otway and Strzelecki Groups provided there is a nearby outcropping quartzose sediment source, as would be provided by Paleozoic metasediments and granites.

1.3 Fluvial deposits of the volcanogenic Strzelecki and Otway Groups

Many observations from the Strzelecki and Otway Groups are consistent with the anastomosing river model, and these units are regarded as representing an ancient example of a multi-channel fluvial depositional system having extensive floodplain development (Duddy, 1983). Complex channels may be some 10 km wide, separated by large stable levee flanked flood basins. At high flood stages, these channels would have large-scale meanders through the floodplain. Due to a literature bias towards consideration of only the channel component of braided river systems, there is at present no place in any classification for truly braided channels set in extensive floodplains. Further, it is not clear whether such a system could be considered analogous to the stable vegetated bank situation of the anastomosing river system.

In deducing the overall depositional system of a fluvial sequence, many factors must be considered apart from the internal nature of the deposits themselves. Such features as depositional rate, climate, supply of detritus, and basin shape all impinge on the development of the fluvial system.

In the case of the Otway and Strzelecki Groups, the average subsidence rate can be roughly calculated from the overall thickness of at least 3 to 6 km of largely volcanogenic sediment deposited over about 40 Ma, giving 0.1 to 0.15 mm/yr (100 to 150 m/Ma). Depositional rates in channels were of the order of several meters per flood cycle, so this gives some idea of the preservation potential of this environment. A similar rate of subsidence (aggradation) is reported for the Brazeau Formation. Deposition was rapid enough to prevent significant weathering of sand-sized unstable volcanic minerals, such as clinopyroxene, before burial.

Rates of deposition on the floodplain are much lower, but the preservation potential in this environment is also low due to the migration of channels. Up to 25 mm of deposition is known on the distal floodplain of the Brahmaputra in a single event. In some areas, probably on levees or in flood basins close to active channels, aggrading paleosoils developed due to a steady input of overbank detritus, insufficient to completely obliterate the colonising plants.

Supply of detritus seems to be a major factor in the multi-channel depositional style developed. An abundant supply of volcanogenic detritus from explosive volcanic centres outside the presently observed basin area is considered to have choked the stream channels, leading to "braiding". The amount of detritus was able to balance the rate of subsidence and keep the graben system above sea-level for at least 30 Ma. The evidence for waxing and waning of flood levels indicated by mudstone drape deposits within the active channel units suggests a climate with seasonal flooding. The abundance and diversity of the preserved vegetation, including in situ liverworts, and the burial diagenesis (from the secondary mineralogy) suggests that rainfall was abundant for most of the year. No mudcracks are known, and there is only minor evidence for oxidation of iron within paleosoil horizons. Some rare features interpreted as permafrost horizons have been described from the Early Cretaceous Strzelecki Group in the Gippsland Basin (Constantine et al, 1998). No such horizons have been observed in the Otway Ranges, but similar features interpreted as dewatering features are common (Duddy, 1983).

The deposits of the Allegheny of West Virginia have many features in common with this depositional system, especially the association of channel bar deposits and extensive floodplain environments. The Brazeau-Paskapoo also has characteristics usually considered to be suggestive of both meandering and braided stream origin. The Lower Cretaceous upper Manville sub-group described as anastomosed, is similar in the association of multi-storeyed channels and extensive floodplains, but is on a somewhat smaller scale.

The most important characteristics for the understanding of the Otway Formation depositional system are considered to be:

1. Multi-storey complex channel deposits with complex erosion surfaces separating individual fining upward cycles. These major channel systems may occupy belts 10's km wide and over 100 m thick.
2. Horizontal mudstone drape deposits generally resting on eroded crossbeds within the active channel complex. These are considered to be characteristic of channel bar tops in multi-channel streams and can often be traced laterally to a mudclast horizon or scour surface.
3. Thick sequences of overbank deposits with coal seams and paleosoil horizons adjacent to multi-storey channels is an essential element. Lacustrine deposits are present throughout but are generally limited in lateral extent. Overall the overbank deposits comprise about half the total volume of sediment.
4. Channel lag deposits due to collapse of levee banks.
5. A general paucity of deeply incised channels.
6. The occurrence of abandoned channel deposits within both the active channel and overbank sequences.

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7. Deposition seems to have occurred largely by vertical accretion in both channel and overbank environments.

A combination of high rainfall, abundant sediment supply from contemporaneous volcanism and a rapidly subsiding low-gradient continental rift basin produced a high-energy environment but with internal features characteristic of a meandering system. The depositional system is summarised in block diagram form in Figure 1.

2. OTWAY and STRZELECKI GROUP SANDSTONES

2.1 Sandstone compositions and the nature of the source volcanics

Petrographically, the channel sandstones are remarkably uniform, originally well sorted and porous, consisting predominantly (~50%) of glassy volcanic rock fragments (now altered to clays), feldspars, and a variety of ferro-magnesian minerals including biotite, hornblende and clinopyroxene, and importantly, apatite, zircon and sphene (Duddy, 1983). The sandstones are quartz-poor with a maximum of ~20% of largely volcanic quartz. The minerals may occur in glassy-volcanic rock fragments or as loose crystals. When deposited the channel sandstones were composed of well-sorted, fine to medium-grained volcanogenic detritus without a clay matrix and with high permeabilities and with initial primary porosities around 40%. Unfortunately, primary porosity was rapidly occluded and permeabilities significantly reduced by a series of diagenetic reactions occurring at relatively shallow depths of burial (see below) and by compaction of the dominant component of altered volcanic rock fragments.

Electron microprobe analyses of unaltered detrital volcanogenic minerals were used to determine the range of magma types contributing to the Otway and Strzelecki Groups. The chemical compositions of pyroxenes, amphiboles and feldspars indicated that detritus was derived from a wide range of magma types from basalts to rhyolites. The dominant volcanoes were of high potassium dacite or silicic andesite composition. These conclusions are supported by the whole rock chemical compositions determined for the sandstones with due allowance for contamination of non-volcanogenic detritus and the effects of post-depositional alteration.

Presently such magma compositions are more common on active continental margins rather than in rift settings although the Basin and Range Province of the central western U.S.A. and the Western Rift in Africa are potential analogues.

2.1 Diagenesis

Diagenesis began immediately after burial, with extensive dissolution of unstable volcanic components - glass, olivine, pyroxene, etc and all grains became rapidly coated with an envelope of Fe and Mg-rich **smectite and/or swelling chlorite** (Figure 3). This occurs at burial depths of only about 10 m (Duddy, 1983) as pebbles of sandstone cemented only by these clay minerals occur reworked into channel conglomerate lenses (e.g Moonlight Head area, Otway Basin). Permeability in the typical Otway and Strzelecki Group sandstones was effectively reduced to millidarcy levels soon after deposition.

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Locally, Mn-bearing calcite cement fills primary porosity forming rounded "cannon-ball" concretions. Concretion formation occurs prior to significant compaction, sealing the labile minerals away from the pore fluids and preserving the unstable volcanic minerals and early formed diagenetic swelling clays from further alteration. Early formed siderite ($FeCO_3$) concretions also occur and these are locally abundant in some areas. The formation of carbonate concretions stopped once the carbonate ions in solution were exhausted (or reached equilibrium), essentially being limited by the exhaustion of oxygen and the onset of reducing conditions. Thus, concretion formation had the effect of lowering the partial pressure of CO^2 ($ppCO^2$) in the pore fluid, enabling zeolites (hydrated Al silicates) to form.

In zeolite-bearing areas, alkali heulandite was the first zeolite to form (dominantly in primary pore spaces) and this was transformed to Ca-heulandite as burial progressed (Figure 4). These early formed zeolite co-exist with unantered volcanic Ca-plagioclse in the upper 1200 to 1500 m of the sediment pile and is referred to as the **andesine-heulandite diagenetic zone.** In the **andesine-heulandite diagenetic zone** porosity varies between ~35 and 15%, with the zeolite heulandite crystallising in the pore spaces. The andesine-heulandite zone approximates to, but does not coincide with, megafloral zone D sediments of Albian age.

At a burial depth of only about 1200 to 1500 metres (corresponding to a maximum paleotemperature of only ~70 to 90°C (derived from apatite fission track studies) and remaining primary porosity of ~15%) and when the concentration of Na in solution had reached the appropriate level, calcic plagioclase and in some cases K-feldpsar were albitized. Albitization promoted the conversion of Ca-heulandite to laumontite within the body of precursor feldspar grains and the formation of new laumontite within remaining primary pore spaces. This is referred to as the **albite-laumontite alteration zone** characterised by the presence of albite with or without laumontite and without other primary labile volcanogenic minerals (Figure 5). The alteration boundary is sharp (localised to within 50 m thickness) and is sub-parallel to bedding. Sandstone porosity in the albite-laumontite mineral zone was reduced to less than 5% by this reaction on a basin wide scale.

This essentially metamorphic reaction also resulted in considerable chemical rearrangement within the whole rock system. Sr and Ba from plagioclase and heulandite and Ba from K-feldpsar were lost from the albite-laumontite zone rocks and were concentrated in heulandite near the base of the andesine-heulandite zone. K and Rb from K-feldspar were probably lost from the sandstones altogether and contributed to newly formed illite in the interbedded volcanogenic mudstones.

With deeper burial smectite and swelling chlorite finally disappeared in favour of discrete chlorite (Figure 6). Locally Al-rich sphene formed under similar conditions to those required for laumontite, its formation probably dependent upon a supply of Ti (and F?) in solution from the breakdown of biotite.

The geothermal gradient during the early Cretaceous was not less than ~45°C/km, and as high as ~65°C/km (Duddy et al., 1991; Duddy, 1994; Duddy, 1997). Swelling chlorite envelopes were replaced by well-formed chlorite plates (Figure 2), often almost completely blocking the remaining porosity (less than ~10%). The consequences for hydrocarbon migration are obvious.

An alternative clay-carbonate alteration occurs pervasively in certain wells such as Anglesea-1 and Fergusson's Hill-1 in the Otway Basin. The upper mineral alteration zone contains fresh plagioclase and carbonate in pores. In the lower zone carbonate and clay minerals replace detrital grains and occlude pores, and any surrounding plagioclase is albitised. The carbonates are Fe and Mg-bearing and the clay minerals are kaolinite and illite-smectite. Such clay-carbonate alteration occurred when the $ppCO_2$ remained high throughout burial, preventing the formation of zeolites.

Development of these mineral alteration assemblages with burial depth is interpreted in terms of a series of sequential reactions between the solid rocks and a pore fluid evolving in an essentially closed system. At various stages the pore fluid and earlier formed secondary minerals have acted as transient sites for mobile ions. The major proportion of all ions including Na and Cl now found in solution were derived from alteration of detritus within the Otway Formation.

The reaction Ca-plagioclase plus heulandite to give albite plus laumontite can be considered a metamorphic reaction on textural grounds and under ideal conditions this mineral assemblage can proceed at temperatures as low as ~70°C. The sharpness of the boundary separating the two main mineral alteration zones - the andesine-heulandite and albite-laumontite zones - resulted from the union of a number of inter-dependent factors:

(1) The supply of a remarkably uniform mixture of volcanogenic detritus to the non-marine depositional basin without the occurrence of less permeable units such as tuffs, volcanic flows or marine mudstones.

(2) A multi-channel stream depositional system maintained throughout the whole time of deposition of some 50 Ma. This produced a basin-wide, interconnected system of well sorted

sand-bodies without major vertical porosity and permeability seals. Pore fluids were maintained under hydrostatic conditions until the formation of the albite-laumontite metamorphic mineral assemblage resulted in rapid, almost total destruction of all effective porosity.

(3) The lack of airfall tuffs and the high degree of mixing of detritus prior to deposition means that areas of vastly different ion concentration during early diagenesis did not occur. Pore fluids were of uniform composition as they were derived predominantly from the alteration of a well-mixed suite of volcanogenic detritus within the sediment pile. The interplay of these factors makes the mineral distribution in the Otway and Strzelecki Groups unique in the geological literature and explains why gross overlapping depth ranges of minerals such as heulandite and laumontite and fresh and albitized plagioclase did not occur.

Because of the high labile component in the sandstones, and derivation of both sandstones and mudstones from volcanogenic detritus, their chemical compositions are similar. In particular both sandstones are mudstones and high in potassium and uranium and will give similar log responses. Lithological variants include relatively rare grits containing exotic terrigenous detritus (usually in marginal localities), soil horizons which are bentonitic, kaolinised sediments occurring locally below the Tertiary unconformity, and finally, phyllite resulting from tectonic shearing of Otway Group sediments near Foster in Gippsland.

3. HYDROCARBON PLAYS IN THE OTWAY & GIPPSLAND BASINS

3.1 Introduction

Brief comments are made in this section on Eumeralla Formation sourced hydrocarbon plays in the Otway Basin drawn from the thermal history analysis presented in Duddy (1997). As for the provenance and diagenetic histories, the underlying thermal and structural history of the Gippsland Basin shares many features with the Otway Basin and these comments are equally relevant to Strzelecki Group sourced plays in the Gippsland Basin.

3.2 Factors controlling commercial HC discoveries in the Otway Basin

Many minor petroleum shows and discoveries have been made in the Otway Basin and only a few small commercial gas fields have been exploited. Most of these shows are in the late Cretaceous Waarre sandstone, the Early Cretaceous Eumeralla Formation or the ?Late Jurassic-Early Cretaceous Pretty Hill Sandstone. The most significant Victorian discoveries are in the region west of the Otway Ranges, in the Port Campbell embayment area, where the Early Cretaceous sediments are buried beneath the Late Cretaceous and Tertiary section.

The quartzose sandstones of the Waarre and Pretty Hill sandstones are the better reservoirs because the sandstones of the Eumeralla Formation are profoundly affected by diagenetic swelling clays that have destroyed permeability while advanced compaction of unstable rock fragments has accentuated porosity destruction. Porosity in the Eumeralla Formation is reduced to near zero where burial exceeds ~2.5 km.

Maturation of source rocks in the Jurassic and Early Cretaceous sections will have commenced, and in the thicker half-graben section completed, in the Early Cretaceous, due to deep burial and elevated geothermal gradients associated with rifting (Duddy, 1997). Basin inversion (eg forming the Otway Ranges) in the mid-Cretaceous (~100 to 95 Ma) involved reversal on both extensional and transfer faults, sometimes with massive uplift and erosion (eg over 3.0 km of removed section at Olangolah-1 in the central Otway Ranges). This inversion episode resulted in the definition of new basin margins for late Cretaceous sedimentation and rejuvenation of Paleozoic basement sediment source terrains, leading to deposition of quartz-rich sediments, and importantly caused cessation of HC generation from early Cretaceous source rocks. Where inversion did not occur (eg the Port Campbell embayment) suitable Otway Formation sediments continued to generate hydrocarbons through to almost the present-day (minor structuring in the Oligocene and Pliocene probably killed generation), and minor oil shows in the early Port Campbell wells may derive from this source. Thus, while the Eumeralla Formation undoubtedly has some good source potential, the lack of high quality reservoirs, the destruction of an efficient "plumbing system" during early diagenesis and hydrocarbon generation over much of the basin prior to major structuring at 100 Ma would seem to act against large discoveries. On a brighter note, it is possible that some early discoveries in the Eumeralla Formation in the Port Campbell region that were abandoned due to "limited reservoir size" may in fact have suffered substantial formation damage during drilling, due to the presence of the highly unstable smectite grain coatings.

Plays involving deeper source rocks (eg. ?late Jurassic Casterton Beds) and Pretty Hill Sandstone reservoirs are possible in deeper graben sections close to basin margins (where the Pretty Hill is best developed), and require identification of inverted and non-inverted basement structures and possibly stratigraphic traps using Eumeralla Formation as a seal.

The most prospective section for significant hydrocarbon discoveries in this area of the Otway Basin would appear to be in the Late Cretaceous section buried beneath the thicker Tertiary basins, where maturation should not have commenced until the mid to Late Tertiary, after the Cretaceous and most Tertiary structuring episodes. The Late Cretaceous Waarre Sandstone is the most likely reservoir but the biggest difficulty with this play would appear to be a lack of known Late Cretaceous source rocks, and the possibly limited migration potential from Early Cretaceous source rocks.

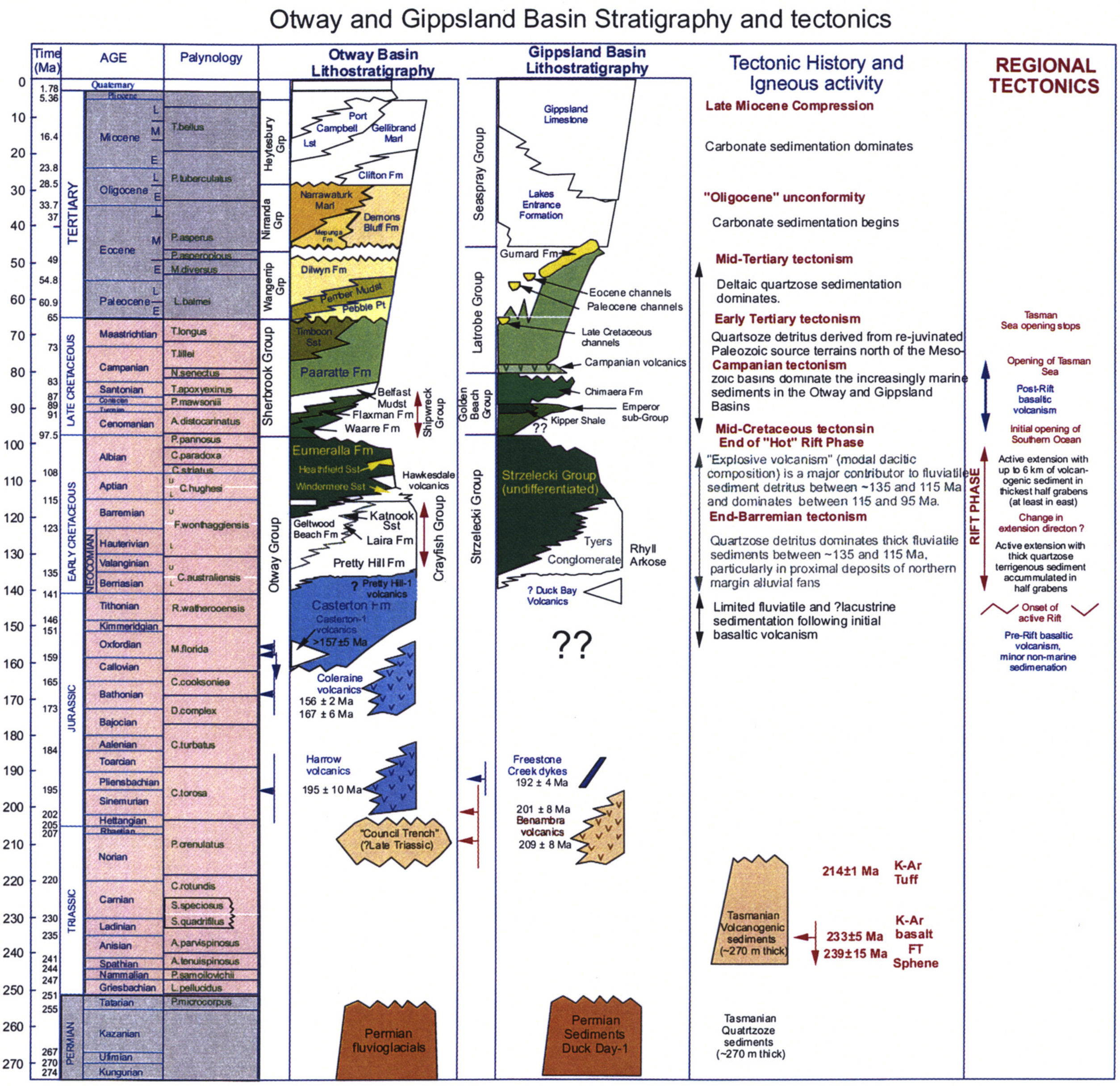

Figure 1:

Generalised litho- and chronostratigraphy of the Otway and Gippsland Basins with notes on recognised tectonic events and associated sedimentation (after Duddy, in prep). Time-scale after AGSO (1995).

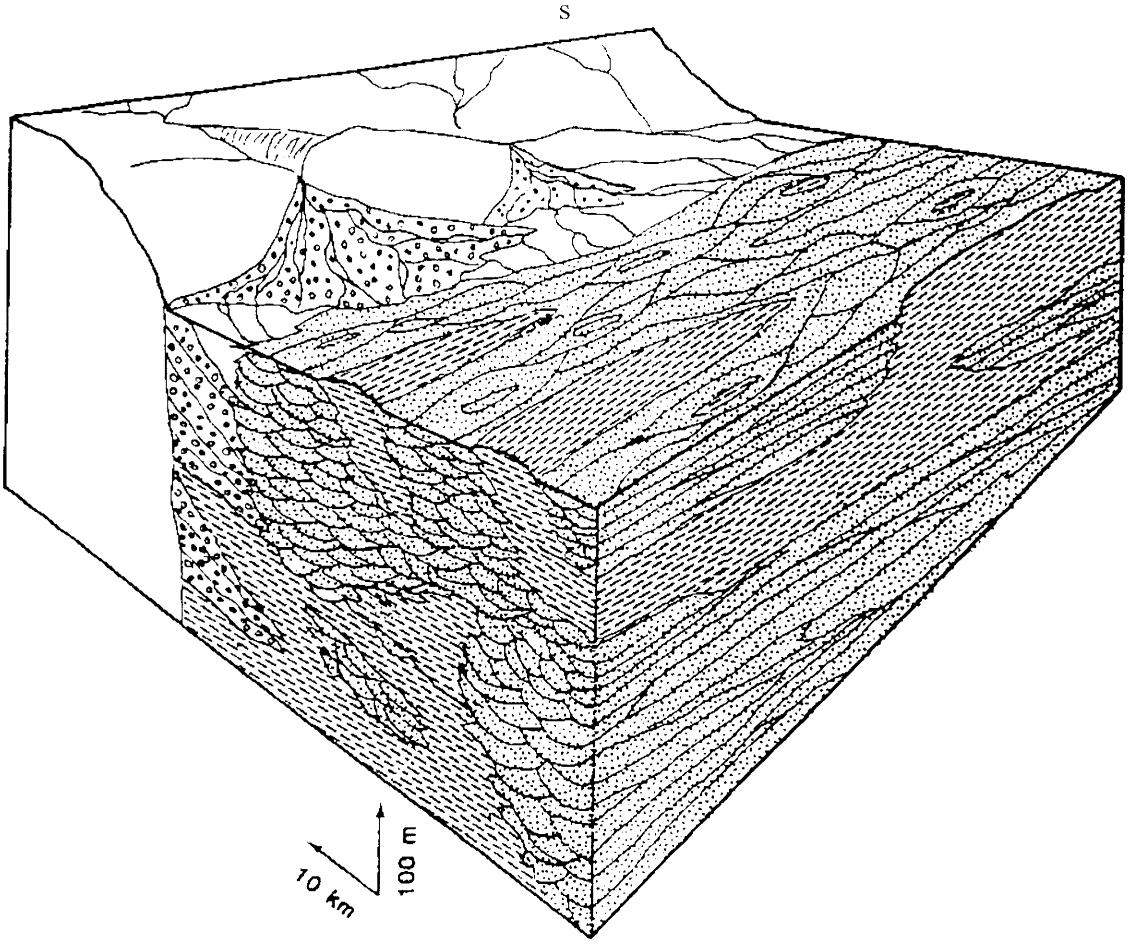

Figure 2: Summary block diagram of the Otway Group depositional system. At the margins of the rift, alluvial fans deposit terrigenous detritus derived from Palaeozoic basement rocks, as now represented by the Pretty Hill Sandstone and Tyers conglomerate (in Gippsland). Towards the axis of the rift, wide, multiple channel streams (anastomosed or braided) deposit thick sequences of volcanogenic sandstone washed from distant volcanoes in the main rift. In between these active channel belts, thick sequences of mudstones and siltstones and coals accumulate in relatively stable (laterally) flood basins. The overall ratio of sand to mud is 1:1. (after Duddy, 1983).

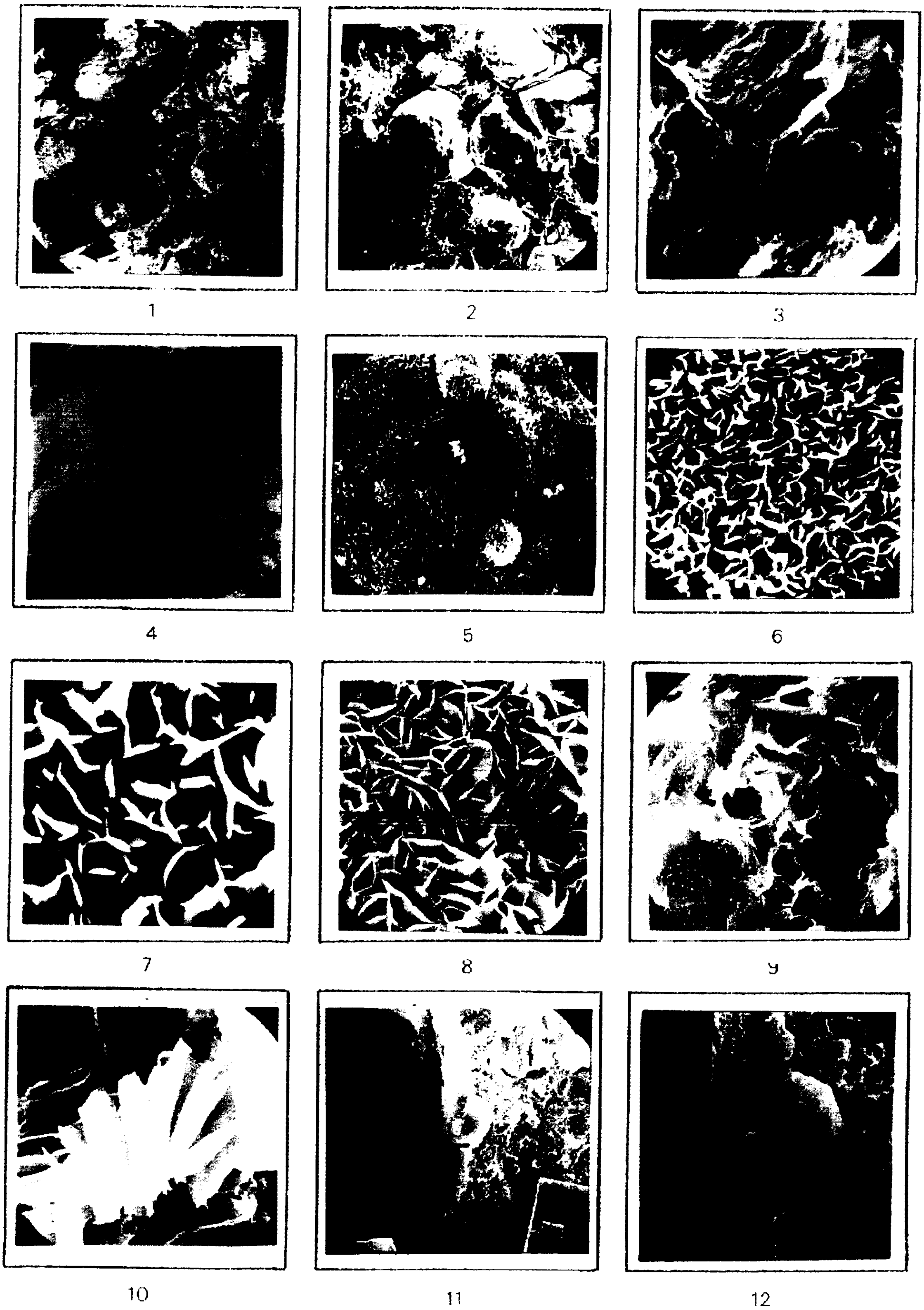

Figure 3: SEM photographs of swelling chlorite-smectite grain coating cements from Otway Group volcanogenic sandstones (captions over page)

Figure 3: SEM photomicrographs of "Swelling chlorite" grain coating cement

1. General view of sandstone showing swelling chlorite grain-coatings, and heulandite in pores. Porosity is moderate but permeability is low. R25020, Locality 65, Otway Ranges. Width of field of view = 867 μm.

2. Same sample as above, again showing swelling chlorite coatings partly stripped from grains. Grainsize ca. 0.3 mm. Width of field of view = 867 μm.

3. Close-up of above showing detail of detrital grains beneath swelling chlorite coatings. Width of field of view = 263 μm.

4. Close-up of above showing typical 'rose petal' or "cornflake" texture of swelling chlorite grain-coating. Similar textures are reported for smectite clays. Width of field of view = 116 μm.

5. Swelling chlorite grain-coatings again showing typical texture with 'fused flakes'. R26637, Moorbanool Bore No.8, 53 m depth. Width of field of view = 67 μm.

6. Swelling chlorite from andesine-heulandite sandstone. R25019, Moonlight Head area, Locality 14. Width of field of view = 39 μm.

7. Detail of above. Width of field of view = 13 μm.

8. Large interlocking swelling chlorite 'petals' in another andesine-heulandite sandstone. R17685, Moorbanool Bore No.8, 129 m depth. Width of field of view = 32 μm.

9. K-bearing swelling chlorite grain-coating films in andesine-heulandite sandstone. R25090, Moorbanool Bore No.8, 93 m depth. Width of field of view = 79 μm.

10. Spectacular swelling chlorite fan' in heulandite-andesine sandstone. R26638, Moorbanool Bore No.8. W idth of field of view = 13 μm.

11. Swelling chlorite coating on slightly etched andesine crystal. Note also the heulandite growing on the clay. Andesine-heulandite sandstone. R26637, Moorbanool Bore No.8, 53 m. Width of field of view = 67 μm.

12. Close-up of skin ca. 8 μm thick. Width of field of view = 26 μm.

[redacted]

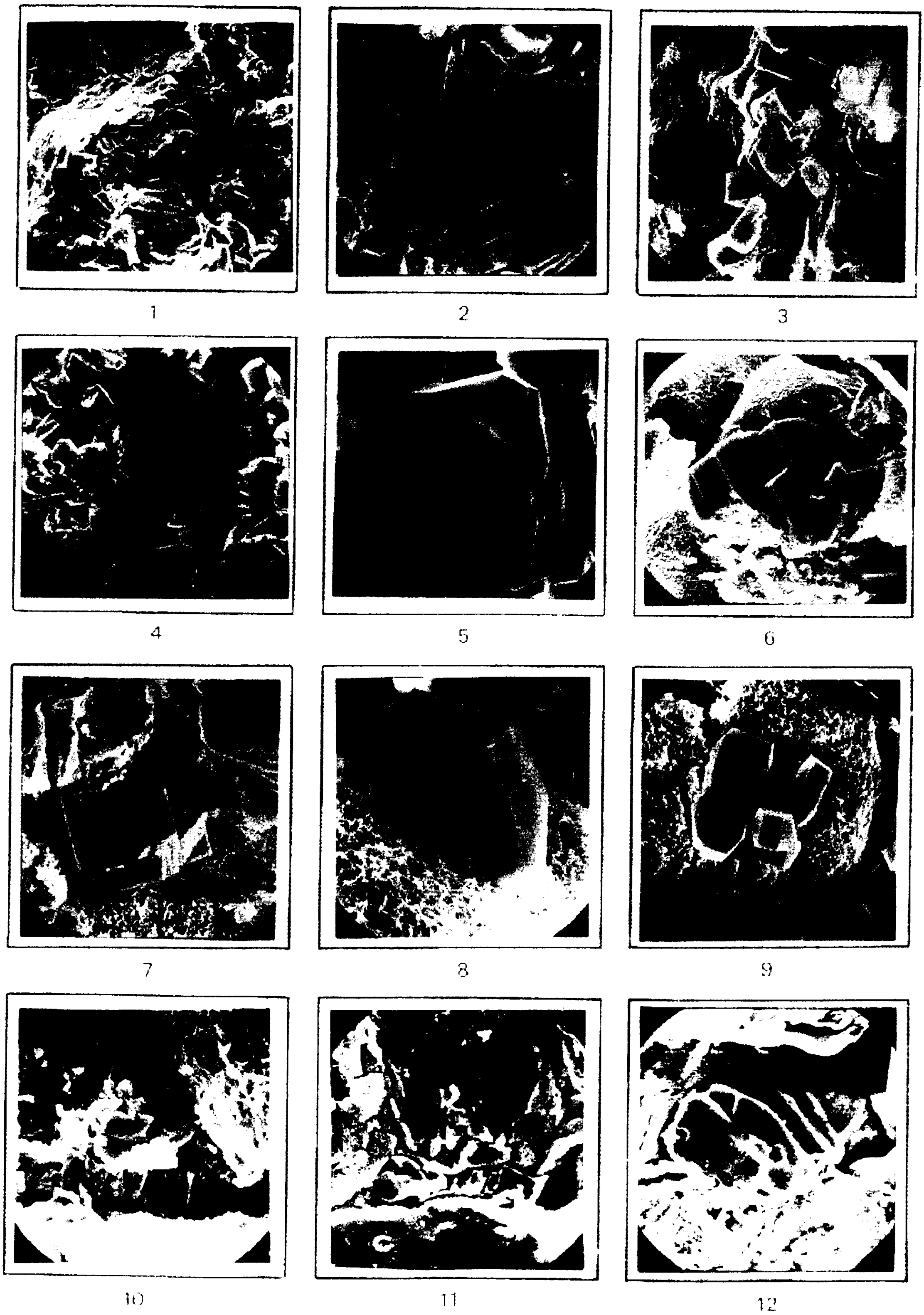

Figure 4: SEM photographs of zeolite pore cements from Otway Group volcanogenic sandstones (captions over page).

[redacted]

Figure 4 caption: SEM photomicrographs of Heulandite group zeolites

1. Heulandite crystals growing in pore space on swelling chlorite grain-coating cement. Note the smooth rear surface of the swelling chlorite coating originally in direct contact with a detrital grain. R26637, Moorbanool Bore No.8, 53 m. Width of field of view = 361 µm.

2. Interlocking heulandite crystals in pore space. The rough surface on many crystals is where they have been attached to the swelling chlorite cement rather than etching. R25090, Moorbanool Bore No.8, 93 m. Width of field of view = 184 µm.

3. Same saple as above showing heulandite and thin chlorite films. Width of field of view = 96 µm.

4. Heulandite in another pore. R26637, Moorbanool Bore No.8, 53 m. Width of field of view = 222 µm.

5. Detail of heulandite crystal showing typical monoclinic crystal shape. Crystal ca. 50 µm high. R26637. Width of field of view = 58 µm.

6. Heulandite crystal on a thin swelling chlorite grain-coat. R26639, Moorbanool Bore No.8. Width of field of view = 133 µm.

7. Large heulandite crystal almost filling a small pore lined with 'rose petal' textured swelling chlorite. Note the under surface of swelling chlorite coating. R 26638. Width of field of view = 158 µm.

8. Single heulandite crystal growing on swelling chlorite. R26637. Width of field of view = 48 µm.

9. Similar to above. R26637. Width of field of view = 96 µm.

10. Alkali-rich heulandite pore fill and K-rich swelling chlorite. R25321, Tullich No.1, Core 1, 266m. Width of field of view = 144 µm.

11. Heulandite pore fill showing possible dissolution rounding. R25020, Moonlight Head area. Width of field of view = 241 µm.

12. Detail of possible etched heulandite from same sample as 11. Width of field of view = 184 µm.

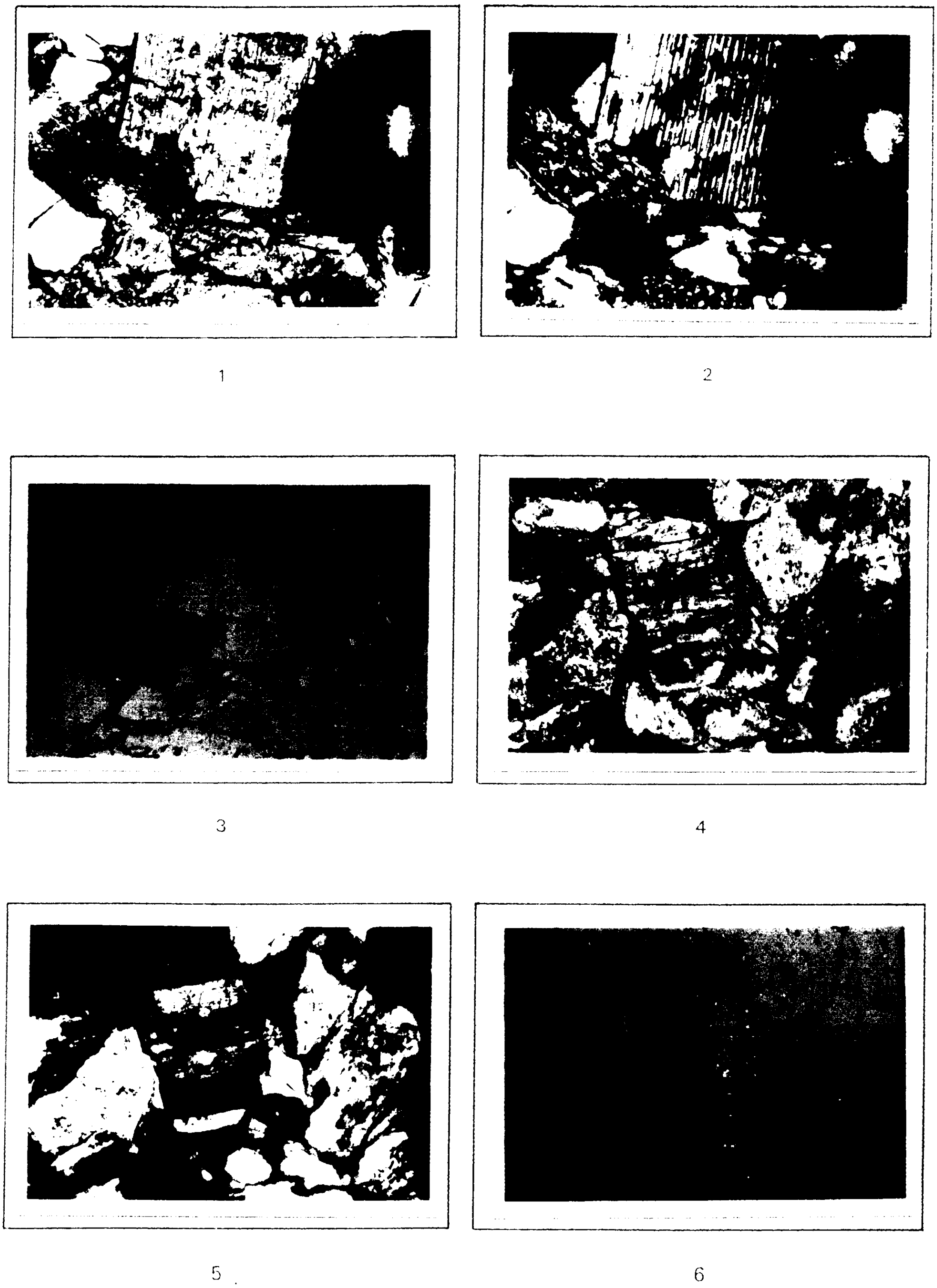

Figure 5: Optical photomicrographs illustrating plagioclase albitization and laumontite occurrence in Otway Group volcanogenic sandstones from Flaxmans-1 (captions over page).

Figure 5 caption: Plagioclase alteration: R25397, Flaxman-1 Core 39, 3085 m.

All fields of view are = 0.36 µm wide.

1-3. Albitized plagioclase (pl) with small chlorite inclusions which are particularly noticeable in reflected light (arrow). Twinning is clearly present.

Laumontite (L) occurs in the pore spaces but does not replace the grain.

1. Plane light. 2. Crossed polars. 3. Reflected light

4-6. Plagioclase (pl) replaced by albite and laumontite with laumontite and chlorite in pores. - Laumontite is clearly visible in reflected light.

4. Plane light. 5. Crossed polars. 6. Reflected light.

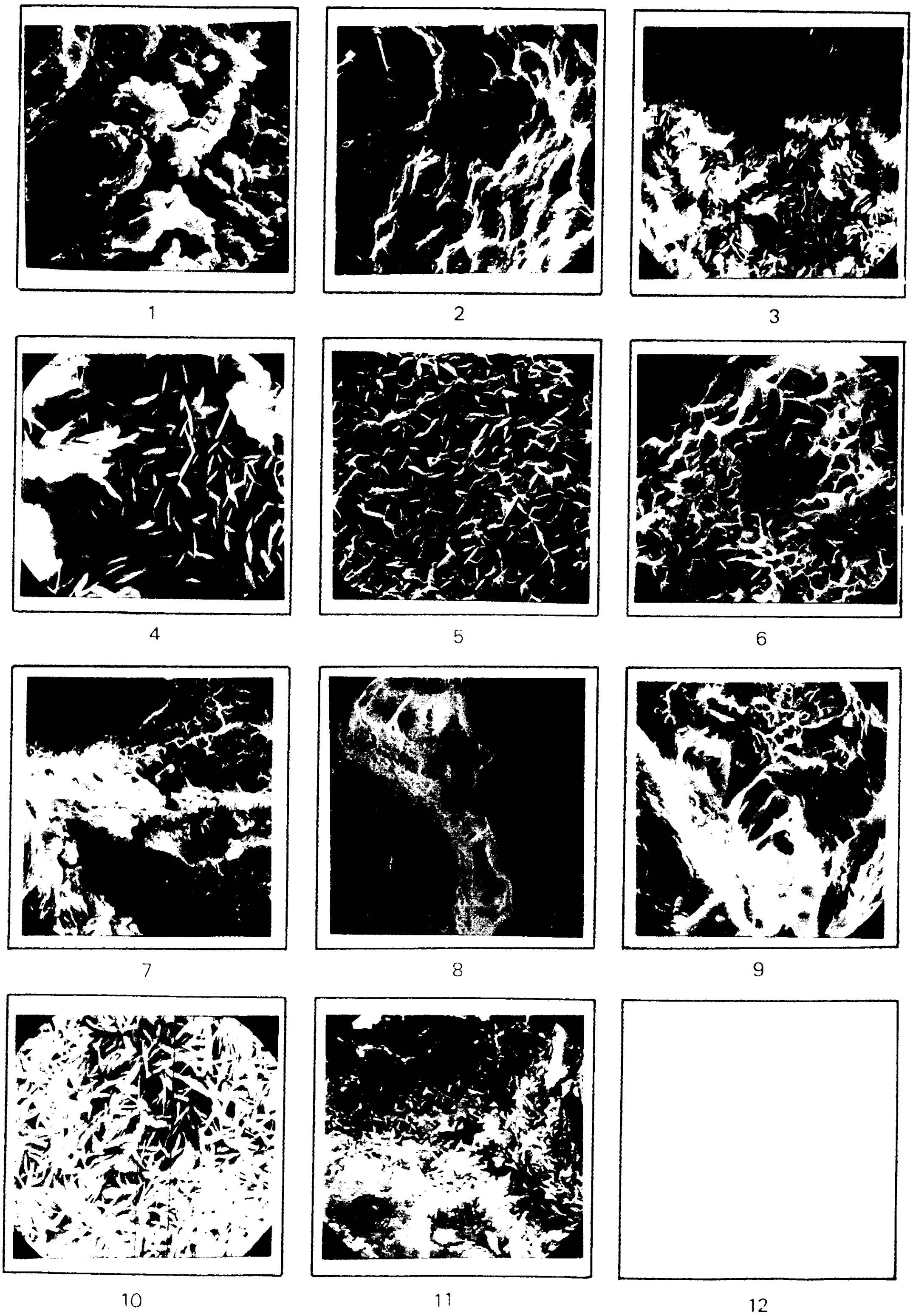

Figure 6: SEM photographs of variation of chlorite grain-coating cements with depth in Otway Group volcanogenic sandstones from Flaxmans-1 (captions over page).

Figure 6: Variation in chlorite morphology with depth in Flaxman's-1.

Core 29, 2333 m Flaxmans-1. R25291.

1. Poorly crystallized "swelling chlorite" pore lining. Width of field of view = 54 µm.
2. Poorly crystallized "swelling chlorite" films on apatite. Width of field of view = 79 µm.

Core 34, 2584 m Flaxmans-1. R 25294.

3. Well crystallized chlorite illustrating individual bladed crystals.
   Width of field of view = 87 µm.
4. Higher magnification of plate 3. Width of field of view = 32 µm.

Core 35, 2709 m Flaxmans-1. R25295.

5. "Swelling chlorite". Width of field of view = 32 um.

6. "Swelling chlorite". Width of field of view = 39 um.

7. "Swelling chlorite" films stretched across pore space. The grain at bottom centre is albitized plagioclase. Note also the small authigenic apatite.
   Width of field of view = 133 µm.
8. Unusual "swelling chlorite" films stretched across pore space.
   Width of field of view = 144 µm.
9. Higher magnification of "swelling chlorite" films stretched across pore space.
   Width of field of view = 79 µm.

Core 39, 3085 m Flaxmans-1. R25297.

10. Well crystallized chlorite. Width of field of view = 43 µm.

Core 44, 3513 m Flaxmans-1. R 25299.

11. Well crystallized chlorite almost completely occluding pore space.
    Width of field of view = 43 µm.

914415 078

PALYNOLOGICAL REPORT

914415 079

Palynological analysis of two composite cuttings samples from Boundary Creek No.1, onshore Gippsland Basin.

by

Alan D. Partridge

Biostrata Pty Ltd

A.B.N. 39 053 800 945

Biostrata Report 2001/29

18th September 2001

Palynological analysis of two composite cuttings samples from Boundary Creek No.1, onshore Gippsland Basin.

by Alan D. Partridge

Summary.

Two composite cuttings samples from the bottom of the shallow Boundary Creek No.1 bore located on the Baragwanath Anticline were analysed by palynology to confirm whether the Strzelecki Group had been penetrated. The shallower sample at 204–210m contained a mixed assemblage dominated by Early Cretaceous spore-pollen from the *C. paradoxa* Zone associated with minor spore-pollen from the Paleocene *L. balmei* Zone. The deeper sample at 210–216m also contained a mixed assemblage this time dominated by caved Eocene spore-pollen from the Latrobe Group assigned to the Lower *N. asperus* Zone, associated with relatively minor numbers of Early Cretaceous spore-pollen. The results confirm that the Strzelecki Group was penetrated below 204 metres.

Introduction.

The samples were dispatched by Lakes Oil N.L. directly to Laola Pty Ltd in Perth for urgent palynological processing on Friday 17th August 2001. Laola received the samples on the following Monday and shipped back the prepared slides by overnight courier the next day. These were received in Melbourne at 12:30pm on Wednesday 22nd August and verbal and written provisional reports were issued the same day.

The shallower sample analysed was a composite of cuttings at 204–07m and 207–10m, while the deeper sample was a composite of cuttings at 210–13m and 213–16m. Both samples gave high organic residues yields from which were prepared microscope slides containing high concentrations of spores and pollen. Zone determinations and age assignments resulting from the microscope examination of the slides are summarised in Table 1, while details of visual yield, palynomorph concentrations, preservation and species diversity are given in Table 2. Lists of Tertiary and Early Cretaceous species recorded are tabulated on Tables 3 and 4. Author citations for the species names can be sourced from Dettmann (1963, 1986) and Helby *et al.* (1987).

Discussion of Assemblages.

The palynomorph assemblage recovered from the shallower sample at 204–210m was dominated by the gymnosperm pollen *Podocarpidites* (36%) and *Microcachryidites antarcticus* (15%), and the spores *Osmundacidites wellmanii* (11%) and *Cyathidites* (10%). Associated with these longranging forms were rare to frequent Early Cretaceous species including *Ruffordiaspora* (al. *Cicatricosisporites*) *australiensis* and eponymous species of the *Coptospora paradoxa* Zone of Dettmann (1963). Mixed in with the dominant Early Cretaceous palynomorphs were rare Tertiary spores-pollen species including the eponymous species of the Paleocene *Lygistepollenites balmei* Zone of Stover & Partridge (1973). Although most of the recorded Tertiary species range into younger Eocene and zones there were no forms recorded that do not also occur in the *L. balmei* Zone. Therefore, unlike the deeper sample there is no evidence of any component in the assemblage that is definitely caved from the Eocene.

The palynomorph assemblage recovered from the deeper sample at 210–216m in contrast was dominated by pollen that generally only become common in Middle Eocene and younger rocks. These are a variety of *Nothofagidites* species which combined represent 26% of the count and the gymnosperm *Phyllocladidites mawsonii* which represents 35% of the count. Also conspicuous are the frequent occurrence of *Tricolpites/Tricolporites* pollen (8%) and *Haloragacidites harrisii* pollen (6%). The rare presence of the index species *Conbaculites apiculatus* ms, *Tricolpites simatus* and *Tricolporites leuros* confirms this Tertiary component in the assemblage is derived from the older part of the Lower *N. asperus* Zone of Stover & Partridge (1973). Associated with the dominant Tertiary pollen are rare spores diagnostic of the Early Cretaceous including *Crybelosporites striatus*, *Foraminisporis asymmetricus* and the distinctive megaspore *Arcellites reticulatus*. The sample interval is therefore interpreted to belong to the *Coptospora paradoxa* Zone, but with heavy down-hole contaminated from a shallower Middle Eocene Lower *N. asperus* Zone interval.

Geological Comments.

Both composite cuttings samples contain significant Early Cretaceous palynomorphs confirming that the interval sampled belongs to the Strzelecki Group. Mixed with, and at times dominating these older fossils, are Tertiary pollen diagnostic of both the Paleocene and Middle Eocene, which indicates that intervals of these ages within overlying Latrobe Group are present in the uncased section above the Strzelecki Group. A precise position of the boundary between the Strzelecki and Latrobe Groups is uncertain as no lithological data or electric logs where available during the preparation of this report.

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HELBY, R., MORGAN, R. & PARTRIDGE, A.D., 1987. A palynological zonation of the Australian Mesozoic. **In** *Studies in Australian Mesozoic Palynology,* P.A. Jell, editor, *Memoir Association Australasian Palaeontologists 4,* p.1–94.

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Table 1: Interpretative data from Boundary Creek No.1.

Sample Type	Depth metres	Spore-Pollen Zone	CR*	Comments and Key Species Present
Composite Cuttings	204–210	**Mixed assemblage** of **PALEOCENE** *L. balmei* Zone and **ALBIAN** *C. paradoxa* Zone	D3 D1	Assignment to *Coptospora paradoxa* Zone based on occurrence of eponymous species in association with secondary index species *Perotrilites majus* while the *Lygistepollenites balmei* Zone is identified by frequent occurrence of eponymous species.
Composite Cuttings	210–216	**Mixed assemblage** of **Middle EOCENE** Lower *N. asperus* Zone and **ALBIAN** *C. paradoxa* Zone	D2 D3	Eocene spore-pollen dominated by *Phyllocladidites mawsonii* 38% and *Nothofagidites* pollen 28% caved from higher in section. Albian spore-pollen rare but include distinctive megaspore *Arcellites reticulatus*.

***Confidence Ratings used in STRATDAT database and applied to Table 1.**

Alpha codes: Linked to sample		**Numeric codes:** Linked to fossil assemblage		
A	Core	**1**	**Excellent confidence:**	High diversity assemblage recorded with key zone species.
B	Sidewall core	**2**	**Good confidence:**	Moderately diverse assemblage recorded with key zone species.
C	Coal cuttings	**3**	**Fair confidence:**	Low diversity assemblage recorded with key zone species.
D	Ditch cuttings	**4**	**Poor confidence:**	Moderate to high diversity assemblage recorded without key zone species.
E	Junk basket	**5**	**Very low confidence:**	Low diversity assemblage recorded without key zone species.

Table 2: Basic assemblage data from Boundary Creek No.1.

Sample Type	Depth metres	Visual Yield	Palynomorph Concentration	Preservation	No. SP Species
Composite Cuttings	204–210	High	High	Poor-Good	41+
Composite Cuttings	210–216	High	High	Poor-Good	48+
				Averages:	**44+**

Table 3. Tertiary species list for Boundary Creek No.1.

Sample Type:	Composite Cuttings	Composite Cuttings
Depth:	204–210m	210–216m
SPORES-POLLEN		
Baculatisporites spp.		0.9%
Clavifera triplex		X
Conbaculites apiculatus †		X
Cyathidites paleospora		0.9%
Dicotetradites clavatus		X
Dilwynites granulatus	X	
Gleicheniidites circinidites		X
Haloragacidites harrisii		6.3%
Ischyosporites irregularis †		X
Liliacidites sp.	X	
Lygistepollenites balmei	X	
Lygistepollenites florinii	X	2.7%
Malvacipollis subtilis		3.6%
Microcachryidites antarcticus		1.8%
Nothofagidites brachyspinulosus	X	1.8%
Nothofagidites deminutus		3.6%
Nothofagidites emarcidus/heterus		20.5%
Nothofagidites goniatus		X
Parvisaccites catastus		X
Periporopollenites polyoratus	X	
Phyllocladidites mawsonii		34.8%
Podocarpidites spp.		7.1%
Proteacidites adenanthoides		X
Proteacidites annularis		2.7%
Proteacidites crassus		X
Proteacidites obscurus		0.9%
Proteacidites reticulatus		X
Proteacidites spp.	X	3.6%
Rugulatisporites mallatus	X	
Sapotaceoidaepollenites rotundus		X
Stereisporites australis		0.9%
Tricolp(or)ates spp.	X	8.0%
Tricolpites simatus		X
Tricolporites adelaidensis		X
Tricolporites leuros		X
Tricolporites paenestriatus		X
Triporopollenites ambiguus		X
Verrucosisporites kopukuensis		X
Total spores:		2.7%
Total Gymnosperms:		46.4%
Total Angiosperms:		50.9%
Total Spore-Pollen Count:		**112**

Table 4. Early Cretaceous species list for Boundary Creek No.1.

Sample Type:	Composite Cuttings	Composite Cuttings
Depth:	204–210m	210–216m
SPORE-POLLEN		
Aequitriradites spinulosus	X	
Araucariacites australis	4.3%	
Arcellites reticulatus		X
Baculatisporites spp.	1.7%	
Ceratosporites equalis	0.9%	X
Coptospora paradoxa	X	
Corollina torosa	0.9%	
Crybelosporites striatus	X	X
Cyathidites australis	0.9%	X
Cyathidites minor	9.6%	X
Cycadopites nitidus	X	
Dictyophyllidites spp.	0.9%	
Dictyotosporites complex		X
Foraminisporis asymmetricus		X
Gleicheniidites circinidites	2.6%	
Laevigatosporites ovatus	X	
Microcachryidites antarcticus	14.8%	X
Nevesisporites dailyi		X
Osmundacidites wellmanii	11.3%	X
Perotrilites majus	0.9%	
Podocarpidites spp.	35.7%	X
Reticulatisporites pudens	2.6%	
Retitriletes spp.	1.7%	X
Retitriletes austroclavatidites	X	
Retitriletes eminulus	X	
Retitriletes facetus	X	
Retitriletes nodosus	X	
Ruffordiaspora australiensis	1.7%	X
Stereisporites antiquisporites	2.6%	X
Trichotomosulcites subgranulatus	1.7%	
Trilete spores undiff.	5.2%	
Triporoletes reticulatus	X	
Total Spores:	43%	
Total Gymnosperms:	5%	
Total Spore-Pollen Count:	**115**	
Other Palynomorphs		
Fungal spores and hyphae	6.4%	
Sigmopollis carbonis	X	
Reworked Fossils	1.6%	
Annulispora microannulata	X	
Aratrisporites spp.	X	
Horriditriletes ramosa	X	X
Microbaculispora sp.	X	
TOTAL PALYNOMORPH COUNT:	**125**	

Palynological analysis of bottom hole sample from Boundary Creek No.1A, onshore Gippsland Basin.

by

Alan D. Partridge

Biostrata Pty Ltd
A.B.N. 39 053 800 945

Biostrata Report 2001/30

16th November 2001

Palynological analysis of bottom hole sample from Boundary Creek No.1A, onshore Gippsland Basin.

by Alan D. Partridge

Summary.

A single sample analysed from 324m near the bottom of the shallow Boundary Creek No.1A bore recovered an abundant Early Cretaceous assemblage that confirms the Strzelecki Group has been penetrated. Unfortunately, the assemblage lacked diagnostic index species and could not be assigned to a zone. Although the assemblage was moderately well-preserved and contained abundant specimens it was overwhelmingly dominated by spores (>93%) and was of relatively low diversity. In combination with the lack of index species these feature suggest a local floral and specialised environment.

Discussion.

The sample supplied was composed of 2cm long pieces of medium grey hard homogeneous mudstone which appear to be uncontaminated by down-hole cavings. About 14 grams of the sample was processed by Laola Pty Ltd to obtain a high residue yield which contained a high concentration of moderately well-preserved palynomorphs. Although four palynological slides were scanned, and these were estimated to contain >15,000 specimens only a moderate diversity assemblage of 25 spore-pollen and 3 algal species was recorded.

The assemblage was dominated by abundant smooth trilete spores of *Cyathidites minor* (62% of spore-pollen count), and contains frequent to common striate schizaeacean spores assigned to *Ruffordiaspora australiensis* (9%) and *Cicatricosisporites hughesii* (<2%). The last two species clearly mark the assemblage as Early Cretaceous in age based on the microfloral zones described by Dettmann (1963) and Dettmann & Playford (1969). The only other moderately common species are *Stereisporites antiquisporites* (5.3%), *Cyathidites australis* (4.7%), and *Osmundacidites wellmanii* (3.5%), all of which have longer ranges and are therefore not particularly age diagnostic.

While the overall assemblage confirms the sample is from the Strzelecki Group both the primary and secondary index species for the Early Cretaceous zones are conspicuously absent from the assemblage, and consequently the samples cannot be assigned to any zone. The only possibly age significant species is *Cicatricosisporites hughesii* which is a consistent accessory species in the Albian *C. striatus* to *C. paradoxa* Zones documented by Dettmann (1963). However, this species is not normally relied on for age dating as it is has also been recorded in my studies from the *B. enneabbaense* Zone in the Carnarvon Basin, which is basal Cretaceous (Berriasian) in age. The Albian age would however be consistent with *C. paradoxa* Zone recorded from between 204 and

216m in the adjacent Boundary Creek–1 bore (Partridge, 2001b), and the broader distribution of the *C. paradoxa* Zone in the onshore Gippsland Basin (Partridge, 2001a; table 1).

Finally, one single, poorly preserved, small specimen of a tricolpate angiosperm pollen was recorded in just one of the slides examined, but no importance is can be placed on its presence in the absence of other index species, so therefore it is interpreted as contamination.

The low diversity and difficulty in zoning the assemblage recovered from the sample is not the result of the usual problems encountered in the Strzelecki Group of low palynomorph recovery and poor preservation. The palynological slides contained abundant specimens (estimated as >3500 specimens per slide) and the preservation is good for the Strzelecki Group. The problem is that the assemblage is simply of low diversity, and no amount of additional searching of the slides is likely to find the required index species.

The low diversity of the assemblage, the overwhelmingly dominance of water-distributed spores (93.5% of the count), and low numbers of wind-distributed gymnosperm pollen (6.5% of count) suggest a depositional site that is somehow cut-off from the influence of regional (or average) vegetation. This could result from a specialised local floral environment or reflect a predominantly local source for the sediments. The rare presence of the algal cysts *Brazilea parva* (Cookson & Dettmann 1959), *Sigmopollis carbonis* (Newman 1965) and *S. hispidus* (Hedlund 1965) in the sample is indicative of the influence of fresh standing-water environments (Srivastava, 1984). However, these species are relatively common throughout the Strzelecki Group and may reflect nothing more than small, ephemeral ponds or billabongs within a fluvial depositional system. It is also unknown whether the algal cysts are *in situ* or have been transported to the depositional site. Overall the palynological assemblage points to a local depositional environment for the sample, but there is insufficient information to identify the geological conditions that allowed it to form.

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DETTMANN, M.E., 1963. Upper Mesozoic microfloras from southeastern Australia. *Proceedings Royal Society of Victoria, vol.77*, pt.1, p.1–148, pl.1–27.

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Table 1. Species list for Boundary Creek No.1A.

Sample Type:	Cuttings
Depth:	324m
Spore-Pollen	
Baculatisporites spp.	2.4%
Ceratosporites equalis	X
Cicatricosisporites hughesii	1.8%
Corollina torosa	1.8%
Cyathidites australis	4.7%
Cyathidites minor	61.8%
Dictyophyllidites spp.	X
Gleicheniidites circinidites	0.6%
Laevigatosporites ovatus	X
Matonisporites cooksoniae	X
Microcachryidites antarcticus	0.6%
Neoraistrickia truncata	X
Nevesisporites dailyi	X
Osmundacidites wellmanii	3.5%
Podocarpidites spp.	2.9%
Polycingulatisporites clavus	X
Retitriletes spp.	4.1%
Retitriletes austroclavatidites	X
Retitriletes eminulus	cf.
Retitriletes facetus	cf.
Ruffordiaspora australiensis	8.8%
Stereisporites antiquisporites	5.3%
Stereisporites pocockii	X
Trichotomosulcites subgranulatus	1.7%
Tricolpites sp.	?
Trilete spores undiff.	2.4%
Total Spores:	93.5%
Total Gymnosperms:	6.5%
Total Spore-Pollen Count:	170
Other Palynomorphs	
Fungal spores and hyphae	X
Brazilea parva	X
Sigmopollis carbonis	X
Sigmopollis hispidus	X

X = Present

SITE SURVEY

KLUGE JACKSON CONSULTANTS PTY. LTD.
A.C.N. 004 778 947
SURVEYORS, ENGINEERS AND ESTATE PLANNERS

914415 091

Office: Sale
Our Ref: 02191-01

DIRECTORS:
H. Peter Kluge
John Jackson

September 10th, 2002

Mr. J. Mulready,
Lakes Oil N.L.
Level 11, 500 Collins St,
Melbourne, Vic., 3000

Dear Sir,

RE: AMG and AHD Survey of Wells at Boundary Creek-1,
Deadman Hill-1 and Protea-1.

We have now completed the above survey and enclose our results.

The table of results shows the co-ordinates to the centre of the sign of the well head.

The levels are as indicated on sketch attached – Levels to the top of cap could not be taken at Boundary Creek and Protea as they were covered at time of survey.

Our AMG co-ordinates have been obtained from co-ordinated marks PM 18, PM 27 (Longford) and 3GI Radio Mast. The AMG co-ordinates are unadjusted using Topcon Total Station and should be of an accuracy of ± 10cm. Latitude and Longitude have been obtained by converting AMG co-ordinates to latitude and longitude.

The AHD levels were obtained from PM 33 and are correct to ± 0.05 cm.

If you have any queries in the matter please contact the writer.

We thank you for your instructions and enclose our account.

Yours faithfully,
KLUGE JACKSON CONSULTANTS PTY., LTD.

PETER KLUGE.
enc.

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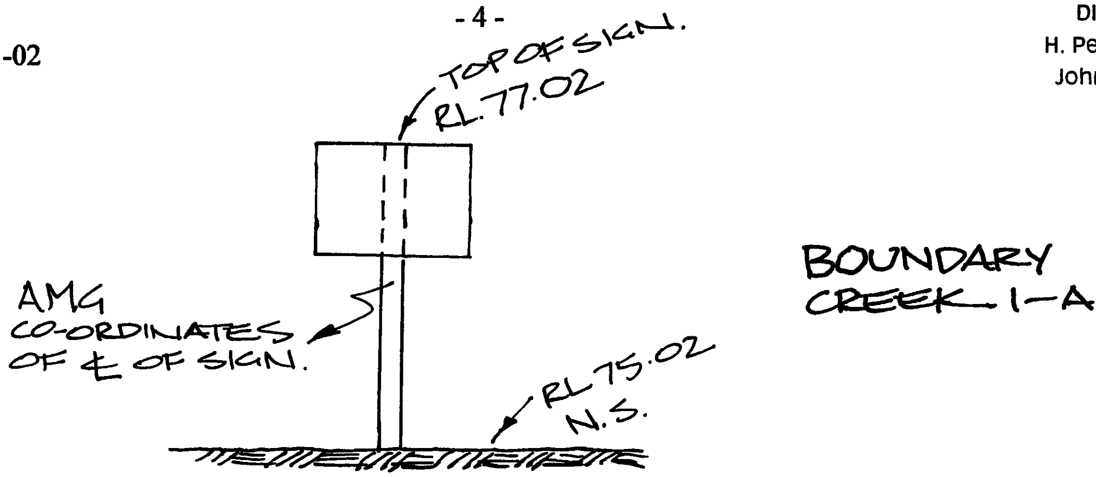

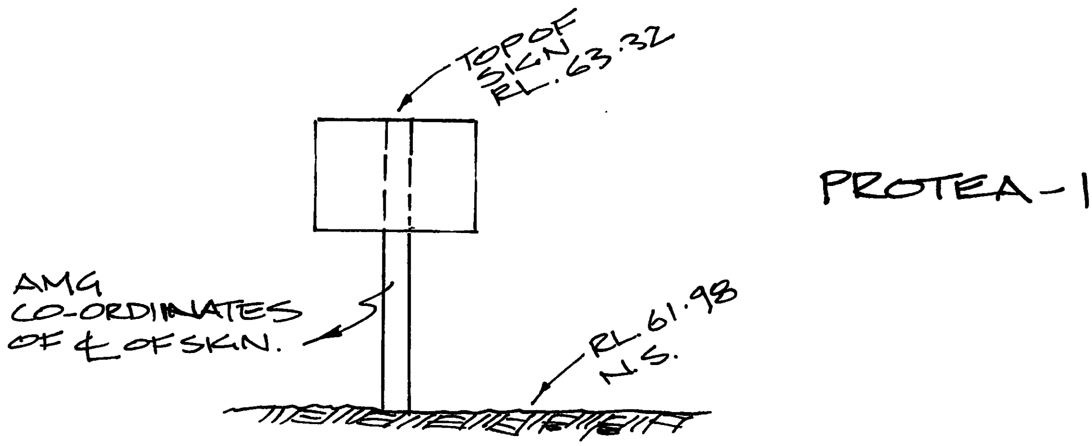

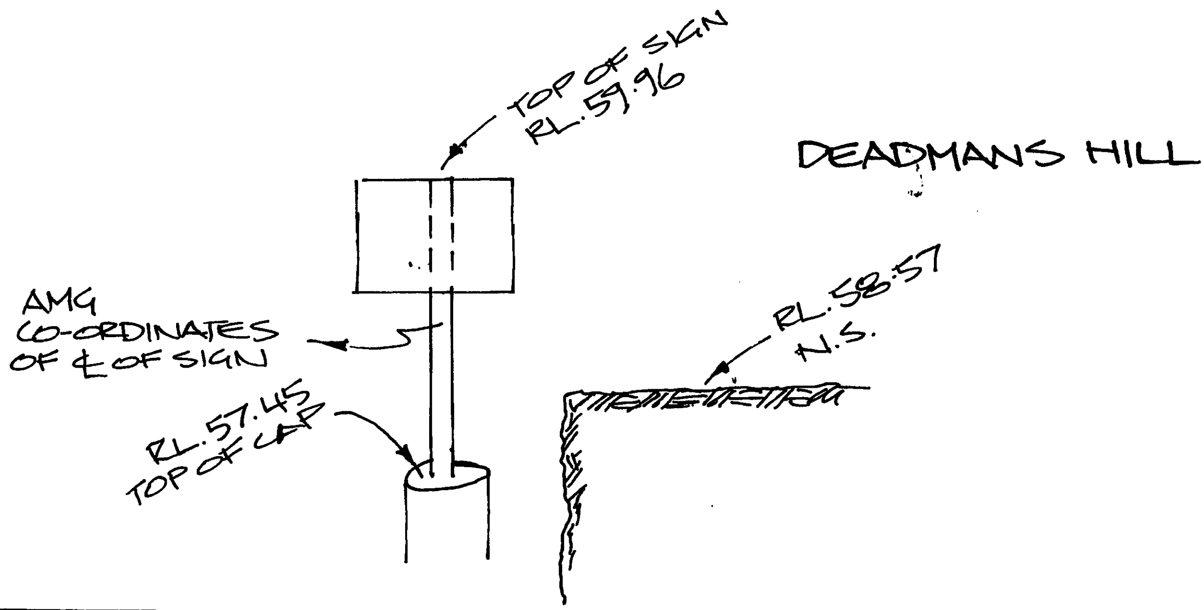

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914415 093

Office: Sale
Our Ref: 02191-02

DIRECTORS:
H. Peter Kluge
John Jackson

September 10th, 2002

TABLE OF SURVEY RESULTS

Boundary Creek - 1

AHD Level of Top of Sign	77.02
AMG Co-ordinate of Centre of sign.	Easting 511 422.91 Northing 5 772 873.47
Latitude	S 38°11'30.73"
Longitude	E 147°07'49.60"
Approximate AHD surface Level at Bore	75.02

The AMG coordinates shown above are for Zone 55.

Coordinates are in AGD 66.

.../3

SALE
45 Macalister Street,
SALE, Vic 3850
(P.O. Box 47)
Telephone (03) 5144 3877
Facsimile (03) 5144 6591

MAFFRA
119 Johnson Street,
MAFFRA Vic 3860
Telephone (03) 5147 2126

TRARALGON
Suite 3/29 Breed Street,
TRARALGON Vic 3844
(P.O. Box 412)
Telephone (03) 5174 4808
Facsimile (03) 5174 6969

CUTTING DESCRIPTIONS

LAKES OIL NL

Boundary Creek Stratigraphic Corehole
Cuttings Descriptions

Depth Interval m	Description
3	SANDSTONE: wht-clr-pl yell, vcg, occ pebbly, unconsol. qtz grns, minor wht cly matrix, subang-rd.
6	SST: a/a yell-pale brn qtz grains
9	SST: wht-clr-pl yell brn loose qtz grns, vcg-occ pebbly, sang rd, v.minor cly mtx adhering to grns
12	SST: a/a with common aggs of lt-med org-brn sst, vfg, well cmted, possibly calc.
15	SST: a/a v.mnr aggrgs. With thin bands wht-lt gy cly, soft, sticky.
18	SST: wht-clr, mnr pale brn, loose qtz grns, vcg-granular, occ. Pebbly, sang-rd, mnr wht cly mtx adhering to grns, occ lamination of soft wht kaolin.
21	SST: a/a
24	SST: a/a
27	SST: a/a mg, increased wht kaolin.
30	80% SST: dom clr, f-mg rare cg & pebbly, unconsol. qtz grns with suspected arg matx. 10% CLY: yellowish brn, soft 10% COAL: brn, soft, dull.
33	COAL: brn, soft-firm, sub-fissile silty, scattered mnr qtz grns f-mg
36	COAL: a/a mnr wht cly incl.
39	COAL: brn, soft-firm, slty, subfissile, with mnr wht arg content.
42	COAL: a/a rare blocky
45	COAL: a/a
48	COAL: a/a
51	COAL: a/a
54	COAL: a/a rare pyr.
57	COAL: a/a becoming very silty
60	SST: wht, clr, occ milky, translucent, c-vcg, well sorted, sang-srded, loose qtz grns, rare wht cly adhering to grns, clean Tr Coal: brn, firm, sl pyr, silty. **<7 inch casing point>**
63	SST: wht-clr, c-vcg, pebbly, clean srded loose qtz grns.
66	SST: a/a
69	SST: a/a but pred vcg-pebbly. Common tr. pyr.
72	SST: vcg-pebbly a/a Tr pyr.
75	20% SST: wht-clr loose qtz grns a/a 80% SST: wh-lt gy, vf-fg sang, kaol mtx, poor vis. por. tr coal
78	80% SST: wht-clr cg-pebbly as loose qtz grns srd 20% SST: wht-lt gy vfg-fg a/a Tr SLTST, gy arg.sdy
81	SST: wht-clr, cg-pebbly srded loose qtz grns

LAKES OIL NL

Boundary Creek Stratigraphic Corehole

Cuttings Descriptions

84	SST: a/a
87	90% SST wht-clr & gy, cg-coarse pebbles, srded loose qtz rns 10% cly, gy-brn, soft, sticky
90	SST: wht-clr & gy, m-cg loose qtz grns, qtz pebbles, srded
93	SST: wht-clr, cg-pebbly srded loose qtz grns
96	SILTST: gy-dk gy, soft, arg.
99	SST: wht-clr, cg-pebbly srded loose qtz grns Tr red staining
102	SST: wht-clr, c-vcg srded loose qtz grns
105	SST: wht-clr, cg-pebbly srded loose qtz grns
108	50% SST: a/a 50% CLAYST: 50% cST: wh-lt gy, soft, argill.
111	CLAYST: a/a
114	SST: wht-clr, translucent, some lt gy sang-srd c-vcg-granular loose qtz grns,rare pyr and carb frags
117	SST: a/a
120	SSt: wht-clr, lt gy, med-vcg, occ pebbly sang-srded looseqtz grns
123	40% SST: a/a 60% CLYST:, lt brn-wht,lt gy, soft, kaol, tr coal.
126	20% SST: a/a 80% CLYST a/a common tr. pyr.
129	90% SST: a/a 10% CLYST a/a
132	60% SST: a/a 40% CLYST a/a tr. coal
135	SST: wh-lt gy, pred cg to occ vcg srd well std loose qtz grns
138	SST: wh-lt gy, pred c-vcg & pebbly, srd loose qtz grns
141	SST: a/a Tr coal
144	90% SST: wht-clr, c-vcg, pred. pebbly srded loose qtz gns. 10% COAL: blk, firm. Tr lt brn soft clay
147	SST: wht-clr, c-vcg well sort srd loose qtz grns Comm tr cly a/a
150	SST: wht-clr, occ gy, c-vcg, pred. pebbly srded loose qtz gns.
153	SST: a/a
156	SST: a/a
159	SST: wht-clr, occ gy, c-vcg, occ pebbly srded loose qtz gns.
162	SST: a/a
165	SST: a/a
168	SST: wht-clr, occ gy, c-vcg, pred. pebbly srded loose qtz gns.
171	SST: wht-clr, occ gy, c-vcg, occ pebbly srded loose qtz gns.
174	90% CLAYST: lt brn, soft, arg. 10% SST: as loose srd qtz pebbles
177	SST: wht-clr, c-vcg, well sort srd loose qtz grns
180	SST: a/a

LAKES OIL NL

Boundary Creek Stratigraphic Corehole

Cuttings Descriptions

183	SST: wht-clr, occ gy, c-vcg, & pebbly sang-srded loose qtz gns.
186	SST: wht-clr, occ gy, c-vcg, pred. pebbly sang-srded loose qtz gns.
189	SST: a/a
192	SST:a/a
195	SST:a/a
198	80% SST: a/a 20% CYST: lt brn soft with carb flx Tr pyr Rare tr coal
201	SST: wh, clr lt gy mg-vcg & pebbly sang-srd loose qtz grns
204	CLYST: lt gy-brn,soft with carb flx
207	CLYST: a/a Common tr. Pyr
210	CLYST: a/a
213	30% CLYST: a/a 70% SST: lt gy vf-fg sang-srd qtz, fg felsp. argill. (Strzelecki FM) Comm Tr coal blk, dk brn, firm Tr pyr.
216	SST: lt gy-gy, a/a
218	SST: a/a **TD**

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CORE DESCRIPTIONS

LAKES OIL NL
BOUNDARY CREEK 1A COREHOLE
Core Descriptions

196.0-196.4 m (0.4 m)
Clay with connglomeratic qtz pebble bands.
Clay is lt gy, soft, plastic. Qtz pebbles are gy & milky, subrded. Pebbles and fragments range to 50 mm.

196.4-202.95 m (6.55 m)
Light grey argillaceous sandstone and sandy claystone with interbeds of conglomeratic quartz pebbles.
Sandstone is light grey, fine grained, subangular, well sorted, sl. micaceous, carbonaceous with frequent carbonaceous partings, argillaceous grading to sandy claystone.
Dip approx. 25 deg.
Pebbles and pebble fragments are quartzose, lt gy & milky, sub-rounded, up to 50 mm.
Background gas 0-3 units.
Thin interbed 197.3-197.38m of sst, lt gy, fg-vcg –gravel, poorly sorted, srded to rded qtz, comm. felspar in arg. matx. Good visual porosity.

202.95– 204.4 m ? (partial recovery) (1.45 m)
Interbeds of lt gy fg sandstone light grey, fine grained, subangular, well sorted, sl. micaceous, weathered felspar, carbonaceous with frequent carbonaceous laminathions, argillaceous, and lt-md gy claystone, soft, plastic, sl mic., pyritic with nodule bands throughourt, esp 203.9, 204.2 m
Dip 20-25 deg. Background gas 0-3 units.

204.4-207.27 m (2.87 m)
Claystone, lt-md gy, soft, plastic, pyritic. Frequent pyrite nodules.
80 degree fracture in claystone with slickenslides at 205.5m.
Dip aaprox. 20 deg.
Background gas 0-3 units

207.27-207.65 m (0.38 m)
Sandstone soft, lt gy, fg,well sorted, subrded, mic, pyritic, carb. consisiting of lt gy felspar qand med gy tz in an argillaceous (kaol?) matrix.
Background gas 0-4 units

207.65 – 214.70 m (7.05 m)
Sandstone: lt-md gy, fg, well sorted, subrded cons. of qtz, felsp. mica and coal frags in an arg matx. Common carbonaceous bands and laminations, tr pyr.
Dip varies 0-25 deg with marked changes in azimuth.
Vertical to sub vertical white striations of indeterminate soft white mineral. Origin uncertain - possible dewatering structure.
Also sub-horizontal fractures with slickenslides.
Background gas 1-2 units

214.70 – 214.82 m (0.82 m)
Sandstone: lt brn-fawn, fg, well sorted, subrded, cons. of qtz, felsp. mica in an arg. tuffaceous? matx.
Dip 0-12 deg

Background gas 1-2 units

214.82 – 233.10 m (18.28m)
<u>Sandstone</u>: lt-med gy f-mg well sorted, subrded cons. of qtz, felsp. mica and coal frags in an arg matx. Tr pyr. Common white subvertical striations a/a and from 222.0 – 226.65 m common sub-vertical fracturing (80 deg.). Clasts of shale at 221.75
Background gas 1-2 units, peak of 15 units at 230 m
Dip 0-12 deg
Backround gas 2-5 units, peak of 11 units at 235-236 m

233.1 – 236.65 m (3.55 m)
<u>Sandstone</u>: lt-md gy, mg, subang-srded, cons of lt gy and clr qtz and wh felsp in a sparse arg matx. Mic., carb., **good visual porosity.** Band of fissile v. carb sst lt-med gy f-mg well sorted, subrded cons. of qtz, felsp. mica and abundant coal frags in an arg matx. from 233.8-233.9 m. Prob. good por. Hydrocarbon odour noted when core freshly broken.
Dip 0-12 deg
Backround gas 2-5 units, peak of 11 units at 235-236 m

236.65 – 243.70 m (7.05 m)
<u>Shale</u>: lt-md-dk gy, firm, carb-v.carb. in part, mic. With thin interbeds of lbrn-cream tuff? & 0cc. sst interlaminations lt-md gy, fg, well sorted, subrded cons. of qtz, felsp. mica and coal frags in an arg matx. Tight.
Dip 0-12 deg
Backround gas 2-5 units, peak of 10 units at 240 m
Also 15 units of overnight gas.

243.7 - 245.45 m (1.75 m)
<u>Sandstone:</u> lt-md gy, consisting of fg, sang wh felspar,gy qtz, mica and carb. frags in an argillaceous matrix. Good visual porosity.
Background gas 0-3 units.
Dip 0-12 deg
Background gas 2-3 units.

245.45 – 252.13 (6.68 m)
Finely interbedded and interlaminated <u>sandstone and shale</u>
Sandstone is lt-md gy, firm, cos. of vf-fg sang felspar, quartz in an arg. matrix. Tight.
Shale: gy, firm, sdy grading to vfg sst. a/a
Dip 0-12 deg
Background gas 2-4 units.

252.13 – 265.5 m (13.37 m)
<u>Sandstone:</u> lt-md gy, consisting of f-mg, sang wh felspar, gy qtz, mica and carb. frags in an argillaceous matrix. Matrix more sparse in part, but still appears tight.
Dip 0-12 deg. High angle fracture at 263.5 m
Background gas 2-4 units

265.5 – 268.6 (3.1 m)
<u>Shale:</u> gry, firm, common partings with shiny slickenslides, silty, sdy in part with nterlaminations of sandstone, lt gy, vf-fg, well sorted, subrded, cons of wh felsp. Gy qtz, mica and common coal frags in an arg. matx. Tight. Dip 0-25 deg.

Background gas 2-4 units.

268.6 – 272.8 m (4.2 m)
Sandstone: lt gy, carb. f-mg, well sorted, sang-srded, cons of felsp. Lt gy qtz, mica and abdt coaly frags in an arg. matx. Tight.
Dip 0-10 deg
Background gas 2-4 units.

272.8 – 276.8 m (4.0 m)
Shale: gry, firm, sl mic. common partings with shiny slickenslides, silty, sdy in part with interlaminations of sandstone, lt gy, vf-fg, well sorted, subrded, cons of wh felsp. Gy qtz, mica and common coal frags in an arg. matx.
Dip 20 deg.
Background gas 2-4 units.

276.8 –285.41 m (8.61 m)
Sandstone: lt gy, carb. f-mg, well sorted, sang-srded, cons of felsp. Lt gy qtz, mica and abdt coaly frags in an arg. matx. Poor - fair visual porosity throughout.
Dip 25 Deg.
Background gas 2-5 units

285.41- 296.55 m (11.14 m)
Shale: lt gy silty-sandy, sl mic., sl carb. with interlaminations of sst. a/a
Thin very carb band at 292.5 with coaly laminations. Coal is black, earthy.
Dip 0-20 deg.
Background gas 4-10 units

296.55 – 316.6 m (20.05 m)
Sandstone: lt gy, silty at top but pred. lt gy, mg, well sort, sang-srded, cons. of felspar, qtz and carb. frags in an arg. matrix. Fair-good porosity.
Dip 0-20 deg.
Background gas 1-9 units

316.6 – 318.4 m (1.8 m)
Shale: lt-md gy, firm, silty, sl.mic., sl.carb., more carb. in part.
Dip 0-10 deg.
Background gas 0-2 units.

318.4 – 321.1 m (2.7 m)
Sandstone: lt gy, fg, srded, well sorted, cons. of wh felsp, lt–clr qtz , mica and carb spx in an arg matx. Rare tr poor porosity.
Interlaminations of shale a/a at top.
Dip 20 deg.
Background gas 0-2 units

321.1 – 324.68
Shale: : lt-md gy, firm, silty, sl.mic., sl.carb with occ. carb partings. Tr. pyr.
Dip 10-20 deg.
Background gas 0-2 units.

324.68 – 326.4 m (1.72 m)
Sandstone: lt gy. Fg, well sorted, srded, cons of wh felsplt gy to clr qtz and abd carb spx in an arg matx. Tight.
Dip 10-20 deg.
Background gas 0-2 units.

326.4 - 346.35 m (19.95 m)
Sandstone: lt-md gy, pred mg, well sorted, sang-srded, cons of wh felsp. lt gy to clr qtz and abd carb spx in an arg sl calc.matx. Tr pyr. Fair- good visual porosity.
Dip 10-20 deg.
Background gas 1-3 units.

346.35 – 347.96 m (1.61 m)
Sandstone: a/a with abundant shale clasts, from several mm to > core diameter. Some elongate, some subrounded.
Dip 0-20 deg
Background gas 0-3 units.

347.96- 348.72 m (0.76 m)
Sandstone: lt gy, vf-mg, mod sorted, cons of sang-srded wh felsp. Gry & clr qtz & mica in an arg. matx.. Good-excellent visual porosity.
Abundant flattened clasts of siltstone & shale.
Dip indeterminate
Background gas 0-3 units.

348.72-353.0 m (4.28 m)
Sandstone lt-md gy, vf-fg, consisting of sang wh. felspar, gy qtz & mica in an arg.matx, Tight. Interlaminated grey shale and siltstone. Dip to 30 deg.

353.0 – 354.18 (1.18 m)
Sandstone: lt-md gy, f-mg, well sorted, cons. Of sang-srded wh felsp, qtz & occ. mica in an arg. matx. Good visual porosity.

354.18-355.0 m (0.82 m)
Sandstone: a/a with large clasts of gy shale to 15 cm in length.

355.0 m- 355.18 m (0.18 m)
Shale: lt gy, hard.

355.18-358.82 m (3.64 m)
Sandstone: lt-md gy, f-mg, well sorted, cons. Of sang-srded wh felsp, qtz & occ. mica in an arg. matx. Good visual porosity.
Dip 20 deg.

358.82-361.5 m (2.68 m)
Shale: gy, firm, with high angle fracture (approx. 70 deg.) at 360.4 m
Occ. silty & sdy interlaminations & fine beds
Dip

361.5 – 363.2 m (1.7 m)
Interbedded and interlaminated Shale a/a & Sandstone: lt-md gy, fg sang-srded, sl. mic. cons. of wh felsp & qtz in an arg. matx. Tight.

363.2 – 363.44 m (0.24 m)
Sandstone: lt-md gy, fg sang-srded, sl. mic. cons. of wh felsp & qtz in an arg. matx. Rare tr. Porosity.

363.44 – 366.5 m (TD) (3.06 m)
Shale: gy firm with high angle fractures (poor reecovery)

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ENCLOSURE 1

Enclosure 1

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PE612385

This is an enclosure indicator page.
The enclosure PE612385 is enclosed within the container PE914415 at this location in this document.

The enclosure PE612385 has the following characteristics:

ITEM_BARCODE = PE612385
CONTAINER_BARCODE = PE914415
NAME = Boundary Creek-1A Production Log
BASIN = GIPPSLAND
ONSHORE? = Y
DATA_TYPE = WELL
DATA_SUB_TYPE = WELL_LOG
DESCRIPTION = Boundary Creek-1A Memory Production Log, Scale 1:200, Enclosure 1 of Well Completion Report
REMARKS =
DATE_WRITTEN = 22-SEP-2001
DATE_PROCESSED =
DATE_RECEIVED = 04-APR-2003
RECEIVED_FROM = Lakes Oil NL
WELL_NAME = Boundary Creek-1A
CONTRACTOR =
AUTHOR =
ORIGINATOR = Lakes Oil NL
TOP_DEPTH =
BOTTOM_DEPTH =
ROW_CREATED_BY = DN07_SW

(Inserted by DNRE - Vic Govt Mines Dept)

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ENCLOSURE 2

Enclosure 2

PE914416

This is an enclosure indicator page.
The enclosure PE914416 is enclosed within the container PE914415 at this location in this document.

The enclosure PE914416 has the following characteristics:

ITEM_BARCODE = PE914416
CONTAINER_BARCODE = PE914415
NAME = Boundary Creek-1 & -1A Mud Log
BASIN = GIPPSLAND
ONSHORE? = Y
DATA_TYPE = WELL
DATA_SUB_TYPE = MUD_LOG
DESCRIPTION = Boundary Creek-1 and Boundary Creek-1A Mud Log, Scale 1:500, Enclosure 2 of Well Completion Report
REMARKS =
DATE_WRITTEN =
DATE_PROCESSED =
DATE_RECEIVED = 04-APR-2003
RECEIVED_FROM = Lakes Oil NL
WELL_NAME = Boundary Creek-1A
CONTRACTOR =
AUTHOR =
ORIGINATOR = Lakes Oil NL
TOP_DEPTH = 200
BOTTOM_DEPTH = 366
ROW_CREATED_BY = DN07_SW

(Inserted by DNRE - Vic Govt Mines Dept)

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ENCLOSURE 3

Enclosure 3

PE914417

This is an enclosure indicator page.
The enclosure PE914417 is enclosed within the container PE914415 at this location in this document.

The enclosure PE914417 has the following characteristics:

```
      ITEM_BARCODE = PE914417
 CONTAINER_BARCODE = PE914415
              NAME = Boundary Creek-1 Composite Log
             BASIN = GIPPSLAND
         ONSHORE? = Y
         DATA_TYPE = WELL
     DATA_SUB_TYPE = COMPOSITE_LOG
       DESCRIPTION = Boundary Creek-1 and Boundary Creek-1A
                     Composite Log, Enclosure 3 of Well
                     Completion Report
           REMARKS =
      DATE_WRITTEN =
    DATE_PROCESSED =
     DATE_RECEIVED = 04-APR-2003
     RECEIVED_FROM = Lakes Oil NL
         WELL_NAME = Boundary Creek-1A
        CONTRACTOR =
            AUTHOR =
        ORIGINATOR = Lakes Oil NL
         TOP_DEPTH = 195
      BOTTOM_DEPTH = 366
    ROW_CREATED_BY = DN07_SW
```

(Inserted by DNRE - Vic Govt Mines Dept)