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I.D. No. 0035B/0061A

SDA 341

Petrologic/diagenetic investigation
of fifteen core samples from Bass 3,
Bass Basin, Australia

by

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January 1982

Shell Development (Australia) Pty Ltd

OR-0332C

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Appendix 1. Petrologic descriptions of samples from Bass-3

Illustrations

	<u>Dr. No.</u>
Fig. 1. Location map, Bass 3	13002

Plates

1	Bass 3	5018.75'	depth	Very fine argillaceous sandstone
2	"	5018.75'	"	Coarse lithoclast (sandstone) in very fine argillaceous sandstone
3	"	5018.75'	"	Microfracture filled with argillaceous matter
4	"	5033.5'	"	Silicified fossil forms a lithoclast in very fine sandstone
5	"	5319'	"	Glauconite aggregates in very fine sandstone
6	"	5319'	"	Lithoclast composed of quartz/glauconite in very fine sandstone
7	"	5621'	"	Carbonaceous laminae in very fine silty sandstone
8	"	5621'	"	Very fine, silty, slightly bimodal sandstone
9	"	5621'	"	Pyrite concretion in fine silty sandstone
10	"	5636.17'	"	Porous quartz siltstone
11	"	5636.17'	"	Pores in quartz siltstone
12	"	5911.83'	"	Carbonaceous lamina in very fine calcareous sandstone
13	"	5911.83'	"	Very fine carbonaceous sandstone cemented by calcareous cement
14	"	5911.83'	"	Calcareous cement in very fine sandstone
15	"	6913.17'	"	Carbonaceous stringers in sandy micaceous siltstone
16	"	6913.17'	"	Carbonaceous stringer (magnified) in sandy micaceous siltstone
17	"	6919.25'	"	Carbonaceous body in silty shale
18	"	6930.25'	depth	Fine-medium sandstone partly cemented by calcareous cement
19	"	6930.25'	"	Partly fractured muscovite
20	"	7441.5'	"	Bimodal, medium-microconglomeratic sandstone
21	"	7441.5'	"	Siltstone lithoclast

22	Bass-3	7441.5'	"	Sandstone lithoclast
23	"	7441.5'	"	Sandstone lithoclast and kaolinite
24	"	7441.5'	"	Polycrystalline pebble
25	"	7441.5'	"	Shale (pebble) lithoclast
26	"	7441.5'	"	Sandstone pebble with authigenic quartz overgrowth - a lithoclast in medium-microconglomeratic sandstone
27	"	7441.5"	"	"Ghost" outlines of detrital grain replaced by calcareous cement
28	"	7448.92'	"	Siltstone with occasional sand-size grains
29	"	7452'	"	Wackestone with coarse lithoclasts
30	"	7452'	"	Lithoclast of quartz/mica sandstone

Summary

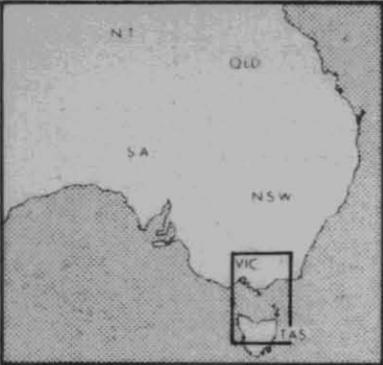
Fifteen core samples from Bass-3 were investigated petrologically in order to determine their composition, diagenesis and reservoir characteristics (depth range ^{2271 - 1529} 7452'-5018'9"). The majority of these samples are fine clastics of Palaeocene/Eocene age, ranging in grain size from shale to medium grained, dominantly argillaceous sandstone. Only one sample is a coarse sandstone, composed of medium to microconglomeratic grains

The coarse sandstone is composed of quartz, polycrystalline quartz (mainly reworked sandstone), lithoclasts and accessory amounts of muscovite and tourmaline. Kaolinite is abundant, it occurs as pseudomorphs after (?)feldspar and as authigenic intergranular clay. Rhombic calcareous matter, probably dolomite partly replaces the clay-matrix and partly corrodes some of the detrital grains.

The siltstones (with one exception), wackestones and fine to medium sandstones are usually laminated and often bioturbated and contain variable amounts of matrix composed of clay, muscovite, siderite, pyrite and occasionally biotite; glauconite is present in the shallow samples (5322'2"-5018'9"). Diagenetically late carbonate, probably dolomite, is abundant in some of the samples from below 5900' depth.

The siltstone from ¹⁷¹⁷5636'2" is composed essentially of quartz and minor amounts of lithoclasts and diagenetic kaolinite.

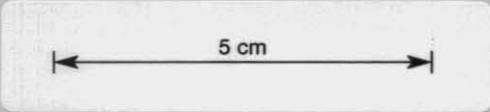
The porosities of the sediments range from 7% to 27% and effective permeabilities from nil to 68mD. The most porous sediment is the quartz siltstone from 5636'2". Compaction is the main porosity reducing agent in the sediment down to 5700' depth. Authigenic quartz and calcareous cement are additional pore-reducing factors below that depth. The wackestones, argillaceous siltstones and fine sandstones have no effective permeability below 5900' depth. The relatively low permeabilities of the other sediments are due to their fine grain size and/or the presence of depositional or diagenetic clay.



146°

148°

333006



VICTORIA

MELBOURNE

38°

Gippsland Basin

BASS STRAIT

40°

BASS-3

Bass Basin

LAUNCESTON

TASMANIA

42°



146°

SHELL - AUSTRALIA E. & P. OIL AND GAS.

LOCATION MAP

BASS-3

Author SDA
Report No. 342

Date DEC. 1981
Drawing No. 13002

FIG. 1

1. Introduction

Fifteen (core) samples from Bass-3 were investigated petrologically with a view to determine their composition, diagenesis and reservoir characteristics (depth 7452'-5018'9"). This investigation forms part of a study aimed at comparing the potential reservoir sandstones of the Bass Basin with those of the Gippsland Basin (Fig. 1).

The Esso/BHP well Bass-3 was drilled in the Bass Basin in 1967 (Lat 39°59'59"S, Long 145°16'57"E). The well penetrated 3568' of Neogene limestones and marls, 935' of Oligocene shale and marls, 785' of Eocene clastics, mainly siltstone and shale, 2240' of mixed clastics and coal of the Eastern View Coal Measures - of the latter 890' were of Eocene age and 1350' of Palaeocene age. The well terminated in metamorphic basement at 7978' bdf (2432m).

A small gas show was encountered from 6744'-39'.

2. Material investigated and mode of presentation

The samples were porosity/permeability plugs cut (by BMR) from cores 5 to 8, 10 and 11. From the ends of these plugs thin sections were prepared and were examined microscopically at SD(A) under polarising and reflected light. The samples (ends of plugs) and the porosity/permeability data were obtained from the Bureau of Mineral Resources.

The petrological descriptions of individual samples are presented in Appendix 1. The percentages of rock constituents shown in these petrological descriptions are visual estimates made from thin sections and/or rock specimens. Thirty plates of polaroid microphotographs are attached to illustrate some of the textural, petrological and diagenetic features of the sediments.

3. Composition and diagenesis of sediments

3.1 Samples examined

A total of 15 samples was investigated of which 14 were of known porosity and 13 were of known permeability. The samples (porosity plugs) were cut from cores 5, 6, 7, 8, 10 and 11. The samples of Cores 5 to 8 are of Eocene age and those of Cores 10 and 11 of Palaeocene age. The depth range of the samples is from 7452' to 5018'9".

3.2 Composition of sediments

The majority of samples examined were fine grained clastics, i.e. shale (Pl 25), siltstone (Pl 16), wackestone (Pl 29) and fine sandstone; only three samples were fine to medium grained sandstones and one was a medium to microconglomeratic sandstone. A characteristic feature of the sandstones investigated is the high proportion of quartzitic grains (c. 82-90%) among the framework minerals. The remaining framework constituents are lithoclasts (5-10%), feldspars (nil to 5%), mica (1-7%) and heavy minerals (trace to 2%) in that order of abundance. Exceptions are the samples from core 8 (5911'0 and 5913'7" depth), which contain a high proportion of lithoclasts, mainly argillites and altered grains.

The majority of the quartzitic grains are quartz grains of single optical orientation. Polycrystalline quartz (i.e. metaquartzite (Pl 24), orthoquartzite (Pl 26), vein quartz) make up about one tenth of the quartzitic grains and chert about one twentieth of the quartzitic grains.

The feldspars are predominantly of orthoclase composition; plagioclase was observed only very occasionally (i.e. in the sample 5913'7"). No feldspars could be identified in the samples below 6930' depth. The lithoclasts are argillites, arenites (Pl 2) and altered, often kaolinised, grains (some of which could be

pseudomorphs after volcanics and feldspars). In the coarse sandstone from 7441'6" and wackestone from 7452', both from the lowermost sequence investigated, the lithoclasts include shale (Pl 25), siltstone (Pl 21), quartzitic sandstone cemented with authigenic quartz (Pl 26), micaceous sandstone (Pl 22, 30), and grains of volcanic origin. The heavy minerals are tourmaline, zircon and rutile. Silicified/pyritised fossils were observed in the argillaceous very fine sandstone from 5033'5" depth (Pl 4).

Some glauconite and aggregates composed of glauconite are present in the samples of Eocene age (5322'2-5018'9 depth, Pl 5 and 6). Carbonaceous matter is present in various amounts and occurs as disseminated submicroscopic matter in the matrix, as reworked fragments (Pl 1, 8), as carbonaceous stringers (Pl 7, 15, 16) or laminae (Pl 12) and as carbonised plant remains (probably plant-root in situ) as eg the sample from 6919'3" depth (Pl 17). In some cases the carbonaceous matter is replaced by pyrite.

Pyrite also occurs as concretions (Pl 9) and is an abundant mineral in the sample 5036'5". Siderite is common in the very fine Palaeocene/Eocene sandstone and siltstone where it is often associated with carbonaceous layers. Dolomite is the principal pore-fill in the sandstone from 5911'10" and 7441'6" depth.

The matrix is composed of a micaceous/argillaceous aggregate with a varying amount of kaolinite and carbonaceous matter (Pl 2, 5). In the very coarse sandstone (7441'6" depth) kaolinite is the only recognisable intergranular clay (Pl 23), in this sample the kaolinite occurs also as large grain-size particles probably pseudomorphs after feldspar.

Samples of argillaceous sandstone from shallow horizons show some fracturing. Some of these fractures are filled with kaolinite-like clay (Pl 3).

3.3 Diagenesis

Compaction, the kaolinisation of chemically unstable grains and the deposition of siderite are the principal post-depositional processes undergone by the siltstones and fine sandstones. The authigenic growth of quartz on the detrital quartz grains is moderately advanced in most samples but only in the quartz rich siltstone (Pl 10, 11) and sandstones does it occur in greater quantities. Calcareous cement of early diagenetic origin (i.e. siderite) occurs mainly in the fine grained carbonaceous sediments. The calcareous cement (presumably dolomite) introduced at a later stage (Pl 18 and 19) is present in significant quantities in three samples i.e. 5911'10" (Pl 13 and 14), 6930'4", and 7441'6" depth (Pl 23, 27). Pyrite seems to be localised to carbonaceous horizons and occurs as a replacement of carbonaceous matter or as concretions (Pl 9).

The following diagenetic sequence is thought to have taken place in the investigated sandstones of Bass-3:

- deposition of siderite
- kaolinisation of grains,
- authigenic growth of quartz,
- introduction of (?)dolomite.
- partial replacement of pre-existing matter by (?) dolomite

Compaction has been in progress throughout the geological history of the sediment and is the main diagenetic process in the argillaceous sediments. In the sample 7441'6" a mineral resembling gypsum occurs in small quantities. This mineral seems to post-date the dolomite cement, which it replaces. The complete absence of feldspars in the lowermost samples is attributed to in situ alteration of feldspars into kaolinite.

3.4 Porosity and Permeability

The measured (BMR) porosities of the samples investigated range from 7 to 27% and permeabilities from nil to 68mD. The samples

7.

with the lowest porosity i.e. 7-8% are the siltstones/wackestones from the lowermost core (samples 7448'11" and 7452' depth, Pl 28 and 29) and the very fine sandstone cemented by calcareous cement (sample 5911'10", Pl 13 and 14). The clean, quartz-rich siltstone (sample 5636'2", Pl 10, 11) and sandstone (sample 5641'8") have the best porosities i.e. 27% and 25% and moderately good permeabilities 58mD and 50mD respectively. The rather low porosity (14%) of the coarse arenite (7441'6" depth) is due to the abundance of dolomite cement (Pl 27) and its relatively low permeability (25 mD) is attributed to the abundance of intergranular kaolinite.

4. Comments

The Esso/BHP and BMR porosity/permeability data (Ref 1) indicate the presence of sandstones with better porosities than those of the samples investigated. The permeability/porosity ratio is rather low for the porous sandstones from Bass-3. This clearly reflects that the measured samples are fine-grained, and/or contain depositional diagenetic matrix.

Even a cursory examination of SP log (ref 1), shows that the cored sections do not represent the most favourable potential reservoir sandstones in the Palaeocene-Lower Eocene section (7830'-5590" depth). In the Middle-Upper Eocene section (above 5590' depth) the sandstones are fine and (unless very clean) of poor reservoir quality.

The predominance of detrital grains of sedimentary origin i.e. shale, siltstone and various types of sandstone in the sample from 7441'6" (coarse arenite), indicates that sedimentary terrain provided a significant amount of detritus for the Palaeocene sandstones in the Bass 3 area. The diagenetic features of the reworked sandstone, such as the state of authigenic quartz overgrowths, indicate that these (reworked) sandstones were, at some stage, buried to approximately 2000 metres depth, prior to their uplift, erosion and transportation to their present location in the Bass 3 area.

The diagenetic minerals also indicate the change in environment of deposition of the sediments penetrated in Bass 3 from the predominantly terrestrial/lagoonal deposits in the Palaeocene to the predominantly marine sequence in the upper part of the Middle-Upper Eocene.

5. References

1. Esso Bass No. 3. Well Completion Report Esso Exploration and Production (Aust) Inc, April 1967.
2. A Review of Petroleum Exploration and Prospects in the Bass Basin, by Robertson C.S., Nicholas E., and Lockwood K.L., Bureau of Mineral Resources, Australia, Record 1979/5.

Appendix 1. Petrologic descriptions of samples from Bass-3

- 1 Core (c) or cutting (DC)
- 2 Strewn sample examined
- 3 Thin section examined

333016

SAMPLE			DEPTH		AGE	%	DESCRIPTION	DIAGENESIS/OTHER COMMENTS
1	2	3	FEET	METRES				
C5	X	X	5018'9"	1529.6	EO(U)	100	<p>Sst, slt, arg, dk brn, vf-f occ v crs grains, mod srt, ang-subrnd, bioturbated, irregular streaks of argillite;</p> <p>Composed of</p> <p>55% Qz</p> <p>7% Polyqz (Qz Sst, Vein Qz)</p> <p>3% Cht</p> <p>1% Fld (Plag, Orth)</p> <p>10% Lcl (Argillites, altered grains, Glc aggreg)</p> <p>2% Micas (Musc)</p> <p>2% Glc (bleached)</p> <p>tr Heavy Min (Tourmaline)</p> <p>tr Opaque Min (Fe-oxide)</p> <p>2% Py</p> <p>18% Matrix (arg/mic dk brn, probably carb)</p> <p>The sediment seem to consist of pallets of fine arenites and argillites, Py occurs as spherical concretions and as bodies of irregular outline - probably replacement of plant-matter. Locally fracture system - parallel to sub-parallel to bedding plane.</p>	<p>Porosity 18.0%</p> <p>Permeability 8mD</p> <p>Sp Gravity 2.71</p> <p>Low visual porosity, some open fractures. Compaction, and pyritisation are the main post-depositional changes.</p> <p>Pore-reduction is due to compaction and the abundance of matrix.</p>

- 1 Core (c) or cutting (DC)
2 Strawn sample examined
3 Thin section examined

333017

SAMPLE			DEPTH		AGE	%	DESCRIPTION	DIAGENESIS/OTHER COMMENTS
1	2	3	FEET	METRES				
C5	X	X	5033'6"	1534	EO(U)	100	<p>Sltst, s, arg, mod srt, ang-rnd, dk gy; irregular arg streaks & Lam, bioturbated; Composed of</p> <p>55% Qz 5% Polyqz (Vein Qz, silicified Foss) 3% Cht 4% Fld (Orth, Plag) 5% Lcl (Qz/Fld Sst, Argillites, Glc aggregates) 1% Mica (Musc) tr Heavy Min (Tourmaline) 7% Py tr Carb matter 20% Matrix (brn/red, argill, mic)</p> <p>Numerous Py bodies - very small to millimetric; patchy distribution of matrix; some Qz grains angular, elongated - probably corroded after deposition; straight and plastically deformed micas are present; some Cht grains seem to be recrystallised Vo; Veinlets, parallel to bedding, partly filled with clay minerals.</p>	<p>Porosity 20% Permeability not determined SP Gravity 2.74 Low visual porosity, well developed fracture system subparallel to bedding. Main diagenetic processes are compaction and formation of pyrite bodies (partly replacement/partly authigenic). Porosity reduction is mainly due to compaction & the presence of arg/mic matrix.</p>

- 1 Core (c) or cutting (DC)
- 2 Strewn sample examined
- 3 Thin section examined

333018

SAMPLE			DEPTH		AGE	%	DESCRIPTION	DIAGENESIS/OTHER COMMENTS
1	2	3	FEET	METRES				
C6	X	X	5319	1621.2	E0(M-U)	100	<p>Sst, arg, vf-crs, poor srt, ang-subrnd dk brn, clay drapes, lam; Composed of 65% Qz 5% Polyqz tr Cht 4% Fld (Orth) 4% Lcl (Qz/Glc Sst) 1% Mica (Musc) and occ Chlorite tr Heavy Min (Zircon) tr Opaque Min tr Glc 1% Py 20% Mtx (clay and carb matter) detrital grains float in dk brn (?)ferruginous matrix or form loosely packed aggregates; matrix dk brn probably ferruginous clay with some very fine carbonaceous matter, slightly bioturbated with "collapse" structures; some Qz grains with auth overgrowths.</p>	<p>Porosity 23% Permeability 20mD Sp Gravity 2.70 Moderately good visual porosity, some pores interconnected by fractures. Compaction is the main post-depositional process. Pore reduction is due to compaction and the abundance of matrix.</p>

- 1 Core (c) or cutting (DC)
- 2 Strewn sample examined
- 3 Thin section examined

333019

SAMPLE			DEPTH		AGE	%	DESCRIPTION	DIAGENESIS/OTHER COMMENTS
1	2	3	FEET	METRES				
C6	X	X	5322'2"	1622.2	EO(M-U)	100	<p>Sst, arg, mic, f-m, poorly srt, ang-subrnd, mainly subang, some lamination, occ clay drapes;</p> <p>Composed of</p> <ul style="list-style-type: none"> 65% Qz 5% Polyqz 3% Fld (Orth) 5% Lcl (argillites, altered grains) 1% Mica 1% Heavy Min (Zircon, Tourmaline) 1% Glc 1% Py 3% Clay drapes 15% Matrix (clay and (?)carb matter) <p>detrital grains surrounded by brn translucent matrix - probably ferruginous, stained clays; micas straight and bent; matrix seems to be depositional.</p>	<p>Porosity 23.0%</p> <p>Permeability 30mD</p> <p>Sp Gravity 2.67</p> <p>Low visual porosity-isolated pores, mainly secondary. Compaction is the main post-depositional process. Pore reduction is due to compaction and the abundance of matrix.</p> <p>Measured permeability (30mD) seems to be too high for this type of sediment.</p>

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Appendix₁
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- 1 Core (c) or cutting (DC)
- 2 Strewn sample examined
- 3 Thin section examined

333020

SAMPLE			DEPTH		AGE	%	DESCRIPTION	DIAGENESIS/OTHER COMMENTS
1	2	3	FEET	METRES				
C7	X	X	5621	1713.3	EO	100	<p>Sst, slt, carb, vf to f (0.02-0.2mm), bim, subang-subrnd, burrowed, gy with dk lam; Composed of 75% Qz 2% Polyqz 3% Fld (Orth, Mcr) 6% Lcl (Argillites) 4% Mica (Musc) 5% Phyllosilicate (yellowish, flaky ?chlorite) 1% Heavy Min (brn Tourm, Zircon) tr Py (concretions) 4% Carb matter tr Calc matter Numerous carbonaceous Lam, some containing bifurcating carb stringers; both fine and silty grains are predominantly composed of Qz; Py occurs as relatively large concretions; feldspars are fresh.</p>	<p>Porosity 21% Permeability 11% Sp Gravity 2.69 Moderately good visual porosity - pores are of minute dimensions. Compaction is the main post-depositional process; authigenic quartz overgrowth are at an early stage of development. Pore reduction is due to compaction, the presence of phyllosilicates and to a lesser degree, by authigenic quartz overgrowths. Relatively low permeability is due to fine grain-size.</p>

- 1 Core (c) or cutting (DC)
2 Strewn sample examined
3 Thin section examined

333021

SAMPLE			DEPTH		AGE	%	DESCRIPTION	DIAGENESIS/OTHER COMMENTS
1	2	3	FEET	METRES				
C7	X	X	5636'2"	1717.9	EO	100	<p>Sltst, qz, average grain-size 0.04mm, occ f grains (up to 0.1mm), slightly bim, subang-subrnd, occ Lam; Composed of 80% Qz and Polyqz tr Fld 8% Lcl (Argillites, altered grains) 4% Musc (Musc) 2% Heavy Min (Zircon, Tourmaline, Rutile) 1% Opaque grains (?Leucoxene) tr Carb matter 1% Calc matter (sid) 4% Matrix (kao) Minute authigenic overgrowths on detrital quartz; very few recognisable feldspars; rather high amount of heavy minerals.</p>	<p>Porosity 27% Permeability 58mD Sp Gravity 2.65 Good visual porosity. Main diagenetic processes were compaction and formation of authigenic quartz overgrowths on detrital quartz. Pore-reduction is due to tight packing of detrital grains (compaction), the presence of matrix and authigenic Qz overgrowths. The calc cement has only minimal effect on the porosity reduction in this sediment.</p>

BASS-3

Appendix 1
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- 1 Core (c) or cutting (DC)
- 2 Strewn sample examined
- 3 Thin section examined

333022

SAMPLE			DEPTH		AGE	%	DESCRIPTION	DIAGENESIS/OTHER COMMENTS
1	2	3	FEET	METRES				
C7	X	X	5641'8"	1719.4	EO	100	<p>Sst, slt, mic, vf, srt, subang-subrnd, lam, gy; Composed of 75% Qz 2% Polyqz 4% Cht tr Fld 5% Lcl (Argillites, altered grains) 7% Mica (Musc, Biot) 2% Heavy Min (Tourm, Zircon, Rutile) 2% Dark matter (?iron-oxides) 3% Carb matter</p> <p>The specimen consists of clean Sst and Sst with carb Lam; the clean Sst is composed of equidistal Qz, Lcl and opaque grains (probably heavy minerals) and is porous, Qz grains have small authigenic overgrowth; Laminated Sst contains laminae composed of muscovite, heavy mineral and dk flakes, partly biotites partly carbonaceous matter.</p>	<p>Porosity 25% Permeability 50mD Sp Gravity 2.62 Good visual porosity. Main diagenetic changes are compaction, kaolinisation and authigenic quartz growth on detrital quartz. Pore reduction is due to compaction and authigenic quartz formation. Permeability is affected by the very fine grain-size of the sediment.</p>

- 1 Core (c) or cutting (DC)
- 2 Strewn sample examined
- 3 Thin section examined

333023

SAMPLE			DEPTH		AGE	%	DESCRIPTION	DIAGENESIS/OTHER COMMENTS
1	2	3	FEET	METRES				
C8	X	X	5911'10"	1801.9	E0	100	<p>Sst, slt, carb, calc, vf (0.02-0.1mm), srt, subang-subrnd, lam, gy, some burrows; Composed of 40% Qz 5% Polyqz (Vein Qz) 3% Cht 1% Fld (Orth) 7% Lcl (Argillites and altered grains) 4% Mica (Musc) tr Heavy Min (Tourmaline) 1% Opaque Min (Py concretions) 30% Calc (?Dol & Sid) 4% Carb 5% Matrix Sediment cemented by calc (?Dol) cement except in parts occupied by carb Lam; carb cement corrodes detrital grains; carb Lam are composed of carbonaceous stringers, micas and siderite; originally the sediment was tightly packed; the apparent open packing in the sandy parts of the Sst are due to corrosion of detrital grains by calc cement.</p>	<p>Porosity 7% Permeability nil Sp Gravity 2.74 Very low visual porosity. Main diagenetic processes are compaction cementation by calcareous cement, corrosion of detrital grains, formation of Py-concretions and deposition of siderite. The last two processes took place diagenetically early. Low porosity is due to the presence of calcareous cement in sandy portions of the sediment and due to compaction/dissolution in carbonaceous (Lam) parts of the sediment.</p>

- 1 Core (c) or cutting (DC)
2 Strewn sample examined
3 Thin section examined

333024

SAMPLE			DEPTH		AGE	%	DESCRIPTION	DIAGENESIS/OTHER COMMENTS
1	2	3	FEET	METRES				
C8	X	X	5913.7	1802.4	EO	100	<p>Sst, carb, silt, vf, mod srt, subang-subrnd, lam, gy; Composed of 40% Qz 6% Polyqz 4% Fld (Mcr, Orth, Plag) 22% Lcl (altered grains) 3% Mica (Muscovite, biotite) tr Heavy Min (Zircon, Tourmaline, Rutile) tr Glc tr Opaque grains (?leucoxene, Py, Fe-oxide) tr Calc (Sid) 10% Carb matter 15% Matrix (Kao, carb particles, fine mica) About half of the specimen examined consists of very fine sandstone and the other half of carbonaceous/micaceous siltstone with sandy bands; carbonaceous Lam are invariably associated with Musc, Biot and ferruginous matter.</p>	<p>Porosity 13% Permeability nil Sp Gr 2.69 Low visual porosity, isolated secondary and intergranular pores; some well developed fractures parallel to bedding. Main diagenetic processes have been compaction and alteration of detrital grains. Pore reduction is due to compaction and abundance of fine and flaky matter particularly of muscovites and carbonaceous stringers.</p>

BASS-3

Appendix 1
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- 1 Core (c) or cutting (DC)
- 2 Strewn sample examined
- 3 Thin section examined

333025

SAMPLE			DEPTH		AGE	%	DESCRIPTION	DIAGENESIS/OTHER COMMENTS
1	2	3	FEET	METRES				
C10	X	X	6913'2	2107.1	PC	100	<p>Sltst, s, carb, mic, srt, subang-subrnd, Composed of 40% Qz 5% Fld (Orth) 10% Lcl (altered grains, argillites) 10% Mica (Musc) 2% Heavy Min (Zircon, Tourmaline, Rutile) 5% Carb matter 10% Calc (Sid) 18% Mtx (Kao, fine micas) Anastomosing carbonaceous stringers, Musc flakes, small siderite nodules and crystals disseminated throughout the rock; preferential alignment of grains although some mica flakes are haphazardly oriented.</p>	<p>Porosity 10% Permeability nil Sp Gravity 2.73 No visual porosity. Compaction is the main post-depositional change. Porosity reduction is due to compaction and the abundance of micaceous/silty matter.</p>

BASS-3

Appendix 1
Page 11

- 1 Core (c) or cutting (DC)
- 2 Strewn sample examined
- 3 Thin section examined

333026

SAMPLE			DEPTH		AGE	%	DESCRIPTION	DIAGENESIS/OTHER COMMENTS
1	2	3	FEET	METRES				
C10	X	X	6919'3"	2109	PC	100	Sh, slt-s composed of Kao, sericite, and Sid (nodules & crystals) groundmass in which float very fine Qz, Musc, Kao, opaque grains and Sid particles; abundance of Tourmaline; large carbonaceous body is probably carbonised plant-root; Kao occupies cracks (or cavities) within the carbonised matter.	Main post-depositional changes are compaction, deposition of clay and carbonisation of organic matter.

- 1 Core (c) or cutting (DC)
- 2 Strewn sample examined
- 3 Thin section examined

333027

SAMPLE			DEPTH		AGE	%	DESCRIPTION	DIAGENESIS/OTHER COMMENTS
1	2	3	FEET	METRES				
C10	X	X	6930.4	2112.4	PC	100	<p>Sst, calc, f-m, srt, subang-subrnd; Composed of 60% Qz 3% Polyqz (Vein Qz, Qz schist, Cht) 9% Lcl (argillites, altered grains) 1% Mica (Musc & bleached Biot) 2% Heavy Min (Tourmaline, Rutile) tr Opaque Min 10% Kao grains 10% Calc matter (Dol) tr Carb matter 5% Matrix (Kao & disintegrated slt fragments) Grain-size bodies of Kao, probably replacement of Fld & ?Biot; patchy distribution of Dol; Dol crs-crystalline, it fills pores and corrodes detrital grains; advanced authigenic Qz overgrowths among adjoining Qz grains.</p>	<p>Porosity 17% Permeability 68mD Sp Gravity 2.67 Moderately good visual porosity - partly secondary. Main diagenetic processes have been kaolinisation of chemically unstable grains - mainly feldspars, growth of authigenic Qz overgrowths, cementation (and corrosion of detrital grains) by dolomite & compaction. Pore reduction is due to pore-fill by dolomite, kaolinite and authigenic quartz.</p>

- 1 Core (c) or cutting (DC)
- 2 Strewn sample examined
- 3 Thin section examined

333028

SAMPLE			DEPTH		AGE	%	DESCRIPTION	DIAGENESIS/OTHER COMMENTS
1	2	3	FEET	METRES				
C11	X	X	7441'6"	2268.2	PC	100	<p>Sst, m-microcgl, mod srt, subrnd; Composed of 40% Qz 14% Polyqz (old Sst, Metaqtz) 4% Cht 5% Lcl (Sltst, Qz/sericite Sst, Sh, altered Vo, calc grains) 1% Mica (Musc) 2% Heavy Min (Tourmaline yel & deep green) 20% Calc (Dol) and (?)Anh 4% Kao 10% Kao matrix Kao occurs as grains (pseudomorphs after some altered mineral) and as intergranular matrix; advanced authigenic Qz overgrowths on some Qz grains; much of intergranular volume is occupied by coarse crystalline Dol; Dol corrodes & replaces detrital grains; (?)Anh partly replaces Dol.</p>	<p>Porosity 14% Permeability 25mD Sp Gravity 2.70 High visual porosity is not representative. Main diagenetic processes were formation of authigenic quartz, formation of kaolinite, alteration of some minerals into kaolinite, introduction of dolomite and compaction; less-widely spread process is introduction of sulphates (?)Anh. Dolomite severely corrodes some detrital grains. Pore reduction is due to (diagenetic) kaolinite filling pores, cementation by dolomite and (to a lesser degree) by authigenic quartz.</p>

BASS-3

Appendix 1
Page 14

- 1 Core (c) or cutting (DC)
- 2 Strewn sample examined
- 3 Thin section examined

333029

SAMPLE			DEPTH		AGE	%	DESCRIPTION	DIAGENESIS/OTHER COMMENTS
1	2	3	FEET	METRES				
C11	X	X	7448'11"	2270.4	PC	100	Sltst, arg to s, gy; composed of clay-sericite groundmass in which float detrital grains of Qz, Polyqz, Mica, Heavy Min (Tourmaline) and opaque minerals (Py); dispersed carbonaceous stringers; about 90% of the rock is composed of siltstone-size components; very occ calcareous pallets.	Porosity 7% Permeability nil Sp Gravity 2.67 No visible porosity. Main diagenetic process is compaction. Porosity reduction is due to compaction and the abundance of very fine grained matrix.

BASS-3

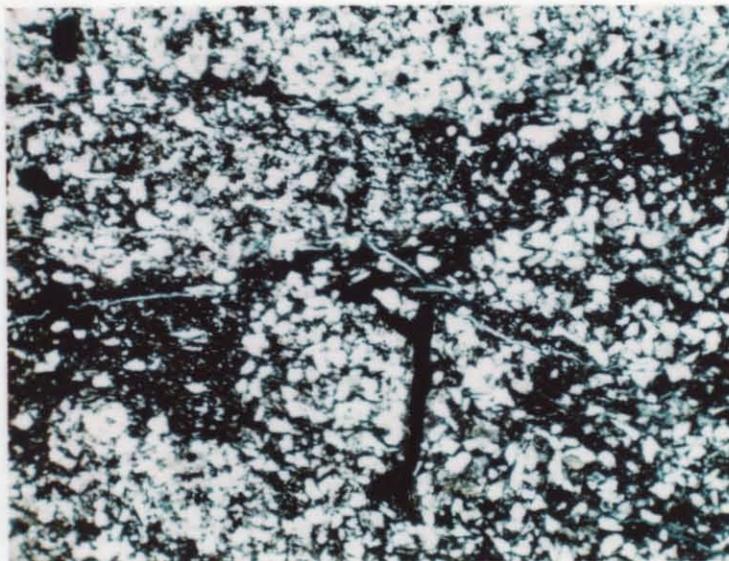
Appendix 1
Page 15

- 1 Core (c) or cutting (DC)
- 2 Strewn sample examined
- 3 Thin section examined

333030

SAMPLE			DEPTH		AGE	%	DESCRIPTION	DIAGENESIS/OTHER COMMENTS
1	2	3	FEET	METRES				
C11	X	X	7452'	2271.4	PC	100	Wkst, slt-gran; grains of Qz, Polyqz, Lcl Mica, kaolinised grains, heavy minerals and calcareous grains float in silty/clayey matrix composed of clay (mainly kao), mica, heavy minerals, opaques and other very fine grains of the same composition as the crs components; lithoclasts are phyllites, mic Sst, kaolinite, partly kaolinised Vo, grains composed of chlorite, siltstone, orthoquartzite, metaquartzite, quartz/mica aggregates (?pegmatite); relatively high proportion of heavy minerals particularly tourmaline; about 60% of the rock is composed of matrix size components.	Porosity 8% Permeability nil Sp Gravity 2.68 Very low visual porosity - mainly intra-granular. Main diagenetic processes are compaction and kaolinisation. Low porosity is due to compaction and the presence of mic/arg matrix.

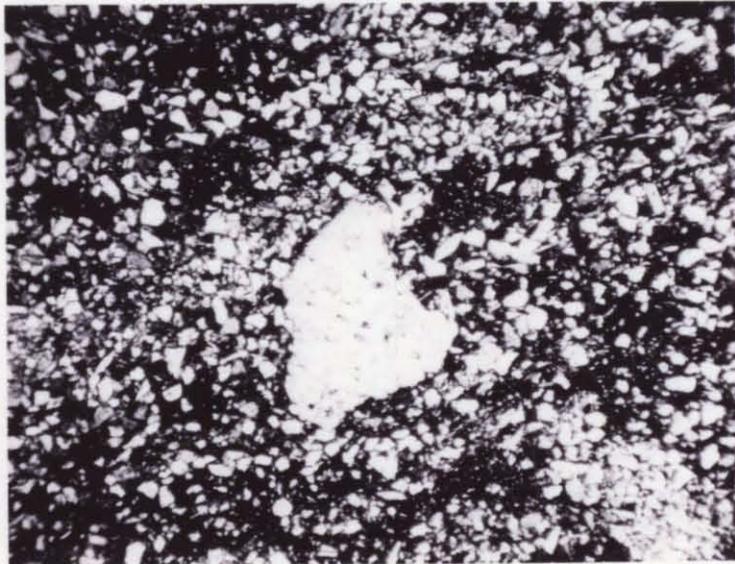
333031



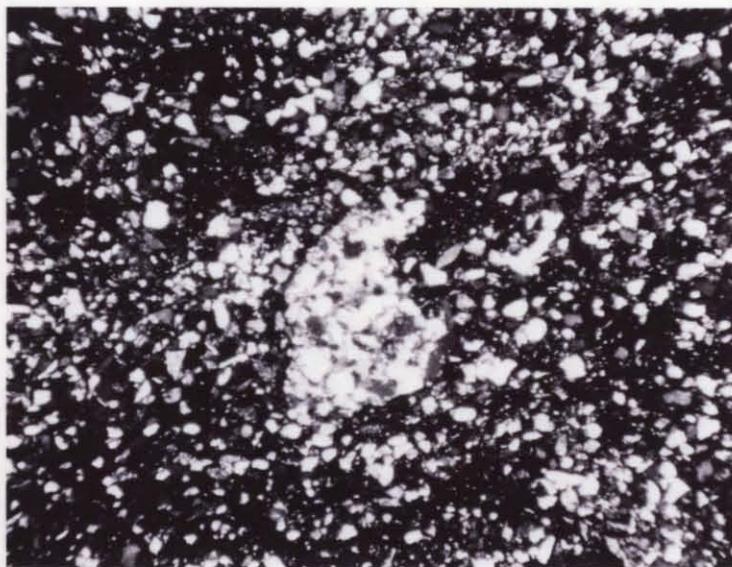
Bass-3 5018.75' depth, Eocene. Very fine sandstone with argillaceous matrix (brown) and carbonaceous fragments (black). Blue epoxy shows visual porosity and microfractures. Porosity 18%, permeability 8 mD (x 37, plane-polarised light).

5 cm

5 cm

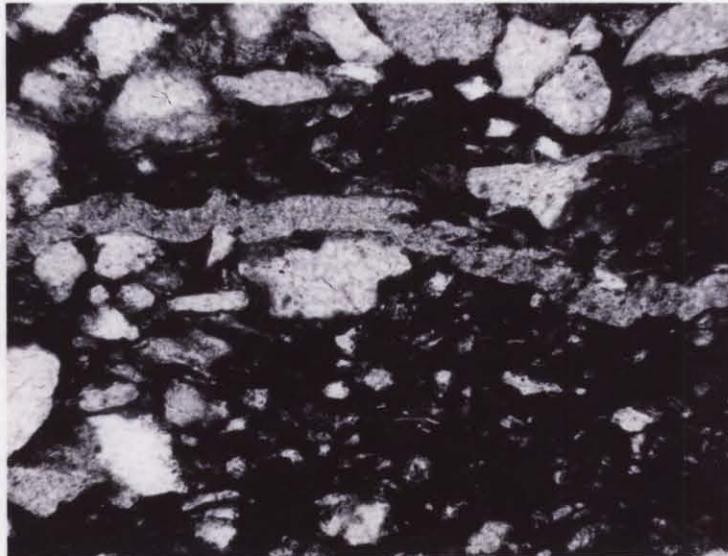


Bass-3 5018.75' depth, Eocene. Very fine sandstone with argillaceous matrix. Occasional coarse lithoclasts composed of reworked sandstone (centre, white). Porosity 18%, permeability 8 mD (x 37, plate-polarised light).

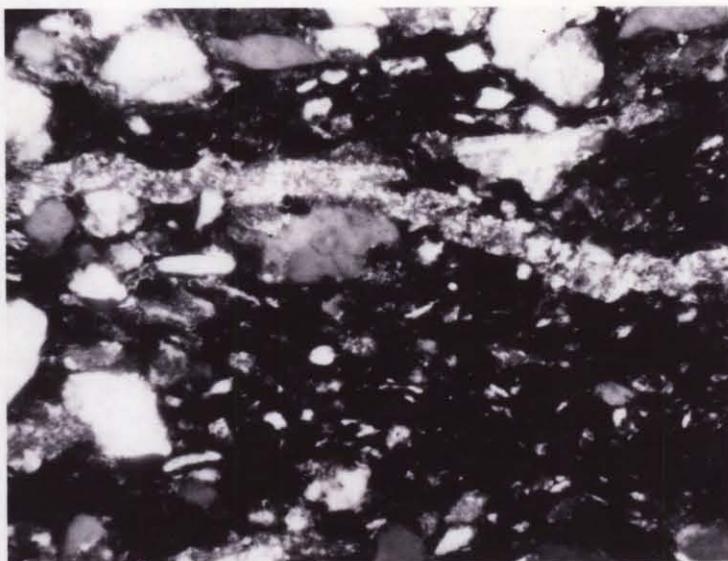


As above, crossed nicols

5 cm



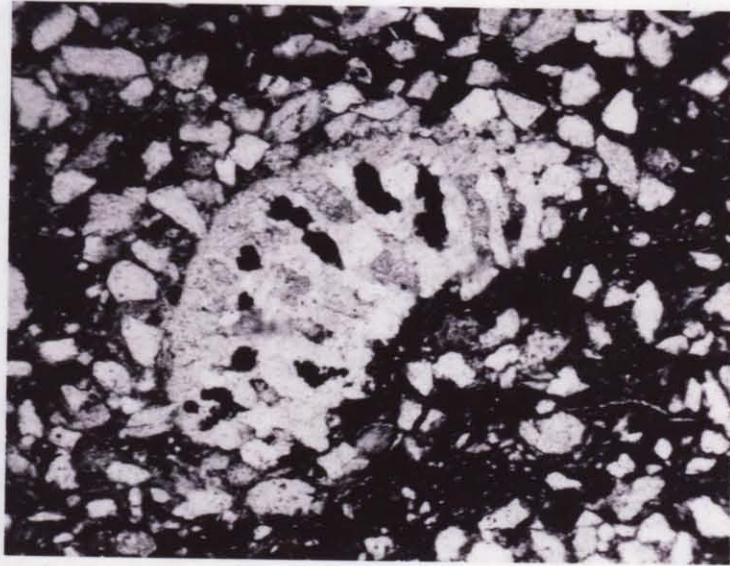
Bass-3 5018.75' depth, Eocene. Microfractures in very fine argillaceous sandstone. The micro-fracture (grey) is filled with clay mineral resembling kaolinite (x 230, plane-polarised light).



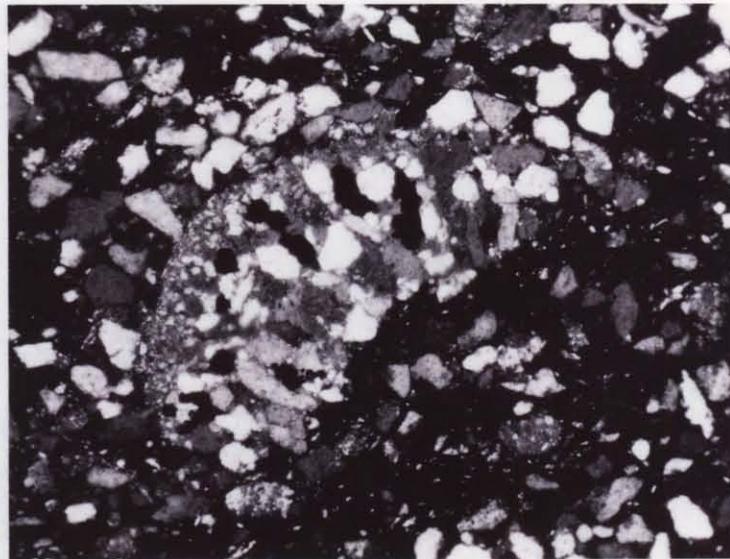
As above, crossed nicols

333034

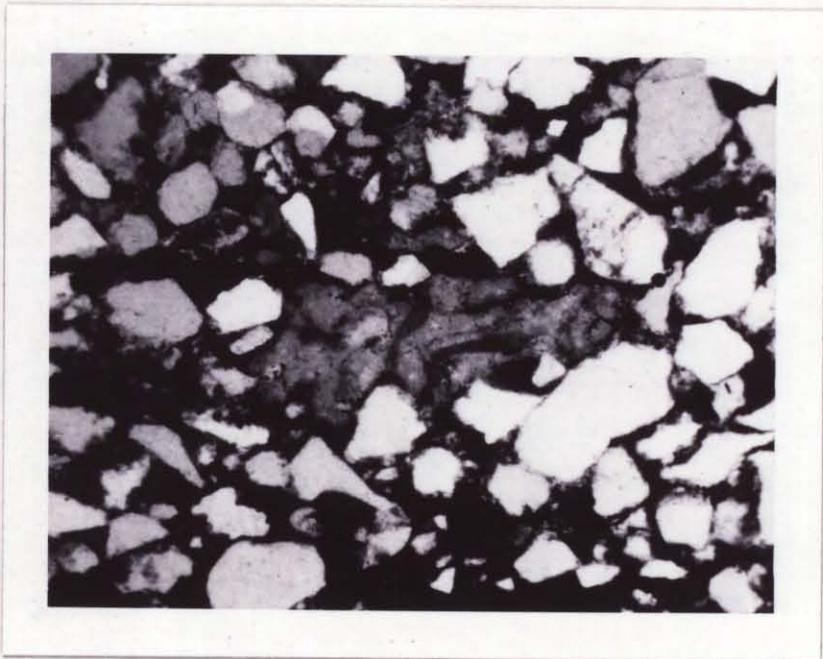
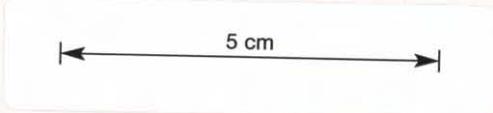
5 cm



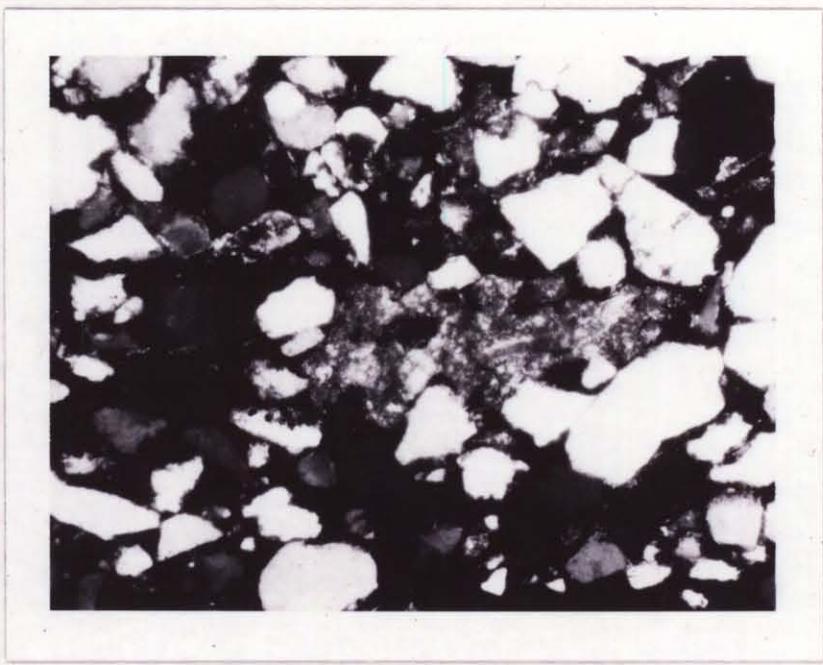
Bass-3 5033.5' depth, Eocene. Siliceous lithoclast (? silicified fossil) in argillaceous very fine sandstone. Porosity 20% (x 92, plane-polarised light).



As above, crossed nicols

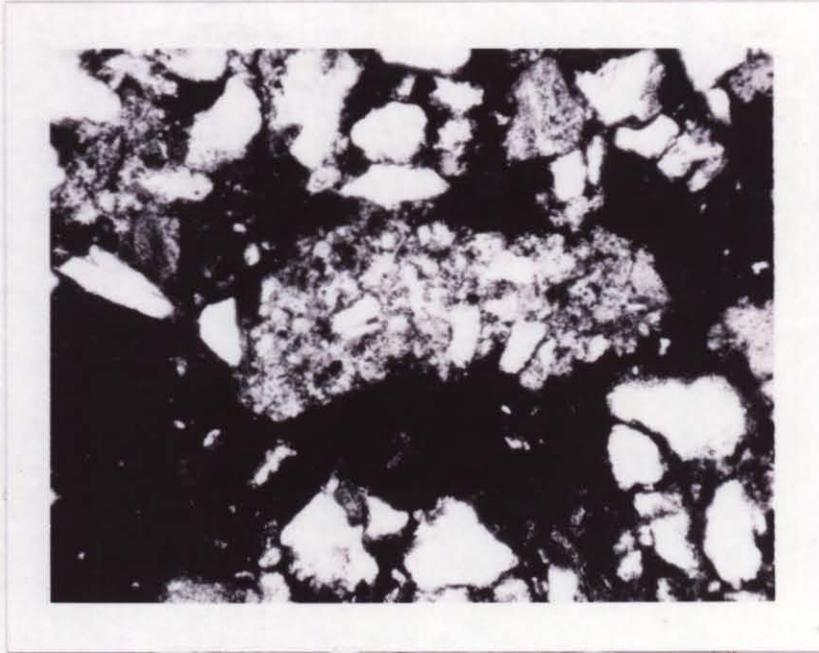


Bass-3 5319' depth, Eocene. Very fine sandstone composed of quartz and argillaceous matrix with occasional glauconite grains and aggregates composed of glauconite (centre). Porosity 23%, permeability 20 mD (x 92, plane-polarised light).

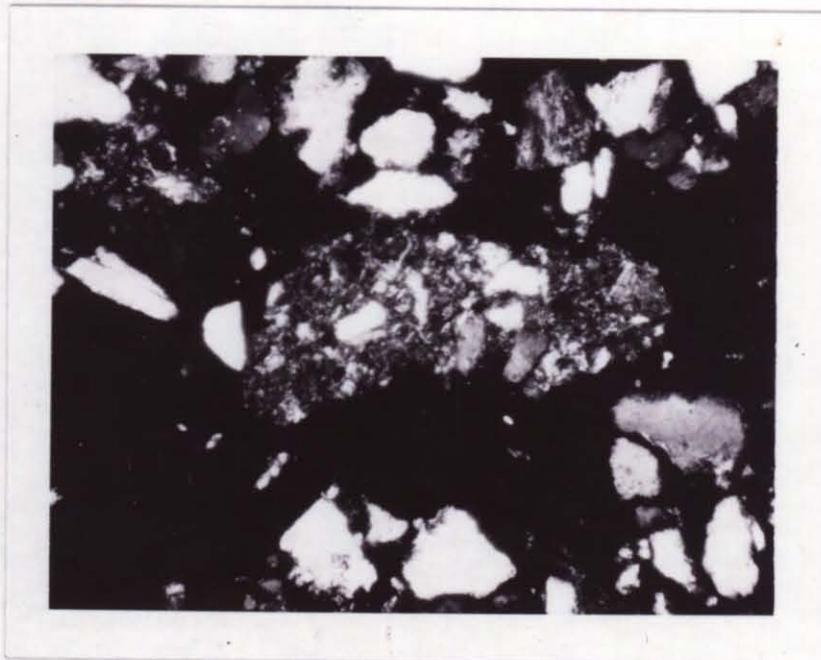


As above, crossed nicols

5 cm

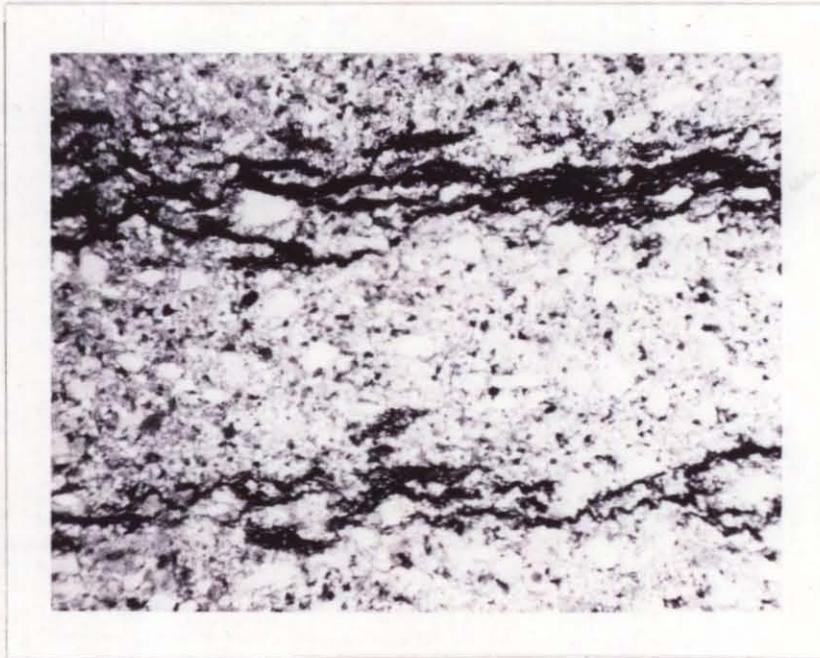


Bass-3 5319' depth, Eocene. Quartz/
glauconite sandstone (grey, centre)
forms a lithoclast in very fine
argillaceous sandstone (x 92,
plane-polarised light).

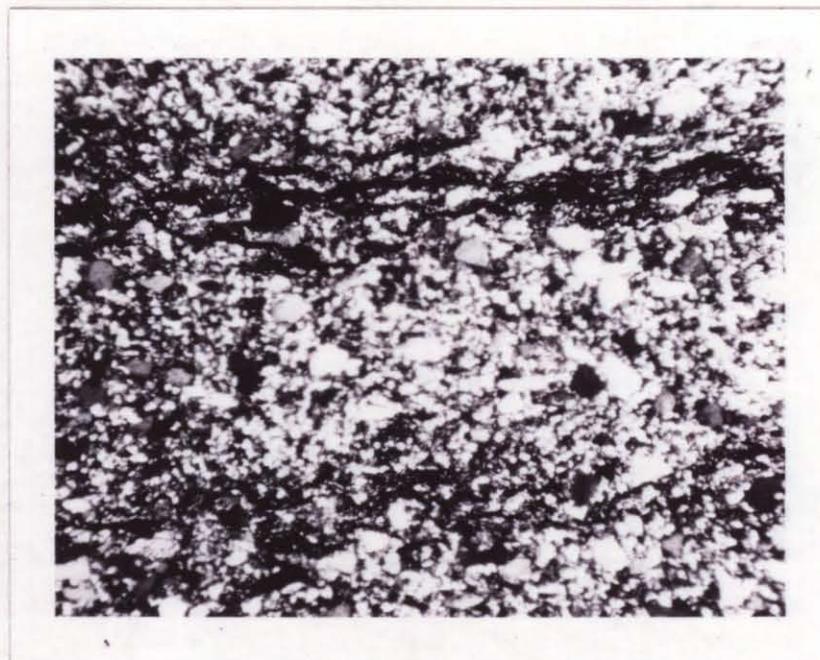


As above, crossed nicols

5 cm



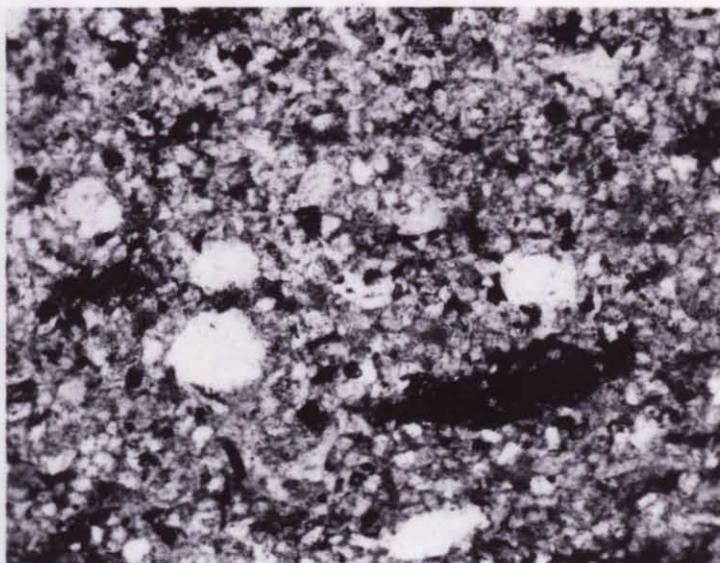
Bass-3 5621' depth, Eocene. Very fine silty sandstone with carbonaceous laminae. Porosity 21%, permeability 11 mD (x 37, plane-polarised light).



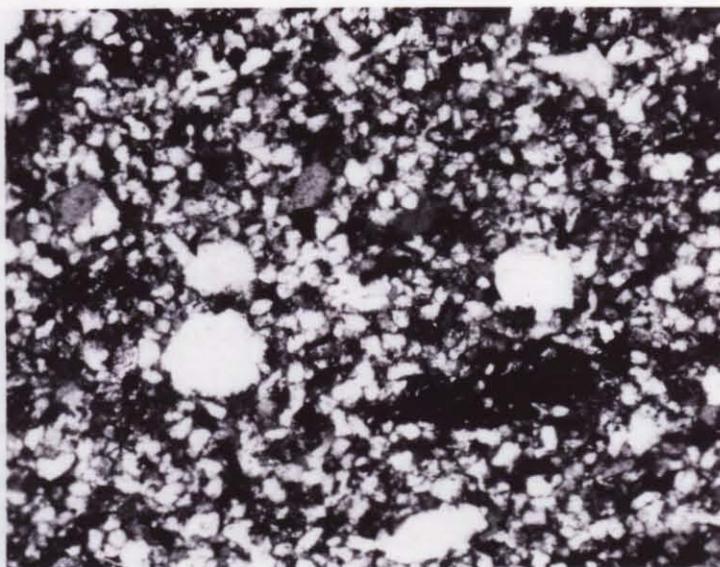
As above, crossed nicols

333038

5 cm



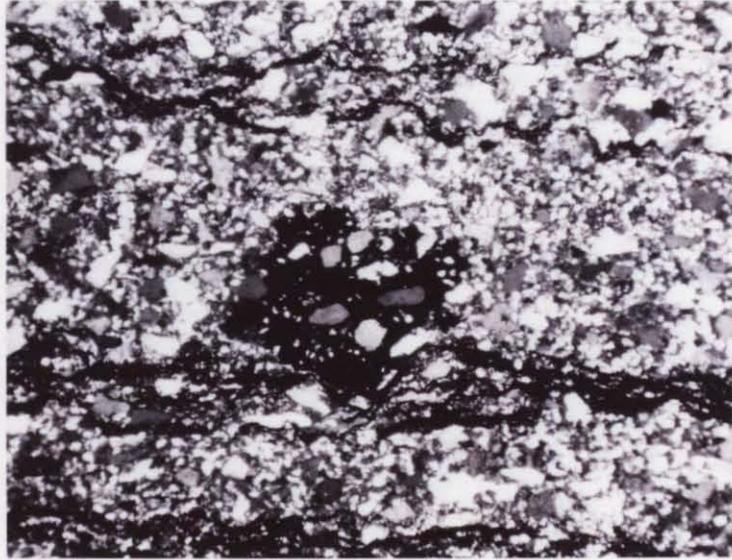
Bass-3 5621' depth, Eocene. Very fine silty sandstone, slightly bimodal in parts; white patches are quartz grains, dark fragment (lower right) is carbonaceous debris (x 37, plane-polarised light).



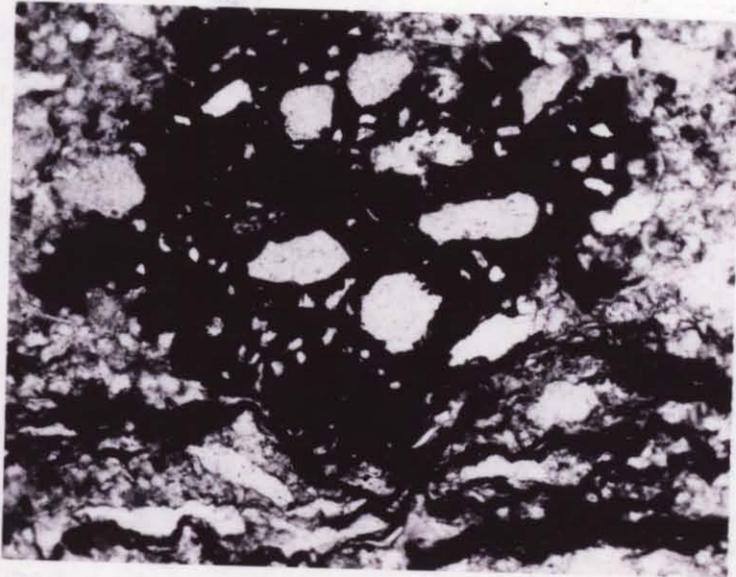
As above, crossed nicols

333039

5 cm

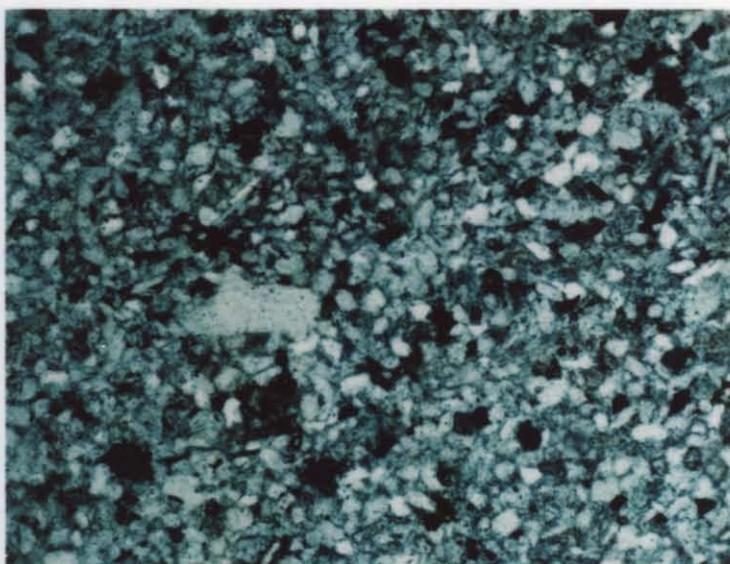


Bass-3 5621' depth, Eocene. Pyrite concretion in fine silty sandstone (x 37, crossed nicols).

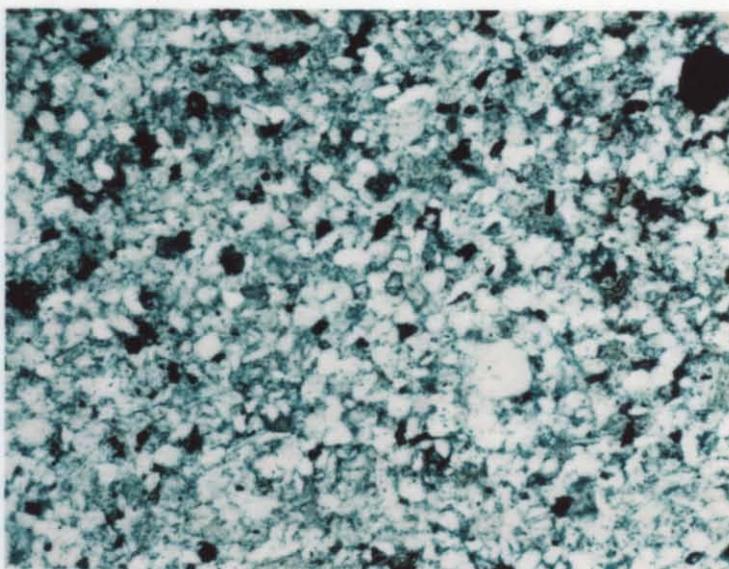


As above, x 92, plane-polarised light.

333040

A horizontal scale bar with arrows at both ends, labeled "5 cm".

Bass-3 5636.17' depth, Eocene. Porous quartz siltstone. Porosity 27%, permeability 58 mD (x 92, plane-polarised light).

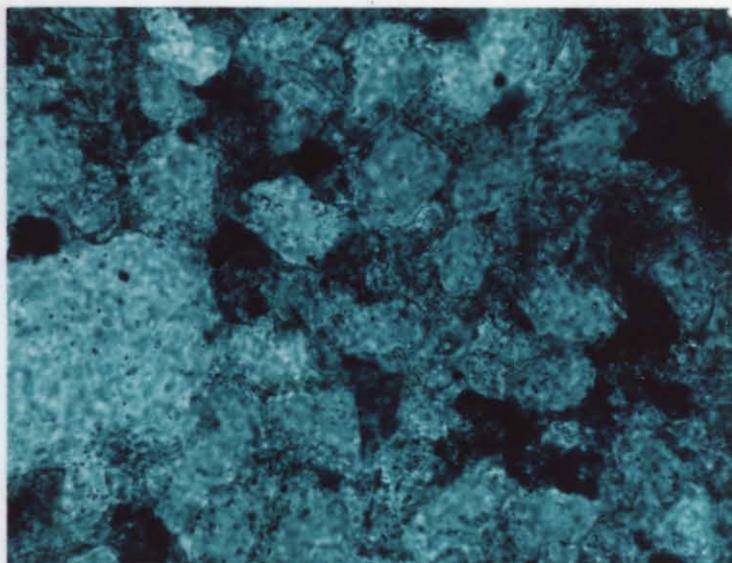


Photomicrograph of the above sample but taken slightly to the right.

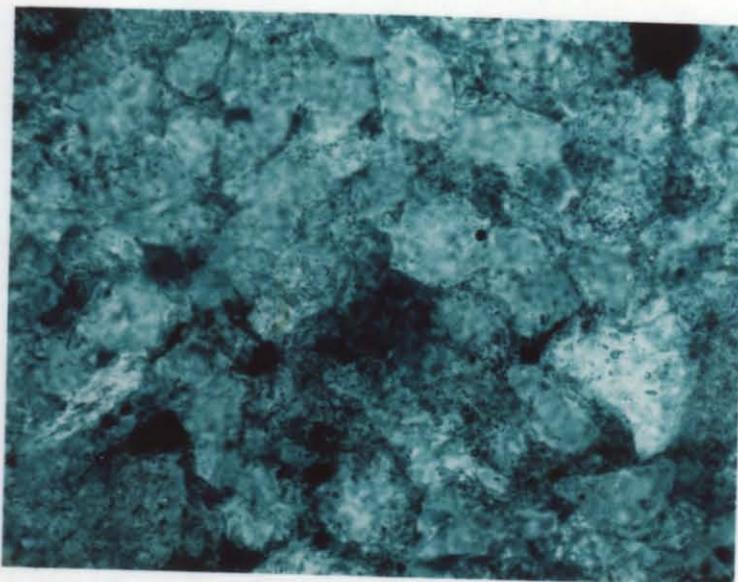
333041



5 cm

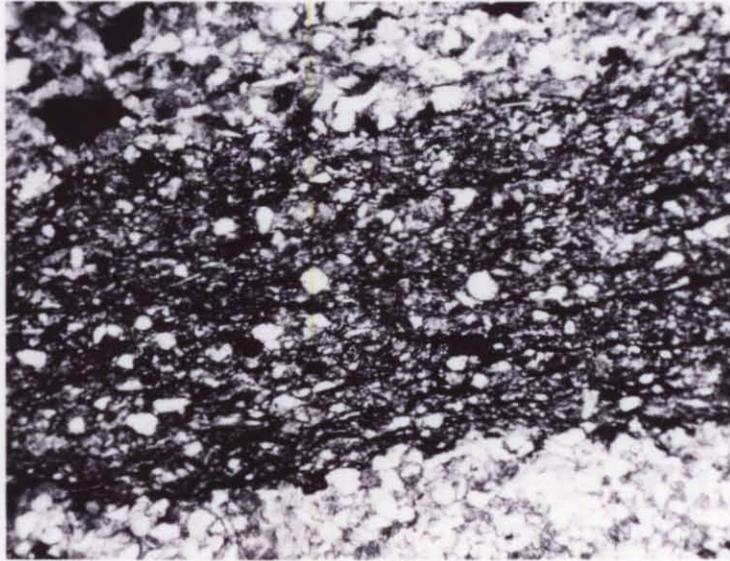


Bass-3 5636.17' depth, Eocene. Porous quartz siltstone, whitish areas are quartz grains, dark areas are pores (x 370, plane-polarised light).

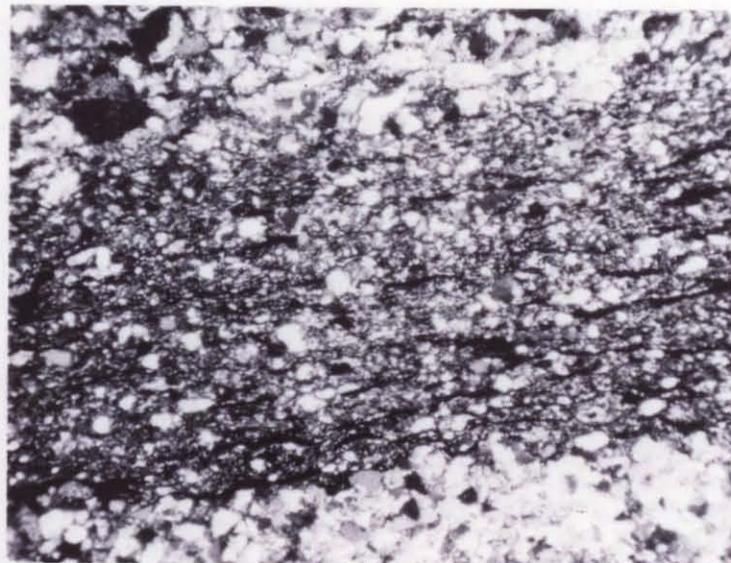


As above, but different part of the siltstone.

5 cm



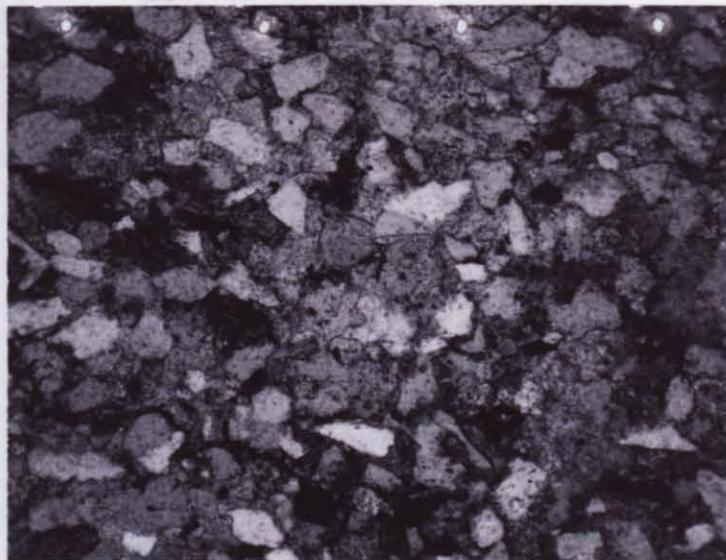
Bass-3 5911.83' depth, Eocene. Carbonaceous laminae (dark band) in very fine calcareous sandstone (light areas). Porosity 7%, effective permeability nil (x 37, plane-polarised light).



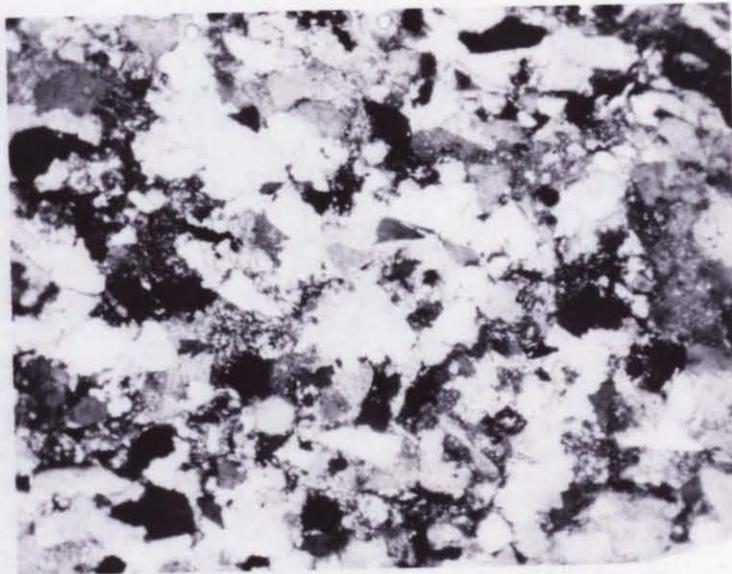
As above, crossed nicols

333043

5 cm



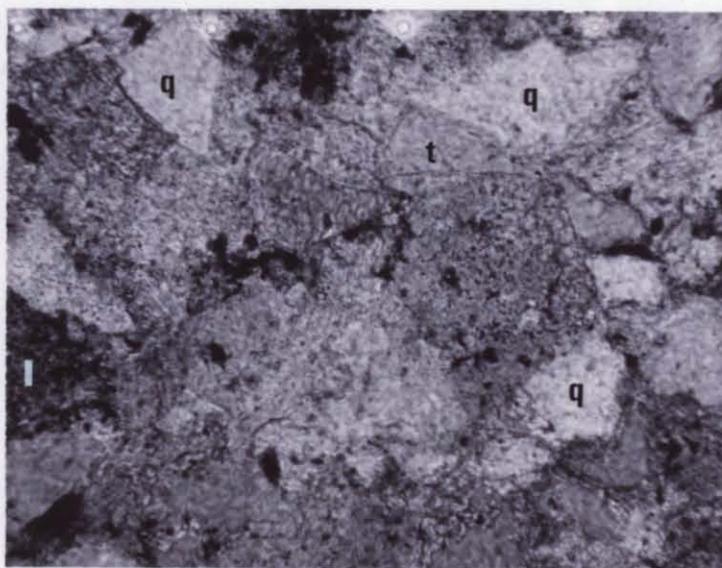
Bass-3 5911.83' depth, Eocene. Very fine carbonaceous sandstone cemented by calcareous cement (x 92, plane-polarised light).



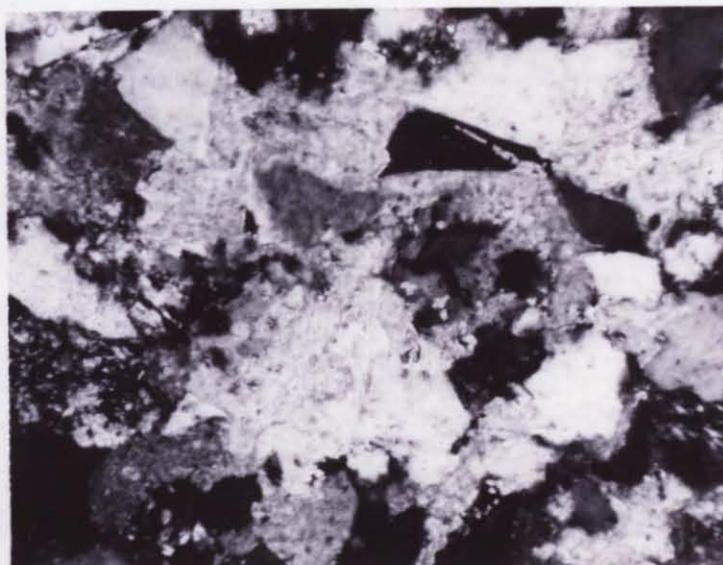
As above, crossed nicols

333044

5 cm



Bass-3 5911.18' depth, Eocene.
Quartz (q), lithoclast (l) and
tourmaline (t) cemented by calcareous
cement. High magnification of the fine
grained (Plate 13) carbonaceous, calcareous
sandstone (x 230, plane-polarised light).

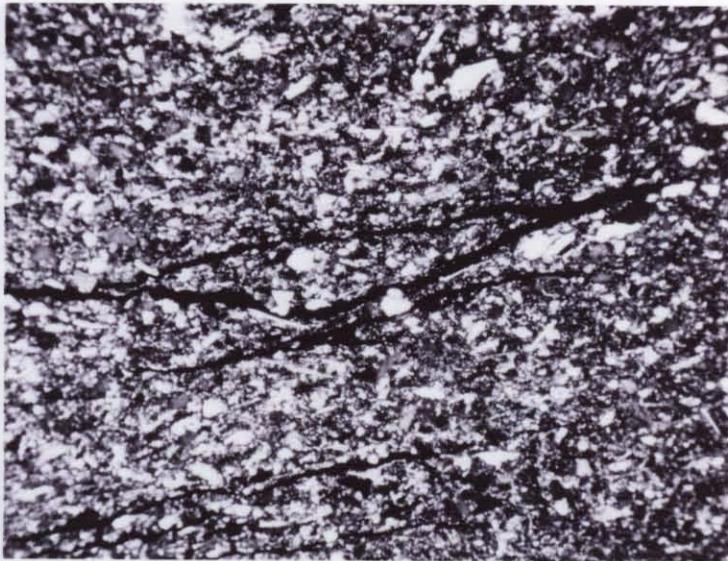


As above, crossed nicols

5 cm

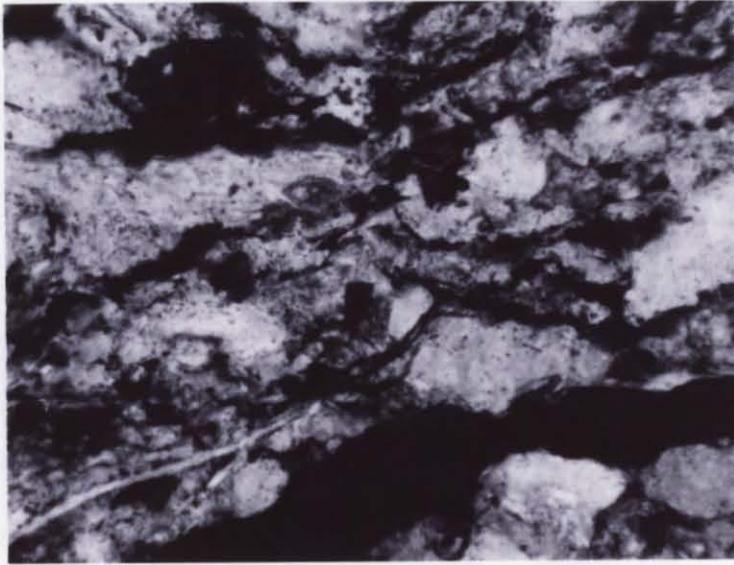


Bass-3 6913.17' depth, Eocene.
Carbonaceous stringers in sandy,
micaceous siltstone. Porosity 10%,
effective permeability nil (x 37,
plane-polarised light).

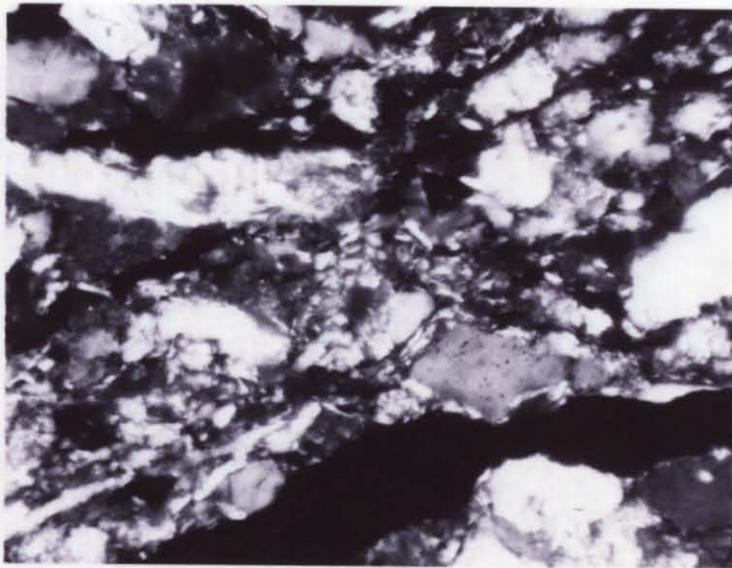


As above, crossed nicols

5 cm



Bass-3 6913.17' depth, Paleocene. Carbonaceous stringers (black) and detrital grains (grey) in sandy micaceous siltstone (x 370, plane-polarised light).

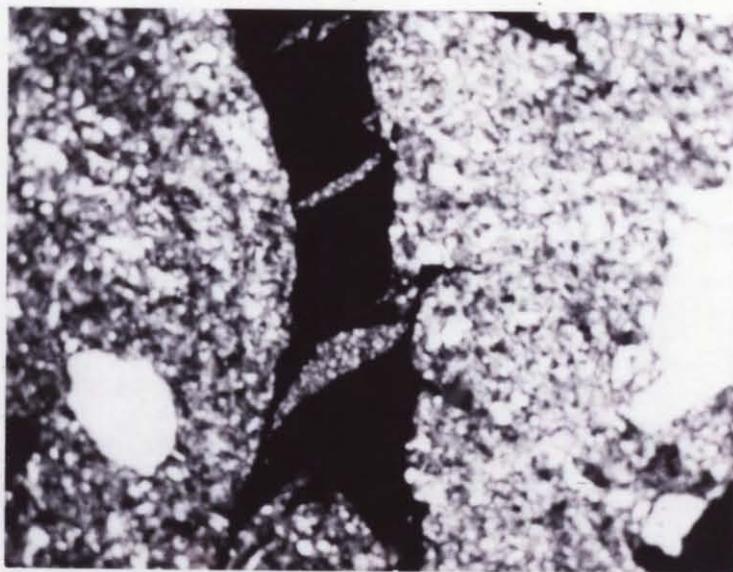


As above, crossed nicols

5 cm



Bass-3 6919.25' depth, Paleocene. Carbonaceous body (probably carbonised plant root) in silty shale. Fractures (white) within the carbonised body are filled with clay, probably kaolinite (x 32, plane-polarised light).



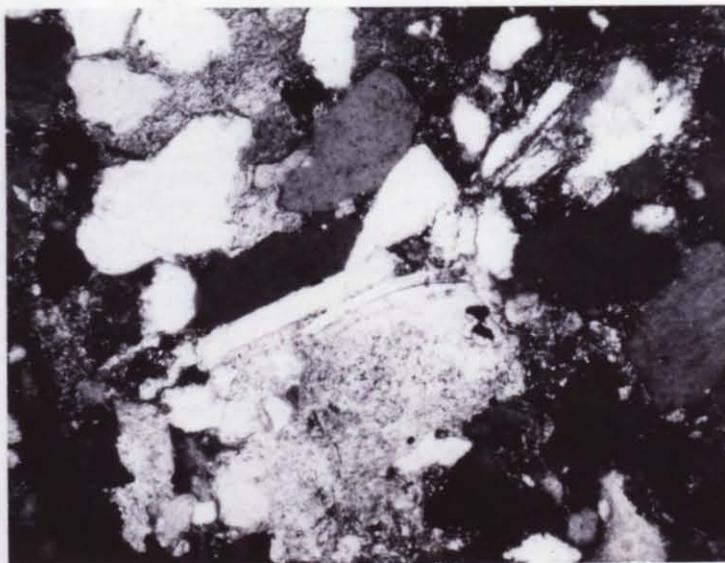
As above, crossed nicols

333048

5 cm

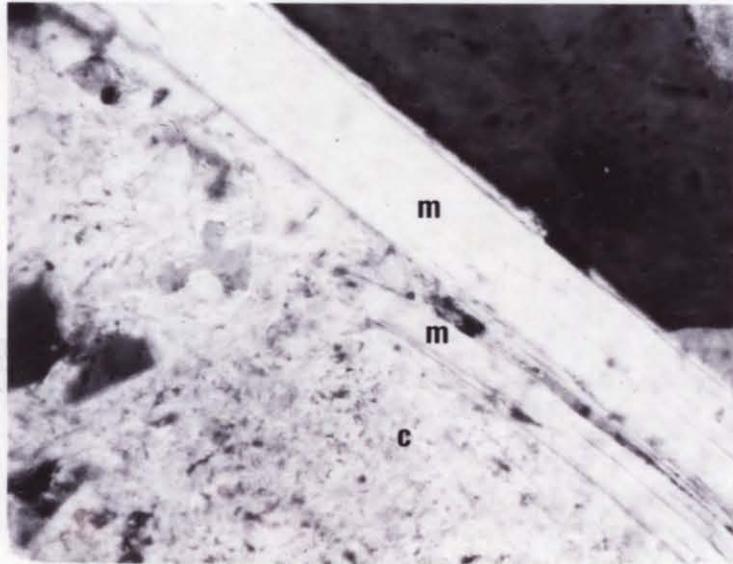


Bass-3 6930.3' depth, Paleocene. Fine to medium sandstone partly cemented by calcareous cement. Muscovite flake (elongated, centre) adjoins quartz (q) grains and calcareous (c) cement. Porosity 17%, permeability 68 mD (x 92, plane-polarised light).

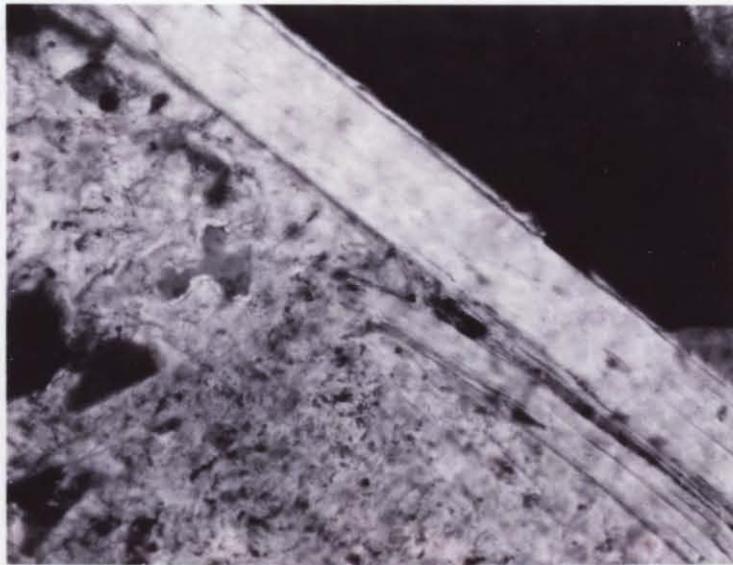


As above, crossed nicols

5 cm

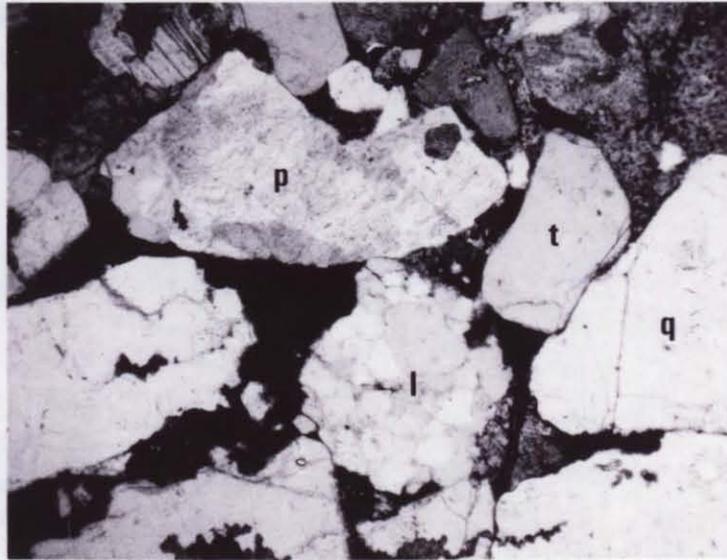


Bass-3 6930.25' depth, Paleocene. Bent and partly fractured muscovite (m) is "invaded" by calcareous cement c. Dark grains on the left side of the microphotograph are remnants of corroded quartz grain (x 370, plane-polarised light).



As above, crossed nicols

5 cm



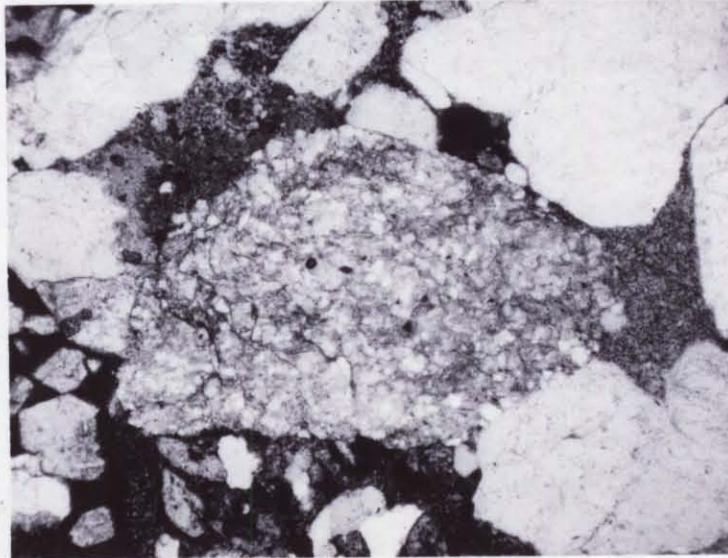
Bass-3 7441.5' depth, Paleocene. Bimodal microconglomeratic sandstone composed of quartz (q), ploycrystalline (p) quartz, lithoclast (l) and tourmaline (t). Porosity 17%, permeability 25 mD (x 37, plane-polarised light).



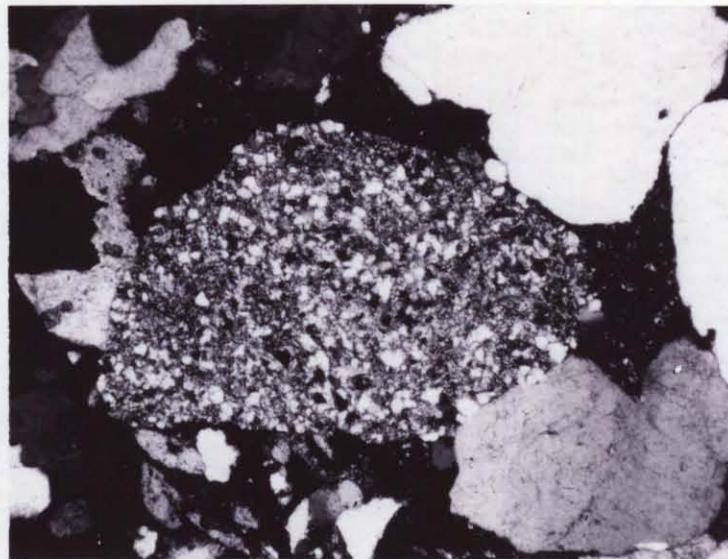
As above, crossed nicols

333 051

5 cm



Bass-3 7441.5' depth, Paleocene.
Microconglomeratic sandstone; the
large grain in the centre is a litho-
clast of siltstone composition (x 37,
plane-polarised light).



As above, crossed nicols

5 cm

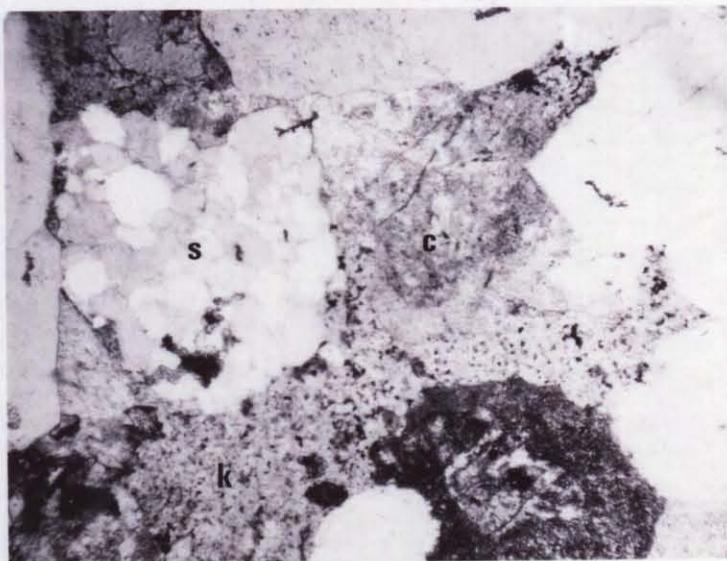


Bass-3 7441.5' depth, Paleocene.
Microconglomeratic sandstone. The
central pebble is an old reworked
micaceous, kaolinitic sandstone
(x 37, plane-polarised light).



As above, crossed nicols

5 cm

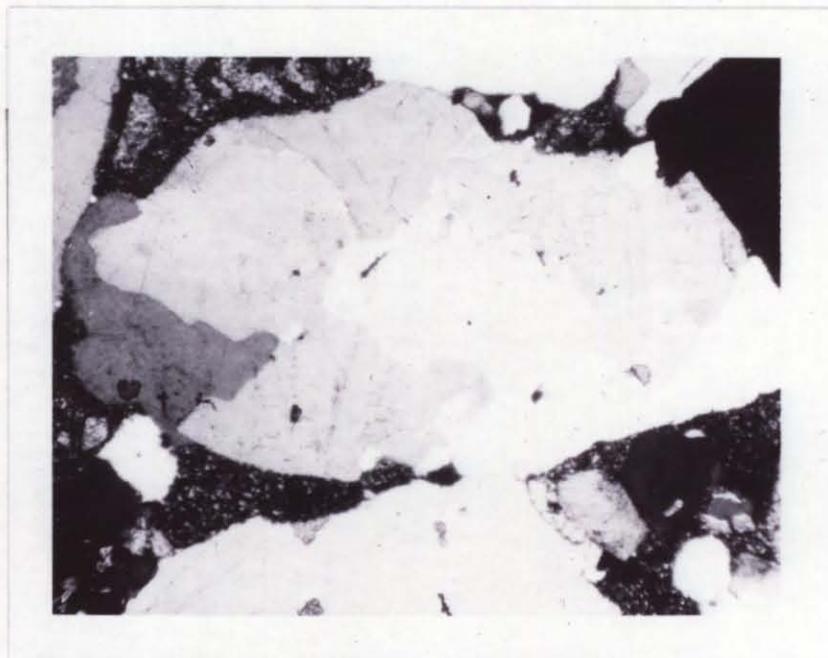


Bass-3 7441.5' depth, Paleocene.
Microconglomeratic sandstone. Pebble
composed of well consolidated sand-
stone(s), kaolinite (k) and cal-
careous cement (c) probably dolomite
(x 37, plane-polarised light).

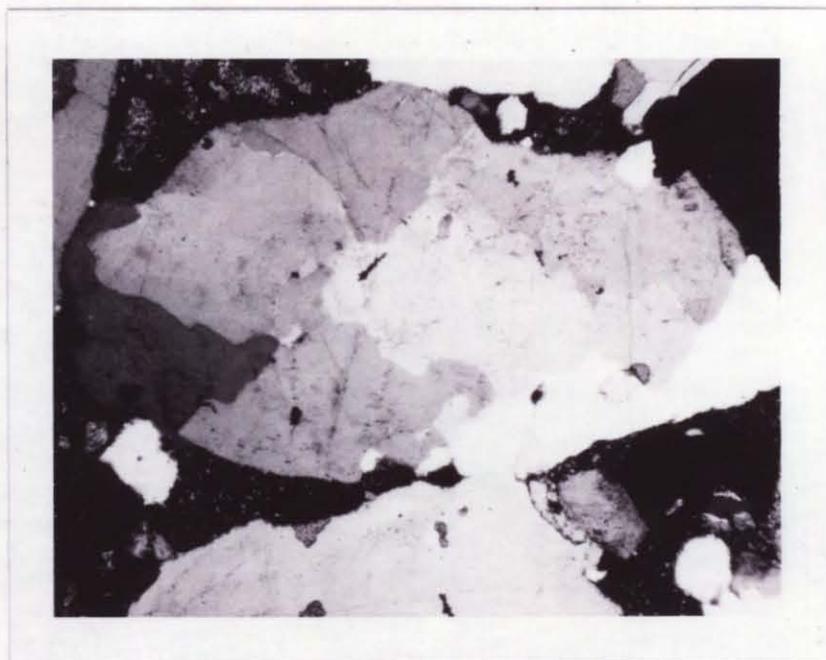


As above, crossed nicols

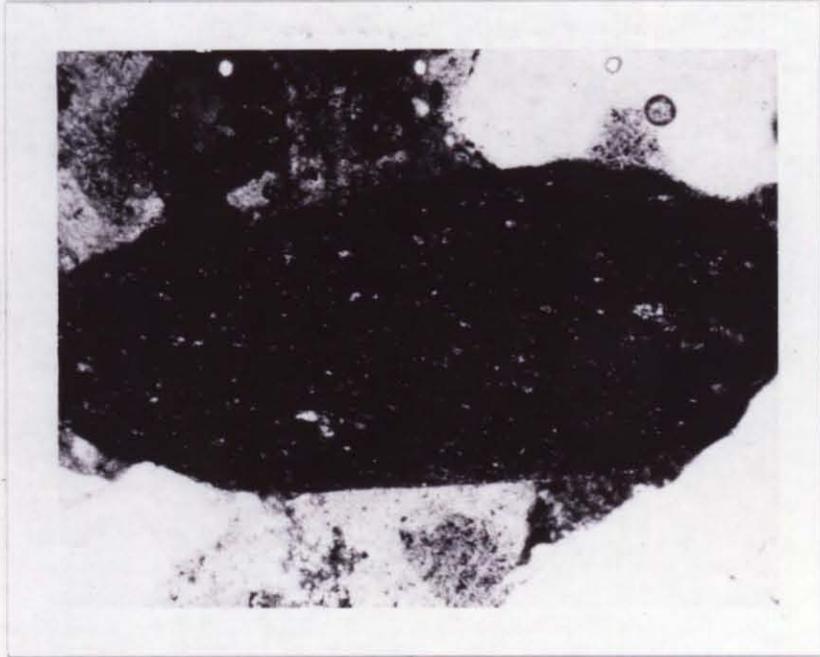
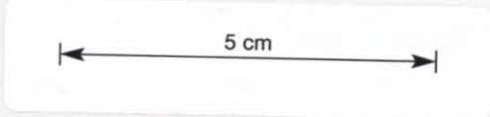
5 cm



Bass-3 7441.5' depth, Paleocene.
Polycrystalline pebble (centre) in
microconglomeratic sandstone (x 37,
plane-polarised light).



Polycrystalline quartz grain in
sandstone.



Bass-3 7441.5' depth, Paleocene.
Shale pebble (centre, black) in micro-
conglomeratic sandstone (x 92, plane-
polarised light).

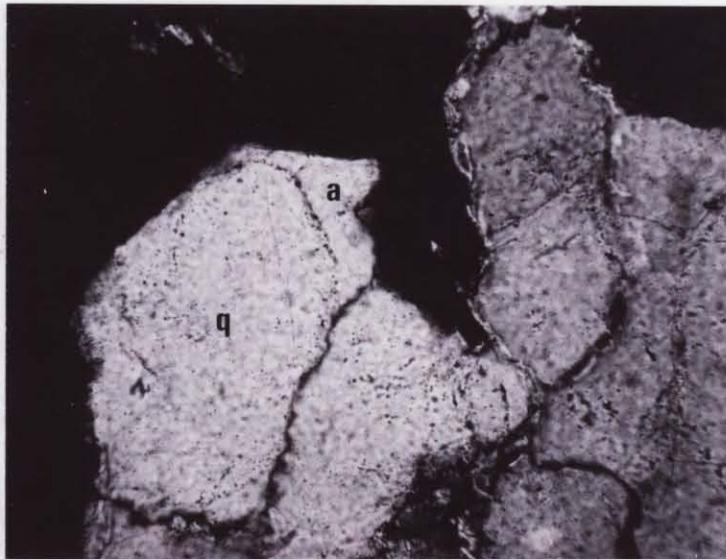


As above, crossed nicols

5 cm



Bass-3 7441.5' depth, Paleocene.
Polycrystalline quartz grain in
microconglomeratic sandstone.
The polycrystalline quartz is a
sandstone composed of quartz with
authigenic overgrowths (x 92, plane-
polarised light).



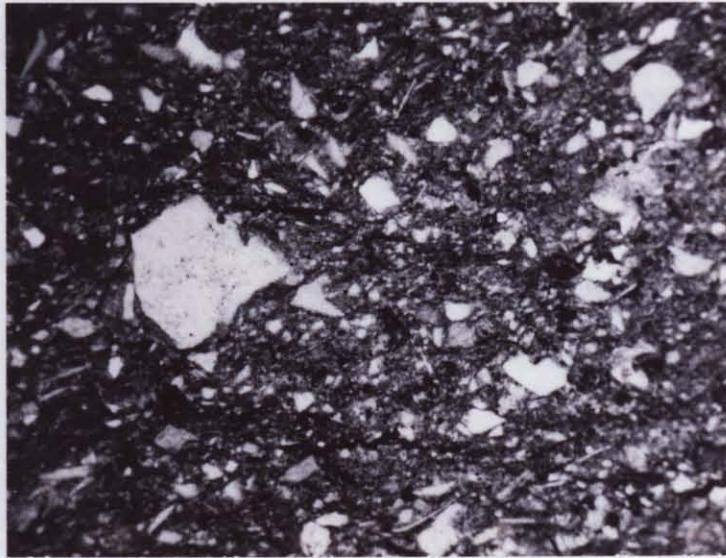
As above, magnification 230 times. Note
detrital quartz (q) with authigenic (a)
overgrowth.

5 cm

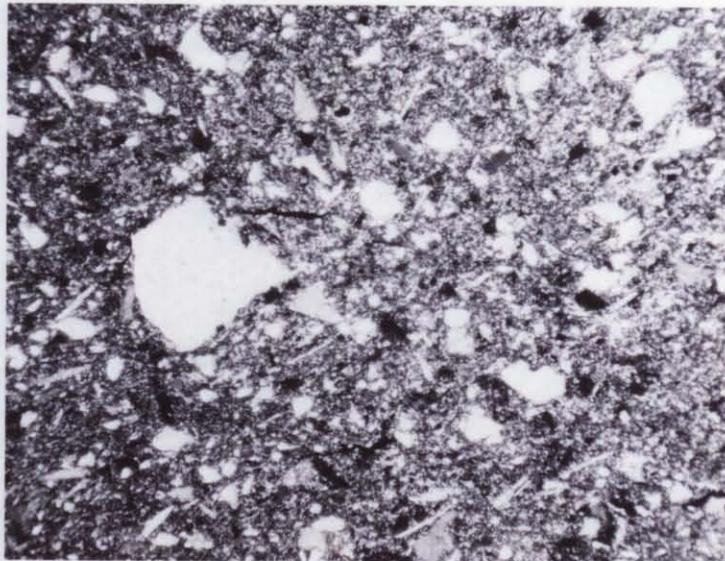


Bass-3 7441.5' depth, Paleocene.
"Ghost" (g) outlines of detrital
grains replaced by calcareous
(? dolomite) cement (d) in micro-
conglomeratic sandstone (x 37,
crossed nicols).

5 cm



Bass-3 7448.92' depth, Paleocene.
Siltstone with occasional sand-size grains;
composed of quartz, mica, heavy minerals
and clay minerals. Porosity 7%, per-
meability nil (x 37, plane-polarised
light).

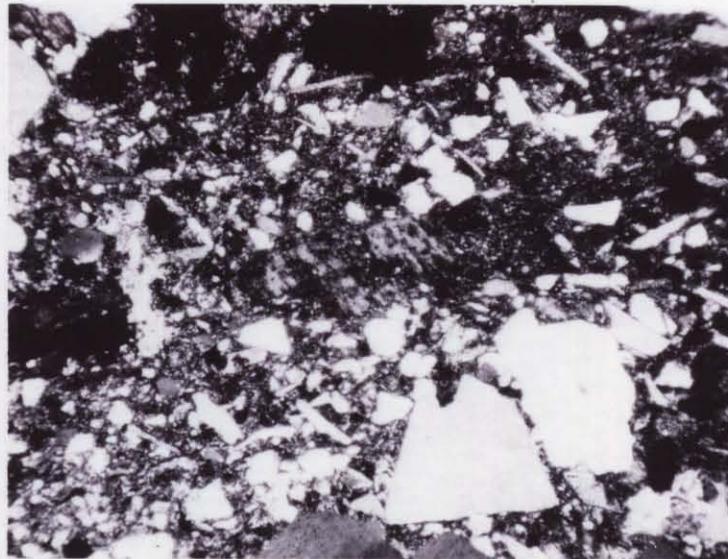


As above, crossed nicols

5 cm



Bass-3 7452' depth, Paleocene.
Wackestone composed of quartz, feldspar
lithoclasts, kaolinised grains (dark
grey, centre) and micas set in fine,
silty/argillaceous matrix. Porosity 8%,
permeability nil (x 37, plane-polarised
light).

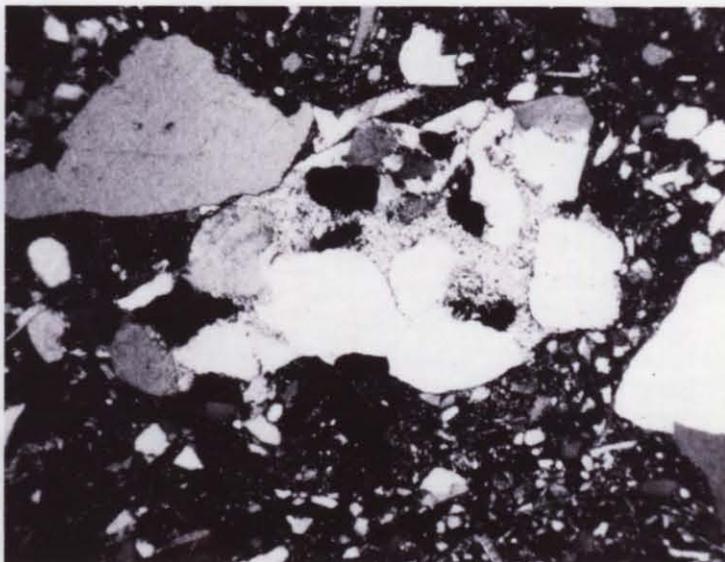


As above, crossed nicols

5 cm



Bass-3 7452' depth, Paleocene.
Lithoclast grain of quartz-mica sandstone
in fine, silty/argillaceous matrix (x 37,
plane-polarised light).



As above, crossed nicols