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SDA 340

# Petrologic/Diagenetic Investigation of eight core samples from Bass-2, Bass Basin, Australia

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Shell Development (Australia) Pty Ltd

## Contents



## Illustrations

## Plates

| | | | |
|---|---|---|---|
| Pl 1 | Bass 2 | 4140.5' depth | Carbonaceous stringers in very fine micaceous sandstone |
| Pl 1 | Bass 2 | 4140.5' " | Sandstone lens in very fine micaceous sandstone |
| Pl 2 | Bass 2 | 4140.5' " | Quartz, muscovite and carbonaceous stringers in very fine micaceous sandstone |
| Pl 3 | Bass 2 | 4749' " | Fine to medium lithic calcareous sandstone |
| Pl 3A | Bass 2 | 4749' " | Calcareous cement in fine lithic sandstone |
| Pl 4 | Bass 2 | 4749' " | Corrosion of quartz by calcareous cement |
| Pl 5 | Bass 2 | 4761.3' " | Fine sandstone cemented by calcareous cement |
| Pl 6 | Bass 2 | 4761.3' " | Corrosion of detrital grains by calcareous cement |
| Pl 7 | Bass 2 | 5068.6" " | Siltstone composed of quartz, feldspar, lithoclasts and micas |
| Pl 8 | Bass 2 | 5074.6" " | Carbonaceous siltstone |
| Pl 9 | Bass 2 | 5508.45' " | Siltstone composed of lithoclasts, feldspars, quartz and micas |
| Pl 10 | Bass 2 | 5509.6' " | Medium grained sandstone |
| Pl 11 | Bass 2 | 5309.6' " | Carbonaceous stringers in medium grained sandstone |
| Pl 12 | Bass 2 | 5509.6' " | Authigenic quartz overgrowths |
| Pl 13 | Bass 2 | 5509.6' " | Plastically deformed grains composed of kaolinite |
| Pl 14 | Bass 2 | 5509.6' " | Intergrown authigenic quartz overgrowths between adjacent quartz grains |
| Pl 15 | Bass 2 | 5515.17' " | Volcanic rock - probably trachyte |

Summary

Eight core samples from Bass-2 were investigated petrologically primarily to assess their composition, diagenesis and reservoir characteristics. Seven of the samples are sediments of Palaeocene and Eocene age (5509'8" to 4140'6") and one sample is an altered volcanic rock of unknown age considered to be basement at the location of the well (possibly Mesozoic).

The sediments investigated comprise siltstones, very fine sandstones and fine to medium sandstones. Irrespective of their grain-size, the framework of these clastics is composed of quartz (including polycrystalline quartz) and lithoclasts with subordinate amounts of potassium-feldspars, plagioclase and heavy minerals. Micas occur in trace amounts in the fine-medium sandstones but are abundant in the siltstones and very fine sandstones where they occur as framework and as matrix mineral in association with clay. The siltstone and very fine sandstones contain considerable amounts of argillaceous/carbonaceous matrix unless they are cemented by calcareous cement which appears to replace the matrix.

The porosity of the investigated sediments ranges from 6% to 25.2% and the permeability from less than 1mD to 73mD. Only the fine-medium sandstones have potential productive permeability values (40mD and 73mD). The main porosity/permeability reducing factors are the presence of depositional/diagenetic matrix and calcareous cement, which is diagenetically late. Some authigenic quartz is present but its effect on poroosity/permeability is not very significant.


Base No. 12992

## 1. Introduction

As part of a study of the reservoir characteristics of sandstones from the Bass and Gippsland Basins eight samples from Bass-2 were examined petrologically with a view to determining their composition, diagenesis and reservoir characteristics (depth 5515'-4140').

The Esso/BHP well Bass-2 was drilled in the Bass Basin in 1966 (Lat 39° 53' 09"S, Long 196° 18' 15"E). The well penetrated 2136' of Neogene calcarenites and mudstones, 632' of Oligocene clastics, 220' of upper Eocene siltstone, 1673' of mixed clastics and coal of the Eastern View Coal Measures and 399' feet of altered volcanics and tuffaceous mudstones of unknown age, possibly Mesozoic. The well terminated in the altered tuffaceous mudstone of 5910' (1801m) depth bdf. No commercial hydrocarbons were encountered.

## 2. Material investigated and mode of presentation

Porosity/permeability plugs were cut from Cores 5, 7, 8 and 9 at the Core and Cutting Laboratory, Bureau of Mineral Resources, Fyshwick. The porosity and permeability measurements were carried out by Core Laboratory, Perth (Appendix 1). Thin sections, prepared from the porosity plugs were examined microscopically at SD(A) under polarising and reflected light.

The porosity/permeability data and petrological descriptions of individual samples are presented in Appendices 1 and 2 respectively. The percentages of rock constituents shown in the petrological descriptions (Appendix 2) are visual estimates made from thin sections and/or rock specimens. Sixteen plates of polaroid microphotographs are attached to illustrate some of the textural, petrological and diagenetic features of the samples.

## 3. Composition and Diagenesis of Sediments

### 3.1 Samples examined

A total of eight samples cut from Cores 5, 7, 8 and 9 were examined. These samples are from 5514'2" to 4140'6" depth. The lowermost sample (5515'2" depth) is a volcanic rock (Pl 15), presumably altered trachyte (Ref 1) and considered to be basement. The remaining seven samples are all siltstones and very fine to medium sandstones, of Eocene (Cores 5 & 7) and Palaeocene age (Cores 8 & 9) age.

### 3.2 Composition of Sediments

Five samples are siltstones and very fine sandstones (Pl 1, 5, 7, 8, 9), and two samples are fine to medium grained sandstones (Appendix 2).

The framework of the fine-medium grained sandstones (from 4749' and 5509.6' depth) is composed of quartz and polycrystalline quartz (c. 75%), chert (c. 2%), feldspars (c. 5%), lithoclasts (c. 15%), micas and heavy minerals (Pl 11). The majority of the polycrystalline grains have the appearance of vein quartz; they make up about one seventh of the quartzitic grains. The feldspars are orthoclase and plagioclase. The micas are predominantly muscovite and occasionally brown biotite. The sandstones from 5509'8" depth contain an appreciable amount of matrix mainly kaolinite (Pl 10, 13) whereas the sandstone from 4749' depth has a considerable amount of intergranular calcareous cement (Pl 3, 3A, 4).

The fine sandstones and siltstones contain greater amounts of micas, carbonaceous matter (Pl 2) and clay matrix. The latter is replaced by calcite in the calcareous sandstones from 4761'4" depth (Pl 5, 6). The lithoclasts of the sediments investigated are altered grains, argillites, occasionally volcanoclasts and grains composed of phyllosilicates (yellow micaceous flakes). Traces of glauconite were present in a sample from 5508'5".

## 3.3 Diagenesis

Compaction and cementation by calcareous (? dolomitic) cement are the main diagenetic processes; authigenic quartz overgrowths are present in sandstones from 4761'4" and 5509'8" feet (Pl 12, 14). The calcareous cement seems to post-date the authigenic quartz. A distinct strain-extinction on dolomite in the sample from 4761'4" suggests that stresses were induced on the sediment after the calcareous cement was introduced into the sandstone. Calcareous cement severely corrodes the detrital grains in samples from 4749' (Pl 4) and 4761'4" (Pl 6). The calcareous cement occurs in patches (e.g. 4749') or is continuous throughout the specimen (e.g. 4761'4"), in the latter case the porosity and permeability of the sandstones is drastically reduced.

Tentatively the paragenetic order seems to be:

- compaction,
- authigenic quartz formation,
- introduction of calcareous cement (? dolomite),
- corrosion of detrital grains by calcareous cement,

- additional compression of the sandstone, inducing strain on the calcareous cement.

### 3.4 Porosity and Permeability

Porosities of the six investigated sediments range from 6 to 25.2% and permeabilities from less than 0.1mD to 73mD. The sample with lowest porosity (6%) is a sandstone which is wholly cemented by calcareous cement. All the other samples are within the porosity ranges of 16% to 25%. The two sandstones with moderately good permeabilities are the partly calcareous-cemented sandstone (4749') with a permeability of 40mD and the medium-grained sandstone from 5509'8" depth (just overlying the basement volcanics) with a permeability of 73mD. The siltstones and very fine sandstones have a permeability of less than 1mD. The low permeabilities of the relatively porous sandstones are attributed to the abundance of kaolinite and depositional matrix and to their fine grain-size (and probably residual hydrocarbon).

## 4. Comments

The Esso/BHP porosity/permeability data (Ref 1) indicates the presence of sandstones with higher porosities (up to 36.2%) and permeabilities (up to 190mD) so that the samples examined in this study are the more consolidated sandstones/siltstones that could be handled by ordinary preparation techniques. The very porous sandstones are probably too friable to be handled for porosity/permeability measurements without using special methods.

The low permeability/porosity ratio of the investigated samples and of those measured by Esso/BHP suggest the fine grain-size of the sandstones and/or the abundance of intergranular argillaceous matrix.

## 5. References

1. Esso Bass 2, Tasmania. Well Completion Report. By Esso Exploration Australia, Inc. June 1966.

2. Esso Bass No. 1 and No. 2 wells, Bass Basin, Tasmania. Bureau of Mineral Resources, Australia, Petroleum Search Subsidy Acts Publication No. 83 (1970).

3. 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.

CL-911-1

CORE LABORATORIES, INC.
*Petroleum Reservoir Engineering*
DALLAS, TEXAS

# CORE ANALYSIS RESULTS

Company SHELL DEVELOPMENT AUST. Formation _____ File WA-CA-141
Well BASS NO 2 Core Type _____ Date Report 27 MAY 81
Field _____ Drilling Fluid _____ Analysts GK, DS
County _____ State _____ Elev. _____ Location _____

## Lithological Abbreviations

ND — SD, ALE — SH, LIME — LM | DOLOMITE — DOL, CHERT — CH, GYPSUM — GYP | ANHYDRITE — ANHY, CONGLOMERATE — CONG, FOSSILIFEROUS — FOSS | SANDY — SDY, SHALY — SHY, LIMY — LMY | FINE — FN, MEDIUM — MED, COARSE — CSE | CRYSTALLINE — XLN, GRAIN — GRN, GRANULAR — GRNL | BROWN — BRN, GRAY — GY, VUGGY — VGY | FRACTURED — FRAC, LAMINATION — LAM, STYLOLITIC — STY | SLIGHTLY — V, VERY — V, WITH — W

| SAMPLE NUMBER | DEPTH FEET | PERMEABILITY MILLIDARCYS KA | POROSITY PER CENT | RESIDUAL SATURATION PER CENT PORE: OIL | RESIDUAL SATURATION PER CENT PORE: TOTAL WATER | SAMPLE DESCRIPTION AND REMARKS |
|---|---|---|---|---|---|---|
| 1 | 4140.6 | 0.33 | 17.5 | | | |
| 2 | 4749 | 40 | 18.9 | | | |
| 3 | 4761.4 | 0.058 | 6.0 | | | |
| 4 | 5068.9 | 0.58 | 19.0 | | | |
| 5 | NO SAMPLE | | | | | |
| 6 | 5074.8 | 0.063 | 16.0 | | | Plug cut in vert plane. |
| 7 | 5509.8 | 73 | 25.2 | | | |

Appendix 2. Petrologic descriptions of samples from Bass-2.

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

336015

| SAMPLE | | | DEPTH | | AGE | % | DESCRIPTION | DIAGENESIS/OTHER COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | FEET | METRES | | | | |
| C5 | X | X | 4140'6" - 41'3" | 1202 | EO | 100 | Sst, arg, carb, mic, slt-vf, poor sorting, ang-subrnd, burrowed, dk gy, distinct alignment of grains, Lam of carb matter, dk gy;<br>Composed of<br>55% Qz<br>5% Polyqz<br>3% Fld (Orth, partly kaolinised)<br>12% Lcl (Argillite, phyllite, mica Aggr)<br>5% Mica (Musc, occ Biot)<br>2% Chlorite<br>1% Heavy Min/Tourm<br>10% Carb matter (carb stringers, pollen, reworked coal)<br>7% Matrix<br>straight and deformed Musc flakes;<br>the sediment is composed of slt carb Sst with lenses and tubular bodies of clean sandstone. | Porosity 17.5%<br>Permeability 0.33mD<br>moderately good visual porosity in lenses of clean Sst.<br>Main diagenetic processes are compaction. Low porosity is due to compaction and the presence of clayey/ micaceous/carbonaceous matrix. |

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

336016

| SAMPLE | | | DEPTH | | AGE | % | DESCRIPTION | DIAGENESIS/OTHER COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | FEET | METRES | | | | |
| C7 | X | X | 4749-50 | 1447.5 | EO | 100 | Sst, calc, f-m (0.05-0.3mm), srt subang-subrnd, gy, some fractures filled with dk matter;<br>Composed of:<br>50% Qz<br>10% Polyqz (Vein Qz)<br>1% Cht<br>2% Fld (Orth, Plag)<br>8% Lcl (Qz/mica Aggr, Vo, Sh)<br>1% Mica (Musc)<br>2% Heavy Min (Tourm)<br>1% Kao grains<br>tr Carb matter<br>25% Calc matter<br>Patchy, concretionary calc (?Dol) cement (approx 2mm in diameter); non-calc parts occupied by clay minerals - Kao & some unidentified isotropic matter; some Fld fractured; occ micas plastically deformed. | Porosity 18.9%<br>Permeability 40mD<br>"Patchy" visual porosity.<br>Main diagenetic processes are partial cementation by calcareous (?dolomite) cement, corrosion of detrital grains by the calcareous cement and compaction. Porosity reduction is due to the presence of calcareous cement and clayey matrix. |

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

336017

| SAMPLE | | | DEPTH | | AGE | % | DESCRIPTION | DIAGENESIS/OTHER COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | FEET | METRES | | | | |
| C7 | X | X | 4761'4"<br>-62' | 1451.3 | EO | 100 | Sst, calc, vf-f (0.05-0.25), occ m, srt, ang-subrnd, gy, dense;<br>Composed of<br>50% Qz<br>6% Polyqz/Vein Qz<br>1% Cht<br>6% Fld (Mcr, Orth)<br>6% Lcl (Argillite, Vo)<br>tr Mica (Musc)<br>tr Heavy Min (Tourmaline, Zircon, Rutile)<br>tr Kao<br>tr Carb matter<br>1% Py<br>30% Calc cement<br>Cemented by calc cement - most likely Dol, Py occurs as minute crystals widely disseminated, orthoclase partly altered to Kao whereas microcline remains unaltered. | Porosity 6.0%<br>Permeability 0.1mD<br>Very low, discontinuous visual porosity. Main diagenetic processes are compaction, cementation by calcareous (?dolomitic) cement and corrosion of detrital grains by the calcareous cement. Low porosity is due to calcareous cement. |

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

336018

| SAMPLE | | | DEPTH | | AGE | % | DESCRIPTION | DIAGENESIS/OTHER COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | FEET | METRES | | | | |
| C8 | X | X | 5068'9" -69'6" | 1545 | PC | 100 | Sltst, carb, mic, average grain size ca 0.04mm, ang-subrnd,<br>gy-beige, lam;<br>Composed of<br>50% Qz and Polyqz<br>6% Fld (Orth)<br>22% Lcl (Argillite)<br>5% Mica (Musc)<br>tr Chlorite<br>tr Heavy Min (Tourmaline)<br>10% Calc (Sid & ankerite)<br>2% Carb<br>5% Matrix<br>Irregular/patchy distribution of ankerite; detrital grains tightly packed; muscovite flakes straight & bent. | Porosity 19.0%<br>Permeability 0.6%<br>Very low visual porosity.<br>Main diagenetic processes are compaction and cementation by calcareous cement-ankerite and siderite.<br>Low porosity is due to compaction and cementation by calcareous cement. |

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

336019

| SAMPLE | | | DEPTH | | AGE | % | DESCRIPTION | DIAGENESIS/OTHER COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | FEET | METRES | | | | |
| C8 | X | X | 5074'8" -75'4" | 1546.8 | PC | 100 | Sltst, carb, mic, average grain-size ca 0.04mm, ang-subrnd, lam, dk brn;<br>Composed of<br>55% Qz<br>5% Fld (Plag, Orth)<br>13% Lcl (Argillite, kaolinised grains)<br>tr Glc<br>7% Mica (Musc)<br>tr Chlorite<br>tr Heavy Min (Zircon)<br>3% Carb matter<br>7% Calc matter (Sid, Ank)<br>tr Opaque matter (?Py, limonite)<br>10% Matrix (Kao, other clay minerals)<br>Feldpsars kaolinised to varying degree mainly advanced; minute authigenic Qz overgrowths on some Qz grains, alternating laminae of carb/sid and non carb/sid bands; siderite mainly nodular; ankerite (ca 1%) partly corrodes detrital grains. | Porosity 16.0%<br>Permeability 0.1mD<br>Very low visual porosity.<br>Main diagenetic processes are compaction, kaolinisation of detrital grains, introduction of (early) siderite and (late) ankerite, authigenic quartz overgrowths.<br>Porosity reduction is due to compaction & to lesser degree the presence of phylo-silicates and clay minerals, pore fill by calcareous cement and authigenic Qz. |

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

336020

| SAMPLE | | | DEPTH | | AGE | % | DESCRIPTION | DIAGENESIS/OTHER COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | FEET | METRES | | | | |
| C9 | X | X | 5508'5" -08'10" | 1679 | PC | 100 | Sst/sltst, lithic, mic, arg, vf, srt ang-subrnd, gy;<br>Composed of<br>30% Qz and Polyqz (Vein Qz)<br>2% Fld (Orth)<br>35% Lcl (Argillites, Kao grains)<br>15% Mica (Musc, Biot)<br>tr Heavy Min (Tourmaline)<br>5% Carb matter<br>13% Matrix (Sid, Kao, sericitic mica, carb)<br>Carbonaceous matter occurs as stringers and as reworked particles; Fld mainly kaolinised; some lithoclasts plastically deformed; fine aggregate of mica-sericite-carb matter separate detrital grains. | No porosity/permeability data. Very low visual porosity. Some well developed fractures parallel to bedding. Main diagenetic processes are introduction of siderite, kaolinisation of chemically unstable grains and compaction. Pore reduction is due to compaction and the abundance of phyllosilicate matrix, which is depositional pro-part. |

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

336021

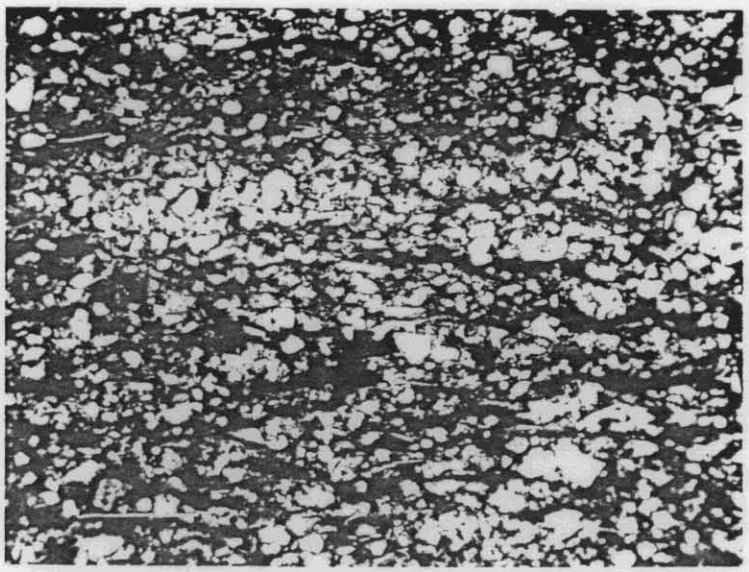
| SAMPLE | | | DEPTH | | AGE | % | DESCRIPTION | DIAGENESIS/OTHER COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | FEET | METRES | | | | |
| C9 | X | X | 5509'8" -10'7" | 1679.4 | PC | 100 | Sst, lithic, arg, f-m, srt, subang-subrnd, friable, brn gy;<br>Composed of<br>55% Qz<br>3% Polyqz (Vein Qz)<br>1% Cht<br>5% Fld (Orth, occ Plag)<br>10% Lcl (Argillite, altered grains, mica/Qz aggreg, Vo)<br>2% Mica (Musc, occ brn Biot)<br>tr Heavy Min<br>2% Kao<br>tr Py<br>20% Matrix (Kao and dk opaque matter)<br>2% Carb matter<br>Abundance of intergranular dark matter, probably HC; occ carb stringers, advanced auth Qz overgrowths on detrital Qz grains; Kao often adjoins auth Qz. | Porosity 25.2%<br>Permeability 73mD<br>Good visual porosity - partly secondary. Main diagenetic processes are kaolinisation, growth of authigenic quartz and compaction. Pore reduction is caused by the presence of matrix (mainly kaolinitic), authigenic quartz and compaction. Large proportion of pore are occupied by dark opaque matter, some of which resembles residual hydrocarbon. |

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

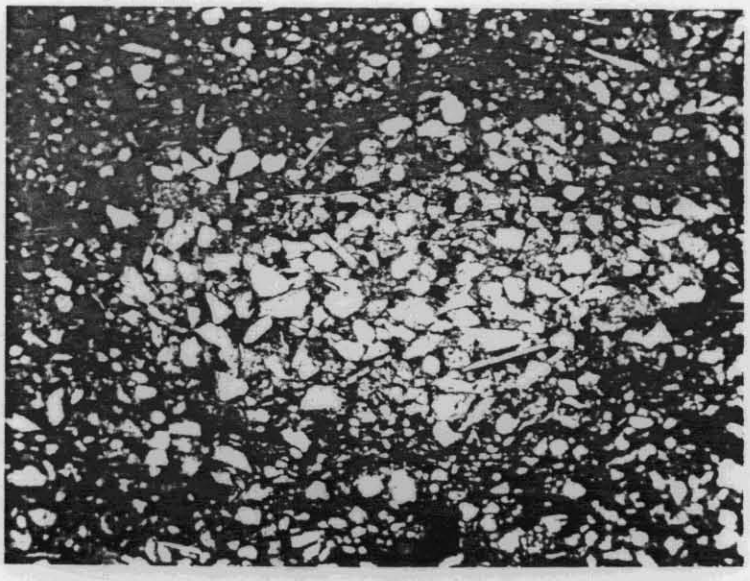
336022

| SAMPLE | | | DEPTH | | AGE | % | DESCRIPTION | DIAGENESIS/OTHER COMMENTS |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | FEET | METRES | | | | |
| C9 | X | X | 5515'2" -9" | 1681.1 | ? basement rock | 100 | Vo, very fine greenish rock composed of chlorite, kaolinite, calc matter and leucoxene; Kao forms main groundmass. Sid occurs as rosette-shaped concretions and Dol as rnd concretions, Leucoxene irregularly distributed throughout the rock; vague flow structures. | Altered volcanic rock. |

5 cm



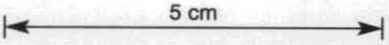
Bass 2 4140.5' depth, Eocene. Very fine silty micaceous sandstone with numerous carbonaceous stringers. Porosity 17.5%, permeability 0.33 mD (x 37, plane-polarised light).

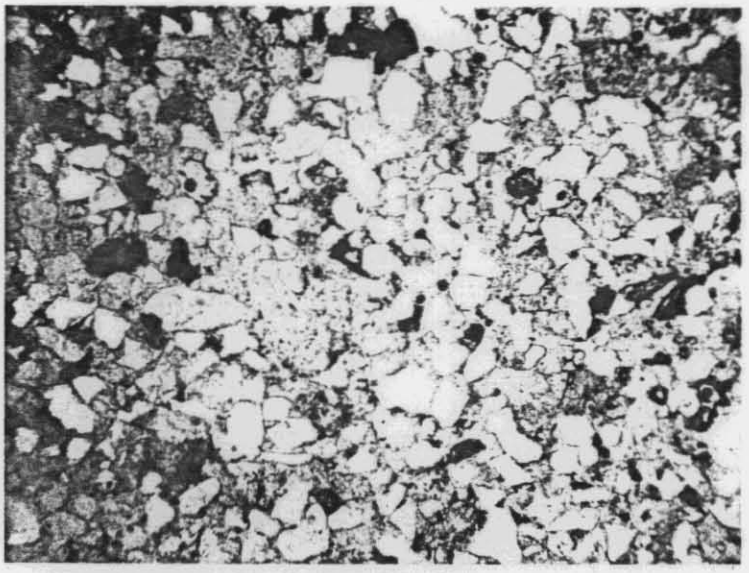


Bass-2 4140.5' depth, Eocene. Burrow filled with sand (or a sandstone pallet) in very fine, silty sandstone (x 57, plane-polarised light).

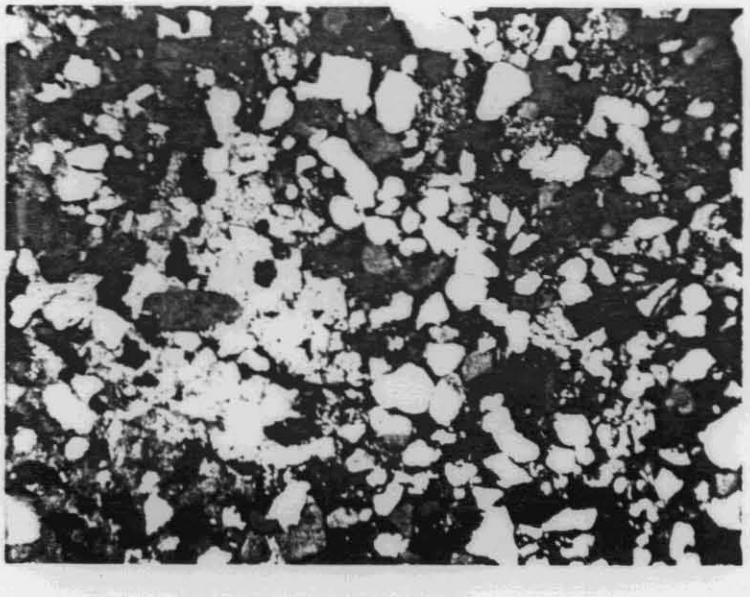

Bass-2 4140.5' depth, Eocene. Very fine silty micaceous sandstone composed of quartz (white rounded grains), muscovite (elongated whitish flakes) and carbonaceous stringers (black, elongated) (x 230, plane-polarised light).

As above, crossed nicols



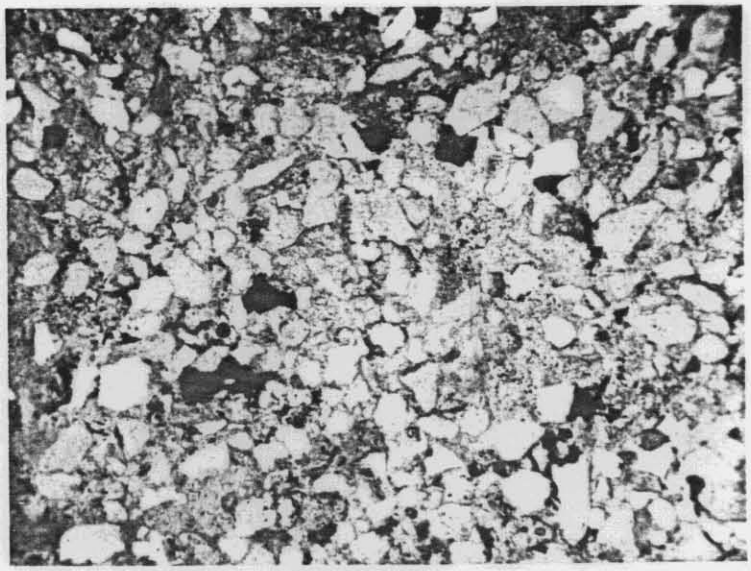



Bass-2 4749' depth, Eocene. Fine to medium lithic sandstone partly cemented by calcareous (light grey, centre) cement. Porosity 18.9%, permeability 40 mD (x 37, plane-polarised light).

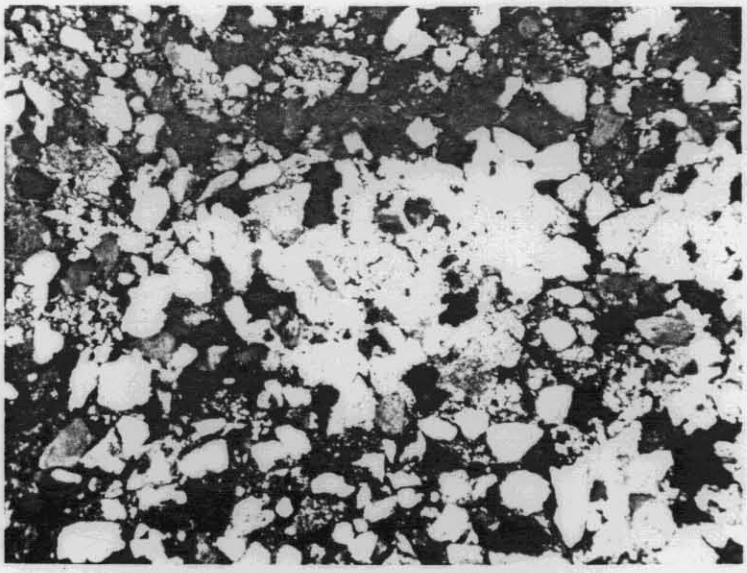


As above, crossed nicols

5 cm

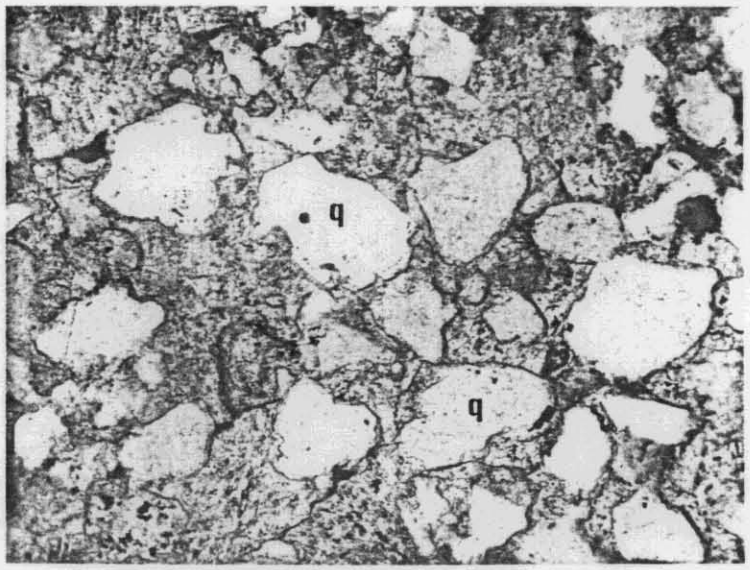


Bass-2 4749' depth, Eocene. Fine to medium sandstone composed of quartz and lithoclasts, partly cemented by calcareous (light grey, centre) cement. Porosity 18.9%, permeability 40 mD (x 37, plane-polarised light).

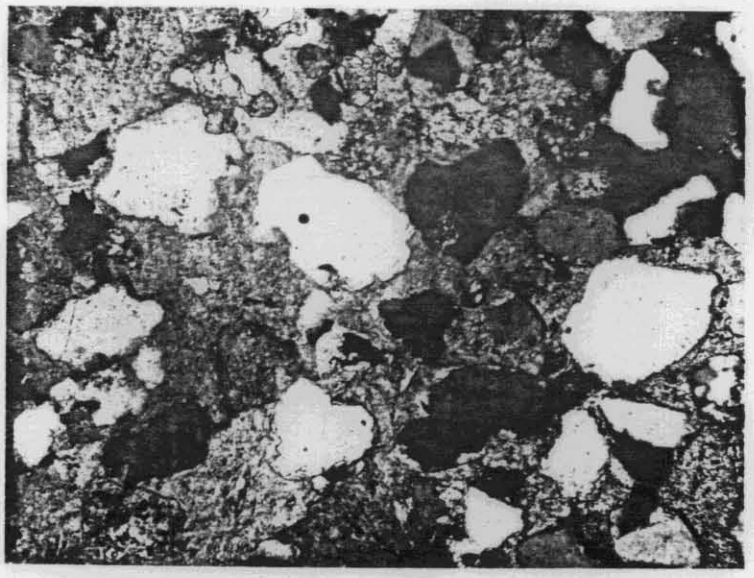


As above, crossed nicols

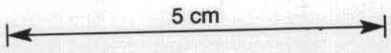
5 cm

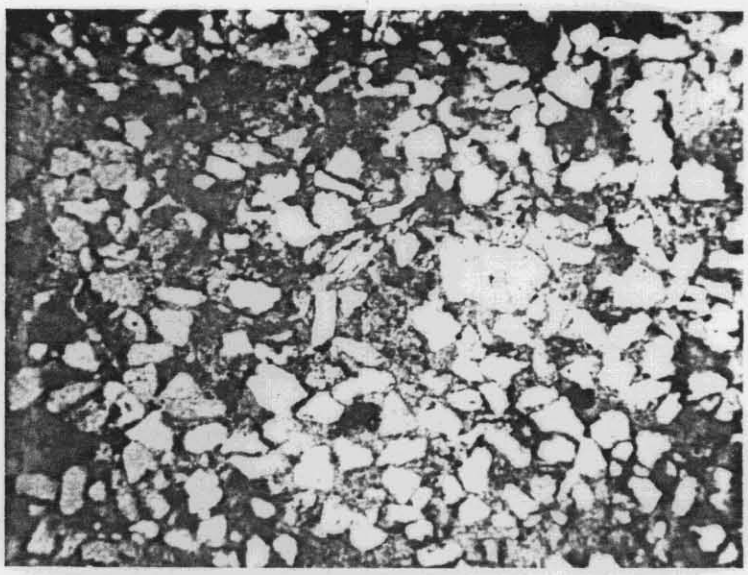



Bass-2 4749' depth, Eocene.
Calcareous cement (grey) partly corrodes quartz (q) grains. Some quartz grains with authigenic quartz overgrowths. Calcareous cement post-dates authigenic quartz overgrowths (x 92, plane-polarised light).

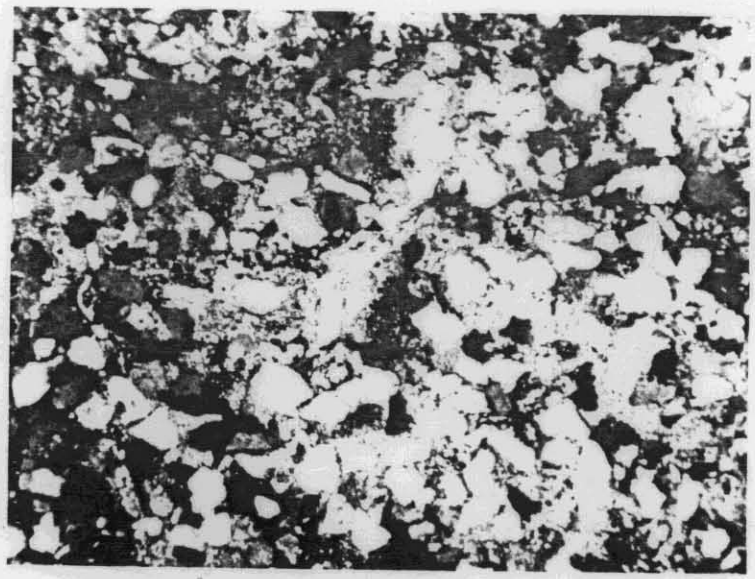


As above, crossed nicols

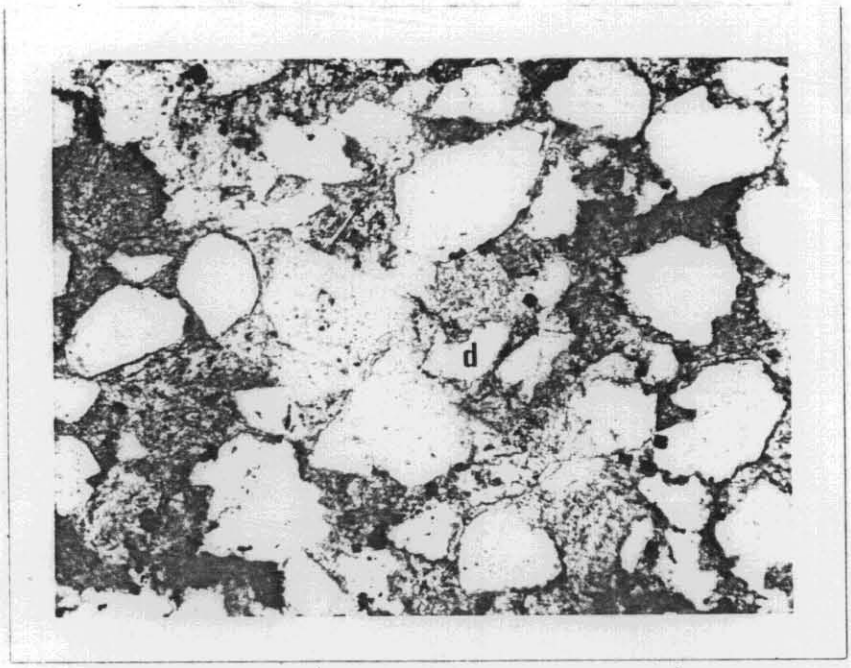


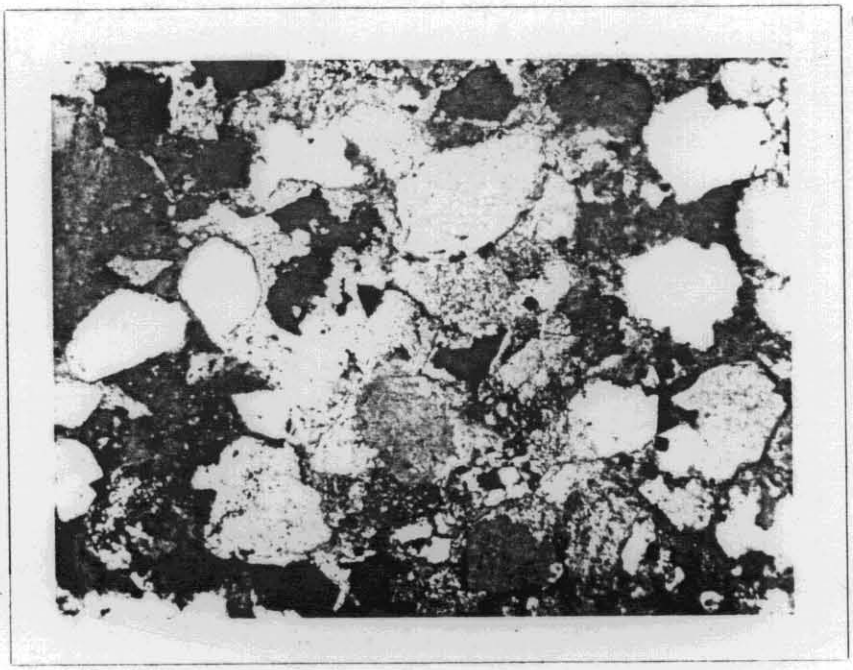
Bass-2 4761.3' depth, Eocene. Fine, calcareous cemented sandstone. Calcareous cement (? dolomite) also corrodes detrital grains. Porosity 6.0%, permeability 0.1 mD (x 37, plane-polarised light).



As above, crossed nicols




Bass-2 4761.3' depth, Eocene. Fine sandstone cemented by calcareous cement. Some detrital grains (d) severely corroded by calcareous matter (x 92, plane-polarised light).



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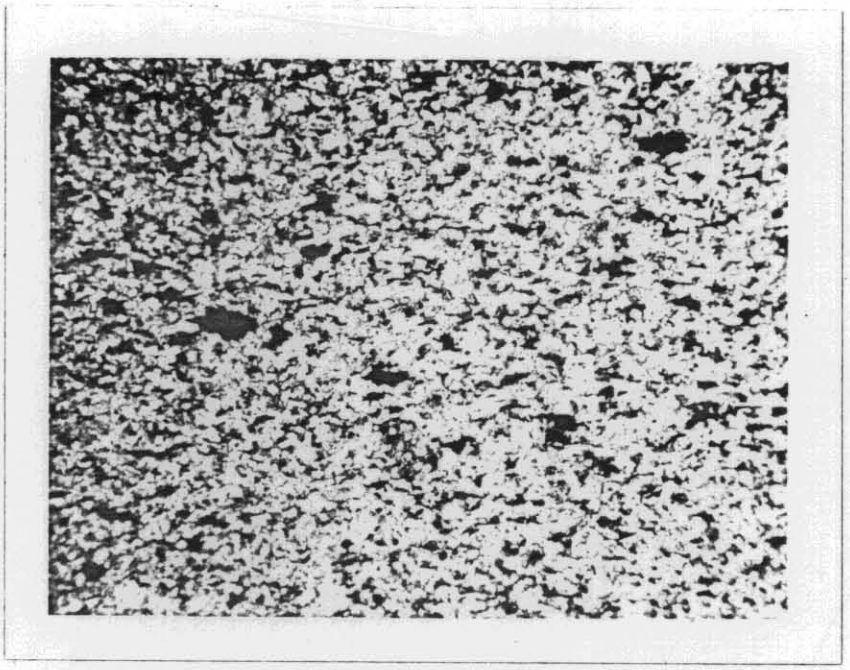
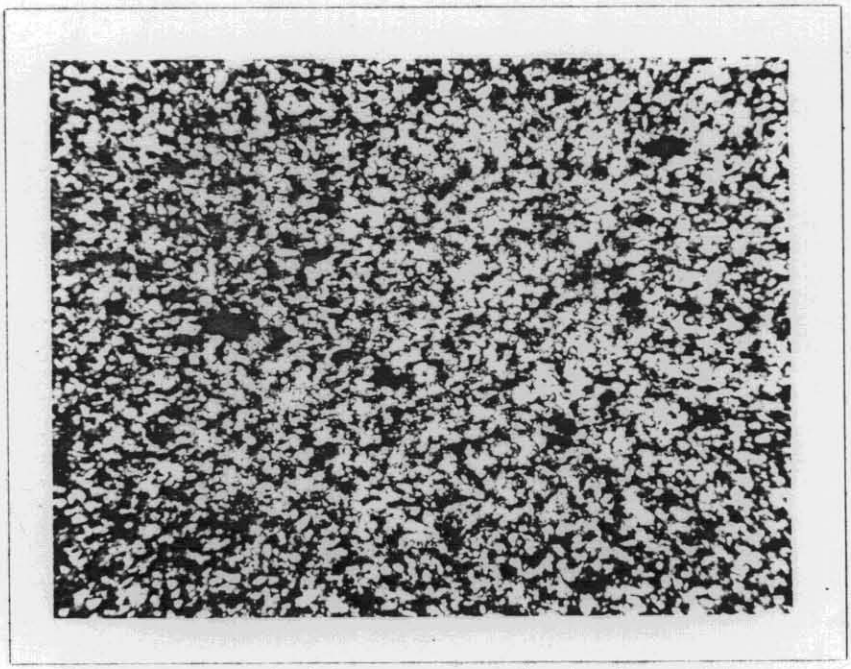



Bass-2 5068.6' depth, Paleocene.
Siltstone composed of quartz, feldspars, lithoclasts and micas; irregular distribution of calcareous cement. Porosity 19%, permeability 0.6 mD (x 37, plane-polarised light).



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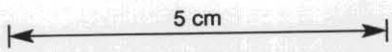
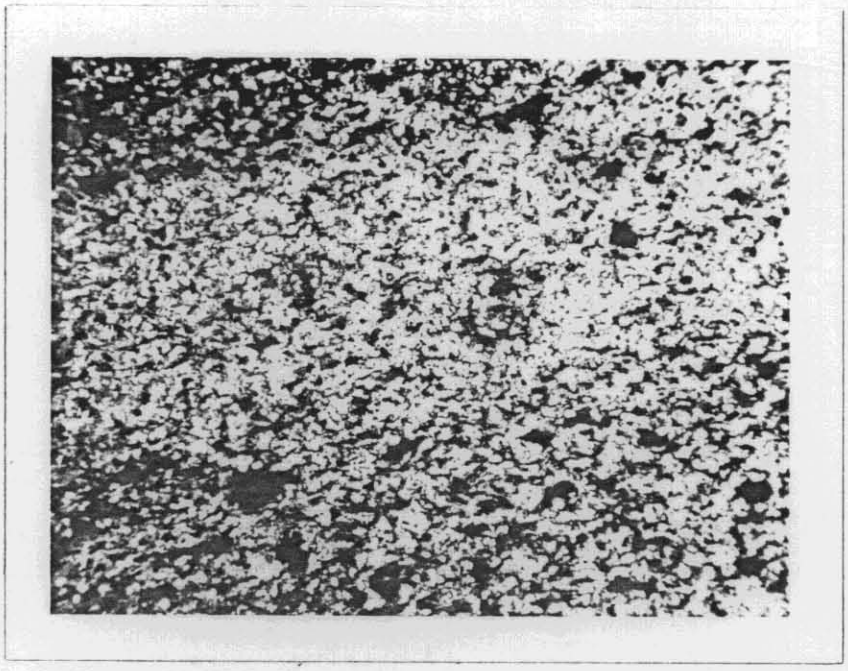
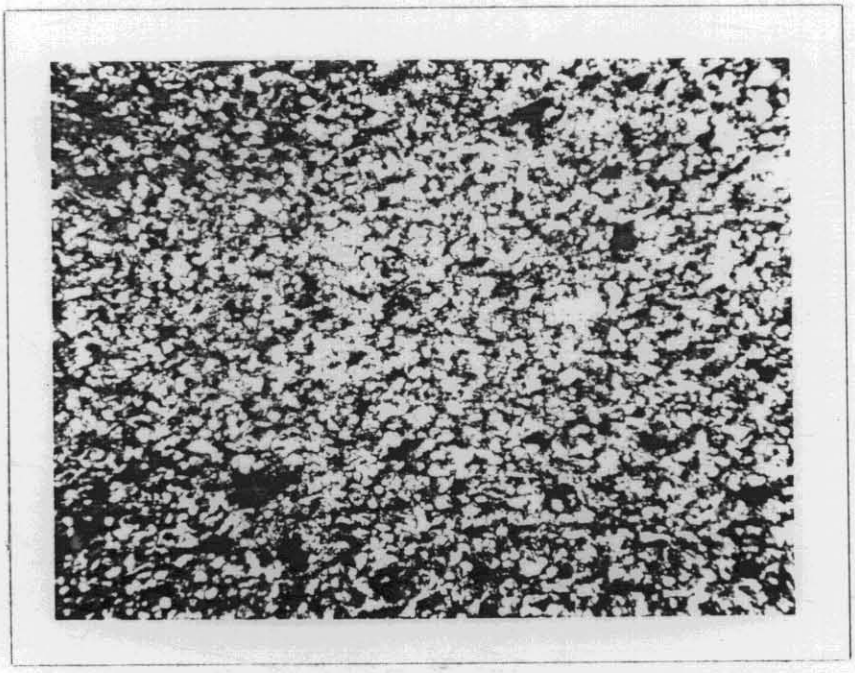


Bass-2 5074.6" depth, Paleocene. Carbonaceous siltstone composed of quartz, feldspars, lithoclasts, muscovite and carbonaceous matter; partly cemented by calcareous cement. Porosity 16%, permeability 0.1 mD (x 37, plane-polarised light).



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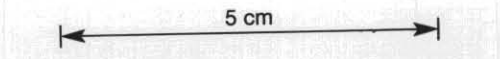
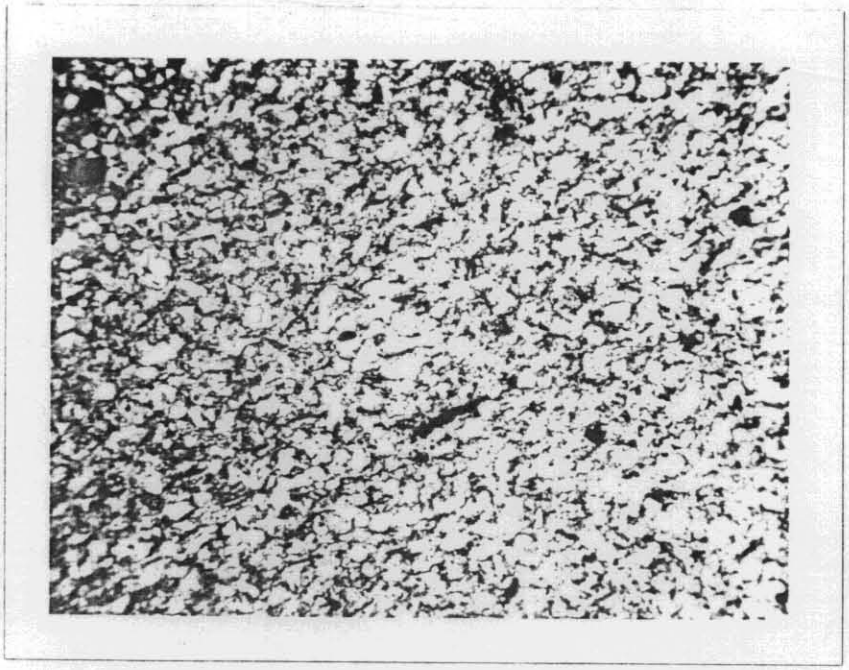
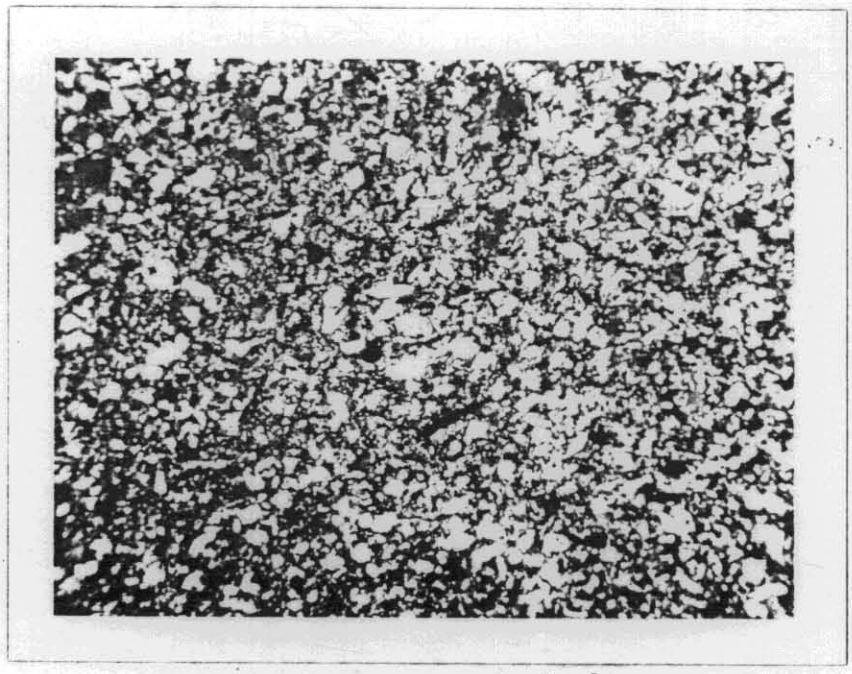


Bass-2 5508.45' depth, Paleocene. Siltstone composed of lithoclasts, feldspars, quartz, micas and carbonaceous matter (x 37, plane-polarised light).



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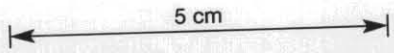
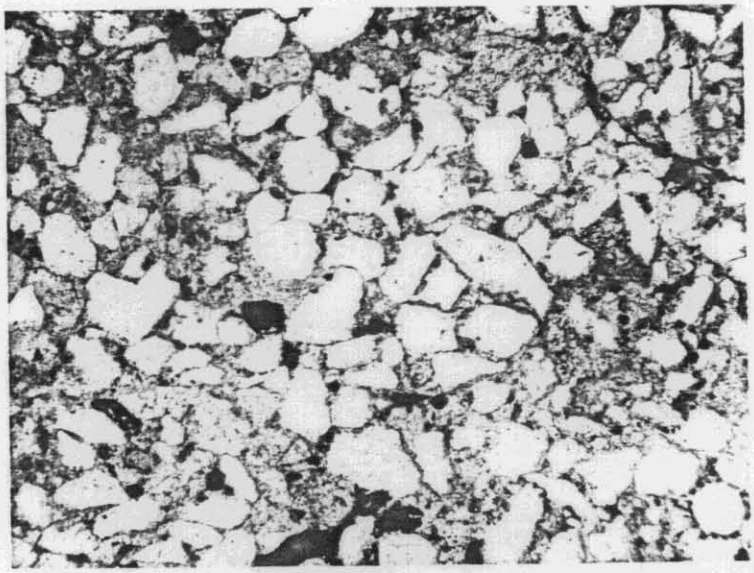
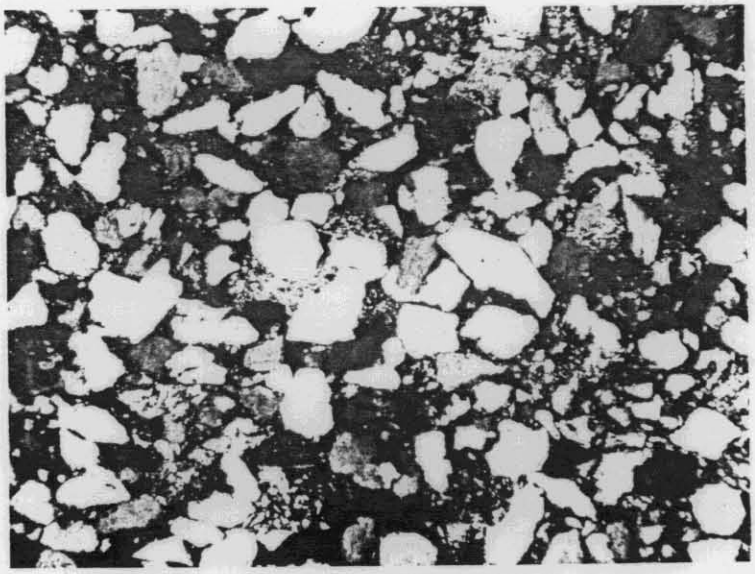


Bass-2 5509.6' depth, Paleocene. Medium-grained sandstone composed of quartz, lithoclasts and feldspars; abundance of kaolinite matrix; some intergranular carbonaceous (dark )matter. Porosity 25.2%, permeability 72 mD (x 37, plane-polarised light).



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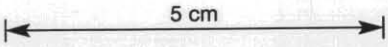
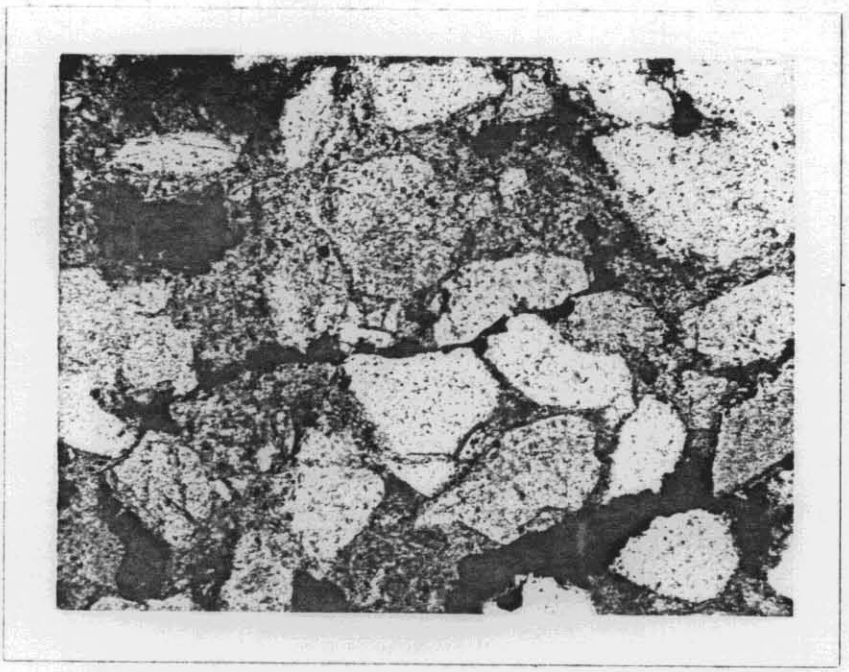
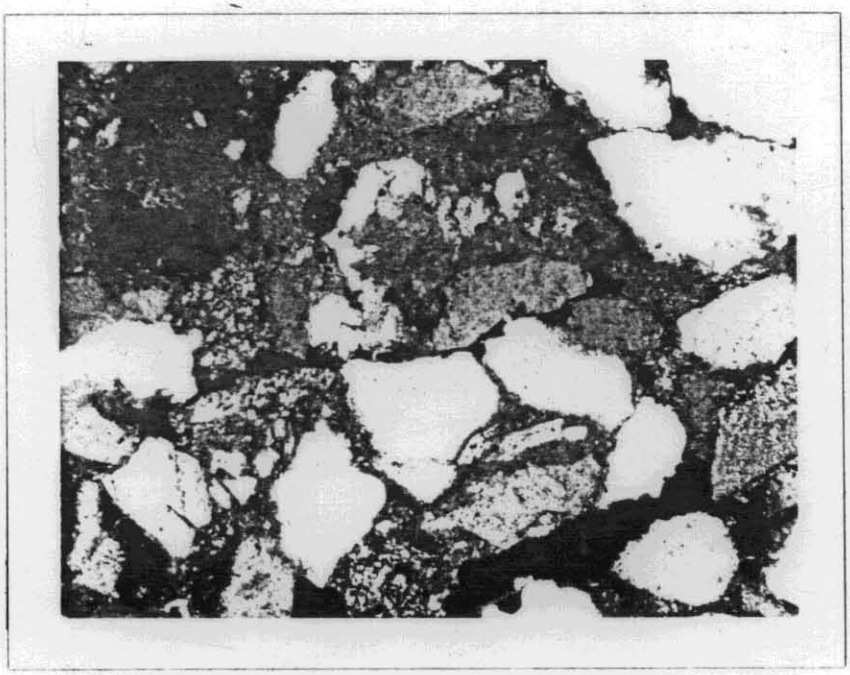


Bass-2 5509.6' depth, Paleocene.
Carbonaceous stringers in medium grained sandstone composed of quartz, lithoclasts and feldspars (x 92, plane-polarised light).



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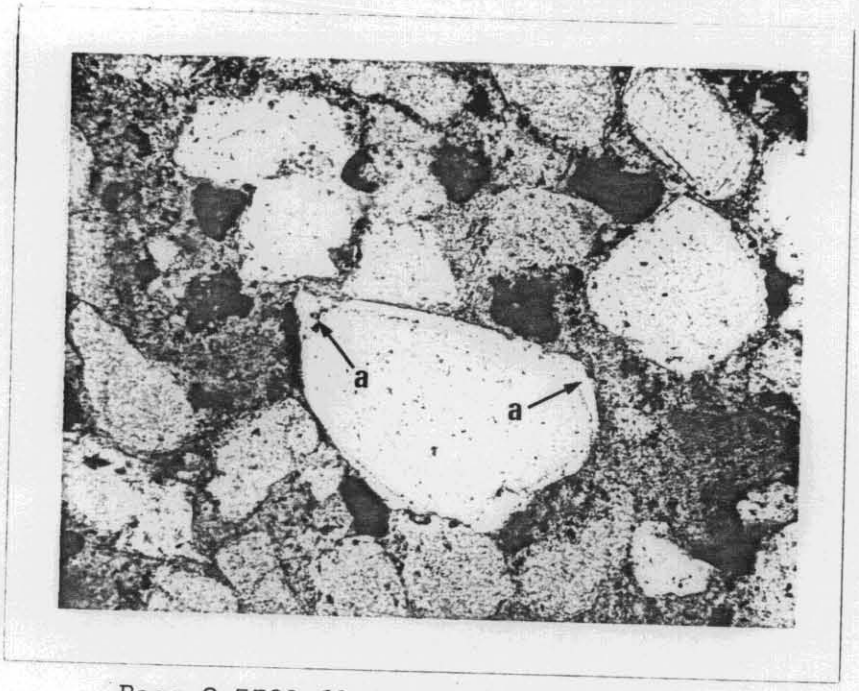
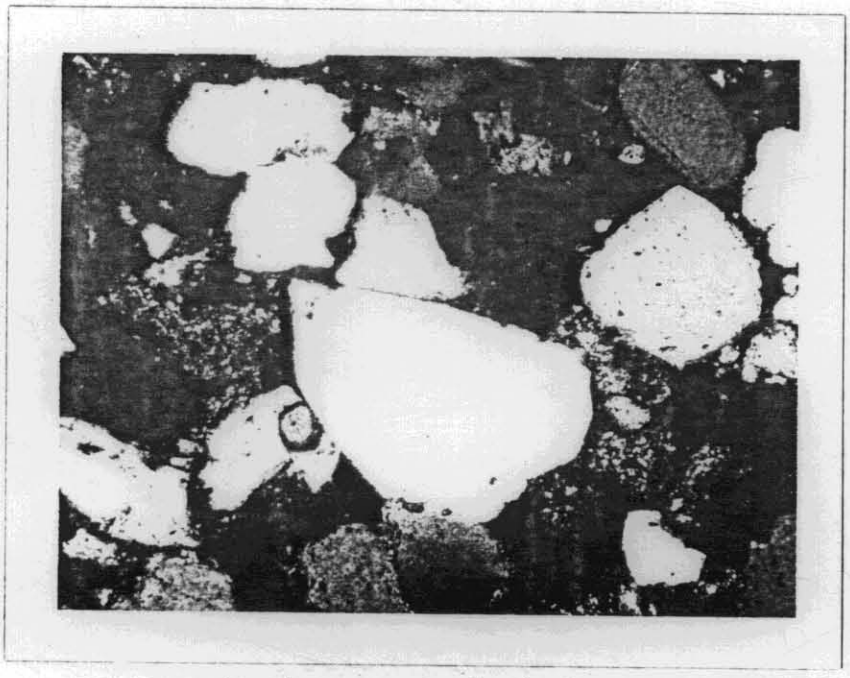



Bass-2 5509.6' depth, Paleocene.
Authigenic quartz overgrowths (a) on detrital quartz grain in medium-grained sandstone (x 97, plane-polarised light).



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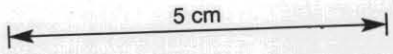
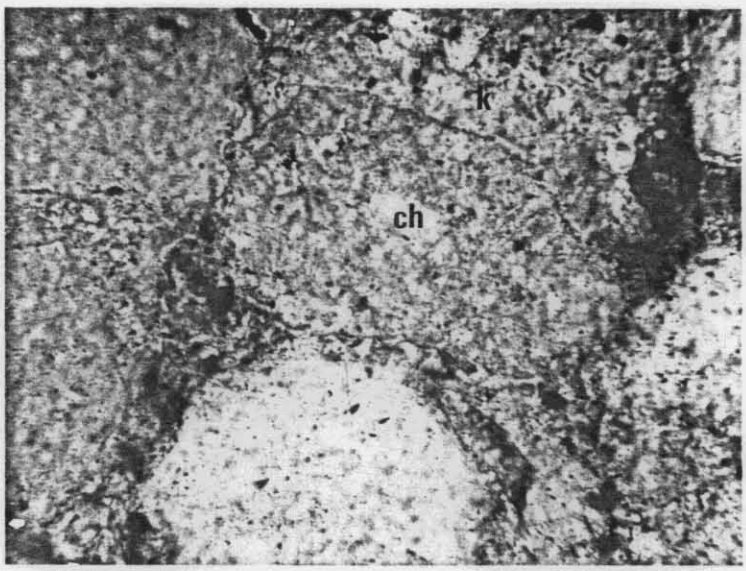
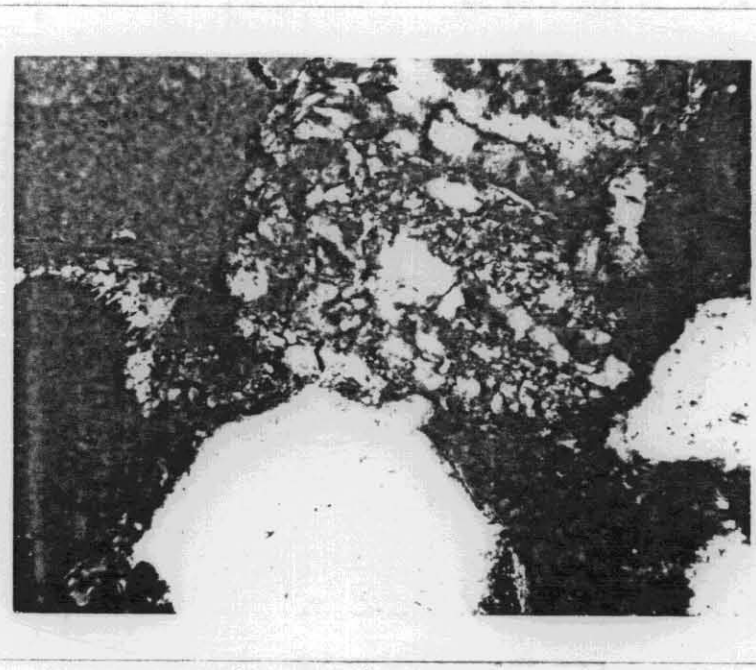



Bass-3 5509.6' depth, Paleocene.
Chert grain (ch) adjacent to plastically deformed grain composed of kaolinite (k) (x 230, plane-polarised light).



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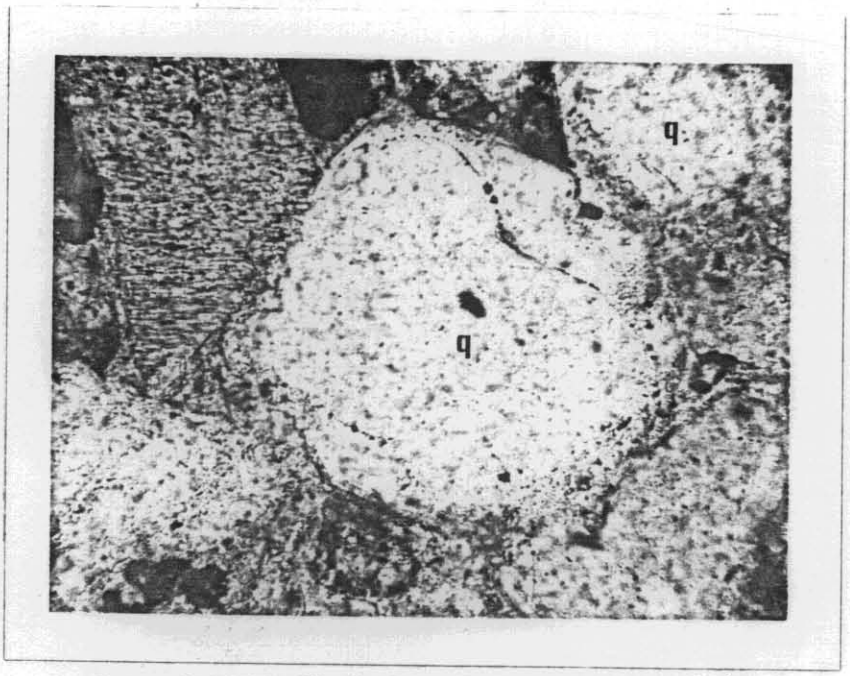
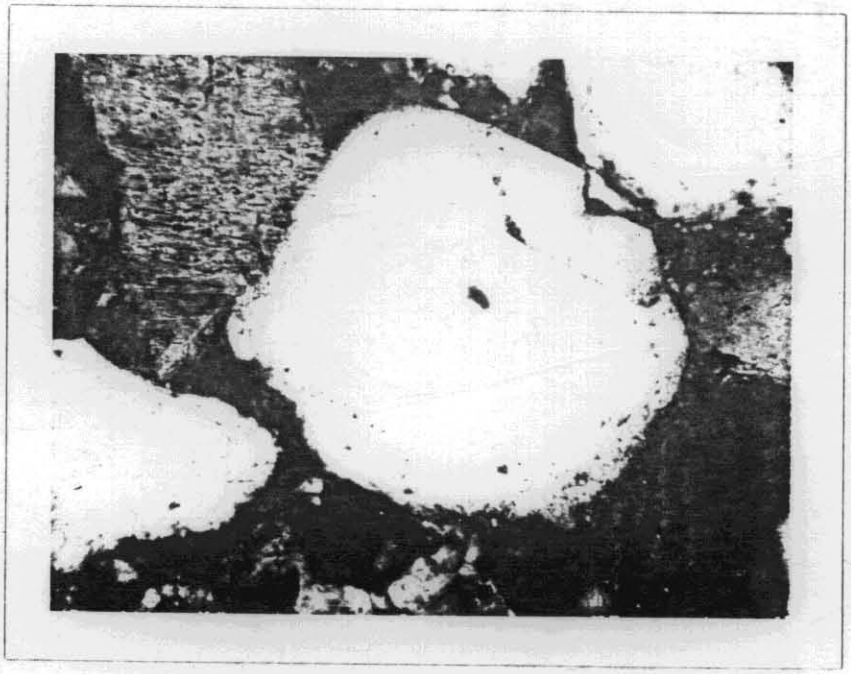


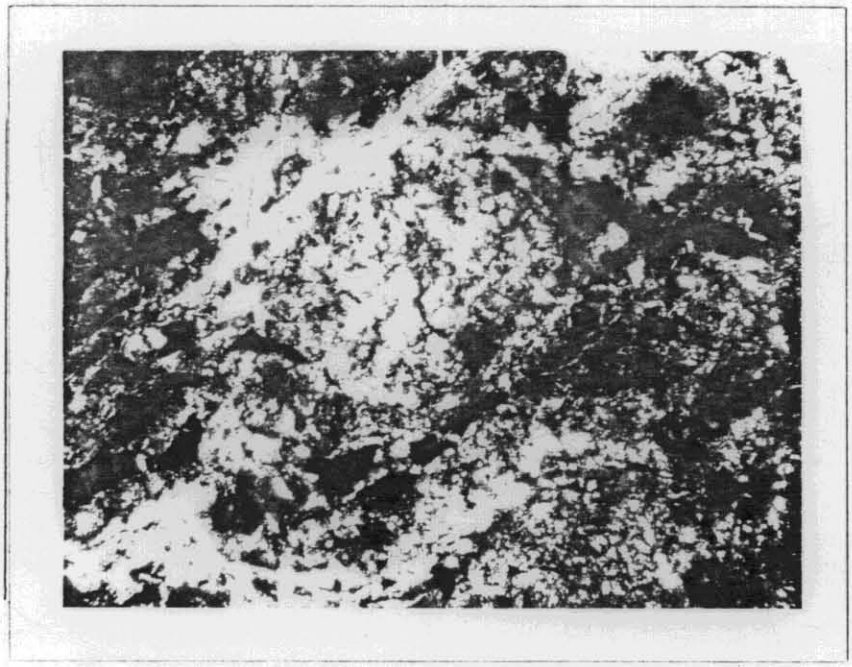

Bass-2 5509.6" depth, Paleocene.
Slightly intergrown authigenic quartz overgrowths of the detrital quartz (q) grains (x 230, plane-polarised light).



As above, crossed nicols

5 cm

Bass-2 5515.17' depth, Basement.
Volcanic rock, composed of phyllosilicate ( white ), siderite (grey) and leucoxene grains (dark, rounded to angular grains) (x 23, plane-polarised light).



As above, crossed nicols