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BASS and GIPPSLAND BASINS
CORE SAMPLE ANALYSIS

Amdel Report for Esso
August, 1967

OR - 025

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

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Please quote this reference in your reply:

MP 3/178/0

3rd August, 1967

Your reference:

The Chief Geologist,
Esso Standard Oil (Aust) Ltd,
GPO Box 4047,
SYDNEY, N.S.W., 2001

Attention: J.L. Elliott

REPORT MP2848-67

YOUR REFERENCE:	Letter dated 3/5/67, 302.0
MATERIAL:	Oligocene Core Samples
LOCALITY:	Bass and Gippsland Basins
IDENTIFICATION:	Esso Bass - 1, cores 7, 8 and 9; Esso Bass - 3, cores 3 and 4; EGS - 1, core 8; EGS - 3, core 3
DATE RECEIVED:	4/5/67
WORK REQUIRED:	Core sample analysis

Petrography and Heavy Mineral Analysis by: G. Williams

Investigation and Report by: E.C. Stock

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for H.W. Fander
P.A. Young
Director.

CONTENTS

CORE SAMPLE ANALYSIS OF SEVEN CORES FROM FOUR WELLS IN BASS AND GIPPSLAND BASINS

SUMMARY

Seven Oligocene lutites and calcareous lutites from the Bass and Gippsland Basins of south-eastern Australia have been examined in the laboratory. The analysis provided data on the petrography, mineralogy, chemical composition and bulk density of the cores. Clay minerals (smectite, kaolin and illite), quartz clasts and carbonate skeletal remains are the main compositional end members.

The Gippsland Shelf cores have bulk densities of about 2.2 and the bulk densities of the Bass cores average 2.0. This 10% difference is attributed to the lower quartz grain content and higher clay content of the Gippsland Shelf cores which, as a consequence, are relatively more perfectly compacted.

The carbonates in the cores are mainly the remains of pelagic and benthonic fauna. There is no evidence to suggest that the smectite (montmorillonite) is authigenic. The weathered products of the early Cainozoic "older basalts" of eastern Victoria may be a likely source for the smectite.

1. AIM OF INVESTIGATION

The core sample analysis was planned to elucidate the most important aspects of the petrology, mineralogy, chemical composition and bulk density of the sediments. It was intended that these data might be useful in explaining some of the properties of the rocks.

2. MATERIAL EXAMINED

The well name, core number and depth, of the seven samples are as follows:

Well	Core	Depth (ft)
Bass - 1	7	3908
	8	4427
	9	4862
Bass - 3	3	4003
	4	4521
Gippsland Shelf - 1	8	3342
Gippsland Shelf - 3	3	5609

3. RESULTS

3.1 Petrographic Descriptions

A portion of each core was thin sectioned and the petrographic descriptions of them are reported below.

The rocks examined are lutites (shales) and calcareous lutites (marls) with clay minerals, quartz grains and organic remains as the essential components. The clay mineralogy was determined by X-ray diffraction (see Section 3.2) and the carbonate mineralogy is reported in Section 3.5.

In none of the thin sections was there evidence (e.g. crystals growing in cavities, large delicate crystals) to indicate that any of the clay minerals are authigenic in origin. However, in some cores, the presence of authigenic silica and euhedral siderite can be demonstrated.

Core 7: TS19188[a]

Location:
Bass No.1 well, core at 3908 ft.

Rock Name:
Grey-brown, fossiliferous, quartz bearing, smectitic mudstone.

Hand Specimen:
Grey-brown, weakly fissile lutite containing fossil fragments.

Thin Section:
A visual estimate of the constituents gives the following:

	%
Quartz	15
Opaques	1
Heavy Minerals	<1
Clayey Groundmass	74
Obvious Fossils	10

There are no sand-sized terrigenous clasts. Silt-sized (median diameter 0.02 mm) quartz grains are set in a turbid, grey-brown clayey matrix. The quartz grains are subangular to monocrystalline with straight to slightly undulose extinction. Bedding is shown by thin, fossil-rich layers and by the orientation of rare muscovite flakes near these layers. Several siltstone clasts occur within the fossil-rich layers and the laminae are compressed beneath and draped over them.

(a) This is a thin section reference number. All thin sections are stored in a thin section library at Amdel unless directed otherwise by a sponsor.

The opaque mineral occurs as isolated grains, irregular lenses in association with the fossil-rich layers and may fill some fossil tests.
The fossil population of this core (and the others) may be larger than indicated in the percentage estimate as silt and clay sized fossil fragments are difficult to distinguish from clay minerals. X-ray diffraction (see Section 3.2) has demonstrated smectite as the dominant clay mineral. Numerous fractures traverse the rock as seen in thin section but many of these may be due to desiccation of the core before sectioning.

Core No.8: TS19189

Location:
Bass No.1 well, core at 4427 ft.

Rock Name:
Brown-grey, fossiliferous, quartz-bearing, smectitic mudstone.

Hand Specimen:
Brown-grey, weakly fissile lutite containing fossil fragments.

Thin Section:
A visual estimate of the constituents gives the following:

	%
Quartz	17
Opaques	1
Heavy Minerals	<1
Muscovite	<1
Clayey Groundmass	70
Obvious Fossils	12

There are no sand-sized terrigenous clasts. Silt-sized grains of quartz, slightly larger (median diameter 0.04 mm) than but similar in shape and sphericity to those in TS19188, are set in a brown clayey matrix. Bedding is displayed in the subparallel orientation of fossil fragments, mica flakes and stringers of quartz grains. The opaque mineral occurs in irregular masses and may fill a few fossil tests.
Fossils may be more abundant than indicated because of the difficulty of identifying some fossil fragments which are brown coloured in thin section.
A number of fractures traverse the rock, in and across the general bedding direction. Some of these are certainly due to desiccation after sampling but others are filled with chalcedonic quartz.

Core 9: TS19190

Location:
Bass No.1 well, core at 4862 ft.

Rock Name:
Grey-brown, quartz-rich, smectitic siltstone.

Hand Specimen:
Grey-brown, weakly fissile lutite with rare fossil fragments.

Thin Section:
A visual estimate of the constituents gives the following:

	%
Quartz	30
Plagioclase	<1
Muscovite	<1
Heavy Minerals	1
Opaques	2
Clayey Groundmass	64
Obvious Fossils	2

The very fine sand size quartz grains are relatively uniform in size and have a median diameter of 0.07 mm. In contrast with Cores 7 and 8 of Bass No.1, the quartz grains are abundant and they range from angular to sub-rounded (majority subangular) in roundness, and from elongate to subspherical (majority sub-spherical) in sphericity. Most of the grains are monocrystalline and show straight or slightly undulose extinction. The plagioclase grains are much the same size as the quartz grains and appear to be cleavage fragments. A banding or lineation is just apparent as shown by some clayey lenses more darkly pigmented in brown than others and by the subparallel orientation of quartz slivers and muscovite flakes. The opaque mineral occurs as very small irregularly shaped patches and fills some fossil tests. Some of the fractures in this rock have been produced in part by desiccation after sampling but others have developed in situ as they are filled with chalcedonic quartz.

Core No.3: TS19192

Location: Bass No.3 well, core at 4003 ft

Rock Name:
Grey-brown, quartz-bearing, smectitic mudstone.

Hand Specimen:
Grey-brown massive lutite with fossil fragments.

Thin Section:

A visual estimate of the constituents gives the following:

	%
Quartz	12
Muscovite	1
Heavy Minerals	1
Opaques	3
Clayey Groundmass	68
Obvious Fossils	15

There are no sand sized terrigenous clasts. The grey-brown clayey groundmass is homogeneous in appearance and cements silt sized (median diameter 0.02 mm), subangular to subrounded, subelongate to subspherical quartz grains and fossil fragments of various sizes.
The bedding is displayed by oriented muscovite flakes, quartz slivers and the clayey fabric. The opaque material (pyrite in part) occurs as disseminated spots, as patches and lenses. The reticulate fracture pattern is, in part, the result of desiccation of the core.

Core No.4: TS19191

Location:

Bass No.3 well, core at 4521 ft.

Rock Name:

Brown, quartz-bearing, smectitic mudstone.

Hand Specimen:

Brown, weakly fissile lutite with no obvious bedding.

Thin Section:

A visual estimate of the constituents gives the following:

	%
Quartz	15
Muscovite	<1
Heavy Minerals	1
Opaques	3
Clayey Groundmass	80

There are no sand-sized terrigenous clasts. Subangular to subrounded, elongate to subspherical silt sized (0.04 mm median diameter) grains of quartz are set in a brown clayey groundmass. Most of the quartz grains are monocrystalline with slightly undulose extinction. Bedding is displayed

by the orientation of thin muscovite flakes, quartz slivers, opaque streaks and alternating quartz-rich and quartz-poor layers. The opaque material also occurs as relatively large (0.2 mm) irregularly shaped masses.
A number of tube-like "passageways" traverse the rock. They are 0.1 mm wide and are presumed to be of organic origin. There are no obvious fossils.
Some of the cracks which parallel the bedding have probably developed through desiccation after sampling.

Core No.8: TS19193

Location:
Gippsland Shelf No.1, Core at 3342 ft.

Rock Name:
Grey, fossiliferous, smectitic mudstone.

Hand Specimen:
Grey, fissile lutite containing abundant fossil fragments.

Thin Section:
A visual estimate of the constituents gives the following:

	%
Quartz	3
Muscovite	<1
Green smectite grains	<1
Opaques	1
Siderite	2
Clayey Groundmass	81
Obvious Fossils	12

There are no sand sized terrigenous clasts. The grey clayey groundmass contains isolated rhombs and clusters of rhombs of authigenic, subhedral siderite about 0.05 mm across. Most of the siderite crystals have ferruginous pellicles and brown turbid cores. Silt-sized quartz and green smectite grains are other clasts supported by the markedly homogeneous groundmass. Bedding is not apparent in thin section. Authigenic silica in the form of chalcedonic vein quartz fills, at least in part, some of the fractures in the rock.

Core No.3: TS19194

Location:
Gippsland Shelf No.3, core at 5609 ft.

Rock Name:
Grey, fossiliferous, smectitic mudstone.

Hand Specimen:
Dark grey, weakly fissile lutite with pebble-sized fossils and small fossil fragments.

Thin Section:
A visual estimate of the constituents gives the following:

	%
Quartz	2
Opaques	1
Heavy Minerals	acc
Muscovite	acc
Clayey Matrix	87
Obvious Fossils	10

The clayey groundmass of the rock is a mottled brown and grey colour, with lenses and patches of darker material. These lenses impart a rough lineation to the rock and it can be seen by the en masse extinction of the clayey matrix under the microscope. Opaque minerals occur as lenses and strings parallel to the general bedding direction. Rare muscovite flakes and shell fragments are similarly aligned. The chambers of whole fossils are not filled with clay. Fractures traverse the rock and some of these can be attributed to desiccation of the core. Authigenic silica in the form of opal/quartz fills a few fossil tests and granular quartz fills some cavities.

3.2 Clay Mineralogy

3.2.1 Method of Treatment

Each sample was disaggregated by gentle crushing and dispersed in water with Calgon. After two settling periods the minus 2 micron and the 20 to 2 micron size fractions were obtained. Oriented specimens of the fractions were prepared and examined on a diffractometer untreated, saturated with glycerol and after heating at 550°C for 1.5 hours.

3.2.2 Terminology and Calculations

The clay mineral terms are used in accordance with the following definitions:

a. Smectites are 12 to 15Å sheet silicates which swell to approximately 18Å when saturated with glycerol. Smectite is the British term for the montmorillonite group of clay minerals and includes the species montmorillonite, nontronite, hectorite, saponite and beidellite.

b. Illite is a non-specific term for mica-like clay minerals with approximately 10Å basal spacings. Illites do not swell with glycerol.

c. Kaolin is the group name for the 7Å clay minerals kaolinite, dickite and nacrite, and halloysite-$2H_2O$. These minerals do not swell with glycerol.

The proportion of each clay mineral in a specimen is determined by measuring the area under the appropriate (001) diffraction peaks on the diffractometer chart obtained from the glycerol treated specimen, and multiplying the areas by correction factors to account for the differences in scattering abilities of the clay minerals. The accuracy of X-ray diffraction methods in clay mineral analysis is affected by the degree of crystallinity and the crystallite size of the clay minerals, by differences in absorption of the clay minerals and from specimen to specimen, and by specimen orientation effects. The errors these variables introduce are such that only semi-quantitative results are possible and the semi-quantitative terminology is as follows:

DOM - Dominant:	greater than 50%
SUBDOM - Subdominant:	between 20 and 50%
ACC - Accessory:	between 5 and 20%
TR - Trace:	less than 5%

Tables 1 and 2 below show the clay mineralogy of the two size fractions obtained by X-ray diffraction.

TABLE 1: SEMI-QUANTITATIVE CLAY MINERALOGY OF THE MINUS 2 MICRON FRACTIONS

Well	Core	Smectite	Illite	Kaolin
Esso Bass - 1	7	DOM	ACC	ACC
" " 1	8	DOM	TR	TR
" " 1	9	DOM	TR	ACC
Esso Bass - 3	3	DOM	ACC	ACC
" " 3	4	DOM	ACC	SUBDOM
EGS - 1	8	DOM	ACC	ACC
EGS - 3	3	DOM	TR	ACC

TABLE 2: SEMI-QUANTITATIVE CLAY MINERALOGY OF THE 20 TO 2 MICRON FRACTIONS

Well	Core	Smectite	Illite	Kaolin
Esso Bass - 1	7	DOM	ACC	ACC
" " 1	8	DOM	TR	TR
" " 1	9	DOM	TR	ACC
Esso Bass - 3	3	DOM	TR	ACC
" " 3	4	DOM	ACC	SUBDOM
EGS - 1	8	DOM	ACC	ACC
EGS - 3	3	DOM	ACC	SUBDOM

3.3 Heavy Mineral Distribution

Heavy mineral separations were done for seven drill hole samples. Twenty grams of each sample were crushed, and the clay and fine silt sized material washed away. The remaining coarser material was separated in tetrabromoethane (SG = 2.95) and the results of the separations are listed in Table 3.

Portions of the heavy fractions were mounted in standard RI oil mounts and examined in transmitted light using the polarizing microscope. The results of this examination are set out in Table 4. Mineral percentages were determined by visual estimation.

Zircon, where it occurs is commonly euhedral and water-clear; it may be rounded or weakly coloured. Cored and zoned varieties are also noted.

Tourmaline is green and blue, and is most likely authigenic in origin.

Quartz is attached to the opaque grains and is very irregular in shape.

Siderite was identified by X-ray diffraction as it is almost the sole constituent of the heavy fraction of EGS No.1 Core 8.

Opaques are the most abundant heavy minerals. They are commonly very irregular in shape, with a multinodular appearance. They also occur as tubular bodies (e.g. in Bass No.3 Core 3) which were determined by X-ray diffraction to be composed of pyrite. Some opaque grains are rounded. In EGS No.3 Core 3, (also Bass No.1 Core 9) many of the opaque grains are magnetic, and in Bass No. 3 Core 4, the majority appear to be sulphides - ?pyrite. Opaque material also fills minute fossil tests.

TABLE 3: HEAVY MINERAL SEPARATION DATA

Sample	Weight taken (after removal of clay, fine silt) gm	Weight heavy fraction gm	Weight light fraction gm	% heavy fraction in 20 gm
Bass No.1 Core 7	8.15	0.02	7.92	0.1
Bass No.1 Core 8	12.80	0.03	12.44	0.15
Bass No.1 Core 9	11.64	0.12	11.42	0.60
Bass No.3 Core 3	5.65	0.20	5.40	1.0
Bass No.3 Core 4	9.12	0.12	8.77	0.60
EGS No.1 Core 8	4.12	0.29	3.68	1.45
EGS No.3 Core 3	11.68	0.77	10.36	3.85

TABLE 4: HEAVY MINERAL DISTRIBUTION IN SEVEN CORES

Mineral	Bass - 1			Bass - 3		EGS - 1	EGS - 3
	Core 7	Core 8	Core 9	Core 3	Core 4	Core 8	Core 3
Zircon	acc	-	9	1	-	-	-
Tourmaline	acc	1	acc	2	-	-	-
Rutile	-	1	9	1	-	-	-
Garnet	-	acc	-	acc	-	-	-
Biotite	-	1	acc	acc	-	-	-
Epidote	-	acc	-	-	-	-	-
Fluorite	-	acc	acc	-	-	-	-
Carbonate	-	acc	6	-	1	-	{ 50
Fossils	2	15	3	30	1	-	{
Quartz	2	2	7	5	4	2	-
Opaques	96	80	66	60	94	1	50
?Muscovite	-	-	acc	-	-	-	-
?Topaz	-	-	acc	-	-	-	-
Green Smectite	-	-	-	acc	-	-	-
Siderite	-	-	-	acc	-	97	-

3.4 Chemical and "Modal" Analysis

Representative portions of each core were crushed and analysed for the elements as indicated in Table 5.

The data in Table 5 have been used to obtain a type of modal analysis in terms of the minerals muscovite, smectite, quartz, pyrite and carbonate. Some gross assumptions have been made in the calculations.

Muscovite is taken[(a)] to contain 10% K_2O, 39% Al_2O_3 and 46% SiO_2. Smectite is taken to contain 1% Fe_2O_3, 2% CaO, 2% MgO, 20% Al_2O_3, and 50% SiO_2.

The Al_2O_3 % and SiO_2% in muscovite and the muscovite per cent in each sample can be calculated from the appropriate K_2O values in Table 5, if K_2O is assumed to be confined to muscovite. The Al_2O_3 not contained in muscovite is attributed to smectite. From this Al_2O_3 value, the Fe_2O_3, CaO, MgO and SiO_2 values and the smectite per cent in each sample can be calculated. The SiO_2 not contained in muscovite and smectite is taken to be representative of quartz. Pyrite (FeS_2) is calculated directly from the S% in Table 5. Carbonate is calculated from the CO_2% as $(Ca,Mg,Fe)CO_3$ provided there is sufficient Ca, Mg and Fe, taken in that order, to satisfy the CO_2. The element oxides not treated in the modal analysis are considered to be associated in the smectite, muscovite and other unnamed opaques.

Table 6 records the results of the modal analyses. It may be seen that the totals for some samples may exceed 100. This is an inherent result of the assumption made in choosing the minerals in the modal analysis and in fixing the composition of these minerals. Nevertheless the modal analysis provides a method of sample comparison.

(a) Mineral composition data are based on the chemical analyses published in Deer, W.A., Howie, R.A. and Zussman, J., "Rock Forming Minerals," Vol 3, Longmans, London, 1962.

TABLE 5: CHEMICAL ANALYSIS OF SEVEN OLIGOCENE CORES FROM THE BASS AND GIPPSLAND BASINS
Weight Per Cent Oxide in Each Core.

Oxide	Esso Bass - 1			Esso Bass - 3		EGS - 1	EGS - 3
	Core 7	Core 8	Core 9	Core 3	Core 4	Core 8	Core 3
SiO_2	55.2	56.9	73.1	51.5	60.1	40.8	45.0
Al_2O_3	12.3	11.5	10.8	12.3	17.3	12.3	17.3
Total Fe as Fe_2O_3	4.15	4.00	3.25	4.25	5.20	5.10	4.65
MgO	1.23	1.26	0.81	1.48	1.18	1.81	1.53
CaO	10.1	9.9	1.89	11.8	1.40	17.2	10.9
Na_2O	0.84	0.83	0.86	0.83	0.73	0.65	0.59
K_2O	1.34	1.27	1.40	1.26	1.55	1.58	1.28
H_2O^+	4.65	4.75	4.25	3.50	5.05	4.75	6.55
H_2O^-	0.88	0.87	0.75	1.07	0.91	1.05	1.01
CO_2	8.05	7.55	1.30	8.95	1.70	14.00	9.70
TiO_2	0.71	0.67	0.78	0.72	1.00	0.57	0.88
P_2O_5	0.03	0.05	0.08	0.03	0.05	0.21	0.07
MnO	0.01	0.01	0.01	0.01	0.01	0.02	0.03
S	0.23	0.71	0.58	1.26	1.63	0.09	0.53

TABLE 6: "MODAL" ANALYSIS OF THE CHEMICAL DATA CONTAINED IN TABLE 5

Well	Core	Muscovite	Smectite	Quartz	Carbonate	Pyrite
Bass - 1	7	13.4	35.6	31.2	18.2	0.43
"	8	12.7	33.0	34.6	17.1	1.32
"	9	14.0	26.4	53.5	2.9	1.08
Bass - 3	3	12.6	37.0	27.2	20.2	2.35
"	4	15.5	56.6	24.7	1.0	3.05
EGS - 1	8	15.8	30.4	18.3	31.5	0.17
EGS - 3	3	12.8	61.4	8.4	19.6	0.99

3.5 Carbonate Content

Powders of the core samples were examined by X-ray diffraction to establish the identity of the carbonate mineral(s). Each sample contained at least two of the following carbonate species - calcite (trigonal $CaCO_3$), magnesian calcite (calcite with a small amount of magnesium proxying for calcium) and siderite (trigonal $FeCO_3$). Foraminifera compose a considerable part of the fossil population and foraminifera are reported to have tests of magnesian calcite (Pettijohn, 1957, p 385)[a].

The relative proportions of each carbonate in a sample is approximately equal to the ratio of the intensities of the appropriate diffraction peaks on the diffractometer chart. This information, together with the CO_2 percentages gives in Table 5, can be used to calculate the carbonate weight per cent. The percentages in Table 7 below are approximate because of the errors introduced from X-ray diffraction measurements and by not knowing the exact amount of magnesium in the magnesian carbonates.

(a) PETTIJOHN, F.J., "Sedimentary Rocks", Second Edition, Harper and Brothers, New York, 1957.

TABLE 7: CARBONATE CONTENTS OF SEVEN OLIGOCENE CORES FROM THE BASS AND GIPPSLAND BASINS

Well	Core	Carbonates	Approximate Weight %
Bass - 1	7	Calcite	10
		Magnesian Calcite	7
Bass - 1	8	Magnesian Calcite	10
		Calcite	6
Bass - 1	9	Calcite	1
		Magnesian Calcite	1
Bass - 3	3	Calcite	10
		Magnesian Calcite	10
Bass - 3	4	Calcite	1.5
		Magnesian Calcite	1.5
		Siderite	1
EGS - 1	8	Calcite	30
		Siderite	2
EGS - 3	3	Calcite	12
		Magnesian Calcite	5

3.6 Bulk Density Determinations

Care was taken to select portions of the cores that were representative and without obvious desiccation cracks for the bulk density (apparent specific gravity) determinations. The results obtained are shown in Table 8 below.

TABLE 8: BULK DENSITIES OF SEVEN OLIGOCENE CORES FROM THE BASS AND GIPPSLAND BASINS

Well	Core	Bulk Density
Esso Bass - 1	7	1.97
	8	2.00
	9	2.00
Esso Bass - 3	3	2.07
	4	1.98
EGS - 1	8	2.21
EGS - 3	3	2.25

4. DISCUSSION AND CONCLUSIONS

The cores examined are composed essentially of a combination of the three minerals smectite, quartz and calcite. Smectite has a density of between 2 and 3, quartz of 2.65 and calcite of 2.7. If perfectly compacted the cores would be predicted to have a density of between 2 and 3.

Core 8 and Core 3 from the Gippsland Shelf wells have bulk densities of 2.21 and 2.25 respectively. These bulk densities are approximately 10% greater than those of the cores from the Bass wells which average 2.00. The results of the analyses suggest reasons for the density differences.

The Bass cores contain between 15 and 30 per cent (by volume) of silt sized and/or very fine sand sized quartz grains, and between 51.5 and 73.1% SiO_2 by weight. The Gippsland Shelf cores contain a maximum of 3 per cent silt sized quartz grains (by volume) and between 40.8% and 45.0% SiO_2 by weight. After adjusting the SiO_2 values to account for the SiO_2 content of the clay minerals (Table 6), it can be shown that they bear a direct relationship with the quartz values estimated in thin section.

These observations imply that the sediments in the Gippsland Shelf cores with their very low quartz content (and corresponding high clay content) have suffered greater compaction, leading to greater bulk densities, than the more silty Bass cores. The relatively well compacted Gippsland Shelf sediments in the cores would be expected to have lower porosities and lower permeabilities that those of the Bass cores.

Other observations that can be made using the results of the investigation include:

1. In the Bass - 1 and Bass - 3 well cores examined, the silt content increases and the carbonate content decreases with depth.

2. The Bass - 3 cores contain about twice the amount of sulphides (pyrite) as any of the cores from Bass - 1 or the Gippsland Shelf wells.

The cores contain at least 50% smectite (montmorillonite) and are therefore bentonitic. In a sediment smectite could be fine-grained detritus from older smectitic sediments, from soils (particularly those produced in a semi-arid climate) or from altered volcanic rocks and ash. Authigenic smectite would be stable in an alkaline marine environment.

There is no evidence to indicate that smectite is authigenic. The smectite in these middle Tertiary sediments may have been derived from the weathered products of the early Tertiary "older basalts" of eastern Victoria.

PLATE 1

FIGURE 1: Bass - 3, Core 4: TS19191, PPL (Plane Polarised Light)
General field of view.

FIGURE 2: Bass - 1, Core 7: TS19188, PPL
General field of view.

FIGURE 3: Gippsland Shelf - 1, Core 8: TS19193, PPL
Siderite rhombs with turbid cores.

FIGURE 4: Gippsland Shelf - 3: TS19194, PPL
General field of view. Compare with Figures 1 and 2 which show more quartz clasts.

ed Light)

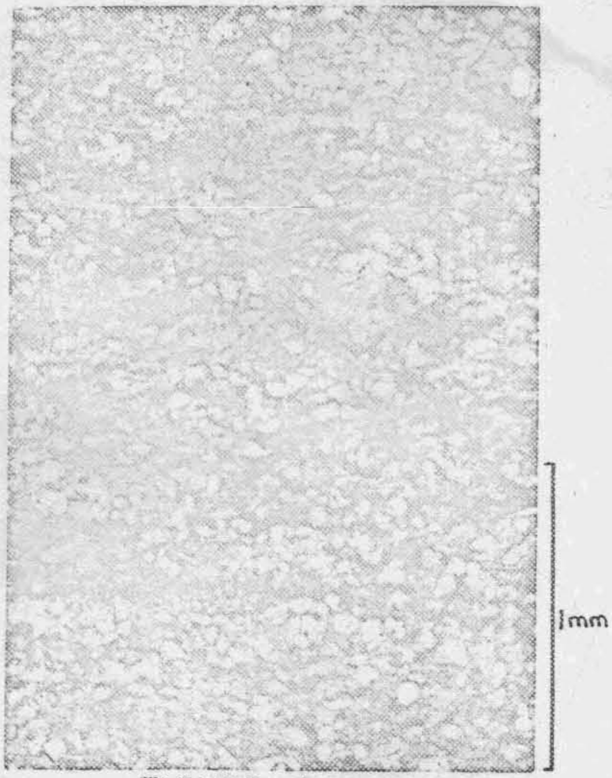

FIGURE 1

FIGURE 2

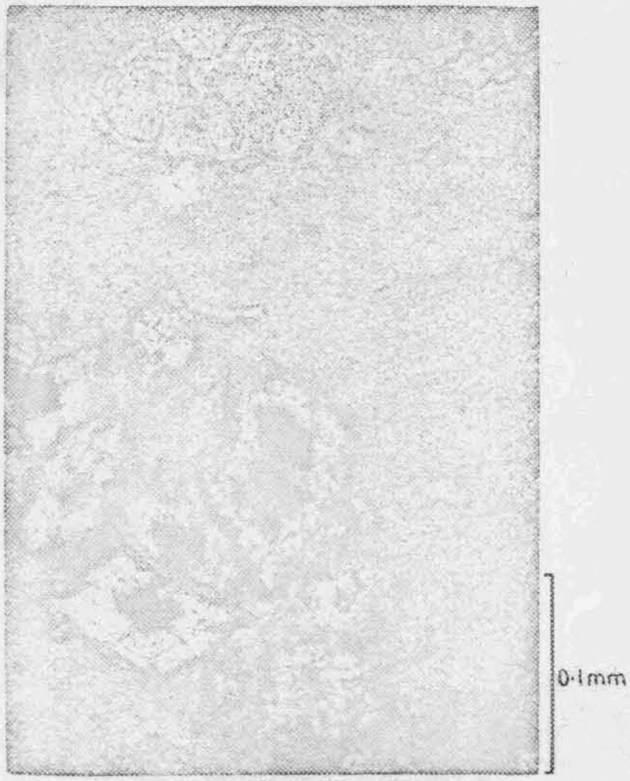

FIGURE 3

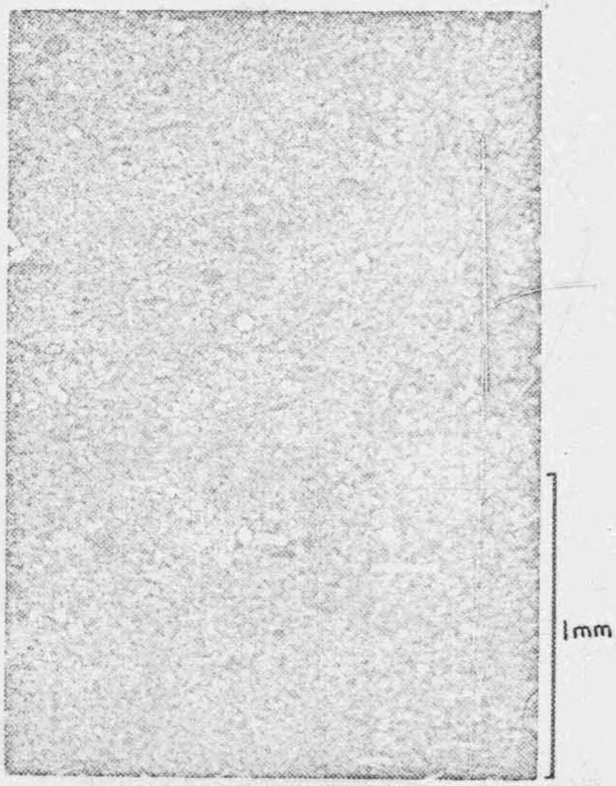

FIGURE 4