1980/21. Sedimentology of the freshwater sequence, Upper Parmeener
         Super-Group, on Fingal Tier.

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Abstract

The sedimentary sequence on Fingal Tier consists of
Upper Parmeener Super-Group siliclastics of fluviatile origin
conformably overlying a glacio-marine sequence of mudstone and
siltstone belonging to the Lower Parmeener Super-Group.

The fluvial system in which the Upper Parmeener Super-Group
siliclastics were deposited was characterised by meandering streams
of moderate to low sinuosity, which changed course often; poorly
developed levee banks; poorly developed channel bars; many point
bars developed on abundant meanders; and many oxbow lakes in which
mud was deposited and in which peat swamps formed.

INTRODUCTION

The marine and glacio-marine mudstone and siltstone of the
Parmeener Super-Group Upper Marine Sequence (Forsyth *et al.*, 1974)
are overlain on Fingal Tier by a sequence of quartz arenites and interbedded
lutites which in turn are overlain by a sequence of coal bearing lithic
arenites.

The sediments have been classified according to the schemes of
Pettijohn (1957) and Folk (1974).

QUARTZ SANDSTONE

The lowest member of the Upper Freshwater Sequence on Fingal Tier
is a series of quartz arenites interbedded with siltstone and mudstone
units.

In hand specimen, the quartz arenites are white in colour with
a sparkling appearance, probably due to the abundant quartz overgrowths.
Macro-features include steep bedding planes dipping at up to 30°,
possibly representing large scale cross-bedding; carbonaceous laminae;
lenticular disturbed bedding; lenses and bands of mudstone and siltstone;
subvertical joints and vertical and horizontal burrows. This lithotype is
less than 50 m thick on Fingal Tier, with individual beds rarely being
thicker than 6 m; the modal thickness is 2 - 3 m.

In thin section, the quartz arenites are composed of well sorted
(unimodal) close packed quartz grains, most of which are mono-crystalline
with undulose extinction and inclusions of sericite. Minor components
include fragments of chert, phyllite and rounded heavy mineral grains
such as rutile, tourmaline, and zircon.

LITHIC SANDSTONE

Lithic arenite

Lithic arenite is the dominant lithotype in the Upper Parmeener
Super-Group, with individual rock units commonly being tens of metres
thick. The thick units typically fine upwards. In hand specimen, the
rocks are grey or mustard in colour and are often massively bedded.

Fluviatile structures such as cross-bedding, with dips of up to 40°, are present. Bottom contacts of individual units are frequently sharp and undulose, and dip at up to 20° to the core axis.

Bands of mudstone (with abundant slickensides), siltstone and clay pellet conglomerate are common. Mudstone and siltstone pellets also occur. Individual pellets range in size from a few to 45 millimetres long. Coal debris occurs as flaser beds of coal, chunks of coal, massive bands of carbonaceous mudstone (rare), coaly partings and wispy carbonaceous laminae which are often contorted. Calcite veins and nodules are present, but not abundant. Some units have a secondary calcareous cement.

The lithic arenites have a closed, grain supported framework, very little matrix, and a unimodal grainsize, ranging from 0.5 mm diameter in the coarse lithic arenites to 0.1 mm diameter in the fine arenites. Occasional samples are poorly sorted with a polymodal grain-size distribution.

The clastic components include fragments of quartz, chert, volcanic glass, mudstone, siltstone, metamorphic rocks such as phyllite, quartzite and schistose rocks, tuffs, chlorite, biotite, iron oxides, muscovite, heavy minerals such as rutile zircon, tourmaline,garnet, reworked pieces of calcite matrix, coal, plant fragments, plagioclase and less commonly K-feldspars.

Authigenic components include secondary chlorite, clay coatings on clastic grains, quartz overgrowths (rare) and the development of a calcareous cement.

Quartz grains are usually equidimensional, and may be angular, sub-rounded or less commonly well rounded. The quartz is dominantly mono-crystalline with undulose extinction, polycrystalline quartz and quartz with straight extinction being rare. Polycrystalline quartz grains in some samples have ragged rims from reaction with the authigenic clay matrix. Quartz composes 10-30% of the rock volume. Chert clasts are usually well rounded and compose less than 10% of the rock volume. Quartz as volcanic glass is relatively uncommon; the sub-rounded glass clasts are invariably devitrified and in most cases chloritised.

Plagioclase feldspar is far more common than K-feldspar. Plagio-clase, usually andesine or oligoclase, occurs as sub-rounded, elongate laths and comprises no more than 10% of the total rock volume. Plagio-clase grains are usually smaller than the quartz grains, a feature indicative of a temperate to warm climate (Folk, 1974).

Alkali feldspar is mostly microcline, with rare grains of perthite. K-feldspar comprises less than one per cent of the rock volume. Albite and orthoclase have also been recognised (Whitehead, 1963), although these minerals are not easily identified unless the thin section has been first treated with cobaltinitrate solution.

Mudstone and siltstone clasts are well rounded, often with growth of secondary chlorite. Siltstone clasts often have flakes of muscovite in a preferred orientation. Mudstone and siltstone both contain quartz clasts and sometimes show small scale banding.

Volcanic rock fragment content is extremely variable, ranging from 0-10%. The most common type of tuffaceous fragment is composed of plagioclase laths (usually andesine) scattered through a devitrified

and chloritised glassy matrix. Tuffaceous fragments which resemble ignimbrite occur, but are not as common. The volcanic rock fragments show a variety of textures, including microporphyritic, eutaxitic, trachytic and flow banded.

Metamorphic rock fragments include rounded clasts of phyllite, quartzite and schistose rocks. Quartzite fragments occasionally contain small garnets. Grains of detrital biotite and chlorite are not uncommon. Biotite flakes frequently show a preferred orientation, while chlorite often occurs as rounded grains and is not as common as biotite. Muscovite grains are even less common and occur as rare flakes with a preferred orientation.

Clasts of coal, usually composed of the maceral inertinite, occur in some samples. Quite large, irregular shaped clasts up to 10 mm long occur, although the long clasts tend to be elongate and have a preferred orientation.

Heavy mineral grains, always well rounded, occur in small numbers, usually 5-10 grains per thin section. Minerals found include rounded tourmaline, zircon with rare sphene, garnet and ilmenite. Whitehead (1963) records prismatic apatite grains and irregular shaped epidote in arkose samples from DDH 1 on Fingal Tier. The depths of the samples given by Whitehead (1963) correspond to bands of lithic arenite. She notes also that apatite and zircon inclusions in the biotite indicate that all three minerals came from the same source.

Authigenic clay overgrowths are more common in the finer grained lithic arenites and the units with the highest matrix content.

Minor associated features

Clay pellet conglomerate bands are not more than 100 mm thick and are composed of well-rounded, elongate clay pellets in a matrix of coarse lithic arenite. The clay pellets are composed of a matrix of quartz grains and clay. The quartz grains are small, less than 0.1 mm diameter, mono-crystalline and well rounded. The matrix accounts for 85% of the rock volume. Larger clasts of quartz, 0.5 mm in diameter, biotite flakes 0.1-0.2 mm long, rare chert clasts 0.2 mm diameter and rare plagioclase laths comprise the remaining 15% of the rock volume. The clay pellets display internal layering.

<div align="center">LUTITE</div>

Lutites in the Upper Parmeener Super-Group are generally quartz-rich shale and mudstone, although chloritic and micaceous mudstone has also been recorded.

Mudstone

Mudstone units are commonly less than one metre thick, but thicker beds of 5-10 m do occasionally occur. In hand specimen, the mudstones are coloured green, brown, grey or black, with grey mudstone being the most common type. Abundant plant fossil debris is found, along with some signs of bioturbation, frequent slickensides, rheomorphic slumping features, minor cross-bedding and occasional laminations. Contacts between mudstone, carbonaceous mudstone and coal are often gradational. Calcite veins and nodules are also found, with nodules being rarer than veins.

Lenses and interbedded laminae of coal,silt and sand are common.
Banding in mudstone is frequently caused by the rapid alternation of
thin beds of carbonaceous and non-carbonaceous mudstone. Quartz occurs
in all the mudstones, invariably fine grained and mono-crystalline.

Brown mudstone

These rocks are fine grained and are composed of silt size
particles (40%), clay particles (20%), and quartz grains, with an abundance
of fine grained quartz comprising 40% of the rock volume. Quartz also
occurs as larger clasts, ranging in size from 1-4 mm diameter. Rheomorphic
slumping and bedding laminae are evident. Rare dessication cracks which
have been filled with granular mineral charcoal (inertinite), clay and
fine quartz grains may be seen. Fine grained sericite is present along
with rare clasts of reworked calcite matrix.

Sandy mudstone

These rocks contain an abundance of small, angular quartz fragments,
<0.01 mm in diameter, with low roundness and low sphericity and often
comprising up to 40% of the rock volume. Silt sized particles comprise
40% of the rock volume with the remaining 20% being clay. Angular plagio-
clase laths are rare. The rocks often contain minor amounts of biotite
as flakes or plates and chlorite as either plates or granular aggregates.
The plate shapes align with their long axes parallel to bedding planes.
Coaly stringers and fragments, clay lenses, and rare clasts of devitri-
fied glass occur.

Banding is commonly caused by the alternation of quartz-rich with
relatively quartz-poor (*i.e.* silt rich) layers. Coal dust or aphanitic
grains of inertinite are sometimes incorporated with the silt, thus
emphasising the layering.

Carbonaceous mudstone

These mudstones invariably show gradational top and bottom contacts
with non-carbonaceous mudstone or coal. The modal occurrence is in coal.

In hand specimen, the carbonaceous mudstone shows frequent and
fine laminations with many lenses and bands of non-carbonaceous mudstone,
siltstone and clay. Slickensides are abundant, as are coaly debris,
wispy coal laminae, coal clasts and plant fragments.

The rocks are composed of fine grained quartz, set in a fine
grained matrix of silt, clay and coal dust. The quartz grains are
sub-rounded to sub-angular with moderate to high sphericity and are mono-
crystalline with undulose extinction. The majority of the quartz grains,
which comprise 40-50% of these rocks, are less than 0.1 mm in diameter.
Plagioclase laths, usually andesine, occur in small quantities in some
mudstone.

The silty matrix is often composed of equal proportions of silt,
clay and aphanitic mineral charcoal. Chlorite and biotite occur as
rare detrital grains in the matrix. Chlorite grains are usually plates
and show a preferred orientation.

The carbonaceous mudstone commonly contains inclusions of sand
grains, either as individual grains or in small lenses. Chunks of
detrital coal ripped from the underlying coal bed are common.

Banding in these rocks is often achieved by alternation of 'coal rich' and 'coal poor' bands of silt and clay. Individual laminae are thin, 1 mm to 0.1 mm in width. The larger detrital particles, such as quartz and coal, show a preferred orientation with the long axes of the clasts being aligned parallel to bedding.

Green mudstone

Green mudstone is most common towards the lower part of the Upper Parmeener Super-Group. The green colour is in most cases due to the existence of glauconite which is not present in mudstone higher up the sequence. These mudstones are composed of fine grained quartz, biotite, chlorite, glauconite and clay minerals. Rounded quartz grains up to 3 mm in diameter are scattered throughout the mudstone and comprise up to 15% of the rock volume. These grains are probably derived from the associated quartz arenites which are also confined to the lower part of the Upper Parmeener Super-Group.

The chlorite occurs as elongate plates and as granular aggregates, which usually show a preferred orientation. The glauconite occurs as minute granular aggregates scattered through the rock, and concentrated in small lenses.

The green mudstone also contains rounded megaclasts of siltstone and quartzite, up to 15 mm in diameter. These megaclasts are most probably dropped pebbles or dropstones, and along with the glauconite content indicate a marine origin for these mudstones. The interbedded and overlying quartz arenites are most probably beach deposits.

Shale

The shales of the Upper Parmeener Super-Group are found almost exclusively interbedded with carbonaceous mudstone and coal. In hand specimen, the rocks are extremely fissile and friable. The constituents are basically the same as the mudstone with the shale having a larger amount of mica. The fissility is produced by the parallel alignment of plates of muscovite and more commonly biotite. Plant fragments are very common in the shale, which also seems to contain a high proportion of calcium-montmorillonite. In summary, the components are fine grained quartz, silt, mica and clay.

Siltstone

Siltstones are coloured grey, dark grey or brown in hand sample and often display fine bedding, rheomorphic slumping and sigmoidal cross-bedding. Thin lenses of mudstone, fine lithic sandstone and clay are not uncommon, and the siltstone sometimes contains abundant plant fossil debris.

Laminae average one millimetre wide, but finer banding occurs. Banding is caused by alternation of:

(1) carbonaceous and non-carbonaceous silt layers,

(2) quartz-rich and relatively quartz-poor silt layers, and

(3) coaly stringers or coal flaser beds set in a matrix of silt, quartz and clay.

The siltstone is composed of fine grained quartz, clay and mineral charcoal. The quartz is very small, mono-crystalline, usually rounded with low sphericity and showing a preferred orientation. Quartz comprises 10-20% of the rock volume. Very small (unidentifiable) silt and clay particles comprise 50% or more of the rock volume. Clasts of inertinite with minor sporonite and gymnospermous wood have been found. Minute grains of detrital biotite, chlorite and rare muscovite and sericite are common. These grains often have a preferred orientation.

Laminite

'Laminite' is the collective name given to the finely laminated units of interbedded lithic sandstone and siltstone, lithic sandstone and mudstone, mudstone and siltstone. The laminae are frequently only 1 mm wide. The first two units almost always show a gradational contact with one of the rock types comprising the interbedded unit.

Interbedded siltstone grades upwards into lithic sandstone, and mudstone/lithic sandstone grades into mudstone. The unit siltstone/mudstone is overlain most often by sandstone, either quartz sandstone or lithic sandstone with a sharp bottom contact. This indicates that the units of lithic sandstone and mudstone or siltstone are probably part of channel deposits, while the interbedded siltstone/mudstone unit is a flood plain deposit which is overlain suddenly by channel deposits (lithic sandstone), produced by processes of channel diversion.

The laminite contains wispy coal laminae, lenses of clay and coaly partings and bands of clay in some samples.

Palaeosols

Palaeosols are not recognised in any of the conventional drill core logs. However, some of the 'dirt bands' in coal seams may represent ancient soil horizons. The dirt bands are composed of quartz grit, sand, silt and clay sized particles and are very friable. The maximum thickness reached is about 100 mm, which is quite shallow for a soil. Soil 2-3 m deep of Triassic age has been recorded in New South Wales (Retallack, 1977). In a rapidly changing flood plain environment with rapid movement of meanders, it is possible conditions did not last long enough for extensive soil development.

ENVIRONMENTS OF SEDIMENT DEPOSITION

The quartz arenite interbedded with shallow marine limestone may be interpreted as being a beach deposit formed during the very first stages of a marine regression. Thicker beach deposits followed as the regression advanced. Quartzwackes were deposited in areas where there was not sufficient energy to effectively round and sort the sandstone, or where sedimentation was too rapid for effective sorting to occur, such as in a shallow lagoon bounded by beach deposits (dunes) on the seaward side.

A flood plain environment formed over the existing beach deposits, probably as the shoreline moved further away towards the east. The flood plain was dissected by streams with moderate to high sinuosity. Lithic arenite and lithic wacke were deposited by channel processes, as evidenced by the cross bedding and scour and fill structures.

Mudstone was deposited in shallow lakes, formed by the cutting off of meanders and channel diversion. Shale and mudstone are finely laminated and not cross bedded, indicating a quiet water environment of deposition.

Interbedding with coal is also indicative of a non-turbulent environment. The ponds and oxbow lakes dried up on occasions, as evidenced by mud cracks.

Silt was deposited in overbank floods on the flood plain, where due to the long period of exposure to wind between floods, the finer clay particles were winnowed out of the overbank flood plain deposits, leaving only silt. Silts are also blown onto flood plains from other areas during times of exposure to wind.

<div align="center">ENVIRONMENT OF COAL DEPOSITION</div>

Coal measure sequences of Triassic age in the Upper Freshwater sequence of the Parmeener Super-Group have been tentatively correlated with the Nymboida and Ipswich coal measures of New South Wales and Queensland (Noldart, 1975). However, the seams from these two coal measure sequences have moderate to high vitrinite contents (Smyth, 1979), and so must have formed under different environmental conditions to the Tasmanian coal.

Dull coal or durain, enriched in semifusinite and fusinite and having a variable quantity of mineral material, is considered by Smyth (*in* Smyth, 1979) to have formed by the flooding of a bog surface with oxygenated water. Decay processes in such an environment are largely aerobic. Such a description fits the whole of the Duncan seam. Where the concentration of mineral matter is high, inertodetrinite is more abundant than semifusinite, otherwise the coal is composed largely of semifusinite with a high mineral content (Smyth, 1979). Such an environment fits the fluvial model derived from Markov Chain Analysis of the coal bearing sequences (Bacon, 1979).

Further information of the environment in which the coal formed may be gleaned from the composition of the coal bed floras. A brief account of floras associated with coal seams is given by Townrow (1962). The flora of the coal measures is dominated by filicales (ferns), pteridosperms (seed ferns) and ginkgoales (maiden hair ferns).

The filicalean family Osmundaceae is represented by the sterile leaves *Cladophlebis*. The pteridosperm family, the Corystospermaceae, are represented by the leaves *Dicroidium*, *Xylopteris* and *Halleophyllum*. The ginkgoales *Ginkgoites* and *Sphenobaiera (Czekanowskia)* are abundant in places but conifers are rare. The leaf *Phoenicopsis elongata* is probably ginkgoalean. Cycadophyte leaves (*e.g. Pterophyllum*) are moderately common, but no lycopods have been found, and the evidence for the equisetalean (scouring rushes) genera *Phyllotheca* and *Neocalamites* is not good, although *Equisetum* stems are quite common throughout the Triassic as a whole (Townrow, 1962).

Megaspore species from lower Mesozoic coal measure sequences in Tasmania have been described by Dettman (1961). The form species *Banksisporites pinguis* (Harris) Dettman occurs in the New Town Coal Measures and is derived from the parent cone *Selaginella hallei* Lundblad. *B.pinguis* is characteristic of the Rhaetic zone of *Lepidopteris* in East Greenland, Sweden, Germany and Poland, and extends upwards into the overlying Liassic sediments containing *Thaumatopteris schencki* (Townrow, 1962). Townrow concludes that rocks of Rhaeto-Liassic age are present in Tasmania.

Retallack (1977) has proposed a reconstruction of the vegetation

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of eastern Australia during Triassic time. A traverse from the 'Pacific' margin of Gondwanaland to a point several hundred kilometres inland would encounter the following vegetation types:Pachydermophylletum (mangrove scrub), Linguifolietum (coastal swamp woodland), Dicroidietum odontopter-oidium (floodplain forest), Phoenicopsetum (levee bank scrub), Dicroidietum odontopteroidium xylopterosum (xerophytic woodland) and Johnstonietum (mallee-like woodland).

The floral association found in coal seams and carbonaceous shales of the Upper Parmeener Freshwater Sequence fit into the Dicroidietum odontopteroidium or broad-leaf forest.

CONCLUSIONS

In the Upper Parmeener Super-Group coal measure sequences in north-eastern Tasmania, xerophytic woodlands of *Dicroidium odontopteroides* and *Xylopteris* grew on silty flood basin areas, while in wetter areas such as in abandoned channels and filled-in cut off meanders, a broadleaf forest of ferns, seed ferns, scouring rushes, maiden hair ferns and cycads grew.

Club mosses (members of the family Pleuromeraceone or lycopods) are not known from Tasmanian Triassic coals. Lycopods are facultative halophytes, which occupied a position similar to that of modern coastal mangrove swamps. Their absence is additional proof of the fluvial origin of the coal-bearing sequences in north-eastern Tasmania.

FLUVIAL MODEL

The coal bearing sequence was deposited in a fluvial system of meandering streams of moderate to high sinuosity, with poorly developed levee banks and poorly developed flood basins between streams as the streams changed course frequently. Point bars are more common than channel bars, indicating a high degree of sinuosity.

Table 1. RATIO OF LUTITE:ARENITE IN TRIASSIC SEDIMENT

Eastern End of Fingal Tier		*Cornwall*	0.8
DDH 41	0.7	*Dalmayne*	
DDH 16			
DDH 24		D3	0.2
		D1	0.1
Western Parts of Fingal Tier		D2	0.2
		D6	0.2
DDH 4	0.5	D7	0.2
DDH 2	0.4	D5	0.2
DDH 3	0.3	D9	0.2
DDH 7	0.3	D8	1.0
		IMI 2	0.8
Southern Parts of Fingal Tier		IMI 1	0.5
		GY 9	0.9
DDH 26	0.7	GY 10	1.15
DDH 27	1.3	GY 12	0.69
Mt Nicholas		*Seymour*	
DDH 8	0.9	(1)	0.7
DDH 9	1.0	(2)	0.6
		(3)	0.7
* from Hale (1962)		(4)	0.7
		(5)	0.3

Table 1 shows ratios of lutite to arenite from several localities. From this data it can be seen that the proportion of lutite is highest on Mt Nicholas and on the south-eastern part of Fingal Tier. These two areas probably represent the 'tail end' of two drainage networks, while the areas of north-western Fingal Tier and Dalmayne represent the upper sections of drainage networks. Sinuosity, and hence oxbow lakes, and lutite is highest in the lowest part of the drainage network. These networks drained eastwards.

REFERENCES

BACON, C.A. 1979. *Sedimentology of the Late Triassic coal measures in north-eastern Tasmania.* B.Sc.Hons.thesis (Part B), University of Tasmania: Hobart.

DETTMANN, M. 1961. Lower Mesozoic megaspores from Tasmania and South Australia. *Micropaleontology* 7:71-86.

FOLK, R.L. 1974 *Petrology of sedimentary rocks (course notes). The University of Texas, Geology 370K, 383L, 383M.* Hemphill:Austin.

FORSYTH, S.M.; FARMER, N.; GULLINE, A.B.; BANKS, M.R.; WILLIAMS, E.; CLARKE, M.J. 1974. Status and subdivision of the Parmeener Super-Group. *Pap.Proc.R.Soc.Tasm.* 108:107-109.

HALE, G.E.A. 1962. Triassic System, *in* SPRY, A.H.; BANKS, M.R. (ed.). The geology of Tasmania. *J.geol.Soc.Aust.* 9(2):217-231.

NOLDART, A.J. 1975. Triassic coal in Tasmania. *Monogr.Ser.australas. Inst.Min.Metall.* 6:300-301.

PETTIJOHN, F.J. 1957. *Sedimentary rocks.* 2nd ed. Harper and Bros: New York.

RETALLACK, G.J. 1977. Reconstructing Triassic vegetation of eastern Australasia:a new approach for the biostratigraphy of Gondwanaland. *Alcheringa* 1:247-278.

SMYTH, M. 1979 Petrology of the Duncan Seam from Duncan Mine, Fingal Tasmania. *Restricted Investigation Report C.S.I.R.O.* 1032R.

TOWNROW, J.A. 1962. Triassic palaeontology, *in* SPRY, A.H.; BANKS, M.R. (ed). The geology of Tasmania. *J.geol.Soc.Aust.* 9(2):224-226.

WHITEHEAD, S. 1963. Specimens of arkose from Fingal No. 1 Bore, Tasmania and from Wellington Park Well, Gippsland, Victoria. *Petrol.Rep.Broken Hill Prop.Co.Ltd.* M.5/63.
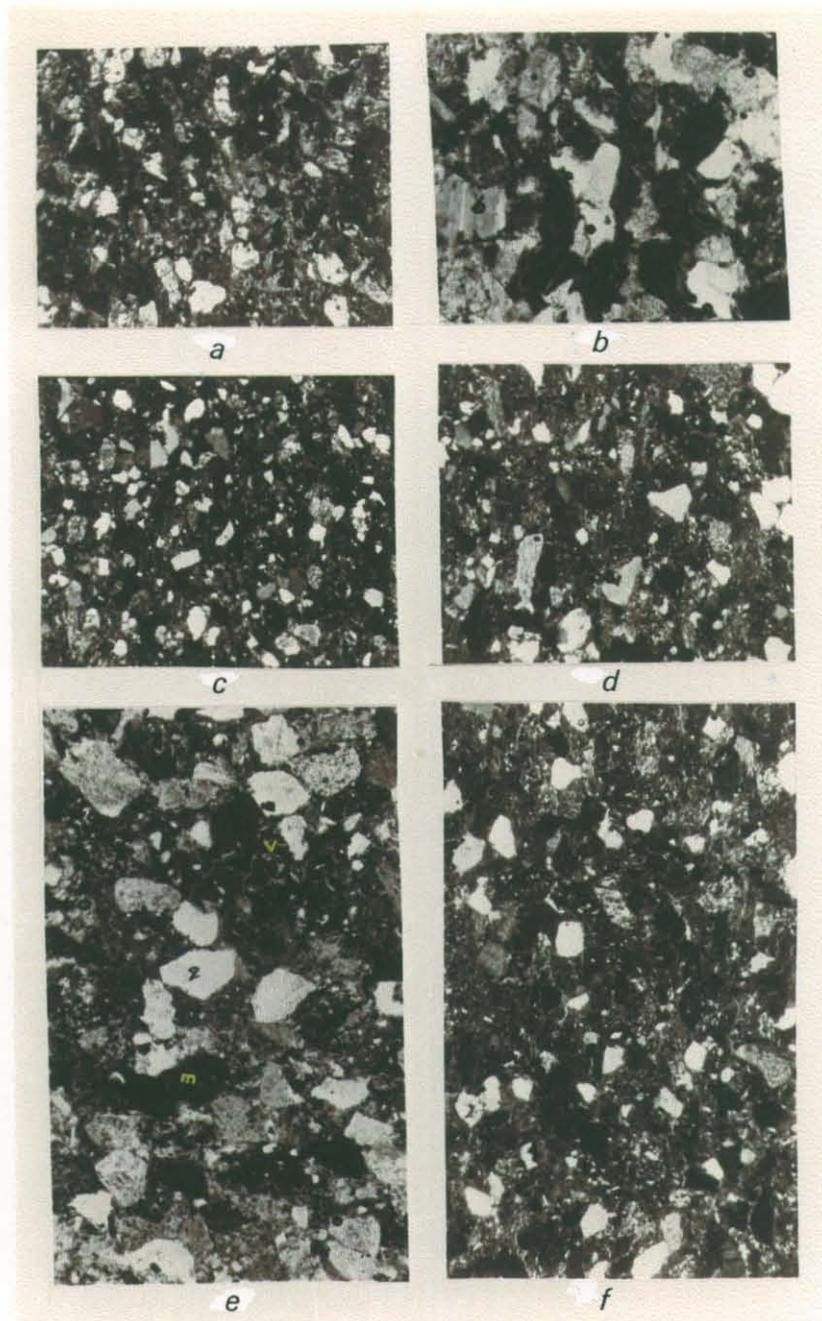
[30 June 1980]

PLATE 1

(a) Medium grained lithic arenite, DDH 7 at 9.04 m depth.   47856 x20,
     nicols crossed.
(b) Medium grained lithic arenite, DDH 7 at 32.93 m depth.   Note biotite
     clasts (b).   47864 x20, nicols crossed.
(c) Medium grained lithic arenite, DDH 7 at 40.43 m depth.   47867 x20,
     nicols crossed.
(d) Medium grained lithic arenite, DDH 7 at 62.33 m depth.   47873 x20,
     nicols crossed.
(e) Medium grained lithic arenite, DDH 7 at 82.32 m depth.   Note mudstone
     (m), volcanic fragments (v) and quartz (q).   47876 x32, nicols crossed.
(f) 47876 x20, nicols crossed.

5 cm
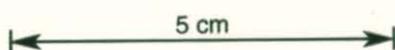
5 cm

PLATE 2

(a) Coal in sandstone. Not biotite in coal and disturbed bedding.
     47874 x20, nicols uncrossed.
(b) Coal flaser bands in fine lithic arenite. 47866 x6, nicols uncrossed.
(c) Coal (inertinite). 47872 x20, nicols uncrossed.
(d) Coal-rich bands in siltstone. 47878 x6, nicols uncrossed.
(e) Coal with patches of vitrain and cutinite with occasional quartz
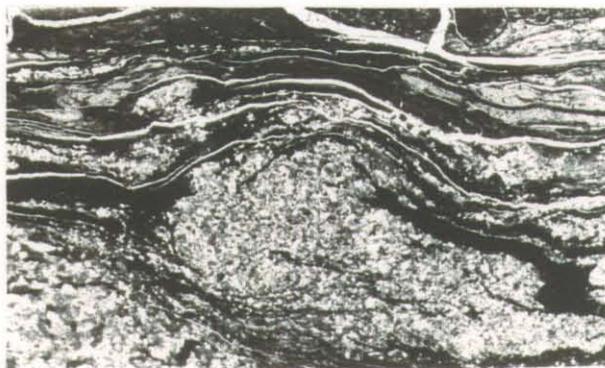   grains. 47886 x20, nicols uncrossed.

5 cm
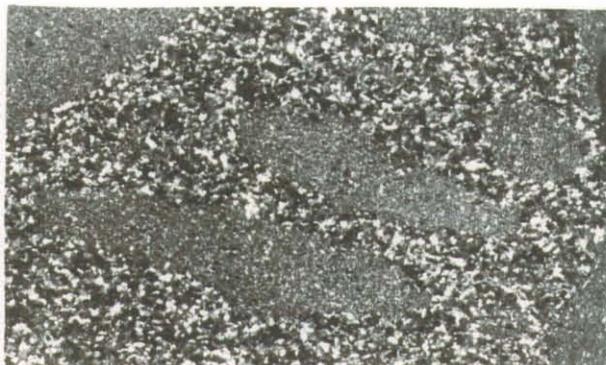
a

b

c

PLATE 3

(a) Clay-mud pellets in fine grained lithic arenite. 47902 x6, nicols
     uncrossed.
(b) Clay pellets and coal clasts in lithic arenite. 47891 x6, nicols
     uncrossed.
(c) Coaly stringers and clay patches in lithic arenite. 47880 x6, nicols
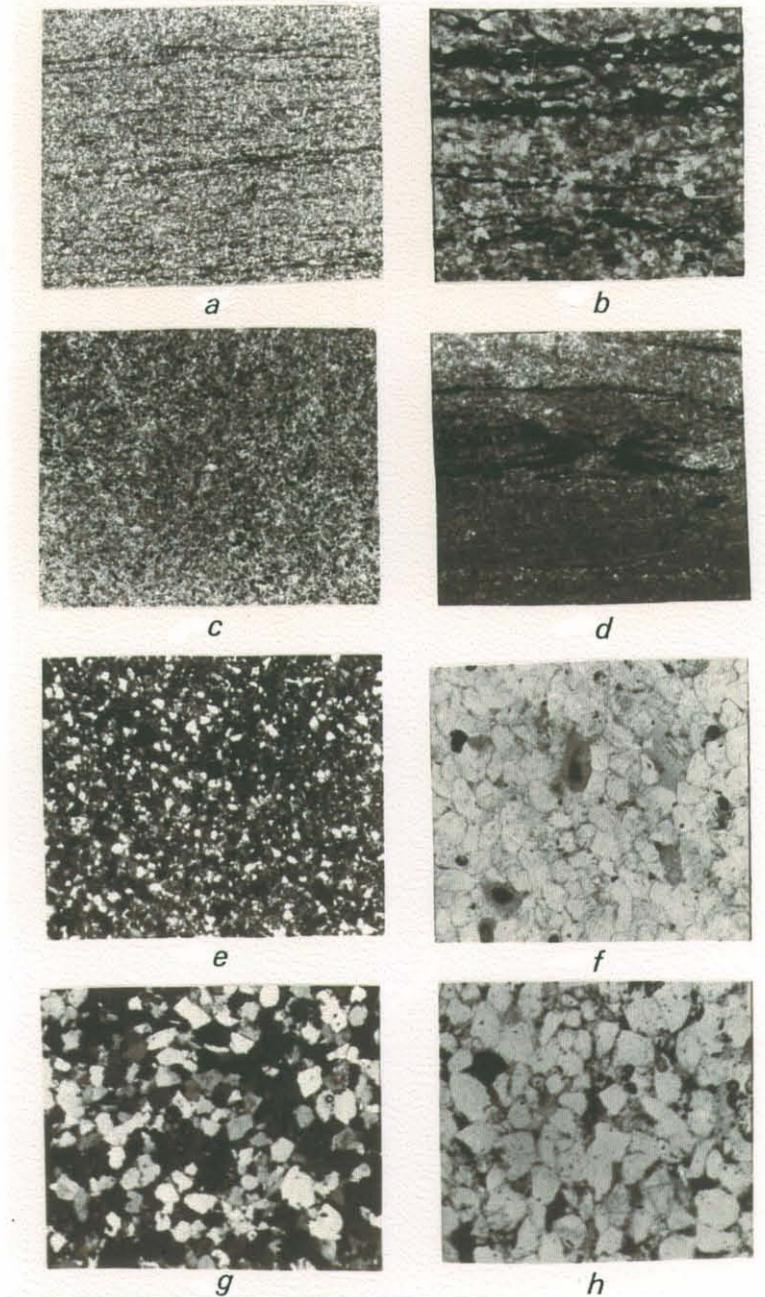   uncrossed.

5 cm

PLATE 4

(a) Banded siltstone, DDH 7 at 262 m.   47900 x6, nicols uncrossed.
(b) 47900 x32, nicols uncrossed.
(c) Siltstone DDH 7 at 217 m.   47894 x32, nicols uncrossed.
(d) Siltstone, DDH 41 at 330.4 m.   47919 x32, nicols uncrossed.
(e) Mudstone, DDH 41 at 335 m.   47920 x20, nicols crossed.
(f) Fine quartz arenite, DDH 7 at 326.05 m.   Note quartz overgrowths
     on sub-rounded quartz grains.   47907 x20, nicols uncrossed.
(g) Fine quartz arenite, DDH 7 at 335.16 m.   47905 x20, nicols crossed.
(h) Quartzwacke.   Note angular appearance of quartz with occasional
     coal fragments set in a silty matrix.   47933 x32, nicols uncrossed.