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DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Petrological Study of East Maitland Planet No. 1 Well, Sydney Basin, New South Wales

by

A.R. Jensen

and R. Bryan

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Records No. 1969/14

PETROLOGICAL STUDY OF EAST MAITLAND (PLANET) NO. I WELL, SYDNEY BASIN NEW SOUTH WALES

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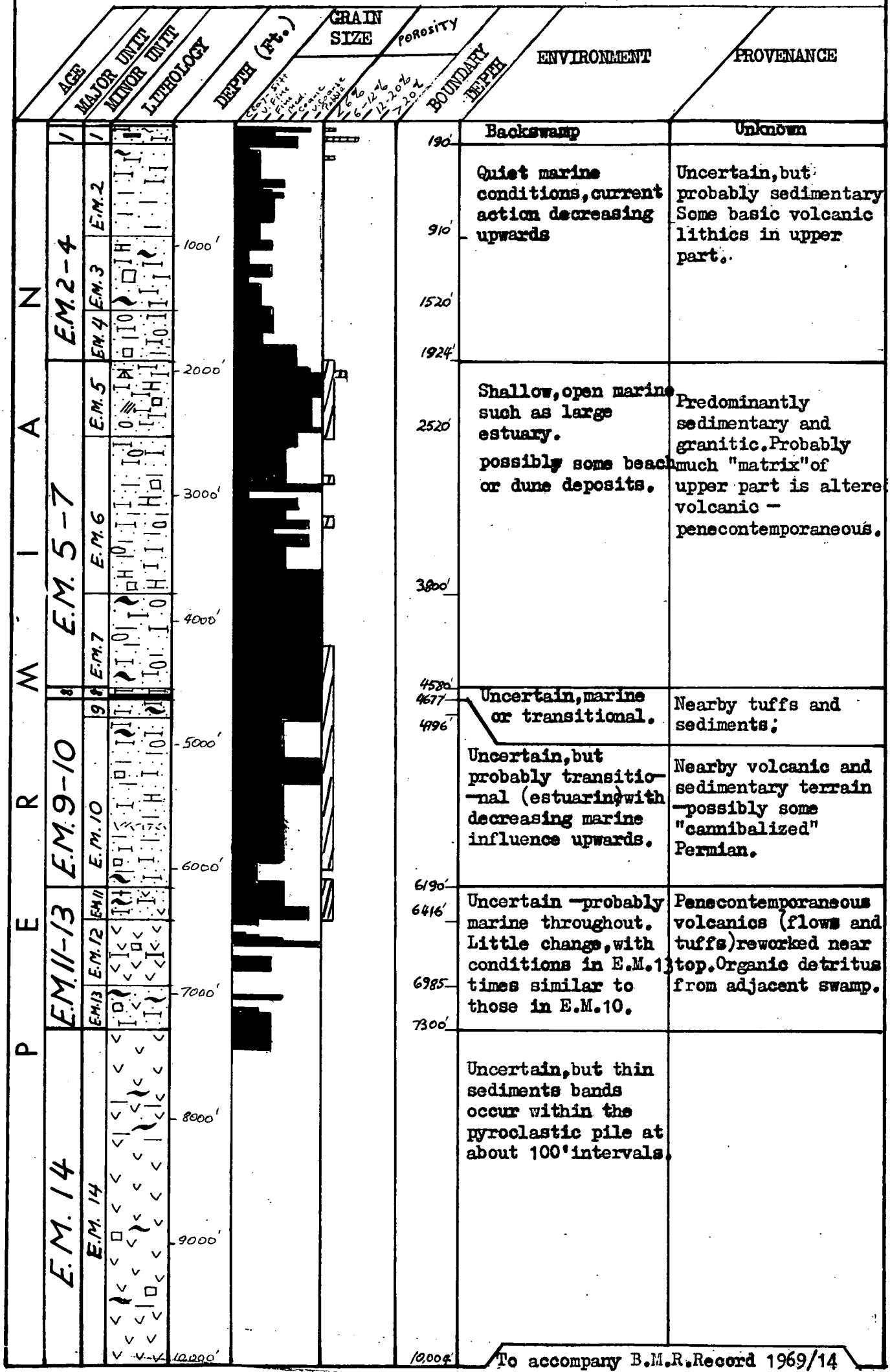
EAST MAITLAND (Planet) No.1

Fig.1

SUMMARY OF PETROLOGICAL RESULTS.



To accompany B.M.R.Record 1969/14

ABSTRACT

This petrological study of East Maitland (Planet) No. 1 Well was made as part of a review of the Sydney Basin, currently being undertaken by the Basin Study Group of the Petroleum Exploration Branch, in conjunction with the Geological Survey of New South Wales. The principal objective of this investigation was to establish and define clearly recognizable rock units, and to re-assess the hydrocarbon potentialities of the section.

Fourteen rock units were recognized, and are set out in Fig. 2. The section commences in the lower part of the Tomago Coal Measures, then penetrates over 6200 feet of dominantly shallow marine sediments split in the lower half by the relatively thin Greta Coal Measures. Underlying the sediments, and extending to Total Depth, is 3600 feet of volcanics - mainly pyroclastics - regarded as equivalent to the Dalwood Group.

It was found that the reservoir potential of the dominantly sandy sequence had been greatly affected by the abundance of highly altered volcanic clasts and ash, and by strong silica and carbonate cementation. None of the units could be regarded as prospective in this area.

GENERAL INFORMATION

WELL DATA

Well Name, Number:	East Maitland (Planet) No. 1 Well
Operating Company:	Planet Oil Company Pty. Ltd.
Location:	
Latitude and longitude:	32°45'47"South, 151°37'05" East
1:250,000 sheet:	Newcastle, S.I./56/2
General location:	1 mile east of East Maitland, New South Wales.
Date Drilled:	22nd October, 1962 - 2nd May, 1963.
Elevation:	
Kelly Bushing:	30,82 feet A.S.L.
Ground:	15.22 feet A.S.L.
Total Depth:	
Schlumberger:	9993 feet.
Driller:	10,004 feet,
Logs Run:	
Electric Log:	Run No. 1, 100 - 660 feet
" "	Run No. 2, 660 - 2973 feet
" "	Run No. 3, 2937 - 4980 feet
" "	Run No. 4, 4979 - 6548 feet
" "	Run No. 5, 6548 - 7723 feet
" "	Run No. 6, 7723 - 9280 feet
" "	Run No. 7, 9280 - 9992 feet
Microlog Caliper:	Run No. 1, 648 - 2935 feet
" "	Run No. 2, 2937 - 4977 feet
" "	Run No. 3, 4977 - 6546 feet
" "	Run No. 4, 6546 - 7723 feet
" "	Run No. 5, 7723 - 9280 feet
" "	Run No. 6, 9280 - 9992 feet
Gamma Ray:	Run No. 1, 100 - 9987 feet
Sonic:	Run No. 1, 68 - 658 feet
"	Run No. 2, 658 - 2934 feet
"	Run No. 3, 2935 - 5690 feet
"	Run No. 4, 5690 - 9989 feet

Formation Testing:

D.S.T. No. 1:	9300 - 9412 feet (mis-run)
D.S.T. No. 2:	9297 - 9412 feet (")

Hydrocarbon Shows:

No significant hydrocarbon shows were detected.

Major Reference used in present study

Planet Exploration Company Pty. Ltd., 1963 - East Maitland Well No. 1, New South Wales: Well Completion Report (unpubl.).

Summary of Major Reference

The well was spudded on 22nd October, 1962, and abandoned on 2nd May, 1963, at a total depth of 9993 feet. The well was spudded near the base of the Permian Tomago Coal Measures which continue to 190 feet. Underlying the coal measures, the Maitland Group (Upper Marine) extended to 4649 feet. This in turn was underlain by the Greta Coal Measures to 4793 feet, and then the Dalwood Group, continued to Total Depth (9993 feet). However, below 6229 feet, tuffs and minor basaltic flows were encountered; while there is no direct evidence of the age of the volcanics, the Company regarded the whole section as Permian.

MATERIAL AVAILABLE

Cuttings:	40 - 9993 feet (total depth), at 10 foot intervals.
Cores:	The full length of recovered core was available for study; this averaged about 8 feet from each of the 33 cores cut.
Wire-line logs:	All wire-line logs listed under "Logs Run" were available at both 5 inch and 2 inch to 100 feet scales.

METHODS

All cuttings were examined under a low power binocular microscope and thin sections were made of lithologies from specific intervals; these were then studied under the petrological microscope. All these descriptions were plotted on the Petrographic Well Log sheets (see Plates 1A-E). The slabbed core was also examined under the low power binocular microscope; at least one thin section was cut from each core. The core descriptions were plotted on Petrographic Core Log sheets (see Plates 2A-G).

One of the prime objects of this study, was the identification of rock units in the thick sequence. At this stage of the study of the Sydney Basin, it was considered unwise to use the rock unit nomenclature established largely from surface studies elsewhere in the northern portion of the basin. For this reason, a numbering system was used; the units are prefixed by "EM", and are numbered in order down the sequence. The set of rock units identified is shown in summary form in Fig. 1.

The sedimentary rock classification of Pettijohn (1957) was used for specific rock names. However, a modification was introduced to cover those quartz-rich rocks (quartz making up over 75% of the clasts), in which detrital matrix is prominent (in excess of 15% of the whole). "Quartz greywacke" is used for rocks in this category.

PERSONNEL

The bulk of the petrology was carried out by A.R. Jensen. He was assisted by Miss K. Lachno, from the University of Sydney, who described most of the volcanic sequence below 6500 feet. This work was completed at the end of 1967, and Jensen prepared a preliminary report and a full set of logs at that time.

In view of additional sub-surface information obtained by the B.M.R. from the northern portion of the Sydney Basin, key intervals from East Maitland No. 1 were re-examined by R. Bryan and S. Ozimic. As a result of this additional work, some alterations were made to Jensen's rock units; a number of the units were combined where it was felt that the distinguishing criteria were not sufficiently clear cut to be of value for correlation. At the same time, Bryan modified the text in accordance with the new petrological results.

GEOLOGY

UNIT EM1

Unit EM1 extends from 40 - 190 feet; no samples were recovered above 40 feet. It is composed of interbedded sandstone, siltstone and silty claystone. Plant fragments and coaly and carbonaceous sediments occur, but no coal seams were encountered.

The unit is clearly shown on the wire-line logs being characterised by very low resistivity and very low sonic velocities.

Boundary criteria Unit EM1 exactly corresponds to the Company pick for the Tomago Coal Measures (Planet 1963). The lower boundary of Unit EM1 is marked by a change from silty claystone to a thin calcareous sub-greywacke. This change is marked by a very sharp increase in resistivity and in sonic velocity; a slight increase in gamma radiation occurs beneath 190 feet.

Depositional environment and provenance There is very little information on these aspects of Unit EM1. Clearly a swampy environment prevailed, with too much terrigenous sedimentation for the development of pure coal seams.

UNITS EM2-4

The sequence making up Units EM2-4 extends from 190 feet to 1924 feet. It consists of a very uniform sequence of siltstone, sandy siltstone, and in places fine sandstone. The only variations within this sequence are the presence of pebbles below 1520 feet, and an increase in sand below 1800 feet. This latter feature is clearly seen on the wire-line logs - resistivity showing a steady increase, and the gamma ray log a corresponding drop.

Unit EM2 (Plates 1A, 2A)

Characteristics Unit EM2 extends from 190 feetto 910 feet, and consists of a thick sequence of highly carbonaceous siltstone in places grading to silty sandstone, overlain by thin calcareous sub-greywacke. The sand component is predominantly quartzose but there are significant amounts of very fine-grained intermediate or basic volcanic lithics, and feldspar fragments. The sediments are invariably carbonaceous and pyritic. Wire-line logs over this interval indicate a very uniform sequence.

Boundary criteria The lower limit of Unit EM2 is somewhat gradational, marking a consistent upward decrease in sand-sized material. At about this depth (910 feet) there is a slight decrease in resistivity and sonic velocity, and a corresponding slight increase in gamma radiation.

Depositional environment and provenance Uniformity of detritus over this interval indicates that, whatever the actual environment, there was a markedly constant supply of silt, mud and fine sand, for a considerable period of time. It is suggested that Unit EM2 is a marine sequence, deposited below wave base, in an area protected from strong currents.

Unit EM3 (Plates 1A, 2AB)

Characteristics Unit EM3 extends from 910 feet to 1520 feet - a thickness of 610 feet. It consists of a very uniform succession of sandy siltstone mudstone and very fine sandstone. The sediments are primarily quartzose but contain highly altered sedimentary lithics and feldspar grains, that may become locally abundant. The sediments are carbonaceous as in Unit EM2, and muscovite is very common. Pyrite and calcite are present throughout and may also be locally abundant. The wire-line logs show rather saw-tooth patterns throughout Unit EM3, but the spread of values is very consistent.

The sediment has been partly reworked by burrowing organisms, and rare marine fossil fragments were found in cuttings at 830 feet. Small scale "scallop structures" (Jensen 1968), are common in Core 3 (1156-1166 feet); they were also observed in cuttings at other levels within Unit EM3. The features are cylindrical structures averaging 5mm. in diameter. Each cylinder is composed of a number of concentric cylinders, outlined by grey laminae rich in dark carbonaceous material. In cross-section the structures appear as a series of "scalloped swirls". The structures are always elongated parallel to the bedding, and it is thought that they represent some type of vegetation - possibly a type of sea weed.

Boundary criteria The lower limit of Unit EM3 is placed at 1520 feet - but based solely on the absence of pebbles above that level. There is essentially little change in the pattern of sedimentation across this boundary. However in view of the tendency in surface mapping in this area to place the boundary between the Mulbring Siltstone and the underlying Branxton Formation at the first appearance of the pebbles, it was thought desirable to highlight this change in East Maitland No. 1. No significant change occurs on the wire-line logs at this level.

Depositional environment and provenance Essentially the same environment is postulated for Unit EM3 as for the overlying Unit EM2 - quiet marine conditions. The minor volcanic provenance apparent in the detritus of the overlying unit EM2 is absent in Unit EM3.

Unit EM4 (Plates 1A, 2B)

Characteristics Unit EM4 extends from 1520 feet tc 1924 feet - a thickness of 404 feet. It consists essentially of sandy siltstone, silty sandstone, and some mudstone. The sediment is pyritic, carbonaceous and micaceous; brachiopod, bryozoan and coral fragments are found in places. "Scallop structures" were also seen in the only core from this interval (Core 5, 1831 - 1841 feet). Only the presence of very sparse, small siliceous pebbles scattered through the section distinguishes Unit EM4 from the overlying Unit EM3.

Boundary criteria The base of the EM4 at 1924 feet is gradational, and could have been placed anywhere over a range of 100 feet. It marks the upward change from clean medium grained sandstone to the sandy siltstone of Unit EM4. The two lithologies are finely interbedded from 1800 feet to 1940 feet, with the sandstone becoming dominant at approximately 1924 feet. It would appear from the resistivity log that below this level the sandstone intervals are much thicker.

Depositional environment and provenance There is no reason to believe that the general environment of deposition of Unit EM4 was any different from that of the overlying Unit EM3. Scattered marine fossils again clearly establish a marine environment. The presence of scattered fine pebbles - always less than 1% of the lithology - simply indicates that the currents operating during deposition were slightly stronger than in the upper sections; the overall scarcity of pebbles, and their fine size, argue against the necessity to invoke a distinct mode of transportation - such as ice-rafting.

UNITS EM5-7

The sequence covered by Units EM5-7 extends from 1924 feet to 4580 feet, and consists of sandstone, generally either quartz-greywacke or greywacke. Minor amounts of siltstone are associated with the sandstone but they almost invariably contain sand-size material. Both the pebble and the carbonaceous content taper off markedly above the base of the sequence. Much of the sand-sized quartz is very angular; "pressure-welding" is also common especially in the upper part of the sequence.

Unit EM5

Characteristics Unit EM 5 extends from 1924 feet to 2520 feet. It consists of fine to medium grained protoquartzite, the quartz grains commonly showing an interlocking fabric. Rare microperthite grains and fine intermediate or basic volcanic lithics occur. The rocks are strongly cemented with silica, siderite, calcite and dawsonite.

The unit is characterised by moderate but somewhat irregular resistivities; the gamma log shows a regular drop in count, as compared with the pattern of the overlying units.

Porosity values from the two quite typical cores cut in Unit EM5 average 4% and reach a maximum of 7%; permeabilities are nil in all cases. Extensive cementation probably accounts for the absence of connected voids.

Boundary criteria The lower boundary of Unit EM5 occurs at 2520 feet, and is marked by a distinct lithological change from siltstone and quartz-greywacke of the underlying unit, to protoquartzite of Unit EM5. The only wire-line log to show a significant change at this level is the sonic - the upward decrease in silt being marked by a slightly higher velocity.

Depositional environment and provenance Abundant fossils at certain levels indicate open marine conditions - probably shelf deposition, with quite shallow water. Some of the non-fossiliferous intervals could even have accumulated in a beach or dune environment.

Unit EM6 (Plates 1A, 2C)

Characteristics Unit EM6 extends from 2520 feet to 3800 feet and consists of very poorly sorted quartz greywacke, greywacke, and sandy siltstone; rare siliceous pebbles occur in the lower part. The sand-sized clasts are predominantly angular quartz and rounded chert grains; locally, meta-quartzite and fine schist lithics are common. Clearly recognisable volcanic lithics are rare, though feldspar porphyry occurs within the quartz greywacke of Core 9 (2888 feet - 2898 feet). However, it seems likely that much of the "matrix" consists of altered fine volcanic clasts and tuffaceous material. Feldspar - especially potash feldspar - occurs throughout, and locally is very common.

As shown on Plate 2C, porosity values are consistently low and permeability nil, in all four cores cut within Unit EM6. This appears to be due to a combination of poor sorting (partly original and partly due to bioturbation) and void filling and replacement by calcite and siderite. Marine fossils occur throughout Unit EM6.

Boundary criteria The lower limit of Unit EM6 is placed at 3800 feet, at the base of a sandy calcarenite containing abundant shell debris. Essentially the same lithologies occur beneath this level, but they are conspicuously carbonaceous, and more pebbly.

Of the wire-line logs, only the resistivity exhibits any systematic change. Above 3800 feet, there is a marked increase in values on the 18'8" log.

Depositional environment and provenance The abundance of marine fossils, and the poorly sorted and commonly bioturbated character of the sediments, indicate deposition in a shallow marine environment below wave base. The angularity of the quartz, and the presence of plentiful potash feldspar and schist fragments in the sandstone, indicate that the amount of abrasion during transportation was not severe. Granitic, volcanic and metamorphic areas have supplied the bulk of the detritus for Unit EM6. It seems likely that volcanism (possibly penecontemporaneous) supplied a much higher proportion of the clasts and matrix than is apparent from the sediments.

Unit EM7 (Plates 1B and C, 2C and D)

Characteristics Unit EM7 extends from 3800 feet to 4580 feet and consists essentially of greywacke, quartz greywacke, and sandy siltstone. Most intervals are carbonaceous, and the two cores from Unit EM7 contain plant fragments and possibly rootlets. The clasts consist of quartz and lithics in about equal amounts; the lithics consist of chert, shale and low grade metamorphic rocks. The sands are essentially fine grained, though some sections are poorly sorted and contain coarse detritus. Only a little plagioclase occurred in Unit EM7, and there were no signs of volcanic lithics. Calcite, siderite and pyrite were all common in places.

The sandstone of Unit EM7 is characterised by the variable amount of dark grey muddy matrix. Some beds are matrix-free, while adjacent beds may contain up to 50 percent or more. In some cases, this mixture of grain sizes is clearly a function of organic churning or bioturbation, but where obvious burrows are lacking and the sediment is laminated, it seems that the grain size mixture develops in direct response to reworking and redeposition of sands and mud by current action.

Boundary criteria The lower boundary of Unit EM7 is placed at 4580 feet. It is marked by a strong lithological change from petromictic pebble conglomerate containing a large proportion of volcanic detritus, to the poorly sorted carbonaceous greywacke and siltstone of Unit EM7. Probably because this underlying conglomerate is choked with very fine (?) volcanic matrix, the boundary at 4580 feet is not clearly shown on any of the wire-line logs.

Depositional environment and provenance The presence of marine fossils, combined with such features as abundant carbonaceous material, poor sorting, cross-lamination, and churned bedding, suggest a shallow near-shore environment of deposition. Such an environment would be found in large estuaries, where sediment is being continually deposited and reworked, and where surrounding swamp areas supply abundant carbonaceous material.

UNIT EM8

Unit EM8 extends from 4580 feet to 4677 feet. It consists of a petromictic pebble conglomerate and one thick coal seam. The unit roughly corresponds to the Cessnock Sandstone Member (but only the uppermost part of the Greta Coal Measures) as shown in the Well Completion Report (Planet, 1963).

Characteristics Lithologically, the terrigenous sediments of Unit EM8 range from petromictic pebble conglomerate to pebbly lithic greywacke. The sequence is very poorly sorted, and the clasts consist of corroded quartz, potash feldspar, crystal tuff, chert and siltstone lithics. Almost certainly, much of the fine matrix is of tuffaceous origin. Near the base of this poorly sorted sandstone is a 14 foot coal seam; the high resistivity and very low gamma reading opposite the seam would indicate that the coal is shale-free.

Despite the sharp lithological change at the top of Unit EM8, none of the wire-line logs change significantly at this point. As mentioned earlier, this is almost certainly due to the choking of the conglomerate with (?) volcanic material.

Boundary criteria The selection of a lower limit to Unit EM8 posed some problems; the lithology of Core 15 (4677 - 4684'6") closely resembles the underlying sequence, though from the cuttings log it would appear that this zone is also characterised by the extremely poor sorting seen in Unit EM8. However it seems likely that this poor sorting is due primarily to caving from the conglomerate overlying the coal seam. For this reason the lower limit of Unit EM8 is taken at the top of Core 15 - 4677 feet. The resistivity, sonic and logs all show decreasing values upwards at about this level.

Depositional environment and provenance There appears to be little direct evidence to indicate a specific environment for deposition of Unit EM8. The presence of marine strata above and below would tend to support a marine or transitional environment for Unit EM8 rather than completely continental deposition. However, no marine fossils were found in Core 14 (4625 - 4628). The thick coal seam could have easily formed in a coastal swamp area, or even in a completely marine environment.

It is clear that the bulk of terrigenous material making up Unit EM8 has travelled only a relatively short distance from its source. Nearby tuffs and sediments were probably the major sources of detritus.

UNITS EM9 - 10

The sequence covered by Units Em 9 and 10 extends from 4677 feet to 6190 feet - a thickness of 1513 feet. It consists essentially of lithic sandstone that increase up the sequence in both grain size and in the percentage of lithics. One thin basalt flow occurs within the sequence.

Unit EM9 (Plates 1C, 2D - E)

Characteristics Unit EM9 extends from 4677 feet to 4796 feet and consists of fine grained lithic greywacke, rich in volcanic and sedimentary lithics, and with a lesser amount of quartz. The greywacke is carbonaceous, but no coal was found. Small amounts of plagioclase are also present. Much of the quartz is very angular. The amount of matrix present is very difficult to determine, due to the partial alteration and "welding" of fine grained sedimentary and volcanic lithics. Unit EM9 is marked by rather low and irregular resistivity and also by a low and somewhat irregular sonic velocity.

Boundary criteria The lower limit of Unit EM9 is placed at 4796 feet. At this level there is a marked upward increase in grain size; there is only a small change in gamma radiation at this level, but there is a sharp increase in resistivity.

Depositional environment and provenance There is no direct information on the depositional environment of Unit EM9. However, being underlain by marine strata and overlain by a thick coal seam, it is likely that Unit EM9 represents a marginal facies, developed during the last stages of a major regression. The detritus was clearly derived from an adjacent volcanic and sedimentary source.

Unit EM10 (Plate 1C, 2D - E)

Characteristics Unit EM10 extends from 4796 feet to 6190 feet and consists of fine lithic greywacke and sandy siltstone, highly carbonaceous towards the base of the unit. Siderite and pyrite are both common. The clasts consist predominantly of quartz with some fine volcanic lithics, and some feldspar. Carbonaceous fragments are common, and (?) rootlets were noted in Cores 16 and 17. Brachiopod fragments were preserved in Core 17.

A thin horizon of microcrystalline vesicular basalt occurs between 5708 and 5722 feet; however in view of the abundance of volcanic activity a short distance below this level, the definition of this basalt as a separate rock-unit did not appear justified. The resistivity log shows a very irregular saw-tooth pattern throughout the unit; however the 18'8" trace clearly shows an increase in readings above 5560 feet; this is approximately the level at which the dominant lithology changes from sandy siltstone to silty sandstone.

Boundary criteria The lower limit of Unit EM10 is placed at 6190 feet, it is marked by a very sharp lithological change from sandstone rich in volcanic lithics to carbonaceous sandy siltstone of Unit EM10. This boundary can be picked on the wire-line logs by the sharp upward decrease in resistivity, a gradual increase in gamma counts, and by a gradual decrease in sonic velocity.

Depositional environment and provenance It is considered that Unit EM10 was laid down under very similar conditions to those prevailing during deposition of Units EM 7 and 8. This is deposition in a "low energy" coastal environment such as large estuaries, where sediment is being continually deposited and reworked, and where surrounding swamp areas supply abundant carbonaceous material.

UNITS EM11-13

The sequence covered by Units EM11-13 extends from 6190 feet to 7300 feet - a thickness of 1110 feet. It consists essentially of pyroclastics (some reworked) and interbedded sandstone and siltstone quite similar to beds near the base of Unit EM10. Thus the sequence marks a transition from predominantly volcanic flows and tuffs with only minor sediments to the overlying sequences where sediments predominate.

Unit EM11 (Plate 1C, 2E)

Characteristics Unit EM11 extends from 6190 feet down to 6416 feet and consists of a thin silty mudstone and pebble conglomerate overlying greywacke. Clasts consist predominantly of crystal and lithic tuff, and large plagioclase and potash feldspar which are probably derived from the crystal tuff. Some metaquartzite fragments are also present. The nature of the matrix is hard to determine, but is probably tuffaceous. Carbonate cement is abundant.

Resistivity values over Unit EM11 are high, but very irregular. Sonic velocities are also high and irregular. Gamma radiation is comparable to that occurring in the overlying greywacke succession.

Boundary criteria The lower boundary of Unit EM11 is placed at 6416 feet; this is within Core 21 (6413- 6418 feet) where there is a contact between pyroclastics and overlying volcanic lithic conglomerate of Unit EM11. The

contact appears to be completely conformable, and in fact may be gradational. Of the wire-line logs, only the gamma log shows a significant change at this level; below 6416 feet, there is a very marked drop in radiation.

Depositional environment and provenance At least part, and probably the whole of the sequence, is marine. The sand and conglomerate appear to have been derived from adjacent penecontemporaneous volcanics, and deposition probably occurred in a marine basin adjacent to the volcanic area.

Unit EM12 (Plates 1C and D, 2D)

Characteristics Unit EM12 extends from 6416 to 6985 feet and consists mainly of basic or intermediate pyroclastics and possibly flows, interbedded with minor petromictic volcanic pebble conglomerate and greywacke. The pyroclastics include light green basic or intermediate lapilli tuff, consisting of sub-rounded to rounded lapilli set in a fine matrix; this has been partially replaced by iron oxide. The wire-line log characteristics are similar to those of the overlying Unit EM11, except for the gamma log which shows a very steady and very low reading throughout Unit EM12.

Boundary criteria The base of the unit EM12 is placed at 6985 feet, where there is the sharp change from pyritic and carbonaceous sandy siltstone and mudstone, to the pyroclastics of Unit EM12. The boundary is clearly shown on the wire-line logs by a small increase in resistivity, a marked increase in sonic velocity, and a very sudden decrease in gamma radiation.

Depositional environment and provenance There appears to have been little or no reworking of the volcanics. There is no direct information on the position of these extrusives with regard to sea level; however as marine fossils have been found in sediments immediately above and below Unit EM12, it is likely that the volcanics accumulated in a marine basin.

Unit EM13 (Plates 1D, 2F)

Characteristics Unit EM13 extends from 6985 feet to 7300 feet and consists of interbedded sandy siltstone and mudstone; towards the base of the unit, pyroclastics are interbedded with these sediments. Clasts consist of about equal amounts of angular quartz and altered (?) very fine volcanic lithics.

Some plagioclase is also pressnt. The sequence is carbonaceous, especially in the upper part; pyrite and carbonate cement occur throughout.

The resistivity, gamma and sonic logs all show the effects of the decreasing pyroclastic component above the base of EM13.

One feature worthy of mention is the striking similarity between the carbonaceous sandy siltstone typical of the upper part of Unit EM13 and the dominant lithology near the base of Unit EM10, almost 800 feet above. It would seem that during lulls in the vulcanism, similar types of fine terrigenous sediment were being supplied to the basin and deposited under similar conditions.

Boundary criteria The lower boundary of Unit EM13 is placed at 7300 feet, where there is a marked changed from a sequence almost entirely composed of pyroclastics and flows, to the interbedded fine sediments and pyroclastics of Unit EM13.

Depositional environment and provenance There is little direct evidence for the type of depositional environment, apart from the presence of marine fossils in the upper portion of Unit EM13. However there is a marked similarity between the upper part of Unit EM13 and the lower part of Unit EM10. It seems likely that essentially the same conditions operated at both times, and that the intervening spasms of vulcanism did not materially alter either depositional environment or provenance.

UNIT EM14 (Plates 1D and E, 2F and G)

Characteristics Unit EM14 extends from 7294 feet to 10004 feet (Total Depth). It consists of highly altered basic and intermediate coarse to fine pyroclastics, with rare thin beds of fine grained sediments which are mainly siltstone and silty sandstone. The volcanics appear to be largely lapilli tuffs; however, in both Core 32 (9402-9412 feet) and in Core 33 (9994-10004 feet) basalt flows are interbedded with the tuff. The basalt is comparatively fresh, and it seems likely that the extreme alteration of the remainder of the volcanics is related to their mode of emplacement; if this suggestion is valid, then on the basis of the cuttings examination it is likely that pyroclastics predominated throughout Unit EM14.

The wire-line logs show very consistent maximum and minimum values for resistivities throughout Unit EM14; the resulting "saw-tooth pattern" shows regular oscillations at approximately 100 foot intervals. The lower resistivities are almost invariably associated with markedly low sonic velocities. These points are interpreted as marking pauses in the eruptive activity.

Environment and provenance There is no direct information as to whether Unit EM14 accumulated under sub-aerial or sub-aqueous conditions. However there are indications that the pyroclastic pile developed intermittently, with the individual layers averaging about 100 feet in thickness.

CONCLUSIONS

COMPARISON WITH WELL COMPLETION REPORT

Figure 2 gives a comparison between unit boundaries chosen in this study and the stratigraphic divisions set out in the Well Completion Report. (Planet 1963). The broad picks are similar, but finer divisions have been attempted in the present study. The only two significant discrepancies are considered below:-

Boundary between Units EM3 and 4.

This boundary is placed, somewhat arbitrarily, within a thick sequence of siltstone, sandy siltstone and fine sandstone; the point chosen at 1520 feet, is where the sparse small pebbles of the lower section finally disappear. However, the gross lithology above 1520 feet differs very little from that below, and had it not been for the importance placed on the "pebble cut out" in surface studies of this interval, it is possible that no boundary would have been inserted.

There is no doubt that the "pebble cut out" was taken as the boundary between the Branxton Formation and the Mulbring Siltstone by the Company, the pick being 1490 feet. However, it is felt that in this area at least, the Branxton - Mulbring boundary was very tentative and might not correspond to the clear lithological break found elsewhere.

Fig.2

EAST MAITLAND (Planet) No.1

COMPARISON OF B.M.R. UNITS WITH COMPANY INTERPRETATION.

B.M.R. Units		BOUNDARY DEPTHS (Ft.)	COMPANY (Planet) No.1		
Major	Minor		Formation	Group	Age
E.M. 1	EM 1	190' 190'	TOMAGO COAL MEASURES		PERMIAN
E.M.2-4	EM 2	910'	MULBRING SILTSTONE	Maitland Group	
	EM 3	1520' 1490'			
	EM 4	1924' 1964'			
E.M.5-7	EM 5	2320'	MUREE S.s.		
	EM 6	2520'	BRANXTON FORMATION		
	EM 7	3800'			
E.M. 8	EM 8	4580' 4583' 4649'	CESSNOCK S.s.		
E.M.9-10	EM 9	4677' 4663'	GRETA SEAM	Greta Coal Measures	
	EM 10	4796' 4793'	UNDIFFERENTIATED		
E.M.11-13	EM 11	6190' 6083' 6229'	FARLEY RUTHERFORD FORMATION	Dalwood Group	
	EM 12	6416'	RAVENSFIELD		
	EM 13	6985'	ALLANDALE – LOCHINVAR FORMATIONS		
E.M. 14	EM 14	7300' 10,004' T.D.			

To accompany B.M.R. Record 1969/14

Boundary between Units EM8 and 9.

This boundary has been placed between well sorted fine grained lithic greywacke and overlying poorly sorted petromict conglomerate and pebbly greywacke. There is some doubt about the position of this boundary, due to the likelihood of contamination of the cuttings by cavings; the tentative boundary has been placed at 4677 feet.

The two rock units would certainly have been described as Farley Formation and Greta Coal Measures, but the Company considered that the change occurred at 4793 feet. If the possibility of caving from the overlying Coal Measure conglomerates is accepted as the explanation of the poor sorting below 4677 feet, lithologies of Units EM8 and 9 correlate very well with Units B 2-4 and B5 from Belford (A.O.G.) No. 1 Well (Ozimic, 1968). If this is correct, then there is a considerable thinning of the Greta Coal Measures between Belford (A.O.G.) No. 1 and East Maitland (Planet) No. 1.

SUMMARY OF NEW DATA

The section studied consisted of over 6400 feet of mainly marine shallow water sediments; one relatively thin interval of coal measures occurs in the lower half of this sequence. Beneath the sediments, 3600 feet of volcanics (predominantly pyroclastics) extend to Total Depth. The whole sequence has been divided into 14 rock units which have been grouped into seven lithogenetic units.

This study of East Maitland (Planet) No. 1 has shown the abundance of volcanic detritus throughout most of the Permian sediments. Commonly the clasts are so altered that they would simply be regarded as matrix in the hand specimen.

The sequence is quite sandy but very tight throughout, due to the combined effects of silica and carbonate cement, and the "choking" of the sands with volcanic clasts and ash.

INFLUENCE OF NEW DATA ON HYDROCARBON PROSPECTS

The present study has confirmed the conclusions of the Company that the Permian sediments in this area are far too tight to be prospective. There may be a connection between the carbonate cementation and the abundance of volcanic clasts and ash; it is possible that some permeability may have been retained in areas further from the centres of vulcanism.

REFERENCES

JENSEN, A.R. 1968 - Upper Permian and Lower Triassic Sedimentation in part of the Bowen Basin, Queensland. Bur. Min. Resour. Aust. Rec. 1968/55 (unpubl.)

OZIMIC, S. 1968 - Petrological Study of Belford (A.O.G.) No. 1 Well, Sydney Basin, New South Wales. Bur. Min. Resour. Aust. Rec. 1968/68 (unpubl.)

PETTIJOHN, F.J. 1957 - Sedimentary Rocks, Harper, New York.

PLANET, 1963 - Planet Exploration Company Pty. Ltd., East Maitland Well No. 1, New South Wales: Well Completion Rep. (unpubl.)

PLATE 1A

PETROGRAPHIC WELL LOG
EAST MAITLAND (PLANET) No 1

Geology by: A.R. Jensen & R. Bryan B.M.R.

WELL NAME, No. EAST MAITLAND (PLANET) No 1
OPERATING Co. Planet Exploration Company Pty Ltd
WELL LOCATION
Lat. 32° 45' 47" S. - Long. 151° 37' 05" E.
Basin Sydney
State New South Wales
Tenement No. 88
1:250,000 Sheet No. SI 56-2

ELEVATION (R.S.L.)
Ground Level +15.22 ft
K.B. Datum 30.82 ft

SAMPLE STORAGE
BMR, Canberra.
N.S.W. Mines Dept.

VERTICAL SCALE: 0 – 50 – 100 – 200 ft

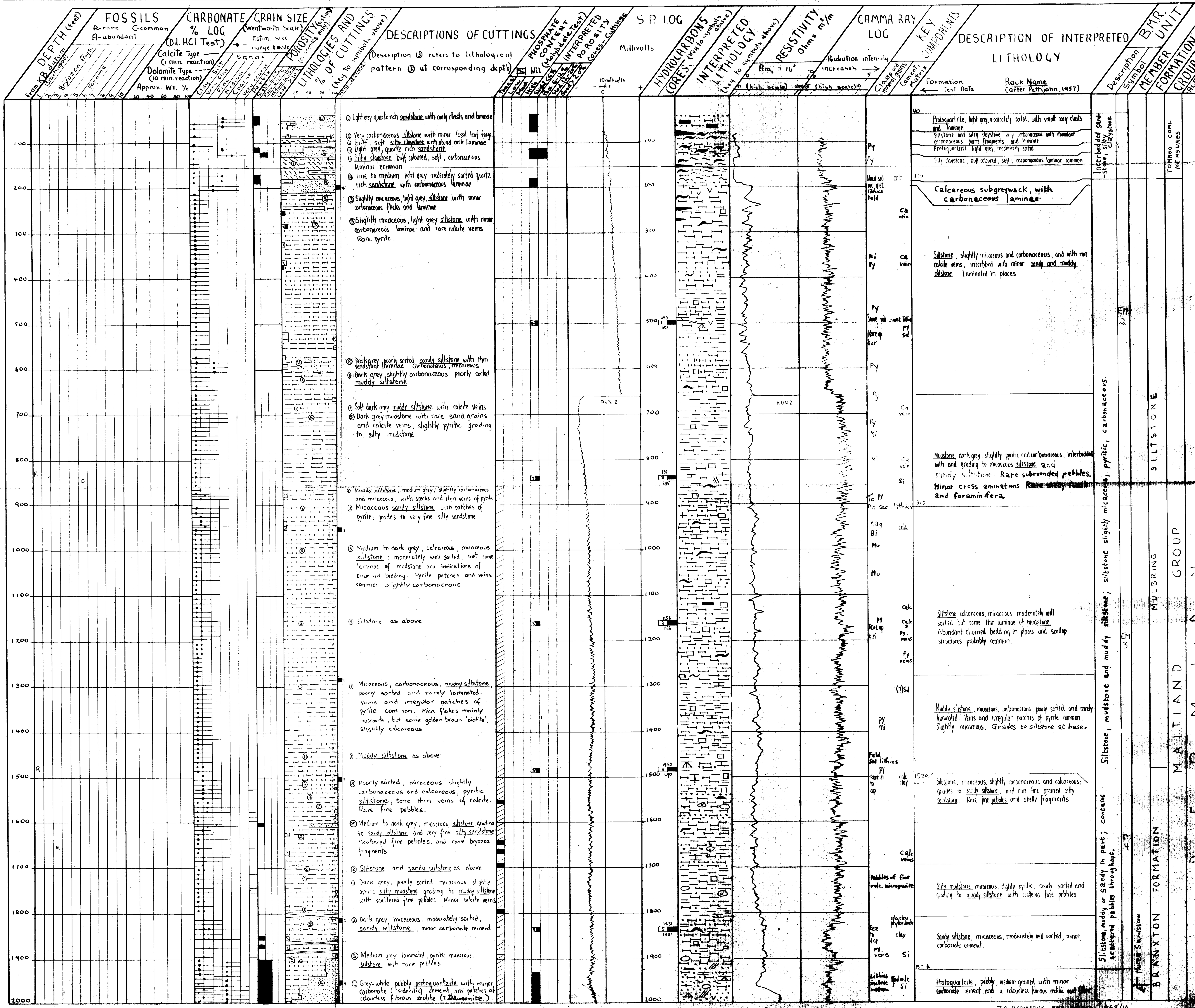
HYDROCARBON SYMBOLS
- Show of oil
- Trace of oil
- Show of gas
- Trace of gas
- Fluorescence

MISCELLANEOUS
- Interval and Number of Formation Test
- Core number (recovery shown in black)
- No sample available from interval

LITHOLOGICAL SYMBOLS
- Breccia to conglomerate
- Sandstone
- Siltstone
- Claystone
- Shale and mudstone
- Coal
- Limestone: Calcirudite, Calcarenite, Calcilutite
- Dolomite

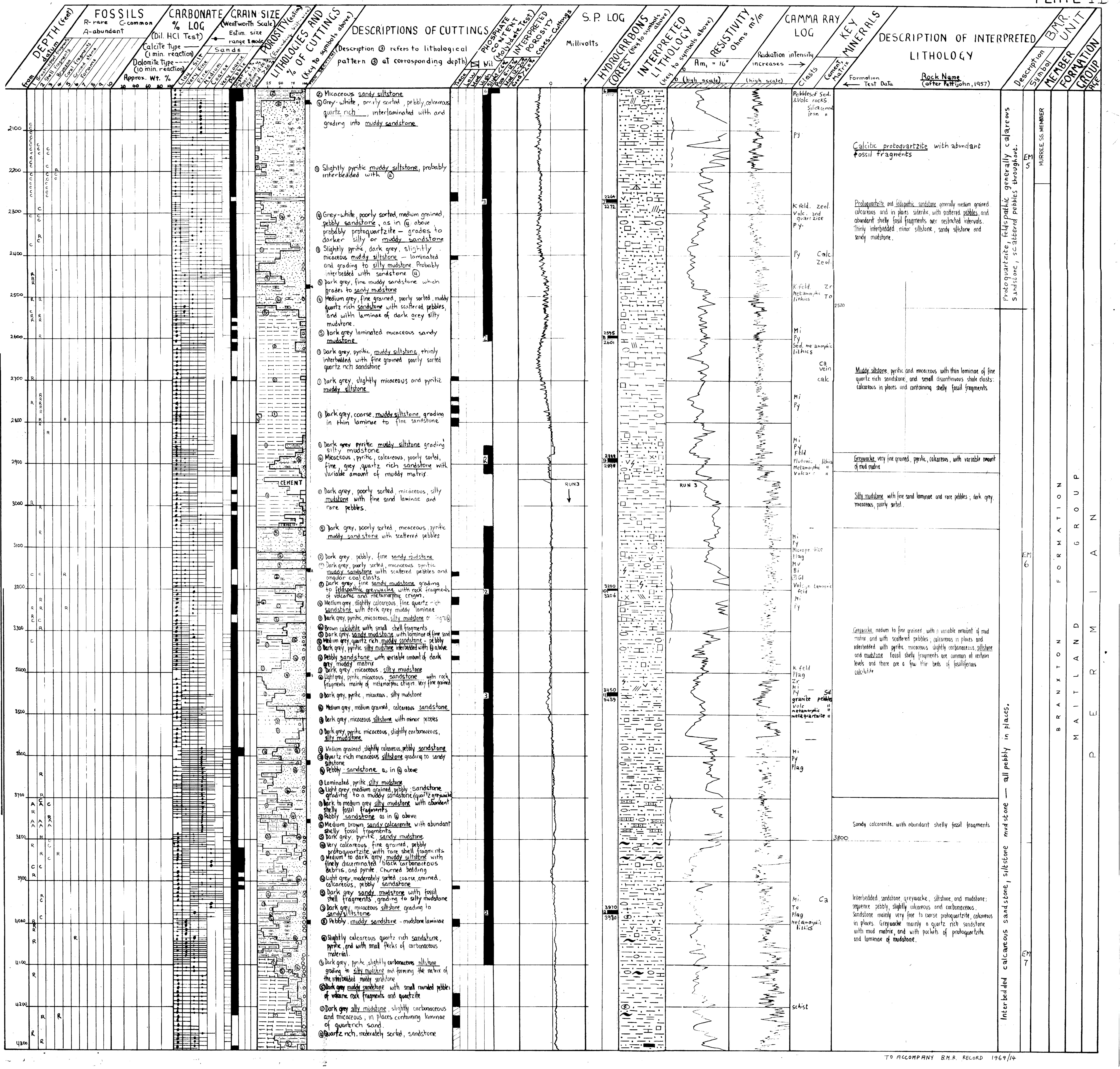
MINERAL ABBREVIATIONS

Si : Silica	Sd : siderite	Gl : Glauconite	Py : pyrite
Lim : Limonite	calc : calcareous	Zr : Zircon	Bi : Biotite
To : Tourmaline	Ser : Sericite	Ca : Calcite	Plag : Plagioclase
Ap : Apatite	Mu : Muscovite	Zeol : Zeolite	carb : carbonaceous
Mi : Mica	R : Rutile		Feld : Feldspar



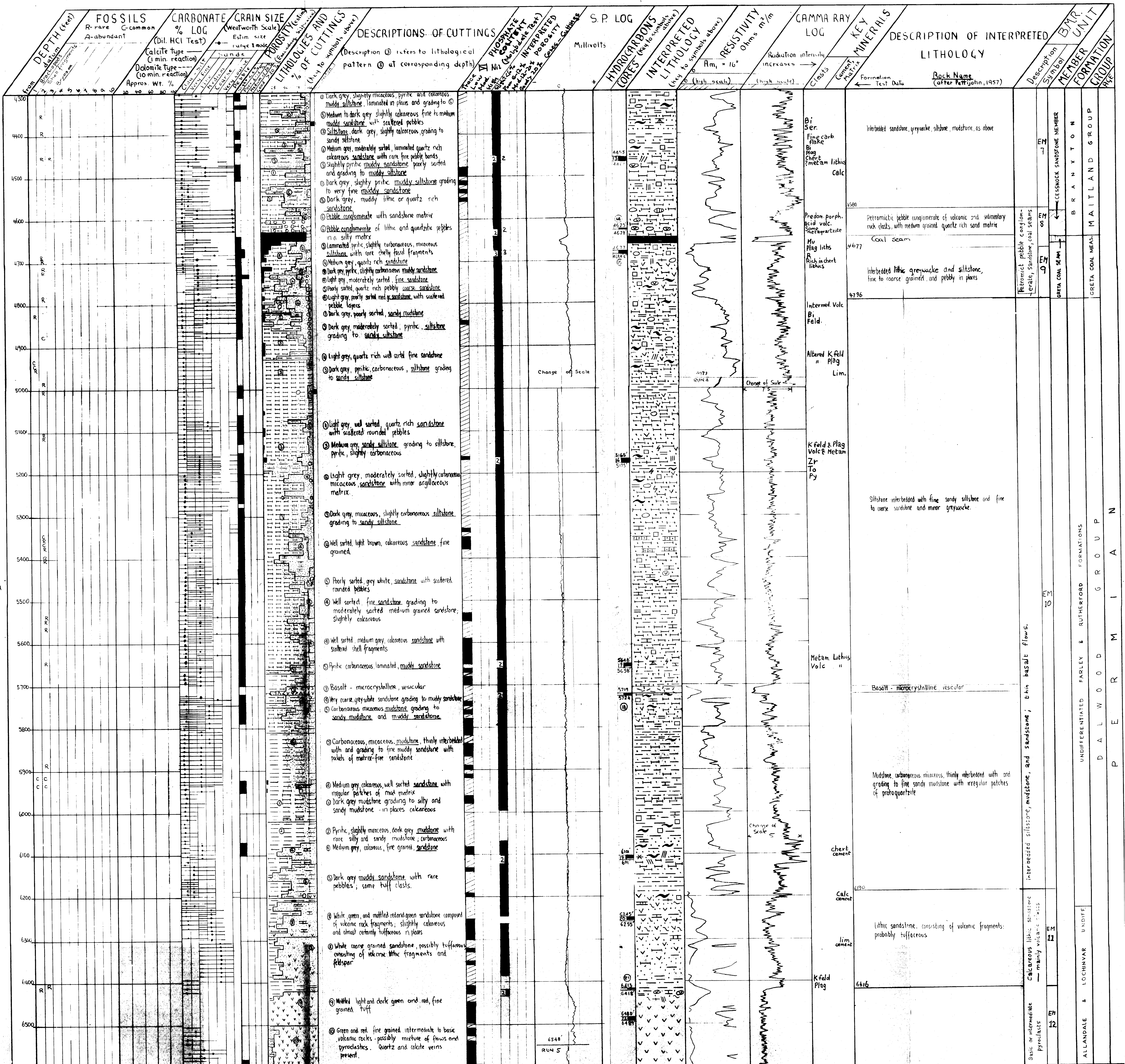
DEPTH (feet) from K.B. datum
FOSSILS R-rare C-common A-abundant
Brachiopods, Bryozoa, frags., Forams
CARBONATE % LOG (Dil. HCl Test)
Calcite type (1 min. reaction)
Dolomite Type (10 min. reaction)
Approx. Wt. %
GRAIN SIZE (Wentworth Scale)
Estim size range & mode
Clay-Silt, Very Fine, Fine, Medium, Coarse, Very coarse, Pebble
POROSITY (estim) (In arenites only)
LITHOLOGIES AND % OF CUTTINGS (Key to symbols above)
THIN SECTION
DESCRIPTIONS OF CUTTINGS
(Description ③ refers to lithological pattern ③ at corresponding depth)
PHOSPHATE CONTENT (Molybdate Test)
INTERPRETED POROSITY
S.P. LOG Millivolts
HYDROCARBONS
CORES (Key to symbols above)
INTERPRETED LITHOLOGY (key to symbols above)
RESISTIVITY Ohms m²/m
GAMMA RAY LOG Radiation intensity increases
KEY COMPONENTS Clasts and mineral grains; Cement, Matrix
DESCRIPTION OF INTERPRETED LITHOLOGY
Formation Test Data
Rock Name (after Pettijohn, 1957)
B.M.R. UNIT Description, Symbol
MEMBER FORMATION GROUP AGE
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
RUN 2
④ Light grey quartz rich sandstone with coaly clasts and laminae
③ Very carbonaceous siltstone with minor fossil leaf frags.
① buff, soft silty claystone with abund. carb. laminae
④ Light grey, quartz rich sandstone
① Silty claystone, buff coloured, soft; carbonaceous laminae common
④ Fine to medium light grey moderately sorted quartz rich sandstone with carbonaceous laminae
③ Slightly micaceous, light grey, siltstone with minor carbonaceous flecks and laminae
③ Slightly micaceous, light grey siltstone with minor carbonaceous laminae and rare calcite veins Rare pyrite.
② Dark grey poorly sorted sandy siltstone with thin sandstone laminae Carbonaceous, micaceous
① Dark grey, slightly carbonaceous, poorly sorted muddy siltstone
① Soft dark grey muddy siltstone with calcite veins
⑤ Dark grey mudstone with rare sand grains and calcite veins; slightly pyritic grading to silty mudstone
① Muddy siltstone, medium grey, slightly carbonaceous and micaceous, with specks and thin veins of pyrite
② Micaceous sandy siltstone, with patches of pyrite; grades to very fine silty sandstone
③ Medium to dark grey, calcareous, micaceous siltstone: moderately well sorted, but some laminae of mudstone, and indications of churned bedding. Pyrite patches and veins common. Slightly carbonaceous
③ Siltstone as above
① Micaceous, carbonaceous, muddy siltstone, poorly sorted and rarely laminated. Veins and irregular patches of pyrite common. Mica flakes mainly muscovite, but some golden brown 'biotite'. Slightly calcareous
① Muddy siltstone as above
③ Poorly sorted, micaceous, slightly carbonaceous and calcareous, pyritic siltstone; some thin veins of calcite. Rare fine pebbles.
② Medium to dark grey, micaceous, siltstone, grading to sandy siltstone and very fine silty sandstone Scattered fine pebbles, and rare bryozoa fragments
② Siltstone and sandy siltstone as above
① Dark grey, poorly sorted, micaceous, slightly pyritic silty mudstone grading to muddy siltstone with scattered fine pebbles Minor calcite veins
② Dark grey, micaceous, moderately sorted, sandy siltstone, minor carbonate cement
③ Medium grey, laminated, pyritic, micaceous, siltstone with rare pebbles
④ Grey-white, pebbly protoquartzite with minor carbonate ('sideritic) cement and patches of colourless fibrous zeolite (? Dawsonite)
Py
Mixed sed. volc. met. lithics Feld
calc
Ca vein
Mi Py
Py
Some volc. met. lithics
Rare op & zr
Py Sd
To Py.
Alt sed. lithics
Plag Bi Mu
calc.
Rare op & zr
Calc Py. veins
(?)Sd
Py mi
Feld. Sed lithics
Rare zr to op
calc. clay
Calc veins
Pebbles of fine volc. microgranite
colourless phyllosilicate
clay
Si
Lithics include metam.
Kaolinite & Si
40
Protoquartzite, light grey, moderately sorted, with small coaly clasts and laminae
Siltstone and silty claystone very carbonaceous with abundant carbonaceous plant fragments and laminae
Protoquartzite, light grey, moderately sorted
Silty claystone, buff coloured, soft; carbonaceous laminae common
192
Calcareous subgreywack, with carbonaceous laminae
Siltstone, slightly micaceous and carbonaceous, and with rare calcite veins; interbbed with minor sandy and muddy siltstone Laminated in places
Mudstone, dark grey, slightly pyritic and carbonaceous, interbedded with and grading to micaceous siltstone and sandy siltstone. Rare subrounded pebbles. Minor cross aminations. Rare shelly fossils and foraminifera
915
Siltstone, calcareous, micaceous moderately well sorted but some thin laminae of mudstone. Abundant churned bedding in places and scallop structures probably common.
Muddy siltstone, micaceous, carbonaceous, poorly sorted and rarely laminated. Veins and irregular patches of pyrite common. Slightly calcareous. Grades to siltstone at base.
1520
Siltstone, micaceous, slightly carbonaceous and calcareous; grades to sandy siltstone, and rare fine grained silty sandstone. Rare fine pebbles and shelly fragments
Silty mudstone, micaceous, slightly pyritic, poorly sorted and grading to muddy siltstone with scattered fine pebbles.
Sandy siltstone, micaceous, moderately well sorted; minor carbonate cement.
Protoquartzite, pebbly, medium grained, with minor carbonate cement, and a colourless fibrous zeolitic
Interbedded sand-stone, silty claystone
Siltstone, mudstone and muddy siltstone; siltstone slightly micaceous, pyritic, carbonaceous.
Siltstone, muddy or sandy in part; contains scattered pebbles throughout.
EM 2
EM 3
EM 4
Muree Sandstone
TOMAGO COAL MEASURES
SILTSTONE
MULBRING
BRANXTON FORMATION
MAITLAND GROUP
PERMIAN

TO ACCOMPANY BMR 1969/14



TO ACCOMPANY B.M.R. RECORD 1969/14

PLATE 1C



TO ACCOMPANY B.M.R. RECORD 1969/14

PLATE 1D

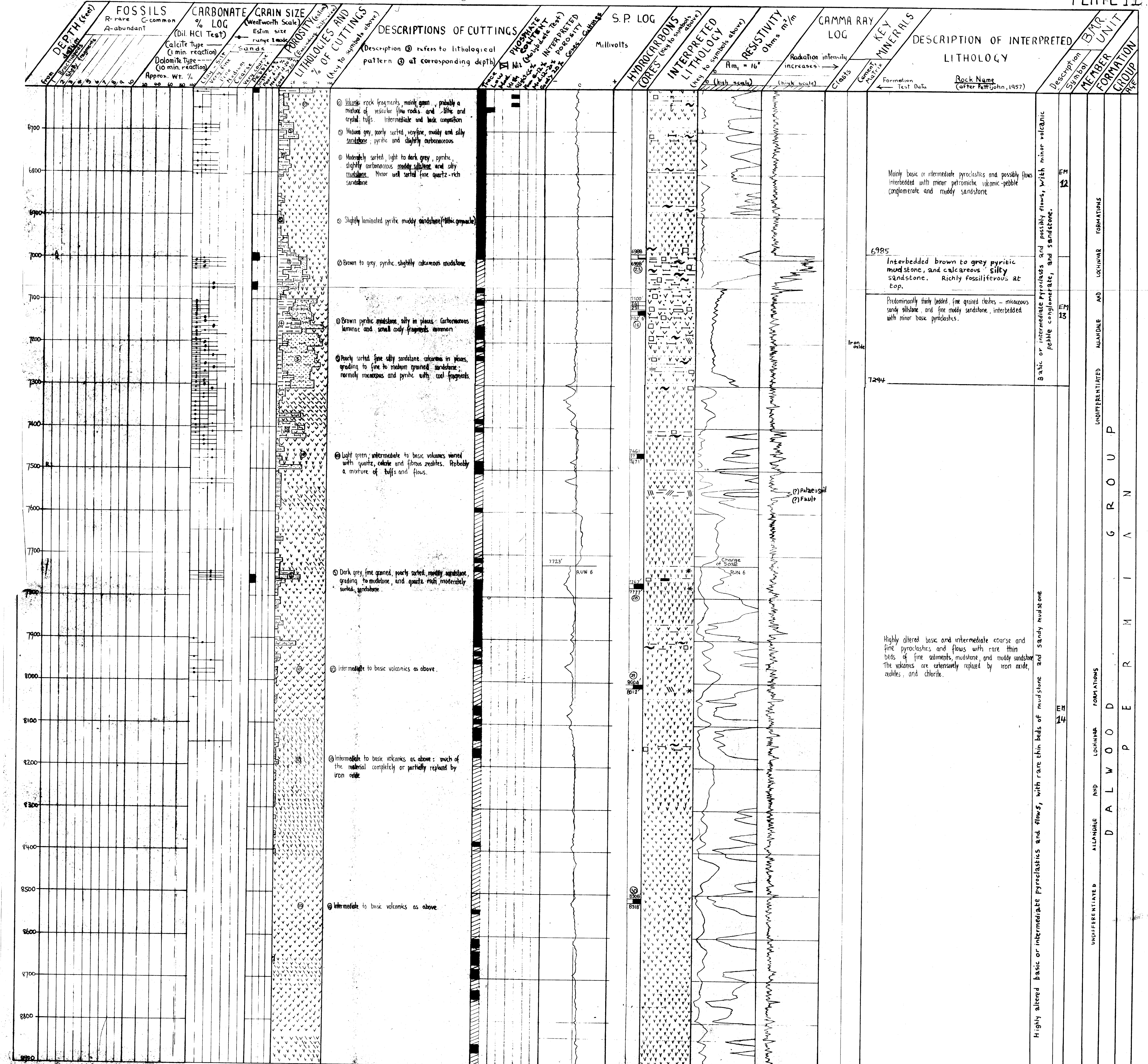
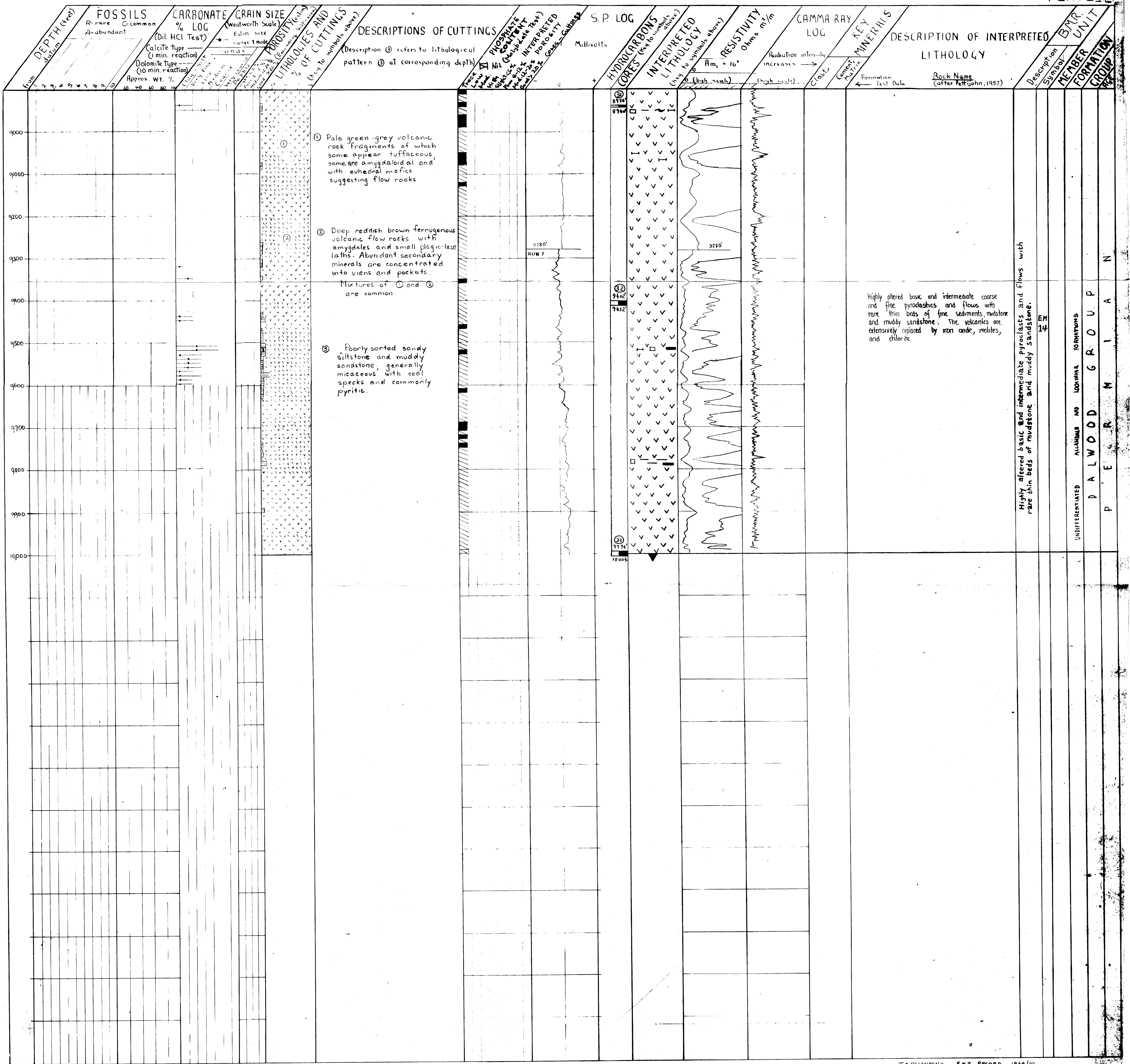

DEPTH (feet)
FOSSILS
R-rare C-common A-abundant
Brachiopods
Shelly fragments
CARBONATE % LOG
(Dil. HCl Test)
Calcite type (1 min. reaction)
Dolomite type (10 min. reaction)
Approx. Wt. %
GRAIN SIZE
(Wentworth Scale)
Sands
POROSITY (estim.)
LITHOLOGIES AND % OF CUTTINGS
(key to symbols above)
DESCRIPTIONS OF CUTTINGS
(Description ③ refers to lithological pattern ③ at corresponding depth)
⑩ Volcanic rock fragments, mainly green, probably a mixture of vesicular flow rocks and lithic and crystal tuffs. Intermediate and basic composition
⑤ Medium grey, poorly sorted, very fine, muddy and silty sandstone; pyritic and slightly carbonaceous
① Moderately sorted, light to dark grey, pyritic, slightly carbonaceous muddy siltstone and silty mudstone. Minor well sorted fine quartz-rich sandstone
⑤ Slightly laminated pyritic muddy sandstone (?lithic greywacke)
② Brown to grey, pyritic, slightly calcareous mudstone
① Brown pyritic mudstone, silty in places. Carbonaceous laminae and small coaly fragments common
⑤ Poorly sorted fine silty sandstone, calcareous in places, grading to fine to medium grained sandstone; normally micaceous and pyritic with coal fragments.
⑩ Light green, intermediate to basic volcanics veined with quartz, calcite and fibrous zeolites. Probably a mixture of tuffs and flows.
⑤ Dark grey, fine grained, poorly sorted, muddy sandstone, grading to mudstone, and quartz rich, moderately sorted sandstone.
⑩ Intermediate to basic volcanics as above.
⑩ Intermediate to basic volcanics as above: much of the material completely or partially replaced by iron oxide
⑩ Intermediate to basic volcanics as above
PHOSPHATE CONTENT
Nil (Molybdate Test)
INTERPRETED POROSITY
Cores - Cuttings
S.P. LOG
Millivolts
7723'
RUN 6
HYDROCARBONS
CORES (key to symbols above)
6988
6998'
7100
7132'
7461
7471'
7767
7777'
8004
8012'
8508
8518'
INTERPRETED LITHOLOGY (key to symbols above)
RESISTIVITY Ohms m²/m
Am₁ = 16"
(high scale)
Change of Scale
RUN 6
GAMMA RAY LOG
Radiation intensity increases
(?) Palaeosoil
(?) Fault
KEY MINERALS
Clasts
Cement, Matrix
Iron oxide
DESCRIPTION OF INTERPRETED LITHOLOGY
Formation Test Data
Rock Name (after Pettijohn, 1957)
Mainly basic or intermediate pyroclastics and possibly flows interbedded with minor petromictic volcanic-pebble conglomerate and muddy sandstone
6985
Interbedded brown to grey pyritic mudstone, and calcareous silty sandstone. Richly fossiliferous at top.
Predominantly thinly bedded, fine grained clastics - micaceous sandy siltstone, and fine muddy sandstone, interbedded with minor basic pyroclastics.
7294
Highly altered basic and intermediate coarse and fine pyroclastics and flows with rare thin beds of fine sediments, mudstone, and muddy sandstone. The volcanics are extensively replaced by iron oxide, zeolites, and chlorite.
B.M.R. UNIT
Description
Symbol
Basic or intermediate pyroclasts and possibly flows, with minor volcanic pebble conglomerate, and sandstone.
Highly altered basic or intermediate pyroclastics and flows, with rare thin beds of mudstone and sandy mudstone
EM 12
EM 13
EM 14
MEMBER
FORMATION
UNDIFFERENTIATED ALLANDALE AND LOCHINVAR FORMATIONS
GROUP
DALWOOD GROUP
AGE
LOWER PERMIAN

PLATE 1E



TO ACCOMPANY B.M.R. RECORD 1969/14

PETROGRAPHIC CORE LOG
EAST MAITLAND (PLANET) Nº 1

PLATE 2A

Geology by: A. R. JENSEN

WELL NAME, Nº.: EAST MAITLAND Nº 1
OPERATING Co.: PLANET OIL CO PTY LTD
WELL LOCATION
Lat: 32° 45' 47" E Long.: 151° 37' 05"
Basin: SYDNEY
State: NEW SOUTH WALES
Tenement No. P.E.L. Nº 88
1:250,000 Sheet Nº NEWCASTLE 156/2

ELEVATION (A.S.L.)
Ground Level 15.22 ft.
K.B. Datum 30.82 ft.

SAMPLE STORAGE
B.M.R. Canberra
N.S.W. Mines Department

Legend: Slump; Graded bedding; Shale clast; Laminated; Thin bedded; Medium bedded; Thick bedded; Massive; Cross bedded; Burrow; Churned bedding; Scallop structure

Interval –1ft: Core not recovered; Position of lost core not known

Porosity (estimated): S – slight <6%; P – Poor 6–12%; M – Medium 12–20%; G – Good >20%

Abundance (estimated): R – rare; C – common; A – abundant

Brachiopod; Foram; Coral; Crinoid; Bryozoa; Plant rootlet; Carbonaceous material; Pyrite; Calcite crystal

Matrix; Lithic fragments; Feldspar

Breccia to conglomerate; Sandstone (Quartz in detailed description); Siltstone; Claystone; Limestone or calcite; Dolomite; Shale and mudstone; Coal; Siderite; Volcanic

AGE	GROUP	FORMATION	BMR UNITS	CORE Nº RECOVERY FOOTAGES	GENERALIZED ROCK NAME (AFTER Folk 1954)	COLOUR
PERMIAN	MAITLAND GROUP	MULBRING SILTSTONE	E.M. 2	1 (9') 495'0" – 504'0"	Carbonaceous, pyritic mudstone with numerous laminae of calcareous siltstone and carbonaceous material. Silt laminae produce shaly fissility. Some signs of post depositional mixing, either by burrowing or slumping	dark grey
					Laminated sideritic mudstone with discontinuous laminae of coarse silt. A little carbonaceous material, disseminated	grey brown
					Carbonaceous silty mudstone with indistinct wavy lamination	dark grey
					Slightly swelling sandy claystone with a little disseminated muddy material; slightly laminated	brown-green
					Slightly carbonaceous muddy siltstone with laminae of coarse siltstone. Laminated – coarser laminae discontinuous.	
			E.M.2 – E.M.4	2 (8'6") 835'0" – 845'0"	Micaceous silty mudstone with rare granules and small biotite flakes	dark grey
					Altered dolomitic marl with irregular packets of pale green slightly swelling clay	green-grey
					Slightly pyritic mudstone with minor coarse sandy patches and rare subrounded quartzite pebbles. Vague discontinuous lamination	dark grey
					Mudstone with rare sand stringers; slightly pyritic and with flecks of black carbonaceous material. Scattered foraminiferal fragments	dark grey
					Slightly pyritic and carbonaceous mudstone – faintly laminated	dark grey
			E.M. 3	3 (10') 1156'0" – 1166'0"	Slightly calcareous, pyritic micaceous siltstone with minor carbonaceous flecks	med grey
					Slightly micaceous, pyritic, carbonaceous, siltstone with abundant small tubes lined with carbonaceous material	

Dip of sedimentary/tectonic structure: 3°

DETAILED DESCRIPTION

Depth of sample sectioned	Specific rock name (after Pettijohn 1957)	Porosity	Permeability (millidarcies) Vertical	Horizontal
495'0"	Laminated sandy mudstone	3	Nil	Nil
1158'4"	Micaceous siltstone	3	Nil	Nil
1165'0"	Muddy siltstone	3	Nil	Nil

Column headings: Roundness; Sorting; Grain-size (Wentworth Scale) Estim. size, Range & Mode – Sands: Clay-silt, Fine, Medium, Coarse, Very coarse, Pebble; Thin-section analysis – % of essential components (Underscored – if material clearly present as cement or matrix; pore space shown as blank) 20 40 60 80 100; Matrix and/or Cement Estim. % of Total Rock: Clay–undiff., Silica, Kaolin Gp., Phyllosilicate, Chlorite, Zeolite, Illite; Accessory minerals (Estim. % or Measured % total rock) "Dark Minerals": Total "Dark", Carbonaceous material, Biotite, Tourmaline; "Light Min": Mica; Zircon, Apatite; Maturity index; Notes (provenance, environment of deposition, diagenesis, palaeontology etc.)

Accessory minerals: 495'0" – C A C R R; 1158'4" – 52 C A C R R; 1165'0" – A C R C

To accompany B.M.R. Record 1969/14


PLATE 2B
DETAILED DESCRIPTION
GENERALIZED DESCRIPTION
CORRELATION
AGE
GROUP
FORMATION
BMR UNITS
CORE No. RECOVERY FOOTAGES
LITHOLOGY
DESCRIPTION
GENERALIZED ROCK NAME AFTER (Folk 1954)
COLOUR
SEDIMENTARY STRUCTURE
DIP & TECTONIC STRUCTURE
DEPTH of Sample sectioned
SPECIFIC ROCK NAME (AFTER PETTIJOHN 1957)
POROSITY
PERMEABILITY millidarcies
ROUNDNESS
SORTING
GRAIN-SIZE (Wentworth Scale) Estim. size Range & Mode
SANDS
THIN-SECTION ANALYSIS
% OF ESSENTIAL COMPONENTS
UNDERSCORED-IF MATERIAL CLEARLY PRESENT AS CEMENT OR MATRIX
POROSITY SHOWN AS BLANK
Matrix and/or Cement Estim. % of Total Rock
Clay-undiff.
Silica
Kaolin Gp.
Phyllosilicate
Chlorite
Zeolite
Illite
ACCESSORY MINERALS
"Dark Minerals"
"Light Min"
MATURITY INDEX
NOTES (provenance, environment of deposition, diagenesis, palaeontology etc.)
PERMIAN
MAITLAND GROUP
MULBRING SILTSTONE
BRANXTON FORMATION
EM 3
EM2 - EM 4
EM 4
EM5 - EM 7
EM 5
1480'0"
4 8'6"
1490'
1831'
5 (10')
1841'
2002'
6 (7'5")
2012
2264'
7 (8')
2272'
Pyritic, slightly carbonaceous siltstone with some micaceous siltstone. Pyrite forms minute spheres in some places
dark grey
dark grey
1483'0"
Laminated muddy siltstone
Pyritic, slightly carbonaceous siltstone
1488' 3"
Calcareous, siltstone with rare small bioclasts
Poorly sorted, pyritic, micaceous, pebbly siltstone with dark muddy laminae and thin bands of very fine quartz rich sandstone. Silt sized carbonaceous shreds and subround pebbles
dark grey
1833'0"
Muddy siltstone
Shelly fragments common. A few recognizable meta-sedimentary rock fragments present
Very coarse silt with disseminated pyrite and carbonaceous or bituminous blebs and a little colourless mica. Muddy and sandy streaks are very common. White non-carbonate forms small veins parallel to bedding. Rare pebbles, some granules
Truncation of scallop structure
dark grey
1838' 3"
Laminated silty mudstone grading to sandy mudstone
Pyritic carbonaceous muddy siltstone
Coarse to medium grained, moderately well sorted sandstone, with minor carbonate cement, minor pale green swelling clay and small patches of a white radiating fibrous mineral. Rare bioclasts. Most grains subangular with moderate sphericity. From 2004'3"-2005'0" large subrounded pebbles and cobbles of sedimentary and volcanic rocks are common; any of low sphericity are oriented with long axis horizontal.
light grey
0°
2002' 0"
Calcareous protoquartzite
Sedimentary and metasedimentary
2008' 3"
Protoquartzite
Moderately sorted, medium grained, calcareous sandstone
light grey
Moderately sorted, fine grained, calcareous sandstone with minor black carbonaceous or bituminous material forming in places vague swirls. Rare volcanic cobbles
light grey
Poorly sorted, medium grained, calcareous pebbly sandstone with finely disseminated carbonaceous material. Some definite volcanic rock pebbles, others possibly quartzite
Medium grained, calcareous, sandstone with scattered pebbles and vague carbonaceous lamination. Rare small patches of swelling clay
0°
2264' 0"
Calcareous protoquartzite
2271'0"
Protoquartzite
Rock fragments sedimentary and metasedimentary
To accompany BMR Record 1969/14

PLATE 2C

DETAILED DESCRIPTION

Columns: AGE · GROUP · FORMATION · B.M.R. UNITS (CORRELATION) · CORE No. RECOVERY FOOTAGES · LITHOLOGY · GENERALIZED DESCRIPTION (GENERALIZED ROCK NAME AFTER Folk 1954) · COLOUR · SEDIMENTARY STRUCTURES / DIP & TECTONIC STRUCTURE · DEPTH of Sample sectioned · SPECIFIC ROCK NAME (AFTER PETTIJOHN 1957) · POROSITY (% where measured; Vertical, Horizontal) · PERMEABILITY (millidarcys) · ROUNDNESS · SORTING · GRAIN-SIZE (Wentworth Scale; Estim. size, Range & Mode; Clay–Silt, Very Fine, Fine, Medium, Coarse, Very Coarse, Pebble) · THIN-SECTION ANALYSIS: % OF ESSENTIAL COMPONENTS (underscored – if material clearly present as cement or matrix; porosity shown as blank; 20 40 60 80 100) · Matrix and/or Cement, Estim. % of Total Rock (Clay–undiff., Silica, Kaolin Gp., Phyllosilicate, Chlorite Gp., Zeolite, Illite Gp.) · ACCESSORY MINERALS ("Dark Minerals", "Light Min.") · MATURITY INDEX · NOTES (provenance, environment of deposition, diagenesis, palaeontology etc.)

AGE: PERMIAN · GROUP: MAITLAND GROUP · FORMATION: BRANXTON FORMATION · B.M.R. UNITS: E.M.5 - E.M.7; E.M.6; E.M.7

Core (recovery), footages	Description	Colour	Dip	Depth of sample	Specific rock name	Porosity	Permeability	Maturity index	Notes
8 (5'10"), 2595'6"–2601'	Calcareous, micaceous, muddy siltstone, with discontinuous dark shaly laminae and angular clasts to granule size	dark grey to black	0°	2594'6"	Fossiliferous muddy siltstone	2	Nil Nil	3	Sedimentary and metamorphic rock fragments. Bioclasts common
	Calcareous micaceous muddy siltstone as above with addition of solitary corals and bryozoa	dark grey to black				2	Nil Nil		
	Calcareous, micaceous, muddy siltstone with abundant crinoid fragments	dark grey to black				3; 4	Nil Nil		
9 (8'6"), 2888'–2898'	Quartz rich muddy sandstone with abundant granules and rare pebbles some of which are volcanic. Lamination vague and discontinuous.	dark grey	5°	2888'0"	Lithic greywacke	2; 2	Nil Nil	1·6	Plutonic and metamorphic rock fragments, rare volcanics.
	Calcareous, slightly micaceous and pyritic, muddy sandstone with scattered coarse sand grains and rare pebbles	dark grey		2892'8"	Greywacke	2	Nil Nil		
	Calcareous, possibly sideritic, carbonaceous, slightly pyritic muddy sandstone with scattered subround and rounded pebbles – volcanic and metamorphic	dark grey		2894'0"	Calcareous lithic greywacke	2	Nil Nil	3	Sedimentary and metamorphic rock fragments common – rare volcanics. Bioclasts common probably bryozoa and crinoids – some forams
	Calcareous, slightly micaceous, muddy sandstone					3	Nil Nil		
10 (3'3"), 3200'–3206'	Slightly calcareous micaceous pyritic muddy sandstone with thin discontinuous muddy laminae. Rare volcanic cobbles	medium grey		3203'0"	Feldspathic greywacke	2; 2	Nil Nil	4·3	Metamorphic rock fragments common – minor sedimentary and acid plutonic.
11 (8'5"), 3450'–3459'6"	Quartz rich sandstone grading to and interbedded with sandy mudstone – one pebble band	light grey				4	Nil Nil		
	Quartz rich sandstone with scattered pebbles, minor clay matrix	light grey		3451'10"	Subgreywacke	3	Nil Nil	3·3	Mainly metamorphic rock fragments, minor acid plutonics.
	Quartz rich sandstone with many angular to subrounded pebbles of quartzite and volcanic rock fragments					4	Nil Nil		
	Quartz rich sandstone with scattered pebbles minor clay	light grey				2	Nil Nil		
	Quartz rich sandstone with muddy matrix and abundance of carbonaceous material especially plant rootlets.	med grey		3456'9"	Sideritic feldspathic sandstone	2	Nil Nil		Quartzite, plutonic and volcanic rock fragments.
12 (9'8"), 3970'–3979'8"	Muddy sandstone with carbonaceous material and subrounded metamorphic sedimentary and volcanic pebbles	med grey		3971'3"	Feldspathic greywacke	2	Nil Nil	5	Rare bryozoa fragments
	Slightly micaceous muddy sandstone grading to minor sandy mudstone – rare granules.					2; 2	Nil Nil		
	Pebbly sandstone with muddy laminae and grading to muddy sandstone. Pebbles of fine volcanics and sediments common	med grey				2	Nil Nil		
				3978'1"	Sideritic, micaceous, protoquartzite	2	Nil Nil	6·4	Matrix of chlorite and framework minerals (quartz, feldspar, mica). Rock fragments metamorphic and chert.

To accompany B.M.R. Record 1969/14


PLATE 2D
CORRELATION
AGE
GROUP
FORMATION
BMR UNITS
CORE No. RECOVERY FOOTAGES
LITHOLOGY
GENERALIZED DESCRIPTION
DESCRIPTION
GENERALIZED ROCK NAME (AFTER Folk 1954)
COLOUR
SEDIMENTARY STRUCTURE
DIP & TECTONIC STRUCTURE
DETAILED DESCRIPTION
DEPTH
Sample sectioned
SPECIFIC ROCK NAME
(AFTER PETTIJOHN 1957)
POROSITY
PERMEABILITY
ROUNDNESS
SORTING
GRAIN-SIZE (Wentworth Scale) Estim. size Range & Mode
SANDS
CLAY-SILT
VERY FINE
FINE
MEDIUM
COARSE
VERY COARSE
PEBBLE
THIN-SECTION ANALYSIS
% OF ESSENTIAL COMPONENTS
UNDERSCORED IF MATERIAL CLEARLY PRESENT AS CEMENT OR MATRIX
POROSITY SHOWN AS BLANK
20 40 60 80 100
Matrix and/or Cement
Estim. % of Total Rock
CLAY-undiff.
Silica
KAOLIN Gp.
Phyllosilicate
Chlorite
Zeolite
Illite
ACCESSORY MINERALS
Estim. R-C-A or Measured % of total rock
"Dark Minerals"
"Light Mix"
Total "Dark"
Pyrite
Biotite
Tourmaline
Zircon
Sericite
Epidote
MATURITY INDEX
NOTES
(provenance, environment of deposition, diagenesis, palaeontology etc.)
PERMIAN
MAITLAND GROUP
BRANXTON FORMATION
E.M.5 – E.M.7.
E.M.7
Cessnock Sandstone Member
E.M.8
GRETA COAL MEASURES
E.M.9
DALWOOD GROUP
FARLEY AND RUTHERFORD FORMATIONS
UNDIFFERENTIATED
E.M.9 – E.M.10
E.M.10
13 (12')
4455
4467
Laminated, slightly pyritic, well sorted, carbonaceous siltstone with dark carbonaceous streaks and small tubes probably rootlets – vertical and oblique. Fine laminae possibly graded
light-med grey
3
4455' Micaceous siltstone
13
Slightly micaceous and pyritic carbonaceous siltstone, with discontinuous carbonaceous laminae cut by vertical carbonaceous rootlets, rare granule sized clasts
medium grey
Slightly micaceous and pyritic carbonaceous siltstone with discontinuous carbonaceous muddy laminae
med grey
4463' Micaceous siltstone
4.5
Siltstone as above; much of the discontinuous lamination caused by probable burrowing and/or disturbance by plant rootlets
14 (1'10")
4625
4628
Petromictic pebble conglomerate of volcanic and sedimentary rock clasts, with medium grained, quartz rich sandy matrix
Mottled light blue grey
5625' Petromictic pebble conglomerate
0.1
Rock fragments mainly porphyritic acid volcanics and minor quartz-rich sediments.
15 (7'5")
4677
Pyritic sandstone with scattered pebble bands. Pebbles rounded and of fine grained volcanic fragments and quartzite.
Light grey
Particularly well sorted lithic sandstone with scattered carbonaceous clasts
Medium grey
4678'6" Micaceous lithic greywacke
0.7
Sandstone sharp contact with underlying conglomerate
Med grey
Low angle
4681'6" Subgreywacke
0.2
Mainly volcanic rock fragments – minor metamorphic. Clay matrix possibly montmorillonite, kaolinite and a little chlorite
16 (10')
5165'
Very fine, slightly micaceous, sandstone with abundant dark grey laminae and wisps of carbonaceous and argillaceous material forming in some places small tubes – ? rootlets.
Med. grey
5169' Lithic greywacke
2
Dark, discontinuous laminae composed of chloritic and carbonaceous material. Rock fragments mixture, mainly metamorphic, some volcanic and sedimentary.
Slightly carbonaceous, sandstone with small clasts of coaly material, and discontinuous laminae of argillaceous material
5174' Micaceous lithic subgreywacke
1.4
17 (8'7")
5648
5658
Slightly calcareous sandstone and muddy sandstone; original composition and structure altered by bioturbation
Thinly interbedded dark grey calcareous, pyritic mudstone, and fine to medium sandstone, intermixed in zones of bioturbation
Mottled brown and grey
5650' Lithic greywacke
1.6
At least some metamorphic fragments
Pyritic, sideritic muddy sandstone with rare angular pebbles and brachiopod shell fragments. Scattered coalified plant material.
vert.?
5653' Feldspathic greywacke
1.1
Rock fragments mainly indeterminate; some volcanic
Pyritic muddy sandstone with scattered calcite and siderite veins; discontinuous subhorizontal lamination
Med grey
Nil
To accompany B.M.R. Record 1969/14

PLATE 2E

DETAILED DESCRIPTION

CORRELATION

AGE: PERMIAN

GROUP: DALWOOD

FORMATION: UNDIFFERENTIATED ALLANDALE AND LOCHINVAR FORMATIONS

B.M.R. Units: EM.9 – EM.10; EM.10; EM.11; EM.11 – EM.13; EM.12

GENERALIZED DESCRIPTION

CORE Nº RECOVERY FOOTAGES

LITHOLOGY

DESCRIPTION — GENERALIZED ROCK NAME (AFTER Folk 1954)

COLOUR

SEDIMENTARY STRUCTURE (See also DIP & TECTONIC STRUCTURE)

DEPTH

Sample sectioned

SPECIFIC ROCK NAME (AFTER PETTIJOHN 1957)

DEPTH	SPECIFIC ROCK NAME	GENERALIZED ROCK NAME — DESCRIPTION	COLOUR	SEDIMENTARY STRUCTURE
5719		Microcrystalline, vesicular basalt	dark grey-green	
5721'	Spilite			
		Pyritic, calcareous, muddy sandstone with abundant brachiopod shell fragments and subround volcanic pebbles, scattered large feldspar grains	medium grey	
5723'4"	Siltstone			
6101' 6"	'Quartz greywacke'			
		Slightly calcareous, micaceous, sandstone, finely laminated in places, with abundant small black coaly clasts.	medium grey	5-10°
6108'	Chlorite siltstone			
6111				
6245		Hard coarse grained, poorly sorted, coarse sandstone composed essentially of volcanic rock fragments and feldspar	Light brown	
		Hard, coarse grained lithic sandstone as above – minor carbonate cement	Light brown	
20 (8'3")				
		Hard, fine grained, slightly calcareous sandstone, composed of volcanic lithic fragments		
		Poorly sorted conglomerate of rounded volcanic pebbles in a volcanic-lithic coarse sand matrix	Dark grey	
6413	Petromictic conglomerate with a coarse grained lithic greywacke matrix			
		Calcareous, poorly sorted, lapilli tuff of pumiceous fragments with a matrix of coarse volcanic-lithic sand and chlorite.	Dark green	
6480		Light green basic or intermediate lapilli tuff consisting of subrounded to rounded volcanic fragments in a fine matrix partially replaced by iron oxide	Light green	
		Very fine grained volcanic rock with scattered elongate probable amygdules – probably a basic flow		
22 (8'7")		Green and red agglomerate composed of subrounded to rounded, basic or intermediate amygdaloidal and porphyritic flow rocks.	Green and red	
		Green-grey volcanic agglomerate as above. Extensive replacement by iron oxide	Green-grey	
6489				

DETAILED DESCRIPTION

POROSITY (% by volume measured) — Estim. Low / Low / Low-Med. / Med-High / High

PERMEABILITY millidarcies — Vertical / Horizontal

ROUNDNESS — Poor / Moderate / Good

SORTING — CLAY–SILT / VERY FINE / FINE / MEDIUM / COARSE / VERY COARSE / PEBBLE

GRAIN-SIZE (v/c. at worth Scale) — SANDS — Estim. size Range & Mode

THIN-SECTION ANALYSIS

% OF ESSENTIAL COMPONENTS — UNDERSCORED – IF MATERIAL CLEARLY PRESENT AS CEMENT OR MATRIX; POROSITY SHOWN AS BLANK

Matrix and/or Cement — Estim. % of Total Rock: CLAY–undiff. / Silica / KAOLIN Gp. / Phyllosilicate / Chlorite / Zeolite / Illite

ACCESSORY MINERALS — Estim. in Grains — Measured % total rock

"Dark Minerals": 1 Tourmaline, 2 Sphene, 3 Tourmaline material, 4, 5, 6

"Light Minerals": 1 Iron oxide, 2 Pyrite, 3 Mica, 4 Epidote, 5 Zircon, 6 Apatite, Calc. Chert, Felsic clasts

MAT. INDEX

DEPTH	Sample sectioned	POROSITY	PERMEABILITY	ROUNDNESS	SORTING	GRAIN-SIZE (SANDS)	% OF ESSENTIAL COMPONENTS	Matrix and/or Cement	ACCESSORY MINERALS	MAT. INDEX	NOTES
5721'	Spilite	2	Nil Nil								Zeolitic
5723'4"	Siltstone	0	Nil Nil						A, C, C	23	At least some plutonic and metamorphic fragments
6101' 6"	'Quartz greywacke'	2	Nil Nil						C R C, A, C R	11	Matrix of phyllosilicates and chlorite with some silica cement.
6108'	Chlorite siltstone	2	Nil Nil						C K, C	5·7	
6245'	Subgreywacke	0	Nil Nil							0·01	Lithic fragments almost entirely of volcanic origin; rare sedimentary rock fragments. Certainly epiclastic – not a tuff
6413	Petromictic conglomerate with a coarse grained lithic greywacke matrix	1	Nil Nil						A	29	Lithic fragments almost entirely volcanic - minor sedimentary rock fragments

NOTES (Provenance environment of deposition, diagenesis, palaeontology, etc.)

To accompany B.M.R. Record 1969/14

PLATE 2F

GENERALIZED DESCRIPTION / DETAILED DESCRIPTION

Correlation: Age – Group – Formation – B.M.R. Units

- **Age:** PERMIAN
- **Group:** DALWOOD GROUP
- **Formation:** UNDIFFERENTIATED ALLANDALE AND LOCHINVAR FORMATIONS
- **B.M.R. Units:** EM 11 – EM 13; EM 13; EM 14; EM. 14

Generalized description columns: Core No. (Recovery) Footages – Lithology – Description (Generalized rock name after Folk 1954) – Colour – Sedimentary structure (see legend) – Dip & tectonic structure

Detailed description columns: Depth of sample sectioned – Specific rock name (Sedimentary rock name after Pettijohn 1951) – Porosity (% where measured: Slight, Poor, Medium, Good) – Permeability (Millidarcies: Vertical, Horizontal) – Roundness – Sorting (Poor, Moderate, Good) – Grain-size (Wentworth scale; Estim. size, Range & Mode: Clay-silt, Very fine, Fine, Medium, Coarse, Very coarse, Pebbles) – Thin-section analysis: % of essential components (20, 40, 60, 80, 100); Matrix and/or cement, estim. % of total rock (Clay-undiff.; Kaolin gp.; Cement symbols see legend) – Accessory minerals, estim. in order of abundance & % total rock ("Dark minerals": Total "Dark", Carbonaceous material, Biotite, Tourmaline, Iron oxide, Pyrite, Mica; "Light min.": Epidote, Zircon, Apatite) – Maturity index (Qtz + chert / feld. + lithics) – Notes (provenance, environment of deposition, diagenesis, palaeontology etc.)

Core (recovery) / footages	Description	Colour	Dip	Depth of sample sectioned	Specific rock name	Porosity	Permeability (V / H)	Accessory minerals	Notes
23 (3'): 6988–6998'	Pyritic, micaceous sandy siltstone with small discontinuous lamellae, rich in shelly fossils including corals + brachiopods. Grades into a muddy sandstone	Dark grey	4°	6988'4"	Very fine grained feldspathic greywacke	2	Nil / Nil	A C C ... A ... R	Carbonate shell fragments. Authigenic tourmaline
26 (8'): 7124'–7131'	Vaguely bedded olive green lapilli tuff of vesicular pumiceous fragments in a crystal tuff matrix	Olive-green				3 3	Nil / Nil		
	Massive lapilli tuff consisting of poorly sorted, ragged pumiceous, amygdaloidal fragments					3 3	Nil / Nil		
27 (8'): 7461–7470				7462'6"	Fine grained, vesicular, spilite, with a trachytic fabric; partially replaced by chlorite, iron oxide, and a fibrous zeolite				
	Dark green-red poorly sorted lapilli tuff of fine grained basic to intermediate flow rocks	Dark-green-red				4 2	Nil / Nil		
	Dark grey poorly sorted lapilli tuff, composed of basic to intermediate lapilli with a white zeolitic cement	Dark-grey							
28 (10'): 7767–7777	Dark red-brown, strongly altered amygdoidal basic volcanic, extensively replaced by a fibrous white zeolite. Representative of whole core	Dark red-brown		7775'	Altered basalt, possibly a spilite, replaced by iron oxide, chlorite, epidote, calcite and fibrous zeolites				

PLATE 2G

CORRELATION: COMPANY INTERPRETN. | AGE | GROUP | FORMN | B.M.R. UNITS

PERMIAN | SYDNEY BASIN | GROUP | DALWOOD | UNDIFFERENTIATED AND LOCHINVAR FORMATIONS | ALLANDALE | EM 14 | EM 14

GENERALIZED DESCRIPTION

CORE No RECOVERY FOOTAGES	LITHOLOGY	DESCRIPTION — GENERALIZED ROCK NAME (Folk 1954)	COLOUR	SEDIMENTARY STRUCTURE (See symbols)	DIP & TECTONIC STRUCTURE
29 (7')		Red-grey poorly sorted lapilli tuff composed of ferruginous fragments of basic to intermediate volcanic rock with rhombic plagioclase pseudomorphs. The rock has been extensively replaced by zeolites. Representative of whole core	Red-grey		
30 (10')		Red grey-green poorly sorted lapilli tuff extensively altered. The rock is composed of green and red amygdaloidal fragments spotted with golden-brown ferruginous pseudomorphs. Green and white secondary minerals are concentrated into veins and pockets	Green-grey		
		Green-grey intermediate-basic volcanic flow or ignimbrite, veined by considerable secondary zeolitic and chloritic minerals. Clusters of pseudomorphed euhedral mafic phenocrysts are set in a fine grained groundmass of feldspars and small mafic crystals	Green-grey		
31 (4')		Extensively altered green-grey, poorly sorted lapilli tuff composed of ferruginous flow fragments with veins and pockets of secondary minerals	Green-grey		
32 (10')		Compact fine grained, intermediate to basic flow or crystal tuff. Dark green nodules surrounded by reaction rims and showing a vague preferred orientation suggest it is a flow. The rock shows relatively little alteration. Representative of whole core	Green-grey		
33 (7'9")		Light green fine grained compact rock spotted with pink-brown mafic pseudomorphs and pockets of green and white secondary minerals. Light grey-green compact rock spotted with maroon fragments. It is extensively altered, with veins and pockets of secondary minerals. Bedding of green and maroon material implies the rock is a tuff	Light-green		
		Fine grained light green material with nodules showing a preferred orientation and vague reaction rims. Lapilli tuff	Light green		

DETAILED DESCRIPTION

DEPTH OF SAMPLE SECTIONED, (After Pettijohn.....1957)	SPECIFIC ROCK NAME
8009' 10"	Altered basic or intermediate lapilli tuff extensively replaced by chlorite, iron oxide, and zeolite probably laumontite and leonhardite
8937' 0"	Altered basic or intermediate tuff extensively replaced by chlorite, zeolite, epidote and iron oxide
9407' 8"	Altered basic flow extensively replaced by chlorite and zeolites

POROSITY (% where measured): SLIGHT <2%; POOR 2-5%; MOD 12-20%; GOOD 20-37%

PERMEABILITY Millidarcys: VERTICAL; HORIZONTAL

ROUNDNESS: POOR; MOD; GOOD

SORTING: CLAY - SILT; VERY FINE; FINE; MEDIUM; COARSE; VERY COARSE; PEBBLES

GRAIN - SIZE (Wentworth Scale) Estim. size Range & Mode — SANDS

THIN - SECTION ANALYSIS

% OF ESSENTIAL COMPONENTS — POROSITY SHOWN AS BLANK — 0 10 20 30 40 50 60 70 80 100

Matrix and/or Cement Estim. % of Total Rock: CLAY-UNDIFF; KAOLIN Gp.

Cement Symbols See Legend

ACCESSORY MINERALS Estim. R-C-A or Measured % Total Rock: TOTAL "DARK"; "Dark Minerals" 1 2 3 4 5 6 7; "Light Mnrl." 1 2 3 4 5; Opl+Chalc; Felds+Lith

MATURITY INDEX

NOTES (provenance, environment of deposition, diagenesis, palaeontology etc.)

To accompany B.M.R. Record 1969/14