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DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1968/31

PETROLOGICAL STUDY OF STOCKYARD MOUNTAIN (FARMOUT) No. 1 WELL, SYDNEY BASIN, NEW SOUTH WALES

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ABSTRACT

This petrological study of Stockyard Mountain (Farmout) No. 1 was undertaken as part of the major review of the Sydney Basin, currently being carried out by the Basin Study Group of the Petroleum Exploration Branch. The principal objective was to establish and define clearly recognisable rock units and to reassess the petroleum possibilities of the section.

Thirteen lithologic units were recognised in Stockyard Mountain (Farmout) No. 1 and are set out in summary form in Fig. 1. The section commences at the surface in Gerringong Volcanics, penetrates 3255' of mostly marine Permian rocks and terminates at 3516' in probable continental sediments which are regarded as non-prospective. These thirteen units have been grouped into five major lithogenetic units.

It was found that porosity and permeability - and hence reservoir potential - have been severely reduced by diagenesis over most of the section. However unit S7 - equated with part of the Nowra Sandstone - contains porous sandstone beds with up to 16% porosity and 11 millidarcies permeability. Some possible source rocks were encountered in unit S11.

GENERAL INFORMATION

Well Data

Well Name, No.:	Stockyard Mountain (Farmout) No. 1 Well.
Operating Co.:	Farmout Drillers No Liability.
Location:	Lat. & Long.: 34°35'42"S, 150°46'53"E 1:250,000 sheet: Wollongong, SI 56-9. General Location: about 10½ miles S.W. of Port Kembla, N.S.W.
Elevation:	Kelly Bushing: 174.3' - datum for well Ground Level: 162.8'.
Total Depth:	Schlumberger: 3516' Driller: 3516'
Logs Run:	Electric Logs: Run 1 - 100-970' Run 2 - 970-2081' Run 3 - 2081-3515' Microlog Caliper: Run 1 - 100-969' Run 2 - 969-2079' Run 3 - 2079-3513'
Formation Testing:	D.S.T. No. 1: 1614-1681' Recovered trace of mud D.S.T. No. 2: 1877-2000' Recovered 3' mud D.S.T. No. 3: 1890-2110' Misrun (packer seat failed) D.S.T. No. 4: 1859-2110' Recovered 560' fresh water.
Hydrocarbon shows:	Very small amounts of gas detected in drilling mud at: 1890-2000' 2000-2010' 2090-2110' and 2600-3180'

Major Reference used in Present Study

Farmout Drillers N.L., 1963 - Stockyard Mountain Well No. 1, N.S.W., Well Completion Report (unpubl.)

Summary of Major Reference

"The drilling operation was carried out from 30th July to 12th October, 1962, to the total depth of 3516 feet. The well passed through rocks of the Permian Shoalhaven Group (Upper Marine Series) to 3297 feet and then non-prospective basement rocks of Devonian age to final depth".

".... The following geological information was obtained from the Stockyard Mountain Well:-

(a) Gerringong volcanics are present only to a depth of 45' and the expected Blowhole Basalt was absent.

(b) A basalt flow occurs in the Berry Shales between 970' and 1250'.

(c) The Nowra Sandstone is porous in subsurface and contains fresh water.

(d) The Conjola is present in the subsurface and a basal conglomerate lies between it and the Devonian.

(e) The "Lower Marine" section is absent, and the "Upper Marine" thickens somewhat from outcrop.

(f) The top of the Devonian is now known to be at 3297' and to dip at relatively shallow angles."

Material Available for Study

Cuttings: 0-3516' (total depth) at 10' intervals. Over cored sections they are available at 5' intervals.

Cores: Samples consisting of about 8" every 2' are available from all 14 cores.

Electric Logs: See well data.

Methods Used

All cuttings samples were examined using a low power binocular microscope, and thin sections were made from selected intervals and examined under a petrologic microscope. The results were entered on cards and subsequently plotted on composite well log sheets at a scale of 1" : 100'. (Plates 1A, 1B). The cores were slabbed and examined under the binocular microscope. Thin sections were examined from each core and the results plotted on core log sheets at a scale of 1" : 2' (Plates 2A, 2B and 2C).

Thirteen units were selected on all aspects of lithology and wire line log characteristics and numbered from the surface. The unit numbers were prefixed by the letter 'S', which is the code letter chosen for this well. These units have been grouped into five major units on lithogenetic grounds. The various units are 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 include those quartz-rich rocks (75% quartz) in which detrital matrix is prominent (15%). "Quartz greywacke" is the term used for rocks in this category.

GEOLOGY

UNIT S1

This unit extends from the surface to 45' and consists of weathered, porphyritic basalt. Its lower boundary is represented by a marked lithological change from volcanics above to grey, sandy shale below. No wire line logs were run over the interval 0-100'.

The Company, in its Well Report, has interpreted this section as belonging to the Gerringong Volcanics which crop out in the immediate vicinity of the well. Fig. 2 gives a comparison of the units picked in this study with formations - established elsewhere from outcrop - shown in the Well Report (Farmout Drillers N.L. 1963).

UNITS S2-5

This sequence is 1565' thick extending from 45' to 1610'; it consists of grey shale, mudstone and siltstone with some protoquartzite beds, and 280' of basaltic rock. The sediments were deposited in a marine environment and have been equated with the Permian Berry Shale by the Company.

Unit S2 (Plates 1A, 2A)

Characteristics: This unit is 795' thick, extending from 45' to 840'; it consists of grey shale with siltstone increasing in the lower part of the unit. Quartz sand and pyrite are scattered throughout these lithologies, and each lithology is gradational with the next. Cores from the unit show lamination, micro-crossbedding and scallop structures. Marine fossils, which occur throughout the unit, include brachiopod shells and spines, fenestellid bryozoa and rare foraminifera. Some plant fragments occur near the top of the unit.

All the electric logs show little variation throughout the unit, and in fact the lack of significant variation in any of the logs characterises this unit. The microlog, which is not shown on the well log, fluctuates about a mean of 50 ohms - m^2/m and has negative separation.

Boundary criteria: The lower boundary is marked by the change from S2 mudstone above, to silicified fine to medium grained protoquartzite of S3 below. This lithological change is accompanied by an increase in the 18'8" resistivity curve reading, from about 90 to 360 ohms - m^2/m. The microlog shows an increase both in the mean reading and in the amount of fluctuation.

Environment and provenance: The sedimentary structures observed, such as lamination and micro-crossbedding, together with the presence of rare marine fossils, indicate that deposition took place in marine waters subject to gentle current action. The origin of the scallop structures is difficult to determine but it is suggested here (Plate 2A) that they are distorted ripple-drift markings as described by Coleman and Gagliano (1965); these authors attribute the structures to "overturning of the foreset laminations of a current ripple," and state that they are produced by the drag of sediment-laden bottom currents. These features are common in several of the environments studied in the Mississippi Delta. No specific indicators of provenance were found in this unit.

Unit S3 (Plates 1A, 2A)

Characteristics: This unit is 130' thick, extending from 840' to 970'; it consists of silicified and calcareous protoquartzite containing interbedded sandy mudstone. The protoquartzite is generally silty, poorly sorted and pyritic; marine fossils are common. The sand/shale ratio is about 9.0 in the middle of the unit and about 0.5 to 1.0 at the top and bottom.

Porosity of the unit is slight (6%) which is partly due to secondary silica and carbonate cement. However, original porosity was probably low (6-12%) because of the poor sorting and siltiness of the sediments.

The 18'8" resistivity curve shows moderate values (150 to 450 ohms - m^2/m.) whereas the microlog fluctuates rapidly and shows some negative separation - suggestive of hard bands with intercalated shaly bands. The other logs lack any real character.

Boundary criteria: The lower boundary of S3 is marked by a lithological change from shale and sandstone to underlying basalt. This is accompanied by a sharp increase in the resistivity readings, and the microlog shows rapidly fluctuating full scale deflections, with virtually no separation. The S.P. curve shows no significant change.

Environment and provenance: The unit was apparently dumped in quiet or deep marine water as indicated by the poor sorting and poor bedding and presence of brachiopods. A dominantly sedimentary provenance is envisaged as fine-grained sedimentary lithics are common; however, the presence of zircon, tourmaline, biotite and plagioclase suggests some granitic or metamorphic source.

Unit S4 (Plates 1A, 2A)

Characteristics: This unit is 280' thick, extending from 970' to 1250'; it consists entirely of dark, olive-black, porphyritic basalt. It is characterised on the 16" normal log by having moderate to high values and on the 18'8" resistivity log by extreme (off-scale) values. This unit is the only section in the well having consistent phosphate readings higher than "trace".

Boundary criteria: The lower boundary is marked by a change from basalt of S4 to shale below, with a corresponding decrease in resistivity from extreme to moderate.

Origin: A volcanic origin has been proposed for this unit because of the very fine grain size and the lack of any evidence of metamorphism of the adjacent sediments. If the unit is intrusive, the Permian age attributed to it on the logs may be incorrect.

Unit S5 (Plates 1A, 2A)

Characteristics: This unit is 360' thick extending from 1250' to 1610'; it consists of interbedded sandy mudstone, shale and fine to medium-grained protoquartzite, with scattered pebbles. The mudstone and shale are carbonaceous at the top of the unit, contain pyrite throughout and are generally sandy; the protoquartzite is dolomitic, silty and contains

sedimentary lithics. Sedimentary structures observed in Core 5 include lamination, scallop structures, churned bedding, and burrow structures; some (?)marine shell fragments were noted. The sand/shale ratio for the unit, taken from cuttings percentages, is about 0.3. The original porosity of the sandy section was probably slight to low due to the presence of clay and silt matrix and has been further reduced by precipitation of carbonate.

The 18'8" resistivity curve registers a gradual increase from the top of the unit (90 ohms - m^2/m) towards the base (450 ohms - m^2/m). The microlog shows two moderate readings with positive separation at 1400' to 1415' and 1450' to 1460' but the other logs are almost featureless.

Boundary Criteria: At the lower boundary of S5 (1610') there is a change from the sandy shale and fine to medium grained silty sandstone above to clean, medium quartz sandstone below. The porosity increases somewhat from slight to low. The S.P. log moves distinctly away from the shale base line below this depth. Resistivity values continue the gradual increase downwards, but the microlog shows a sudden decrease from 75 down to only 10 ohms - m^2/m, and begins to exhibit positive separation.

The boundary also represents a major break between the thick sequence of shales, mudstones and siltstones with minor sandstone and basaltic rock, designated as UNITS S2-5, with the underlying, predominantly sandy sediments of UNITS S6-8.

Environment and Provenance: Poor sorting, abundance of silt and clay, presence of (?) marine fossils and lamination, churning and burrowing of the sediment suggest deposition in quiet, shallow marine waters. The scallop structures (also found in unit S2) may indicate the presence of intermittent, sediment-laden bottom currents. Sedimentary lithics, plagioclase and K-feldspar are present and suggest that the sediments were derived from a mixed sedimentary and granitic source.

UNITS S6-8

This sequence is 610' thick and extends from 1610' to 2220'. It consists almost entirely of quartz-rich sandstone, and contains porous horizons, pebble beds and minor shale beds; it is commonly silicified. Volcanics, which appear in the cuttings, have apparently caved from higher in the well as there is no other evidence to suggest that volcanics occur in this interval. The sediments were deposited in agitated, marine water, and have been equated with the Nowra Sandstone and the upper part of the Wandrawandian Siltstone by Hare et. al (1963) - See Fig. 2.

Unit S6 (Plates 1A, 1B, 2B)

Characteristics: This unit is 260' thick and extends from 1610' to 1870'; it consists of protoquartzite, with common shale incursions from 1710' to 1810'. The protoquartzite is clean, contains minor chert, K-feldspar and sedimentary lithics, and is mostly silicified. Sand/shale ratios of about 7 are common for the unit. Porosities although thought to have been moderate to high originally, have been severely reduced to less than 12% by the development of secondary silica.

The S.P. log remains monotonous and positive, although a few millivolts higher than the overlying unit. The resistivity values continue the gradual increase noted in Unit S5 and the 18'8" curve goes off scale at 1750'. The microlog registers moderate values, and positive separation from 1610' to 1720'; but below that the microlog increases in value, fluctuates rapidly, and exhibits negligible separation.

Boundary Criteria: The lower boundary of this unit is recorded most distinctly by the electric logs. This change is accompanied by a reduction in silicification and an increase in the number of pebbles, while there is a corresponding increase in porosity from slight to moderate. The S.P. log shifts distinctly to the left and reads zero millivolts. The 16" normal drops from 180 to below 90 ohms - m^2/m and the 18'8" moves back sharply to 300 ohms - m^2/m from off scale. The microlog decreases from 65 to 5 ohms - m^2/m and begins to display positive separation.

Environment and Provenance: There is no evidence of a marine environment for this unit except its lithological similarity to the underlying unit S7, which contains marine fossils. Deposition apparently took place in agitated water as the sandstone is well sorted and bedding thickness is greater than 5cm. The sandy shale intercalations suggest intermittent low energy conditions. The presence of chert, sedimentary lithics and plagioclase indicates a sedimentary provenance, possibly with some igneous rock source.

Unit S7 (Plates 1B, 2B)

Characteristics: This unit is 240' thick and extends from 1870' to 2110'. It is a pebbly protoquartzite containing numerous thin porous horizons and is cemented in part by siderite and dolomite. The lack of quartz overgrowths and general silicification - in contrast to the overlying unit - appears to have been due to the presence of white clay coatings on the quartz grains. These uncemented beds have porosities from 12-20%, and horizontal and vertical permeabilities of 6 and 11 millidarcies respectively; they are saturated with fresh water. A high sand/shale ratio of about 15 was recorded for unit S7.

The S.P. log records around zero millivolts with minor fluctuations; the 16" normal fluctuates between 70 and 160 ohms - m^2/m and the fluctuations are accentuated on the 18'8" curve which drops to about 100 to 200 ohms - m^2/m opposite porous beds, but gives higher readings opposite cemented horizons. The microlog gives low readings over most of the unit; numerous readings of between 5 and 15 ohms - m^2/m show positive separation and define porous beds.

Boundary criteria: At the lower boundary - between S7 and S8 - there is a return to conditions observed in the overlying unit S6. The protoquartzite becomes silty and silicified, and the porosity changes from moderate back to slight. The S.P. shows very little shift but the resistivity increases slightly; the microlog reading increases from about 15 to 60 ohms - m^2/m and begins to fluctuate rapidly.

Environment and provenance: The abundance of rounded pebbles, lack of fine detritus and presence of marine fossils indicate that unit S7 was deposited in agitated, marine water. The burrow structures and carbonaceous stringers provide supporting evidence for shallow, near-shore deposition. Pebbles of quartz, chert, shale, phyllite and granite suggest a diverse provenance for this unit.

Unit S8 (Plates 1B, 2B)

Characteristics: This unit occurs over a thickness of 110' and extends from 2110' to 2220'; it consists of silicified protoquartzite grading downwards to quartz greywacke at the base, and containing interbeds of shale and siltstone. Lithologically, it resembles unit S6. Core 8 appears to be representative of only the lower 20 feet of unit S8; here clay-silt matrix is abundant, and the sediment contains mudstone laminae and large shell fragments. The sand/shale ratio is about 12 over most of the unit, decreasing to 7 at the base; porosity is slight. Volcanics still persist in the cuttings but are regarded as cavings.

The S.P. log reads about the same as the overlying unit; the 16" normal curve reads between 120 and 170 ohms - m^2/m. decreasing downwards and reflecting the higher clay-silt content towards the base. The 18'8" fluctuates between 250 and 500 ohms - m^2/m and appears to delineate hard cemented sandstone (high readings) and shaly or silty beds (lower readings). The microlog fluctuates rapidly between 10 and 80 ohms - m^2/m.

Boundary criteria: At 2220' the lower boundary of unit S8 is marked by a lithology change from silty sandstone above to grey shale below. There is little change in the S.P.; the 16" normal curve drops from 120 to 90 ohms - m^2/m and the 18'8" resistivity curve drops sharply from 410 to 210 ohms - m^2/m. Over a 5' interval the microlog decreases from 75 to 5 ohms - m^2/m.

This boundary also marks the base of UNITS S6-8 and separates this sequence of quartz sandstones and minor shales from the underlying UNITS S9-12 characterised by interbedded shales, siltstones, sandstones and volcanics.

Environment and provenance: The unit S8 was deposited in intermittently quiet and agitated marine waters. This is indicated by the presence of clean, well-sorted sandstone with shaly and silty interbeds, containing marine fossils and exhibiting laminations. The unit appears to have been derived from sedimentary and granitic rocks, as sedimentary lithics are common and plagioclase, K-feldspar and biotite are present.

UNITS S9-12

This sequence occurs over 1080', from 2220' to 3300'; it consists of interbedded shales, siltstones, sandstones and volcanics with minor limestone; 50' of conglomerate occur at the base. The sediments are included in the "Conjola Beds" and the lower two thirds of the Wandrawandian Siltstone in the Company's Well Report.

Unit S9 (Plates 1B, 2B)

Characteristics: Unit S9 is 290' thick, extending from 2220' to 2510'. It consists of shale, siltstone and sandy siltstone with beds of fine and medium to coarse-grained protoquartzite. A thin sandy limestone bed containing abundant spines, bryozoans and shelly debris occurs between 2370' and 2400'. The sand/shale ratio from cuttings percentages is 1.5.

The S.P. log for unit S9 shows more character than in the higher units. Down to 2380' it has a positive reading of about 5 millivolts except from 2310' to 2340' where it increases to -10 millivolts opposite a protoquartzite bed. From 2380' to 2500' the curve reads 20 millivolts - except from 2400' to 2420' where another sandstone is encountered and the S.P. reading increases accordingly. The 16" normal curve reads fairly low throughout (between 80 and 140 ohms - m^2/m) except for the interval 2370' to 2400' where a limestone is encountered and the resistivity increases to 200 ohms - m^2/m. The 18'8" curve behaves in a similar manner but shows an even more marked increase at this interval. The microlog reveals some porosity between 2310' and 2330' and possibly some porosity at 2400' to 2420'. In other parts of unit S9, porosity has been severely reduced by siderite, dolomite and calcite cement and diagenetic quartz.

Boundary criteria: At the lower boundary of S9 there is a lithological change from thinly interbedded siltstone, shale and fine sandstone to underlying medium-grained sandstone. The S.P. curve increases gradually by about 10 m.v. over an interval of 20 feet, but at 2510' the 16" normal curve increases from 90 to 140 ohms - m^2/m; the 18'8" curve also shows an increase at that depth. The microlog decreases from 70 to 10 ohms - m^2/m.

Environment and Provenance: The abundance of siltstone and shale which is at least in part laminated and cross-bedded, suggests quiet waters with gentle currents operating; while the presence of plant fossils in shale (core 9) indicates a fresh water or near-shore environment. The intervening clean sandstone beds are indicative of intermittent agitated water conditions. The limestone interval contains marine fossils. A near-shore marine environment is envisaged for the whole unit S9.

The sediments have been derived at least in part from a sedimentary source- indicated by the presence of shale and siltstone lithics.

Unit S10 (Plates 1B, 2B)

Characteristics: The unit is 450' thick and extends from 2510' to 2960'; it consists of alternating protoquartzite and dolomitic tuff with one bed of black carbonaceous shale at 2750' to 2770'. The protoquartzite is commonly silty and contains dolomite and pyrite; in places the protoquartzite grades to orthoquartzite but lithics are common especially at the base of the unit. Dolomite veining is present throughout most of the section.

The dolomitic tuff has been highly altered and is difficult to identify but it contains rare subangular grains now composed of cryptocrystalline silica, and carbonate pseudomorphs of euhedral (?) feldspar and (?)mafic minerals. These are embedded in a fine groundmass of carbonates (calcite, dolomite, ankerite and siderite), finely divided silica and clay minerals. Kaolinite and a mixed layer clay were identified with X-ray diffraction by the N.S.W. Department of Mines (Farmout Drillers N.L. 1963). A sand/shale ratio of 4 was recorded for Unit S10.

The S.P. curve has an undulatory character, showing contrasts of up to 20 millivolts over the interval. Minor peaks exist opposite some sandy beds but generally the various lithologies are not distinguished by the S.P. The 16" normal gives a characteristic smooth curve reading 50 - 90 ohms - m^2/m opposite the tuff beds, and in general slightly higher readings opposite sandstone beds. A similar trend is seen in the 18'8" resistivity curve but some anomalies are also present; the high resistivity from 2715' to 2750' cannot be explained. The microlog indicates some low porosity at the top of the unit but extensive caving has seriously affected the microlog.

Boundary criteria: The lower boundary of S10 at 2960' is marked by the change from protoquartzite to underlying shale and subgreywacke. The increase in lithic content downwards is gradational but the sediments below 2960' are markedly more shaly than those of S10; thus the presence of the shale band immediately below 2960' is regarded as significant. The S.P. and 16" normal curves show no appreciable change at the boundary, but the 18'8" curve decreases from 280 to 150 ohms - m^2/m over a 20 foot interval.

Environment and Provenance: No cores of the sediments are available from this unit and no fossils have been recorded. However the range in grain size and sorting of the sediments suggests deposition in quiet and agitated water, with periodic volcanic activity.

Unit S11 (Plates 1B, 2C)

Characteristics: This unit is 295' thick and extends from 2960' to 3255'; it consists of subgreywacke, carbonaceous shale and a thin horizon of dolomitised tuff. The subgreywacke contains abundant sedimentary lithics - about 15-40% of the framework - and up to 10% feldspar. The subgreywacke is generally well sorted, commonly carbonaceous, and cemented with dolomite. Carbonaceous shale is abundant between 3040' and 3170' and is associated with very minor amounts of coal. The dark shales represent possible source rocks but they are thin and probably of little importance. The sand/shale ratio is 1.9 for the unit.

The S.P. log records low values and little variation over this interval. The 16" normal readings are close to 90 ohms - m^2/m, but fall to 50 ohms - m^2/m opposite the carbonaceous shale. The 18'8" curve also records low readings: 200 ohms - m^2/m opposite the lithic sandstones, and between 70 and 150 ohms - m^2/m opposite the shales. The microlog shows positive separation over the 3050' to 3070' and 3080' to 3090' intervals but this may be caused partly by cavings. The remainder of the curve registers low values, and negative separation.

Boundary criteria: The lower boundary of unit S11 is placed at 3255', where the lithology changes from subgreywacke to underlying petromict conglomerate. At this depth the 16" normal curve begins to increase from 70 ohms - m^2/m until it reaches 120 ohms - m^2/m at 35 feet below the boundary. The 18'8" curve behaves in the same manner, increasing from 120 to 270 ohms - m^2/m. The microlog increases from 10 to 50 ohms - m^2/m, but fluctuates markedly and shows negative separation.

Environment and Provenance: The preservation of coal and carbonaceous material implies that deposition took place in a restricted environment. The presence of interbedded shales and well sorted sandstones suggests alternating quiet and agitated conditions. Steep cross-bedding in Core 11 provides evidence of strong currents. No fossils were found in this unit. A local sedimentary provenance is envisaged because of the abundance of sedimentary lithic grains. The common presence of plagioclase suggests some igneous rock influence.

Unit S12 (Plates 1B, 2C)

Characteristics: Unit S12 is only 45' thick, extending from 3255' to 3300'. It consists entirely of conglomerate. Core 12 appears typical of the unit and consists of pebbles and cobbles of sedimentary, volcanic, granitic and metamorphic rocks, embedded in a coarse-grained dolomitic sandstone matrix. Original porosity was probably moderate to high but has been reduced to slight - a maximum of 5% - by dolomite and siderite cementation.

The S.P. log reads a steady 20 millivolts over the interval; the 16" normal resistivity reads about 120 ohms - m^2/m, but decreases to 90 ohms - m^2/m or less at the upper and lower boundaries of the unit. The microlog fluctuates markedly about a mean of 35 ohms - m^2/m, and shows no separation.

Boundary criteria: The lower boundary of unit S12, placed at 3300', is marked by a lithological change from conglomerate to an underlying fine to medium grained lithic sandstone, containing minor shale beds.

At the boundary, the S.P. log shows a slight kick to the left, and the 16" normal resistivity a small drop. The only change that is likely to be significant is the increased resistivity shown in the 18'8" curve. Generally the electric logs are of little help in picking this boundary.

This is regarded as a major boundary marking the beginning of a new cycle of deposition - referred to earlier as UNITS S9-12; this commences with a conglomerate phase (unit S12). The underlying sediments apparently belong to a continental facies and are characterised by the presence of red beds.

Environment and Provenance: This conglomeratic unit is a well washed sediment and has been deposited in strongly agitated or rapidly flowing water. The components have been derived from sedimentary, volcanic, granitic and metamorphic rocks.

UNIT S13: (Plates 1B, 2C)

This major unit has a thickness of 216+', extending from 3300' to total depth of 3516'; it consists of flat-bedded lithic sandstone, shale and siltstones, and commonly shows red coloration. These sediments are regarded as economic basement of (?)Devonian age by Farmout Drillers N.L. (1963).

Characteristics: The lithic sandstone is mostly fine to medium grained, and grades from dolomitic subgreywacke at the top to silicified and dolomitic protoquartzite with scattered pebbles and minor siltstone towards the base. The sandstone is white, pale grey, pink or pale green; in Core 13 the sandstone shows grain size layering, and low angle cross-bedding. A variety of shales occur, ranging in colour from grey, green, pink to red-brown; a clay-shale occurs from 3365' to 3410', and a silt-shale and siltstone from 3470' to 3516' (T.D.). Core 14 - the bottom core - intersects the lowermost shales, and shows lamination, graded beds and minor pebbly mudstone. The sand/shale ratio is 1.1 for UNIT S13.

The S.P. log reads low (20-30 m.v.) and shows little character; the 16" normal reads between 60 and 120 ohms - m^2/m, again with little character. The 18'8" resistivity curve registers moderate values (190-290 ohms - m^2/m) down to 3365' and then decreases to 90 to 160 ohms - m^2/m between 3380' and total depth. Generally, the sandstones and shales of this unit are not clearly differentiated by the electric logs.

Environment, Provenance and Age: The most striking feature of unit S13 is the red colour of the sediments. This, together with the fact that no fossils were found in the unit, suggests deposition in an oxidising environment - probably continental; this is in contrast to the greyish sediments of the overlying, predominantly marine succession, which contain no red beds but where abundant organic matter is preserved, and pyrite is common.

The good sorting, low angle cross-bedding, and grain-size layering of the sandstones indicates the presence of fluctuating currents at the time of deposition. On the other hand, lamination and graded bedding in the red shales and siltstones indicates that deposition took place in still water at some times. Channel and overbank deposits on a flood plain would be compatible with these features.

A sedimentary and granitic provenance is suggested by the presence of chert, shale lithics, and K-feldspar and plagioclase. The occurrence of rare volcanic lithics indicates some volcanic influence.

The age of unit S13 is not known. Farmout Drillers N.L. (1963) proposed a Devonian age at the suggestion of the New South Wales Mines Department. This was probably based on field evidence and is supported by the red coloration which is typical of Devonian sediments in this basin and other areas of the world. However in the Stockyard Mountain Well there is no structural discordance between S13 and overlying Permian units. Furthermore, no deformation or alteration of S13 sediments has occurred as is usual for Devonian basement sediments of the Sydney Basin, and no significant change in provenance can be detected between this unit and the immediately overlying Permian units.

This evidence suggests that the time break between unit S13 and the overlying conglomerate S12 may be much smaller than inferred by the company.

CONCLUSIONS

Degree of agreement with Well Completion Report.

Figure 2 gives a comparison between unit boundaries chosen in this study and the stratigraphic subdivisions set out in the Well Completion Report (Farmout Drillers N.L. 1963). Some of the boundaries closely match the formation picks of the Company but the major units defined in the present study commonly differ. The two major differences are discussed below:-

Boundary between units S8 and S9: This major boundary was chosen between the dominantly sandstone sequence of UNITS S6-8 and the underlying interbedded shales, siltstones, sandstones and volcanics. The Company has picked the boundary between the Nowra Sandstone and Wandrawandian Siltstone at 2065' near the base of the porous sandstone - here designated as unit S7. However, it was found that the sediments of S6 and S8 are almost identical and that S7 represents a porous interval within a tight sandstone sequence. Consequently UNITS S6-8 are regarded as a lithogenetic unit.

Subdivision of UNIT S9-12: An obvious disparity between the two interpretations occurs in the upper part of UNITS S9-12. The Company has chosen the major Wandrawandian Siltstone - Conjola Formation boundary at 2549' at the uppermost of a series of volcanics; this boundary falls within unit S10 (Fig. 2). It is accepted that unit S10 is characterised by the presence of a number of volcanic horizons but in the present study, its upper and lower boundaries were picked on the changes in character of the sedimentation.

Other differences in boundary picks between the two studies are relatively minor.

Summary of new data:

The section examined consists of 3300 feet of dominantly marine sediments consisting of 12 lithologic units; this is underlain by a unit made up of probable continental sediments, at least 216 feet thick.

White clay coatings on the sand grains in porous beds of unit S7 apparently played an important part in inhibiting quartz diagenesis, and thus preserving some original porosity. Elsewhere in the section, quartz diagenesis in the form of overgrowths has contributed substantially to the reduction of porosity.

The time break between units S13 and S12 may be quite small; Unit S13 may be younger than Devonian.

Possible influence of new data on hydrocarbon prospects:

The only interval in this well which is of interest to the search for hydrocarbons is unit S7, which contains porous and permeable sandstone beds within a marine succession. The presence of clay coatings on the sand grains appears to be a controlling factor in preserving porosity.

REFERENCES

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FARMOUT DRILLERS N.L. 1963 - Stockyard Mountain Well No. 1, N.S.W. Well Completion Report, March, 1963 (unpubl.)

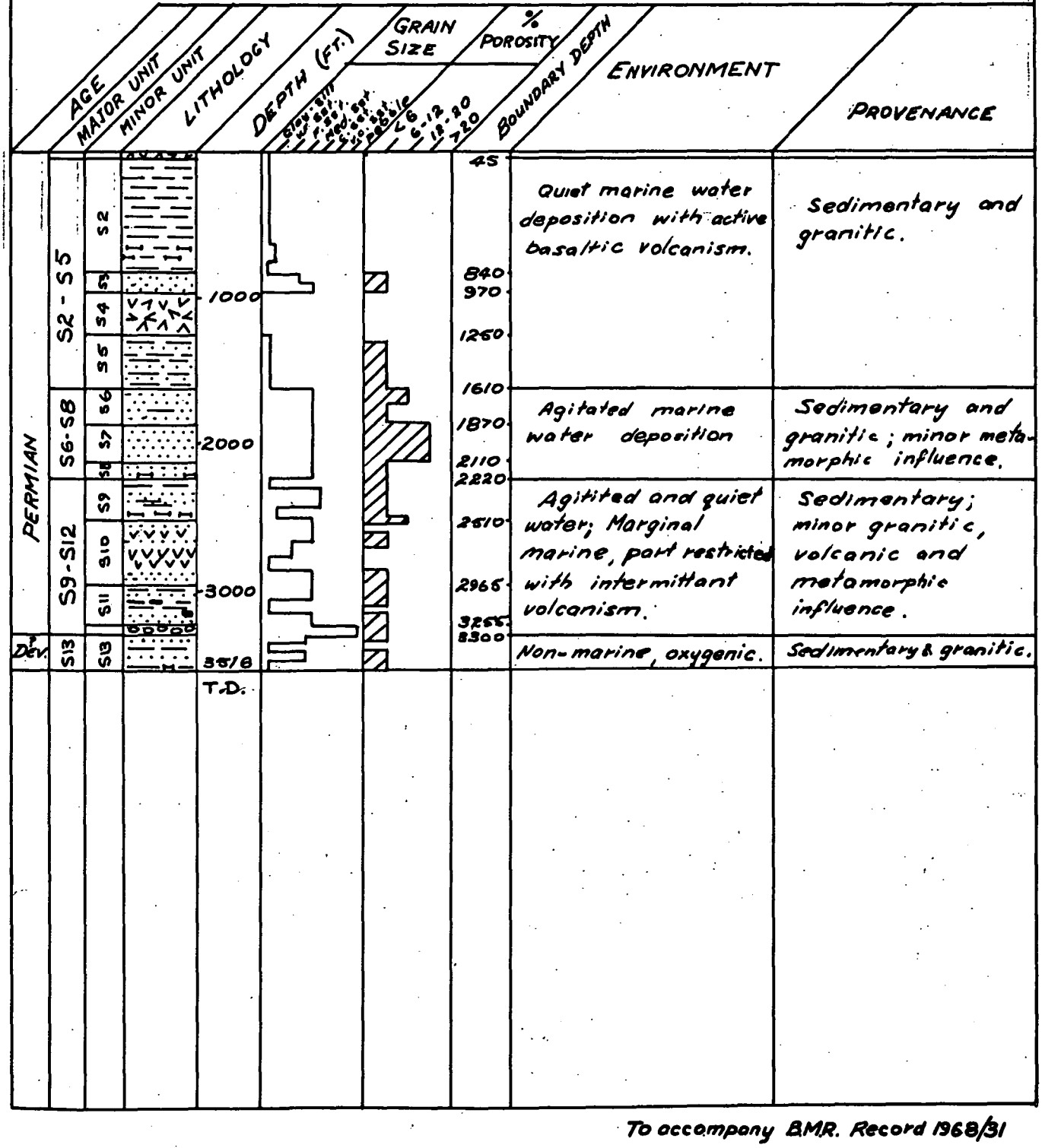
PETTIJOHN, F.J., 1957 - Sedimentary Rocks, New York, Harper.

Fig 1

STOCKYARD MOUNTAIN

(FARMOUT) No.1 WELL

Summary of Petrological Results.



To accompany BMR. Record 1968/31

Fig.2

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

B.M.R. UNITS		BOUNDARY DEPTHS (FT.)	COMPANY (F.D.N.L., 1963)		
MAJOR	MINOR		FORMATION	GROUP	AGE
S1	S1	45	GERRINGONG VOLCANICS	SHOAL-HAVEN GROUP	PERMIAN
S2-S5	S2	840	BERRY SHALES		
	S3	970			
	S4	1250			
	S5	1610			
S6-S8	S6	1870	NOWRA SANDSTONE		
	S7	2110			
	S8	2220			
S9-S12	S9	2510	WANDRAWANDIAN SILTSTONE		
	S10	2960	CONJOLA BEDS		
	S11	3255			
	S12	3300	BASAL CONGLOMERATE		
S13	S13		? DEVONIAN SEDIMENTS		? DEVON.

45 1610 2065 2549 3255 3297

To accompany BMR. Record 1968/31

PETROGRAPHIC WELL LOG

STOCKYARD MOUNTAIN (FARMOUT) No.1

Geology by. P. J. Alcock

Plate 1A

WELL NAME, No: STOCKYARD MT. No 1
OPERATING Co: FARMOUT DRILLERS NL.
WELL LOCATION
Lat: 34° 35' 41" S — Long: 150° 46' 53" E.
Basin: SYDNEY
State: N.S.W.
Tenement No: P.E. 1.63
1:250.000 Sheet No: SI56-9

ELEVATION (A.S.L.)
: Ground Level 162 ft.
: K.B. Datum 174 ft.

SAMPLE STORAGE
: B.M.R., Canberra

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

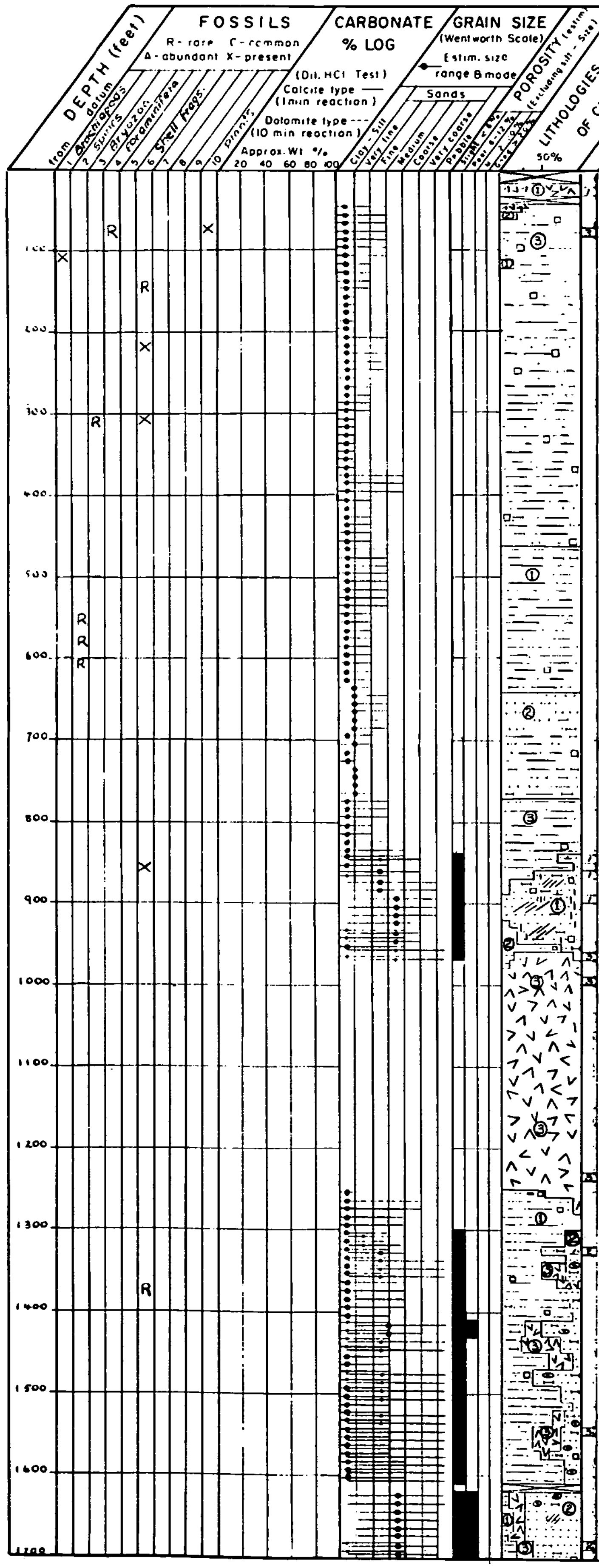
MISCELLANEOUS
- Interval and Number of Formation Test
- No sample available from interval

Scale: 0 – 100 – 200 ft.

LITHOLOGICAL SYMBOLS
- Breccia to conglomerate
- Quartz sand, sandstone
- Siltstone
- Claystone
- Shale and mudstone
- Coal
- Limestone: Calcirudite, Calcarenite, Calcilutite
- Dolomite
- Silica
- Siderite
- Pyrite
- Basalt
- Tuff
- Lithics

MINERAL ABBREVIATIONS

Fd	Feldspar	Chl	Chlorite
Plag	Plagioclase	Fe	Iron oxide
K-Fd	K-Feldspar	Py	Pyrite
Aug	Augite	Si	Silica
Mi	Mica	Sid	Siderite
Ser	Sericite	Ca	Calcite
Gl	Glauconite	Dol	Dolomite



DESCRIPTIONS OF CUTTINGS

(Description ③ refers to lithological pattern ③ at corresponding depth)

① WEATHERED PORPHYRITIC BASALT.

② WELL CEMENT.

③ SHALE: FIRM, GREY: GRADES TO MUDSTONE. CONTAINS COMMON PYRITE & FINE SAND COMPOSED OF QUARTZ WITH MINOR PLAGIOCLASE, MUSCOVITE, CHLORITE AND MICACEOUS LITHICS. BECOMING SILTY TOWARDS BASE.

① MUDSTONE: FIRM, GREY, SLIGHTLY FLAGGY, MICACEOUS. GRADES TO SILTSTONE IN PARTS. APPEARS GRADATIONAL WITH ③ ABOVE.

② SILTSTONE: FIRM, GREY, SLIGHTLY FLAGGY, MICACEOUS. GRADES TO MUDSTONE IN PARTS.

③ MUDSTONE: FIRM, GREY, SLIGHTLY FLAGGY, SLIGHTLY SANDY. GRADES TO SANDY SHALE AT BASE.

① PROTOQUARTZITE: LIGHT-MEDIUM GREY, SILICIFIED, PART CALCAREOUS, PART SILTY, PART PYRITIC. CONTAINS ABUNDANT QUARTZ., COMMON CHERT AND CHLORITIC, SERICITIC AND CALC. LITHICS;

② MUDSTONE: FIRM, GREY, SANDY.

③ VOLCANICS: MOSTLY BASALTIC. PARTLY ALTERED TO DOLOMITE, CALCITE AND SILICA.

① MUDSTONE GRADING TO SHALE: FIRM, GREY, MOSTLY SANDY.

② DOLOMITIC PROTOQUARTZITE: LIGHT GREY. CONTAINS ABUNDANT QUARTZ, COMMON CHERT, SHALE LITHICS, SERICITISED GRAINS AND CARBONACEOUS MATERIAL.

③ VOLCANICS: AS FOR 3 ABOVE

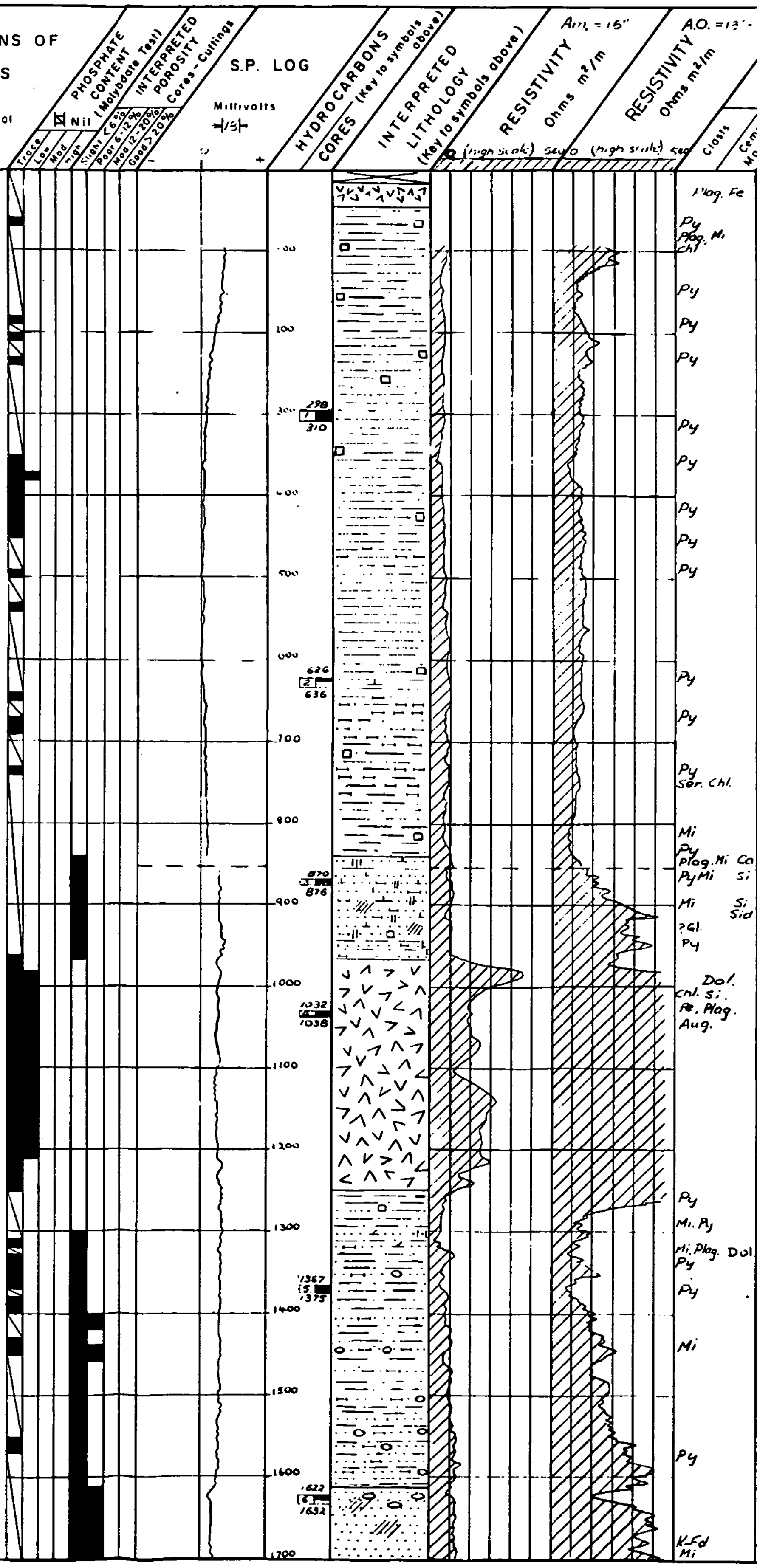
① MUDSTONE GRADING TO SHALE: AS FOR ① ABOVE.

② PROTOQUARTZITE: RESEMBLES 2 ABOVE. PEBBLY IN PART.

③ VOLCANICS: AS FOR 3 ABOVE; MOSTLY BASALT.

① SANDY SHALE.

② PROTOQUARTZITE: WHITE, CLEAN ABUNDANT QUARTZ; MINOR CHERT, K. FELD. AND SEDIMENTARY LITHICS.



DESCRIPTION OF INTERPRETED LITHOLOGY

Formation ← Test Data | Rock Name (after Pettijohn, 1957)

WEATHERED PORPHYRITIC BASALT.

FIRM GREY SHALE GRADING TO MUDSTONE: PART SANDY AND PYRITIC.

CORE 1 SHOWS LAMINATION, MICRO-X-BEDDING AND SCALLOP STRUCTURES; CONTAINS MARINE FOSSILS.

FIRM GREY MUDSTONE: CONTAINS MINOR SILTSTONE AND GRADES TO SILTSTONE AT BASE. CORE 2 IS POORLY BEDDED, CALCAREOUS AND CONTAINS SCALLOP STRUCTURES AND MARINE FOSSILS.

FIRM GREY SILTSTONE: SLIGHTLY FLAGGY, GRADING TO MUDSTONE IN PARTS.

FIRM GREY MUDSTONE: SLIGHTLY FLAGGY AND SANDY. GRADES TO SANDY SHALE AT BASE.

CALCAREOUS AND SILICEOUS PROTOQUARTZITE: CONTAINING MINOR INTERCALATIONS OF SANDY MUDSTONE. CORE 3 IS POORLY BEDDED, POORLY SORTED AND CONTAINS MARINE FOSSILS.

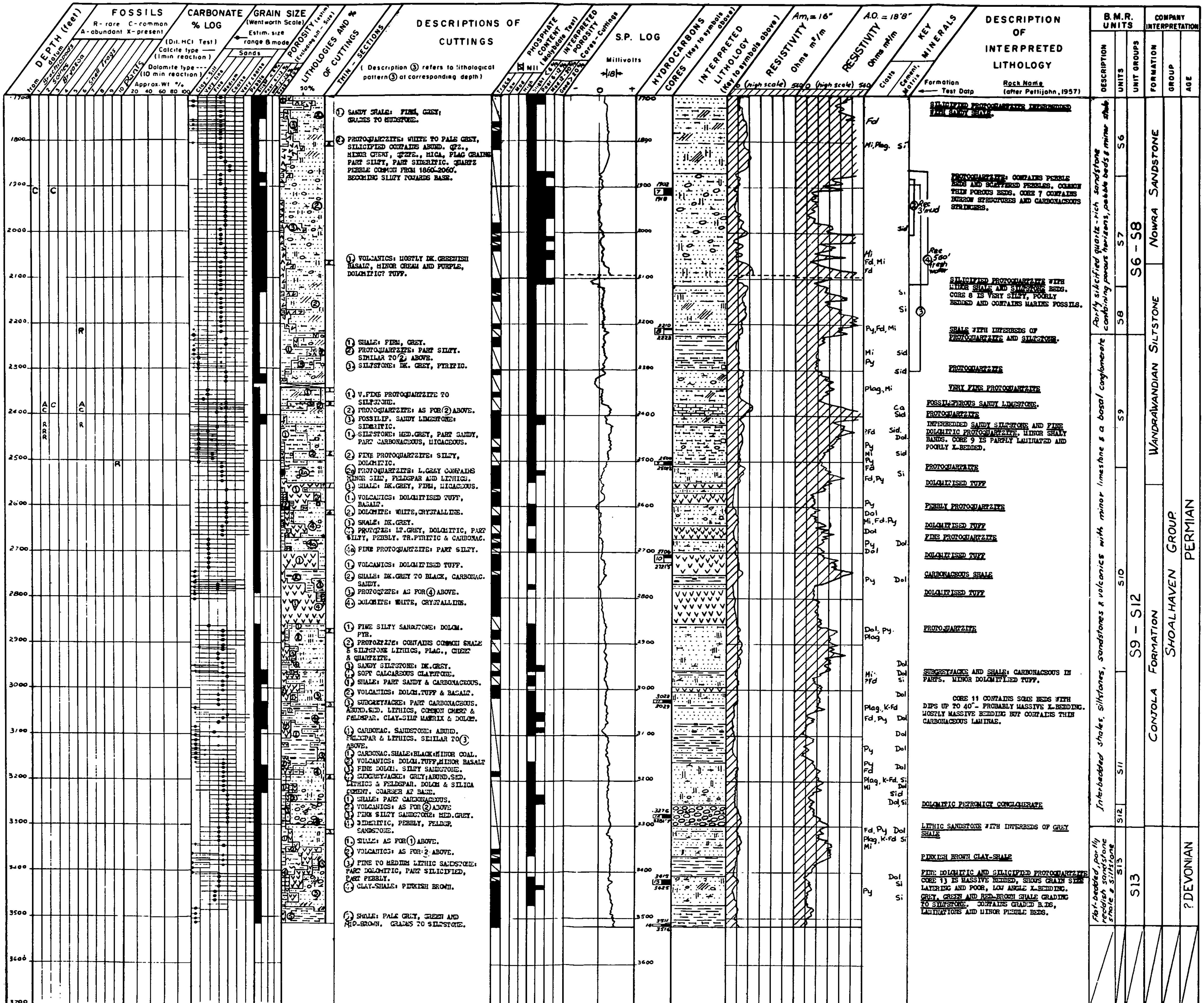
BASALTIC VOLCANICS: CORE 4 IS A PORPHYRITIC BASALT COMPOSED OF LABRADORITE MICROLITES AND PHENOCRYSTS, WITH SUBORDINATE AUGITE, BIOTITE, MAGNETITE AND CHLORITE. THE CORE IS TYPICAL OF THIS UNIT.

INTERBEDDED SANDY MUDSTONE, SHALE AND PROTOQUARTZITE: CONTAINS SCATTERED PEBBLES. CORE 5 SHOWS LAMINATIONS, SCALLOP STRUCTURES, CHURNED BEDDING AND BURROW STRUCTURES AND CONTAINS MARINE FOSSILS.

① Rec. fr. mud — SILICIFIED PROTOQUARTZITE PEBBLY IN PART. CORE 6 IS A MASSIVE CLEAN SANDSTONE.

B.M.R. UNITS / COMPANY INTERPRETATION

DESCRIPTION	UNITS	UNIT GROUPS	FORMATION	GROUP	AGE
	S1	S1	GERRINGONG VOLCANICS		
Grey, partly sandy shale, mudstone & siltstone; silicified, calcareous & dolomitic protoquartzite, and a thick basaltic rock	S2, S3, S4, S5	S2 – S5	BERRY SHALE	SHOALHAVEN GROUP	PERMIAN
	S6	S6 – S8			


DEPTH (feet) from datum
FOSSILS
R - rare C - common A - abundant X - present
Brachiopods
Corals
Bryozoa
Snail frags
Plants
CARBONATE % LOG
(Dil. HCl Test)
Calcite type (1 min reaction)
Dolomite type (10 min reaction)
Approx. Wt %
20 40 60 80 100
GRAIN SIZE (Wentworth Scale)
Estim. size range & mode
Sands
POROSITY (estim.) (Excluding silt - Size)
LITHOLOGIES AND % OF CUTTINGS
50%
THIN - SECTIONS
DESCRIPTIONS OF CUTTINGS
(Description ③ refers to lithological pattern ③ at corresponding depth)
① SANDY SHALE: FIRM, GREY; GRADES TO MUDSTONE.
② PROTOQUARTZITE: WHITE TO PALE GREY, SILICIFIED CONTAINS ABUND. QTZ., MINOR CHERT, QTZTE., MICA, PLAG GRAINS PART SILTY, PART SIDERITIC. QUARTZ PEBBLE COMMON FROM 1860-2060'. BECOMING SILTY TOWARDS BASE.
③ VOLCANICS: MOSTLY DK. GREENISH BASALT, MINOR CREAM AND PURPLE, DOLOMITIC? TUFF.
① SHALE: FIRM, GREY.
② PROTOQUARTZITE: PART SILTY. SIMILAR TO ② ABOVE.
③ SILTSTONE: DK. GREY, PYRITIC.
① V.FINE PROTOQUARTZITE TO SILTSTONE.
② PROTOQUARTZITE: AS FOR ② ABOVE.
③ FOSSILIF. SANDY LIMESTONE: SIDERITIC.
① SILTSTONE: MED.GREY, PART SANDY, PART CARBONACEOUS, MICACEOUS.
② FINE PROTOQUARTZITE: SILTY, DOLOMITIC.
②a PROTOQUARTZITE: L.GREY CONTAINS MINOR SILT, FELDSPAR AND LITHICS.
③ SHALE: DK.GREY, FIRM, MICACEOUS.
① VOLCANICS: DOLOMITISED TUFF, BASALT.
② DOLOMITE: WHITE, CRYSTALLINE.
③ SHALE: DK.GREY.
④ PROTQTZE: LT.GREY, DOLOMITIC, PART SILTY, PEBBLY. TR.PYRITIC & CARBONAC.
④a FINE PROTOQUARTZITE: PART SILTY.
① VOLCANICS: DOLOMITISED TUFF.
② SHALE: DK.GREY TO BLACK, CARBONAC. SANDY.
③ PROTOQTZTE: AS FOR ④ ABOVE.
④ DOLOMITE: WHITE, CRYSTALLINE.
① FINE SILTY SANDSTONE: DOLOM. PYR.
② PROTOQTZTE: CONTAINS COMMON SHALE & SILTSTONE LITHICS, PLAG., CHERT & QUARTZITE.
③ SANDY SILTSTONE: DK.GREY.
④ SOFT CALCAREOUS CLAYSTONE.
① SHALE: PART SANDY & CARBONACEOUS.
② VOLCANICS: DOLOM.TUFF & BASALT.
③ SUBGREYWACKE: PART CARBONACEOUS. ABUND.SED. LITHICS, COMMON CHERT & FELDSPAR. CLAY-SILT MATRIX & DOLOM.
① CARBONAC. SANDSTONE: ABUND. FELDSPAR & LITHICS. SIMILAR TO ③ ABOVE.
① CARBONAC.SHALE: BLACK: MINOR COAL.
② VOLCANICS: DOLOM.TUFF, MINOR BASALT
③ FINE DOLOM. SILTY SANDSTONE.
④ SUBGREYWACKE: GREY; ABUND.SED. LITHICS & FELDSPAR. DOLOM & SILICA CEMENT. COARSER AT BASE.
① SHALE: PART CARBONACEOUS.
② VOLCANICS: AS FOR ② ABOVE
③ FINE SILTY SANDSTONE: MED.GREY.
④ SIDERITIC, PEBBLY, FELDSP. SANDSTONE.
① SHALE: AS FOR ① ABOVE.
② VOLCANICS: AS FOR ② ABOVE.
③ FINE TO MEDIUM LITHIC SANDSTONE: PART DOLOMITIC, PART SILICIFIED, PART PEBBLY.
④ CLAY-SHALE: PINKISH BROWN.
⑤ SHALE: PALE GREY, GREEN AND MID-BROWN. GRADES TO SILTSTONE.
PHOSPHATE CONTENT (Molybdate Test)
Nil
Trace
Low
Mod
High
INTERPRETED POROSITY Cores - Cuttings
S.P. LOG
Millivolts
HYDROCARBONS (Key to symbols above)
CORES (Key to symbols above)
INTERPRETED LITHOLOGY (Key to symbols above)
RESISTIVITY Ohms m²/m
Am = 16"
RESISTIVITY Ohms m²/m
A.O. = 18'8"
KEY MINERALS
Clasts
Cement, Matrix
Formation Test Data
DESCRIPTION OF INTERPRETED LITHOLOGY
Rock Name (after Pettijohn, 1957)
SILICIFIED PROTOQUARTZITE INTERBEDDED WITH SANDY SHALE.
PROTOQUARTZITE: CONTAINS PEBBLE BEDS AND SCATTERED PEBBLES. COMMON THIN POROUS BEDS. CORE 7 CONTAINS BURROW STRUCTURES AND CARBONACEOUS STRINGERS.
Rec 3' mud
Rec 560' fresh water
SILICIFIED PROTOQUARTZITE WITH MINOR SHALE AND SILTSTONE BEDS. CORE 8 IS VERY SILTY, POORLY BEDDED AND CONTAINS MARINE FOSSILS.
SHALE WITH INTERBEDS OF PROTOQUARTZITE AND SILTSTONE.
PROTOQUARTZITE
VERY FINE PROTOQUARTZITE
FOSSILIFEROUS SANDY LIMESTONE.
PROTOQUARTZITE
INTERBEDDED SANDY SILTSTONE AND FINE DOLOMITIC PROTOQUARTZITE. MINOR SHALY BANDS. CORE 9 IS PARTLY LAMINATED AND POORLY X-BEDDED.
PROTOQUARTZITE
DOLOMITISED TUFF
PEBBLY PROTOQUARTZITE
DOLOMITISED TUFF
FINE PROTOQUARTZITE
DOLOMITISED TUFF
CARBONACEOUS SHALE
DOLOMITISED TUFF
PROTOQUARTZITE
SUBGREYWACKE AND SHALE: CARBONACEOUS IN PARTS. MINOR DOLOMITISED TUFF.
CORE 11 CONTAINS SOME BEDS WITH DIPS UP TO 40° - PROBABLY MASSIVE X-BEDDING. MOSTLY MASSIVE BEDDING BUT CONTAINS THIN CARBONACEOUS LAMINAE.
DOLOMITIC PETROMICT CONGLOMERATE
LITHIC SANDSTONE WITH INTERBEDS OF GREY SHALE
PINKISH BROWN CLAY-SHALE
FINE DOLOMITIC AND SILICIFIED PROTOQUARTZITE CORE 13 IS MASSIVE BEDDED, SHOWS GRAIN SIZE LAYERING AND POOR, LOW ANGLE X-BEDDING.
GREY, GREEN AND RED-BROWN SHALE GRADING TO SILTSTONE. CONTAINS GRADED BEDS, LAMINATIONS AND MINOR PEBBLE BEDS.
B.M.R. UNITS
DESCRIPTION
UNITS
UNIT GROUPS
Partly silicified quartz-rich sandstone containing porous horizons, pebble beds & minor shale
Interbedded shales, siltstones, sandstones & volcanics with minor limestone & a basal conglomerate
Flat-bedded, partly reddish sandstone shale & siltstone
S6
S7
S8
S6 - S8
S9
S10
S11
S12
S9 - S12
S13
COMPANY INTERPRETATION
FORMATION
GROUP
AGE
NOWRA SANDSTONE
WANDRAWANDIAN SILTSTONE
CONJOLA FORMATION
SHOALHAVEN GROUP
PERMIAN
? DEVONIAN

WELL NAME, No.: STOCKYARD MT No.1	ELEVATION (A.S.L.)	
OPERATING Co: FARMOUT DRILLERS NL.	Ground Level ... 162 ft.	
WELL LOCATION	K.B. .. Datum. 174 ft.	
Lat.: 35°34'41" S. Long.: 150°46'53" E.		
Basin: SYDNEY		
State: N.S.W.	SAMPLE STORAGE	
Tenement No. P.E.L. 69	B.M.R Canberra	
1:250,000 Sheet No. SI 56-9		

Structure symbols: BEDDING > 5 cm.; " 1–5 cm.; " 0.5–1 cm.; " 0.1–0.5 cm.; " < 0.1 cm.; CROSSBEDDING; MICRO-CROSSBEDDING; GRADED BEDDING; UNDULATE BEDDING; SCALLOP STRUCTURES; ORGANIC MIXING; BURROW STRUCTURES; DIP; JOINTS; SLICKENSIDES

PETROGRAPHIC CORE LOG

STOCKYARD MOUNTAIN (FARMOUT) No.1

Geology by: P.J. Alcock

Plate 2A

Interval –1" (6540'6" – 6541'6"): Core not recovered

Position of lost core not known

Porosity (estimated)		Abundance (estimated)	
S – Slight	< 6%	R – Rare	< 1%
P – Poor	6–12%	C – Common	1–3%
M – Medium	12–12%	A – Abundant	> 3%
G – Good	> 20%		

Legend: Lithics; Feldspar; Silica; Basalt; Tuff; Pyrite; Breccia to conglomerate; Quartz sand, sandstone; Siltstone; Claystone; • Limestone; • Dolomite; Coal; Shale and mudstone; • Calcirudite; • Calcarenite; • Calcilutite

• Symbols used to designate carbonate minerals (Calcite, Dolomite etc) in the "Essential Components" column

CORRELATION: AGE / GROUP / FORMN. (COMPANY INTERPRETN.) / B.M.R. UNITS

GENERALIZED DESCRIPTION: CORE No. RECOVERY FOOTAGES / LITHOLOGY / DESCRIPTION (GENERALIZED ROCK NAME) / COLOUR (Rock Colour Chart G.S.A. 1963) / SEDIMENTARY STRUCTURE (see Symbols) / DIP & TECTONIC STRUCTURE

DETAILED DESCRIPTION: DEPTH OF SAMPLE SECTIONED, ANALYZED / SPECIFIC ROCK NAME (After Pettijohn 1957) / POROSITY (% where measured) / PERMEABILITY (Millidarcys) / ROUNDNESS / SORTING / GRAIN-SIZE (Wentworth Scale; Estim. size Range & Mode; SANDS) / THIN-SECTION ANALYSIS: % OF ESSENTIAL COMPONENTS (Cross hatched if material clearly present as cement and/or matrix; porosity shown as blank) – Matrix and/or Cement, Estim. % of Total Rock (Clay-undiff; Kaolin Gp; Cement Symbols see Legend) / ACCESSORY MINERALS (Estim. R, C, A or Measured % of Total Rock): Dark Minerals – Pyrite, Iron oxides, Zircon, Tourmaline, Pyroxene, Biotite, Chlorite, Muscovite-sericite; Light Minerals – Plagioclase, K-Feldspar; MATURITY INDEX / NOTES (provenance, environment of deposition, diagenesis, palaeontology etc)

Age: PERMIAN; Group: SHOALHAVEN GROUP; Formation: BERRY FORMATION; B.M.R. units: S2 – S5 (S2, S3, S4, S5)

Core No. (recovery) / footages	Description	Colour	Sed. structure	Depth of sample	Specific rock name	Accessory minerals / maturity index	Notes
Core 1 (12'), 298–310 (300, 306, 308); B.M.R. unit S2	**Mudstone**: poorly laminated, sub-horizontal with scallop structures.	Med dk. grey					Sedimentary & volcanic source rocks. Deposition in quiet marine waters with gentle currents. Origin of scallop structures obscure. Here they occur in lenses parallel with the bedding suggesting depositional rather than organic origin (distorted ripple drift markings?) Fossils include brachiopod shells & spines, & rare fenestellid bryozoa
	Mudstone: poorly laminated. Contains v. dk grey lenses, blebs of mudstone. Rare lenses of pyritic sandstone with ? volcanic lithics	Med. dk. grey					
	Sandy mudstone: contains darker grey mudstone as above. Also well developed scallop structures, dissem. pyrite, brachiopod shells, limestone frags.	Med. dk grey					
	Mudstone: laminated, micro-cross bedded. Scallop structures, minor qtz sand, brachiopod spines, ? bryozoa	Med dk grey		305'4"	Laminated mudstone	R A A C	
	Mudstone: scallop structures in thin lenses beds. Minor qtz. sand.	Med dk grey.					
	Mudstone: Contains v. dk. grey laminae, lenses, blebs of mudstone. Minor faint scallops, micro-crossbedding. Rare small brachiopod shells & spines.	Med dk grey					
Core 2, 626–636	**Mudstone**: poorly bedded. Minor scalloped layers. Generally similar to core 1.	Med dk grey.		627'3"	Calcareous mudstone.	R A C A	Depositional environment as for Core 1. Fossils include small shell fragments.
Core 3 (5'), 870–876 (871, 874); B.M.R. unit S3	**Calcareous greywacke**: poor, undulose bedding. Contains pebbles & grains of qtz. & chert, common grey & black lithics, dk. grey silt stringers, abund. calc. & dolom. silt matrix	Med. grey		871'	Poorly sorted calcareous protoquartzite.	R R C R 6·7	Sedimentary & ? granitic provenance. Deposition in quiet marine waters. Fossils include brachiopods & unidentifiable shell fragments.
	Fossiliferous greywacke: similar to above. Contains abund. shell frags – mostly brachiopods.	Med. grey					
	Fossiliferous greywacke: calcareous & dolomitic. Contains pyritic grains, white ? weathered feldspar, grey lithics, silt stringers, brach. shells & qtz. pebbles.	Med grey		875'2"	Poorly sorted calcareous protoquartzite.	C R R C R R 7·5	
Core 4 (6'), 1032–1037 (1033); B.M.R. unit S4	**Basalt**: massive, fine grained with occ. large plag. phenocrysts. Common vert. fractures & joints with slickensided surfaces.	Olive black		1033'	Porphyritic basalt (Labradorite microlites, phenocrysts)	C R C C	Vertical fractures & joints with slickensided surfaces are common.
	Basalt: as above	Olive black					
	Basalt: as above	Olive black.					
Core 5 (7'8"), 1367–1375; B.M.R. unit S5	**Shale**: Contains numerous thin dk. grey laminae, lenses, blebs of shale & minor pyritic shale. Rare shell frags.	Med. grey & dk. gr.					Sedimentary & granitic provenance. Deposition in quiet marine water. Some layers show undisturbed, parallel bedding; others contain scallop structures, while still other segments are organically churned & contain burrow structures. Scattered, angular to rounded pebbles were apparently "dropped". Fossils limited to rare calcareous shell fragments.
	Sandy mudstone: contains patches, lenses, laminae of silty v.f. sandstone. Scallop structures in parts. Minor ang.-rd. pebbles & calc. shell frags.	Med grey & dk. gr.					
	Sandy mudstone: churned by organisms. Contains worm burrows, shell fragments. Poorly interbedded with v.f. silty sandstone	Med. grey & dk. gr.		1372'	Poorly interbedded fine dolomitic qtz greywacke & fine sandy mudstone.	R C R R	
	Sandy mudstone: laminated, contains laminae & small lenses of dk. grey mudstone. pebbles ang.-rd qtz & limestone.	Med grey & dk. gr.					

Plate 23 B

DETAILED DESCRIPTION

CORRELATION: AGE / GROUP / FORMN (COMPANY INTERPRET N.) / B.M.R. UNITS

GENERALIZED DESCRIPTION: CORE Nº RECOVERY FOOTAGES / LITHOLOGY / DESCRIPTION (GENERALIZED ROCK NAME) / COLOUR (Rock Colour Chart G.S.A. 1963) / SEDIMENTARY STRUCTURE (See Symbols) / DIP & TECTONIC STRUCTURE

DETAILED DESCRIPTION: DEPTH OF SAMPLE SECTIONED, ANALYZED / SPECIFIC ROCK NAME (After Pettijohn 1957) / POROSITY % where measured (SLIGHT <6%, POOR 6-12%, MED 12-20%, GOOD >20%) / PERMEABILITY Millidarcys (VERTICAL, HORIZONTAL) / ROUNDNESS / SORTING (POOR, MOD., WELL) / GRAIN-SIZE (Wentworth Scale) Estim size Range & Mode: CLAY-SILT, VERY FINE, FINE, MEDIUM, COARSE, VERY COARSE, PEBBLES (SANDS) / THIN-SECTION ANALYSIS: % OF ESSENTIAL COMPONENTS (CROSS HATCHED IF MATERIAL CLEARLY PRESENT AS CEMENT AND-OR MATRIX; POROSITY SHOWN AS BLANK) 20 40 60 80 100; Matrix and/or Cement Estim % of Total Rock (CLAY-UNDIFF; KAOLIN Gp) 0 10 20 30 40 50 60 70 80 90; Cement Symbols See Legend / ACCESSORY MINERALS Estim R-C-A or Measured % Total Rock: "Dark Minerals" (TOTAL "DARK", Pyrite, Zircon, Biotite), "Light Mnl" (Chlorite, Muscovite-sericite, Plagioclase, K-Feldspar) / MATURITY INDEX (Qtz+Chert / Feld+Lith) / NOTES (provenance, environment of deposition, diagenesis, palaeontology etc.)

AGE: PERMIAN
GROUP: SHOALHAVEN GROUP

Formation	B.M.R. Units	Core Nº	Footages
NOWRA SANDSTONE (S6 - S8)	S6	6 (5')	1622'–1632' (1623, 1626)
NOWRA SANDSTONE (S6 - S8)	S7	7 (14'3")	1902'–1918' (1904, 1906, 1912, 1914)
NOWRA SANDSTONE (S6 - S8)	S8	8 (1'7")	2210'–2213'
WANDRAWANDIAN SILTSTONE (S9 - S12)	S9	9 (7')	2500'–2507'6" (2502, 2505)
CONJOLA FORMATION (S9 - S12)	S10	10	2706'–2721'5" (2707, 2710)

Core	Description	Colour	Depth of sample	Specific rock name	Porosity %	Permeability (vert. / horiz.)	Accessory minerals	Maturity index
6	Quartz sandstone: massive, silicified. Contains abund. qtz., minor grey & green chert, soft white & yellow-brown grains (? weathered feld.), hard black grains & dolomite.	Light grey						
6	Quartz sandstone: as above.	Light grey						
6	Quartz sandstone: as above	Light grey	1626'10"	Silicified protoquartzite	8	Nil / Nil	R R C	10
7	Quartz sandstone contains pebble beds. Pebbles & sand grains of qtz., chert, soft black mudstone & soft micaceous lithics. Minor weathered feld., clay matrix & second. silica	Light grey	1902'10"	Porous protoquartzite			R R	9
7	Greywacke & qtz. sandstone: poorly bedded. Thin bed of qtz sandstone as above. Remainder contains abund. white & orange clay matrix. Brachiopods & bryozoa common in parts.	Brownish grey	1904'10"	Quartz greywacke			R R R R R	13
7	Quartz sandstone: contains stringers carb. mudstone; pebbles qtz., chert, phyllite. Poorly bedded.	Light grey						
7	Quartz sandstone: contains carb., pyritic mudstone stringers, clean sandstone beds.	Light grey						
7	Quartz sandstone: carb. stringers & fragments. Bedding poor, well consolidated.	Light grey						
7	Quartz sandstone: similar to top segment. Poorly cemented.	V. Light grey	1913'1"	Porous protoquartzite.	16	11 / 6	C C R	8·7
7	Pebbly quartz sandstone: contains common carb. mudstone stringers distorted by loading. Pebbles (mostly in beds) of qtz., chert, qtzte., granite, soft white clay.	Light grey						
8	Very silty greywacke: grades downwards to laminated sandy mudstone. Rare large shell fragments.	Med. dk grey	2211'	Quartz greywacke	6	Nil / Nil	C R R C R	5·6
9	Shale: laminated, firm, fissile. Contains darker grey stringers & blebs of mudstone, minor sandy shale beds.	Dk. grey						
9	Shale: interlaminated with very fine sandstone. Undulate, subhorizontal laminations, x-bedding up to 10°. Vert dolomite veins.	Med. grey & dk grey	2503'	Very fine quartz greywacke	4	Nil / Nil	C R	17
9	Shale: faintly laminated, firm, contains scattered sand & patches dissem. pyrite. Rare plant fragments & leaves.	Med.-dk grey						
9	Shale. well laminated, firm. Contains numerous v. dk grey laminae, lenses, blebs of mudstone; scattered qtz. sand; patches, grains & pebbles of pyrite.	Dk. grey & V. dk. grey						
10	Tuff: dolomitic, fine grained.	Light yellow-grey.						
10	Tuff: as above.	Light yellow-grey.	2709'4"	Dolomitised tuff: contains brown laths (pseudomorphs after ?amphibole) and dolomitised volcanic rock fragments.				
10	Tuff: as above.	Light yellow-grey.						

NOTES

Core 6: Sedimentary & granitic provenance. Deposited in agitated water. Silicified by secondary quartz overgrowth.

Core 7: Sedimentary & granitic provenance. Deposited in marine water: mostly agitated. Clay coating on quartz grains apparently inhibited quartz diagenesis. Porosities up to 16% encountered in some beds. Occasional burrow structures are present. Brachiopod & bryozoan molds are common in parts.

Core 8: Sedimentary & granitic provenance. Deposited in quiet marine water. Fossils: rare large shell fragments (? brachs).

Core 9: Sedimentary provenance in part. Deposited in quiet, restricted ?marine water. Fossils include leaves & other plant fragments.

Core 10: Almost completely dolomitised.

CORRELATION

Age: PERMIAN / ? DEVONIAN; Group: SHOALHAVEN GROUP; Formation: CONTOLA FORMATION (BASAL CONGLOMERATE); Company Interpret.: S9 – S12, S13; B.M.R. Units: S11, S12, S13

GENERALIZED DESCRIPTION / DETAILED DESCRIPTION

Columns: Core Nº Recovery Footages; Lithology; Description (Generalized Rock Name); Colour (Rock Colour Chart GSA); Sedimentary Structure (See Symbols); Dip & Tectonic Structure; Depth of Sample Sectioned, Analyzed; Specific Rock Name (After Pettijohn 1957); Porosity (% where measured); Permeability (Millidarcys); Roundness; Sorting; Grain-Size (Wentworth Scale, Estim. size, Range & Mode); Thin-Section Analysis: % of Essential Components (cross hatched if material clearly present as cement and/or matrix; silt shown as blank), 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; Dark Minerals: Total "Dark", Pyrite, Zircon; Light Min.: Muscovite-Sericite, Plagioclase); Maturity Index (Qtz+Chert / Feld+Lith); Notes (provenance, environment of deposition, diagenesis, palaeontology etc.)

Core Nº (Recovery)	Footages	Description	Colour	Sed. Structure	Dip	Depth of Sample	Specific Rock Name	Accessory Minerals	Maturity Index	Notes
11 (7')	3022–3024'	Dolomitic lithic sandstone: firm, massive, steeply dipping. ?x-bedded. Minor dk. grey carb. mudstone laminae.	Med. grey	⌀ ≡	40					Dominantly sedimentary provenance with some ?granitic influence
		Dolomitic lithic sandstone: as above, but gently dipping. Minor carb. mudstone stringers with pyrite.	Med. grey	⌀ ≡	5	3025'	Subgreywacke	R, R, A	0.8	Deposited in agitated water with moderate current action.
	3028'	Dolomitic lithic sandstone as above, but lacks carb. mudstone; subhorizontal bedding.	Med. grey	⌀						
		Fine dolomitic lithic sandstone. Contains thin parallel laminae of carb mudstone.	Med. grey	≡						
12 (5'7")	3276'–3277'	Dolomitic petromict conglomerate: firm. Contains rounded pebbles & cobbles of: silicified sandstone & siltstone, chert, quartzite, soft shale sandy mudstone, acid volcanics & quartz. Matrix of coarse dolomitic quartzose sandstone.	Multi-coloured: Lt. to dk. grey, green, white, buff, orange	⌀		3279'	Petromict conglomerate.	R, A	? 6	Sedimentary, volcanic & ?granitic provenance. Deposited in strongly agitated or rapidly flowing water.
	3281'–3282'	Dolomitic petromict conglomerate: as above.		⌀						
13 (9')	3415'–3417'	Fine dolomitic quartz sandstone: hard, firm. Faint grain size layering. Contains abund. qtz., common green chert, minor black ?carbonaceous grains. Siliceous & dolomitic cement. Dolomite becoming rare downwards.	Light grey	⌀		3416'	Fine dolomitic protoquartzite	R, R, R, A	3·1	Sedimentary & granitic provenance. Deposited under uniform moderate energy conditions with gentle current action.
		Fine to med. quartzose sandstone. Contains layers of med. sst. & f. sst. Constituents as above.	Light grey							
	3422'	Fine quartzose sandstone. uniform texture, firm, siliceous cement. Constituents as above.	Light grey	⌀						
	–3425'	Fine quartzose sandstone: as above.	Light grey	⌀		3423'6"	Fine protoquartzite.	R, C	3.3	
14 (4'6")	3511'–3512'	Shale: red-brown, graded, laminated & firm with minor claystone, greenish grey siltstone & f. sandstone.	Red-brn. & green-grey.	≡						Sedimentary provenance in part. Minor volcanic & ?granitic influence
	–3515'–3516'	Clay-shale: red-brown, laminated, firm. Interbeds of greenish grey silty shale, minor claystone. Pebbly mudstone at top. Sub-ang. to sub-rd. pebbles of: siltstone, hard, f-med. qtz. sandstone, fine siliceous lithics, red-brown claystone, volcanics & limestone	Red-brn. green-grey.			3513'8"	Red-brown pebbly mudstone.	R		Deposited in still, ?fresh water under oxidising conditions. These beds are flat lying, parallel with the overlying Permian sediments.

Porosity (thin-section samples): Nil