COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1964/185

A PETROLOGICAL STUDY OF THE SEDIMENTS FROM THE FROME BROKEN-HILL, PRETTY HILL No 1 WELL, OTWAY BASIN, VICTORIA.

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ABSTRACT

In Pretty Hill No. 1, unit thicknesses are notably attenuated over the locally shallow basement and the sequence is considered condensed.

Unit R (Basal Sandstone) is described for the first time in wells so far studied by the Basin Study Group. Unit R, together with unit M, is tentatively subdivided. No break was detected between the latter two units but unconformity between units M and Gh, and between Bb and Bc, is postulated. Unit J (the equivalent of the Waarre Formation), is missing. "Break conditions" without evidence of actual angular unconformity are considered to have existed during "unit Gh and unit Dd times".

Unit Dd is compared with lithologically and petrographically similar horizons, in other wells studied or being studied, and a correlation is suggested.

Microfaunal evidence suggests that the Tertiary-Cretaceous boundary lies within unit Gb and the Cretaceo-Jurassic boundary lies well within unit R (at a depth of about 7200 feet).

No significant shows of hydrocarbons were reported from the well.

INTRODUCTION

Pretty Hill No. 1 Well was drilled for Frome-Broken Hill Pty. Ltd., approximately 13 miles N.N.W. of Port Fairy in the Otway Basin of S.W. Victoria. Details of the well and its location are given below;

Location	38° 13' 30" S	Latitude
	142° 07' 30" E	Longitude

(1 mile = 1" military map of Hawkesdale)

1:250,000 Sheet No. J54-11-9

Total Depth = 8124 feet (driller)

" " = 8129 " (electric log)

Elevation G.L. - 189' A.S.L.

Reference Point (R.T.) - 202' A.S.L.

Completion Date - Oct. 13th 1962.

The cost of the complete drilling operation was subsidised under the Commonwealth Petroleum Search Subsidy Act 1959-1961.

Samples of all cuttings (except the interval 3800 to 3900 feet) and 19% of all cores taken were made available for re-examination. Samples of cuttings were generally of small quantity.

The main references in studying the well, were the well-completion report and the composite well-log (F.-B.H., 1962).

The study was undertaken as part of the review of the Otway Basin currently (1964) being made by the subsurface section, Petroleum Exploration Branch of the B.M.R.

Pretty Hill No. 1 is the first well to reach economic basement through a virtually complete sequence of sediments (below and inclusive of Units Bb and Bc) and its study is of singular importance particularly with respect to Unit R (the "Basal Sandstone"), previously unencountered in studies.

"BASEMENT"

Between 7874 feet and 8129 feet (T.D.) rock which Frome-Broken Hill geologists considered to be basement was encountered.

The rock is dense, hard, dark green, holocrystalline, very fine grained igneous rock, much fractured and altered. Toward the base, the rock becomes darker, and veining more pronounced.

Thin-section examination shows that the rock is rich in euhedral phenocrysts, most of which are entirely replaced by a chloritic mineral. The chlorite is often replaced by a brown, high-relief mineral (? sphene). It is probable, judging from the shape of the pseudomorphs which vary between 0.2 and 0.5 mm. in largest dimension, that they were of olivine and augite.

Very fine-grained augite and sodic plagioclase constitutes the groundmass, the plagioclase showing ophitic relationship with the augite. Very small subspherical grains of iron ore make up 5% of the rock on average. No preferential orientation is shown by rod-like crystals.

Veins are filled with calcite or chlorite, and vesicles are filled with chalcedony or chlorite.

Between the uppermost and bottom cores, (Nos. 22 and 23) there is a distinct difference in grain-size of the groundmass from 0.07 (average) at the top to approximately 0.1 mm. at the bottom. There is also an increase in the amount of iron oxide from top to bottom. It is probable that the rock is a much altered lamprophyre.

UNIT R ("Basal Sandstone")

In Pretty Hill No. 1 well, the "Basal Sandstone" was encountered for the first time in wells so far studied and it is thus important as a standard unit upon which to base future comparison. The unit is 1910 feet thick, extending from immediately beneath Unit M (the "Otway Group") at 5964 feet, to 7874 feet, the surface of the basement.

The rocks of this interval are characteristically light grey, friable, subangular, coarse-grained, moderately sorted sandstones, approximating "protoquartzite" composition (Pettijohn 1957). The feldspar/lithic ratio is very close to 1 in most sections examined so that naming the rock is difficult.

The matrix is kaolinitic, sometimes slightly siliceous and is replaced in varying degrees, by siderite. Garnet is an abundant accessory.

After separating the heavy fractions with bromoform, garnet, siderite and siderite rock were estimated for each cutting sample within unit R. The garnet and siderite-rock fractions were used, together with cuttings descriptions and electric log characteristics to divide the unit into the following intervals (see fig. 1).

Interval 7874 - 7370 feet.

Angular, medium to coarse-grained, moderately to well sorted 'protoquartzites' which show many fluctuations in grain-size. Feldspar is dominantly microcline, which, together with orthoclase constitute up to 10% of the rock.

Lithic fragments show great diversity and comprise up to 15% of the rock. Metaquartzite, micrometaquartzite, mica schist, chloritic schist, volcanic glass, chert, and some volcanic rock showing (?) trachytic texture were recognised.

Quartz commonly shows overgrowth and pressure solution. Quartz and feldspar occur in myrmekitic intergrowth in some rare detrital grains. Garnet is notably abundant within the interval.

The kaolinite cement is partly replaced by siderite, particularly toward the top of the interval.

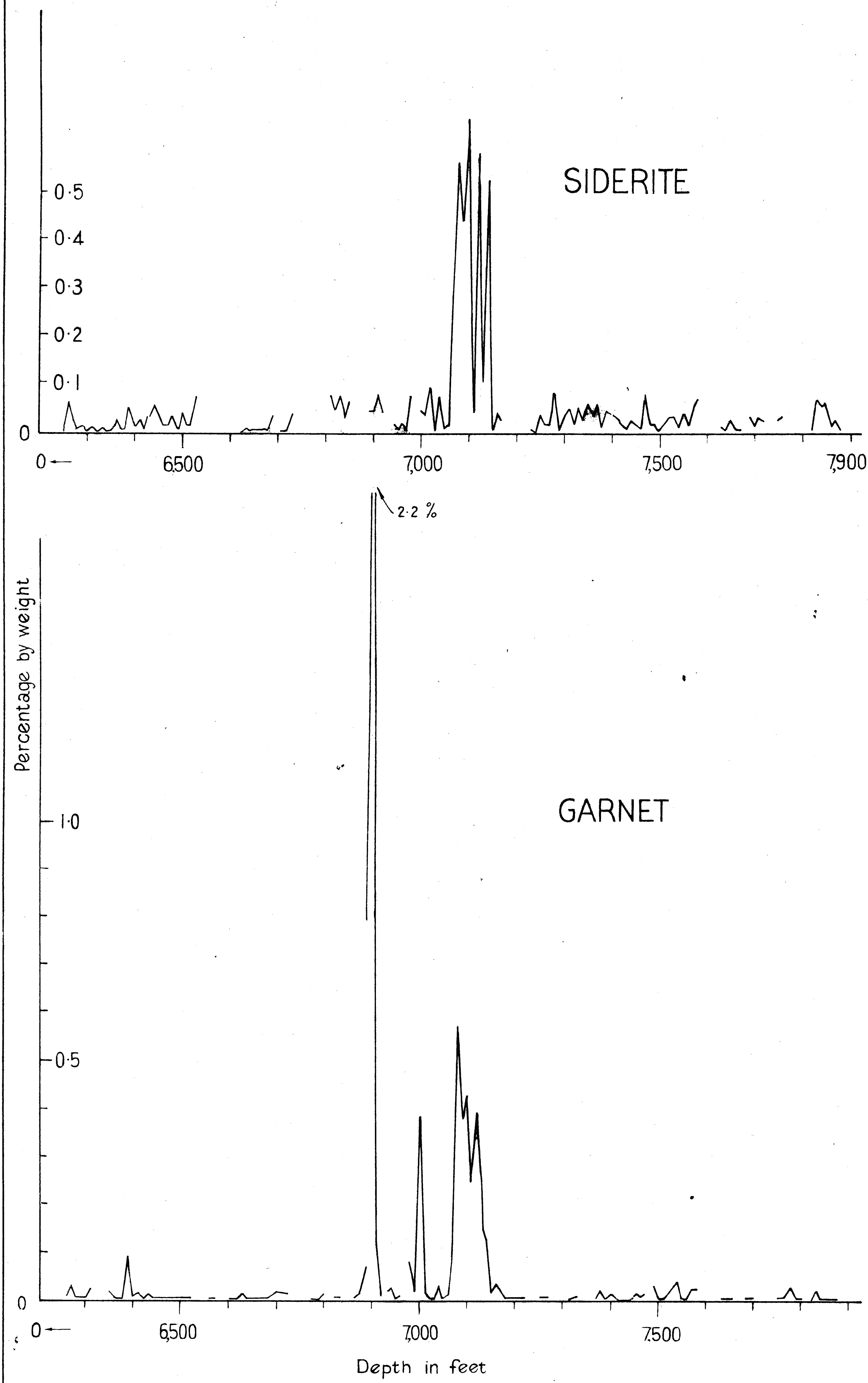
Thin coal seams are abundant, as indicated in the cuttings, and the microlog indicates the occurrence of some of these.

Dips of the order of 15° were measured on core 21 but these may have been taken on cross-bedding planes so that the dip value is to be regarded as a maximum.

Interval 7370-7210 feet.

This interval contains a fairly uniform succession of subangular to subrounded, coarse grained, moderately sorted protoquartzites, the kaolinite cement of which is partly or almost wholly replaced by siderite. The siderite tends to be pellicular so that the porosity is only slightly reduced. In rare cases, the sideritisation is almost complete reducing the porosity to a low value. Garnet is much less abundant than in the lower interval. Coal is abundant in cuttings in the upper part of the interval but the microlog suggests that the seams are thin. Siderite rock horizons appear to be equally thin. Siderite rock horizons appear to be equally thin.

Angles of dip of up to 30° were measured in core 20, but must be regarded as a maximum value, as cross-bedding planes may have been measured.



HEAVY MINERAL ABUNDANCE IN UNIT 'R'

Bureau of Mineral Resources Geology and Geophysics

To accompany Record No. 1964/185

X AUS-2-41

T.E.

Interval 7210-6880 feet

The interval is characterised by a conspicuous overall abundance of garnet, and a relatively small average grain-size.

The top 20 feet and the lower 40 feet are angular silt-sized to very fine-grained, well-sorted orthoquartzites, and the remainder of the sequence is of fine to medium-grained protoquartzites which become coarse towards the top of the interval. Siderite has replaced the matrix of the coarser horizons to some extent, though the finest-grained horizons are unaffected. Abundant coal in cuttings samples, correspond to a prominent maximum in the S.P. and resistivity curves over the range 7000-7030 feet. Numerous slight maxima occur elsewhere in the interval, in the microlog.

Siderite rock seldom forms more than 2% of the cuttings samples and the strata may be inferred to be relatively thin and widely spaced.

Interval 6880-6550 feet

Paucity of coal and siderite characterises this interval.

Core 19 (6690 - 6702 feet) is a light-grey, friable, fine to medium-grained protoquartzite. Some bedding with dip of 30° is visible but again this may not be true bedding. Truncations, scour-and-fill structure and small-scale cross-bedding are observable. These structures suggest deposition in a high-energy environment, accompanied by rapid burial.

Thin sections of cores between 6690-6696 feet reveal that the rock is an angular to subrounded, moderately well sorted protoquartzite.

Quartz shows some pressure solution, overgrowth and welding. Microline and minor orthoclase constitute the feldspars. The lithic fragments are the same as those described for interval 7874-7370 feet. The matrix, both in hand-sample and thin-section shows minor patchy development of siderite. Examination of cuttings and heavy mineral samples shows that the amount of siderite is generally low within this interval.

Garnet is markedly less abundant. Grain-size distribution and electric log curves show little significant variation. Siltstone observed in the cuttings is probably caving from a higher horizon.

Interval 6550-6250 feet

This interval contains a relatively uniform sequence of protoquartzites, the grain-size distribution of which remains moderately uniform This uniformity also characterises the electric log curves.

Examinations of core 18 and thin sections show that the rocks of this interval are friable, angular to subrounded, medium to very coarse-grained poorly to moderately sorted protoquartzites. The cuttings contain abundant grey siltstone fragments which are not indicated on the S.P. curve below 6250 feet and are probably cavings.

Garnet and siderite abundance curves both reach maxima within the interval. Siderite appears in cuttings near the base.

Interval 6250 - 5964 feet

The lower limit of this interval is well defined from the S.P. curve by an abrupt positive change which corresponds to a thin silty horizon. Many similar horizons interbedded with the sandstones, occur throughout the interval. The S.P. curve indicates either the occurrence of shale streaks or a generally increased amount of argillaceous material over the interval.

Argillaceous siltstone which first appears at 6240 feet is medium-grey, compact, moderately sorted and quartzose; the matrix is kaolinitic.

The sandstones which dominate the lithology of the interval, very both in composition of clastic material and cementing medium. The lowest rocks are typical of the underlying intervals and show the same mineral composition and cementing media. Toward the top of the interval calcite-cemented sandstones become more abundant. With this increase, there is a concomitant increase in the abundance of lithic material, and the dominant feldspar changes from microcline to sodic plagioclase.

Sandstones from the cuttings at 6070 feet were sectioned and described. These were friable, grey, angular to subangular, fine grained subgraywackes (Pettijohn 1957). Within the relatively small thickness of this interval the rocks are of transitional nature, between the typical kaolinite-cemented protoquartzite of unit R and the calcite-cemented subgraywacke of Unit M.

The change in depositional environment reflected in the sediments appears to have been from a paralic environment with only slight marine influence, to one in which marine influence was negligible.

The Unit R is a relatively uniform succession of protoquartzites containing characteristic microcline feldspar, and garnet as an abundant accessory. Throughout the interval, the cementing medium is kaolinite, sometimes slightly siliceous and generally replaced by siderite to some extent in all the thin sections examined.

The garnet which characterises the unit is typically angular and pink, orange or reddish purple in colour. Within the interval 6880 feet to 7210 feet the unusual abundance of garnet ($> 2\%$) may afford a useful parameter for comparison with other wells.

Caution has been exercised in the interpretation of individual cutting samples because of the possibility of caving in such a friable lithology. The overall interpretation of lithology should however, be reliable.

Cores 19 and 20 have previously been examined for their spore content (Evans 1962), but specimens were only obtained from core 20 (7200-7214 feet), core 19 being barren.

From the assemblage found in core 20, the possibility arises that this horizon is of Jurassic age (Evans 1962). In this case core 20 of Pretty Hill could be as old or older than the bottom core of Eumeralla No. 1. The problems are discussed by Evans (1963) and comparisons made with other wells.

Relation between Units R & M

The change from 'Unit R' to 'Unit M' lithology takes place through the thin transition zone, 6250 feet to 5964 feet. Changes which take place within this interval give rise to the typical Unit M lithology distinct in the nature of the cementing media and in the proportions and variety of the lithic and feldspathic components.

Compositional changes include a rpaid increase in the amount of lithic material present, and the appearance of sodic plagioclase as the dominant feldspar in core 16. The disappearance of garnet is also noticeable.

In their well completion report, Frome-Broken Hill point out that angular unconformity between units R and M at 5964 feet is suggested by seismic work and from the dipmeter survey of the interval 5700-6696 feet.

Our examination however, failed to reveal any sign of unconformity.

The shattered and slickensided state of core 16 (5935-5947 feet) may be due to the intersection of the well-hole with a fault-plane. Fractures are at a high angle.

Porosity and Permeability of Unit 'R' sediments (F-B.H. 1962)

Tests conducted by the Bureau of Mineral Resources (Petroleum Technology) reveal very high porosities and permeabilities for cores taken within unit R. Values range from 200 to 2756 md., and effective porosity ranges between 19% and 25%.

UNIT M. ("Otway Group")

Unit M is the thickest in the section, with a total thickness of 3035 feet. The top is at 2929 feet and the base at 5964 feet.

Petrographic comparison of similar lithologies within the unit shows that subdivision is difficult on the basis of composition. Tentative subdivision has therefore been performed on the basis of the "sandstone-siltstone" ratio as estimated from cuttings samples and electric logs. The three major intervals are described as follows:

Interval 5964-5400 feet

In this interval the lithology is dominantly arenaceous. As a result of thin section examination the rocks are classified as subgraywackes (Pettijohn 1957) having dominant lithic fragments and up to 12% feldspar (mostly sodic plagioclase, with very minor microcline and orthoclase). The angular to subangular, fine to medium-sized grains, poorly-sorted, are set in a recrystallised calcite cement.

The lithic fraction, sometimes making up 50% of the rock is characterised by volcanic material, which is abundant, and in some cases predominant. The term "volcanic sandstone "(Williams, Gilbert and Turner, 1954) would be most suitable in many cases.

The main lithic types present are chert metaquartzite, shale, devitrified volcanic glass (?), microlitic and andesitic fragments, and chloritic tuffaceous rocks. The clastic material is characteristically immature in all sections studied. Plant remains were noted in the subgraywackes.

The finer sediments are mostly grey siltstones and mudstones with chloritic and kaolinitic matrices. Micaceous material and plant remains are abundant. Colour may range from light grey to dark-brown, pale-green, or very dark grey.

Cores at 5424-5400 feet are of light-grey, friable, subangular, fine to medium-grained, poorly to moderately-sorted subgraywackes. Flakes of carbonaceous matter occur throughout and the lowest core contains a carbon rich lamina. Large pellets of dark grey mudstone and small pellets of light grey mudstone abound in the lowest core and give the rock the appearance of an "intraformational breccia". If it does represent an "intraformational breccia" then it would appear to have formed in a wholly subaqueous environment. Alternatively and more probably, it could have been formed by the injection of the argillaceous rock into the sandstone, penecontemporaneous with deposition, while both rocks were still essentially fluid. Such an occurrence could be attributed to the differential loading of overlying beds.

Coal seams are abundant, and mostly thin, though a thick seam occurs from 5610 to 5620 feet, as estimated from the cuttings.

Estimated bedding dip is of the order of 20°.

Core 16, which contains the first definite L. Cretaceous faunas, was taken just above the Unit M-Unit R boundary, (Evans 1962). This is why the boundary between the Cretaceous (undifferentiated) and the L.Cretaceous, has been placed just above the unit boundary.

Interval 5400-4000 feet

This is a dominantly argillaceous succession with interbedded subgraywackes.

Thin-section examination of the argillaceous rocks reveals that chloritic and hydromicaceous material are abundant and ubiquitous constituents. Fine and very-fine quartz-grains evenly dispersed, sometimes constitute up to 10% of these rocks.

In Core 13 (4940-4942 feet), thin beds of very fine grained sandstone and siltstone alternate to give a "varved" appearance. Brown mica and fine carbonaceous flakes are abundant in the coarser layers.

Thin section examination of sandstone from core 13 shows it to be a subangular very-fine to fine-grained, well sorted bimodal lithic graywacke. Albitic plagioclase with minor microcline and orthoclase constitute approximately 7% of the rock. The assemblage of lithic material is the same as in the lower interval (5964-5400 ft.) Silty matter with abundant chlorite and kaolinite form the matrix.

The coarsest sandstones of the interval are found mainly in cuttings below 4700 feet and above 4300 feet. These are angular to subrounded, fine to medium-grained moderately sorted sandstones, best described as subgraywackes. With respect to concentration and composition, no significant variations are apparent.

Throughout the length of core 10 (4315-4323 feet) distorted bedding and small-scale fault structures are found in thinly interlaminated sandstones and mudstones. The deformation was probably penecontemporaneous with deposition, and due to differences in fluidity, and response to overburden.

Rocks of this interval are vitually barren of diagnostic fauna (F-B.H. 1962) and no study has been made of the plant remains which are often preserved. Carbonised plant remains occur in finely disseminated form in brown siltstone and as coarser fragments in grey mudstones.

Thin coal seams occur at numerous horizons and reflect continuous oscillation in conditions.

Interval 4,000-2929 feet

Arenaceous sediments dominate within this interval. The lower sandstones are largely similar to those already described, but those in the uppermost part of the interval show significant differences. The argillaceous sediments are similar to those already described. Chloritic material is abundant and ubiquitous in the matrix of all sections examined, though most abundant in the argillaceous rocks, in which it occurs with kaolinite and illitic material. Flakes of biotite occur in the coarsest sandstones and micaceous minerals are abundant in the mudstones. The micas resemble muscovite, but could be "bleached biotite", as pointed out by Edwards and Baker (1943), for the "Jurassic arkoses" of southern Victoria.

Sandstones examined in thin-section were subgraywackes; the finest sandstones were poorest in feldspar and kaolinite. The subgraywacke-type sandstones, calcite-cemented, were abundant in cuttings throughout much of the interval. Sorting of these sediments was generally poor.

At the top of the interval, immediately beneath unit Gh, core 7 (2928-2940 feet) is of a green-grey, friable, medium-grained sandstone. Lithic fragments constitute up to 40% of the rock, feldspar and quartz are approximately equal in abundance (10%). Unlike the typical sandstone for unit M, chlorite and zeolite constitute the cementing media. Zeolite, clearly diagenetic in origin is colourless and shows faint cleavage. At a comparable stratigraphic horizon, approximately 360 feet below the top of the "Otway Group" (Unit M), in Flaxmans No. 1 well, the zeolite heulandite has been derived and described by Baker & McAndrew (1961).

The abundant calcite cement which is found throughout the entire unit seems most likely to have been introduced at a late stage in diagenesis in most, if not all cases, since no good evidence for primary calcite has been found. Small pebbles of mudstone and quartz make up approximately 7% of the rock. Reworking of the underlying sediments during deposition of the succeeding bed, or post-depositional interworking of both in high-energy conditions, is suggested. There is evidence of reworking in thin-section also. Grains are chlorite coated, and this appears to be depositional, though it could alternatively be early diagenetic. Immediately above core 7, a pebble conglomerate is described (F-BH) 1962 the base of which has been considered to be the unconformable upper limit of the Otway Group. No sample was available for examination.

Conditions appear to have been constantly fluctuating, between typical paralic and deeper water conditions. Angularity of the clastic constituents, freshness of the feldspars and lithic materials suggested rapid sedimentation.

Relationship between Units M and Gh.

The lower limit of the pebble conglomerate horizon at 2929 feet has been taken as the unconformable boundary between the units.

An abrupt change in the nature of the sediments occurs across this horizon and it is a clear break. Whether or not the unconformity is an angular one is difficult to state, though dip readings above and below this horizon are so closely similar that any diversion at the unconformity is slight. This would tend to indicate that a disconformable relationship exists.

Porosity and Permeability of Unit M (F-B.H. 1962)

Cores 7, 13, 14 and 16 have been examined by the Bureau of Mineral Resources (Petroleum Technology) and effective porosities between 18-38% have been determined. Permeabilities are very low within the unit, as represented in the cores (see appendix I). Thin-section study indicates that the low permeability may be due to either the generally argillaceous nature of the sediments, or to the ubiquitous calcitization which occurs throughout the unit. Relatively porous zones could conceivably be sealed off from each other by clayey or calcitized parts.

Comments on the absence of Unit J

No evidence for the existence of unit J was found in studying Pretty Hill No. 1 well.

In Flaxmans No. 1, (Baker & McAndrew, 1961) the equivalent of unit J (Waarre Fm) has been studied and is characteristically a white, coarse to very coarse grained, pure orthoquartzite of high porosity and permeability. It has been found between the two unconformities which mark the top and the base of the units equivalent to the units M and Gh respectively, and is generally of small thickness.

Core 7 (2928-2940 feet) taken from the horizon of a conspicuous resistivity maximum, immediately beneath unit Gh was closely examined as a possible correlate. No similarity to Waarre formation lithology was found except for its high porosity, and the absence of the Waarre Formation from the sequence is concluded.

Insufficient data exists at present, to estimate the areal extent of unit J in the eastern sub-basin. If it is discontinuous, then valuable stratigraphic traps may be present.

Unit Gh ("Flaxman's Beds")

This unit is defined as the interval 2929-2830 feet, bounded by an unconformity from the underlying unit M. The basal deposit is a thin quartz pebble conglomerate. In the cuttings deeply iron-stained quartz sands with some lithic fragments are mixed with obvious cavings though it is often not clear which is the true lithology. Some small pieces of dark grey, micaceous sandstone in cuttings 2890-70 feet appear to represent the true lithology, judging from electric log curves.

A very marked resistivity maximum over a thickness of 30 feet (2865-2835 feet) marks the horizon of a ferruginous chamosite oolite rock. The rock is medium to dark brown and friable and grains and limonite ooliths show high polish. The oo liths have detrital quartz grains, limonite pellets as nuclei and coatings of chamosite which show good concentric lamination.

Limonite and goethite containing patches of siderite form the cement. The rock could have been primarily sideritic, since hydrated and oxidised; alternatively the compositioncould have been chamositic with limonite cement, subsequently reduced and hydrated to a combination of carbonate, oxide and hydroxide components.

These deposits were evidently laid down in an iron-rich depositional medium within a high energy environment, in which the amount of chemical precipitation exceeded the influx of terrigenous material. These conditions, probably associated with emergence, are followed by a slight transgression and deposition of unit Gf, in perhaps brackish water conditions.

The lithology of the upper "Flaxman's Beds" of Port Campbell Nos. 1 and 2 wells, corresponds closely to that described above and here too the horizon is marked by sharp resistivity maxima.

Unit Gf. ("Belfast Mudstone")

In Pretty Hill No. 1, this unit occupies the interval 2830-2625 feet. The unit is easily distinguished lithologically and by the S.P. and resistivity curves. S.P. deflection is nil and resistivity characteristically low, except over the sandy interval at the bottom of the sequence.

Cores 5 and 6 were taken from within the Unit Gf between 2726 and 2716 feet and 2734 and 2726 feet respectively. There was no recovery from core 5.

The rock is dark grey-green, small glauconite pellets protruding conspicuously from the core. Thin section examination shows that glauconite constitutes up to 50% of the rock. The bright-green micro-crystalline pellets are up to 0.8mm. in diameter, average size being about 0.6 mm.

Enclosing the pellets is a carbonaceous siltstone matrix, containing pyrite, some chlorite and finely divided micaceous material. Fine, sand-sized quartz grains (up to 0.25 mm.) are sparsely, but uniformly distributed throughout.

In the sections examined, several spore cases were noted as well as various foraminifera which were infilled with glauconite and pyrite. Fish remains, fragments of ammonites and a coral were also identified from core 6 (F-B.H., 1962). The age of the deposit was determined as Upper Cretaceous from the foraminifera assemblage.

Examination of the cuttings shows that the lowest part of the interval (2830-2770 feet) is sandy and at the base, pebbles of up to 1.0 cm. diameter were found. Following the time of dominantly chemical sedimentation a new episode in the supply of terrigenous material begins with the sandy material of the basal Belfast Mudstone. The sandy interval marks the beginning of the transgression and has therefore been included in the Belfast Mudstone Formation. During upper Belfast Mudstone times conditions appear to have been stable and slow deposition took place in brackish water (Taylor 1964). Sedimentation was slow and organic matter was present in sufficient quantity to encourage the formation of prolific amounts of glauconite pellets. The environment may perhaps best be described as of "barred basin" type in which anaerobic, slightly alkaline, reducing conditions prevailed.

Unit Gd ("Paaratte Fm")

The lower limit of the unit has been placed at 2625 feet and the upper limit at 2370 feet.

Characteristically the unit consists of carbon -cemented feldspathic sandstones (subrounded), grey-brown micaceous, slightly gypsiferous silts, sandy limestones and thin siderite rock horizons. Sharp resistivity maxima mark the horizons of hard dark, compact siderite rock.

In this section the siderite rock is found to be very slightly sandy, and very finely crystalline, crystals being of the order of 0.05 mm. in largest dimension. The sand grains, of either quartz or metaquartzite, are angular.

The limestone sections examined, are generally less sandy, and also finely crystalline. The sand material is the same as that in the siderite, and homogeneously distributed throughout the limestone. In hand. specimen the limestone is white to pale-brown in colour.

Quartz sand, with less than 5% feldspar usually constitutes the largest proportion of the cuttings samples. This loose sand is angular to subrounded, (mainly subangular) and coarse-grained. The grains show a characteristic slight frosting. No cement is associated with this lithology in cuttings samples and thin-sections of grains were examined in order to determine the nature of the cementing medium. Siderite and kaolinite were found in an embayment of one grain, but the order of formation was not clear.

The siltstone is soft, dark-brown and slightly fissile, and core 4 shows light-coloured clay interbeds. It is well sorted and carbonaceous with a micaceous matrix containing kaolinite. Patches of siderite pervaded the entire section examined, and iron-oxide is an abundant accessory throughout. The carbonaceous material tends to be confined to thin laminae (core 4).

Within core 4 the presence of Nelsoniella aceras together with the absence of Xenikoon australis has been taken to indicate that the age of the core is ".... somewhat below uppermost Cretaceous". (F-BH 1962).

There is no sign of unconformity between unit Gd and the underlying unit Gf, nor with the overlying unit Gb. The upper boundary of unit Gd is well marked in the electric logs.

Unit Gb. (Unnamed unit)

Unit Gb extends from the Unit Gd at 2370 feet to the base of Unit Dd at 2160 feet. The S.P. deflection and higher resistivity distinguish the unit from that underlying it.

Cuttings samples consist of loose quartz sand with abundant lithic fragments, some feldspar, a small proportion of carbonate rock fragments and some siltstone. The loose sand constitutes, on average, more than 60% of the samples. These sands are identical to those described from unit Gd, both in composition and texture; as in unit Gd, no indication of the cementing medium was found in cuttings samples.

It can be inferred from the elctric log, that cementation was less well developed than it was in the underlying unit. Thin section examination of grain samples reveal both kaolinite and siderite in some embayments but it is not possible to say which, if either, mineral was primary.

Carbonates are the most abundant subordinate lithology present in cuttings, and sandy limestone is dominant over finely crystalline siderite rock. Sandy representatives of both rock-types contain only quartz and some metaquartzite grains.

Conditions within the environment of deposition appears to have changed very little from that under which Unit Gd formed. Marine influence is slight and fluctuates with the dominant fresh, or brackish water influence.

Unit Dd. (Bahgallah Fm. Equivalent)

In the Pretty Hill No. 1 well, this unit is well-defined and occupies the interval between 2160 feet and 2030 feet.

The S.P. curve shows little disturbance but the resistivity curve shows a series of sharp peaks, and is generally higher than for unit Gb. The peaks coincide with the well cemented oolitic and pelletal horizons, above and beneath which are dark brown, micaceous, pyritic siltstones The ooliths are chiefly brown, or green and are embedded in a matrix of ferriferous chlorite, which ranges in colour from dark-green to dark-brown and even black. Pyrite is abundant, and rare pyrite-cemented oolite occurred in cuttings samples.

Thin section examination of cuttings reveals that the colour differences reflect clear compositional differences between ooliths, pellets, and cement, or matrix. Ferriferous chlorite, the principle cementing medium, is green, and finely crystalline; various stages of sideritisation of the cement are visible, and where it is most advanced, there appears to have been conversion of the cementing medium, to brown hydrous oxides or iron. Siderite frequently occurs as subspherical aggregates showing radial arrangement of constituent crystals.

An additional process of chemical differentiation involves removal of iron from the cement into either the ooliths and pellets or to segregations within the cement. The ferriferous chlorite is left as remmant patches, surrounded by a clay mineral which also outlines the iron-enriched ooliths. The exact composition of the clay mineral is not known but it is probable that it was formed by the removal of iron from the ferriferous chlorite.

In ooliths, quartz grains commonly are the nuclei, around which concentric layers of ferriferous chlorite (apparently chamosite) have accumulated; in other ooliths the nuclei appear to have been of the same composition as the cementing medium. Pellets, which tend to be light brown in colour are replaced partly or completely by siderite, and their outlines are preserved.

The concentric laminae of the ooliths are often selectively replaced, most probably as a result of primary compositional differences between laminae. Variation in composition of the oolitic coating reflects primary changes in the chemical depositional environment.

In the thin sections examined some clastic quartz and lithic material, thinly coated with iron oxide and traces of phosphatic material is present. Varied and extensive diagenetic changes make it difficult to make any inference about depositional environment.

The chemical environment would appear to have been approximately neutral with respect to both redox potential and pH. Chemical precipitation accounts for most of the sedimentation, the supply of terrigeneus material having fallen off as the regression reached its final extent, and shallow water conditions of high-energy were produced over large areas. On the evidence available, and that gained from elsewhere (Kenley, 1954) the base of unit is considered an unconformity. In this part of the basin, the unconformity may take on the character of a 'paraconformity' (Dunbar & Rodgers 1957. - - - 'Flat plane of unconformity with no angular discordance- -').

No fossils were found in this unit. In core 2 (1836-16 feet) of unit Db however, a molluscan and foraminiferal fauna "---characteristic of the Pebble Point and Bahgallah Formations"... (F.-B.H. 1962) is described, the fauna is considered to be typical of the Palaeocene. It is evident that Unit Dd is of probable Palaeocene age though the upper boundary of the Palaeocene is at least 200 feet above it.

Unit Db. ("Dartmoor Fm.")

The base of the unit is at 2030 feet and the top at 1284 feet; it may be divided into two sub-units.

Sub unit Db2

The following three intervals which compose sub-unit Db2 are described:

Interval 2030-1910 feet

The moderately to well sorted sandstones of this interval vary in grain-size from coarse to very coarse. The sandstone is light greenish-grey in colour which on closer examination is found due to an unusually large amount of green quartz grains.

At approximately the same horizon in Port Campbell No. 1 well (2325-2110 feet), similar coloured quartz grains were noted. In both cases the sand grains were coated with greenish clay material which also filled embayments and formed vermicular cavities within the grains themselves. Should similar features be found at comparable horizons in other wells, this observation may deserve further evaluation as a criterion for correlation.

With respect to rounding and surface texture of the grains this interval shows greater affinity to the underlying strata, than to those above. The grains are subangular and show slight frosting similar to that described for the sands of units Gb and Gd.

Some feldspar and lithic grains are present. Lithic grains are mainly chert and metaquartzite and are the same as those found in underlying units.

No cement was found in cuttings samples, so thin-sections were made of grains from the loose sand for closer examination. Most grains had no coatings at all although some contained siderite in embayments.

Interval 1910-1770 feet

In the lower part of the interval (1910-1850 feet) the cuttings contained fragments of hard, brown, crystalline siderite rock together with a less hard, silty lithology. Thin section examination shows that the slight variation in hardness and tightness, appears due to differences in siderite crystal size and in the content of sandy material, Some sandy siltstones are partly sideritised.

The clastic material present is the same as that in the 2030-1910 feet interval, with the addition of some chloritic pellets.

Dark brown, micaceous, carbonaceous and pyritic mudstones and siltstones form the upper part of the interval. Fine interlamination of these rock types is apparent in core 2 and the rocks appear to be slightly gypsiferous. S.P. and resistivity log values are uniformly low.

Interval 1770-1600 feet

The sandstones of this interval are distinguishable from those found between 2030-1910 feet in the degree of rounding, surface texture, and composition. No definite evidence of the nature of the cement was found although thin-sections of grains showed carbonate adhering to, and enclosed within, some of the grains. The cuttings samples contained mostly loose sand and suggest very poor cementation.

No green quartz was present, but rose-pink and smoky quartz was common. Pyrite and muscovite are abundant accessory minerals and amber occurs in many samples. No change in the nature of the lithic grains was noted.

The grains generally exhibit a relatively high polish and are distinct in this respect from those of the lowest interval of the sub-unit.

Thin beds of calcite-cemented feldspathic sandstone and thin, dark-brown micaceous siltstones constitute the remainder of the interval.

Sub-Unit Db_1

Interval 1600-1284 feet

The cuttings samples contain loose sands very similar to those of the underlying interval. Thin-section study of grains again revealed no cement, and the only conclusion which can be drawn is that cementation was poor. Fragments of sideritised dolomitic sandstone in some samples are probably cavings from unit Bc. Pyrite, muscovite and amber occur in accessory amounts.

Coal seams, present at several horizons, are particularly well represented in cuttings between 1400-1380 feet. Some thin silty intervals are carbonaceous, micaceous and pyritic.

The sediments reflect a gradual change in depositional environment from marginal marine to non-marine and paralic, upward through the unit. This is best illustrated by the disappearance of carbonate-bearing rocks and the occurrence of coal seams in the sub-unit Db1.

As far as can be detected, the sandstones above 1910 feet, show no change in texture or composition. The sandstone of the lower interval of sub-unit Db_2 below 1910 feet appears to be atypical of the sequence as a whole and more closely related genetically to the sandstones of units Gb and Gd. It is possible that the lower interval of Db_2 owes its origin to reworking of units Gb and Gd.

Unit Bc. (Nelson Formation Equivalent)

In the well completion report (F.-B.H. 1962) this unit was considered absent, although a local depositional break was postulated. Cuttings show however, a distinct sandy ferruginous interval between 1284 feet and approximately 1250 feet.

Cuttings are of medium to coarse-grained loose sand, many grains of which are coated with iron oxide. Core 1 (1282-1284 feet) is medium-brown, compact, silty limonitic carbonate rock containing coarse-grained, angular, ill-sorted sand grains and ooliths. It is slightly fossiliferous. In thin section the rock is dolomitic, though much sideritised. The abundant ooliths are recrystallised but the original outline is preserved. Quartz and some metaquartzite, with minor oligoclase feldspar and phosphatic material constitute the clastic fraction of the rock.

The sediment of core 1 appears to have been the product of very slow sedimentation in turbulent, shallow water, within a marginal marine environment. This marks a distinct change from the paralic depositional environment suggested for the underlying deposits.

It is not possible to determine whether or not an unconformity exists, but it seems highly probable, in view of the abrupt change in lithology.

Unit Bb. (Gambier Ls.)

Unit Bb is encountered between 1250 feet and 40 feet. The unit was subdivided into four intervals. Each interval is well marked lithologically and by the electric logs. The rocks reflect very little change in depositional environment from Unit Bc and are grouped together informally, as one unit.

Interval 1250-1120 feet.

The deposits of this interval are mostly fairly-hard, pink to reddish-brown, slightly dolomitic calcarenites, with minor marly intercalations, which are distinguishable in the electric logs but are not represented in the cuttings.

Colouration, due to finely disseminated iron-oxide, becomes slightly less pronounced towards the top of the interval, this being the only apparent change in general lithology.

Porosity and permeability are high throughout. The rock is composed, chiefly of polyozoal debris with several varieties of foraminifera and molluscs. Thin-section of the rocks shows that some of faunal remains have glauconitic infillings.

No significant fluctuation is obvious on the calcilog graph, but the insoluble residues are of slightly variable composition. Limonite ooliths with quartz-grain nuclei and clear quartz grains are most abundant in the lower part of the interval. Glauconite, in various stages of oxidation becomes more abundant upward. Study of the fauna between 1220 feet and 1160 feet, carried out by Frome-Broken Hill, (1962) indicates that this interval is no older than basal Longfordian (upper Oligocene).

Interval 1120-420 feet

The cuttings consist mostly of skeletal debris, sometimes up to 90%. Marl is poorly represented and it is inferred, in view of the uniformity of the electric logs within the interval, that the marl has been carried away in the drilling mud. The result has been the concentration of the coarser skeletal debris.

Polyozoa and foraminifera are most abundant with scaphopods, gastropods, echinoids, pelecypods and annelids. Fish teeth and scales are also present.

The base of the marl, below 1000 feet is considered to be of Longfordian age.

Glaucophane is commonly found in the insoluble residues, and a pale green coloured variety of rutile was found in a few samples. Well-polished quartz grains and small glauconite pellets are abundant throughout in the insoluble residues. Argillaceous material is most abundant in the upper part of the interval.

Interval 420-50 feet

These rocks are a uniform sequence of friable, cream to buff-coloured biocalcarenites which are both porous and permeable.

Foraminifera and polyozoa, with echinoid fragments form the bulk of the rock, with a conspicuously larger proportion of ostracods, and brachiopods than was observed in the lower intervals.

Though glaucophane occurs in many insoluble residue samples, it is rare. Quartz and glauconite pellets constitute the greater part of the samples.

Interval 50-40 feet

This cuttings sample was of a hard dark red-brown, extremely ferruginous quartzose sandstone. Traces of this lithology occur as caving for several hundred feet.

CONCLUSIONS

The light grey garnetiferous protoquartzites of unit R and the grey and greenish-grey chloritic siltstones, subgraywackes and volcanic sandstones of unit M make up almost 5000 feet of sediments. Heavy mineral content and sand/shale ratio respectively have been used to establish subdivisions which may however be of only restricted applicability. Unit J, the Waarre Formation equivalent is not present. The upper Cretaceous sediments, units Gh, Gf, Gd and Gb are well characterised lithologically, also unit Dd (the "Bahgallah Formation" equivalent), of?Palaeocene age. The coarse-grained orthoquartzitic sandstones of unit Db, overlain by the marls and biocalcarenites of units Bc and Bb, have been divided into 2 subunits.

Unit R overlies?basement rock with unconformity. The brackish-water sediments of Unit R are followed upwards by the immature non-marine deposits of unit. Emergence, transgression and increase of salinity to brackish-water conditions are reflected through units Gh, Gf, and Gd. A regression culminates with the deposition of unit Dd. Renewed transgression with a temporary reversion to paralic conditions in unit Db times eventually gives way to full marine conditions in unit Bc times.

Orthoclase and sodic plagioclase in unit M replace the microcline of unit R, as the dominant feldspar and the abundant garnet is confined to unit R. Lithic grains are metaquartzitic or rarely of acidic volcanic origin in unit R, but in unit M acid to intermediate volcanic rocks are dominant among the lithic fraction. In rocks younger than lower Cretaceous, lithic material is confined to metaquartzitic types.

The kaolinite cement for unit R is replaced to some extent by siderite. In unit M, calcite replaces chlorite cement and corrodes labile grains extensively. The origin of the calcite is not known. Unit Gd contains siderite and calcite cement and units Gh and Dd contain limonite and chlorite cemented intervals. Jurassic rocks may be present below approximately 7200 feet in unit R and definite L.Cretaceous rocks below core 16 (5935-47 feet). Between this horizon and 2929 feet the rocks are of undifferentiated Cretaceous age. The Cretaceous-Tertiary boundary lies either in topmost unit Gd or within unit Gb. The Palaeocene-Eocene succession extends from the base of unit Dd up to 1284 feet. Above this the succession is considered to be of Oligocene-Miocene age.

Unit R sediments appear to have been derived from a regionally metamorphosed area and unit M sediments from an area of abundant acidic and intermediate volcanic extrusive rocks, and low-grade metamorphic rocks.

With regard to the petroleum possibilities, the extent and structure of unit J (absent in the Pretty Hill No. 1 succession) which posesses good reservoir characteristics (F.-BH 1964) deserves more detailed study toward the east. High porosity and v. low to zero permeability characterises unit M. The reservoir characteristics of unit R are of a high order, though only a trace of gas was detected from a coal stringer (F.-B.H., 1962). Units Gb, Gd and Dd also appear to posess good reservoir characteristics.

The conception of the Pretty Hill No. 1 succession as a condensed sequence is borne out by the petrological study and by independent microfaunal studies (F.-B.H. 1962).

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APPENDIX I

CORE ANALYSIS SAMPLE DESCRIPTIONS

Core 1 (1284-86 ft.).

Medium yellowish brown (10YR 5/2), soft faintly laminated, very poorly sorted sideritic siltstone. Major clastic constituents are quartz and muscovite, and abundant carbonaceous matter. Grains are coated with limonite and are siderite cemented. Porosity is very high and permeability low (35% and 3-4md respectively.) Siderite cement probably accounts for the high bulk density (S.G. Siderite = 3.83 - 3.88)

Core 2 (1816-18 ft.).

Dark, yellowish brown (10YR 3/2), soft, slightly fissile, thinly laminated, well sorted siltstone. Quartz, carbonaceous material, micas and pyrite are the main constituents in order of abundance. Lamellibranch valve fragments are present. Epidote and tourmaline are accessory minerals. Pyrite tends to be mainly spheroidal and interstitial. The small amount of argillaceous matrix explains the very high porosity (40%) and the relatively low bulk density.

Core 3 (2373 - 83 ft.).

No recovery.

Core 4 (2383 - 2403 ft.).

Dark yellowish brown (10YR 3/2), soft, slightly fissile, thinly laminated, well sorted, siltstones and claystones. The clastic material is dominantly quartz with minor feldspar (untwinned). The rock contains abundant carbonaceous material and mica flakes, and is slightly pyritic, gypsiferous and sideritic. The high porosity appears due to the relatively good sorting. Interlamination of clays with siltstones explains the low vertical permeability value. The reason for the high horizontal permeability could be either

i) "interlaminar" permeability (permeation along bedding planes),

or ii) permeability attributable to shrinkage cracks which are parallel to bedding - assuming these were present at the time of core analysis.

Core 5 (2716 - 26 ft.).

No recovery.

Core 6 (2728-30 ft.).

Very dark greenish grey, soft, very glauconitic argillaceous siltstone. Glauconite pellets constitute up to 50% of the rock; carbonaceous matter, mica flakes and pyrite are abundant. Porosity is very high and permeability moderate. The high bulk density is due to the abundance of iron pyrites (S.G. = 4.95-5.1). This lithology is also subject to shrinkage cracking and an anomalously high permeability may be given.

Core 7 (2928-40 ft.)

Medium grey (N5) friable, subangular fine-grained, poorly sorted, subgraywacke. Aphanitic, siliceous and andesitic fragments, with rare metaquartzite fragments constitute the lithic fraction (up to 50%). Quartz and feldspar are each approximately 7%. Pore spaces are rimmed with chlorite and partly infilled with zeolite. Porosity is very high (38%) and permeability is moderate (70md). Low grain density (no high density grains are present in quantity) and high porosity are responsible for the abnormally low bulk density of 1.65.

Core 8 (3342-44 ft.)

Light grey (N7), compact, thickly bedded argillaceous siltstone. Abundant chlorite and hydromica, flakes of carbonaceous material and plant remains. Porosity is very high (32%) and permeability nil.

Core 9 (3812-14 ft.)

Slightly yellowish grey, compact, finely interlaminated claystones and carbonaceous argillaceous siltstones. Chlorite, mica and hydromica are abundant. Small scale cross-bedding present.

Porosity is high (26%V, 27%H) and permeability very slight (3md-horizontal), and nil (vertical).

Core 10 (4317-19 ft.)

Light grey, slightly carbonaceous claystone and minor interlaminated siltstones which are chloritic and hydromicaceous. Root traces are visible in the sample, also numerous penecontemporaneous small scale deformation structures: slumping, faulting and folding.

Porosity is high (25%) and permeability nil.

Core 11 (4635-40 ft.)

Light grey, compact, chloritic silty claystone with inclusions, and interlaminae, of siltstone. Slight penecontemporaneous deformation. Bedding indistinct. Porosity 22% and permeability nil.

Core 12 (4640-42 ft)

Light olive grey, compact, indistinctly bedded, chloritic argillaceous siltstone. Traces of carbonaceous material and abundant hydromica. (?) Root traces present. High porosity (22%) and nil permeability.

Core 13 (4940-4961 ft.)

Light grey (5B 7/1) compact, poorly laminated, moderately sorted, subangular, very fine to fine-grained subgraywacke. Lithic material abundant (40%), feldspar and quartz each approximately 10%. Matrix kaolinitic and slightly calcareous. Porosity is high (22%) and permeability nil. The slight calcitisation is the most likely cause of the nil permeability, blocking off adjacent pore spaces.

Core 14 (5400-20 ft.)

Light grey, subangular, poorly sorted, fine to medium-grained subgraywacke. Lithic grains (40%) abundant; quartz and feldspar each 20%. No bedding visible in sample. Cement chloritic, slightly kaolinitic, and distinctly calcareous. It is evident that the elimination of permeability and reduction in porosity has been caused by the introduction of calcite.
Porosity 18% (H); 20% (V)

Permeability nil.

Core 15 (5420-24 ft.)

Light grey sandstone (as core 14), with abundant claystone pellets up to 1 cm.in length. Probable intraformational "conglomerate". The matrix is chloritic and kaolinitic. Introduction of calcite into pore spaces of this sandstone has eliminated permeability (as in core 14).
Porosity 21% (H).
Permeability Nil.

Core 16 (5935-47 ft.)

Interbedded light grey (N7) siltstones and medium grey claystones, showing much penecontemporaneous deformation. Matrix kaolinitic and very slightly calcareous. Sample shows fracturing at approximately 45°. Porosity 19% (V), 18% (H). Permeability has been completely eliminated by calcitisation, as in cores 14 and 15.

Lack of permeability in all samples of unit M lithology (cores 7 to 16 inclusive) except core 9, can be explained as either due to

a) very fine porosity, as in argillaceous sediments;
or b) calcitisation; (as in cores 14, 15 and 16) the introduction of calcite tends to block pore connections (i.e. accumulation or precipitation tends to occur at points of grain contact), thus obliterating permeability before noticeably affecting the porosity.

The lower density values of samples from unit R (Cores 17 to 21 inclusive) is marked. The low bulk density values are due to the high porosity together with the lower grain density. The dominance of quartz and the absence of minerals of high density (other than very minor siderite) is characteristic of this lithology.

Core 17 (6070-80 ft.)

Very light grey, friable, subangular to subrounded, moderately sorted, fine to medium-grained garnetiferous sandstone. The kaolinite cement which is partly replaced by siderite, appears to fill in all porosity. The high porosity found in analysis must be due to very fine interstices. This type of porosity (measured with gas), would be much less effective for liquids.
Permeability is low (2md-V)

Core 18 (6376-88 ft.)

Light yellowish grey, slightly friable, angular to subrounded, poorly sorted very fine to coarse-grained orthoquartzitic sandstone, containing abundant pink garnets. Examination with the binocular microscope, and in thin-section, reveals very high, coarse porosity and a relatively slight patchy development of kaolinite. Measured porosity is high (22%) and permeability very high (2,097 md, vertical; 2,756 md, horizontal)

Core 19 (6690-6702 ft.)	Light, yellowish grey (5Y 8/1), slightly friable, angular to subrounded, poorly sorted, very fine to coarse-grained orthoquartzitic sandstone containing abundant pink garnets. More extensive development of kaolinite cement than present in core 18, and slight sideritisation (as observed in binocular examination and in thin-section), has little effect on porosity (25%-V, 21%-H), though permeability is lower than in core 18 (967md-V, 363 md-H.).
Core 20 (7200-14 ft.)	Light yellowish grey (5Y 7/2), well cemented, angular to subrounded, poorly sorted, very fine to very coarse-grained garnetiferous sandstone. The well developed kaolinite cement is extensively replaced by siderite (rhombohedral). Porosity is high (23%-V, 22%-H), though it is evidently a very fine type of porosity unlike that of core 18. Permeability is correspondingly lower - 198 md (V), 197md (H).
Core 21 (7585-7597 ft.)	Light yellowish grey (10YR 8/2), well cemented, angular to subrounded, poorly sorted, v. fine to coarse-grained garnetiferous sandstone. Kaolinite cement, partly replaced by rhombohedral siderite. Porosity and permeability are high; 20% V, 19% H and 526 md - V, 865 md - H, respectively.
Cores 22 and 23 (7885-87 ft., 8115-17 ft.)	Hard, very dark green (5Y 2/1), aphanitic igneous rock with lighter coloured phenocrysts. Fractures which are most marked in core 23, are generally infilled with calcite or chlorite. The high porosity could be due to the abundance of fractures; this is contradicted by the lack of permeability however. No porosity is apparent in thin-sections examined, and to explain the very high value determined (37%) the presence of sub-microscopic pore spaces accessible to gases only must be envisaged. These pore spaces could be made more accessible to gaseous media by the fractures mentioned above.

Petroleum Technology Laboratory, Bureau of Mineral Resources Geology and Geophysics Canberra

Date: 4th December, 1964

CORE ANALYSIS RESULTS

Notes:- (i) Unless otherwise stated, the porosities and permeabilities were determined on two small plugs (V & H) cut at right angles from the core or sample. Ruska porosimeter and permeameter were used, with air at 30 p.s.i.g. and dry nitrogen, respectively, as the saturating and flowing media. (ii) Residual oil and water saturations were determined using Soxhlet type apparatus. (iii) Acetone test precipitates and fluorescence of solvent after extraction are recorded as, nil, trace, fair, strong or very strong.

Well or Area	Core or Sample No.	Depth in ft. From:- To:-	Lithology	Effective Porosity in % by Vol		Absolute Permeability in Millidarcys		Avg. density in gms./cc		Fluid Saturation in % Pore Space.		Acetone Test		Solvent after Extraction.		Remarks
				V	H	V	H	Dry Bulk	Apparent Grain	Water	Oil	Colour	Precip-Itate	Colour	Flour	
Pretty Hill No. 1	1	1284' 1286'	Siltstone and shale	35	35	3	4	2.00	3.08	27	Trace	Orange	Very Strong	Trace	Trace	
	2	1816' 1818'	siltstone and sandstone	40		N.D.		1.84	3.03	48	Nil	Pale yellow	Nil	Trace	Fair	Pieces only insufficient for plugs
	3			NIL CORE RECOVERY												
	4	2389' 2391'	Siltstone and sandstone	36	37	Nil	33	1.91	3.08	21	Trace	Pale yellow	Very strong	Trace	Trace	Pyrites obvious
	5			NIL CORE RECOVERY												
	6	2728' 2730'	Siltstone and sandstone	N.D.	42	N.D.	39	1.95	3.39	30	Nil	Trace	Nil	Nil	Trace	All vertical plugs crumbled
	CORE NO 7 REPORTED OCTOBER 1962															
	8	3342' 3344'	Siltstone	32	32	Nil	Nil	2.00	2.93	31	Nil	Pale yellow	Nil	Pale yellow	Fair	

Petroleum Technology Laboratory, Bureau of Mineral Resources Geology and Geophysics Canberra.

CORE ANALYSIS RESULTS

Date: 4th December, 1964

Notes:- (i) Unless otherwise stated, the porosities and permeabilities were determined on two small plugs (V & H) cut at right angles from the core or sample. Ruska porosimeter and permeameter were used, with air at 30 p.s.i.g. and dry nitrogen, respectively, as the saturating and flowing media. (ii) Residual oil and water saturations were determined using Soxhlet type apparatus. (iii) Acetone test precipitates and fluorescence of solvent after extraction are recorded as, nil, trace, fair, strong or very strong.

Well or Area	Core or Sample No.	Depth in ft. From:- To:-	Lithology	Effective Porosity in % by Vol		Absolute Permeability in Millidarcys		Avg. Density in gms/cc		Fluid Saturation in % Pore Space		Acetone Test		Solvent after Extraction		Remarks
				V	H	V	H	Dry Bulk	Apparent Grain	Water	Oil	Colour	Precip-itate	Colour	Fluor	
Pretty Hill No.1	9	3812' 3814'	Sandstone	26	27	Nil	3	2.09	2.83	11	Nil	Faint trace	Nil	Nil	Trace	Pyrites obvious
	10	4317' 4319'	Siltstone and shale	25	25	Nil	Nil	2.13	2.88	17	"	Pale yellow	Trace	Pale yellow	Fair	Pyrites obvious
	11	4635' 4640'	Siltstone and shale	22	22	"	"	2.23	2.84	16	"	Pale yellow	Trace	Pale yellow	Fair	Pyrites obvious
	12	4640' 4642'	Shale	22	22	"	"	2.25	2.89	23	"	Trace	Nil	Trace	Trace	
		CORES NOS. 13 AND 14 REPORTED OCTOBER 1962														
	15	5420' 5424'	Sandstone	N.D.	21	N.D.	Nil	2.18	2.74	21	Nil	Trace	Nil	Nil	Trace	Small pieces only No "V" plug
		CORES NOS. 16 TO 21 REPORTED OCTOBER 1962														
	22	7885' 7887'	Dolerite	6	3	Nil	Nil	2.74	2.85	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	Pyrites obvious

Additional Information:

General File No. 62/399
Well File No. 62/115

Petroleum Technology Laboratory, Bureau of Mineral Resources, Geology and Geophysics Canberra.

Date: 15th October, 1962

CORE ANALYSIS RESULTS

Note: (i) Unless otherwise stated, the porosities and permeabilities were determined on two small plugs (V & H) cut at right angles from the core or sample. Ruska field porometer and permeameter were used, with air and dry nitrogen, respectively, as the saturating and flowing media. (ii) Oil and water saturations were determined using Soxhlet type extraction apparatus. (iii) Acid solubilities were determined using 15% commercial hydrochloric acid. (iv) N.D. means Not Determined.

Well or Area	Core or Sample Number	Depth in ft. From:- To:	Effective Porosity % by Vol.		Absolute Permeability Millidarcies		Avg. density in gms/cc		Fluid Saturation			Acid solubility % by vol.	Oil Characteristics			Virgin Bulk Dens. gms/cc	Salinity of core water P.P.M. Na cl.
			V	H	V	H	Dry bulk	Grain	Water: % pore space	Oil: % pore space	Oil: Metric tons/acreft		Fluorescence in solvent	Colour of extracted oil	Fluorescence of extracted oil		
Pretty Hill No. 1	7	2928' 2940'	N.D.	38	N.D.	70	1.65	2.66	82	Nil	Nil	Nil	N.D.	Nil Oil	N.D.	1.96	17,350
"	13	4940' 4961'	25	24	Nil	Nil	2.04	2.71	80	1	3	25	Bluish-white	Yellow-brown	Whitish-yellow	2.24	21,100
"	14	5400' 5420'	20	18	Nil	Nil	2.20	2.71	95	Not Measurable		30	Bluish-white	N.D.	N.D.	2.38	19,900
"	16	5935' 5947'	19	18	Pencil split	Nil	2.29	2.80	77	3	6	21	Strong bluish White; green-yellow bloom	Yellow brown	Greenish yellow	2.44	21,600
"	17	6070' 6080'	24	22	2	No pencil	2.07	2.65	80	Not Measurable		9	Faint bluish-white	N.D.	N.D.	2.26	18,400
"	18	6376' 6388'	22	22	2,097	2,756	2.07	2.64	70	Nil	Nil	13	Nil	Nil Oil	N.D.	2.22	6,250

Additional information: Acetone Tests: Core No. 7 - Negative
" " 13 - Faint positive
" " 14 - Negative
" " 16 - Positive
" " 17 - Faint positive
" " 18 - Negative

General File No. 62/399

Well File No. 62/1115

Petroleum Technology Laboratory, Bureau of Mineral Resources, Geology and Geophysics, Canberra.

Date: 13th November, 1962

CORE ANALYSIS RESULTS

Notes (i) Unless otherwise stated, the porosities and permeabilities were determined on two small plugs (V & H) cut at right angles from the core or sample. Ruska field porometer and permeameter were used, with air and dry nitrogen, respectively, as the saturating and flowing media. (ii) Oil and water saturations were determined using Soxhlet type extraction apparatus. (iii) Acid solubilities were determined using 15% commercial hydrochloric acid (iv) N.D. means Not Determined.

Well or Area	Core or sample number	Depth in ft. from: to:	Effective porosity % by vol.		Absolute permeability millidarcys.		Avg. density in gms/cc		Fluid saturation			Acid solubility % by vol.	Oil Characteristics			Core Water salinity P.P.M. Na Cl.
			V	H	V	H	Dry Bulk	Grain	Water: % pore space	Oil; % pore space	Oil: Metric tons/acre ft		Fluorescence in solvent	Colour of extracted oil	Fluorescence of extracted oil	
Pretty Hill No. 1	19	6690' 6702'	25	21	967	363	2.11	2.73	79	Nil	Nil	N.D.	Nil	Nil Oil	N.D.	3,140
"	20	7200' 7214'	23	22	198	197	2.15	2.77	81	"	"	"	"	" "	"	2,990
"	21	7585' 7597'	20	19	525	865	2.19	2.72	74	"	"	"	"	" "	"	3,200

Additional information: Acetone tests carried out on all samples gave negative results

General File No. 62/399

Well File No. 62/1115

Petroleum Technology Laboratory, Bureau of Mineral Resources Geology and Geophysics Canberra.

Date: 4th December, 1964

CORE ANALYSIS RESULTS

Notes: (i) Unless otherwise stated, the porosities and permeabilities were determined on two small plugs (V & H) cut at right angles from the core or sample. Ruska porosimeter and permeameter were used, with air at 30 p.s.i.g. and dry nitrogen, respectively, as the saturating and flowing media. (ii) Residual oil and water saturations were determined using Soxhlet type apparatus. (iii) Acetone test precipitates and fluorescence of solvent after extraction are recorded as, nil, trace, fair, strong or very strong.

Well or Area	Core or Sample No.	Depth in ft. From: To:	Lithology	Effective porosity in % by vol.		Absolute permeability millidarcys.		Avg. density in gms/cc		Fluid Saturation in % Pore Space		Acetone Test		Solvent after Extraction		Remarks
				V	H	V	H	Dry Bulk	Apparent Grain	Water	Oil	Colour	Precipitate	Colour	Fluor	
Pretty Hill No.1	23*	8115' 8117'	Dolerite	37		Nil		2.44	3.81	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	

*NOTE increase in porosity and grain density compared with core No. 22

Because of this the above characteristics were checked and confirmed by three different methods (1) Air injection (2) Gas expansion (3) Washburn Bunting.

Additional Information:

General File No. 62/399

Well File No.

Plate I

COMPOSITE WELL LOG

PRETTY HILL Nº1

LAT. 38° 13' 30"
LONG. 142°07' 30"
ELEV. (GROUND) 189 ft. A.S.L.
SCALE 1 inch = 100 ft.

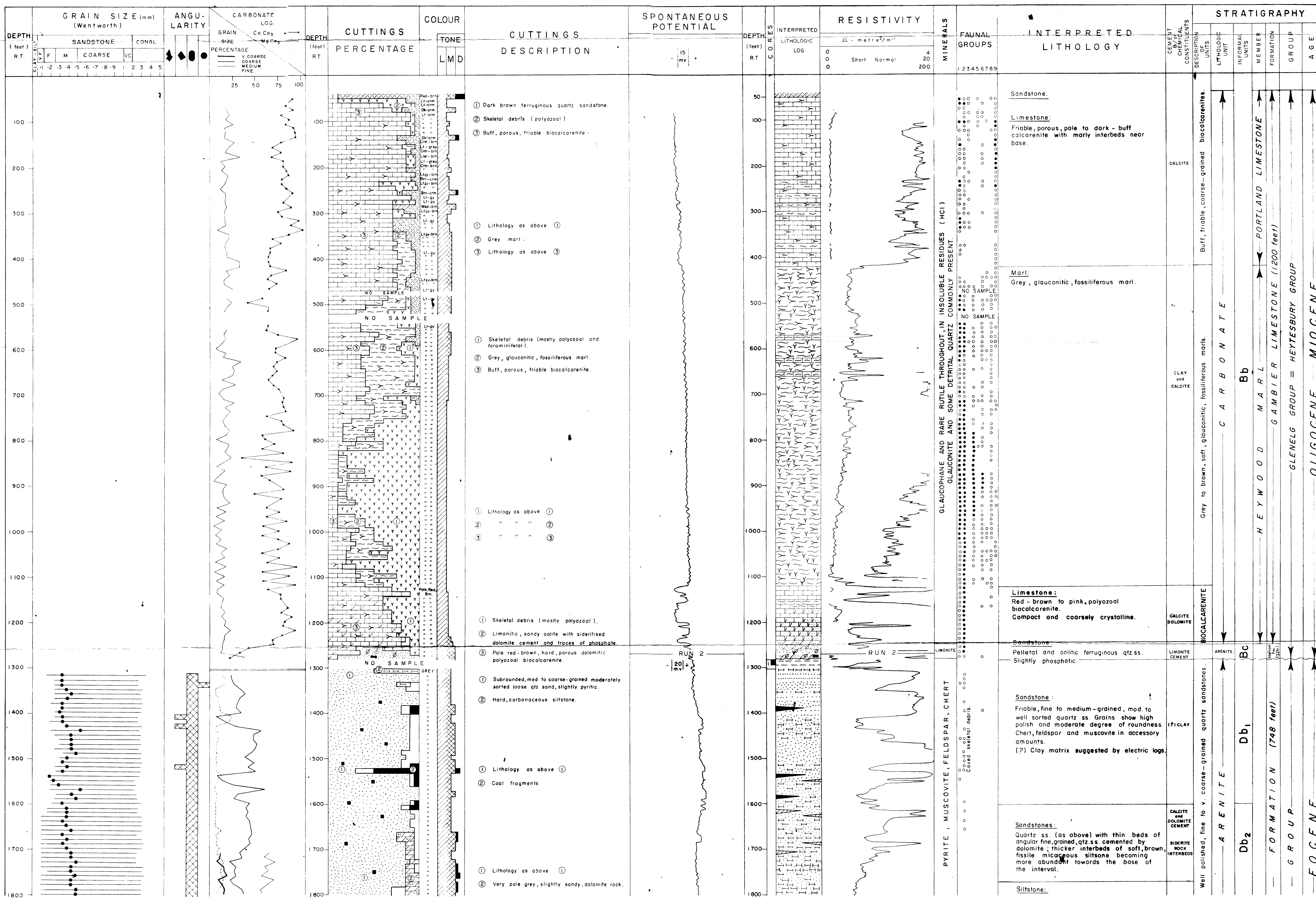
B.M.R. WELL INDEX Nº 156 (Core & Cutting Laboratory)

Company: FROME-BROKEN HILL Co. PTY. LTD.
Basin. OTWAY
State: VICTORIA

R E F E R E N C E

Sandstone.
Ferruginous quartz sandstone.
Siltstone.
Claystone.
Marl.
Limestone.
Sandy limestone and calcite - cemented sandstone.
Dolomite and sandy dolomite.
Dolomitic limestone and sandy dolomitic limestone.
Siderite and sandy siderite.
Coal.
Igneous rock.
Casing cement.
Y Skeletal debris
Phosphate
Pyrite
ø Limonite
Gypsum
Glauconite
Pellet
Oolith

FAUNAL GROUPS
1. Foraminifera
2. Polyzoa.
3. Ostracoda.
4. Gastropoda.
5. Brachiopoda.
6. Lamellibranchia.
7. Fish fragments.
8. Echinoid fragments.
9. Scaphopoda.
○ Present.
● Abundant.



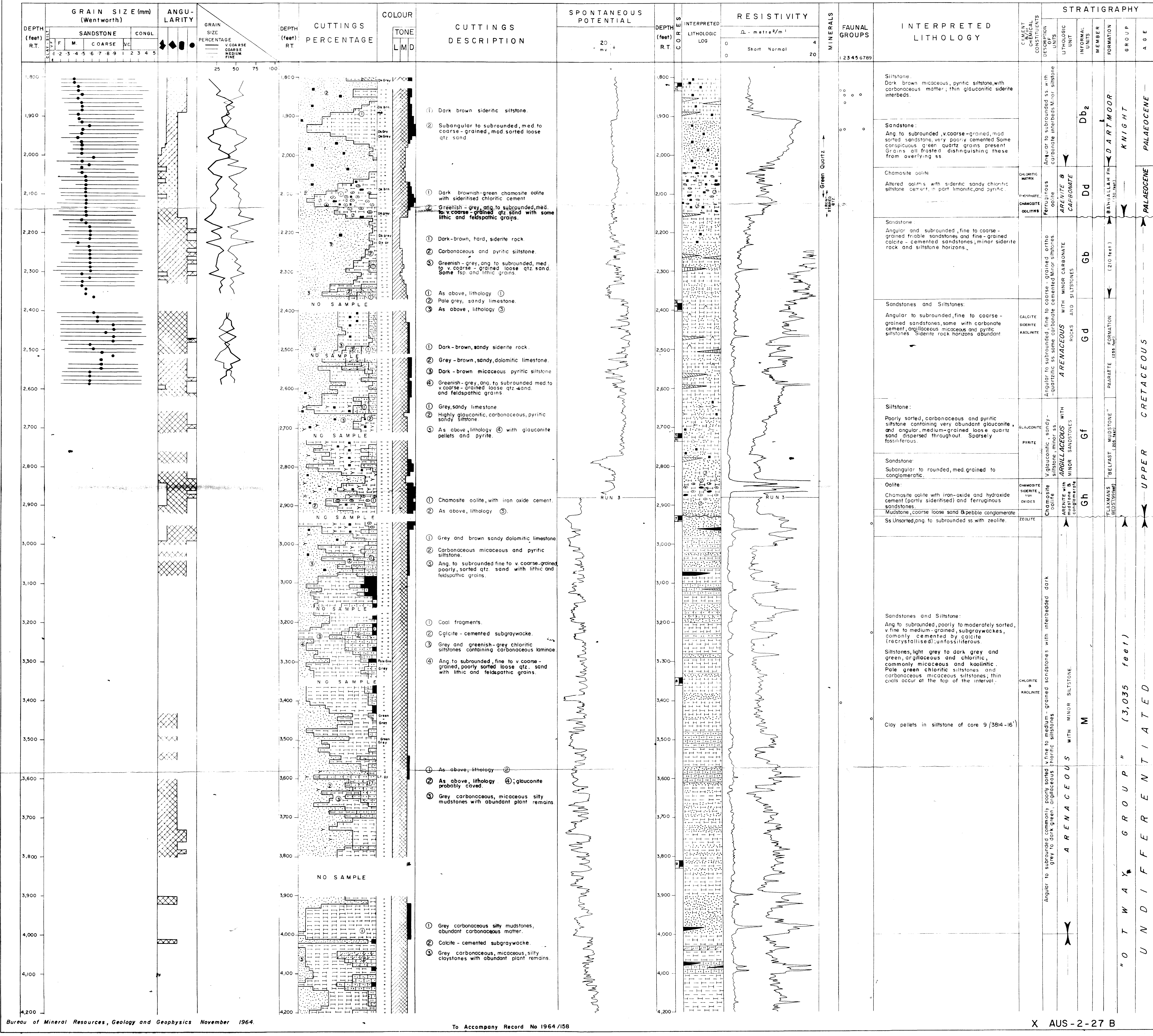
Bureau of Mineral Resources, Geology and Geophysics September, 1964.

To accompany Record No 1964/158

X AUS - 2 L 27A

Plate 2

PRETTY HILL No. 1

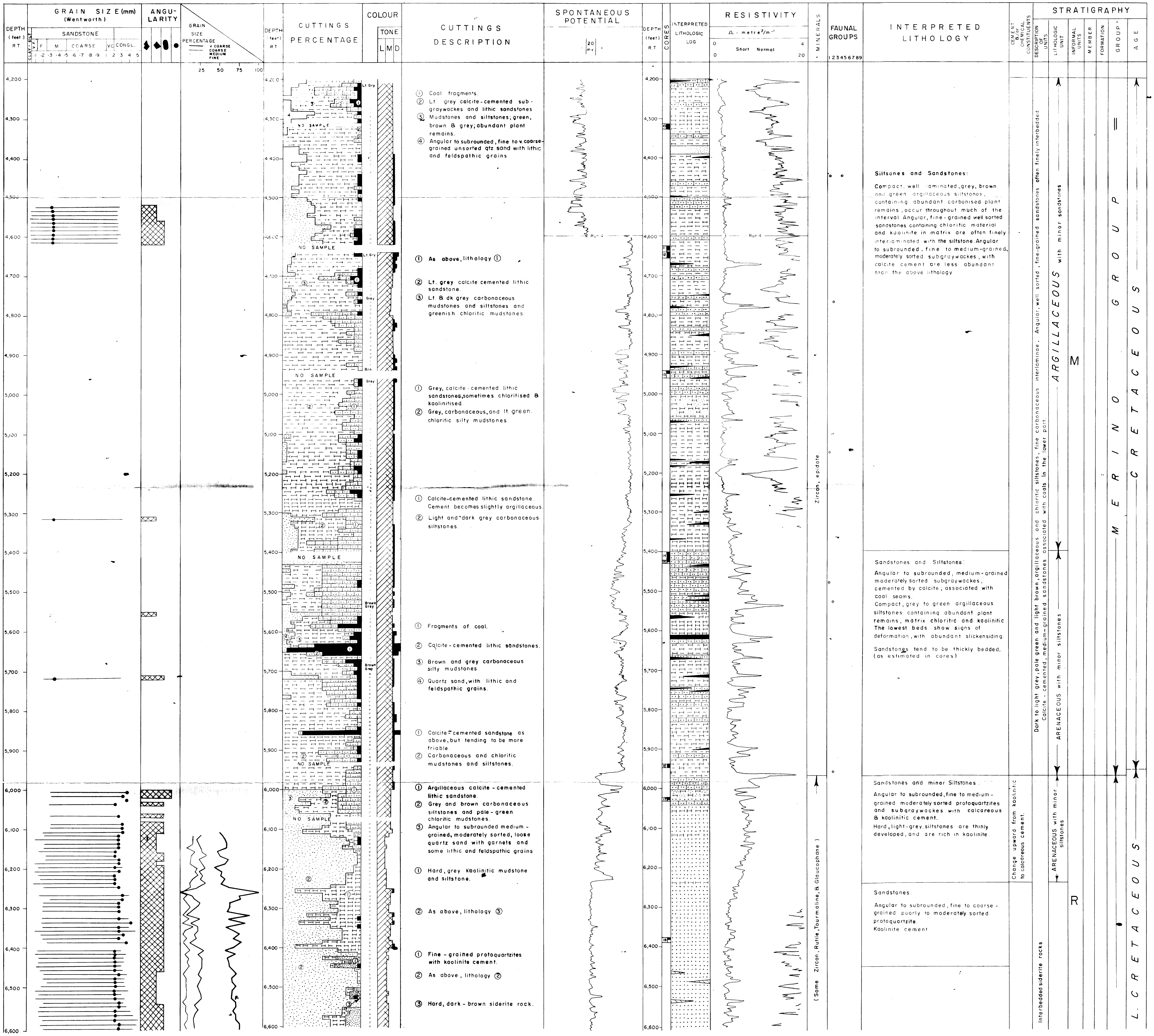


Bureau of Mineral Resources, Geology and Geophysics November 1964.

To Accompany Record No 1964/158

X AUS-2-27 B

PRETTY HILL Nº1



PRETTY HILL No 1