BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

RECORD 1984/33

SHALLOW STRATIGRAPHIC DRILLING, GEORGINA BASIN, 1978 AND 1980

by

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SUMMARY

Four fully-cored stratigraphic holes drilled in Cambrian rocks of the Georgina Basin in 1978 and 1980 are described in this record, along with some basic data on chemistry and mineralogy. Some of the rocks from the Currant Bush Limestone in BMR Mount Isa 1 and Camooweal 2 are sufficiently rich in organic carbon to be considered to be oil shales, although since these only occur as thin beds, they can only considered to be a minor occurence. These are the first samples taken from the Camooweal oil shale occurence since its discovery in 1945.

Detailed interpretation of sediments from these holes is included in several published papers and conference proceedings which are included in the references.

INTRODUCTION

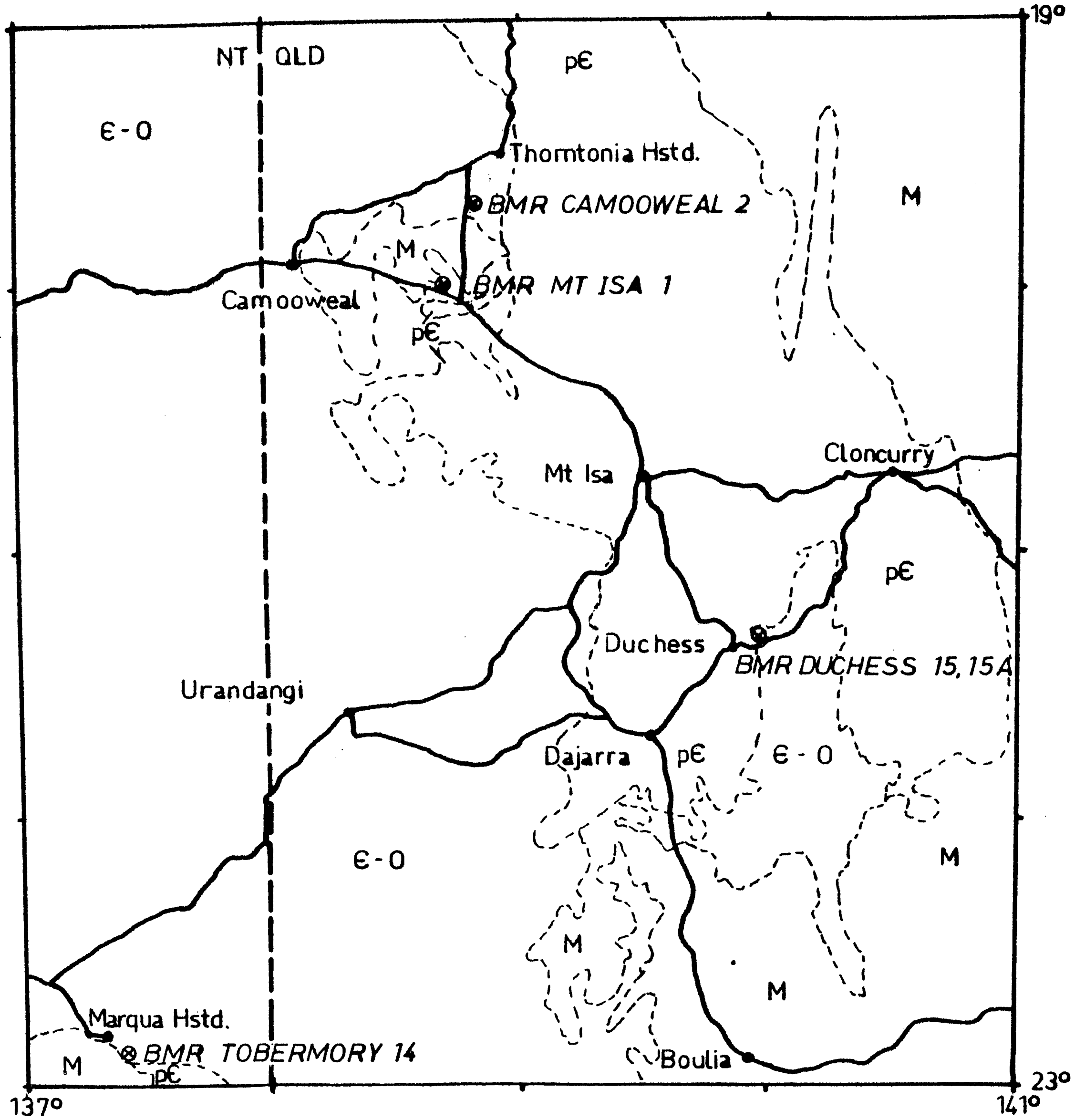
This report describes four fully cored stratigraphic holes drilled in the Georgina Basin in 1978 and 1980. Limited information on these has been given in the Georgina Research series of records (primarily Simpson, 1980b; also Simpson, 1980a; Shergold, 1979a, 1979b, 1981) and Shergold and Walter (1979), but furthur study of the cores has led to changes in the interpretation of lithology and stratigraphy, and hence this report supercedes earlier ones.

Organic-rich rocks were encountered in all the holes, but detailed study has been limited to those in BMR Mount Isa 1 and Camooweal 2, where black carbonate mudstones with organic carbon contents of up to 16% are present (Glikson & Gibson, in press; Gibson, in press; Gibson & Boreham, 1984; Gibson & Boreham, in press). The organic rich rocks in Mount Isa 1 and Camooweal 2 comprise the Camooweal oil shale occurrence, first described by Shepherd (1945), and since included in synopses of Australian oil shale as a little-known minor occurrence (e.g. Swarbrick, 1974; Raphael & Saxby, 1980; Gibson, 1981; Gibson & Rutland, 1981; Day, 1981, 1983a, 1983b).

The accompanying well logs (Plates 1 to 4) show generalised lithologies only, and irregularly bedded nodular limestone and mudstone is shown by a regularly repeating pattern of lithologies. However, the Currant Bush Limestone in Mount Isa 1 and Camooweal 2 has been logged in detail, and changes in lithology shown on the log reflect actual changes rather than being diagrammatic.

FIGURE 1.

LOCALITY MAP



M	Mesozoic rocks
Є-O	Georgina Basin
pЄ	Precambrian basement

100 km

BMR MOUNT ISA 1

Location: 20°01'S, 138°40'E; west side of north-south track connecting Barkly Highway with 40-Mile Plain bore, about 0.5 km from the bore (Fig. 1).

Purpose: To investigate reports of oil shale encountered during drilling of the 40-Mile Plain bore in the early 1940's (Shepherd, 1945); to provide general stratigraphic and lithological information.

History: Drilled in late 1978, no wellsite geologist (cores marked and packed by drillers). Drillsite selected by C.J. Simpson. Cored from 30.5 m to 250.6 m (total depth).

Lithology (see also Plate 1 and Appendix 1):

0-12.2	Cream sandy clay, with ferruginous fragments above 4.6, and chips of light grey fine dolomitic limestone below 7.6 (cuttings).
12.2-30.5	Light grey fine limestone (cuttings).
30.5-32.0	Nodular fine limestone, interbedded stylolitic black organic calcareous mudstone, skeletal wackestone.
32.0-41.4	Laminated grey-green calcareous siltstone or silty fine limestone, with rare thin massive beds of the same lithology. Contains sparse organic matter towards the base. Grades to:
41.4-42.3	Laminated tan coloured fine limestone with organic partings. Grades to:
42.3-44.7	Laminated green-brown silty limestone with thick massive laminae. Grades to:
44.7-45.3	Laminated fine limestone, with organic partings throughout, but concentrated in the lower 9 cm, along with some possible evaporite pseudomorphs.
45.3-45.4	Massive lime mudstone with rare spicules and skeletal fragments; large voids filled with sparry calcite; possible fenestral fabric.
45.4-46.2	Grey-green calcareous siltstone or silty limestone, massive in top 6 cm, then laminated with organic partings.
46.2-46.8	Tan nodular laminated fine limestone, with organic partings and one 7 cm bed of white micrite.

46.8-139.9	Repetitive cyclic sequence, cycles consisting of: 1. Tan, laminated, fine peloidal micritic limestone with minor organic lamellae. Laminae and thin beds of massive peloidal micrite (probably large, flat nodules); thin silicified zones (cherts), with bedding and organic matter preserved undistorted with respect to the surrounding rock may be present. Coarse pyrite common and rarer sphalerite present in cherts. Grades gradually up into: 2. Green-grey, laminated, fine silty limestone or calcareous siltstone, with increased organic content and rare early diagenetic nodules. Some laminae fining up. Grades over several cm up into: 3. Black to dark brown laminated, organic-rich carbonate mudstone, with variable silt content, and minor interlaminated white to pink micrite. This lithology is later referred to as oil shale. Where silicified (rare), organic content is much lower. Grades over several mm to lithology 1 above. Lithology 1 rarely exceeds 1 m thick in any cycle, lithology 2 ranges from 0 to 10 m, and 3 ranges from 2 to 15 cm (commonly 4 to 6 cm). Siltstone is slumped at 52.3-52.4 m. An unusual bed at 76.57-76.58 consists mainly of ragged analcite crystals set in a matrix of sparry calcite and barite, with scattered biotite (concentrated near the base of the bed), and detrital silt (only near the base of the bed). A volcanic origin seems most likely. The detrital silt consists of quartz, muscovite, and rare feldspar.
139.9-172.2	Cycles generally as above, but some organic-rich rocks occur over intervals of 0.5 m or more, with numerous laminae of rippled fine grainstone and/or beds of massive fine limestone.
172.2-172.7	Organic-rich carbonate mudstone with micrite laminae in the top 8 cm.
172.7-176.8	Grey-green laminated siltstone, bioturbated (?) above 174.2 m, slumped from 174.2 to 174.6 m, rippled from 174.6 to 174.8 m. Organic matter extremely sparse.
176.8-178.5	Laminated green-grey siltstone with organic lamellae and minor slumping.

178.5-182.1	Nodular fine limestone with laminated organic-rich carbonate mudstone between nodules.
182.1-182.6	Nodular calcareous siltstone.
182.6-208.1	Nodular fine limestone with laminated organic-rich carbonate mudstone between nodules. Silicified in part. Minor, partly dolomitised coarse grainstone laminae and thin beds between 201.3 and 201.5 m.
208.1-211.4	Nodular fine limestone as above, with interbedded partly dolomitised and silicified grainstone beds.
211.4-214.7	As above, but all lithologies strongly dolomitised. Glauconite abundant. Grainstone becomes abundant with depth.
214.7-214.8	Medium to very coarse dolomite grainstone with intraclasts up to 3 cm. Glauconitic, very pyritic.
214.8	Erosion surface.
214.8-231.4	Nodular fine dolomitic limestone. Rare thin beds of stylolitic black organic carbonate mudstone or calcareous shale.
231.4-250.6	Dolostone, strongly silicified in places, stylolitic, partly vuggy. Mainly wackestone and mudstone above 239 m, and mainly coquina and grainstone below. Minor stylolitic black shale.

Interpreted stratigraphy:

0-12.2	Regolith.
12.2-182.6	Currant Bush Limestone.
182.6-214.8	Inca Formation.
214.8-250.6	Thorntonia Limestone.

Palaeontological determinations (by J. Shergold and J. Laurie):

84.6 *Diplagnostus* sp. indet.
Linarssonia sp. indet.

BMR CAMOOWEAL 2

Location: 19°43'S, 138°48'E; 5.5 km southeast of Top Harris Waterhole, about 300 m east of the Yelvertoft-Thorntonia beef road (Fig 1).

Purpose: To determine whether oil shale similar to that in Mount Isa 1 is present in the Currant Bush Limestone and Inca Formation in this part of the Undilla Sub-basin; to provide general stratigraphic and lithological information.

History: Spudded 19-6-80. Cored from 3.6 m. Lost circulation at 128 m in porous dolomite, and drilled to TD of 132.4 m mainly without circulation, despite several attempts to cement cavities.

Lithology (see also Plate 2 and Appendix 2):

0-2.4	Regolith
2.4-5.7	Weathered fine silty limestone, silicified in part.
5.7-13.7	Laminated grey-green calcareous siltstone or very silty limestone, with minor organic lamellae. Occasional early diagenetic nodules. Grades to:
13.7-13.9	Tan coloured laminated fine limestone, with organic lamellae (dispersed in an early diagenetic nodule). Grades over 1 cm to:
13.9-79.4	Repetitive sequence as in Mount Isa 1: tan to pinkish coloured laminated fine limestone with organic lamellae, with intercalated massive micritic limestone and silicified patches, becoming siltier and grading up in most cases to laminated calcareous siltstone with organic lamellae, grading up to a thin dark organic-rich carbonate mudstone, which grades over a few mm to laminated limestone at the base of the next cycle. Two cycles (bases at 36.0 and 44.7 m) have two organic mudstone beds at their tops, separated by laminated limestone. Two organic mudstone beds (at 18.3 and 48.1 m) are separated from the underlying siltstones by thin limestone beds (17 and 3 cm respectively). The organic content increases up most cycles, but especially towards the base of the interval, the organic mudstone may have relatively low organic content (but still higher than the underlying rocks), resulting

	in a rock with alternating dark and light coloured thin laminae, rather than all dark in handspecimen.
79.4-107.0	Cycles generally similar to those above, but: 1. In many cycles, no gradation in lithologies is apparent between the organic mudstone intervals. 2. The organic mudstones are generally interbedded with laminae and thin beds of fine grainstone over intervals of up to 20 cm. The mudstones do not seem to have a particularly high organic content. 3. The laminated limestones are more organic-rich than in the interval above, and as a result are grey rather than tan or pink. The tan colour is developed in rare early diagenetic nodules with expanded bedding.
107.0-118.8	Nodular siliceous fine limestone, with interbedded fine siliceous organic-rich carbonate mudstone (the latter being predominant in some parts of the core), and laminae and beds of rippled fine grainstone. Evaporite pseudomorphs at 109 m.
118.8-132.4	The descriptions given below are abbreviated from those given by Southgate in Shergold (1981) and Southgate (1983).
118.8-119.3	Breccia. Blocks of mudstone, wackestone, and a phosphatic lag in a mud matrix; veins of saddle dolomite.
119.3	Scalloped disconformity surface.
119.3-121.1	Light grey-pink recrystallised vuggy dolomite.
121.1-125.0	Mottled dolomitic limestone, dominantly burrowed mudstone with thin wackestone and packstone beds.
125.0-126.0	Cyclic sequence: grainstone and packstone grade up into phosphatic glauconitic packstone and wackestone, overlain by non-phosphatic burrowed mudstone.
126.0-130.2	Light grey-pink recrystallised vuggy dolomite.
130.2-132.4	Medium to coarse recrystallised dolomite.

Interpreted stratigraphy:

0-2.4	Regolith.
2.4-107.0	Currant Bush Limestone.
107.0-119.3	Inca Formation.
119.3-132.4	Thorntonia Limestone.

Palaeontological determinations (by J.H. Shergold):

18.2	Onymagnostus sp. indet. Scrobiculate ptychagnostids This occurrence may or may not indicate the early Undillan *Ptychagnostus punctuosis* zone.
48.1	*Aotagnostus* sp. indet. *Goniagnostus (Criotpus)* cf *lemniscatus* Sponge spicules. The agnostids probably indicate the late Floran zone of *Euagnostus opimus*.
77.7	agnostid trilobites sponge spicules

BMR DUCHESS 15 & 15A

Location: 21°22'S, 139°59'E; 200 m southeast of Engine Well; about 1 km northwest of the Duchess-Cloncurry road crossing of the Burke River (Fig. 1).

Purpose: To obtain core of the Roaring Siltstone for study of its potential as a source rock, and to determine if it contains source rocks rich enough to be oil shale; to obtain general lithostratigraphic information.

History: BMR Duchess 15 was abandoned at 11 m due to loss of circulation in a weathered zone. BMR Duchess 15 A, drilled 1 m to the west, encountered good drilling conditions to 95.5 m, where circulation was lost. The hole was then drilled without circulation, despite several attempts to cement fractures, in highly weathered siltstone and sandstone of the Roaring Siltstone. This contains a large supply of fresh water, probably derived from outcrop several km to the north, and it is probable that this has been a major factor in the weathering. The hole was abandoned at 105 m without reaching fresh Roaring Siltstone.

Lithology (see also Plate 3):

0-1.0	Sandy soil.
1.0-95.6	Light to dark grey, massive to laminated, silty fine peloidal limestone, grading to dark grey calcareous siltstone and shale. Rare fine grainstone and packstone laminae in the limestones. Organic lamellae and pyrite common. Bitumen-like material present in vugs and fractures below 50 m.
95.6-95.8	Grey-brown, laminated calcareous siltstone and silty shale, with rare fine quartz sand laminae.
95.8-95.9	Highly weathered, brown-grey, calcareous silty shale, with calcareous nodules.
95.9-96.3	Highly weathered, brown-grey, non-calcareous laminated siltstone.
96.3-97.3	Brown-grey laminated siltstone, with rare fine quartz sand laminae.
97.3-105.0	Highly weathered, yellow-brown laminated siltstone and fine quartz sandstone.

Interpreted stratigraphy:

0-1.0	Regolith
1.0-95.6	Devoncourt Limestone
95.6-105.0	Roaring Siltstone.

BMR TOBERMORY 14

Location: 22°53'S, 137°27'E. 5 km south-southwest of Black Tank, Marqua Station. Drill site is 100 m south of the peak of the more westerly of two small hills of Mesozoic rocks (Fig. 1).

Purpose: To provide core for stratigraphic, palaeontological, and lithological study of the Marqua beds (being redefined as Hay River Formation by Shergold, in press), including its potential as a black shale bearing sequence.

History: The hole was continuously cored, except for the intervals 0-3.0, 6.0-7.7, and 10.3-10.6 m. Drilling to 116 m was supervised by an on-site geologist.

Lithology (based largely on information from J.H. Shergold; see also Plate 4):

0-1.0	Soil.
1.0-13.0	Weathered grey calcareous siltstone.
13.0-85.3	Laminated dark grey calcareous siltstone, nodular in places, interbedded with pale grey to white slightly coarser laminae, and thin beds of dark grey bituminous shale (2% of the interval).Intercalated pale grey fine-grained fetid limestone. Pyrite present as grains and pods. Breccia at 33.97-.98; crystalline dolomite at 30.22-.24. The siltstone is dolomitic below 78.07 m.
85.3-86.8	Pale grey vuggy shelly dolostone (grainstone).
86.8-86.9	Breccia of fine limestone with dolomite veins.
86.9-107.3	Intercalated dark grey fine-grained fetid silty limestone. Oolitic at 91.67-.74; shelly grainstone at 102.02-102.37; pyrite, fluorite present as accessories.
107.3-107.8	Vuggy dolostone (grainstone).
107.8-109.5	Fractured and veined, bituminous, calcareous shale.
109.5-122.8	Purple, blue-grey, and buff-brown, blotchy, brecciated, and vuggy dolostone; chert nodules and layers at 109.6-110.4 and 112.8-114.3; fossiliferous at 113.6-113.8.
122.8-123.4	Aphanitic purple dolostone, with upward decreasing sand content. Gradational boundaries.

123.4-124.8	Gradation between lithologies above and below.
124.8-128.7	Basal pebble conglomerate, passing upwards into pale grey medium to coarse sandstone with laminated and flaser bedded siltstone.
128.7-131.5	Dark grey medium sandstone passing upwards into pale grey siltstone. Uppermost 11 cm is olive green mudstone. Disseminated and laminated pyrite throughout.
131.5-143.0	Intercalated pale purple fine to medium sandstone, and purple, brown and green interlaminated mudstone and siltstone. Slumping in fine sandstone at 139.1, and in siltstone at 138.7; sandstone arkosic at 141.8-142.6 m.

Interpreted stratigraphy:

0-1.0	Regolith.
1.0-86.8	Upper Hay River Formation (Undillan-Floran).
86.8-109.5	Lower Hay River Formation (Ordian).
109.5-128.7	Red Heart Dolomite.
128.7-143.0	Adam Shale.

GEOCHEMISTRY

Samples from Mount Isa 1 were despatched for organic analysis in early 1979. Fisher assay (pyrolysis) was carried out by the ACIRL laboratory at Rockhampton (Table 1), and TOC, extract, and Rock-Eval analysis by Robertson Research (Tables 1 & 2). Gas chromatograms are shown in Figure 2.

Robertson Research concluded that 'although insuffiently immature to have generated large quantities of hydrocarbons', the samples assayed by Rock-Eval are 'potentially, very good oil source rocks....the absence of higher molecular weight n-alkanes with a pronounced odd-carbon number preference and the relative prominence of steranes and triterpanes in the gas chromatograms of the saturate hydrocarbon fraction of these samples....indicate a predominantly lower plant input resulting in a sapropelic kerogen'. The samples were classified as 'immature-early mature'. Fisher assay confirms that the richer rocks are of oil shale grade.

Furthur samples were submitted to AMDEL in 1983 for kerogen analysis. These were demineralised with hydrochloric acid and hydrochloric/hydrofluoric acid. Kerogen was isolated by floatation in chloroform. Results are given in Table 3, and on this basis, they are considered to be typical of Type II kerogens.

Total organic carbon content (Leco furnace) was also determined for a large number of samples from Mount Isa 1 and Camooweal 2 by AMDEL. These results are shown in Table 4 along with total carbon, S (combustion and measurement of SO2), Fe (atomic absorption), and trace elements (a/a). Shergold (in press) gives chemistry (including TOC, P and trace metals) of a number of samples from BMR Tobermory 14).

TABLE 1. ORGANIC ANALYSES, BMR MOUNT ISA 1.

Depth	Unit	TOC	Fisher Assay (l/t)	Extract ppm of rock	H/C ppm of rock	H/C mg/g TOC	H/C % of extract	Alkane % of H/C
53.78-.83	CB Lst	0.85	7	679	35	4	5	41
55.83-.87	''	-	1	-	-	-	-	-
100.38-.41	''	-	83	-	-	-	-	-
107.56-.63	''	16.28	101	8278	395	2	5	76
117.43-.49	''	13.80	82	-	-	-	-	-
119.41-.49	''	16.60	106	6645	810	5	12	25
138.53-.59	''	4.57	23	2598	615	13	24	19
138.60-.64	''	-	2	-	-	-	-	-
188.37-.45	Inca F.	8.99	59	4413	1030	11	23	37
188.58-.61	Inca F.	-	36	-	-	-	-	-
250 approx	Th. Lst.	3.26	-	1275	60	2	5	28

TABLE 2. ROCK-EVAL DATA, BMR MOUNT ISA 1.

Depth	Unit	TOC	Temp max. pyrol.	Hyd. Index	Oxy. Index	Prod. Index	Potential yield ppm
107.56-.63	CB Lst	16.28	429	703	8	0.04	114500
119.41-.49	''	16.60	432	592	9	-	98500
138.53-.59	''	4.57	432	797	26	0.05	36400
188.37-.45	Inca F	8.99	430	703	3	0.1	63200
250 approx	Th Lst	3.26	429	739	9	-	24100

TABLE 3. KEROGEN ANALYSES, BMR MOUNT ISA 1 AND CAMOOWEAL 2

Sample	Well	Depth	Unit	%C	%H	%N	%O	%S	%Ash	H/C	O/C
82700036	Cam 2	36.04-.11	CB Lst	57.6	6.1	2.1	6.7	4.2	16	1.27	0.087
82700044	''	76.76-.86	''	56.3	6.2	1.6	6.7	2.8	22	1.32	0.080
82700052*	''	100.56-.62	''	16.2	2.2	0.55	4.4	8.0	57	1.63	0.204
82700062	''	115.54-.60	Inca F	46.0	5.2	1.3	3.5	7.4	22	1.36	0.057
82700074	MI 1	106.58-.63	CB Lst	62.5	6.5	2.8	6.8	4.7	14	1.25	0.082
82700085	''	165.28-.35	''	48.7	5.4	1.6	6.1	7.9	25	1.33	0.094
82700089	''	231.65-.72	Th Lst	56.8	6.4	1.3	5.0	7.0	19	1.35	0.066

*Sample 82700052 contained practically no chloroform floatable kerogen, and analyses were therefore carried out on the total demineralised sample. Given the high ash content of the demineralised sample, the oxygen content is likely to be unreliably high.

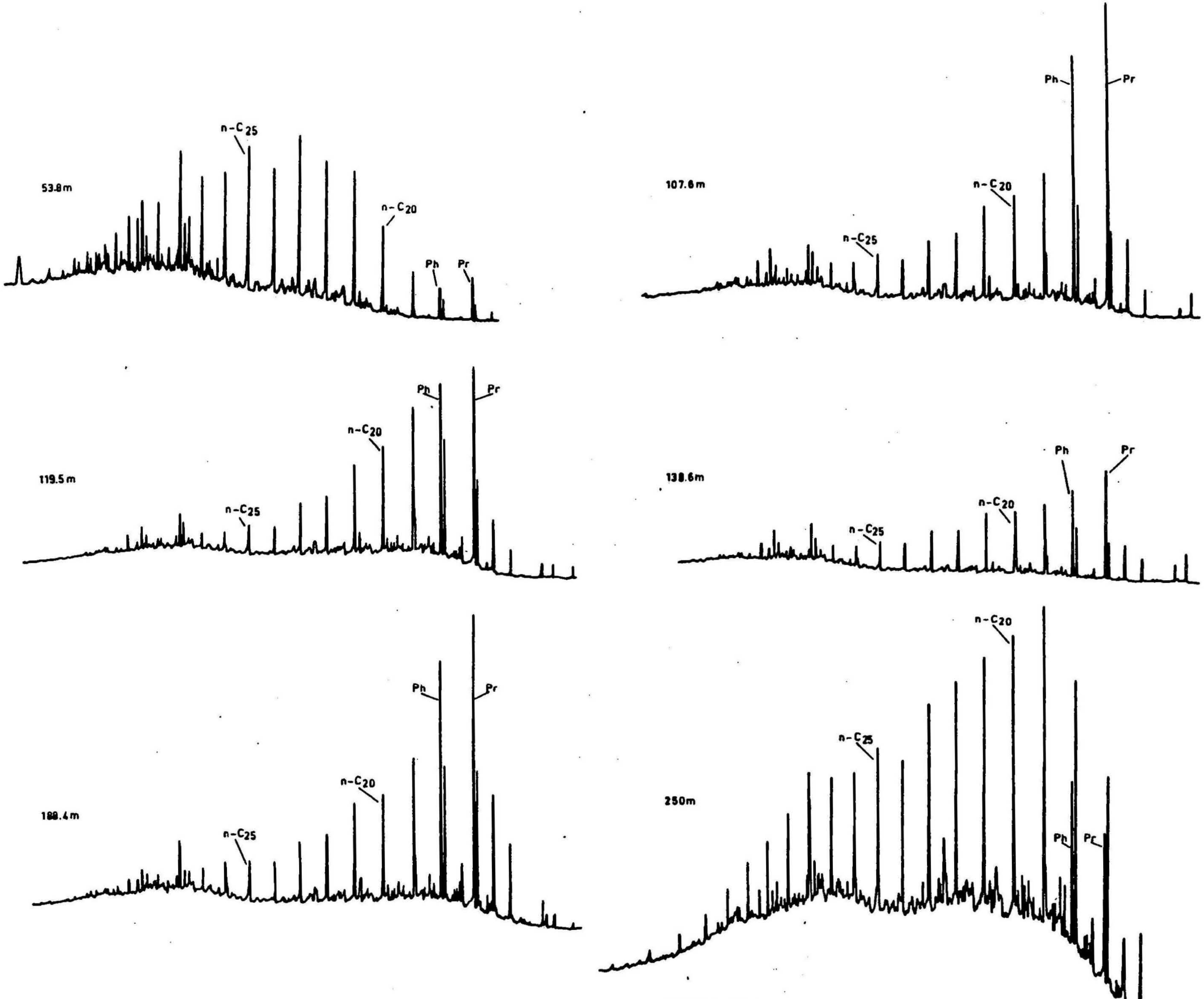


FIGURE 2. GAS CHROMATOGRAMS OF SATURATED EXTRACTS FROM BMR MT ISA 1

TABLE 4. GEOCHEMISTRY, BMR MOUNT ISA 1 AND CAMOOWEAL 2

Sample	82700027	82700028	82700029	82700030	82700031	82700032	82700033	82700034	82700036	82700038	82700039	82700040
Hole and depth	C.2,6.99	C.2,13.90	C.2,13.93	C.2,21.18	C.2,21.21	C.2,21.45	C.2,21.74	C.2,22.12	C.2,36.08	C.2,54.67	C.2,54.88	C.2,55.48
Strat. Unit	C.B. Lst	C.B. Lst	C.B.Lst	C.B.Lst	C.B.Lst	C.B.Lst	C.B.Lst	C.B.Lst	C.B.Lst	C.B.Lst	C.B.Lst	C.B.Lst
C total %	5.45	11.6	11.6	14.4	8.25	8.84	9.50	11.1	14.7	12.1	5.90	6.10
C org %	0.48	3.02	7.30	10.1	2.22	1.28	0.69	0.62	11.7	5.90	0.79	0.48
S%	0.35	0.28	0.97	0.78	0.68	0.40	0.17	0.07	1.30	0.80	0.68	0.67
As ppm	20	80	30	70	70	70	80	120	20	<20	30	50
Bi ppm	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cd ppm	<1	<1	<1	<1	<1	<1	<1	<1	2	3	<1	<1
Cr ppm	10	10	20	20	10	10	10	<10	20	10	10	10
Co ppm	5	<5	5	5	10	5	<5	<5	30	35	5	10
Cu ppm	14	18	32	46	30	20	14	6	70	42	20	22
Fe %	1.30	0.75	1.70	1.40	1.50	1.20	0.73	0.23	2.25	1.20	1.40	1.60
Pb ppm	30	35	20	35	35	40	35	35	30	20	30	30
Mn ppm	270	240	180	140	170	170	130	100	220	170	180	240
Mo ppm	1	3	11	3	2	2	2	2	14	25	3	3
Ni ppm	15	10	30	30	20	15	15	5	45	35	15	20
Ag ppm	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tl ppm	20	40	20	30	30	30	40	40	25	<10	20	30
V ppm	30	60	100	130	80	60	60	20	190	140	40	50
Zn ppm	16	14	20	26	55	40	50	6	40	28	16	20

Sample	82700041	82700042	82700043	82700044	82700046	82700047	82700050	82700052	82700054	82700055	82700058	82700059
Hole and depth	C.2,56.02	C.2,70.66	C.2,73.97	C.2,76.81	C.2,77.75	C.2,77.79	C.2,86.80	C.2,100.59	C.2,106.70	C.2,107.88	C.2,108.78	C.2,109.83
Strat Unit	C.B. Lst	C.B. Lst	C.B. Lst	C.B. Lst	C.B. Lst	C.B. Lst	C.B. Lst	C.B. Lst	C.B. Lst	Inca Fmn	Inca Fmn	Inca Fmn
C total %	11.2	10.9	8.15	12.0	11.2	11.1	6.10	6.40	7.75	8.00	9.30	8.35
C org %	0.20	2.70	1.35	4.80	7.75	7.05	1.07	2.10	2.34	3.86	3.48	5.90
S %	0.04	0.74	0.48	0.62	0.86	0.58	0.76	1.53	1.01	1.76	1.27	0.89
As ppm	110	80	50	20	50	40	30	<20	30	50	80	30
Bi ppm	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cd ppm	<1	<1	1	5	95	24	2	3	2	<1	<1	3
Cr ppm	<10	10	10	10	40	40	10	10	20	10	10	20
Co ppm	<5	5	10	25	5	5	5	25	5	5	10	15
Cu ppm	8	38	44	48	200	160	40	40	50	40	34	60
Fe %	0.23	1.20	1.30	1.10	1.20	1.10	1.70	2.10	1.50	1.50	1.30	0.78
Pb ppm	35	40	35	40	25	30	30	35	35	30	25	20
Mn ppm	110	200	210	160	160	150	230	300	250	110	210	85
Mo ppm	1	11	6	12	41	20	8	20	9	19	19	15
Ni ppm	5	20	30	70	120	90	35	30	45	45	60	110
Ag ppm	<1	<1	<1	<1	2	2	<1	<1	<1	<1	<1	1
Tl ppm	40	30	30	30	20	30	20	25	20	10	30	<10
V ppm	40	80	240	200	930	590	230	50	320	220	200	630
Zn ppm	8	22	90	100	4700	1000	160	32	230	75	22	620

Sample	82700061	82700062	82700065	82700067	82700069	82700070	82700071	82700072	82700073	82700074
Hole and depth	C.2, 113.21	C.2, 115.57	C.2,68.16	M.I.1,50.19	M.I.1.81.98	M.I.1,93.99	M.I.1,94.22	M.I.1,94.83	M.I.1,95.23	M.I.1,106.60
Strat. Unit	Inca Fmn	Inca Fmn	C.B. Lst	C.B. Lst	C.B. Lst	C.B. Lst	C.B. Lst	C.B. Lst	C.B. Lst	C.B. Lst
C total %	7.40	6.30	8.00	13.1	8.80	12.1	7.45	8.20	9.10	17.5
C org %	3.06	3.04	3.42	9.40	0.65	6.95	0.80	0.71	0.54	13.5
S%	1.14	1.33	1.08	0.40	0.36	0.72	0.59	0.44	0.21	1.32
As ppm	60	<20	<20	20	30	40	40	40	20	<20
Bi ppm	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cd ppm	<1	3	2	3	4	4	4	4	3	3
Cr ppm	10	20	20	20	10	20	10	10	10	20
Co ppm	5	15	30	25	30	25	25	25	20	30
Cu ppm	24	40	50	44	18	60	26	28	18	70
Fe %	1.10	1.55	2.10	1.50	1.20	1.60	1.60	1.40	0.79	1.80
Pb ppm	40	40	30	20	25	15	35	40	35	35
Mn ppm	220	250	300	190	200	160	200	190	150	170
Mo ppm	2	5	21	5	10	16	12	10	6	15
Ni ppm	25	35	40	45	30	35	30	30	25	45
Ag ppm	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tl ppm	20	20	<10	<10	<10	<10	<10	<10	<10	30
V ppm	70	130	140	60	50	130	40	100	60	110
Zn ppm	10	25	34	38	32	34	26	44	26	35

Sample	82700075	82700076	82700077	82700079	82700080	82700081	82700083	82700084	82700085	82700086	82700088	82700089	82700090
Hole and depth	M.I.1,106.66	M.I.1,107.01	M.I.1,117.46	M.I.1,123.81	M.I.1,124.09	M.I.1,124.22	M.I.1,135.26	M.I.1,141.76	M.I.1,165.32	M.I.1,185.62	M.I.1,215.73	M.I.1,231.69	M.I.1,247.70
Stat. unit	C.B. Lst	C.B. Lst	C.B. Lst	C.B. Lst	C.B. Lst	C.B. Lst	C.B. Lst	C.B. lst	C.B. Lst	Inca F.	Th. Lst	Th. Lst	Th. Lst
C total %	10.3	10.7	17.8	16.2	8.70	9.50	13.0	12.2	11.0	10.6	12.8	10.2	7.15
C org %	2.40	0.70	13.8	11.6	1.16	1.00	10.1	7.6	6.95	7.55	5.65	8.30	5.25
S%	0.44	0.14	1.45	1.15	0.42	0.27	1.43	1.21	1.79	1.77	1.54	2.37	1.68
As ppm	30	20	<20	20	<20	<20	<20	20	20	20	20	<20	20
Bi ppm	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cd ppm	4	4	3	3	5	4	3	4	3	3	4	2	2
Cr ppm	10	<10	20	20	10	10	20	20	20	20	20	20	30
Co ppm	30	25	30	30	25	30	30	25	25	20	20	10	15
Cu ppm	28	12	80	65	22	18	60	60	70	60	65	50	32
Fe %	1.00	0.40	2.10	1.70	1.30	0.86	2.10	2.00	2.25	1.70	0.92	1.50	1.7
Pb ppm	30	25	20	25	45	30	15	30	40	25	30	40	45
Mn ppm	180	190	200	160	210	160	210	180	200	140	160	350	240
Mo ppm	10	7	29	18	9	10	27	27	18	34	5	8	4
Ni ppm	30	25	40	35	35	30	45	45	60	35	80	55	75
Ag ppm	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tl ppm	<10	<10	<10	<10	<10	<10	<10	<10	25	<10	<10	20	<10
V ppm	60	40	120	170	70	110	170	150	130	100	50	30	80
Zn ppm	22	12	38	36	30	50	40	50	60	14	90	28	22

DETRITAL CONTENTS, BMR MOUNT ISA 1 AND CAMOOWEAL 2

The insoluble content of many of the geochemical samples was determined by dissolving the carbonate component in warm HCl, and weighing the residue after washing and filtering. From this figure the organic component (1.27 x TOC - the factor was determined from the average atomic composition of the organic matter), and pyrite (1.88 x S) were subtracted to give the detrital content (Table 5). Note that repeat digestions give very closely matching results. These figures correlate very well with the non-carbonate fraction, minus organic matter and pyrite, figures determined from chemistry (assuming all inorganic carbon is in calcite), although this method gives a slightly higher figure. The correlation coefficient is 0.98. This method cannot be applied to silicified samples.

The results show that the siltstones have approximately equal detrital and carbonate fractions, and that many of the limestones have an appreciable detrital fraction. The oil shales generally have high detrital contents.

TABLE 5. DETRITAL CONTENTS, BMR MOUNT ISA 1 AND CAMOOWEAL 2

Sample	8.33x Cinorg% = calcite% (1)	1.27 x TOC% = OM% (2)	1.88x S% = pyrite% (3)	Theoretical Detrital% 100-(1+2+3)	Detrital% by acid digestion
82700027	41.4	0.6	0.7	57	54
28	71.5	3.8	0.5	24	-
29	35.8	9.4	1.8	53	49, 50
30	35.8	12.8	1.5	50	43
31	50.3	2.8	1.3	46	41
32	63.0	1.6	0.8	35	28
33	73.4	0.9	0.3	26	21
34	87.3	0.8	0.1	12	9
36	25.0	14.9	2.4	58	51
38	51.7	7.5	1.5	39	36
39	42.6	1.0	1.3	55	47, 48
40	46.8	0.6	1.3	51	44, 44
41	91.7	0.3	0.1	8	7, 8
42	68.3	3.4	1.4	27	27
43	56.7	1.7	0.9	41	35, 36
44	60.0	6.1	1.2	33	33
50	41.9	1.4	1.4	55	51
52	35.8	2.7	2.9	59	-
54	45.0	3.0	1.9	50	52
65	38.2	4.3	2.0	55	52
67	30.8	11.9	0.8	57	-
69	67.9	0.8	0.7	31	26
70	42.9	8.8	1.4	47	41
71	55.4	1.0	1.1	42	35
72	62.4	0.9	0.8	36	30
73	71.3	0.7	0.4	28	23
74	33.3	17.2	2.5	47	-
75	65.8	3.1	0.8	30	-
76	83.3	0.9	0.3	16	-
77	33.3	17.5	2.7	46	46
79	38.3	14.7	2.2	45	43
80	62.8	1.5	0.8	35	31
81	70.8	1.3	0.5	27	23
83	24.2	12.8	2.7	60	50
84	38.3	9.7	2.3	50	50
85	33.8	8.8	3.4	54	-
88	59.6	7.2	2.9	30	-
89	15.8	10.5	4.4	69	-
90	15.8	6.7	3.2	74	-

NATURE OF THE ORGANIC MATTER

The organic-rich carbonate mudstones encountered in this drilling program have organic contents of up to 16%, and yield up to 100 l/t of oil on Fisher assay. Hence they could be termed oil shales. However, they are of quite different composition from other Australian oil shales, as carbonate is the main inorganic component of the rock, silt is common, but clay minerals are rare or absent. Oil shales of the Cretaceous Toolebuc Formation of the Eromanga and Carpentaria Basins are most similar, consisting of lamellar organic material, with interstitial carbonate (coccoliths), minor silt, and clay (Ramsden, 1983; Ozimic & Saxby, 1983).

The organic matter in the rocks described in this report has been studied by Hutton (1980, 1982) from the University of Wollongong, Russell & Saxby (1980) from CSIRO, and Glikson (1983, 1984; also Glikson & Gibson, in press) from ANU. The main type of organic matter from all but Tobermory 14 is a 'vitrinite-like' maceral, which may be referred to as bituminite. Small amounts of lamellar alginite, and a maceral identified as humic acid by Glikson, are present.

Hutton (1982) describes the organic matter from Tobermory 14 as non-fluorescing 'vitrinite like material' with optical properties consistent with those of some bitumens, and interstitial bitumen with a weak brown fluorescence. Ro max. is much higher than for the organic matter from the other wells, being about 2% as opposed to about 0.2-0.5%. The high reflectivity may indicate that the Tobermory rocks are supermature with respect to petroleum generation, and this may explain some of the differences in the organic matter.

WIRELINE LOGS, BMR MOUNT ISA 1

A good set of wireline logs were taken in late 1980 and are shown on Plate 1. Log responses in the Thorntonia Limestone are fairly predictable, but there seem to be some unusual responses in the other units.

The Thorntonia Limestone displays log responses consistent with water-bearing vuggy dolomite, i.e. highly negative SP, generally low gamma, moderate to high density, high neutron and high resistivity. Some of the density minima and gamma peaks correspond to thin black shales at about 215, 220 and 231 m.

In the Currant Bush Limestone, the SP curve shows small negative deflections opposite intervals composed of a number of interbedded lithologies. Rather than indicating thick beds of porous, water-bearing rock, the deflections probably represent borehole currents flowing between thin slightly permeable laminae and siltstone beds (relatively low resistivity), past highly resistive limestone and oil shale beds. Numerous concave and convex inflexion points are present on the original logs (detail has been lost on transcription to Plate 1), strengthening this interpretation.

The gamma log clearly distinguishes between the relatively pure fine limestones and the siltstones, which contain muscovite (and hence potassium), and thus give a higher gamma count. Some of the organic-rich beds appear to correspond to gamma peaks, but the logging speed of 9 m per minute and time constant of 3 seconds means that the count from 45 cm of section is averaged, and the thin organic-rich beds, even if fairly highly radioactive, would not be expected to greatly influence the log. The peaks probably represent the siltstones directly below the organic-rich beds.

The density log shown minima opposite almost all the organic-rich beds, reflecting their high organic content. The relatively pure, fine limestones show greatest density, and the siltstones are intermediate, owing to their increased quartz content. The logging speed and time constant result in the averaging of 10 cm of section, sufficiently sensitive to pick up the organic-rich beds.

The neutron log shows many large sharply defined maxima, and is virtually paralled by the single point resistivity log, except for the interval 182-198 m. There is a fairly close correlation (allowing for a small discrepancy in log depths) between organic-rich beds and neutron peaks, which would be expected from the high hydrogen content (the kerogen has hydrogen density approximately equal to that of water). However, the 3 second time constant means that the count from 45 cm of section is averaged, whereas the organic-rich beds are generally less than 10 cm thick. Hence they would not be expected to give so clear a peak. An alternative interpretation is that the peaks correlate with the fine limestones which occur immediately above almost all the organic-rich beds; this wouild account for a peak at 68-69 m which cannot be related to an organic-rich bed. However, if this interpretation is correct, the log response should be due to increased water content, and hence porosity in the limestones, a conclusion a little difficult to accept, as the limestones are fine-grained, and have very low porosity.

The resistivity peaks also probably correlate with the limestones, although reasons for their relatively higher resistivity are not known.

The interval 182-198 m has relatively low neutron count, high resistivity, and low density. In conventional clastic rocks, this combination could indicate a gas saturated zone, but in this case the rocks are nodular fine limestone with interbedded organic-rich shales.

GEOCHEMICAL ANALYSIS OF OIL STAINED CORE FROM BMR DUCHESS 15A

(by K. Jackson)

The following analytical results were obtained:

Depth	TOC%	EOMppm	SATSppm	AROMppm	POLARppm	Pr/Phy
59.01	1.9	5178	1097	849	3320	1.8
91.90	0.18	1158	294	170	687	1.3

EOM	total solvent extractible organic matter
SATS	saturated hydrocarbons in the EOM
AROM	aromatic hydrocarbons in the EOM
POLAR	polar, NSO containing compounds in the EOM
Pr/Phy	pristane/phytane ratio calculated from the relevant peaks in the SATS capillary gas chromatograph.

The core at 59.01 m contained a viscous 'oily' material filling a vug. The analytical results, when plotted on a TOC vs total hydrocarbon crossplot (SATS + AROM) led to the interpretation of an oil-stained core. The core at 81.90 m contained a less viscous 'oily material on a parting in the core; again the analytical data led to the interpretation of an oil stained core (i.e. relatively high hydrocarbon content compared with TOC).

The gas chromatograms (Fig 3) from the SATS fractions do give us some idea on the origin of this oil. In essence, both profiles are similar, although the core at 59.01 m does exhibit higher pristane and phytane contents. I conclude that the oil stains have originated from marine source rocks of a mature nature, but certainly not from advanced levels of organic maturity. The evidence for this is:

1. The low pristane/phytane ratios are generally thought to be indicative of marine rocks.
2. The limited range of n-alkanes, only reaching around n-23; terrestrial organic matter would contain significantly higher molecular weight n-alkanes.
3. The relatively high pristane/n-C_{17} and phytane/n-C_{18} ratios are considered indicative of moderate levels of thermal maturity.

However, an alternate explanation for the more viscous nature and the high pristane and phytane contents of the 'oil' at 59.01 m is biodegradation. It has been documented that biodegradation of an oil can decrease its viscosity, and preferentially destroy n-alkanes, thus producing an apparent increase in the pristane and phytane contents. It is always difficult to assess the possible degree of biodegradation, but I feel that the 59.01 m 'oil' has suffered some degree of bacterial action. Nevertheless, the evidence of a marine source of moderate maturity is still valid, based on the results for the 'oil' extracted from the core at 91.80 m.

XRD MINERALOGY

Several samples from BMR Mount Isa 1 and Duchess 15A were analysed for mineralogy by XRD. Results are given in Tables 6 and 7.

TABLE 6. XRD MINERALOGY, BMR MOUNT ISA 1

Depth	Lithology	Mineralogy
30.65	silicified laminated limestone	calcite major, quartz major, sphalerite major
55.14	laminated limestone	calcite major, dolomite minor, quartz minor
54.98	massive fine limestone	calcite major, possible dolomite and quartz trace
76.54	laminated siltstone	quartz and calcite major, dolomite minor, clays
76.55	? rock of volcanic origin	calcite, analcite, barite major, clays

It was originally thought that the last sample contained the mineral wairakite, a calcium analogue of analcite, but subsequent detailed chart traces suggested that the mineral was in fact analcite. Wairakite has been found in hydrothermal areas such as the North Island of New Zealand, at temperatures of about 180°C and low pressures, but such conditions are unlikely to have occurred in Mount Isa 1.

TABLE 7. XRD MINERALOGY, BMR DUCHESS 15A

Sample No.	Depth	Quartz	Calcite	Dolomite	Feldspar	Illite*	Kaolin	Mixed*
82700013	21.03	XXX	XX	X	-	X	X	X
14	9.89	XXX	XX	tr	-	X	X	X
15	32.13	XXX	XX	tr	-	X	X	X
16	42.15	XX	XXX	tr	-	X	-	?
17	65.00	XXX	XX	X	-	X	X	X
18	77.17	XXX	XX	X	-	X	X	X
19	83.37	XXX	XX	X	?	X	X	X
20	92.11	XXX	X	XX	-	X	X	X
21	93.68	XXX	X	XX	-	X	X	X
22	95.28	XXX	XX	X	X	X	X	X
23	95.48	XXX	XX	X	?	X	X	X
24	95.70	XXX	XX	X	-	X	X	X
25	96.36	XXX	tr	XX	?	X	X	X
26	97.28	XXX	tr	XX	-	X	X	X

XXX, XX,X: major components, with indication of abundance in non-clay fraction.
tr: trace
?: possibly present

* Much or all of the illite detected by XRD is probably muscovite
** Mixed layer clays including smectite

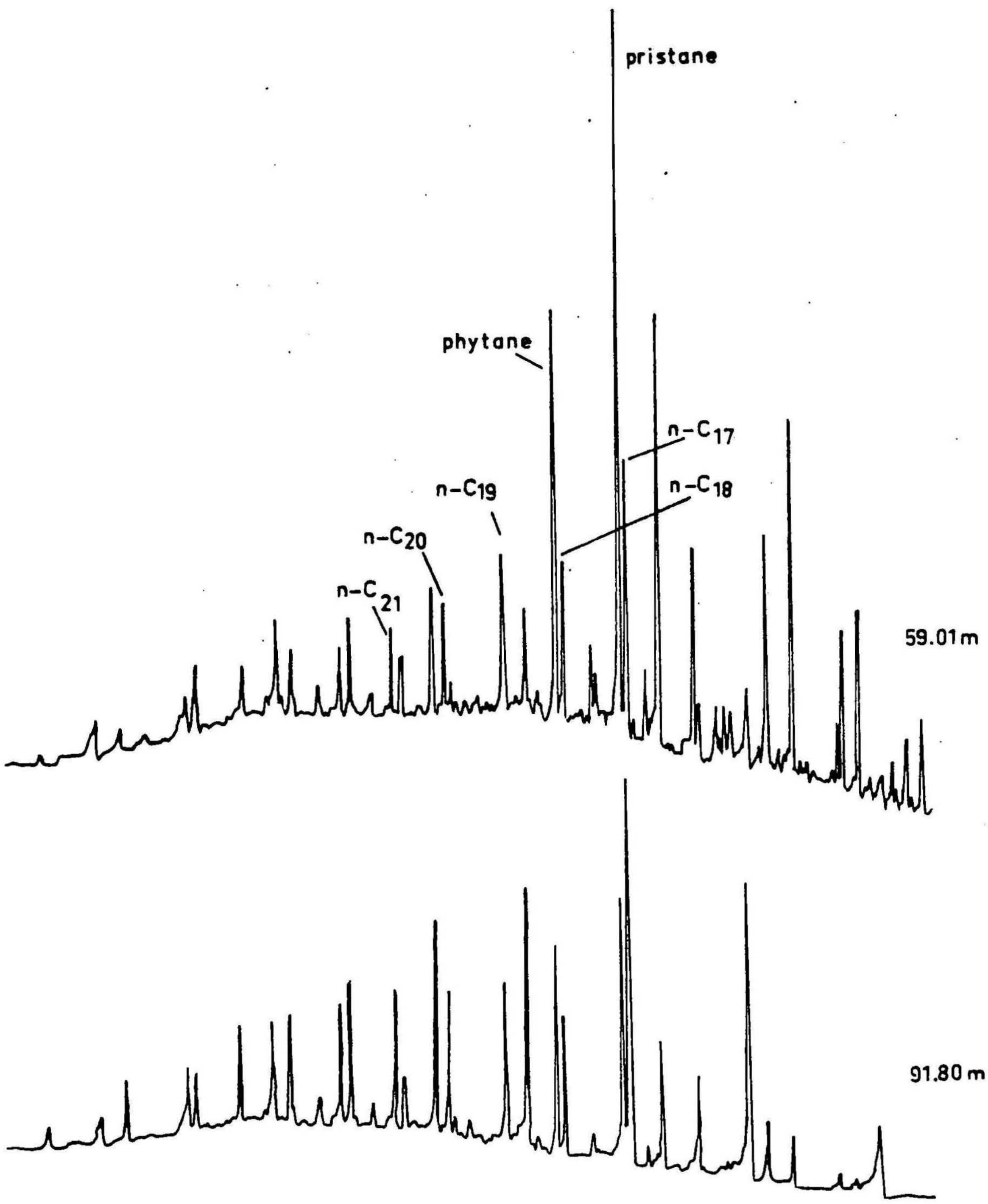


FIGURE 3. GAS CHROMATOGRAMS OF SATURATED FRACTION OF 'OIL' FROM BMR DUCHESS 15A

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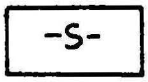
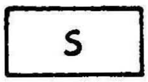
APPENDIX 1. DETAILED LITHOLOGICAL LOGS, BMR MOUNT ISA 1

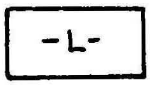
Explanation of symbols:



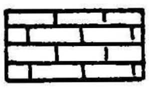
laminated calcareous siltstone with organic lamellae

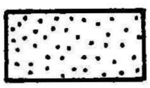


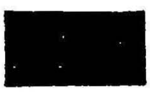
massive organic-free calcareous siltstone



laminated fine limestone with organic lamellae


massive fine limestone

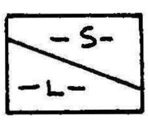

carbonate grainstone


organic-rich silty carbonate mudstone (oil shale)

≠ silicification


early diagenetic nodules


slumping



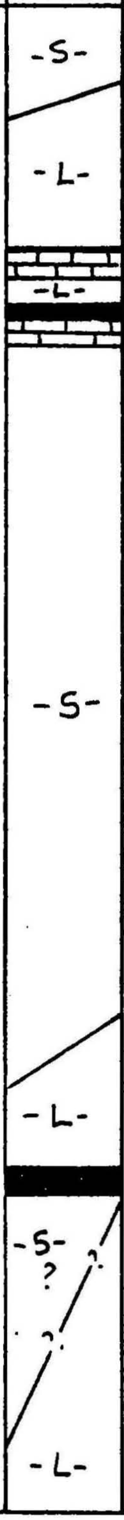
sloping boundary indicates gradation in lithologies

The distinction between laminated siltstone and limestone was made largely on texture (sound and feel when a metal object is scraped along the core) and colour. In general, the siltstone has a grey-green colour, and the limestone is pinkish or tan.

WELL Mount Isa 1

Sheet 1

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
46					
47					
48					
49					
50					



COMMENTS

WELL Mount Isa 1

Sheet 2

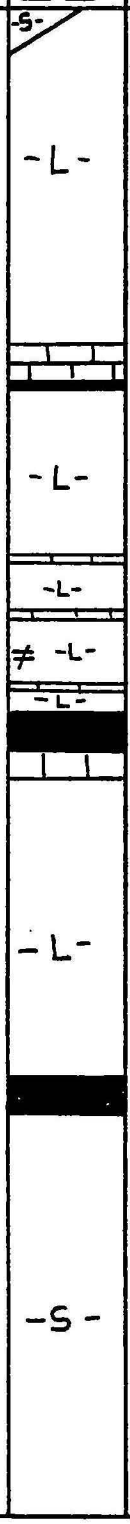
DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
50			-L-		
51			-S-		
52					
53			-S-		
54			-L-		

COMMENTS

WELL Mount Isa 1

Sheet 3

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
54					
55					
				Micrite beds diagrammatic	
				Oil shale has laminated limestone interbeds	
56					
				Oil shale has laminated siltstone interbeds	
57					
58					



COMMENTS

WELL Mount Isa 1

Sheet 4

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
58					
			-S-		
59					
60					
			-S-		
61					
62					

COMMENTS

WELL Mount Isa 1

Sheet 5

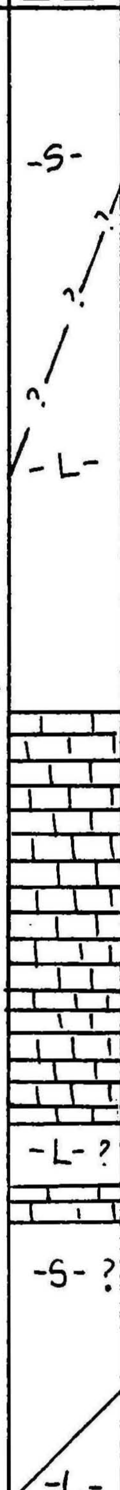
DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
62					
63					
			-S-		
64					
65			-L-		
			-S-		
66					

COMMENTS

WELL Mount Isa 1

Sheet 6

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
66					
67					
68					
69					
70					



COMMENTS

WELL Mount Isa 1

Sheet 7

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
70			-L-		
71			-L- -L- -L-	Micrite beds diagrammatic 79.29-.31 coquinite	
			-S-		
72					
73					
74					

COMMENTS

WELL Mount Isa 1

Sheet 8

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
74			-S-		
75					
76			-S-	76.57-.58 Analcite / calcite / barite / biotile / silt rock.	
			-S-		
77					
78			-S-		

COMMENTS

WELL Mount Isa 1

Sheet 9

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
78			-S-		
			-L-		
79			-S-		
80			S ?		
			-S-		
81			? ?		
			-L-		
			-S- OR -L-		
82					

COMMENTS

WELL Mount Isa 1

Sheet 10

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
82					
				82·47 – ·72 Micrite diagrammatic	
				82·72 – ·76 Interbedded laminated limestone, micrite and oil shale	
83					
84					
85					
86					

COMMENTS

WELL Mount Isa 1

Sheet 11

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
86					
			-S-		
87					
88					
			-S-		
89					
90					

COMMENTS

WELL Mount Isa 1

Sheet 12

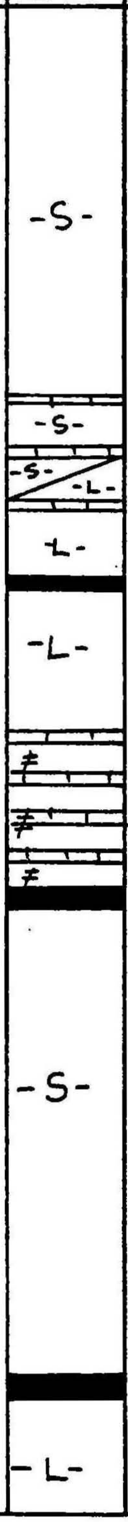
DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
90					
			-S-		
91					
			-L-		
92					
93			-S-		
			≠-L-		
94					

COMMENTS

WELL Mount Isa 1

Sheet 13

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
94					
95					
96				Micrite and silicification shown diagrammatically Oil shale has minor laminated limestone and micrite laminae	
97					
98					

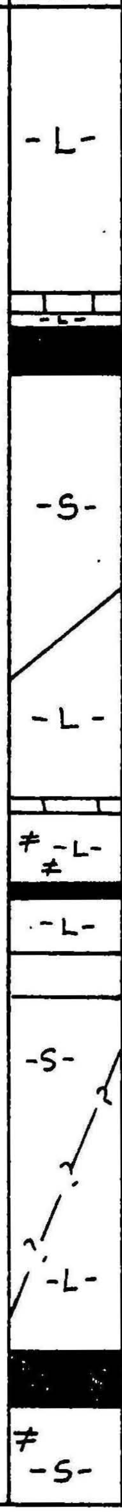


COMMENTS

WELL Mount Isa 1

Sheet 14

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
98					
99					
100				100.51 – .63 Interbedded laminated limestone, wackestone, and micrite.	
101					
102					



COMMENTS

WELL Mount Isa 1

Sheet 15

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
102			-S-		
103					
104			-S-		
105					
106					

COMMENTS

WELL Mount Isa 1

Sheet 16

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
106			-S- ≠		
107			-S- ? ≠		
108			-S-		
109					
110					

COMMENTS

WELL Mount Isa 1

Sheet 17

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
110					
			-S-		
111					
112					
			-S-		
113					
114					

COMMENTS

WELL Mount Isa 1

Sheet 18

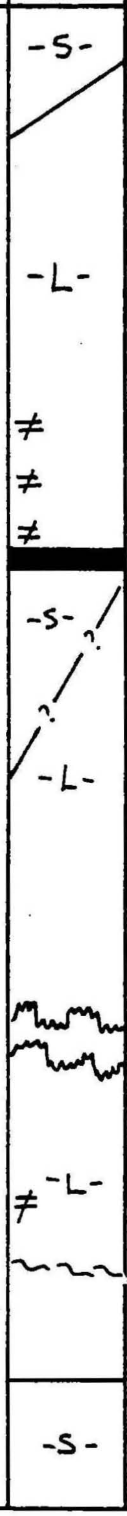
DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
114					
115					
116			-S-		
117			-L-		
			-S-		
118					

COMMENTS

WELL Mount Isa 1

Sheet 19

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
118					
119					
120					
				Styblites	
121				121·25 – ·65 interbedded organic-rich and organic poor laminated fine limestone	
122					

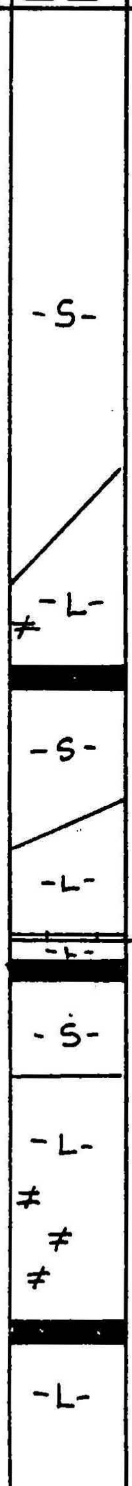


COMMENTS

WELL Mount Isa 1

Sheet 20

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
122					
123					
124					
125				Chert diagrammatic	
126					



COMMENTS

WELL Mount Isa 1

Sheet 21

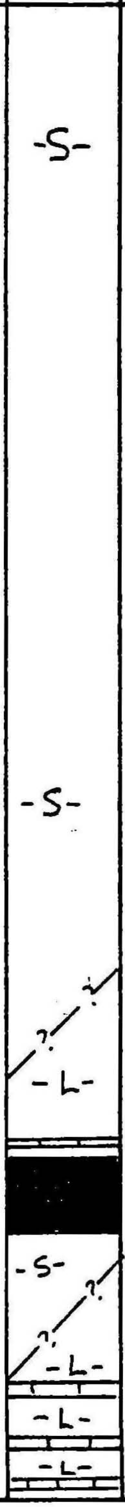
DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
126			≠ ≠ ≠ -L-	Chert diagrammatic	
127			-S-		
128					
129			-S-		
130					

COMMENTS

WELL Mount Isa 1

Sheet 22

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
130					
131					
132					
133					
134				Micrite beds diagrammatic	

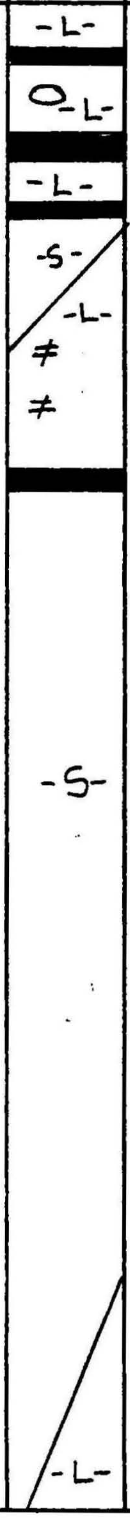


COMMENTS

WELL Mount Isa 1

Sheet 23

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
134					
135				Chert diagrammatic	
136					
137					
138					

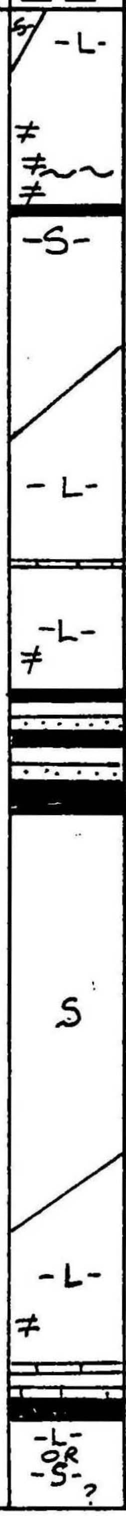


COMMENTS

WELL Mount Isa 1

Sheet 24

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
138					
				Chert diagrammatic	
139					
				139.82 - 140.15 Interbedded oil shale, laminated limestone and grainstone shown diagrammatically	
140					
141					
				Micrite beds diagrammatic	
142					



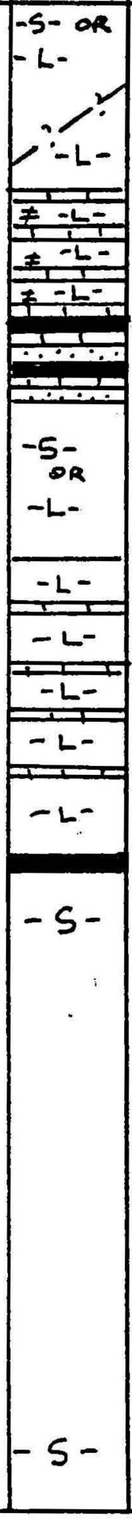
COMMENTS

WELL Mount Isa 1

Sheet 25

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT

142



142.43 - .84 Micrite and chert diagrammatic

142.84 - 143.05 Interbedded oil shale, micrite and grainstone shown diagrammatically

143

Micrite diagrammatic

144

Oil shale has minor micrite and grainstone laminae

145

146

COMMENTS

WELL Mount Isa 1

Sheet 26

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
146					
			-S-		
147					
			-S-		
148					
			-L- -L- -L-	Micrite diagrammatic	
			-L-	Oil shale has micrite laminae near top, and grainstone near base	
149					
			-S-		
			-L-	149.97 – 150.03 Oil shale silicified in part. Micrite and grainstone laminae	
150					

COMMENTS

WELL Mount Isa 1.

Sheet 27

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
150					
			-S-		
151					
			-L- ≠		
				Interbedded oilshale grainstone and micrite shown diagrammatically	
152			-S- OR -L-		
			- L -		
153			≠≠		
				Grainstone shown diagrammatically	
			-S-		
				? barite in nodule	
154					

COMMENTS

WELL Mount Isa 1.

Sheet 28

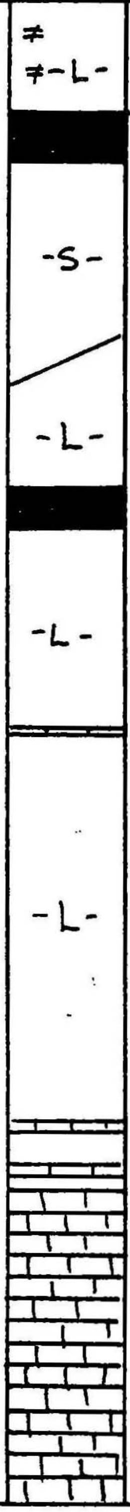
DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
154			-S-		
155			-S-		
				Oil shale low grade. Boundaries gradational	
156			-S-		
157			-L-		
158					

COMMENTS

WELL

Sheet 29

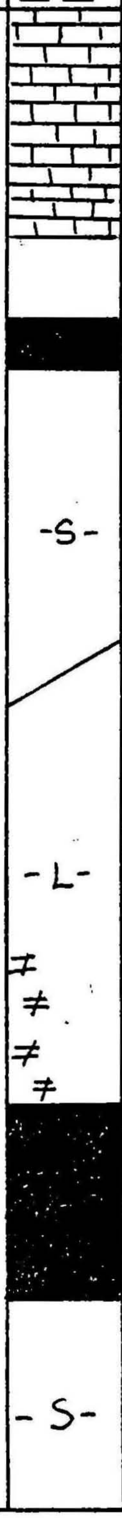
DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
158				Chert diagrammatic	
				oil shale has thin micrite laminae	
159					
160					
161				Micrite diagrammatic	
				161.16 – 162.60 Complex interval – mainly micrite, thin interbeds of organic-rich laminated limestone. 1 cm intraclast bed at 161.35, erosional feature at 161.75	
162					



COMMENTS

WELL Mount Isa 1

Sheet 30

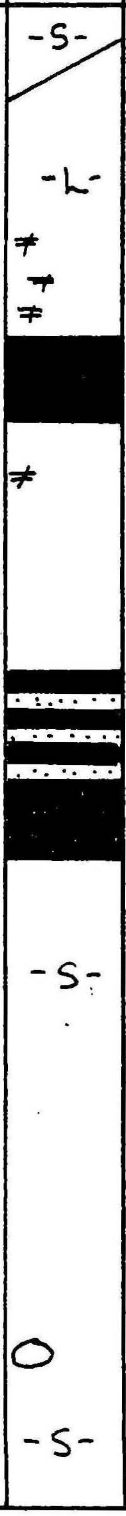
DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
162					
				162.60 — .82 Interbedded organic-rich laminated limestone, micrite, and grainstone	
163					
164					
				Silicification diagrammatic	
165					
166					

COMMENTS

WELL Mount Isa 1

Sheet 31

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
166					
				Silicification diagrammatic	
167				167.09 - 167.76 Interbedded micrite and laminated organic-rich limestone	
168				Grainstone diagrammatic	
169				Siltstone apparently more organic-rich at 169.66 - .72 and 169.96 - 170.18	
170					



COMMENTS

WELL Mount Isa 1

Sheet 32

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
170					
171			-S-		
172			-L-		
				Limestone laminae in top 8cm of oil shale	
173			-S-		
174					

COMMENTS

APPENDIX 2. DETAILED LITHOLOGICAL LOGS, BMR CAMOOWEAL 2

Symbols are as for Appendix 1.

WELL	Camooweal 2				
	Sheet 1				
DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
4					
			≠		
			-S-		
5	1				
				Obviously weathered to 5·7m	
6			-S-		Currant Bush Lst.
7	2				
			-S-		
8					

COMMENTS

WELL Camooweal 2

Sheet 2

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
8	2				
9	3		-S-		Currant Bush Lst.
10					
11			O O O O		
12	4				

COMMENTS

WELL Camooweal 2

Sheet 3

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
12			-S-		Currant Bush Lst
13	4				
			-L-	Upper bdy. of oil shale transitional over 1cm, lower over several cm. Oil shale has minor laminae and lenses of fine lst.	
14			-S- O		
15	5			Very gradational bdy.	
			-L- ≠		
16			≠		

COMMENTS

WELL Camooweal 2

Sheet 4

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
16	5		≠ -L-	Oil shale has sharp upper bdy, and has minor laminae and lenses of fine lst.	
			-L-		
17	6		≠		
18	7			Massive lst has a few <1cm beds of laminated lst with organic lamellae Oil shale has irregular laminae of coarse carbonate	Currant Bush Lst.
19			-S-		
20					

COMMENTS

WELL Camooweal 2

Sheet 5

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
20					
21	8			Oil shale has gradational bdys	Currant Bush Lst.
22				gradational bdys.	
23	9			gradational bdys.	
24					

COMMENTS

WELL Camooweal 2

Sheet 6

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
24			≠ ≠ -L-		
	9				
25					
26			-S-		
27	10				
28					

COMMENTS

WELL Camooweal 2

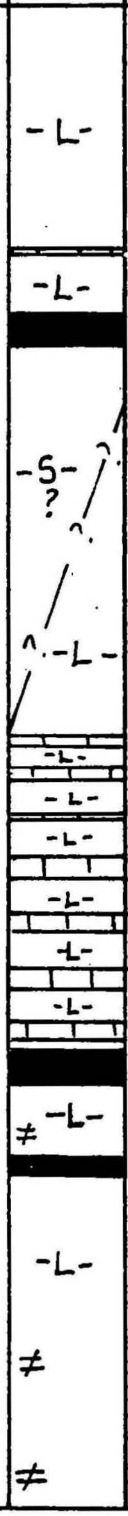
Sheet 7

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
28					
	10		-S-		
			S	Massive siltstone	
29					
			-S-		
			S	Massive siltstone	
30			-S-		
	11		? ? ?	base of siltstone very difficult to determine	Currant Bush Lst.
31					
			-L-		
32					

COMMENTS

WELL Camooweal 2

Sheet 8

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
32	12				Currant Bush Lst
				Gradational bdys.	
33					
34				Micrite beds diagrammatic	
				Oil shale has sharp bdys	
35	13			Oil shale has sharp upper and gradational lower bdy	
36					

COMMENTS

WELL Camooweal

Sheet 9

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
36			-L-	Oil shale has rapid gradational bdy at top and slower gradation at base	
37	13				
			-S-		
38					Currant Bush Lst
39	14		O		
40			≠ ≠ ≠		

COMMENTS

WELL Camooweal 2

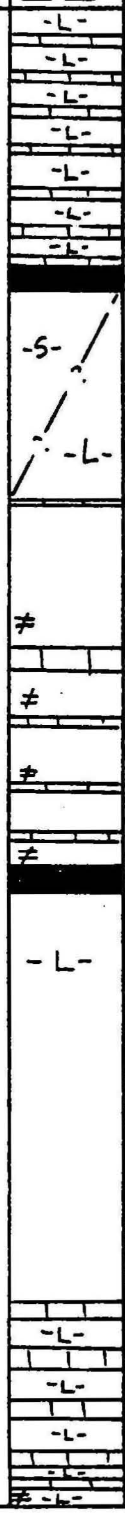
Sheet 10

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
40			-L-	gradational bdys.	
	14		-S-		
41					
			-L-		
			-L-		
			≠ -L-		
42			≠ -L-	41.82 - 42.14 Micrite beds diagrammatic only	
			-L-	gradational bdys	
	15		≠ -L-	gradational bdy at base, sharp at top	Currant Bush Lst
43			-S-		
44			-L-		

COMMENTS

WELL Camooweal 2

Sheet 11

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
44–48	16, 17			43.94 - 44.68 Micrite beds shown diagrammatically 45.65 - 46.29 Micrite beds and silicification shown diagramatically 47.45 – .95 Micrite beds shown diagrammatically. One micrite bed thins appreciably over width of core.	Currant Bush Lst

COMMENTS

WELL Camooweal 2

Sheet 12

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
48			≠-L-	48·05 Oil shale silicified in part.	Current Bush Lst
			-L- OR -S- ?		
49	17				
50					
51	18		-L- OR -S- ?		
52					

COMMENTS

WELL Camooweal 2

Sheet 13

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
52	18			52.62-.82 Micrite shown diagrammatically	
53				Oil shale partly silicified	
54	19			Oil shale has thin laminae and lenses of calcite	Currant Bush Lst
55					
56				Micrite diagrammatic	

COMMENTS

WELL Camooweal 2

Sheet 14

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
56			-L-	Micrite diagrammatic	
			-L-		
			-L-		
57			≠		
			≠		
			≠ -L-	Micrite diagrammatic Oil shale has thin laminae and lenses of calcite	
	20				Currant Bush Lst
58			-S-		
59					
	21				
60					

COMMENTS

WELL Camooweal 2

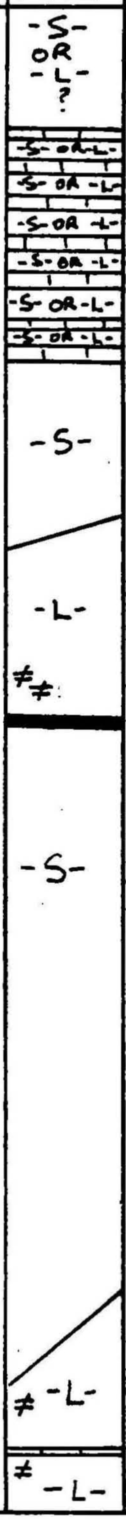
Sheet 15

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
60					
			-S-		
61	21		-L-		
			-L-		
62			-S-		Currant Bush Lst
63	22		-L-		
			-S- OR -L- ?		
64					

COMMENTS

WELL Camooweal 2

Sheet 16

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
64	22			Micrite beds diagrammatic	Currant Bush Lst
65	23				
66					
67					
68					

COMMENTS

WELL Camooweal 2

Sheet 17

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
68			≠ -L-		
69			-S-		
	24				
70					Current Bush Lst
			-L-	Laminated limestone has high TOC (2.7%).	
71			-S-		
	25				
72					

COMMENTS

WELL Camooweal 2

Sheet 18

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
72			-S-		
			-L-		
73	25		≠	73.60 - .79 Laminated carbonate, fairly organic-rich	Current Bush Lst
74		10°	-S-	73.92 - 74.91 Slumped siltstone	
75	26		-S-		
		60°	-L-		
76		45°			

COMMENTS

WELL Camooweal 2

Sheet 19

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
76					
			-L-		
	26				
			-L-		
			-L-		
				Oil shale has grainstone laminae	
77		45°	-S- OR -L-		
				Some slumping	
		10°		Massive silty fine limestone	
			-L-		
				Oil shale has grainstone laminae, abundant spicules, sphalerite,	
78					Current Bush Lst
			-S-		
	27				
			-L-		
79					
				Oil shale not very rich in O.M.	
			- S -		
80					

COMMENTS

WELL Camooweal 2

Sheet 20

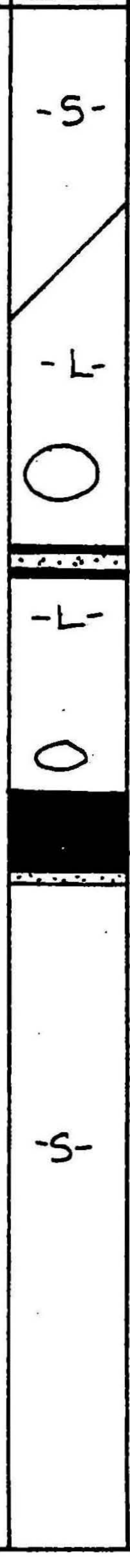
DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
80	28				
81				81·28 – ·44 Interbedded grainstone (80%) and organic-rich laminated limestone; minor oil shale	Currant Bush Lst
82					
83	29			82·27 – ·32. Interlaminated grainstone and oil shale	
84					

COMMENTS

WELL Camooweal 2

Sheet 21

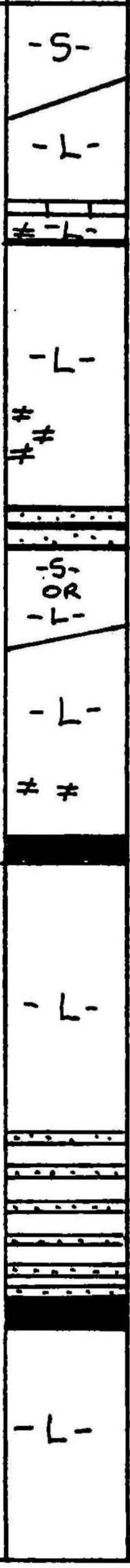
DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
84	29				
85				early diagenetic nodule	
				interlaminated grainstone and oil shale	
86					Current Bush Lst
87	30				
88					



COMMENTS

WELL Camooweal 2

Sheet 22

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
88	30				
89	31			interbedded grainstone and minor oil shale	
90					Currant Bush Lst
91				interbedded grainstone and organic-rich laminated fine limestone	
92	32				

COMMENTS

WELL Camooweal 2

Sheet 23

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
92			-L-		
93					
	32		-L-		
94					Current Bush Lst
95					
	33		≠≠ ≠≠ -L-		
				95.87 - .92 Interlaminated grainstone and dark laminated limestone (organic-rich)	
96			-L-		

COMMENTS

WELL Camooweal 2

Sheet 24

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
96					
			-L-		
97	33				
			≠ O		
98					
			-S- OR -L- ?	Evaporite pseudomorphs	
	34				Currant Bush Lst
99					
			-S- OR -L-		
100					

COMMENTS

WELL Camooweal 2

Sheet 25

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
100	34		-S- OR -L-		Currant Bush Lst
101	35		-S- OR -L-		
			-L-		
102				Interlaminated grainstone and oil shale	
103			-L-		
104					

COMMENTS

WELL Camooweal 2

Sheet 26

DEPTH	CORE	DIP	LITHOL. LOG	LITHOLOGY	UNIT
104			-L-		
				interlaminated grainstone and oil shale	
105			-S- OR -L-		
	36				Currant Bush Limestone
106			-S- OR -L-		
107	37			106.98 - 113.74 Nodular interbedded black shale, fine limestone and grainstone. Silicified. 113.74 – 117.46 Interbedded black shale and fine limestone. Silicified. Not nodular. 117.46 – 118.76 Interbedded fine siliceous limestone and black shale. Nodular.	106.98 Inca Fmn
108					

COMMENTS Inca Fmn not logged in detail.

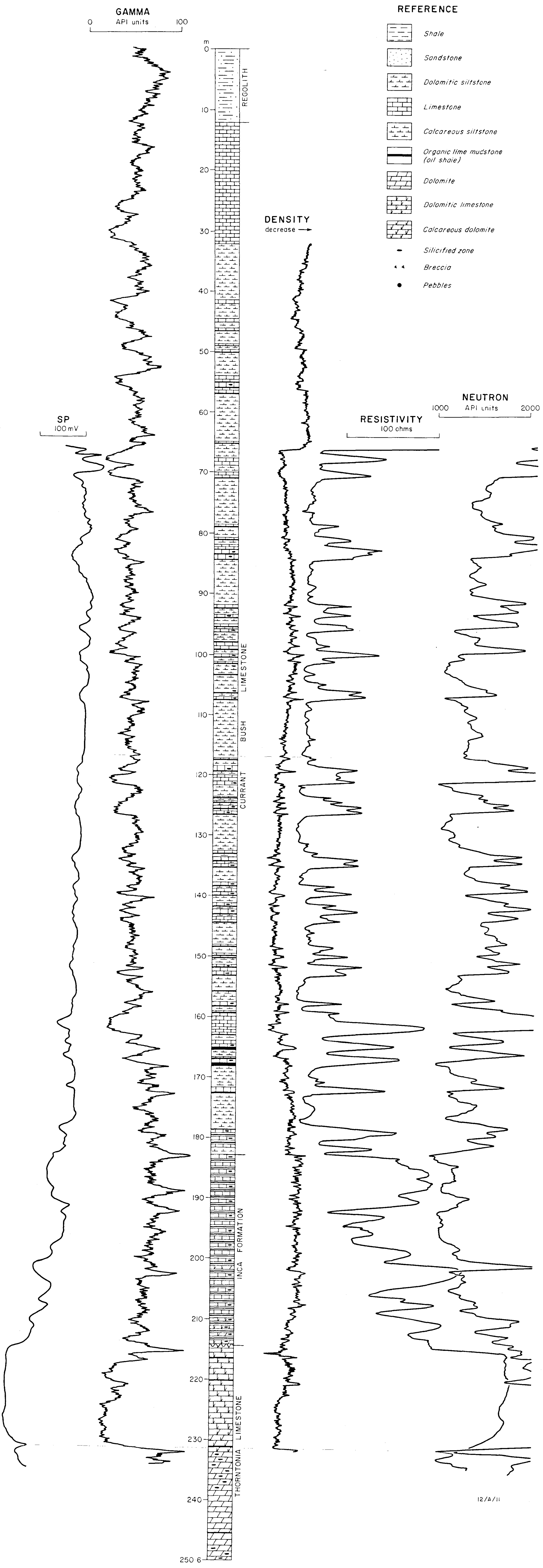


Plate 1. BMR Mount Isa 1

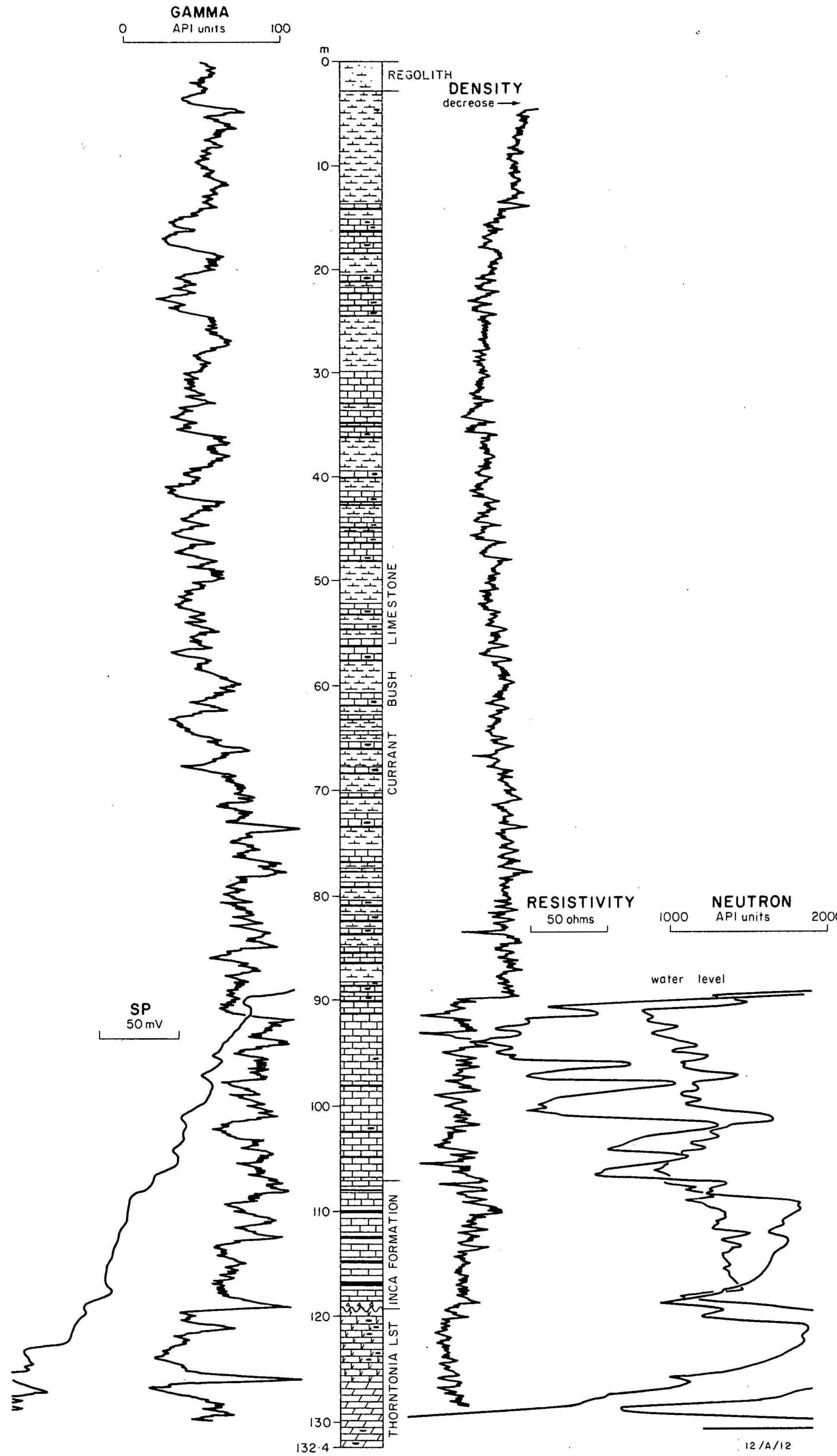


Plate 2. BMR Camooweal 2

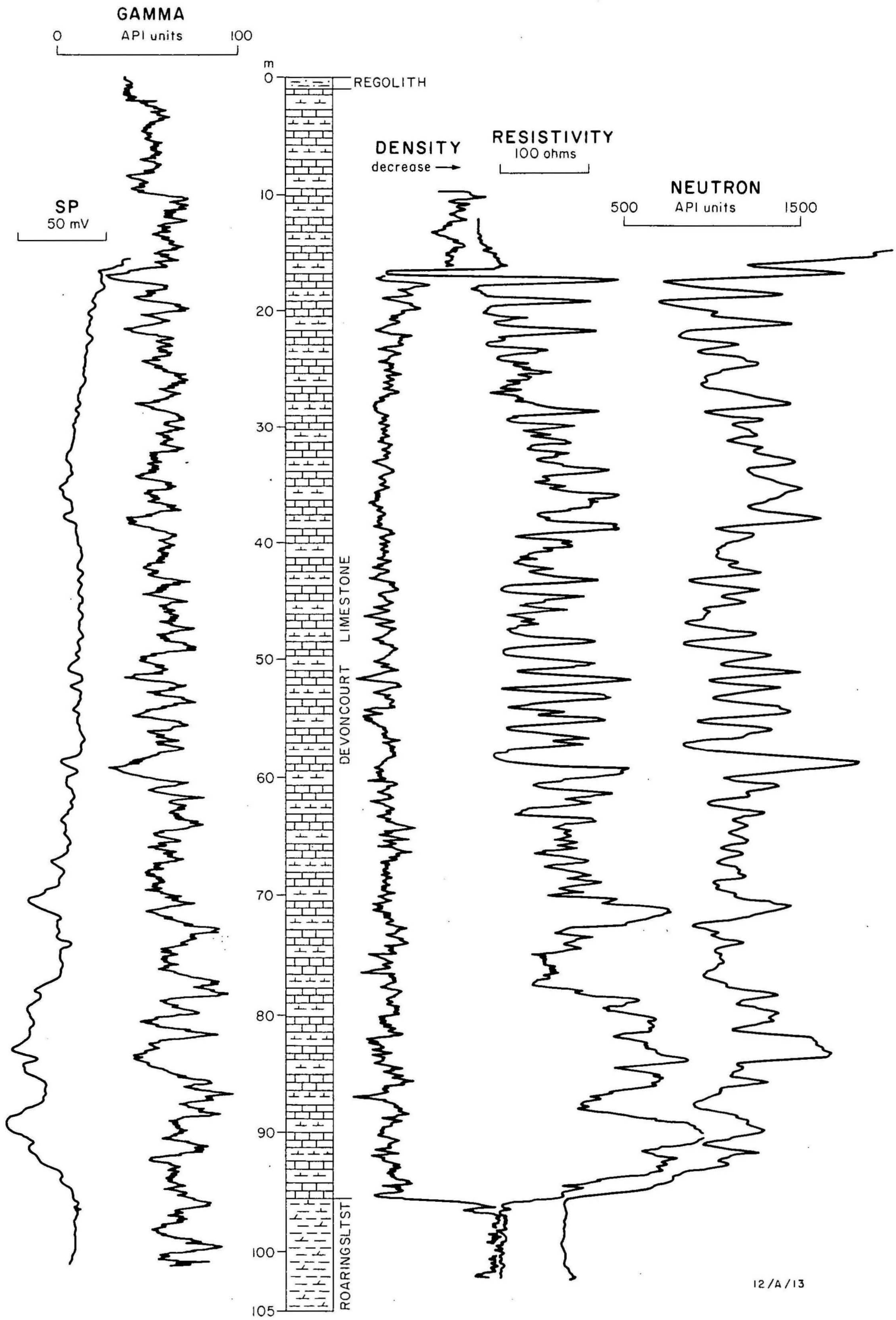


Plate 3. BMR Duchess 15A

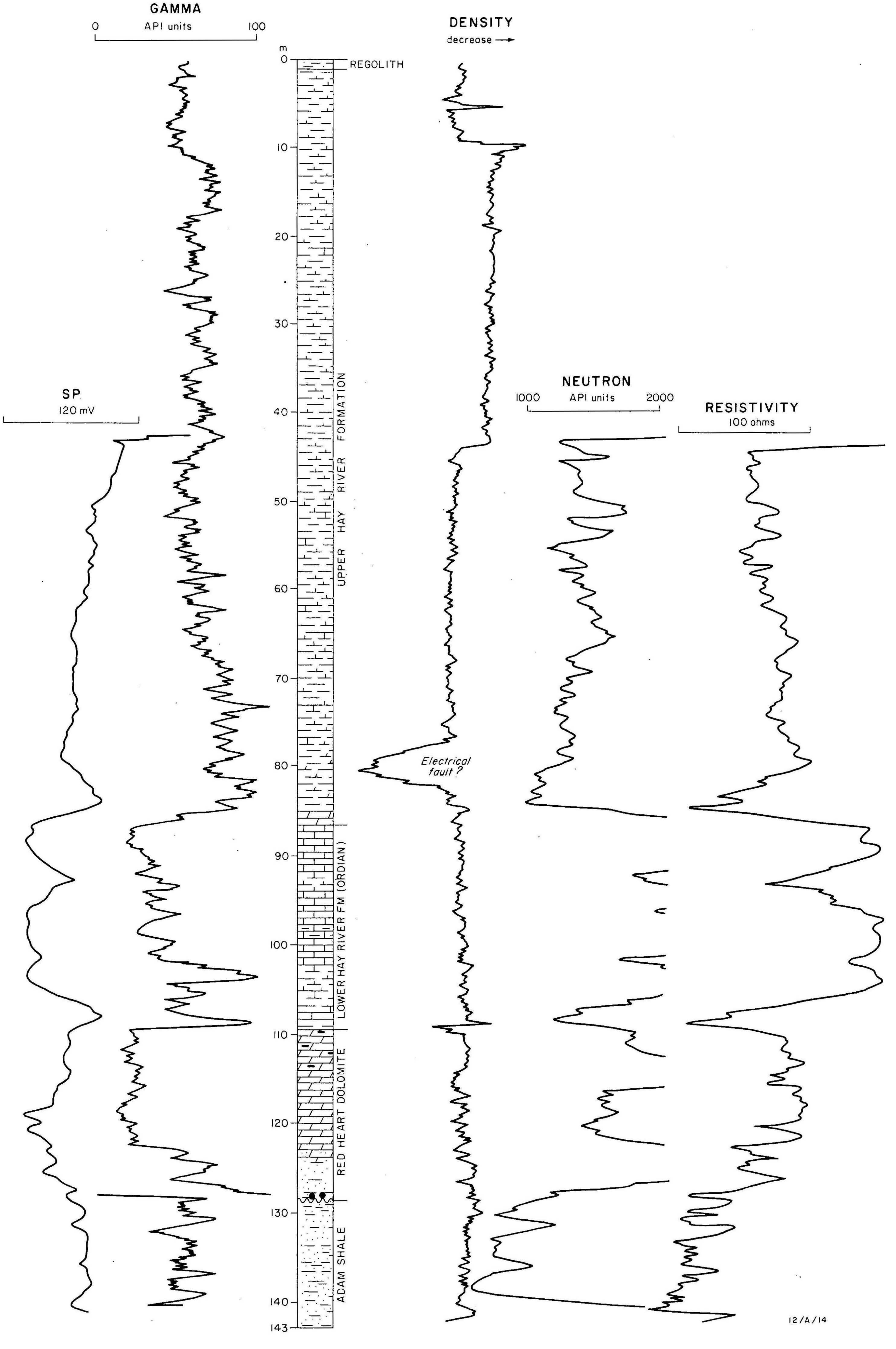


Plate 4 . BMR Tobermory 14