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# The Occurrence of Oil in DDH/AP1 Johnny Creek Anticline, AMADEUS BASIN. N.T.

**BUREAU OF MINERAL RESOURCES,
GEOLOGY and GEOPHYSICS**
**Department of Minerals and Energy,**
**cnr. Constitution Avenue and Anzac Parade,**
**Parkes,**
**Canberra, A.C.T.**

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# JOHNNY CREEK ANTICLINE, AMADEUS BASIN, N.T.



by

J. Barrie

Records 1965/78



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## INTRODUCTION

On August the 10th, 1963 a hole being drilled under contract by Associated Diamond Drillers for the Bureau of Mineral Resources to investigate the presence of phosphatic sediments, intersected oil-bearing sandstone in Ordovician rocks. On August the 13th the Magellan Petroleum (N.T.) and Exoil companies cored Cambrian dolomite bleeding oil in their Alice Springs No. 1 well, 16 miles south of Alice Springs. These two occurrences were the first significant discoveries of oil in the Amadeus Basin. This report records the occurrence of oil in DDH/AP1, drilled at the eastern end of the Johnny Creek Anticline, 145 miles west-south-west of Alice Springs.

The Amadeus Basin is located south-west of Alice Springs, in the southern part of the Northern Territory of Australia (fig. 1). The Basin trends westerly and is approximately 500 miles long by 150 miles wide. It is bounded on the north by the Arunta Complex and in the south by the igneous and metamorphic complexes of the Musgrave, Mann, and Petermann Ranges. The Basin is filled almost entirely with Upper Proterozoic and Palaeozoic sediments with a maximum thickness of over 30,000 feet along the northern margin. The rocks of the Basin are essentially shelf deposits and except for the northern and southern marginal zones, have been subjected to moderate folding and faulting.

During the period 22nd July to 28th October, 1963, the Bureau of Mineral Resources carried out a programme of core drilling to evaluate known occurrences of phosphorite in the Stairway Sandstone of the Ordovician Larapinta Group, in the Amadeus Basin, N.T. (Barrie, 1964).

Four drill holes were completed: AP1, on the eastern end of the Johnny Creek Anticline, AP2, on the southern edge of the Levi Range, AP3, on the southern flank of the James Range, and AP4 in the extreme south-east corner of the Lake Amadeus 1:250,000 sheet area. All four holes were logged geologically, and the last three were also logged electrically with a (B.M.R.) Widco 1,000 foot Logmaster by T. Quinlan and J. Barrie.

All cores are stored in Canberra at the B.M.R. Core and Cuttings Laboratory, Fyshwick, where they are available for examination.

Nx casing remains in the top of each hole, AP1, AP2, and AP3 have screwed metal caps, and AP4 a wooden plug. AP1 was plugged at 650 feet and cemented with a quarter barrel of 'Fondu' and one bag of Portland cements.

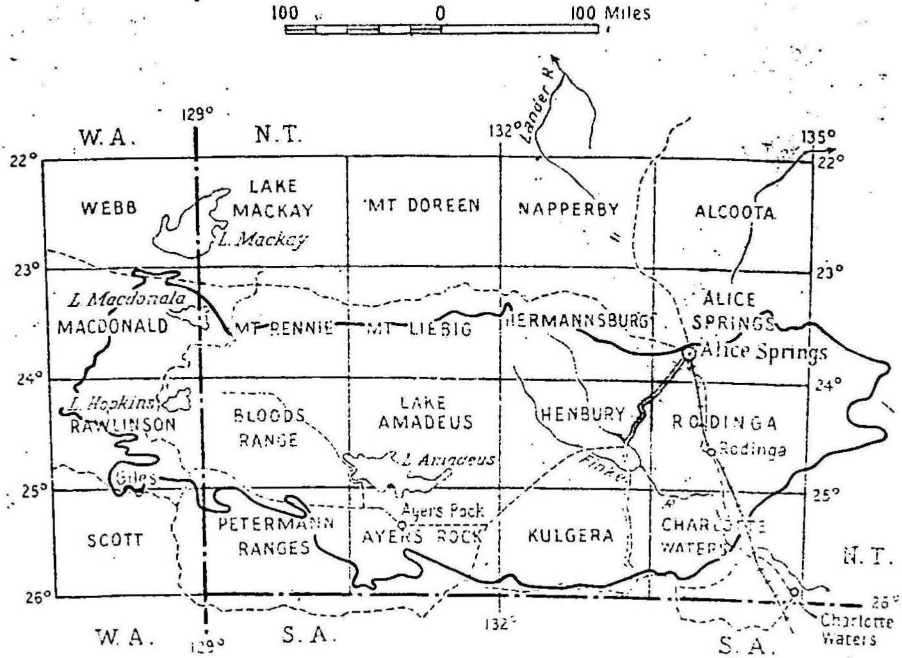
## OCCURRENCE OF OIL

Sandstone containing free oil was intersected between 652'5" and 656'10", 659'3" and 661', and 674' and 675'4" in AP1, fig. 2. Residual hydrocarbons were present also in several fractures through to the bottom of the hole at 918'. These intervals and other parts of the core fluoresced under ultra violet light.

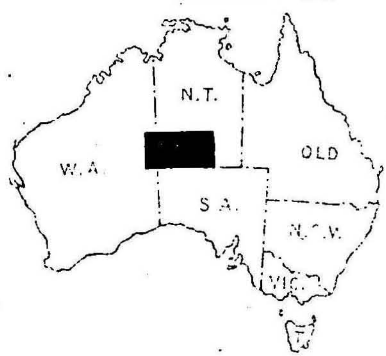
It is unfortunate that the core was exposed to sunlight for approximately three hours before being placed under cover, and that the sample analysed was exposed to the atmosphere for 4 days before reaching the laboratory for analysis. Consequently a certain proportion of the oil fraction evaporated. Because of this it should be noted that when the core was fresh, the smell of 'oil' was very strong at least 30 feet from the core tray in open air, and that the surface of the core was wet with oil to the touch. The sample, immediately before analysis, was not wet to touch and required breaking to expose a fresh surface before a smell of oil could be detected.

Fig. 1

# LOCATION OF AMADEUS BASIN WITH REFERENCE TO AUSTRALIAN 1:250,000 AND 1:253,440 MAP SERIES




## LOCALITY MAP




*Bureau of Mineral Resources, Geology and Geophysics. March,* 

GD 155

*To accompany Record* ~~1964/~~195 1965/78

G52/4/13

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

# GEOLOGICAL LOG OF DRILL HOLE

Fig 5

PROJECT: AMADEUS BASIN PHOSPHATE

HOLE NO.: AP.1 — ANGLE: 90° — BEARING: — ELEVATION: 2200' (APPROX.)

LOCATION: JOHNNY CK. FOUR MILE LAKE AMADEUS — LATITUDE: 24° 17' S — LONGITUDE: 131° 41' E (APPROX.)

TOTAL DEPTH: 918' — DEPTH TO WATER TABLE: 100'

Core size: NX (0–20'), BX (below 20'). Lifts: Ten foot core barrel with bottom discharge bit.

Core recovery: AV. 50% (0–70'); AV. 88% (70–104'); 90 to 100% (below 104').

Dip: 20°, 18°, 25°, 20°, 18°, 20°, 20°, 20°, 20°, 16°, 18°, 20°, 21°, 16°, 20°, 17°, 20°, 20° (downhole).

| Footage | Colour | Texture | Lithology | Rock Unit |
|---|---|---|---|---|
| 0–20' | Reds & browns | | Sand, gravel and clay | STOKES Fm. |
| 20'–70' | Brown cream grey | Silt to vfg minor f & mg | Calcareous siltstone, sandy siltstone and sandstone and thin beds limestone. | STOKES Fm. |
| 70'–104' | White grey | Vf-fg | Calcareous sandstone, sandy siltstone and siltstone and thin bands pellets, nodules and minor lime. | STAIRWAY SANDSTONE |
| 104'–162' | White minor grey | Fg | Sandstone and occasional thin bands sandy siltstone and siltstone; rare pellets. | STAIRWAY SANDSTONE |
| 162'–201' | Grey | Vf-fg | Sandstone and siltstone, slumps, burrows and trails common; occasional thin pellet bands. | STAIRWAY SANDSTONE |
| 201'–486' (268', 362') | Grey to dark grey | | Siltstone and shale calcareous in part and thin beds sandy siltstone and silty sandstone; many thin pellet bands, rare limestone: disseminated pyrite. | STAIRWAY SANDSTONE |
| 486'–682' (543', 584', 614') | White minor grey | F, m, and cg | Sandstone, more or less silicified, with many thin pellet bands in upper part; thin siltstone and sandy siltstone bands occur throughout. | STAIRWAY SANDSTONE |
| 682'–881' (754') | Dark grey to black with minor grey | | Shale and siltstone with thin beds limestone and silty sandstone: thin oolitic pyrite beds at top, disseminated vfg pyrite throughout: several tight fractures, mostly filled with calcite and minor residual hydrocarbons. | HORN VALLEY SILTSTONE |
| 881'–907' | Grey | Vf-mg | Silty sandstone and glauconite, minor pyrite, hydrocarbons and limestone. | HORN VALLEY SILTSTONE |
| 907'–918' | White | F-cg | Sandstone and glauconite, hydrocarbons. | PACOOTA SANDSTONE |

T.D. 918'

**Mineral content:**

All core registered +ve $P_2O_5$ with field reagent. Assay from intervals 0–257', 469'–504', 669'7"–690'5" and 706'9"–729'10" ranged up to 11·3% but mostly were <1%.

Oil-bearing sandstone occurs between 652'5"–656'10", 659'3"–661'0", and 674'0"–675'4". Residual hydrocarbons are present in fractures to the bottom of the hole.

DRILL: Mindrill A 3000

DRILLER: O.K. Frederickson

COMMENCED: 22-7-63

COMPLETED: 17-8-63

REMARKS: Drilling fluid – water – consumption less than 400 gallons per 10 hour shift.

LOGGED: J.B.

SAMPLED: W.G.

ASSAYED: Rum Jungle/Canberra

SHEET ...... OF ......

Appendix I contains a report of an analysis of a sample of the oil-bearing sandstone made at the Petroleum Technology Laboratory, B.M.R., Canberra.

Trap It is significant that the oil saturation begins immediately below a thin silt band 2 to 8 mm thick. Elsewhere in the core it is common to find fluorescence concentrated below such bands and becoming progressively weaker away from the band.

Figure 3 shows the basal sandstone unit of the Stairway Sandstone arching over the axis of the Johnny Creek Anticline. About one mile along the axis (to the north-west) this sandstone is breached by a deep creek to within approximately 100 feet of the base of the sandstone. As the oil sand is within the lower 50 feet of the sandstone, lateral continuity of the silt band across the anticlinal axis would represent a cap for a reservoir in the basal sandstone.

However, the thinness of the band, the unlikely lateral continuity of such bands, and the need to support a pressure column of over 500 feet, detracts from the feasibility of a substantial oil reservoir in the Stairway Sandstone in this part of the structure. In addition it is difficult to believe that an unfractured trap could be preserved so close to the surface and above the water table (100 feet).

The irregular or patchy distribution of the oil appears to be a result of silicification. This suggests that although the oil is trapped in the core sample by a thin silt band, on a larger scale it may be trapped by the absence of porosity/permeability due to silicification.

In either case, the occurrence of oil in AP1 core probably represents a small local deposit with dimensions of mere tens of feet.

Source The presence of oil in fractures through to the Pacoota Sandstone suggests a source in pre-Larapinta Group rocks. Such potential source rocks are the Cambrian Limestones and the Bitter Springs Limestone. Hydrocarbons have been found in each of these units, in the Amadeus Basin. However, the oil may have migrated laterally from the Horn Valley Siltstone, regarded as one of the best source rocks and present in close proximity to the oil sands.

The Johnny Creek Anticline, whose culmination lies approximately 15 miles north-west of AP1, appears to have a subsidiary 'closure' on its eastern limb (fig. 3). This closure is indicated by the shape and topography of the outcrop of the basal sandstone unit of the Stairway Sandstone. The limb of the anticline plunges to the south-east, and in the north-west the outcrop of the basal sandstone is reflected as a low saddle, even though the drainage of the headwaters of Johnny Creek is to the north-west. The structure would require a detailed survey to determine the amount of vertical closure (this work has been carried out since by the tenement holder).

The presence of oil in AP1, the close proximity of this subsidiary structure, and the excellent cap rock properties of the Horn Valley Siltstone, highlight the Pacoota Sandstone as an oil reservoir. It could be tested by a shallow (say 1,000 feet) hole sited on the highest point of the outcrop of the basal sandstone unit of the Stairway Sandstone.

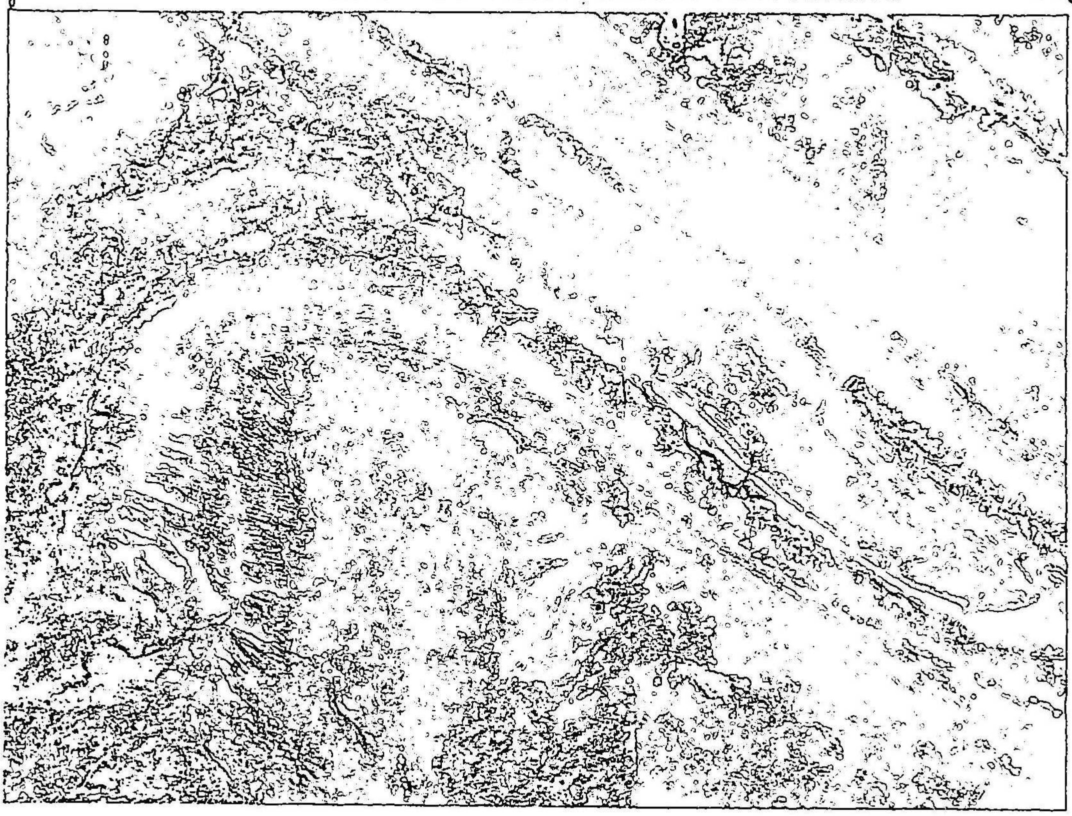
Core Analysis Appendix I contains a report of an analysis of a sample of the oil-bearing sandstone made at the Petroleum Technology Laboratory, B.M.R., Canberra.

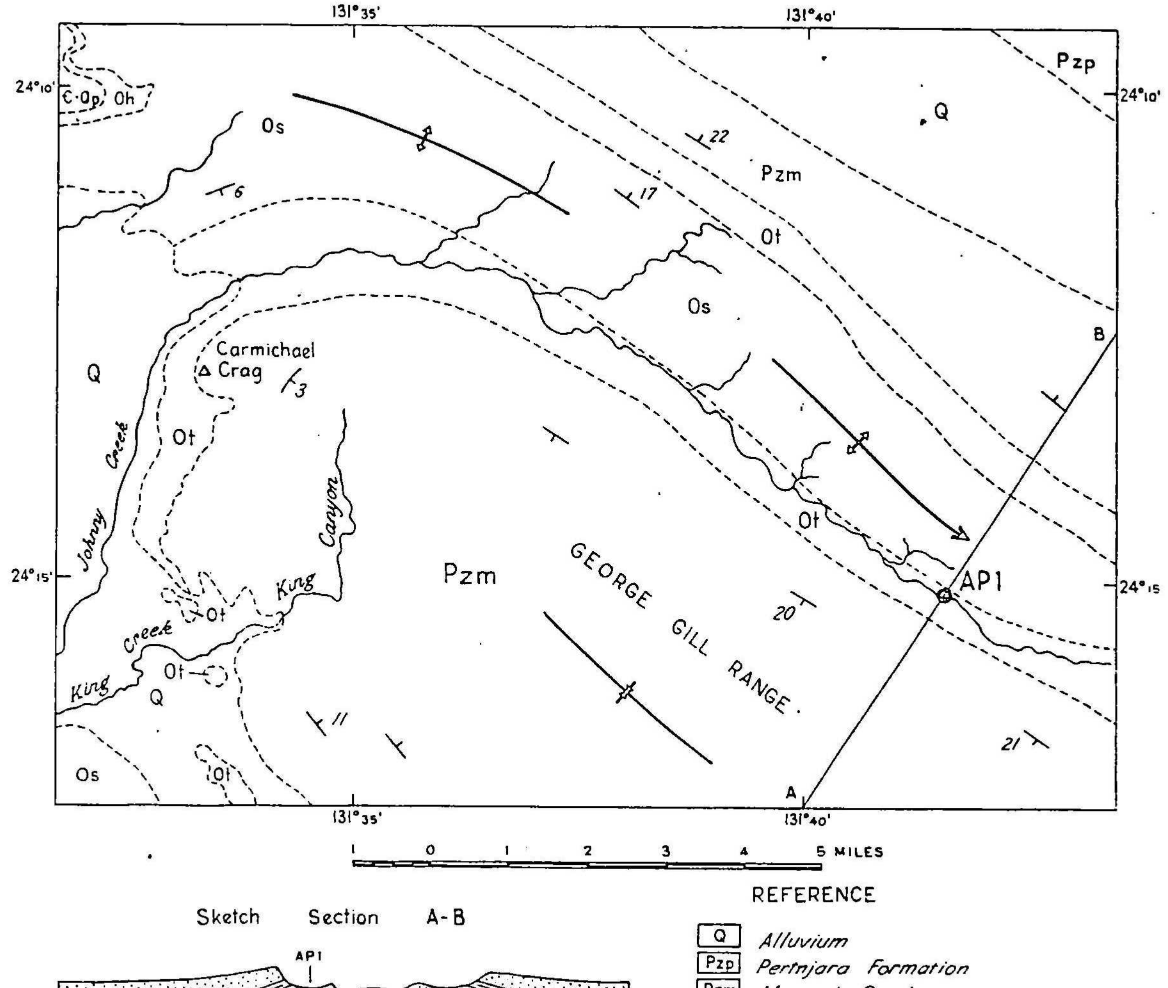
Three items are worthy of comment; although no firm conclusions are attempted.

1. The low porosity and permeability. This is due principally to silicification of the sandstone as indicated in a thin section of the oil sand (Morgan, 1964).

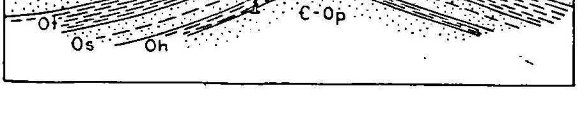
# EASTERN END – JOHNNY CREEK ANTICLINE

Fig. 2






Sketch Section A-B




REFERENCE

| | |
|---|---|
| Q | *Alluvium* |
| Pzp | *Pertnjara Formation* |
| Pzm | *Mereenie Sandstone* |
| Ot | *Stokes Formation* |
| Os | *Stairway Sandstone* |
| Oh | *Horn Valley Siltstone* |
| €-Op | *Pacoota Sandstone* |

2. The low water content. Comparison with core analyses of oil sands from many parts of the world shows that the figures of 7 percent and nil percent water are anomalously low. Typically the water content as shown by core analyses ranges from 20 percent upwards. Caran (1951) states that 'cores cut with diamond bits, using water-base mud, normally show total water saturations between 15 and 20 percent of the pore space when cores are oil productive.' He also states that 'clean sands with permeabilities above 1,000 millidarcys may have connate-water saturations less than 15 percent of the pore space.' The permeability of this sand is only 25/27 millidarcys. The low water content may be explained by evaporation during the time the core was exposed from cutting to core laboratory. However, it is unlikely that the mechanics of evaporation of connate water from pore space will allow the level of water content to become so low in the relatively short time of four days. Although it cannot be demonstrated whether the figure obtained is representative of a fresh sample the supposition that the sand was relatively dry at the time of emplacement of oil must be considered.

   For example: The basal sandstone may have been exposed some time before deposition of the following units of the Stairway Sandstone. At this stage surficial silicification may have taken place causing porosity/permeability traps. Oil, already forming in the underlying Horn Valley Siltstone, moved upwards into the dry basal sand of the Stairway Sandstone and was trapped against the silicification barriers.

3. The distillation curve indicates the presence of high and low fractions of hydrocarbons and a relative lack of intermediate fractions. Typically such curves are straight. This lack of intermediate fractions may indicate the presence of two populations of oil i.e. oil derived from two different sources. The possibility that the low fraction is the oxidation product of the high fraction is considered unlikely since the sediments are unoxidized. However, aerated ground waters, for example, may have oxidized the oil without affecting the sediments.

Possible contaminants:

1. Drill rod grease. An abnormal feature during drilling of the hole was the need to apply drill rod grease after each lift from approximately 250' onwards. In the upper part of the hole much of this grease returned with the drill water and was floated off in the sumps before recirculation. In the lower part of the hole, during drilling of the Horn Valley Siltstone, the drill water became very muddy. It appears that an appreciable quantity of the grease became emulsified or formed a fine suspension with the mud and was recirculated to the bottom discharge bit. Core from the lower part of the hole contained blebs of oil and 'skin deep' fluorescence from contamination in this manner.

However, in the zone of oil sand it is considered that such contamination did not occur because:

a) drilling had been in sandstone for 170' and the drill water was relatively clean. It is extremely unlikely that any grease was recirculated to the cutting face over this interval.

b) the oil sand already was saturated with fluid.

c) adjacent clean porous sands (some parts were completely uncemented) showed no sign of contamination.

d) none of the oil sand compared with other parts of the core which were demonstrably contaminated.

2. Kerosene rag. The drilled used pieces of hessian and a kerosene bucket for cleaning threads and parts of the core bit. A few instances were noted where fibres of hessian had been circulated through the cutting face and had become impaled in fractures. Such fibres and any grease associated with them were quite distinct from the oil sand and from residual tars found in some fractures through to the bottom of the hole.

Note: Since the drilling was for phosphate and oil contamination could not affect a phosphate assay no special precautions were taken against such contamination during the drilling of this first hole of the programme.

## REFERENCES

BARRIE, J., 1964 - Phosphate drilling, Amadeus Basin. Bur.Min.Resour.Aust. Rec. 1964/195.

CARAN, J.G., 1951 - Core analysis in SUBSURFACE GEOLOGIC METHODS, Colorado School of Mines, 295-320.

## APPENDIX I

## OIL-SATURATED CORE (STAIRWAY SANDSTONE) FROM B.M.R. DDH/AP1, SOUTH FLANK OF JOHNNY CREEK ANTICLINE, AMADEUS BASIN, N.T.

by

H.S. Taylor-Rogers

Attached are tabulated results of core analysis carried out 14th to 19th August, on a piece of core taken on 10th August, 1963, in this drill hole. The interval cored was from 652'5" to 660' and the piece tested was from 655' to 656' section of the core. Four feet of the core were oil-saturated, the remainder showing oil staining in and around fractures and small cavities.

The saturating (residual) fluid was extracted with suitable solvents and then subjected to exhaustive fractionation; the resulting cuts or fractions were further corrected for solvent contamination. The core section from which the extraction was made was exposed to atmospheric conditions for several days prior to testing. This exposure resulted in some weathering of the fluid.

The oil sample so obtained, weighing about 6 grams was found to be a highly mobile, black fluid with strong napthenic odour and a density of 0.95 gm/cc. On distillation the following results were obtained:

| | |
|---|---|
| Initial boiling point (I.B.P.) | $70^{\circ}$-$75^{\circ}$ C |
| Fraction I.B.P. - $120^{\circ}$ | 23.5% w/w |
| Fraction $120^{\circ}$-$200^{\circ}$ | 2.5% w/w |
| Fraction $200^{\circ}$-$300^{\circ}$ less than | 2.0% w/w |
| Fraction $300^{\circ}$-$350^{\circ}$ | 14.0% w/w |
| Fraction above $350^{\circ}$ | 57.0% w/w |

A graphic representation of these results is attached.

A notable cracking was observed during distillation at temperatures above $150^{\circ}$ C.

The combined fractions, boiling between $120^{\circ}$ and $350^{\circ}$ were analysed by liquid/solid chromatography and were found to have the following (approximate) hydrocarbon-type ratios:

Saturates/olefins/aromatics = 6/1/14

The residue (above $350^{\circ}$ C) contained 7% w/w wash, most of which was due to silica. Aluminium and some heavy metals were also detected. Quantitative determinations were made of the following elements:

| | | |
|---|---|---|
| Iron | - | 0.05% w/w |
| Calcium<br>Magnesium | } | 0.09% w/w |
| Sulphur | - | [illegible] |
| Phosphate | - | nil |

Paper chromatography of the distillation residue showed the presence of resins, polar compounds, waxes and other hydrocarbons. The presence of asphaltenes could not be established conclusively.

These preliminary tests were carried out in the Petroleum Technology Laboratory by P.G. Duff (core analysis) and J. Puchel (characterization of oil).

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

## CORE ANALYSIS RESULTS

Date: 14th-19th August, 1963.

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 permeater 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 Sozhlet type apparatus.

(iii) Acetone test precipitates and fluorescence of solvent after extractions are recorded as, nil, trace, fair, strong or very strong.

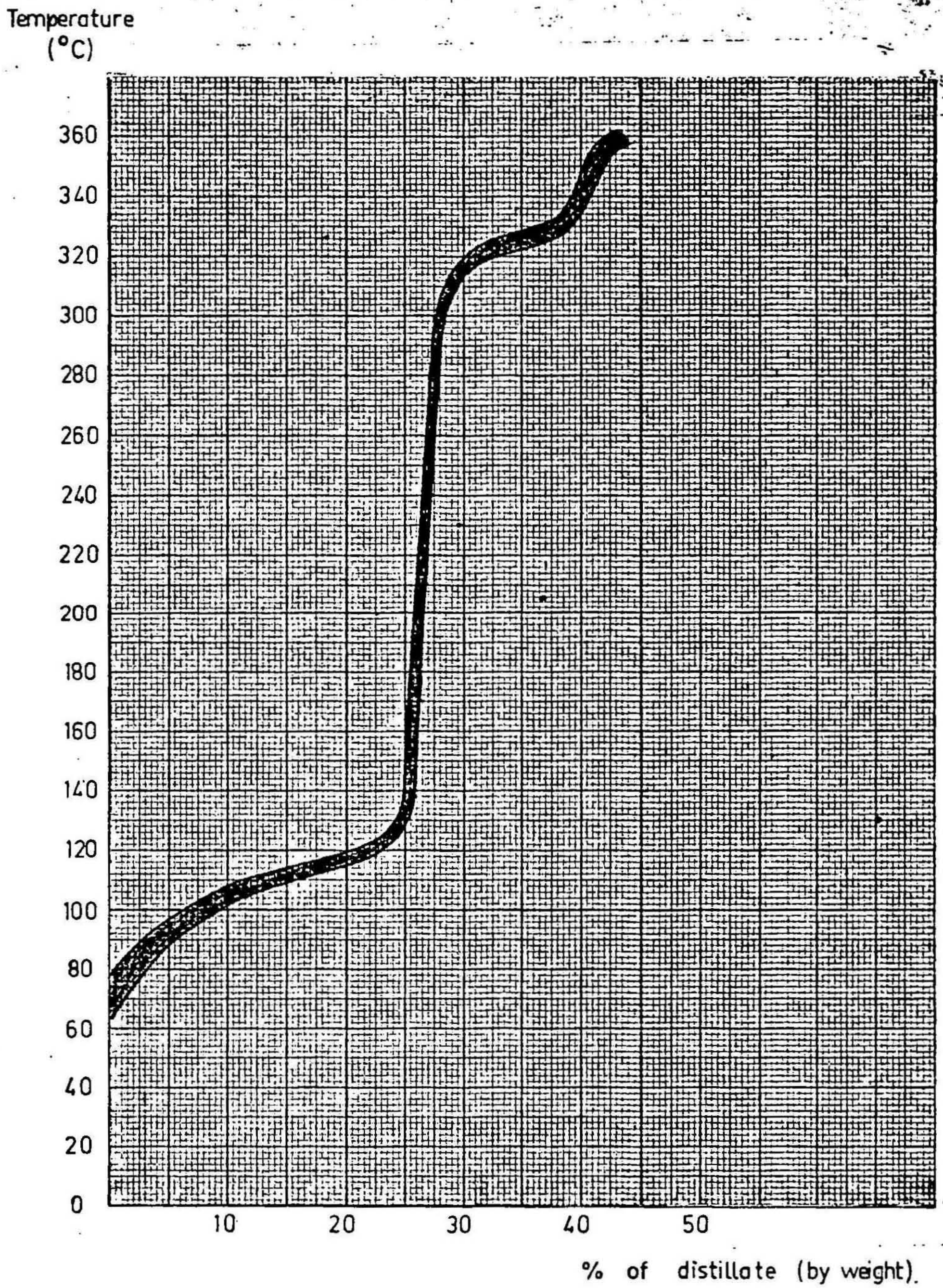
| Well or Area | Core or Sample No. | Depth in feet - From: To: | Lithology | Effective Porosity in % by Vol. | | Absolute Permeability in Millidarcys | | Average Density in gms/cc. | | Fluid Saturation in % Pore Space. | | Acetone Test | | Solvent after Extraction | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | V | H | V | H | Dry Bulk | Grain | Water | Oil | Colour | Precipitate | Colour | Fluor. | |
| B.M.R. D.D.H./ A.P.1 | 652'5" - 660' | 655'-656' (A) | Clean, fine-gr. quartz sandstone | 9 | 8 | - | 21 | 2.42 | 2.65 | 7 | 40 | Strong green-yellow | Very strong | Red Orange green bloom | Strong milky blue-white | |
| Johnny Creek Anticline | - | -"- (B) | " | N.D. | N.D. | N.D. | N.D. | N.D. | N.D. | Nil | 39 | " | " | " | " | |
| Amadeus Basin N.T. | - | -"- (C) | " | 9 | 8 | 27 | 21 | 2.45 | 2.68 | N.D. | N.D. | N.D. | N.D. | N.D. | N.D. | |
| Approx. Location 24°45'S | - | -"- (D) | " | 9 | | N.D. | | 2.44 | 2.68 | N.D. | N.D. | N.D. | N.D. | N.D. | N.D. | |
| 131°45'E | -"- | -"- (E) | -"- | 9 | | N.D. | | 2.42 | | 5.35* | 46.5* | N.D. | N.D. | N.D. | N.D. | * Determined by J.Puchel |

Additional information: Broken core bright yellow fluorescent throughout.
Solubility in 15% Hydrochloric acid - nil.

File No.62/399
File No.62/318

# DISTILLATION CURVE

Amadeus Basin, B.M.R. - D.D.H./AP 1




To accompany Record No 1965/ 78 F W