3. GEOLOGICAL DATA

(Note: all depths are loggers depths unless otherwise stated).

3.1 Geological Summary

Ronald 1 was designed to test a fault independent, seismically defined closure. The structure is located on the "Arnold Arch", a regional feature first recognised on seismic acquired in 1992.

A significant proportion of the Kyalla Member is absent over the "Arnold Arch" and preserved in two areas to the east and south-west known as the Balmain and Burdo "deeps" (Plan PetNTcw9491). These "deeps" are considered important hydrocarbon kitchens. Structures along the "Arnold Arch" are ideally placed to receive hydrocarbons migrating updip from these areas.

The primary reservoir objectives of **Ronald 1** were the Moroak Sandstone Member of the McMinn Formation and the "Jamison Sandstone". Minor amounts of oil and gas were recovered from the "Jamison Sandstone" in **Jamison 1** and significant oil shows were encountered in the Moroak Sandstone in **Elliott 1**. The secondary reservoir objectives were intra-formational sands in the "Hayfield Mudstone" and Kyalla Member of the McMinn Formation. Minor amounts of gas were flowed from the "Hayfield Sand" at **Jamison 1**, **Mason 1** and **Shortland 1** and some oil was recovered from the sand in **Balmain 1**. Encouraging oil shows were encountered in intra-Kyalla Member sands in **Elliott 1**.

The well spudded in unconsolidated to poorly consolidated clays, silts and minor sands, interpreted to be the Cretaceous Mullaman beds, which persisted to 64.3m. A very thin (17.2m) Cambrian Jinduckin Formation is interpreted below the basal sand of the Mullaman beds.

The top of the Cambrian Tindall Limestone was indicated by a change in drilling character (i.e. increased torque, formation "grabbing the bit") and the appearance of minor limestone in returns otherwise obscured by cavings. The formation top was picked as 81.5m using the gamma-ray log.

The top of the Antrim Plateau Volcanics was picked at 187.0m where the gamma-ray curve increased from 15 GAPI to a consistent 60-70 GAPI (through casing). The top was less apparent whilst drilling as the ROP didn't decrease to characteristic rates (10-20min/m) until 214m and returns were obscured by cavings. The faster than expected penetration rates through the top 27m of the basalt sequence suggest that it was weathered and/or vesicular and fractured.

The first hydrocarbon shows occurred in a zone interpreted to be a weathered flow top (vesicular and fractured) in the Antrim Plateau Volcanics. The zone of interest is 361.5 to 368.0m as interpreted from electric logs, penetration rates and geology. Bright pale yellow hydrocarbon fluorescence was noted in crystalline calcite (possibly vein fill) and gas readings peaked at 1327 ppm Cl. A gas flow rate of roughly 2000 cu ft/day was calculated using 900 cu ft/min air injection and 0.133% gas. Brief flares at the blooie line following connections were noted after the zone had been intersected and gas readings remained elevated. The zone is believed to have continued flowing low rate gas for the duration of the hole.

The well entered the "Hayfield Mudstone" at 559.3m immediately penetrating the "Carbonate Marker" unit which can be correlated across the Beetaloo Sub-basin. The unit is distinctive on electric logs and is characterised by a light olive grey, coarse, calcareous siltstone in cuttings.

From 573.3 to 695.5m the well intersected greyish and blackish red, brownish, greenish and dark greenish grey siltstones and claystones. The interval 695.5 to 714m contained a trace to 40% sandstone in cuttings and is interpreted to be a distal correlative of the "Hayfield Sand". This sand is better developed in the central Beetaloo Sub-basin. No fluorescence or increased gas readings were noted.

Below 714m the well intersected predominantly brownish grey, dark greenish grey and brownish black siltstones and claystones with traces of very fine to fine grained sandstone. Gas readings remained relatively constant and when the "Jamison Sandstone" was intersected at 772.7m it was found to be water wet.

The "Jamison Sandstone" can be subdivided into an upper unit between 772.7 and 800.5m of fine to medium grained sandstone with minor siltstone and claystone, a middle unit between 800.5 and 831.7m of interbedded very fine to fine grained sandstone and claystone, and a lower unit between 831.7 and 871.7m of predominantly fine grained sandstone with abundant clay matrix and minor claystone. Up to 40% dull yellow green pinpoint fluorescence with rare bright pinpoint fluorescence was noted in the basal 12m of the "Jamison Sandstone" and gas readings increased to a maximum 2995 ppm total gas (C_1 to trace C_5). Minor amounts of formation water were produced from the zone and foam injection became necessary to clean the hole.

The Kyalla Member of the McMinn Formation can also be sub-divided into three units. The upper unit between 871.7 and 904.3m is composed of greyish black to black claystone with a trace of micaceous siltstone, the middle unit between 904.3 and 945m consists of claystone with minor siltstone and glauconitic sandstone, and the lower unit between 945 and 1042m consists of claystone with minor siltstone and sandstone interbeds increasing in frequency towards the base. The top of the lower unit corresponds to a baseline shift in the resistivity log which can be correlated to other wells in the northern and central Beetaloo Sub-basin. No significant fluorescence or increases in gas over background were noted in the Kyalla Member.

Below the Kyalla Member **Ronald 1** passed sharply into the Moroak Sandstone member of the McMinn Formation. A medium to coarse grained, clean quartz sandstone with good reservoir characteristics was intersected between 1045.5 and 1072m. A corresponding order of magnitude increase in gas readings is attributed to the decreased dilution factor caused by an influx of large volumes of saline formation water from the zone (although the water is also believed to contain some dissolved gas). DST 1 was carried out after logging to assess the reservoir potential of the interval. Results indicate the zone initially produced formation water at approximately 3000 barrels/day before killing itself. Minor gas was also produced.

The reservoir quality of the Moroak Sandstone declined below 1072m and the proportion of interbedded micaceous siltstones and greyish black claystone increased. **Ronald 1** reached a total depth of 1150m in interbedded sandstones, siltstones and claystones of the Moroak Sandstone.

3.2 Well Objectives and Performance

Ronald 1 was designed to test two potential reservoirs on a fault independent, seismically defined closure. No significant hydrocarbons were encountered and the well was plugged and abandoned as a dry hole.

Formation tops were generally 60 to 100m off prognosis. Most significantly the Antrim Plateau Volcanics came in 87.9m high and were 191.3m thicker than prognosed, and the Kyalla Member was 176.7m thinner than prognosed.

A comparison of prognosed and actual formation tops is given in Table 4 and shown diagrammatically on Plan PetNTcw9435.

FORMATION NAME	PROGNOSED TOP (m KB)	ACTUAL TOP (Logger m KB)	DIFF TO PROGNOSED TOP (m)	ACTUAL THICKNESS (m)	THICKNESS DIFFERENCE (m)
Undifferentiated Surface	Surface (4.9)	-	-	-	-
Mullaman beds	NP	Surface (5.3)	NP	59.0	NP
Jindunckin Formation	84.9	64.3	20.6(H)	17.2	68.8 (Tn)
Tindall Limestone	170.9	81.5	89.4 (H)	105.5	1.5 (Tk)
Antrim Plateau Volcanics	274.9	187.0	87.9 (H)	372.3	191.3 (Tk)
"Hayfield Mudstone"	455.9	559.3	103.4 (L)	213.4	3.4 (Tk)
"Jamison Sandstone"	665.9	772.7	106.8 (L)	99.0	9.0 (Tk)
Kyalla Member (McMinn Fm.)	755.9	871.7	115.8 (L)	170.3	176.7 (Tn)
Moroak Sandstone (McMinn Fm.)	1102.9	1042.0	60.9 (H)	+108.0	-
Velkerri Formation	1452.9	-	-	-	-

Table 4 : Comparison of Prognosed and Actual Formation Tops and Thicknesses for **Ronald 1**.
Note: H = High, L = Low, Tn = Thin, Tk = Thick

3.3 Stratigraphy

Ronald 1 intersected 559.3m of Palaeozoic section and 590.7m of Proterozoic section.

A brief stratigraphic summary based on wellsite lithological descriptions and wireline log characteristics is presented below. A stratigraphic table is provided for reference (PetNTcw4588). Appendix 9 contains a full description of cuttings including a record of mud gas readings and observed fluorescence. A composite log is included as Plan PetNTcw9493.

Note: Cuttings samples were not collected until 109m. The top of the hole was logged with reference to samples from a nearby waterbore and electric log data.

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Mullaman beds (Cretaceous)

Surface to 64.3m (59.0m thick).

Moderate and greyish pink, light brown, pale yellowish brown and dark yellowish orange claystone, occasionally silty. Greyish orange sandstone at base, very fine to medium grained, quartzose.

Jinduckin Formation (Cambrian)

64.3 to 81.5 (17.2m thick).

Predominantly moderate yellowish brown and dark reddish brown siltstone. Minor pale orange to greyish orange crystalline limestone.

Tindall Limestone (Cambrian)

81.5 to 187.0m (105.5m thick).

Predominantly dark yellowish orange, greyish orange and light grey, finely crystalline to crypto-crystalline, cherty limestone, minor siltstone in places. A fine to medium grained, calcareous sandstone may exist between 170 and 187m. It is difficult to determine if returns have been obscured by cavings.

Antrim Plateau Volcanics (Cambrian)

187.0 to 559.3m (372.3m thick).

Dark grey to greyish and brownish black, finely crystalline (pyroxene, amphibole, feldspar, magnetite, quartz) basalt, occasionally weathered to a dusky brown colour.

"Hayfield Mudstone" (Proterozoic)

559.3 to 772.7m (213.4m thick).

559.3 to 573.3m
Light olive grey, coarse, calcareous siltstone fining upwards to a greyish and blackish red, very dusky red claystone. Trace white, crypto-crystalline calcite.

573.3 to 695.5m
Interbedded greyish and blackish red, very dusky red, dark greenish grey, non-calcareous, silty claystones, and brownish and light greenish grey, occasionally calcareous siltstones. Trace white crypto-crystalline calcite.

695.5 to 714.0m
Interbedded brownish grey, brownish black and dark greenish grey siltstone and very fine to occasionally fine grained sandstone.

714.0 to 766.0m
Interbedded brownish grey to brownish black micromicaceous siltstone and dark greenish grey claystone. Trace sandstone, generally very fine grained, occasionally fine grained, particularly below 752.0m

766.0 to 772.7m
Interbedded very fine to medium grained sandstone, brownish grey siltstone and dark greenish grey, pyritic claystone.

Jamison Sandstone (Proterozoic)

772.7 to 871.7m (99m thick)

772.7 to 800.5m
Sandstone, fine to medium grained, rarely coarse grained, grading to siltstone, brownish grey, non-calcareous argillaceous, grading to claystone, dark greenish grey, pyritic, in a fining upward package overlain by a coarsening upward package.

800.5 to 831.7m
Interbedded very fine to fine grained sandstone and dark greenish grey claystone.

831.7 to 871.7m
Predominantly fine grained, occasionally medium grained sandstone with rare orange and black coloured lithic inclusions. Minor interbedded dark greenish grey claystone.

Kyalla Member, McMinn Formation (Proterozoic)

871.7 to 1042m (170.3m thick)

871.7 to 904.3m
Predominantly brownish, greyish and olive black claystone, occasionally grading to brownish grey and brownish black micaceous siltstone.

904.3 to 945m
Interbedded greyish black and black claystone, brownish black micaceous siltstone and very fine to fine grained, glauconitic sandstone.

945 to 1042m
Greyish and brownish black claystone with minor interbedded brownish black micaceous siltstone and fine grained, glauconitic sandstone. Sandstone interbeds increase in frequency towards the base of the unit and are rarely medium grained.

Moroak Sandstone, McMinn Formation (Proterozoic)

1042 to 1150m (TD) (+ 108m thick)

1042 to 1045.5m
Light grey, fine grained sandstone, trace pyrite and glauconite.

1045.5 to 1072m
Predominantly medium grained sandstone grading to coarse in places, quartz grains well sorted, sub-angular to sub-rounded, very clean, no clay matrix. Minor interbedded greyish and brownish black claystone.

1072 to 1099.5m
Fine to medium grained sandstone, occasionally very fine grained, siliceous cement, siliceous and argillaceous matrix, rarely glauconitic. Minor interbedded greyish and brownish black claystone.

1099.5 to 1150m
Interbedded very fine to medium grained sandstone (rarely coarse grained), light grey, micaceous siltstone and greyish black claystone.

3.4 Contributions to Geological Knowledge

Information gained from the **Ronald 1** well has greatly increased the understanding of the northern Beetaloo Sub-basin:-

- The existence of the "Arnold Arch" as a regional pre-Jamison Sandstone structure has been proven. Correlation of **Chanin 1** to **Ronald 1** demonstrates that approximately 170m of section was stripped from the top of the Kyalla Member before the Jamison Sandstone was deposited.

- Correlation of units within the Kyalla Member shows an additional thinning of approximately 40m. This thinning could be attributed to growth of the "Arnold Arch" and/or Ronald structure during deposition of the Kyalla Member, or regional west-east thinning toward the Bauhinia Shelf.

- Excellent reservoir potential of the upper Moroak Sandstone has been demonstrated. The interval 1045.5 to 1072m has good reservoir characteristics as inferred by cuttings and electric logs, and when tested flowed saline formation water at an estimated initial rate of 3000 barrels/day before killing itself.

- The "Jamison Sandstone" at **Ronald 1** is predominantly composed of sandstones with a high clay matrix component (and hence poor reservoir characteristics) and interbedded claystones. The cleanest sands occurred at the very top and base of the sandstone. Small volumes of formation water and minor fluorescence were encountered in the basal "Jamison Sandstone" at **Ronald 1**.

- Rock-Eval results from **Ronald 1** and other wells indicate that the Kyalla Member did not mature prior to deposition of the Jamison Sandstone. A preliminary correlation of maturity profiles across the Beetaloo Sub-basin suggests that maturation did not occur until some time after the deposition of the Antrim Plateau Volcanics.

Considering the existence of adequate source rocks (particularly downdip in the "Balmain" and "Burdo" deeps), good reservoir rocks, optimal timing of oil generation and optimal maturity, the lack of hydrocarbons at **Ronald 1** is best explained by an absence of closure or by fault breaching of the Ronald structure. Absence of closure appears to be the most likely explanation as both reservoir horizons came in significantly off-prognosis and the seismically fast Cambrian basalt was almost 200m thicker than prognosed. If the basalt has thickened locally a significant pull-up of seismic reflectors would be expected.

The structural validity of the Ronald structure is currently being investigated. The "Arnold Arch" remains an exciting exploration fairway ideally placed to receive hydrocarbons generated in kitchens to the east and south-west.

KEYWORDS

Petroleum, Proterozoic, Rotary Drilling, Hydrocarbons, Joint Venture, McArthur Basin, Roper Group, Drill Stem Test, Well logs.

LOCATION

Approximately 83km east of Daly Waters.

AMG Zone 53
E 410 399m
N 8 202 313m
Latitude 16° 14' 57.0" South
Longitude 134° 09' 41.5" East
1:100,000 Sheet Arnold River 5765
1:250,000 Sheet Tanumbirini SE53-2

LIST OF DPO's

77759, 77760, 77764, 77765, 77767.

DESCRIPTOR

This report details the drilling and results of the petroleum exploration well **Ronald 1**.