The table below illustrates the sharp increase in penetration rates and bit footage when air and mist were used as circulating fluids.

Drilling Method	Footage	Hours Required	No. of Hours	Ft./hr.	Ft./Bit
Mud Drilling 12¼" surface hole	292	19	1	15.4	292
Mist Drilling 12¼" hole	1529	74	4	20.6	382
Air Drilling 8¾" hole (a) without hammerdril	2548	84½	5	30.2	510
(b) with hammerdril	479	43	2	11.1	240
Mud and Water Drilling 8¾" hole	2079	427½	21	4.9	99

Note: Does not include coring runs.

G E O L O G Y

Summary of Previous Work:

Geological - Several reconnaissance and locally detailed surveys have been carried out in the Rodinga-Finke area notably by the Horn Expedition (1896, 1897), David and Howchin (1924), Chewings (1914, 1928, 1935) and Ward (1925). No regional stratigraphic mapping of the area was attempted until 1959 and 1960 when Leslie, MacLeod and Wulff of Frome-Broken Hill Ltd. compiled comprehensive reports and maps on the southern and eastern margins of the Amadeus Basin. Since 1960 the Bureau of Mineral Resources has been mapping the Amadeus Basin on National Grid 1:250,000 series but as yet the Rodinga Sheet, in which Mt. Charlotte No. 1 was located, remains unpublished.

Geophysical - The first geophysical work within the present boundaries of Oil Permit No. 72 was a helicopter gravity survey by Mines Administration for Flamingo Petroleum Pty. Ltd. in the south eastern part of the area in 1960. A survey by the Bureau of Mineral Resources over the remainder of the area was carried out in 1961. In 1962,

the Bureau of Mineral Resources conducted a reflection and refraction seismic survey between the Mt. Charlotte and Black Hills ranges. In 1963, a semi-detailed aeromagnetic survey was conducted over all of the permit area by Aero Service Limited for Finke Oil Co. Pty. Ltd.

In mid-1964, Geophysical Associates Pty. Ltd. conducted a two-month reflection seismic survey for Finke Oil Co. Pty. Ltd. in a magnetic depression area between the Mt. Charlotte and Black Hills ranges. This survey included the detailing of a structure immediately north of the Finke River in the north-west part of the permit area on which the Mt. Charlotte No. 1 location was chosen.

Drilling - No previous drilling for oil had been carried out in the Rodinga-Finke area and the nearest test well was Exoil Ooraminna No. 1 almost 60 miles to the north of the Mt. Charlotte No. 1 location.

REGIONAL GEOLOGY:

Proterozoic and Devonian units of the Amadeus Basin has been recognised in the Rodinga-Finke area by Frome-Broken Hill Ltd. and the Bureau of Mineral Resources. Archaean granites and metamorphics crop out in the extreme south west of O.P. 72 and are exposed in an inlier in the Hale River 40 miles to the north east of the permit. This latter exposure is skirted by the basal Amadeus sedimentary unit, the Heavitree Quartzite which is approximately 1000 feet thick there. The unit has thinned appreciably from the Heavitree Macdonnell Range type section. The Heavitree Quartzite is conformably overlain by the Bitter Springs Limestone, measured at Hale River as 2000 - 3000 feet of gypsiferous and cherty dolomite and limestone, often contorted and brecciated and containing large algal colonies. Immediately north of the permit basic volcanic rocks, attributed to flows, and/or sills, are placed at the top of the mapped Bitter Springs formation.

To the north of O.P. 72 Frome-Broken Hill Ltd. have measured up to 5000 feet of congolmerates, felspathic sandstones, siltstones, shales, limestones and dolomites as the "Pioneer Formation" which overlies unconformably the Bitter Springs. These beds lack sequence and lateral continuity and as they are occasionally tillitic in nature they are correlated with the Areyonga Formation of the northern Amadeus type section. Along the southern outcrop margin of the Amadeus Basin and projecting to the Black Hills Range in southern O.P. 72, the Bureau of Mineral Resources has mapped the Inindia Beds, up to 7000 feet of strata lithologically identical with and consequently equated with the Areyonga Formation. The next unit, the Pertnjara Formation, as defined in the Amadeus type section, conformably overlies the Areyonga and comprises up to 3000 feet of dark shales and siltstones with an algal limestone member becoming predominent in the upper part of the formation towards the eastern edge of the basin. This type of lithology is seen in the Pertatataka along the northern margin of O.P. 72. However, over the southern half of the Amadeus Basin and outcropping in the Black Hills, the Bureau has outlined the topographically prominent Winnall Beds, a sandstone-siltstone sequence over 2000 feet thick, which unconformably overlies the Inindia Beds. Despite the difference in lithology the Winnall Beds have been correlated with the Pertatataka Formation due to their similar position in the stratigraphic sequence. This correlation appears to be verified in the Black Hills, where there is a facies variation from Winnall sandstone and siltstone in the south west to dominantly vari-coloured shale and siltstone of Pertatataka aspect in the north eastern end of the range. On very meagre fossil evidence the Pertatataka is considered to be Upper Proterozoic and the Winnall Beds most probably Lower Cambrian.

PERTATAKA ? → OP72/72

The Arumbera Formation is an unfossiliferous coarse to fine clastic unit which lies conformably beneath fossiliferous Cambrian strata. Approximately 3000 feet of Arumbera have been measured in the north eastern Amadeus region where it lies conformably on the Pertatataka, but it thins westward and southward over folded and eroded Proterozoic rock (see later under Structure). The overlying Pertaoorta Group comprises 4000 feet of clastic-carbonate sequence which, as mapped by the B.M.R., shows rather complex facies variation throughout the basin. In the central regions the group in its lower part is made up of the Hugh River Shale overlain by the Goyder Formation, a sandstone unit. South westward the lower section becomes very sandy and several members are discernible while eastward the group becomes richer in carbonates almost to the total exclusion of clastics. The carbonate facies commences as limestone stringers at the top and base of the Hugh River Shale and soon becomes identifiable to the east as the Chandler (lower) and Jay Creek Limestones. The former is very cherty and contorted, the folding possibly being due to incompetent evaporites. The Jay Creek facies grades upward into the Goyder and merges downward with the Hugh River, eventually resting directly upon Chandler. Thus over the eastern part of the basin the Jay Creek and Hugh River are difficult to separate and they are usually both referred to as Jay Creek. The Pertaoorta Group is abundantly fossiliferous and contains algal-achaeocyathid reefs in the eastern part of the basin.

Over the northern Amadeus Basin the Larapinta Group conformably overlies the Goyder Formation and comprises the Pacoota Sandstone (maximum measured thickness 2500 feet), the Horn Valley Shale (up to 650 feet thick), the Stairway Sandstone (1300 feet) and the Stokes Formation of siltstones and carbonates (1800 feet). The Pacoota is transitional

upon the Goyder and contains Upper Cambrian fossils in its lower horizons and Lower Ordovician forms in its upper part. The other Larapintine formations are rich in Ordovician fossils. Over the more folded southern part of the Amadeus region the Pacoota and Horn Valley wedge out by progressive onlap and the Stairway becomes the basal transgressive unit of the Larapinta, overlying unconformably the older Cambrian and Proterozoic strata.

In the western and central Amadeus Basin the ?Silurian Mereenie Sandstone, up to 2500 feet of mostly clean white sandstone, overlies the Stokes Formation generally with conformity. However, on some structures, the basal part of the Mereenie is absent and the unit unconformably overlies truncated Larapinta. In the south eastern Amadeus region all of the Mereenie has been removed, possibly in part by pinchout on structures but probably mainly from erosion prior to deposition of the succeeding Pertnjara.

The Pertnjara Formation is a continental fill type deposit comprising up to 10,000 feet of vari-coloured siltstones, sandstones and conglomerates of Devonian age. The basal 1500 feet of the formation is predominantly siltstone while the remainder consists of coarser clastics which reach their maximum thickness over the northern downwarped half of the Amadeus Basin. South eastward to the Rodinga-Finke area the lower siltstone and the upper sandstone of the Pertnjara grade laterally into the Horseshoe Bend Shale and Idacowra Sandstone formations respectively, of the Finke Group. Additional units of the group appear as the basal Polly Conglomerate followed by the Langra Sandstone, a sandstone-conglomerate sequence, which bring the maximum exposed thickness of the group in the area to 1500 feet.

Over the south eastern Amadeus Basin and outcropping in the eastern part of O.P. 72, sediments of the Great Artesian Basin outcrop, first as mesas and buttes, then south eastward dipping beneath the Simpson Desert. The units recognised are the Permian Crown Point Formation, comprising fluvial and glacial clastics, the ?Jurassic continental De Souza Sandstone and the marine Cretaceous Rumbelara Shale, each separated by unconformity.

STRATIGRAPHIC TABLE

Age	Lithological Unit	Formation Tops Depth	Subsea	Thickness
Devonian	Pertnjara Formation	Surface	+1260'	1200'+
Ordovician	Stairway Sandstone	1200'	+60'	345'
Cambrian	Jay Creek Limestone	1545'	-285'	785'
Cambrian	Chandler Limestone	2330'	-1070'	742'
Cambrian	Arumbera Formation	3072'	-1812'	60'
Proterozoic	Pertatataka Formation	3132'	-1872'	1923'
Proterozoic	Bitter Springs Limestone	5055' ← 4763'? OP 72 of 72.	-3795'	1888'+

Formations Penetrated:

Surface Sands 0' - 56' (Thickness 56')

Age: Caïnozoic

Pertnjara Formation: 56' - 1200' (Thickness 1144'+)

Age: Devonian

Red brown, silty, slightly micaceous shale and brown, grey, or tan, fine to medium grained, friable sandstone. The sand is well rounded, frosted, poorly sorted grains, has good porosity and is a water aquifer. The basal 50' of unit comprises red, green and some purple fine textured shales.

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Stairway Sandstone: 1200' - 1545' (Thickness 345')

Age: Ordovician

Thinly interbedded tan, slightly calcareous sandstone and pale grey-green, grey to grey-purple, silty, micaceous, shale with occasional thick beds of sandstone. The sandstone is very fine to fine at top becoming coarser downwards till basal 40' is poorly sorted, conglomeratic. The grains are well rounded, frosted, poorly cemented giving good porosity. The unit is very phosphatic throughout and shows worm tube impressions.

Jay Creek Limestone: 1545' - 2330' (Thickness 785')

Age: Cambrian

Mainly red brown, silty to gritty, micaceous shale. Traces of grey to brown, slightly calcareous siltstone 1550' - 1760' with interbeds up to 5' thick of light tan to white, crypto-crystalline, hard, silicified dolomite 1560' - 2330'. Trace anhydrite and phosphate are associated with dolomite throughout.

?Chandler Limestone: 2330' - 3072' (Thickness 742')

Age: Cambrian

Principally white to light tan, coarsely crystalline halite. Generally pure but some grey-brown clay interstitial impurities and interbeds of earthly light grey to brown, calcareous siltstone 2800' - 2895'.

Arumbera Formation: 3072' - 3132' (Thickness 60')

Age: Cambrian

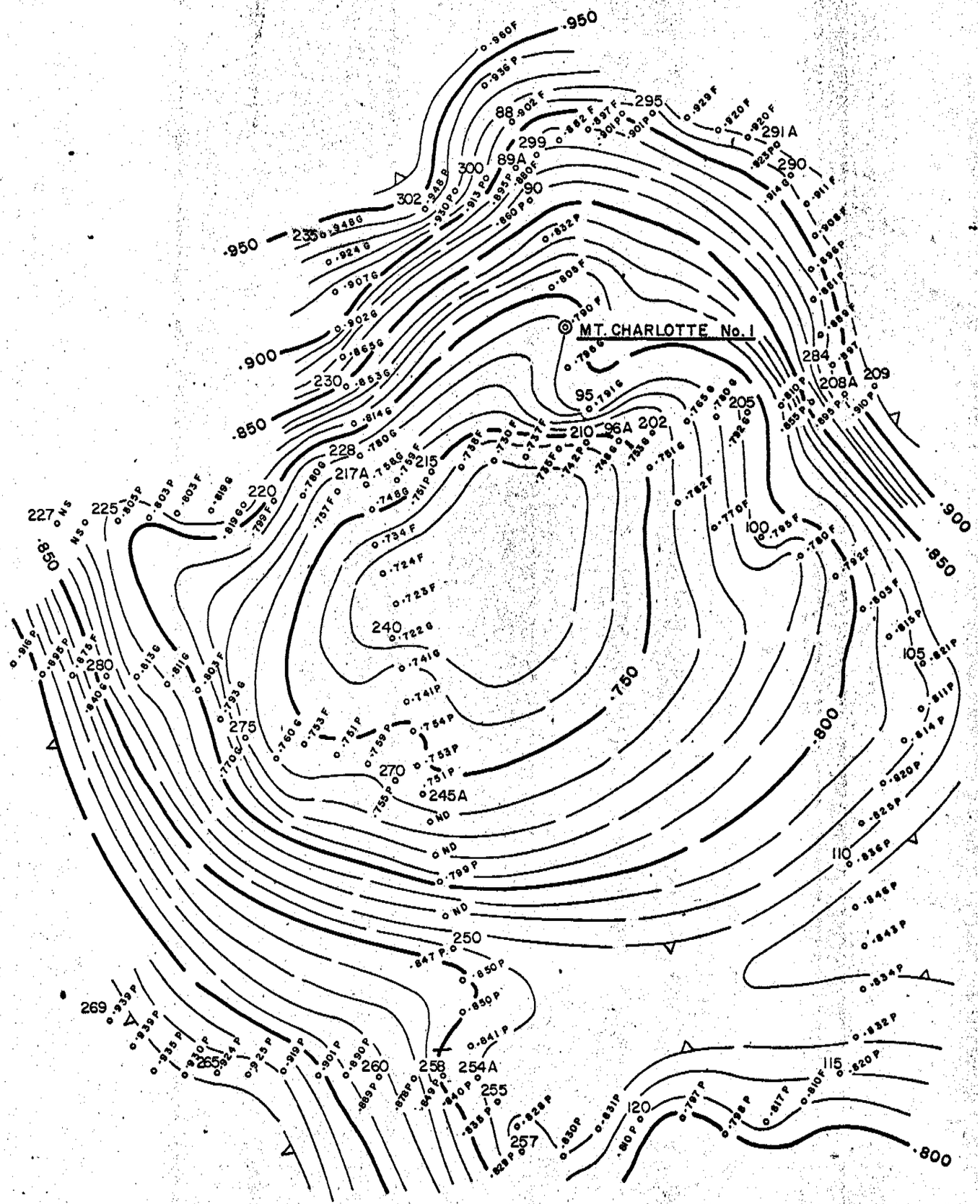
Predominantly grey to red-brown, silty, micaceous shale with minor amount grey to brown, sandy siltstone.

Pertatataka Formation: 3132' - 5055' (Thickness 1923')

Age: Upper Proterozoic-Cambrian.

3132 feet - 4672 feet mainly grey to dull greenish and brownish-grey, silty, firm micaceous shale. Thin interbeds of similar siltstone, associated with green glauconite

Figure 3



MT. CHARLOTTE No. 1

SEISMIC STRUCTURE MAP

Showing

Structure Contours on

BITTER SPRINGS HORIZON

CONTOUR INTERVAL : .010 secs.
DATUM PLANE : + 1000 feet.

0 1 2 miles

pellets 3132' - 3320'. Brown colour and dolomitic content increases below 3870' with some thin free dolomite beds 4499' - 4672'. 4672' - 5055' dolomite, white, pink, tan, light to very dark grey, very fine textured, generally siliceous (cherty from 4672 feet to 4750 feet). Local algal-like structures developed. Small amount of anhydrite throughout interval. Black grey and brown silty micaceous shale occurs as thin bedded to lenticular partings, rarely as five foot beds. Scattered sandstone beds are poorly sorted, dark grey, very argillaceous, tight.

Bitter Springs Limestone: 5055' - 6943' (Thickness 1888' +) (not corrected for dip)

Age: Proterozoic

Predominantly white, grey, grey-green, and occasionally pink dolomite, silicified and gypsiferous. Trace anhydrite 5217' - 5860' and considerable orange to honey coloured chert 6805' - 6910'. Dark grey to grey-green and purple silty, micaceous shale finely interbedded with dolomite through sequence and buff, purple to colourless glauconitic siltstone grading downward to sandstone which becomes prominent in interval 5600' - 6040'. Beige to orange coarsely crystalline salt 6106' - 6240', 6316' - 6324', 6710' - 6805' with considerably disturbed and contorted sediments suggesting an intrusive origin for the salt.

Structure

The eastern part of the Amadeus Basin can be divided into two structural categories separated roughly along a zone extending eastward from James Range to the Hale River Archaean inlier. North of this zone, the basin shows considerable post Devonian downwarp, a thick cover of Mereenie and Pertnjara Formations, gentle fold elements and reasonable conformity between stratigraphic units. To the south of this zone, there has been considerable tectonic disturbance, indicated by tight, occasionally

recumbent folding, major faulting and appreciable interformational movement expressed by major unconformities. Surface mapping suggests the main unconformity is post Pertatataka - pre Arumbera (Wells, Stewart and Skwarko 1964; Ranford and Cook, 1964).

Figure 3 is a seismic structure contour map of a Bitter Springs reflector showing the Mt. Charlotte structure. The anticlinal axis is approximately 1½ miles south of the well location. A shallow seismic horizon, which ties to a unit of the Jay Creek Formation between 1545 and 2330 feet, was also mapped. This horizon showed slightly more than 100 feet of structural closure which was centred half a mile north of the wellsite. The site was thus chosen midway between the two anticlinal axes to obtain closure at both horizons.

The velocity survey and the intergrated acoustic log indicate that the lower horizon may tie to a shalier zone at approximately 5470 feet which is about 400 feet below the selected top of the Bitter Springs Limestone at 5055 feet. The dolomite section between 4672 and 5470 feet appears to thin south of the location. Towards the Black Hill Range, the Bitter Springs shows increasing structural relief, presumably caused by the major orogeny which occurred along the southern margin of the Amadeus Basin at the end of the Proterozoic.

North from the wellsite, the Bitter Springs thickens. About 5,000 feet of Bitter Springs can be expected in the fold indicated by seismic surveys midway between the Mt. Charlotte No. 1 location and the Mt. Charlotte Range.

Seismic evidence indicates that total depth of the well is approximately 1000 feet to 1500 feet above the base of the Bitter Springs. The total thickness of the Bitter Springs Formation at the location should be

approximately 3500 feet.

The interpretation of the aeromagnetic survey conducted in 1963 indicates magnetic basement in the area to be at approximately 9000 feet. This agrees quite well with the postulated depth to basement from the results of the seismic survey and the Mt. Charlotte No. 1 well.

RELEVANCE TO OCCURRENCE OF PETROLEUM

The most significant indications of hydrocarbons found in the Mt. Charlotte well came from black shales in the Bitter Springs Limestone. Small gas kicks on the gas detector and faint traces of fluorescence recorded in the Bitter Springs over the interval 5,230 to 5,660 feet and gas kicks from 6,720 to 6,760 appear to have been associated with a dark grey (organic-rich?) shale. Of particular interest is the wet composition (Appendix 4) of the gas extracted from dry cores and run through a chromatograph. These potential source rocks considerably enhance the prospective possibilities of the Bitter Springs formation in this part of the Amadeus Basin, particularly if they can be found associated with reservoirs with effective closure.

POROSITY AND PERMEABILITY OF SEDIMENTS PENETRATED

The shallow Pertnjara and Stairway sandstone samples had the only visible permeability. The sandstones were clean and moderately silicified but poor sorting, especially in the Stairway sandstones, has slightly reduced the porosities. Visual estimates of porosities average 15% or higher in the rarely preserved grain clusters and would be considerably higher where better sorting and reduced cementation occurs. The logs indicate Pertnjara and Stairway sandstone beds with average porosities of 20%, but permeability is questionable.

From 1545 to 4810 feet no permeability was found in shales, dolomites and massive salts. Fluid entry at the 4810 to 4820 level prevented further air drilling on this well. As the fluid level rose some 4300 feet above the aquifer, significant permeability was present as well as reservoir pressure.

Fractured and recemented dark grey shales were recovered in a core at 5424 feet but drill stem test No. 1 covered the zone and the interval was tight.

CONTRIBUTIONS TO GEOLOGICAL CONCEPTS AS A RESULT OF DRILLING

Mt. Charlotte No. 1 proved the majority of mapped Amadeus Basin sequence to the north persists to the south-eastern margin of the Basin. The Areyonga Formation is absent only 50 miles south-west from where almost 5,000 feet of the formation has been reported. Along the southern margin of the basin, the unit lies disconformably and unconformably on its contiguous formations and, in this tectonic enviroment, truncation both from onlap and erosion can be expected.

The Arumbera Formation is thin in the well but this is in accord with mapping to the west (Ranford and Cook loc. cit) where the formation is thin over the southern disturbed block and is absent altogether over some Proterozoic highs. The structure on which Mt. Charlotte No. 1 was drilled is probably "bald headed" i.e. an incipient feature formed over previously folded and eroded Proterozoic sediments.

That the lower Larapinta and all of the Mereenie are missing from the Mt. Charlotte No. 1 section was anticipated from outcrop mapping, the former being apparently due to onlap pinchout and the latter from both onlap and pre-Pertnjara erosion. A normal Pertaoorta section was penetrated, the Jay Creek being somewhat thinner

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than expected and the Goyder being absent. A Hugh River Shale type facies dominates the Jay Creek Limestone formation.

Both the Bitter Springs and Jay Creek Formations can now be mapped reliably by seismic methods within the existing area of seismic control.

The thick salt member of the Chandler Formation was not anticipated in this well. Re-examination of the seismic records indicate that the salt cannot be recognised with sufficient certainty to be mapped with normal quality data obtained by the conventional method of recording.

STRATIGRAPHIC COLUMN

Before and After Drilling

MT. CHARLOTTE No. 1