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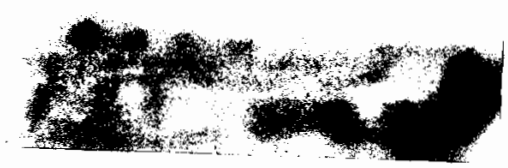
PRELIMINARY PETROLEUM PROSPECTS

OF

ONSHORE PETROLEUM EXPLORATION

APPLICATION 225 (VICTORIA RIVER)



BY A.C.M. LAING M.Sc

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INTRODUCTION

The area applied for is in the Victoria River Basin of the Northern Territory with the boundaries as shown in Fig. 1.

The area covers part of a number of cattle stations. The vegetation consists of low (5m) tree cover and grassland in a savannah landscape. The climate is warm dry monsoonal with the wet period from December to March and a long dry season from April to November. Average annual rainfall is 25 inches. The main road from Katherine to Wyndham runs through the area. There is a store and police station at Timber Creek otherwise the nearest towns are Kununurra and Wyndham to the west and Katherine to the east. There are numerous station tracks in addition to the main road providing good access in the dry season.

TOPOGRAPHY

Five topographical divisions are recognised:

(1) Plateaux
(2) Limestone ridges and domes
(3) Stony downs
(4) Grassy plains
(5) Alluvial flats.

Plateaux:

The Victoria River, and its tributaries have dissected the sub-horizontal Jasper Gorge Sandstone, leaving great plateaux and deep gorges. The plateaux have different levels, ranging up to 600 feet above sea level, between Timber Creek and Coolibah, and up to 1000 feet at the headwaters of the Humbert River. The Pinkerton range forms a high scarp along the Baines River.

Limestone ridges and domes:

The Skull Creek Limestone forms low ridges and domes ranging to a maximum of 100 feet. These show typical karst pattern.

Stony Downs:

This division consists of low, rolling, stony downs, developed on the Antrim Plateau Volcanics. The basalt "boulders" range up to 1 foot in diameter.

Grassy Plains:

The Bynoe Siltstone and Angalarri Siltstone weather to form flat, open plains, with a heavy growth of kangaroo grass and a few scattered trees, as seen between Skull Creek and Coolibah, and around Auvergne.

Alluvial Flats:

These are developed along all the major streams, except where the latter run in narrow gorges through the plateaux.

REGIONAL STRUCTURE

The area covers part of the Victoria River Basin which contains 5,000 feet of unmetamorphosed Upper Proterzoic Sandstone, shale limestone and dolomite, partly almost flat lying, partly gently folded.

PREVIOUS WORK

Traves (1955) regionally mapped the area. Laing and Allen (1956) mapped part of the area in detail for Associated Freney Oilfields N.L.

Sweet (1977) remapped the area and prepared a comprehensive bulletin on the Precambrian geology of the Victoria River Region, Northern Territory.

STRATIGRAPHY

The stratigraphy of the area may be summarised as follows:

Quaternary	Alluvium	
Tertiary	Laterite	
Lower Cambrian	Antrim Plateau Volcanics.	
Upper Proterozoic	Duerdin Group Quartz sandstone & conglomerate	575 ft.
	Bullo River Sandstone Brown ferriginous sandstone,grit and conglomerate	300 ft.
	Shoal Reach Formation Dolomitic sandstone	350 ft.
	Spencer Sandstone Quartz sandstone	560 ft.
	Lloyd Creek Formation	250 ft.
	Pinkerton Sandstone Sandstone and shales	300 ft.
	Saddle Creek Formation Siltstone	300 ft.
	Angalarri Shale Green shale	500-1000 ft.
	Jasper Gorge Sandstone Red sandstone	maximum 600 ft.
Upper Proterozoic	Bynoe Siltstone Purple and green siltstone and shale	500 ft.

Skull Creek Limestone dolomitic limestone and chert (thickness 900 ft)	⇌	Timber Creek Formation Siltstone and siliceous limestone

The Stratigraphic terminology is based on Laing and Allen (1955) in the lower part of the section and on Sweet (1977) and Pontifex and Sweet (1972) in the upper part of the section not mapped in detail by Laing and Allen (1955) and included by them as Pinkerton Beds.

It is impossible to use the later BMR (Sweet 1977) terminology without adjustment in the lower part of the section as their mapping in the south east corner of the Auvergne Sheet (Pontifex and Sweet 1972) shows a section - Jasper Gorge Sandstone
Timber Creek Fmt
Skull Creek Limestone
whereas their stratigraphic column claims the section is
Jasper Gorge Sandstone
Skull Creek Limestone
Timber Creek Fmt.

However, the mapping confirms the Laing and Allen (1955) inference of a gradational boundary between Skull Creek Limestone and Timber Creek Formation.

Discussing the units in more detail and basically quoting from Laing and Allen (1956)

Skull Creek Limestone:

The oldest formation cropping out in the Permit is the Skull Creek Limestone, which consists of about 1,000 feet of dolomitic limestone, chert and very minor amounts of quartz sandstone and siltstone. The base is nowhere exposed. In the northern, western and south western limits of its outcrop, the formation grades laterally into the Timber Creek Formation, a unit made up of siltstone, dolomitic limestone with chert, and sandstone.

The type section for the Skull Creek Limestone is in the domes on the Timber Creek-Jasper Gorge road, twenty miles from Timber Creek Police Station. At this locality, Skull Creek, from which the formation takes its name, runs close to the road, in the gap between the western two domes. Detailed studies were made of this type section and two other sections in the Permit.

The carbonate rock which forms the bulk of the unit is described as dolomitic limestone, on the basis of field determinations (on colour, texture, hardness, resistance to acid, presence of dolomite rhombs on weathered surface) supplemented by etching and staining tests on a few selected specimens. The authors believe that more or less pure limestone occurs in the formation, but was not recognised definitely in the field.

The colour of the dolomitic limestone ranges from fawn to grey, rarely pink, on the weathered surface, and a fresh surface shows a different shade of the same colours, some with a tinge of pink. The grain size ranges from very fine to medium crystalline. Weathered surfaces show numerous small rhombs of dolomite. The very fine-grained beds tend to be silicified; otherwise, the carbonates are relatively pure, giving in acid solution, only a very little insoluble residue, probably argillaceous.

Exposed surfaces of the dolomitic limestone beds show fluting and potholing, characteristic of carbonate rock weathering. There are also many small fissures, possibly caused by dolomitisation, which results in slight reduction in volume of the rock affected.

Where the formation is considerably weathered, a secondary limestone or caliche has developed in the soil.

"Marker" Members:

Two members of the Skull Creek Limestone are sufficiently distinctive in lithology, and widespread in occurrence to be useful as marker beds. The first of these, the "upper marker", crops out about half way up the type section at Skull Creek. Sweet (1977) refers to this as the Supplejack Dolomite member. It consists of well-bedded, dark grey dolomitic limestone, grey to fawn in colour on fresh surface, fine to medium in grain, and shows dolomite rhombs on the weathered surface. In its typical outcrop, the rock is slightly fluted, deeply dissected and pot-holed. It ranges in

thickness, the maximum measured being 36 feet in the middle dome at Skull Creek. In many outcrops the marker is underlain by a bed of dark grey dolomitic limestone, with numerous thin layers of chert. The marker bed itself rarely contains chert. It has its own characteristic vegetation, being favoured by a small compact bushy tree with a small broad green leaf.

This "upper marker" is very widely distributed, being found almost everywhere the Skull Creek Limestone crops out. In addition to being readily recognisable on the ground, it has a characteristic pattern on air photographs. It proved of considerable value in the elucidation of structure, and in correlating the numerous sections studied. Although it was used as datum in the latter work, this is not meant to suggest that this marker is considered to be isochronous throughout; rather, it probably varies slightly in age from one locality to another, i.e. we have purely "rock" correlation, not "time" correlation.

The second marker member; the "lower marker", is found some 80 to 100 feet stratigraphically below the "upper marker" in the type section. It consists of a number of beds of fawn dolomitic limestone, each with several horizons of small brown spheroidal bodies, up to 1/8" diameter, and apparently of argillaceous composition. Some beds are partly silicified. The member has a thickness of 80 feet (maximum) in the type section. No satisfactory explanation can be offered for the mode of formation of the small spheroidal bodies; they do not appear to be oolitic.

This "lower marker" is much more restricted in its distribution than is the "upper marker". Besides its occurrence in the sections at Skull Creek and Surprise Creek, it was found only near Bullita Outstation. Unlike the "upper marker" it does not form a prominent outcrop, and cannot be recognised on air photographs. It was of some limited use in correlating the Skull Creek and Surprise Creek sections.

Fossil "Algae":

Certain forms, believed to be of organic origin were found at many horizons within the Skull Creek Limestone. They are circular to oval in plan, and raised semi-circular in section, being composed of a large number of thin hemi-spherical layers, suggesting growth lines.

In size they range from several inches to three feet in diameter. At certain localities they are numerous and form small biostromes. Most are composed of limestone, generally not dolomitic. Some small representatives preserved as silica were collected near Timber Creek, and other siliceous forms, oval in section, were found north east of Victoria River Downs.

None of the forms examined had any definite organic structure. However, they bear a superficial resemblance to the supposed fossil alga Collenia, described by Fairbridge (1950) from a late Precambrian limestone in Western Australia, and by Traves (1954) from a limestone (probably equivalent to the Skull Creek Limestone) at Top Spring, 80 miles east of Victoria River Downs. They have therefore been given for convenience, the general name "algae", pending palaeontological study.

These supposed fossils were not of stratigraphic value.

Chert:
The Skull Creek Limestone contains a large amount of chert, developed as thin irregular bends and nodular layers within the dolomitic limestone, and thick irregular masses interbedded with it.

The chert composing the thin layers is fawn to brown in colour on the weathered surface, and grey on fresh surface. It is extremely fine grained, probably cryptocrystalline. In some outcrops, the chert cuts across the bedding planes of the limestone, and possesses fantastically contorted forms. These structures probably were formed by movement of the silica as a gel during consolidation of the beds after deposition.

The massive chert is white to red-brown in colour, and extremely fine grained. Outcrops of it may be seen at the junction of the Timber Creek-Coolibah road with the road to Jasper Gorge, and also where the Coolibah road crosses Skull Creek. It is up to 100 feet in thickness.

Both developments of chert appear to be chemical deposits.
The massive chert lies near the top of the Skull Creek Limestone and can be mapped as a separate member from its distinctive pattern on the air photographs. However, areas so mapped contain many inliers of the limestone not delineated.

Sandstone:

The Skull Creek Limestone contains very little sandstone. Near the base of the type section, at Skull Creek, there are several thin beds (the thickest 3 feet)of fine grained, pink, calcareous quartz sandstone. Similar sandstone crops out near the base of the Surprise Creek section. In the section west of the Pigeon Hole road, there is possibly thirty feet of quartz sandstone, siliceous in part, but having a very poor outcrop. In the middle of the anticline east of Bullita Outstation, there is a little white to brown fine quartz sandstone, with calcareous cement.

Siltstone:

Only an insignificant amount of siltstone was found within the Skull Creek Limestone. It is green and purple or dark red in colour, and mostly calcareous.

Depositional Environment:

The Skull Creek Limestone appears to have been formed as a chemical deposit in a quiet, marine basin, slowly subsiding. The lateral gradation with the Timber Creek Formation suggests that the shares of the basin lay to the north and west. The surrounding areas were probably almost at base-level, providing mainly fine detritus (clay and silt) and solutions rich in lime, magnesia and silica.

Timber Creek Formation

The Timber Creek Formation is the lateral variation of the Skull Creek Limestone and it consists mainly of purple siltstone with minor siliceous limestone, fine sandstone and chert. The type section is a hill on the east side of Timber Creek, 5 miles south of the Police Station. A well-defined marker bed of contorted chert boulders, in the section persists over an area of 5 or 6 square miles. Siliceous limestone predominates in the upper part of the formation.

The position of the gradational boundary has been estimated on the ground as the place where more than 20% purple siltstone enters into a predominantly limestone section. This was found to be about where a change in air photograph pattern took place from the distinctive limestone pattern to the pattern for bedded, fine grained, clastic rocks.

The gradational boundary swings around west of the Skull Creek Limestone and south to the Sandford Gorge.
A section was also measured in the upper Humbert River. This is presented as a stratigraphic column with the type section at Timber Creek.

Five miles south of Timber Creek a 50 feet band of chert is found near the top of the Timber Creek Formation.

Current ripple marks are common in the siltstone of the Timber Creek Formation outcropping along Gibbie Creek north of Mt. Sandford Outstation. They were also found in limestone along the Humbert-Bullita Outstation track.

Bynoe Siltstone

This formation includes the Victoria River Shale as described by Brown (1895). The formation was renamed Coolibah Formation to avoid confusion with the Victoria River Group of Traves (1955), by Laing and Allen (1956). Sweet used the term Bynoe Siltstone for this unit and this is used here.
The type section of the lower part of the formation is at the crossing of the Victoria River at Coolibah; and of the upper part on a mesa just south of the Timber Creek-Coolibah road, some 4 miles from Coolibah.

The total thickness of the formation measured in its type sections is 500 feet. The plotted stratigraphic column of the upper 400 feet is given in Sheet 7.

The formation mostly consists of alternate 2 feet beds of purple siltstone and hard, light green, laminated shale. Both lithological types are dominantly siliceous but the formation becomes more calcareous in its lower part.

An indication of the environment of deposition can be obtained from the different sedimentary features seen. These included mud cracks, swash marks, ripple marks - all indications of shallow water deposition.

The following are the dimensions of ripple marks measured:

Wavelength.	Amplitude	Index	Locality
3.18cm	.159cm	20	Jasper Gorge
5.08cm	.635cm	8	Victoria River Downs Road
3.5cm	.5cm	7	Coolibah Crossing

The Bynoe Siltstone as mapped lies unconformably on the Skull Creek Limestone with an angular unconformity of about 5 degrees. This unconformity was examined on the ground in three localities, 8 miles west of Coolibah Homestead, 6 miles west of Humbert River Homestead, and at the Head of Spring Creek, a few miles south west of Bullita Outstation.

The unconformity is well exposed near Humbert River, where a band of limestone, apparently the basal member of the Bynoe Siltstone, overlies 2 to 10 feet of limestone fragments in a reddish recemented earthy deposit, taken as representing the old land surface. This surface dips northwards at about 2 degrees. About 2 miles south of this locality a small outlier of Bynoe Siltstone is surrounded by Skull Creek Limestone topographically higher.

The Bynoe Siltstone as mapped does not overlie on Timber Creek Formation anywhere. The following relationship probably holds:

Jasper Gorge Sa. dstone	Jasper Gorge Sandstone
	partly conformable
unconformity	partly disconformable
Timber Creek Formation	Bynoe Siltstone.
	unconformity
	Skull Creek Limestone

Jasper Gorge Sandstone:

The Jasper Gorge Sandstone is equivalent to the Victoria River Sandstone of Brown (1895), who gave this name to the sandstone cropping out in scarps round the lower reaches of the Victoria River. Traves (1955) used the term Victoria River Group which included the Victoria River Sandstone (now Jasper Gorge Sandstone), Victoria River Shale (now Bynoe Siltstone) Skull Creek Limestone and Timber Creek Formation. As one widespread unconformity was found in the area (at the top of the Skull Creek Limestone and Timber Creek Formation), the term Victoria River Group has been abandoned. Because of possible confusion with the Victoria

River Group, the names Victoria River Sandstone and Victoria River Shale have also been abandoned.

The type section for the Jasper Gorge Sandstone is at the eastern end of the Jasper Gorge where about 600 feet of red and white predominantly quartz sandstones overlie green shale of the Bynoe Siltstone.

The base of the Jasper Gorge Sandstone was traced by eye along the scarp south of the Timber Creek-Coolibah road. The basal red marker sandstone was not continuous over this distance but as one sandstone bed lensed out another appeared just under or over it.

On a mesa about 5 miles west of the Coolibah Turn-off on the main road the following section was measured.

25 ft.	red sandstone strongly outcropping
200 ft.	green and purple shale partly obscured by scree
50 ft.	red sandstone strongly outcropping.

The Jasper Gorge Sandstone can be traced on the air photographs west from Coolibah along the Victoria River to Timber Creek where only about 50 feet of red sandstone cap the mesas.

Further west still, south of Auvergne Homestead in the East Baines Gorge the Jasper Gorge Sandstone is about 150 feet thick. There it lies on Timber Creek Formation and is overlain by Auvergne Shales.

It is thought that the formation has a maximum thickness of 200 feet south of Auvergne, on the sandstone plateau east of the West Baines River.

South of the Sandford Gorge the Jasper Gorge Sandstone lies unconformably on the Timber Creek Formation. Further south still it is found as inliers in the Antrim Plateau Volcanics south of Mt. Sandford Outstation.

The Jasper Gorge Sandstone is a red, mainly current-bedded, quartz sandstone. It becomes progressively more felspathic southwards suggesting its source was in that direction. The round, sand-size grains of quartz are either cemented with siliceous cement in optical continuity with the grains or with ferruginous cement.

Sedimentary features indicative of the origin of Jasper Gorge Sandstone are ripple marks, rain drop prints, mud cracks, salt crystal marks and probable worm tracks. There are conglomerates present containing mud pellets, shale and chert pebbles. The ripple marks are oscillation ripple marks. The following is a list of those measured in the Jasper Gorge area:

Wavelength.	Amplitude	Index
10.37 cm	1.27cm	8
83.7 cm	8.0cm	10
3.15cm	0.38cm	8
41.9cm	3.66cm	11.5
33.1cm	3.66cm	9.1
38.1cm	3.66cm	10.5

All that can be deduced is that the rocks containing the oscillation ripple marks must have been laid down in less than 60 fathoms of water, and probably in much shallower water close to a shoreline, as suggested by the mud cracks and rain prints.

It is believed that the Jasper Gorge Sandstone does not represent exactly the same time interval all over the Permit. Figure 8 shows the probable relationship in the northern half of the Permit.

South of Coolibah Homestead the Jasper Gorge Sandstone lies with probable disconformity on the Bynoe Siltstone. Of the chert and shale pebbles found in the sandstone, the chert pebbles appear to be from the Skull Creek Limestone, while some of the shale pebbles may be derived from the underlying Bynoe Siltstone.

In two places in Jasper Gorge itself and at the north end of Sandford gorge (30 miles north of Mt. Sandford Outstation), the Bynoe Siltstone grades up into the Jasper Gorge Sandstone without a distinct break.

In a small outlier five miles north of Bullita Outstation the Jasper Gorge Sandstone directly overlies the Skull Creek Limestone. This is apparently the case also in the Moolooloo Anticline on the eastern edge of the Permit.

At Timber Creek and also on the Mt. Sandford-Victoria River Downs road, the Jasper Gorge Sandstone lies unconformably on the Timber Creek Formation.

Angalarri Shale

The area of outcrop of the formation also includes the valley of the West Baines River from its junction with the Victoria River to 10 miles north of Kildurk Station, and the lower slopes of the Pinkerton Range.

Typically it is a green shale. It lies apparently conformably on the Jasper Gorge Sandstone. The exact contact was not found and the relationship is inferred from the field mapping and air photo interpretation, which indicate that the Jasper Gorge Sandstone dips gently below the formation.

The thickness of the Auvergne Shale is not definitely known. Measured dips are, as is usual with shales, rather anomalous. No bores have definitely penetrated the formation. The inferred thickness is about 1,000 feet, although the formation may be twice that thickness. The average width of outcrop of the formation is about 16 miles.

There are several areas near the Jasper Gorge Sandstone boundary where a joint pattern rather similar to that of the sandstone can be seen on the air photographs, although there is no outcrop of sandstone. These areas are assumed to be of Jasper Gorge Sandstone with a thin cover of Auvergne Shale.

Pontifex and Sweet (1972) describe the formations in the Bullo River area as follows:-

> "The Saddle Creek Formation is in most places marked by a basal sandstone about 7 m thick resting conformably on Angalarri Siltstone. The composition of this sandstone is fairly uniform throughout the area and it is characterized by abundant cross-bedding, ripple marks, festoon cross-laminations, and flame structures. The overlying 90m of siltstone contain several beds of sandy oolitic dolomite in the southwest part of the Pinkerton Range. These beds lens out toward the north east, and near the Victoria River the siltstone contains massive, friable, glauconitic fine-grained sandstone. The siltstone is thin in the north east.

The overlying Pinkerton Sandstone forms the main escarpments and dissected plateaux in the Pinkerton and Yambarra Ranges. A massive basal quartz sandstone bed about 25 m thick is overlain by at least two thinner sandstone bands with interbedded siltstone. A prominent ridge of Pinkerton Sandstone extends along the south side of the Victoria River Fault for about 80 km. This is the basal sandstone, folded to near vertical or overturned adjacent to the fault.

The Pinkerton sandstones are texturally mature, and petrographic evidence suggests that they were derived from pre-existing sedimentary rock. The extent and thickness of the basal sandstone, and its composition, indicate that it formed during a single transgression, with minor fluctuations influencing deposition of the upper part of the unit.

The Lloyd Creek Formation is exposed generally only where it has been protected from erosion by overlying sandstone. Its base is taken at the first dolomite (which in some places contains intraformational breccia), above the Pinkerton Sandstone. The presence of oolites, stromatolites, and intraformational breccia, indicate that the formation was deposited in a shallow-water, fairly high-energy environment.

The Spencer Sandstone has a fairly prominent basal bed up to 15m thick of brownish grey, thin-bedded, flaggy to blocky, fine to medium -grained sandstone characterized by small-scale cross-laminations, ripple marks, mud flakes and minor halite casts. The poorly exposed upper part of the unit is slightly calcareous."

DETAILED STRUCTURE

Regionally, the area forms an Upper Proterozoic sedimentary basin, the Victoria River Basin. The oldest deposits now exposed in this basin have two distinct facies. A marginal one represented by the Skull Creek Limestone. The western and southern sides of the basin are defined by the gradational boundary of the Timber Creek Formation - Skull Creek Limestone.

Overlying these beds unconformably are very shallow water beds (Bynoe Siltstone and Jasper Gorge Sandstone) indicating that the basin was gradually filling up.

The geological structures in the area are of a type peculiar to the Precambrian nuclei on the western side of Australia and consist mainly of long narrow zones of steeply dipping beds between large areas of almost flat-lying strata.

The steeply dipping zones are not aligned consistently in any one direction but tend to lie around diamond-shaped blocks.

They can be classified into two types as follows:-

1. Monoclines
2. Domes and anticlines.

The monoclines have an elbow in which there is a sharp change from flattish dips of about 15 degrees to steep dips of 40 degrees or more on the upthrow side. On the downthrow side there is a more gradual change from steep to shallow dips.

The monoclines run in long sinuous lines about 1/4 mile wide. They die out lengthwise by gradually flattening out.

The monocline 4 miles east of Bullita Outstation at the head of the East Baines River, forms the western limb of an assymmetric anticline.

Domes and a few anticlines are found along the line of these steep zones. The domes are mostly faulted at an acute angle to their long axis with horizontal displacement of beds. Such faults were found with horizontal throw of up to 400 feet, in some cases in a clockwise sense, in others anticlockwise.

The domes are also peculiar in that there is a sharp transition from the steep (23 degrees plus) beds with closure to the surrounding gentle dipping beds (10 degrees).

The average dimension of the actual domes is about 60 x 40 chains though two domes, one at Humbert River, the other north west of Mt. Sandford Outstation, were different in that they were circular in outcrop rather than elliptical.

The average dip of the Timber Creek Formation and Skull Creek Limestone outside the steep zones is 5 to 10 degrees. The overlying Jasper Gorge Sandstone and Bynoe Siltstone have an average dip of one to two degrees.

Steep zones mainly occur in the Timber Creek Formation and Skull Creek Limestone but there are a few in the Jasper Gorge Sandstone. One was seen in the Pinkerton Beds.

The explanation here adopted for the monoclines, domes and anticlines is that they are formed by slight readjustment along diamond-shaped crustal blocks. Where these blocks have moved apart slightly a monocline was formed. Where they moved closer together an anticline resulted.

Where there is slight horizontal movement between blocks a dome is formed which if horizontal movement continues, becomes faulted approximately along its axis.

There are at least two periods of folding in the area, one before the deposition of the Bynoe Siltstone, one after the deposition of the Jasper Gorge Sandstone, although folding, caused by movement between the crustal blocks, probably occured at intervals throughout geological time.

Since its deposition the Jasper Gorge Sandstone has been folded into a geanticline in effect inverting the Victoria River Basin. In the north west portion of the area it has been tilted 2 degrees to the north west. On the eastern side of the area it dips east south east under the Antrim Plateau Volcanics at about the same angle.

A number of structures mapped are folds in either the Skull Creek Limestone or the Timber Creek Formation.

Most of the structures mapped in the Skull Creek Limestone were exposed to the same horizon about 800 feet below the top of the formation. The sequence below this is unknown.

However, there is a structure on the north western sides of the basin below which the Jasper Gorge Sandstone dips. This is on the edge of the Victoria River Basin and represents the best oil prospects. This is the Bullo River Anticline (see photogeological map). The Bullo River Anticline is about 40 miles long. Its southern flank represents a reversal of the general north western regional dip. Its northern flank is adjacent to the Victoria River Fault (Sweet 1977 p.59) which is upthrown to the north faulting older Proterozoic beds of the Halls Creek Mobile Zone against the Bullo River Sandstone exposed along the Bullo River Anticline. There are several closed culminations along the Bullo River Anticline indicated on photogeology. There is also a persistent report of an oil seepage (see section on Petroleum Prospects).

Other structures within the application area are:-

(a) Skull Creek Domes closed in Skull Creek Limestone, section underlying unknown.

(b) Bullita Structure also closed in Skull Creek Limestone and underlying section unknown.

(c) Dick Creek Structure closed in Timber Creek Fmt.

(d) East Baines Structure closed in Timber Creek Fmt.

PETROLEUM PROSPECTS

The rocks of the Victoria River Basin consisting of shale, siltstone, limestone, dolomite and sandstone are suitable formations for the generation of oil and are unmetamorphosed. Within the Skull Creek Limestone are numerous traces of Collenia (algae). Moreover there are persistent reports of oil occurrences in the area.

Stokes, Commander of HMS Beagle in 1839 found bitumen which was used to caulk the Beagle in a well sunk at what later became the Victoria River Depot some 12 miles west of the present Timber Creek Police Station. His account is quoted below:-

> "The sandstone which prevailed everywhere was in a decomposed state, but there was a very decided dip in the strata to the south-east, of about 30 degrees. On the east side of Water Valley (near Holdfast Reach), I found the same kind of slate, noticed before at Curiosity Peak; but what most interested me was a bituminous substance found near the bottom of the wells recently dug, and 23 feet from the surface of the ground. It was apparently of a clayey nature when first brought up, but became hard and dark upon exposure to the air, and ignited quickly when put into a flame of a candle."

A prospector, William Archibald Campbell claimed that in 1904 he found an oil seepage in the Bullo River. His sworn statement is quoted below:-

> "I, William Archibald Campbell, of 51 George Street, Fitzroy, in the State of Victoria, Prospector do solemnly and sincerely delcare
>
> 1) That I was prospecting the country in the vicinity of the Victoria River, Northern Territory, from the twentieth day of July 1904 to the twenty-eighth day of September 1904 for oil, coal and minerals, and during the month of September I was exploring the country adjoining and to the southward of Shoal Beach, as charted in the British Admiralty Chart of the

River, and I found a large tributary running into the said Shoal Reach, trending generally in a West to West South West direction. I explored this tributary and the ranges near to same, for a distance of approximately fifty miles from its junction with the Victoria River. At about fifty miles from the said junction, navigation is practically stopped by a rock bar running across the said tributary.

Prospecting the adjoining ranges, I found distant about seven miles and bearing South West twenty degrees South from the said rock bar, a very conspicuous mountain peak with noticeable black rocks on its top. While examining in a gorge distant about three miles bearing North thirty degrees West from the said mountain, oil oozing from between the strata of the sandstone rock on the side of the gorge. I examined same, and brought samples of it back to my boat on the river and thence with me to Melbourne, and produced to me at the time of making this declaration and marked numbers One and Two are bottles containing samples of the said oil strained by me ---- AND I make this solemn declaration conscientiously believing the same to be true and by virtue of the provisions of an Act of the Parliament of Victoria rendering persons making a False Declaration punishable for wilful and corrupt perjury.

The bottles of oil were analysed as follows:-

1) Labelled "Samples of Petroleum Oil, Victoria River, by W.A. Campbell".

"Specific gravity of original sample 0.826 at 15°C. The oil was subjected to fractional distillation in the Engler distilling apparatus. The following fractions were obtained:-

To 150°C 16% (Napthas) Specific gravity 0.797 at 15°C.

150-300°C 63% (Petroleum burning oils) Sp. Gr. 0.807 at 15°C.

Above 300°C 21% (Residual oils containing mineral lubricating oils) Total 100.0%

The sample contains 1% of saponifial oil and ½% of pitch.

The burning fractions were examined and found to resemble Borneo petroleum".

2) Labelled "Samples of Mineral Wax, Victoria River, N.T. by W.A. Campbell"

"The wax was purified and gave the following results:

Melting Points:- 54 - 59°C (according to degree of purification)

Specific Gravity 0.90 at 15°C

The wax was amorphous.

The purified wax more closely resembles paraffin than ceresin in ozokerite.

The original sample contains 1.9% of saponifiable matter".

Oil seepages and residues have been found at several other localities in the Northern Territory. They appear to be in the base of the Lower Middle Cambrian limestone or in the Lower Cambrian, Antrim Plateau Volcanics. Traves (1955) considers that the asphaltite, found in these Volcanics at Pompey Springs, has originated from the underlying Upper Proterozoic sandstones.

Blatchford (1922) inspected the place from which Mr. Oakes first obtained asphaltite in the Kimberleys. It is located about 1/2 mile up the Negri River from its junction with the Ord River and about 1½ miles downstream from the place where the Ord River Station - Wyndham road crosses the Negri River. On Traves' (1955) map of the Hardman Basin, it appears to lie within the area of outcrop of the Negri Group (Lower Middle Cambrian). The succession at this place is:

Negri
Antrim Plateau Group
Upper Proterozoic Sandstone

Asphaltite (pitch) was found also in a well at Texas Homestead, on the bank of the Ord River, some 5 miles upstream from the Negri junction.

Blatchford (1922, p.20) states:

"In every instance which came before my notice the pitch was in the basalt or the limestone immediately above. It had not impregnated the limestone to any appreciable extent. In hand specimens, the basalt is seen to be extremely vesicular, the vesicles being sometimes empty, sometimes completely filled with pitch, lime or rarely silica, and very often partially filled with lime and pitch. It is further noticeable that thin veins of pitch sometimes

impregnate the lime and at times the reverse. Not uncommonly the lime forms a coating to the vesicle, the central position being pitch. The pitch also fills the cracks in the rock and in this form occurs in quote considerable quantities."

Several samples of the asphaltite were analysed by Dr. E.S. Simpson (1922). Two analyses made by him are as follows:
No. 6507, junction Ord and Negri Rivers (Oakes' Find) submitted by Mr. P. Durack.
No. 8229, junction Ord and Negri Rivers (Oakes' Find) submitted by T. Blatchford.

	6507	8229
C	89.40	89.30
H	7.26	6.95
S	0.68	0.57
N	0.41	0.36
O	2.25	2.82
	100.00	100.00
Ash	0.43	0.49
Moisture	0.37	0.84
Volatiles	41.54	38.20
Fixed Carbon	56.27	41.00
Ash	1.82	19.96
	100.00	100.00
	Volatile Matter.	
Water	1.74	1.90
Oil	19.89	16.00
Gas	19.91	20.30
	41.54	38.20

The high fixed carbon percentages in the above analyses seem to indicate that the asphaltite has been in the basalt a very long time. It is therefore likely that the oil seepage forming this asphaltite started and stopped sometime in past geological time."

A further occurrence of asphaltite was examined by Opik and Traves in 1949 (Traves 1955) at Pompey Springs, 15 miles north north east of Mistake Creek Homestead.
Traves (1955) states:

> "At this locality there are a number of seepages along a fault line in the Antrim Plateau Volcanics, and on the margins of the seepages and in the neighbouring outcrops of vesicular basalt, a shiny black coating of asphaltite has been deposited. The water of the seepage is a dark colour and appears to be bringing up the oil residue."

The Jasper Gorge Sandstone and Bullo River Sandstone are friable quartz sandstones with porosity and permeability. Pontifex and Sweet (1972) refer to water bores into Pinkerton Sandstone, Jasper Gorge Sandstone and Timber Creek Formation giving good yields indicating good permeabilities. They are potential reservoir beds. The Jasper Gorge Sandstone is overlain by the Angalarri Siltstone which is an adequate trap rock.

There is also a number of dolomites in the sequence.

Closed culminations along the Bullo River Anticline are thought to be the most favourable potential traps. There are also closed structures lower in the sequence e.g. Skull Creek Dome, etc.

CONCLUSIONS AND RECOMMENDATIONS

The Upper Proterozoic rocks of the Victoria River Basin are unmetamorphosed, gently dipping, have oil shows and large closed structures and so must be regarded as having high potential for oil accumulations.

In other parts of the world notably U.S.S.R. there are substantial hydrocarbon accumulations in Upper Proterozoic rocks. The Upper Proterozoic in the Victoria Basin are less disturbed and less indurated than much of the New Zealand Cretaceous.

The recommended future work is -

(1) Check geological mapping of Bullo River Anticline
(2) Drilling of a number of holes on selected culminations on the Bullo River Anticline and other structures.

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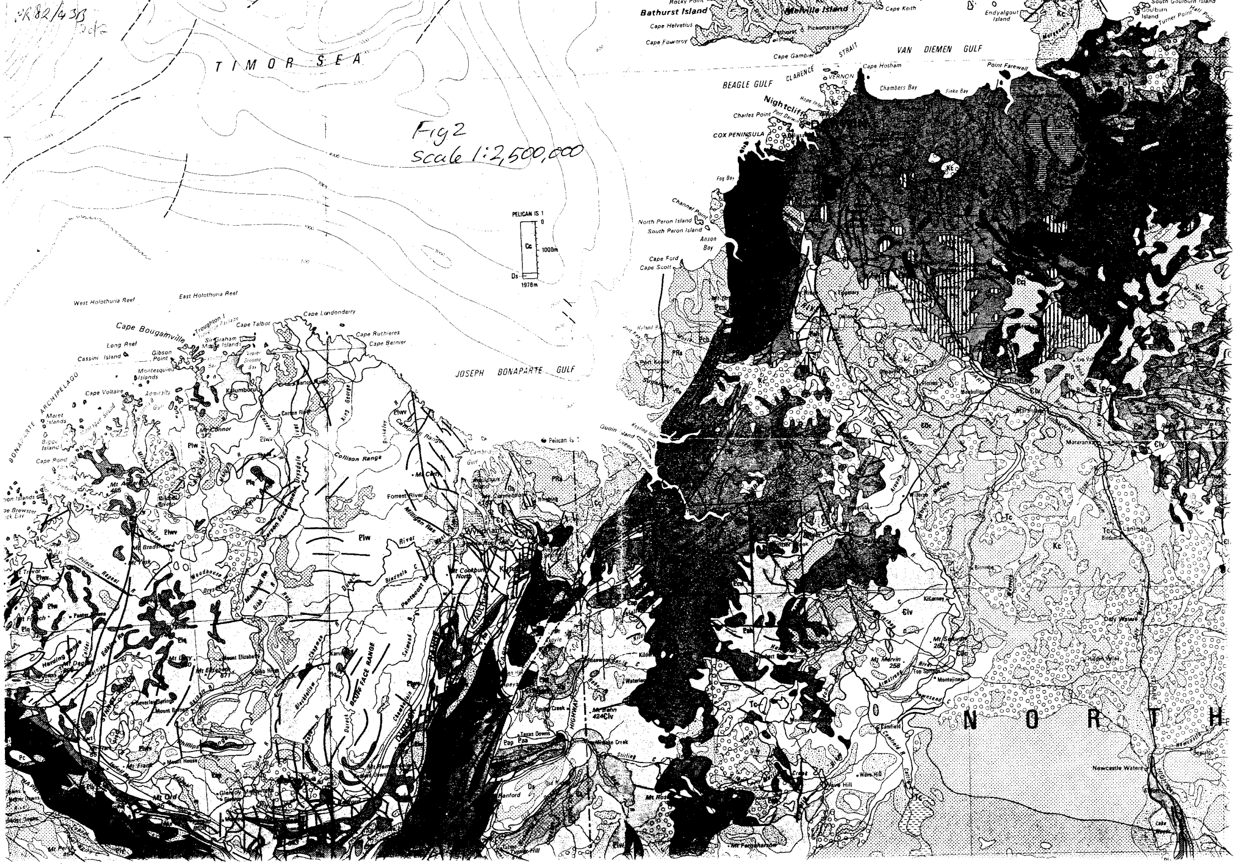

Fig 2
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