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WESTRALIAN OIL

PETROLEUM PROSPECTS OF BONAPARTE GULF BASIN

North West Australia

Prepared by Leo W. Stach, M.Sc.,
Consulting Petroleum Geologist

30th April, 1958

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A U S T R A L I A.

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I N T R O D U C T I O N.

The Bonaparte Gulf Palaeozoic sedimentary basin is located in the Darwin-Wyndham area of northwestern Australia (see Location Maps), partly in the State of Western Australia and partly in the Northern Territory. Access to the area for motor vehicles from the port of Wyndham is relatively easy and airfields are located at Darwin (international airport) and Wyndham. Motor vehicles can traverse most of the area without too much difficulty, except during the wet season from November to March; temporary airstrips for light planes can be readily prepared in most parts of the area. Neglecting the area along the east shore of the Joseph Bonaparte Gulf, where shallow boring for coal has shown that only a thin cover of later Palaeozoic sediments rests on the Precambrian basement, the main portion of the basin at the head of the Gulf has an area of a little more than 3,000 square miles. Three organizations hold the permits to explore this area, and the boundaries of their permits are shown on the location map. Gulf Oil Syndicate (GOS) holds that portion of the basin lying within Western Australia (about 2,000 square miles), Westralian Oil Limited (WOL) holds the south-eastern portion at the head of the basin within the Northern Territory (about 350 square miles), and Associated Australian Oilfields (AAO) hold the north-eastern sector within the Northern Territory (about 850 square miles),

and the unfavourable area along the east shore of the Gulf. Westralian Oil Limited and Gulf Oil Syndicate are willing to operate together and offer a percentage share of the interest in their combined permits to other organizations capable of conducting and financing an exploration and drilling program within their combined permit areas; it is probable that Associated Australian Oilfields would also be amenable to a similar proposal if it were considered necessary to control the entire area of the basin before outside interests would participate. Fifty-fifty subsidy has also been offered by the Australian Government for deep stratigraphic test wells drilled at approved locations; since no wells have yet been drilled to any significant depth within this large sedimentary basin, such a project would rate a high priority for this subsidy. The prospects of this as yet untested basin would be considerably enhanced if any significant result should eventuate from the intensive program of geophysical geologic surveys, and exploration drilling that is currently being conducted by WAPET (80 percent Caltex) in the geologically similar Fitzroy Basin to the southwest (see Location Map).

PREVIOUS INVESTIGATION AND OPINIONS.

The petroleum prospects of the Bonaparte Gulf basin were first investigated by Frank Reeves in 1947 on behalf of Standard Vacuum Oil and other interests. Reeves later published a brief review of the geology and oil prospects of this basin ('Australian Oil Possibilities', A.A.P.G. Bulletin, vol.35 (12) December, 1951, pp.2498-2501); he stated that 'because of the small size of the basin and the possibility that the Permian in many areas directly overlies pre-Cambrian rocks, Standard Vacuum decided that the basin did not merit further investigation, and the concession was cancelled in 1949'. However, Reeves concluded that:

(...3/.)

'Despite the small size of the Bonaparte Gulf Basin, the possibility that pre-Cambrian rocks may directly underlie Permian strata in the central part of the basin and the absence of surface indications of oil, it is believed that the basin may be classed as possibly oil-bearing. This opinion is based on the probability that several thousand feet of Devonian and Carboniferous reef limestones occupy coastal margins of the basin and are overlain by 1,000 to 2,000 feet of Permian shales and sandstones. Slumping over pre-Cambrian hills and limestone reefs and fracture zones along post-Palaeozoic faults are a definite possibility and contribute to the oil prospects of the basin.'

Shortly thereafter, the Australian corporation AMPOL acquired prospecting rights to the Bonaparte Gulf basin which later passed, together with permits in other areas, to the West Australian Petroleum Company (WAPET), formed jointly by Caltex (80 percent) and AMPOL Exploration (20 percent) in about 1952. The prospecting rights to the Bonaparte Gulf basin were later relinquished by WAPET early in 1955 while their exploration effort was being concentrated in the Carnarvon and Fitzroy-Canning basins, after the discovery of a substantial flow of crude oil from Rough Range No.1 well in the Carnarvon basin in December 1953. Gulf Oil Syndicate was then granted the permit to explore that part of the basin within Western Australian territory by the Western Australian Government, and the area within the Northern Territory was divided between Westralian Oil Limited and Associated Australian Oilfields by the Northern Territory Administration in mid-1955. During this time also, the Bureau of Mineral Resources made a geological survey of the Ord-Victoria region, which includes the Bonaparte Gulf basin in its northwestern sector; the results of this survey were published by D.M. Traves ('The Geology of the Ord-Victoria Region', Dept. of National Development, Bureau of Mineral Resources, Bulletin No.27, 1955). This survey, covering an area of 70,000 square miles, was made by photogeologic interpretation tied in with ground traverses made during nine months spent in the field. With regard to the petroleum potentialities of the Bonaparte Gulf basin, Traves stated:

'The total thickness of the Palaeozoic sediments (Cambrian, Ordovician, Devonian, Carboniferous, Permian) in the Bonaparte Gulf basin is about 15,000 feet; but the thickness of Palaeozoic sediments in any one locality may not be more than 5,000 feet...throughout the Bonaparte Gulf basin, the distribution of Permian sediments in no way reflects the distribution of older Palaeozoic sediments, and in some places the Permian sediments directly overlie Precambrian rocks.'

'In the Burt Range there are no Cambrian sediments and the upper Devonian sediments overlie Antrim Plateau volcanics (lower Cambrian)... In the Burt Range basin, the possible source rocks of Burt Range limestone (Upper Devonian) are overlain by possible reservoir sediments of Enga sandstone (Carboniferous). Unfortunately these are exposed throughout most of the Burt Range, and only in a very small area are they capped by Septimus limestone (Carboniferous). To the north of the Burt Range, the Septimus limestone, capped by sandstones of the Weaber Group (Permian), dips below the alluvium of the Keep plain, and it is in this area that at least the three requirements of source, reservoir, and seal may be found...'

'The whole Bonaparte Gulf basin, although only slightly folded, has been severely faulted. No traces of oil have been found at any of these faults at the surface or in any water issuing from springs and seepages. Very few fold structures are found in the basin, although numerous fault blocks could provide oil traps...'

Traves concluded that 'on present knowledge of stratigraphical units and their distribution in the Bonaparte Gulf basin, the possibility of finding an oilfield is slight; but the Keep River area warrants further investigation.'

After a study in mid-1955 of all available data, including the manuscript of the section on stratigraphy and the maps of Traves' report, the writer made an evaluation of the prospects of the Bonaparte Gulf basin on behalf of Westralian Oil Limited; in this report ('Evaluation of the Petroleum Potentialities of Permit Areas held by Westralian Oil Limited', L.W. Stach, 24 June 1955) the writer summarized his conclusions concerning the portion of the Burt Range embayment lying within WOL's permit, as follows :

'The prospects of finding commercial accumulations of petroleum within the area recently granted to Westralian Oil Limited in the Bonaparte Gulf Basin in the Northern Territory are restricted to the area of about 250 square miles of Palaeozoic sediments found along the western margin of the permit. The possibilities of the existence of suitable source-rock, reservoirs, and caprock, and the existence of conditions favourable for both structural and stratigraphic overlap traps, justify a detailed investigation of this area, but the geologic knowledge of this area is not yet sufficient to enable a more definitive evaluation to be made.'

Traves' remarks (1955, pp.103, 104) concerning the Carlton embayment are as follows :

'In the Carlton Basin, Devonian sediments overlies the Cambrian and Ordovician Carlton Group, but no late Palaeozoic sediments have been found... In the Carlton Basin, complex strike faulting makes estimation of the actual thickness of Palaeozoic sediments at any one locality impossible, and the fault blocks of Cambrian sediments are not regarded as oil prospects. Farther northwest, east of Winbing, the Upper Devonian Burt Range Limestone, a possible source of oil, is overlain by sediments of the Weaber Group; but how far the Burt Range Limestone extends east below the Weaber Group is unknown. No trace of it has been discovered on the eastern side of the Permian sediments near Legune, where they overlies Precambrian sediments.'

In 1957 W.F. Schneeberger, of Ball Associates, Denver, reviewed the prospects of the Carlton embayment on behalf of GOS.

Pertinent extracts from his report are as follows;

'Structurally, the Bonaparte Gulf basin is a marginal trough of the Australian continent surrounded by large areas of Precambrian basement. An unknown and very likely major part of the basin is submerged in the Indian Ocean. The stratigraphic record, comprising the time from Cambrian to at least the Permian, shows that the basin during this time had been an area of subsidence, with several interruptions; the western part of the basin is rather undisturbed, except for some faulting. The Proterozoic Nullagine series is overlain by a normal succession of Cambrian-Ordovician rocks, Devonian reef limestones and the Permian Weaber group. The rocks are dipping gently to the east at 10 to 23 degrees, whereas, within the Permian sediments, dips are even lower and do not exceed 10 degrees. There are a number of normal faults in the western part of the Permian outcrop area.'

'Aerial photographs show some indirect indications of folding in two areas- one in the easternmost part of the Permian outcrop, close to the Northern Territory border, and the other in the north. On May 24, 1956, Doeringsfeld, Amuedo, and Ivey of Denver, specialists in photogeology, reported as follows :

"1. There is no direct evidence of anticlinal structures within the outcrop area of the Permian rocks.

2. A regional structural high might be postulated to trend northward from the Weaber Range to the vicinity of the North branch of Grant Creek.

3. If the indications of possible east-west strike of Permian beds on the northern part of the map are correct, then the area in the vicinity is anomalous and might consequently contain east-west trending structures."

'There is little information available as to the extent of the Palaeozoic formations into the Indian Ocean. However, the two tiny islands off the north shore, i.e. Rock Island and Pelican Island, consist of Permian sediments, possibly of the Weaber Group.'

'As far as the present geologic knowledge goes, prospects can be forecast for the Cambrian-Ordovician, but especially for the reef

limestones and dolomites of the Upper Devonian. The Cambrian-Ordovician has lately come under more intensive study as a possible source and reservoir formation in many parts of Australia. The interest was stimulated by the shows of waxy crude found by Santos Limited while drilling the Pirie-Torrens basin in South Australia. Ordovician sediments were also studied by W.F. Schneeberger in the Fitzroy basin where they are definitely petroliferous.'

'The Upper Devonian reef limestones are the younger prospective formation. They are developed in a thick section along the western and southern margins of the basin. In analogy with the Fitzroy basin it is assumed that the forming of reefs in Devonian time was not confined to the margins but extended also into the interior parts of the basin, especially around and across buried ridges. Such a ridge is indicated to exist between Weaber and Oak Creeks.'

'In western Canada production is obtained from the Middle Devonian reef complex where it is capped and separated from the non-productive Upper Devonian reefs by a green, impervious shale. In the Bonaparte Gulf basin, the many shale interbeds within the Devonian limestones could have acted as an effective seal. If such a condition can be found in a closed anticline, on the flanks of a buried ridge or along a fault, the Devonian reefs would constitute a first-class prospect.'

'In our opinion the prospects of the Bonaparte Gulf basin as far as they can be evaluated at present on the available information, warrant further exploratory work.'

RECENT INVESTIGATIONS BY WESTRALIAN OIL LIMITED.

Since 1955, when WOL was granted its permit to explore in the south-eastern sector of the Bonaparte Gulf basin, additional information concerning the geology of the basin from surface surveys has been obtained by WOL's own geologic survey parties and by parties operating under contract to WOL. Gravity surveys have been made by AAO in their area adjoining WOL's permit to the north, and these were extended southward to cover WOL's permit under contract agreement with AAO. Gravity reconnaissance lines have also been surveyed across the basin by the Bureau of Mineral Resources, so that the broad features of the gravity picture of the basin are now reasonably clear. The Bureau of Mineral Resources have also made long seismic reconnaissance traverses across the basin in critical areas and a number of traverses covering in some detail an area to the south of Spirit Hill, in the north-western part of WOL's permit, where a structural high was suspected to be present. WOL has also conducted a limited amount of shallow structure drilling in this same area

and they have had palaeontological studies made to check the stratigraphic correlation between the rather scattered outcrops within their area.

Within WOL's and AAC's permit areas all surface outcrops have been mapped in detail and photogeologic interpolation in other areas of the basin between outcrops that have been actually examined on the ground have practically exhausted the possibilities of obtaining more data from surface survey, except possibly in GOS' area. The gravity data cover a fair proportion of the whole area of the basin, but competent interpretation of these data is not yet available.

Reconnaissance seismic work has been carried out within the basin, which has provided some information on the subsurface structure, but more detailed coverage is still needed before a satisfactory interpretation of the subsurface character of the basin can be made. The small amount of shallow structure drilling, to not more than a few hundred feet, has provided some information within a very limited area. Apart from these shallow holes, no well has yet been drilled to any significant depth anywhere within the entire area of the basin. As yet, no information has been obtained concerning the offshore extension of the basin to the north into Bonaparte Gulf, which shelves gently to depths of 200 feet about 100 miles northward from the southern shore of the Gulf.

The additional new data obtained over the past few years have tended rather to enhance than to detract from the prospects for the existence of petroleum accumulations within the Bonaparte Gulf Basin. This additional new information is outlined in E.P. Utting's report for WOL entitled 'Report on Exploration and Geology within Permit No.3., Northern Territory, during 1956'; this report deals mainly with the Burt Range embayment. The significant points are summarized as follows:

1. Contrary to Traves' statement (1955) that 'the whole Bonaparte Gulf basin, although only slightly folded, has been severely faulted', it is evident from surface surveys that major faulting

is present only within a short distance basinward from the eastern margin of the Burt Range embayment, and from the southern margin of the Carlton embayment. The major part of the basin appears to have been little affected, if at all, by faulting; both the gravity and seismic data support this view.

2. Outcrop mapping has indicated reversals of dip along the eastern margin of the Burt Range embayment from the vicinity of Spirit Hill southward to the Amphitheatre area; however, the dips are generally of the order of a few degrees only, and the scattered nature of the outcrop makes it difficult to define the extent of these structures and to determine whether definite closure exists. Throughout this area most, if not all, the thickness of the prospective Upper Devonian Burt Range Limestone formation could be expected at depth.

3. Shallow drilling and re-checking of outcrops have shown that the Burt Range Limestone formation, about 4,000 feet in thickness, has considerably more shale between the many limestone beds than was formerly suspected. These dark shales were found to be gypsiferous and pyritic, and as such could be considered as potential source rocks; their lack of permeability would also make effective seals for the potential limestone reservoirs interbedded with the shales.

4. Contrary to Traves' inference (1955) that the thickness of Palaeozoic sediments in any one locality within the Bonaparte Gulf Basin 'may not be more than 5,000 feet', the seismic evidence suggests that the Palaeozoic section above the Proterozoic basement may be considerably thicker within the basin. Seismic traverses in the Milligan Hills area indicate a sharp angular unconformity at a depth of about 9,000 feet, which is taken to be the contact between the Proterozoic and the Palaeozoic sequence; the seismic evidence also suggests that the Palaeozoic sequence is probably becoming thicker northward

toward the mouth of the Burt Range embayment.

5. The seismic reconnaissance line to the north of Spirit Hill indicates a discordance in attitude between the practically flat-lying sediments of the Weaber group exposed at the surface and the underlying probably Upper Devonian sequence, in which marked gentle undulations are evident. This discordant relation suggests that structures may have been developed in the older formations that are now concealed beneath the younger sediments of the Weaber group, which generally show a gentle regional basinward dip.

PROPOSED PROGRAM.

A considerable amount still remains to be learned of the subsurface stratigraphy and structure of the Bonaparte Gulf basin before its potentialities can be adequately evaluated, and the data already available provide justification for further exploration. In the writer's opinion the following immediate steps should be taken to advance our knowledge of the subsurface geology of the basin:

1. Critical review and interpretation of all the presently available gravity and seismic data, followed by additional seismic traverses in critical areas.
2. Drilling of a stratigraphic test well to about 10,000 feet, preferably located in the vicinity of the surface structures that are apparent along the eastern side of the Burt Range embayment, to determine the character of the palaeozoic subsurface sequence in the vicinity of these possible traps and to locate potential reservoirs.
3. Perhaps for later consideration, an airborne magnetometer survey of the offshore area within the Bonaparte Gulf to determine the seaward extension of the basin.

This program is at present beyond the financial resources of the permit holders, who are willing to negotiate a percentage interest in their permits with any organization capable of financing and conducting such a program. Should more detailed

information be required prior to arranging a visit by a representative to investigate all the detailed reports that are available, copies of the reports by Traves (1955) and Utting (1956) could be forwarded for inspection by Westralian Oil Limited.

(signed)

LEO. W. STACH,
Petroleum Geologist.

LOCATION MAPS

BONAPARTE GULF BASIN

