As at 1 January 1991 the Bonaparte Basin was known to contain five major and nine minor petroleum accumulations, and over 20 wells with significant indications of hydrocarbons, including some residual or biodegraded accumulations. Most of the major oil accumulations, e.g. Jabiru, Challis/Cassini, Skua, and Talbot, are trapped in Triassic and/or Jurassic reservoirs sealed by Cretaceous marine shale. Estimated recoverable petroleum reserves in the Bonaparte Basin as at 31 December 1990 comprised 5.992 x 10^6 m³ of oil, 18.60 x 10^6 m³ of natural gas liquids, and 111.189 x 10^6 m³ of sales gas.

**Ashtmore-Cartier geological setting**

The Vulcan Sub-basin, Ashmore Platform, Jabiru Terrace, and Northern Browse Basin are in the Commonwealth Territory of Ashmore-Cartier Islands. They were the major structural elements formed here during the Mesozoic breakup of Gondwana. They were created by crustal extension mainly during the Middle and Late Jurassic, and together constitute a structurally complex zone.

Most structures evident on seismic records in the Ashmore-Cartier region have been caused by periodic rifting. These rifting episodes controlled the pattern of fault formation and thus also the location and size of some elements and sealing horizons. Intense block faulting and formation of grabens began towards the end of the Middle Jurassic (Callovian) and established the dominant southwest-northeast tectonic grain throughout much of the region, particularly the Vulcan Sub-basin and its flanking terrace and platform. The Vulcan Sub-basin incorporates several Troughs and a horst-and-graben zone and lies between the Ashmore Platform to the northwest and the Londonderry High and Jabiru Terrace to the southeast. The northern part of the sub-basin has subsided since the Miocene, forming the Cartier trough. The thick Late Jurassic sediments in the sub-basin appear to be thin or absent on the Ashmore Platform and Londonderry High. Early Cretaceous and younger sediments onlap onto these features and extend throughout the region.

The Jabiru Terrace has had the most detailed seismic coverage. The seismic sections contain features that commonly resemble the tensional faulting and extension models derived from laboratory experiments.

**Petroleum plays**

The known oil accumulations are all located on a structural high-up dip of or next to a major fault system along which oil has migrated out of mature Jurassic source rocks. The tilted horsts comprise Plover Formation (Jurassic), Flamingo Group (Jurassic), and Sahul Group (Triassic) reservoirs, overlain by the base-Cretaceous regional seal of the Bathurst Island Group. Closure is fault-dependent, the faults being Late Jurassic, although post-Miocene reactivation has caused some trap destruction.

**Additional potential exists to test further valid plays that may involve some elements from previously successful play types. Submarine fan complexes in the Flamingo Group are a significant new play with very large potential trap sizes. Mainly located on the downthrow side of generally Oxfordian fault scarps they would rely on migration from downdip Jurassic source rocks. Maastrichtian turbidite sands are a further play that has demonstrated potential (oil in Puffin 1 and 2 wells).**

**Fig. 4. Structural elements and petroleum accumulations in the western part of the Bonaparte Basin, Western Australia and Territory of Ashmore-Cartier Islands.**
Fig. 5. Ashmore–Carriker Reefs region, showing present permit areas, vacant acreage, petroleum exploration wells, and prospects/leads/ drilled structures.

Ashmore Platform. The vacant areas on the Ashmore Platform offer an opportunity to identify additional leads and prospects or to test known prospects likely to have potential for petroleum trapped in Triassic, Jurassic, and Cretaceous sequences, as well as in new play concepts.

The Ashmore Platform area is transected by a set of northeast-trending faults in the pre-breakup sequence. These faults relate to the Middle Jurassic rifting phase and generally terminate at the Callovian breakup unconformity. The second major set of faults dates from the Miocene. On the Ashmore Platform the Miocene faults are generally west-southwest-trending and they overprint, and in some cases reactivate, the earlier faulting. In places the younger faults appear to offset the deeper faults trending and they overprint, and in some cases reactivate, the earlier faulting. The interaction has generally form good to excellent reservoirs. They also reactivate, the earlier faulting. In places the older trends have amplified the older trends. The structures now they combine both fault and dip closure. The main play in the ‘Nancar’ area is the structural closures on the upthrown sides of the major faults. These closures have been mapped at the intra-Valanginian level. The main targets are the Vulcan and Plover Formations. The main problem in the area because of a thin vertical seal. Also radiolarites are expected to be present and to be a major risk because of their ability to reservoir hydrocarbons in extensive zones of low permeability.

Vulcan Sub-basin and Jabiru Terrace. The areas likely to be available for application in Release 2 of 1991 will be designated within the vacant blocks covering the Vulcan Sub-basin and Jabiru Terrace. They offer typical Timor Sea plays, with the Jurassic or Triassic as major targets and plenty of scope to identify and evaluate a variety of other stratigraphic and structural leads and prospects. Structural leads evident present are mapped on seismic data at Cretaceous and younger levels.

The nearest well to the Vulcan Sub-basin areas that recovered oil was on the Puffin Horst, which extends into the eastern part of the ‘Pascal’ area. Five wells have been drilled on the Puffin Horst trend: Puffin 1 to 4 and Parry 1. Puffin I contained a small oil column and Puffin 2 flowed 4608 BOPD, the reservoir in both cases being the Chalkywell sand. Significant oil shows have been observed. Major structural closures on the upthrown sides of the major faults. These closures have been mapped at the intra-Valanginian level. The main targets are the Vulcan and Plover Formations. The main targets are the Vulcan and Plover Formations. The main problem in the area because of a thin vertical seal. Also radiolarites are expected to be present and to be a major risk because of their ability to reservoir hydrocarbons in extensive zones of low permeability.

The potential source section (Late Jurassic) is thin and undermature in the northern part of the Jabiru Terrace; thus, long-distance migration from thicker, mature source rocks (e.g. Sahul Syncline) is required for traps to be filled. Oil samples recovered from Avocet 1A can be correlated with that found in Late Jurassic sediments in Flamingo I in the eastern part of the Jabiru Terrace. Leads are recognised on the same trend as the Avocet and Barita wells, where significant oil shows have been observed. Major structural closures on the upthrown sides of the major faults. These closures have been mapped at the intra-Valanginian level. The main targets are the Vulcan and Plover Formations. The main problem in the area because of a thin vertical seal. Also radiolarites are expected to be present and to be a major risk because of their ability to reservoir hydrocarbons in extensive zones of low permeability.

The source-rock quality of the Late Jurassic is generally good in this area and there is a reasonably closely-spaced grid of seismic lines.

The potential source section (Late Jurassic) is thin and undermature in the northern part of the Jabiru Terrace; thus, long-distance migration from thicker, mature source rocks (e.g. Sahul Syncline) is required for traps to be filled. Oil samples recovered from Avocet 1A can be correlated with that found in Late Jurassic sediments in Flamingo I in the eastern part of the Sahul Syncline. Leads are recognised on the same trend as the Avocet and Barita wells, where significant oil shows have been observed. Major structural closures on the upthrown sides of the major faults. These closures have been mapped at the intra-Valanginian level. The main targets are the Vulcan and Plover Formations. The main problem in the area because of a thin vertical seal. Also radiolarites are expected to be present and to be a major risk because of their ability to reservoir hydrocarbons in extensive zones of low permeability.

The Sahul Syncline. and Avocet Horst. The main plays are rollovers along the young (post-Miocene) faults in the north and tilted fault blocks in the south. The main targets are the upper Vulcan Formation and Plover Formation sandstones below the intra-Valanginian and Kimmeridgian unconformities. These sandstones generally form good to excellent reservoirs. They are sealed by a condensed section of the Echuca Shoals Formation, which in turn is overlain by the radiolarite of the upper Jamieson Formation. Breaching of traps along the minor faults is the main problem in the area because of a thin vertical seal. Also radiolarites are expected to be present and to be a major risk because of their ability to reservoir hydrocarbons in extensive zones of low permeability.

The Late Jurassic Vulcan Formation is a moderate to good reservoir in the northern Jabiru Terrace. The sands were deposited on the continental slope. The Late Jurassic section thickens to the north and is thick in the grabens. The source-rock quality of the Late Jurassic clays is good but their organic content (TOC) is low, needing a higher degree of maturity before expulsion can take place. Such a maturity
Multidisciplinary studies in the Vulcan Sub-basin, Timor Sea

Since the discovery of the Jabiru and Challis oil fields in the mid 1980s, the Vulcan Sub-basin has been one of Australia's most active oil exploration areas. Despite this, success recently has been elusive, mainly because a detailed understanding of its structure and development has been lacking. This is critical, as the oil-bearing structures have probably developed as a direct result of structural reactivation during the Mesozoic and Tertiary.

To support exploration BMR has been carrying out a major study of the Sub-basin and nearby tectonic provinces, acquiring 20 000 line-km of high-resolution airmag data, 1894 km of deep crustal (12-14 s) seismic-reflection, and nearly 3000 km of high-resolution seismic reflection and water-column-geochemistry data. Integration with conventional industry seismic data has shown that the tectonic history is more complex than previously thought.

Interpretation of image-processed airmag data and flight-line profiles has revealed a major set of NW-trending features that offset the NE-trending normal faults within, and especially along, the margins of the sub-basin. These features can be mapped in detail on seismic and are believed to be transfer faults which accommodated major crustal extension during the Permo-Carboniferous. Extension in the Triassic and Jurassic was relatively minor, and thus within the central sub-basin, where the Triassic and Jurassic are thick, transfer faults are not well-developed and are difficult to map. Rather, flexure over, or reactivation along, more deeply seated Permo-Triassic transfers was responsible for significant structuring of the Triassic and Jurassic.

Several hydrocarbon discoveries are near intersections of the NW and NE fault systems, which thus may be important in the entrapment of hydrocarbons. Water-column hydrocarbon anomalies were detected along a major transfer zone, implying that these zones can provide migration pathways. A prominent transfer zone separates the Vulcan Sub-basin from the Browse Basin, and may have affected sedimentation in both areas. In the central Vulcan Sub-basin, a major transfer separates the Paqualin and Swan Grabsens from the Cartier Trough to the north. Recognition of these transfer faults has potentially major implications for our understanding of the structural and sedimentological history, and the petroleum prospectivity, of this region.

For further information contact Dr Geoff O'Brien or Mr John Needham (Marine Geoscience & Petroleum Geology Program) at BMR, or Dr Mike Etheridge of Tectonex Geoscientists Pty Ltd, PO Box 3778, Manuka, ACT 2603.

# Browse Basin Petroleum Prospectivity Study

This soon-to-be-released publication gives a regional overview of the underexplored Browse Basin (excluding the Territory of Ashmore-Cartier Islands) and a detailed evaluation of areas to be considered for release by the Federal and West Australian Governments in Vacant Area Release No.2 of 1991. The precise areas to be released will be announced in early November. The package summarises regional geology, exploration history, hydrocarbon discoveries, regional geophysics, palaeogeography and play concepts. Plates and figures include: regional cross-sections, interpreted seismic sections, regional and prospect level TWT maps, palaeo-geographic time slices, composite logs, well and engineering summaries, prospect montages, burial history plots, source rock/maturation data, and porosity data.

The Browse Basin (Fig. 6) is wholly offshore, trends NE-SW, and underlies 100 000 km² of the continental shelf and slope west of the Kimberley district of Western Australia. Most of the basin lies in water depths greater than 200 m. Exploration began in 1963, when an aeromagnetic survey by Woodside (Lakes Entrance) Oil Company NL discovered a sedimentary basin seaward of the Kimberley Block.

A regional to semi-detailed grid of seismic data of varying quality has since been acquired. Twenty-two wells have been drilled, of which four were stratigraphic tests of the central basin margin, four are interpreted not to have tested valid structural closures, and 11 encountered either hydrocarbon accumulations or significant shows. The biggest discovery in the basin is the Scott Reef gas/condensate accumulation; Woodside Petroleum estimates recoverable reserves at Scott Reef as 499 x 10⁹ m³ of gas and 34.3 x 10⁶ kL of condensate.

Fig. 6. Browse Basin study area.