DEVONIAN PROSPECTIVITY ON THE HALLOWS TREND AND THE NORTHERN ANDADO SHELF

Executive Summary

- **The Hallows Trend, in the vicinity of Blamore-1, coincides with a faulted Devonian platform probably related to a basement high at depth. The platform is unable to be mapped in detail due to a dearth of seismic but its eastern margin is faulted and vertical hydrocarbon seepage in the form of a gas chimney is recognised.**

- **Oil shows reservoired in the top Algebuckina Sandstone in Blamore-1 are probably sourced from the Palaeozoic and are unlikely to have a Jurassic – Early Cretaceous origin. The exploration potential of the Hallows Trend must now be viewed in terms of not only charge from Permian source rocks, but also oil/gas charge from the Devonian sequence in the general area. Targets for entrapment must be considered at all stratigraphic levels in the Mesozoic and Palaeozoic.**

- **The Camelot Lead resides updip on the southern crest of the Hallows Trend where it is terminated by the Camelot Transform Fault. All updip hydrocarbon migration would have been focussed towards this potential fault barrier which requires incremental seismic to reach prospect status. The absence of hydrocarbon shows in wells updip of this fault (McDills -1 and Etringimbra-1) could testistfy to the veracity of the fault trap impeding hydrocarbon migration. Subtle 4 way dip closures down dip of the Camelot Lead thus also become attractive targets.**

- **New regional study of the prospective Devonian sequence has expanded its exploration potential. This is true on the Northern Andado Shelf where an almost complete absence of data at this level has hindered exploration. However, a recent modern seismic line (CB08-01) has imaged a Devonian Platform under Blamore Prospect and has also defined downlapping Devonian strata on the northwestern Andado Shelf. Basin margin reef and backreef facies are possibly present updip of the newly recognised downlapping basin facies, presenting a facies mosaic analogous to that now proven to the northeast on the margins of the Hale River Block.**

- **A new lead (Newcrown Lead) is a hanging wall fault play on the southern Andado Shelf. A major north trending normal fault, downthrown to the east, is pivotal to this lead and a significant amplitude anomaly occurs near the top Devonian in the hanging wall. The Devonian is probably the only possibly mature source sequence in the region of the Andado Shelf/ Eringa Trough.**

Introduction

The potential of the Devonian sequence in the Simpson Desert area has only recently been recognised (Ambrose and Heugh, 2010 qnd 2011) but Central Petroleum is actively pursuing this new target sequence over much of its exploration acreage. The Devonian age ascribed to the sequence is based on:

- The fact that the sequence directly underlies the basal Crown Point Formation unconformity. Where the sequence has been intersected near TD in several wells it is unmetamorphosed and flat lying.
- The sequence is basically undeformed, and younger Permian – Cretaceous sequences are often draped over massive carbonate depositional elements. Older Cambrian-Ordovician sequences would have been deformed/metamorphosed during the Delamerian Orogeny (Early Ordovician) and this does not appear true in the case of the target sequence under discussion.
- Devonian sediments occur in McDills-1 and these comprise a coarse alluvial sequence. The nearest Devonian marine influence is recorded in the Cravens Peake beds in the Toko Syncline and this marine incursion spread to the northern Warburton Basin where reefal/platform buildups are clearly portrayed on seismic.
- A similar style of barrier reef and carbonate platform development is recognised in Devonian marine carbonate facies of the Canning Basin which are described extensively in the literature.

Exploration mapping by CTP is underway on the margins of the Hale River Block and over the Arltunga High. However, a prospective Devonian section is now interpreted on the Hallows Trend to the west and also on the northwestern Andado Shelf.

The Hallows Trend is contiguous with the McDills Trend to the south which was penetrated by the McDills-1 and Etingimbra-1 exploration wells, both of which were dry holes without significant hydrocarbon shows. To the north on the Hallows Trend, Blamore-1 recorded a residual oil column in the top of the Late Jurassic Algebuckina Sandstone (Blamore-1, 31 m column). Whilst commercial oil was not encountered in this well, the residual oil column was consistent with pre-drill models predicting oil charge from the Madigan Trough and its margins to targets provided by the first reservoir / seal couplet above the Triassic sequence in the event this seal was missing; in this case the top Algebuckina Sandstone. This concept was verified by the results from Blamore-1.

The key parameters of the oil extracted from the residual hydrocarbon column in the top Algebuckina Sandstone are:

- The oil samples are not biodegraded.
- There is geochemical evidence that kerogen formation occurred in a dysoxic environment of deposition with strong bacterial reworking of possibly marine organic matter.
- Dr Chris Boreham suggests an early to late Palaeozoic age for the oils. Overlying silty shales in the Early Cretaceous Murta Member are not believed to be the source for these oils although this unit does act as top seal to the Algebuckina Sandstone.

HRDZ's and Gas Chimneys

HRDZ's stands for Hydrocarbon-Related-Diagenetic Zones recognised in the sedimentary column in basins where both oil and/or gas have been generated. In a general sense a hydrocarbon leakage zone has a root where leakage from the reservoir is initiated whereas the top of the chimney is recognised where the leakage terminates.

HRDZ's and gas chimneys have been described in detail in the Timor Sea where these carbonate cemented zones are generally restricted areally (200-1000 m wide and up to 5 km in length). These dimensions correspond very closely with analogous zones developed in the

eastern Warburton Basin (in the Vivien Prospect area- Ambrose and Heugh,2010) where hydrocarbons appear to be emanating from Palaeozoic source rocks. HRDZ's in the latter and in the Timor Sea are spacially associated with major, underlying fault systems. This is definitely the case in the Guinevere area. The cemented zones could be largely due to hydrocarbon oxidation as evidence from the US Gulf Coast and the North Sea have shown that surficial and near surface carbonate cementation is commonly associated with the oxidation of migrating hydrocarbons (O'Brien and Woods, 1995).

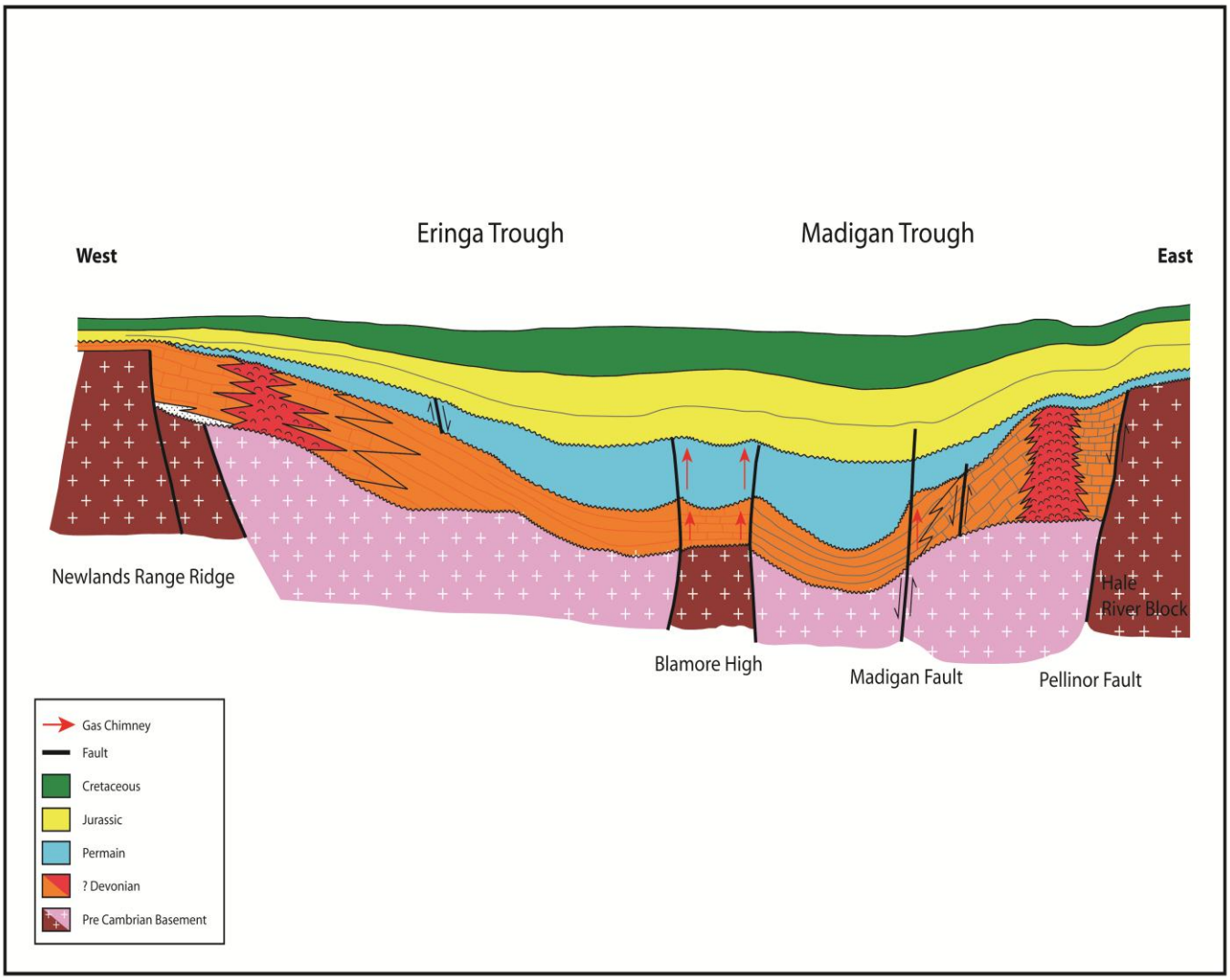

Figure 1 Simpson Desert Cross-section

Gas chimneys are desribed in regional context in Figure 1 (red arrows) and based on seismic they appear to emanate from the pre-Permian Palaeozoic section penetrating as high as the Jurassic / Cretaceous. Significantly no source rock facies are recognised in the Palaeozoic section in the vicinity of the Mc Dills High which is consistent with the absence of Palaeozoic source rock facies in this general area as confimed by the results in McDills-1 which reached the early Cambrian. Preliminary regional facies modelling of the Palaeozoic (Figure 4) shows that the northern areas are more likely to host carbonate buildups than the McDills High (alluvia-fluvial facies) and areas to the south where drill holes have intersected steeply dipping Ordovician sediments. These contrast with the undeformed Devonian sequences to the north.

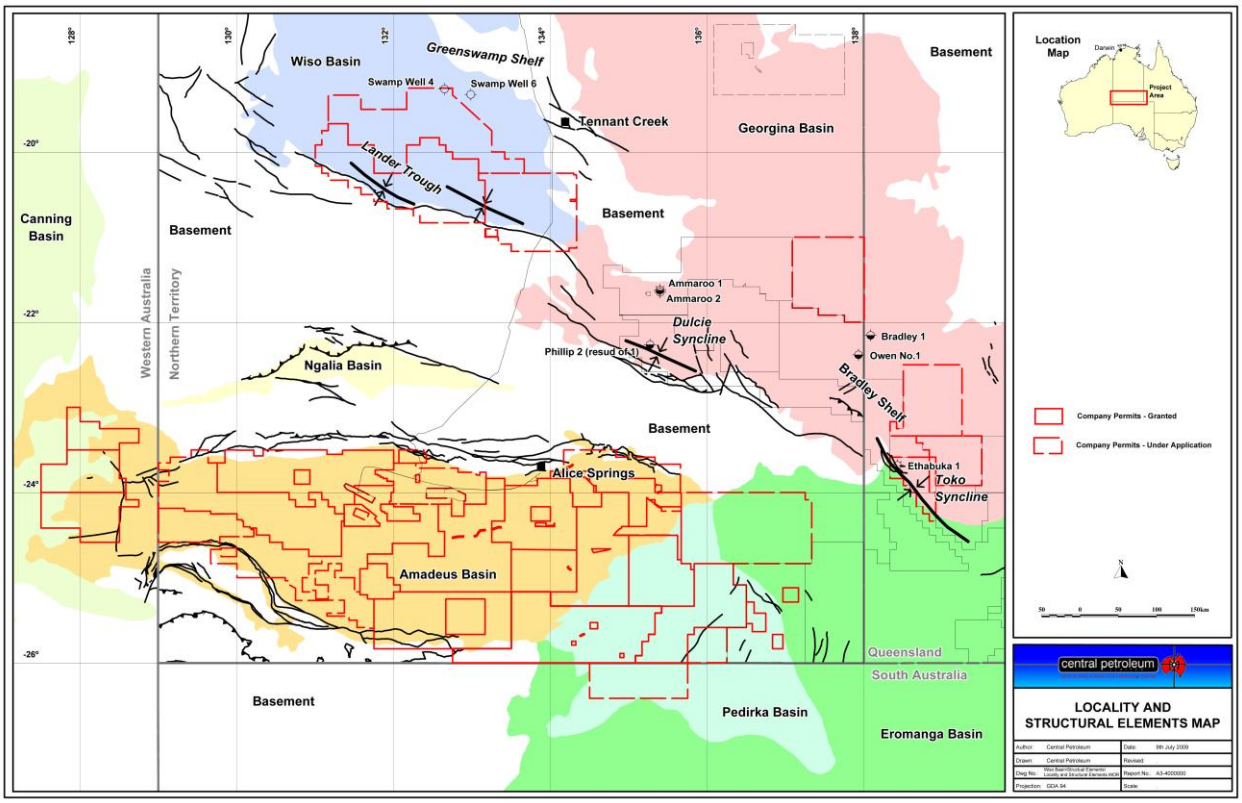

Figure 2 Location Diagram

In the Simpson Desert area the potential for direct hydrocarbon indicators in the Warburton Basin sequence has received little attention. However, studies in this area of higher stratigraphic levels by Ambrose et al (2007), yielded evidence for oil migration which came from calcite cements often observed in the basal sandstones of Poolowanna Formation Cycle 2 (Early Jurassic). These probably relate to chemical reactions involving migration of carbon dioxide which is thought to be a precursor to oil migration from deeper sequences (Momper, 1980). Structures in the Cooper Basin area containing calcite cemented zones in the Jurassic Namur Sandstone (Algebuckina Sandstone equivalent) are three and a half times more likely to contain oil than those which do not (Jensen- Schmidt ,1989). Overall the calcite cemented zones are believed to represent migration – related diagenetic zones.

A gas chimney has been identified on the eastern margin of Blamore structure on the Hallows Trend. The zone emanates from the lower part of the Palaeozoic sequence and has many similarities with a linear gas seepage zone bounding the southern margin of the Vivien structure. At Blamore the zone is quite narrow (100-200 m across) and is denoted by vertically stacked mini-teepee structures which may represent a “pipe” like conduit or , as is the case at Vivien, there may be a thin tabular vertical anomaly denoting a fault plane. The anomaly terminates in the Mid-Permian and appears to be controlled by a near vertical fault which may have been a hinge line controlling the western margin of the Madigan Trough. Certainly there is a marked change in Palaeozoic dips across this hinge line and overall there are many similarities with the Madigan Fault which controls the eastern margin of the Madigan Trough.

Blamore Devonian Platform (Blamore Deep Lead)

Devonian reflectors beneath the Crown Point Formation at Blamore structure are believed to represent a carbonate platform and at least one gas chimney can be recognised. This correlates with the notion that Devonian sourced oil/gas may have found its way to the top Algebuckina Sandstone in Blamore-1 probably via fault conduits. Only two dip lines are of sufficient length to cover the margins of the carbonate platform at Blamore and little can be

deduced about its morphology or structural configuration. Reprocessing of the existing seismic grid to evaluate the deeper horizons should be considered and the Devonian sequence needs to be remapped at several horizons to establish it's potential.

The Devonian has never been penetrated in full in this area except in Mc Dills 1 where the section comprises a thick sequence of sandstones and red beds. This is a coarse alluvial facies which is not representative of more basinal carbonate seqences to the north and east discussed elsewhere. A thin section of red beds was also intersected in Colson-1 and Simpson-1 and regional seismic correlations indicate this section extends over the Blamore Platform probably providing top seal to the underlying carbonate platform. Thus the Blamore Deep lead has a good chance of top seal and hydrocarbon charge based on seismic criteria. However, what is lacking is confirmation of entrapment and viable reservoir, and further data are required to complete an assessment of these outstanding play components.

Camelot Fault Trap

The possibility of a deeper Devonian source rock on the Hallows Trend gives encouragement to the Camelot Fault play, which occurs updip to the south against the Camelot Transform Fault; charge to this potential trap relies on a southward fill-spill migration pathway updip along the Hallows Trend. Structural interpretation of the McDills/ Hallows Trend indicates that they are parallel and contiguous, but denote disparite structural histories. The most obvious difference is that the massive Miocene-Recent fault reactivation on the western margin of the asymmetric McDills Trend is absent on the Hallows Trend, which is largely symmetrical with faulting only recognised at Devonian levels. Structure at higher stratigraphic levels includes an element of drape.

Two dry holes occur on the Mc Dills Trend ie Mc Dills-1 and Etingimbra-1, both of which did not record any significant hydrocarbon shows which suggests the Camelot Fault shielded this trend from updip charge emanating from more deeply buried areas to the north, on and adjacent to the Hallows Trend.

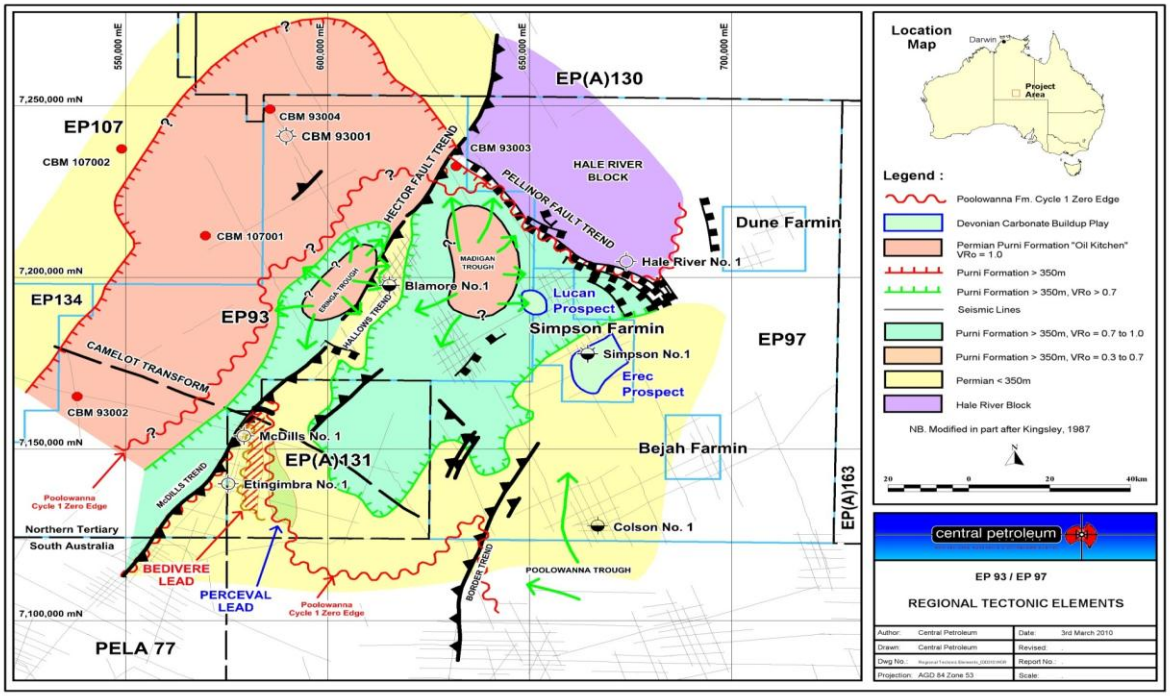

Figure 3: Location Diagram

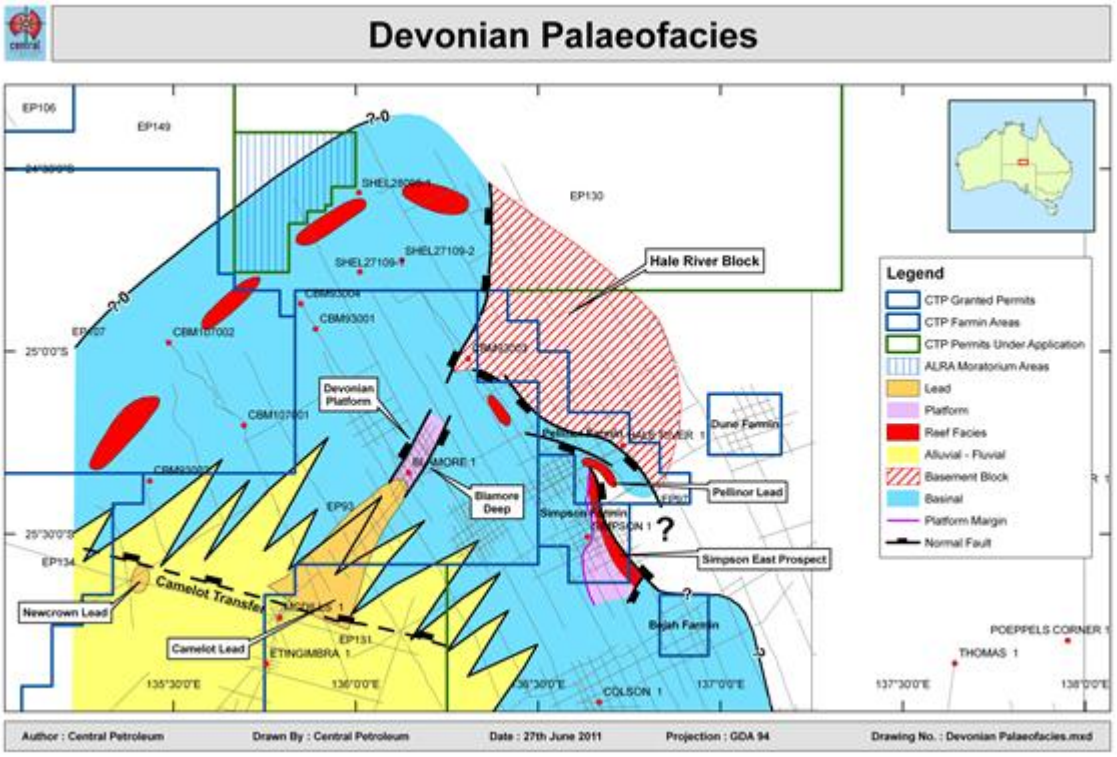

Figure 4

Andado Shelf Devonian Play

The Devonian sequence is largely unknown on the Andado Shelf and there are no penetrations in water bores or coal exploration wells with the possible exception of coal stratigraphic hole Shel 28095-1 which intersected 5 m of ? Devonian red beds in the base of the well. There are a number of seismic lines transecting the Andado Shelf at 5-15 km spacing but only two modern dip lines are available to help clarify Palaeozoic palaeogeography in the absence of drill hole data and outcrop ie A85-NT01, CB08-01.

Seismic line CB08-01 is significant in that Devonian reflectors are clearly denoted below the Permian sequence. The reflectors are clear enough to describe an interpreted platform section over the Blamore High with a gas chimney interpreted on the faulted eastern margin. The sequence extends updip across the Andado Shelf towards the basin margin and seismic downlap suggests depositional patterns analogous to those in the Devonian section down dip of the Hale River Block. The seismic downlap recognised on line CB08-01 may portend up dip reef development; eg, the Pellinor barrier reef facies mosaic lies updip of the Madigan Fault, where Palaeozoic basinal downlap is recognised at depth. The presence of Devonian basin margin reefs updip on the Andado Shelf remains highly speculative but regional facies relationships point to this possibility (Figure 4).

Newcrown Lead: A significant Devonian fault play is recognised on the southernmost dip line (A 85-NT01) named Newcrown Lead (Figure 4). A major normal fault (Newcrown Fault) cuts Mesozoic and Palaeozoic reflectors setting up a hanging wall fault play at these levels. Whilst the absence of seismic precludes detailed mapping of the play, a major amplitude anomaly resides at or near the top Devonian where the sequence is in juxtaposition to the fault. The potential for the Devonian sequence to source gas and probably oil, is supported by the presence of gas chimneys and HRDZ's to the east on the Madigan High. Downdip of Newcrown Lead the Devonian section in the Madigan Trough occurs at depths of 2.5 to 3 seconds (> 5000 m) indicating it would certainly have reached the oil/gas generation window. Limited seismic control suggests the Newcrown Fault could provide the first trap updip of this hydrocarbon kitchen and the amplitude anomaly should be carefully assessed to test its veracity. At present there is no seismic control to the south of A85-NT01; however older

1960's vintage data indicate the fault could extend NNE for 70 km. Indeed, a very similar Palaeozoic involved, normal fault intersects line CB08-01 at Shot Point 45, but it is unlikely to be connected directly with the Newcrown Fault.

The Newcrown Lead is of particular interest because of a seismic amplitude anomaly at the Devonian Level, but vertical migration to traps at higher stratigraphic horizons is a possibility where hanging wall reservoir targets are juxtaposed against sealing lithologies. The fact there appears to be some wrenching on the Newcrown Fault and that thick Cretaceous shales are juxtaposed across the fault, both support the notion that hydrocarbons have not migrated up the fault plane to surface. Certainly, if source beds are present, the Devonian is likely to have generated hydrocarbons in the Eringa Trough and vertical migration up section to various reservoir seal couplets configured in a hanging wall fault trap present attractive targets given seismic verification.

Conclusions

- **Exploration of the Devonian sequence in the northern Simpson Desert area has expanded from the area of the eastern Pedirka Basin (the Arltunga High and the margins of the Hale River Block) to the Hallows Trend and the northern Andado Shelf in the central - western Pedirka Basin.**

- **On the Hallows Trend the Blamore Deep lead occurs at Devonian levels below the Blamore Structure. A carbonate platform is interpreted with associated hydrocarbon leakage recognised at the platform margins. The residual hydrocarbons in the top Algebuckina Sandstone at Blamore-1 are believed to be sourced from the Devonian. Incremental seismic is required to mature this Devonian lead to prospect status.**

- **The apex of the Hallows Trend occurs at the intersection with the Camelot Transform Fault. New concepts regarding Devonian hydrocarbon charge give impetus to the Camelot Fault Play which occurs at this intersection and additional seismic is required over this high priority play.**

- **A new regional seismic line transecting the Hallows Trend and Andado Shelf (CB08-01) defines downlapping basinal Devonian strata on the Andado Shelf. To the west in a landward direction, basin margin reef and back reef facies may be present to complete a depositional facies mosaic analogous to that now proven to the northeast on the margins of the Hale River Block.**

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