Ebony Coal Ltd

Red Dog Project

Technical Review

EL 29006, 29007, 29008
29009, 29010, 29011
and 29142

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Global Ore Discovery is an Australian based consultancy that was founded in 2003 and provides leading technical services to the domestic and international energy, minerals and water industry.

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1. Executive Summary

This report has been prepared by Global Ore Discovery (Global Ore) consulting for the sole use of Red Dog Exploration (Aust) Pty Ltd a wholly owned subsidiary of Ebony Coal Ltd, for the purpose of planning coal exploration in tenures of interest, Bonaparte Basin. Seven licence areas (ELs 29006, 29007, 29008, 29009, 29010, 29011, 29142) have been subject to detailed geological investigations aimed at prioritising areas prospective for field follow up and scout drilling. The area covered by these exploration licences are shown in Figure 1. Current licences are held in the name of Red Dog Exploration (Aust) Pty Ltd.

A substantial GIS database has been compiled and constructed in the review of the Red Dog tenements. This database provides the framework into which new information can be incorporated and will facilitate dynamic revision of the geological model and targeting before, during and after field exploration programs.

Key works and findings of the review are outlined below:

- The Early Permian Kulshill Group, Bonaparte Basin is a prospective stratigraphic package for coal occurrences. Ebony’s Red Dog tenure covers an estimated 1605 km² of this priority target stratigraphy.

- Data compiled, processed and interpreted includes government geological mapping, historic petroleum and coal exploration drilling, gravity, structure, satellite imagery, published papers and seismic data.

- Within the Red Dog tenure, multiple coal intersections >0.4m are reported in historic coal and petroleum drilling. The greatest net coal thickness recorded in historic drilling is 4m, comprising a seam of 1.5m at 52m, 0.6m at 62m, 0.9m at 120m and 1m at 348m based on interpretation of downhole wireline logging in petroleum well, Keep River-1.
• The specific net coal intersections of priority interest are as follows:
  o 4m within EL 29010, Permian Kulshill Group, Petroleum Well
  o 0.9m within EL 29010, Permian Kulshill Group, Coal bore
  o 0.4m within EL29010, Permian Kulshill Group, Coal bore

• The reliability of the geological data available from drilling is limited due to the lack of geophysical downhole logging and high water flows diluting the chip returns. Where drilling failed to report coal, historic drill sites should be considered “Partially Tested at shallow depths” and these sites should be made a lower priority for in-ground exploration by Ebony.

• Historic coal drilling has been limited to either rotary or rotary/percussion and consisted of 38 coal bores at centres of approximately 9 kilometres and depths less than 136m, within and around the Red Dog tenements.

• 21 of those 38 coal boreholes (10m-136m) have been drilled without reporting coal or carbonaceous material. In some cases these holes are interpreted to have not been drilled to a sufficient depth to test the complete Permian package; however it is interpreted that in general the risk of discontinuous seams is high.

• There is information on Bonaparte Basin Permian coal quality available from coal intersections reported in historic petroleum wells; Keep River-1, Kulshill-1 and Kulshill-2. Of these wells, historic Keep River 1 was drilled within the Red Dog tenure and vitrinite reflectance (Ro_max) measurements undertaken on the coal cuttings returned results ranging from 0.41% to 0.56% (Meyer, 1983).

• 5 prioritised areas of interest for in-ground exploration have been mapped by integrating coal occurrence & cover thickness data, structural interpretations, depth of weathering contours extracted from historic exploration reports and interpretations of depositional palaeoenvironment.

• The prospective coal bearing stratigraphy is present at shallow depths, less than 100 metres, providing an opportunity to drill test a significant lateral extent of the Permian sedimentary package with conventional truck-mounted drill rigs.

• Permian coal-bearing Kulshill Group stratigraphy is generally interpreted to dip shallowly (<5 degrees) north to northwest.
• ELs 29006, 29007, 29008 and 29009 cover Proterozoic basement of the Sturt block and are not considered prospective for coal occurrences with the exception of a 180 km² scab that is interpreted from satellite and gravity data as a possible Palaeozoic to Mesozoic sub-basin that could be explored as a conceptual exploration target.

Recommendations

• Design a staged exploration program which respects the size of the Red Dog tenement holding and progressively refines from province to project scale.

• Core drilling the 1.5m at 52m, 0.6m at 62m, 0.9m at 120m and 1m at 348m coal intersections at Keep River 1 to confirm coal occurrence and collect samples for proximate analysis.

• Core drilling as near as possible to the 0.5m at 77.8m and 0.4m at 86.2m coal intersections in RD81BC6 to confirm coal occurrence and collect samples for proximate analysis.

• Seismic surveying between two known coal intersections targeting shallow reflectors to 1/ test the validity of seismic in this area as an exploration tool and 2/ help understand the potential for lateral coal seam continuity between known observation points.

• Focus scout drilling on the Global Ore Priority 1 areas of the Permian package where coal occurrences are interpreted to lie under thinner cover and depth of weathering is shallow.

• As a secondary objective of the scout drilling program, test those areas where historic coal drilling has been completed, but reached only shallow depths.

• Ebony’s aspirational target of at least 100Mt implies a necessary footprint size of around 5 kilometres by 5 kilometres assuming a coal seam thickness of 3 metres. It is recommended that Ebony refrain from drilling within 2km of ‘Partially Tested’ sites unless field evidences suggests there is potential for major stratigraphic offset by a significant fault.

• Establish a data sharing arrangement with the adjoining exploration holders, specifically to facilitate access to any drilling data adjacent to Ebony’s Red Dog EL 29010 and EL 29011. Petroleum exploration holders include Territory Oil and Gas Pty Limited and to the west Advent Energy Limited. Mineral exploration holders include Leopold Mining Pty Ltd and Golden Gecho Pty Ltd to the west and Tenant Creek Gold in the centre of Ebony’s licences. Data sharing agreements with mineral explorers will be of most value where the competitor’s/partner’s data intersects the onshore Bonaparte Basin (beyond the Basement).
• Establish a data sharing arrangement with Bonaparte Basin coal explorers and on that basis, extend the current desktop study to the basin margin in Western-Australia and north over competitor exploration applications within the Northern Territory. Coal explorers include Top End Energy and Waratah Coal.

• Parts of ELs 29008, 29009, 29010, 29011 and 29142 cover 956 km² of tidal flats and it is recommended to prioritise exploration on the landward side.
2. Overview

Ebony is an Australian private company that is focused on facilitating rapid resource delineation of large open cut coal targets capable of supporting lowest cost delivered energy to export markets. The Company’s tenement package, that is the focus of this report and held within a 100% owned subsidiary Red Dog Exploration (Aust) Pty Ltd, is referred to as the Red Dog Project in the Bonaparte Basin. The Red Dog Project is located within 73 kilometres of Port Keats and within 100 kilometres of the only deep water port between Broome and Darwin at Wyndham (Department of Planning and Infrastructure WA, 2008) Western Australia, Figure 1.

Ebony is planning to explore the potential of the Red Dog area with a coherent, systematic exploration program aimed at defining inaugural coal resources within the district.

The Red Dog Project has been subject to detailed geological investigations aimed at 1/ identifying references to coal in historic exploration data, 2/ building a GIS database as a framework for further geological analysis and 3/ interpreting the extent of permissive stratigraphy to assist the planning of a scout drilling program.

It is recommended to proceed with exploration on the premise that the permissive stratigraphy a) occurs from shallow depths (accessible by truck mounted drill rigs), b) has the potential to host seams greater than half a metre thick within range of port infrastructure and c) covers areas where community impacts are likely to be minimal.

Location

The Red Dog Project is comprised of seven Exploration Licences; EL29006, EL29007, EL29008, EL29009, EL29010, EL29011 and EL29142. The closest towns to this project area are Kununurra and Wyndham, in north east Western Australia. The tenements are separated in a northeast - southwest direction, by tenure operated by Kimberly Metals and Tennant Creek Gold which are exploring for Iron and Lead-Zinc respectively. The project area covers 4,263 square kilometres within the Keep River Area.
Figure 1: Location of Red Dog Project Area

Permian Kulshill Outcrop
3. Methodology

A comprehensive search of previous explorations conducted within and around the Ebony EPC package has been completed. This investigation has compiled drill log data recorded within the region from 1960 onward, including coal exploration, mineral exploration, petroleum exploration; water bore data, seismic uphole data, and gravity surveys.

All downhole data compiled was encoded and validated into a master database to:

- Determine the spatial occurrence of coal and carbonaceous material
- Establish the stratigraphy and extent of target Permian sediments
- Facilitate the integration of multiple geological and geophysical datasets
- Provide a framework to generate unique interpretations that can dynamically incorporate field work and scout drilling results

Separate Fact and Interpreted geology maps are available with explanatory notes recovered in various formats from the Northern Territory Geological Survey. Global Ore Discovery has compiled these into a single data format to produce a cycle map that distinguishes between Proterozoic basement and the Palaeozoic and Cainozoic cover sequence.

Landsat imagery has been acquired and processed as an aid for remote stratigraphic interpretation.

Seismic datasets have been reviewed by third party re-processing specialists. Vibroseis sources were used and elucidation of thin, shallow reflectors that may represent shallow coal seams would be challenging.
4. Regional Geology

The Bonaparte Basin is a Cambrian to Recent fan-shaped hydrocarbon-bearing basin extending over 270,000 km² offshore and onshore. It is comprised of southern Palaeozoic and northern offshore Mesozoic depocentres and hosts known remaining reserves of 33.42 GL of oil and 668.55 BCM of gas (Cadman et al., 2003). The Red Dog tenements are situated in the southern onshore Bonaparte Basin, which is bounded by the Proterozoic Kimberley Block to the west and Sturt Block to the east (refer to Figure 2).

Bonaparte Basin Evolution

The evolution of the Bonaparte Basin is geographically and tectonically linked to both the Proterozoic Halls Creek Mobile Zone and at least two Phanerozoic rifting events of the northwest Australian continental margin.

The timing of the first rifting phase is poorly understood but probably occurred between the Cambrian and Early Carboniferous, resulting in the development of the north-westerly oriented Petrel Sub-basin (Beere et al., 1988). The second rifting phase began in the Late Carboniferous and was followed by offshore events; Late Triassic compression and Jurassic breakup of Gondwana and sea-floor spreading in the Timor Sea, northwest of the Petrel Sub-basin.

Onshore, the Bonaparte Basin has its genesis in Early to Mid Palaeozoic transcurrent wrench faulting within the northeast trending Halls Creek Mobile Zone. The basin is developed west of the Halls Creek Mobile Zone, via predominately northeast trending strike slip faulting, from the Early Palaeozoic until the Mid Palaeozoic. The structure is conspicuously oblique to that of the adjacent Palaeozoic Petrel Sub-basin (Petroconsultants, 1990) (Figure 3). This is thought to be a product of a failed extensional system which formed part of the first rifting phase, between the Cambrian and Early Carboniferous (Meaney, 2006).

Southern onshore Bonaparte Basin Setting

The southern onshore Bonaparte Basin abuts the relatively unmetamorphosed basement of the Proterozoic Kimberley Block to the west and the similarly aged Sturt Block to the east Figure 2. The immediate west of EL 29006 and EL 29006, coincides with the western boundary of the Halls Creek Mobile Zone, the Cockatoo Fault (Figure 3).

The Pincombe Ridge, a northeast trending basement Inlier, subdivides the onshore sector of the basin into the Carlton sub-basin which extends into W.A. and the Burt Range and Keep Inlet sub-basin that are confined to N.T. (Figure 3). Both sub-basins are interrelated through time and genesis;
both tectonically active due to rifting in the Late Devonian to Late Carboniferous. The two sub-basins became inactive once the Petrel Sub-basin became a major Palaeozoic depocentre (Dunster et al., 2000).

**Onshore Bonaparte Basin Stratigraphy**

Upper Devonian to Late Carboniferous sediments are of marine origin and consist predominately of coarse to medium grained clastics, evaporites and carbonates of pre-rift Cockatoo, Ningbing and Langfield Groups. (Meaney, 2006). The overlying Late Carboniferous Weaber Group comprises basal submarine fans, through offshore sandstones, deltaic, interbedded fluvial-deltaic to fluvial sediments.

Onshore, Permian stratigraphy is restricted to the Lower Permian Kulshill Group, with younger Palaeozoic sediment missing from the stratigraphic record. The Kulshill Group consists of multiple sequences of alluvial fan conglomerates, delta-fluvial silty sandstones and glacial-marine tillite and shales (Gorter et al., 2008). Onshore Mesozoic sedimentary rocks are deeply eroded, commonly lateritised, remnants of thin basin-edge facies. (Dunstar et al., 2000).

Cainozoic material within the Red Dog area of interest includes consolidated brecciated chert, ferruginous laterite, shallow surficial cover of undifferentiated gravel and sand as well as black and superficial soil derived from underlying carbonates or volcanics. Quaternary sediments include terrace deposits and coastal alluvium consisting of unconsolidated mud, silt and salt crusts (Dunstar et al., 2000).

**Bonaparte Basin Architecture**

The Bonaparte Basin is floored with tilted, rotated fault blocks of Upper Devonian to Late Carboniferous sediments of pre-rift genesis of the Cockatoo, Ningbing and Langfield Groups (Meaney, 2006). During Carboniferous rifting and subsidence the syn-rift sediments of the Weaber Group were deposited unconformably. Lower Permian sediments of the Kulshill Group are post-rift in nature and sheeted the earlier pre-rift and syn-rift sediments. The post-rift sediments were uniform across the basin proper but the record of Lower Permian sedimentation is in many places incomplete. In the Southern onshore Bonaparte, south of about Port Keats, sequences of the Upper Kulshill package are not recorded.

Lower Permian sedimentation, in response to six periods of basin and hinterland uplift, occurred in alluvial fan, fluvial, shore face, and offshore glacial-marine environments. Where basin subsidence did not occur, coarsening-upward progradational fluvial to fan sequences formed. Alluvial fans formed at the foot of the Cockatoo Fault that fed directly into the sea, resulting in a narrow fluvial
belt and rapid facies changes. Figure 4A (Beere et. al, 1988). Subsequently greater accommodation from basin deepening exceeded sediment influx resulting in marine deposition Figure 4B & C. This was followed by Basin uplift partially eroding the marine deposits and re-introduced sedimentation of alluvial deposits Figure 4D. This tectonic cycle was repeated several times creating multiple Permian sequences Figure 4E (Beere et. al, 1988).

Onshore Triassic and later Mesozoic lithology are non-existent as a product of both 1/ Late Triassic compression, uplift and erosion (Cadman et. al, 2003) and 2/Mesozoic extension that deeply eroded sediment onshore and created offshore basins to deposit Mesozoic sediment into major Jurassic depocentres.
Figure 2: i) Basin Architecture and ii) Structural Elements of the onshore and offshore Bonaparte Basin. (Department of Resources, Energy and Tourism, 2010)
Figure 3: Basal tract and major structural elements of the southern onshore Bonaparte Basin (Duchemin, 1966)
Figure 4A-E: Tectonic and sedimentary controls of multiple depositional environments in the Keep Inlet Formation, Kulshill Group

4A Alluvial Fan deposited from Fault
4B & 4C Basin Deeping = Transgression Accomodation > Sediment Influx
4D Basin Uplift-Marine Erosion
4E Repeated cycles of A, B, C and D
5. Local Geology and Stratigraphy

Figure 6 shows mapped and interpreted outcrop geology over the Red Dog tenement area. Basement of the southern onshore Bonaparte Basin is relatively unmetamorphosed Proterozoic rocks which are in turn overlain by the basalt flows of the Antrim Plateau Volcanics of Cambrian age. Ordovician to Middle Devonian sediments are unknown in the onshore Bonaparte Basin indicating that this was a period of non deposition or erosion.

Late Devonian deposition commenced with a reef complex established along the edges of the Keep Inlet/Burt Range sub-basin, N.T. (Cockatoo Formation) and Carlton Sub-Basin, W.A. (Ningbing Limestone) (Figure 5). The Devonian reef complex is overlain by a clastic-influenced carbonate shelf, the Langfield Group. The contact is conformable in the Keep Inlet/Burt Range sub-basin and disconformable in the Carlton sub-basin (Meaney, 2006). Recognition of this limestone or calcareous lithology outcropping or intersected at shallow depths is indicative of the lateral extent of Early Carboniferous, the beginning of the post rift sequence (see Figure 5).

In all southern Bonaparte sub-basins the deposition of the Langfield Group, was followed by that of the Mid to Late Carboniferous Weaber Group. The contact is an angular unconformity.

The Weaber Group is unconformably overlain by the coal-bearing Kulshill Group, in both the Carlton and Keep Inlet/Burt Range sub-basins. This Late Carboniferous to Permian unit forms a shallowly north-northwest dipping (less than 5 degrees) sheet-like cover over the older units of the southern onshore Bonaparte Basin (refer to Figure 5). Nearer to, but not at the basin margin, the cycles of Kulshill Group sedimentation are interpreted to have occurred in fluvial settings and alluvial fans (possibly with localised distal swamped deltaic and lacustrine environments permissive for coal accumulation) and basinward, as shoreface and glaciomarine environments (Beere et al, 1988).

Group Formation Lithology

Descriptions of the group formation lithologies are provided below as stratigraphic references to assist field geologists to distinguish between prospective units and end of hole logging. The following descriptions have been sourced from the Keep River-1 well completion report.
The reporting geologist has subdivided the prospective Kulshill Group into the following members. Note the Keep Inlet Formation is considered partially laterally equivalent to the Kuriyippi Formation (Beere et al., 1988).

**Keep Inlet Formation (Thickness: 480m)**
- Silty shale sequence from 42m to 219m, siltstones are argillaceous, with poor to medium sorting, interbedded shale characterised by coal seams at 52m, 61m, 120m. Coal is described as vitreous.
- Sandstone sequence between 219m to 480m, sandstone are generally fine-medium grained, well sorted, contain traces of pyrite, coal and minor feldspar grains, from about 304.8m. Grain size increases in sandstone and contains characteristic pebbles. Dark shale rich in pyrite with coal; becomes micro conglomeratic between 399m-438m.
- Coal has been observed in both sequences with net thicknesses of 4 metres.

The following descriptions have been sourced from the most recent well completion report Weaber-5, 1997. The reporting geologist has subdivided the Weaber Group into the following members:-(Irwin, 1998)

- **The Point Spring Sandstone (Thickness: 115.5m)** this clastic unit is composed of bioturbated and fossiliferous parallel and cross bedded sandstones.
- **The Tanmurra Formation (Thickness: 136m)** a unit of fine grained sandy calcarenites, calcareous and dolomitic quartz sandstones, medium grained oolitic calcrudite and sandy calcarenites of deltaic origin.
- **The Milligans Formation (Thickness: 722m)** a deep water marine unit of black partly calcareous and fossiliferous shales. This was previously known as Milligans Beds.

The following descriptions have been sourced from the Auvergne Explanatory Map sheet Notes. The geologist has further subdivided the Weaber Group into the following members: - (Dunstar et. al, 2000)

- **The Border Creek Member** (member of Point Spring Sandstone) a unit of fluvio-deltaic pebbly sandstone with minor laminated shale and siltstone. The unit is not present in the Petrel sub-basin.
• **The Burvill Formation** (unconformably above the Milligans Formation) a unit of fine grained, bioturbated and fossiliferous sandstones with parallel and low angle cross bedding and minor medium to coarse grained, thickly bedded sandy limestone.

In the north-western most parts of EL 29010, there is some potential for scout drilling to intersect the Upper Kulshill Package. The following descriptions of the Upper Kulshill package are sourced from the Kulshill-1 well completion report, 1966 (*Duchemin et al*, 1966)

• **Keyling Formation (Thickness: 550m)** consists mostly of sandstone with lesser amounts of siltstone and shale, coal, conglomerate and very minor limestone. Previously known as the Sugarloaf Formation

• **Treachery Shale (Thickness: 510m)** predominantly carbonaceous, argillaceous, tillitic and varved siltstone; with claystone and minor amounts of sandstone. Previously known as the ‘Microconglomeritic Shale member’ from the Kulshill Formation.

• **Kuriyippi Formation (Thickness: 370m)** consists of a series of upward-fining cycles overlain by glacial strata. The cycles are generally 30–90 m thick are formed from sandstones with variable clay and carbonate cements, overlain by carbonaceous siltstone and shale. Coal was reported from the *D.birkheadensis* assemblage in several onshore stratigraphic holes. Cores from the *D.birkheadensis* assemblage-bearing Kuriyippi Formation generally display characteristics of fluvial deposition. The Kuriyippi Formation is predominately an offshore unit that is thought to be partially the lateral equivalent of the Keep Inlet Formation. (*Beere et. al, 1988*).
Figure 5: East West conceptual cross-section that illustrates the rift-basin architecture of the Southern Onshore Bonaparte Basin (Caye, 1969)
Figure 6: 250K outcrop geology mapping that shows Permian outcrop in bright blue, coal intersections in black circles, Proterozoic basement in dark grey, Palaeozoic basement in light grey, Post Permian (Cenozoic) in light orange and Quaternary sediments in light yellow.

Local Geology-Remote Sensing

Figure 7 shows Landsat Geocover satellite imagery over the prospective parts of the Red Dog tenement area and adjacent Lower Permian outcrops, W.A.. Although there is no definitive signature that correlates with the outcrop, the dark purple has been interpreted to be predominantly shallow subcropping Lower Permian.
Figure 7: Landsat Geocover with outcropping Permian Keep Inlet Formation highlighted
Figure 8: Stratigraphic Table of the southern onshore Bonaparte Basin.
6. Structural interpretation

Prior to the Lower Permian, the southern onshore Bonaparte Basin was composed of a number of distinct subbasins, each with its own depositional system; the Carlton, the Keep Inlet and the Burt Range Sub-basin. The Keep Inlet and Burt Range Sub-basins are bounded to the east by the Cockatoo Fault. Global Ore Discovery has interpreted an array of second-order NW oriented transfer faults which accommodate NW block down throw on NE oriented normal faults that parallel the Cockatoo Fault to the east and Pincombe ridge to the west. Along the western edge of the basin, second-order NE oriented transfer faults accommodate NE block down throw on NW oriented normal faults, Figure 9.

The formation of these transfer faults is important as they create a structural boundary between depocentres that influenced the pattern of sediment deposition in the developing Carlton and Keep-Inlet Sub-basins.
7. Geophysics Analysis

Gravity

The Gravity map shows the Free Air Anomaly Gravity over the Red Dog area of interest. The grid shows gravity highs in red/orange and gravity lows in purple/blue. A structural interpretation is displayed as solid black lines with triangles on one side which point to the down thrown block. Interpreted depocentres are outlined by solid pink lines located in the centre of the map window. These depocentres not only are the likely area of the thickest sedimentation they are interpreted to have a higher proportion of marine influence in the Permian stratigraphy.

Figure 10 Global Ore Discovery fault interpretation from Free-Air anomaly Gravity, Transfer Faults in solid black (no triangle). Normal faults shown with black triangles to the interpreted down thrown block.
Seismic
Regional seismic surveys were historically completed by various Petroleum companies. Interpretation reports were not routinely collected by the NT government for pre 1980’s surveys. The available interpretation reports recovered in this review have focussed on definition of reflectors beneath the Permian package unconformity and these are not able to provide useful seismic data for understanding the form of shallower coal bearing stratigraphy.

Seismic datasets have been reviewed by third party re-processing specialists. Almost all the datasets lack sufficient field location and geometry data for effective reprocessing. The Forsyth and Spirit Hill surveys both have geometry information from the SEGY header and shallow reflectors are observable from the shot gathers with high fold, however Vibroseis sources were used and elucidation of thin, shallow reflectors that may represent shallow coal seams would be challenging.

The Skull Creek 2D SS 1965 and Legune 2D SS 1964 surveys cover parts of EL 29010, and EL 29011. The reports included 2D seismic reflection and refraction sections, and an interpretation of reflectors and horizons shown on those sections. No correlation could be determined between the seismic reflectors and Lower Permian unconformity. Seismic refraction interpretation from the Legune 2D survey identified the base of weathering in section which correlates well with seismic uphole drilling.
Figure 11: Location of Seismic Surveys in and around the Red Dog Tenements
8. Historic Exploration

Coal exploration summary
A small number of prior coal exploration licences have been held within the onshore Bonaparte Basin.

The first recorded coal exploration was conducted in 1906 by the South Australian Department of Mines. The project involved coal bores around Port Keats, Cliff Head, Cape Ford, Anson Bay and Cape Hay where coal is in outcrop. No specific outcrop locations are shown in historic reports, however outcropping Kulshill Group is mapped (Figure 1). These bores intersected thin (no thickness specified), discontinuous coal seams considered uneconomic in 1909 and the search was abandoned.

In the mid 1960’s Lower Permian coals were intersected in the **Kulshill 1**, and **Kulshill 2** petroleum exploration wells, drilled by Australian Aquitaine Petroleum Pty Ltd *(Duchemin and Creevey, 1966)*. These intersections spurred on a second phase of coal exploration at Port Keats, undertaken by Theiss Brothers Pty Ltd, Coal Licence 172. Theiss concluded the coals were thin, discontinuous and of no appreciable areal extent *(Lalor, 1967)*. The coals were hosted by unconsolidated sediments and, with equipment available at the time, could not be mined by either open cut or underground methods.

Coal exploration continued in the Port Keats area (Figure 13) with drilling by Utah Development Company in 1972 and maceral analysis by Western Mining Corporation Limited (WMC) in 1982. WMC’s literature review of Utah’s drilling and their own coal quality analysis of historic petroleum well cuttings led them to conclude that the coal potential of the Port Keats area is limited as the Lower Permian coal seams are thin and discontinuous. They concluded that neither open cut mining nor underground mining would be economic in this area in 1982 *(Meyer, 1982)*.

All these companies had investigated the shallow Lower Permian coal in the **Upper** Kulshill Group, outcropping in the Port Keats area. It should be noted that the coal seams targeted by Ebony within the Red Dog tenure (Southern onshore Bonaparte) are hosted in the **Lower** Kulshill Group.

By 1981 Consolidated Zinc Rio Tinto Australia (CRA) established a drilling program motivated by Lower Kulshill Group coal seams recorded in Aquitaine Petroleum’s exploration well, **Keep River 1**. This well is located within Red Dog EL 29010. CRA was granted three tenements; Coal Licence 1 (N.T.), Temporary Reserves 7886H (W.A.) and Temporary Reserves 7885H (W.A.). Coal Licence 1 located in Northern Territory extended for 2360 square kilometres, overlapping the area of the north-west Red Dog EL 29010. Temporary Reserves 7886H and 7885H are located in Western Australia, approximately 1km from the Red Dog EL 29010 and together covered 346 square kilometres.
CRA drilled a total of 23 holes, of which 5 holes intersected coal, and 7 holes were abandoned. The greatest net coal, 1.8 metres thick, was recorded in the W.A. tenement, Temporary Reserve 7885H, where five coal seams were intersected in RD81BC7. *(For depths, thickness and seam descriptions refer to Table 1).* Current interpretation places these intersections within the Keep Inlet Formation.

**Coal Licence 172**

**LALOR, R.M. 1967 — REPORT ON COAL EXPLORATION IN CL172 PORT KEATS AREA NT, GEOTECHNICS PTY LTD**

The report was obtained from the Northern Territory’s Petroleum Exploration Database (PEX); the Company Report number is CR1968-0070. The report focuses on;

- The intentions and results of the drilling programme (pg5-8)
- Downhole lithological descriptions (pg8-11)
- The location of the boreholes (pg11-13)

Coal Licence 172 was granted to Theiss Brothers Pty Limited in 1966. Geotechnics Pty Ltd on behalf of Theiss Brothers investigated the possible economic occurrence of coal in the Port Keats Area. The drilling program consisted of five holes, located along the interpreted strike of the Upper Kulshill group, each hole was approximately 180 metres deep. Out of the five holes, four intersected coal with the thickest seam recorded in Kuriyippi-4, 0.6m thick at depth of 170m *(Lalor, 1967)*. Seam thickness was estimated from the cuttings and by the drill rate as the drill water tended to wash the coal away *(Lalor, 1967)*, before it entered the core barrel. The coal quality was noted as predominantly bright, black and bituminous and in some places pyritic.

**Coal Licence 1 and Temporary Reserves 7886H**


The report was obtained from the Northern Territory’s Petroleum Exploration Database (PEX); the Company Report number is CR1983-0177. The report summarizes;

- Downhole lithological descriptions (pg16-42)
- Downhole wireline geophysical logs (pg44-48)
- The location of the boreholes (pg43)
The report was obtained from the Western Australian Petroleum Exploration Database (WAMEX);

The Report number is A36019. The report contains;

- Downhole lithological descriptions (pg11-25)
- Downhole wireline geophysical logs (pg29,32,33)
- Correlation of the boreholes (pg30,31)
- The location of the boreholes (pg43)

Coal Licence 1, Temporary Reserves 7886H and 7885H were granted to Consolidated Zinc Rio Tinto Australia in 1981. Coal Licence 1 is the only historic coal exploration licence within the current Red Dog Project area under which drilling has been conducted. CRA drilled a total of 23 shallow bores into the interpreted Lower Kulshill Group at depths less than 136m. Seven of these holes were abandoned having failed to penetrate unconsolidated Cainozoic sediments and gravel deposits. The majority of the holes are located south and east of Aquitaine’s Keep River-1 historic petroleum well.

In Coal Licence 1, two boreholes, RD81BC6 and RD81BC5 (within 1.1 kilometres of one another), intersected coaly material. RD81BC6 recorded the best occurrence with a 0.5 metre coal seam at 77.8 metres and a 0.4 metre coal seam at 86.2 metres. CRA relinquished the coal exploration licence as the coal was described as thin, discontinuous and shaly (Johnson, 1983).

Independent geologists Beere and Mory reviewed all coal exploration in the southern Bonaparte Basin, conducted prior to 1988. They concluded that the coal potential has been inadequately tested due to the wide spacing of coal bores, the lack of core drilling and lack of downhole geophysical logging (Beere et al, 1988).

Adjacent to the Red Dog tenure in Western Australia, within Temporary Reserves 7886 and 7885H, multiple coal seams were intersected in RD81BC7, at a total net coal thickness of 1.8m. The descriptions of the five coal range from bright, dull and shaly (Table 1). Drilling was completed using rotary air/percussion techniques and significant volumes of water were encountered, creating problems with sample return (Mc Bain, 1982). CRA conducted no step out drilling from this intersection, with their nearest scout holes nearly 4km to the northeast and southwest.
### Table 1 Summary of coal seams in RD81BC7

<table>
<thead>
<tr>
<th>Thickness of Seam</th>
<th>Floor Depth of Seam (m)</th>
<th>Seam Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>49.3</td>
<td>Coal, mixed; mainly bright</td>
</tr>
<tr>
<td>0.4</td>
<td>63.8</td>
<td>Coal, dull</td>
</tr>
<tr>
<td>0.2</td>
<td>74.9</td>
<td>Coal, shaly</td>
</tr>
<tr>
<td>0.4</td>
<td>91.8</td>
<td>Coal, dull</td>
</tr>
<tr>
<td>0.5</td>
<td>98.4</td>
<td>Coal, mixed, mainly bright</td>
</tr>
</tbody>
</table>

### TEMPORARY RESERVES 8689H-8694H


The report was obtained from the Western Australian Petroleum Exploration Database (WAPEX); the Report number is A1104. The report contains;

- Lithological descriptions (pg16-36)
- The location of the boreholes (pg37)
- A drill-section plan of the boreholes (pg38)

Temporary Reserves 8689H-8694H were located in W.A. to the north-west of Red Dog EL 29010. Utah Development targeted coal in Permian sediments and drilled 15 boreholes (CGDH1-15), to depths between 70 and 264m, totalling 1875m. All holes intersected Permian sediments and 12 holes intersected sandstone and mudstone rich in coal partings and coal stringers. Drilling was completed using rotary mud drilling techniques with depth to oxidation measured between 8 and 38 metres. Wet season conditions disrupted access resulting in additional locations not being drilled. Utah Development Co. were unable to determine the significance of coal scum in drilling returns and collected neither core samples nor wireline geophysical downhole data. Despite recognising potential for coal accumulation within the Permian package, Utah Development Co. surrendered the licence.

### Coal Licence 2


The report was obtained from the Northern Territory’s Mineral Exploration Database (MEX); the Company Report number is CR1983-0300. The key content of the report is;

- Vitrinite reflectance and maceral analysis (pg10-13)
WMC conducted coal quality analysis on cuttings from historic petroleum wells, Keep River 1, Moyle 1, Kulshill 1 and Kulshill 2. Vitrinite reflectance (Ro max) measurements returned results for Keep River 1 cuttings from 0.41% to 0.56% (Meyer, 1983). Maximum vitrinite reflectance (Ro max) measurements from cuttings taken from petroleum wells drilled in the Port Keats area were 0.37% in Kulshill 1, 0.42% in Kulshill 2 and 0.55% in Moyle 1.

**Petroleum exploration**

**OP 2**

Authority to Prospect OP2 granted to Australian Aquitaine Petroleum Pty Ltd in 1968, covered the entire southern onshore Bonaparte Basin, including Port Keats and the current Red Dog tenement area (*Figure 13*). They drilled four wildcat exploration wells in the mid 1960’s, looking for commercial oil reserves. Three of these wells, **Kulshill 1, Kulshill 2 and Moyle 1** were collared in Upper Permian Kulshill Group sediments. **Keep River 1** located within what is now Red Dog EL 29010 (in the south of OP2) collared in Keep Inlet Formation of the Lower Permian Kulshill Group. **Kulshill 1** and **Kulshill 2** recorded approximately 2.5 metres of net coal at 186m depth, in the Fossil Head Formation. **Moyle 1** penetrated a thinner section of the Kulshill Group and encountered no coal seams other than “Brown Coal fragments” within the sandstone unit from the Upper Kulshill Group.

**Keep River 1** was drilled to a total depth of 4,652 metres ending on the 23rd February, 1969. The top of the well (0-219m) intersects the shale-dominated sequence of the Lower Kulshill Group which contains minor beds of siltstone, very fine-grained sandstone, coarse-grained pebbly sandstone, and coal beds. Seam thickness interpreted from wireline logging approximates 1.5m, 0.6m and 0.9m intersected at 52m, 61m and 120m. In the sand-dominated sequence of the Lower Kulshill Group a further 1m thick coal seam was intersected at 348m.

A coal quality analysis of Aquitaine’s wells was completed by Western Mining in 1983, measuring the mean maximum vitrinite reflectance and maceral type. The coals are chiefly vitriniterits so these fluctuations in vitrinite content are paralleled by fluctuations in inertinite content. The variations in organic matter type indicate changes in the environment of deposition from an oxidising environment in sample ‘348m’ to a more reducing environment in sample ‘120m’ and back to more oxidising environment in samples ‘61m’ and ‘52m’. The presence of lamalginitne and telalginitne in sample ‘52m’ possibly indicates a lacustrine environment of deposition. (*Meyer, 1983*).
OP 186/RL1

Authority to Prospect OP186 was granted to petroleum explorers Australian Aquitaine Petroleum Pty Ltd and Santos. In 1982, Aquitaine drilled Weaber 1 to a total depth of 1950m. The well is located within the Tennant Creek Gold tenement that lies between Ebony’s Exploration Licence 29010 and Exploration Licence 29006. Weaber 1 is collared in the Kullshill Group and intersected 250 metres of sedimentary stratigraphy interpreted to be the base of the Kulshill Group.

The well intersected siltstones of the Lower Kulshill Formation hosting a 1 metre coal seam and vitreous laminations of coal at 207 metres depth. Weaber 2 & Weaber 2A were drilled by Santos in 1988. The wells are adjacent to one another and are located 2.3km WNW of Weaber1. Weaber 2 was abandoned at 445m due to severe hole problems. Weaber 2A was subsequently drilled 125m to the north. At 134m, Weaber 2 intersected vitreous laminations of coal within the siltstone from the Lower

Figure 12: Detailed lithology log and wireline data, Keep River 1, from 0 - 500 ft (Caye, 1969)
Permian sequence. The Lower Permian sequence intersected by Weaber 2A consists of fine grain sandstone with minor interbedded conglomeratic sandstone; however no coal is recorded in the lithological descriptions.

**Weaber 3, 4 & 5** were drilled under the terms of Retention licence, RL-1 (Capital Energy NL and Amity Oil N.L). Weaber 3 was drilled in 1994, to a total depth of 1465m. It is located approximately 2km from Weaber 1 and Weaber 2, it is also collared at the Lower Kulshill Formation, however it failed to intersect coal. Weaber 4 and 5 were drilled by Amity Oil NL in 1997, Weaber 4 recorded trace sub-vitreous coal within the interpreted Lower Permian sandstone sequence at 450 metres depth, while Weaber 5 recorded similar sandstone with shale interbeds lithology but with no reported coal hits.

**OP 3**

Authority to Prospect OP3 was granted to petroleum explorers Oil Development N.L in 1960. Oil Permit 3 contains the exploration well **Spirit Hill 1**, located 12km to the south of Red Dog EL 29010. Spirit Hill 1 is a continuously cored diamond drill hole, drilled to 749 metres by Westralian Oil Limited in the 1959 dry season, and carried down to its final depth of 915m by Oil Development N.L. during the 1960 dry season. The drilling of this well has shown that the stratigraphy begins at the Lower Carboniferous sequence. Although carbonaceous material and trace coal are recorded within the Septimus Limestone unit, the coal-bearing Early Permian stratigraphy is non-existent.

**EP 126**

Authority to Prospect EP 126 was granted to Australian Aquitaine Petroleum Pty Ltd, on 12th August, 1979. **Skull 1** was drilled on 20th August, 1984. **Skull 1** was drilled to a total depth of 2000m. The well was terminated in the Early Carboniferous sediments of the Milligans Formation without penetrating any limestone. Kulshill Formation, Tanmurra Formation, Milligans Formation were encountered in stratigraphic order from top. Several thin coal horizons were intersected between 130 -145m. Coal in cuttings is described as dominantly brittle with soft puggy intercalations.

**Mineral Exploration**

**E.L 2167**

This permit was granted to Elf Aquitaine Trako Mines Ltd. and St Joe Bonaparte for the purpose of Lead-Zinc exploration in the Early Carboniferous, Burt Range Formation (Langfield Group). The work program, conducted in 1982, involved a single stratigraphic diamond drill hole, NBK 1046. The hole was collared in the Late Carboniferous Milligans Formation and drilled to a depth of 343 metres. Trace coal was intersected within black dolomitic mudstone of the Milligans Formation, at a shallow depth of 60 metres.
E.L 4413

Authority to Prospect E.L 4413 was granted to Elf Aquitaine Trako Mines Ltd. And St Joe Bonaparte during 1984 in search of Mississipi Valley Type Lead–Zinc. 19 holes were drilled along the southern and northern Bonaparte Basin margin. NBK 1002 intersected trace coal at 74 metres, within the calcareous Point Spring Sandstone.

Figure 13: Outline of historical tenements and exploration drilling
Seismic Uhole

During August 1997, 69 upholes were drilled into Cainozoic material from 20 to 45m for the "Spike Seismic Survey" on Exploration Permit EP 66 for Amity Oil NL. Samples from the holes were retained and geologically logged in May, 1998. Amity Oil interpreted the geomorphology of the Ord River palaeochannel and its tributaries of the Keep, Sandy and Alligator Springs rivers based on the logging data collected from the seismic upholes. The subcrop locations of several geological formations from the Cambrian through to the Upper Carboniferous were interpreted. The Amity seismic upholes are useful for the Red Dog Project as they outline the zones of Cainozoic deposition, Cainozoic thickness, base of weathering and oxidation (Figure 15).

Figure 14: Seismic uhole and waterbore map
Waterbores

Waterbores have been compiled from within the Red Dog area of interest and provide a record of Cainozoic thickness. The bores drill depth range from 7m to 900m with only 5 bores exceeding 100m. Although coal is not reported, the lithology logs allowed interpretation of Permian and Cainozoic thickness and depth of weathering data. The Cainozoic thickness was plotted and correlated with Global Ore’s fault interpretation. A major increase in the depth of weathering (from less than 15m to more than 40m) coincides with the broadening of the Ord River palaeochannel and thickness of Cainozoic material and may be fault controlled; possibly a NW trending transfer fault, east side down (Figure 16).
Figure 15: Contour map showing base of weathering/oxidation data from historic drilling data
Figure 16: Cenozoic thickness from drill hole data with Global Ore fault interpretation
9. Coal bearing stratigraphy

This analysis has reviewed the historic exploration data for evidence of coal occurrences and then focussed on interpreting the extent of permissive Permian stratigraphy (Kulshill Group) to assist planning on-ground exploration within the Red Dog tenements.

There are three lithologies hosting coal in and around the Red Dog Area of Interest. The Lower Carboniferous Burt Range calcareous sandstone/silty dolostone, and two sequences within the Lower Permian Kulshill Group 1/ the Keep Inlet Formation Shale sequence, 2/ the Keep Inlet Formation Sandstone sequence. The Shale sequence from the Keep Inlet Formation contains the thickest seams (~1.5m) and indicates the depositional conditions during this period of the Lower Permian were amenable to the formation of coal.

The Keep Inlet Formation outcrops 1.2km west from Red Dog EL 29010. The outcrops are mapped as calcareous, feldspathic and lithic quartz sandstone, locally pebbly (See Figure 6) The outcrops are described as visually similar to the Upper Kulshill Group (Sugarloaf sandstone) at Port Keats, N.T. (Williams, 1982).

The CGDH holes were drilled 8km west from the Keep Inlet formation outcrops; the drilling encountered darker more carbonaceous mudstones that produced a thick scum of fine coal on the surface of the mud pit. (Williams, 1982). This coal scum was speculated to originate from fine coal stringers and coaly partings in mudstone, which is interpreted as the Keep Inlet Formation Shale sequence.

Conglomerates and Tillites are noted at the top of some CGDH holes and the possible glacial re-working of Lower Permian sediments with adverse affects on lateral continuity of any coal seams that may be present cannot be excluded.

Coal intersections

Figure 17 shows the distribution of coal mentions in and around the Red Dog exploration licences. Coal intersections hosted in sandstone, mudstones and shales of the Lower Permian cluster around EL 29010. The thickest net coal (4m) is recorded in the Keep River-1 petroleum well in the centre of EL29010.

Figure 18 maps the depth to first coal intersection and the distribution of recorded Permian stratigraphy. Clearly not all the Permian stratigraphy hosts coal and detailed analysis of scout drilling
and on-ground mapping should focus on defining lithostratigraphy in sufficient detail to target localised coal accumulations.

Figure 19 maps the coal host lithology recorded from historic drilling data. Coal references in and around EL 29010 and EL 29142 are consistently associated with mudstones and sandstone.

Table 1 lists the hole type, location, description of the coal as per the historic log (total coaly interval in metres) and coal-host lithology. The quality of these descriptions is limited by the lack of core drilling and downhole wireline logging.
Figure 18: Depth to coal and drill holes that have recorded Permian lithology

Red Dog Project
Coal Depth Map
Red Dog Project
Coal-Host Stratigraphy Map

Figure 19 Coal host lithology recorded from historic drilling data
<table>
<thead>
<tr>
<th>DH ID</th>
<th>Type</th>
<th>Easting</th>
<th>Northing</th>
<th>Coal Description</th>
<th>Coal Host Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weaber 1*</td>
<td>Pet Well</td>
<td>514060.2</td>
<td>8302792</td>
<td>White Sandstone with Siltstone, carbonaceous with laminations of vitreous coal. (115-130m) Coal Seam (208-209m)</td>
<td>Shale &amp; Sandstone</td>
</tr>
<tr>
<td>Weaber 2*</td>
<td>Pet Well</td>
<td>511806.5</td>
<td>8303258</td>
<td>Siltstone interbedded with trace coal and sandstone. (134-147m)</td>
<td>Siltstone</td>
</tr>
<tr>
<td>Weaber 3*</td>
<td>Pet Well</td>
<td>513739</td>
<td>8304882</td>
<td>Coal Seam (1m)</td>
<td>Shale</td>
</tr>
<tr>
<td>Weaber 4*</td>
<td>Pet Well</td>
<td>514060</td>
<td>8302791</td>
<td>Sandstone with Trace Coal</td>
<td>Sandstone</td>
</tr>
<tr>
<td>Keep River 1</td>
<td>Pet Well</td>
<td>509775.6</td>
<td>8323234</td>
<td>Coal Seam (52-53.5m), Coal Seam (62-62.6m), Coal Seam (121-121.9m) Coal Seam (348-349m)</td>
<td>Silty Shale &amp; Sandstone</td>
</tr>
<tr>
<td>RD81BC5</td>
<td>Coal Bore</td>
<td>507808.5</td>
<td>8314835</td>
<td>Coal Seam (33-33.5m)</td>
<td>Mudstone</td>
</tr>
<tr>
<td>RD81BC6</td>
<td>Coal Bore</td>
<td>507280.4</td>
<td>8313857</td>
<td>Coal Seam (77.3-77.8m), Coal Seam (85.8-86.2)</td>
<td>Sandstone</td>
</tr>
<tr>
<td>RD82BC11</td>
<td>Coal Bore</td>
<td>509606.4</td>
<td>8323098</td>
<td>Thin Coal Partings</td>
<td>Mudstone</td>
</tr>
<tr>
<td>RD81BC3*</td>
<td>Coal Bore</td>
<td>497532.9</td>
<td>8325673</td>
<td>Coal laminations</td>
<td>Sandstone</td>
</tr>
<tr>
<td>RD81BC7*</td>
<td>Coal Bore</td>
<td>495633.9</td>
<td>8316793</td>
<td>Bright Coal Seam (49-49.3) Dull Coal Seam (63.4-63.8) Shaly Coal Seam (74.7-74.9) Dull Coal Seam (91.4-91.8) Bright Coal Seam (97.9-98.4)</td>
<td>Sandstone</td>
</tr>
<tr>
<td>Skull 1*</td>
<td>Pet Well</td>
<td>495121.3</td>
<td>8310305</td>
<td>Multiple Coal Fragments</td>
<td>Sandstone</td>
</tr>
<tr>
<td>NBK1046</td>
<td>Mineral Hole</td>
<td>520100</td>
<td>8296300</td>
<td>Trace Coal</td>
<td>Dolomitic Mudstone</td>
</tr>
<tr>
<td>NBK1002*</td>
<td>Mineral Hole</td>
<td>542673</td>
<td>8323061</td>
<td>Trace Coal</td>
<td>Calcareous Siltstone</td>
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<tr>
<td>CGDH14*</td>
<td>Coal Bore</td>
<td>487012.1</td>
<td>8341539</td>
<td>Mudstone, Carbonaceous. A lot of Coal scum (48-70m)</td>
<td>Mudstone</td>
</tr>
<tr>
<td>CGDH12*</td>
<td>Coal Bore</td>
<td>485159</td>
<td>8342731</td>
<td>Mudstone, minor Sandstone bands, Some Coal scum (18-88m)</td>
<td>Mudstone</td>
</tr>
<tr>
<td>CGDH12*</td>
<td>Coal Bore</td>
<td>485159</td>
<td>8342731</td>
<td>Mudstone, Carbonaceous, Coal scum (88-90m)</td>
<td>Mudstone</td>
</tr>
<tr>
<td>CGDH13*</td>
<td>Coal Bore</td>
<td>484993.8</td>
<td>8341525</td>
<td>Mudstone, Carbonaceous, some Carbonaceous Sandstone with Coal stringers. Lot of Coal Scum (14-56m)</td>
<td>Mudstone</td>
</tr>
<tr>
<td>CGDH15*</td>
<td>Coal Bore</td>
<td>481309.9</td>
<td>8342401</td>
<td>Sandy Mudstone, fine – medium grained, Carbonaceous with Coaly stringers. Minor Quartz Feldspathic Sandstone with Coaly partings. A lot of Coal scum (16-76m)</td>
<td>Sandy Mudstone</td>
</tr>
<tr>
<td>CGDH15*</td>
<td>Coal Bore</td>
<td>481309.9</td>
<td>8342401</td>
<td>Quartz Feldspathic Sandstone with Coal partings (76-88m)</td>
<td>Sandstone</td>
</tr>
<tr>
<td>CGDH11*</td>
<td>Coal Bore</td>
<td>482395</td>
<td>8343423</td>
<td>Mudstone, very Carbonaceous, Coal scum (48-50m)</td>
<td>Mudstone</td>
</tr>
<tr>
<td>Bore</td>
<td>Interval</td>
<td>Coal Type</td>
<td>Description</td>
<td>Note</td>
<td></td>
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<tr>
<td>------</td>
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<td>------</td>
<td></td>
</tr>
<tr>
<td>CGDH10*</td>
<td>480747.3-8344446</td>
<td>Coal Bore</td>
<td>Fine grained, slightly Carbonaceous Muddy sandstone, some Coal scum (42-92m)</td>
<td>Muddy Mudstone</td>
<td></td>
</tr>
<tr>
<td>CGDH9*</td>
<td>47905-8346290</td>
<td>Coal Bore</td>
<td>Sandstone with Coal Partings (28-36m)</td>
<td>Sandstone</td>
<td></td>
</tr>
<tr>
<td>CGDH9*</td>
<td>47905-8346290</td>
<td>Coal Bore</td>
<td>Sandstone with Carbonaceous Mudstone, some Coal scum (40-44m)</td>
<td>Sandstone/Mudstone</td>
<td></td>
</tr>
<tr>
<td>CGDH9*</td>
<td>47905-8346290</td>
<td>Coal Bore</td>
<td>Interbedded Mudstone and Carbonaceous Mudstone, with Coal scum (58-62m)</td>
<td>Mudstone</td>
<td></td>
</tr>
<tr>
<td>CGDH9*</td>
<td>47905-8346290</td>
<td>Coal Bore</td>
<td>Sandstone with minor Carbonaceous Mudstone 1%-2%, bright black Coal particles (102-108m)</td>
<td>Sandstone/Mudstone/Coal</td>
<td></td>
</tr>
<tr>
<td>CGDH8*</td>
<td>478639.6-8347536</td>
<td>Coal Bore</td>
<td>Fine grained, dark grey to black, lot of coal scum (16-18m)</td>
<td>Mudstone</td>
<td></td>
</tr>
<tr>
<td>CGDH8*</td>
<td>478639.6-8347536</td>
<td>Coal Bore</td>
<td>Quartz Feldspathic, Coal partings in sandstone and on broken faces (24-50m)</td>
<td>Sandstone</td>
<td></td>
</tr>
<tr>
<td>CGDH8*</td>
<td>478639.6-8347536</td>
<td>Coal Bore</td>
<td>As above with Coarser and with Pebble horizons (50-54m)</td>
<td>Sandstone</td>
<td></td>
</tr>
<tr>
<td>CGDH8*</td>
<td>478639.6-8347536</td>
<td>Coal Bore</td>
<td>Dark Grey to Black fine grained, lot of Coal scum (54-60m)</td>
<td>Mudstone</td>
<td></td>
</tr>
<tr>
<td>CGDH8*</td>
<td>478639.6-8347536</td>
<td>Coal Bore</td>
<td>Dark Grey to Black fine grained, lot of Coal scum (64-74m)</td>
<td>Mudstone</td>
<td></td>
</tr>
<tr>
<td>CGDH8*</td>
<td>478639.6-8347536</td>
<td>Coal Bore</td>
<td>Carbonaceous Mudstone and Quartz Feldspathic, with lot of Coal partings and Coal scum (92-96m)</td>
<td>Sandstone/Mudstone</td>
<td></td>
</tr>
<tr>
<td>CGDH8*</td>
<td>478639.6-8347536</td>
<td>Coal Bore</td>
<td>Quartz Feldspathic, Coal partings (96-100m)</td>
<td>Sandstone</td>
<td></td>
</tr>
<tr>
<td>CGDH8*</td>
<td>477188.4-8349634</td>
<td>Coal Bore</td>
<td>Fine grained, very dark, and possibly coaly (52-54m)</td>
<td>Mudstone</td>
<td></td>
</tr>
<tr>
<td>CGDH5*</td>
<td>472307.8-8351215</td>
<td>Coal Bore</td>
<td>Feldspathic sandstones, some Coal stringers in Sandstone chips (20-26m)</td>
<td>Muddy Sandstone</td>
<td></td>
</tr>
<tr>
<td>CGDH5*</td>
<td>472307.8-8351215</td>
<td>Coal Bore</td>
<td>Carbonaceous mudstone with minor Quartz feldspathic sandstones, sample contains 10% Coal (26-32m)</td>
<td>Mudstone</td>
<td></td>
</tr>
<tr>
<td>CGDH5*</td>
<td>472307.8-8351215</td>
<td>Coal Bore</td>
<td>Sandy Mudstone with Coal Stringers and hard Coal chips (32-46m)</td>
<td>Sandy Mudstone</td>
<td></td>
</tr>
<tr>
<td>CGDH5*</td>
<td>472307.8-8351215</td>
<td>Coal Bore</td>
<td>Quartz feldspathic Sandstone, Coal partings are common, and sandstone chips show coal stringers (50-62m)</td>
<td>Sandstone</td>
<td></td>
</tr>
<tr>
<td>CGDH6*</td>
<td>470611-8351657</td>
<td>Coal Bore</td>
<td>Coal Scum (4m)</td>
<td>Mudstone</td>
<td></td>
</tr>
<tr>
<td>CGDH2*</td>
<td>466730.6-8351840</td>
<td>Coal Bore</td>
<td>Fine grained Mudstone, With Coal Partings or Coal Stringers, minor Coal scum (96-104m)</td>
<td>Mudstone</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Drillholes that intersected coal. Brackets denote net interval over which coal, coal scum or trace coal was recorded (* denotes intersections beyond 500m outside the Red Dog tenements)
10. Prospectivity summary

Red Dog EL's 29010, 29142 and 29011 are interpreted to cover predominantly shallowly (less than 5 degrees) north-northwest dipping coal bearing Permian terrestrial to marine influenced stratigraphy (Kulshill Group) of the onshore Bonaparte Basin. A number of shallow coal/coaly intersections up to a net thickness of 4m (Keep River-1) occur within the tenure in historic petroleum wells, coal drillholes and water bores. Drillholes around Keep River-1 that are greater than depths of 100m, are widely spaced; an average of 15km apart. In addition, these drillholes are drilled by rotary methods and generally lack downhole geophysical logging.

The interpretation of the coal intersections indicates that a number of coal horizons occur within the package. These coal seams are interpreted to cluster into an upper and lower package, however individual seams intersected to date are discontinuous and unable to be correlated or extended between drillholes that in some particular cases are less than 200m apart.

The shale sequence of the Keep Inlet Formation (Lower Kulshill Group) is considered an exploration priority and is interpreted to be shallowly covered by Cainozoic sediment of 2-40 m across much of EL29010, 29142 and 29011. North-west of EL 29010 in Western Australia, potential Upper Kulshill has been described in outcrop and warrants exploration for both Port Keats equivalent coal measures and thicker accumulations of coal in the underlying Keep Inlet Formation shale sequence.

In detail, coal prospectivity within the Red Dog Tenure has been defined by considering

- Thickness/indications of coal
- Presence of Permian stratigraphy
- Depth of Weathering
- Thickness of Cover
- Potential for marine progradation
- Lateral Continuity
- Coal Quality

Review of the prospectivity factors has led Global Ore to subdivide the onshore Permian stratigraphy covered by EL 29010, 29142 and EL 29011 into five domains (Figure 20, Table 3). A sixth area which is considered to have the magnetic and gravity signature of a conceptual Permian sub-basin within basement has been defined in EL 29008. Vast regions within EL 29010, 29142 and EL 29011 are as yet underexplored and should be considered for future on-ground and in-ground exploration.
Figure 20 shows the prospective domains in the following colours; **Red**: Known coal occurrences, proximal to basin margin, indications that there is less weathering, probably less marine influenced. **Orange**: Carbonaceous occurrences, proximal to basin margin, indications of significant weathering, possibly less marine influenced. **Green**: No known coal occurrences, distal to the basin margin, possibly more marine influenced and **Blue**: Conceptual Early Permian sub-basin from satellite and gravity data interpretation.

Figure 21 shows schematic a footprint of approximately 100 million tonnes assuming a coal thickness of 3m and density of 1.45. No modifying factors have been accounted for and no expectation that exploration of the Red Dog licences will yield a resource of this size is implied.
Red: Known coal occurrences, proximal to basin margin, indications that there is less weathering, probably less marine influenced. Orange: Carbonaceous occurrences, proximal to basin margin, indications of significant weathering, possibly less marine influenced. Green: No known coal occurrences, distal to the basin margin, possibly more marine influenced and Blue: Conceptual Early Permian sub-basin from satellite imagery and gravity data interpretation.

Figure 20 Prospectivity domains interpreted by Global Ore Discovery including fault interpretation
Figure 21 Prospectivity domains and drillholes with coal intersections showing schematic footprint of ~100Mt in-situ coal assuming a 3m coal seam and a density of 1.45.
<table>
<thead>
<tr>
<th>Priority</th>
<th>Permian Stratigraphy</th>
<th>Coal Intersections</th>
<th>Potential for Marine Progradation</th>
<th>Depth of Weathering</th>
<th>Cover Thickness</th>
<th>Coal Lateral Continuity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 High</td>
<td>Known outcrop, intersections of coal in Coal Bores and Petroleum Wells</td>
<td>Numerous</td>
<td>Low</td>
<td>&lt;15m</td>
<td>&lt;10m</td>
<td>Low-Moderate (some intercepts)</td>
</tr>
<tr>
<td>A2 High</td>
<td>No intersections or outcrop, interpretation suggest that prospective stratigraphy is highly likely to be present</td>
<td>None (No drilling)</td>
<td>Low</td>
<td>&lt;15m</td>
<td>&lt;10m</td>
<td>Unknown (no intercepts)</td>
</tr>
<tr>
<td>A3 Moderate</td>
<td>No intersections or outcrop, interpretation suggest that prospective stratigraphy is highly likely to be present</td>
<td>None (Some Shallow Drilling)</td>
<td>Low</td>
<td>&gt;30m</td>
<td>&gt;20m</td>
<td>Unknown (no intercepts)</td>
</tr>
<tr>
<td>A4a Low</td>
<td>No intersections or outcrop, interpretation suggest that prospective stratigraphy is highly likely to be present</td>
<td>None (Some Shallow Drilling)</td>
<td>Moderate</td>
<td>&lt;15m</td>
<td>&lt;10m</td>
<td>Unknown (no intercepts)</td>
</tr>
<tr>
<td>A4b Low</td>
<td>No intersections or outcrop, interpretation suggest that prospective stratigraphy is highly likely to be present</td>
<td>None (Some Shallow Drilling)</td>
<td>Moderate</td>
<td>&gt;30m</td>
<td>&gt;20m</td>
<td>Unknown (no intercepts)</td>
</tr>
<tr>
<td>A5 Very Low</td>
<td>Potential for conceptual development for Permian stratigraphy</td>
<td>None (No drilling)</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown (no intercepts)</td>
</tr>
</tbody>
</table>

Table 3: Factors used in prospectivity classification of areas shown in Figure 20
11. Surrounding activity

The Bonaparte Basin is under active investigation by exploration companies looking for large tracts of open ground proximal to the growing Asian markets. Waratah Coal holds a substantial land package over Permian stratigraphy to the NE of the Red Dog tenements. The exploration licence application was made a number of years ago and is not yet granted, probably due to protracted Native Title negotiations.

12. Exploration Risks

It is prudent to outline a number of exploration risks that pertain to coal exploration within the Red Dog project. Desktop evaluation to date has necessarily been broad scale and the summary provided here should be considered as general for planning the exploration program rather than specific to any exploration play that may develop within the Red Dog Project.

12.1 Coal Occurrence

Coal reports in petroleum well Keep River 1, when tested by true coal explorers during the 1980’s have not been substantiated. However coal bores and petroleum wells have generally intersected coal in the Permian Kulshill Group. Although the relatively small number of available waterbore logs have failed to record coal, only 2 water bores have been drilled through the Kulshill Group stratigraphy to depths greater than 100m. The entirety of the Red Dog Project remains untested by core drilling targeting coal.

12.2 Lateral continuity

Lateral continuity of coal bearing horizons has not yet been demonstrated and would be a priority of any successful scout drilling program. Cyclic fault movement particularly on the south-eastern edge of the Southern onshore Bonaparte Basin leads to marine sedimentary caps and coarse clastic alluvial fan bases to the coal host stratigraphy. This cyclicity allows for the development of the stacked coal horizons observed in some drilling.

The stacked horizons without detailed wireline logs, lack of consistent stratigraphic markers and lack of well-resolved shallow seismic complicates the interpretation of lateral continuity.

In areas of EL 29010 and EL 29011, historic drilling, and in some cases, multiple historic coal boreholes, seismic upholes and waterbores have failed to obtain laterally equivalent sequences despite having been drilled between a pair of holes in which coal and/or carbonaceous occurrences
were reported. This suggests caution should be applied in assuming long range lateral continuity of coal within the Kulshill Group.

12.3 Coal thickness

The thickest coal seam intersection recovered in this review was 1.5m at 52m in Keep-River-1. The majority of seams intersected by percussion drilling by CRA reportedly ranged from 0.2m to 0.5m. However, the presence of multiple seam horizons may provide the opportunity for a greater net coal thickness.

12.4 Coal depths

The Red Dog Project tenements are interpreted to cover 1744 square kilometres strike of shallowly covered (2-40m) Permian Kulshill Group. Exploration is expected to test the complete package of Permian sediments and may require drilling boreholes in excess of 500 metres at the deepest region within EL 29010. Up-dip projections of coal reported in Keep River 1 may provide shallower targets.

Ebony’s large holding, including all eastern updip projections of the Kulshill Group to the basement unconformity provides potential for coal intersected at depth within a scout drilling program to be intersected at shallower depths within the Ebony package assuming the seam continues laterally.

12.5 Coal quality

There is very limited information on coal quality. However, vitrinite reflectance (RoMax 0.4-0.56) data has been collected on the Keep River 1 core. Downhole wireline data is available from RD81BC7; however the resistivity and density sample spacing prohibits an accurate interpretation of parting or ash content. Broadly, the upper seams appear to contain less ash than the lower seams, based on an interpretation of the resistivity and spontaneous potential logs. Detailed wireline logging and laboratory analysis should be carried out on any cored coal collected by Ebony to confirm the coal character and suitability for conventional energy generation.

13. Barren Zones

East of the Cockatoo Fault, Ebony’s Red Dog tenements EL 29006, EL 29007 and EL 29008 cover unprospective Proterozoic basement; a possible exception being an conceptual, low prospectivity potential sub-basin in EL 29008. The blocks that overlie basement may be useful to Ebony when complying with their relinquishment schedule to ensure tenure over the most prospective Permian ground is maintained.
14. Recommendations

The Permian Kulshill Group within the Red Dog tenements EL 29010, EL 29142 and EL 29011 is prospective for coal accumulations occurring at depths that have potential for open cut development. A large area (1605 sqkms including tidal flats) of interpreted prospective stratigraphy remains significantly under explored for coal.

- The interpreted paleoenvironment indicates that coal is likely to form in a discrete belt in zones of braided river development away from alluvial fans dominantly along the south-eastern edge of the onshore southern Bonaparte Basin.
- A scout drilling program is recommended to validate historic coal intersections and provide a basis to prioritise targets for step-out exploration. (Figure 20) shows a prospectivity map highlighting the areas on which Global Ore recommends initial exploration focus.
- Seismic surveying, focused on shallow reflectors should be considered to establish the lateral continuity of any coal seams intersected by scout drilling. Factors that would influence the degree to which shallow seismic would be successful include the depth of weathering, depth to coal and seam thickness; all of which would be known following the scout drilling program.
- A scoping study of the economics for coal development in the region should be undertaken to understand the characteristics (size, strip ratio, coal quality) of a potentially economic coal resource and provide a commercial context to the interpretation of historic drilling and future scout drilling results.

Specifically,

- Core drill the 1.5m at 52m, 0.6m at 61m, 0.9m at 120m and 1m at 348m coal intersections at Keep River 1 to confirm coal occurrence and collect samples for proximate analysis.
- Core drill as near as possible to the 0.5m at 77.8m and 0.4m at 86.2m coal intersections in RD81BC6 to confirm coal occurrence and collect samples for proximate analysis.
16. References


Cadman, S.J. and Temple, P.R., 2003, Bonaparte Basin, Northern Territory (NT) Western Australia (WA), Australian Petroleum Accumulation Report 5-2nd Edition, Department of Industry Tourism and Resources, GA.


Department of Planning and Infrastructure, WA, 2008.


