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Exploring for the future: Kidson Sub-basin seismic interpretation

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SUMMARY

Exploring for the Future is a four-year $100.5 million initiative by the Australian Government conducted in partnership with state and Northern Territory government agencies and universities that aims to boost northern Australia's attractiveness as a destination for investment in resource exploration. The acquisition of deep crustal seismic reflection data in the Kidson Sub-basin (Canning Basin) between the Kiwirrkurra community and Marble Bar in northern Western Australia was a major EFTF objective, and was completed in August 2018. This paper presents the preliminary geological interpretation of the sedimentary succession imaged by the Kidson Sub-basin seismic line.

Key words: Canning Basin, Kidson Sub-basin, deep crustal seismic.

INTRODUCTION

Exploring for the Future (EFTF) is a four-year $100.5 million initiative by the Australian Government conducted in partnership with state and Northern Territory government agencies and universities that aims to boost northern Australia's attractiveness as a destination for investment in resource exploration (e.g. Henson et al., 2018). Under the EFTF program, Geoscience Australia, together with state and territory partners, have used both established and innovative techniques to collect new pre-competitive datasets on an unprecedented scale, to better understand the geology and associated energy, mineral and groundwater resource potential across northern Australia.

The Exploration Incentive Scheme (EIS) is a Western Australian State-Government initiative that aims to encourage exploration in Western Australia for the long-term sustainability of the State's resources sector.

The onshore component of the Canning Basin covers approximately 430,000 km^2 and is dominated by two northwest–southeast-trending depocentres: the Fitzroy Trough–Gregory Sub-basin complex, and the Willara Sub-basin–Kidson Sub-basin complex (Kennard et al., 1994a; Ghori, 2013; Department of Mines and Petroleum, 2014; 2017). These two major depocentres are separated by the Broome and Crossland Platforms (e.g. Hashimoto et al., 2018), a northwest-southeast-trending platform of shallow basement. The onshore sedimentary succession comprises a Lower Ordovician to Lower Cretaceous succession up to 15 km thick in the Fitzroy Trough–Gregory Sub-basin and up to 5 km thick in the Willara Sub-basin–Kidson Sub-basin. Hashimoto et al. (2018) reviewed the available data within the Canning Basin and identified a significant seismic data gap across the Kidson Sub-basin.

In order to address this recognised seismic coverage gap, we report the completion of a new reflection seismic line (18GA-KB1), imaging, from east to west, the Kidson Sub-basin and components of the Proterozoic Paterson Orogen and Archean Pilbara Craton. This new survey, L211, was administered by Geoscience Australia, under the EFTF program, and co-funded by the Geological Survey of Western Australia through the Western Australian State-funded EIS program. Data acquisition was completed by Geokinetics Pty Ltd. We present preliminary geological interpretations of this newly acquired dataset and anticipate this new information will enable better understanding the geological evolution of the Canning Basin and, as a consequence, its hydrocarbon resource potential. Although a significant length of the western end of line 18GA-KB1 traverses across Mesoarchean Pilbara basement and Proterozoic Paterson Orogen, the crustal architecture and mineral resource potential of those components will not be addressed here but will be presented, in detail, elsewhere.

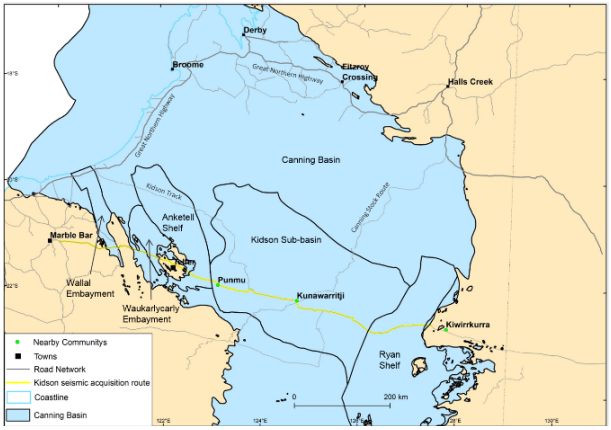

Figure 1. Location map of the Geoscience Australia – Geological Survey of Western Australia Kidson seismic line (18GA-KB1).

METHOD AND RESULTS

The acquisition of the Kidson Sub-basin seismic survey (L211) was a collaboration between Geoscience Australia and the Geological Survey of Western Australia under the EFTF

program. The 872 km seismic line was acquired (notably the longest continuous onshore seismic line conducted on the Australian continent) on the road near the Kiwirrkurra community in the east to approximately 20 km east of Marble Bar (Figure 1). Prior to this survey, the Kidson Sub-basin contained only sparse seismic coverage with the most recent surveys acquired in the late 1980s. Additionally, there are few wells in the vicinity of the new seismic line; the most recently drilled well within 100 km of the line is Patience 2 (Nerdlihc Company Inc) completed in 2001. The most informative well for stratigraphic control for line 18GA-KB1 is the Kidson 1 well (drilled by West Australian Petroleum Pty Ltd) completed in 1966, which is offset some 15 km to the south of line 18GA-KB1, and which reached a depth of ~4.4 km.

The seismic line 18GA-KB1 was acquired by Geokinetics using an array of three Inova AHV-IV PLS364 (62 000 lb) Vibroseis vehicles (Figure 2), configured to image the entire crustal thickness. Vibrator points were centred between the station locations, every 40 m, along the lines. Receiver arrays consisted of two strings of six geophones, laid every 20 m, centred on the surveyed station points.

The seismic line images the following major subdivisions of the Canning Basin including the Ryan Shelf, the Kidson Sub-basin, Anketell Shelf, Waukarlycarly Embayment, and the Wallal Embayment (Figure 1). The survey also images the Proterozoic sediments of the Yeneena Basin in the area around the Telfer Dome.

Figure 2. Vibroseis vehicles in the Kidson Sub-basin taken during the acquisition program (photo credit: Leon Normore, GSWA).

The primary objectives of the survey are to:

- establish the subsurface geology and stratigraphy of the Kidson Sub-basin
- determine the extent and nature of embayments and troughs and their relationship with adjacent Basin systems
- identify regional faults, folds and other structural elements controlling basin evolution
- determine the extent of major geological elements such as the Centralian Superbasin, the west Arunta Orogen, the Paterson Orogen and the Archean Pilbara Craton, and the location and nature of their boundaries

PRELIMINARY SEISMIC INTERPRETATION

Completed datasets will be formally released at APPEA 2019, and a more detailed interpretation will be available and presented at AEGC 2019.

Preliminary interpretation of the near final prestack time migration (PSTM) seismic data (currently being processed by Velseis Processing Pty Ltd) reveal the full length of the Kidson Sub-basin revealing a major, well preserved, depocentre, around 350 km long and as much as 4 sec two-way-travel-time (= TWT; ~6 km) deep. The data quality across the Kidson Sub-basin, in particular, is excellent, clearly revealing reflectors that are readily traceable across the entire east-west length of sub-basin and illustrating a mostly conformable and continuous sedimentary package. Stratigraphic control from an offset well (Kidson 1) strongly suggests a lower mixed carbonate-clastic-evaporite early Ordovician to Devonian stratigraphy, unconformably overlain by clastic dominated Permian Grant Group. Notably, part of this stratigraphy includes the late Ordovician to early Silurian Carribuddy Group, which contains thick salt units (e.g. the Mallowa Salt and Minjoo Salt), units which appear, in Line 18GA-KB1, to be continuous across much of the Kidson Sub-basin.

Few extensional structural elements are evident within the Kidson Sub-basin highlighting its development as a passive intracratonic sag-fill basin during much of the Palaeozoic. Basin inversion structures at the eastern edge of the sub-basin include faulting and upright folding. Lower units (Carribuddy Group) uplifted by basin inversion are truncated by erosion and subsequently overlain by younger sediments (Grant Group) with an obvious unconformity. This unconformity can be readily traced across the Kidson Sub-basin, recognised, in parts, as deeply incised erosional channels cutting into older units. This unconformity is probably the widely recognised unconformity at the top of Devonian-Carboniferous strata (e.g. Parra-Garcia et al., 2014), and formed, at least in part, in response to uplift due to the latter compressive stages of the Alice Spring Orogeny, locally referred to as the Meda Transpression. These observations also suggest the Kidson Sub-basin, prior to structural inversion at the eastern end, may have been contiguous with the Palaeozoic component of the Amadeus Basin further to the east. To the western end of Line 18GA-KB1, the sedimentary successions below the Meda unconformity, progressively thin towards the western end of the sub-basin with a number of clear onlapping relationships observed.

The Waukarlycarly Embayment (Figure 1), imaged at the western end of line 18GA-KB1, is a northwest-southeast elongated depocentre contained between basement platforms. The Waukarlycarly Embayment is ~28 km wide and contains sedimentary packages that are 1.5 s to almost 2 s TWT deep, deepening slightly to the west. Sedimentary rocks within the embayment appear to be conformable with minimal disruption by internal deformation or structural reactivation. The seismic character of the imaged reflectors within Waukarlycarly Embayment appear to closely correlate with the sequence of imaged reflectors within the Kidson Sub-basin, suggesting a similar sequence of sedimentary packages.

Similarly, the Wallal Embayment (around 24 km wide) is another northwest-southeast elongated depocentre contained between basement platforms and is imaged to a depth of 1.5 s TWT. Layers within the upper sedimentary package appear subparallel and conformable, while the lower sedimentary package (below 0.5 s TWT) appears to show thickening towards the east. Previous seismic surveys to the northwest of 18GA-KB1 demonstrate the seaward continuity of both the Waukarlycarly and Wallal Embayments, and which have been elsewhere demonstrated (with well control) to have been infilled by Ordovician-aged sediments, with the Meda

Transpression angular unconformity separating subsequent Permian sedimentation (e.g. Parra-Garcia et al., 2014). Thus the Waukarlycarly and Wallal Embayments appear to contain all the essential geological elements of the larger Kidson Sub-basin to the east.

CONCLUSIONS

The Kidson Sub-basin seismic survey, acquired as part of the Exploring for the Future Program, in partnership with, and co-funded by, the Geological Survey of Western Australia, is a foundation dataset which has provided valuable insight into the geology and resource potential of the Kidson Sub-basin. Preliminary interpretations of the seismic data suggest existence of ~6 km deep sedimentary basin, containing a lower conformable package of Ordovician-Devonian clastic sediments, carbonates and evaporates. Prior to the Alice Springs Orogeny aged Meda Transpression, the Kidson Sub-basin was probably continuous with the Palaeozoic of the Amadeus Basin of central Australia. Subsequent to minor basin inversion, Permian clastic sedimentation was deposited on a regional unconformity. This seismic data provides valuable insight about the southern region of the Canning Basin and will assist in future resource evaluations.

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