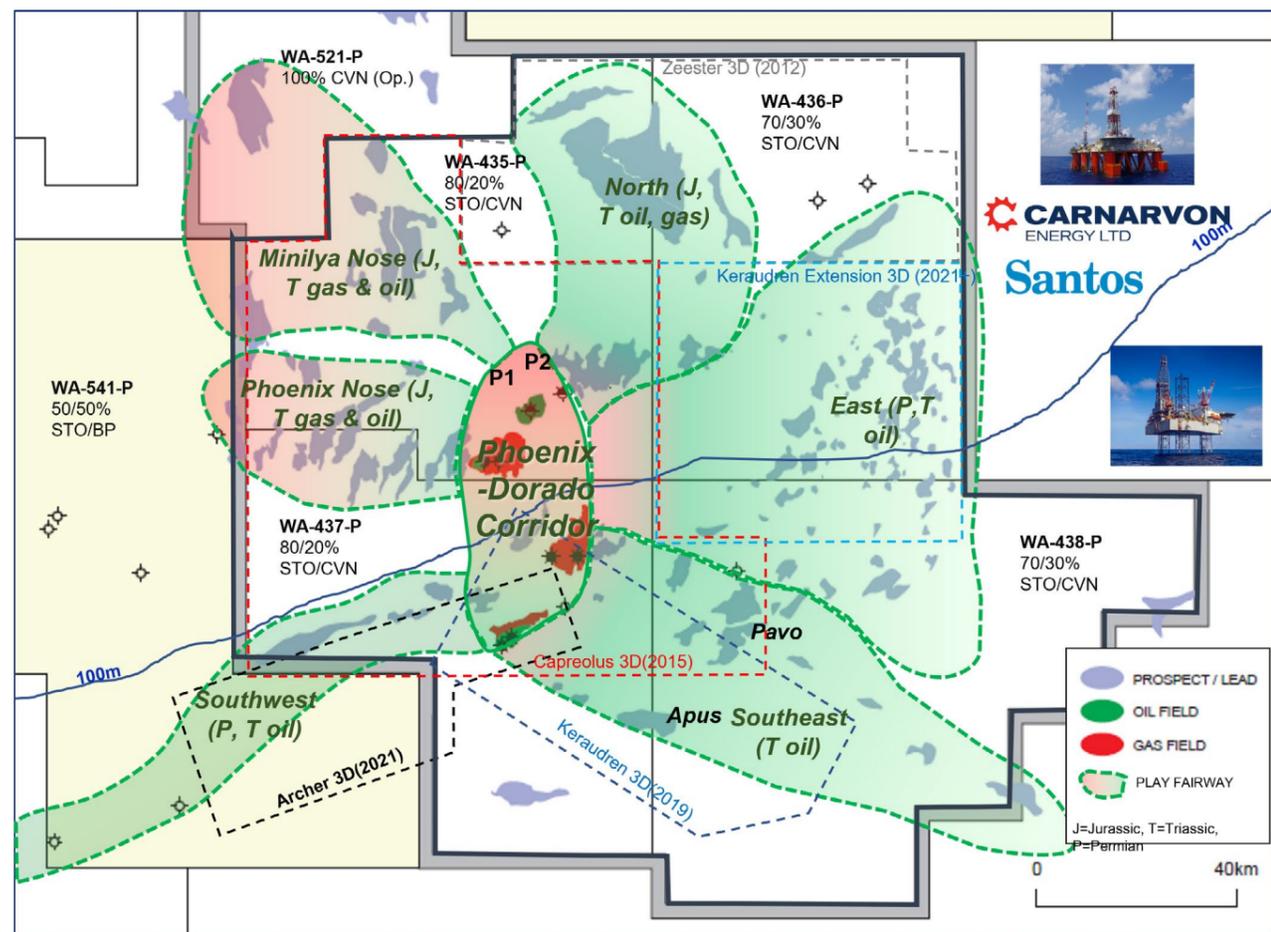


# Bedout sub-basin: Putting Carnarvon Energy's geological gem under the microscope

**Image 1.1:** Bedout sub-basin play fairways, showing the Phoenix-Dorado Corridor (PDC) and the 2014-2018 discoveries.



EXPLORATION in the Bedout sub-basin over the past decade has netted good results for Carnarvon Energy.

Following the basin-opening oil discovery at Phoenix South (2014) and continued oil & gas discoveries at Roc

(2015-16), Carnarvon, with its joint venture partner Santos, made the game-changing, history-making Dorado-1 volatile-oil discovery in 2018. Dorado was the largest Australian oil discovery in 30 years and one of the larger discoveries on the North West Shelf in barrels of oil-equivalent terms, at a time

when many observers felt all big fields had been found and future exploration would be a "mopping up" exercise. The Dorado discovery was labelled as transformative for the national energy landscape. When in production from early 2026, Dorado is expected to produce up to 100,000 barrels of oil

per day, in which Carnarvon has a 20% equity.

Until 2022 there had been nine exploration wells drilled in the Bedout Basin. Five wells drilled before the modern era of 3D seismic data resulted in one discovery (Phoenix-1, 1980). The drilling success rate in the Bedout sub-basin in the modern era – with good quality 3D seismic data underpinning selection of the best prospects – has been excellent, with three out of four exploration wells delivering discoveries.

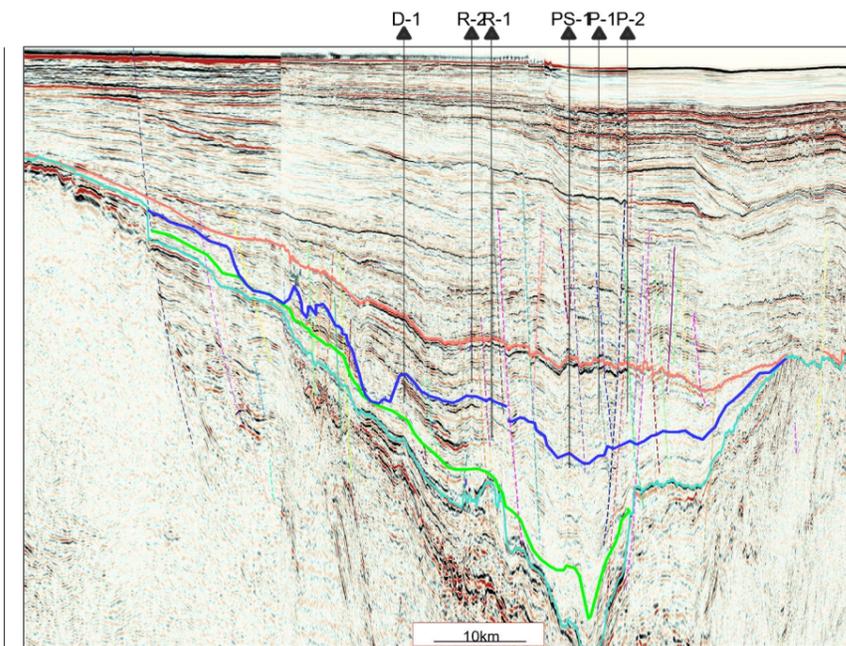
Carnarvon and Santos are drilling two wells, Pavo-1 and Apus-1, in their latest drilling program, which commenced in February 2022. The Pavo and Apus prospects lie 45km east and 32km south-east of Dorado respectively and are of substantially similar play style to that discovery, each being structural closures bounded by shale-filled canyons. There are high hopes for additional commercial discoveries in both wells. Carnarvon has a 30% interest in the Pavo-1 well, and 20-30% in Apus-1 (the well straddles the boundary of two blocks).

Up until the 2022 drilling program, only 6% of the basin area within four core permits (WA-435/436/437 and 438-P) had been drilled in the modern era since 3D seismic was first acquired in 2011. In this area, known as the Phoenix-Dorado Corridor (PDC), there are four discoveries.

Beyond the Dorado canyon-edge play, the Bedout sub-basin has a very rich and diverse set of play types, and these may be found in every direction around the PDC.

## Bedout sub-basin geological elements present a positive story

The basin has all of the required geological elements in place, and the conditions for hydrocarbon generation, entrapment and preservation are excellent. There are at least 12 key play types, with only two (faulted horsts such as Roc and Phoenix, and canyon-edge structural closures) tested to date. There is a proven, working petroleum system in the basin, as demonstrated in the four discoveries made to date. This, coupled with the dramatic improvement in 3D seismic data quality in the last four to five years, makes for an attractive



**Image 1.2:** Regional north (right) to south (left) seismic profile in the Bedout sub-basin. Caley unconformity is the blue horizon.

and improving exploration risk profile. Reviewing the geological elements in detail makes for a compelling story:

- There are multiple clean, quartzose reservoirs, which for several reasons maintain their high porosity at depth.
- There is a rich hydrocarbon source proven within the Middle Triassic Caley Member of the Archer Formation, which is both liquids- and-gas-generative. In the Archer Formation, which hosts the highest volume discoveries, the source-rocks are generally interspersed with the reservoirs, making for efficient migration and pooling of hydrocarbons.
- At least four excellent regional seals exist and there are many semi-regional seals which show promise for as-yet undrilled plays. The seals are interspersed between the multiple reservoirs, making for a very play-rich setting.
- Finally, there is a very wide range of structural and stratigraphic trap styles, and within each trap style there are multiple prospects.

Having all of the geological elements in place does not, of itself, guarantee the creation of multiple commercial hydrocarbon pools. Dynamic conditions for hydrocarbon generation, entrapment and preservation must have been

favourable over geologic time. In the Bedout sub-basin these dynamic conditions have been excellent:

- In terms of sequencing, the pattern of deposition of reservoirs, sources and seals, deposited in the right order, followed by the gentle structuring, and steady, slow basin subsidence, has created a very good environment for the generation and pooling of hydrocarbons.
- The early, gentle structuring, including normal faulting, has not been disrupted by tectonic uplift. In many basins around the world disruptive uplift causes destruction, or at least reduction in size, of formerly large, simple traps.
- The Bedout sub-basin is also 'cool' – that is, it has had low-to-moderate geothermal gradients (ground temperature, increasing with depth) – meaning key source rocks were gently 'cooked', such that they have only recently (in geological time) been expelling hydrocarbons into waiting traps. Low temperatures have also promoted the preservation of good reservoir porosities at greater depths than normal.
- The multitude of interbedded source/reservoir pairs has allowed for very efficient local sourcing and minimisation of dispersion and dissipation of hydrocarbons.

### A plethora of prospects

A new basin with low relative exploration maturity having had the success it has delivered to date, in the modern, 3D-seismic era is positive. The basin is now proven – hydrocarbons have been discovered and flow-tested. The four discoveries have collectively delivered approximately 200mmbbl of recoverable liquids and 1.1Tcf recoverable gas (Carnarvon estimates, gross, 2C).

Six highly prospective but untested play fairways surround the area explored to date, each with distinct, attractive exploration geology characteristics containing a mix of multiple plays. From the latest mapping, the Bedout sub-basin acreage has around 100 individual

prospects in those play fairways, from around 12 different play types.

Among these prospects are many options for Dorado tie-backs (depending on fluid type, but roughly within 50km of Dorado) or new stand-alone developments. There are at least 10 identified prospects that are potentially transformational – large gas or liquids/gas prospects which, on successful drilling, could change the commercial direction of the basin and potentially de-risk large groups of commercial-sized prospects.

The prospect portfolio, already rich and diverse, will almost certainly grow after the analysis of new 2021-22 3D seismic acquisition and reprocessing, which will be actively worked on by the interpreters from mid-2022.

### Improved seismic data helping unlock potential

An important key to unlocking the Bedout sub-basin has been the advent of 3D seismic data acquisition and processing. Over the past five years there has been a dramatic improvement in seismic data quality.

Good quality seismic data is integral to lowering exploration risk, as the better the traps and constituent geological elements can be imaged and the more informative the seismic amplitude balance, the more confidence can be had in the presence and positive inter-relationships of traps, seals, reservoirs and source rocks. With better seismic data, the geological probability of success of prospects improves.

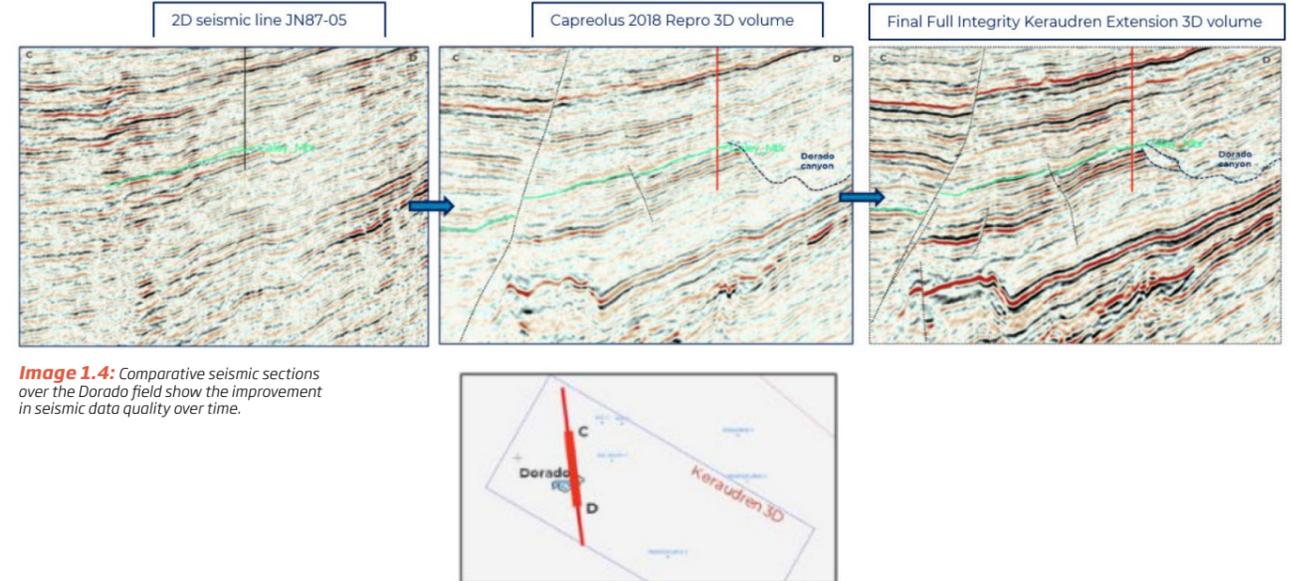
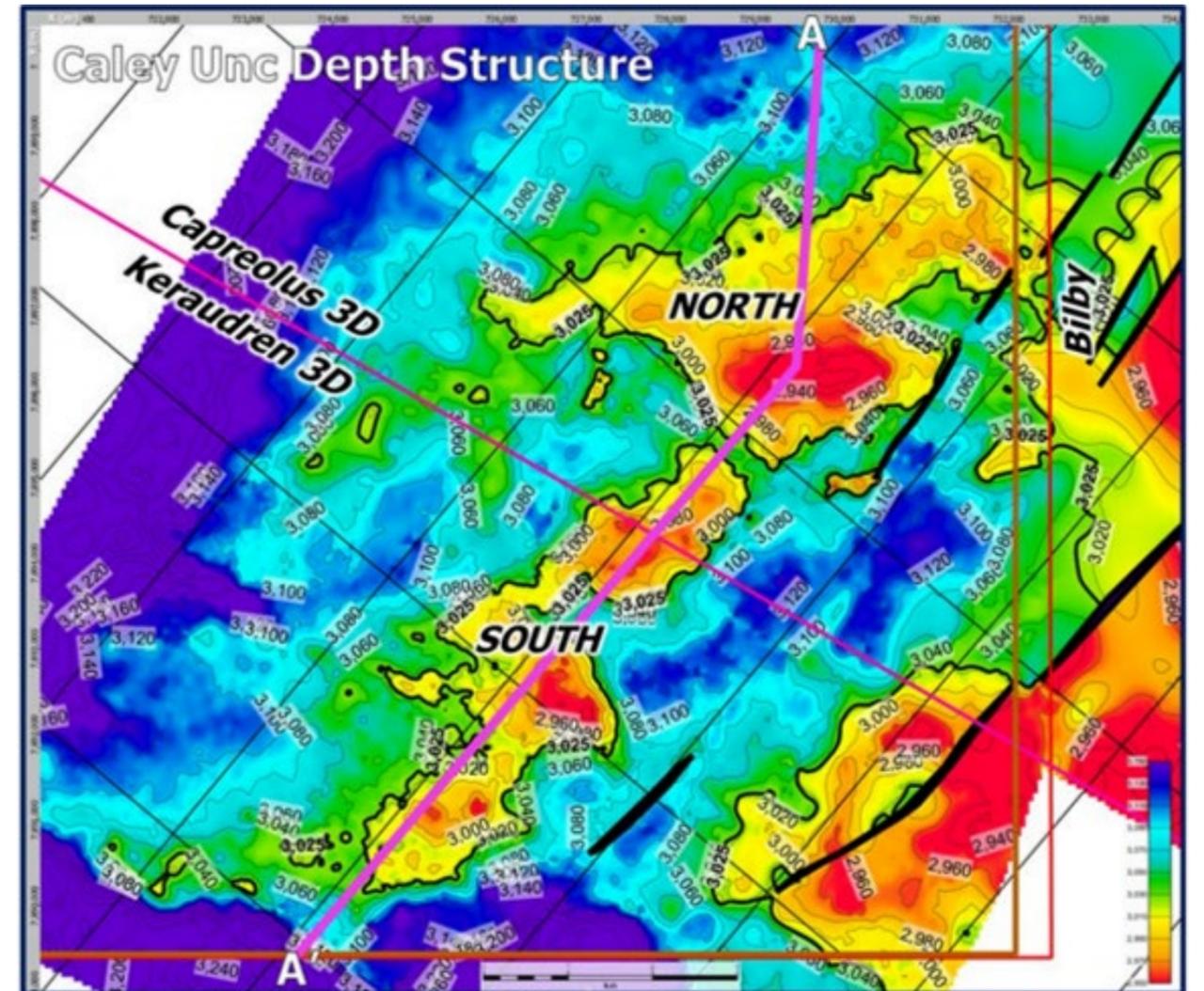
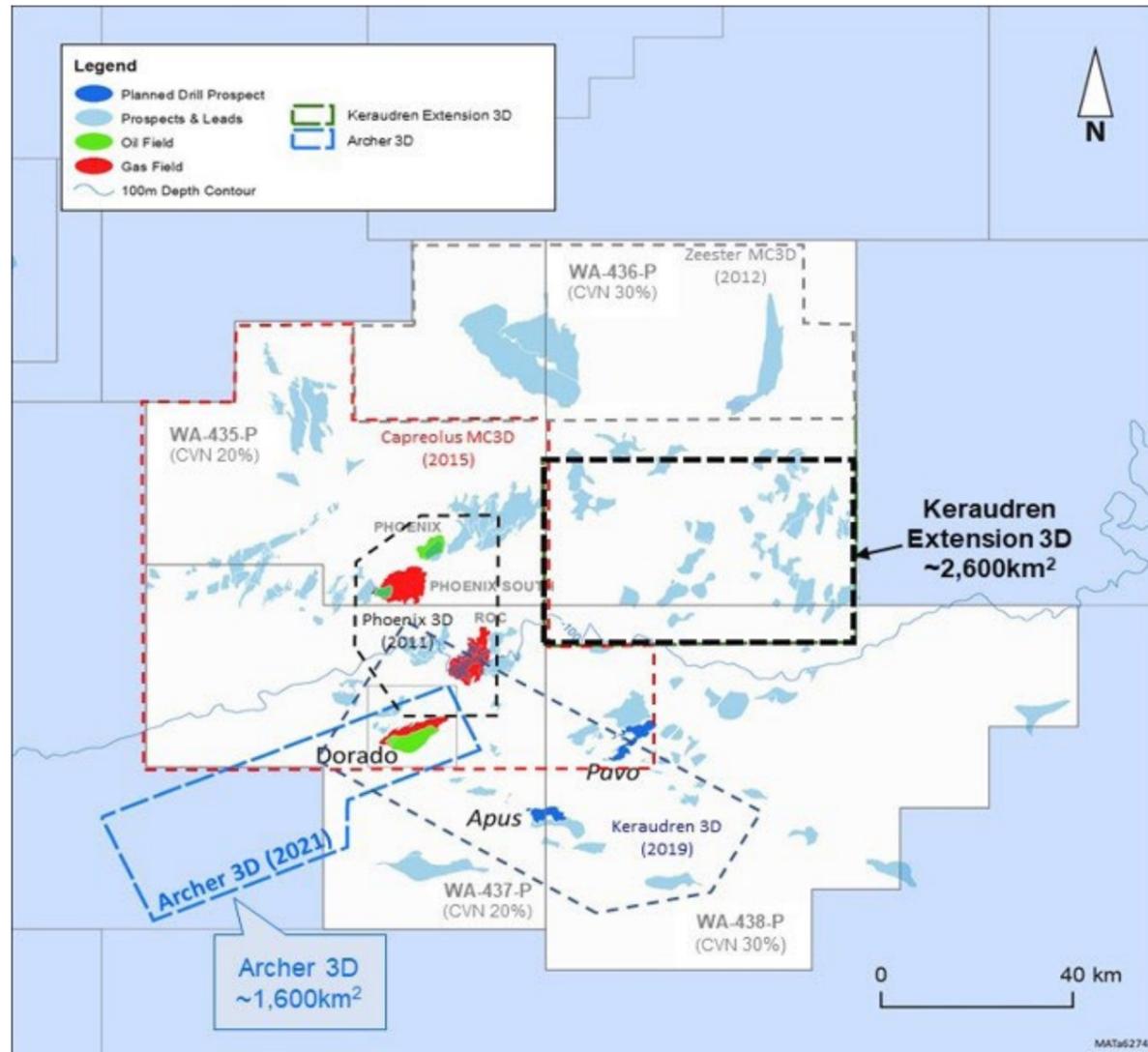


Image 1.4: Comparative seismic sections over the Dorado field show the improvement in seismic data quality over time.



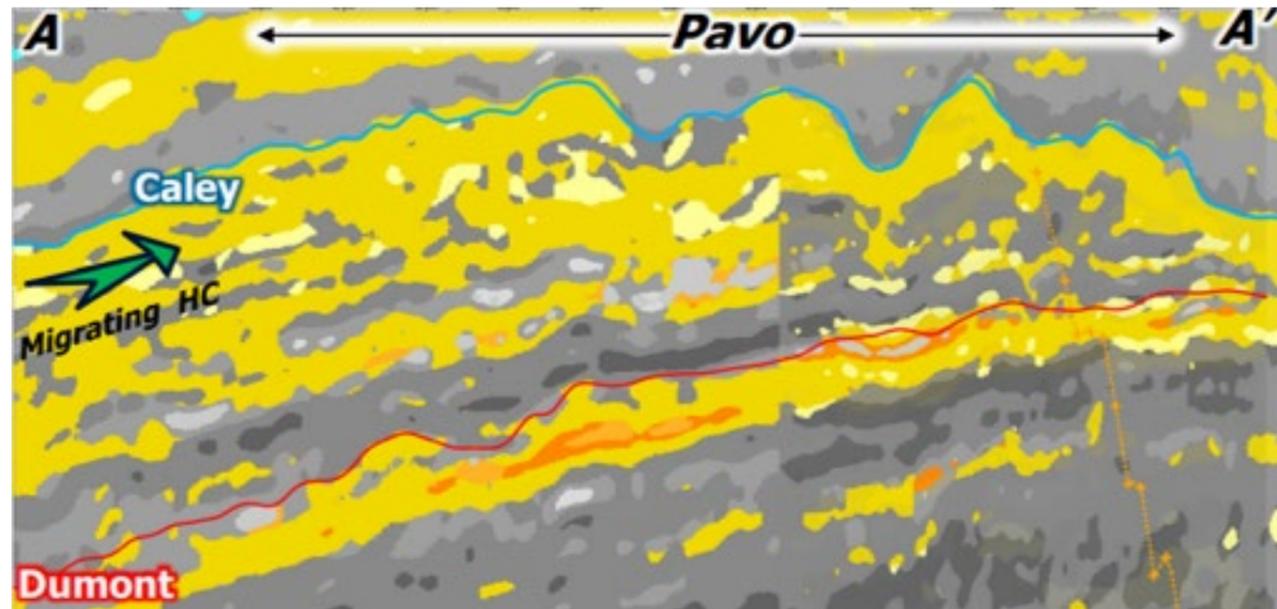


Image 1.5: Pavo seismic cross section.

The enhanced quality of seismic data over time and the improved interpretive outcomes as a consequence has greatly assisted geological understanding of the area. An example of this is shown in the zoom-in below of the key Caley reservoir section over Dorado in its trapping configuration with top-sealing Hove Member shale, and lateral sealing canyon-fill shales. The original 2D data made it difficult to discern the Dorado trap, or wider faulting and stratal relationships. The original Capreolus 3D data acquired in the centre is much improved compared to the 2D, but interpretation uncertainties remain, and the focussing and amplitude balance is imperfect. The most recent Keraudren 3D section on the right benefits from the latest acquisition and processing techniques and was acquired to target the Caley Member. The section has excellent sharpness, amplitude balance and interpretability relative to the previous 3D, and to the original 2D.

On this latest 3D data, key aspects of the trap configuration (the Dorado canyon shale-fill adjacent to the Caley Member reservoirs), the top-and lateral seals, the reservoirs and the structure (faulting) are very well imaged, and as a result Carnarvon can have great confidence in the seismic interpretation of both the Dorado hydrocarbon accumulations away from well control, and exploration prospects.

In 2021 the Bedout sub-basin JV acquired 3,129km<sup>2</sup> of new full-fold 3D

over two of the six play fairways. New data will allow the teams to mature and de-risk further sets of leads and prospects, particularly in southern WA-436-P where there looks to be a number of Dorado-sized leads. New 3D seismic will complement the nearly 7000km<sup>2</sup> of Keraudren acquisition and Zeester-Capreolus 3D seismic reprocessing completed in 2021.

In mid-2022 a further 602km<sup>2</sup> of 3D multi-azimuth (MAZ) reprocessing over Dorado is expected to be completed, which should deliver an even greater improvement in 3D seismic data quality. Carnarvon and Santos have also recently acquired a further 592 km<sup>2</sup> of new 3D seismic acquisition, completed in February 2022. Data collected will add to the 3D seismic acquired last year and complement the now very substantial 3D seismic data base in the Bedout Basin.

Coverage of 3D seismic data in the Bedout sub-basin now comprises close to 70 per cent of the prospective area. This is an impressive achievement given there was no 3D data in the basin prior to 2011 and the four-permit area is more than 22,000km<sup>2</sup>.

**Pavo-1 in focus**

The Pavo-1 well targeted a very attractive prospect, with the same trap style as Dorado, namely the Caley Formation sands under thin Hove Formation shale seals, with lateral seal provided by canyon-fill shales.

Carnarvon’s pre-drill work outlined a target of important scale, with mean recoverable volumes of 82 million barrels of liquids and 108 Bcf of gas. This attractive prospect had an estimated one-in-three (34%) geological probability of success calculated by the Carnarvon team.

The key risks were hydrocarbon charge (long-range migration) and top-seal (thickness). At the time of writing, the Pavo-1 has drilled to a depth of 3,600 metres over the Caley and Dumont Members, and is further planned to be deepened to penetrate deeper stratigraphy to investigate the Permian carbonates. Although not yet available for publication, information from these intervals will be highly valuable in assessing the portfolio north, south and east of Pavo.

At the time of writing, logging while drilling (LWD) tools had indicated porous and permeable reservoir intervals with similarity to the Dorado reservoir. Elevated gas readings and increased resistivity were observed between 2,944m and 3,003m indicating the presence of hydrocarbons. Wireline logging results were expected in the fourth week of March 2022.

**Apus-1 in focus**

The Apus-1 well will also be targeting a similar trap style as Dorado, namely the Caley Member sands under thin Hove Member shale seals with lateral seal provided by canyon-fill shales. A second reservoir is

expected to be provided by the intra-Archer Formation’s Milne Member. The main difference between Apus and Dorado is that the lateral seal will be provided by both the Apus Canyon fill and the Dorado Canyon fill.

With drilling anticipated to commence in early April 2022, the Apus-1 well has the potential to deliver considerable information relating to the larger Apus structure, which includes the Apus Trunk. However, at this stage Carnarvon has confined its mean recoverable volume estimates to 235Mmbbl liquids and 408Bcf of gas, from the two target sands in the main Apus structure. Carnarvon ascribes a one-in-four (23 per cent) geological probability of success.

Key risks for this prospect, similar to Pavo, are hydrocarbon charge (long-range migration) and top-seal (thickness). The higher risk relative to Pavo’s 34% relates mainly to more complex interpreted charge/migration pathways. Large-scale volume potential, and the possibility to penetrate the deeper (lower Triassic and Permian) stratigraphy, make Apus an exciting drill prospect.

**Bedout sub-basin - an exciting future**

The Bedout sub-basin’s large scale, it’s now proven nature, its broad and deep prospectivity, and its position in shallow water, in the Australian jurisdiction, places the basin in the upper echelon of prospective hydrocarbon-bearing basins worldwide. This makes for a

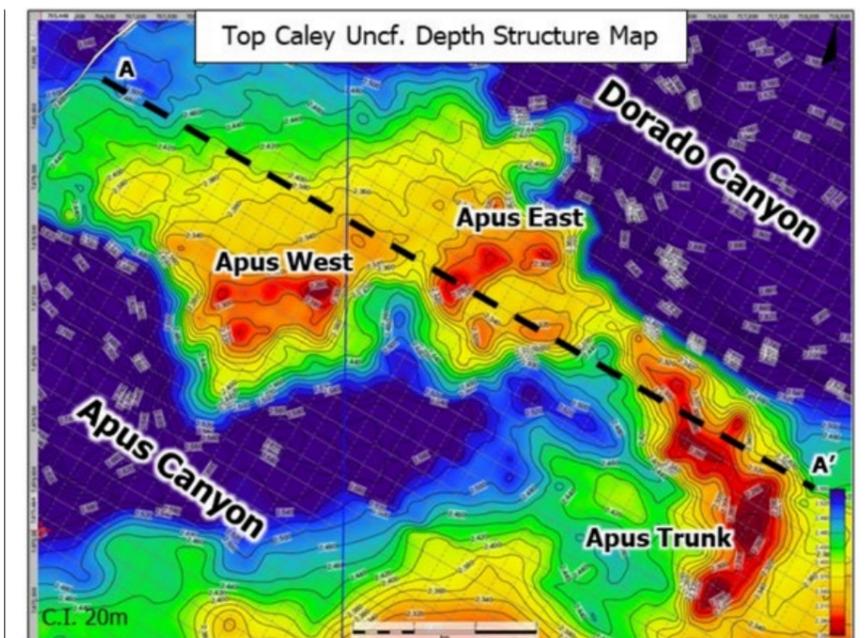


Image 1.6: Apus depth.

very exciting period ahead for the joint venture.

It is quite unique for a company of Carnarvon’s size to hold a position in almost all of the prospective acreage over such a large, highly prospective basin. Such commanding acreage positions are typically secured by larger companies. This a very attractive asset of the Company, especially given the basin is highly prospective for both liquids and gas.

Carnarvon’s exploration portfolio in the larger acreage area outside the proven

Phoenix-Dorado Corridor comprises many additional prospects, some of which are potentially transformational. With persistence, diligent and thorough assessment, and now with the latest dramatic improvements in seismic data quality, Carnarvon and its partner Santos are well positioned in what is an outstanding, highly prospective basin.

It is to Carnarvon’s substantial advantage that the potential of this basin has been overlooked by majors who have operated in the North West Shelf for many decades. ▶

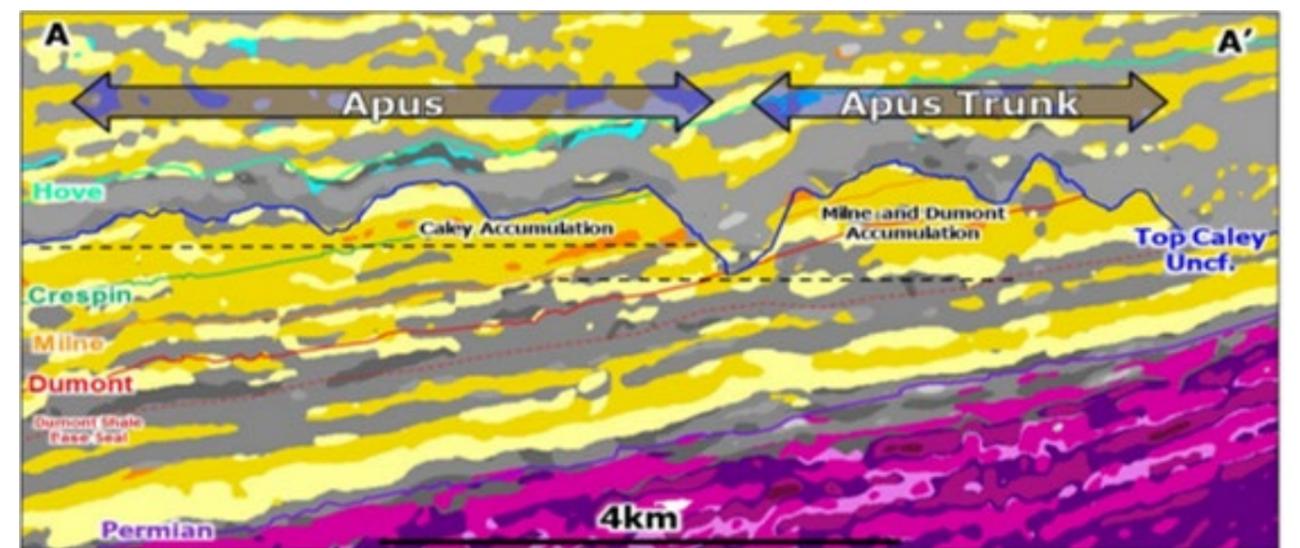


Image 1.6: Apus seismic cross section.