

SANTOS – FRONTIER OIL AND GAS

COMPILED FOR

SANTOS QNT PTY LIMITED
(A.B.N. 80 007 550 923)

DUKAS 1 / DUKAS 1 ST1

INTERPRETED WELL COMPLETION REPORT

EP 112 / NORTHERN TERRITORY

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DUKAS 1 / DUKAS 1 ST1

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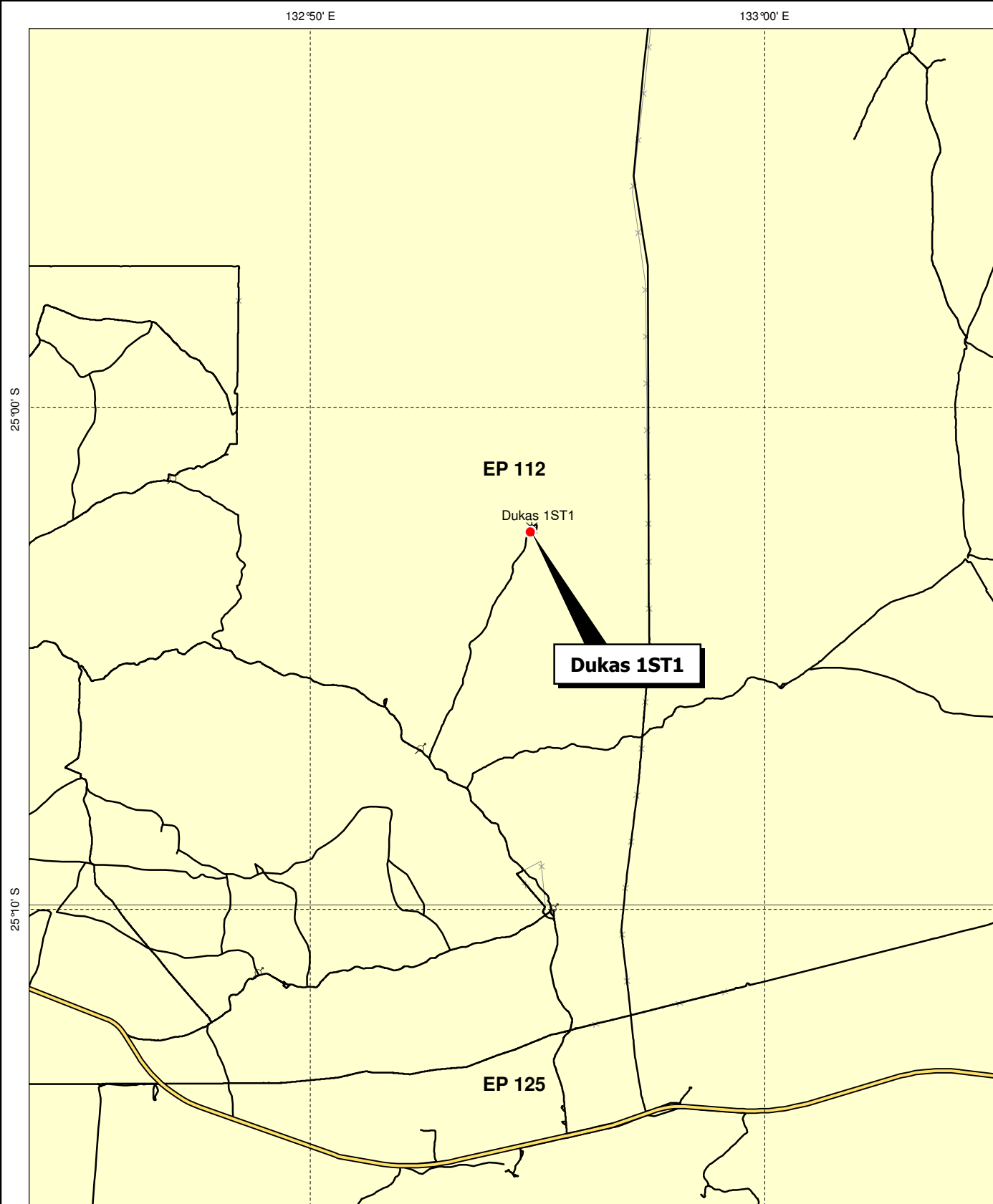
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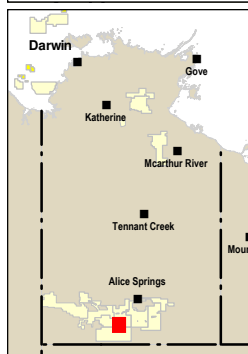
LIST OF ABBREVIATIONS

ADR	Automated Drilling Rig
API	American Petroleum Institute
ASCII	American Standard Code for Information Interchange
Azi, AZI	Azimuth
bbls	Barrels (unit of volume = 42 USgallons)
BHA	Bottom Hole Assembly
BG	Background Gas
BU, B/U	Bottoms Up
CAL	Caliper
CAST	Circumferential Acoustic Scanning Tool
CBL	Cement Bond Log
CBU	Circulate Bottoms Up
CG	Connection Gas
CSV	Comma Separated Values ASCII file (*.csv)
CO2	Carbon Dioxide
DEN	Density
DLL	Dual Lateral Log
ECD	Effective Circulating Density
EMW	Equivalent Mud Weight
FG	Formation Gas
FID	Flame Ionization Detector
FIT	Formation Integrity Test
Ftklb, ft-klb	Foot kilo pounds (measurement of torque)
GEM	Gamma Elemental Minerology
gpm	US gallons per minute
GR	Gamma Ray
HI	Hydrogen Index (mg hydrocarbon/g TOC)
hi vis	High Viscosity Mud Sweep
hrs	Hours
HSE	Health, Safety and Environment
IL	InLine
KCl	Potassium Chloride
Klbs	Kilo pounds
LAS	Log ASCII Standard data file (*.LAS)
LOT	Leak Off Test
M/LWD	Measurement and Logging While Drilling
MFT	Pressure testing wireline tool
mMDRT	Measured Depth Below Rotary Table (rig floor) in metres
MSFL	Micro Spherical Focused Log
MSL	Mean Sea Level (AMSL – above mean sea level)
mTVDRT	True Vertical Depth Below Rotary Table (rig floor) in metres
NB	New Bit
Neut	Neutron
NP	Not Prognosed
PDC	Polycrystalline Diamond Cutters
PDF	Portable Document Format
pH	Potential Hydrogen
PJSM	Pre Job Safety Meeting
POOH, POH	Pull Out Of Hole (tripout)
ppg	pounds per gallon (measurement of mud density)
psi	pounds per square inch
QGM	Quantitative Gas Measurement
RES	Resistivity
RIH	Run in hole
RPM	Revolutions pre minute
ROP	Rate of Penetration
RR	Re-run
SDL	Surface Data Logging (Mudlogging)
SGR	Spectral Gamma Ray
SP	Spontaneous Potential
SPP	Stand Pipe Pressure
SS	Subsea
ST	Side Track
SWC	Sidewall Cores
TD	Total Depth
TG	Trip Gas
TOC	Total Organic Carbon
TVD	True Vertical Depth
UBD	Underbalanced Drilling
VSP	Vertical Seismic Profile
WBM	Water based mud
WOB	Weight on bit
XL	Xline
XO,X/O	Cross over
xLOT	Extended Leak Off Test
XRMI	X-tended Range Micro Imager
YP	Yield Point

REGIONAL LOCATION MAP



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SANTOS EXPLORATION PERMITS

Santos

EP 112 - Amadeus Basin

Dukas 1ST1

Location Map

0 2 4 6 8 10 Km

Scale: 1:200,000

7 November 2019, File No. AMDEUS 186



WELL CARD

Well Name		Dukas 1		Petroleum Title	EP 112 (NT)	Basin		Amadeus	
Well Purpose		Exploration		Status	Plugged back	Parent Well Name		N/A	
Spud Date		16/04/2019		TD Date	07/05/2019	Side-track Date		16/05/2019	
Primary Objective		Heavitree Formation			Rig(s) Name	Ensign 965			
Secondary Objective		Basement			100k Map Sheet	-			
Total Depth		MD	TVD	Side-Track Kick-off Dpth	1156m MDRT (side tracked to Dukas 1 ST1)				
	Driller	1275	1267.9						
	Logger	N/A	N/A						
Location (GDA 94)	Coordinates	Surface	Bottom Hole	Drill Datum (RT)	Datum		RT		
	Latitude	25°02'24.20"S	-		GL (AHD)		494.4		
	Longitude	132°54'52.78"E	-		RT		501.6		
Zone	Easting	289 607m	289 627m	Seismic Station	Survey	Inline	Xline		
					AMSAN1 6	DK203	CSP08-07		
					Shot Pt	-	-		
Well Summary									
The Dukas 1 well was spudded at 07:15hrs on 16 th April 2019 with the drilling rig Ensign 965. The 17-1/2” deep conductor hole in this well was drilled from 25m to 764m, with the 13-3/8” deep conductor set at 759.3m. A Formation Integrity Test (FIT) was performed to 21.0ppg EMW. 12-1/4” surface hole was then drilled to 1100m. Drilling operations changed from mud to air and drilling continued from 1100m to 1275m.									
The drill string became stuck at 1273m after a connection. After attempting to free the string, performing a blind back off and subsequently only being able to recover some of the fish, a decision was made to plug back and abandon Dukas 1. A kick-off BHA was made up and time drilling with mud occurred from 1130.3m to 1156m at which point 100% formation was observed. Dukas 1 was sidetracked to Dukas 1 ST1 at 18:30hrs on 16 th May 2019.									
Hole and Casing Design (Drillers Depths)						Drilling Fluid			
Type	Hole Size	Depth mMD	Casing Size	Shoe mMD	Shoe mTVD	Hole Size	Type		
Conductor 1	26"	25m	20"	25m	25m	17-1/2”	KCl/Polymer		
Conductor 2	17-1/2”	764m	13-3/8"	759.3m	757.4m	12-1/4”	KCl/Polymer		
Surface	12-1/4”	1275m	10-3/4”	Not Run	Not Run	12-1/4”	Air/Mist/Foam		
Stratigraphy – Formation Tops (Loggers Depths)				Formation Evaluation					
Formation	Depth			Run	Measurement	Depth Interval mMD			
	mMD	mTVD	mTVDSS			From	To		
Surficial Deposits	7.0	7.0	494.0	LWD 1	GR-D&I	54	764		
Undiff Paleozoic	22.0	22.0	479.6	LWD 2	GR-D&I	764	831		
Petermann Uncon	507.0	506.0	-4.4	LWD 3	GR-D&I	831	995		
Areyonga Fm	507.0	506.0	-4.4	LWD 4	GR-D&I	995	1100		
Wallara Fm	724.0	722.3	-220.7	LWD 5	GR-D&I	1100	1275		
Bitter Springs Gp	830.0	827.6	-326.0						
Johnnys Creek Fm	830.0	827.6	-326.0						
Loves Creek Fm	986.0	981.5	-479.9						
TD	1275.0	1267.9	-766.3						
Mud Logging				Formation Testing (DST)			DFIT	No	
3m samples collected from 25m to 1150m, 6m samples from 1150m to 1275m (TD).				N/A			HF	No	
Coring			Hydrocarbon Shows						
N/A			No oil fluorescence shows, or gas shows were encountered during drilling operations at Dukas 1.						
Completion									
Dukas 1 was plugged back and sidetracked to Dukas 1 ST1 at 18:30hrs on 16 th May 2019.									

Well Name	Dukas 1 ST1	Petroleum Title	EP 112 (NT)	Basin	Amadeus		
Well Purpose	Exploration	Status	Plugged & Suspended	Parent Well Name	Dukas 1		
Spud Date	16/04/2019	TD Date	02/08/2019	Rig Release Date	21/08/2019		
Primary Objective		Heavitree Formation		Rig(s) Name	Ensign 965		
Secondary Objective		Basement		100k Map Sheet	-		
Total Depth (suspended)		MD	TVD	Side-Track Kick-off Depth	1156m MDRT		
	Driller	3704	3692.8				
	Logger	3705	3693.8	Drill Datum (RT)	Datum		RT
Location (GDA 94)	Coordinates	Surface	Bottom Hole		GL (AHD)		494.4
	Latitude	25°02'24.20"S	-		RT		501.6
	Longitude	132°54'52.78"E	-				
Zone	Easting	289 607m	289 658m	Seismic Station	Survey	Inline	Xline
					AMSAN16	DK203	CSP08-07
53 South	Northing	7 228 996m	7 228 819m		Shot Pt	-	-

Well Summary

Mud drilling of the 12-1/4" surface hole proceeded from kick-off point at 1156m to 2162m. Wireline Suite 1, Run 1: XRMI-X Dipole Sonic-GR and Run 2: QuadCombo-GEM was performed at this time. Following wireline Suite 1, drilling resumed with 12-1/4" surface hole drilled ahead from 2162m to surface casing point at 2604m.

10-3/4" casing was set at 2601m and a Leak Off Test (LOT) performed to 23.6ppg EMW. 9-1/2" intermediate hole was then drilled to 2997m with mud. At this point the top drive was changed out due to a failed gearbox. Drilling resumed from 2997m to 3391m.

While out of the hole, shut in casing pressure was observed. The drill string was stripped in hole to 3383m, circulating 13.1ppg kill mud at 300m intervals. The mud weight was then raised to 13.3ppg.

Intermediate hole drilling resumed from 3391m to what was intended as the 9-1/2" section TD at 3515m. Wireline Suite 2, Run 1: TripleCombo-GEM, Run 2: CAST-XRMI-X Dipole Sonic and Run 3: RDT-GR (equipment failure) was performed at this time. The 8-5/8" intermediate liner was run and the liner packer prematurely set at 23m while being run in hole on drill pipe. The liner was subsequently cut free, at which point the casing dropped to bottom and was then successfully fished out of hole.

Following setting a cement plug and pressure testing the casing, the plug was then drilled out. Drilling of the 9-1/2" hole resumed from 3515m to 3704m (suspended TD) with 12.2ppg mud. A visual flow check showed a 3bbl gain over 20 minutes, the well was shut in. The well was killed with 16.1ppg mud and the mud weight was then raised to 16.4ppg. It was decided there would be no further drilling in Dukas 1 ST1, TD was reached at 08:30hrs, 2nd August 2019 - the primary target was not intersected. A total of eight bit runs were performed in Dukas 1 ST1.

Wireline Suite 3 was conducted: Run 1: QuadCombo (cable head fault while running in hole at 2100m); Run 2: QuadCombo; Run 3: XCT SWC, 26 cores attempted, 21 full cores recovered (plus 3 rubble). A cement plug was then set from 3704m to 3453.5m. Wireline Suite 3 continued, Run 4: VSP-GR (zero offset and 500m offset).

Dukas 1 ST1 has been plugged and suspended for possible future re-entry, Plug 1A: 3704m-3453.5m; Plug 1B: 3453.5m-3204m; Plug 1C: 3204m-2954m; Plug 1D: 2954m-2704m; Plug 1E: 2704m-2557m; Plug 1F: 2531m-2297m; Plug 2: 1220m-1142.4m; Plug 3: 250m-103.3m. The rig was released at 23:59 hours, 21-08-2019.

Hole and Casing Design (Drillers Depths)						Drilling Fluid	
Type	Hole Size	Depth mMD	Casing Size	Shoe mMD	Shoe mTVD	Hole Size	Type
Conductor 1	26"	25m	20"	25m	25m	17-1/2"	KCl/Polymer
Conductor 2	17-1/2"	764m	13-3/8"	759.3m	757.4m	12-1/4"	KCl/Polymer
Surface	12-1/4"	2604m	10-3/4"	2601m	2591.2m	12-1/4"	Air/Mist/Foam
Intermediate	9-1/2"	3704m	P&A	-	-	12-1/4"	KCl/Polymer
-	-	-	-	-	-	9-1/2"	KCl/Polymer

Stratigraphy – Formation Tops (Loggers Depths)				Formation Evaluation			
Formation	Depth			Run	Measurement	Depth Interval mMD	
	mMD	mTVD	mTVDSS			From	To
Surficial Deposits	7.0	7.0	494.0	LWD1	GR-D&I	1156	1234
Undiff Paleozoic	22.0	22.0	479.6	LWD2	GR-D&I	1234	1938
Petermann Uncon	507.0	506.0	-4.4	LWD3	GR-D&I	1938	2162
Areyonga Fm	507.0	506.0	-4.4	S1R1	XRMI-SONIC-GR	28	2160
Wallara Fm	724.0	722.3	-220.7	S1R2	QUADCOMBO-GEM	33	2156
Bitter Springs Gp	830.0	827.6	-326.0	LWD4	GR-D&I	2162	2604
Johnnys Creek	830.0	827.6	-326.0	LWD5	GR-RES-D&I	2604	2853
Loves Creek Fm	986.0	981.5	-479.9	LWD6	GR-RES-D&I	2853	3391
Gillen Fm	1233.0	1226.2	-724.6	LWD7	GR-RES-D&I	3391	3515
Upper Gillen Fm	1233.0	1226.2	-724.6	S2R1	TRIPLECOMBO-GEM	1980	3514
Gillen Evap	1379.0	1372.0	-870.4	S2R2	CAST-XRMI-SONIC	2589	3506
Top Halite	2103.0	2093.3	-1591.7	S2R3	RDT-GR	Equipment Failure	
TD	3705.0	3693.8	-3192.2	LWD8	GR-RES-D&I	3515	3704
				S3R1	QUADCOMBO	Equipment Failure	
				S3R2	QUADCOMBO	3399	3704
				S3R3	XCT SWC	3125.3	3693
				S3R4	VSP-GR	15	3360
Mud Logging				Formation Testing (DST)		DFIT	No
3m samples collected from 1156m to 2389m, 6m samples from 2389m to 2467m, 3m samples from 2467m to 3004m, 6m samples from 3004m to 3392m, 3m samples from 3392m to 3704m (TD).				N/A		HF	No
Coring	Hydrocarbon Shows						
N/A	No oil fluorescence shows were encountered during drilling operations at Dukas 1 ST1. Several poor gas shows were observed, with total gas peaks of up to 40 units over a background of 7 units (97/3/Tr %).						
Completion							
Dukas 1 ST1 has been plugged and suspended for possible future re-entry, Plug 1A: 3704m-3453.5m; Plug 1B: 3453.5m-3204m; Plug 1C: 3204m-2954m; Plug 1D: 2954m-2704m; Plug 1E: 2704m-2557m; Plug 1F: 2531m-2297m; Plug 2: 1220m-1142.4m; Plug 3: 250m-103.3m. The rig was released at 23:59 hours, 21-08-2019.							

1 GEOLOGY

The Amadeus Basin is a Neoproterozoic to Late Palaeozoic-aged basin predominantly located in the southern part of the Northern Territory (Figure 1). It is bounded to the south by the Musgrave Province and to the north by the Arunta Region, where the basement and overlying sedimentary units have been uplifted during two major intracratonic orogenic events (the 580–530 Ma Petermann Orogeny and the 450–300 Ma Alice Springs Orogeny) (Close *et al* 2003, Edgoose 2013). The south eastern flank of the Amadeus Basin shows different basement configuration with most of the sediments onlapping the Fregon East basement (Plummer 2015).

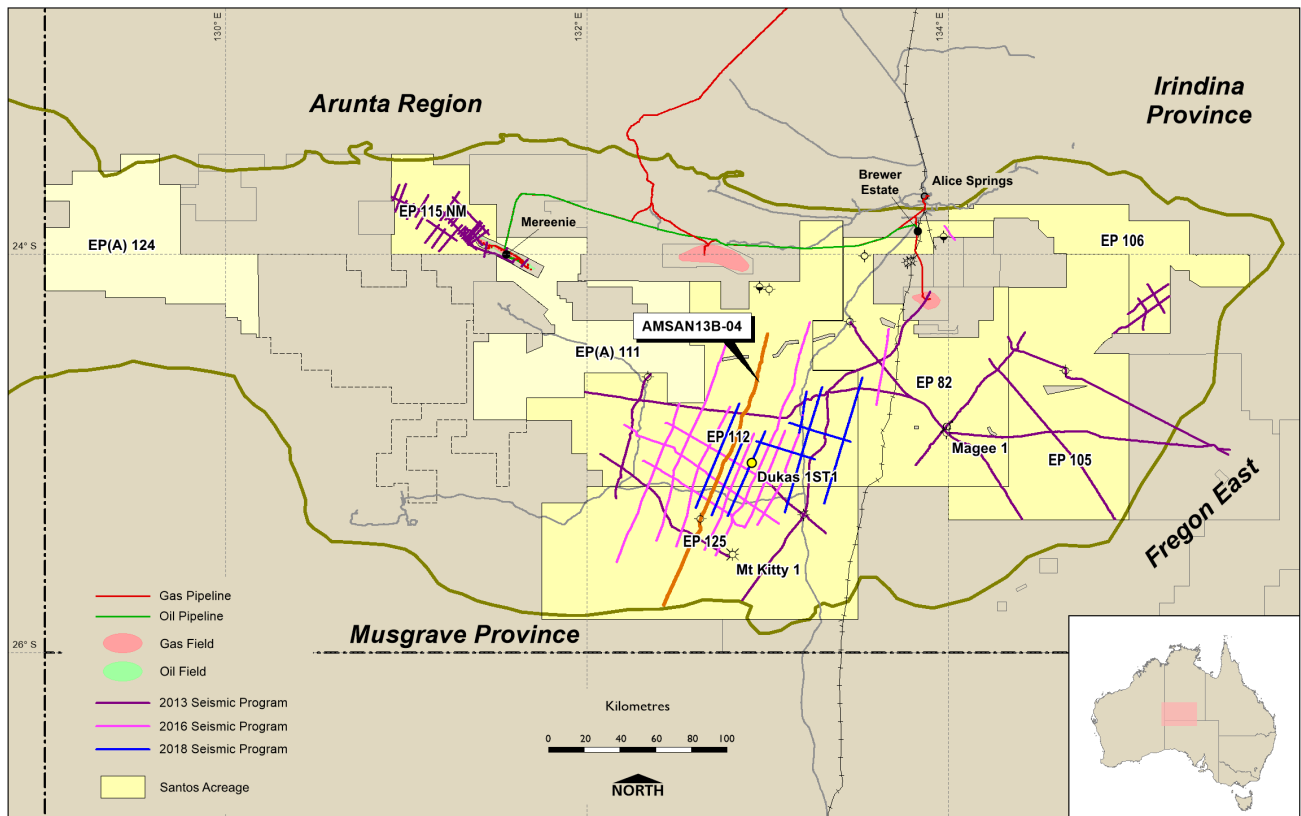


Figure 1: Amadeus Basin, Northern Territory showing Santos operated exploration permits and 2D seismic programs.

The northern and the southern parts of the Amadeus Basin can be differentiated by their sedimentary succession and associated primary petroleum systems (Bache *et al* 2018). In the northern Amadeus Basin, a thick Middle Cambrian to Devonian succession overlies a Neoproterozoic to Early Cambrian succession and includes the Ordovician Mereenie and Palm Valley fields. In the south-eastern Amadeus Basin, the Middle Cambrian to Devonian succession does not exceed 1.5 km in thickness above the prominent Petermann unconformity (Figure 2). Primary petroleum systems are Neoproterozoic to Early Cambrian and are generally shallower than those in the northern part of the Amadeus Basin.

Prospective plays in the south-eastern Amadeus Basin include fractured basement and basal Heavitree Formation (fluvio-marine sandstone) sealed by Gillen Formation evaporites, dolomite encased in halite or fractured on anticlinal structures, and post-evaporite Neoproterozoic to Early Cambrian sandstones (Figure 2). Santos is pursuing the Heavitree-Gillen conventional play.

The Amadeus Basin is currently largely underexplored. Of the 38 exploration wells drilled in the basin, only two have intersected the pre-salt section. The first well to test the Heavitree–Gillen play was Magee 1, drilled by Pacific Oil and Gas in 1992 (Figure 1). The well was located near the interpreted depositional edge of the Heavitree Formation and flowed low-rate gas containing hydrocarbons and helium from a thin Heavitree Formation reservoir. More than 20 years lapsed before a second test of the Heavitree–Gillen play was conducted in 2013–14 when Santos drilled Mt Kitty 1 some 140 km south-west of Magee 1. Mt Kitty 1 did not intersect the Heavitree Formation but flowed gas containing hydrocarbons and helium from fractured granitic basement. This test confirmed the existence of an extensive sub-salt petroleum system as well as the excellent sealing capacity of the Neoproterozoic evaporites.

Further Heavitree–Gillen play exploration resulted in drilling of the Dukas Prospect in 2019.

Heavitree-Gillen Play

Primary Reservoir = Heavitree Formation

Secondary Reservoir = Fractured Basement

Source = Lower Gillen Formation black shales

Seal = Gillen Formation evaporites

The Heavitree Formation (Reservoir) and its interpreted south-western equivalent the Dean Quartzite, is the basal unit of the Amadeus Basin. It outcrops on the northern and south-western margins of the Amadeus Basin, where thicknesses can range from 100 m to 400 m. Outcrops comprise massive, thick quartzite beds with rare mudstones and conglomerates. It is heavily silicified in the thrusts observed in outcrop along the MacDonnell Ranges, but much less silicified in the Limbla Cliffs near the north-east basin margin. The Heavitree Formation was deposited in intertidal and fluvial environment (Lindsay, 1999).

Conformably overlying the Heavitree Formation is a thin unit of grey to black shales and siltstones (lower Gillen Formation, Source) followed by a thick succession of dolostones interbedded with halite and anhydrite (Gillen Formation, Seal). A 15 m pyritic black shale interval at the base of the Gillen Formation was discovered in a mineral hole (BL002) on the north-east structural margin of the Amadeus Basin, proving that conditions were suitable for the accumulation of organic rich rocks. TOC values average 3.12% over the 15m black shale, with a maximum value of 7.5%. The black shale is overmature and original TOC values would have averaged 6% over the interval. Only the proximal evaporitic succession has been sampled down to basement. Anoxic conditions in the centre of the restricted evaporitic basin were possible, resulting in source rock preservation as demonstrated by the BL002 mineral hole.

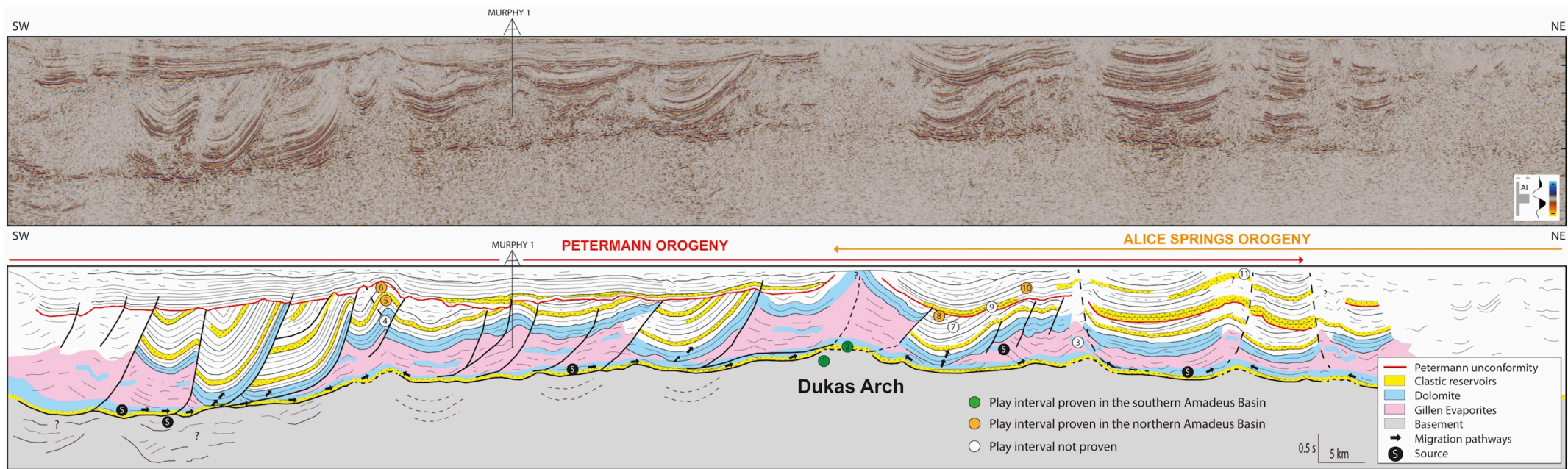


Figure 2: Seismic profile AMSAN13b-04 and associated line drawing across the Amadeus Basin highlighting the Petermann unconformity and the thicker Middle Cambrian to Devonian succession in the northern Amadeus Basin. Refer **Figure 1** for 2D seismic line location.

2 PROSPECT DESCRIPTION

The Dukas Prospect is in Petroleum Exploration Permit EP 112 within the Amadeus Basin, onshore Northern Territory, approximately 170km southwest of Alice Springs (Figure 1).

The Dukas Prospect was first identified as a lead by the AMSAN13 regional seismic survey and Frogtech SEEBASE™ regional basement map. The follow up AMSAN16 seismic survey was acquired in two rounds between December 2016 and April 2018. These data aided delineation of multiple sub-salt closures on a large regional high, optimally located to receive charge from the interpreted Neoproterozoic depocentre to the north. The Dukas Prospect, with a lowest closing contour area greater than 500 km², was the most material interpreted structural closure (Enclosure 2).

Seismic imaging over the Dukas Prospect is variable, with imaging quality decreasing westward as structural complexity above the Gillen Formation evaporites increases, and fast Neoproterozoic sediments are at or near surface.

The Dukas 1 well was proposed to test the Dukas Prospect. The Heavitree Formation was the primary reservoir target, with a secondary target within underlying fractured basement. The primary well objectives were to determine reservoir presence/deliverability (presence and quality representing the critical risk for technical success) as well as to understand gas composition. The nearest offset wells are Murphy 1 located ~40 km to the southwest, and Erldunda 1 located ~40 km to the southeast.

The Dukas 1 ST1 well was plugged and suspended above the primary reservoir target after formation pressures approaching well system limits were encountered. Although the well did not reach the Heavitree Formation target objective, it has provided valuable information to support progression of the Heavitree–Gillen play exploration in the south-eastern Amadeus Basin.

3 RESULTS OF DRILLING

3.1 STRATIGRAPHY

The challenges associated with exploring the Heavitree–Gillen play in the frontier Amadeus Basin have been described in previous publications (eg Menpes *et al* 2018 and Bache *et al* 2018). In summary, the southern Amadeus Basin dataset is characterised by a combination of complex structure, sparse 2D seismic coverage with zones of poor imaging quality, significant lateral and vertical velocity anisotropy, and sparse well control. Significant post-drill changes to the Dukas Prospect structural model highlight the subsurface uncertainties associated with challenging frontier basin datasets.

Pre-drill expectations attributed far less uplift and erosion of Inindia Beds equivalent strata than was encountered by the Dukas 1 ST1 well. The ESE/WNW striking Dukas frontal thrust is now understood to have undergone significant movement during the Peterman Orogeny (figures 3 and 4), resulting in almost complete erosion of Inindia Beds equivalent strata, with only approximately 220m remaining between the Petermann and Areyonga unconformities (as opposed to pre-drill expectations of ~1300m). Consequently, the Gillen Formation evaporites were encountered ~1400m high to pre-drill expectations, resulting in the intersection of over 2300m of high velocity evaporites.

The Dukas 1 ST1 well is the deepest well drilled in the Amadeus Basin with a total drilled depth of 3705m measured depth rotary table (MDRT) (3694m true vertical depth RT). The Phanerozoic succession at the well location was relatively thin with the Petermann Orogeny unconformity interpreted at 507m MDRT (Figure 5, Enclosure 1). The Areyonga Formation was encountered below the unconformity, indicating significant erosion of the younger Neoproterozoic succession. The Areyonga unconformity was intersected at 724m MD RT, with 106m of Wallara Formation drilled before intersecting the top of the Bitter Springs Group. All three formations of the Bitter Springs Group (the Johnnys Creek, Loves Creek and Gillen formations) were present at the well location.

A much thicker Gillen Formation evaporite succession than originally prognosed was encountered. In total, Dukas 1 ST1 intersected ~2322m of Gillen Formation evaporites, comprising primarily anhydrite and halite. The top of the Gillen Formation evaporites, comprising massive anhydrite, was intersected at 1379m MDRT, with the first halite encountered at 2103m MDRT. Significant overpressure below a deeper, thick halite interval, and encouraging gas shows including helium, confirmed the excellent sealing capacity of the Gillen Formation evaporites. A steeply dipping carbonate bed and possible non-evaporite inclusion was intersected between 3270m and 3405m MDRT.

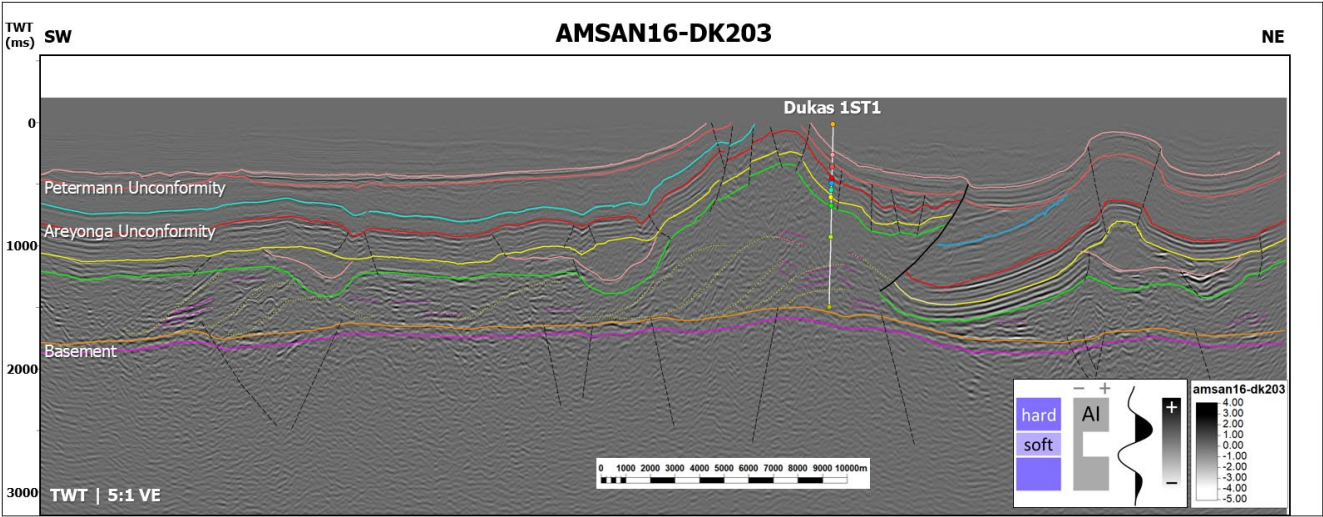


Figure 3: Post-drill interpretation of seismic line AMSAN16-DK203

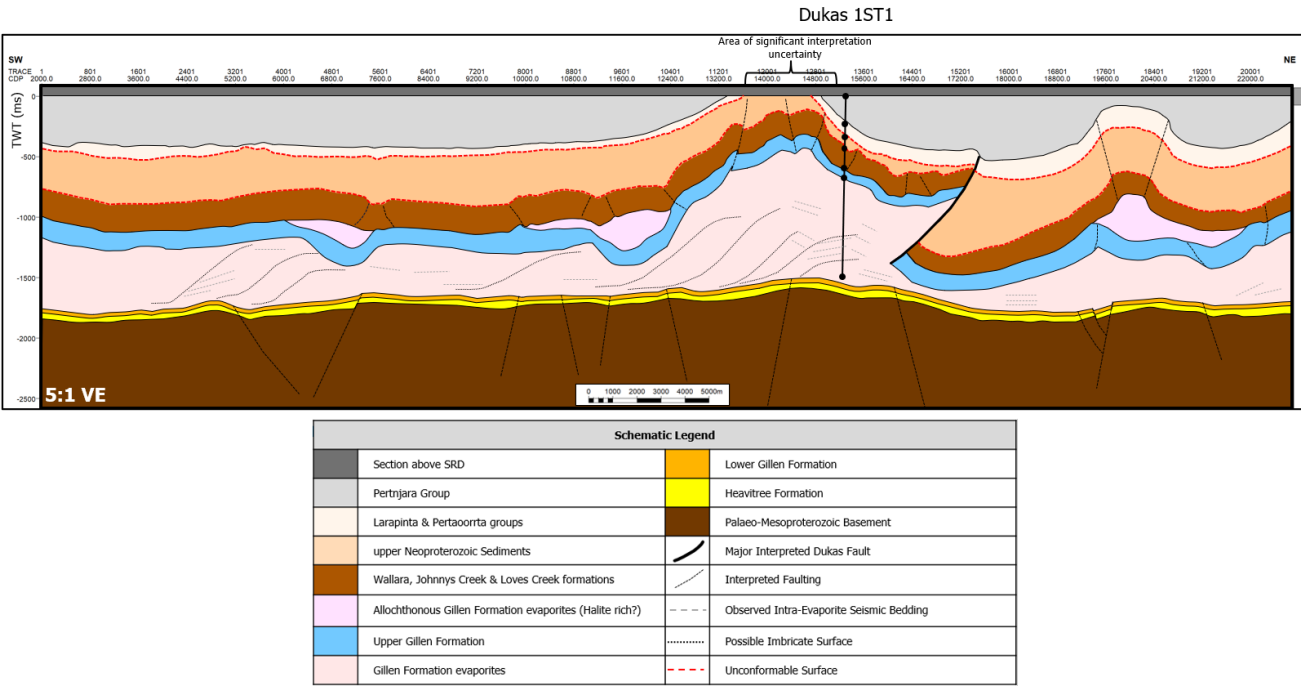


Figure 4: AMSAN16-DK203 geological schematic

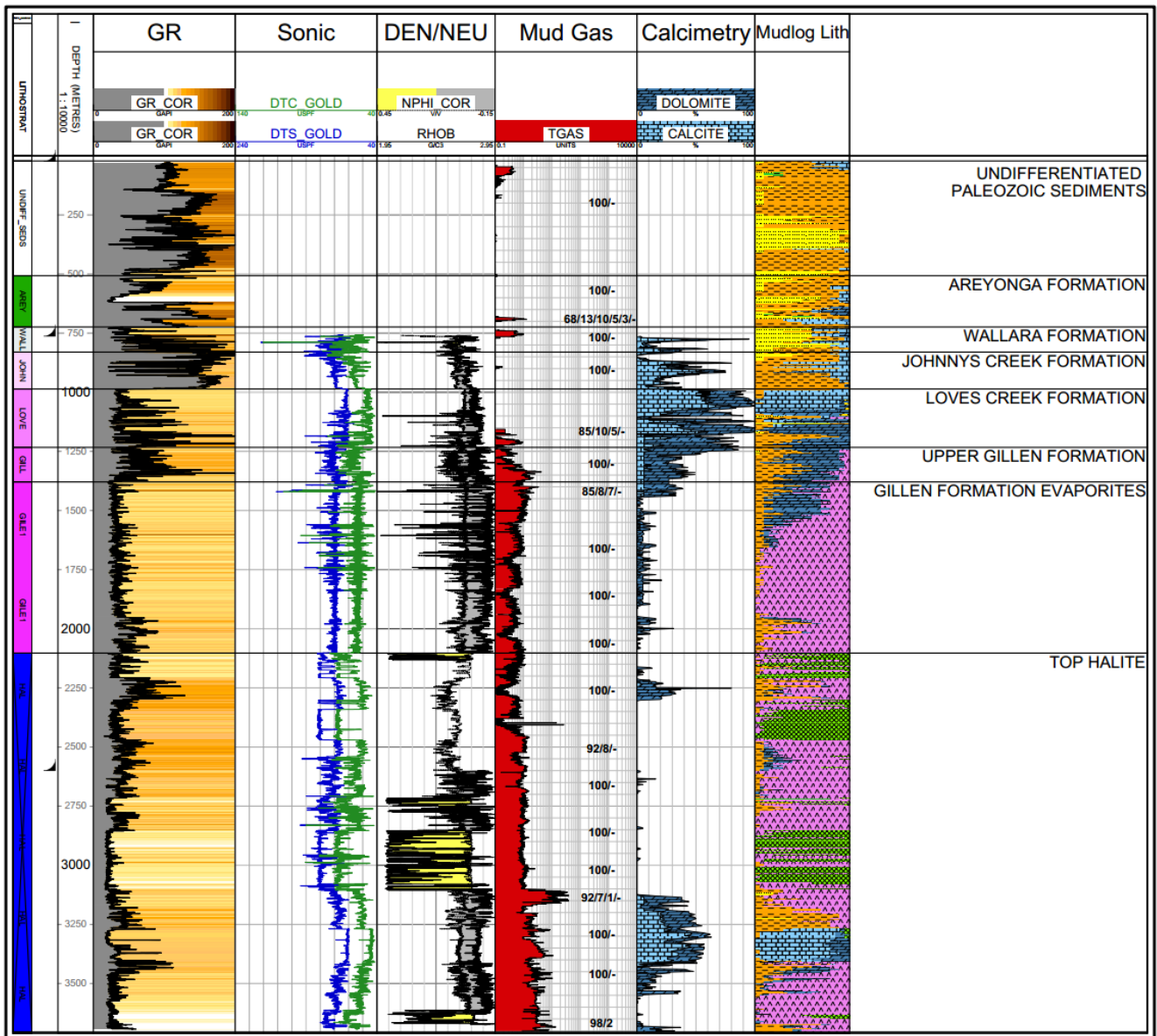


Figure 5: Dukas 1ST1 composite log of petrophysical, calcimetry, mud gas and cuttings lithology data

The suspended total depth formation was the Gillen Formation of the Bitter Springs Group. The primary target Heavitree Formation and Basement secondary target were not reached. Formation tops in Dukas 1 / Dukas 1 ST1 ranged from 0.4m low (undifferentiated Palaeozoic sediments) to 1435.3m high (Wallara Formation).

WELL	FORMATION	PROG (mRT)	PROG (mSS)	ACTUAL (mRT)	ACTUAL (TVDSS)	HIGH / LOW (m)	THICK (m)
Dukas 1	Surficial Deposits	7.0	494.0	7.0	494.0	-	14.4
Dukas 1	Undifferentiated Palaeozoic	22.0	480.0	22.0	479.6	0.4m L	484.0
Dukas 1	Petermann Unconformity	802.0	-300.0	507.0	-4.4	295.7 H	-
Dukas 1	Areyonga Formation	1745.0	-1243.0	507.0	-4.4	1238.7 H	216.3
Dukas 1	Wallara Formation	2158.0	-1656.0	724.0	-220.7	1435.3 H	105.3
Dukas 1	Bitter Springs Group	2237.0	-1735.0	830.0	-326.0	1409.0 H	2866.2+
Dukas 1	Johnnys Creek Fm	2237.0	-1735.0	830.0	-326.0	1409.0 H	153.9
Dukas 1	Loves Creek Formation	2321.0	-1819.0	986.0	-479.9	1339.1 H	244.7
Dukas 1 ST1	Gillen Formation	2489.0	-1987.0	1233.0	-724.6	1262.4 H	2467.6+
Dukas 1 ST1	Upper Gillen Formation	2489.0	-1987.0	1233.0	-724.6	1262.4 H	145.8
Dukas 1 ST1	Gillen Fm Evaporites	2764.0	-2262.0	1379.0	-870.4	1391.6 H	2321.8+
Dukas 1 ST1	Top Halite	NP	NP	2103.0	-1591.7	NP	1600.5+
Dukas 1 ST1	Total Depth	3652.0	-3150.0	3705.0	-3192.2	-	-

Table 1: Formation tops intersected in Dukas 1 / Dukas 1 ST1.

Post-drill Top Basement Prognosis

A zero offset VSP and two offset VSPs (NE and SW) were recorded at Dukas 1ST1 (Appendix 10). The survey objectives were to establish an accurate time-depth relationship for the well, and to image potential basement reflectors below the suspended well TD. Top basement from the offset VSPs tied to 2D seismic data is now picked at ~ 3600m TVDSS (~4100m TVDRT), approximately 400m below the current suspended well TD (Figure 6).

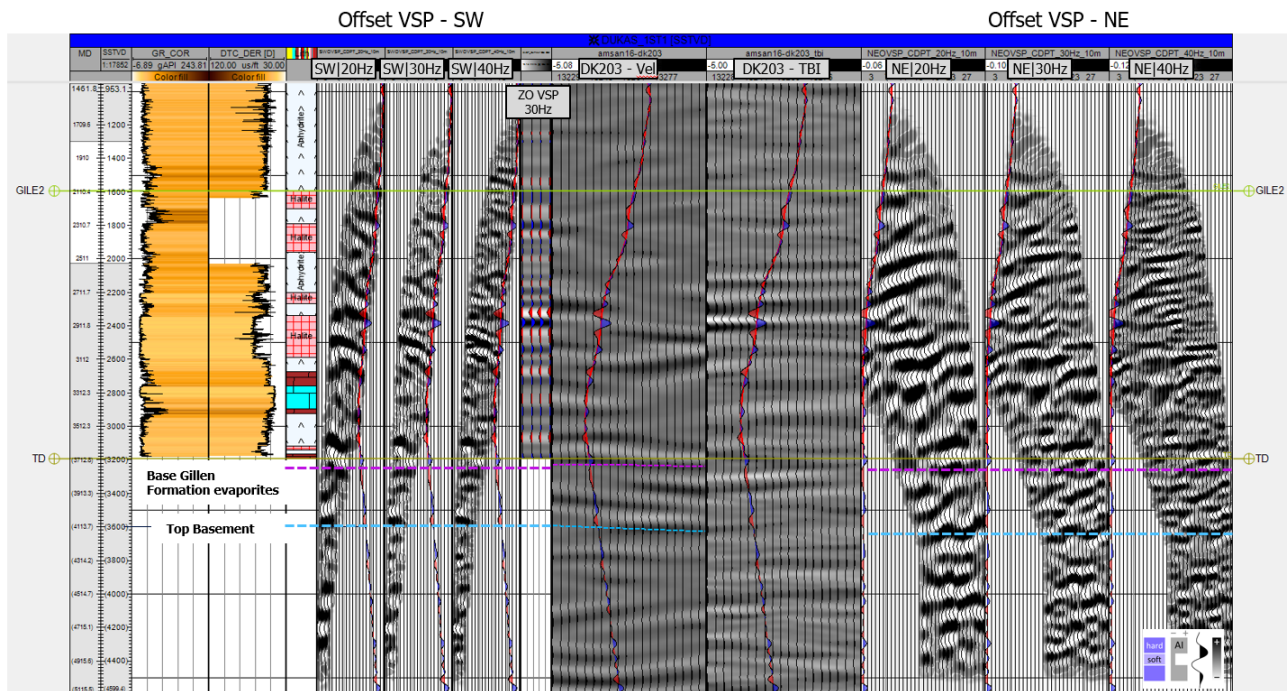


Figure 6: Base Gillen Formation evaporites and Top Basement picks on Offset VSP stacks.

3.2 LITHOLOGY AND DEPOSITIONAL ENVIRONMENT

A brief description of lithology follows. More detailed descriptions can be found in Appendix 2 of the Basic Well Completion Report.

Neoproterozoic Bitter Springs Group

The well reached total depth at 3705m after penetrating 2321.8m of the Gillen Formation evaporites. The top of the Gillen Formation evaporites was intersected at 1379.0m RT (-870.4mSS) 1391.6m high to prognosis. The Gillen Formation evaporites consist of anhydrite and halite, interbedded with minor siltstone and dolomite. The anhydrite is off white, clear to translucent, very fine to fine, minor medium, crystalline to micro crystalline, commonly sucrosic, firm to moderately hard, commonly brittle. The first halite was intersected at 2103.0m RT (-1591.7mSS). The halite is translucent orange, clear to translucent, light yellow, very coarse to coarse, crystalline and brittle. The evaporites were deposited in a restricted hypersaline environment.

Overlying the Gillen Formation evaporites is the upper Gillen Formation, intersected at 1233.0m RT (-724.6mSS), comprising medium to dark grey brown siltstones and light to medium grey dolomite.

The upper Gillen Formation is overlain by the Loves Creek Formation, intersected at 986.0m RT (-479.9mSS). The formation comprises arenaceous to cherty dolostones and stromatolitic limestones, interpreted to be deposited during a marine transgression and early highstand (Southgate, 1991).

The Johnny's Creek Formation 830.0m (-326.0mSS) conformably overlies the Loves Creek Formation and is 153.9m thick at this location. The formation comprises medium red brown siltstones with occasional light grey to off white limestone beds, deposited under terrestrial and lacustrine conditions (Southgate, 1991).

Neoproterozoic Wallara and Areyonga formations

Overlying the Bitter Springs Group is the Wallara Formation, intersected at 724.0m (-220.7mSS). The formation comprises sandstone, which is clear to translucent, pink red, fine to coarse, friable to hard, with tight visual porosity, interbedded with siltstone and limestone. The thickness at this location is 105.3m.

The Areyonga Formation, intersected at 507.0m (-4.4mSS), unconformably overlies the Wallara Formation. The Areyonga Formation comprises a lower siltstone dominated unit, and upper sandstone dominated unit that records the post-Sturtian glaciation marine transgression and highstand. The lower unit comprises dark grey to black siltstones and claystones and red brown siltstones, with lesser red brown dolomite, white to light grey limestone and very fine to medium grained sandstone. The upper unit comprises fine to medium grained sandstones and red brown siltstones with minor limestone. The thickness at this location is 216.3m.

Undifferentiated Palaeozoic Sediments

The undifferentiated Palaeozoic sediments intersected at 22.0m (+479.6mSS) unconformably overlie the Areyonga Formation. Comprising interbedded red brown siltstone and light grey to off white sandstone layers, the thickness at this location is 484.0m.

Quaternary Sediments

A thin veneer of Quaternary aeolian surficial deposits intersected at 7.0m (+494.0mSS) lies at the surface.

3.3 RESERVOIR PROPERTIES AND QUALITY

Reservoir intervals were encountered across the Wallara, Johnnys Creek and Loves Creek formations, however these were absent any shows and interpreted to be wet. Limited (2.7m) low deliverability reservoir is interpreted within the upper Gillen Formation as thin stringers. This is deemed wet. No reservoir quality intervals were observed below the top of the Gillen Formation evaporites.

A massive carbonate section was intersected within the Gillen Formation evaporites between 3270 and 3420mMDRT. Log interpretation of this interval indicates it is extremely tight, confirmed by RCA from the RSWCs, which indicate <2% PHIT at ambient conditions and extremely low permeability (Appendix 4). There are no indications of fractures or secondary porosity on image logs for this section, or indeed for the entire Gillen Formation evaporites.

Reservoir properties and quality of the Heavitree Formation primary target or the Basement secondary target have not been able to be ascertained due the well being plugged and suspended without reaching these zones.

3.4 GEOCHEMISTRY OF SOURCE ROCKS

Areyonga Formation

Dark grey to black siltstones over the interval 682-691m in the Areyonga Formation have good source potential. The TOC content ranges 1.84 – 3.37% (Figure 7), and averages 2.66%, the HI ranges 115-147, and averages 135 (Appendix 6). Pyrolysis Tmax and organic maceral reflectance data (Table 2 and Appendix 7) indicate the interval is in the oil window. Abundant bitumen, occurring mostly as fine anastomosing networks associated with the mineral matrix and rarely as blocky masses, is described in the organic matter descriptions.

Bitter Springs Group

Limited source rock potential was identified on logs across the Bitter Springs Group, with respect to Spectral GR response. No advanced mineral processing of the GEM tool was undertaken, and there are too few calibration points to generate a reliable TOC curve through alternative methods. As such, no continuous TOC log exists within the interpreted dataset. Nonetheless, 12 samples across the Gillen Formation were analysed based on elevated uranium response, with only one sample yielding a TOC greater than 1 % (1213-1216m, 1.45%) (Figure 7). Organic maceral reflectance data (Table 2 and Appendix 7) indicate the Gillen Formation is in the gas window.

Drilling was terminated before the anticipated source rocks of the lower Gillen Formation beneath the Gillen Formation evaporites was intersected.

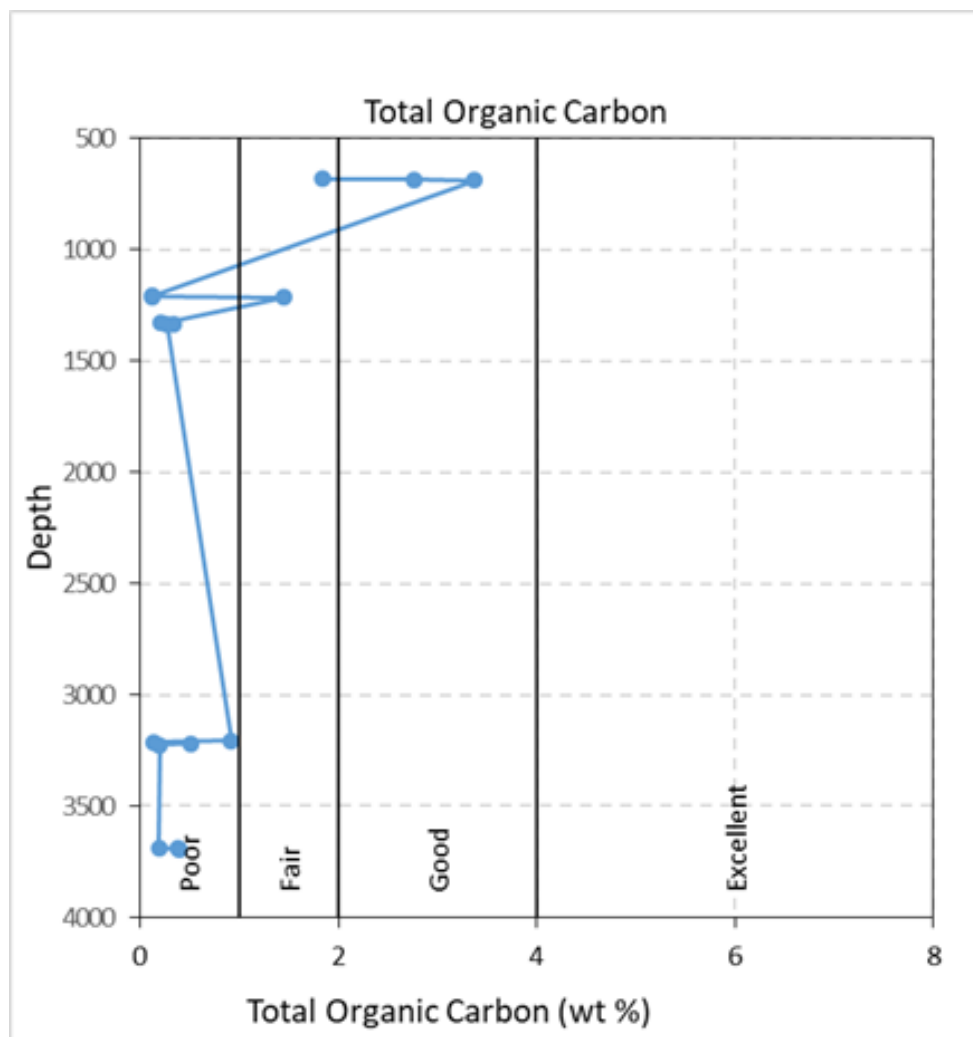


Figure 7: Dukas 1 and Dukas 1 ST1 Total Organic Carbon (TOC) analysis.

Depth from (m)	Depth to (m)	Vitrinite like Clasts Reflectance (%) Measured	Vitrinite Reflectance (%) Calculated	Inertinite Reflectance (%) Measured	? Alginite Reflectance (%) Measured	Pyro Bitumen Reflectance (%) Measured	Primary Bitumen Reflectance (%) Measured	Zooclast - Chitinozoan Reflectance (%) Measured	Zooclast (undiff) Reflectance (%) Measured	Organic Matter Undiff. Reflectance (%) Measured
682	685	0.88					0.659	0.766	1.82	
685	688	0.87					0.625	0.727		
688	691	0.878					0.716	0.723		
1207	1210						1.492			
1210	1213						1.591			
1213	1216						1.646			
1330	1333				1.406		1.514			
1333	1336				1.42					
1336	1339				1.426					
3208	3214				2.904					
3214	3220				2.982					
3220	3226				2.894					
3226	3232				2.88					
3689	3692									
3692	3695				3.40		3.77			
3695	3698				3.55		3.80			

Table 2: Organic matter reflectance data from cuttings, Dukas 1 / Dukas 1 ST1

3.5 HYDROCARBON INDICATIONS

No oil fluorescence shows were encountered during drilling operations at Dukas 1 / Dukas 1 ST1. Several poor gas shows were observed (Table 3), with total gas peaks of up to 40 units over a background of 7 units (97/3/Tr %).

Gas levels were monitored from the surface to TD, using an FID total gas detector and FID chromatograph. Total gas was monitored in gas units (1unit = 200ppm methane equivalent in air) and the chromatograph was calibrated to measure ppm (parts per million) concentrations of the alkane gasses methane, ethane, propane, butane and pentane.

While drilling through the Gillen Formation evaporites, two separate kicks, both with a minor gas response, were encountered. The gas response differed in its magnitude between the mudlogging unit FID and the Pason gas hot wire mass spectrometer, with Pason gas higher overall (max ~15units). While the level of calibration of the Pason system is unclear, this may be an indicator that any gas within the system at this location is rich in inerts, resulting in under-representation with the FID. This is supported by Isotube gas analyses, which, while heavily contaminated with air, indicated the presence of helium, hydrogen, nitrogen and carbon dioxide (Appendix 2).

Log Analysis

Dukas 1 ST1 logs were analysed over the Wallara Formation and Bitter Springs Group (Johnnys Creek Formation, Loves Creek Formation, upper Gillen Formation, Gillen Formation evaporites). Petrophysical log analysis indicates no net pay in Dukas 1 ST1 (Appendix 1, Enclosure 5). The well has been plugged and suspended without reaching the Heavitree Formation primary target or the Basement secondary target.

Drilled Gas Peak Table

Depth (m)	Formation	Date	Peak (U)	B.G. (U)	Ratio
3114	Gillen Formation evaporites	23/06/19	36.0	1.0	98/2/Tr
3128	Gillen Formation evaporites	23/06/19	40.0	7.0	97/3/Tr
3143	Gillen Formation evaporites	23/06/19	35.0	7.0	98/2/Tr
3150	Gillen Formation evaporites	23/06/19	38.0	7.0	96/4/Tr/Tr
3272	Gillen Formation evaporites	24/06/19	8.5	2.0	100% C1
3274	Gillen Formation evaporites	24/06/19	8.5	2.0	100% C1
3327	Gillen Formation evaporites	25/06/19	5.0	2.0	71/7/6/11/5
3382	Gillen Formation evaporites	25/06/19	11.0	4.0	97/1/1/1/Tr
3454	Gillen Formation evaporites	02/07/19	10.0	2.0	99/1
3459	Gillen Formation evaporites	02/07/19	9.0	2.0	99/1
3478	Gillen Formation evaporites	02/07/19	10.5	2.0	99/1

Table 3: Gas peaks recorded while drilling in Dukas 1 / Dukas 1 ST1.

3.6 POST DRILL STRUCTURAL INTERPRETATION AND TRAP INTEGRITY

Post-drill structural analysis

The acquired wellbore and 2D seismic data have undergone an integrated interpretation workflow to produce an updated post-drill structural model reflecting the geology intersected by the Dukas 1 ST1 well.

The resistivity and acoustic image logs acquired in Dukas 1 ST1 indicated a high degree of deformation, flowage and shearing in the Gillen Formation; the logs demonstrated little primary depositional structure or thickness preservation for this interval. Dips in the Gillen Formation evaporites therefore record the structure of stratiform intervals rather than primary bedding (Warren, 2019, Appendix 8).

The dip data were analysed using a combination of statistical curvature analysis techniques (SCAT) and traditional structural analysis techniques (stereonet, roseplots) (Hansberry, 2019). SCAT relates wellbore bedding dip and azimuth data to the bulk curvature of the structural setting in order to identify structural features such as folds and faults in the subsurface (refer Bengtson, 1981). SCAT analysis of evaporitic, salt-rich lithologies is confounded by high variability of orientations (Figure 8). However, it is useful for identifying shear zones and major structural discontinuities (ie detachments).

The image log data and SCAT interpretation were used to support seismic interpretation of the greater Dukas area and aid in structural evolution analysis of the prospective area.

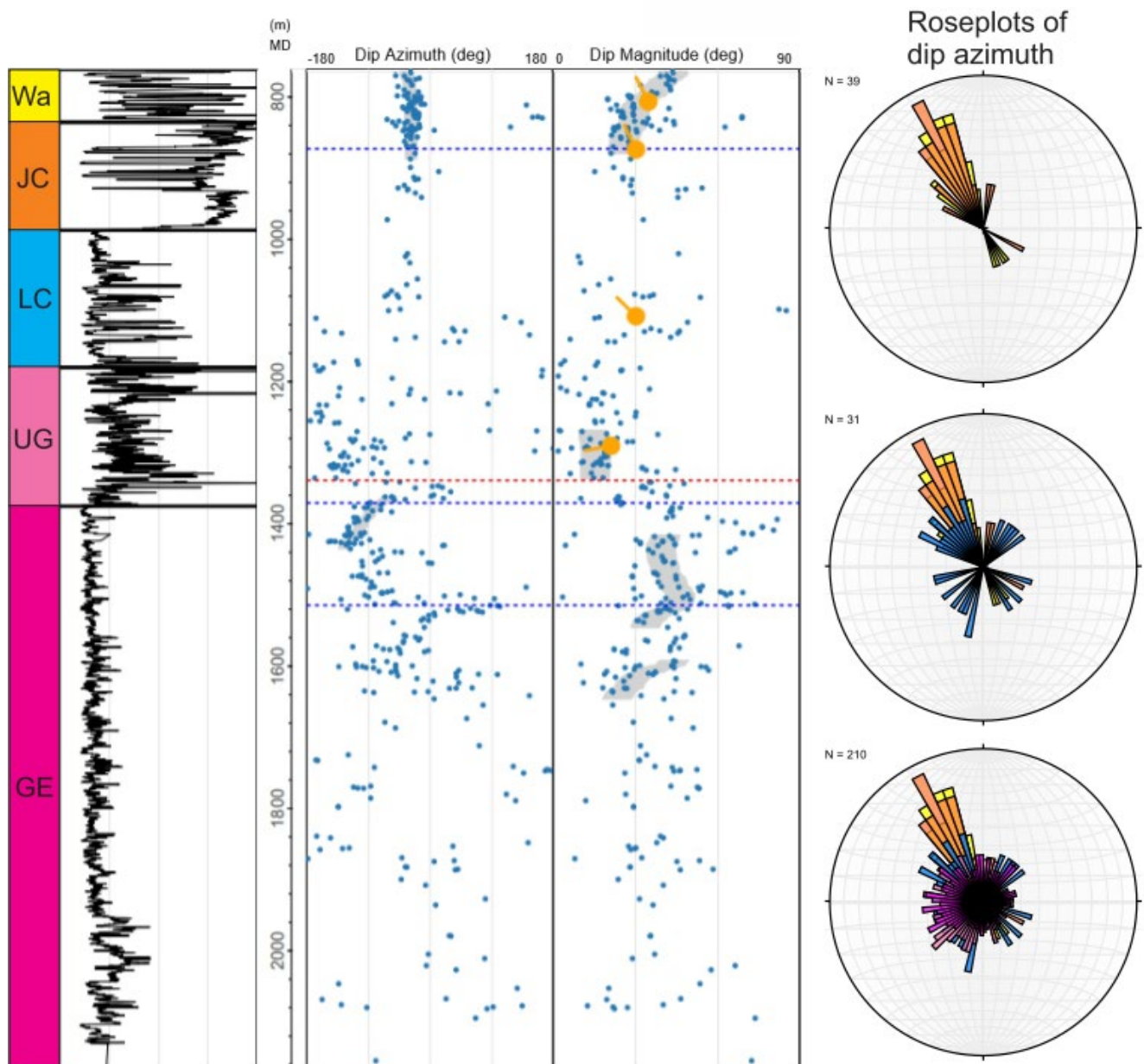


Figure 8: Composite well card of formations and dip data in upper well section (750–2150 m MDRT). Roseplots illustrate counts of dip azimuth with 5° bins, colours correspond to formation on far left (Wa = Wallara Formation, JC = Johnnys Creek Formation, LC = Loves Creek Formation, UG = upper Gillen Formation, GE = Gillen Formation evaporites). Top roseplot illustrates structural trend in Wallara and Johnnys Creek formations; middle roseplot adds Loves Creek Formation; bottom roseplot adds Gillen Formation.

Dukas area structural evolution

The Petermann Orogeny resulted in the development of a south-over-north thrust fault detaching in the Gillen Formation evaporites. Evaporite mobilisation resulted in an apparent salt weld forming below the thrust fault, possibly as the result of thrust loading. Uplift and erosion resulted in the loss of the Neoproterozoic succession down to the Areyonga Formation over the Dukas structural crest. (Figure 9). An anhydrite caprock in the Gillen Formation evaporites, to depths of >1500m below the Petermann Orogeny unconformity surface, is interpreted to have developed at this time.

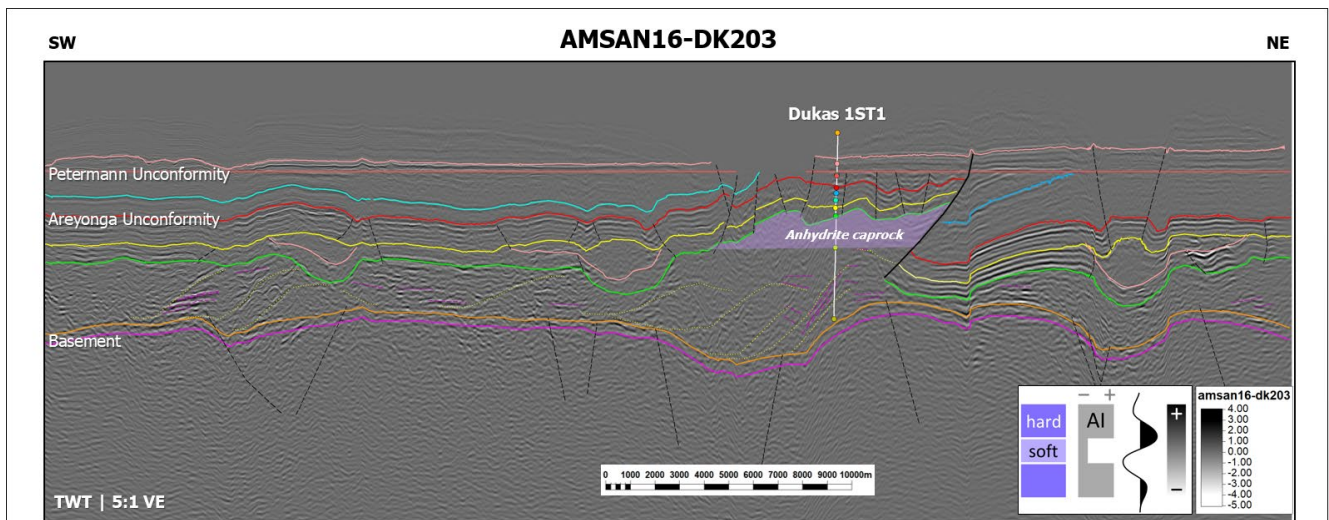


Figure 9: Seismic line AMSAN16-DK203 flattened on the interpreted Petermann unconformity

The Alice Springs Orogeny resulted in gentle folding of the supra-salt succession and thickening of the Gillen Formation evaporites within the Dukas anticline (Figure 3, Enclosure 4). The salt weld is interpreted to have “locked” the Gillen Formation detachment zone, such that shortening was accommodated in the Dukas anticline.

Dip data analysis suggests the structural thickening of the Gillen Formation evaporites is the result of mixed brittle–ductile deformation. This is likely controlled by competency contrast in the protolith where rheologically weak layers (ie halite) can flow or act as diffuse detachment zones where shortening is accommodated along multiple high-strain shear zones separating more competent blocks. However, if the quantity or rate of shortening exceeds this capacity, shortening and thickening is achieved by brittle imbrication.

The Gillen Formation shows a northwest-southeast striking trend, consistent with the Petermann Orogeny, with a minor west-northwest–east-southeast overprint attributed to the Alice Springs Orogeny (Figure 10). The clastic-dominated Johnnys Creek and Wallara formations show a strong east-northeast–west-southwest striking trend. This is inconsistent with general Alice Springs and Petermann orogeny trends and is interpreted as a localised trend at the well location.

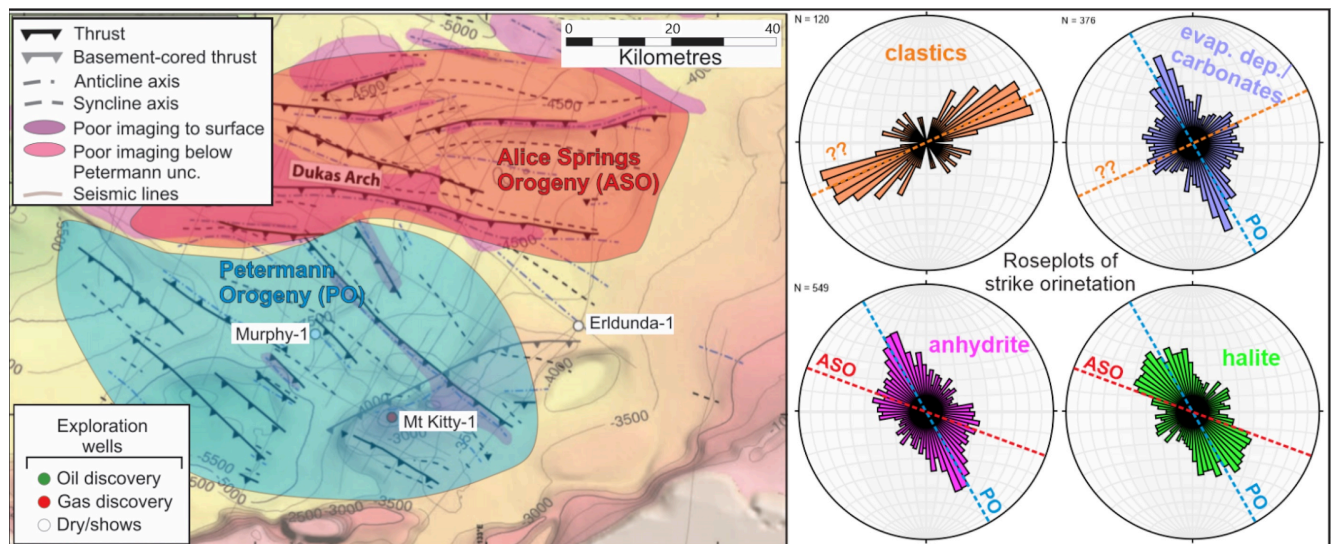


Figure 10: Comparison of regional structural trends in the south-eastern Amadeus Basin (left, after Bache et al 2018), and gross-breakout of structural trends based on lithology in the Dukas 1 ST1 image log data. Roseplots show strike of bedding planes in each broad lithology: Clastic dominated Wallara and Johnnys Creek formations (top left); Gillen Formation carbonates (top right); anhydrite (bottom left); and halite (bottom right). Dashed lines on roseplots indicate interpretation of observed strike trends association with the broadly northwest-southeast (PO = Petermann Orogeny), and west-northwest-east southeast (ASO = Alice Springs Orogeny) trends identified in Bache et al (2018).

Trap Integrity

Post drill re-interpretation efforts have focused on attributing the correct amount of offset to the frontal thrust fault and accounting for the impact on depth conversion caused by the thick, high velocity evaporite section. Additionally, a multi-z horizon and velocity modelling approach has been utilized to assign appropriate velocities to younger formations in the footwalls of high displacement thrust faulting.

The post drill Basement depth structure map (Enclosure 3) shows the Dukas 1ST1 well is located near the lowest closing contour of the Heavitree/Basement structural closure, compared with the near crestal location on the pre-drill map (Enclosure 2).

3.7 GEOTHERMAL GRADIENT

A bottom hole temperature of 94°C at 3693m TVDRT was calculated from wireline temperature data (Suite 3), resulting in an average geothermal gradient of 18.9°C/km (Appendix 5). This is comparable to offset wells Mt Kitty 1 (19.7°C/km; Adderley, 2015) and Murphy 1 (19.0°C/km; Menpes, 1991).

3.8 GEOMECHANICAL TESTWORK

Nine Gillen Formation sidewall core samples were submitted to the CSIRO for Unconfined Compressive Strength (UCS) testwork. Sample preparation included obtaining vertical plugs from the sidewall cores so that UCS is measured parallel to drilling direction. UCS test results ranged from 1697 psi in a halite sample to 28079 psi in a carbonate sample (Appendix 9).

3.9 WATER ANALYSIS

One water sample, acquired after water was encountered in the Loves Creek Formation during underbalanced drilling operations (sampled at 22:00 hrs on 7 May 2019), was analysed by Bureau Veritas. Results are included as Appendix 3.

3.10 RELEVANCE TO HYDROCARBON POTENTIAL

The well data provides a contribution to evaluation of the hydrocarbon potential of the area despite the target objectives not being intersected. The expected seal for target Heavitree Formation reservoir, the Gillen Formation evaporites, has been confirmed to be present. Significant overpressure below a deeper, thick halite interval, and encouraging gas shows including helium, confirm the excellent sealing capacity of the Gillen Formation evaporites.

4 SUMMARY AND CONCLUSIONS

Dukas 1 ST1 was spudded at 07:15 hours on the 16th April 2019 with the drilling rig Ensign 965. The well was drilled ahead to TD at 1275m. Due to a section of the BHA being left stuck in hole, a decision was made to plug back and abandon Dukas 1. Dukas 1 ST1 was sidetracked from 1156m and drilled ahead to a suspended TD of 3704m (driller). Total depth was reached at 08:30hrs on the 2nd of August 2019. Drilling was terminated after formation pressures approaching well system limits were encountered.

The Dukas 1 ST1 well is the deepest well drilled in the Amadeus Basin. Dukas 1 / Dukas 1 ST1 penetrated as far as the Neoproterozoic Gillen Formation in the stratigraphic succession. Formation tops ranged from 0.4m low (undifferentiated Palaeozoic sediments) to 1435.3m high (Wallara Formation). The primary target Heavitree Formation and fractured Basement secondary target were not reached.

No oil fluorescence shows were encountered during drilling operations at Dukas 1 / Dukas 1 ST1. Several poor gas shows were observed, with total gas peaks of up to 40 units over a background of 7 units (97/3/Tr %). Dukas 1 ST1 logs were analysed over the Wallara Formation and Bitter Springs Group. Petrophysical log analysis indicates no net pay in Dukas 1 ST1.

Although the well did not reach the Heavitree Formation target objective, it has provided valuable information to support progression of Heavitree-Gillen play exploration in the south-eastern Amadeus Basin. The presence of hydrocarbons, helium, and overpressure confirm the presence of a working petroleum system in the area, effectively trapped by a thick, evaporite seal. The well is also an important calibration point in an underexplored segment of the basin, aiding seismic interpretation and depth conversion to delineate potentially large sub-evaporite structural traps.

Dukas 1 ST1 has been plugged and suspended for possible future re-entry and deepening to test the Heavitree Formation and fractured Basement reservoir targets. Cement suspension plugs were set as follows: Plug 1A: 3704m-3453.5m; Plug 1B: 3453.5m-3204m; Plug 1C: 3204m-2954m; Plug 1D: 2954m-2704m; Plug 1E: 2704m-2557m; Plug 1F: 2531m-2297m; Plug 2: 1220m-1142.4m; Plug 3: 250m-103.3m. Ensign 965 was released at 23:59 hours on the 21st of August 2019.

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