Oil Search

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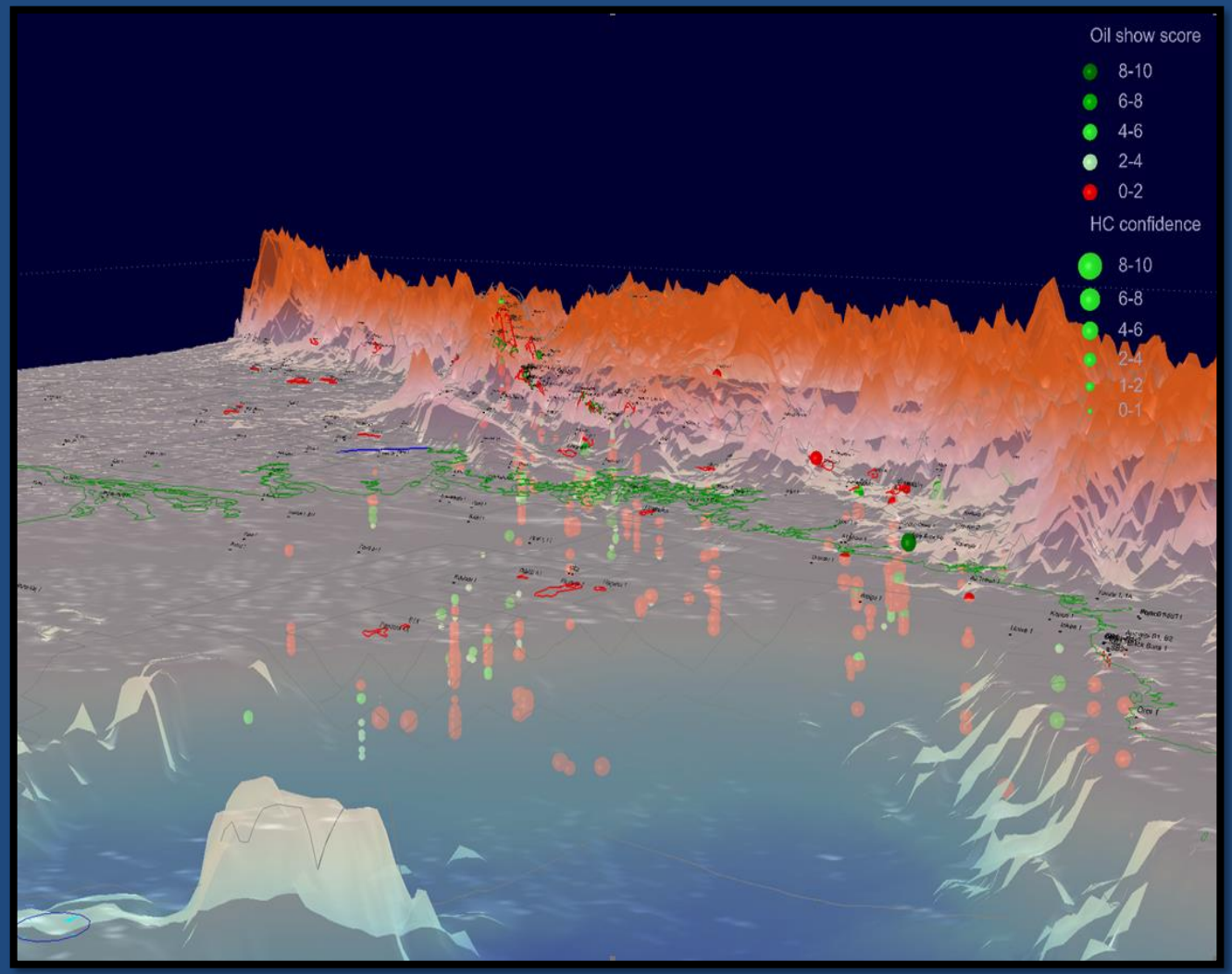
1ST PAPUA NEW GUINEA PETROLEUM GEOSCIENCE CONFERENCE AND EXHIBITION

Hydrocarbons putting on a show! - Development of a PNG shows database

Mervin Kendino[1]*, Amy-Yvette Kaumi[1], David Holland[1], Julianne Lamb[1], Andrew Murray[2].
[1]Oil Search Ltd, [2]Murray Partners PPSA PTY. LTD.



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OVERVIEW

1. A century of petroleum exploration in PNG
2. Development of PNG hydrocarbon shows database
3. Methodology: Capturing data
4. Show Ranking System
5. Working Example
6. Application of shows in exploration
7. Conclusion

1. Over a century of petroleum exploration in PNG

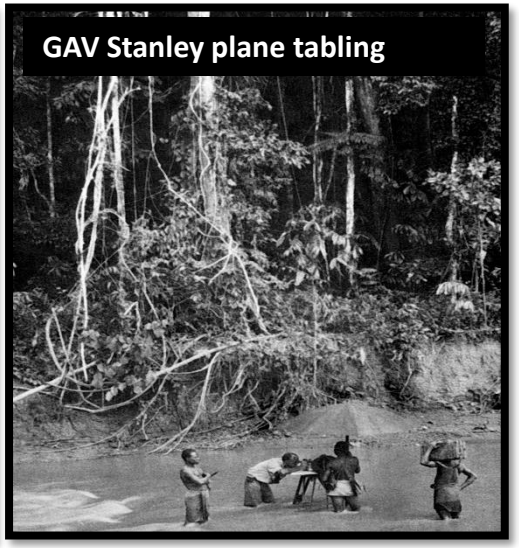
Capturing a hundred years worth of hydrocarbon shows

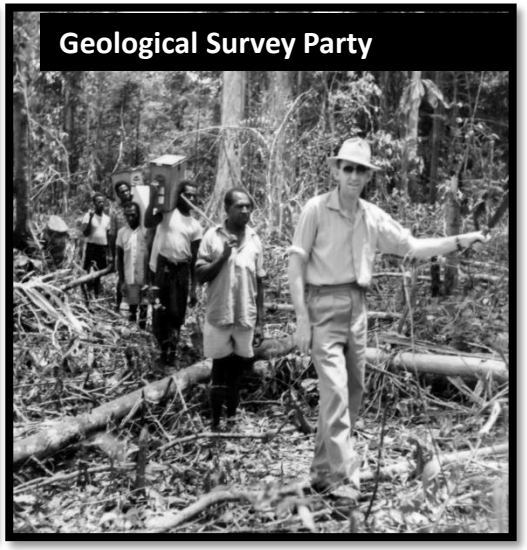
Key dates and figures

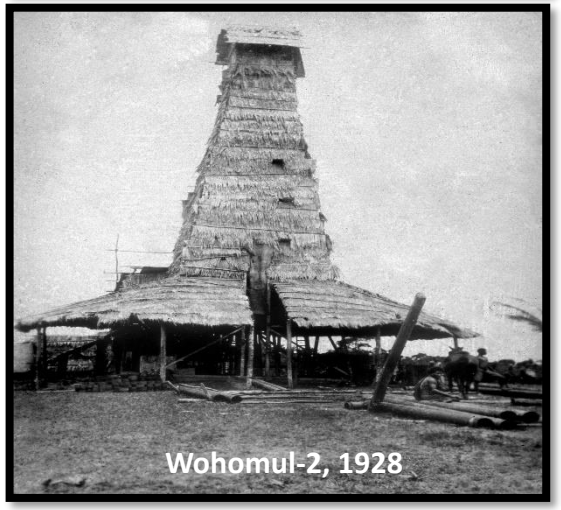
- 1911: First reports of oil and gas seeps at Vailala
- 1913: First well drilled at Upoia
- 2013: 100th Anniversary of drilling
- 600+ wells drilled over a century

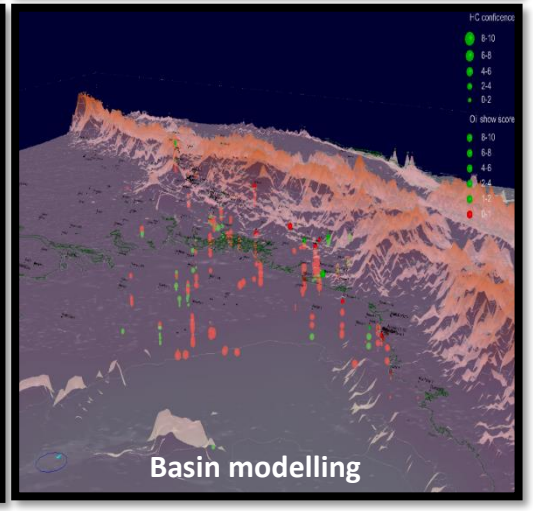
Relevance to shows database

- Advancement in oil field practices
- Detailed reference set of highly variable HC shows









Types of shows and its importance

Show Type	Significance
Continuous Phase	Trapped oil or gas
Residual	Migrated hydrocarbons
Dissolved Gas	Gas present in petroleum system
In Kerogen	Oil or gas present in source rock

AAPG WIKI, 2016

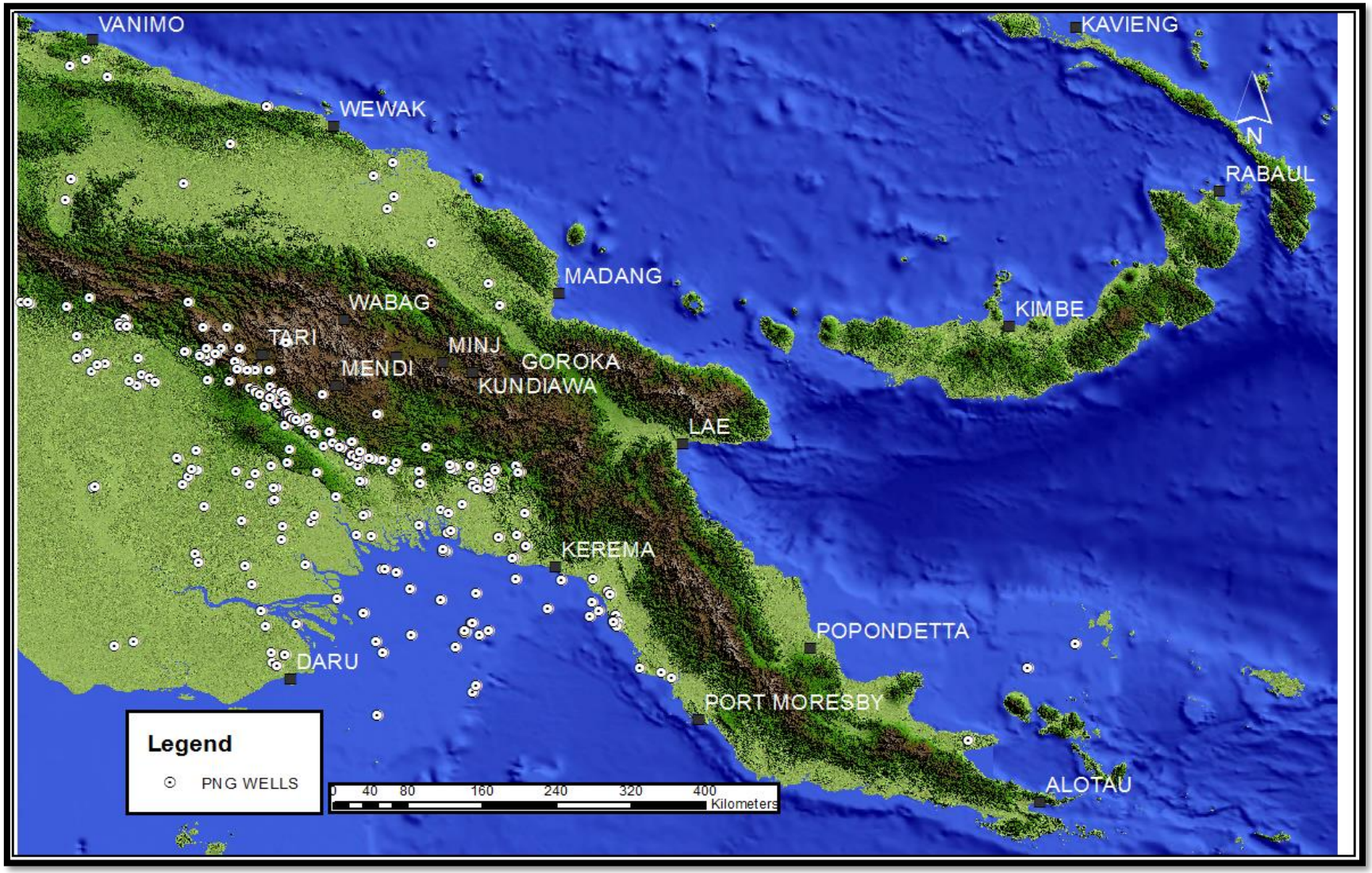
- A good show is a strong indication of a working petroleum system
- It is important, for good petroleum system analysis practice, to be systematic in reporting and using show information

2. PNG HYDROCARBONS SHOW DATABASE

Capturing a wide variety of hydrocarbon shows

PNG shows database

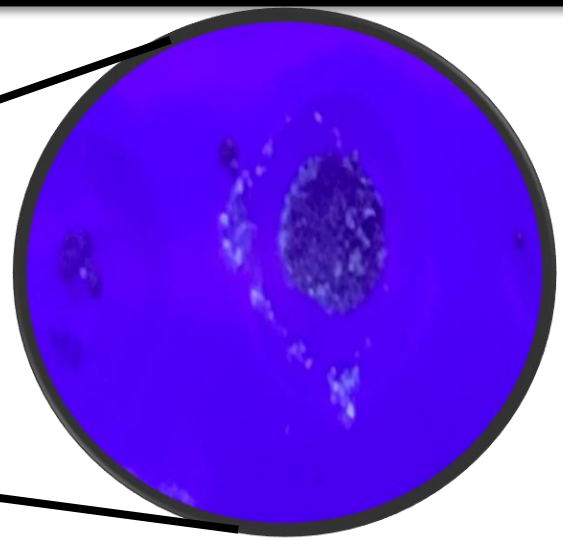
- More than 600 PNG wells drilled of which 300 have been captured
- Systematic review and catalogue of HC shows from wells
- Captured in a database using a standard classification system



Definition of shows in context of the shows database

Definition: Any hydrocarbons found while drilling which have the compositional and isotope characteristics typical of thermogenic, migrated fluids.

- A “show” can be anything from a DST of a hydrocarbon bearing interval through to fluorescence seen by a mud logger in cuttings



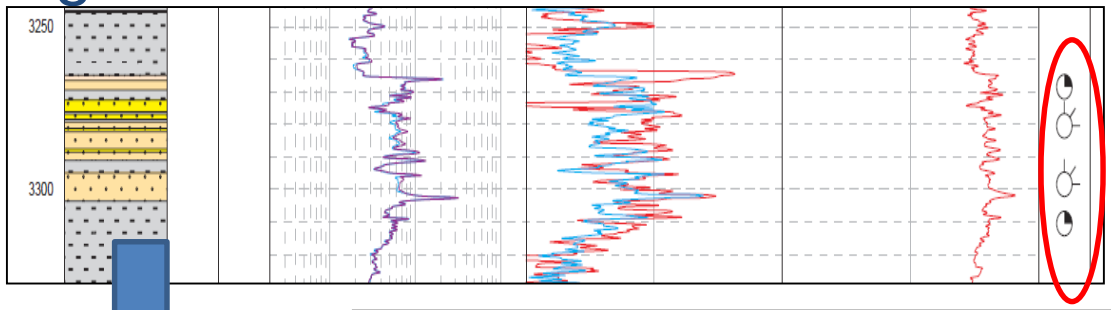
Fluorescence seen in cuttings, Kimu-2

3. Methodology: Capturing data

WCR/Composite Logs

Make entry onto spreadsheet

Rank the show using Andrew Murray's ranking system



3275.0m : Strong yellow fluorescence, instant milky white cut, milky yellow cut residue fluorescence. Seen in approximately 70% of core.

Well	Depth of HCs Top (m)	Depth of HCs Top (TVD-m)	Elevation (m)	Depth of HCs Top (TVDSS-m)	Depth of HCs Base (m)	Formation of HCs	Gas show score	Oil show score	HC confidence	Main HC type	Report Reference	Show Origin	Comment	X	Y	Z (Well TD)	TD Fm.	Well Class	Drilling Fluid Type
ADD 1	1149.096	1147.93	-776.13	-371.80	1374.65	Upper Ieru	5	0	5	Gas	RP03670	MUDLOG	MUDLOG: Backgrnd gas was consistantly low throughout the section. It ran	731735.67	9298899.31	2181.76	Toro A	Oil well	
Kimu 1	1620	1619.77	-64.6	1555.17	1642	Alene Sandstone	10	0	10	Gas	RP07473	DST	DST #1 Dry Gas 7.5mmscf/day through 1/2" choke One open hole straddle p	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	1873.5	1873.27	-64.6	1808.67	1879	Imburu C	0	4	4	Oil	RP07473	CUTTINGS	CUTTINGS- Poor decreasing to trace show. No stain, 50-80% of sandstone	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	1873.5	1873.27	-64.6	1808.67		Imburu C	0	8	8	Oil	RP07473	SFT	SFT 1.3 Gal sample Chamber 3 Trace of gas with an oil film	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	1933	1932.77	-64.6	1868.17	1975	Imburu C	0	3	3	Oil	RP07473	CUTTINGS	CUTTINGS-lagifu 1933m-1975m 15-30%, dull to mod br patchy to solid yell dir	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	1933	1932.77	-64.6	1868.17	1938	Imburu C	0	3	3	Oil	RP07473	CUTTINGS	CUTTINGS-Trace show. No stain, 30% dull patchyto solid yellow fluorescen	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	1938	1937.77	-64.6	1873.17		Imburu C	0	4	4	Oil	RP07473	SWC	SWC-(Quartzone sandstone) – trace show. Tracedim gold pin point direct flu	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	1938.5	1938.27	-64.6	1873.67	1952	Iagifu A	0	3	3	Oil	RP07473	CUTTINGS	CUTTINGS-Poor decreasing to Trace show. No stain, 30% decreasing to 10	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	1963	1962.77	-64.6	1898.17	1967	Iagifu A	0	3	3	Oil	RP07473	CUTTINGS	CUTTINGS-Trace show. No stain, 15% decreasing to trace dull to moderatel	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	1967	1966.77	-64.6	1902.17	1975	Iagifu A	0	3	3	Oil	RP07473	CUTTINGS	Trace show. No stain, 20% decreasingto 15% dull to moderately bright patchy	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	1980	1979.77	-64.6	1915.17		Iagifu A	0	4	4	Oil	RP07473	SWC	SWC -(Quartzone sandstone) – trace show. No mstain, trace dull spotty to p	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	2026	2025.77	-64.6	1961.17	2032	Iagifu A	0	3	3	Oil	RP07473	CUTTINGS	CUTTINGS: Trace show. Pale brown oil stain, traceto 30% moderately bright	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	2039	2038.77	-64.6	1974.17		Iagifu A	0	4	4	Oil	RP07473	SWC	SWC-(Quartzose sandstone) – trace show. Nostain, dull spotty to patchy yel	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	2056	2055.77	-64.6	1991.17	2080	Iagifu A	0	5	5	Oil	RP07473	CUTTINGS	CUTTINGS-Poor to trace show. Trace to 50% ofsandstone and trace to 30%	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	2062	2061.77	-64.6	1997.17		Iagifu A	0	4	4	Oil	RP07473	SWC	SWC-(Quartzose sandstone) – trace show. Verydull to dim, patchy orange to	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	2073	2072.77	-64.6	2008.17		Iagifu A	0	7	7	Oil	RP07473	SWC	SWC-(Glauconitic quartzose sandstone) – Poor to fair show. No stain, 90%	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	2243	2242.77	-64.6	2178.17	2244.5	Koi-lange	0	3	3	Oil	RP07473	CUTTINGS	CUTTINGS: Trace show. Silty claystone; no stain,30% moderately bright yell	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Kimu 1	2254	2253.77	-64.6	2189.17	2260	Koi-lange	0	3	3	Oil	RP07473	CUTTINGS	CUTTINGS: Trace to 10% ss has mod RT patchy to occ solid yellow dir fluor	730892.1	9207080.94	2270	LJ11 Barikewa	Gas Well with Oil Shows	
Korka 1	2023	2008.08	-1696.93	311.15		Haito Member	4	0	4	Gas	RP13245	MUDLOG	MUDLOG: Connection Gas. TG_0.1 %, C1, C2, C3, iC4, nC4, C5 (ppm): 757 / !	678689.6686	9384391.896	3340	Digimu	Dry Hole	
Korka 1	2052	2037.05	-1696.93	340.12		Haito Member	4	0	4	Gas	RP13245	MUDLOG	MUDLOG: Connection Gas. TG_0.06 %, C1, C2, C3, iC4, nC4, C5 (ppm): 463	678689.6686	9384391.896	3340	Digimu	Dry Hole	
Korka 1	2081	2066.03	-1696.93	369.1		Haito Member	4	0	4	Gas	RP13245	MUDLOG	MUDLOG: Connection Gas. TG_0.08 %, C1, C2, C3, iC4, nC4, C5 (ppm): 564	678689.6686	9384391.896	3340	Digimu	Dry Hole	
Korka 1	2109	2094.01	-1696.93	397.08		Haito Member/Fault	4	0	4	Gas	RP13245	MUDLOG	MUDLOG: Connection Gas. TG_0.07 %, C1, C2, C3, iC4, nC4, C5 (ppm): 503	678689.6686	9384391.896	3340	Digimu	Dry Hole	
Korka 1	2138	2122.99	-1696.93	426.06		Haito Member/Fault	4	0	4	Gas	RP13245	MUDLOG	MUDLOG: Trip Gas. TG_0.2 %, C1, C2, C3, iC4, nC4, C5 (ppm): 974 / 11 / 4 / 1 /	678689.6686	9384391.896	3340	Digimu	Dry Hole	

4. Show Ranking System

- Based on the Show Classification System
- Different sources have different Rankings
- The main show categories are:

Increasing order of confidence

1. Flow
2. Recovery
3. Pressure Survey
4. Log
5. Core
6. Mud Logging
7. Side Wall Cores
8. Cuttings

Hydrocarbon occurrence confidence score (1 to 10 for gas and oil separately)

Well	WELL
Depth of HCs	DEPTH
Formation of HCs	FORMATION

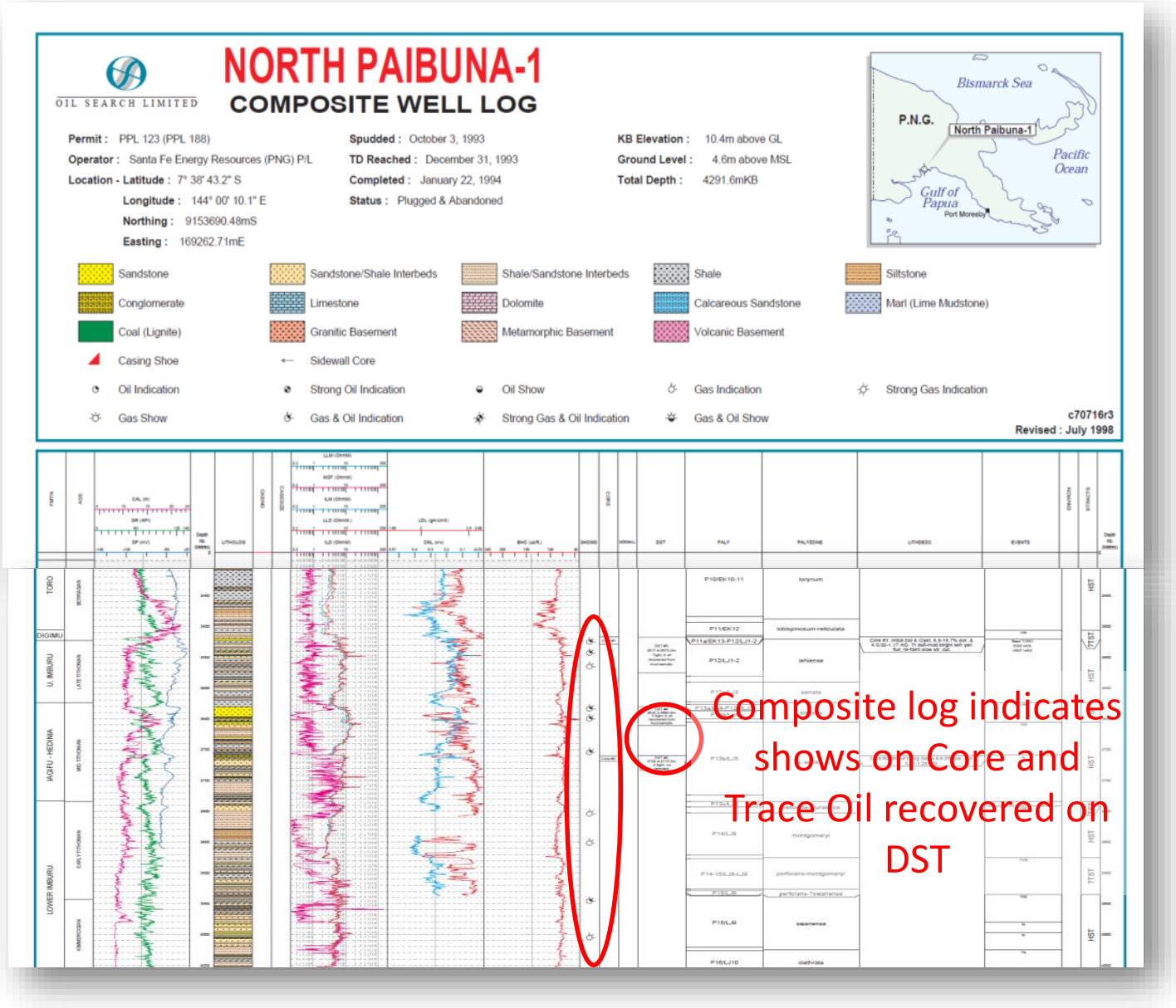
	Category	Show name	Show Code	Strength	Description	Oil and Gas Score
Hydrocarbons flow tested to surface	HS FLOW	Gas flow	G5	10	Measured flow rate of gas	0
	HS FLOW	Oil flow	L5	10	Measured flow rate of clean oil	0
	HS FLOW	Trace gas	G2	8	Unmeasured volume or flow of gas observed or solution gas recovered from water during flow test	0
	HS FLOW	Trace oil	L2	8	Oil scum, globules or emulsion or unmeasured volume of oil recovered during flow test	0
Hydrocarbons recovered to surface in wireline tools	HS RECOVERY	Gas recovery	G3	10	Discrete recovery of gas	0
	HS RECOVERY	Oil recovery	L3	10	Discrete recovery of clean oil	0
	HS RECOVERY	Trace gas	G2	8	Recovered an unmeasured volume of gas (validity confirmed by chemical analysis)	0
	HS RECOVERY	Trace oil	L2	8	Oil scum, globules or emulsion or unmeasured volume of oil recovered (validity confirmed by chemical analysis)	0
Hydrocarbons indicated from good, multi-point, pressure gradients	HS PRESSURE SURVEY	Measured gas gradient	G2	8	Pressure measurement clearly shows a gas zone	0
	HS PRESSURE SURVEY	Measured oil gradient	L2	8	Pressure measurement clearly shows an oil zone	0

5. Working Example

Composite Logs

Quick reference to observed shows

- The best place to begin your search for shows-Composite Log
- The composite logs indicate the type and location of the show but will not give you much data



Well Completion Reports (WCR)

A more detailed source of information

The Hedinia Member sandstones, which occur from 11910 feet, had minor oil florescence shows. Very fine to fine-grained sandstones from 11902 to 11910 feet have no direct florescence but trace to common small droplets of very pale brown oil were observed floating on top of the sample water. Mud from the same interval had a trace of very dim yellow green fluorescence. From 11910 to 11935 feet the sandstones are similar and have rare traces of dim yellow green patchy florescence and a very weak diffuse to occasional slow streaming cut. Mud gas shows for this sandstone range up to 1300 units (C1 to C5) with gas wetness ratios of 14.1 to 14.8.

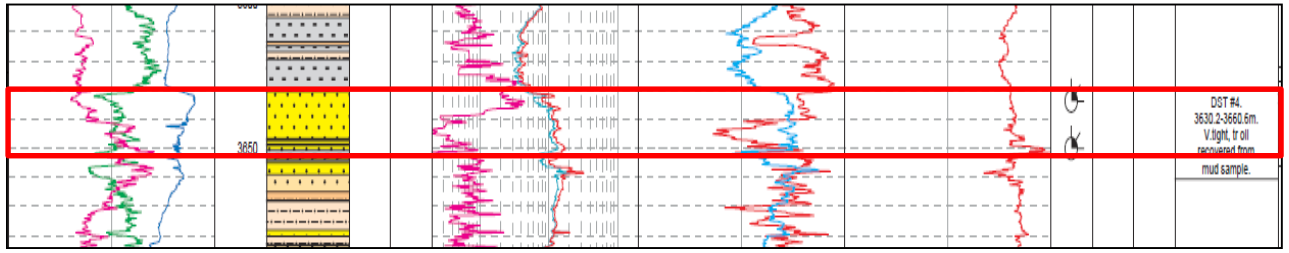
2.8 Test Results

Due to the favorable gas and oil shows encountered during drilling, and the uncertainties inherent in the formation evaluations, five tests were run over the following intervals:

DST #1: 13946'-14080' (Open Hole)
Very Tight, No Recovery
DST #2: 13340'-13370', 13388'-13408'
Very Tight, No Recovery
DST #3: 12170'-12190'
Very Tight, No Recovery
DST #4: 11910'-12010'
Very Tight, Trace oil recovered from drilling fluid
DST #5: 11540'-11620', 11680'-11730'
Tight, Trace oil recovered from drilling fluid

None of the tests encountered any significant infux of fluid or gas. Mud samples were sent for geochemical analyses, and trace amounts of possible liquid hydrocarbons were extracted from drilling fluids during DST's 4 and 5.

- To get more data we look in the Well Completion Report
- We can already see some valuable data that we can record in our shows database
- Zone of interest is the Imburu C Sand from 3630m-3660m



Pick	Interp	Obs	MD (meters)	Quality	Conf	Source	T/D	Created	Updated
Era Beds	AAA	1	8.84			SW		2010-05-10	2010-12-10
Darai Limestone	AAA	1	543.1			GeoFrame		2010-05-10	
Puri Limestone	AAA	1	1809.87			SW		2010-05-12	
Mendi Group	AAA	1	2949.6			GeoFrame		2010-05-10	
Bawia Member	AAA	1	3049.2			SW		2010-05-10	2010-05-12
Upper Ieru	AAA	1	3049.2			GeoFrame		2010-05-10	
Juha Member	AAA	1	3127			GeoFrame		2010-05-10	
Alene Member	AAA	1	3182.26			SW		2010-05-10	2010-05-12
Alene Sandstone	AAA	1	3311.9			GeoFrame		2010-05-10	
Toro Formation	AAA	1	3456.79			SW		2010-05-12	
Toro A	AAA	1	3458.4			GeoFrame		2010-05-10	
Toro B	AAA	1	3502.9			GeoFrame		2010-05-10	
Toro C	AAA	1	3516.6			GeoFrame		2010-05-10	
Imburu A	AAA	1	3522.9			GeoFrame		2010-05-10	
Digimu	AAA	1	3535.6			GeoFrame		2010-05-10	
Imburu C	AAA	1	3631.7					2011-11-22	
Imburu D	AAA	1	3708.4					2011-11-22	
Iagifu A	AAA	1	3708.4			GeoFrame		2010-05-10	
Koi-Iange	AAA	1	4065.6			SW		2010-05-10	2010-05-13
TD	AAA	1	4291.58			GeoFrame		2010-05-10	

Formation identification, Openworks

Scoring the Show

Information from WCR

2.8 Test Results

Due to the favorable gas and oil shows encountered during drilling, and the uncertainties inherent in the formation evaluations, five tests were run over the following intervals:

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Very Tight, No Recovery
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DST #4: 11910'-12010'
Very Tight, Trace oil recovered from drilling fluid
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Ranking System

Hydrocarbon occurrence confidence score (1 to 10 for gas and oil separately)

Well	WELL	
Depth of HCs	DEPTH	
Formation of HCs	FORMATION	

	Category	Show name	Show Code	Strength	Description	Oil and Gas Score
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	HS FLOW	Oil flow	L5	10	Measured flow rate of clean oil	0
	HS FLOW	Trace gas	G2	8	Unmeasured volume or flow of gas observed or solution gas recovered from water during flow test	0
	HS FLOW	Trace oil	L2	8	Oil scum, globules or emulsion or unmeasured volume of oil recovered during flow test	0
Hydrocarbons recovered to surface in wireline tools	HS RECOVERY	Gas recovery	G3	10	Discrete recovery of gas	0
	HS RECOVERY	Oil recovery	L3	10	Discrete recovery of clean oil	0
	HS RECOVERY	Trace gas	G2	8	Recovered an unmeasured volume of gas (validity confirmed by chemical analysis)	0
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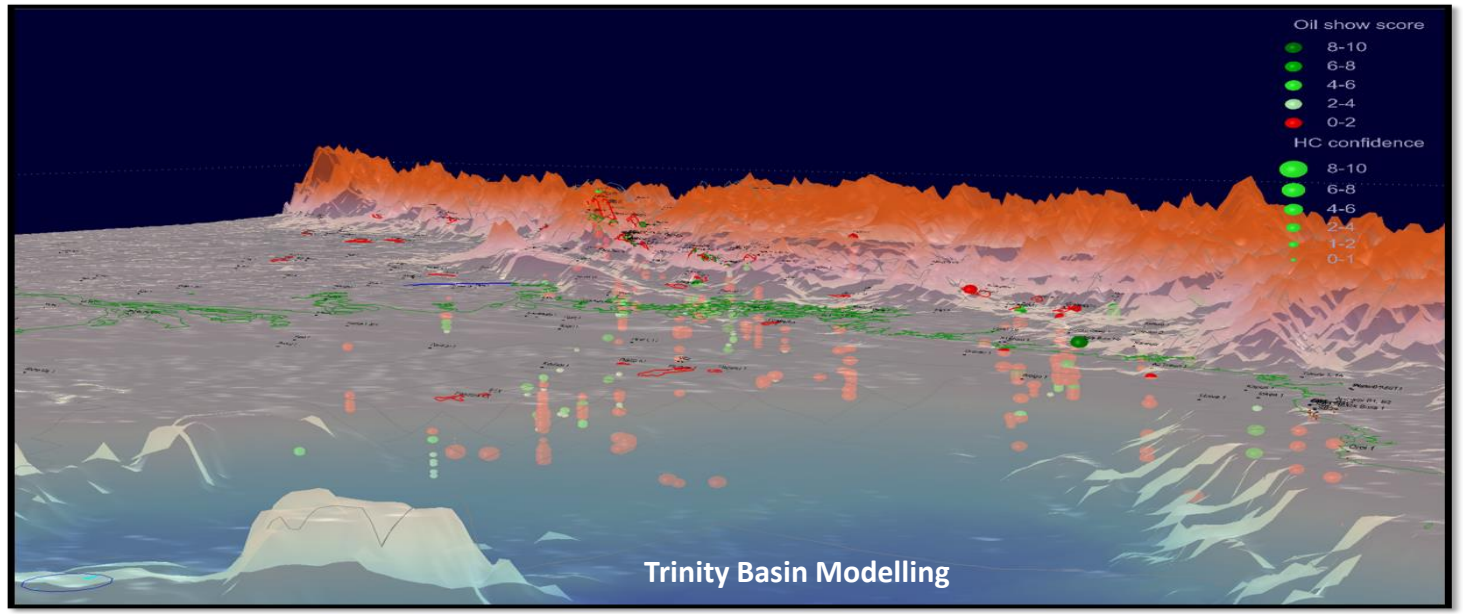
Hydrocarbons indicated from good, multi-point, pressure gradients	HS PRESSURE SURVEY	Measured gas gradient	G2	8	Pressure measurement clearly shows a gas zone	0
	HS PRESSURE SURVEY	Measured oil gradient	L2	8	Pressure measurement clearly shows an oil zone	0

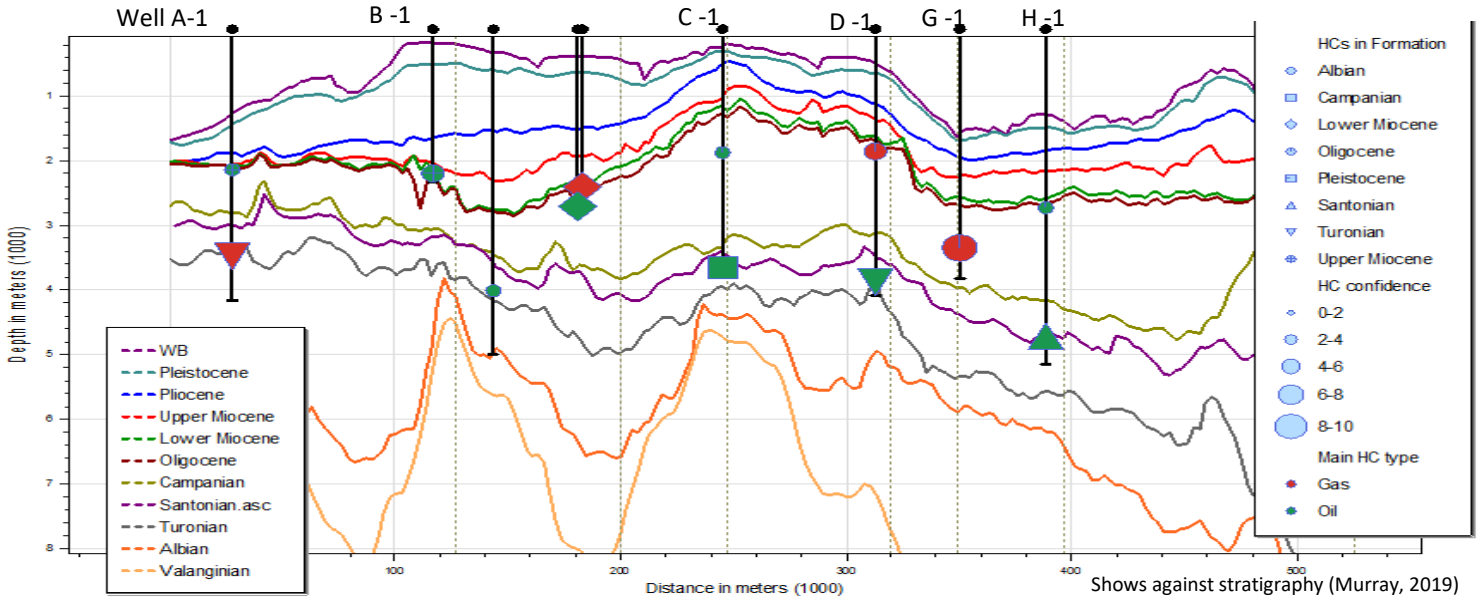
» Shows information from WCR matched against description in ranking system to give a confidence score

6. Application in Exploration

The shows data is utilized in a number of projects

- Used for Basin Modelling to support migration work
- Shows data is displayed with seismically derived depth converted surfaces
- Has an input into multiple software that can support our play analysis work
- Pinpoint zones for further analysis

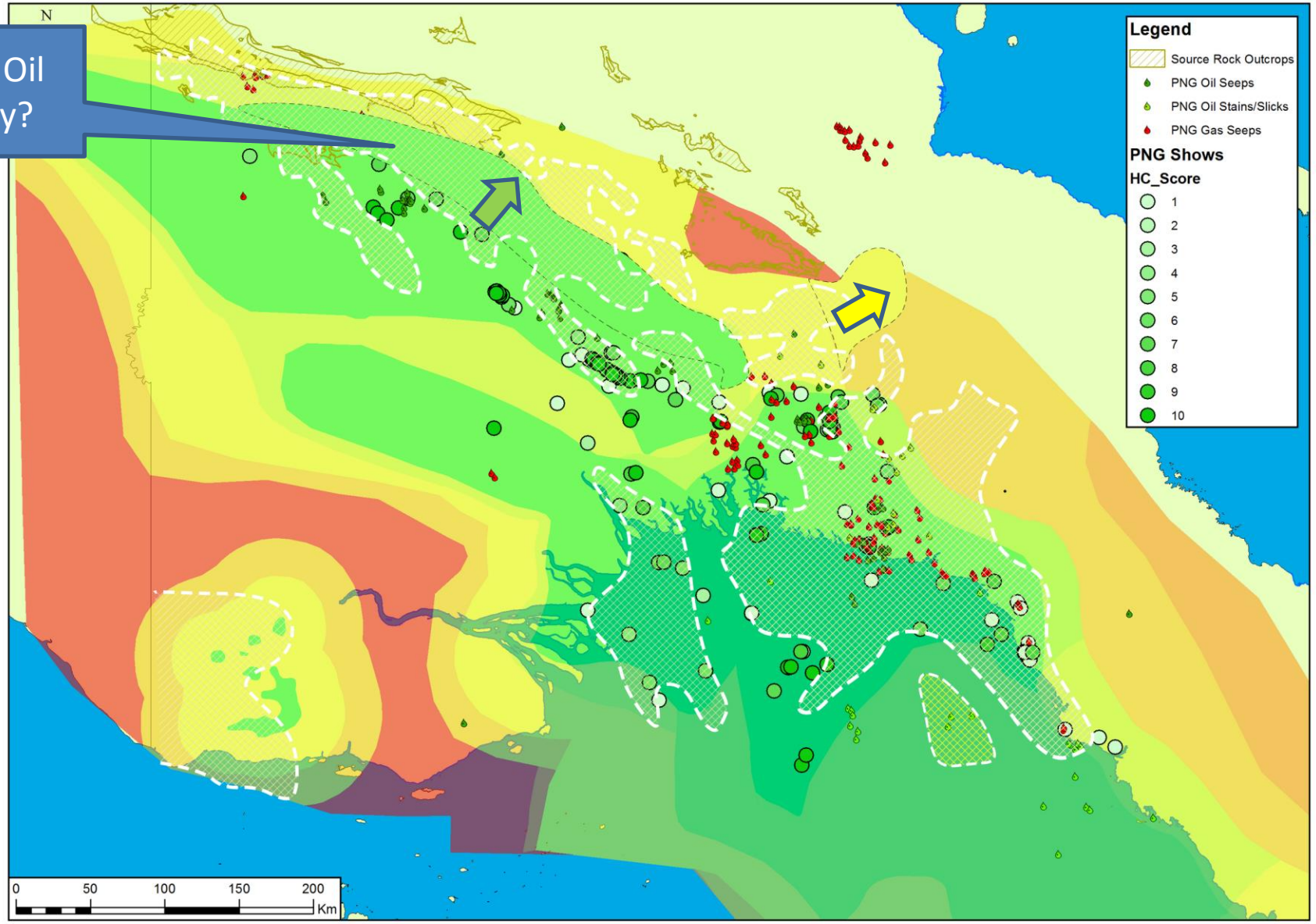




Shows against stratigraphy (Murray, 2019)

Re-Calibration of Charge Fairway

Extend Oil Fairway?

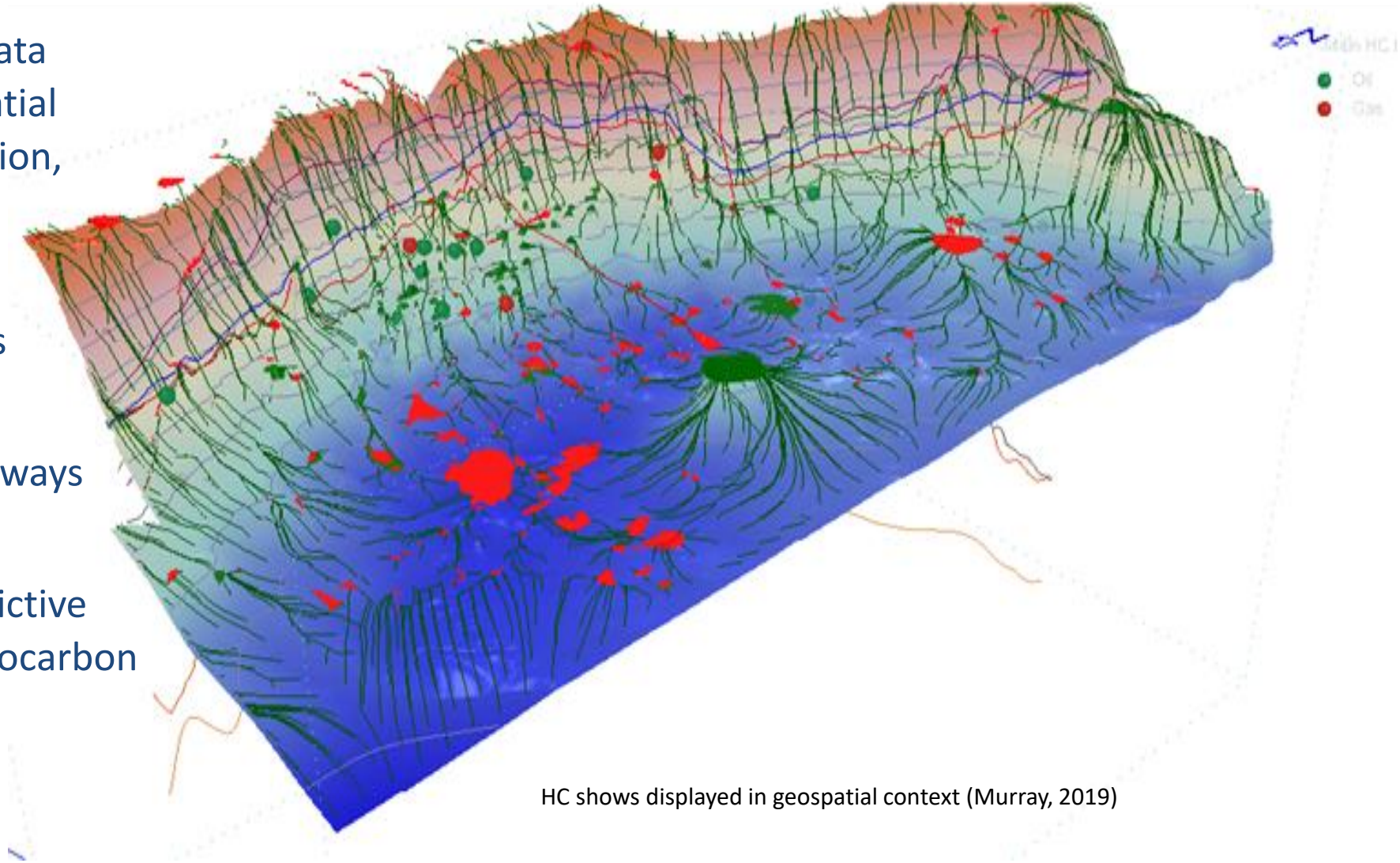


7. Conclusion

The digital hydrocarbon show data along with software derived spatial displays enables rapid visualization, assisting explorers as they;

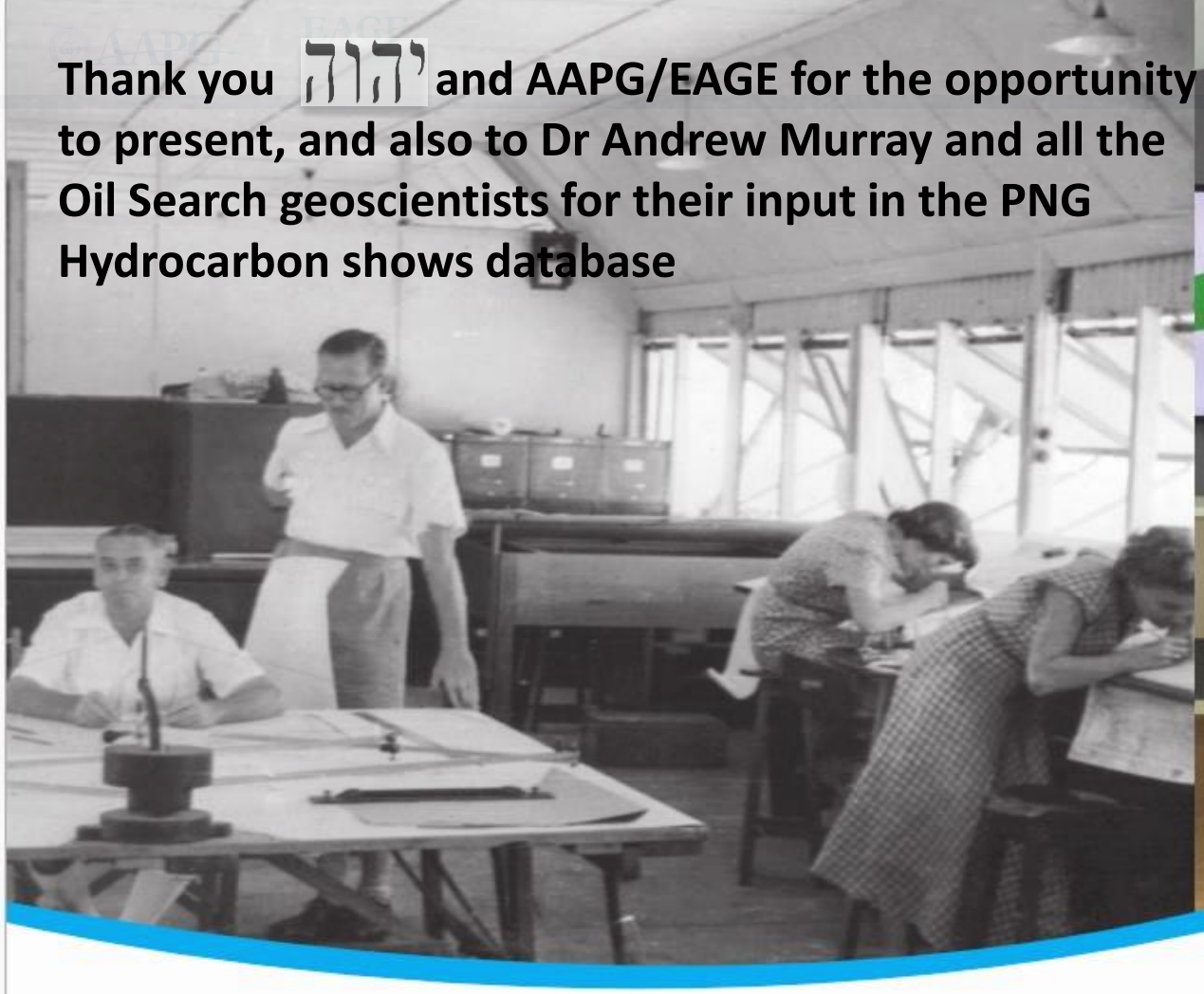
- Seek to identify new patterns
- Seek to prioritize focus areas
- Test potential migration pathways

These provide a calibrated predictive tool to assist explorers risk hydrocarbon charge.



HC shows displayed in geospatial context (Murray, 2019)

Thank you יהוה and AAPG/EAGE for the opportunity to present, and also to Dr Andrew Murray and all the Oil Search geoscientists for their input in the PNG Hydrocarbon shows database



References

He, Z and Murray, A, 2019, Top Down Petroleum Systems Analysis: Exploiting Geospatial Patterns of Petroleum Phase and Properties. AAPG Annual Convention 2019, San Antonio

Schowalter, T and Hess, P, 1999, Interpretation of Subsurface Hydrocarbon Shows. Discovery Article#40001.

Murray Partners PPSA*

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