Apex Spectral Technology, Inc

presents

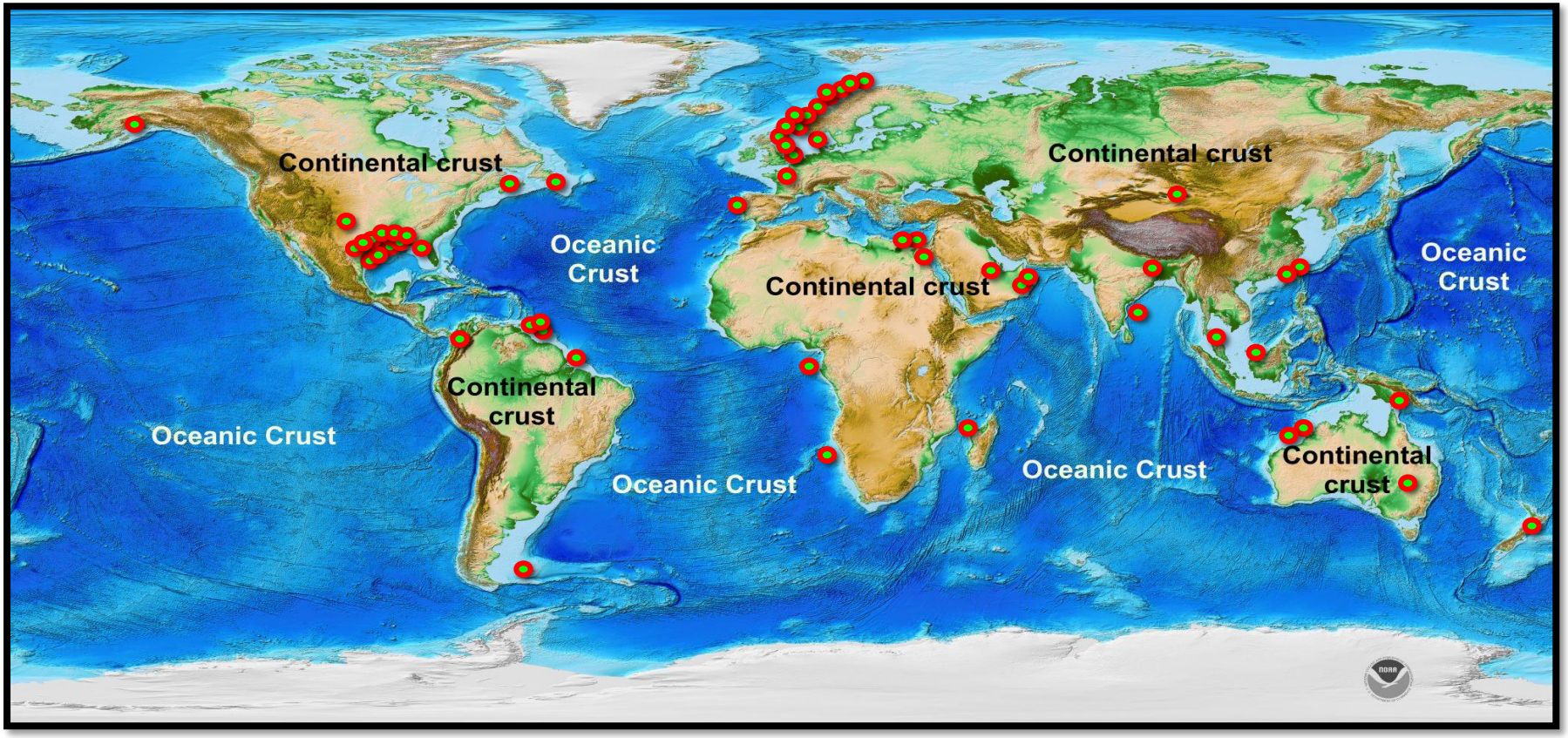
Apex Spectral & ADF® Introduction

ADF® Oman, West of Shetlands & Jamaica Results

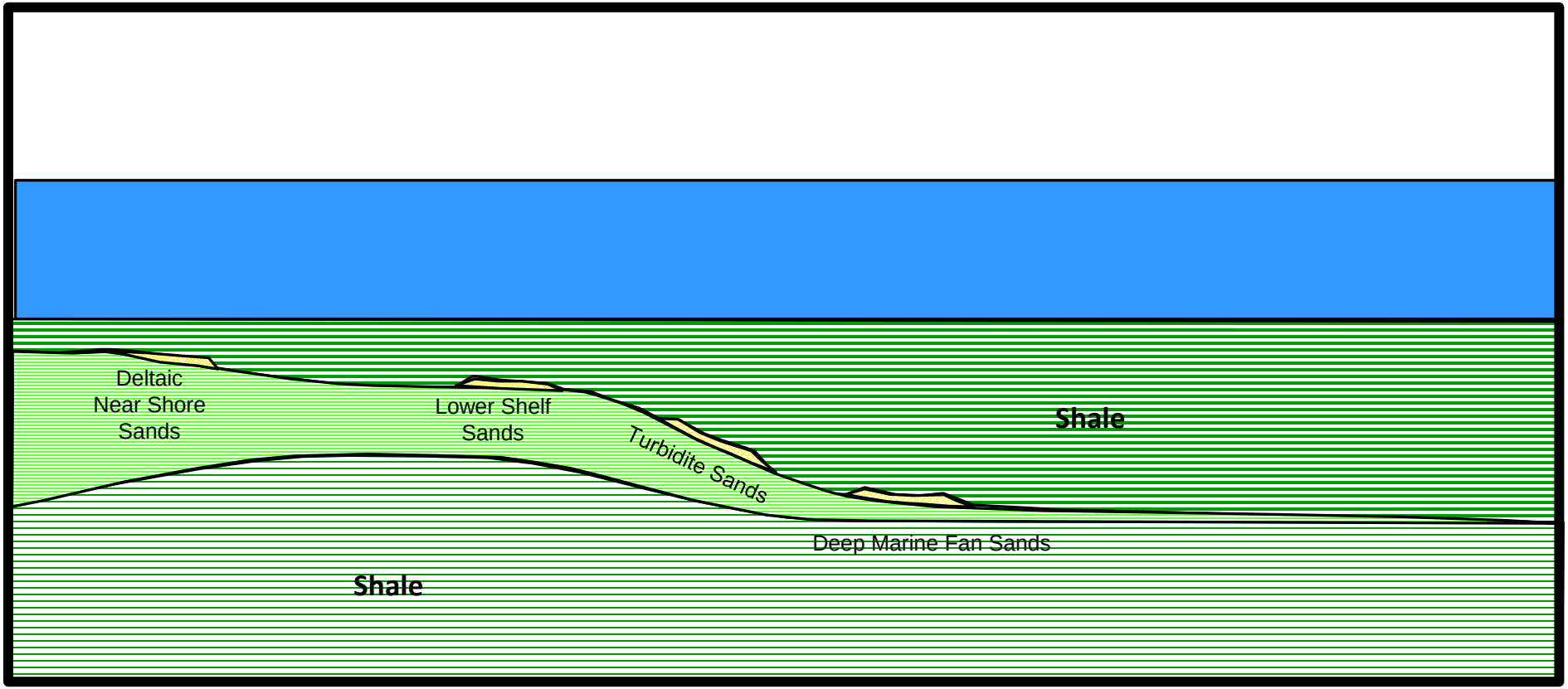
Apex Spectral Introduction

- Founded in 2002, in business 21 years.
- Focused on frequency domain interpretation from the beginning.
- Discovered a first principle 1975 over simplification in seismic theory.
- Invented a new DHI (ADF®) that can image O&G reservoirs in non-Class III sandstones & carbonates
- Invented, patented, commercialized, published ADF®.
- Applied ADF® worldwide.
- Published ADF® blind results in a paper sponsored by Shell/PDO at 2021 EAGE.

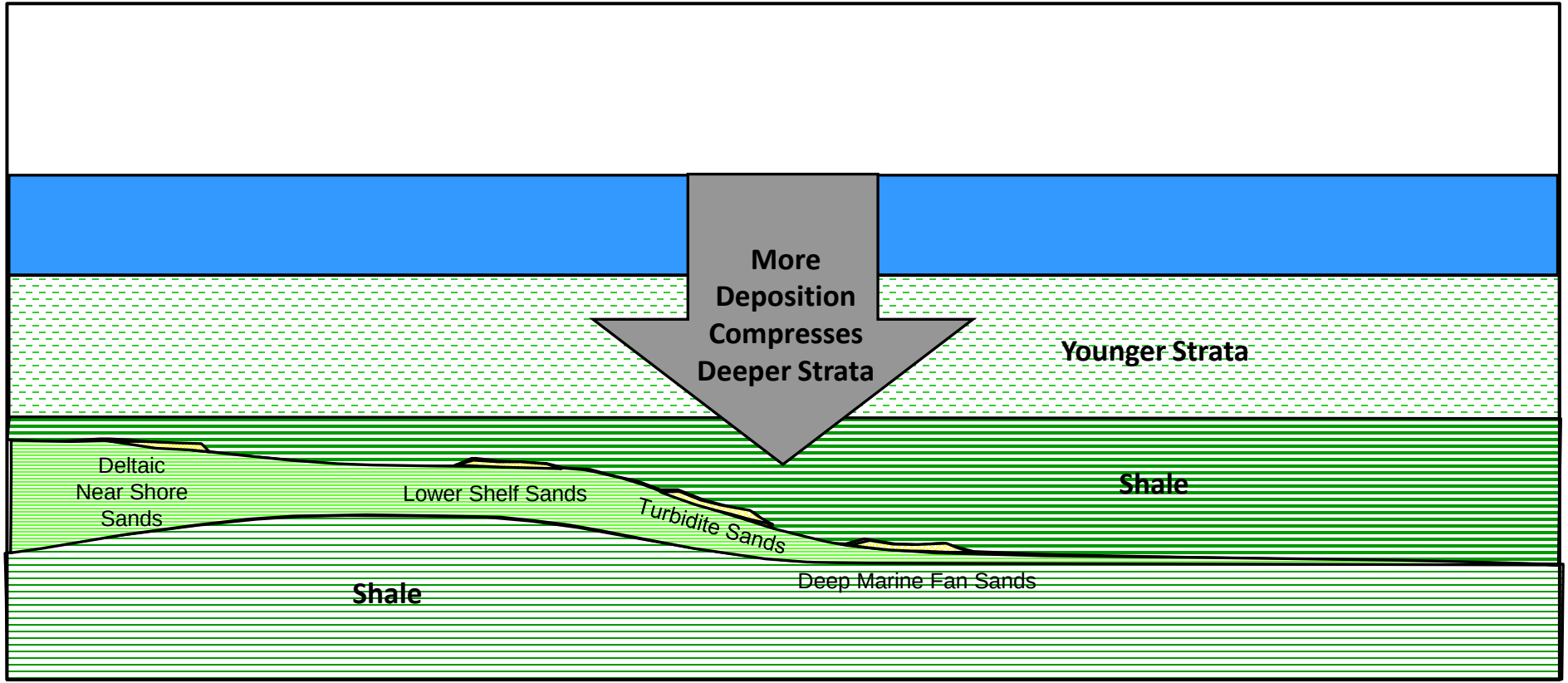
Apex Spectral ADF® Projects



Young Sands Are *Slower* than Shales Creating Gas Bright Spots & AVO



Sands are *no longer slower* than shales; bright spot & AVO become ineffective



Distal Class I and II pay sands can be materially de-risked with ADF®

OIL NOW

Featured | News

Updated: August 27, 2021

After encountering 45 dry holes over a period of 50 years, along came Liza

By OilNOW | August 27, 2021 | 0

A Noble drill ship offshore Guyana

Updated August 27, 2021

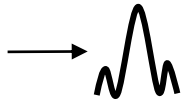
Before 2015, offshore Guyana was considered a "high-risk frontier basin" with *45* wells drilled over a span of years resulting in no commercial discovery. *

- **"Wood Mackenzie said… High-risk exploration as chance of commercial success is lower (5% vs 8% in emerging and 11% in mature basins) due to uncertainty around field size and hydrocarbon type (oil versus natural gas)."**
- **Shell relinquished the Stabroek block before Exxon picked it up. Liza, the Stabroek discovery well, was a commitment well that Exxon tried to get out of drilling.**
- **45 times in a row some combination of amplitude, AVO and Elastic Impedance (industry mainstay fluid type deterministic tools) didn't work. Nonetheless, some believe the theory behind these methods is mature.**
- **The industry's track record self-evidently speaks for itself. Seismic theory behind industry mainstay tools is fundamentally flawed.**

What is Seismic Data?

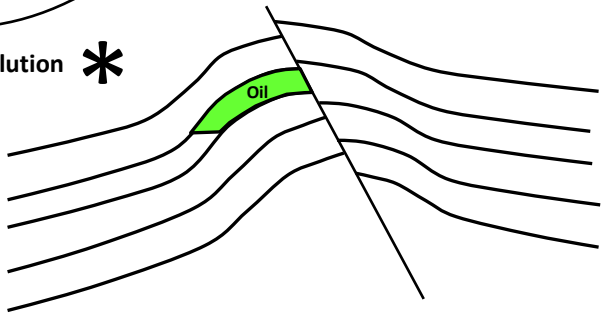
Hitting a range of keys creates a wavelet

A Wavelet



A wavelet contains a *range* of frequencies

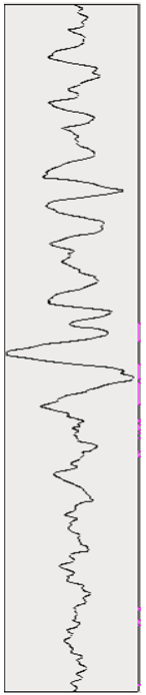
Convolution *



Reservoirs have Perm and Relative Perm

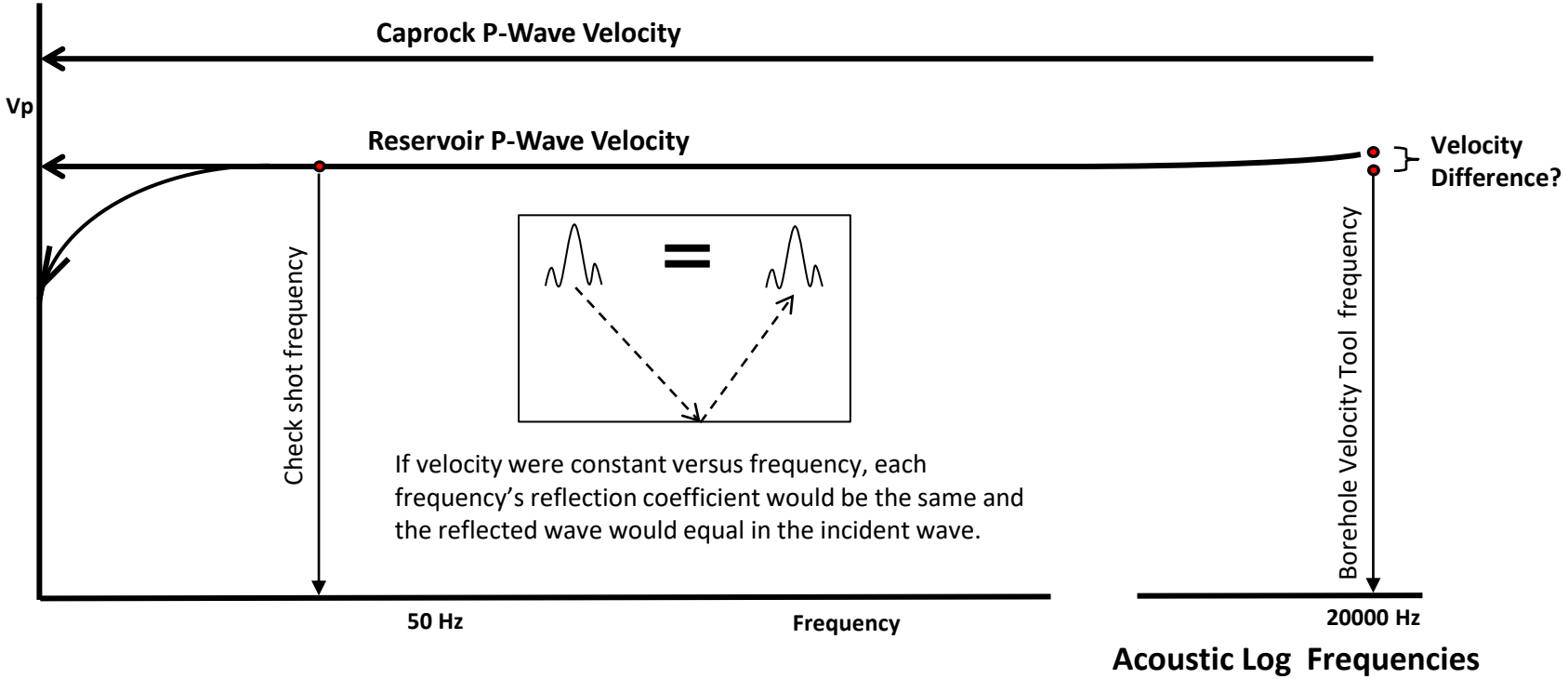
=

Receiver



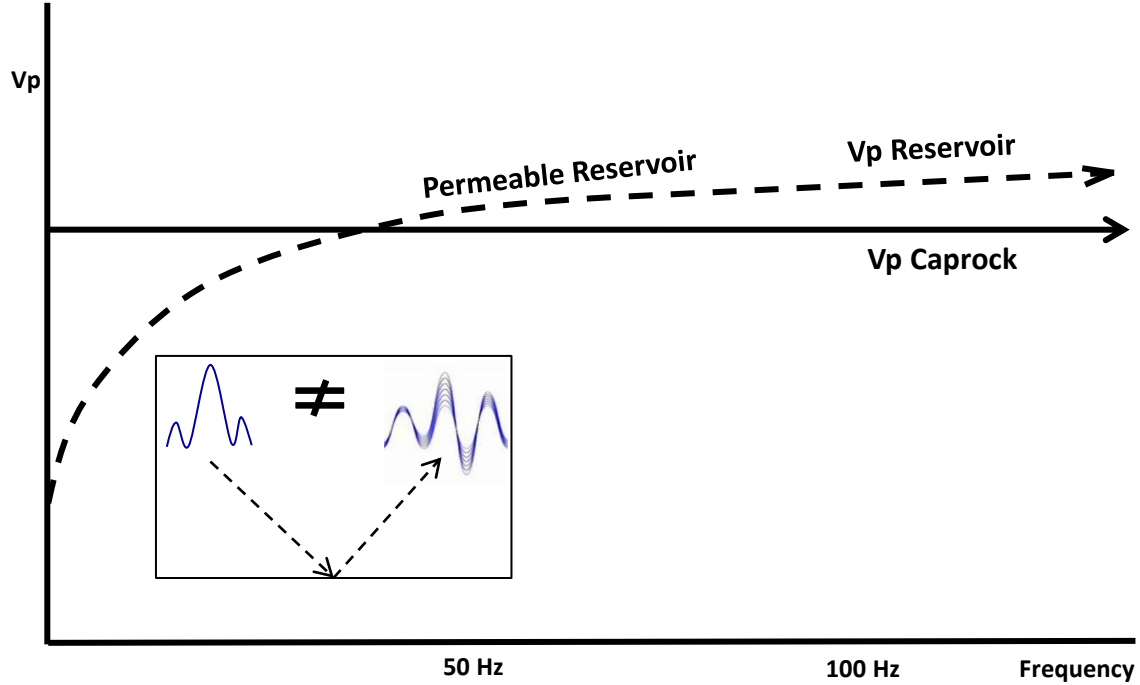
Seismic is wavelets & geology

The industry made a first principal simplification in 1975. They assumed no dispersion in seismic.



No dispersion is the foundation of the idea that the wavelet can be treated as static

Permeable reservoirs cause pronounced P wave velocity dispersion



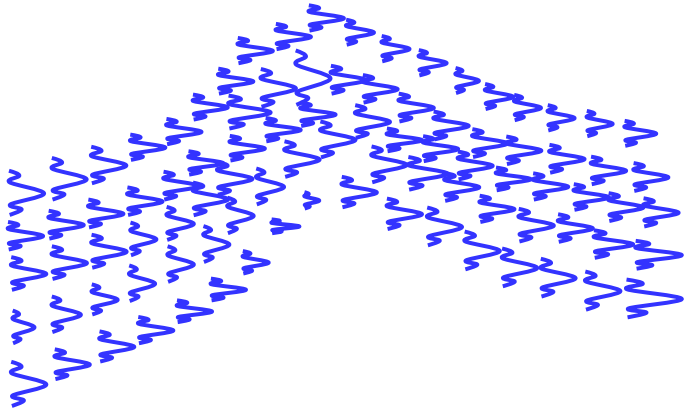
Dispersion makes the wavelet highly dynamic

One Wavelet Per Volume or *Per Sample?*

One wavelet

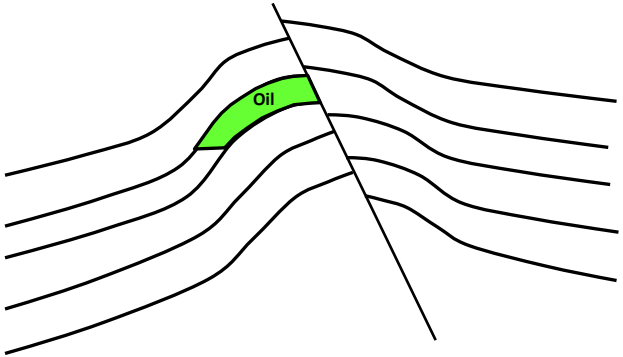
Or

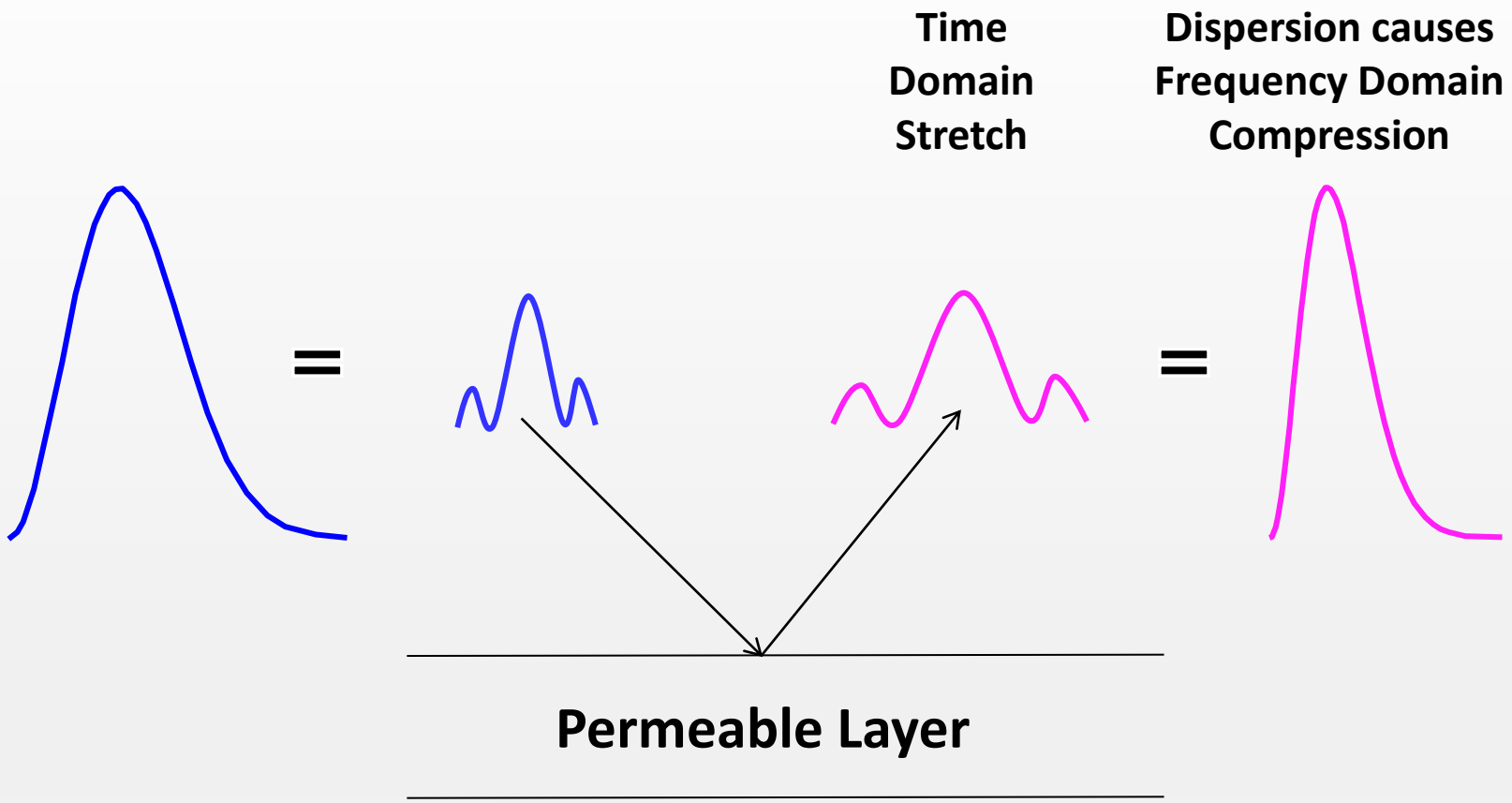
One wavelet per sample



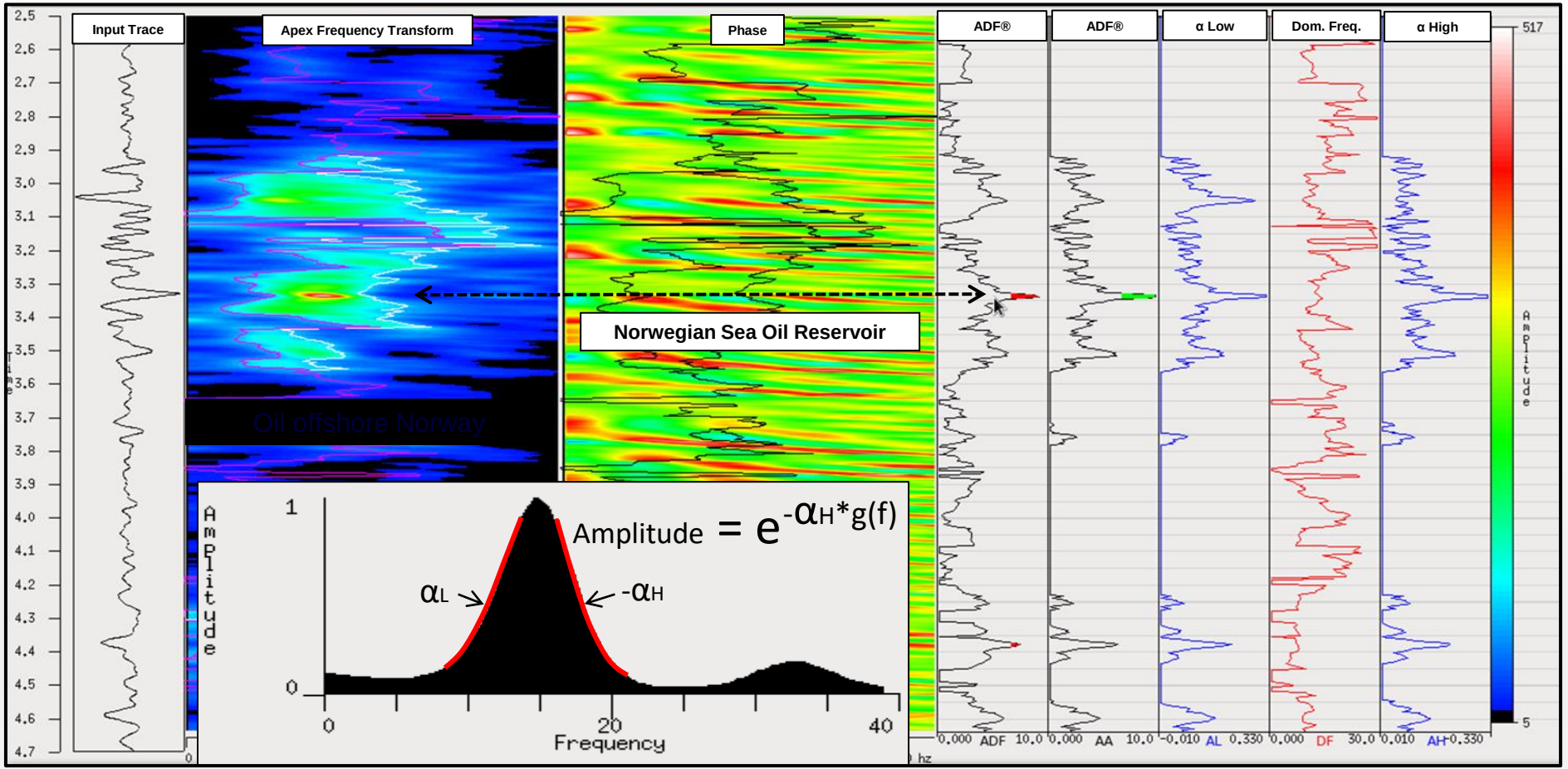
&

Geology




Time
Domain
Stretch
Dispersion causes
Frequency Domain
Compression
=
=
Permeable Layer

Dispersion causes frequency domain compression



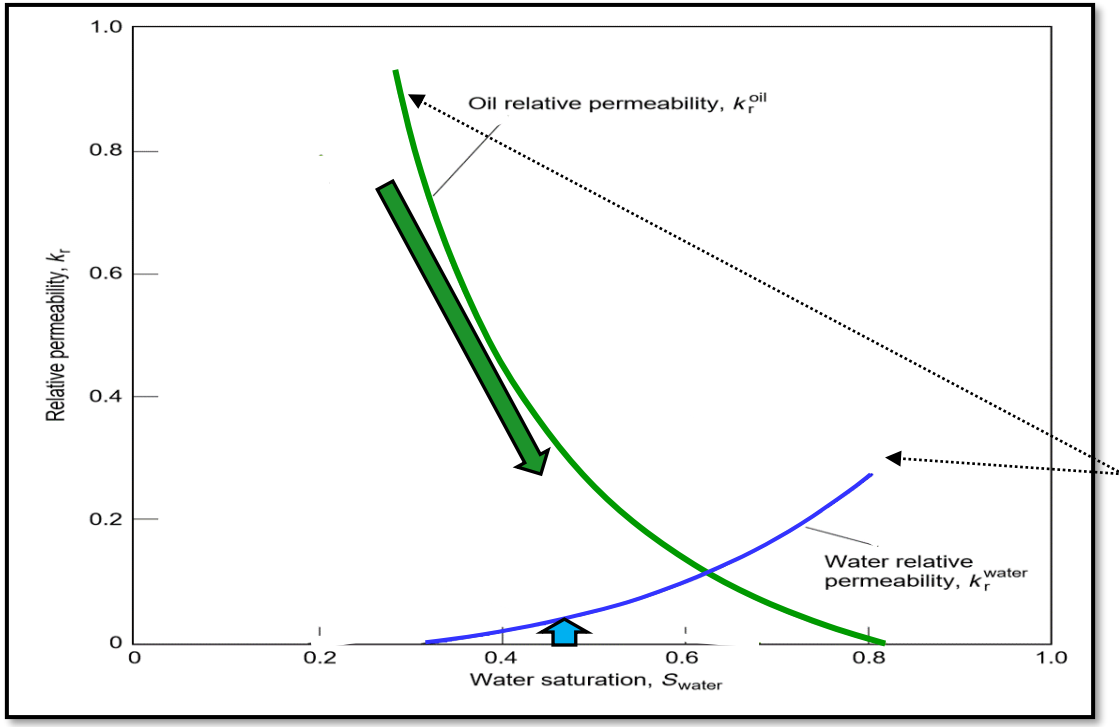
ADF® & Dispersion (“frequency dependent P-wave velocity”)

- **Fluid movement** in pore throats due to the seismic wave **causes dispersion**
- ***Perm, relative perm and thickness*** determine fluid movement
- ADF® images dispersion/***perm, relative perm & thickness***
- ADF® is **independent of amplitude**
- *ADF® **uses only seismic** as input, no well data is used*

*ADF® is broadly patented

Two types of Perm – Intrinsic and Relative

The large relative permeability drop as a reservoir is produced causes *large* ADF® 4D effect



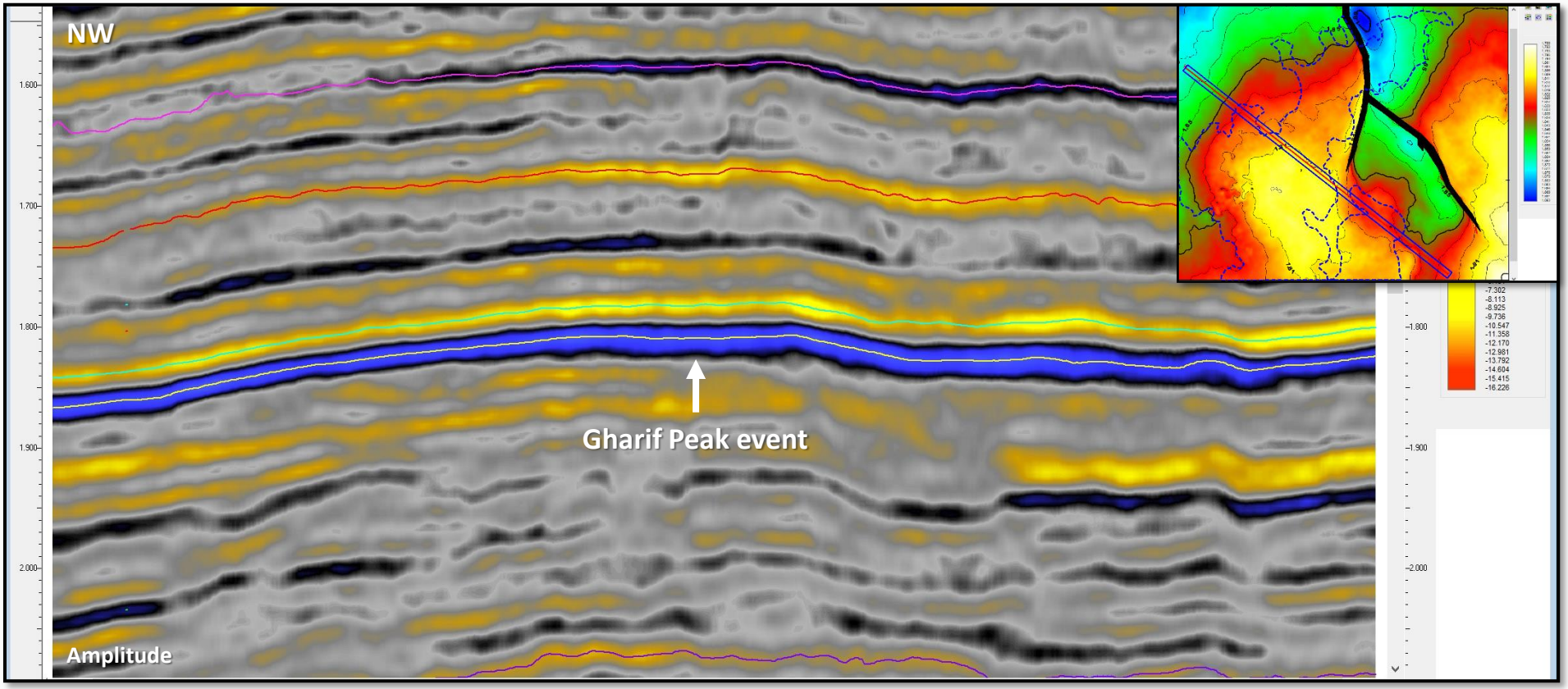
Relative permeability causes ADF® to be a DHI because oil typically has much higher relative perm than brine

Toward Improved Prediction of Reservoir Flow Performance; John J. Buckles, Randy D. Hazlett, et al

Shell/PDO Oman Blind Test Proof of Concept Project

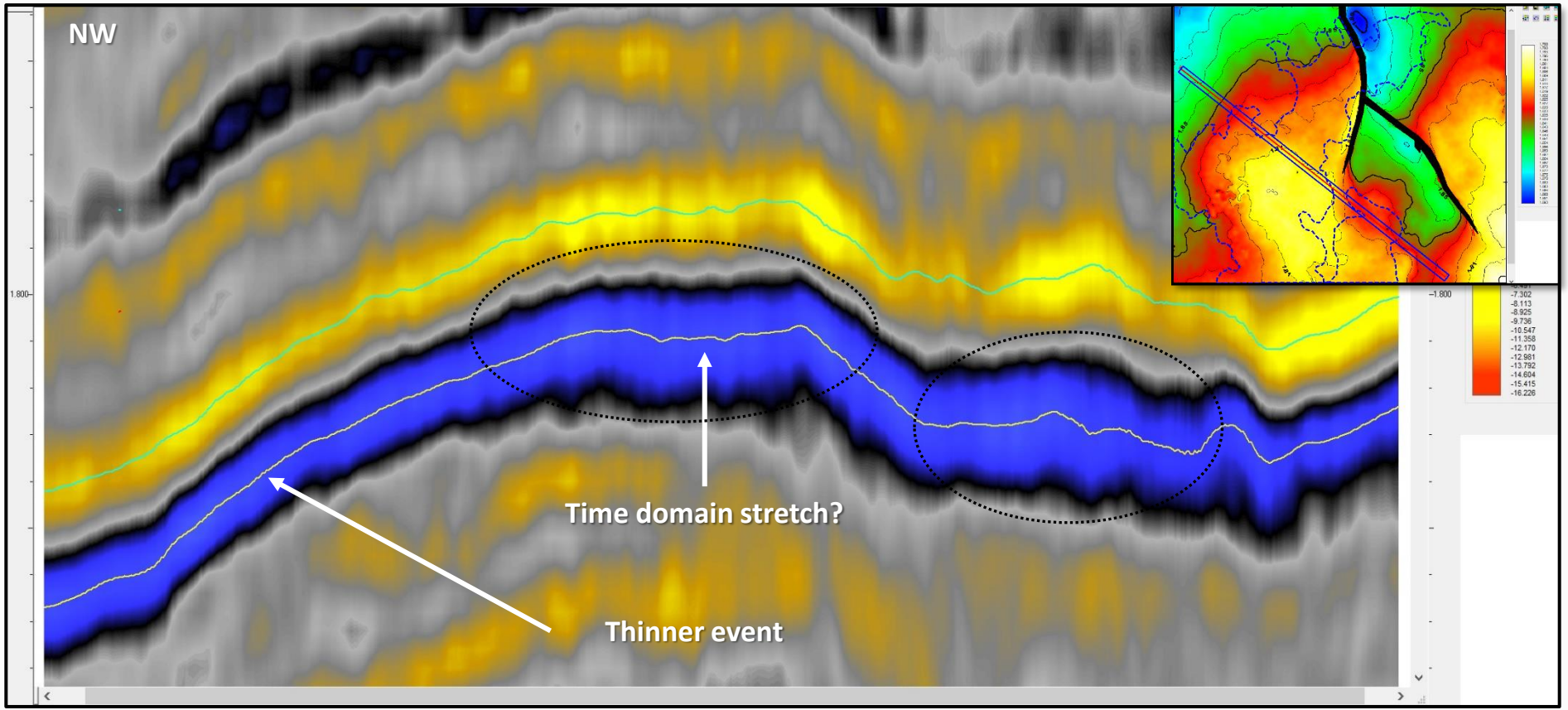
“Dispersion Imaged Field with No Amplitude DHI”

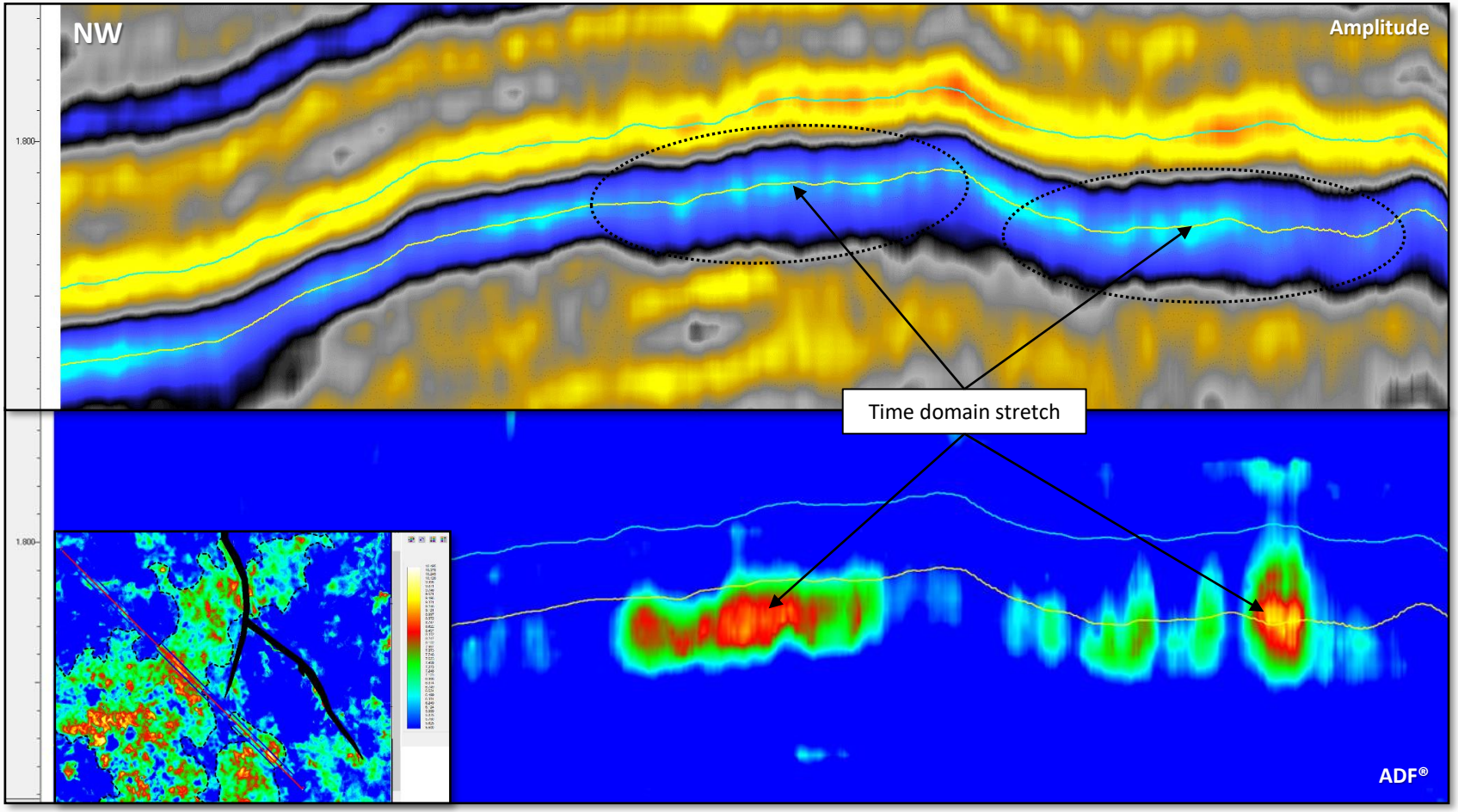
Published October 21, 2021



Courtesy of Petroleum Development Oman

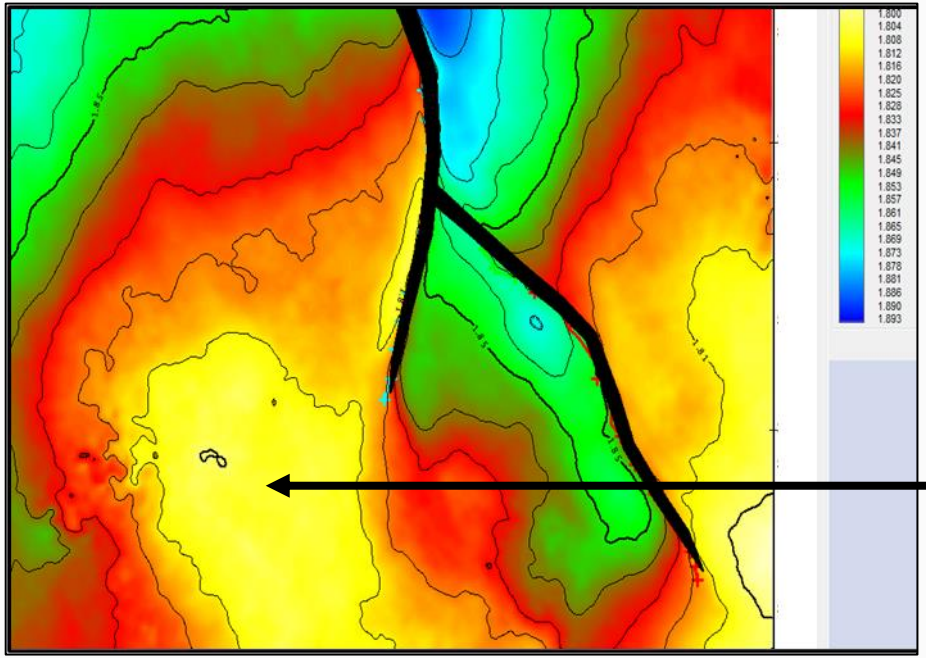
Zoom-In of Previous Slide



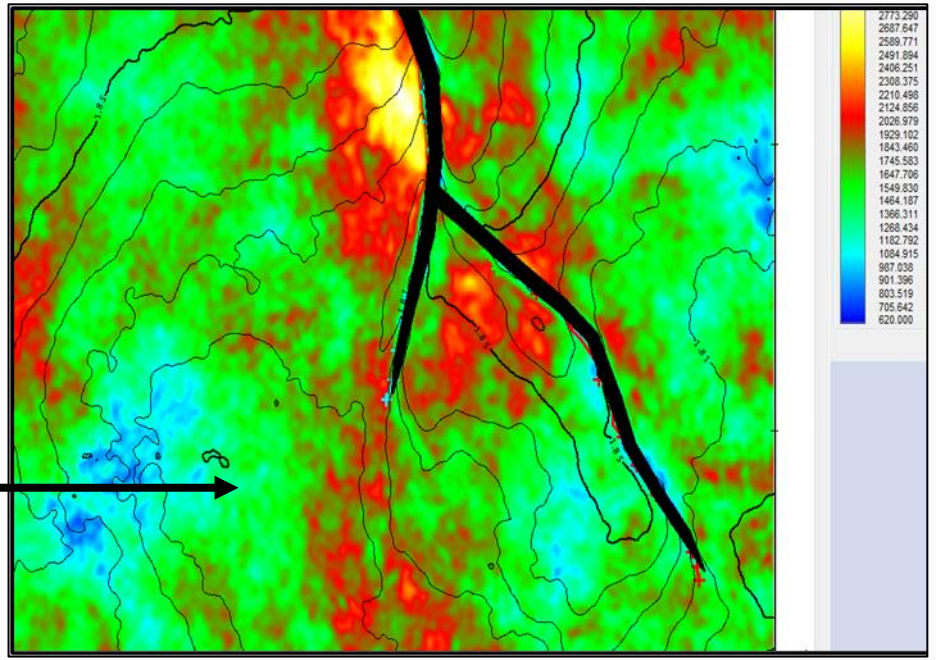


Courtesy of Petroleum Development Oman

Gharif Peak Time Structure



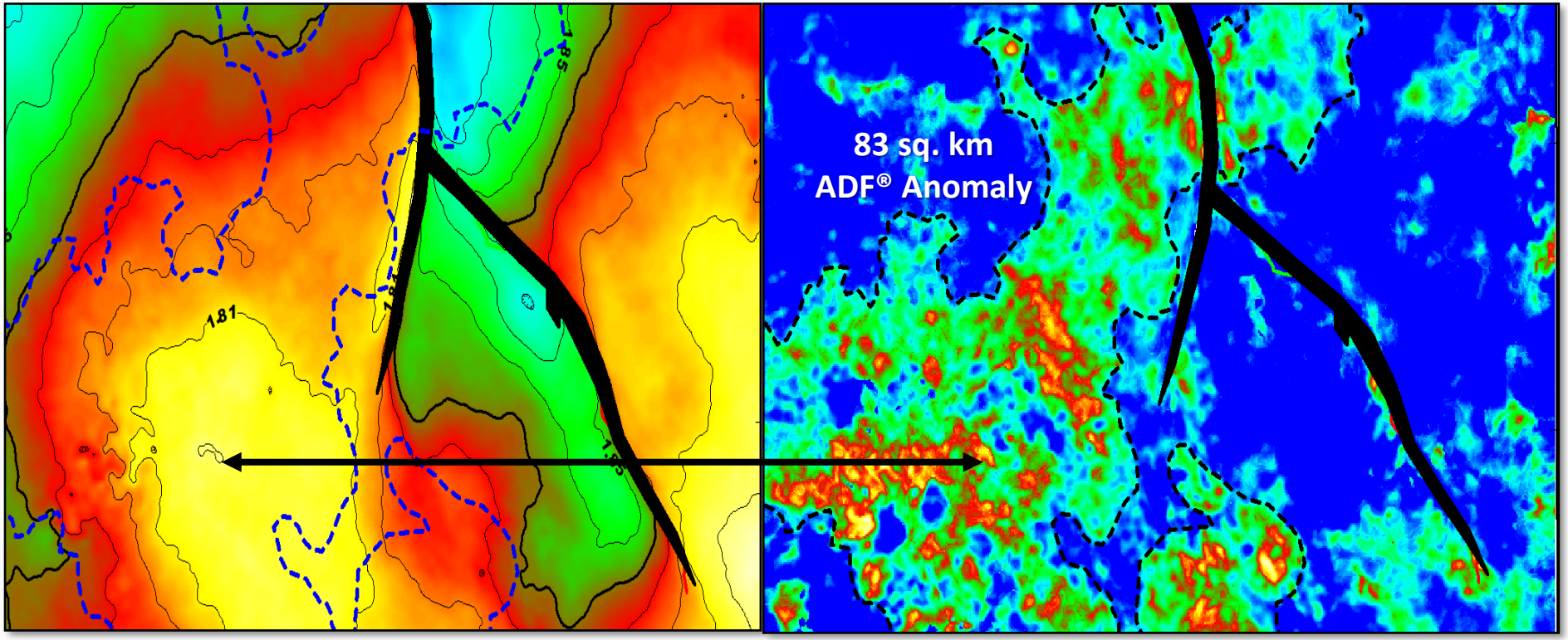
Gharif Peak Amplitude



Amplitude shows no correlation to structure

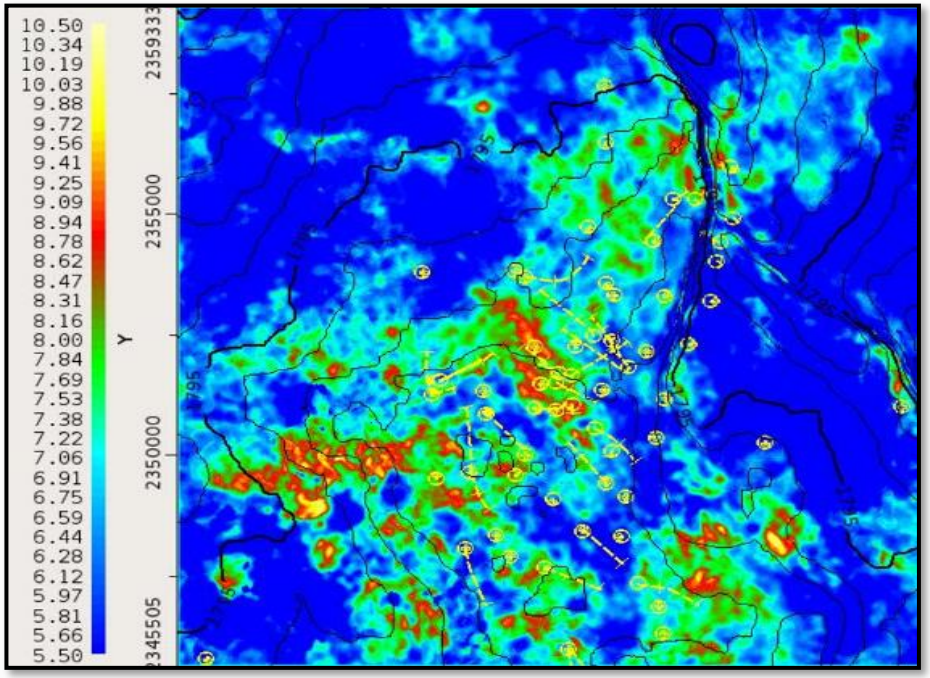
Gharif Peak Time Structure

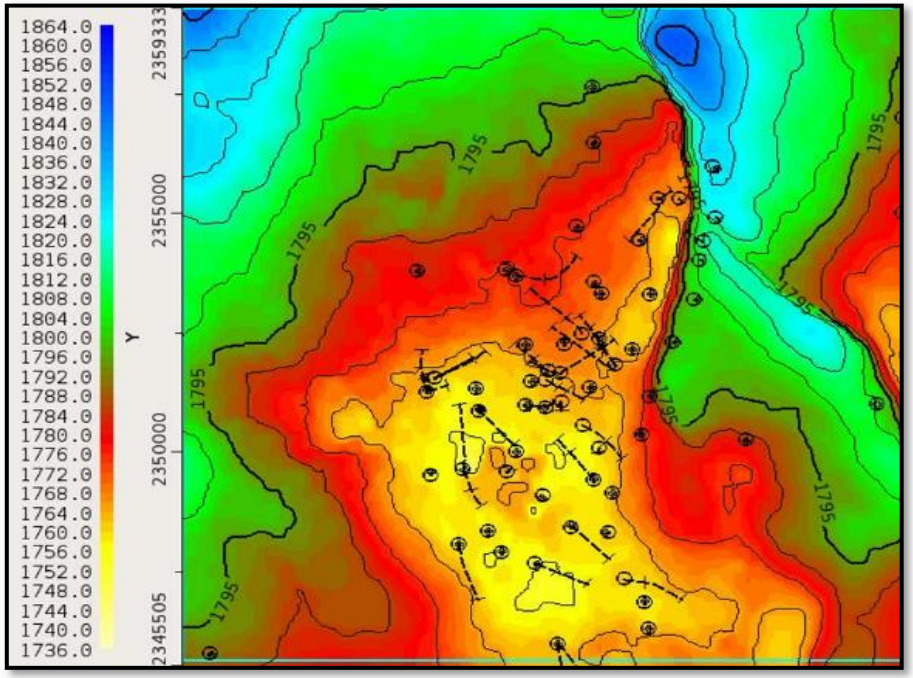
Gharif ADF®

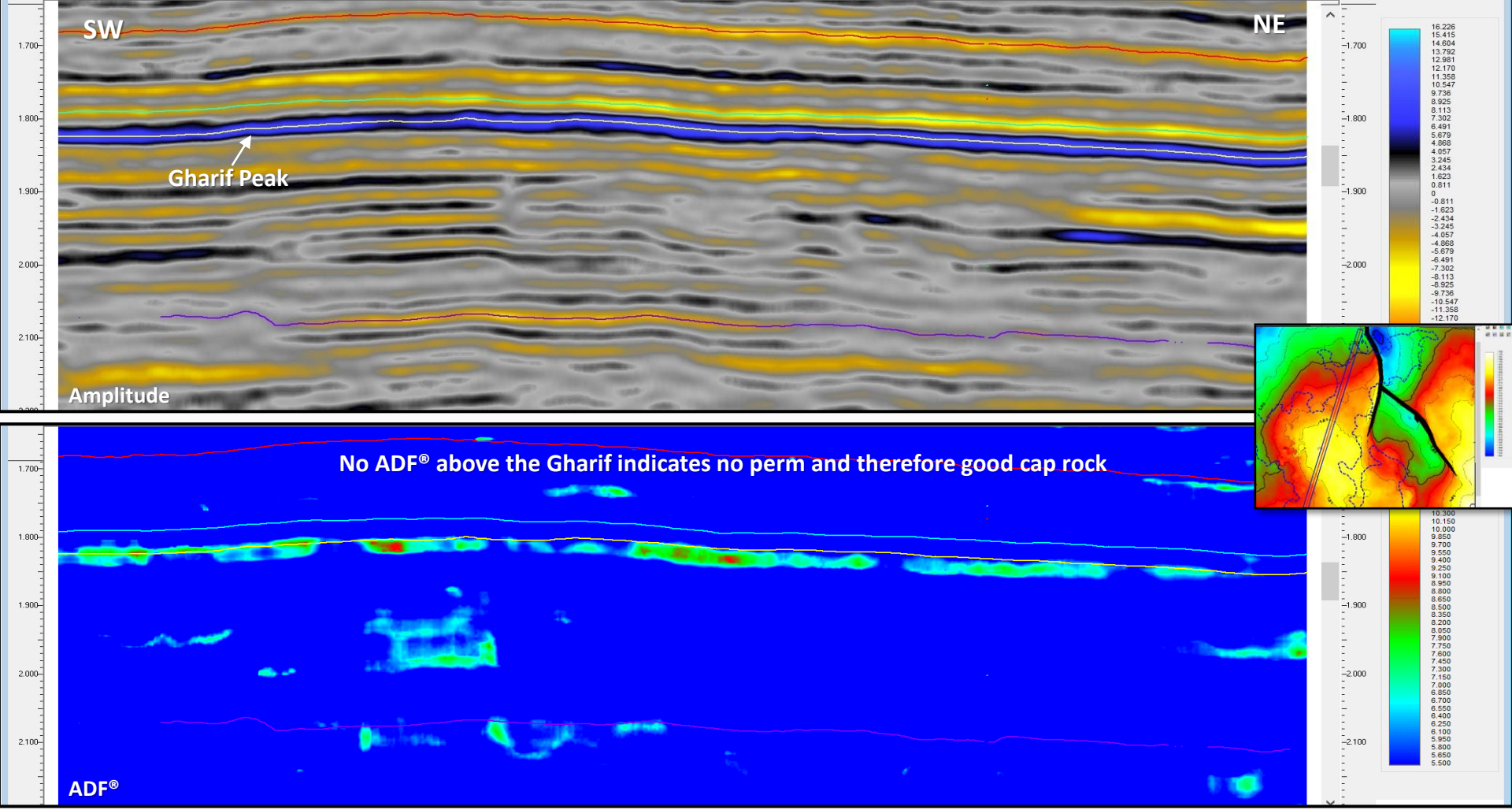


ADF® shows significant correlation to structure

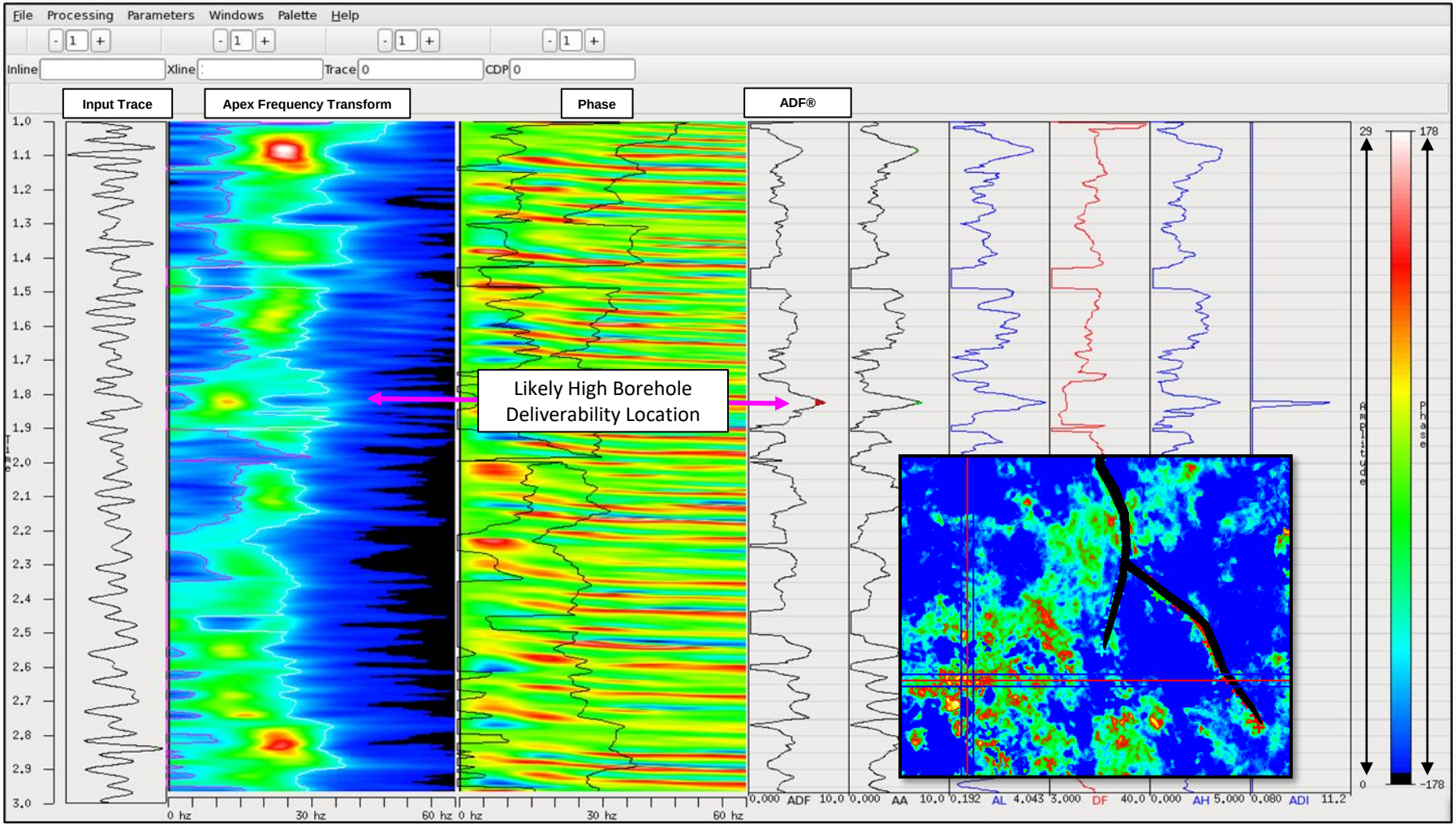
PDO Provided Well Spots Show Good Match to ADF® and Some Likely Depletion Effects







Courtesy of Petroleum Development Oman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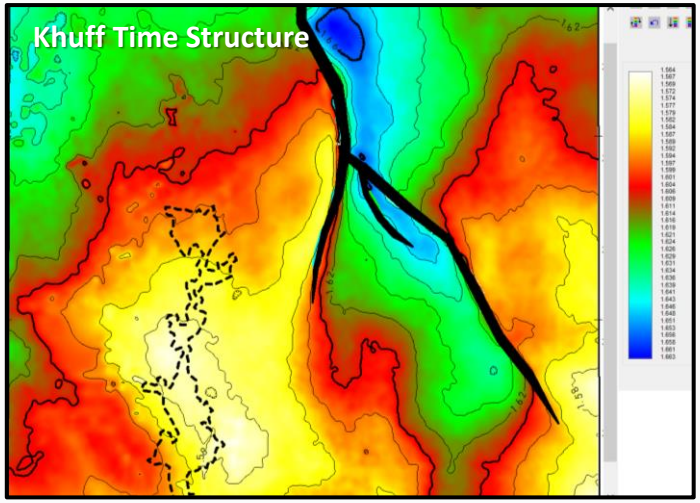
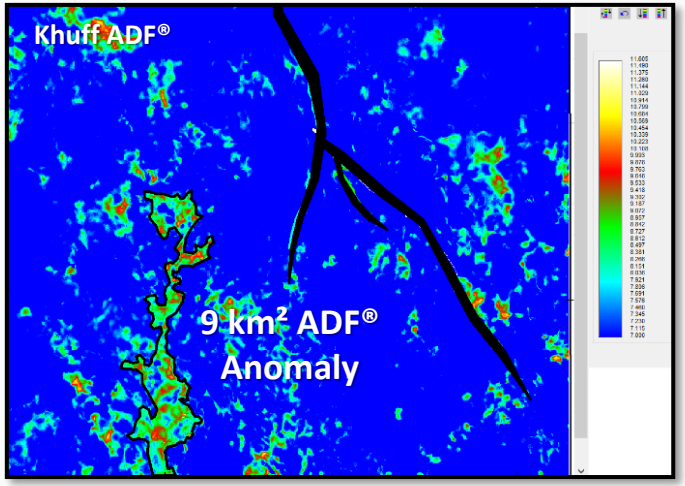
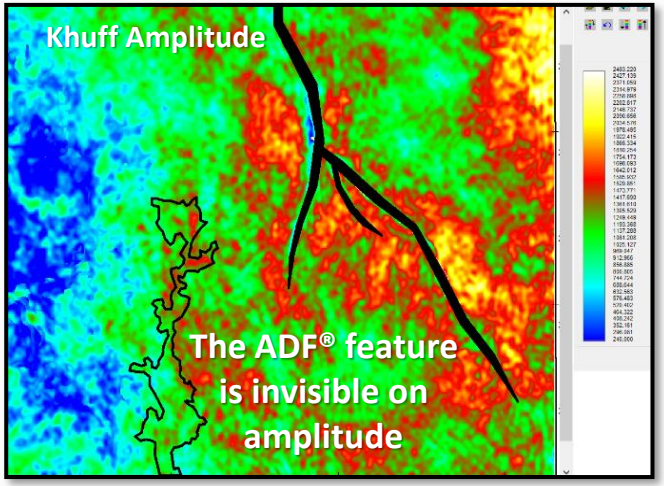
CDP 0
Input Trace
Apex Frequency Transform
Phase
ADF®
Likely High Borehole Deliverability Location
0 hz
30 hz
60 hz
ADF
AA
AL
DF
AH
ADI
Amplitude
Phase
178
-178

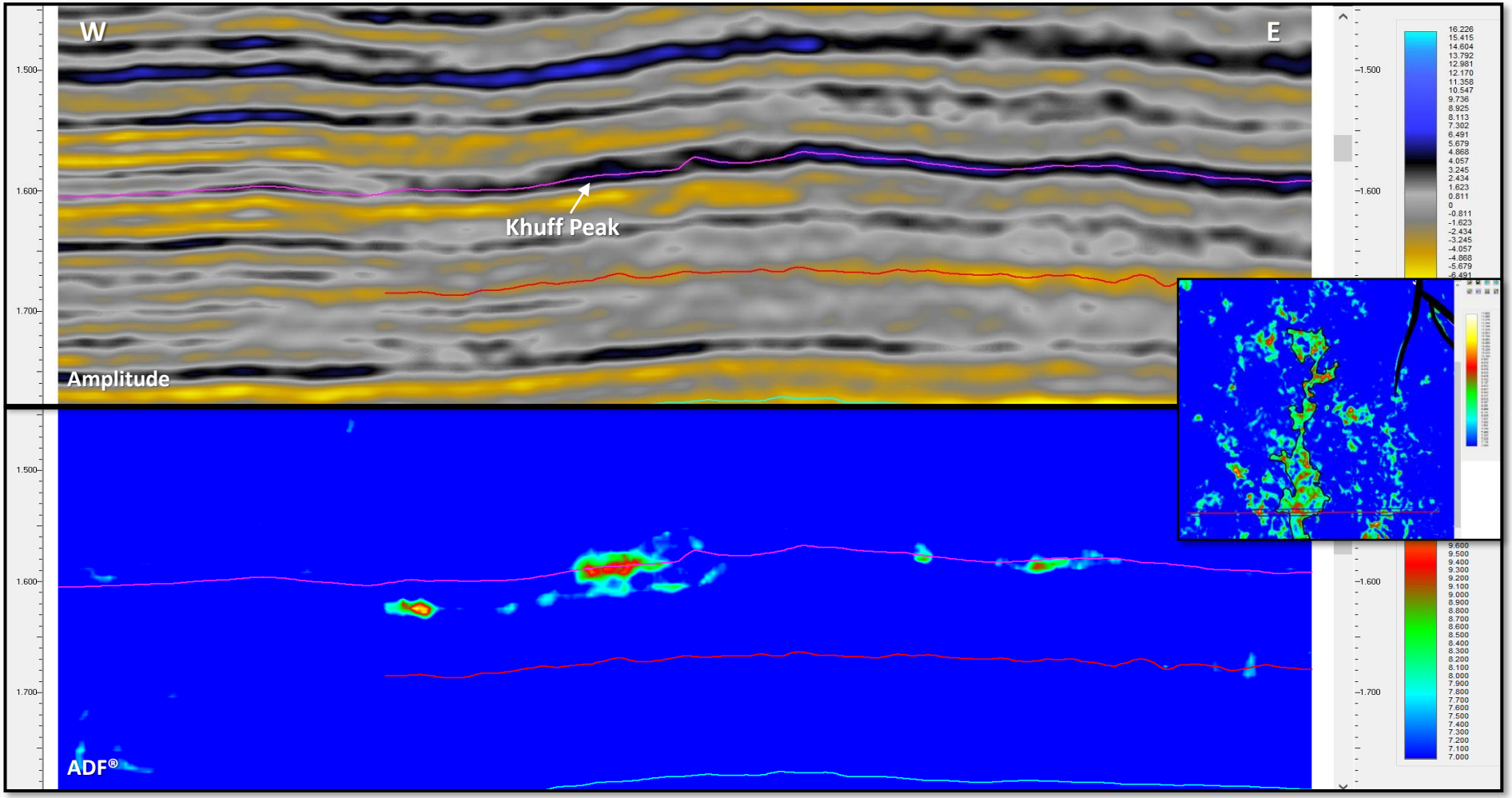
Khuff Carbonate ADF® Analysis

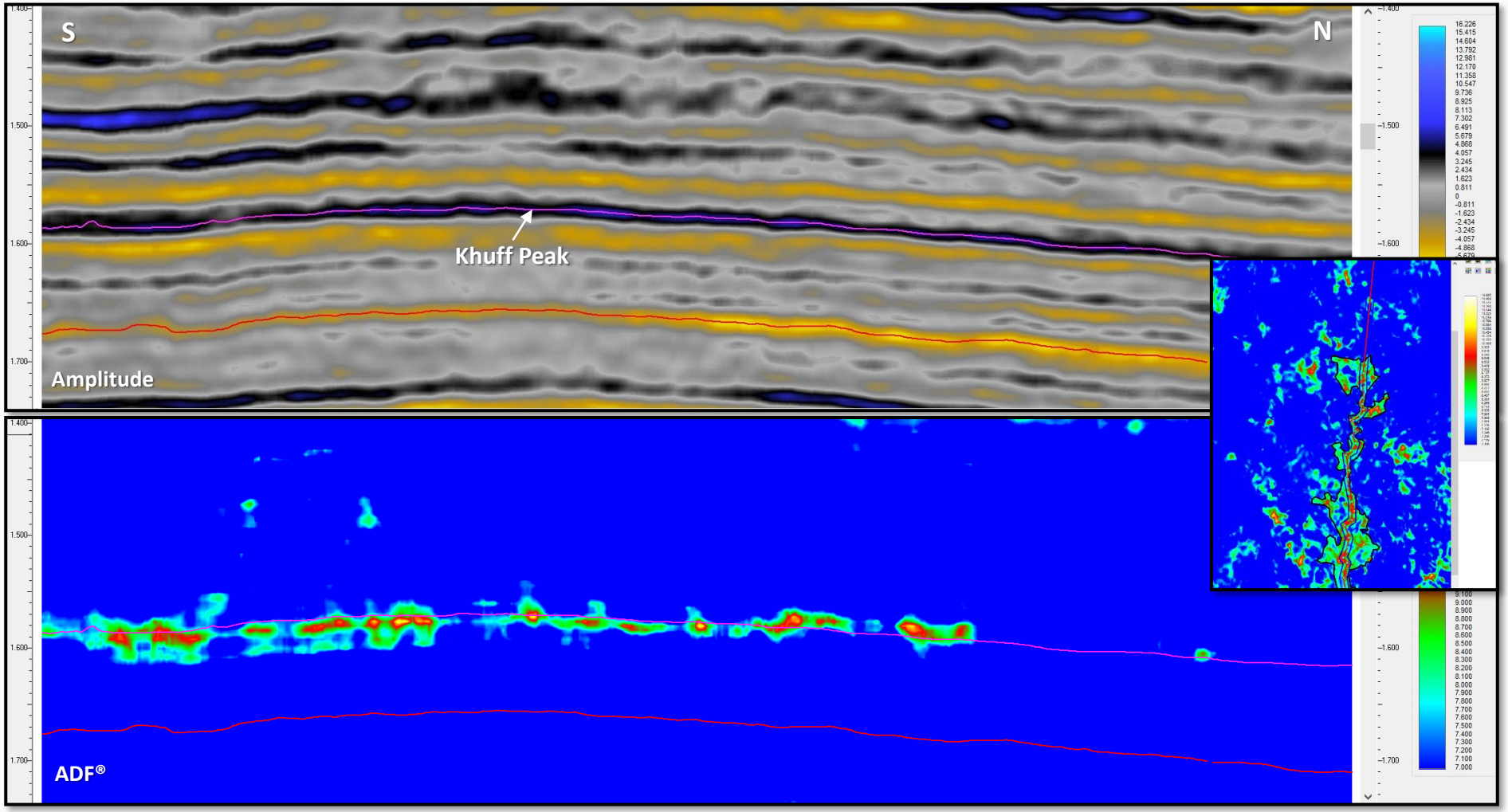






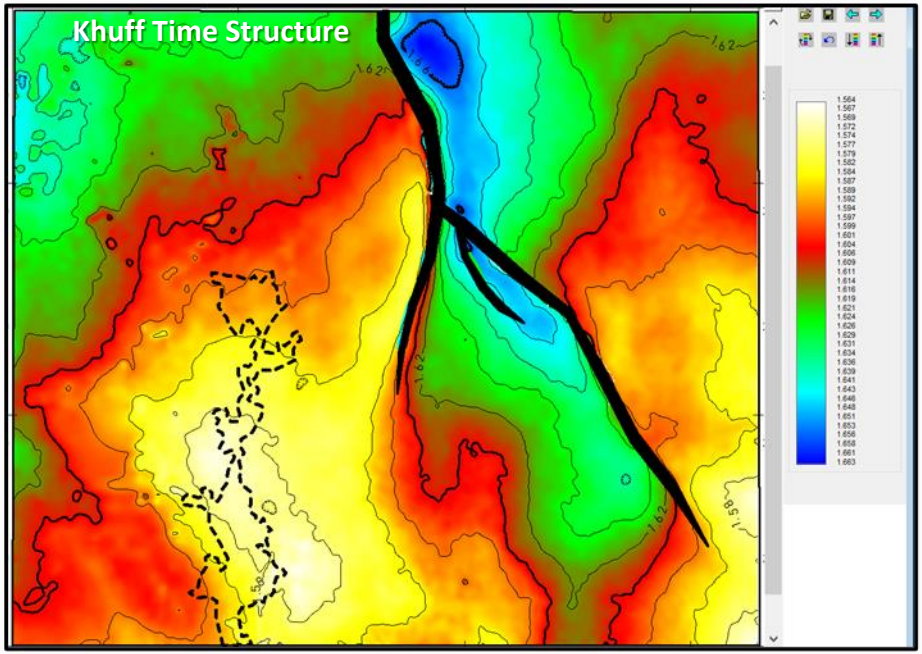
Courtesy of Petroleum Development Oman

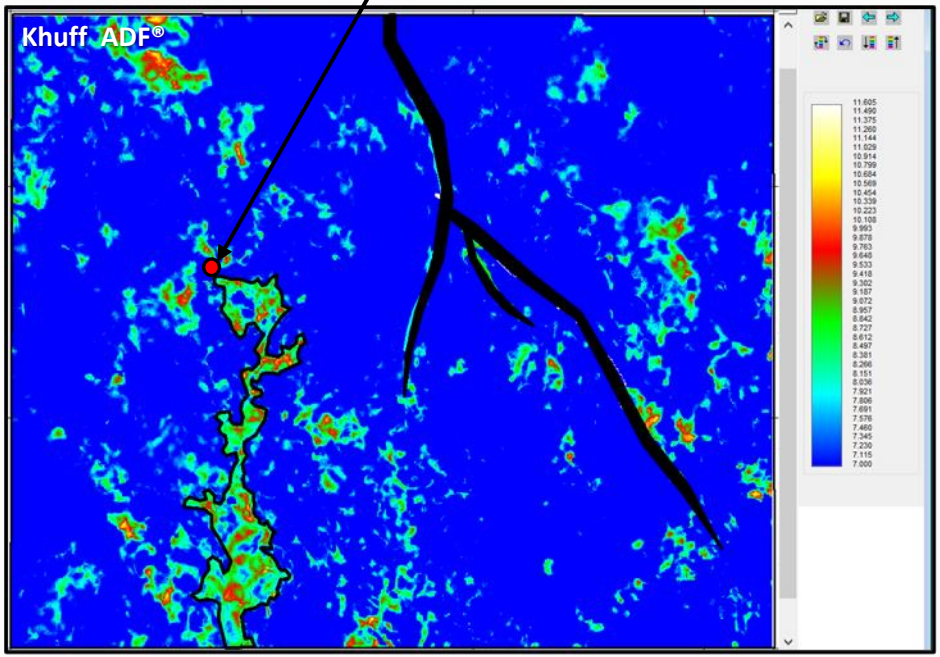

W
E
Khuff Peak
Amplitude
ADF®
1.500
1.600
1.700



Courtesy of Petroleum Development Oman

Well MBR35 was interpreted to be “HC at Khuff level” by PDO

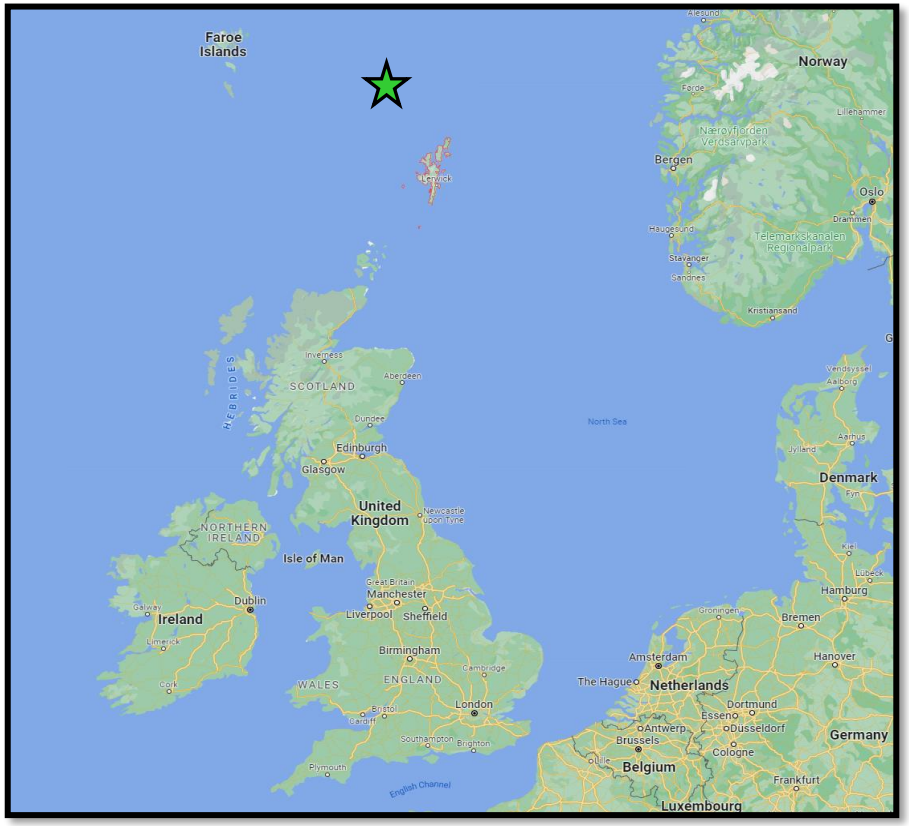


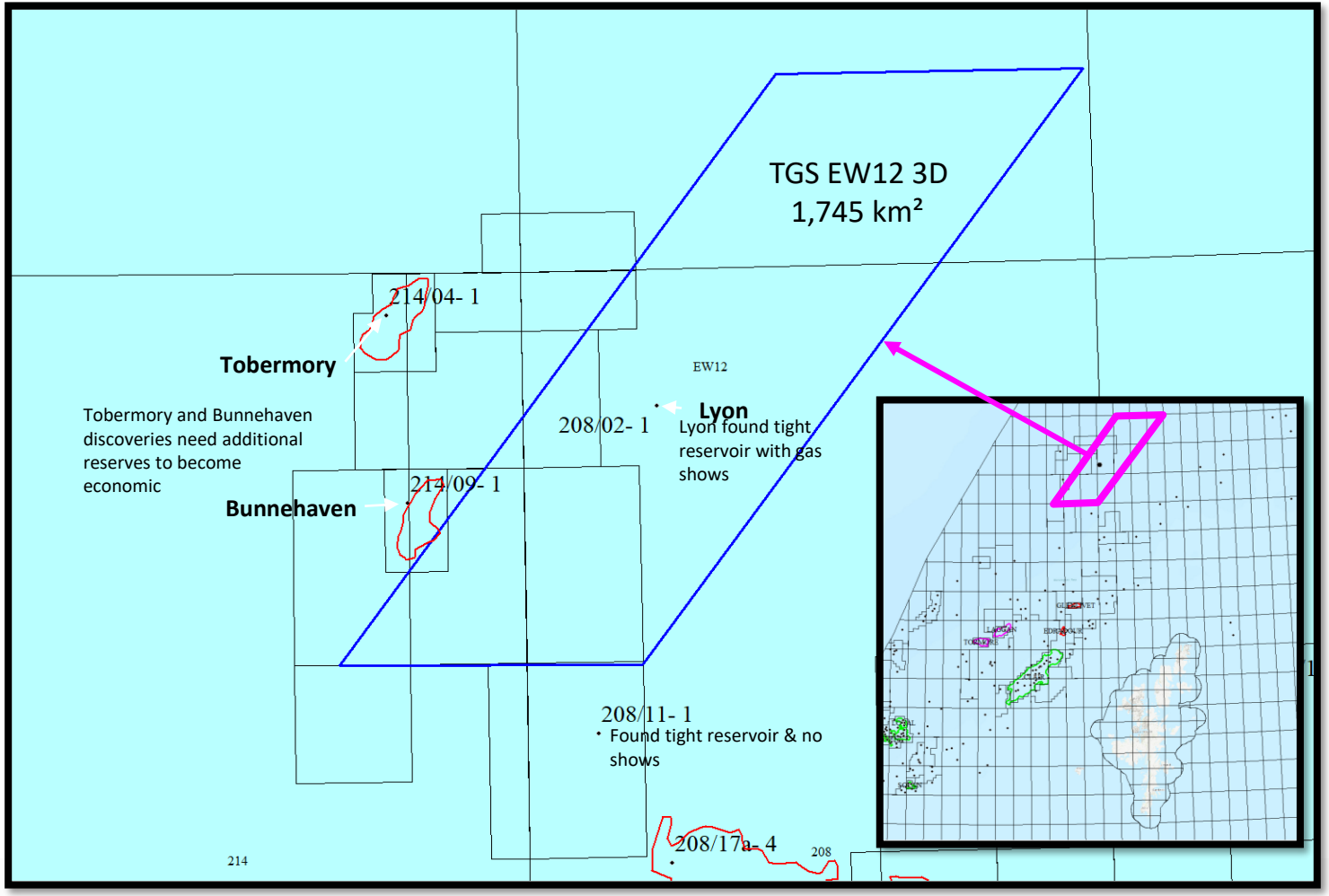


Summary Comments

- These results illustrate ADF® is a material risk reducer in siliciclastic strata.
- These results support ADF® being a material risk reducer in carbonates.

West of Shetlands TGS EW12 3D Prospects




TGS EW12 3D
1,745 km²
214/04- 1
Tobermory
Tobermory and Bunnehaven discoveries need additional reserves to become economic
214/09- 1
Bunnehaven
EW12
208/02- 1
Lyon
Lyon found tight reservoir with gas shows
208/11- 1
Found tight reservoir & no shows
208/17a- 4
214
208

Shallow sands

Eocene/Paleocene distal sands

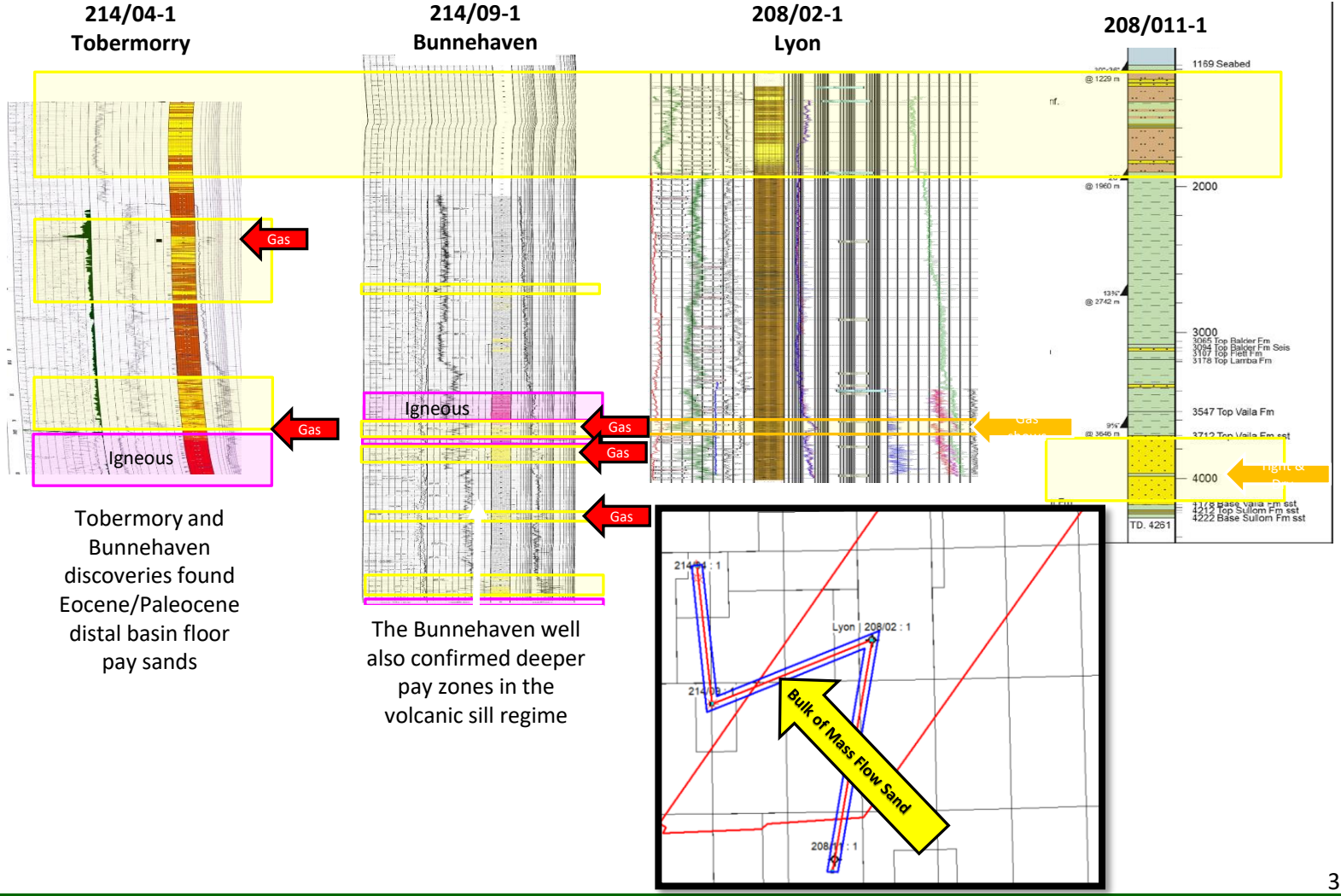
High amplitude section

214/04-1 Tobermorry

214/09-1 Bunnehaven

208/02-1 Lyon

208/011-1



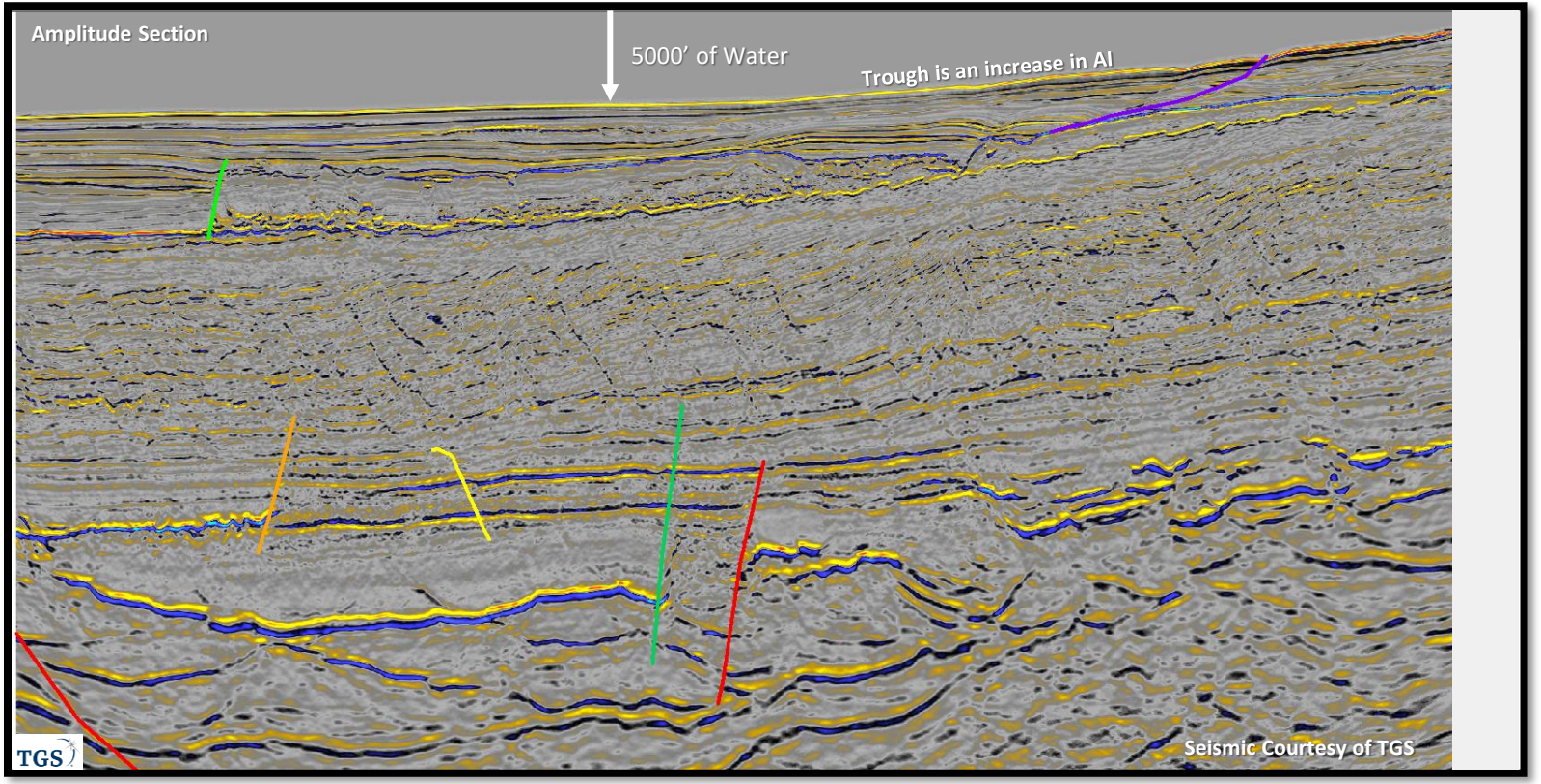
Tobermory and Bunnehaven discoveries found Eocene/Paleocene distal basin floor pay sands

The Bunnehaven well also confirmed deeper pay zones in the volcanic sill regime

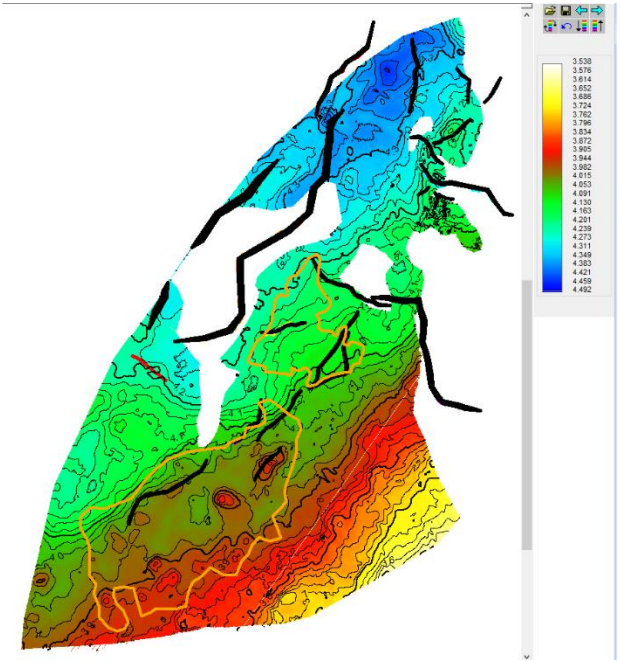
Shallow distal sands

Eocene/Paleocene distal sands

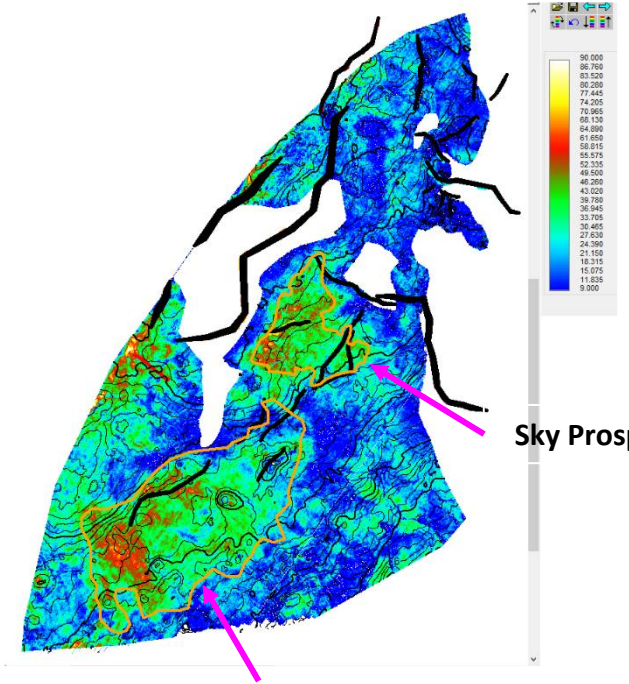
High amplitude volcanic sills & sands



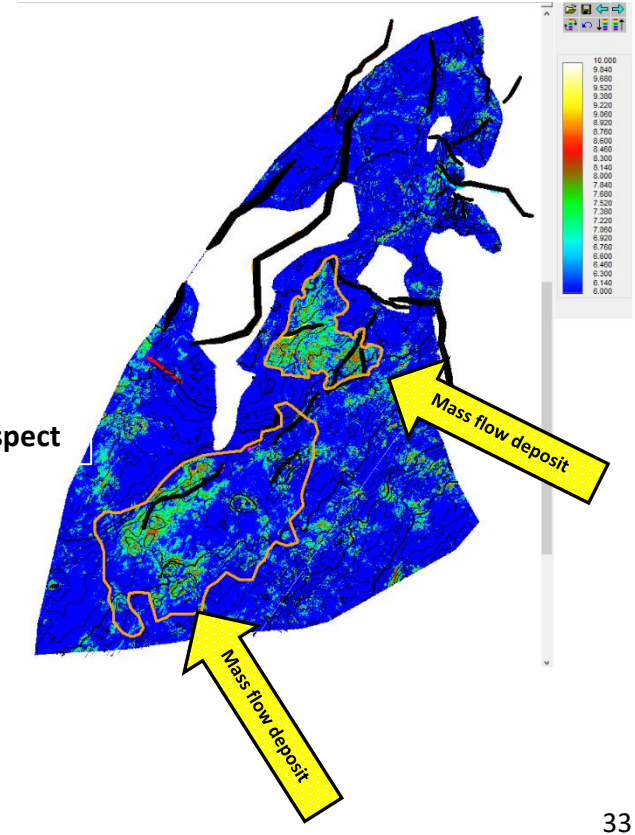
Top Flett Time Structure



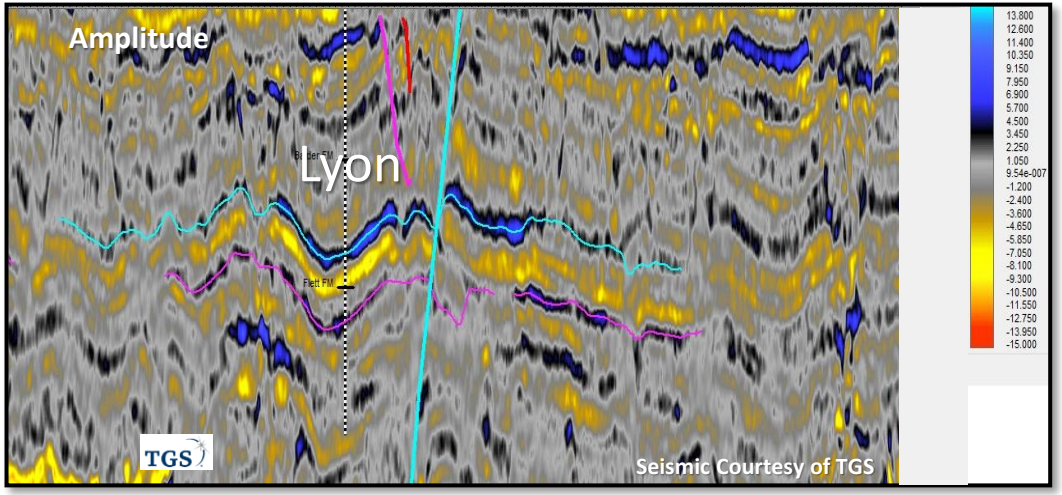
Top Flett Max Amp

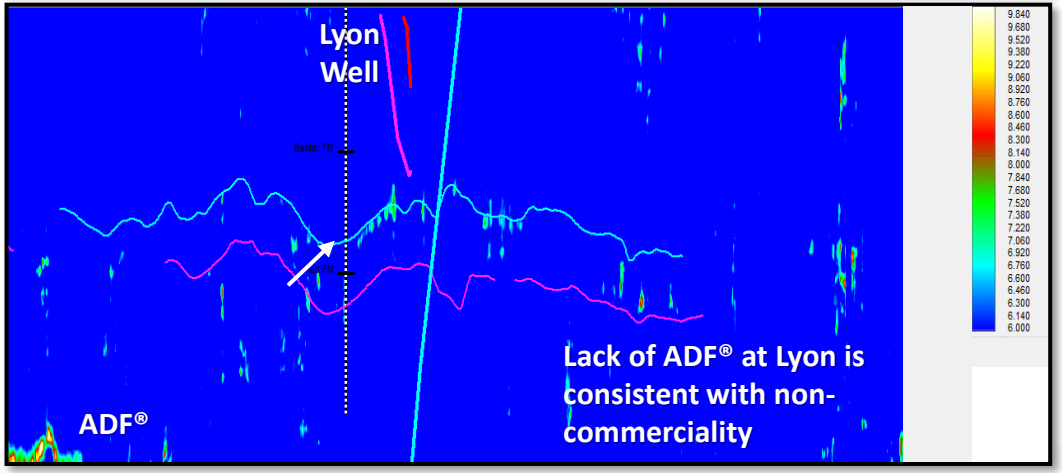


Top Flett Max ADF®



Seismic Courtesy of TGS


Amplitude
Lyon
Balder FM
Flett FM
TGS
Seismic Courtesy of TGS
13.800
12.600
11.400
10.350
9.150
7.950
6.900
5.700
4.500
3.450
2.250
1.050
9.54e-007
-1.200
-2.400
-3.600
-4.650
-5.850
-7.050
-8.100
-9.300
-10.500
-11.550
-12.750
-13.950
-15.000


Lyon
Well
Balder FM
Flett FM
ADF®
Lack of ADF® at Lyon is consistent with non-commerciality
9.840
9.680
9.520
9.380
9.220
9.060
8.920
8.760
8.600
8.460
8.300
8.140
8.000
7.840
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6.760
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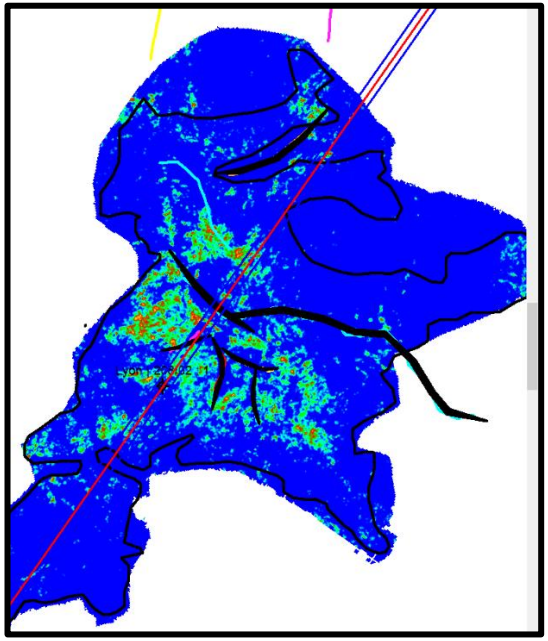
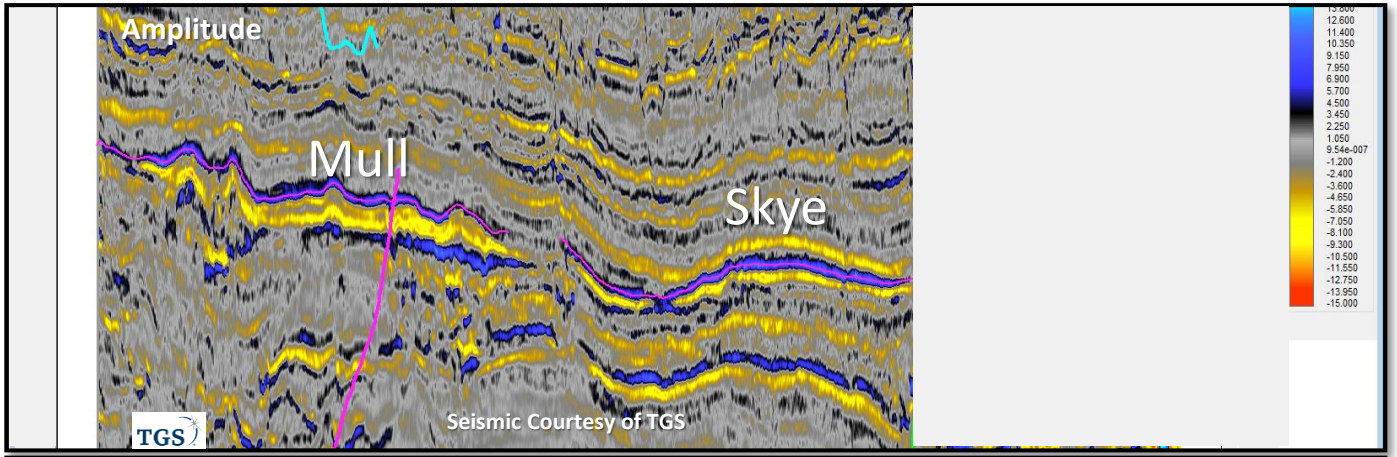
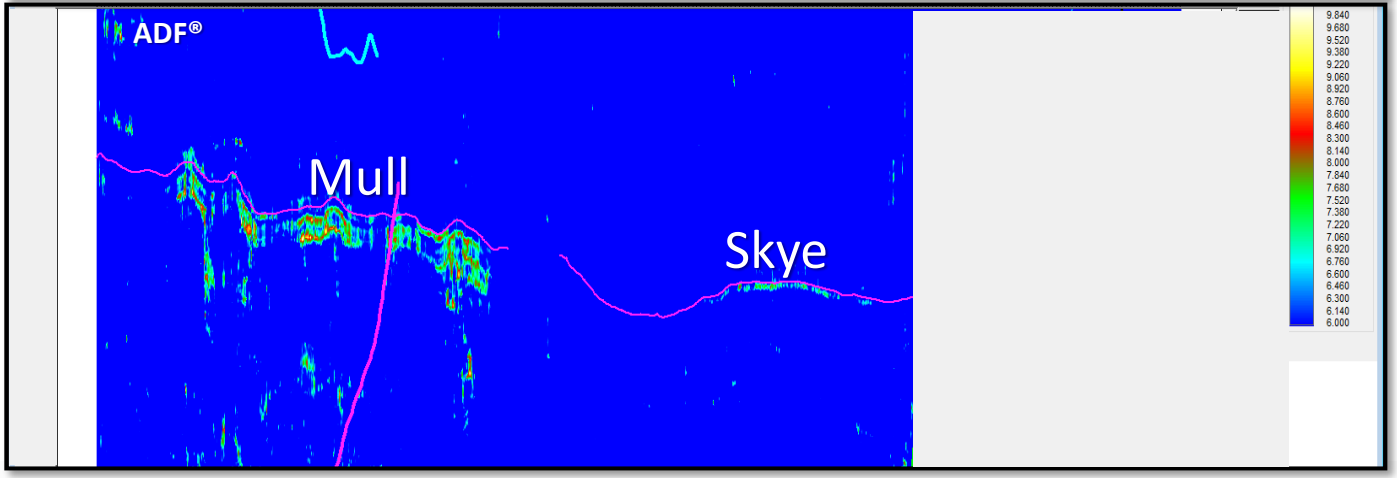
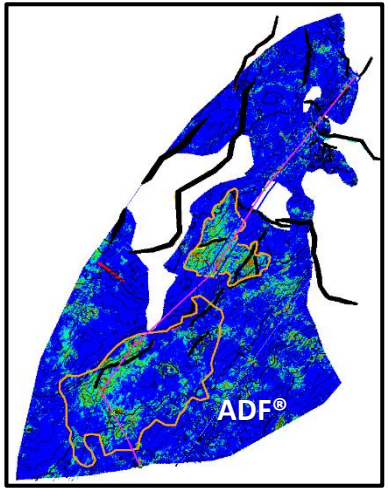
6.460
6.300
6.140
6.000

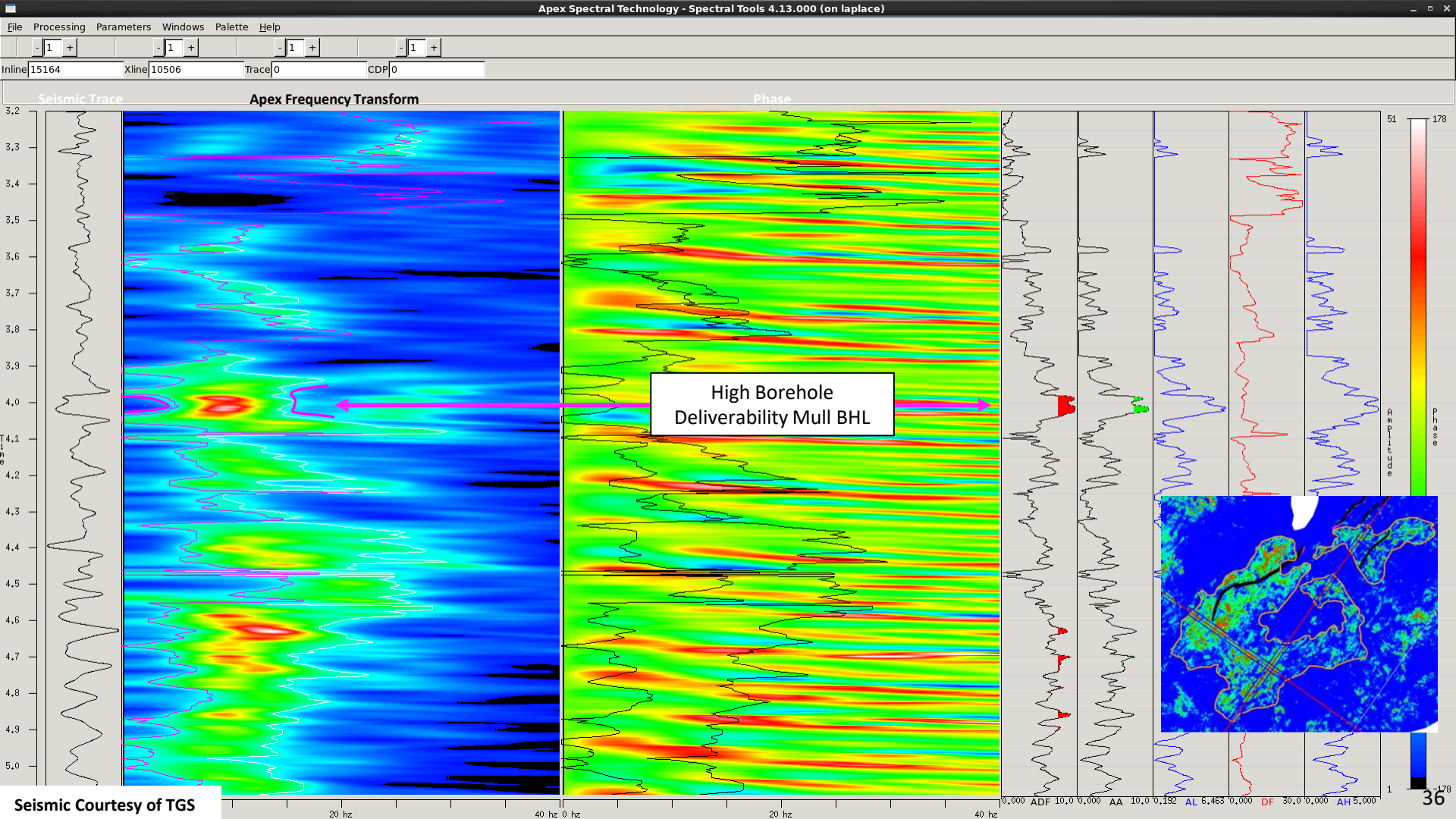


Mull and Skye are anomalously dispersive compared to the Lyon





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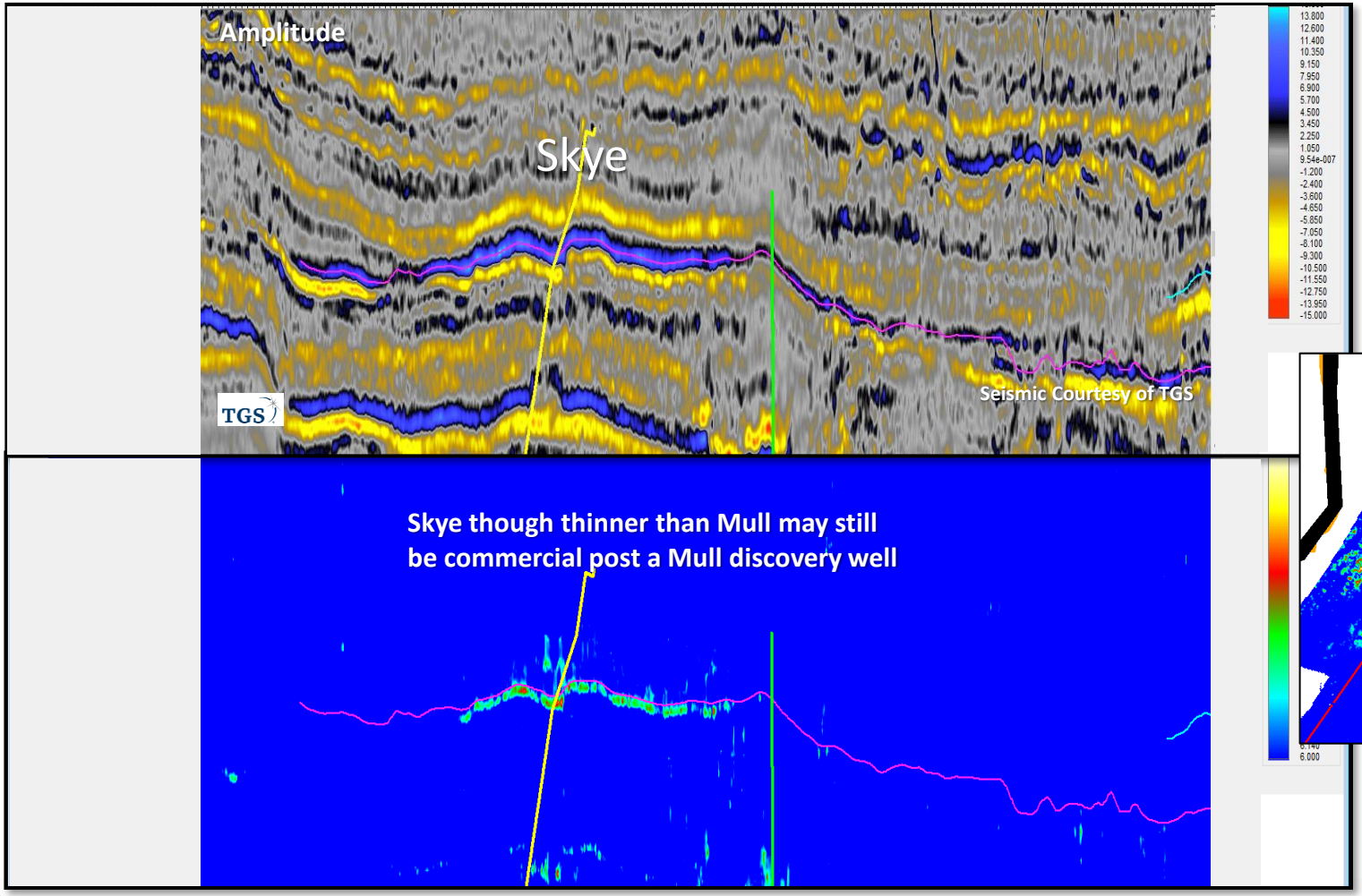
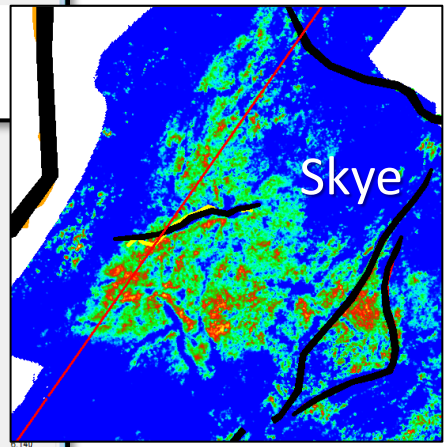
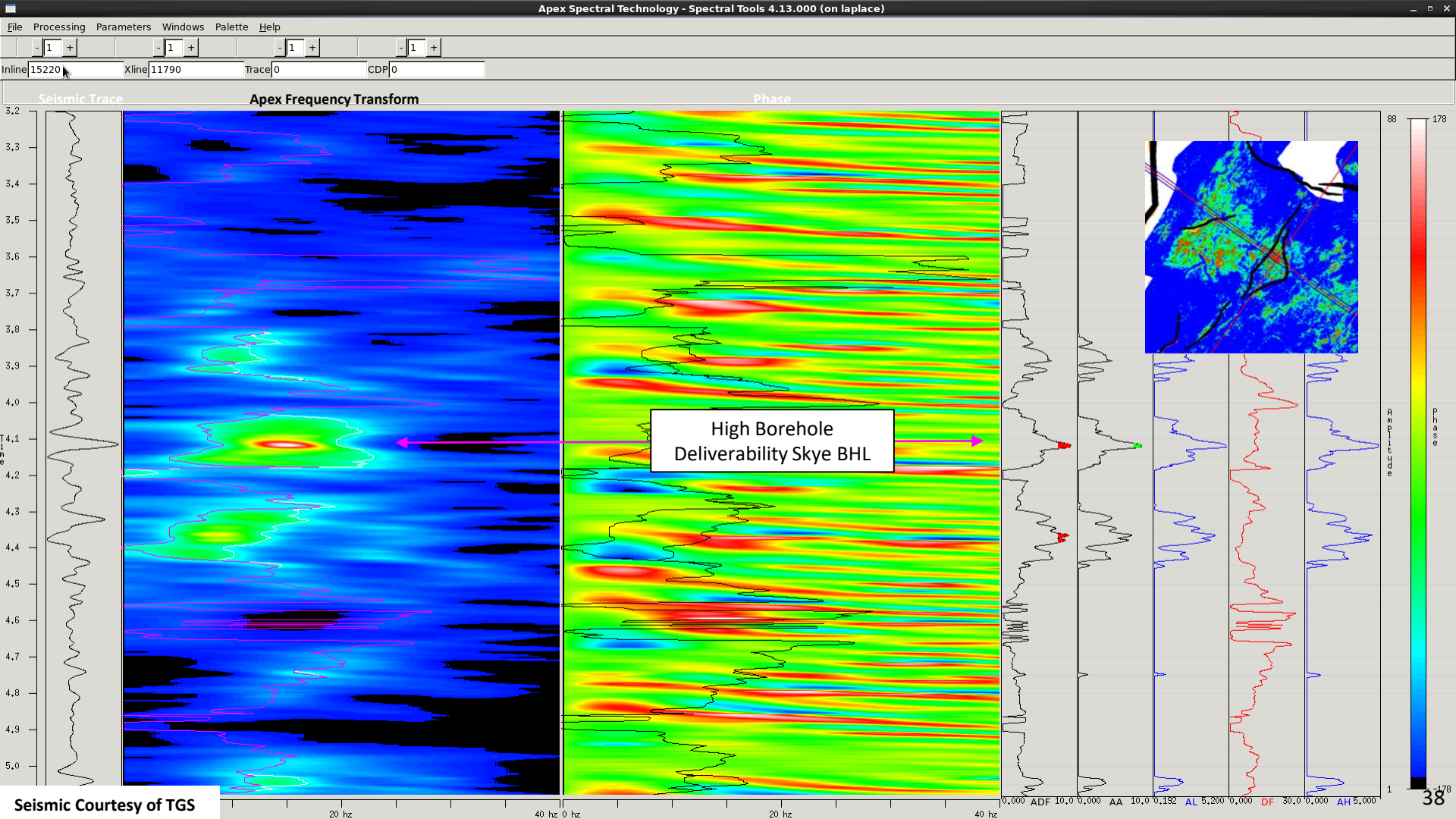
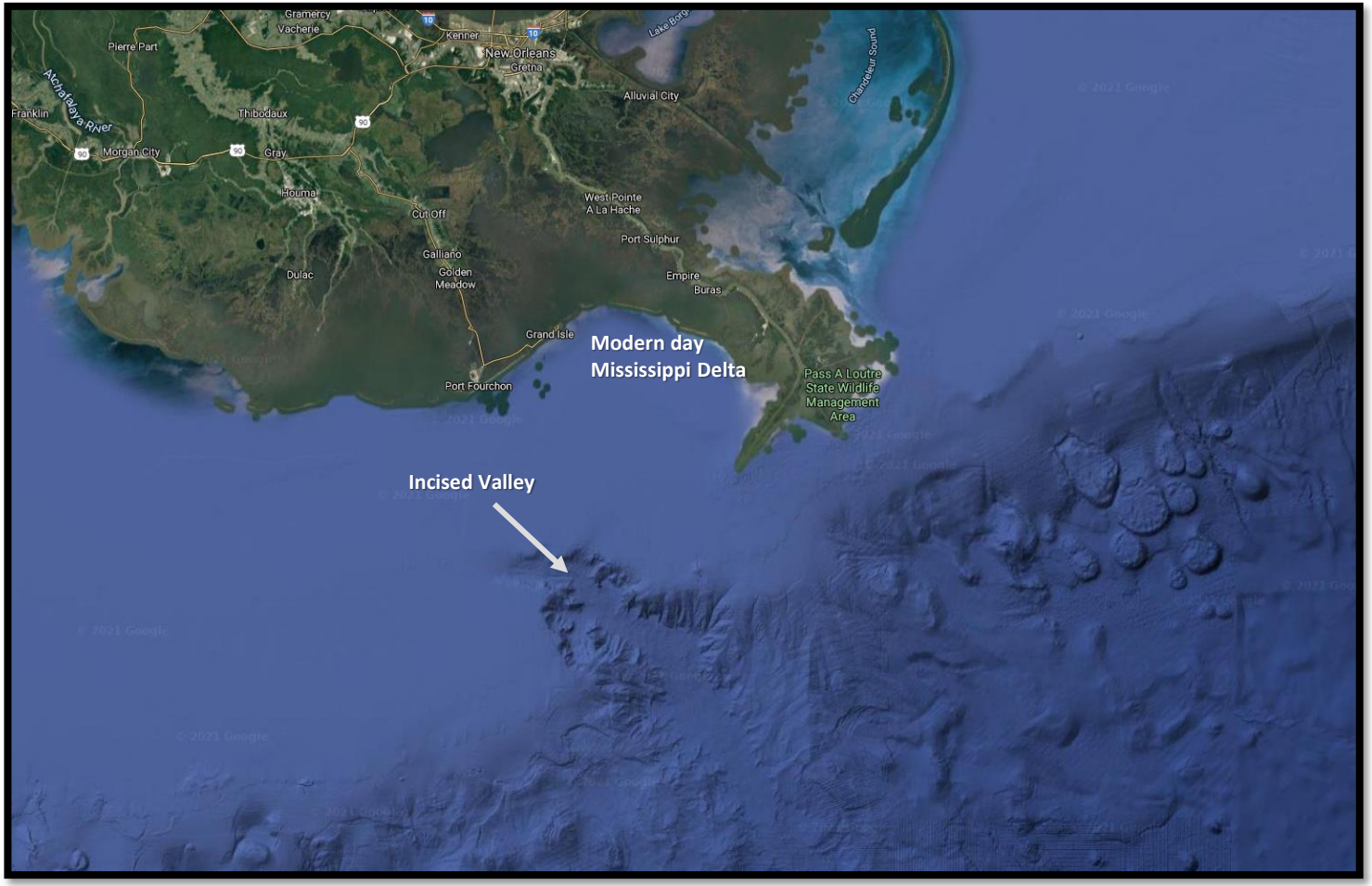
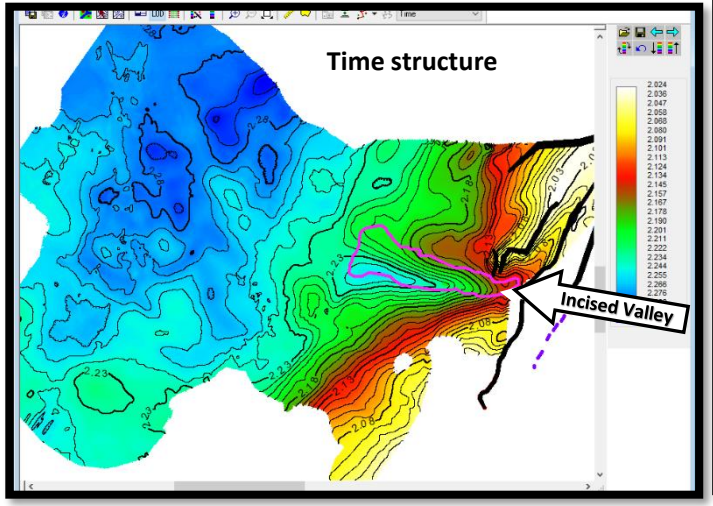
Seismic Trace
Apex Frequency Transform
Phase
High Borehole Deliverability Mull BHL
Time
20 hz
40 hz
0 hz
20 hz
40 hz
ADF
AA
AL
DF
AH
Amplitude
Phase
Seismic Courtesy of TGS

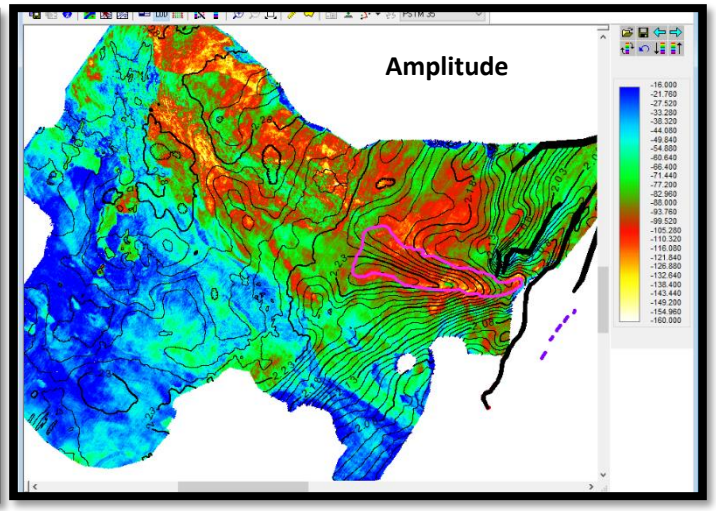

Amplitude
Skye
TGS
Seismic Courtesy of TGS
13.800
12.600
11.400
10.350
9.150
7.950
6.900
5.700
4.500
3.450
2.250
1.050
9.54e-007
-1.200
-2.400
-3.600
-4.650
-5.850
-7.050
-8.100
-9.300
-10.500
-11.550
-12.750
-13.950
-15.000
Skye though thinner than Mull may still
be commercial post a Mull discovery well
6.000

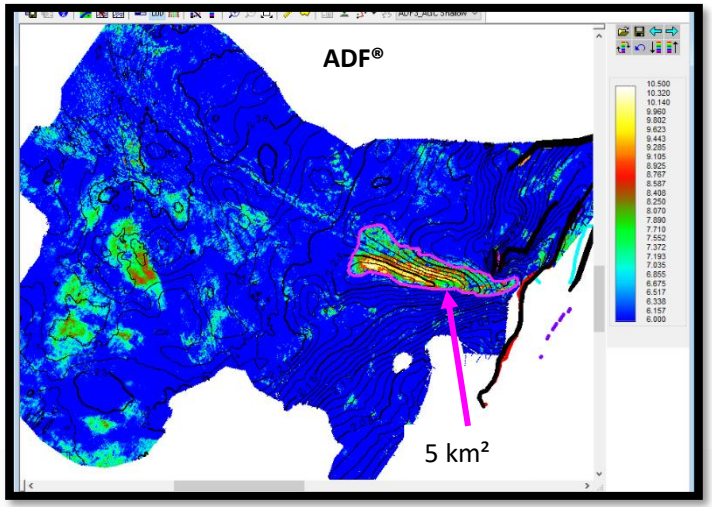

Skye


Apex Spectral Technology - Spectral Tools 4.13.000 (on laplace)
File Processing Parameters Windows Palette Help
Inline 15220 Xline 11790 Trace 0 CDP 0
Seismic Trace
Apex Frequency Transform
Phase
High Borehole
Deliverability Skye BHL
20 hz
40 hz
0 hz
20 hz
40 hz
ADF
AA
AL
DF
AH
Seismic Courtesy of TGS


Gramercy
Vacherie
Kenner
New Orleans
Gretna
Lake Borg
Chandeleur Sound
Pierre Part
Alluvial City
Franklin
Atchafalaya River
Thibodaux
Morgan City
Gray
Houma
Cut Off
West Pointe
A La Hache
Port Sulphur
Galliano
Golden
Meadow
Dulac
Empire
Buras
Grand Isle
Modern day
Mississippi Delta
Port Fourchon
Pass A Loutre
State Wildlife
Management
Area
Incised Valley

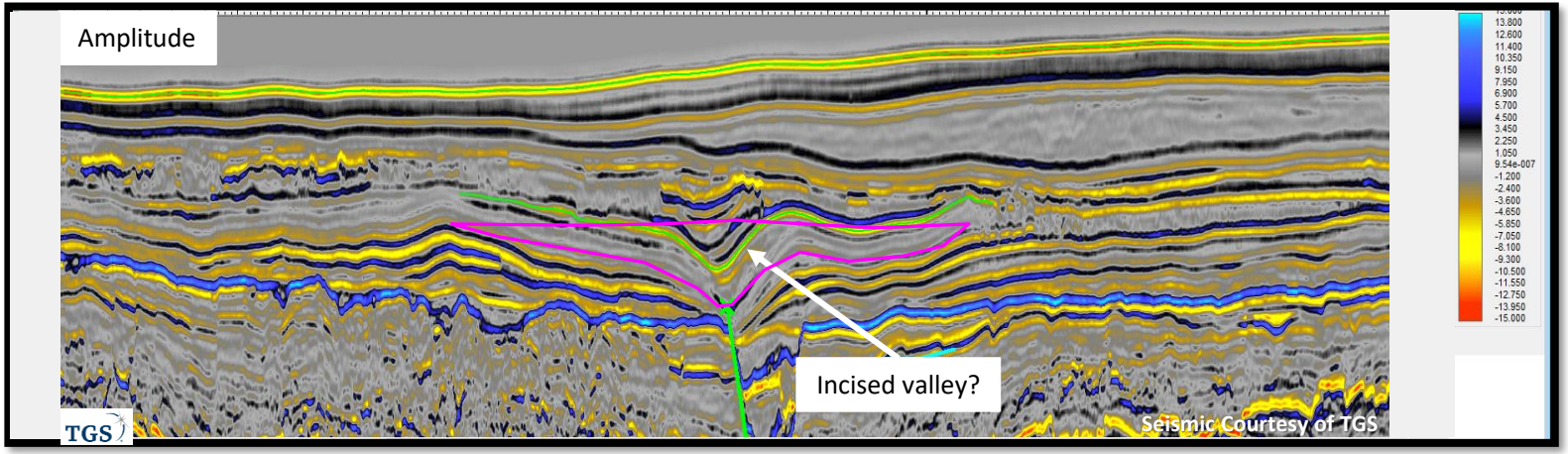


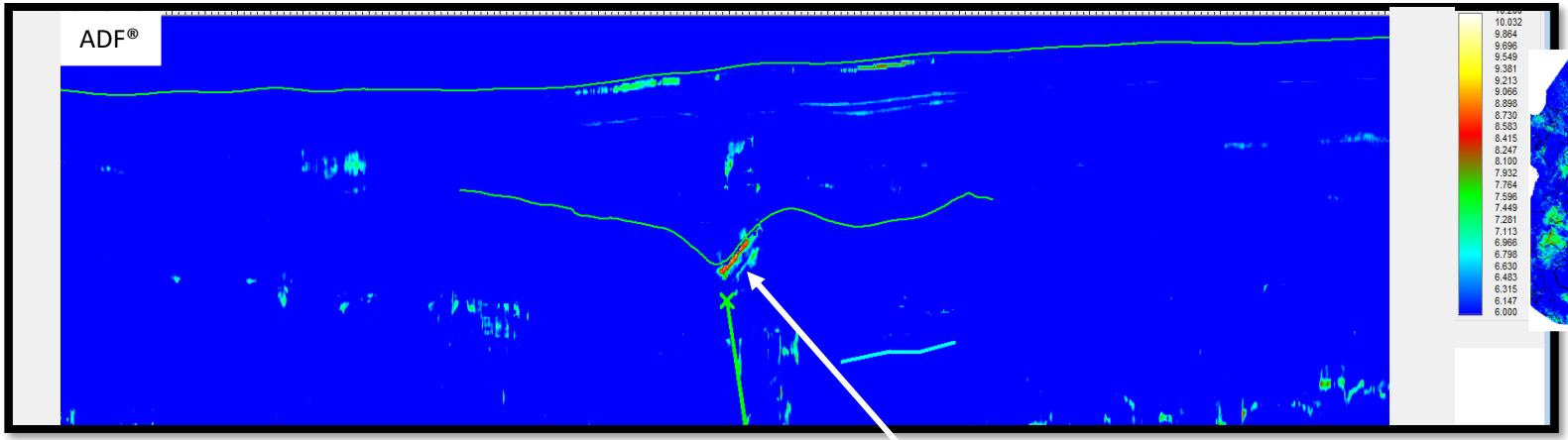


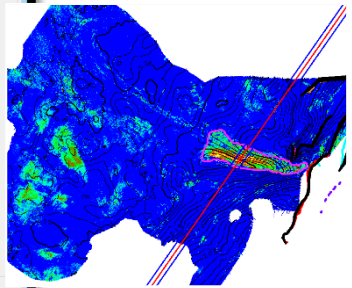


Seismic Courtesy of TGS

Seismic Courtesy of TGS

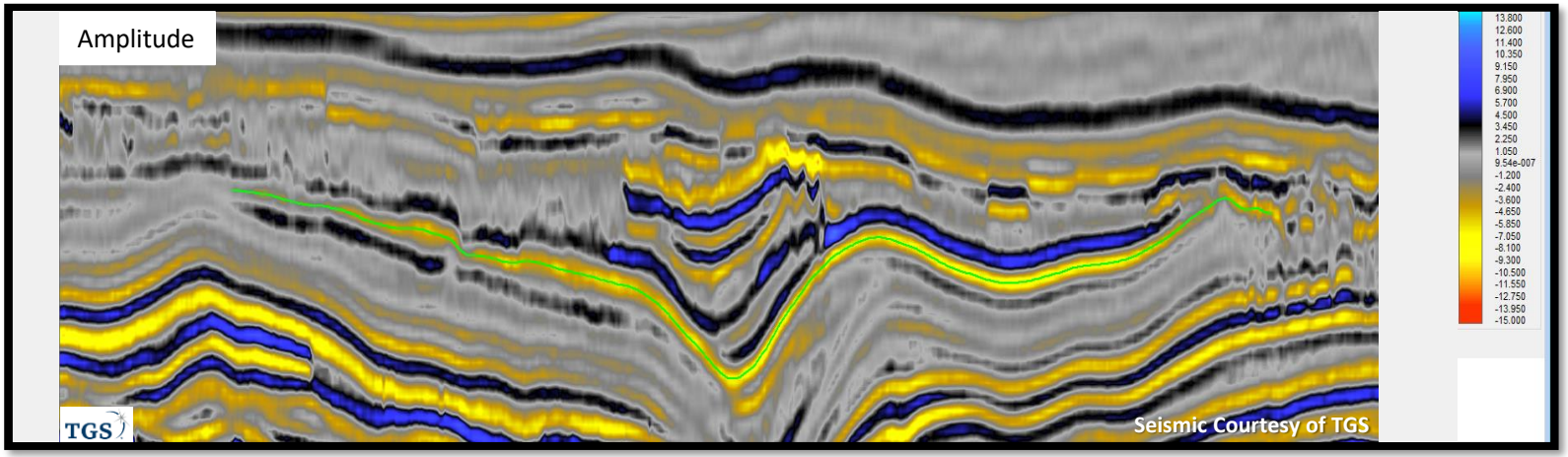


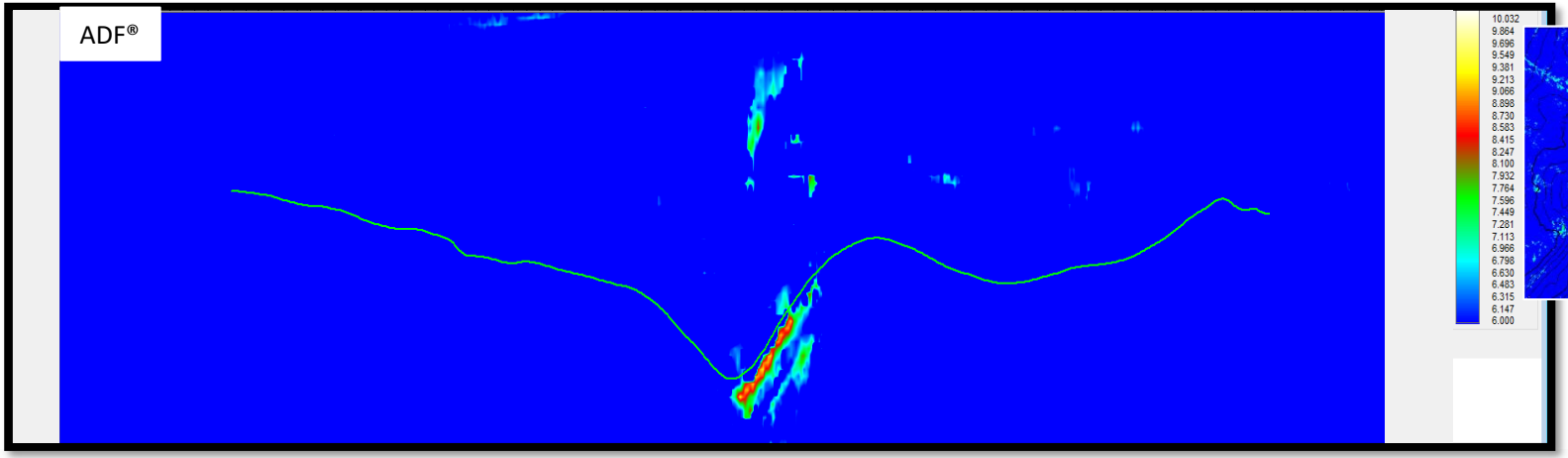


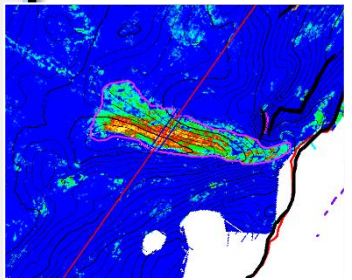


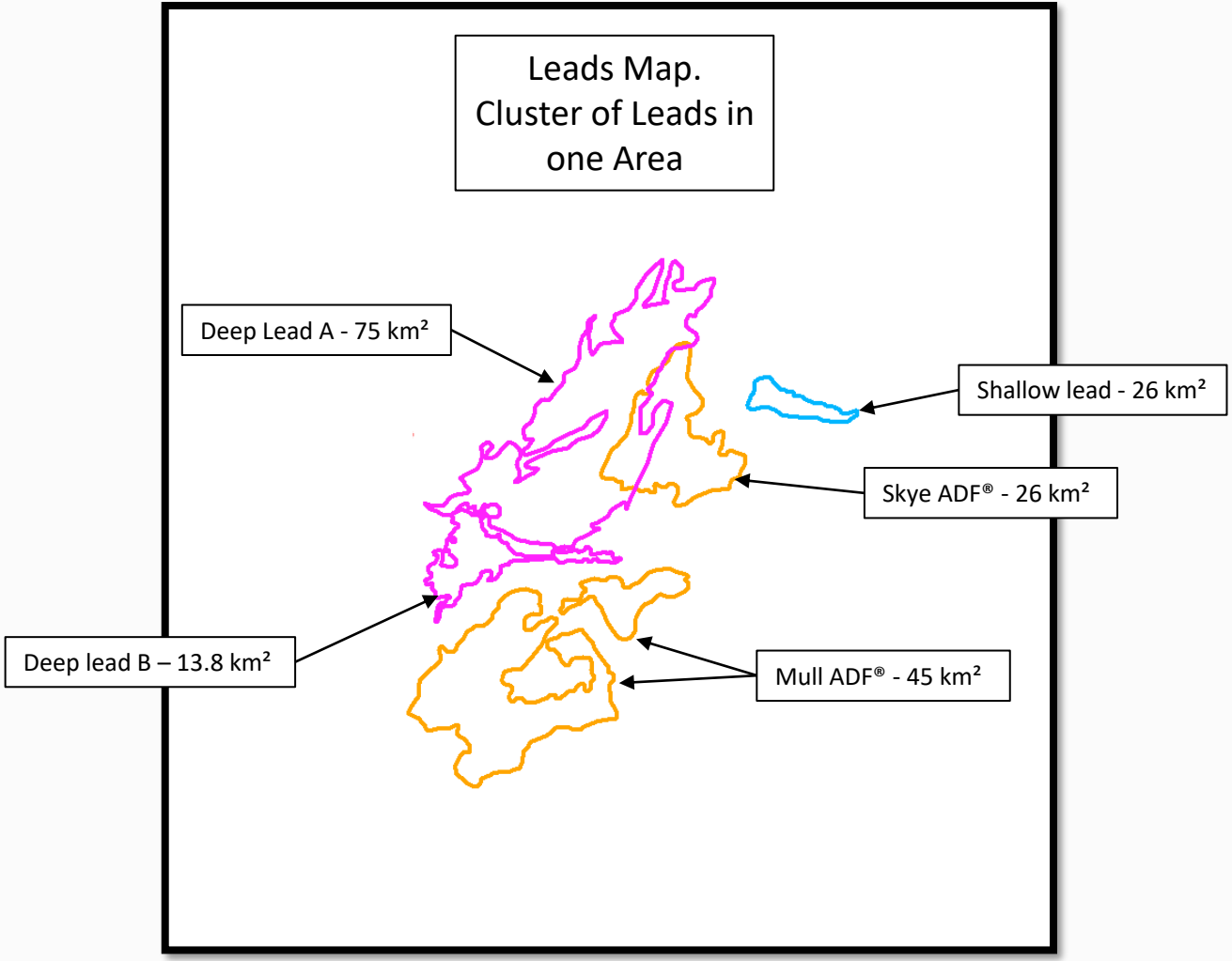
That this anomaly only appears on one side of the incised valley is auspicious as well as the termination at spill point.

Seismic Courtesy of TGS








Leads Map.
Cluster of Leads in one Area
Deep Lead A - 75 km²
Shallow lead - 26 km²
Skye ADF® - 26 km²
Deep lead B – 13.8 km²
Mull ADF® - 45 km²

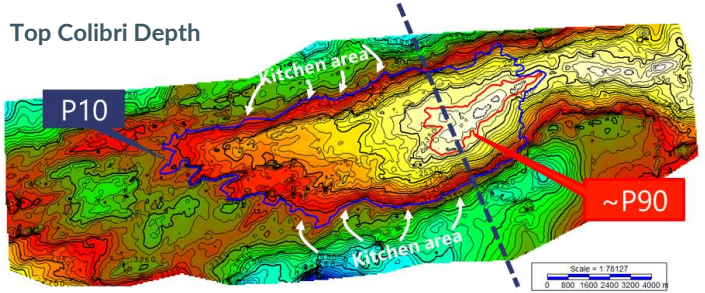
WoS EW12 Prospect Comments

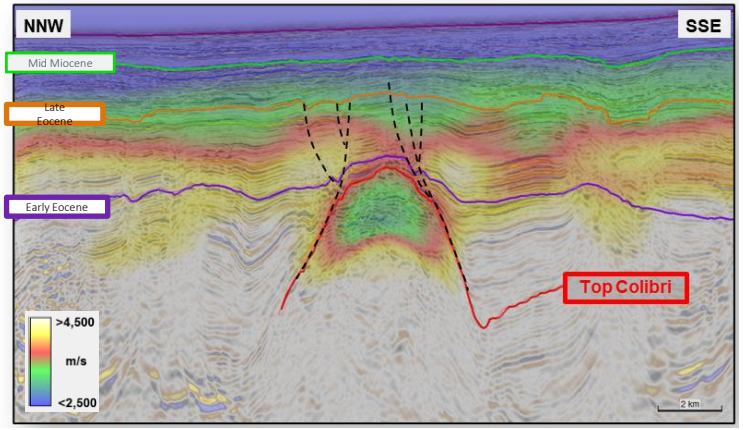
- ADF® shows there are numerous clustered prospects in EW12 that are highly prospective.
- ADF® shows Lyon to be tight consistent with the well's result.
- ADF® indicates Mull is likely hydrocarbon charged.
- ADF® indicates Mull has roughly 45 km² of permeable reservoir.
- ADF® indicates Sky likely has accretive reserves to a hub class Mull location.
- ADF® could help spot test wells in locations with the necessary high borehole deliverability.

United Oil & Gas Colibri Prospect

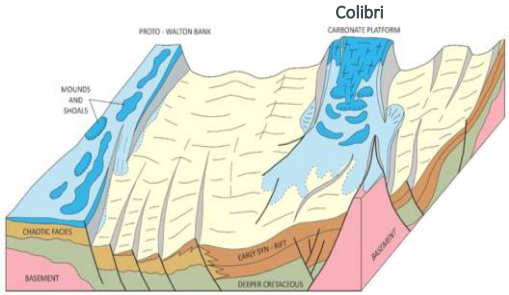
THE COLIBRI PROSPECT

- Reservoir: Large syn-rift horst of porous, fractured and/or karstified platform carbonates
- Trap & Seal: Truncation of westward dipping carbonates in an E-W trending horst to relay ramp, sealed by overlying Lower Eocene marine shales
- Source & Charge: Charge focus from Cretaceous kitchens to north and south; modelled charge timing, expulsion volumes and reservoir temperature all favourable
- Prominent low velocity anomaly evident on 3D seismic across Colibri which conforms with structure
- Velocity and gravity modelling both indicative of porosities of >20%
- Pore pressure gradient modelling indicates intact seal across Colibri



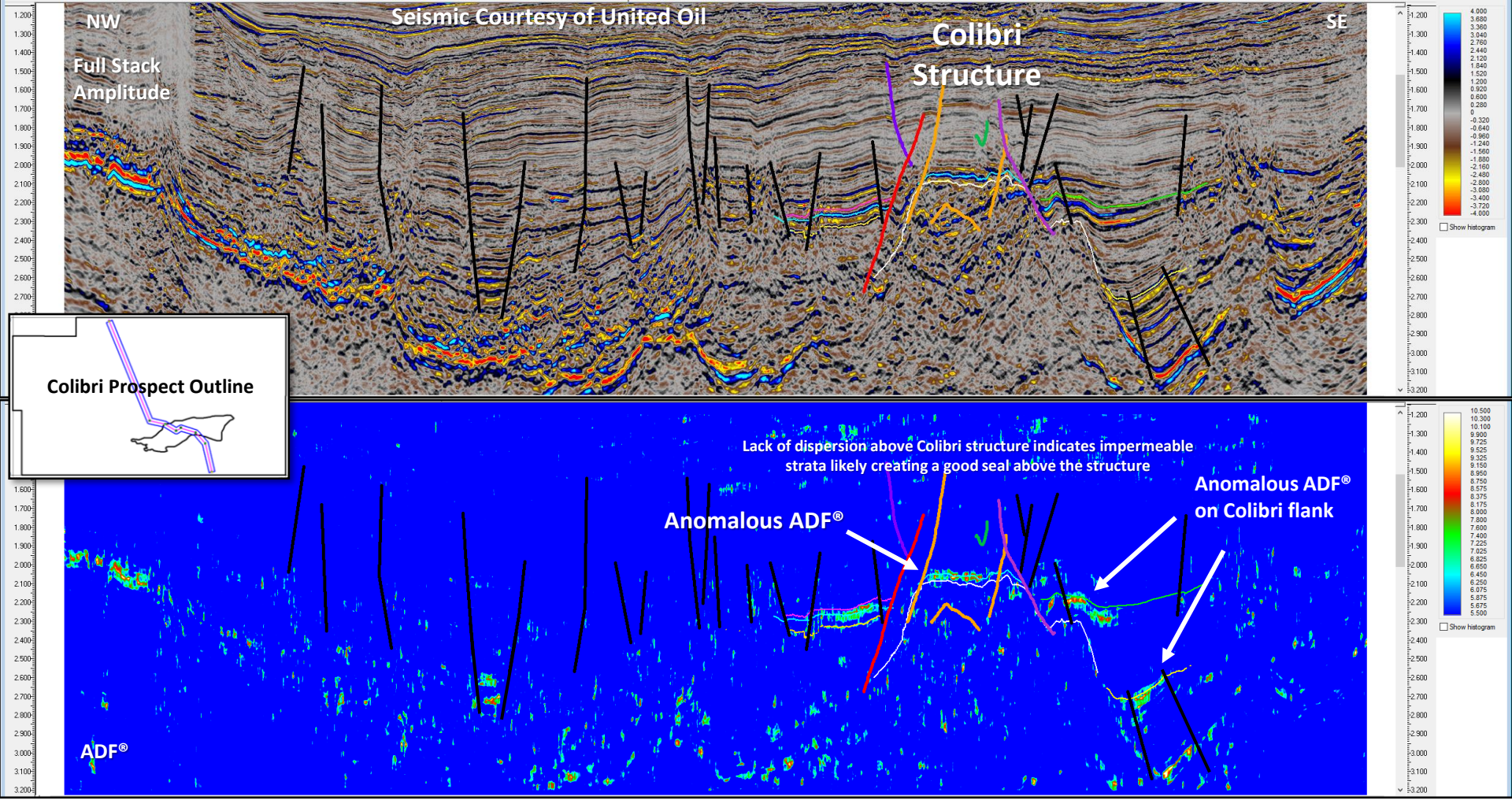


Depositional Model



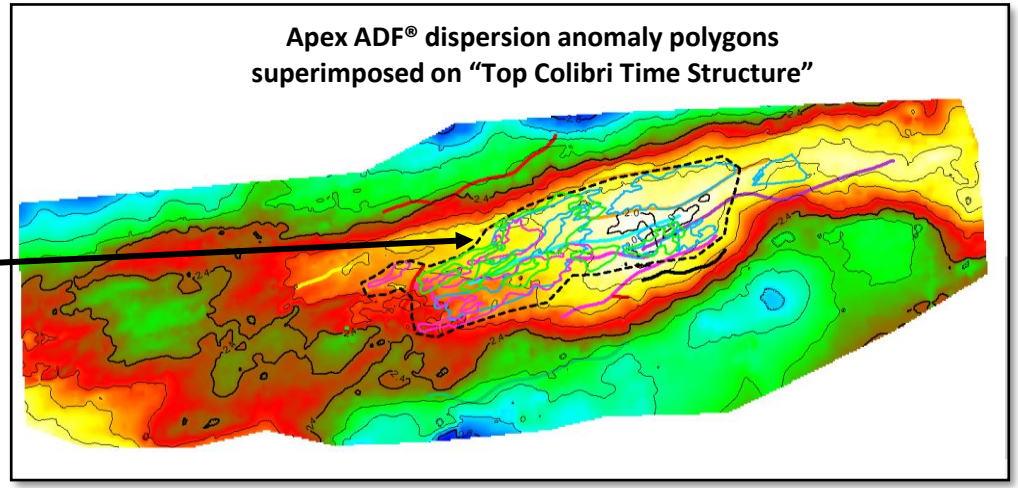
Cretaceous rudist limestones in outcrop and from core

Volumes (MMstb)[1]	1U	2U	Mean	3U	Pg
Colibri	33.4	223	406	964	19%

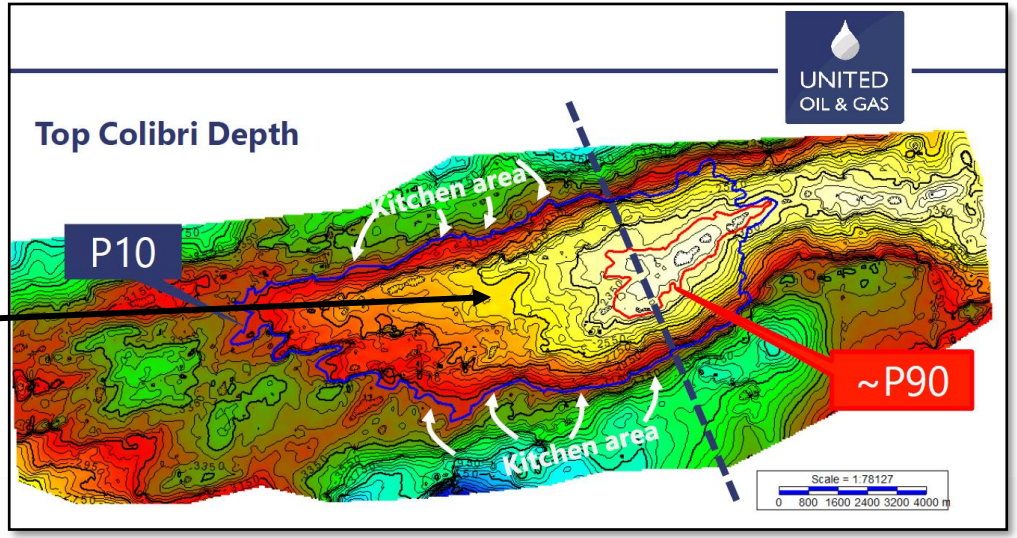

NW
Seismic Courtesy of United Oil
SE
Full Stack Amplitude
Colibri Structure
Colibri Prospect Outline
Lack of dispersion above Colibri structure indicates impermeable strata likely creating a good seal above the structure
Anomalous ADF®
Anomalous ADF® on Colibri flank
ADF®

Anomalous dispersion is associated with the Colibri structure and is more prominent on the west flank of the high at multiple intervals

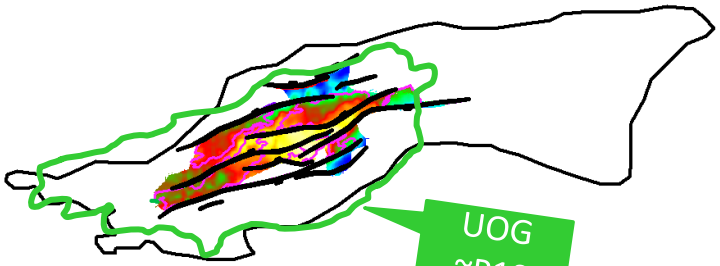
Regional grouping of dispersive ADF® anomalies associated with UOG P10 polygon. Multicolored polygons are individual anomalies at different intervals.



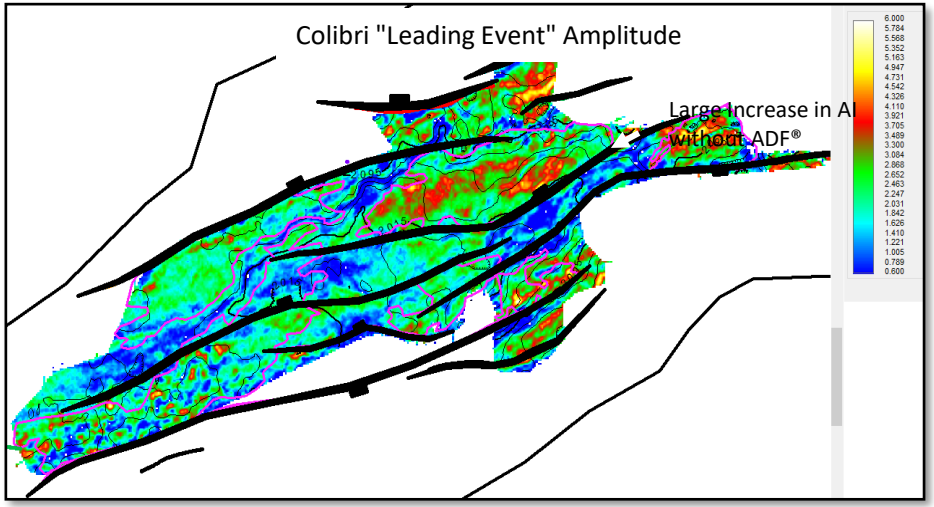
ADF® indicates support for overall reserves being the mean case



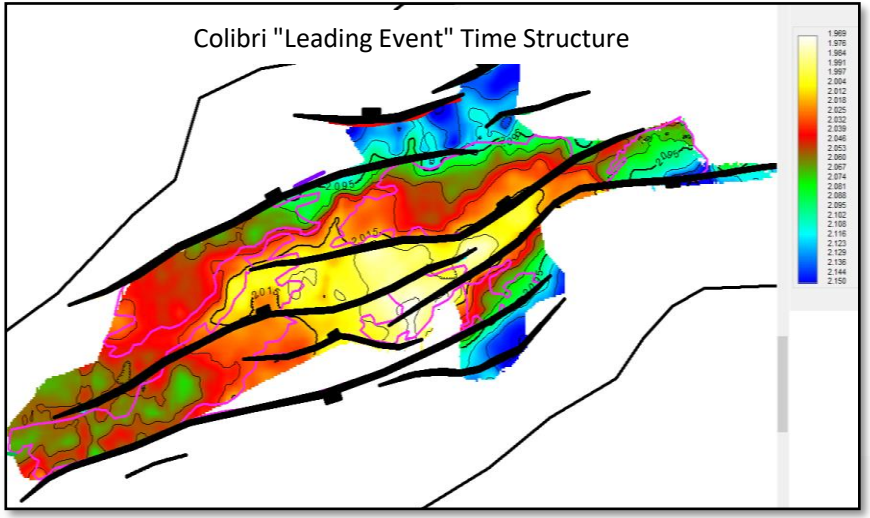
Colibri Structure Outline



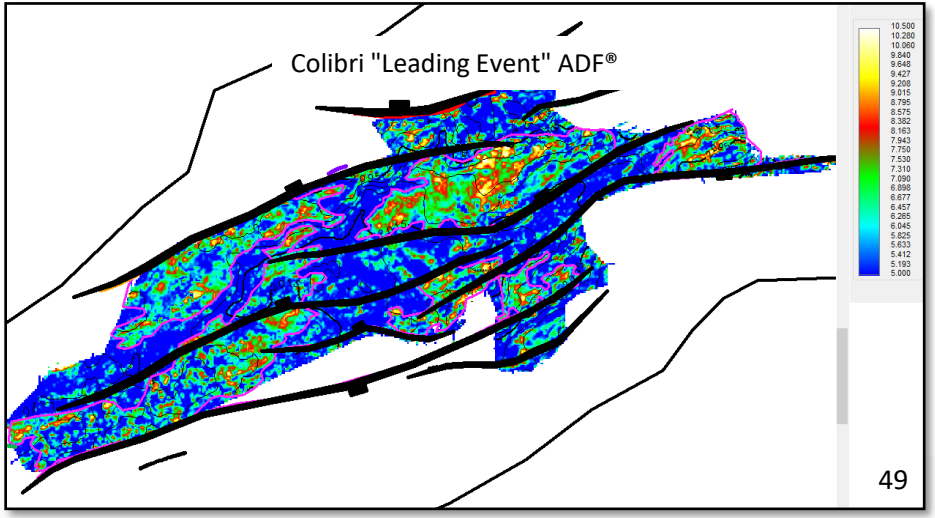
Colibri "Leading Event" Amplitude

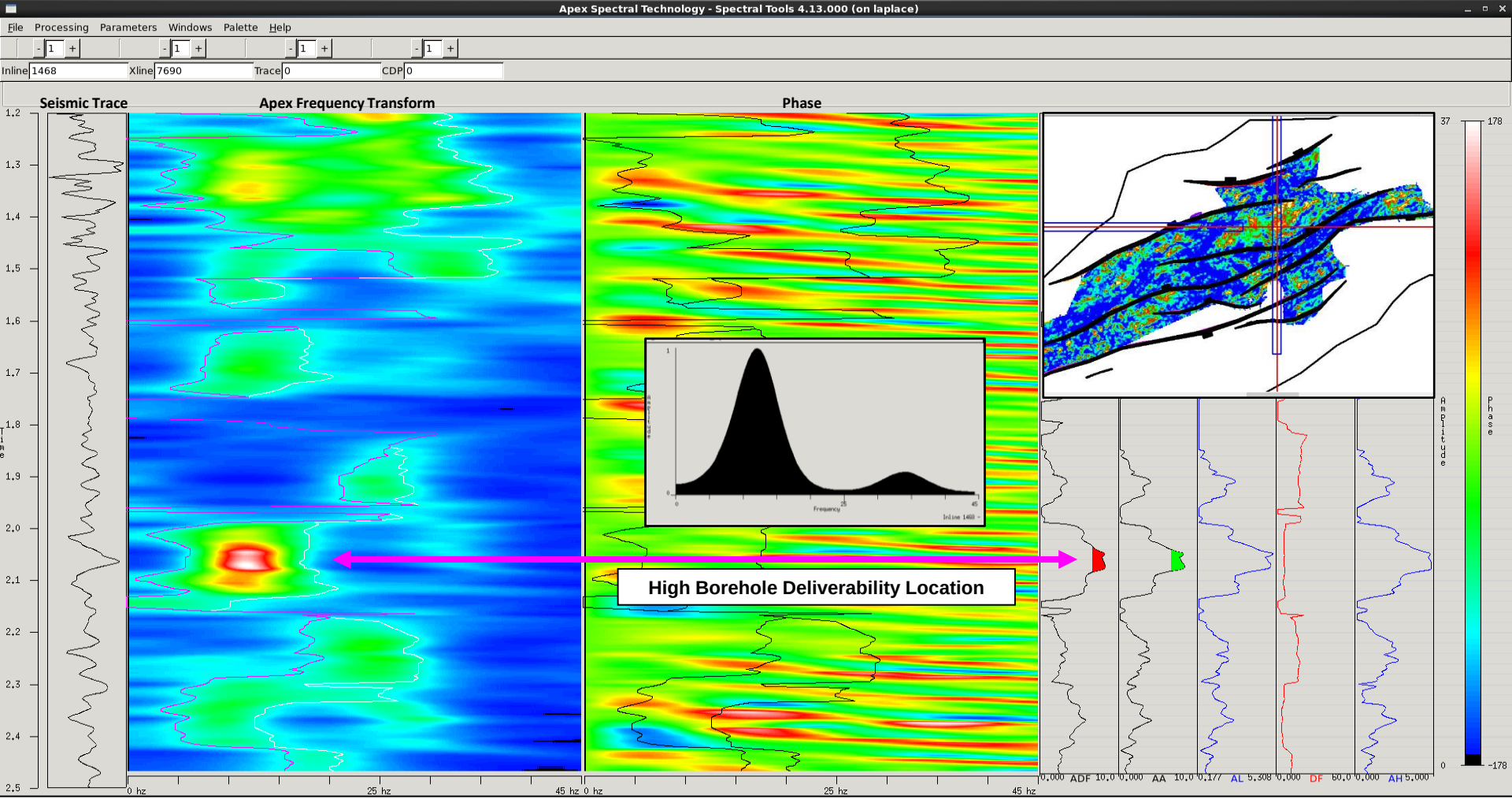


Colibri "Leading Event" Time Structure



Colibri "Leading Event" ADF®

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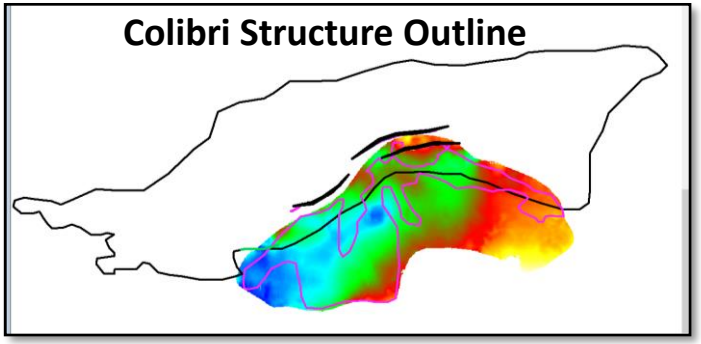
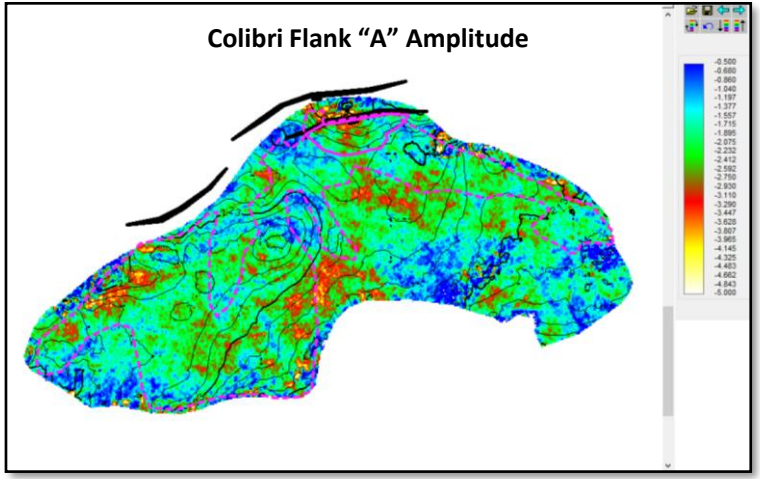
Seismic Trace
Apex Frequency Transform
Phase
High Borehole Deliverability Location
0 hz 25 hz 45 hz
ADF AA AL DF AH
Amplitude
Phase

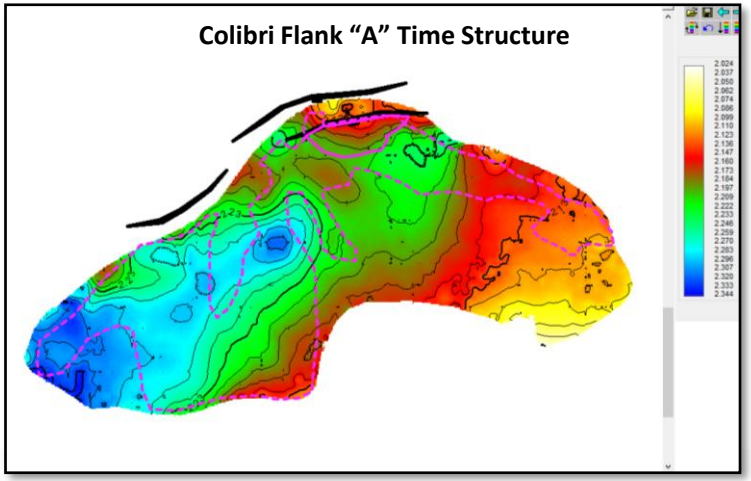
Colibri Structure Outline



Colibri Flank “A” Amplitude

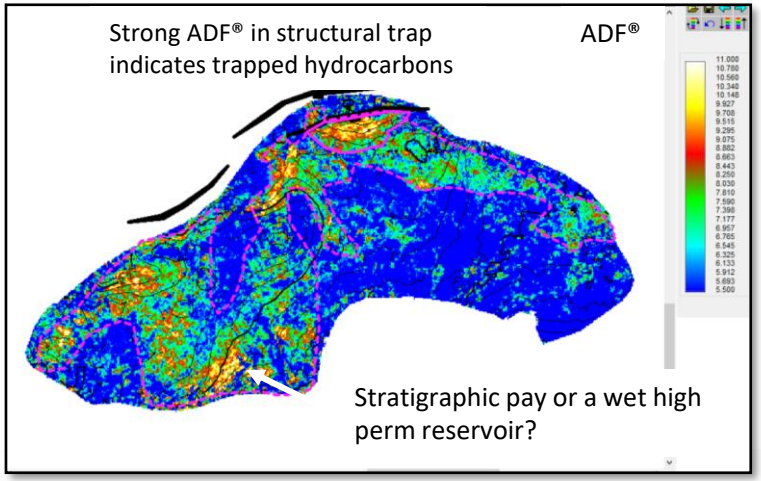


Colibri Flank “A” Time Structure

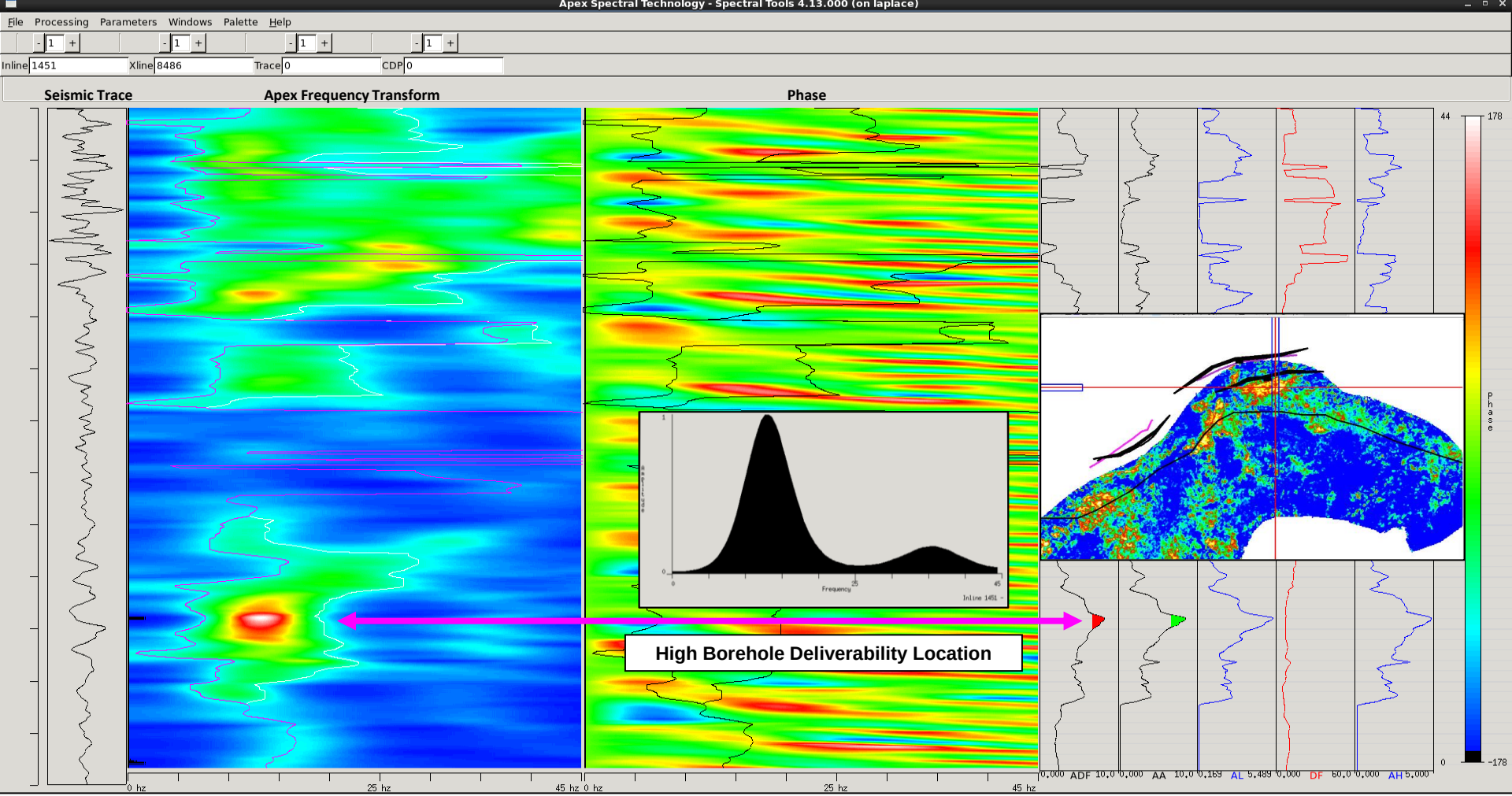


Strong ADF® in structural trap indicates trapped hydrocarbons

ADF®



Stratigraphic pay or a wet high perm reservoir?


Apex Spectral Technology - Spectral Tools 4.13.000 (on laplace)
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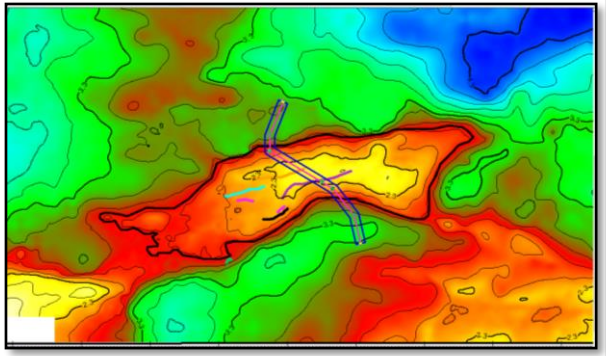
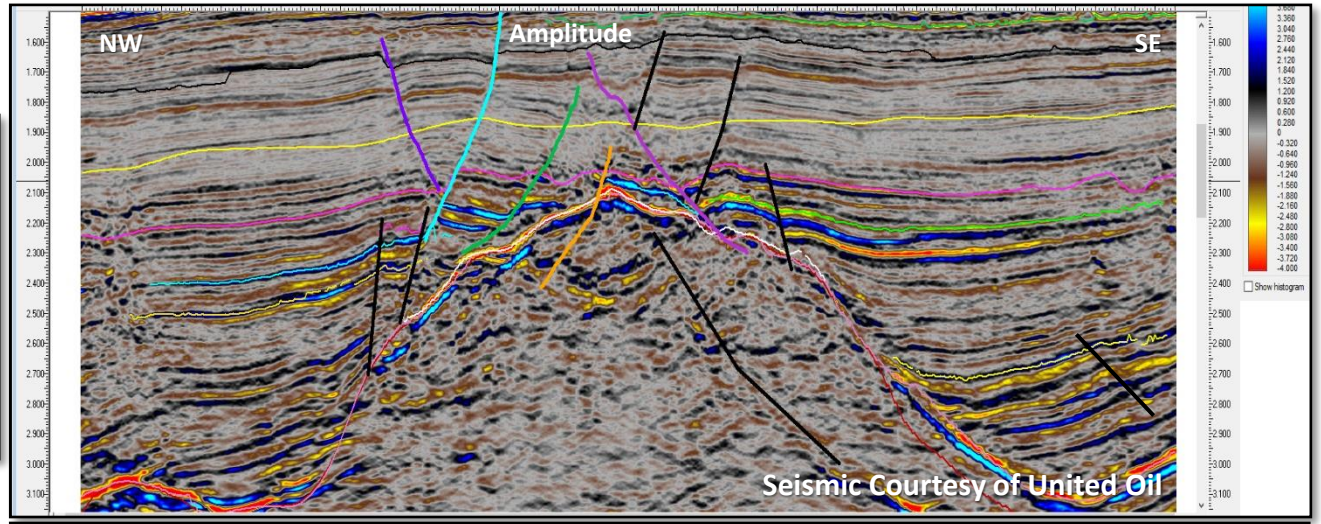
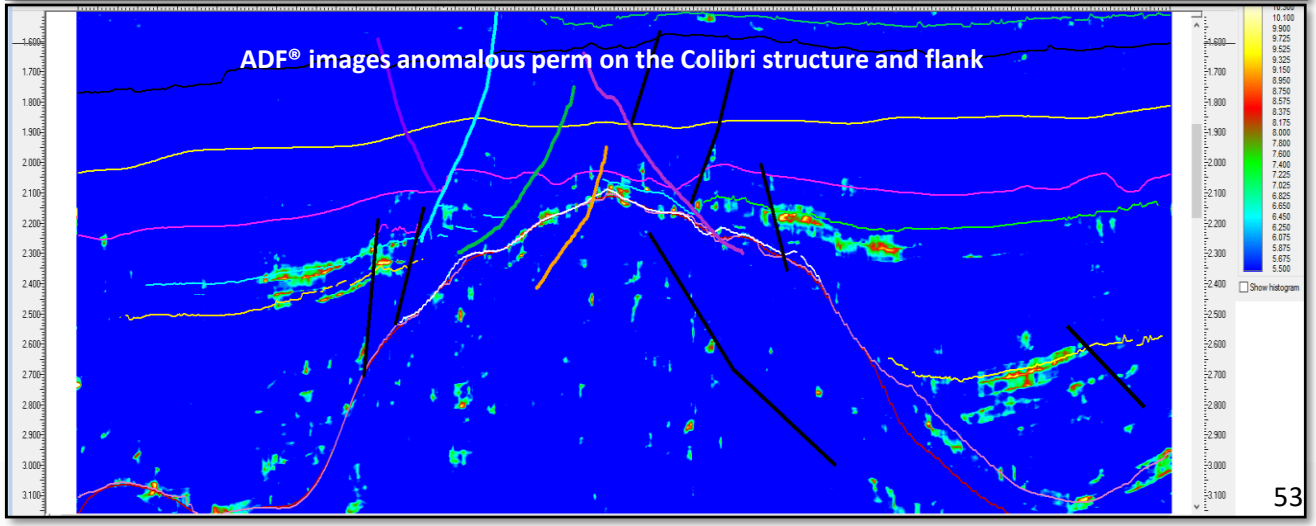
Inline 1451 Xline 8486 Trace 0 CDP 0
Seismic Trace
Apex Frequency Transform
Phase
High Borehole Deliverability Location
0 hz 25 hz 45 hz 0 hz 25 hz 45 hz
ADF 10,0 0,000 AA 10,0 0,189 AL 5,489 0,000 DF 60,0 0,000 AH 5,000
Phase
178
-178
44
0
Frequency
Inline 1451

Colibri Time Structure







Colibri Comments

- ADF® indicates a working hydrocarbon system around Calibri.
- ADF® indicates commercial level perm and likely hydrocarbon charge.
- ADF® indicates likely trapped hydrocarbons on the crest and flanks of Calibri.
- ADF® could help spot test wells in locations with high borehole deliverability.

End