Apex Spectral Technology, Inc

presents

An Apex Spectral Introduction

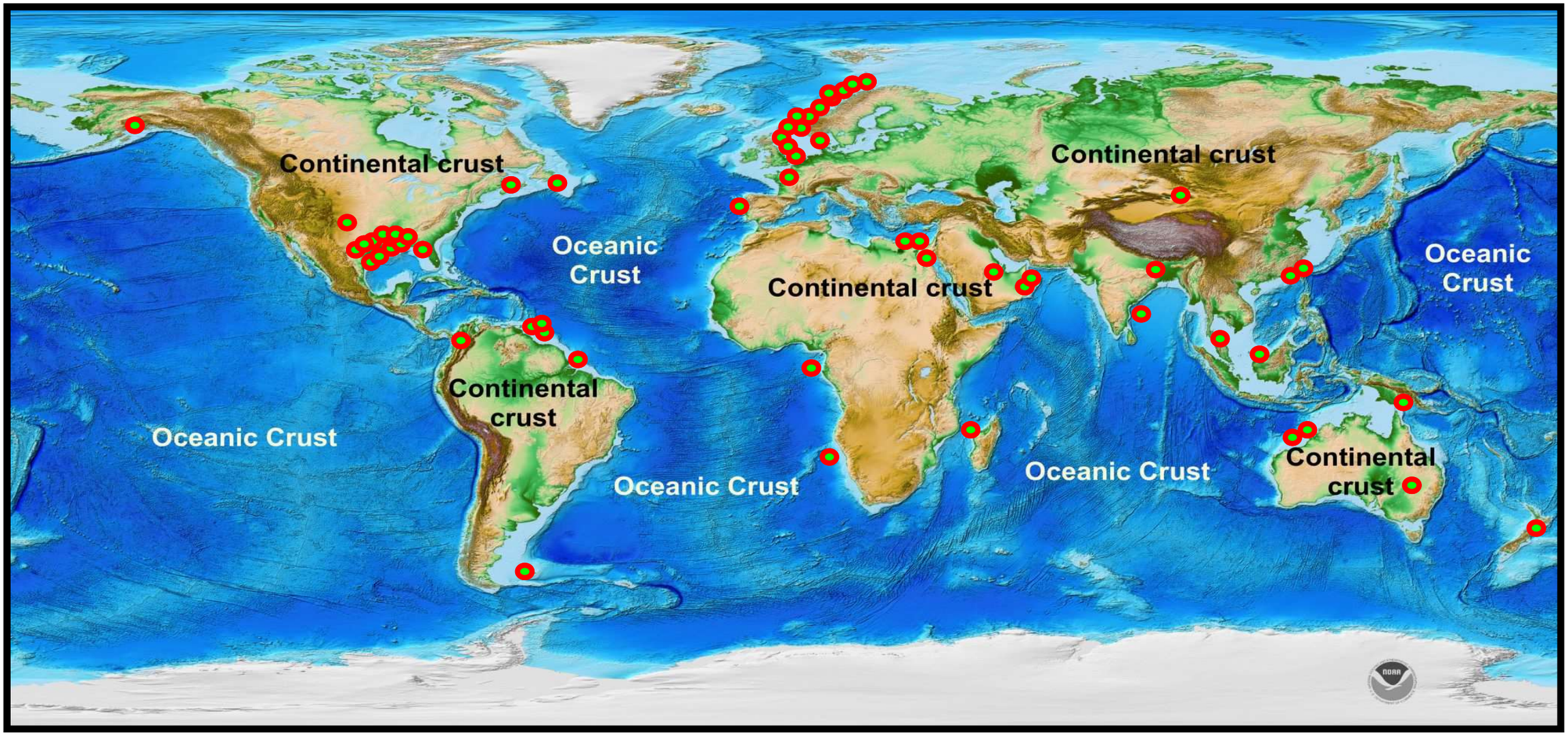
An ADF® Introduction and…

ADF® Results from Oman, West of Shetlands & Jamacia

Apex Spectral Introduction

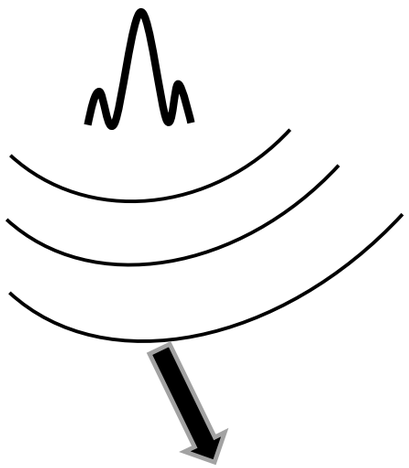
- In business for 21 years. Incorporated January 16, 2002.
- Focused on frequency domain interpretation from the beginning.
- Exploited an over simplification in seismic theory that goes back to 1975.
- Has invented a new "ADF®" DHI that can image hydrocarbon reservoirs in various types of geology where past tools are ineffective.
- Has patented, commercialized, published & honed ADF® technology over 20 years.
- Has performed ADF® projects worldwide.
- Passed a blind test using seismic data only as input (i.e., no well data) for Shell's Oman subsidiary (PDO). Subsequently Shell/PDO and the Oman Ministry of O&G sponsored Apex to publish the test results showing ADF®'s broad effectiveness in a peer reviewed paper at the EAGE in 2021.

Apex Has Performed ADF® Projects Worldwide



Seismic Data is Wavelets and Geology

Wavelets contain a range of frequencies like a range of keys on a piano



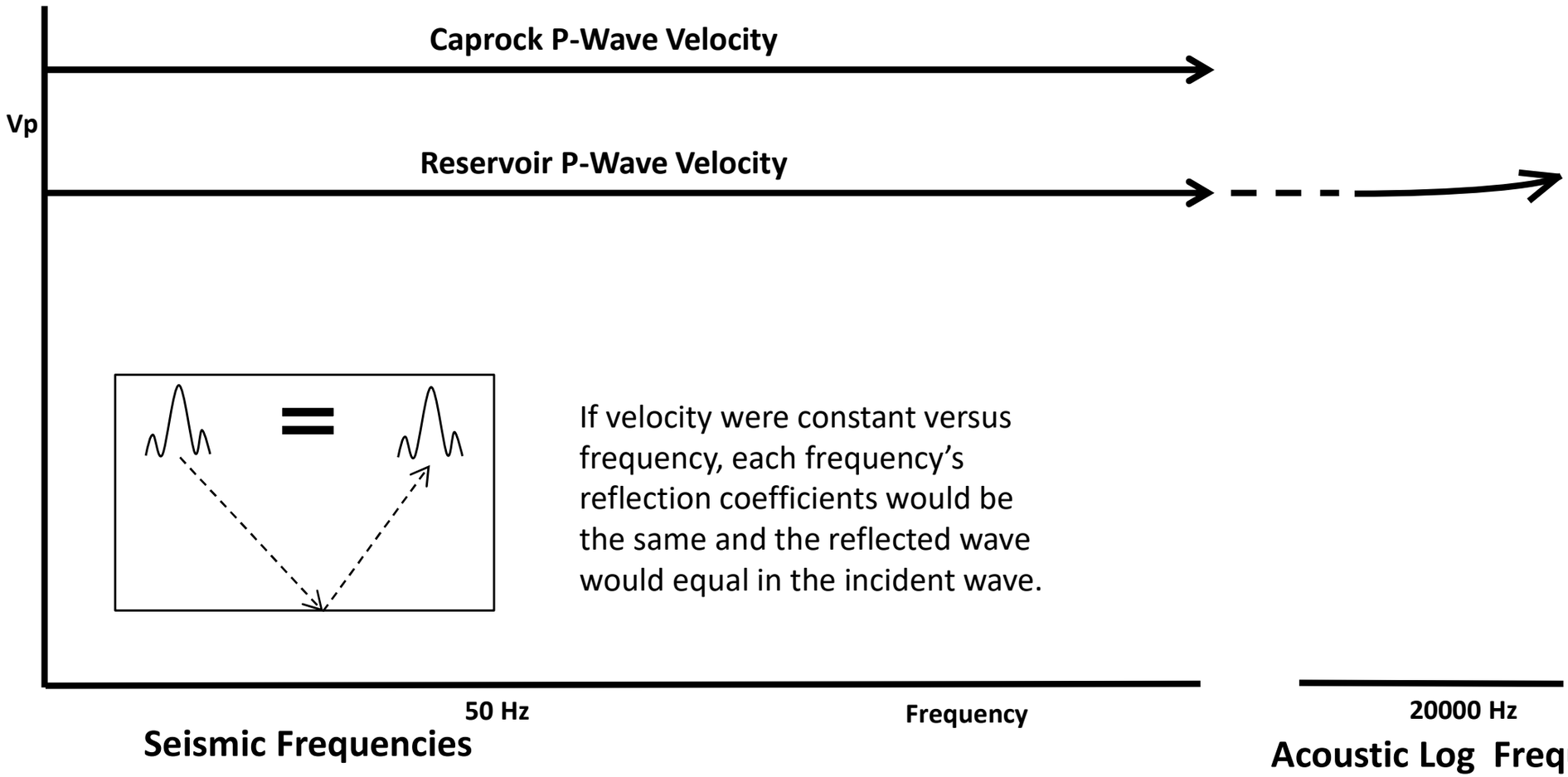
Geology

Seismic

Seismic is Wavelet(s) and geology
(excluding noise)

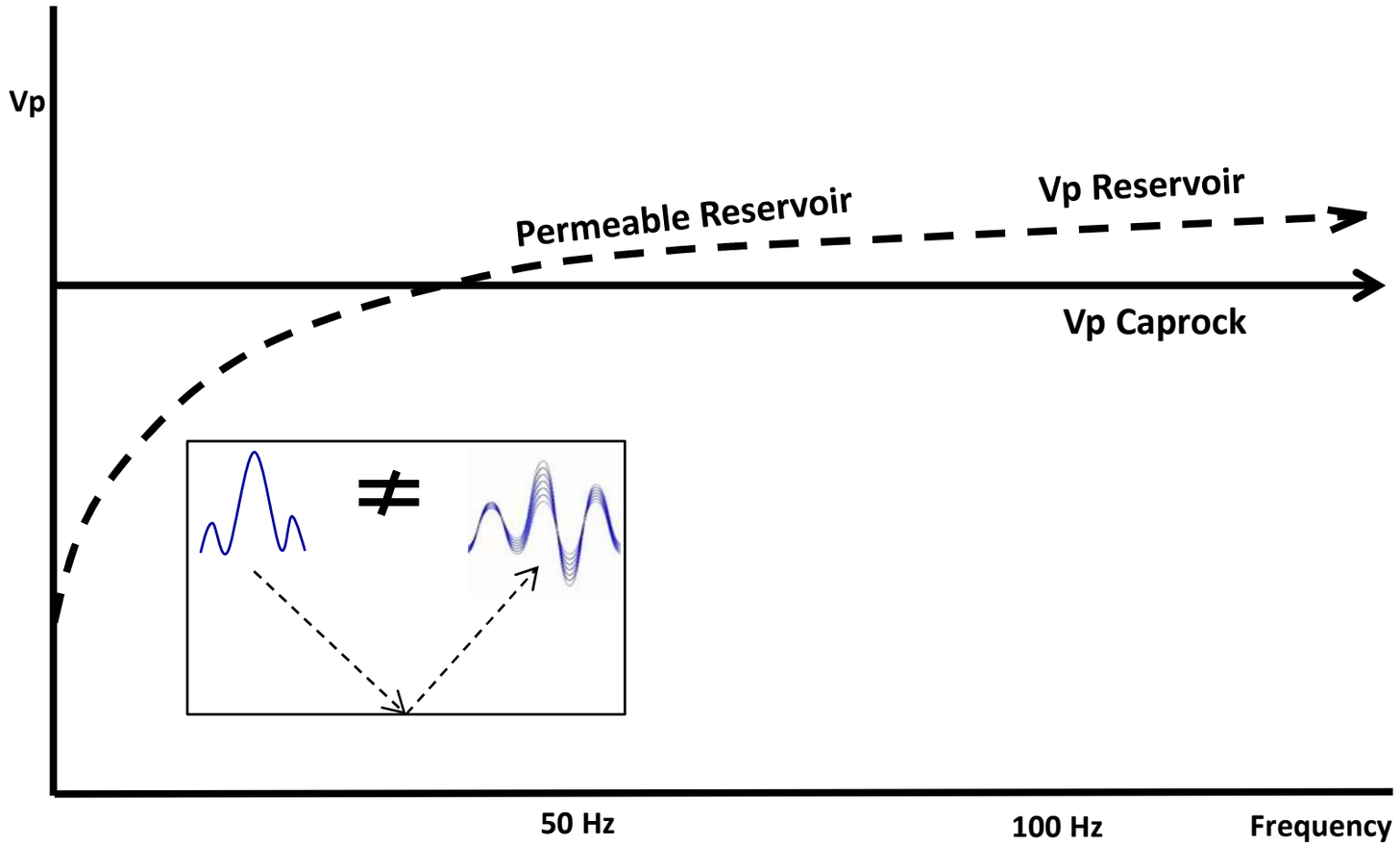
Geology includes *perm and relative perm*

The industry made a first principal simplification in 1975 by assuming 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



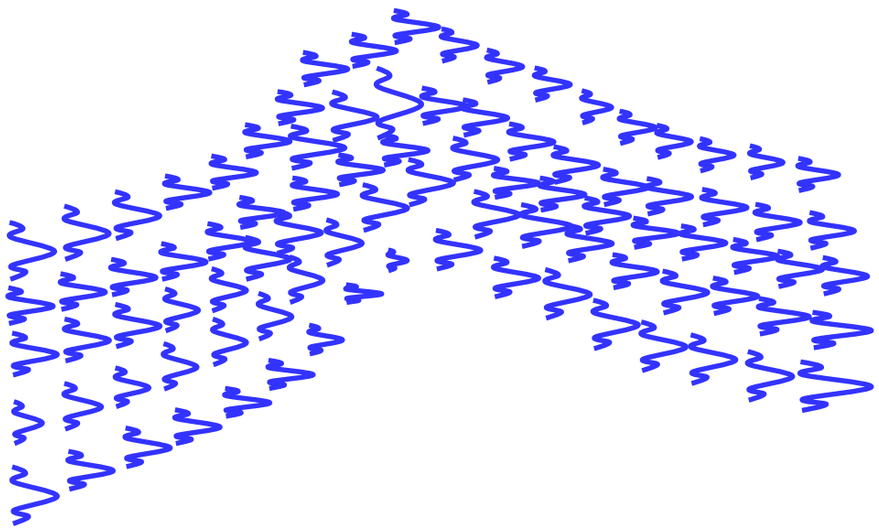
Dispersion makes the wavelet highly dynamic

Seismic data has one wavelet per sample

One wavelet per volume

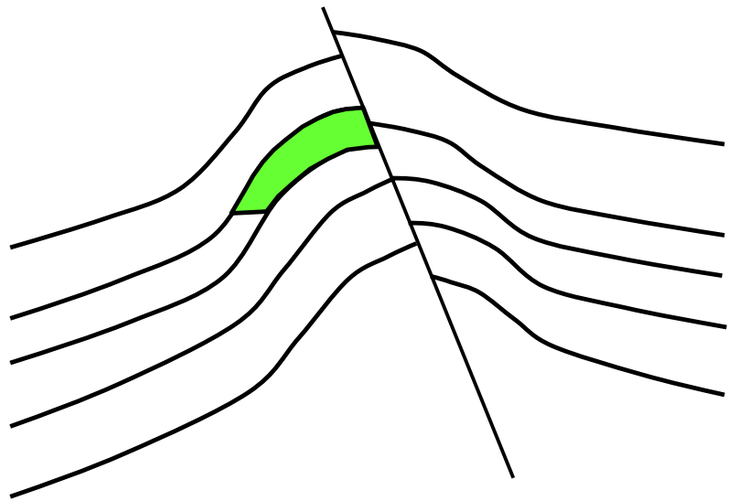
Or

One wavelet per sample

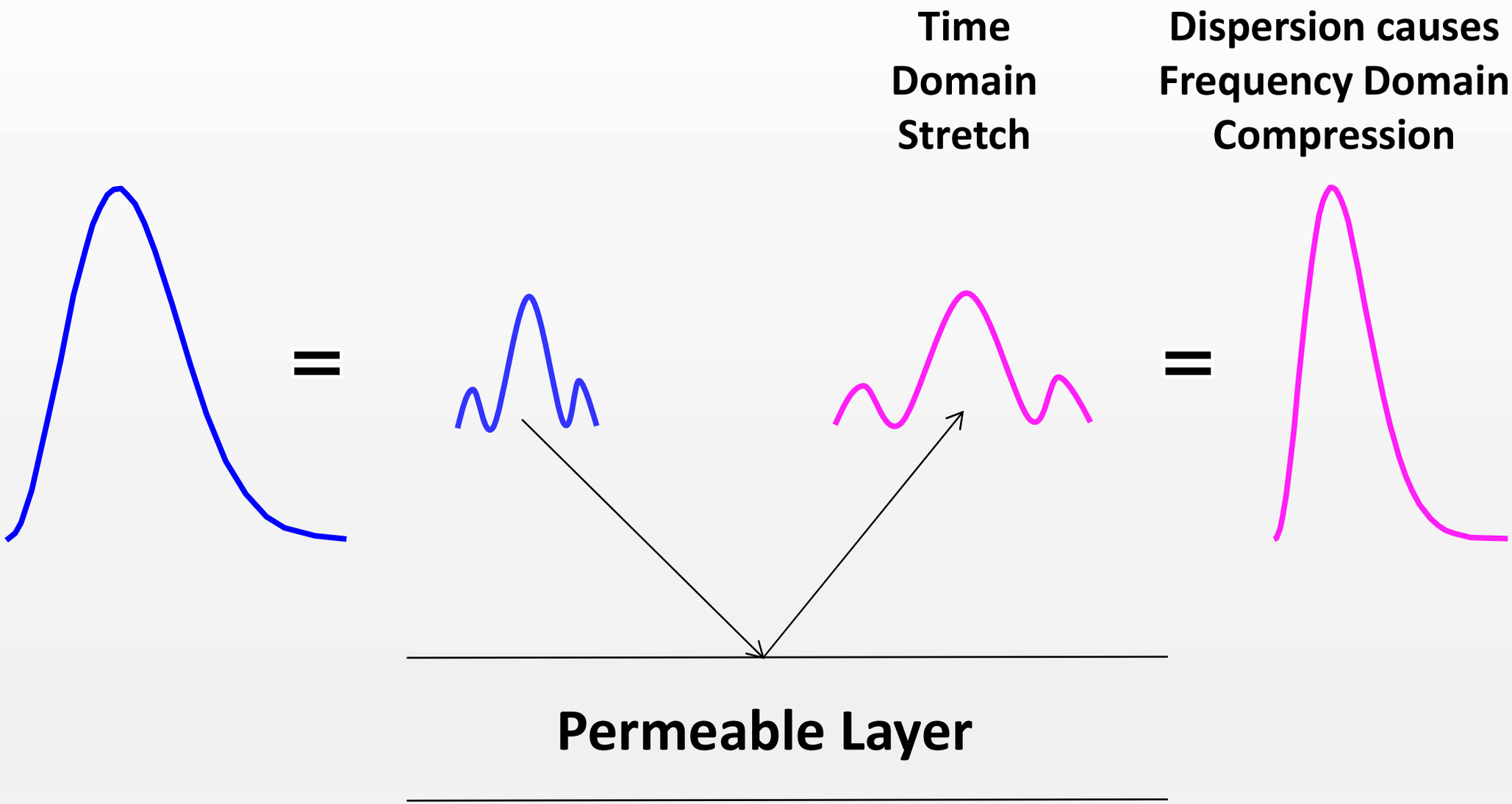


and

Geology

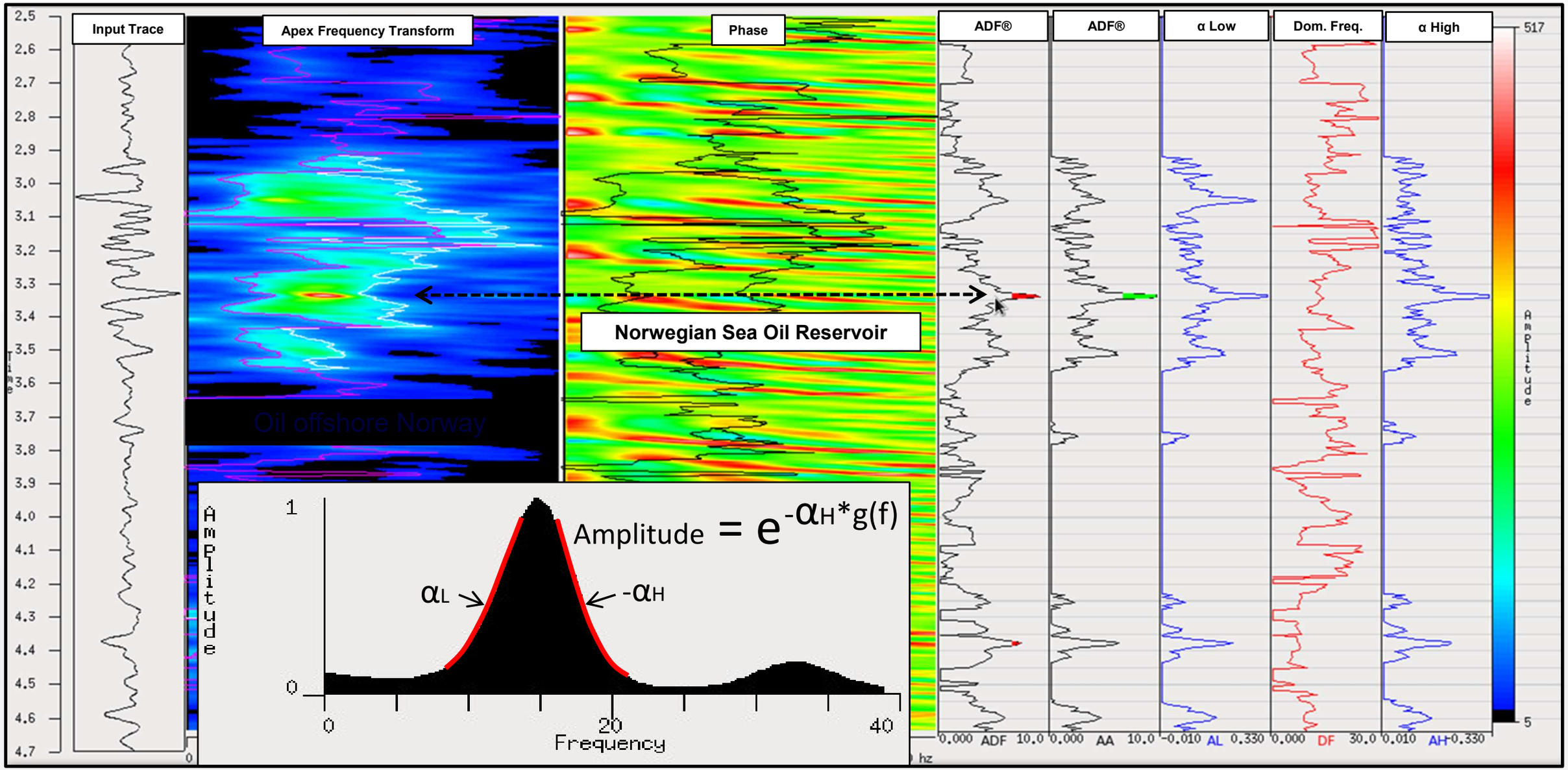


Wavelets contain perhaps half of the information in seismic



All stretch is not associated with dispersion and all stretch is not measured

Dispersion causes frequency domain compression



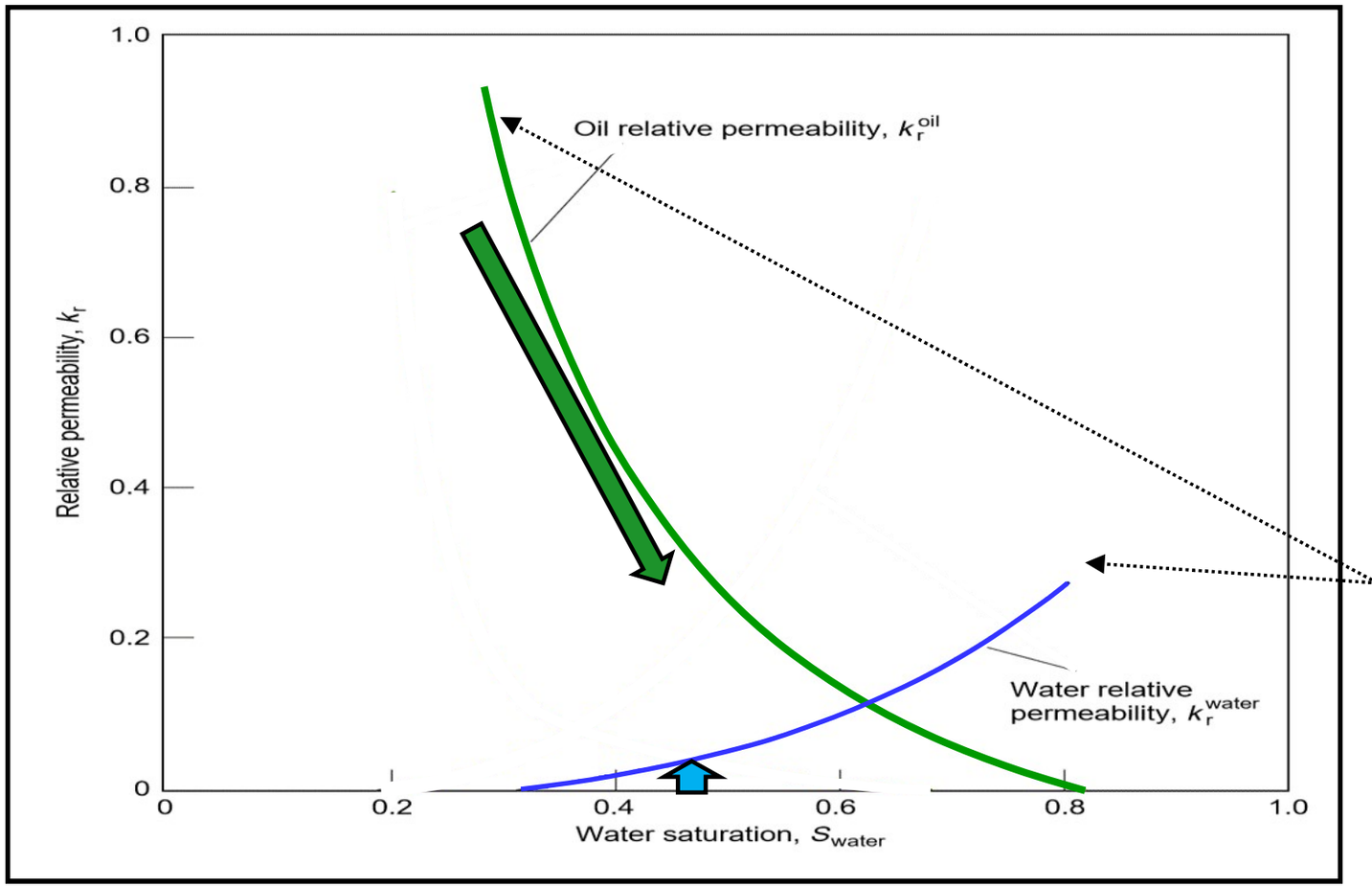
ADF® & Dispersion (“frequency dependent P-wave velocity”)

- **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

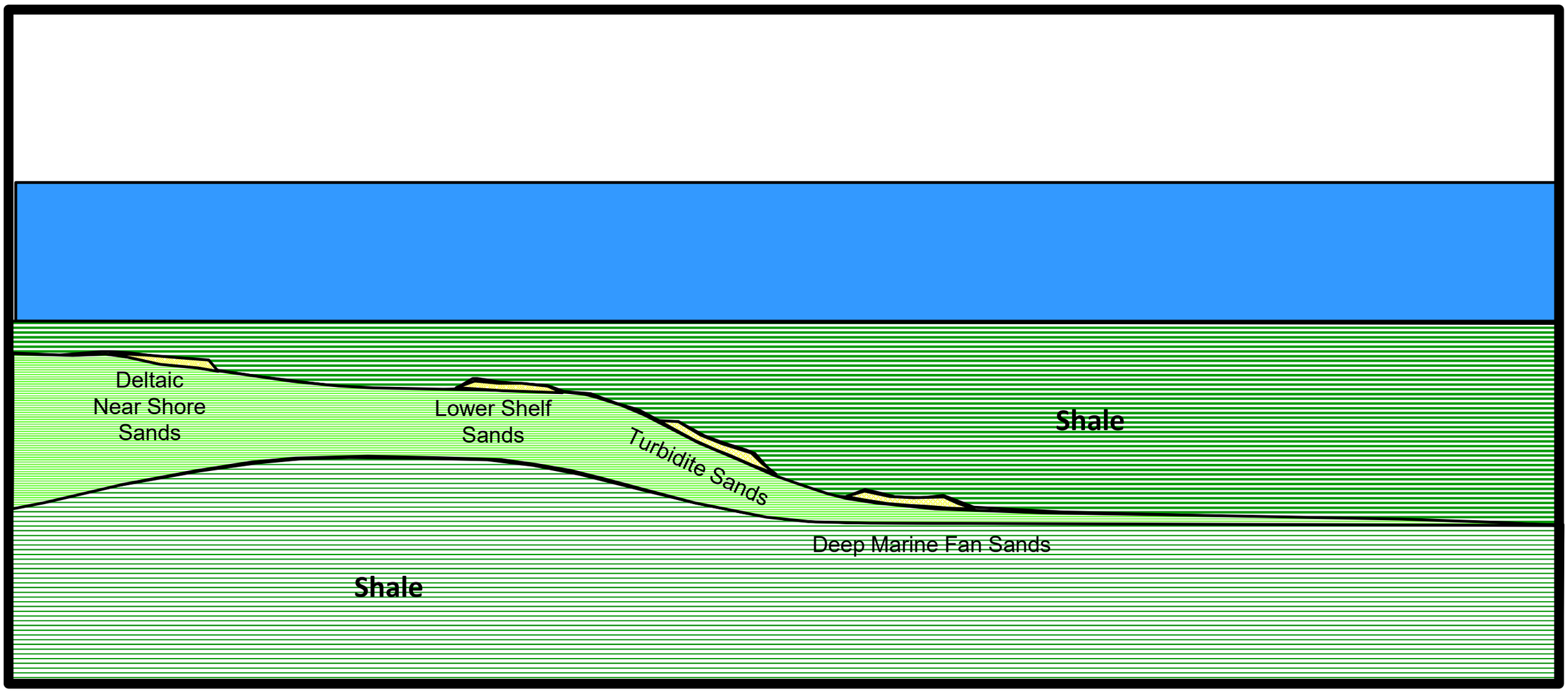
The large relative permeability drop as a reservoir is produced causes *large* ADF® 4D effect



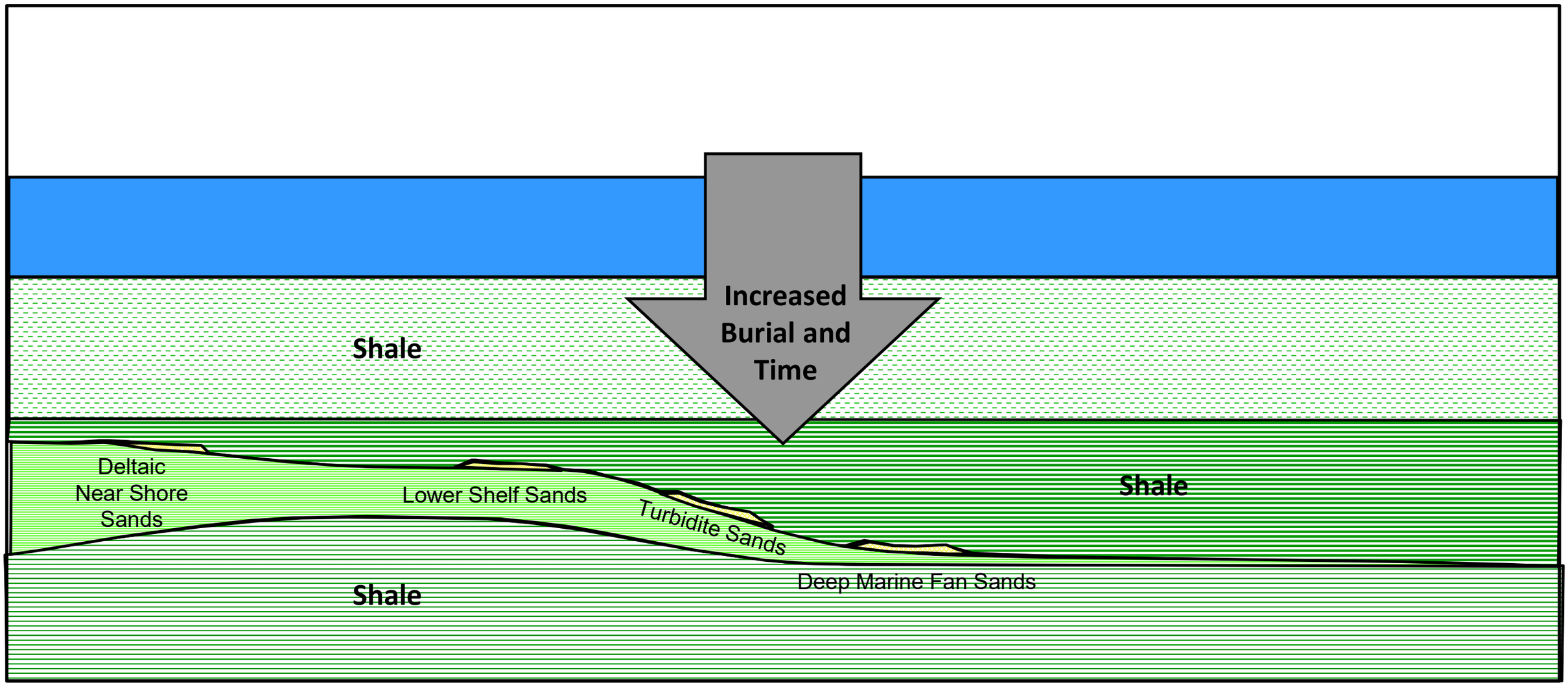
Relative permeability causes ADF® to be a DHI because oil typically has much higher relative perm than brine

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

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



Where sands are *not slower* than shales bright spot & AVO become ineffective

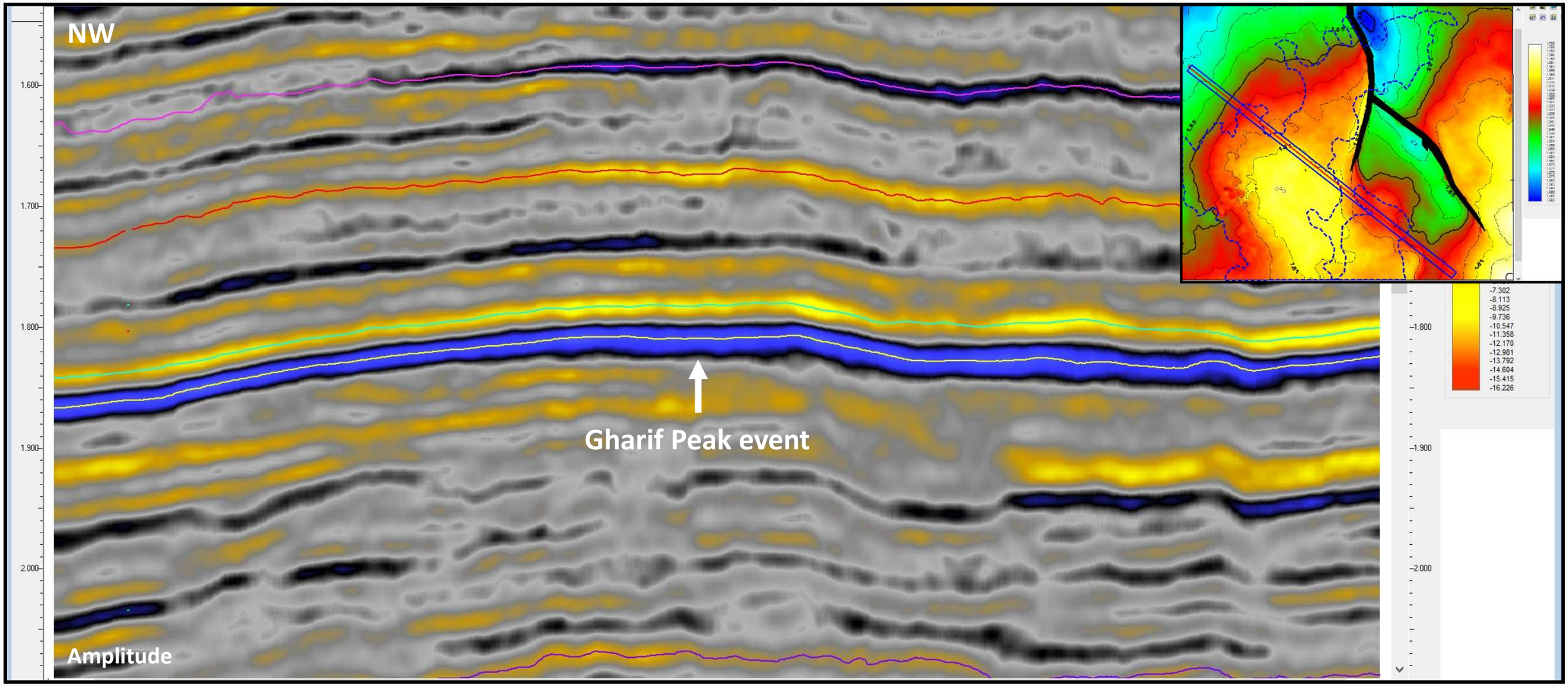


Distal Class I and II pay sands can be materially de-risked with ADF®

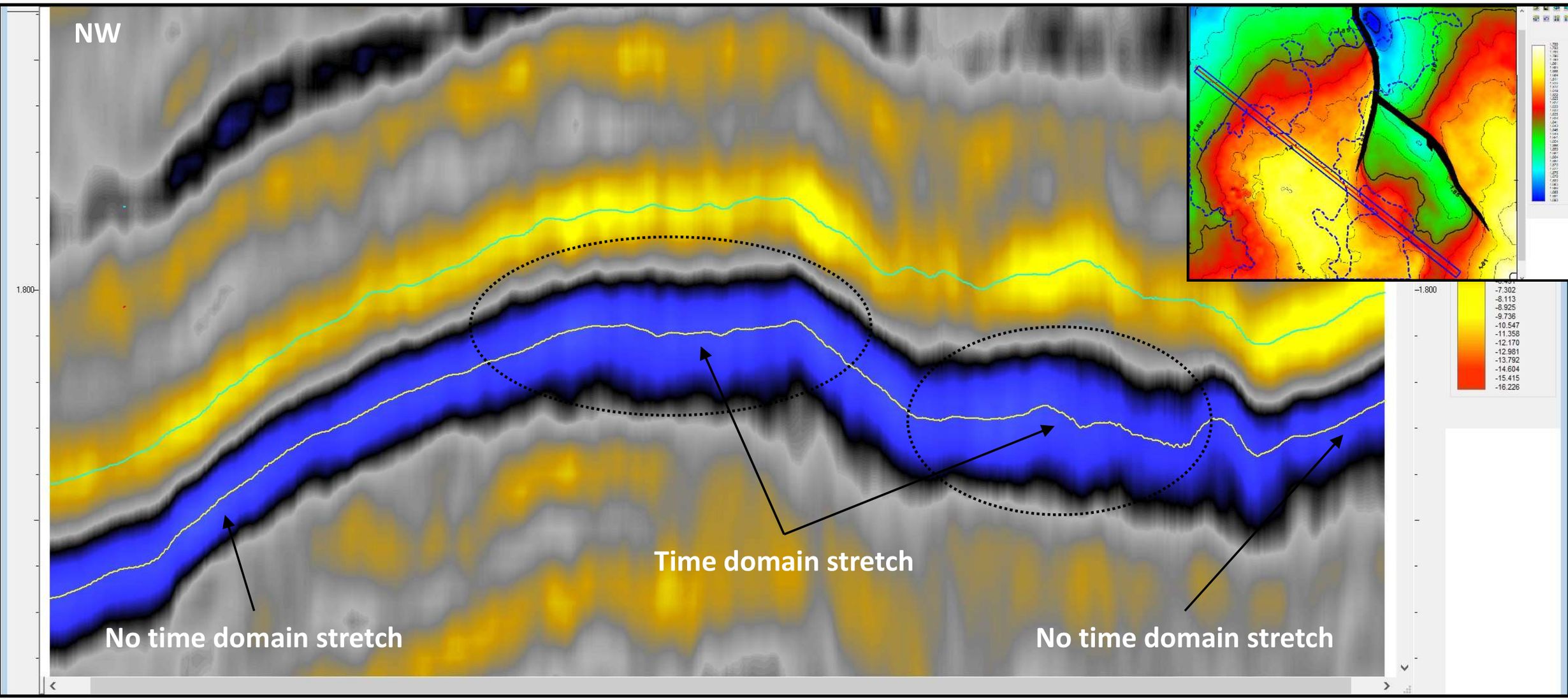
Shell/PDO Oman Blind Test Proof of Concept Project

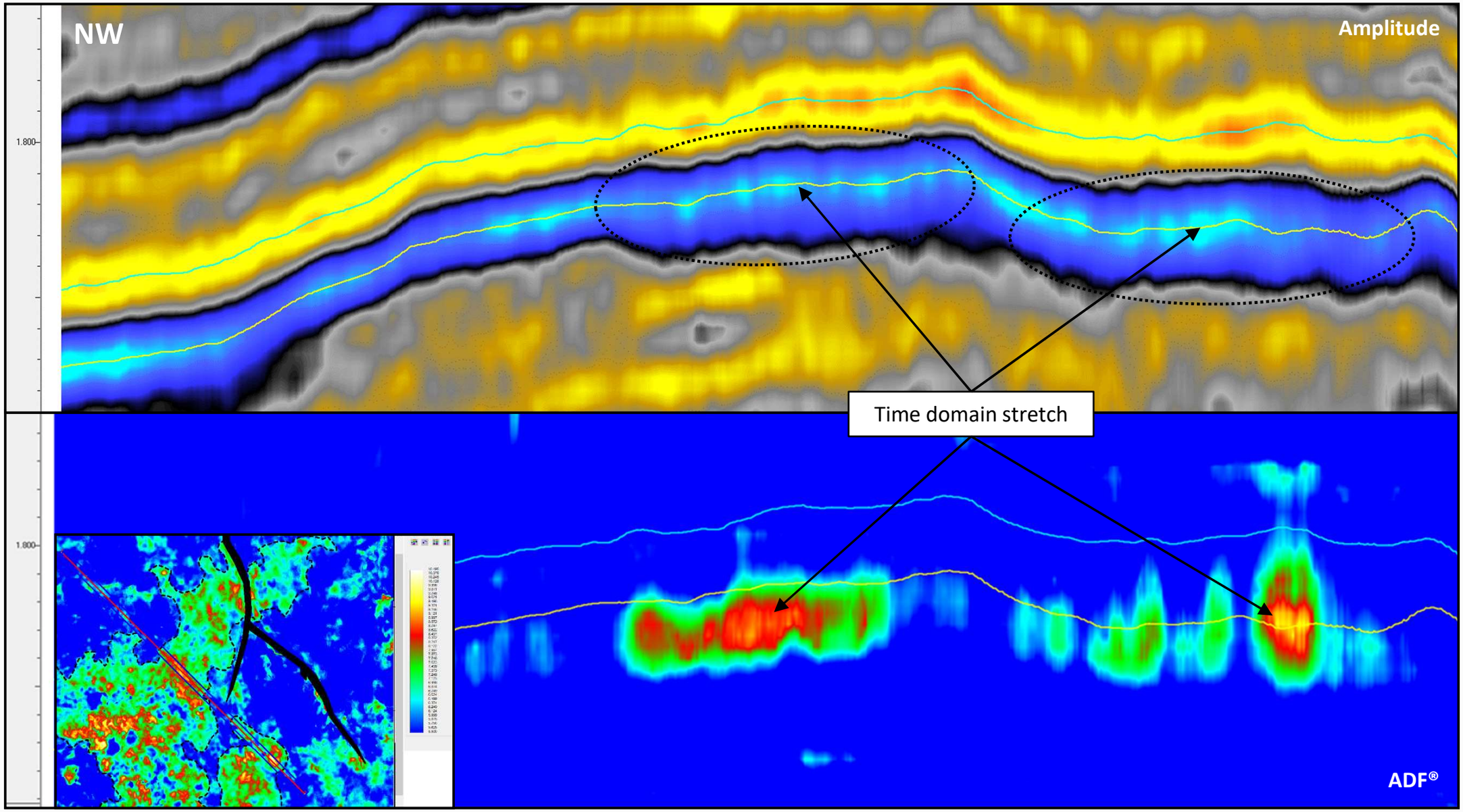
"Dispersion Imaged Field with No Amplitude DHI"

Published October 21, 2021


NW
1.600
1.700
1.800
1.900
2.000
Gharif Peak event
Amplitude
-7.302
-8.113
-8.925
-9.736
-10.547
-11.358
-12.170
-12.981
-13.792
-14.604
-15.415
-16.226

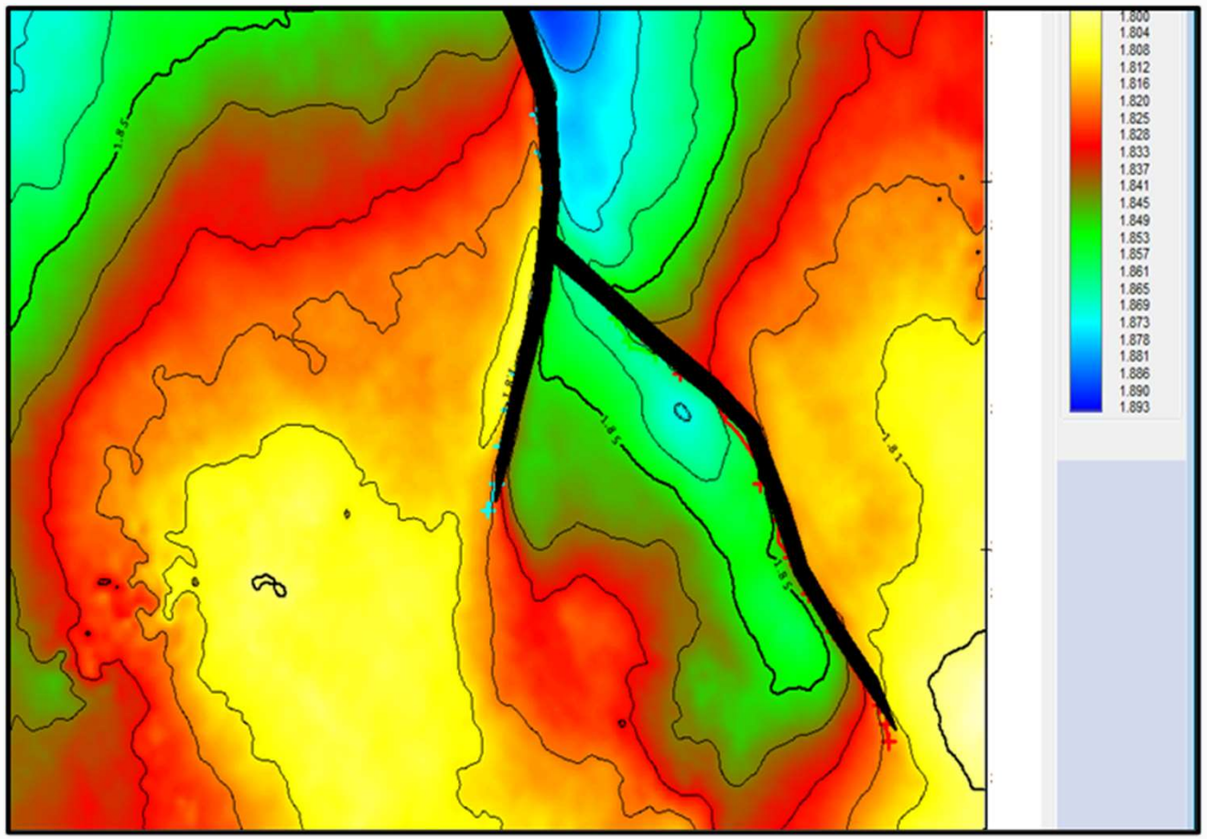
Zoom-In of Previous Slide



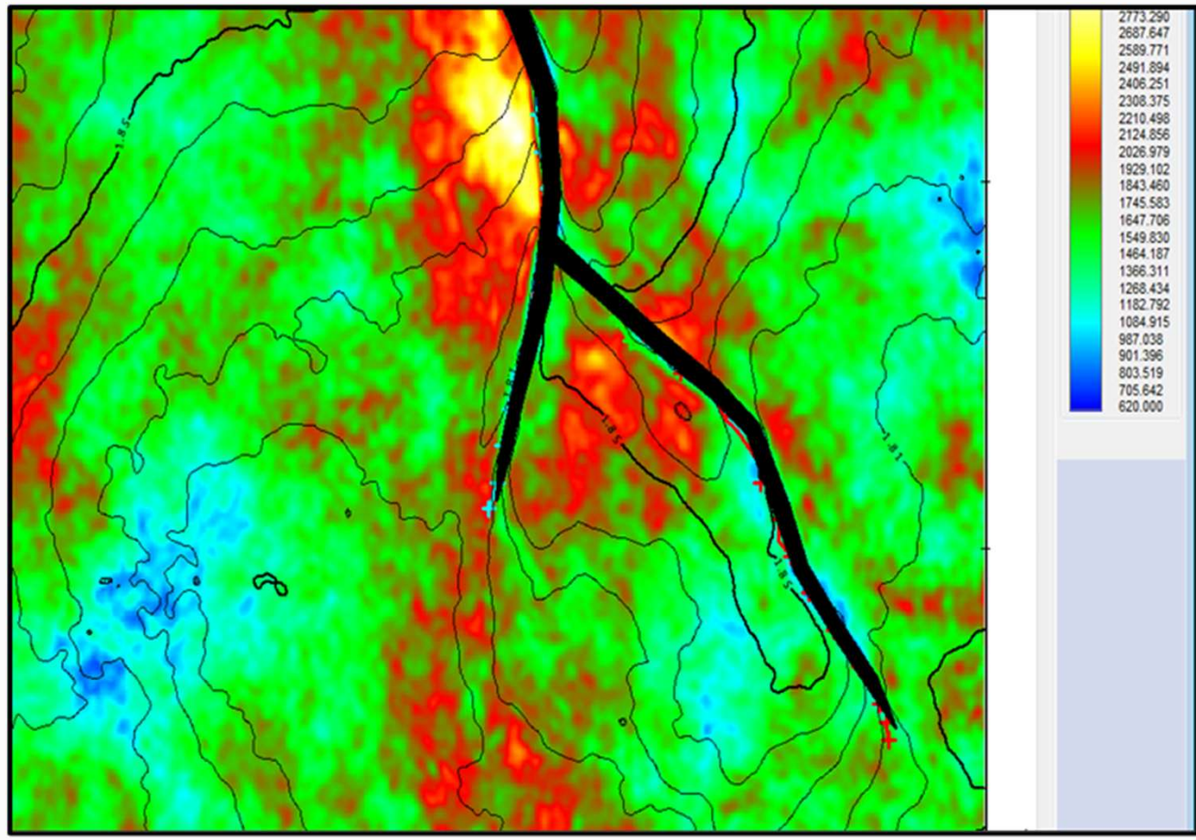


Courtesy of Petroleum Development Oman

Gharif Peak Time Structure

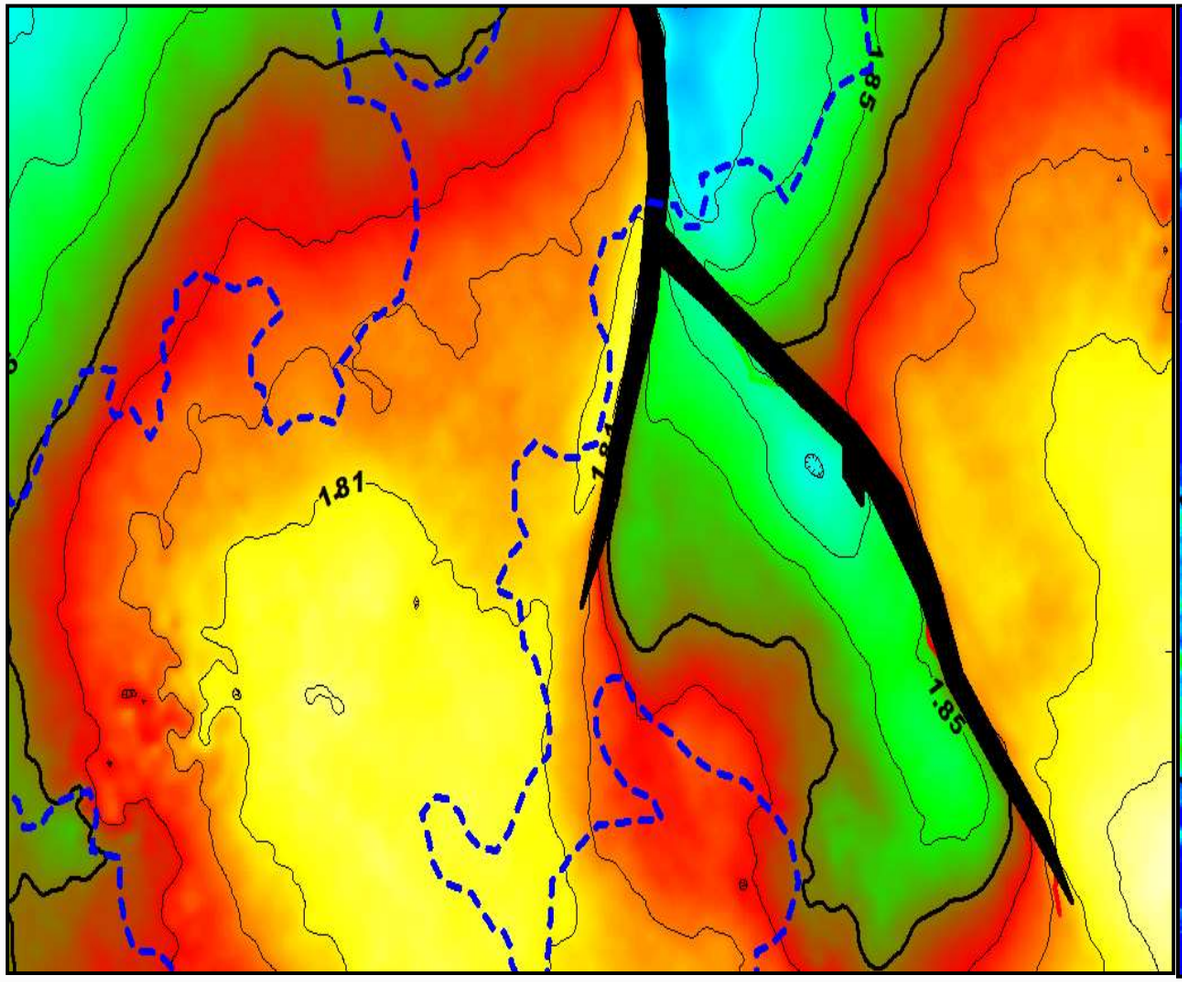


Gharif Peak Amplitude

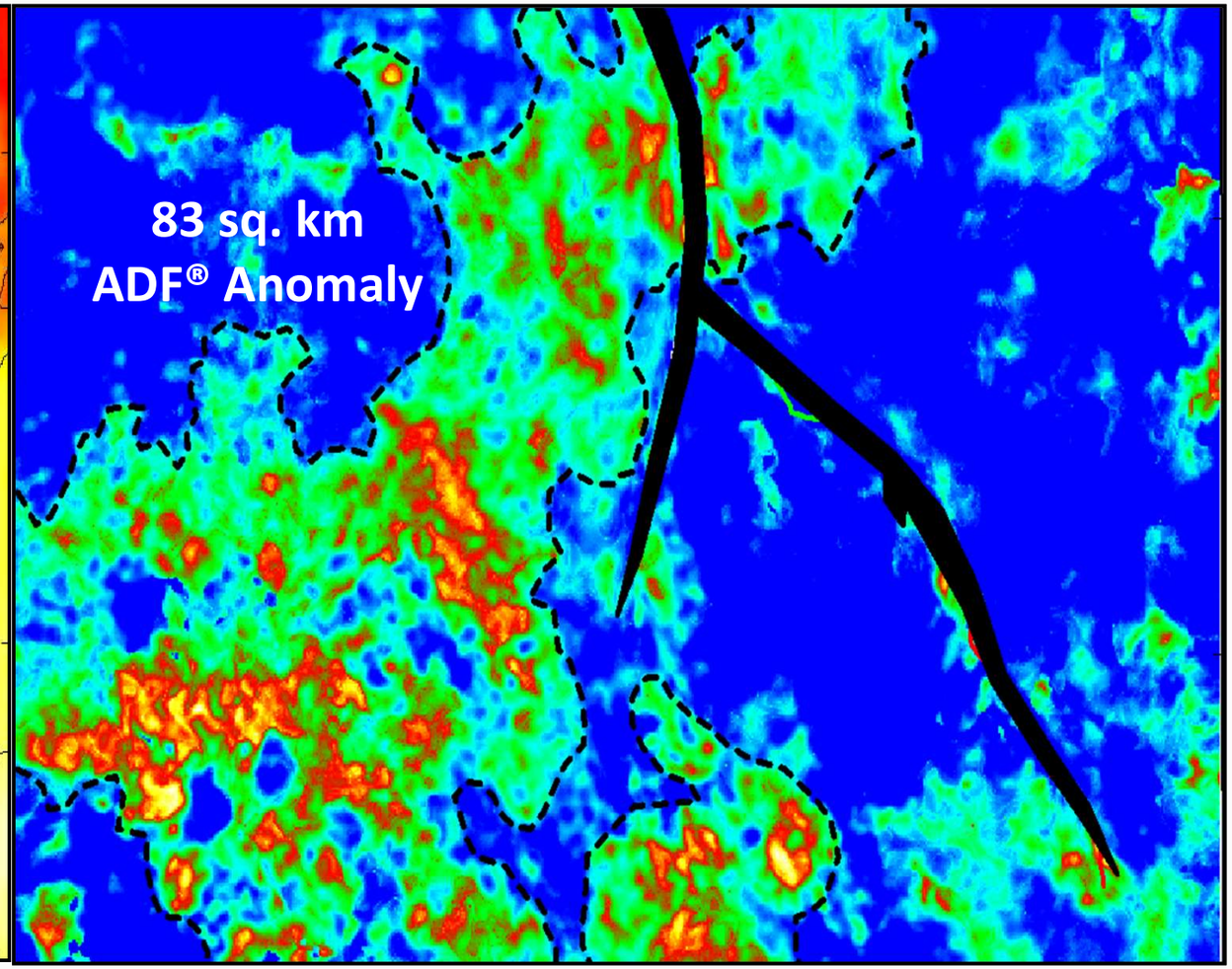


Amplitude shows no correlation to structure

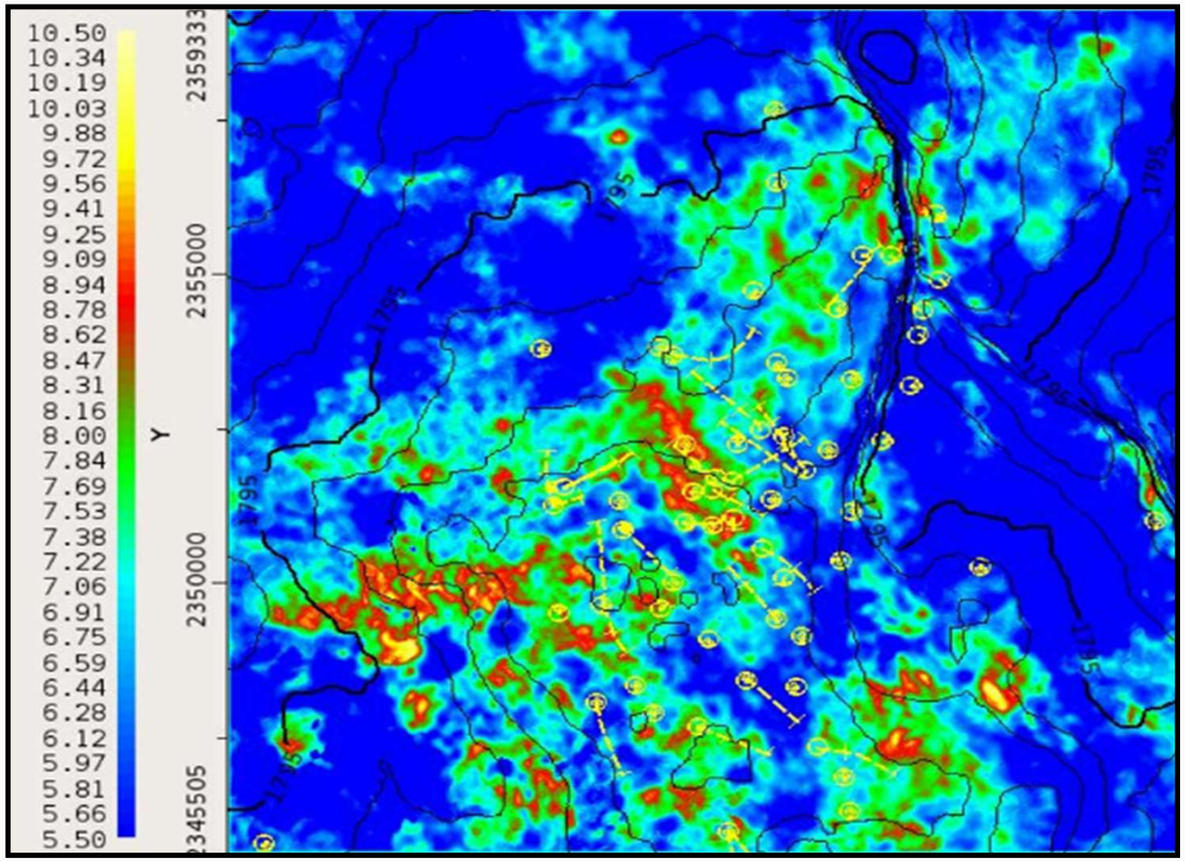
Gharif Peak Time Structure

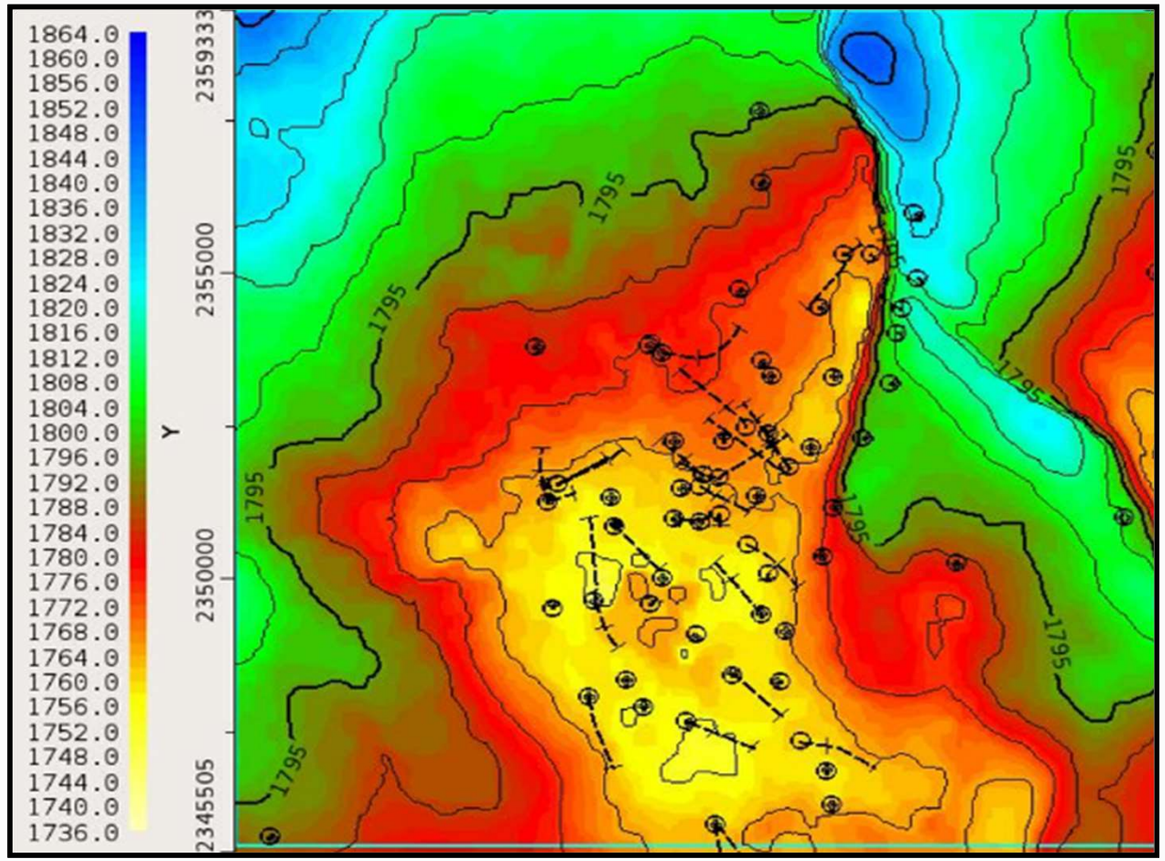


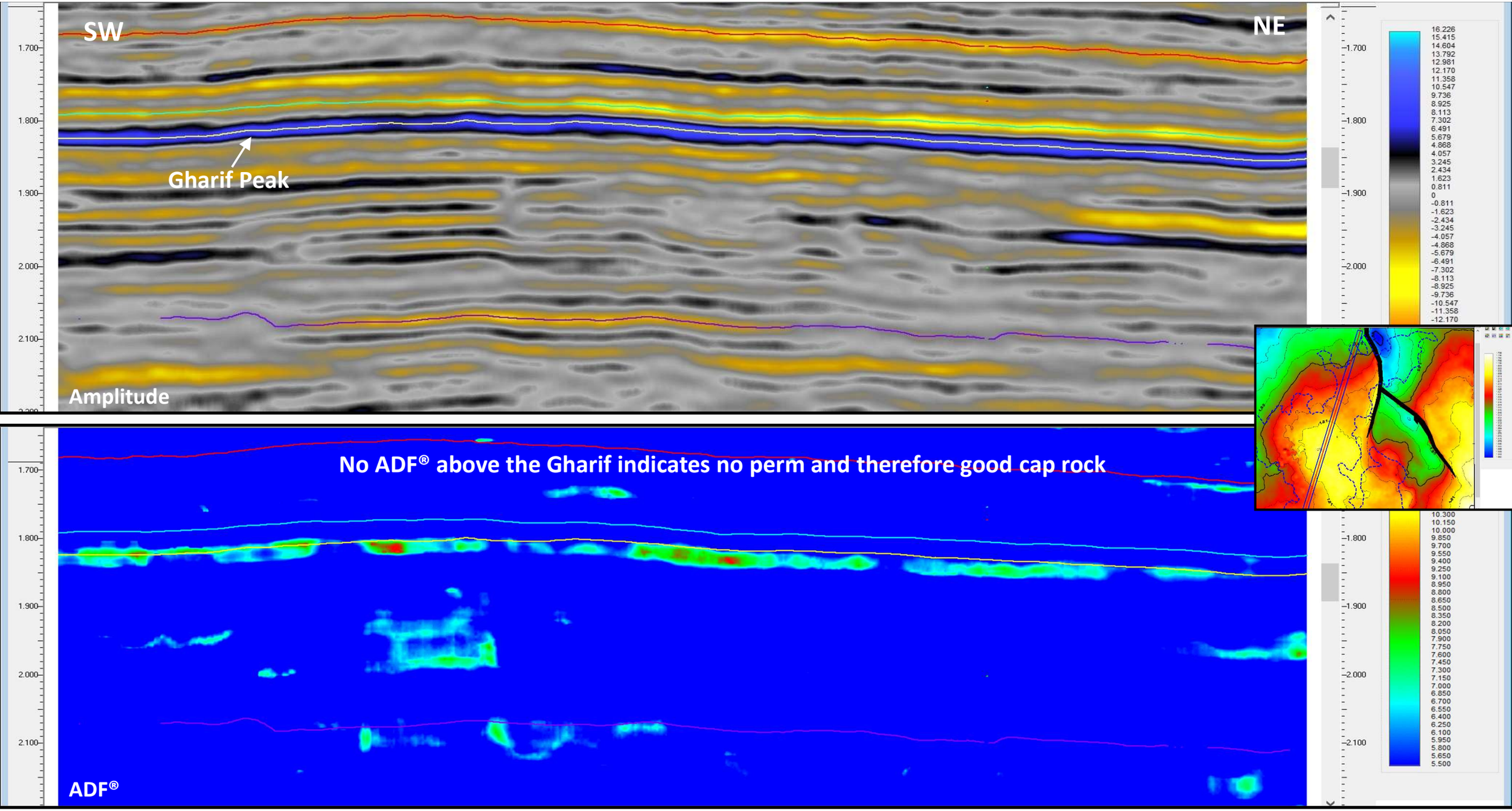
Gharif ADF®



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






SW
NE
Gharif Peak
Amplitude
No ADF® above the Gharif indicates no perm and therefore good cap rock
ADF®
1.700
1.800
1.900
2.000
2.100
16.226
15.415
14.604
13.792
12.981
12.170
11.358
10.547
9.736
8.925
8.113
7.302
6.491
5.679
4.868
4.057
3.245
2.434
1.623
0.811
0
-0.811
-1.623
-2.434
-3.245
-4.057
-4.868
-5.679
-6.491
-7.302
-8.113
-8.925
-9.736
-10.547
-11.358
-12.170
10.300
10.150
10.000
9.850
9.700
9.550
9.400
9.250
9.100
8.950
8.800
8.650
8.500
8.350
8.200
8.050
7.900
7.750
7.600
7.450
7.300
7.150
7.000
6.850
6.700
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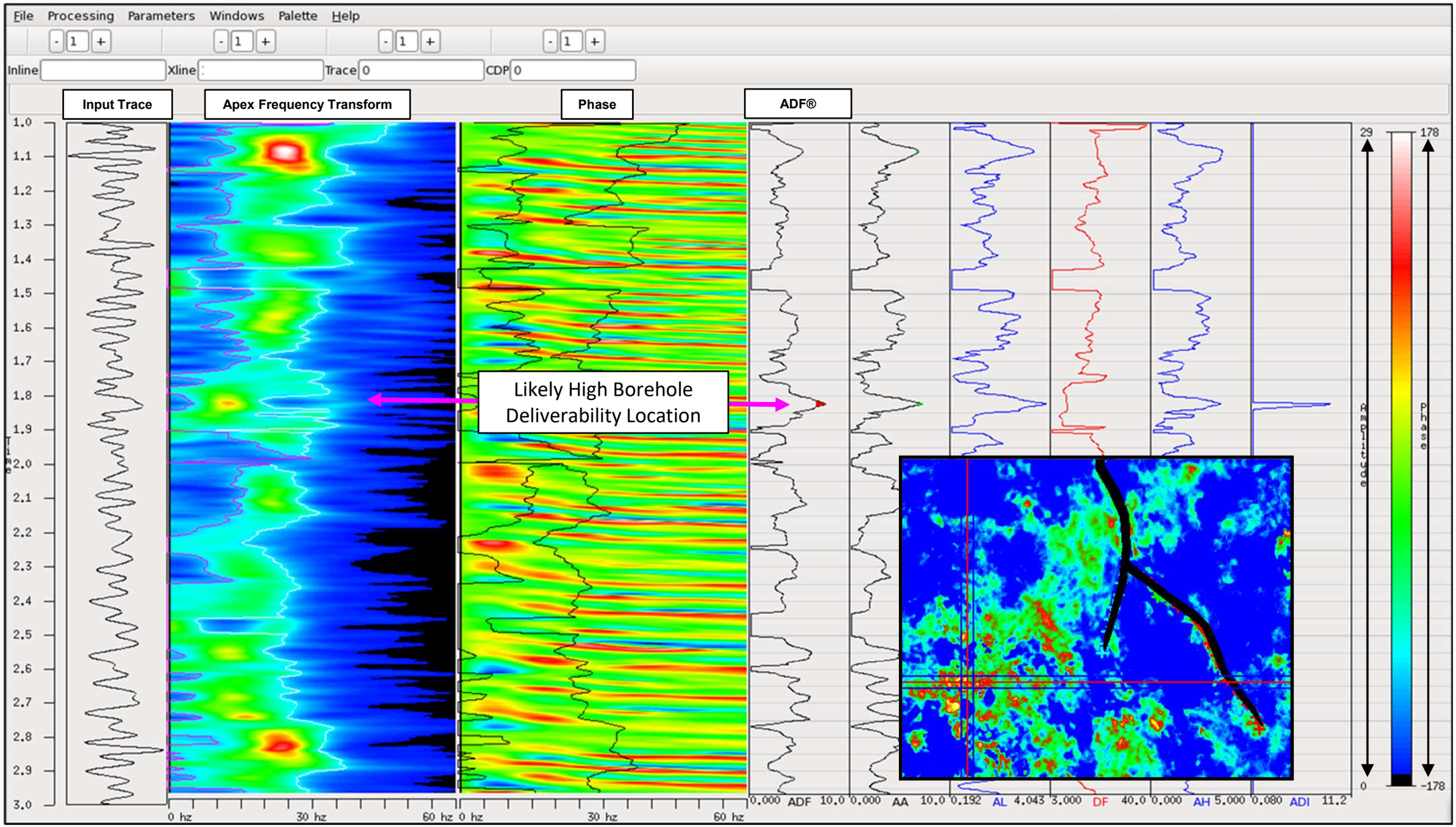
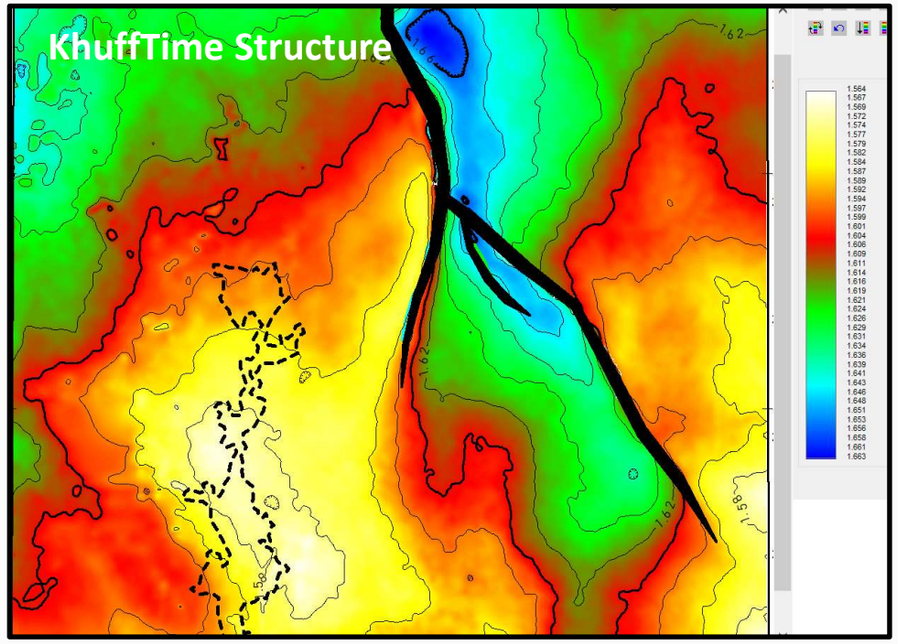
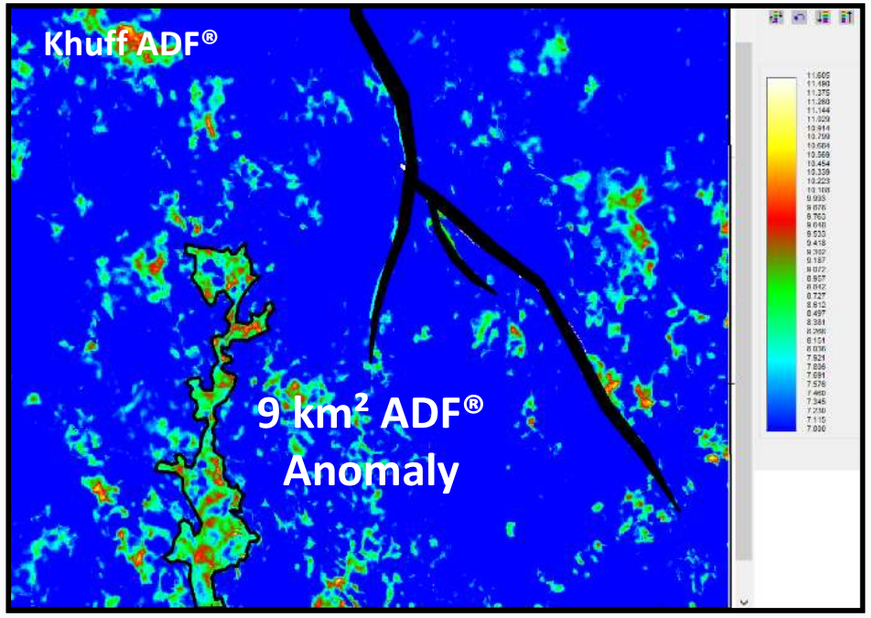
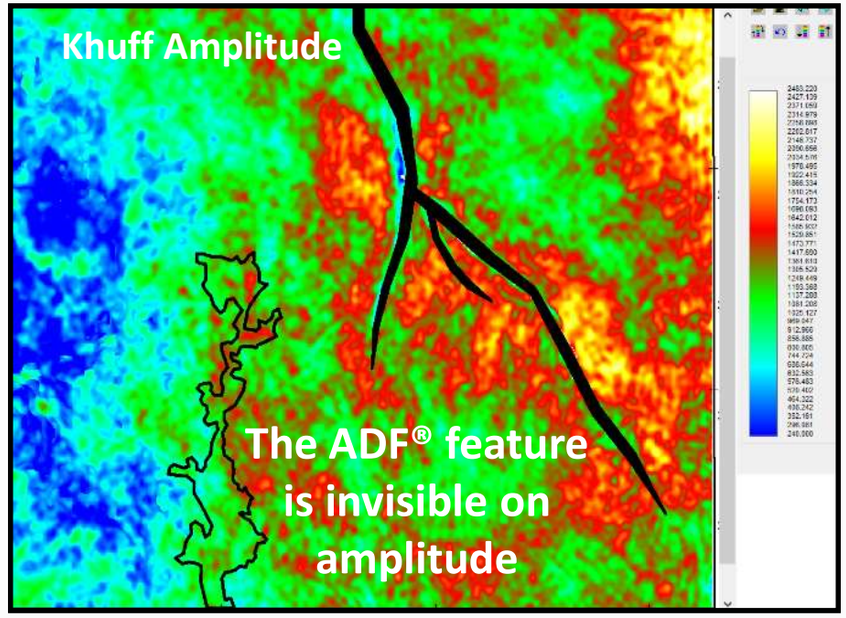
6.400
6.250
6.100
5.950
5.800
5.650
5.500


File Processing Parameters Windows Palette Help
Inline
Xline
Trace 0
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

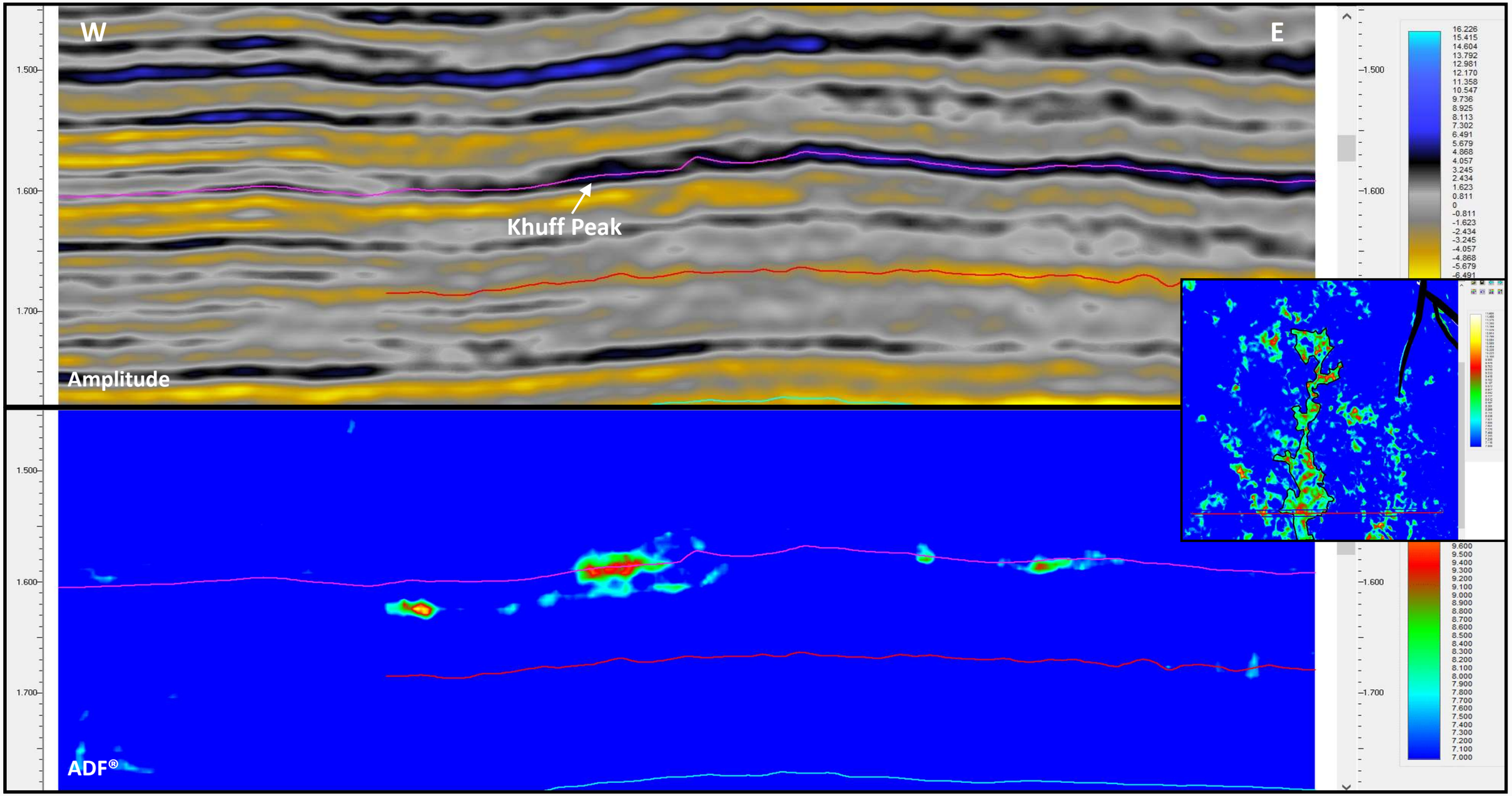
Khuff Carbonate ADF® Analysis



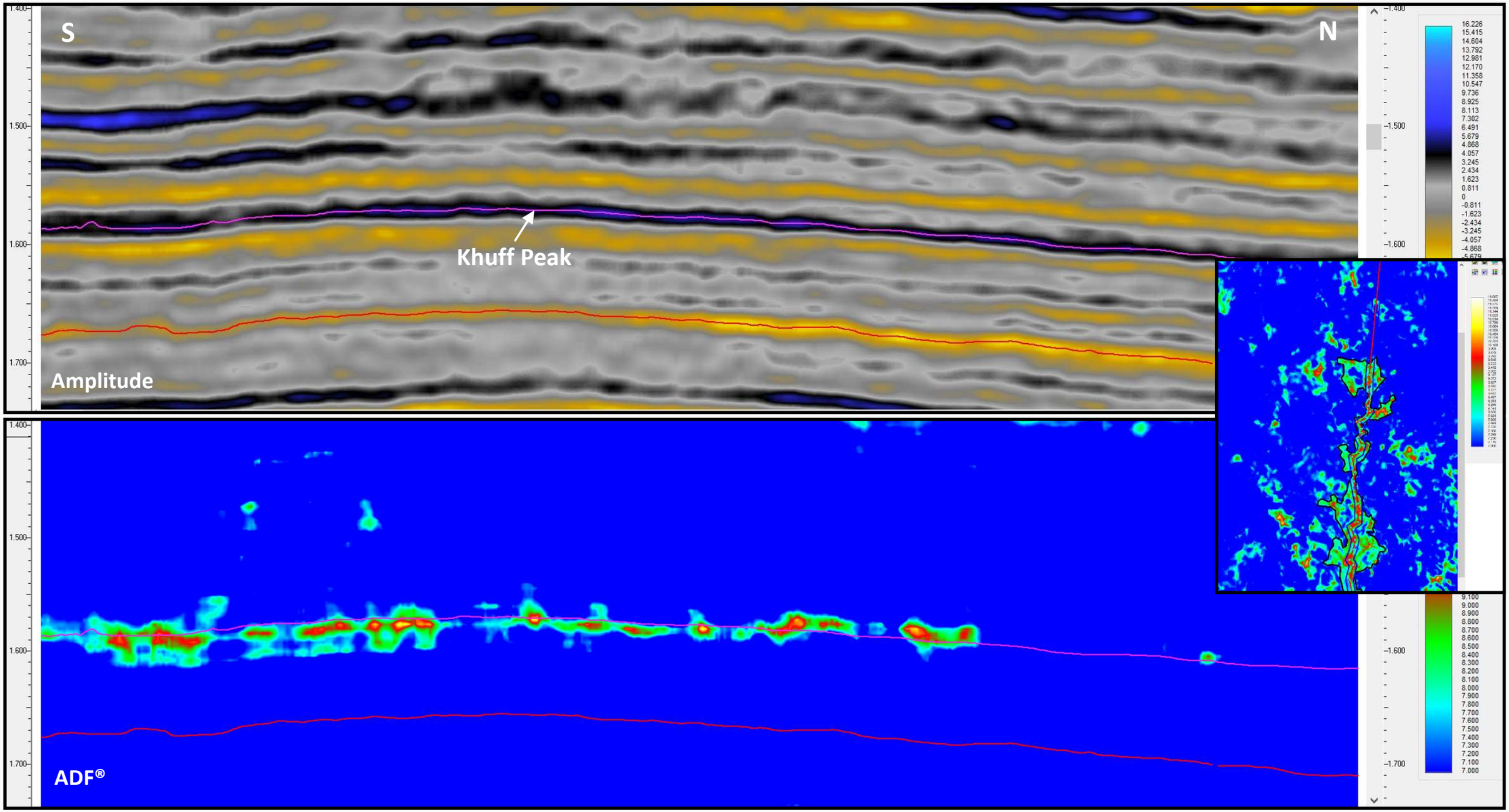




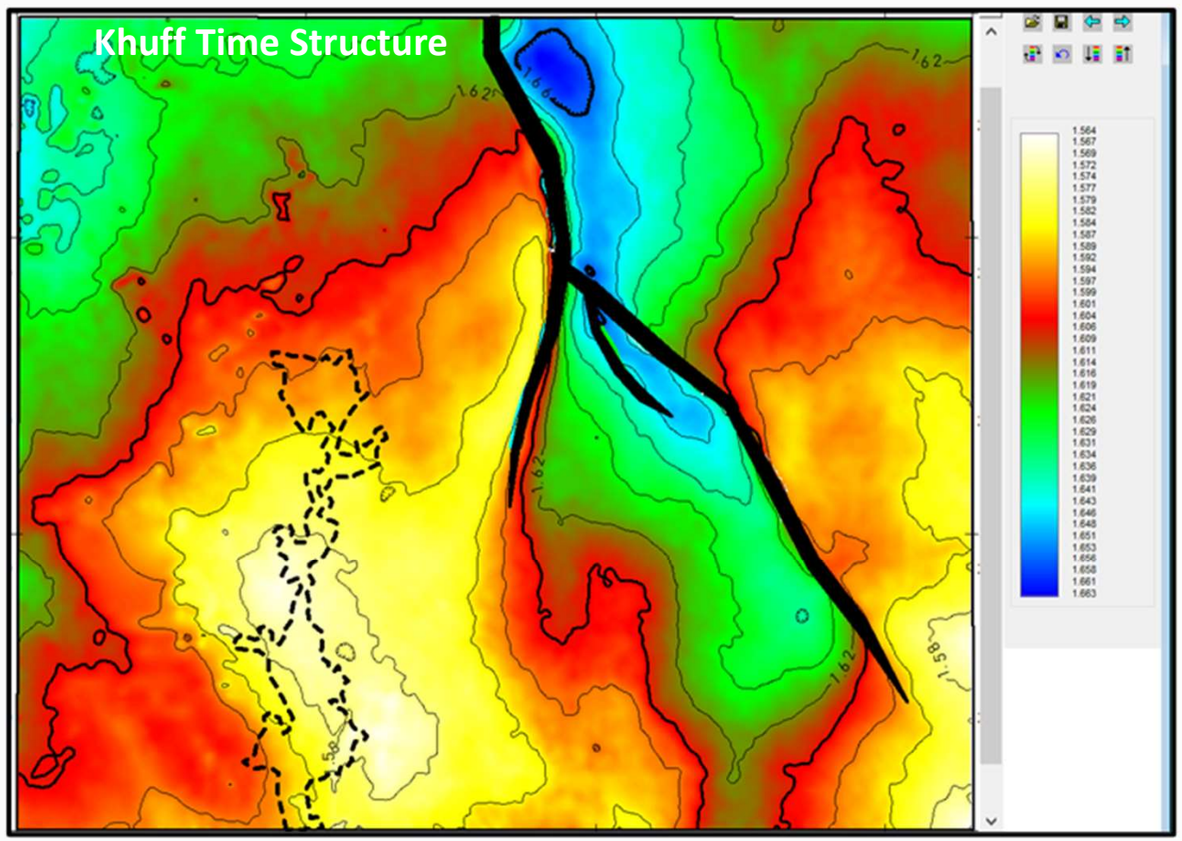
Courtesy of Petroleum Development Oman

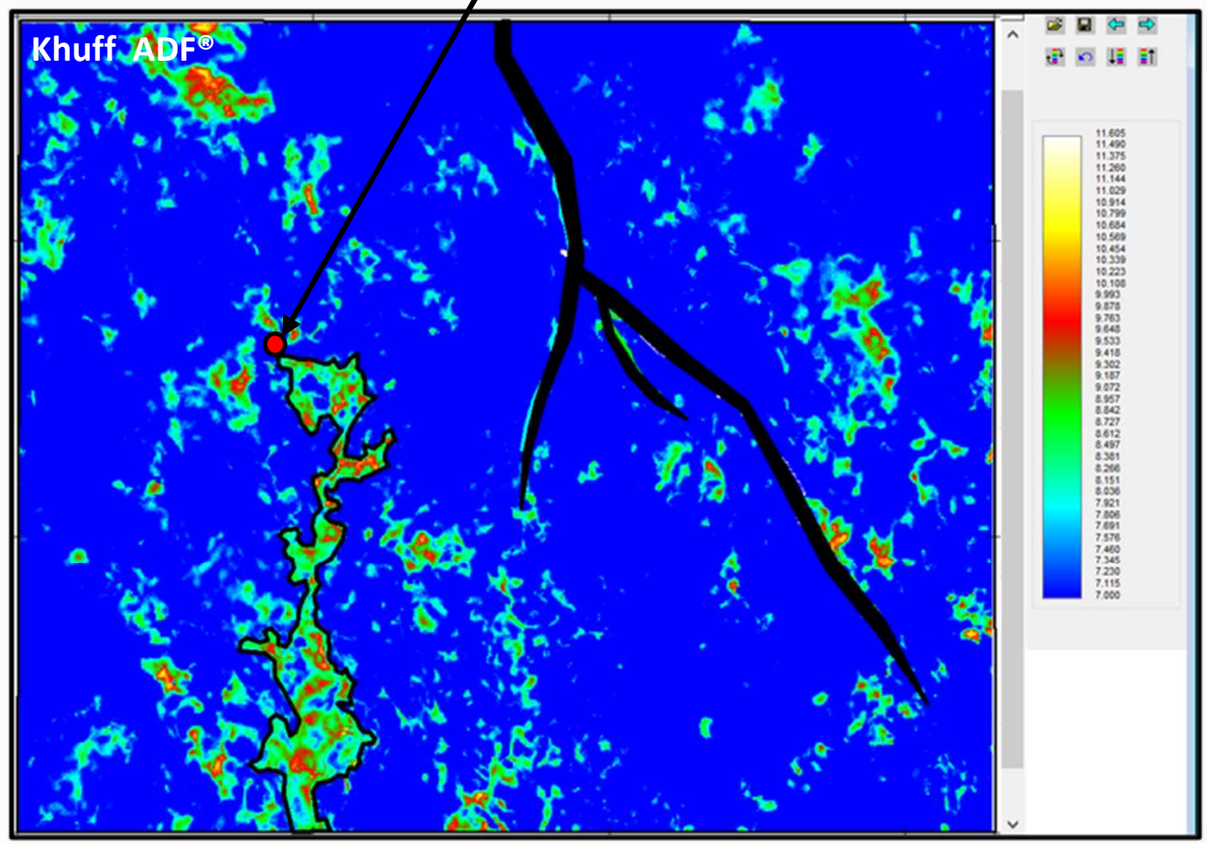


Courtesy of Petroleum Development Oman


S
N
Khuff Peak
Amplitude
ADF®
1.400
1.500
1.600
1.700
16.226
15.415
14.604
13.792
12.981
12.170
11.358
10.547
9.736
8.925
8.113
7.302
6.491
5.679
4.868
4.057
3.245
2.434
1.623
0.811
0
-0.811
-1.623
-2.434
-3.245
-4.057
-4.868
9.100
9.000
8.900
8.800
8.700
8.600
8.500
8.400
8.300
8.200
8.100
8.000
7.900
7.800
7.700
7.600
7.500
7.400
7.300
7.200
7.100
7.000

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

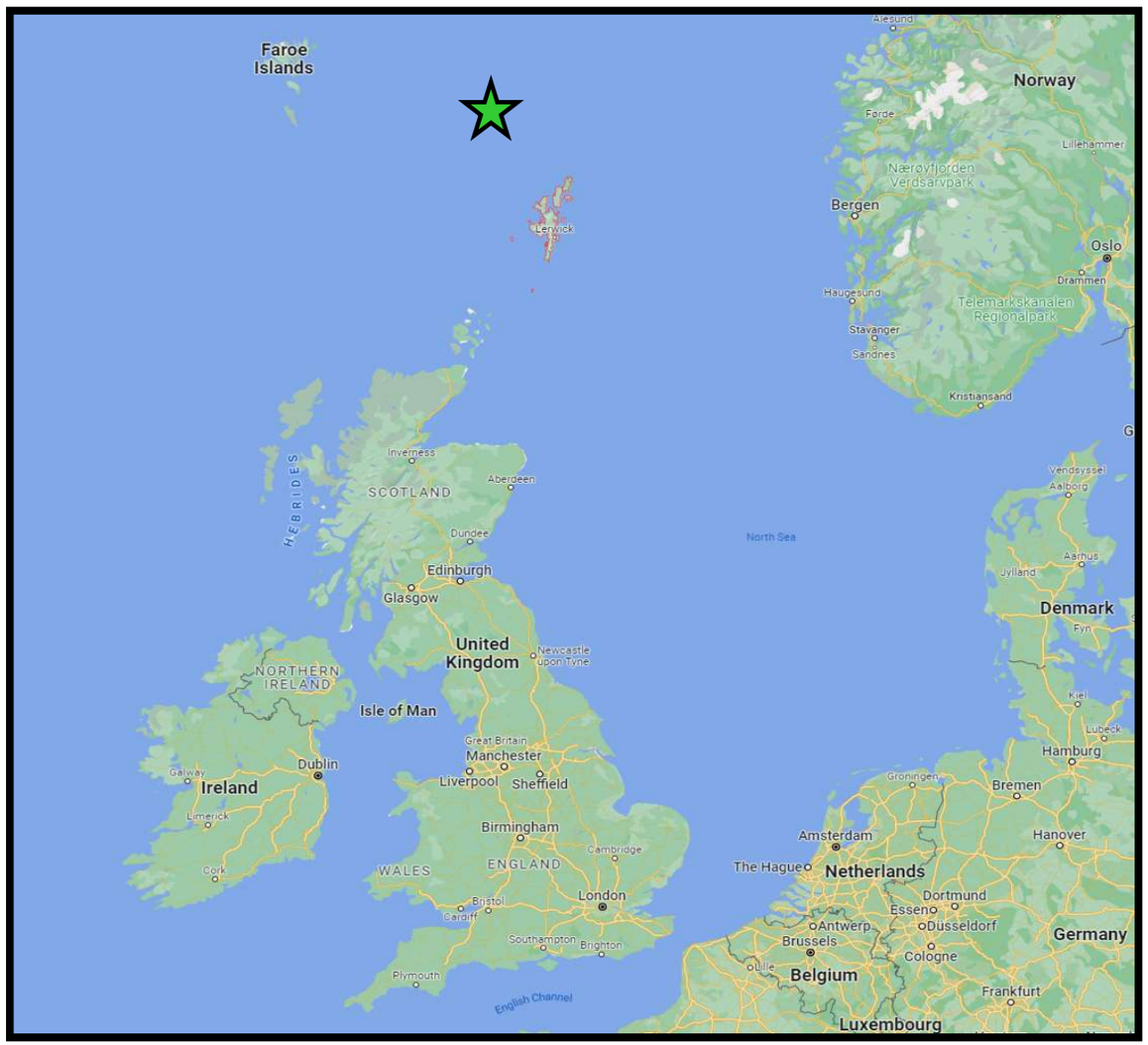


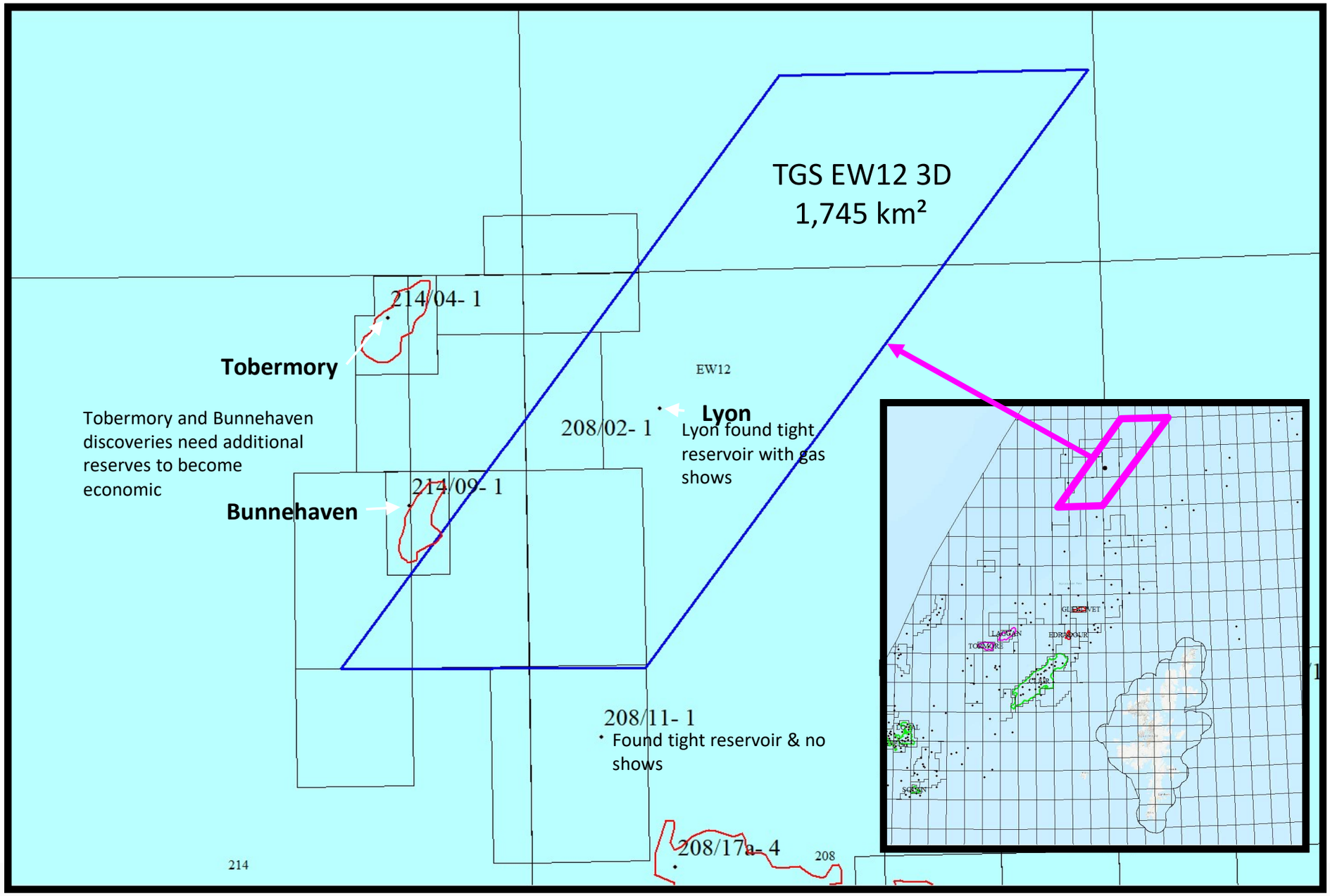


Summary Comments

- 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

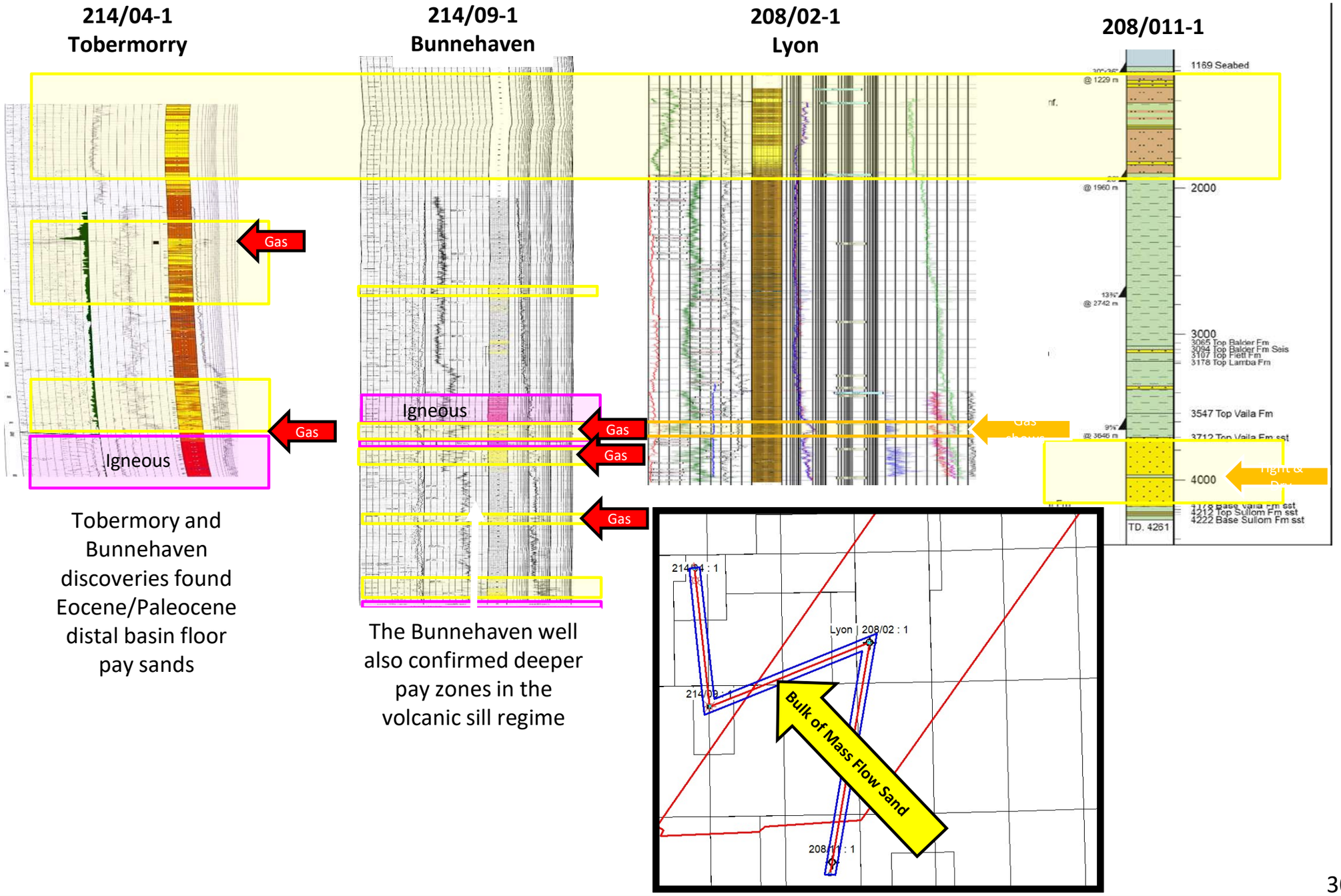



TGS EW12 3D
1,745 km²
214/04- 1
Tobermory
EW12
Lyon
208/02- 1
Lyon found tight reservoir with gas shows
Tobermory and Bunnehaven discoveries need additional reserves to become economic
214/09- 1
Bunnehaven
208/11- 1
Found tight reservoir & no shows
208/17a- 4
214
208

Shallow sands

Eocene/Paleocene distal sands

High amplitude section



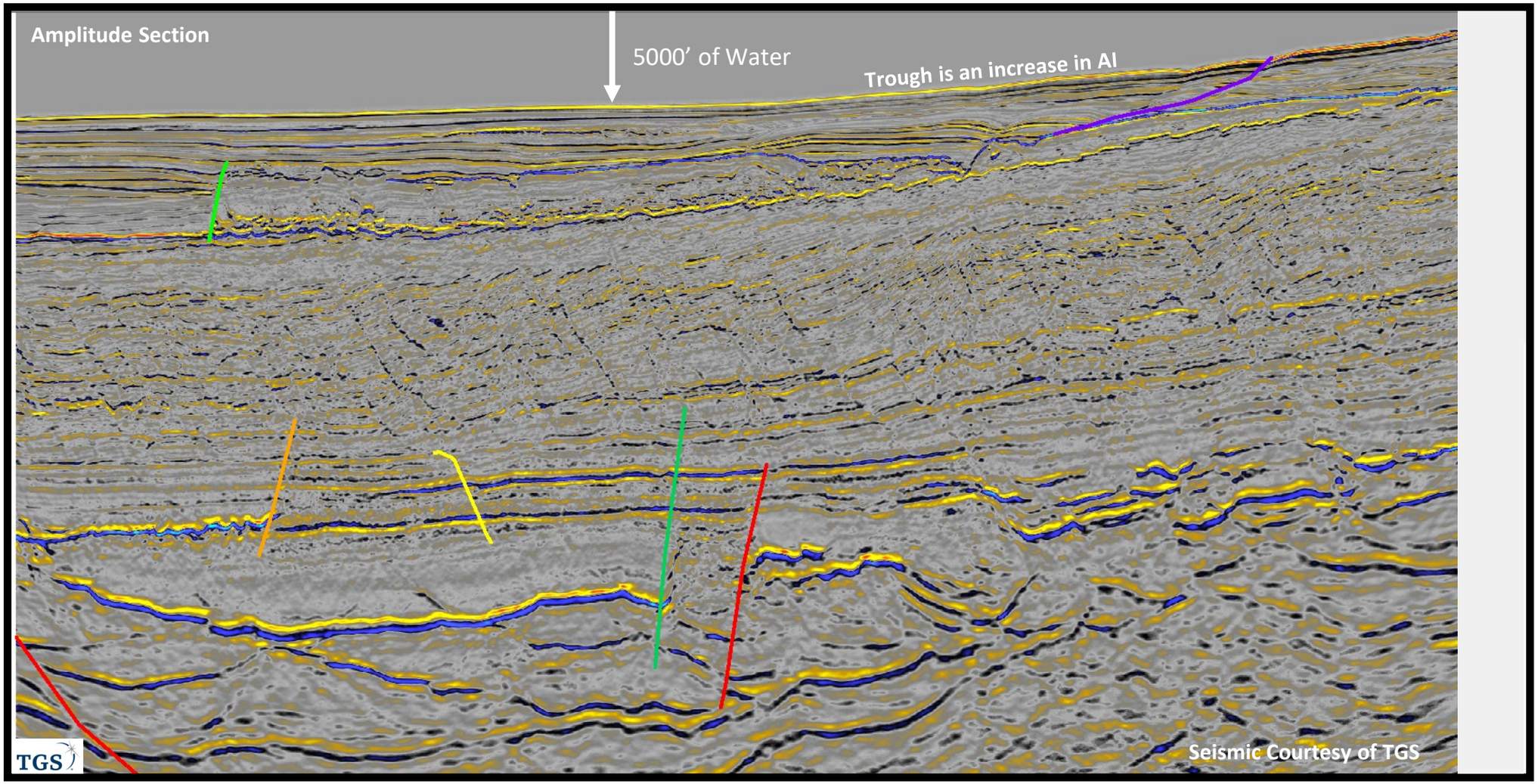
Tobermory and Bunnehaven discoveries found Eocene/Paleocene distal basin floor pay sands

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

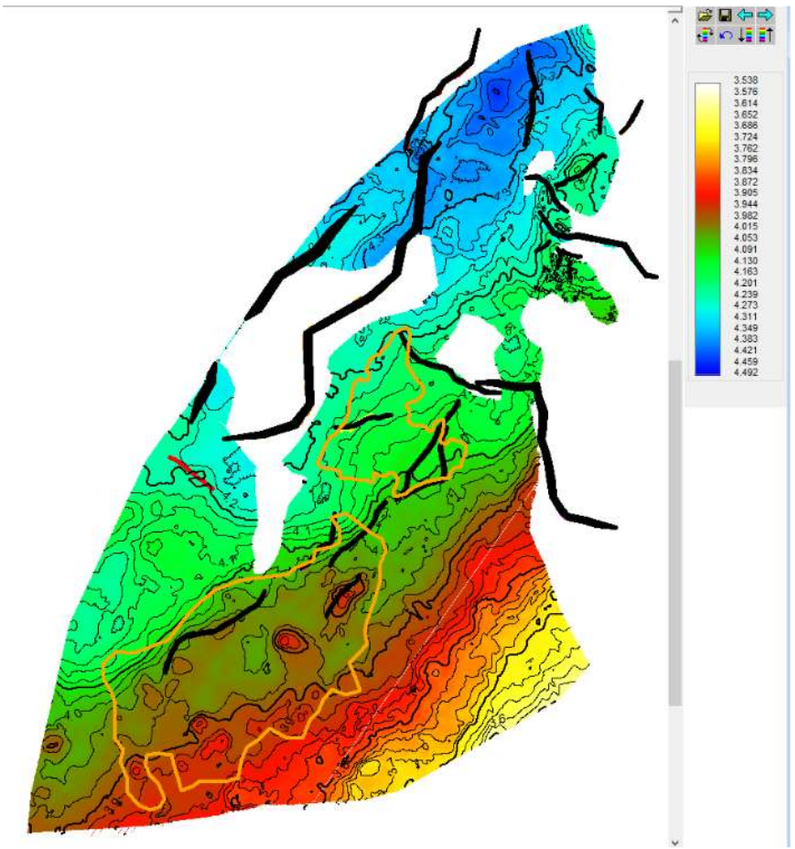
Shallow distal sands

Eocene/Paleocene distal sands

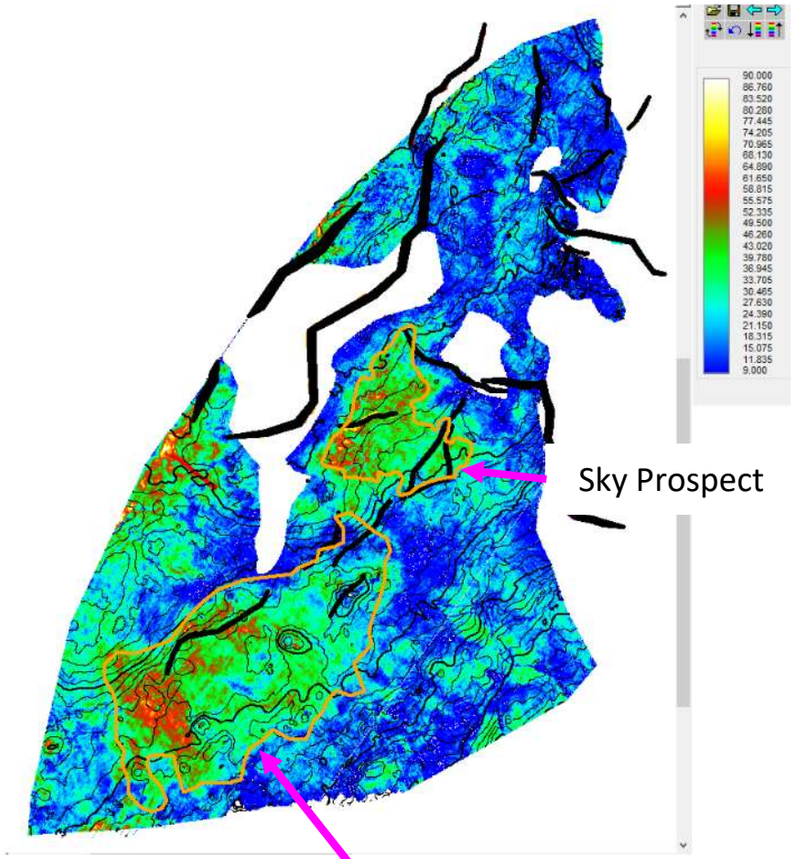
High amplitude volcanic sills & sands



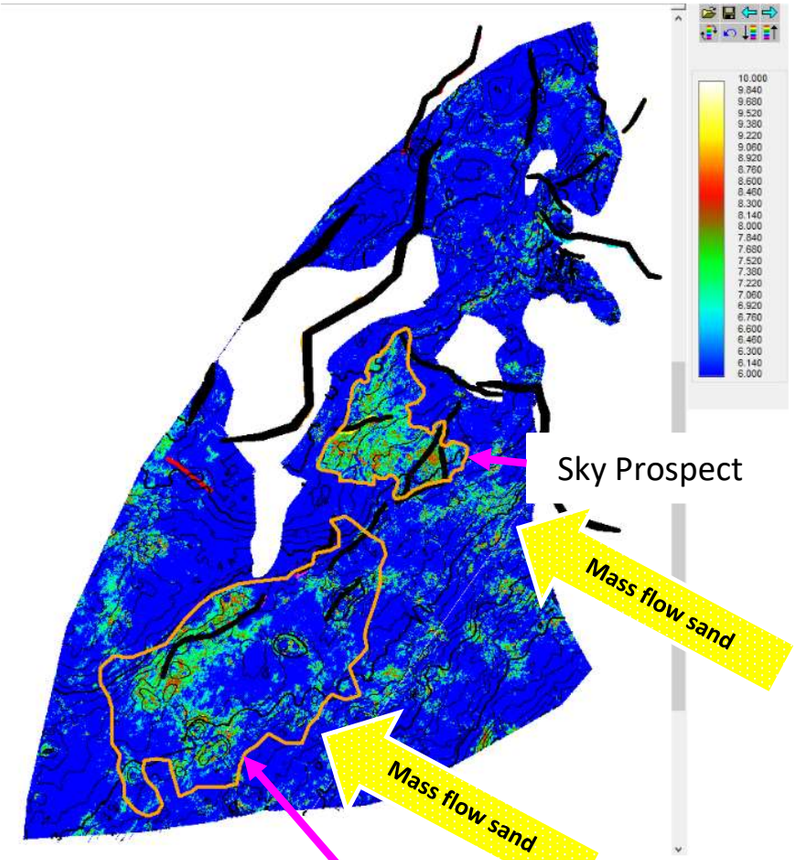
Top Flett Time Structure



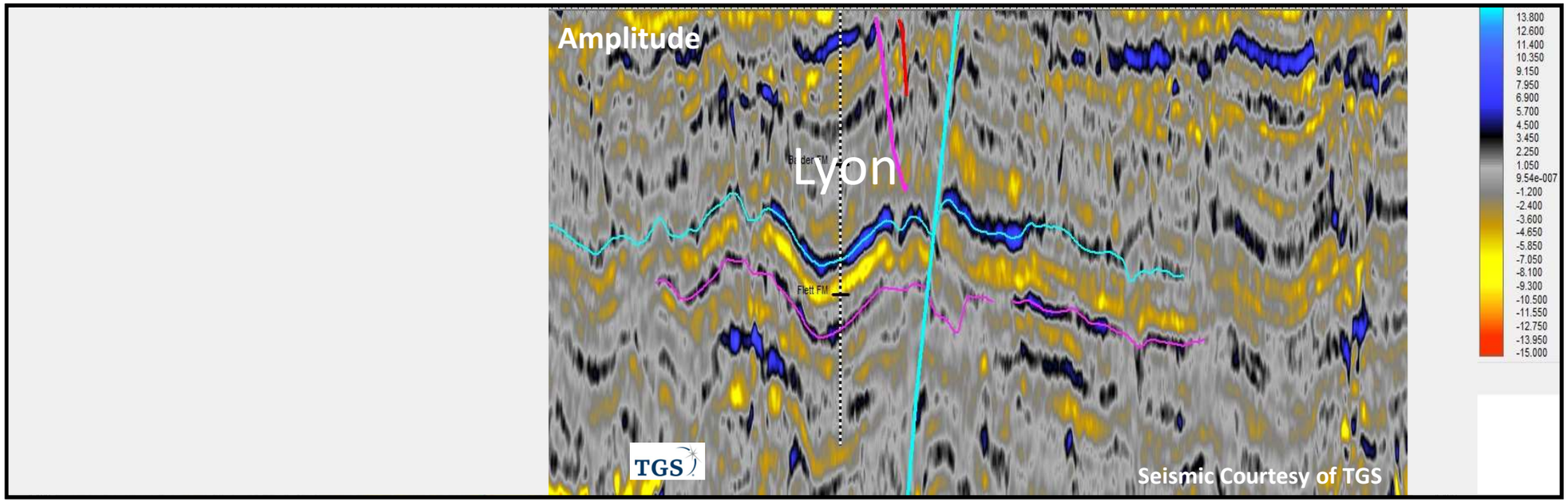
Top Flett Max Amp

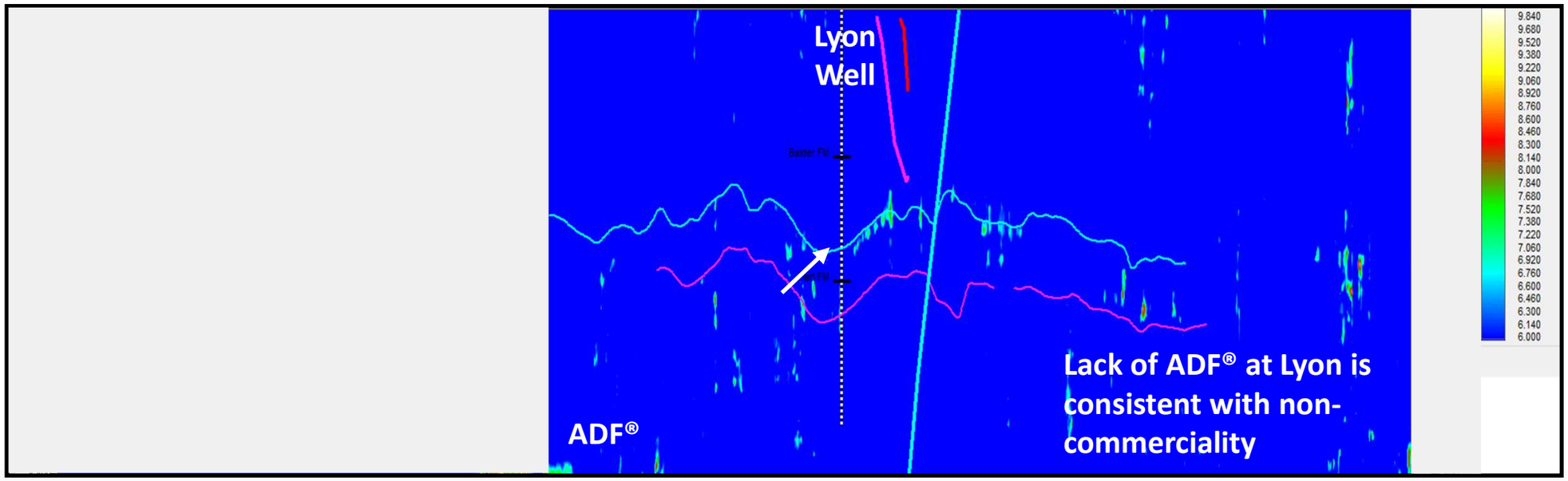


Top Flett Max ADF®



Seismic Courtesy of TGS


Amplitude
Lyon
Bader 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
Bader 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
7.680
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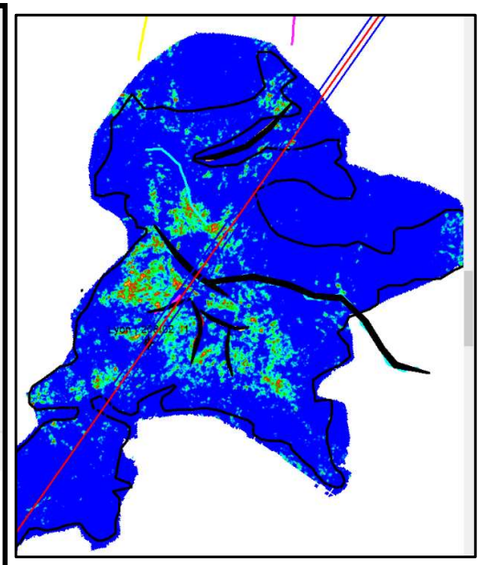
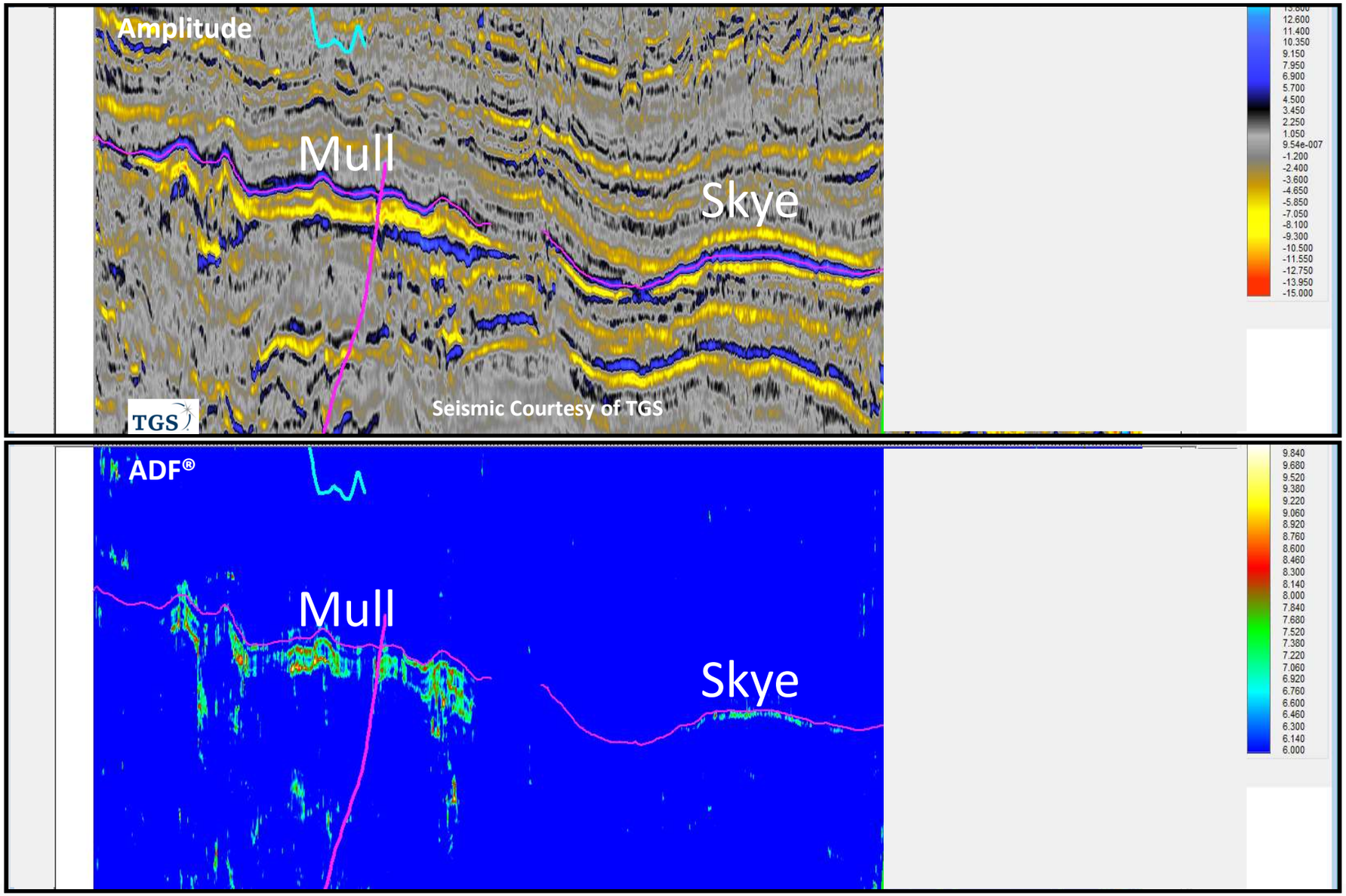
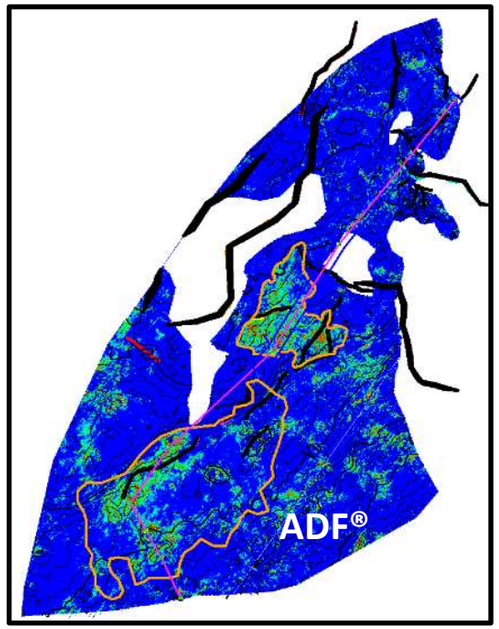
7.220
7.060
6.920
6.760
6.600
6.460
6.300
6.140
6.000

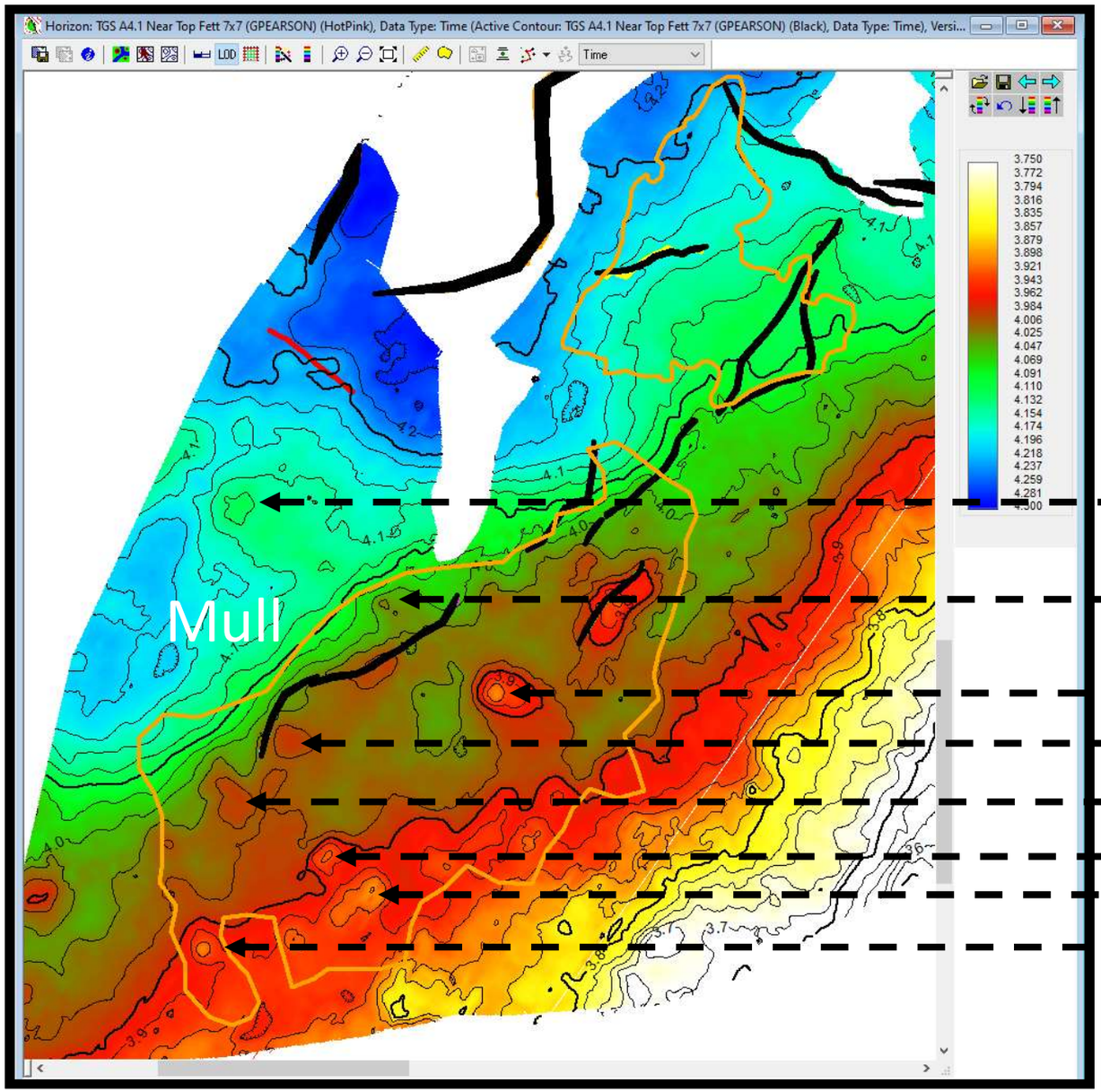


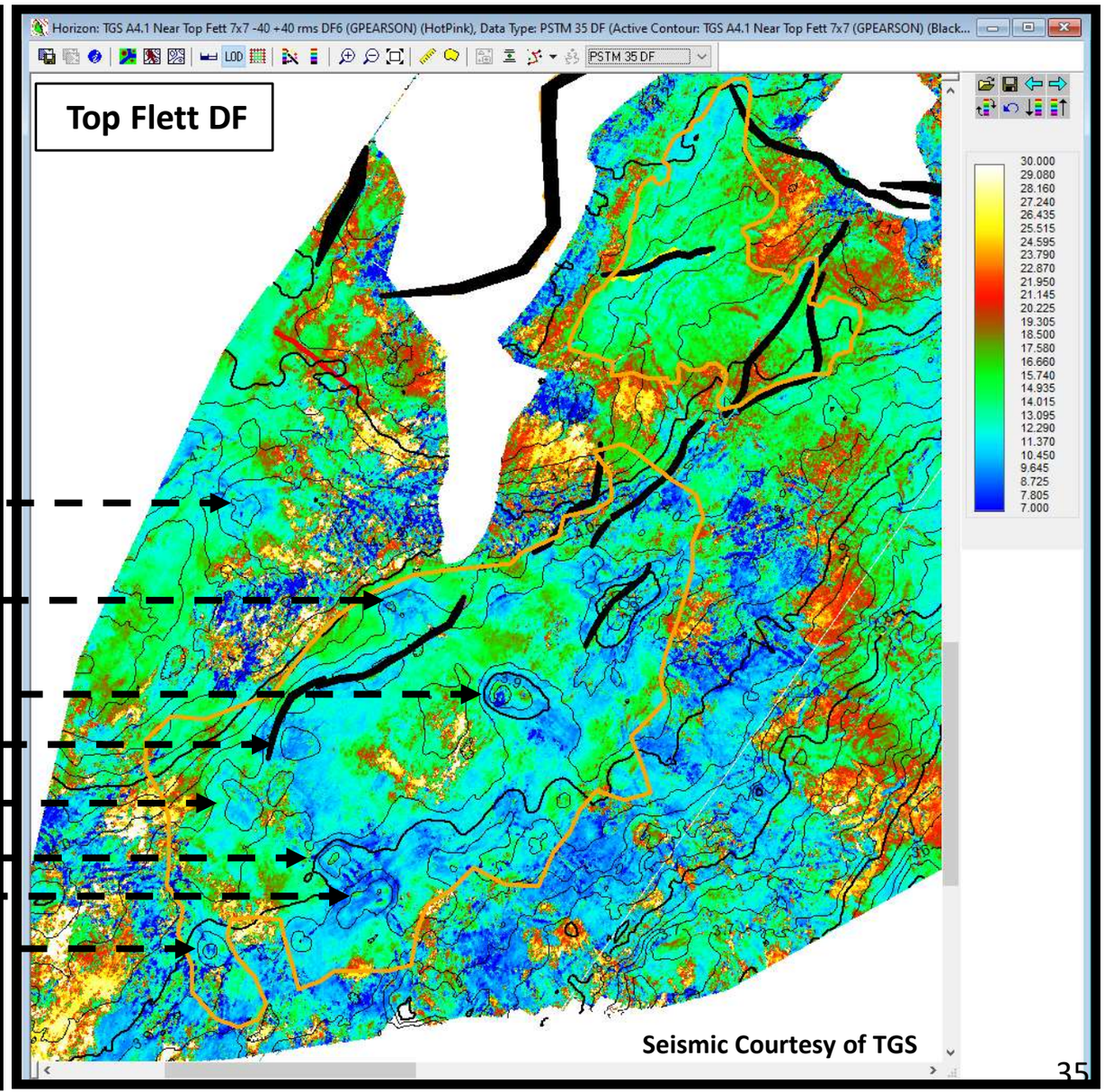
Mull and Skye are anomalously dispersive compared to the Lyon





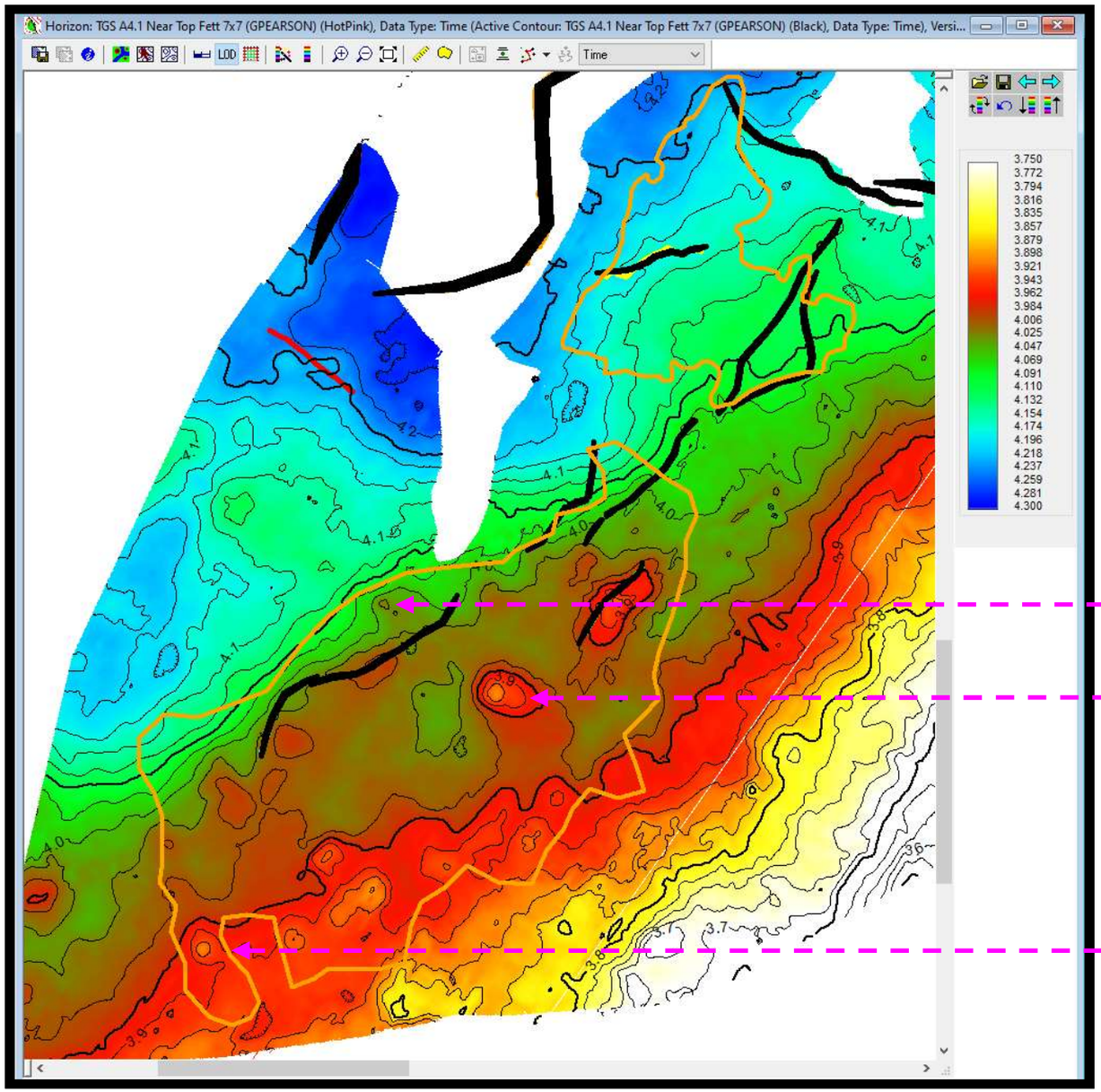
Mull has low DF in top of structures covered by the mass flow deposit sands strongly indicating gas charge

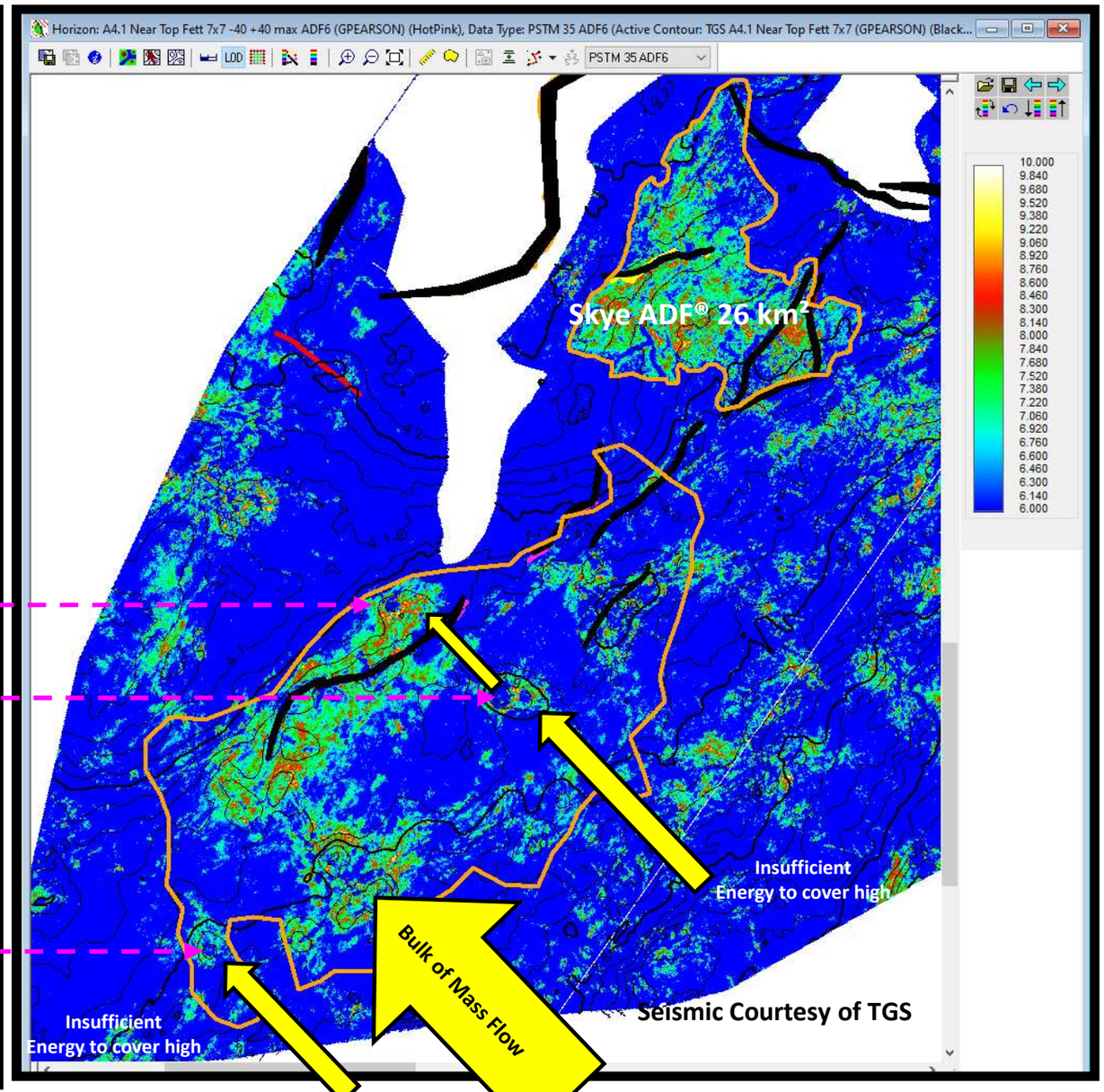


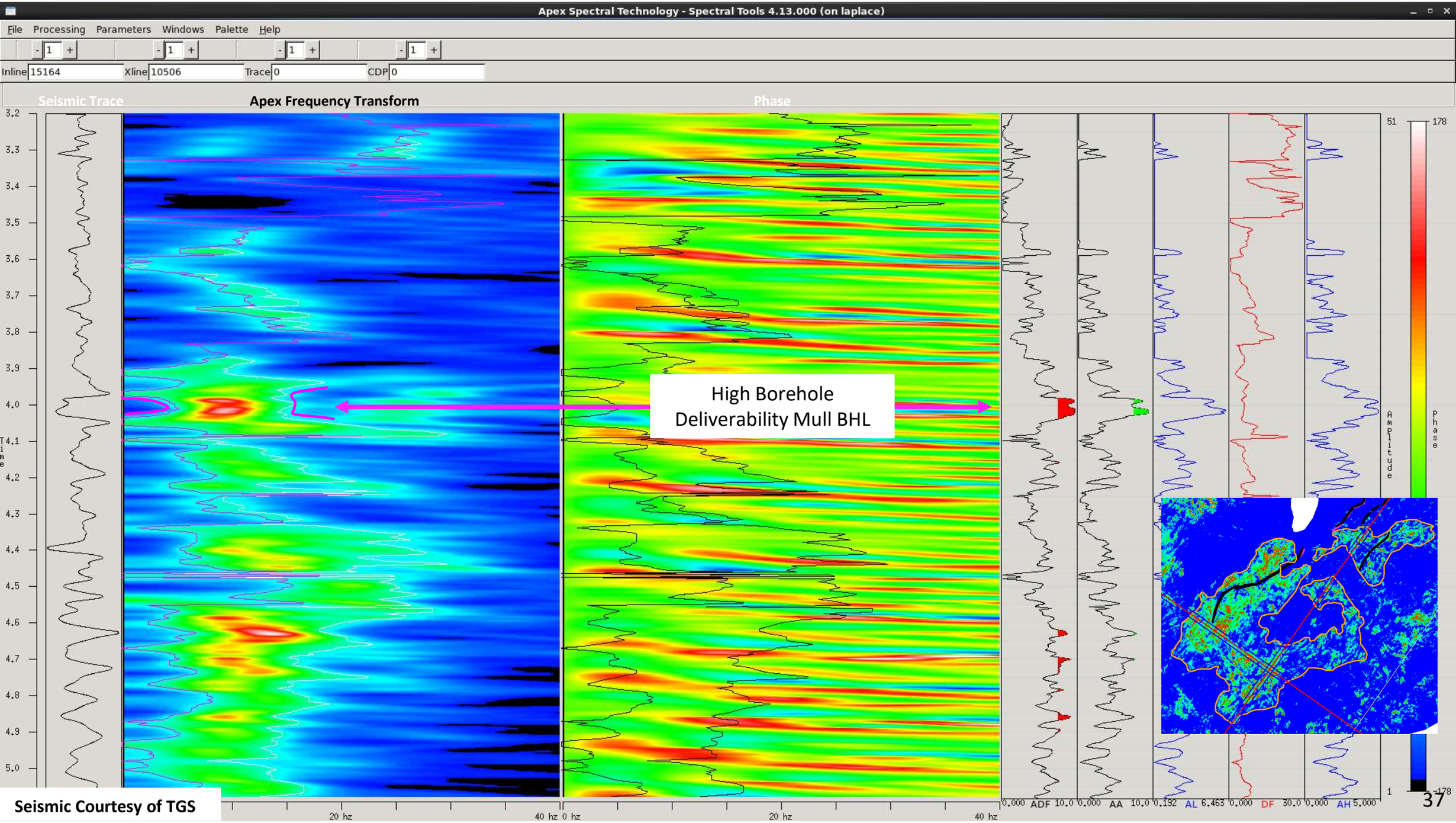


Seismic Courtesy of TGS

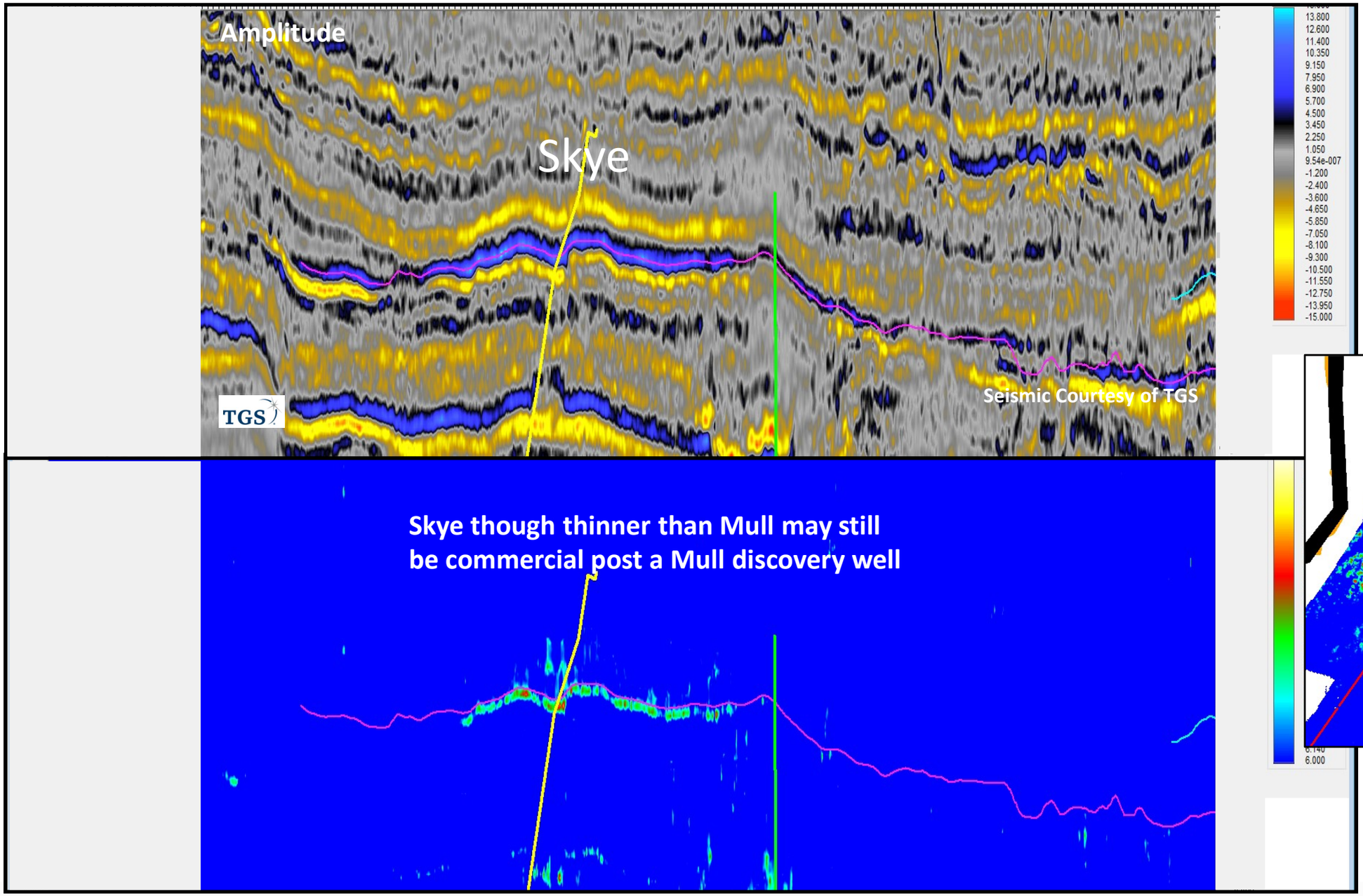
Strong ADF® in front of bald on top paleo highs where heavier grains would have dropped out is consistent with ADF® measuring bulk volume perm.

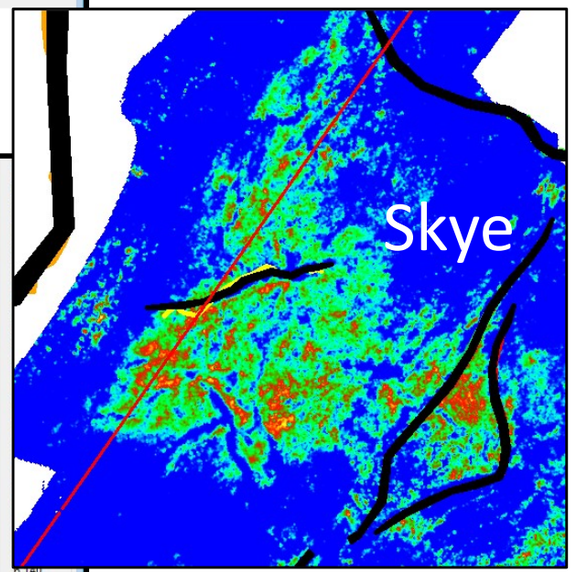


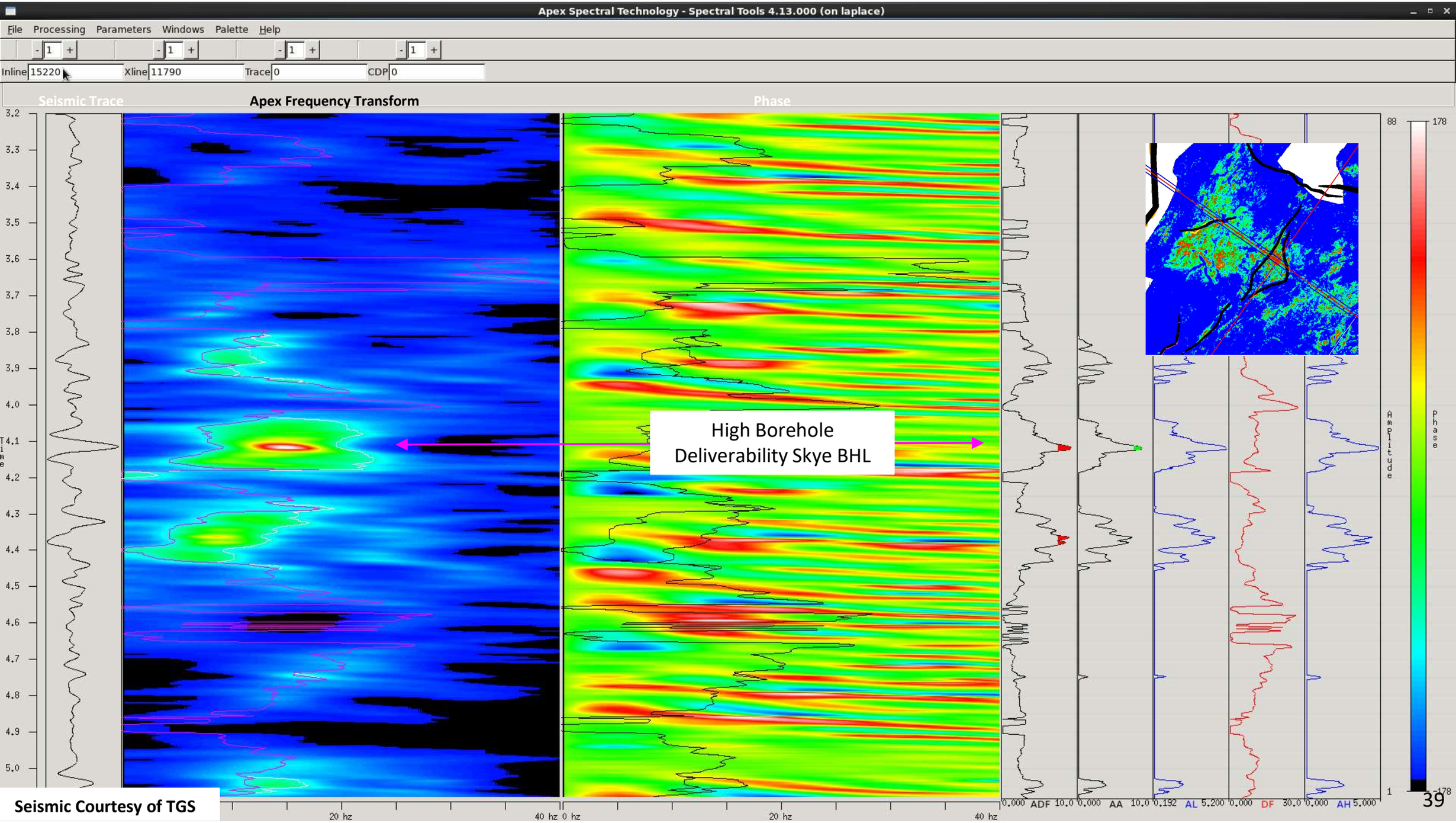




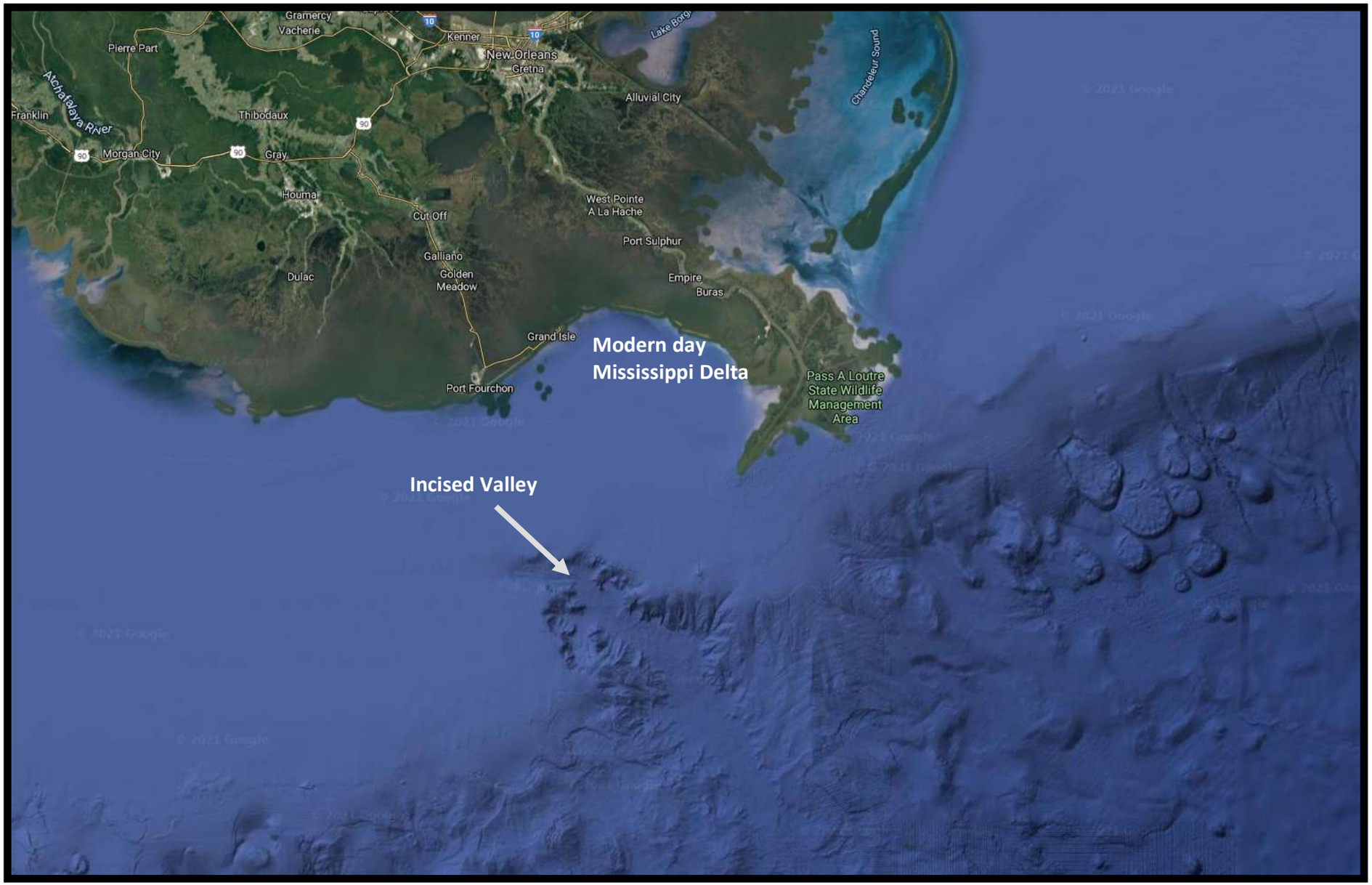
Seismic Courtesy of TGS


Amplitude
Skye
Seismic Courtesy of TGS
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

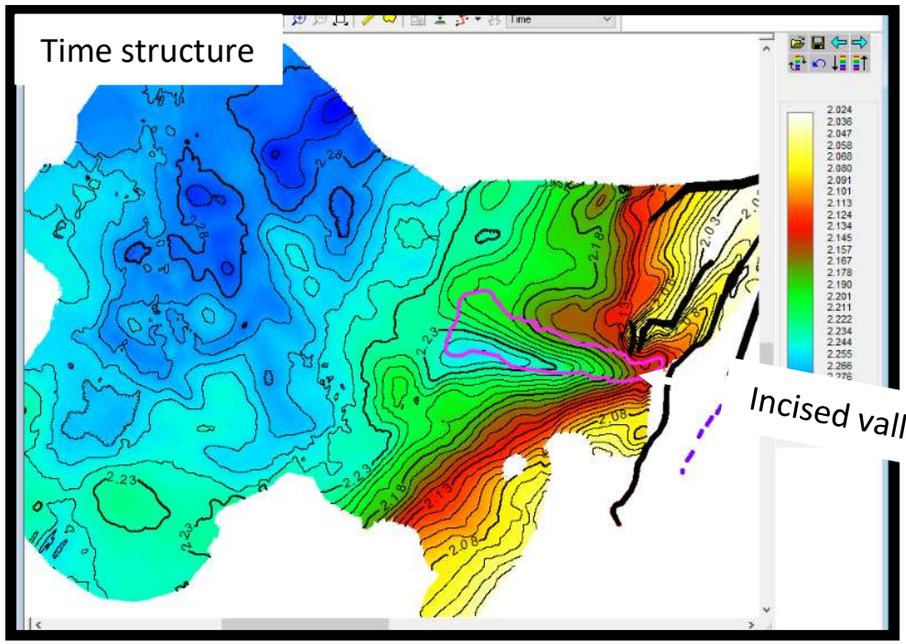

Skye

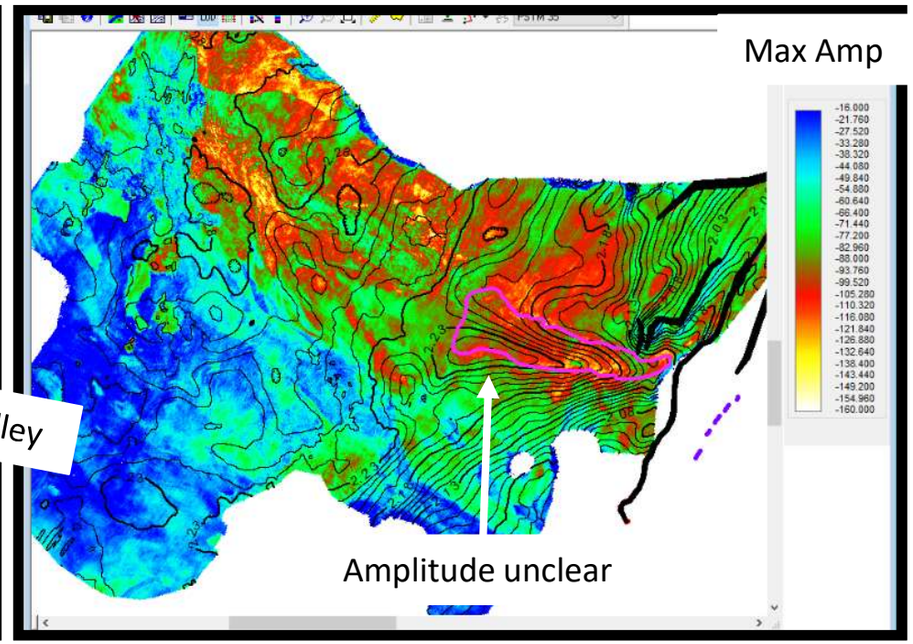


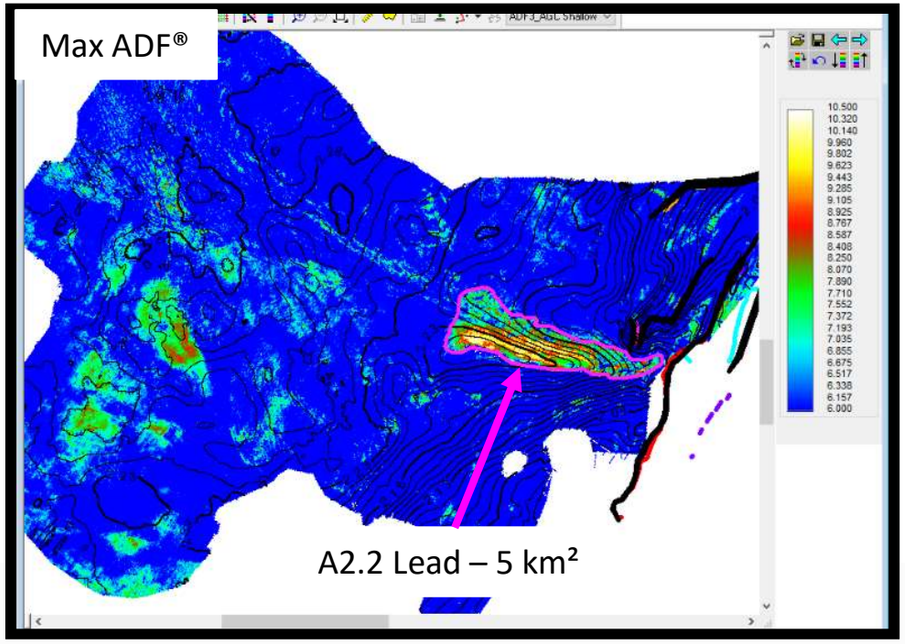
Seismic Courtesy of TGS

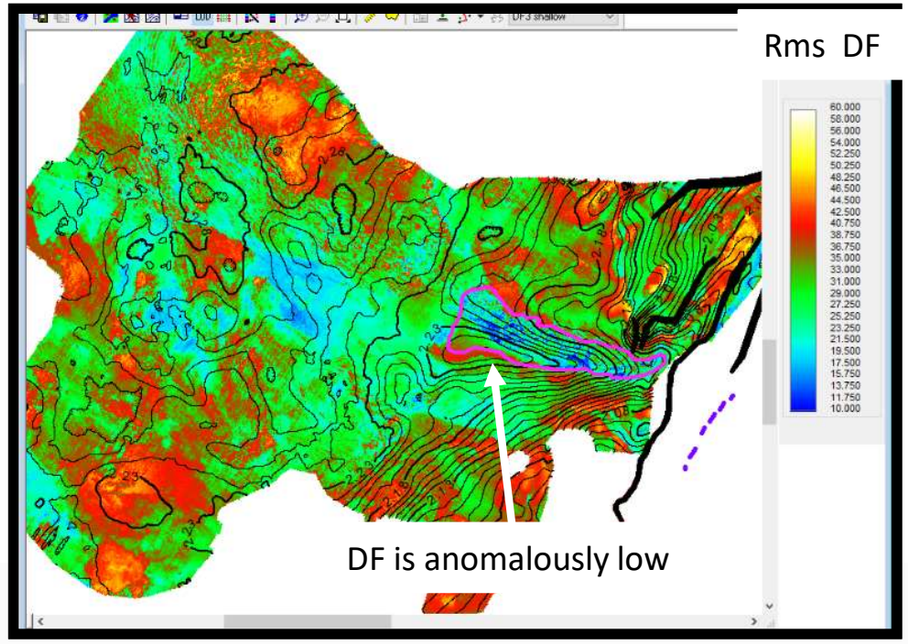

Gramercy
Vacherie
Pierre Part
Kenner
New Orleans
Gretna
Lake Borg.
Chandeleur Sound
Alluvial City
Franklin
Atchafalaya River
Thibodaux
Morgan City
Gray
Houma
Cut Off
West Pointe
A La Hache
Port Sulphur
Galliano
Golden
Meadow
Dulac
Empire
Buras
Grand Isle
Modern day
Mississippi Delta
Port Fourchon
Pass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

Seismic Courtesy of TGS









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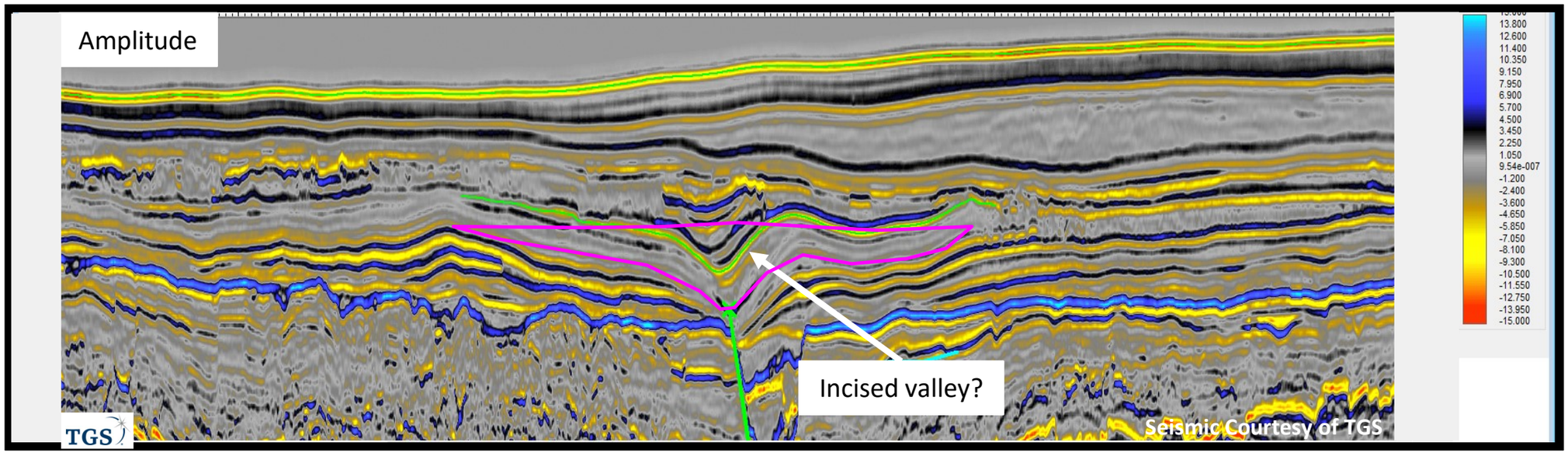
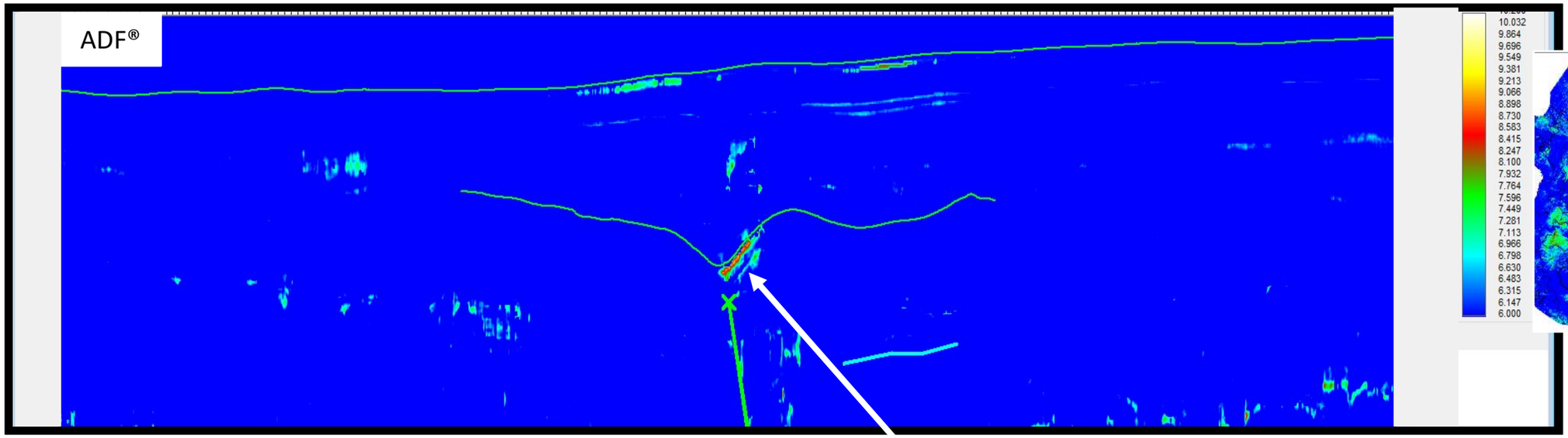
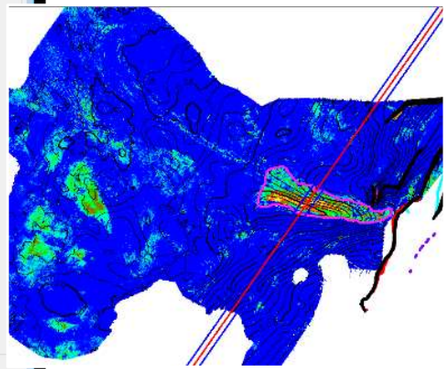
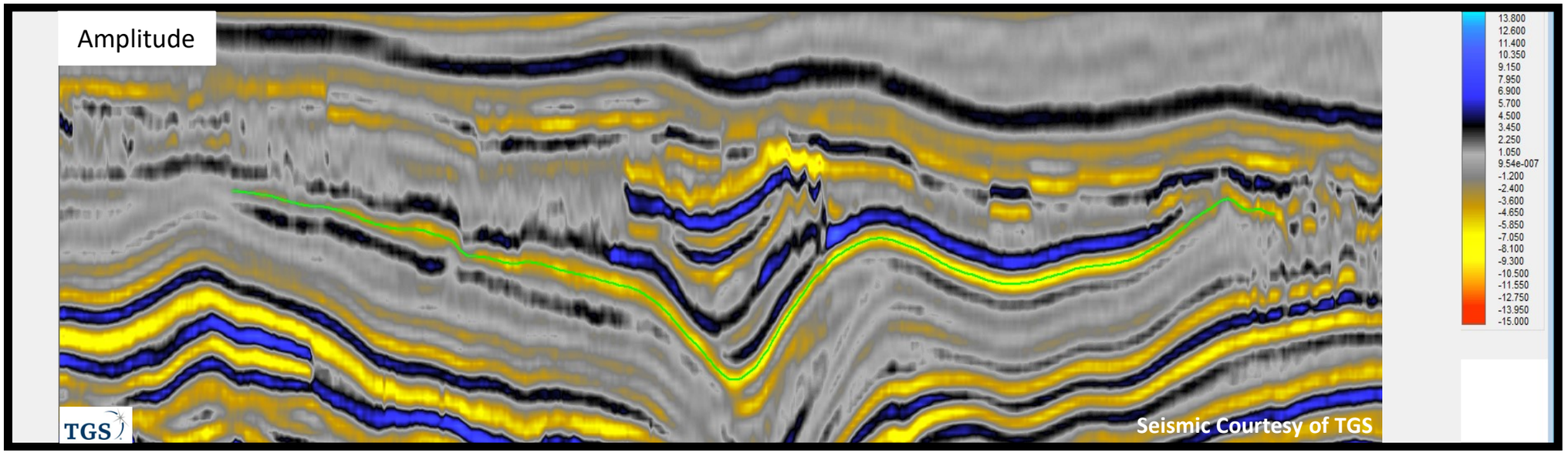


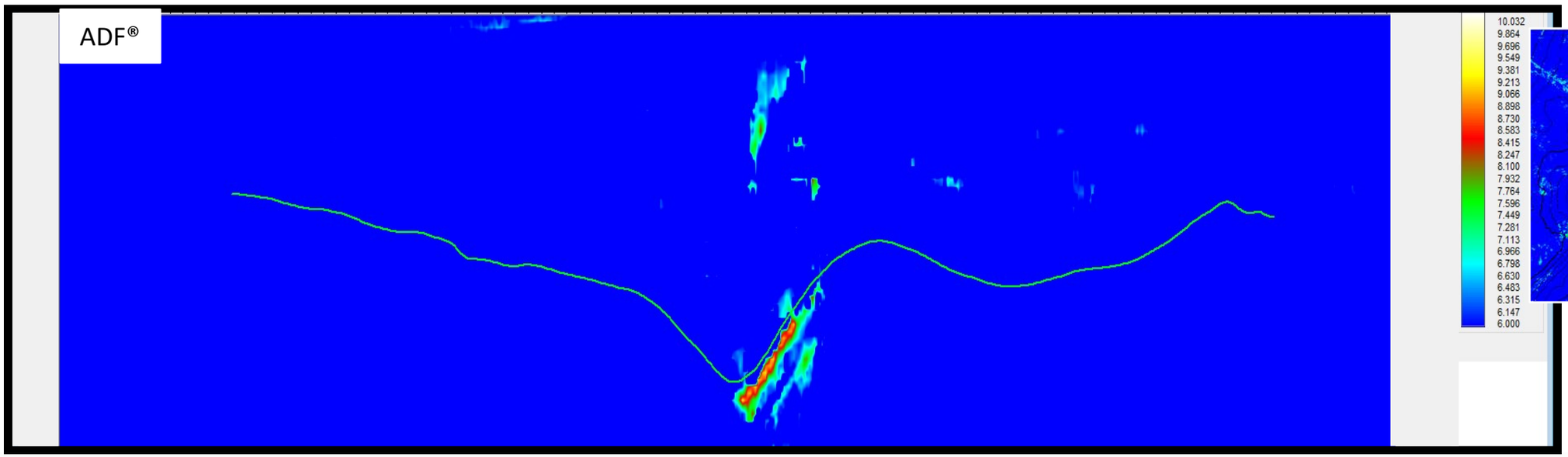


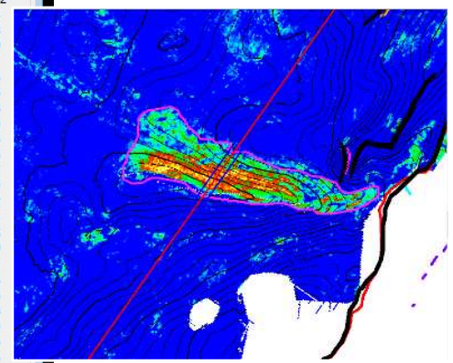


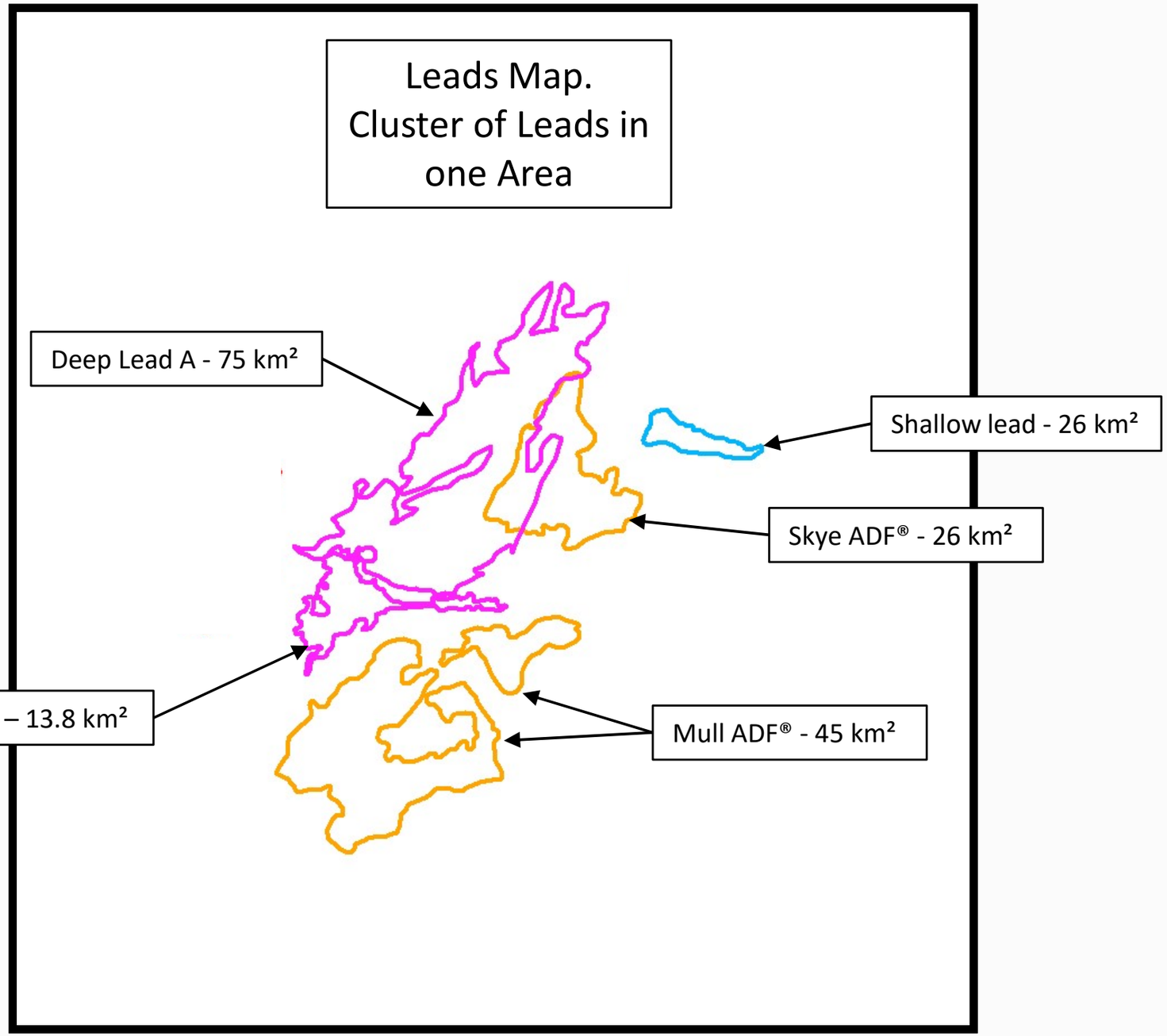
That this anomaly only appears on one side of the incised valley is auspicious as well as the termination at spill point.

Seismic Courtesy of TGS





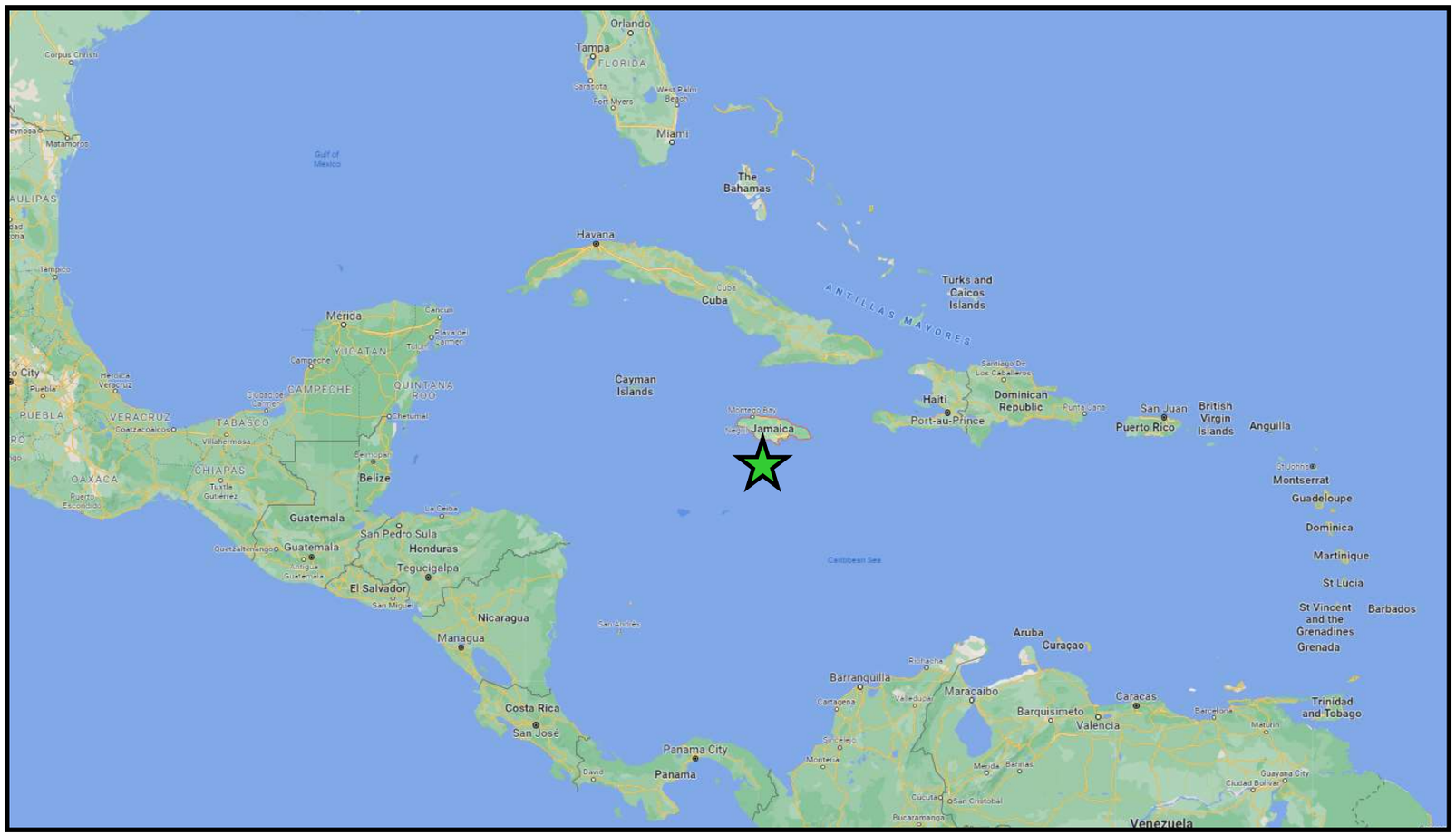



Leads Map.
Cluster of Leads in one Area
Deep Lead A - 75 km²
Shallow lead - 26 km²
Skye ADF® - 26 km²
Deep lead B – 13.8 km²
Mull ADF® - 45 km²

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 km^2 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.

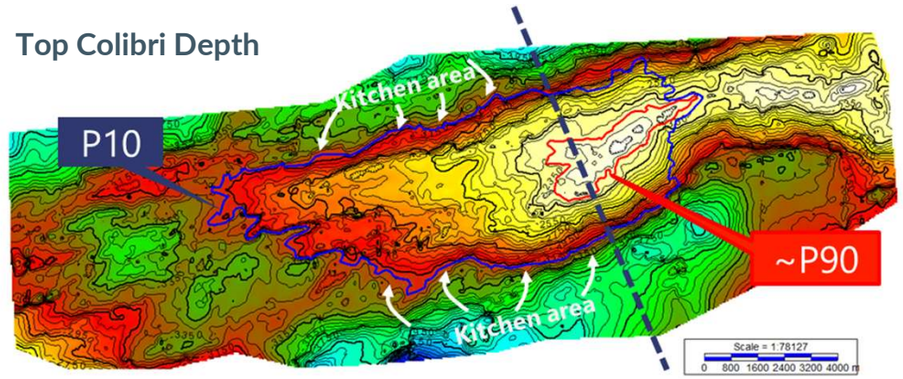
United Oil & Gas Colibri Prospect

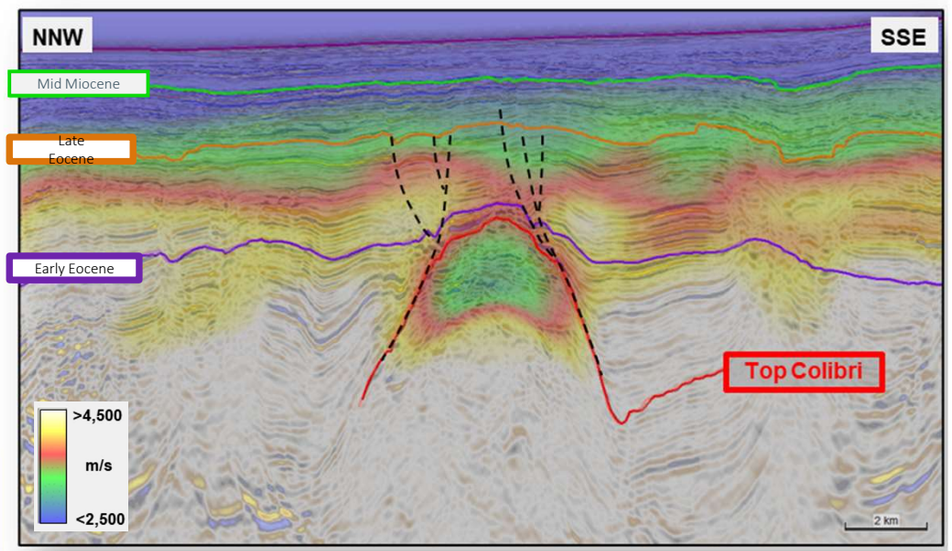


THE COLIBRI PROSPECT

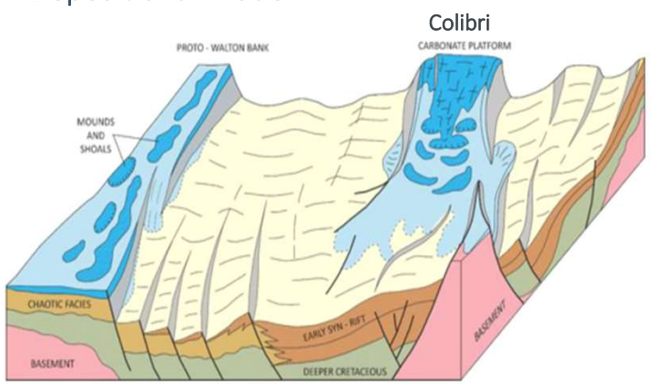
- Reservoir: Large syn-rift horst of porous, fractured and/or karstified platform carbonates
- Trap & Seal: Truncation of westward dipping carbonates in an E-W trending horst to relay ramp, sealed by overlying Lower Eocene marine shales
- Source & Charge: Charge focus from Cretaceous kitchens to north 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

Top Colibri Depth



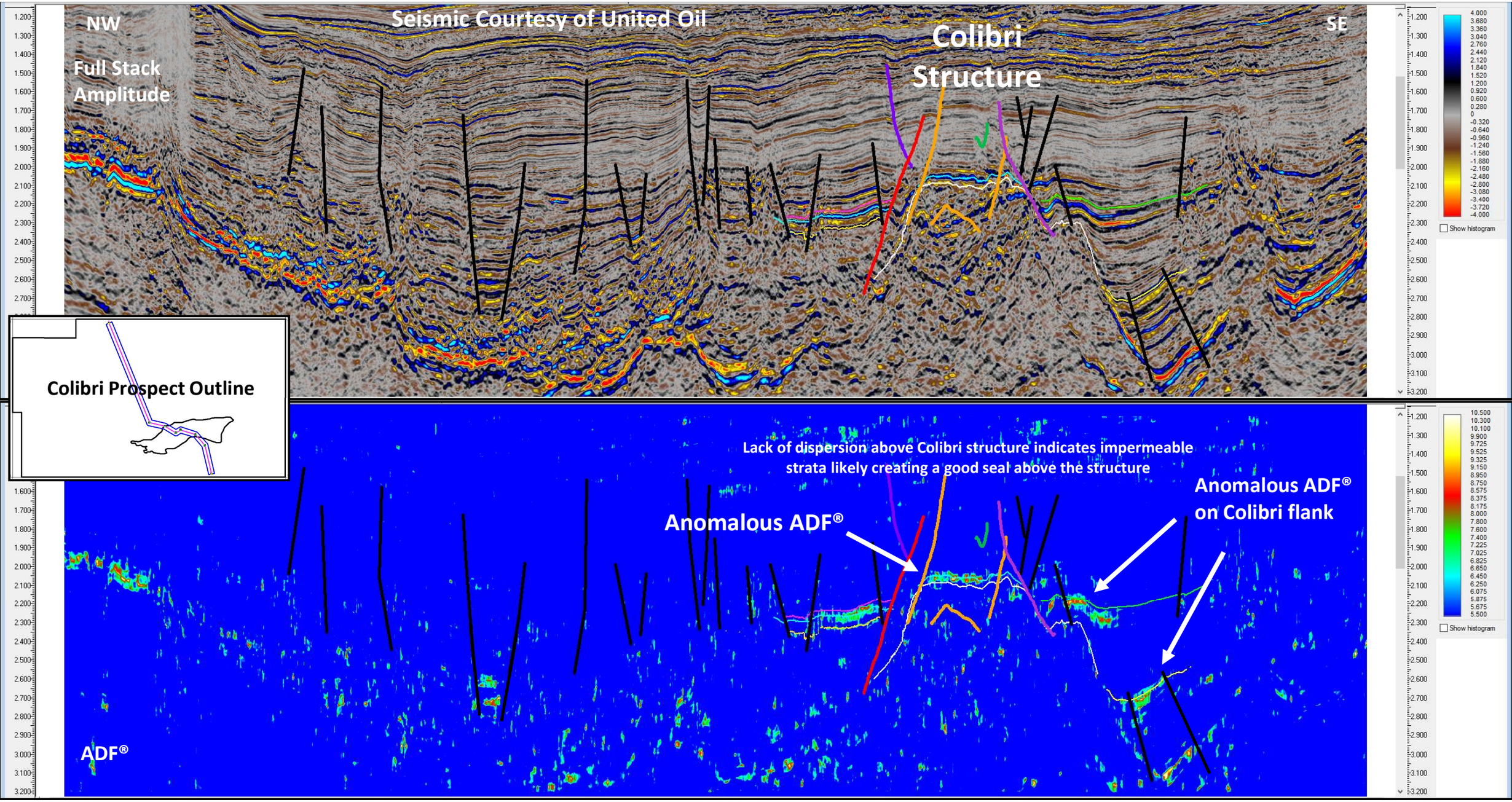


Depositional Model



Cretaceous rudist limestones in outcrop and from core

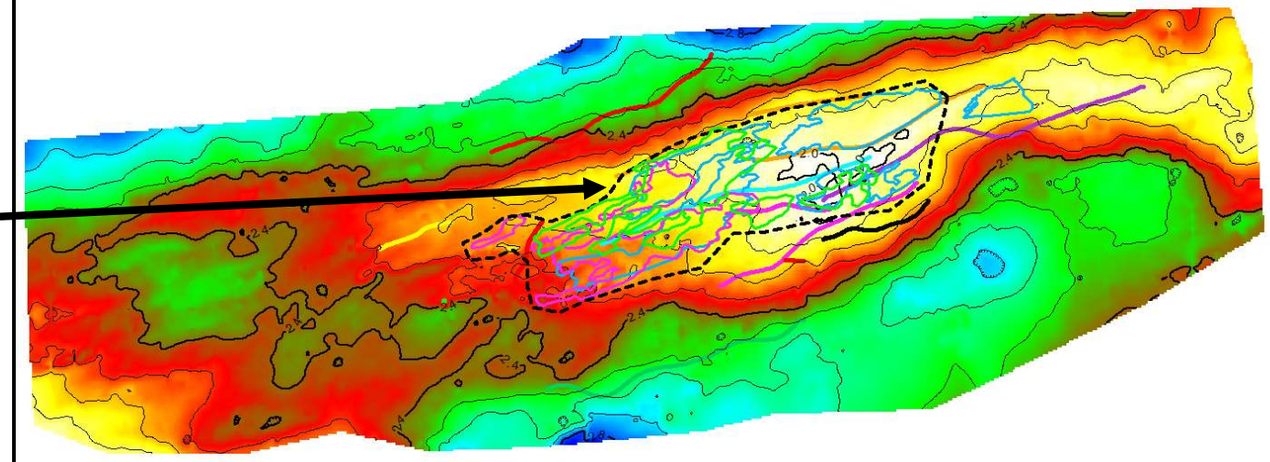
Volumes (MMstb)[1]	1U	2U	Mean	3U	Pg
Colibri	33.4	223	406	964	19%


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®

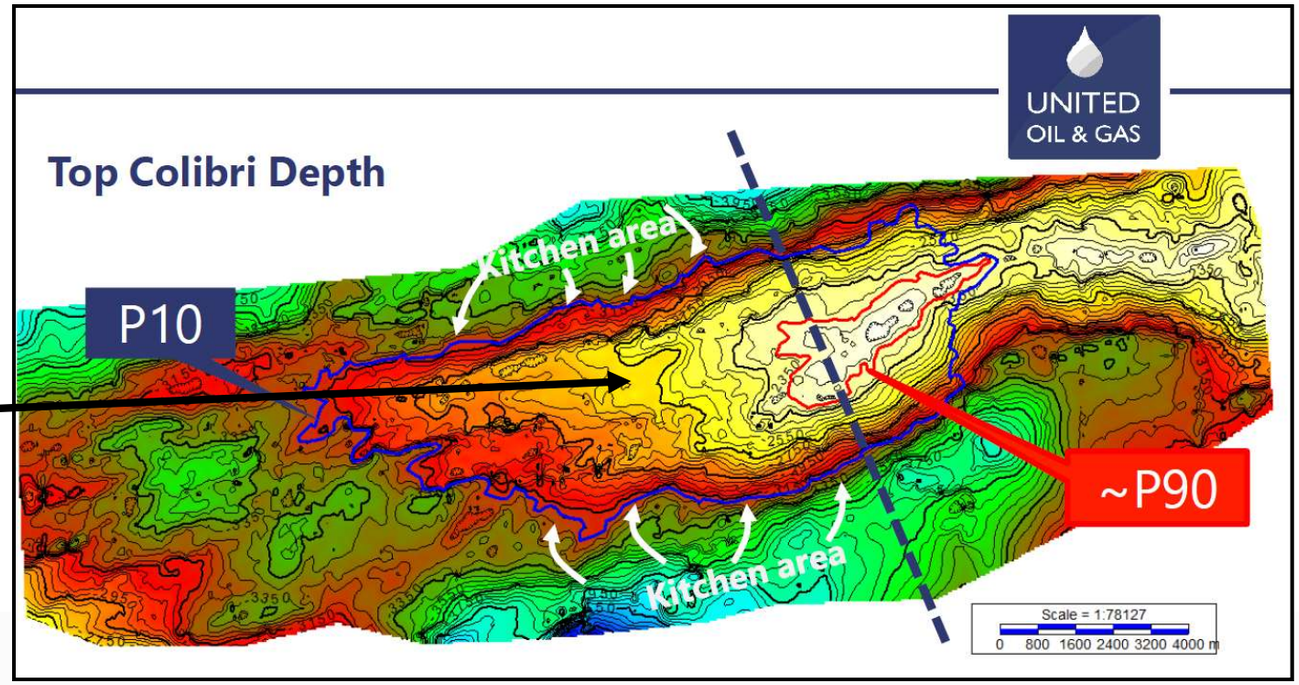
Anomalous dispersion is associated with the Colibri structure and is more prominent on the west flank of the high at multiple intervals

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

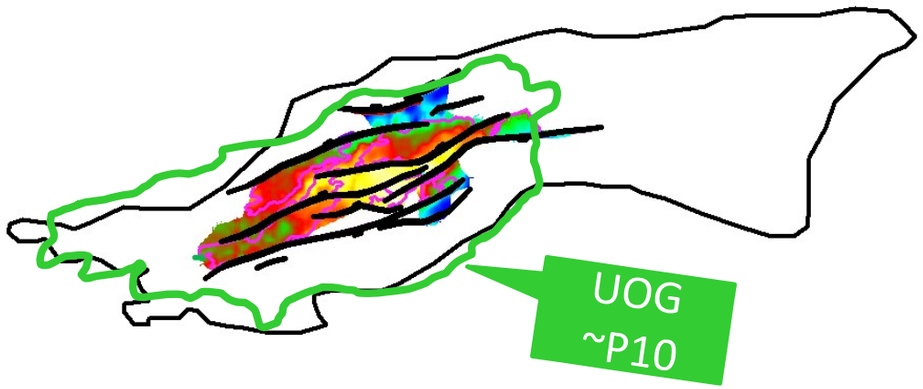
Apex ADF® dispersion anomaly polygons superimposed on "Top Colibri Time Structure"



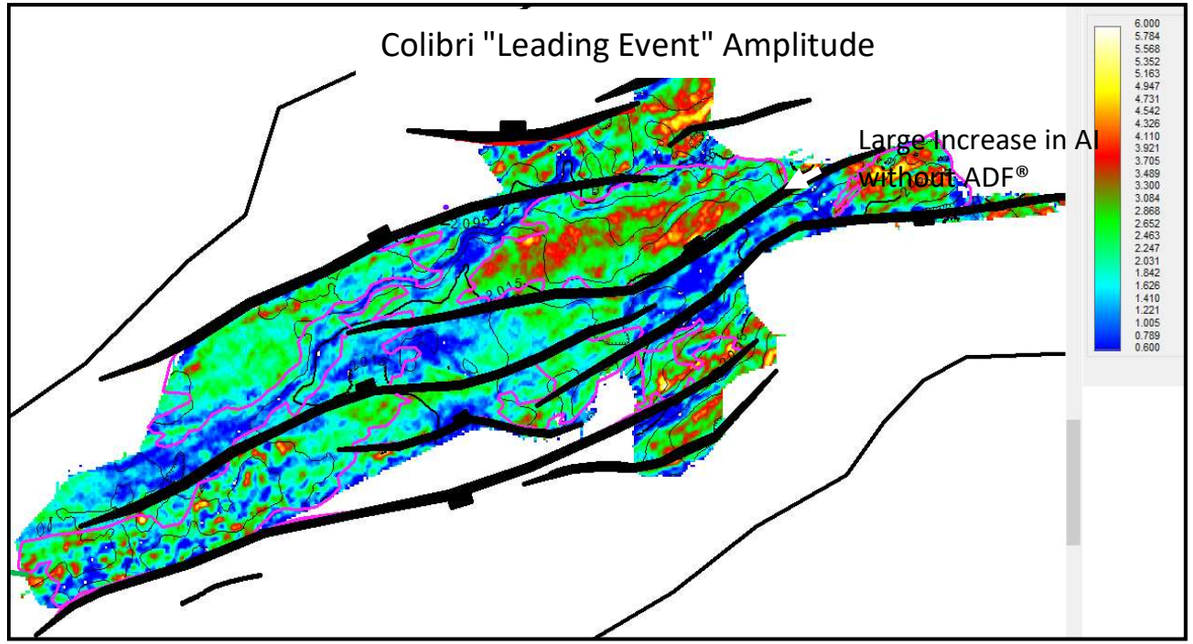
ADF® indicates support for overall reserves being the mean case



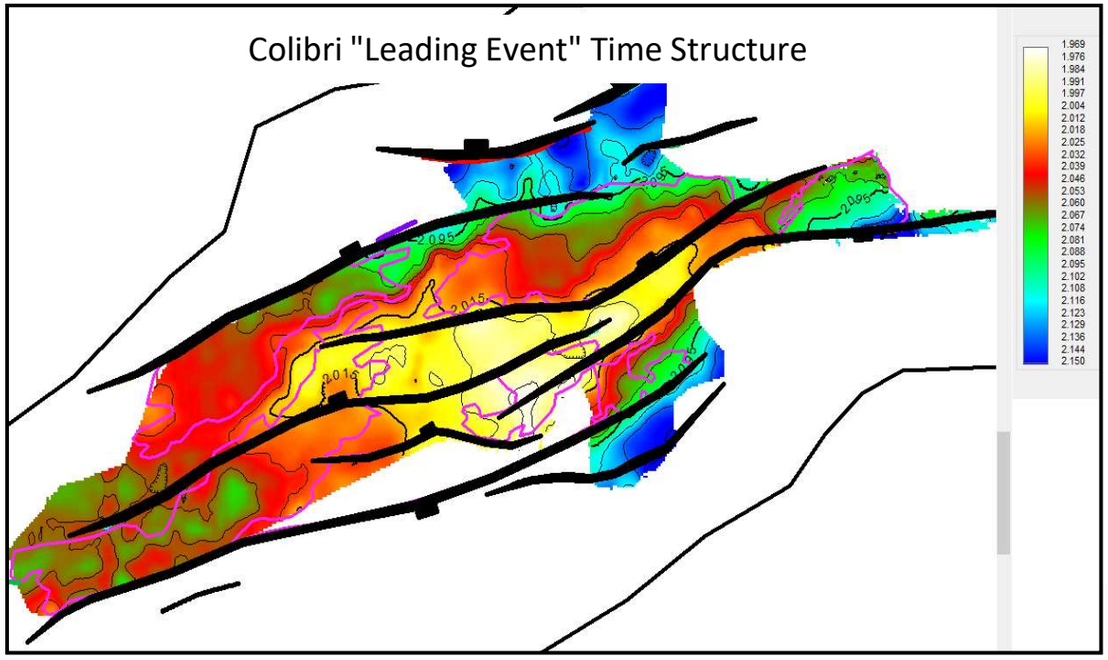
Colibri Structure Outline



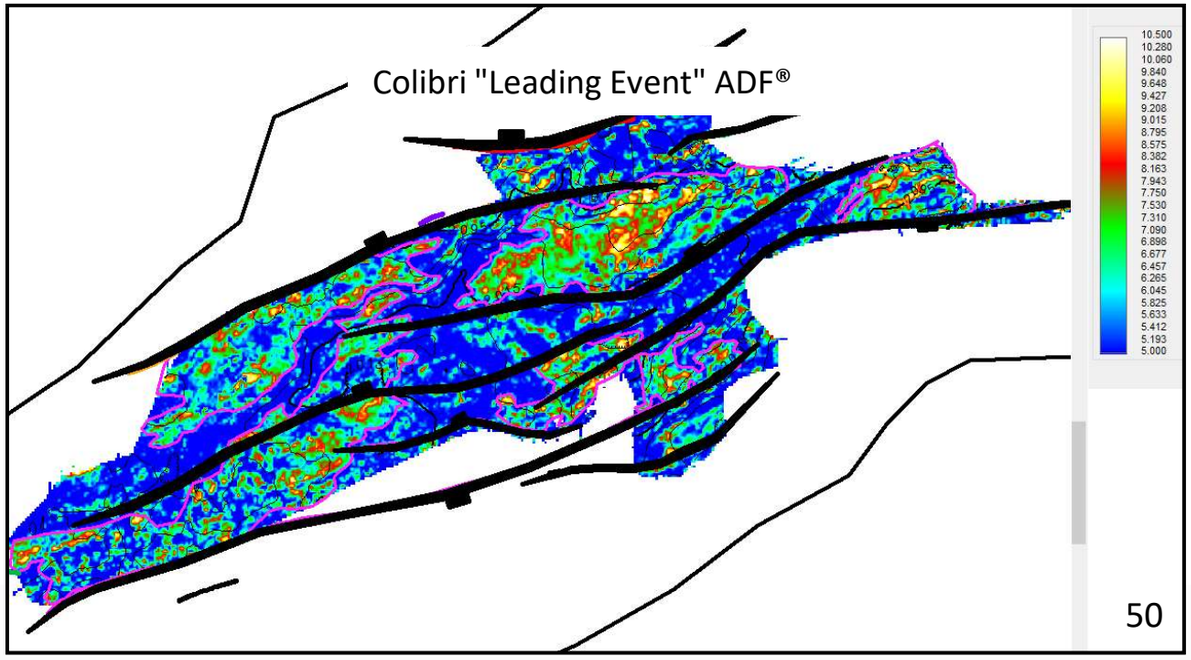
Colibri "Leading Event" Amplitude

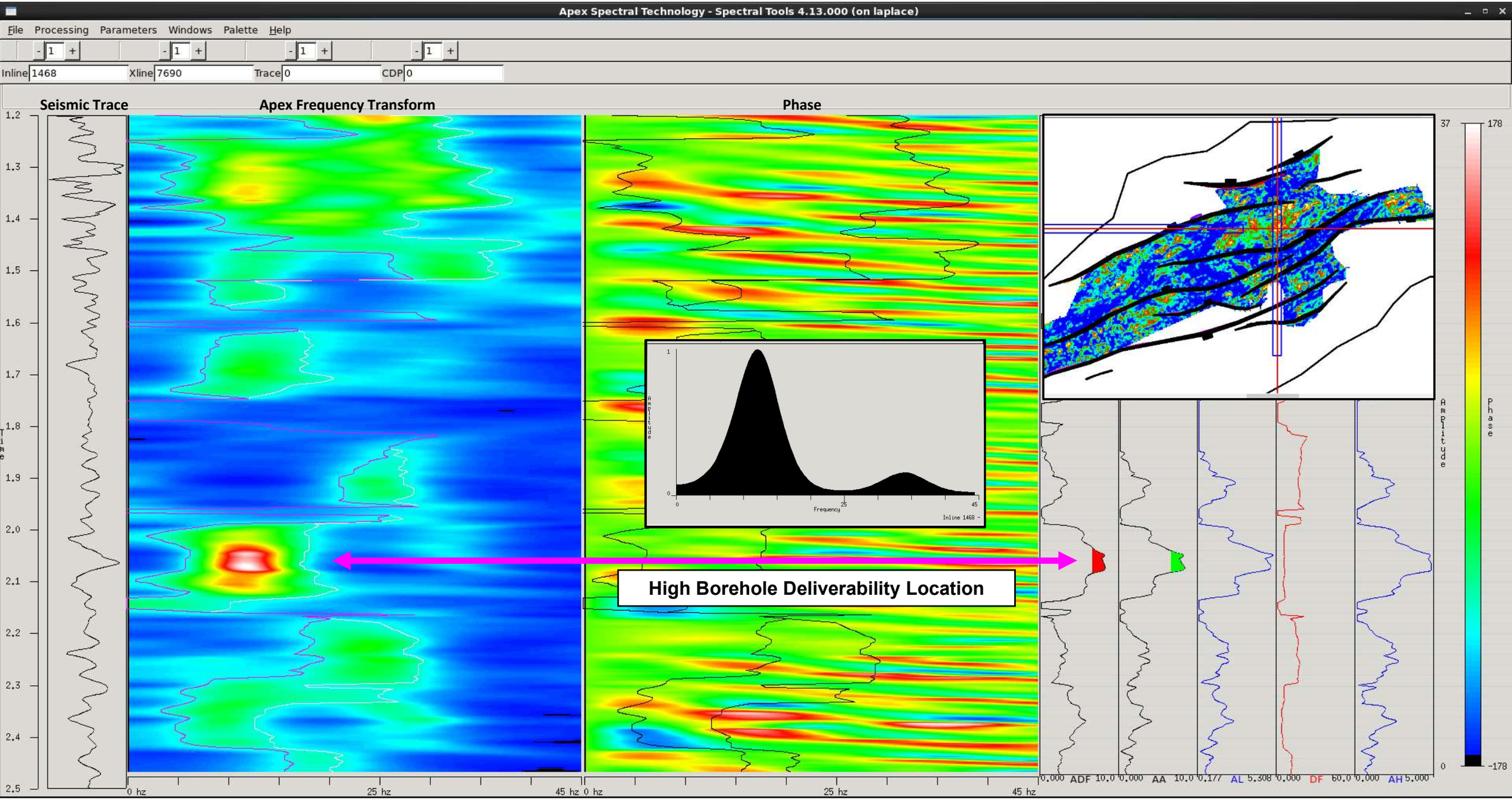


Colibri "Leading Event" Time Structure

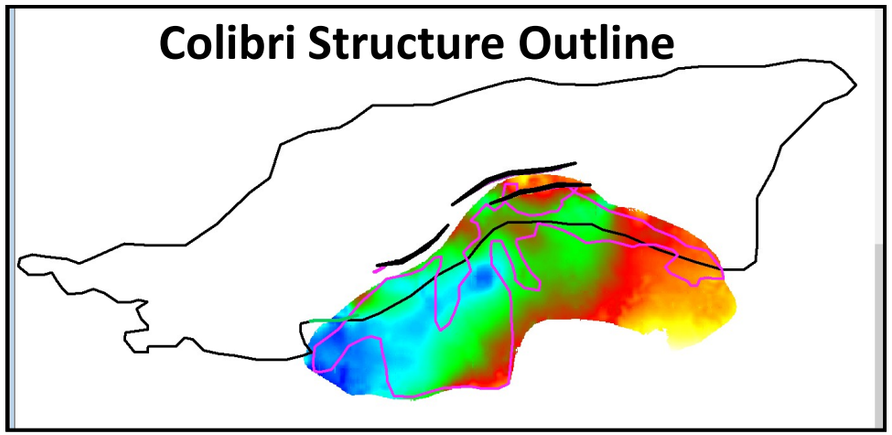


Colibri "Leading Event" ADF®

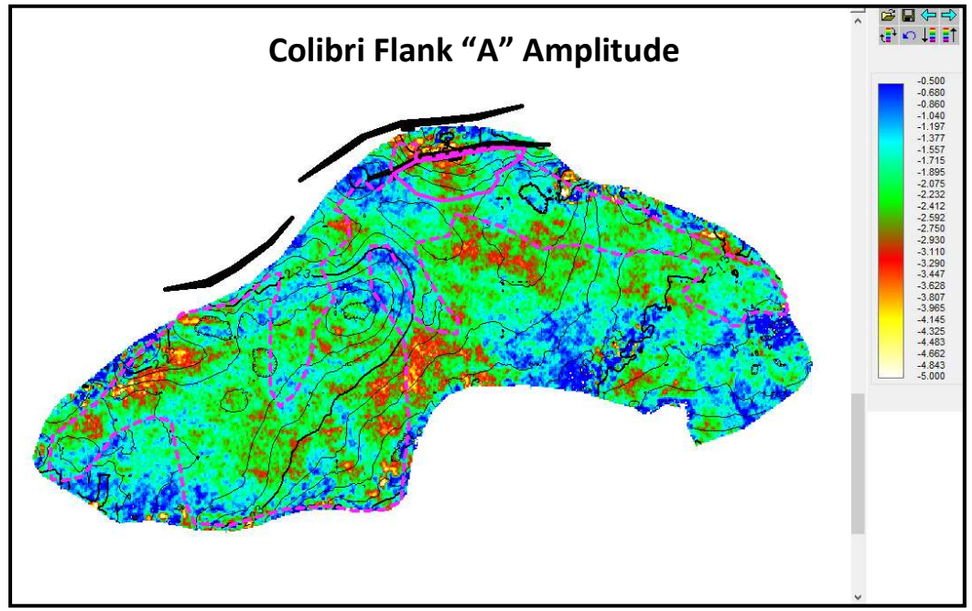



Apex Spectral Technology - Spectral Tools 4.13.000 (on laplace)
File Processing Parameters Windows Palette Help
Inline 1468 Xline 7690 Trace 0 CDP 0
Seismic Trace
Apex Frequency Transform
Phase
Frequency
Inline 1468
High Borehole Deliverability Location
Amplitude
Phase
ADF 10.0 0.000 AA 10.0 0.177 AL 5.308 0.000 DF 60.0 0.000 AH 5.000
0 hz
25 hz
45 hz 0 hz
25 hz
45 hz

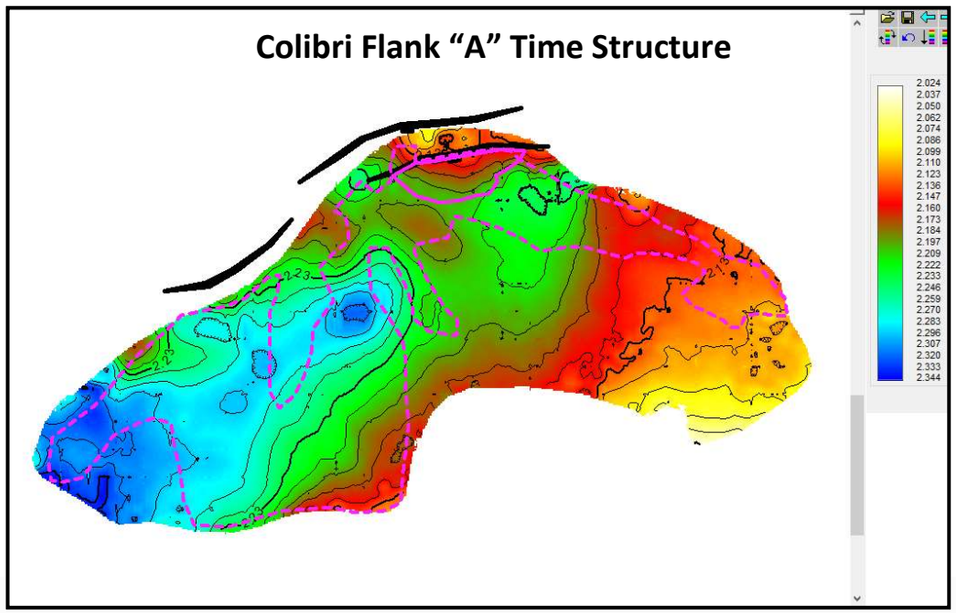
Colibri Structure Outline



Colibri Flank “A” Amplitude

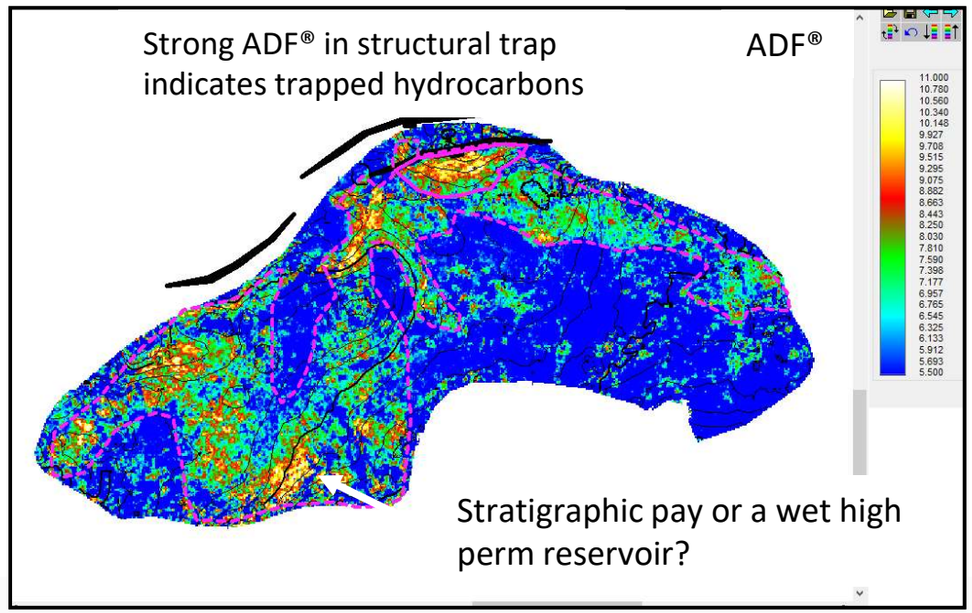


Colibri Flank “A” Time Structure

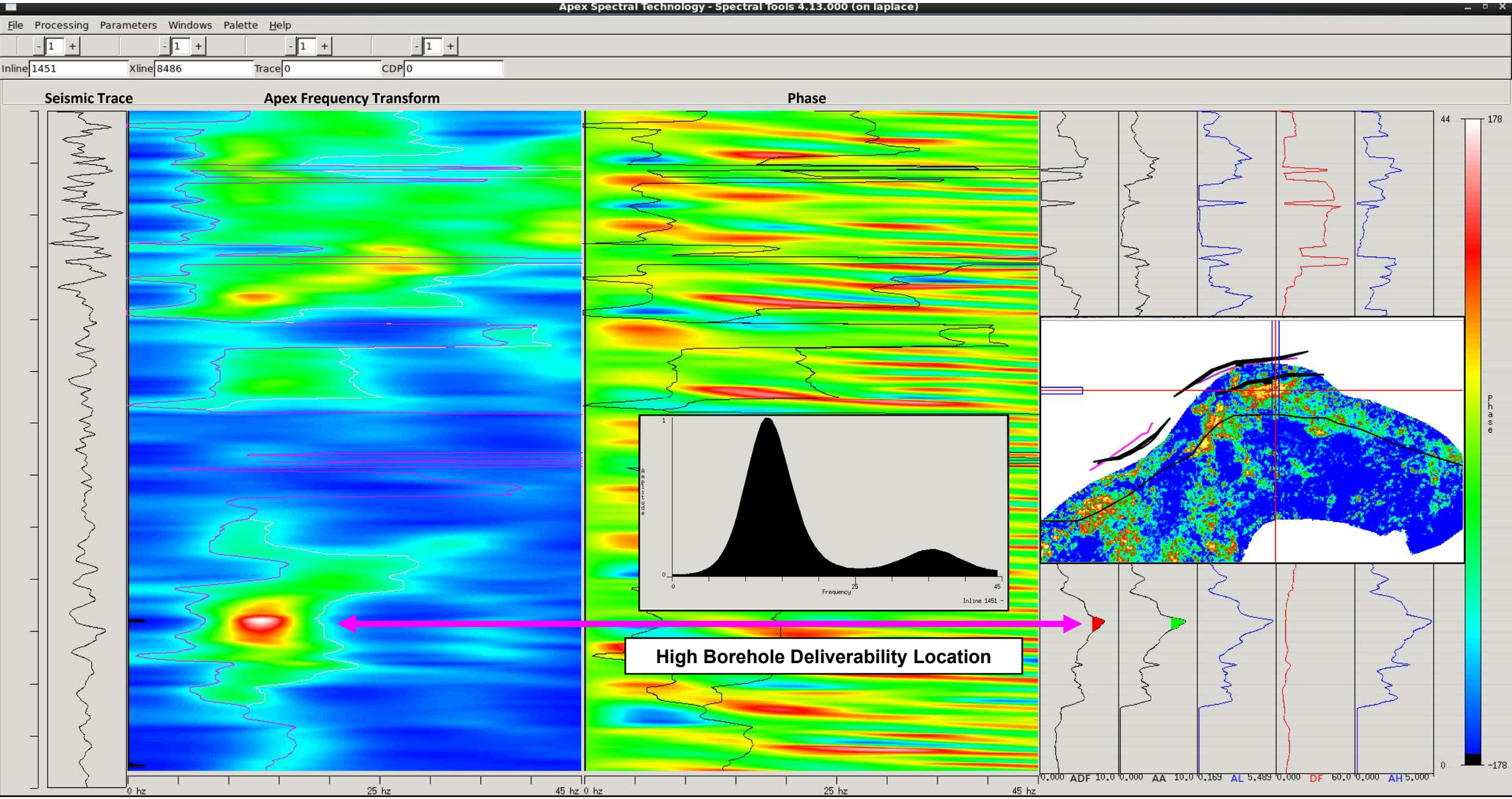


Strong ADF® in structural trap indicates trapped hydrocarbons

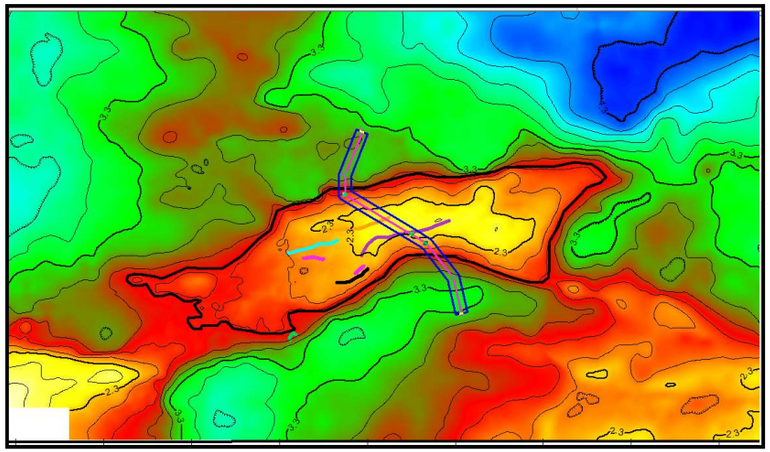
ADF®

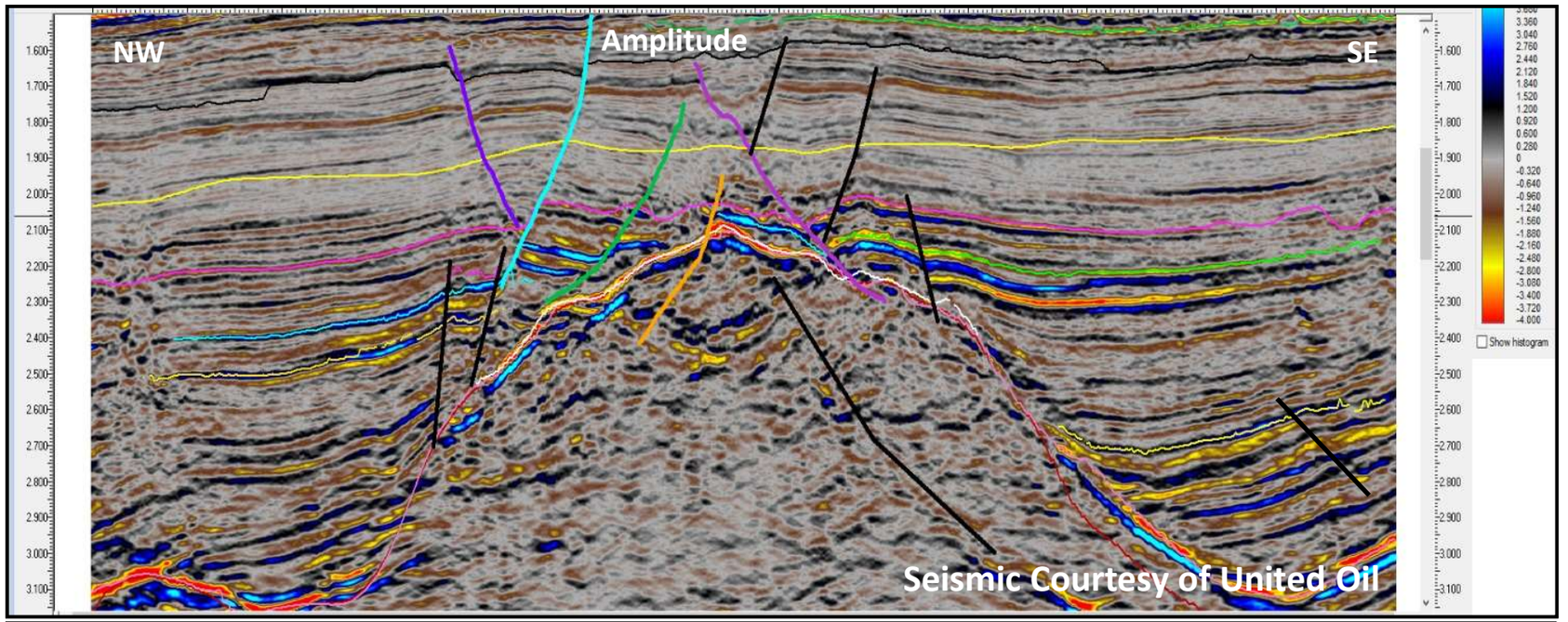


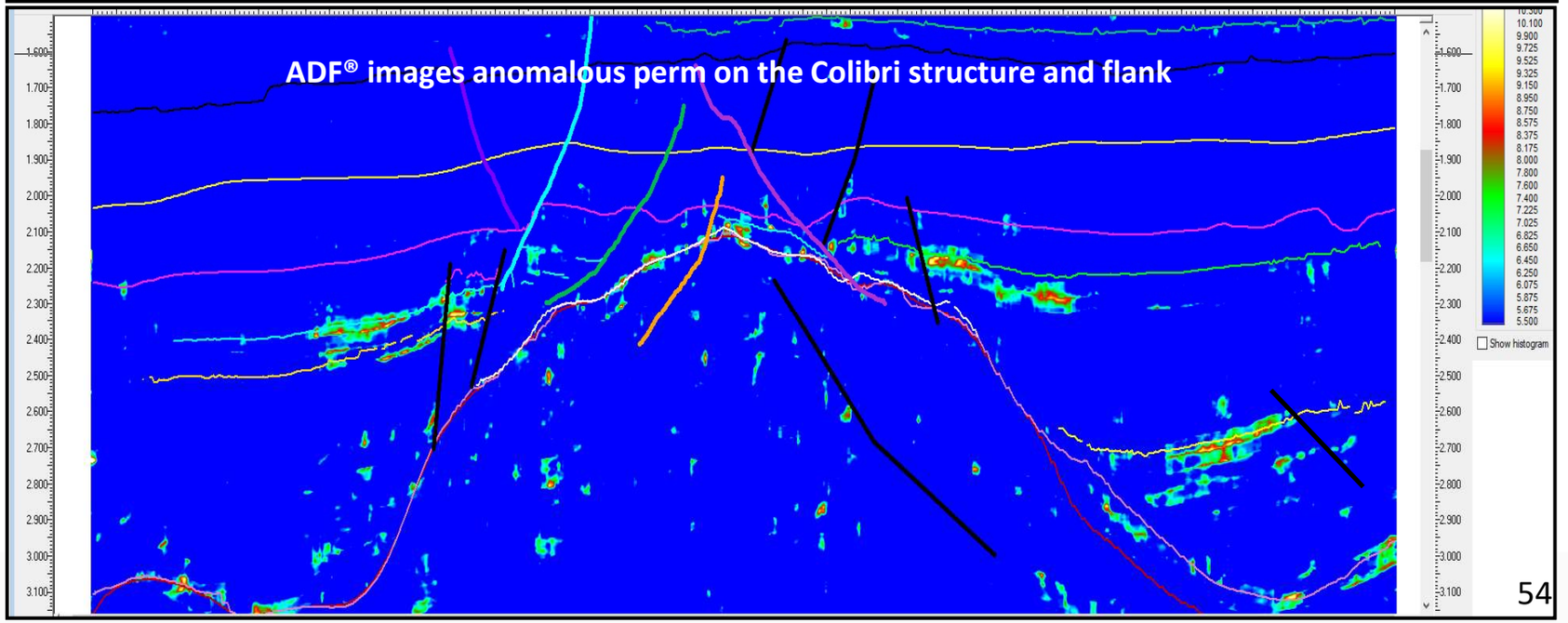
Stratigraphic pay or a wet high perm reservoir?


Apex Spectral Technology - Spectral Tools 4.13.000 (on laplace)
File Processing Parameters Windows Palette Help
Inline 1451 Xline 8486 Trace 0 CDP 0
Seismic Trace
Apex Frequency Transform
Phase
0 hz 25 hz 45 hz 0 hz 25 hz 45 hz
Frequency
Inline 1451
High Borehole Deliverability Location
ADF 10.0 0.000 AA 10.0 0.169 AL 5.489 0.000 DF 60.0 0.000 AH 5.000
Phase
178
-178

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