Structural and Stratigraphic 3D Seismic Interpretation of Middle Cretaceous in South East Muglad Basin, South Sudan*

Dorar Hamdoba Elshaikh Saror[1] and Zuhar Zahir Bin Tuan Harith[2]

Search and Discovery Article #30269 (2013)**
Posted May 31, 2013

*Adapted from oral presentation given at 2013 Pacific Section AAPG, SEG and SEPM Joint Technical Conference, Monterey, California, April 19-25, 2013

[1]White Nile (5B) Petroleum Operating Company, Khartoum, Sudan (dorar15@gmail.com)
[2]Universiti Teknologi PETRONAS, Tronoh, Perak, Malaysia (zuharza@petronas.com.my)

Abstract

In this study, the structural system, and the seismic interpretation of Middle Cretaceous in JK Field in Southeast Muglad basin were interpreted using 3-D seismic data volume, well logs, and seismic attributes. The main use of seismic attributes was to create an intuitive display that allows an interpretation task to be performed both more efficiently and more effectively in characterizing structural and depositional settings of JK field in Southeast Muglad basin.

To demonstrate structural setting of the study area 3D seismic data were interpreted. Three main seismic reflectors, three horizons, were picked. The most dominant structure in the area is the north-northwest, south-southeast-trending normal faults and northeast-southwest-trending minor normal faults were developed in Middle Cretaceous; later east-west faults were active in Late Cretaceous when the hydrocarbons were trapped. Most of the older faults face towards northeast and the younger faults face towards northwest-forming structural traps, where hydrocarbons are trapped. Formation tops in the JK field, three layers, were picked based on petrophysical well logs, and maps were prepared on each. The results of this part of the study show that the interbedded sandstones with shale of the three formations, in particular the sandstones, were formed in meandering channels of delta system. Shaly units of the three formations, interpreted as potential seals, are of variable thickness and extent. The reservoir is the braided-stream sandstones of Bentiu Formation, and the top seal is the fluvial shale of Aradeiba Formation. Most of the traps are normal fault blocks with high dependency on the lateral seal across the faults. The mutual positions of source, reservoir, and top seal were associated with a higher risk in the lateral seal.

Seismic interpretation of the area shows that the three main seismic facies correspond to the three stratigraphic formations above the basement.. Some distributary channel-fill features were also observed within the Bentiu Formation, but they are not continuous through the area because of the faulting. These elements give reasonable explanation for the hydrocarbon distribution in the area of study and explain why in some wells there were no hydrocarbon shows.

Structural and Stratigraphic 3D Seismic Interpretation of Middle Cretaceous in South East Muglad Basin, SouthSudan

Prepared by: Dorar Hamdoba Elshaikh Saror
Geophysicist

Contents

Objectives

- To understand the stratigraphy of reservoir zones in JK field in SE Muglad Basin.
- To understand some of the hydrocarbon potential areas in the reservoir formations and sediment supply.

Methodology

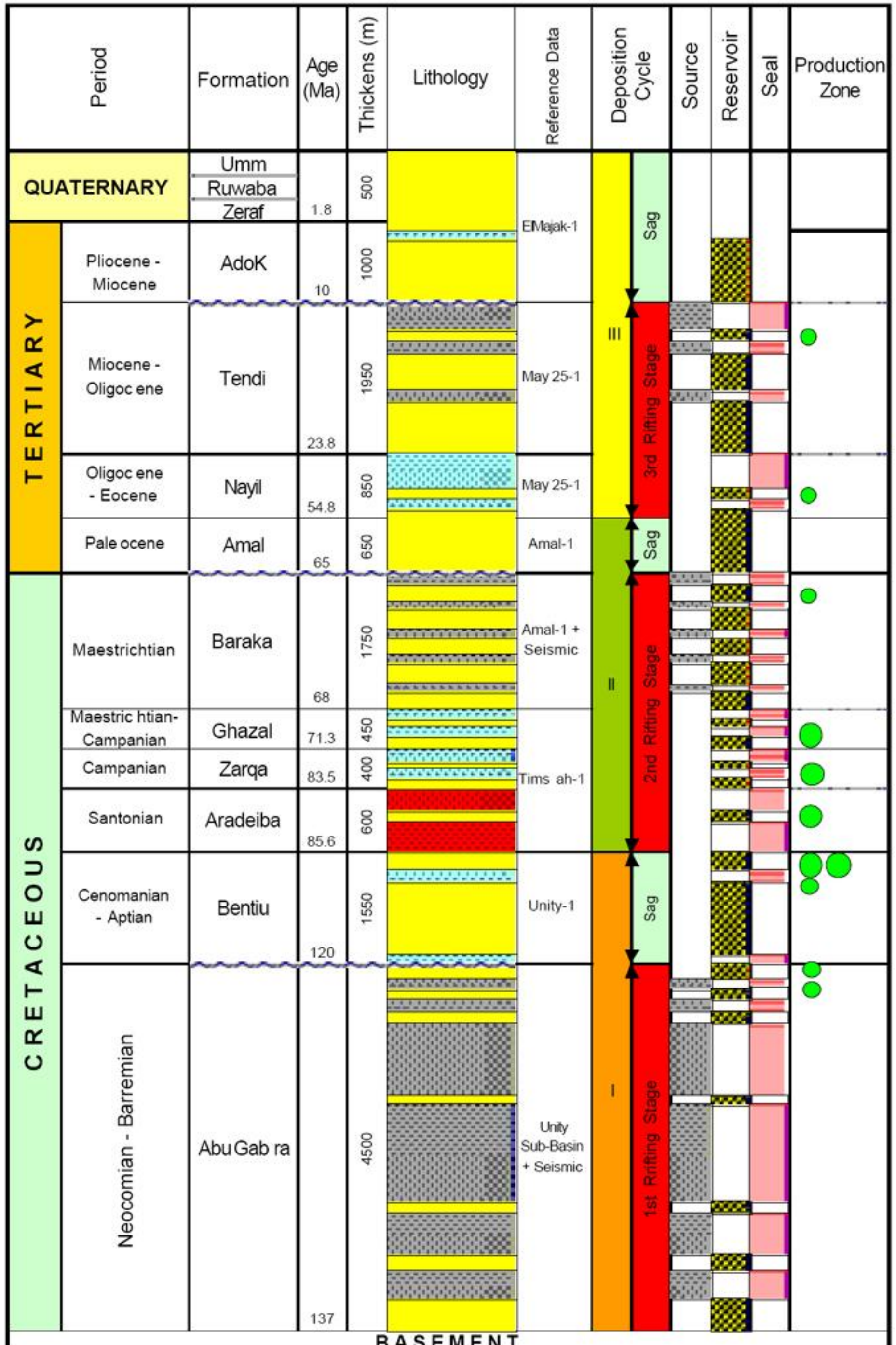
- Identify the structures using 3D seismic interpretation of the field.

- To use seismic stratigraphic and structural attributes with wells petrophysical results to define the seal, reservoir and source criteria for each formation.

Introduction to Muglad Basin And JK field area

General Stratigraphic Column

Muglad Basin, Sudan



- Aradeiba Formation
- Bentiu Formation
- Inra Bentiu Formation
- Abu Gabra Formation

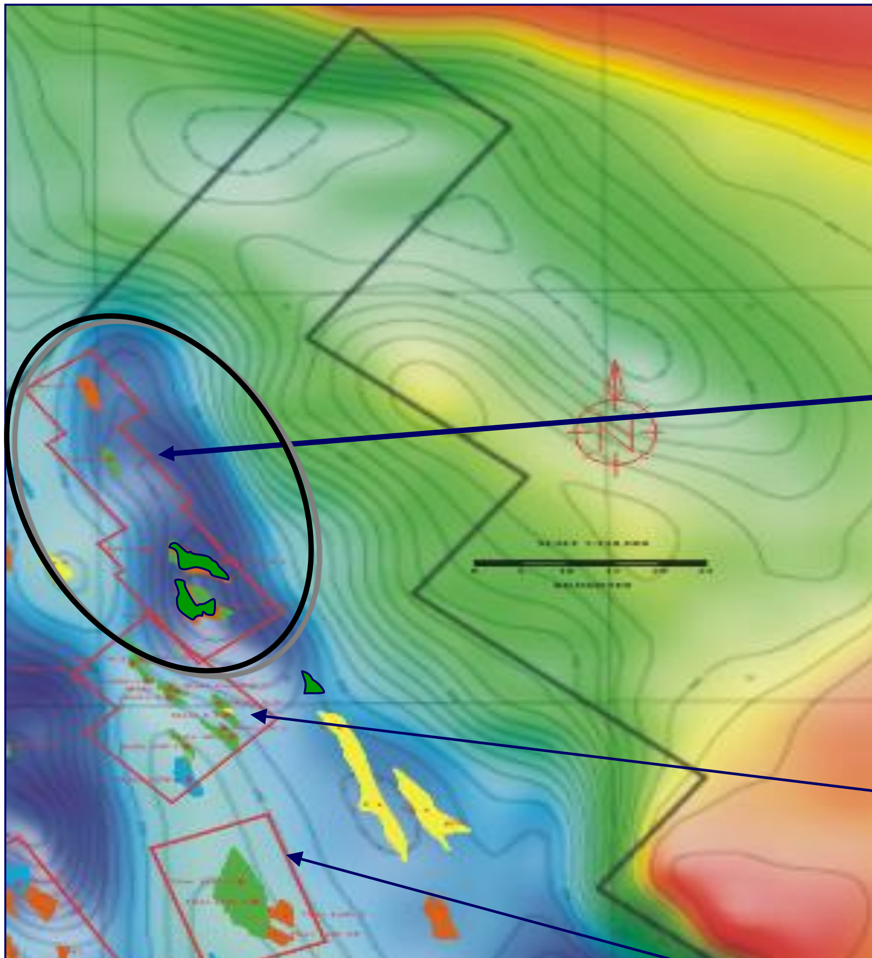
Source rock and Reservior

•Aradeiba is interbedded sandstone and claystone (seal).

•Bentiu is the main (reservior).

•Abu Gabra acts as the (source) rock claystone (rich organic).

Gravity Map of Southeast Muglad Basin JK field



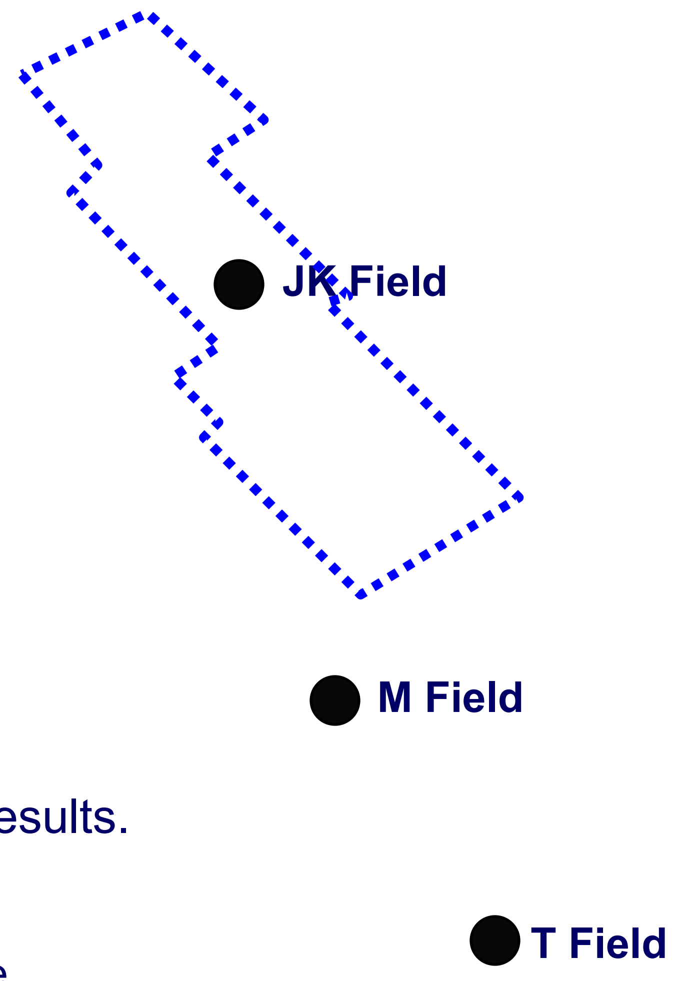
JK 3D field
JK is located in the eastern flank of the northern part of Muglad Basin

M 3D feild
•Bentiu producing oil field
•And Intra Bentiu oil

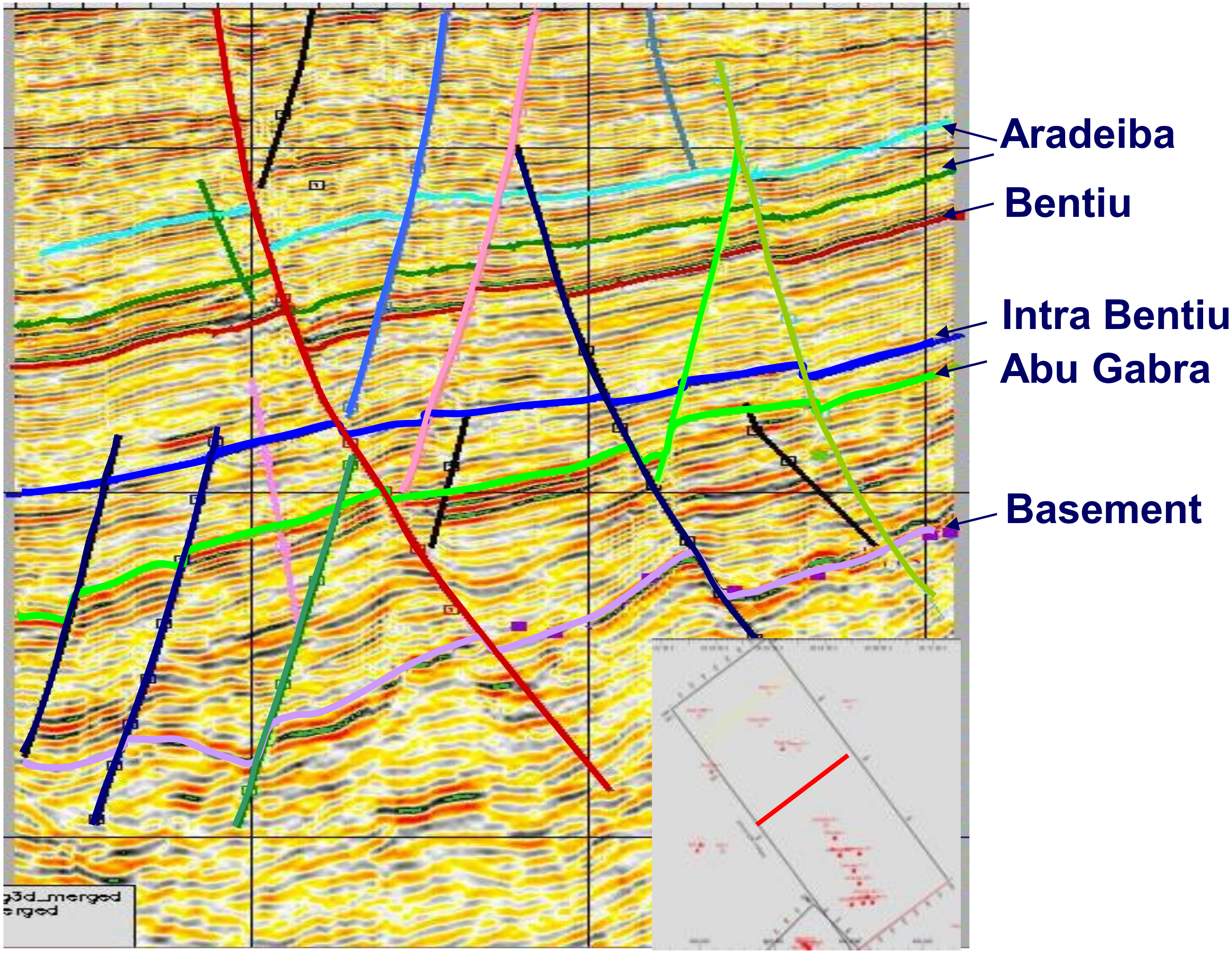
T 3D feild
•Bentiu producing oil field

JK Location

- **Location**
  - 50 km north T Producing field.
  - 20 km north of M Producing field
- **Area coverage**
  - 3D Seismic Data
    - **JK 392 sq km.**
    - **2044 Inlines**
    - **800 Crosslines**
- **Data**
  - 9 Exploration Petrophysical Wells results.
- **Software**
  - PETREL seismic interpretation Package.

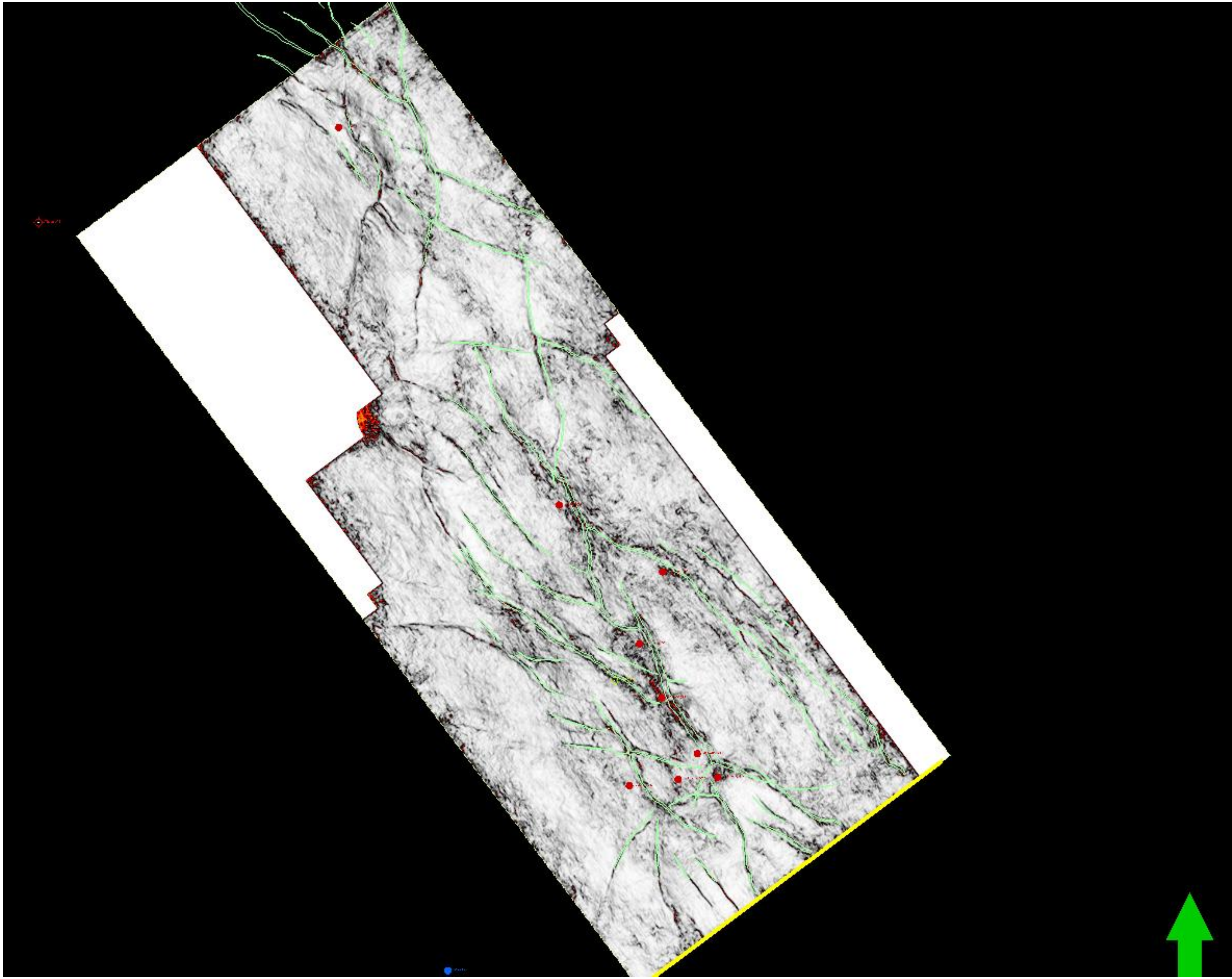


Horizon and Fault Interpretation

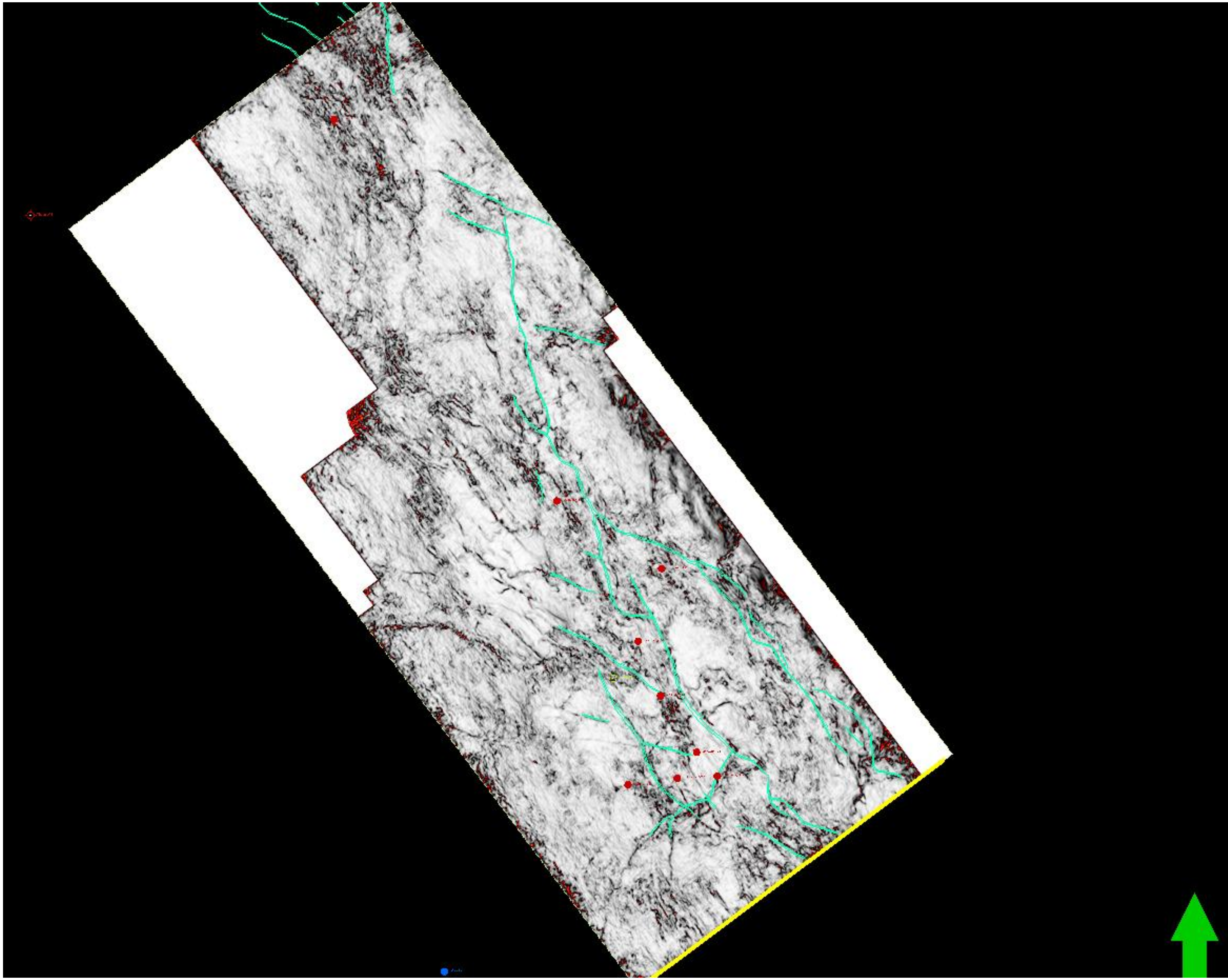


Variance Slices

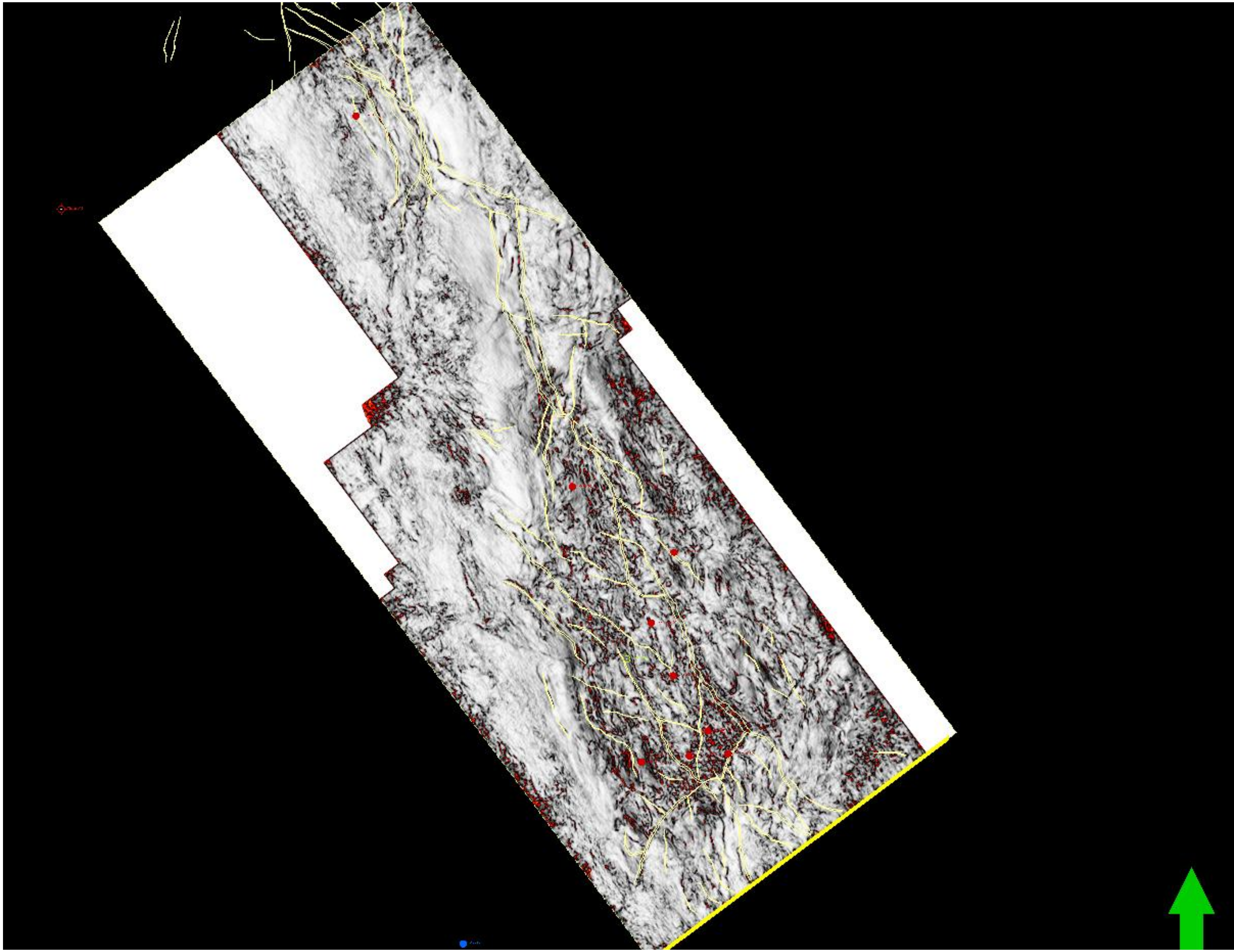
Fault Detection



Fault Boundary ”green” in Bentiu Variance slice at 1500 ms



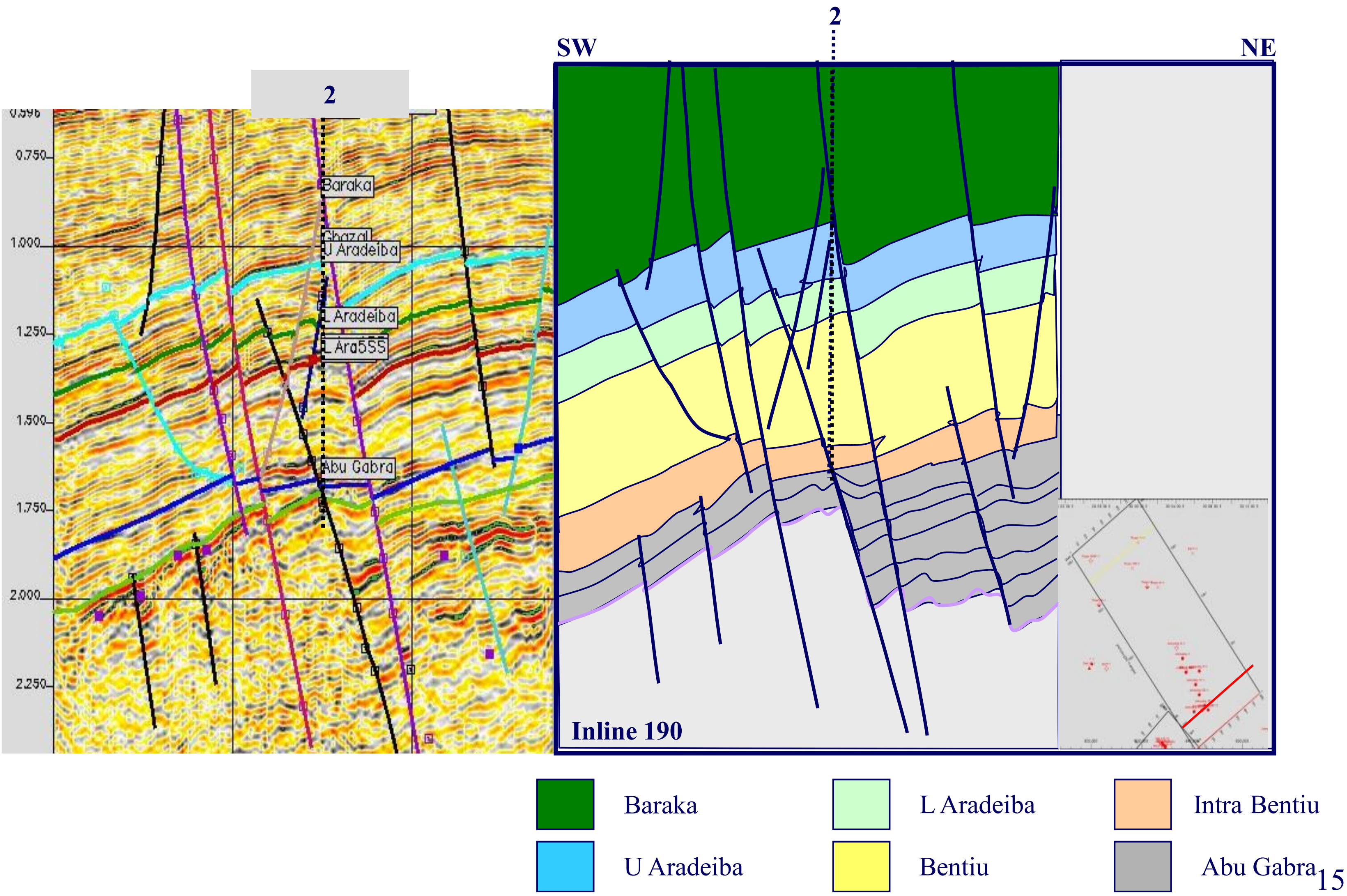
Fault Boundary “Blue” in Intra Bentiu Variance slice at 1700 ms



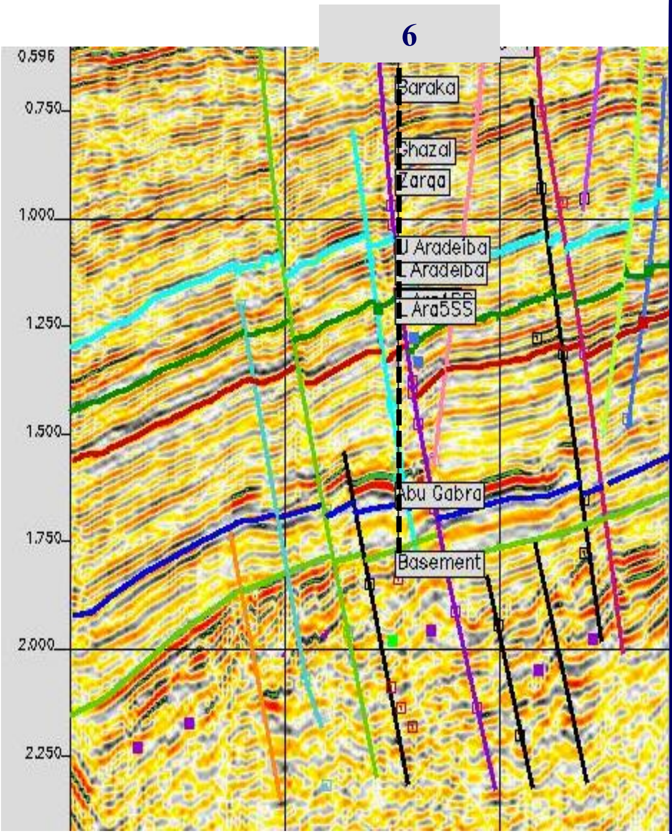
Fault Boundary “yellow” in Abu Gabra Variance slice at 1800 ms

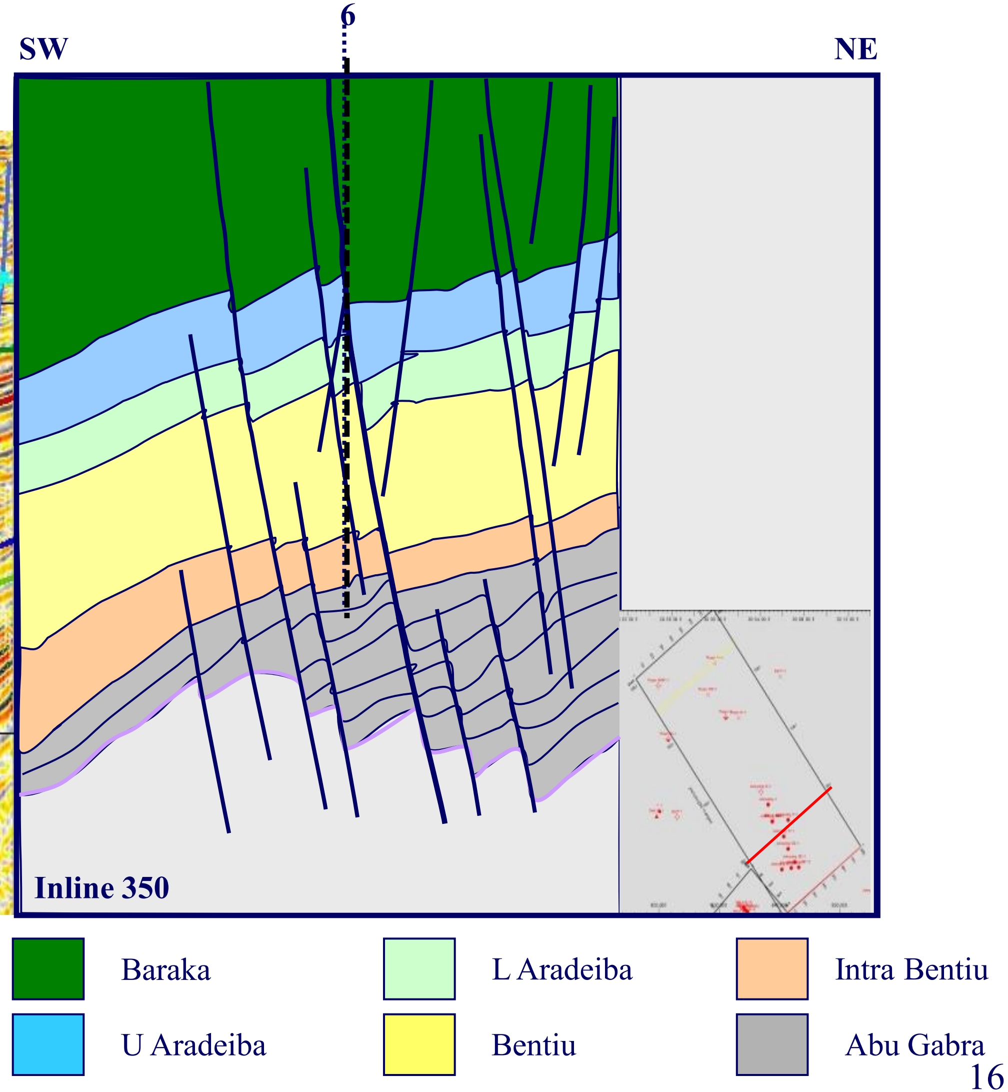
Seismic Cross Section Analysis

Well #2 seismic cross section

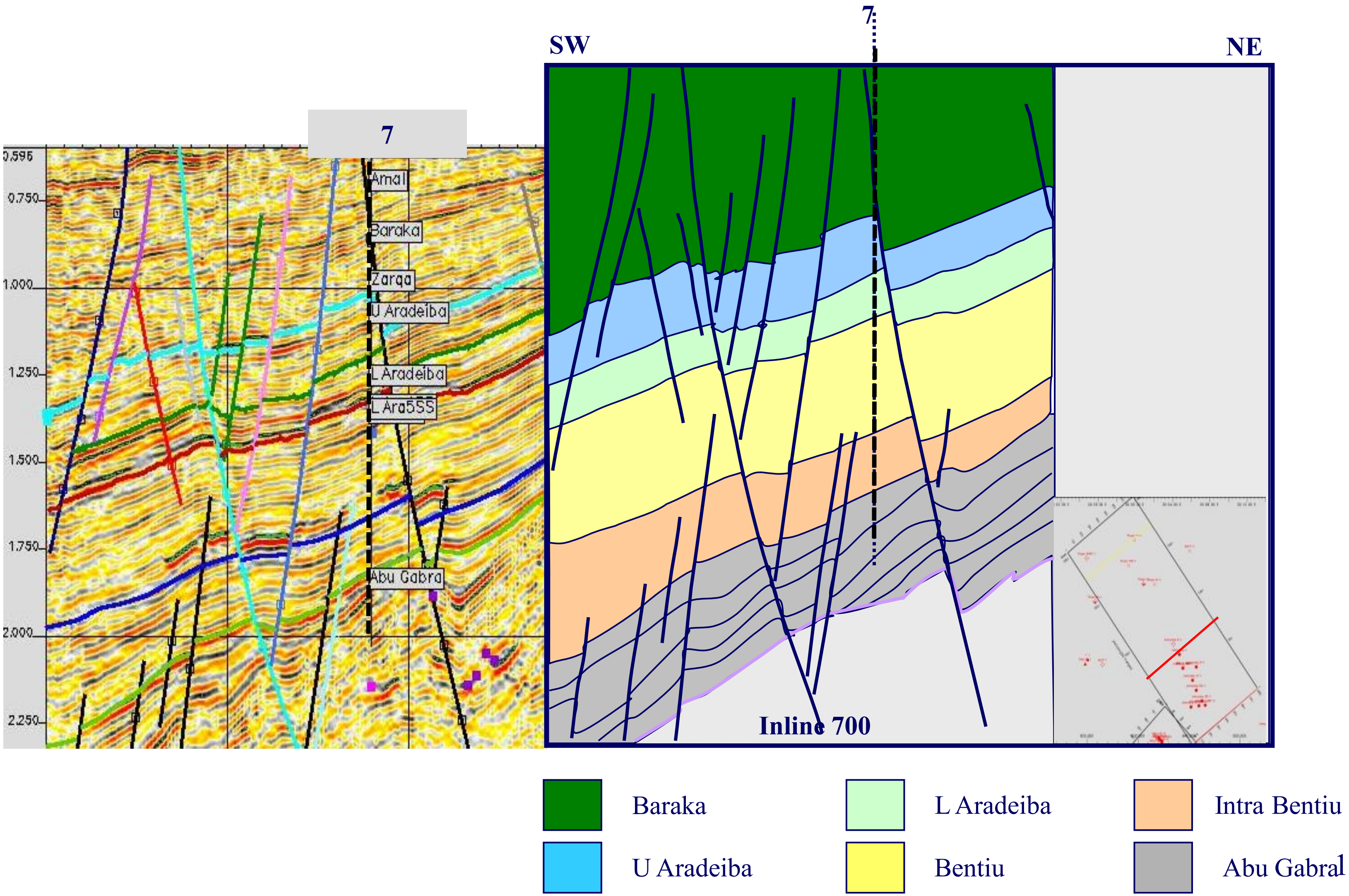


Well #6 seismic cross section

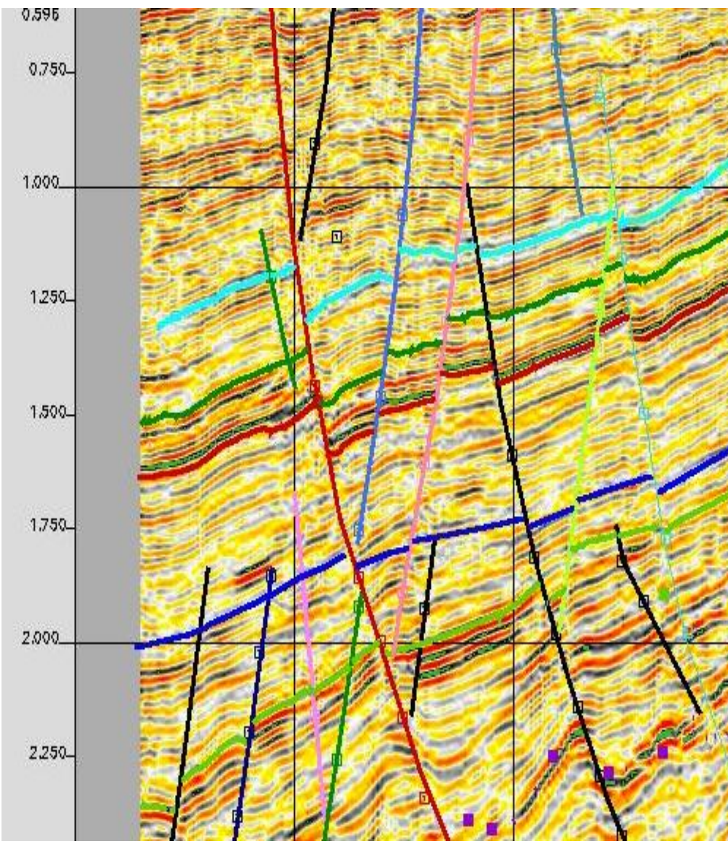


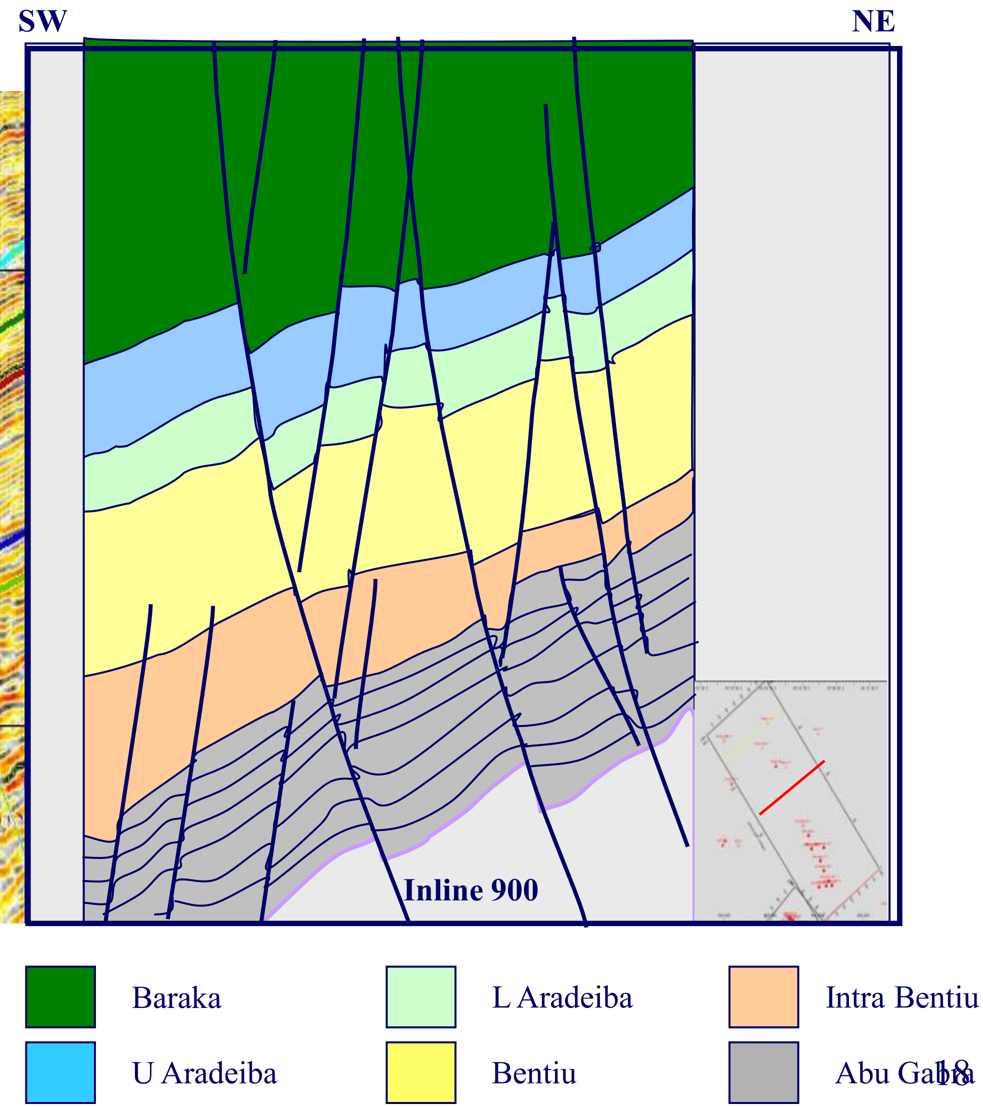


Well #7 seismic cross section

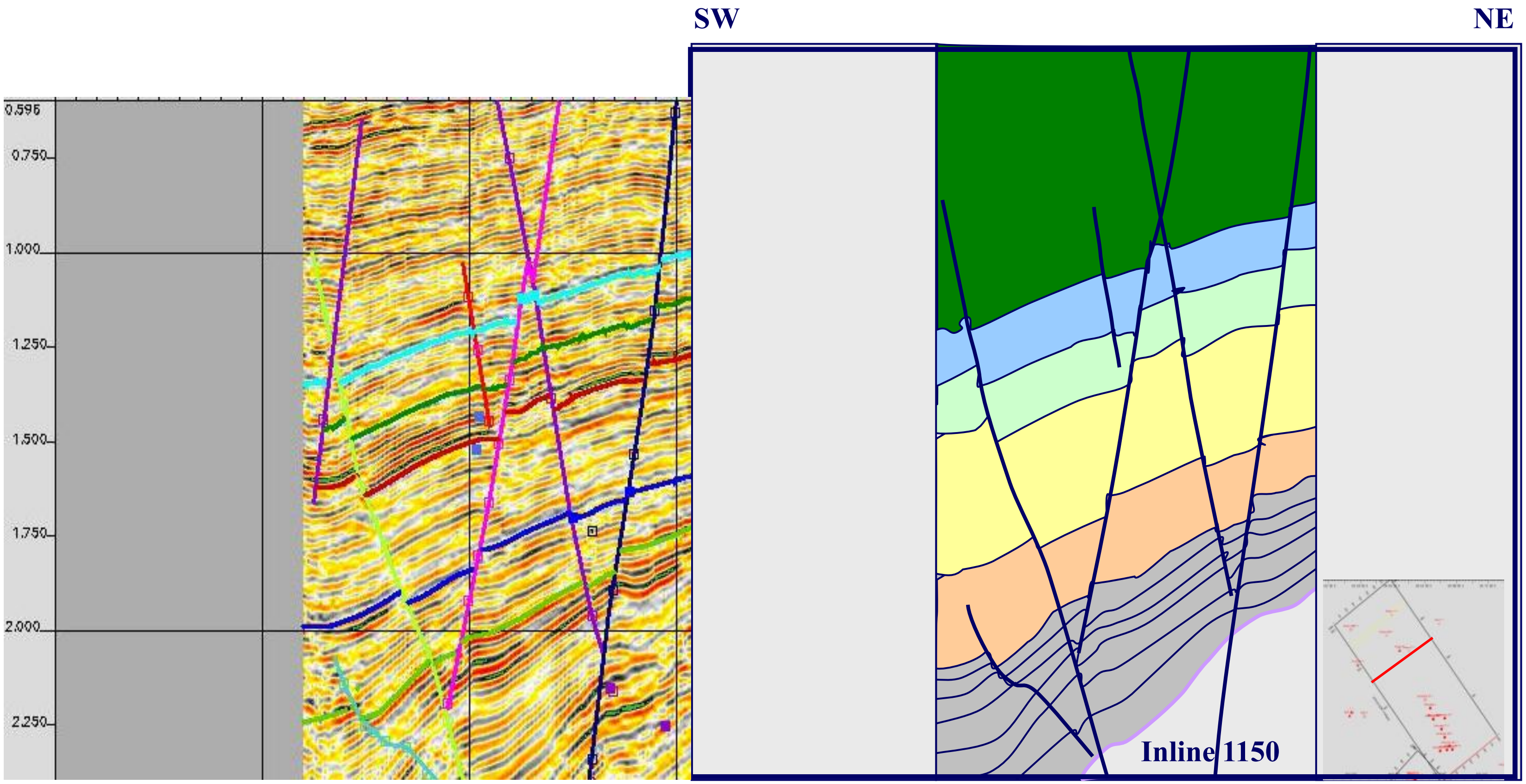


Seismic cross section between well#7 and well#8



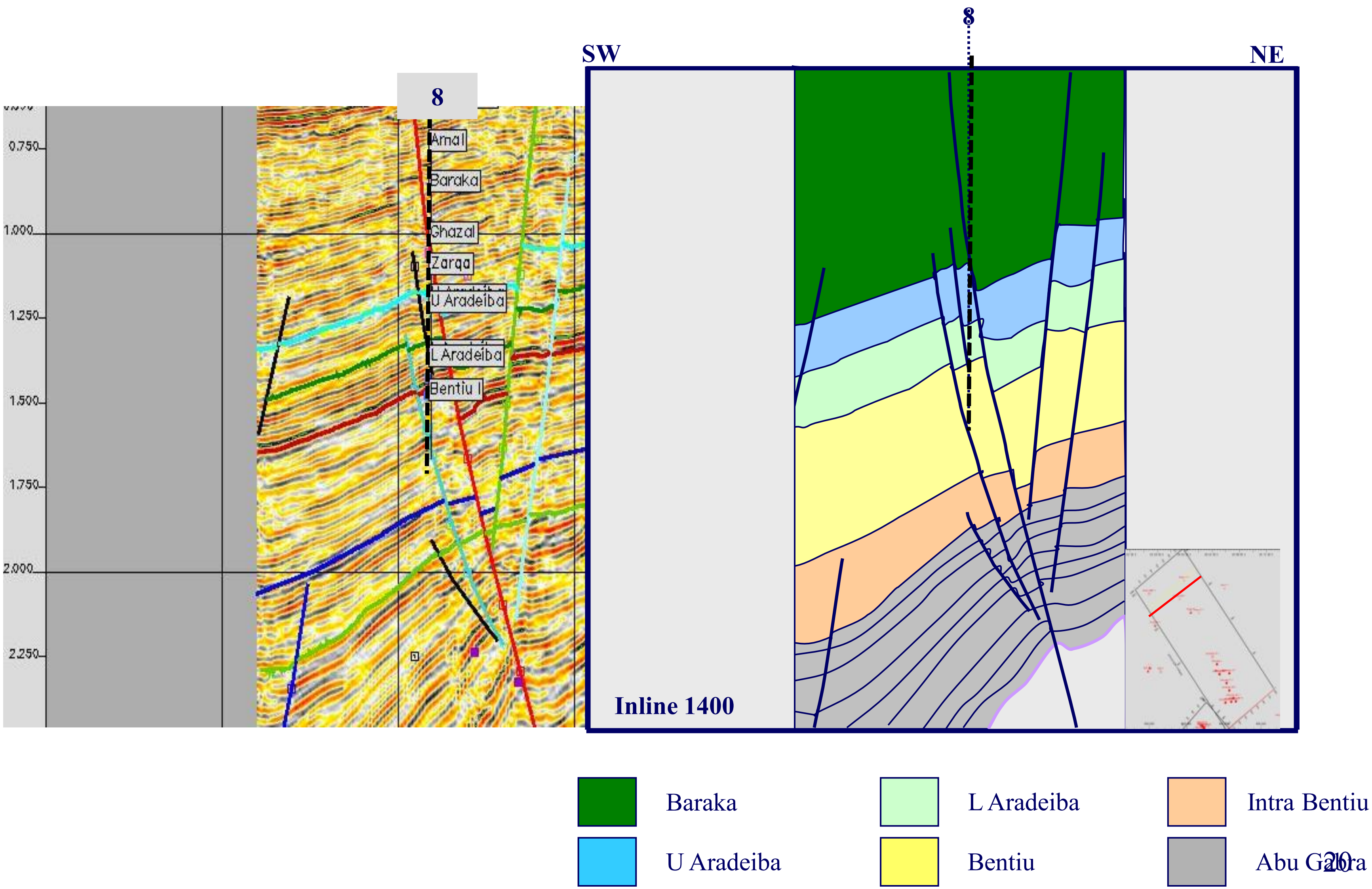


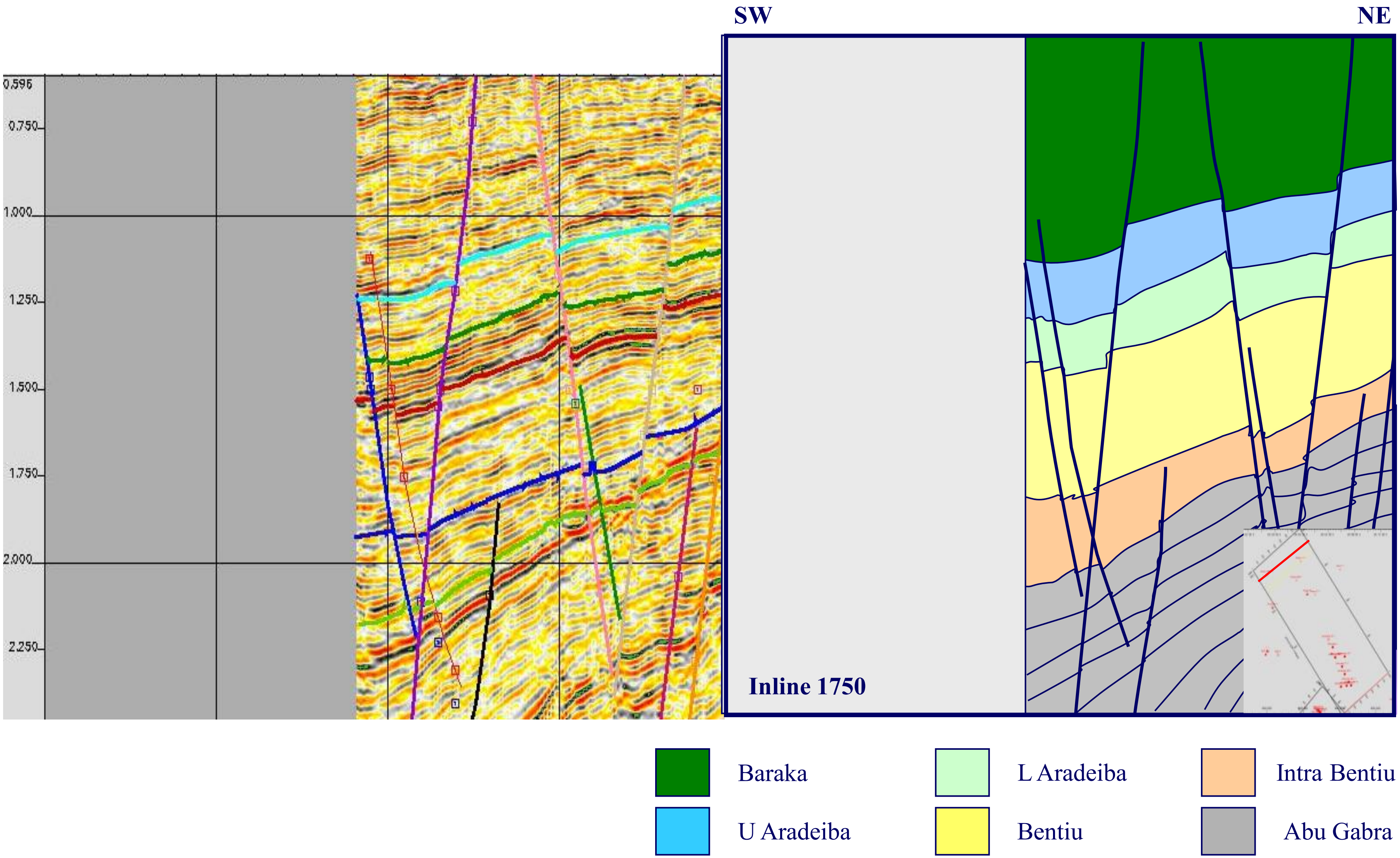
Seismic cross section between well#7 and well#8



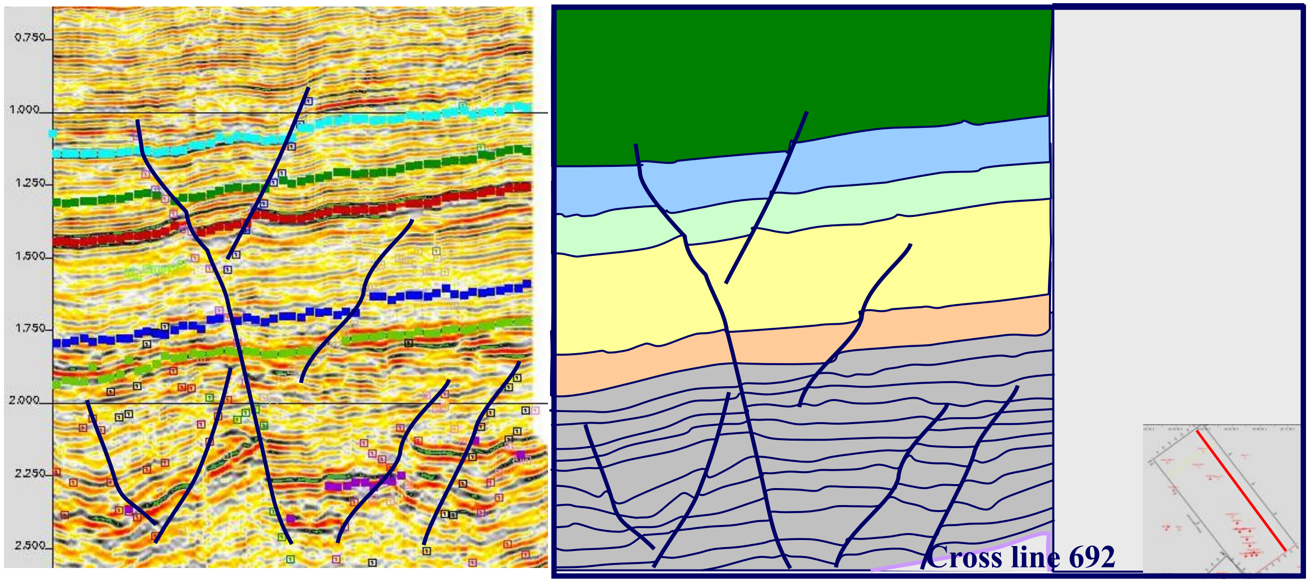
Baraka
U Aradeiba
L Aradeiba
Bentiu
Intra Bentiu
Abu Gabra

Well #8 seismic cross section

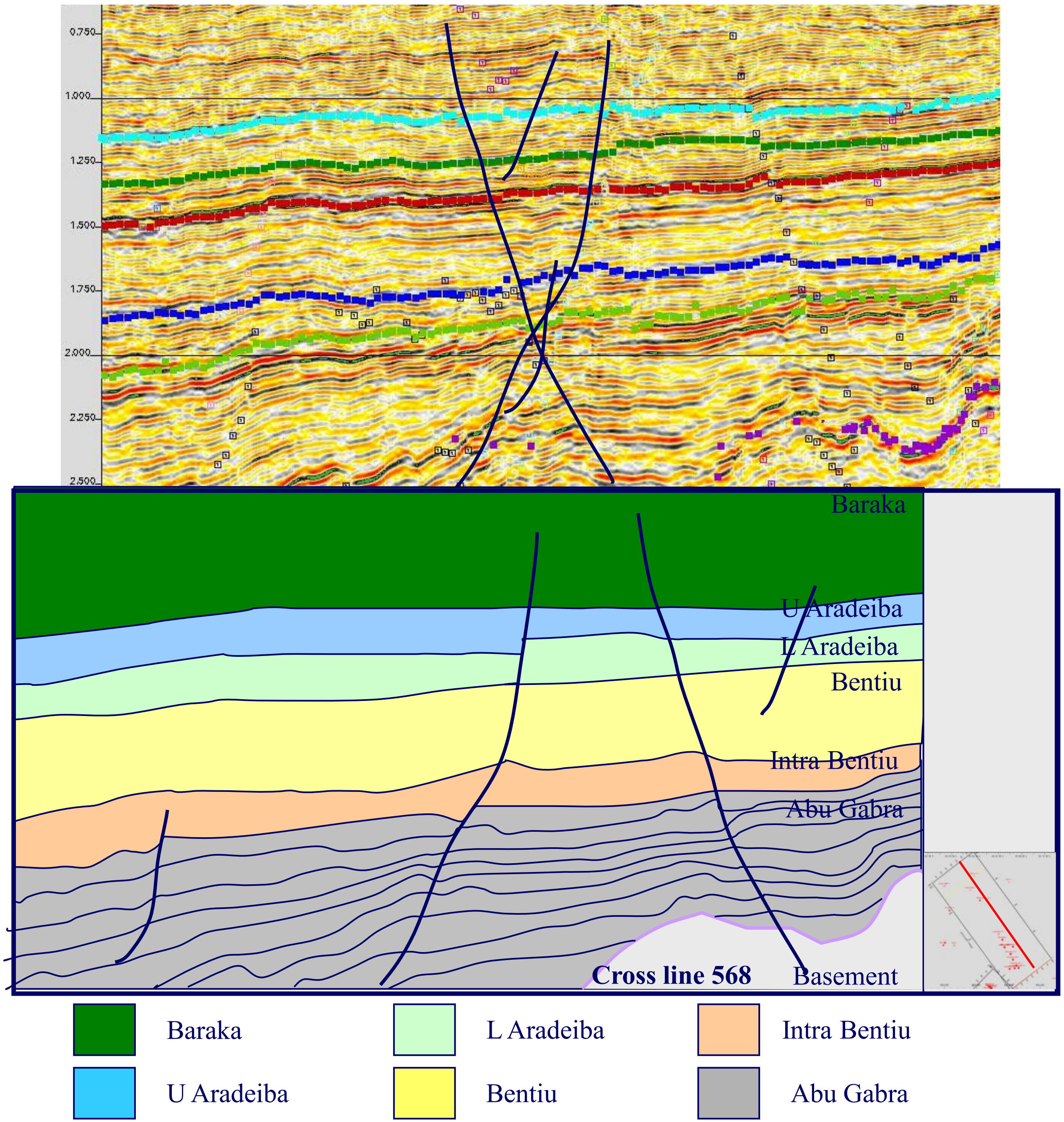


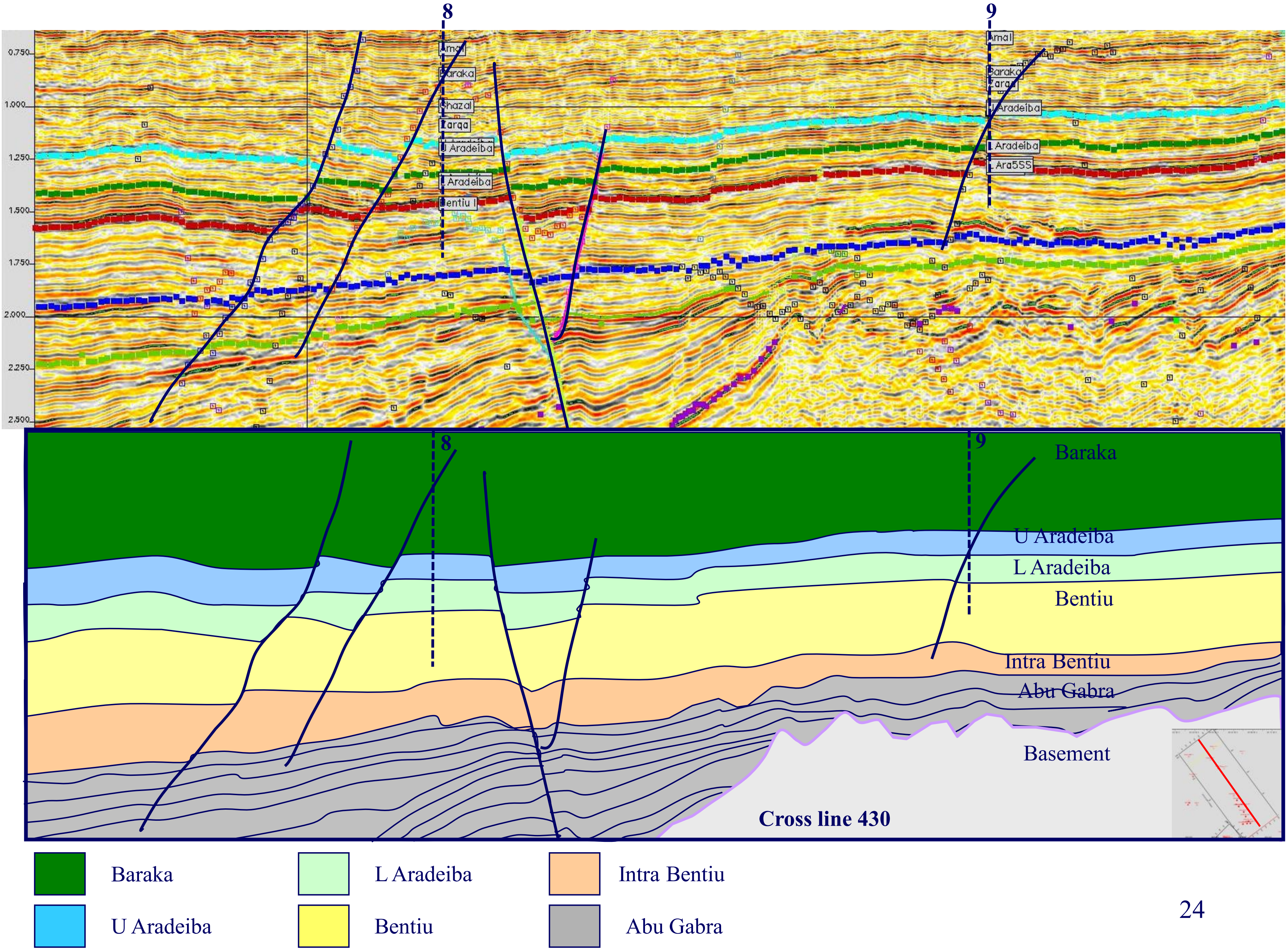

0.595
0.750
1.000
1.250
1.500
1.750
2.000
2.250
SW
NE
Inline 1750
Baraka
U Aradeiba
L Aradeiba
Bentiu
Intra Bentiu
Abu Gabra

Crossline seismic cross section

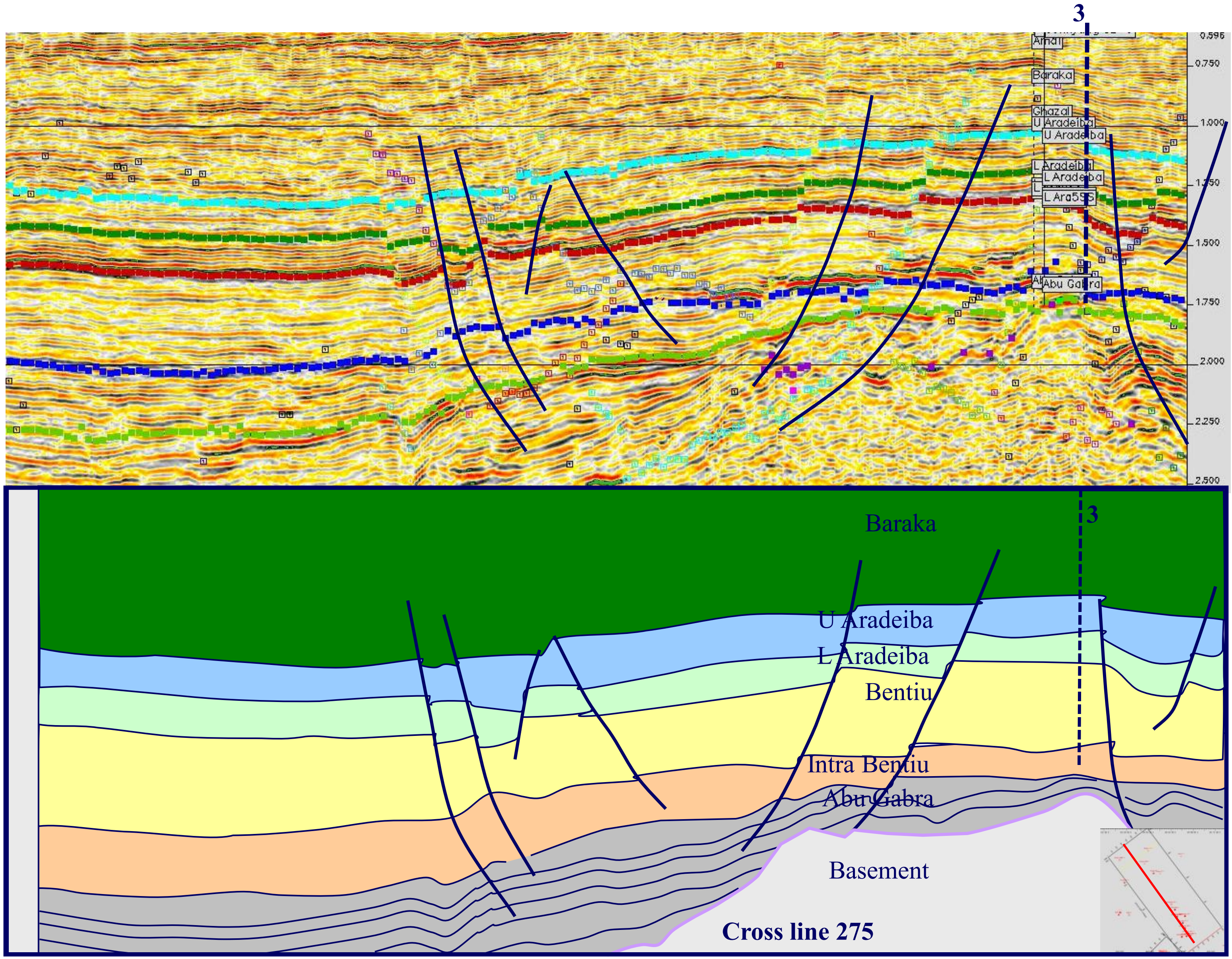


	Baraka		L Aradeiba		Intra Bentiu
	U Aradeiba		Bentiu		Abu Gabra

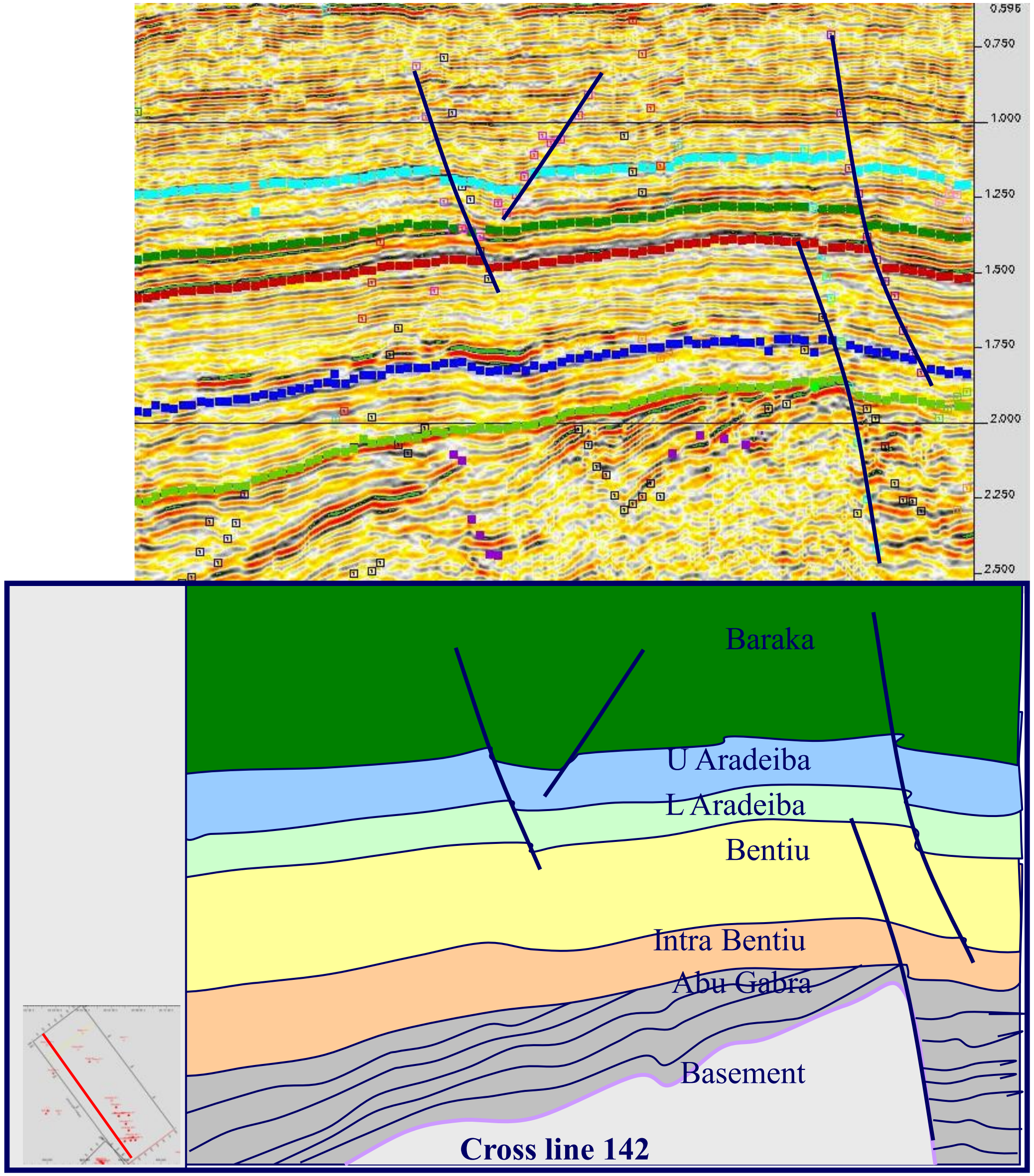

0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
Baraka
U Aradeiba
L Aradeiba
Bentiu
Intra Bentiu
Abu Gabra
Cross line 568
Basement
Baraka
L Aradeiba
Intra Bentiu
U Aradeiba
Bentiu
Abu Gabra



8
9
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
Amal
Baraka
Shazal
Zarqa
U Aradeiba
L Aradeiba
Bentiu I
Baraka
U Aradeiba
L Aradeiba
Bentiu
Intra Bentiu
Abu Gabra
Basement
Cross line 430
Baraka
L Aradeiba
Intra Bentiu
U Aradeiba
Bentiu
Abu Gabra



	Baraka		L Aradeiba		Intra Bentiu
	U Aradeiba		Bentiu		Abu Gabra



Baraka

U Aradeiba

L Aradeiba

Bentiu

Intra Bentiu

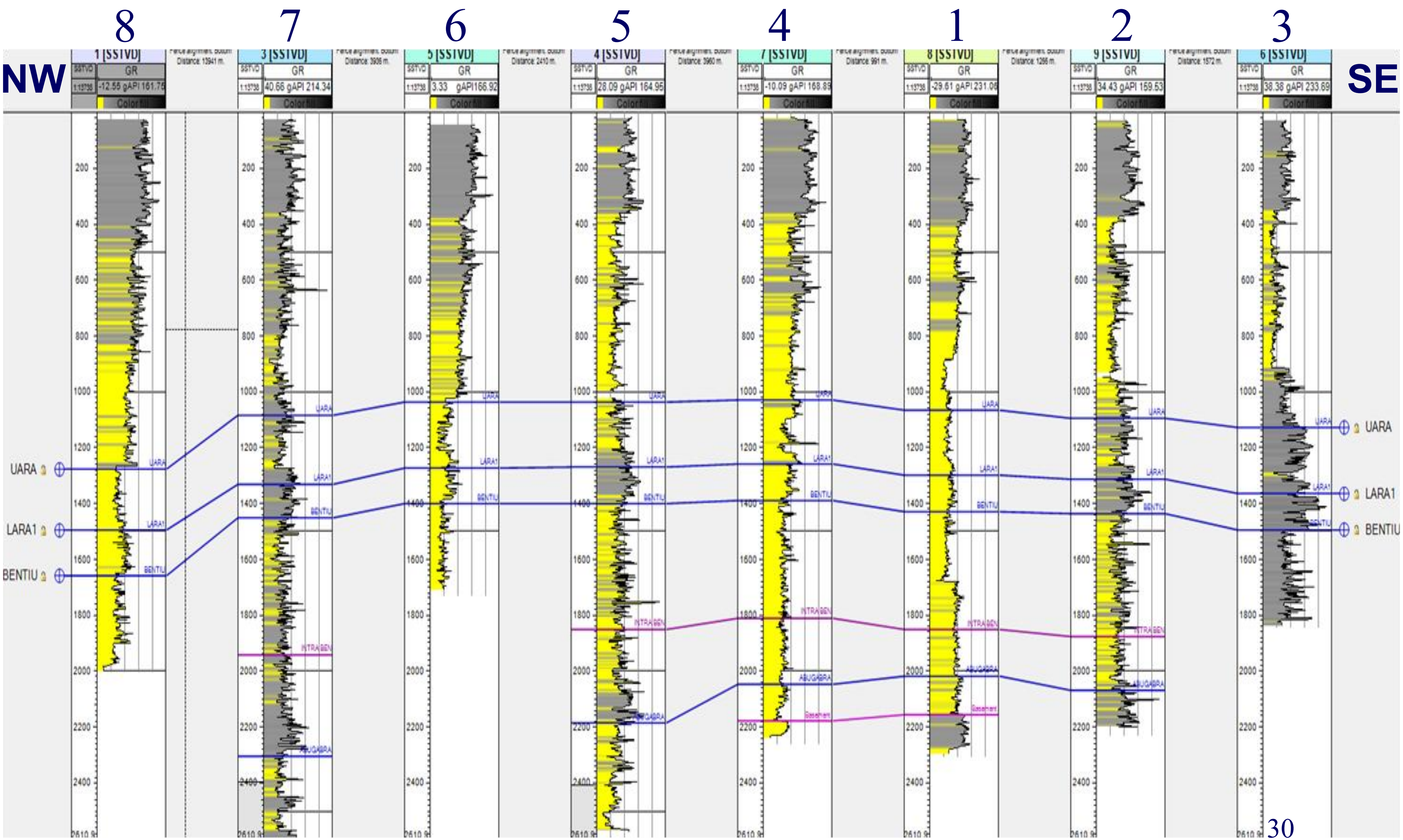
Abu Gabra

Well Correlation

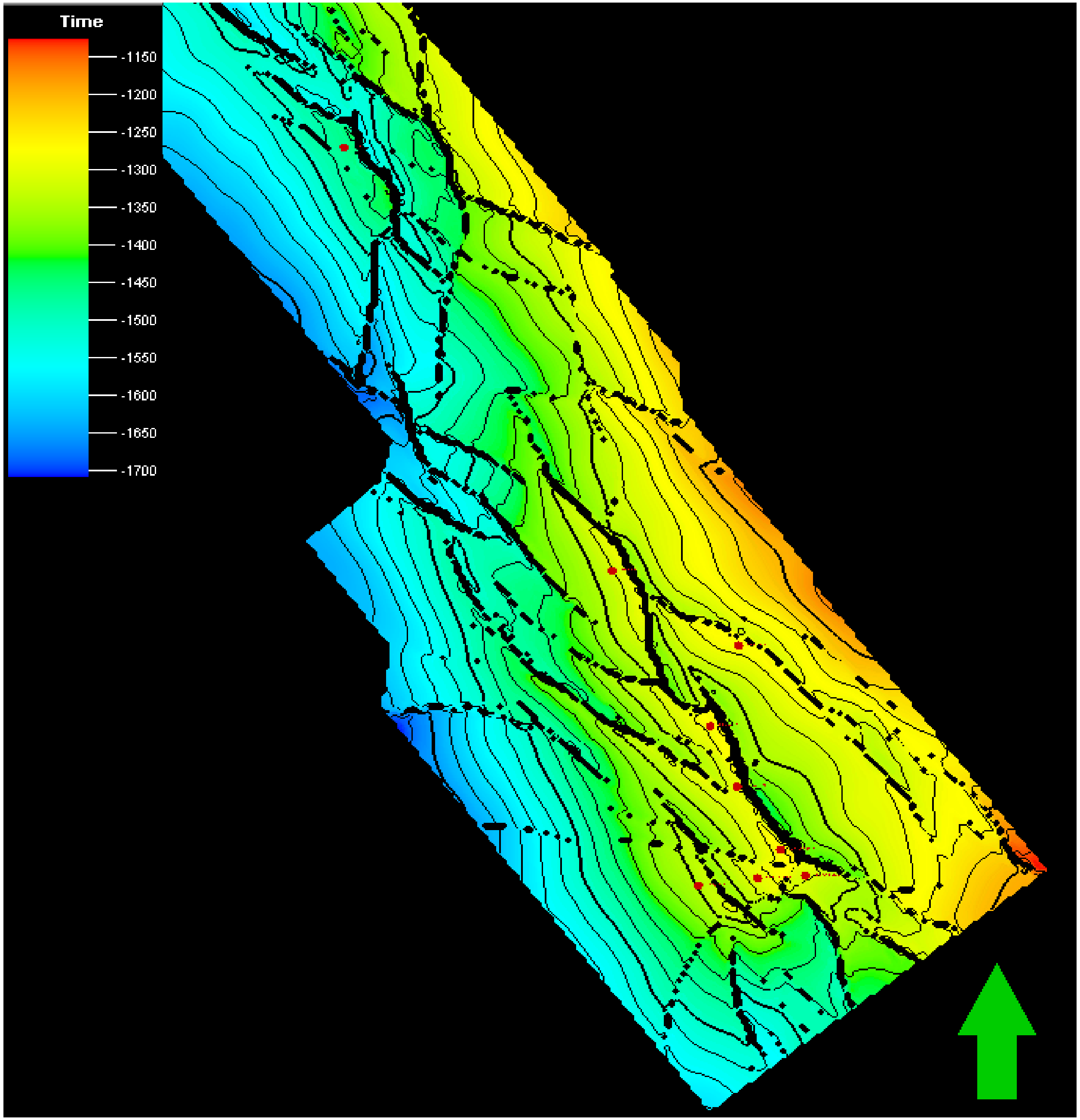
The use of well correlation to data

- Gamma logs
- Formation tops

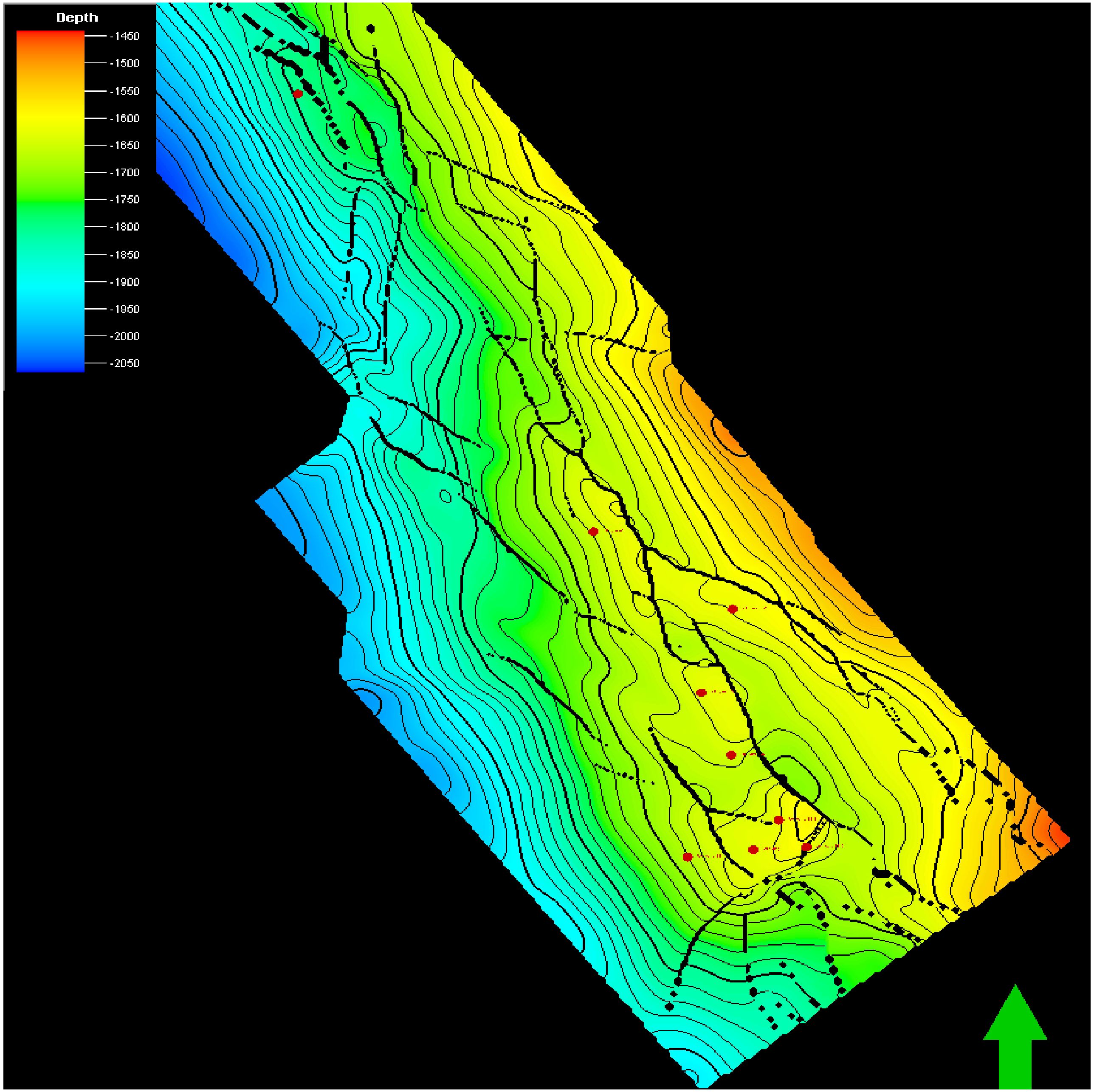
Well Correlation



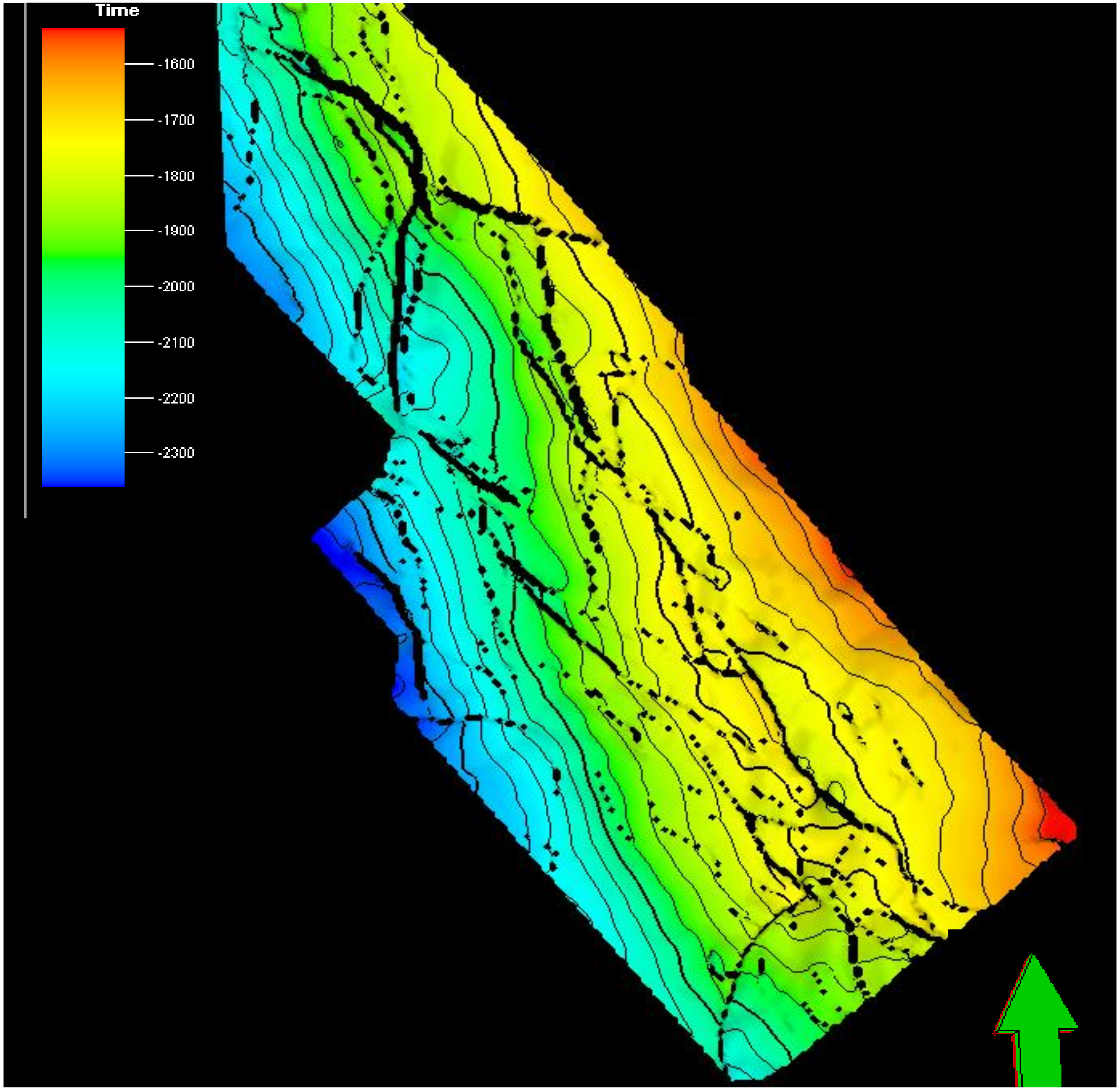
Depth Maps



Bentiu Depth Structure



Intra Bentiu Depth Structure



Abu Gabra Depth Structure

Attribute Analysis

Well Correlation

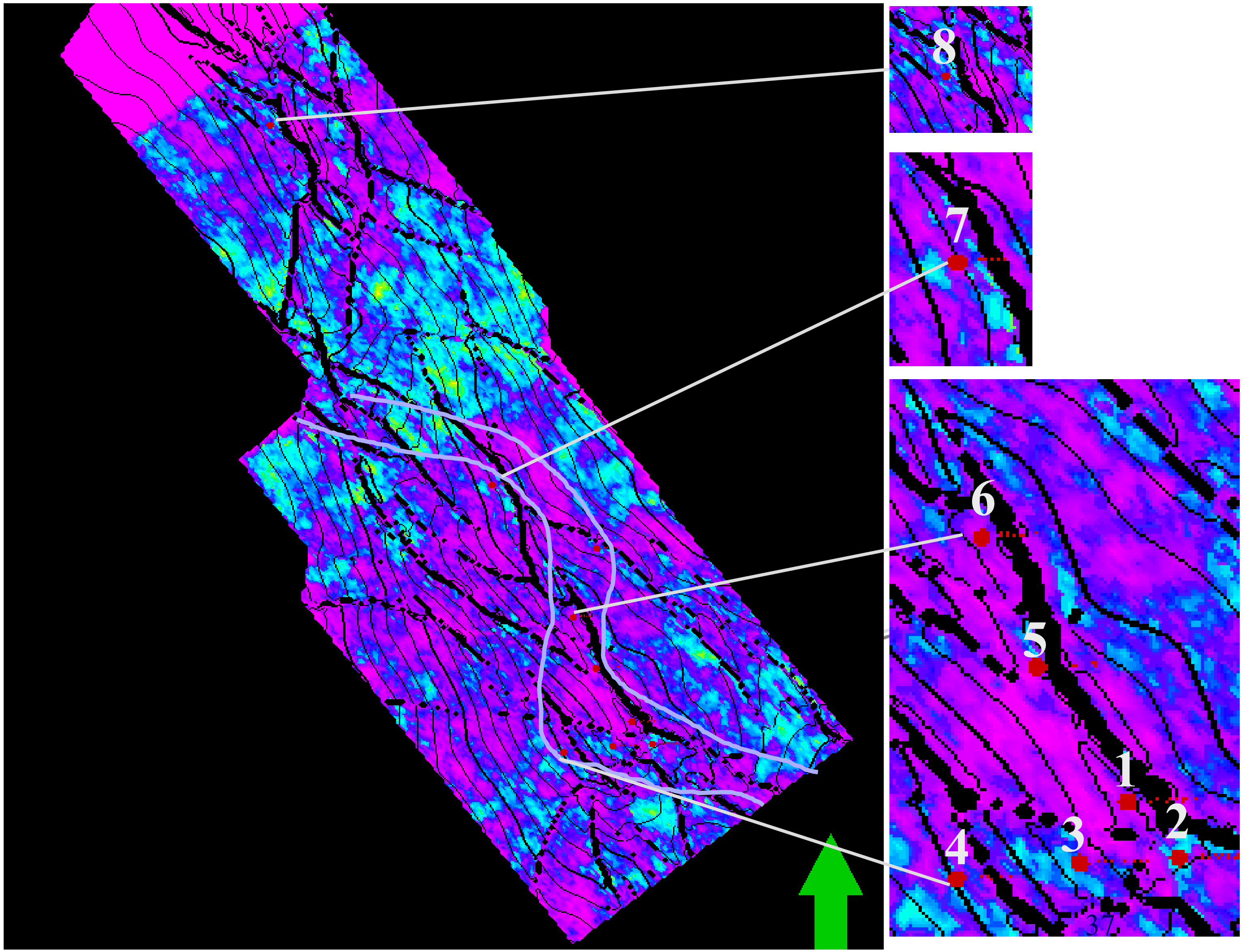
The use of well correlation to data

- Gamma logs
- Formation tops

Bentiu Average Energy

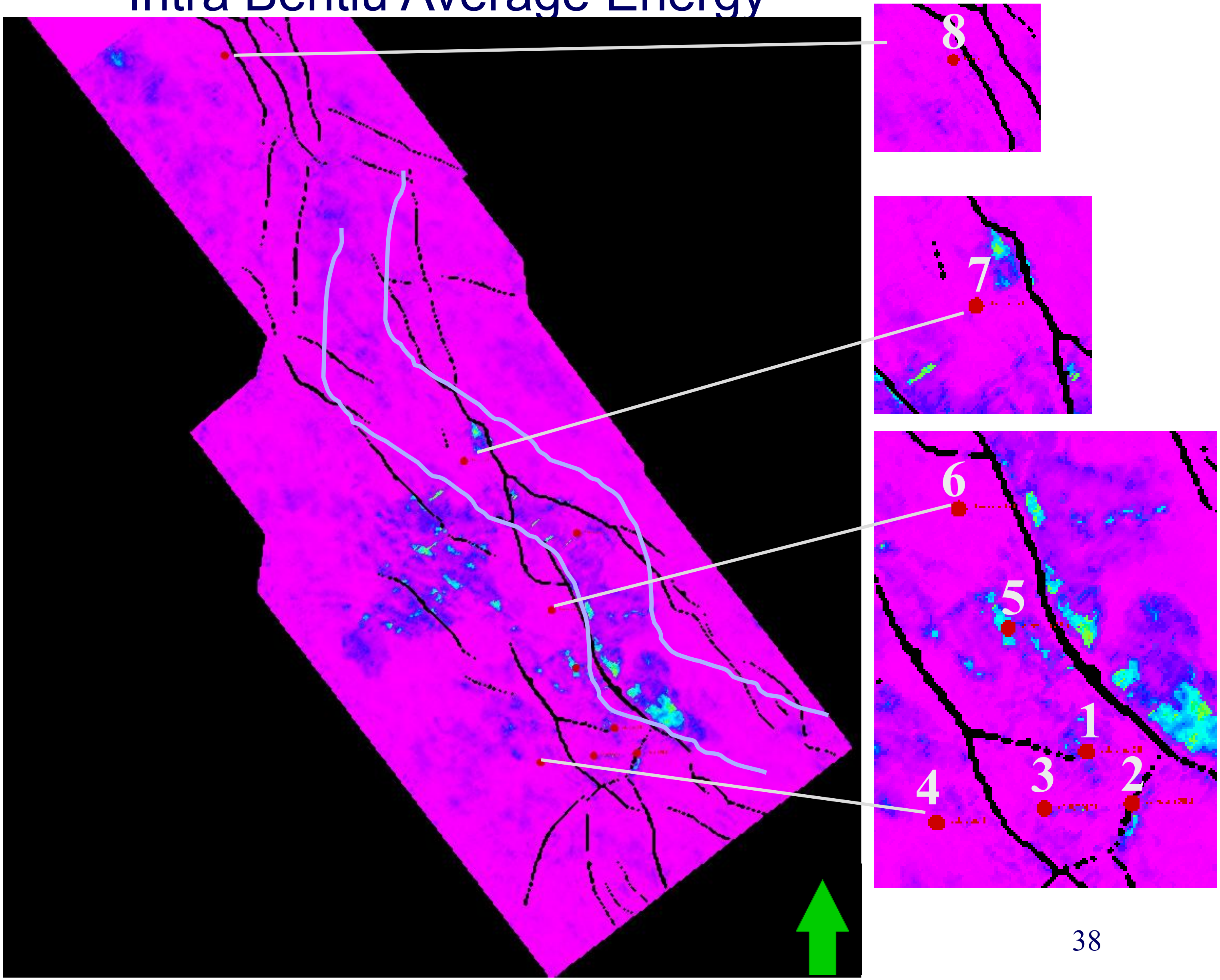
Well result:

1. Oil
2. Oil
3. Oil
4. Oil
5. Oil
6. Oil
7. Water
8. Oil



Intra Bentiu Average Energy

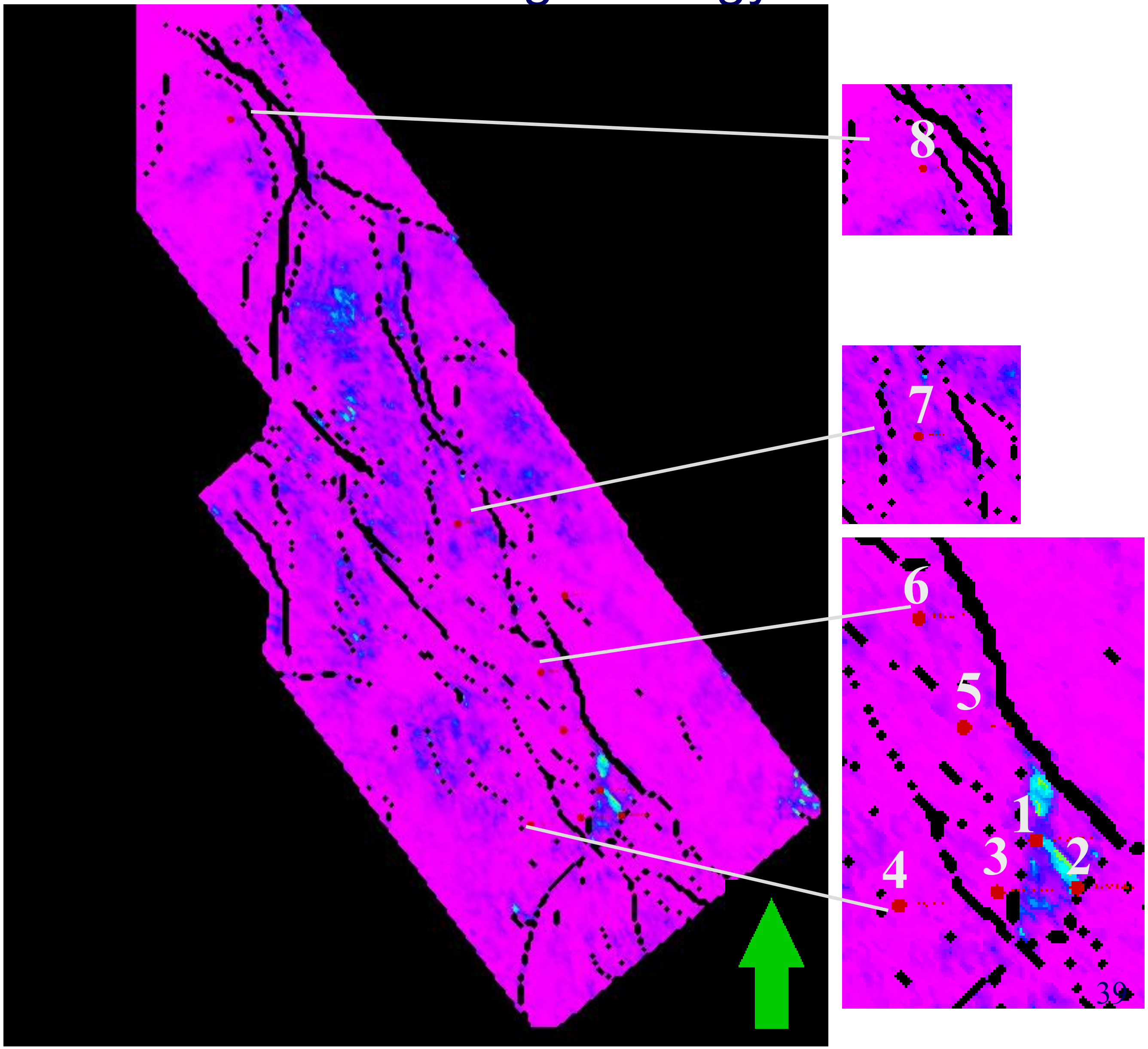
Well result:
1. Water
2. Water
3. Water
4. NP.
5. Water
6. Water
7. Water
8. NP.



Abu Gabra Average Energy

Well result:

1. Water
2. Water
3. Water
4. NP.
5. Water
6. Poor Oil
7. Oil
8. NP.



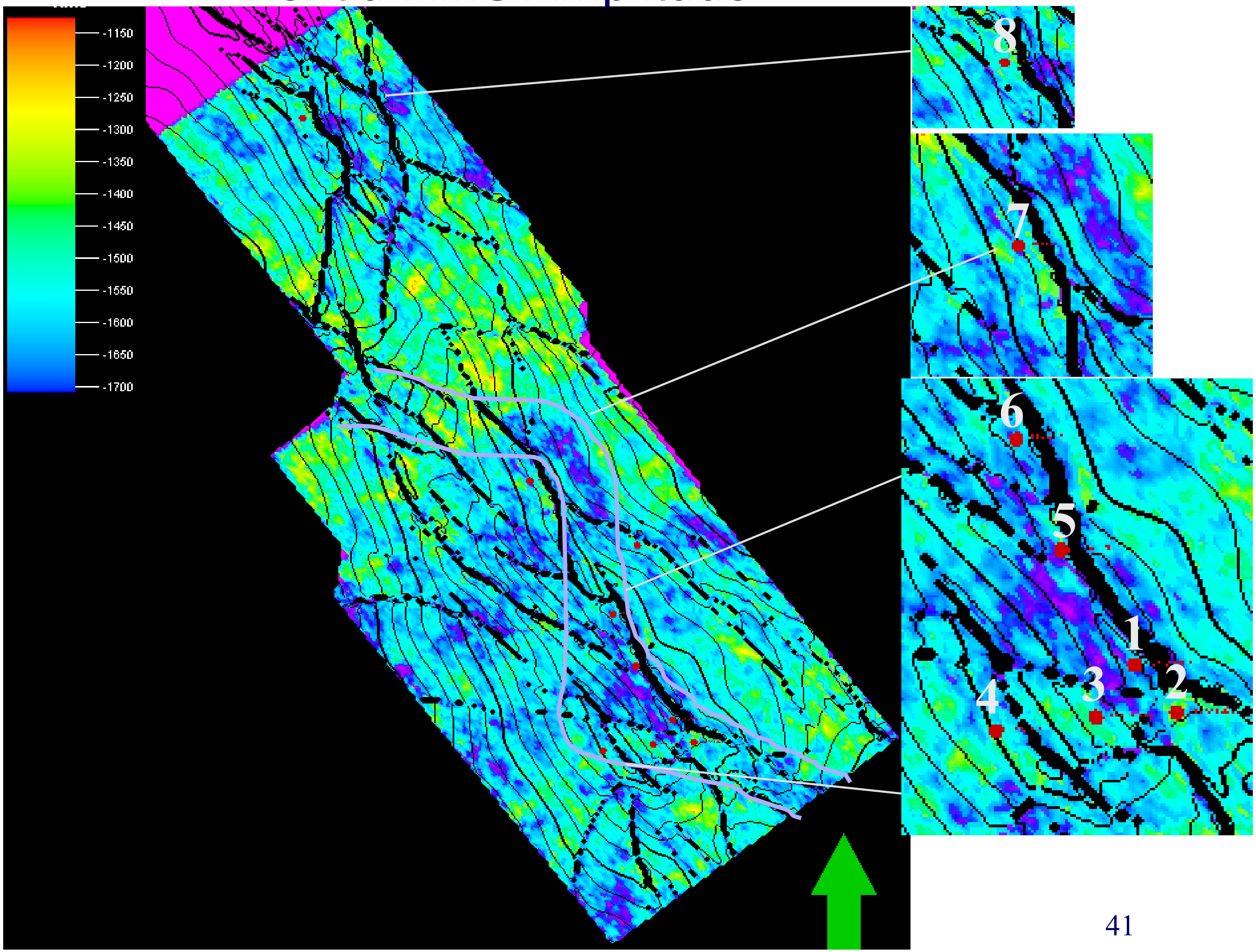
RMS (root mean square) amplitude

A post-stack attribute that computes the square root of the sum of squared amplitudes divided by the number of samples within the specified window used. With this, one can measure reflectivity in order to map direct hydrocarbon indicators in a zone of interest. However, RMS is sensitive to noise as it squares every value within the window.

$$x_{\mathrm{rms}} = \sqrt{\frac{1}{n}\left({x_1}^2 + {x_2}^2 + \cdots + {x_n}^2\right)}$$

Bentiu RMS Amplitude

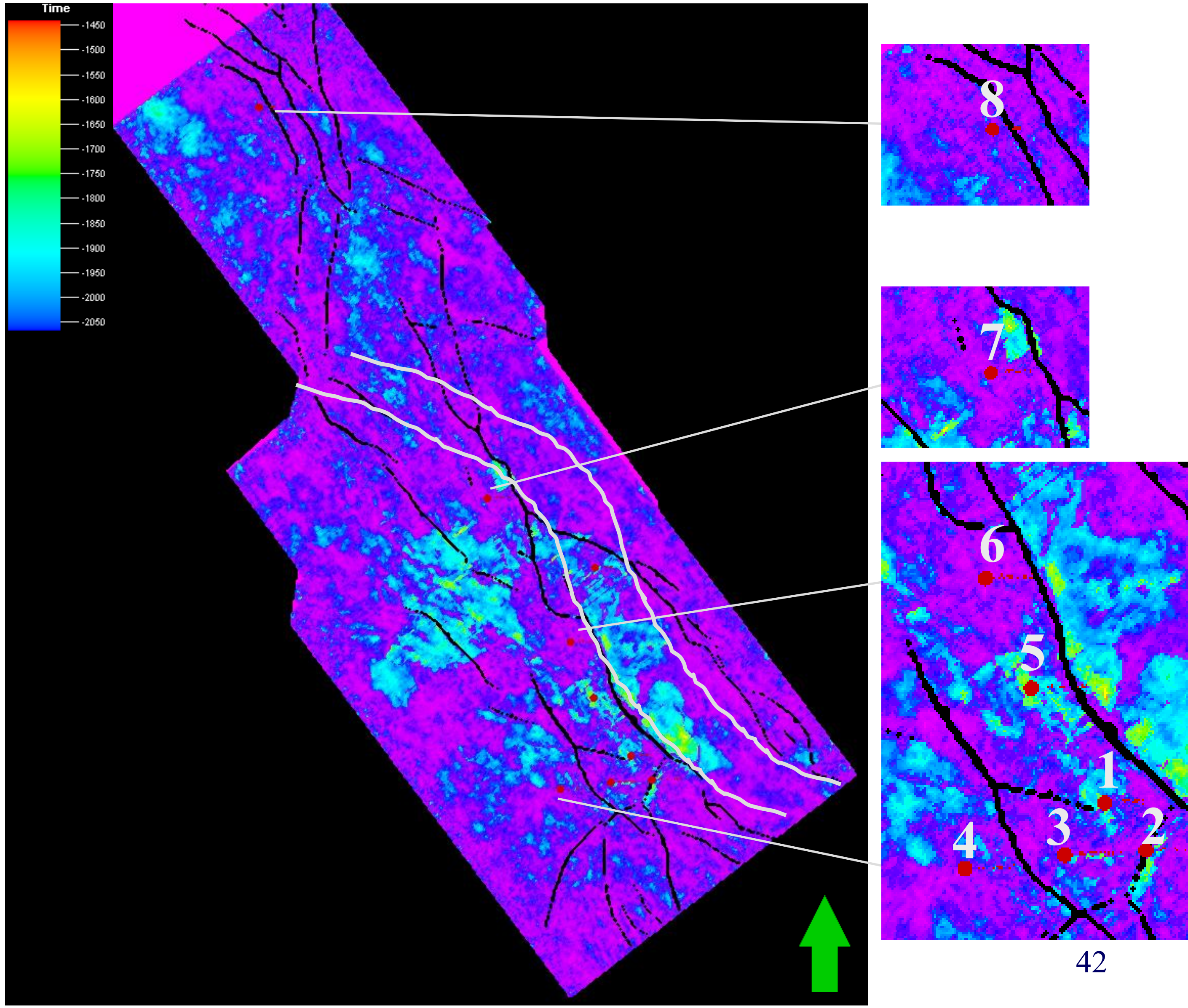
Well result
1. Oil
2. Oil
3. Oil
4. Oil
5. Oil
6. Oil
7. Water
8. Oil



Intra Bentiu RMS Amplitude

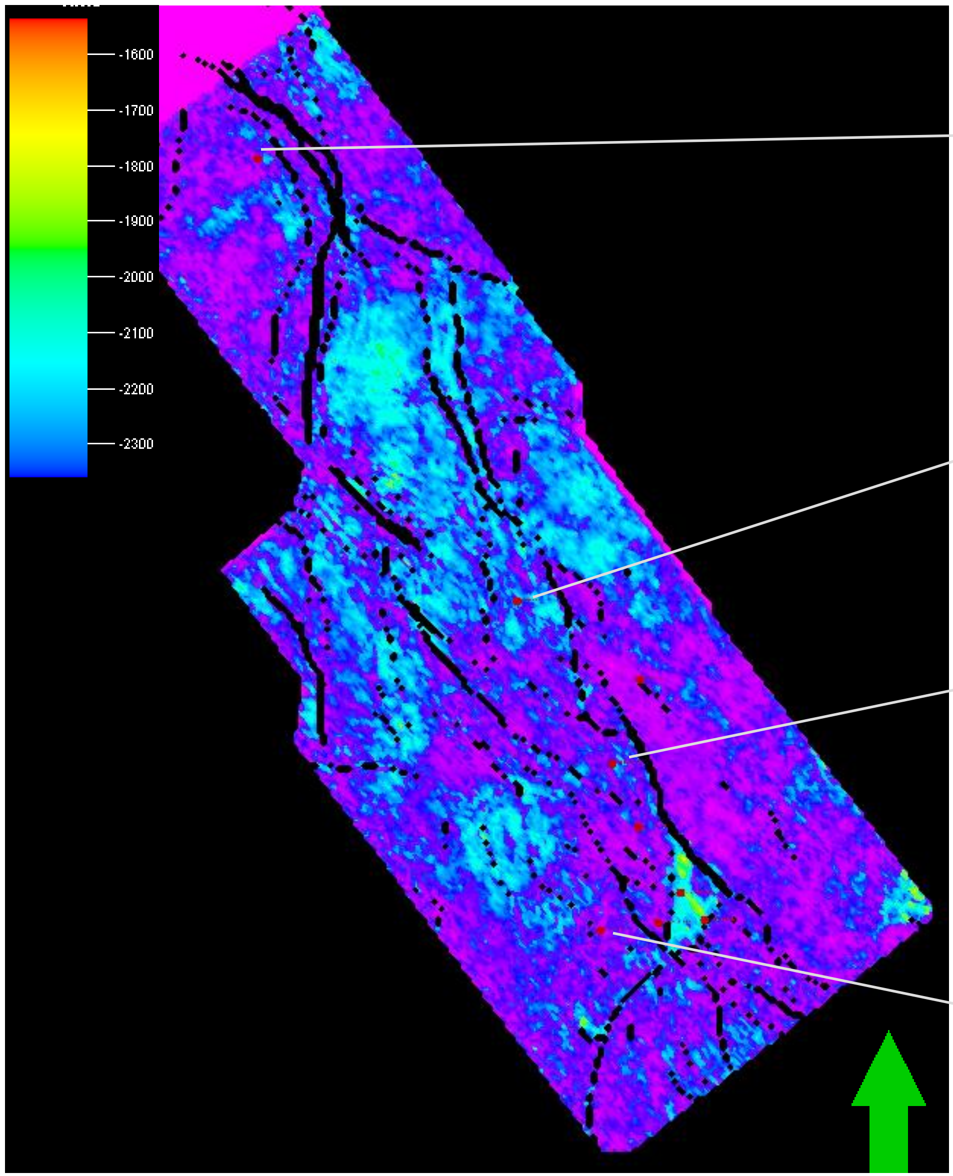
Well result:

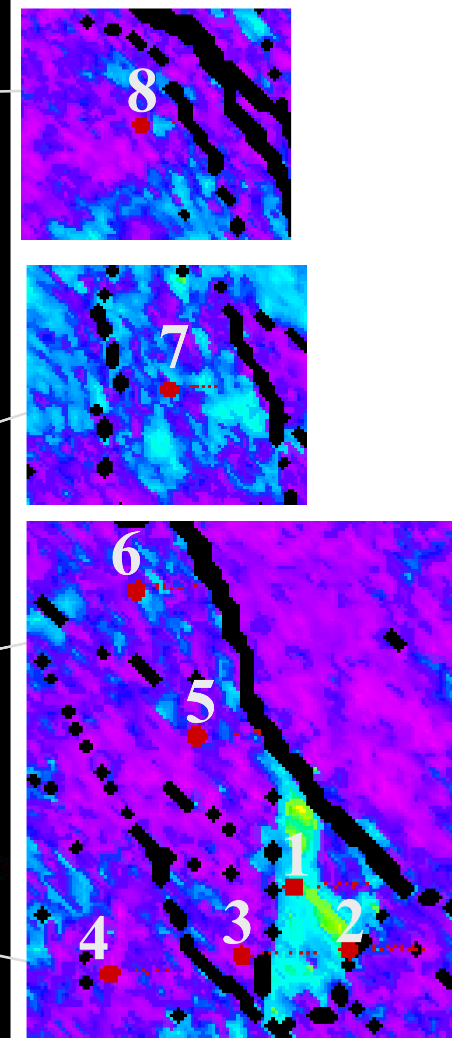
1. Water
2. Water
3. Water
4. NP.
5. Water
6. Water
7. Water
8. NP.



Abu Gabra RMS Amplitude

Well result:
1. Water
2. Water
3. Water
4. NP.
5. Water
6. Poor Oil
7. Oil
8. NP.





1,2&3 high RMS (Volcanic)

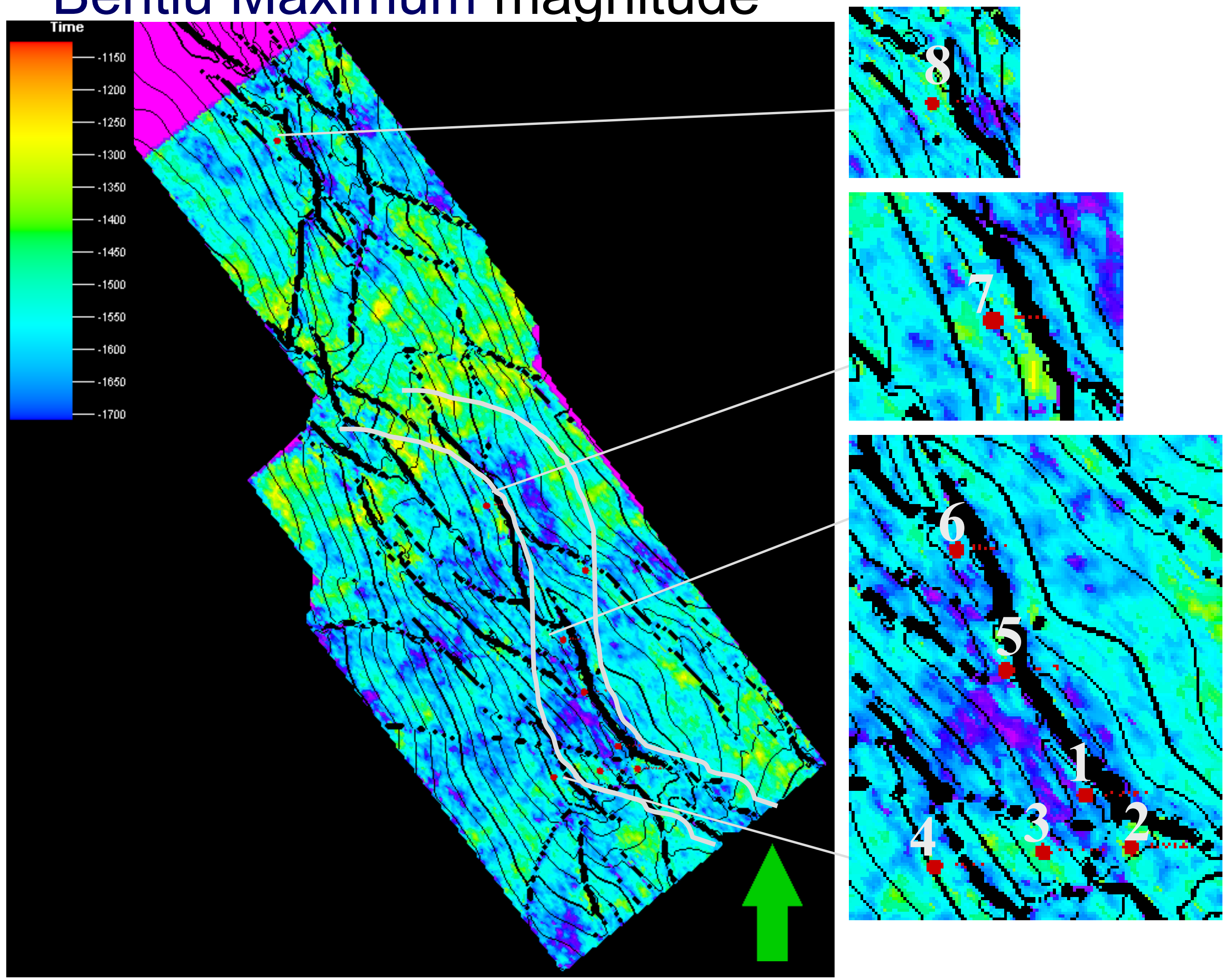
Maximum magnitude

A post-stack attribute that computes the maximum value of the absolute value of the amplitudes within a window. This can be used to map the strongest direct hydrocarbon indicator within a zone of interest.

Bentiu Maximum magnitude

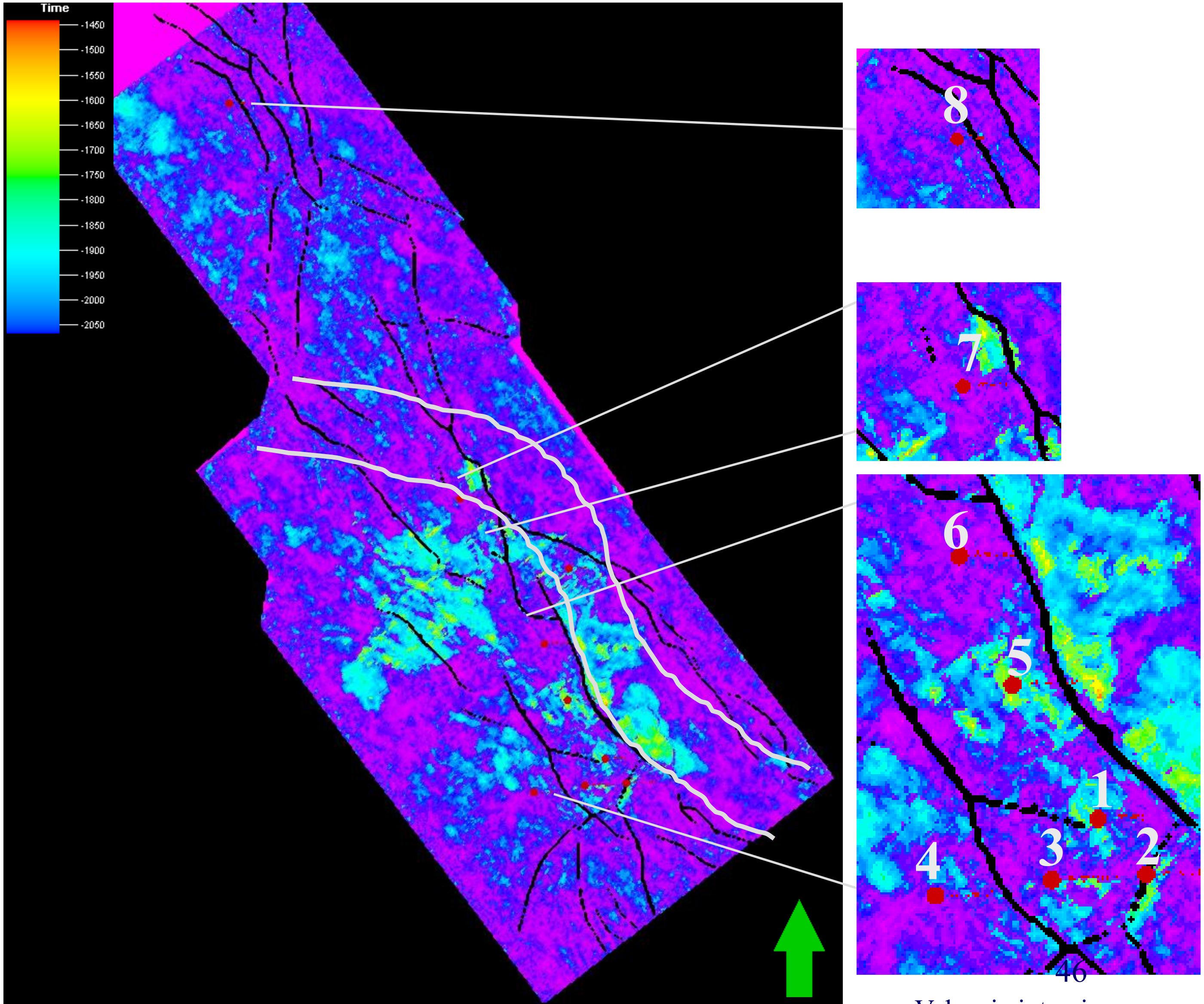
Well result:

1. Oil
2. Oil
3. Oil
4. Oil
5. Oil
6. Oil
7. Water
8. Oil



Intra Bentiu Maximum magnitude

Well result:
1. Water
2. Water
3. Water
4. NP.
5. Water
6. Water
7. Water
8. NP.

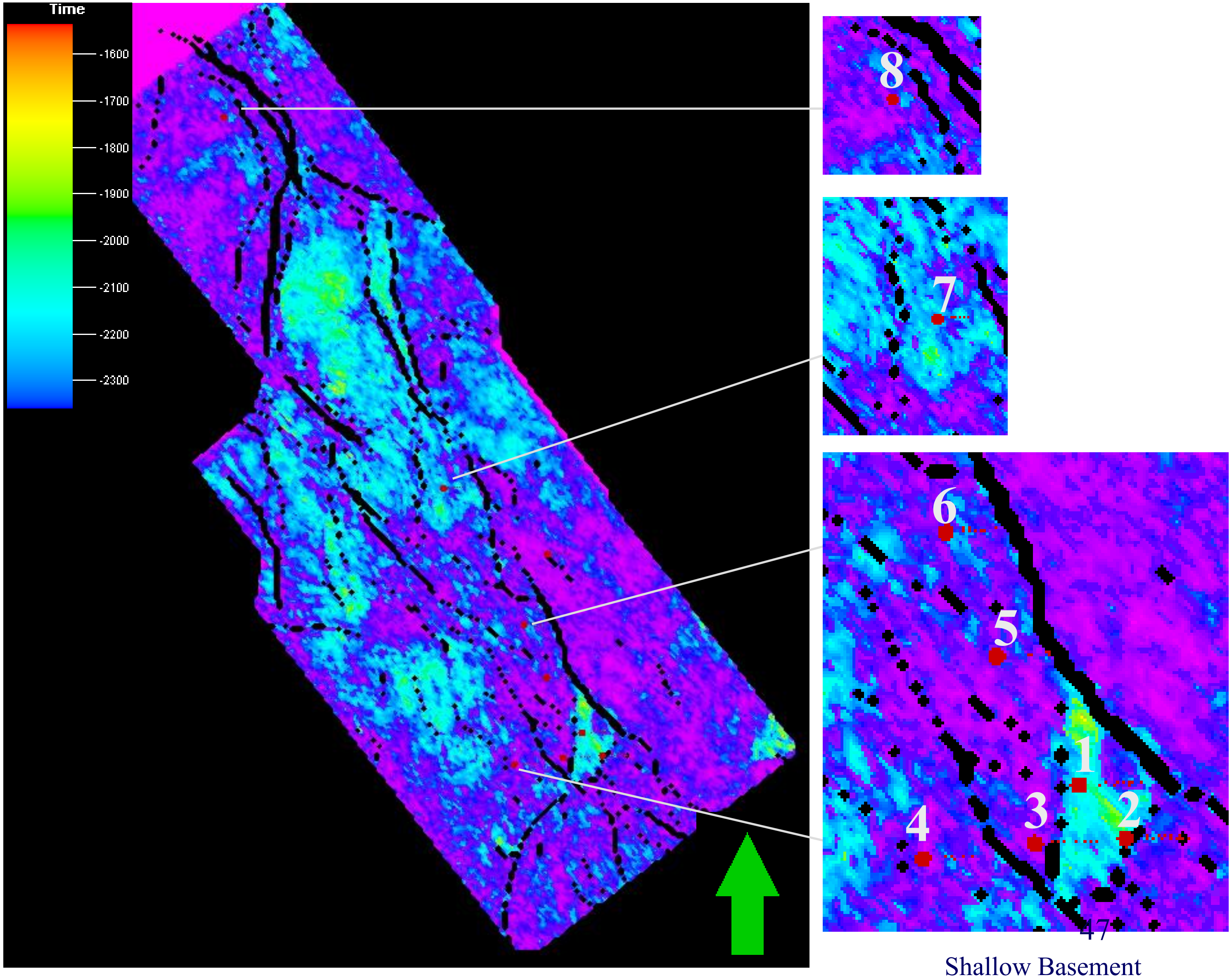


Volcanic intrusions

Abu Gabra Maximum magnitude

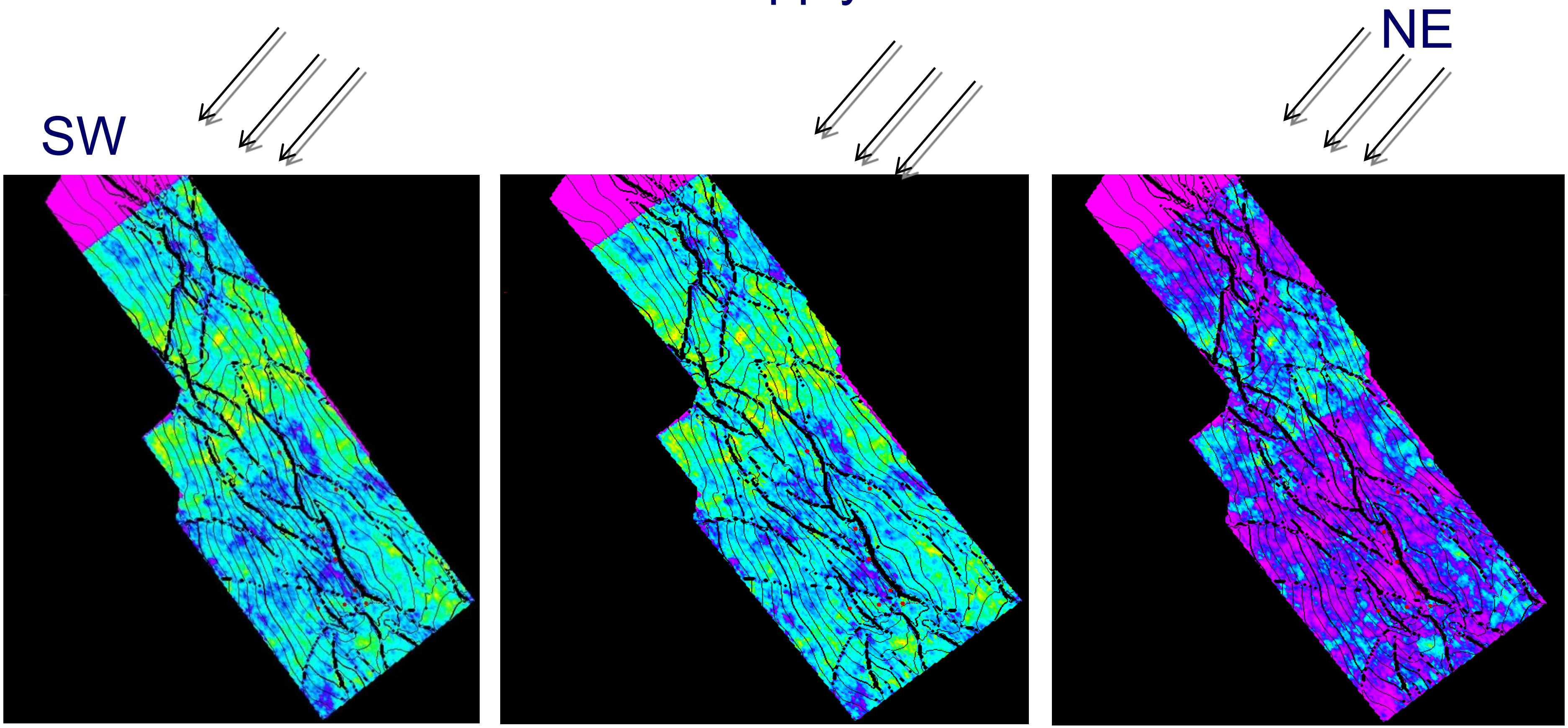
Well result:

1. Water
2. Water
3. Water
4. NP.
5. Water
6. Poor Oil
7. Oil
8. NP.



Shallow Basement

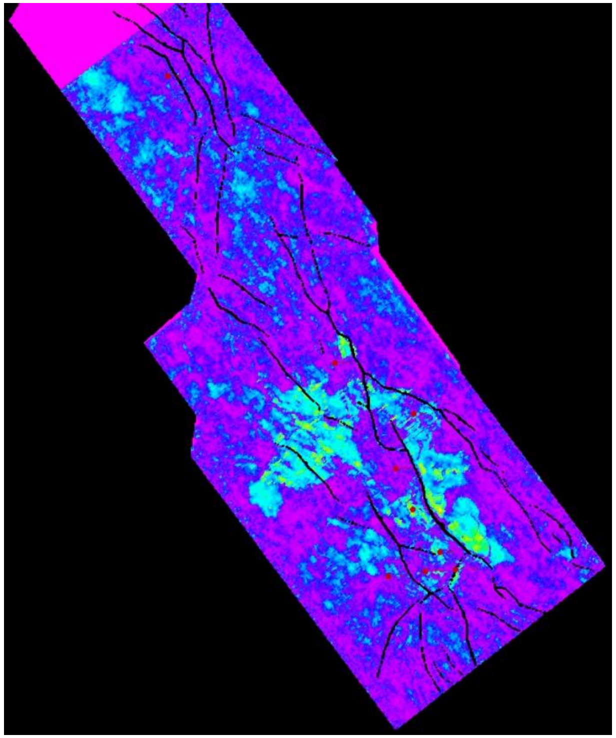
Sediment Supply Direction



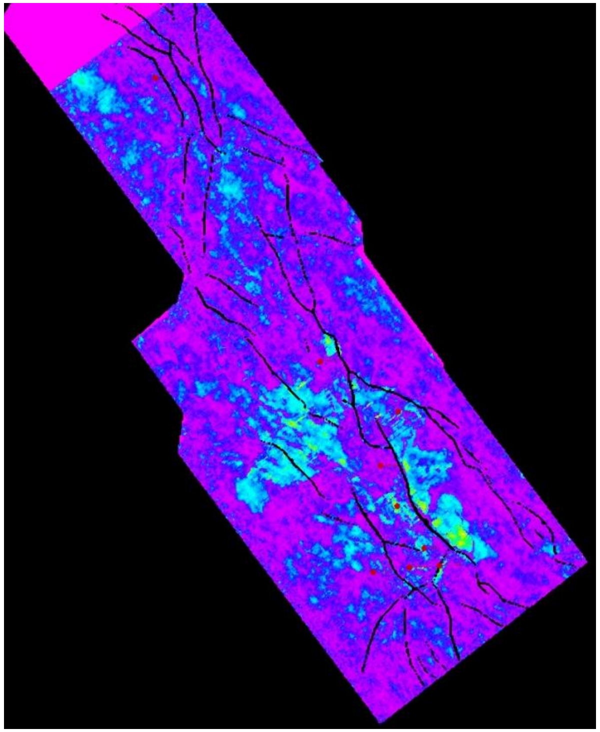
Max Magnitude RMS Average Energy

Bentiu Reservoir Formation

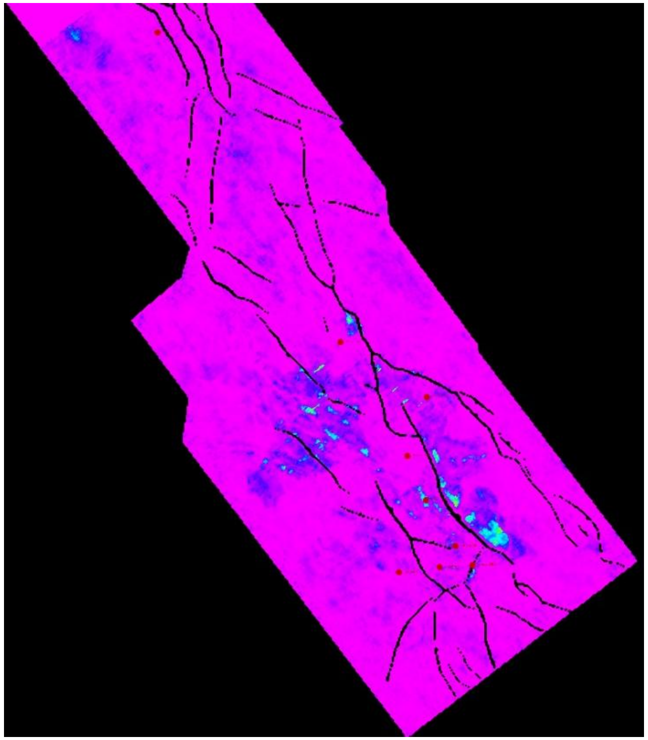
Intra Bentiu different attributes



Max Magnitude



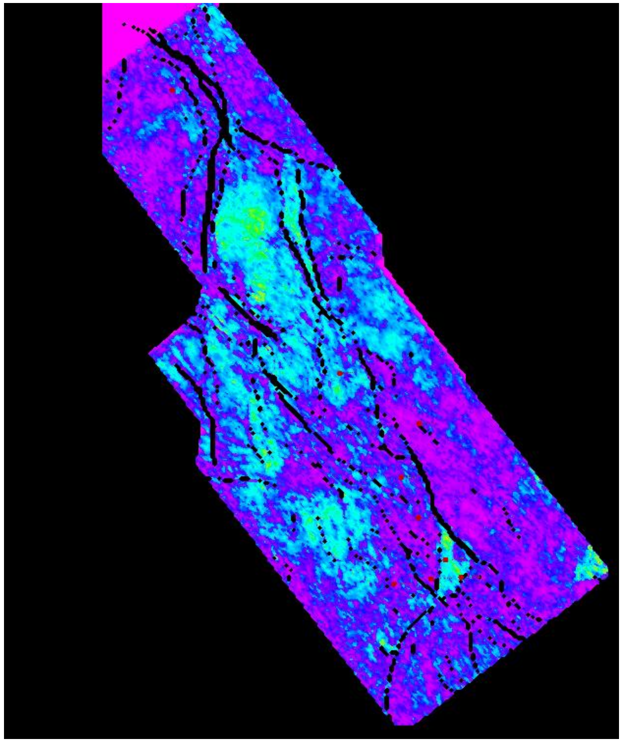
RMS



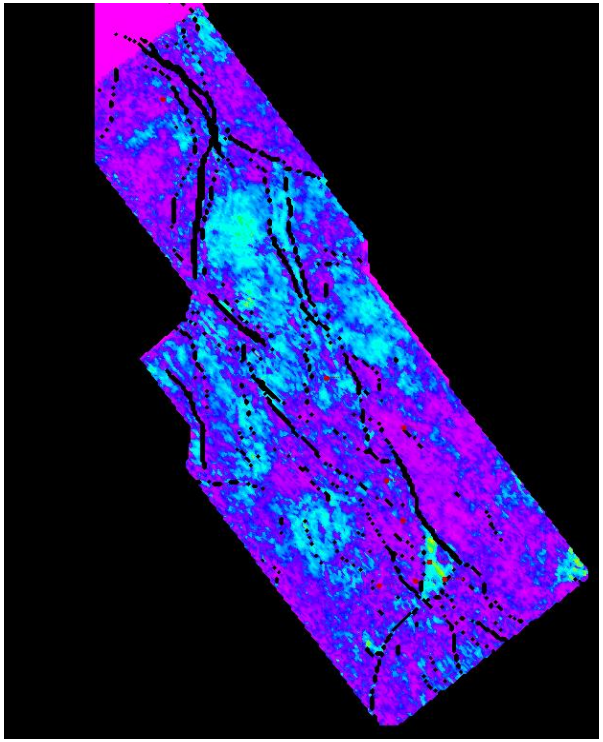
Average Energy

Abu Gabra different attributes

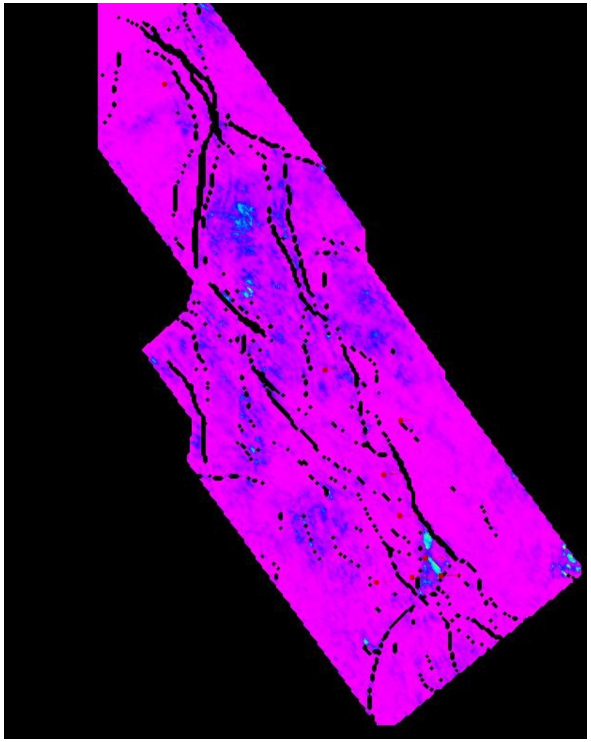
Stratigraphic Traps – Pinch-out structure



Max Magnitude



RMS



Average Energy

Structural Conclusions

Based on this study, it can be concluded that:

- The area has sets of NNW-SSE fault pattern, the older faults were developed in Late Cretaceous time, followed by EW faulting which were active in Mid to Early Cretaceous time.
- Most of the older faults face towards NE and the younger faults face towards NW.
- The expected sediment supply was from NE direction, based on features of the Abu Gabra.

Stratigraphic Conclusions

- From seismic cross-section of the field, the Bentiu thickens towards the north west and thins towards the southeast; the former is expected direction of the sediment supply to the basin.

- At Abu Gabra (source) level, the interpretation identifies some potential structural and stratigraphic traps (pinch-out structure); it is possible that the Abu Gabra may be a target for "unconventional" exploration.

Thank You