Integrated Study on Wara Prospectivity in Khashman Area, Kuwait*

Arun Kanti Dey[1], Bhaskar Chakrabarti[1], Lin Ye[1], Meshal Al-Wadi[1], Hanan Abu-Hebiel[1], and Jalal Mohamad Dashti[1]

Search and Discovery Article #50606 (2012)**
Posted May 28, 2012

*Adapted from oral presentation at GEO-2012, 10th Middle East Geosciences Conference and Exhibition, Manama, Bahrain, March 4-7 March 2012

[1]Exploration, Kuwait Oil Company, Ahmadi, Kuwait (ADEY@kockw.com)

Abstract

Technological advancement along with new concept and continuous collection of geo-scientific information necessitate a fresh approach to re-assess the hydrocarbon potential of the areas where exploration started in the middle of last century but are yet to be fully explored. Khashman is such an area where exploration history dates back to the early 1960s and the presence of hydrocarbon in the Wara Formation of Middle Cretaceous age has been confirmed from exploratory drilling but the formation is yet to emerge as a prolific producer. This presentation deals with the re-evaluation of Wara prospectivity in Khashman area.

Pre-stacked time migration processed seismic data along with subsurface information obtained from eight wells drilled on the Khashman structure are the data set for this study. Sparse subsurface information and evaluation of hydrocarbons in drilled wells based on 1960s and 1980s technology are the main challenges in the present work.

A volume based seismic attribute study like Most Positive Curvature, Dip Corrected Structure etc. reveals the presence of three sets of faults viz, NW-SE, ENE-WSW and E-W. The oldest set is NW-SE along which small culminations of Khashman structure are aligned and the youngest is a strike slip E-W set. This complex fault architecture divides the area into several blocks.

The compartmentalization nature is suggested by the presence of different oil water contacts in different blocks. A picture on regional seismic facies distribution was extracted from phase studies in frequency domain at the reservoir interval. Integration of seismic facies with lithofacies interpreted from core and log studies confirms the presence of two depositional units in the Wara Formation - delta to coastal plain at the base and fluvial to estuarine at top. A facies probability map indicates thickening of deltaic deposits towards the N/NE and its gradual pinching out into coastal plain sediments towards the S/SW. Petrophysical

analysis reveals the best reservoir quality developed in fluvial sediments towards the S/SW where effective porosity ranges between 15% and 25% and water saturation between 30% and 40%.

This study has proven more drillable reserves and thus enhanced the prospectivity of the Wara Formation. It also leads to the identification of several prospects in different blocks. We demonstrate the necessity of continuous revision of partially explored areas for reassessment of hydrocarbon prospects with the help of the most current data sets, experiences, concepts and advanced technology.

Integrated Study on Wara Prospectivity in Khashman Area, Kuwait

Arun Kanti Dey
Bhaskar Chakrabarti
Lin Ye
Meshal Al-Wadi
Hanan Abu-Hebiel
Jalal Mohamad Dashti

Manama, Bahrain

March 7, 2012

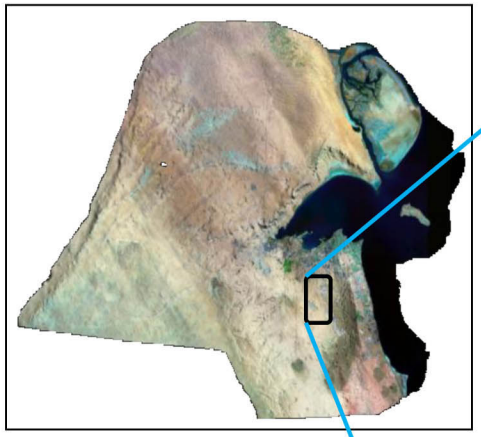
GEO 2012 Bahrain International Exhibition and Convention Centre
10th Middle East Geosciences Conference and Exhibition

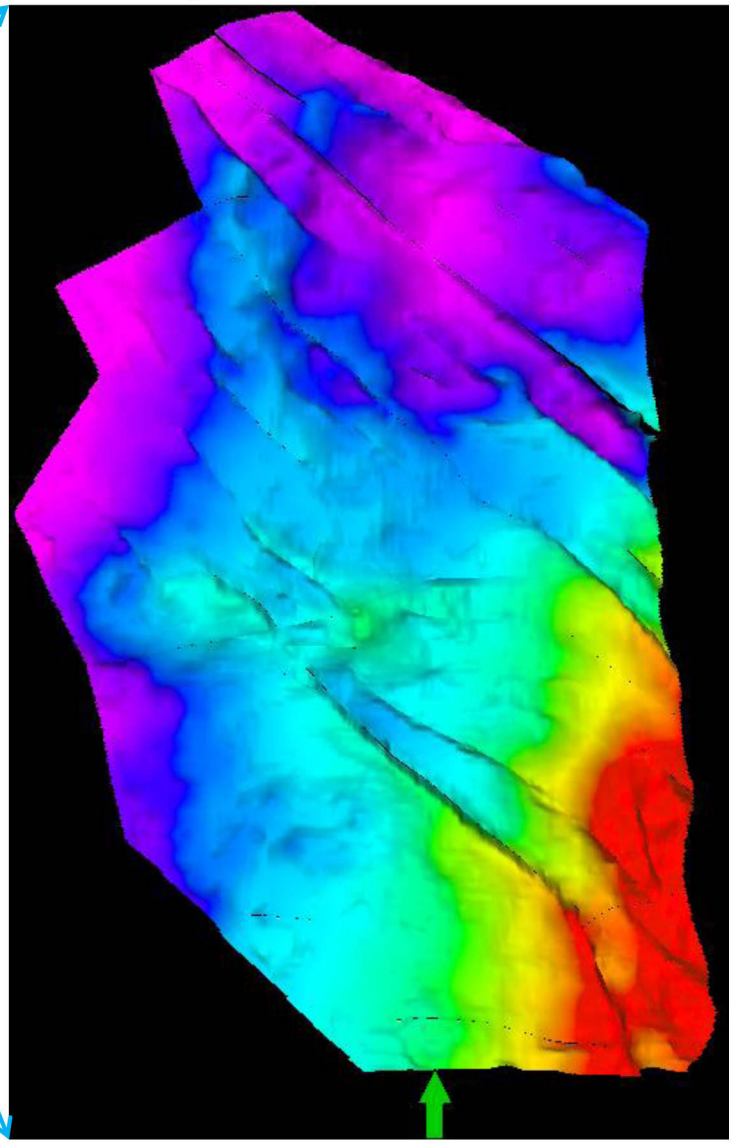
CONTENTS

- Introduction
  - Study Area
  - Historical Perspective
  - Major Challenges
  - Data Set Used
- Fault Mapping
  - 3D Seismic Attribute – Cube
  - Horizon Based Seismic Attribute at Reservoir Level
  - Depth and Fault Segment Map – Wara Top
- Reservoir Characterization
  - Work Flow
  - Sequence Stratigraphic Framework
  - Core Study
  - Integration of Core and Log Facies
  - Stratigraphic Correlation
  - Isochore Map
  - Seismic
  - Facies Model – Upper Wara
  - Petrophysics
  - Net Map - Wara
- Conclusions
- Way Forward

INTRODUCTION

Study Area

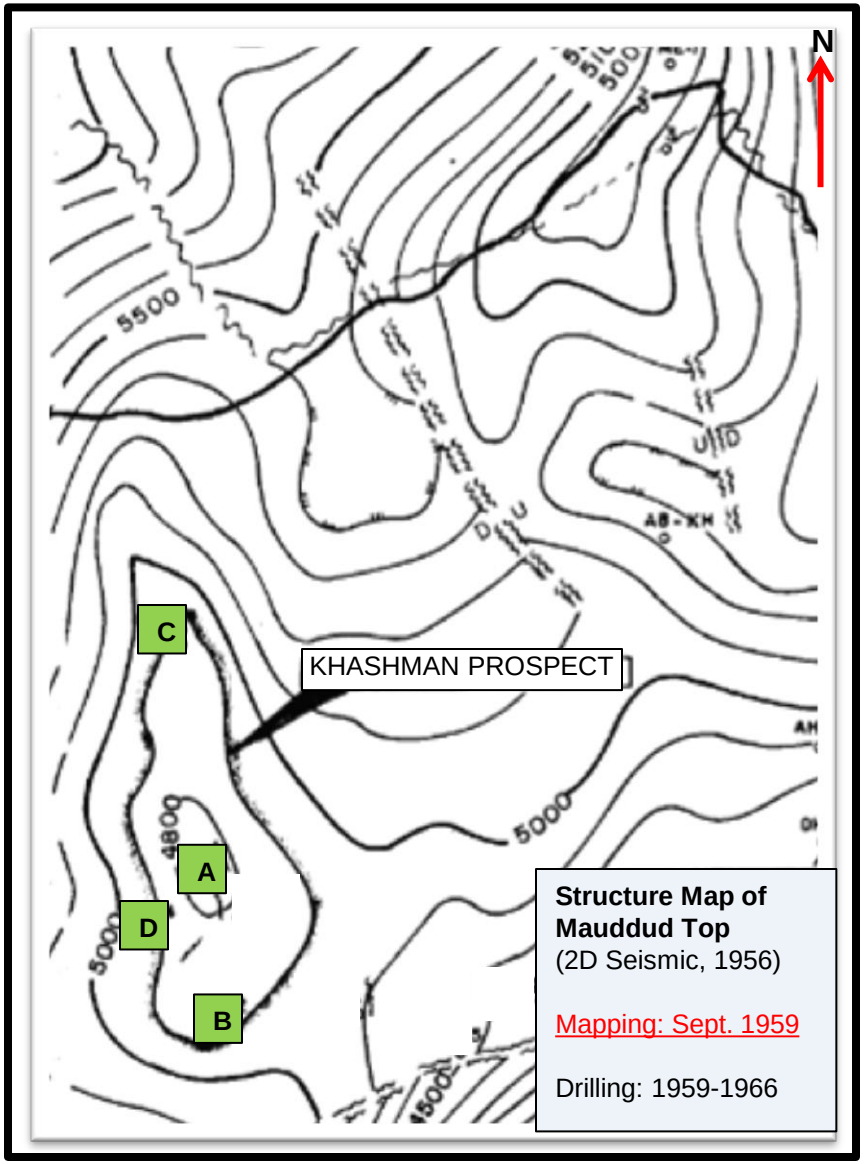


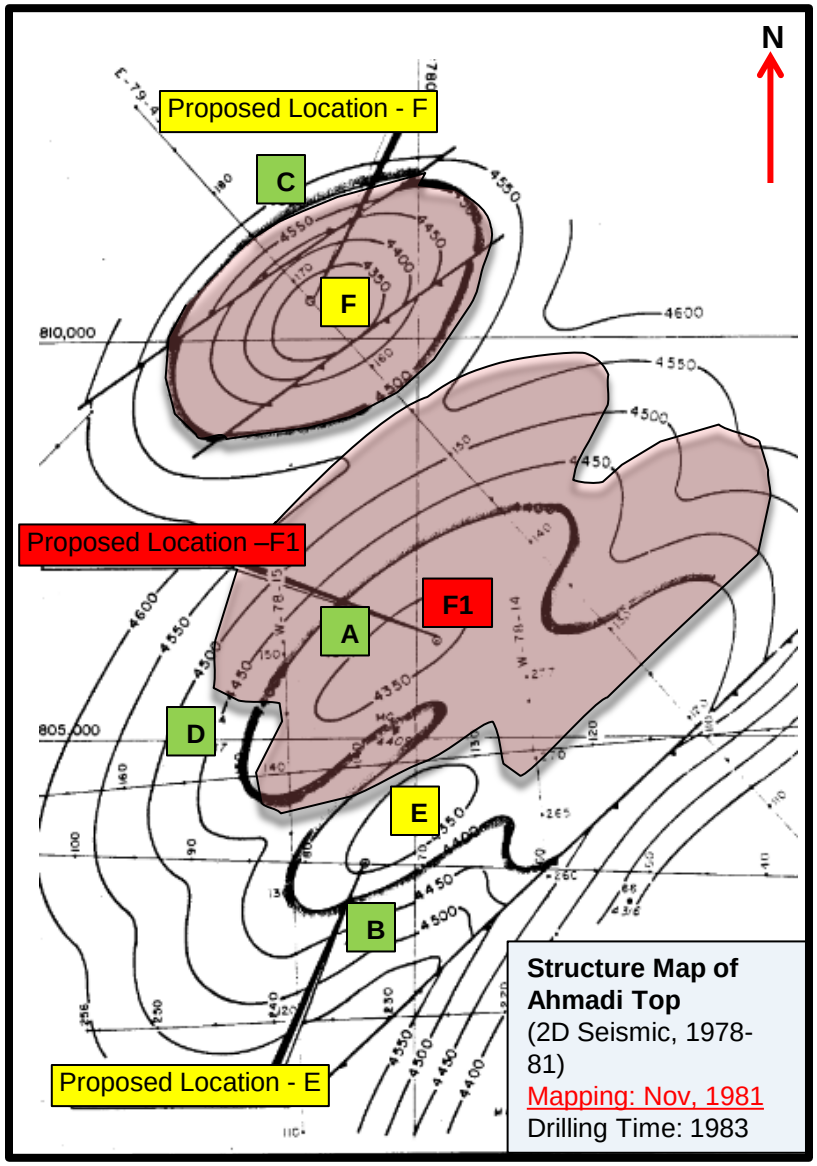


- Khashman: North-West extension of Magwa structure.
- To date 8 wells drilled as Khashman wells.
- 2 wells produced hydrocarbon on testing from Wara Formation and 1 well from underlying Burgan Formation
- 5 wells abandoned.

INTRODUCTION

Historical Perspective

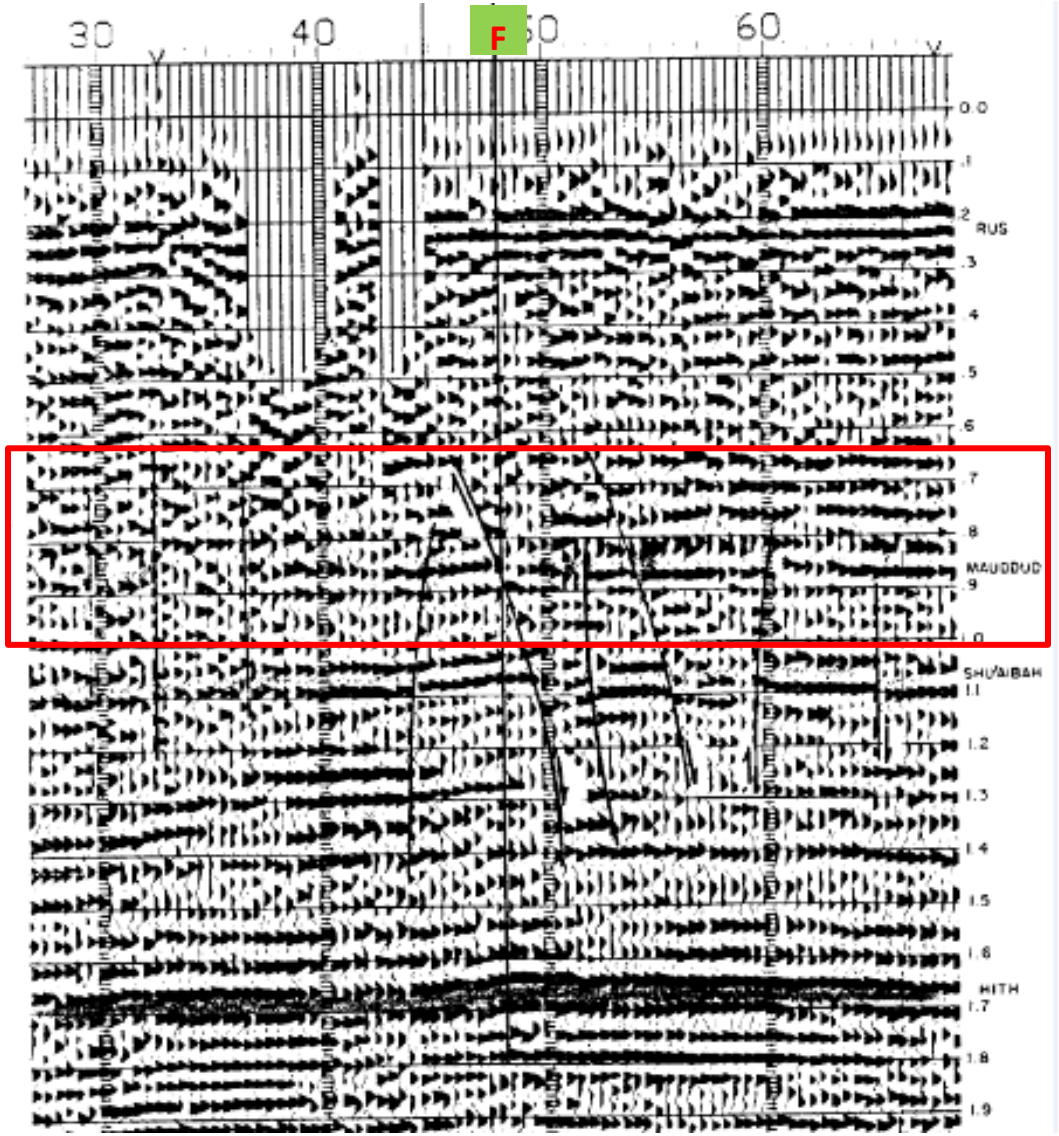




INTRODUCTION

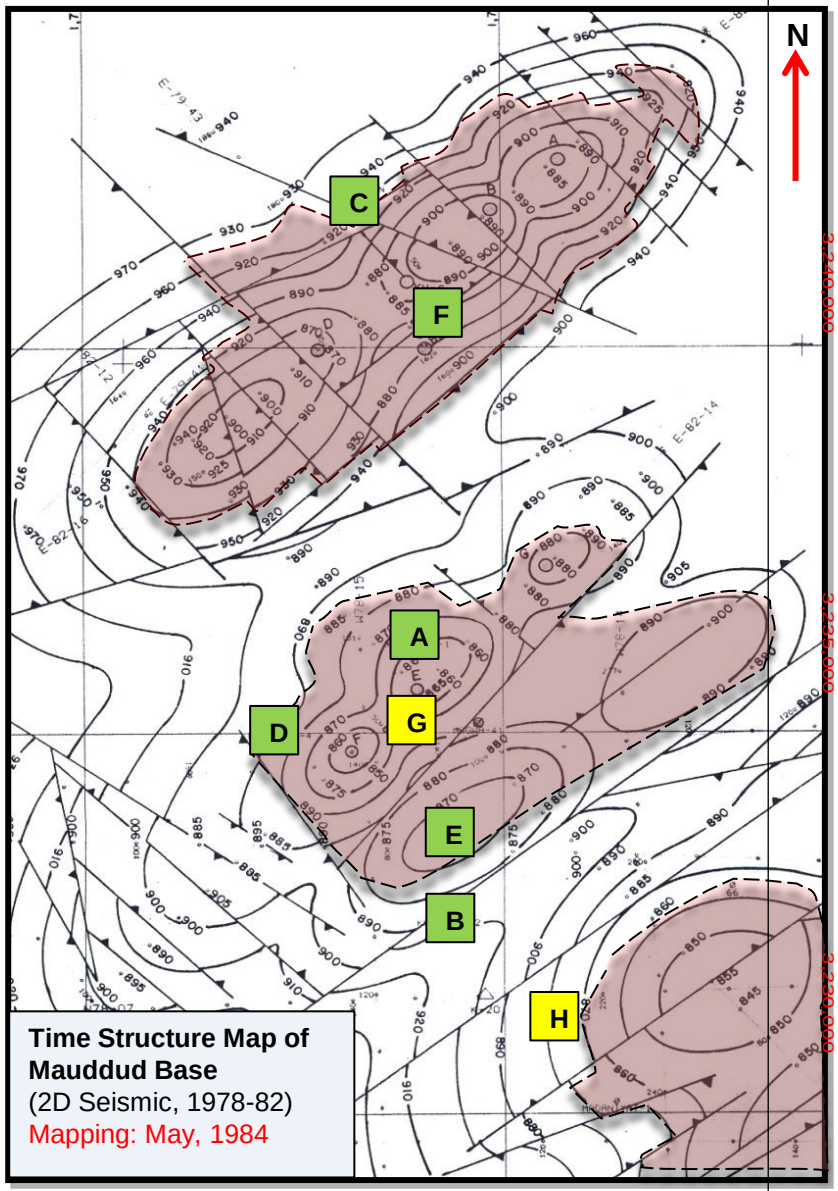
Historical Perspective

SEISMIC SECTION FOR RELEASING WELL- F

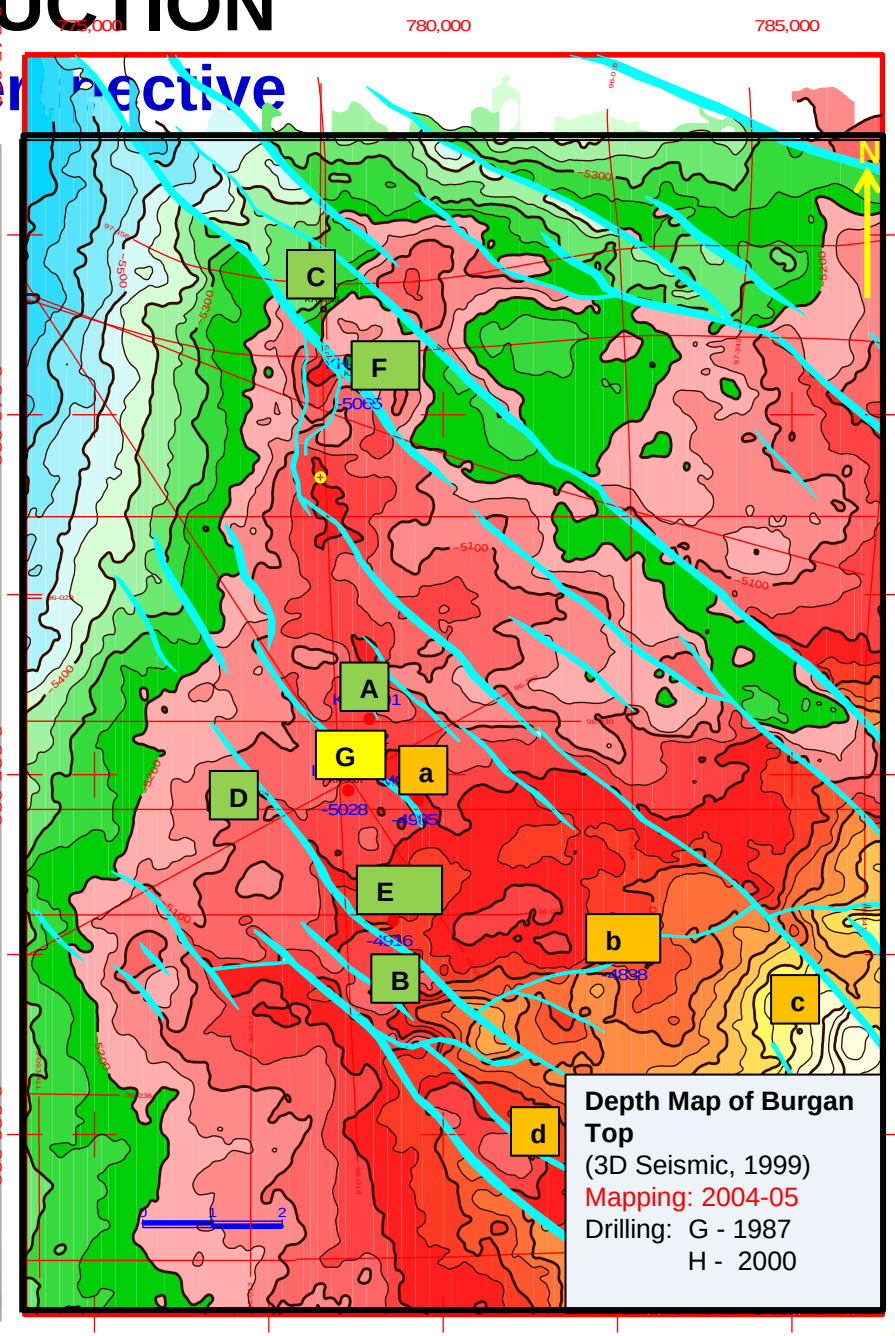


INTRODUCTION

Historical Perspective



Time Structure Map of Mauddud Base
(2D Seismic, 1978-82)
Mapping: May, 1984



Depth Map of Burgan Top
(3D Seismic, 1999)
Mapping: 2004-05
Drilling: G - 1987
H - 2000

INTRODUCTION

Major Challenges

- A complex fault architecture.
- A complex litho-facies association.
- Sparse Subsurface Information
- Hydrocarbon evaluation on the basis of technologies available during early 60-80s
- Subsurface picture unable to explain:
  - ✓ Well Results
  - ✓ Different HDT level in different wells
  - ✓ Reservoir Quality

INTRODUCTION

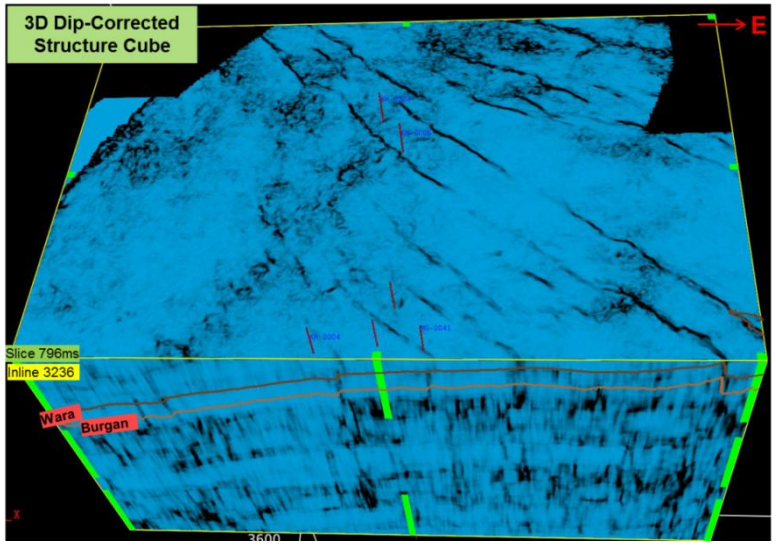
Data Set Used

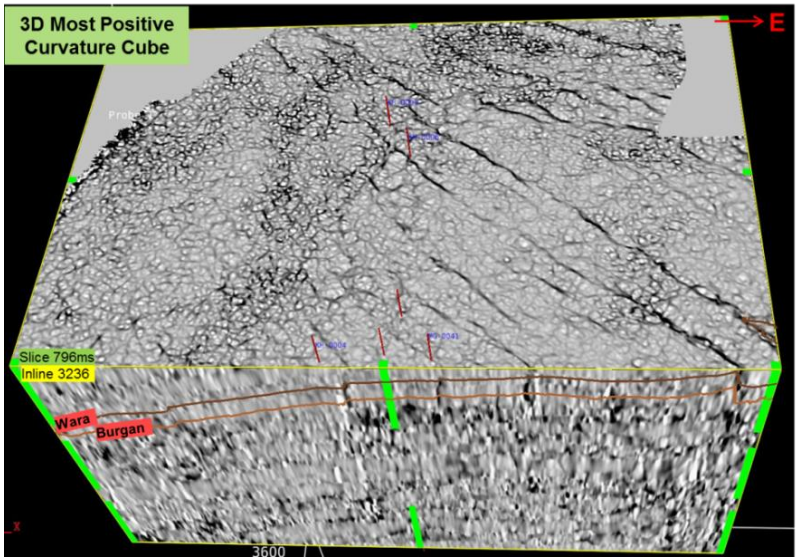
- PSTM reprocessed 3D seismic (2006) of 360 Sq. Km over Khashman area.

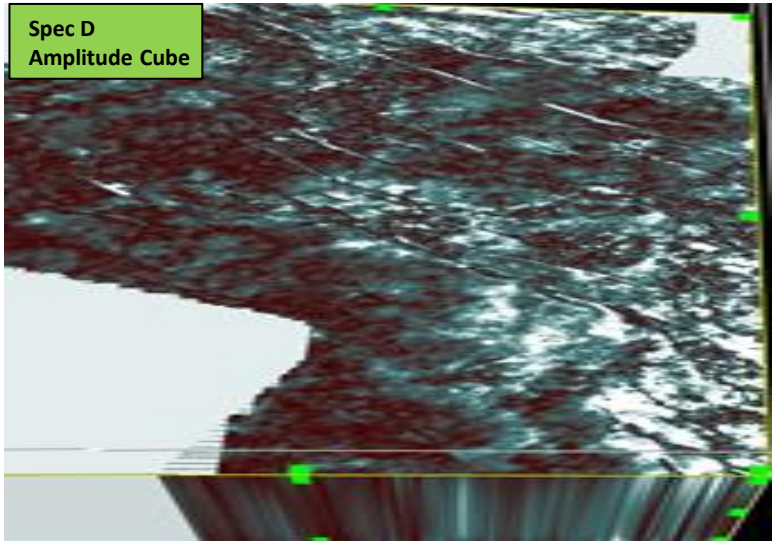
- G & G information from 17 wells drilled in Khashman – Magwa area
  - ✓ Wire line log
  - ✓ Core
  - ✓ Production testing

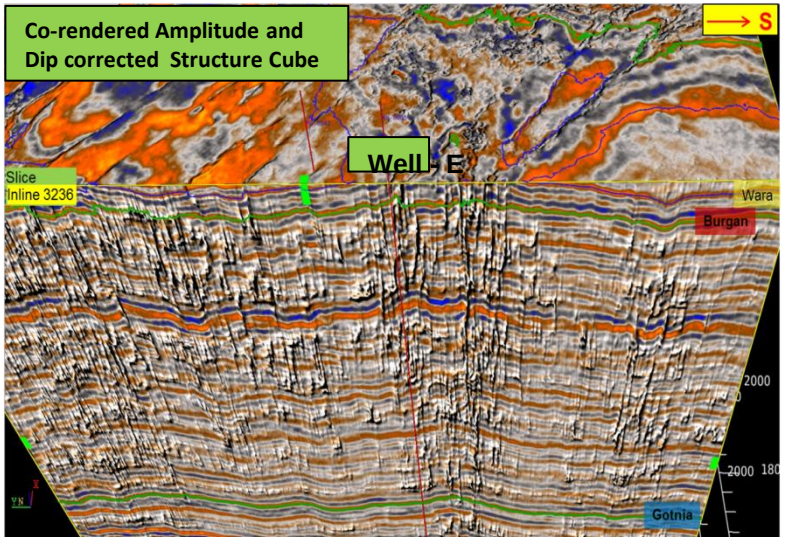
FAULT MAPPING

3D Seismic Attribute - Cube



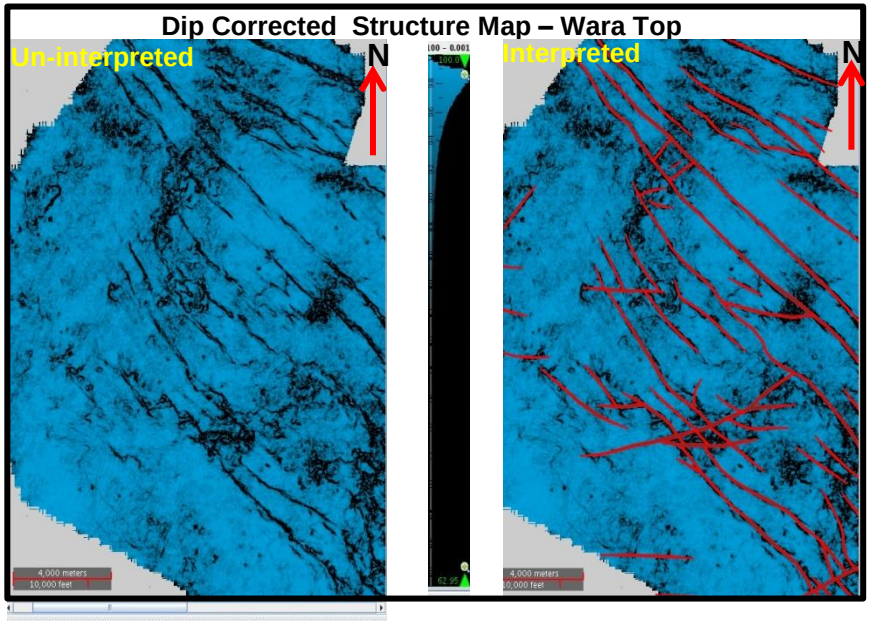


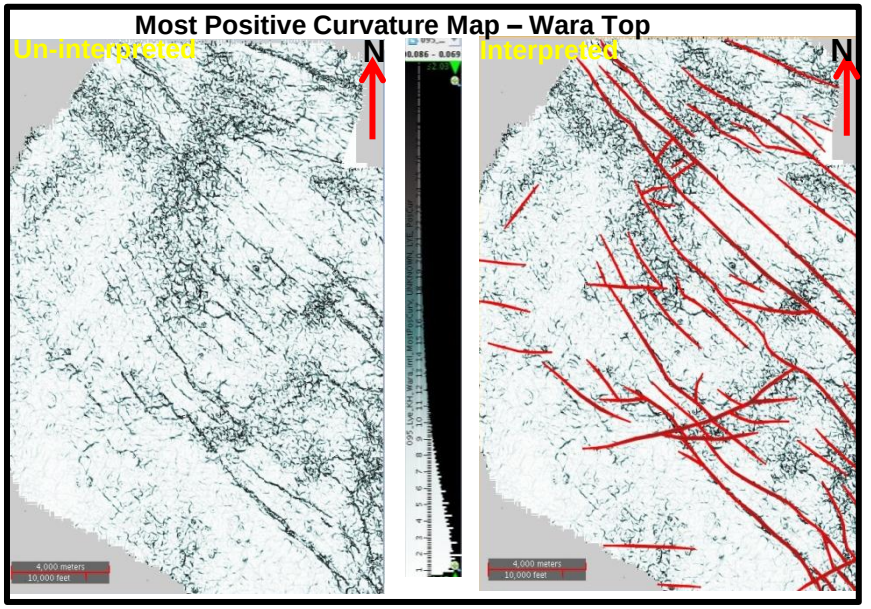


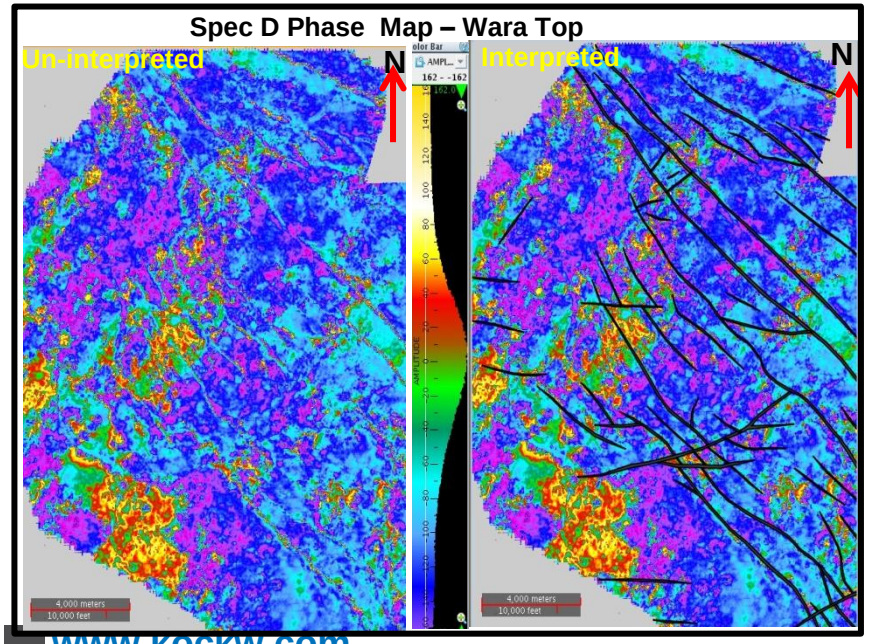


FAULT MAPPING

Horizon Based Seismic Attribute at Reservoir Level



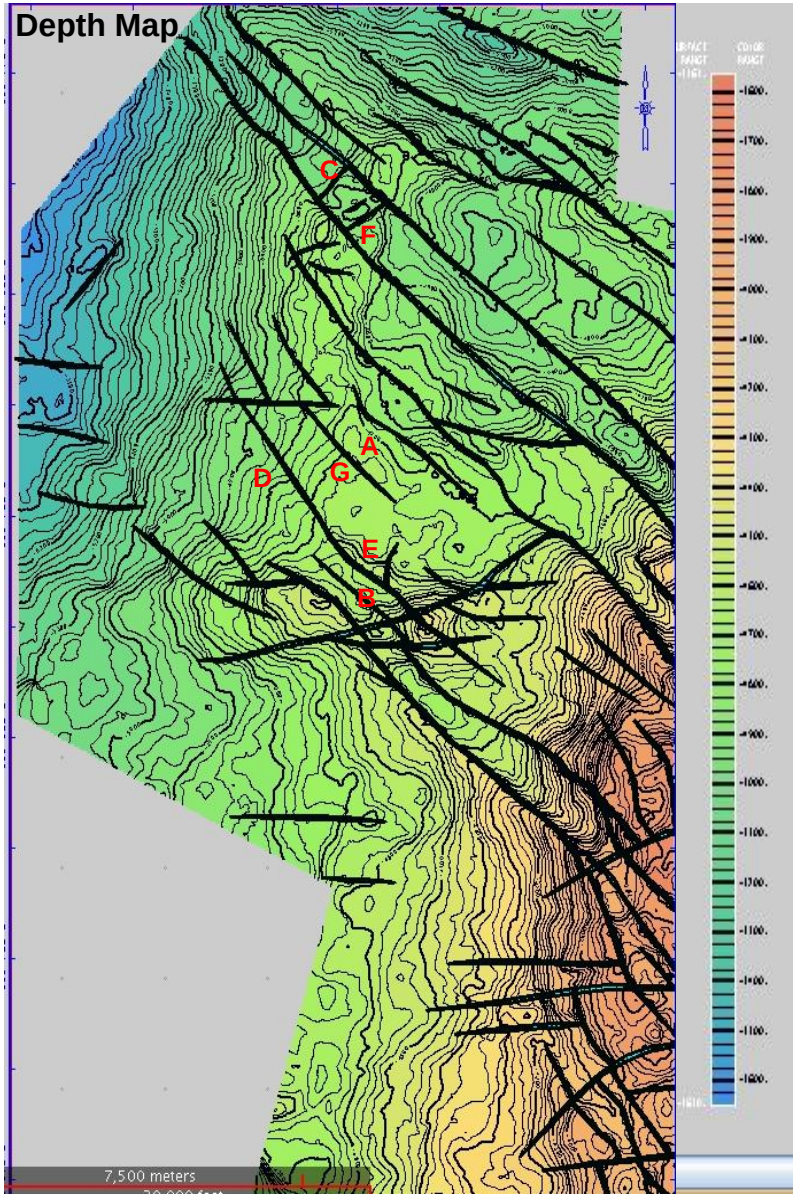


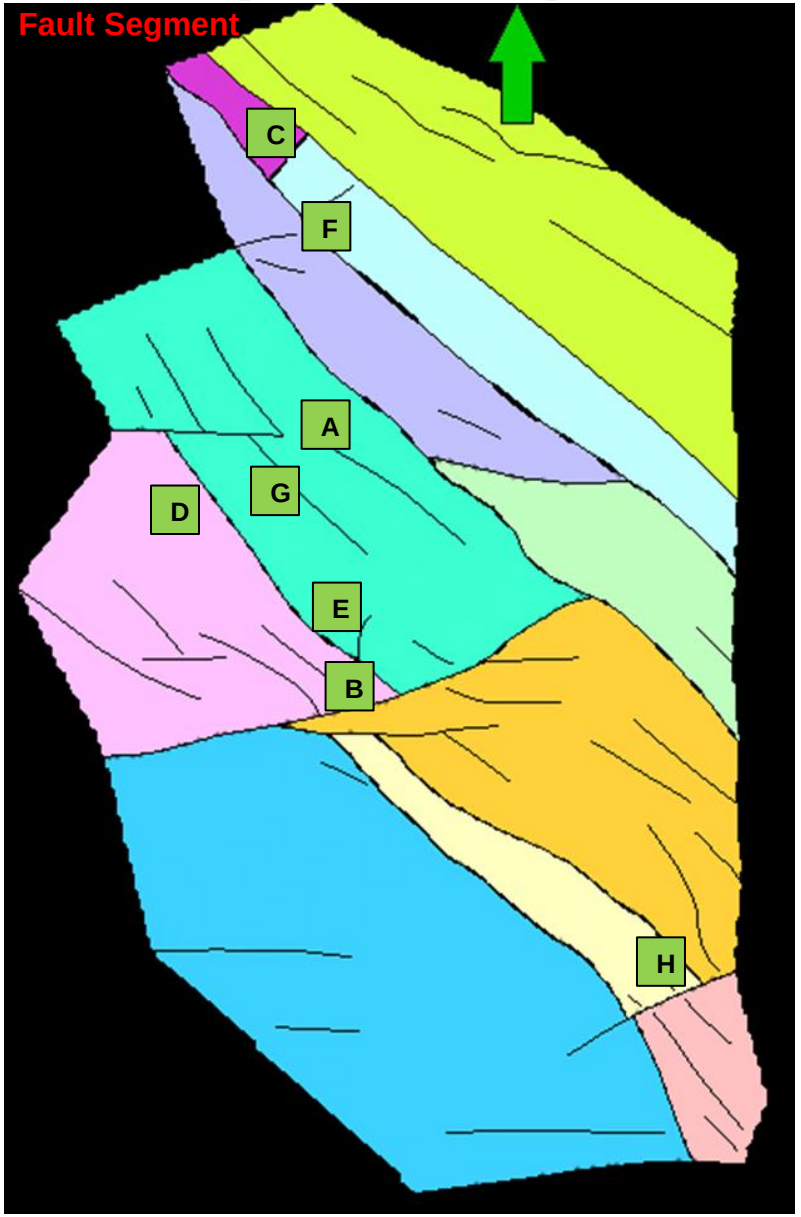


- Black color traces indicate fault / fracture traces.
- Three sets of fault W-E, NW-SE and NE-SW.
- These faults divide Khashman into different fault blocks.

FAULT MAPPING

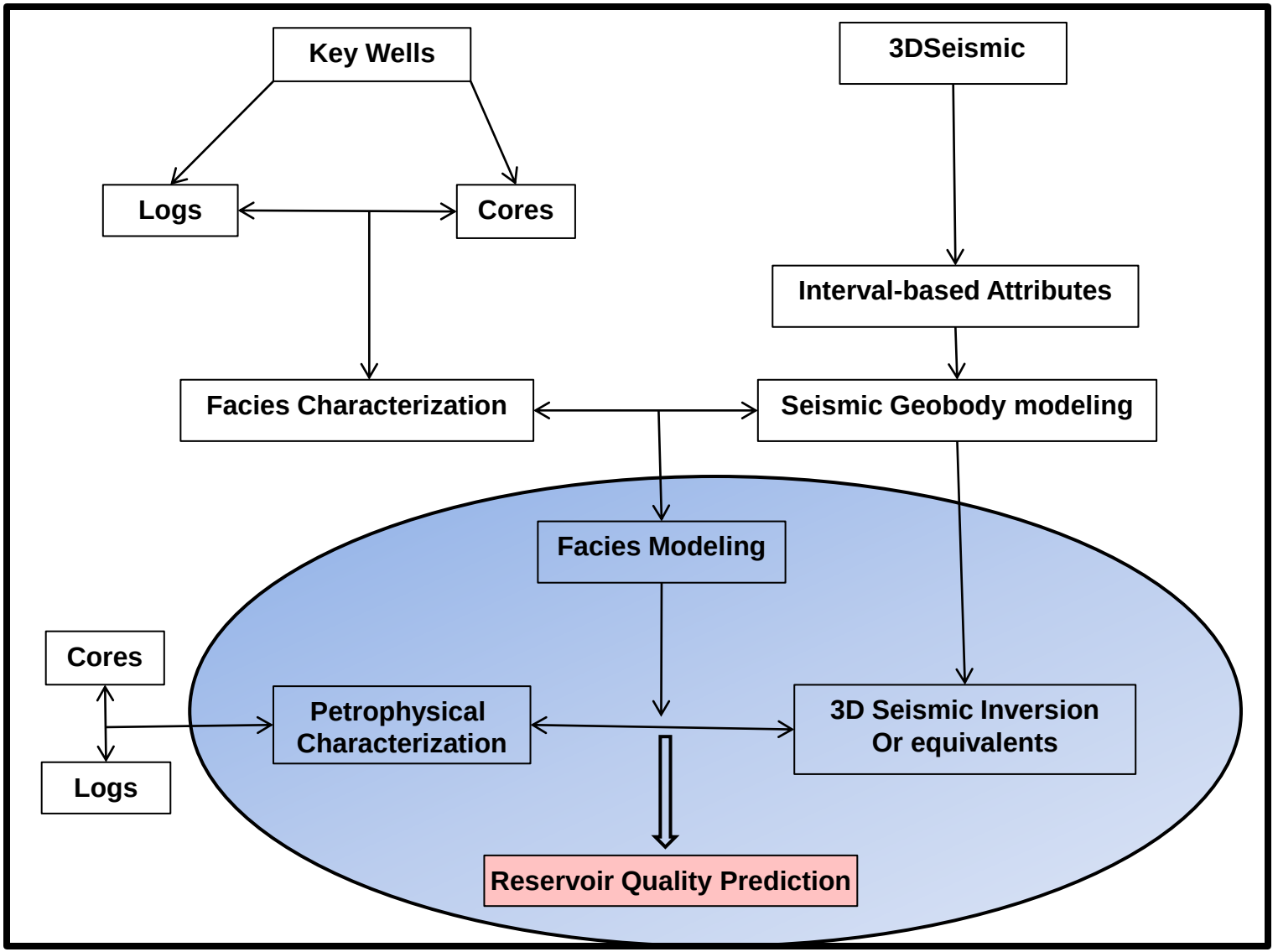
Depth and Fault Segment Map-Wara Top





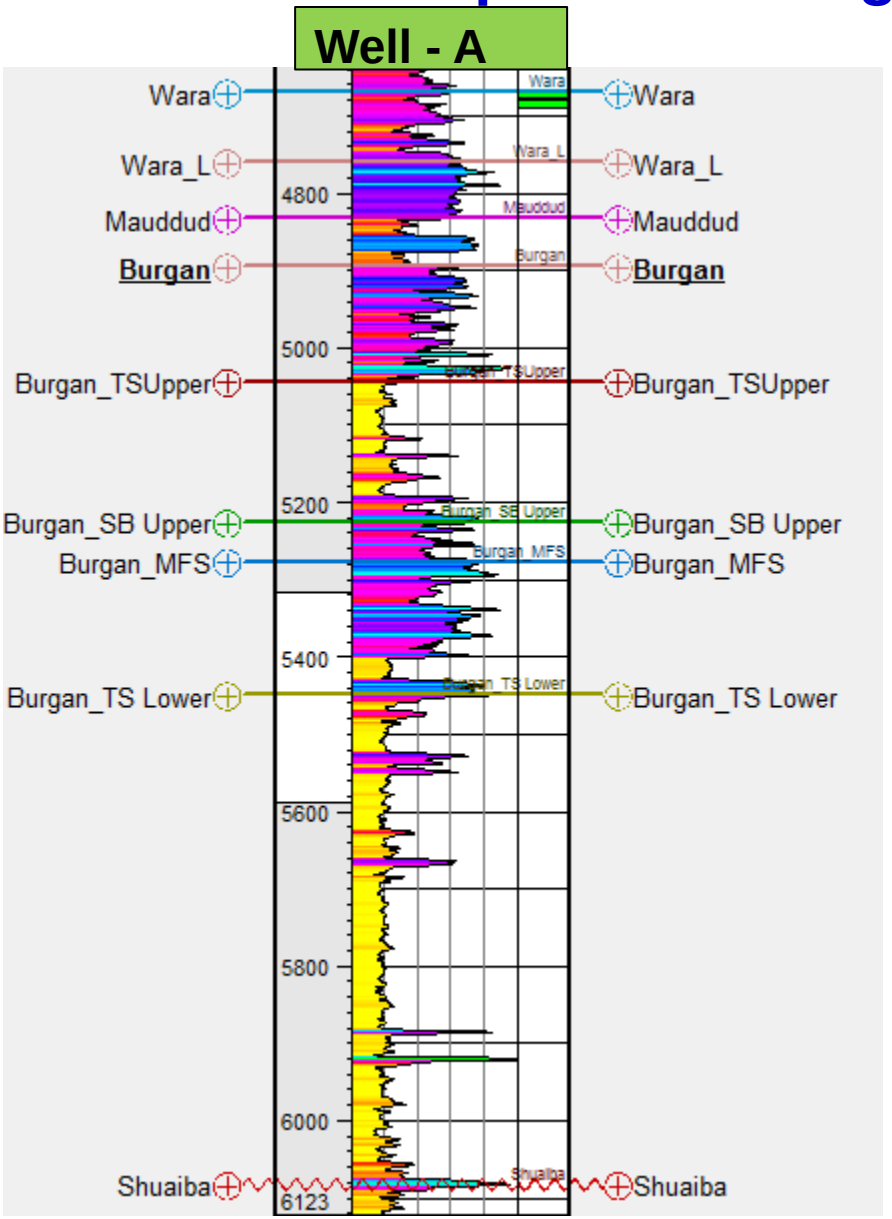
RESERVOIR CHARACTERIZATION

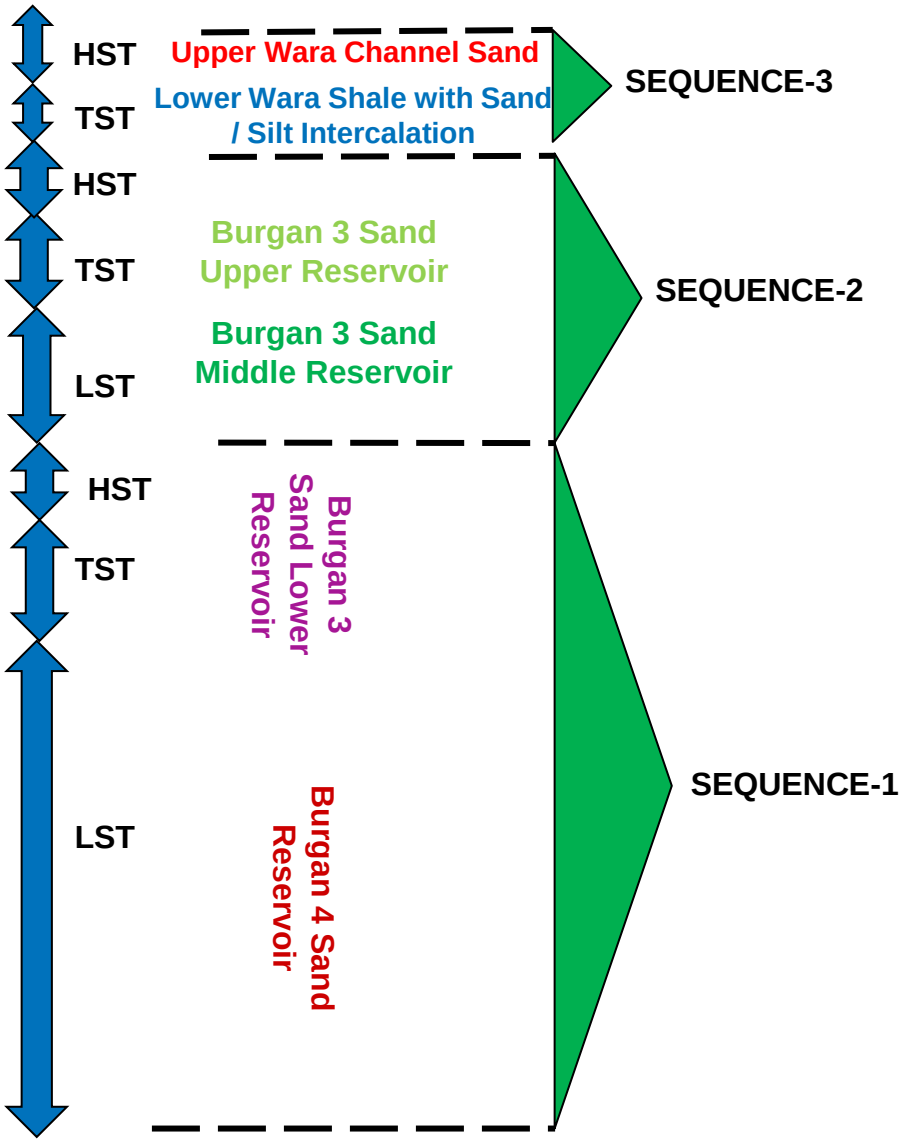
Work Flow



RESERVOIR CHARACTERIZATION

Sequence Stratigraphic Framework





RESERVOIR CHARACTERIZATION

Core Study: Upper Wara

Well - A

Deposition in distributary channel system. No evidences for large fluvial braided system deposits

RESERVOIR CHARACTERIZATION

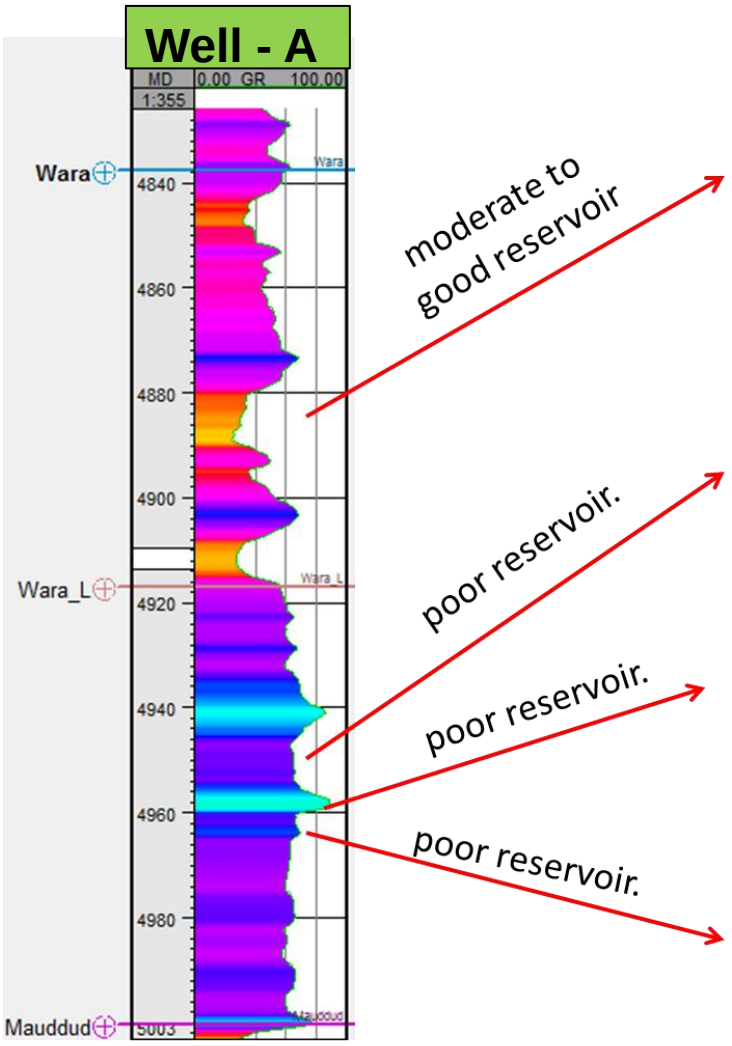
Core Study: Lower Wara

Well - A

Deposition in coastal plain with evidences for marginal to shallow marine incursion.

RESERVOIR CHARACTERIZATION

Integration of Core and Log Facies



Medium grained, light brown Sst

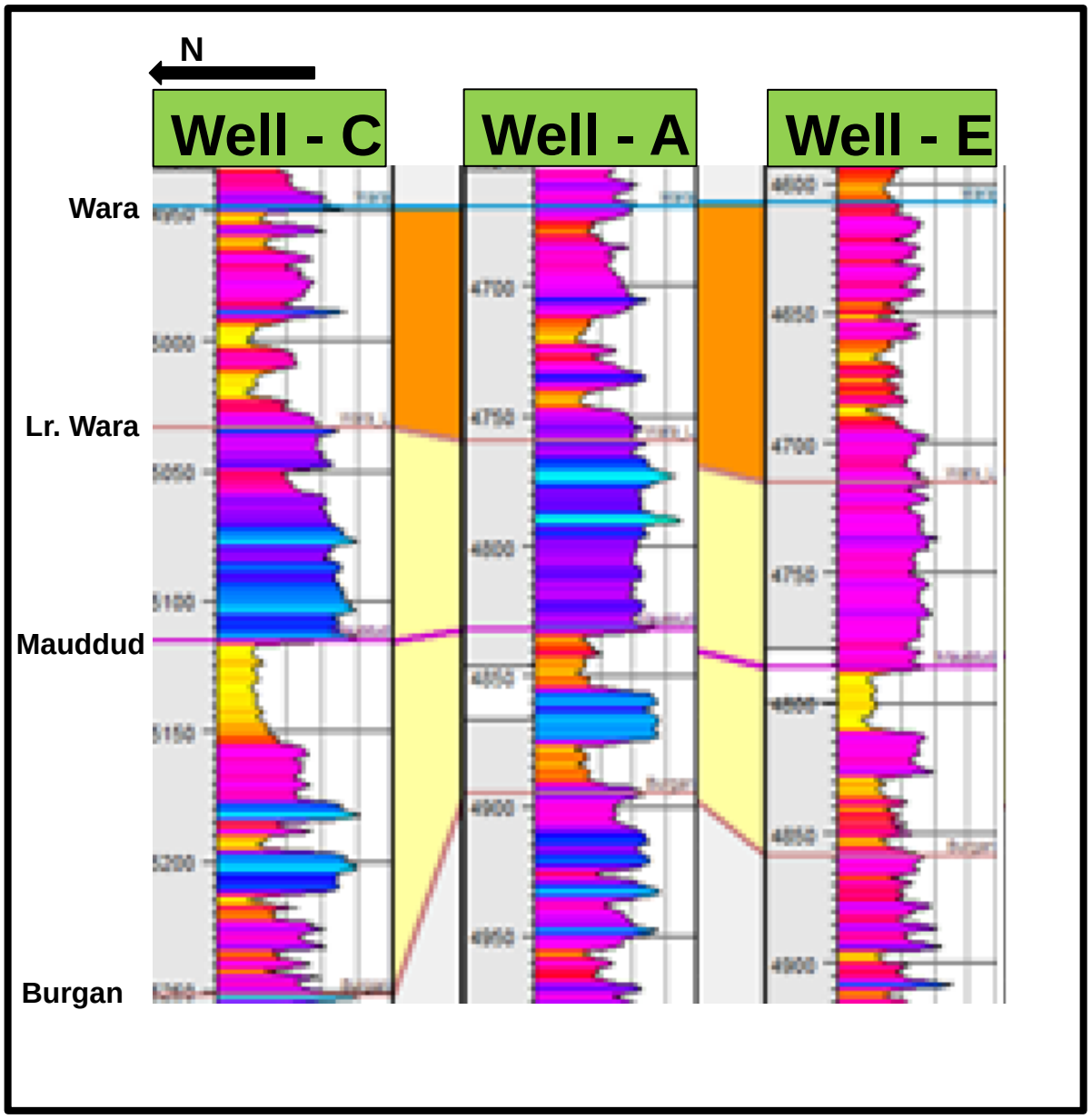
V. Fine grained, greenish grey glauconitic Sst.

Carbonaceous shale with leaf impression.

Intercalations of Shale, Siltstone with rare v. fine grained Sst laminae.

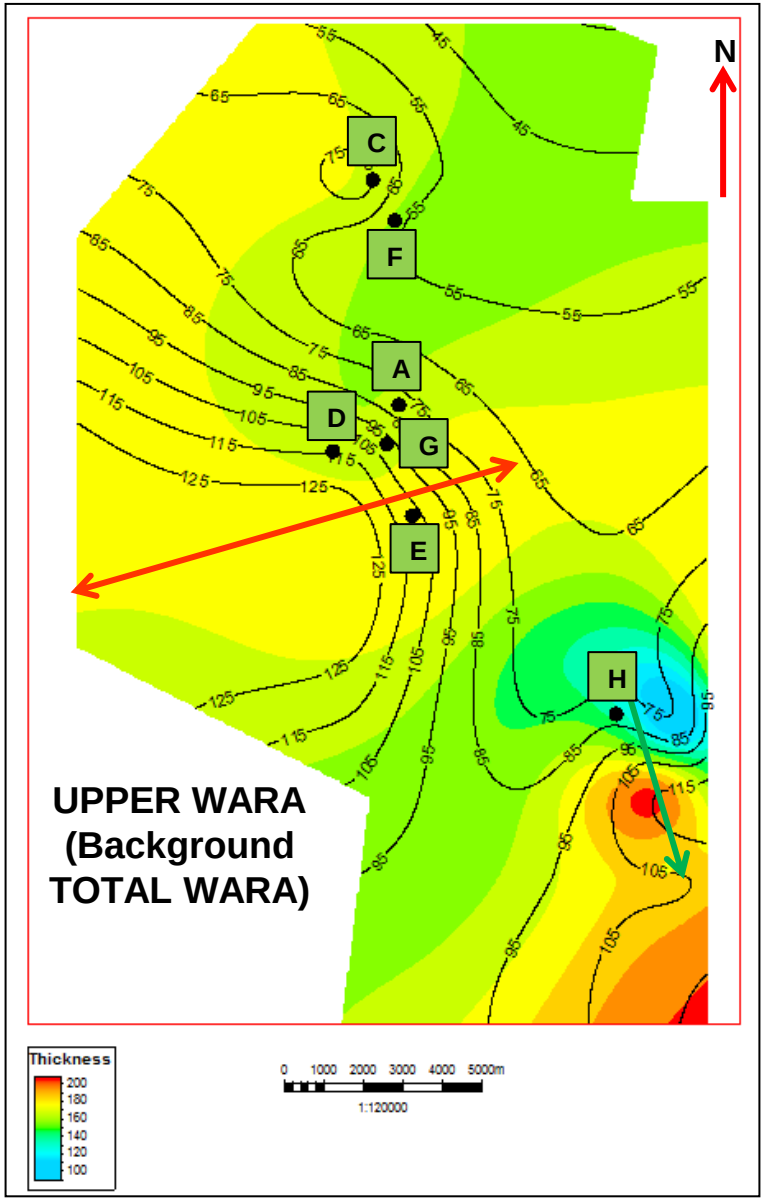
RESERVOIR CHARACTERIZATION

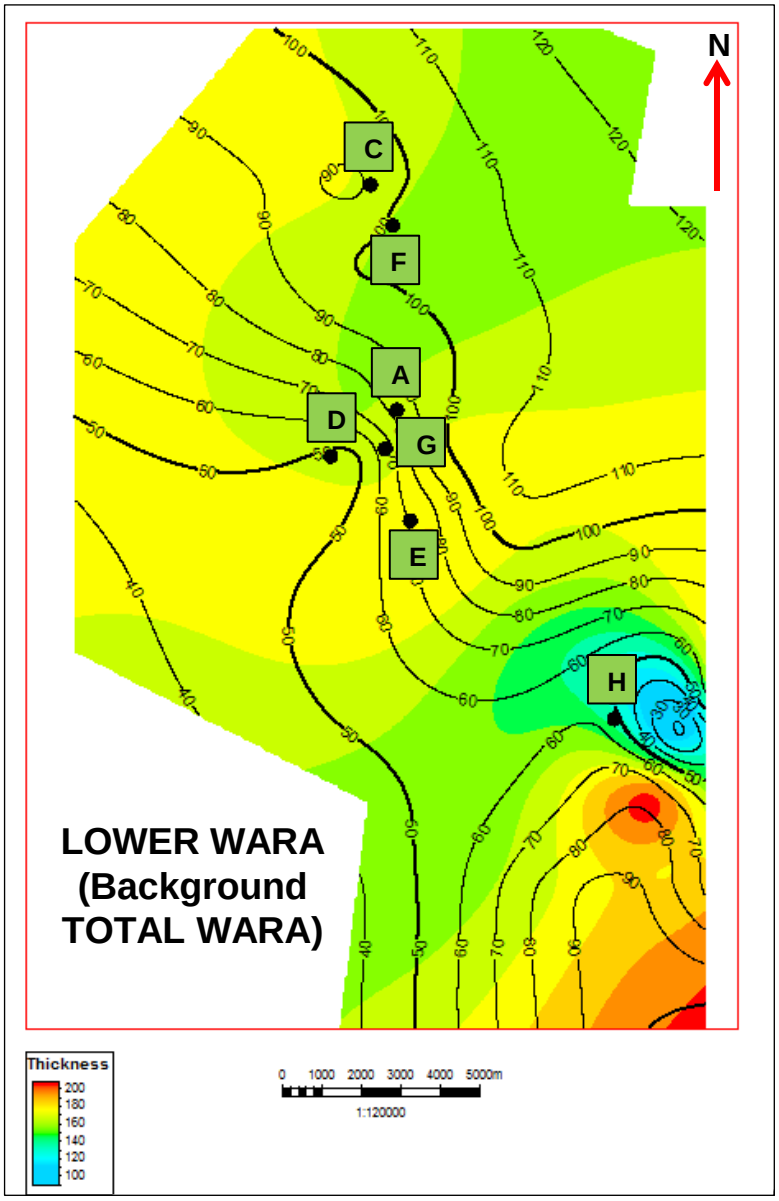
Stratigraphic Correlation



RESERVOIR CHARACTERIZATION

Isochore Map

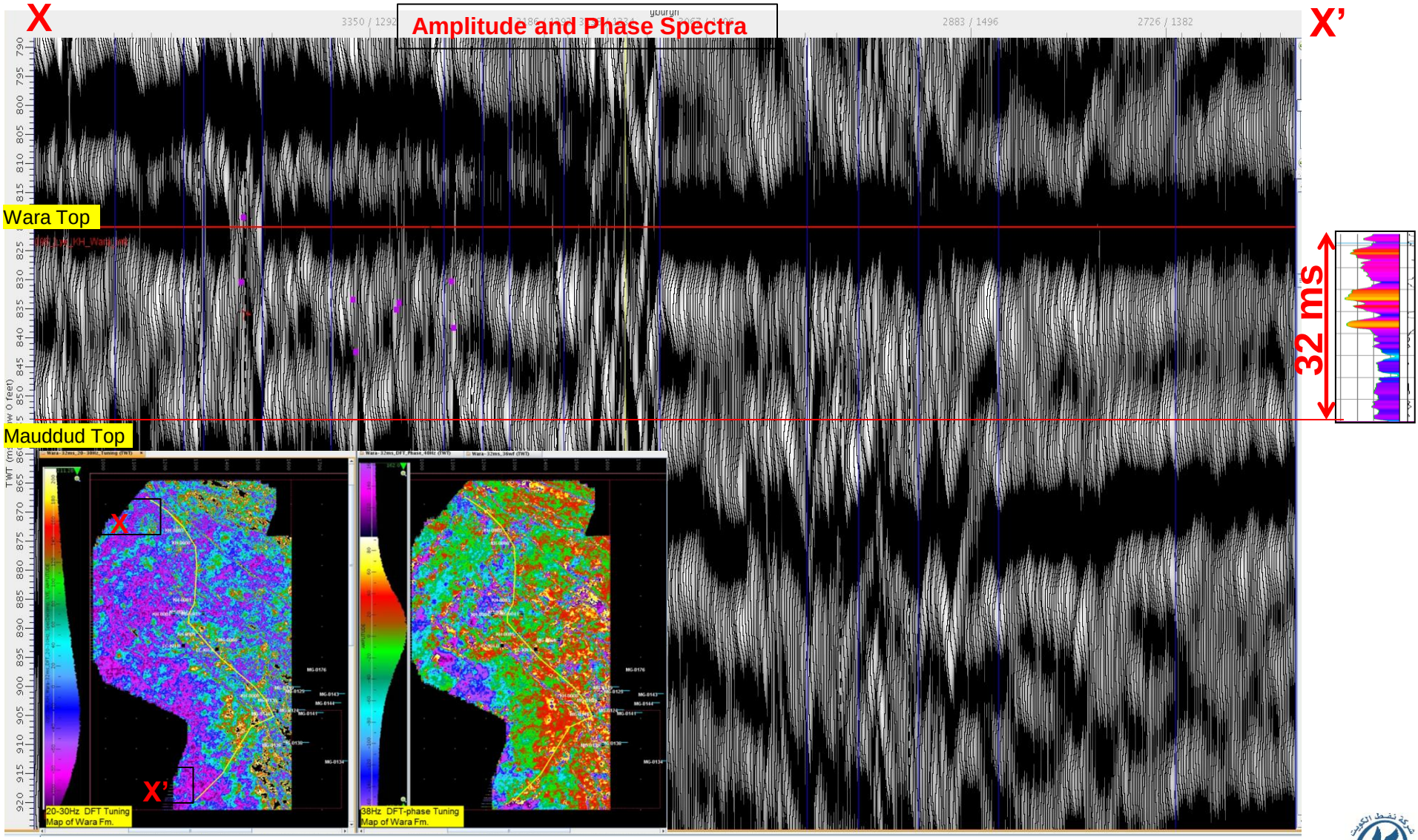




RESERVOIR CHARACTERIZATION

Seismic

Arbitrary Seismic Profile - SpecD



RESERVOIR CHARACTERIZATION

Seismic

Analysis Window

Geological Interval

Interval-based Seismic Attributes

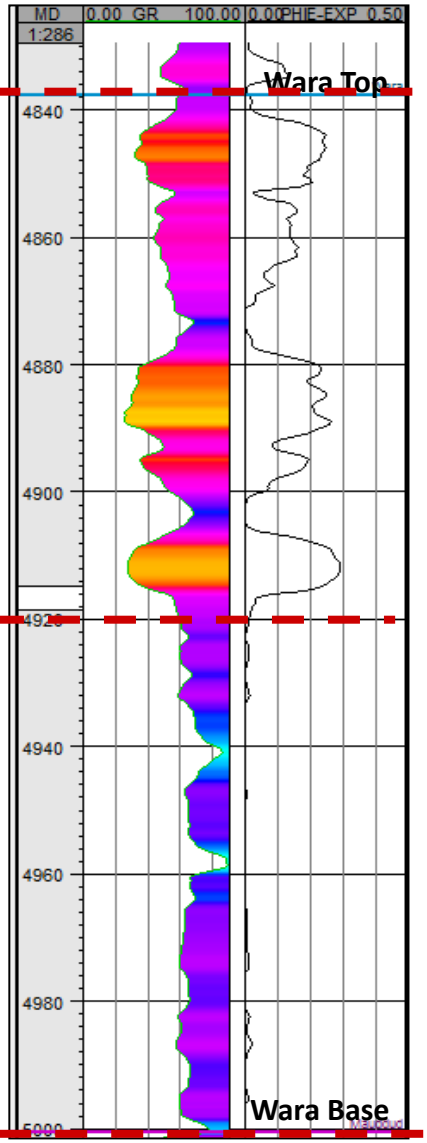
Wara Clastic Environment

Distributory Channel

Medium grained, light brown Sst, moderate to good reservoir

Delta - Coastal Plain

Very Fine grained, greenish grey glauconitic sandstone with intercalations of shale, carbonaceous at places and siltstone. Poor reservoir



20 ms Window

24 ms Window

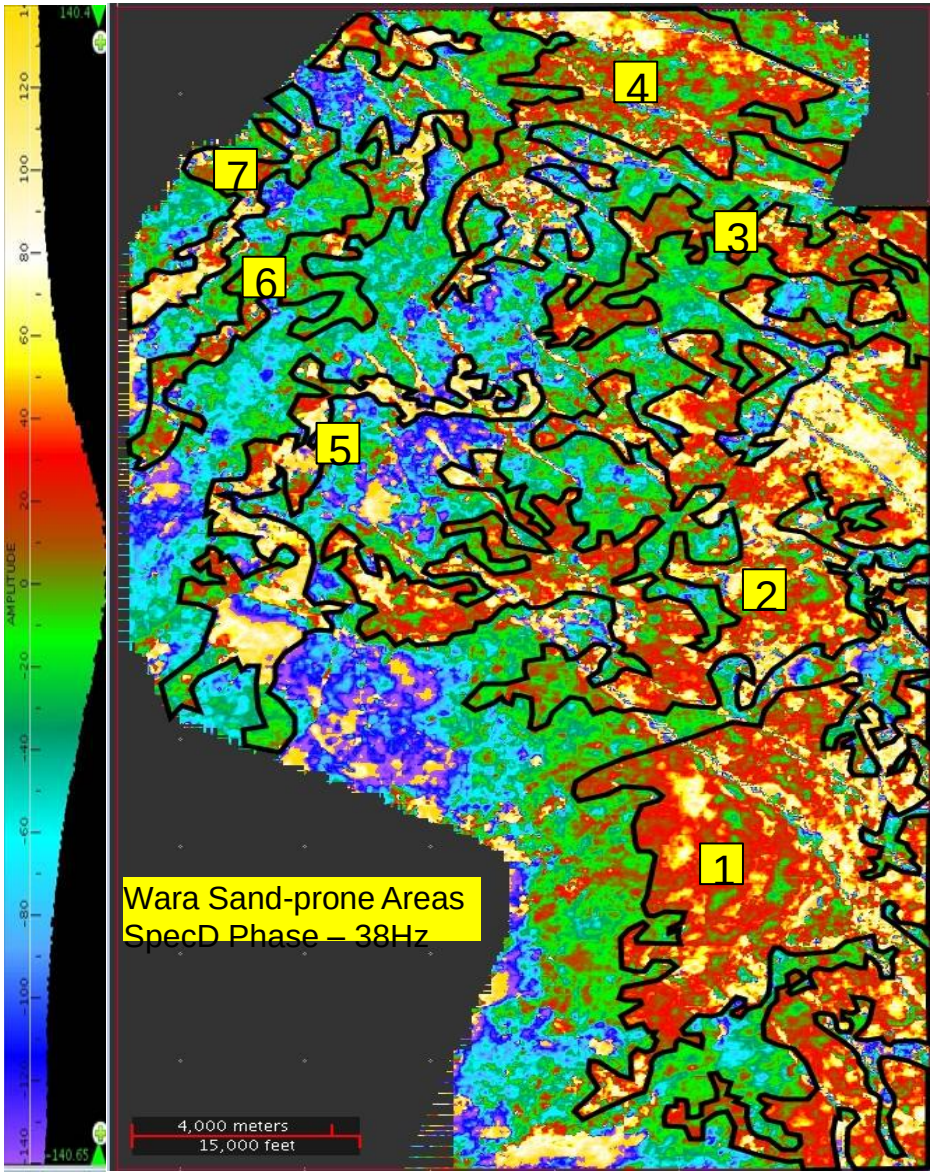
28 ms Window

32 ms Window

RESERVOIR CHARACTERIZATION

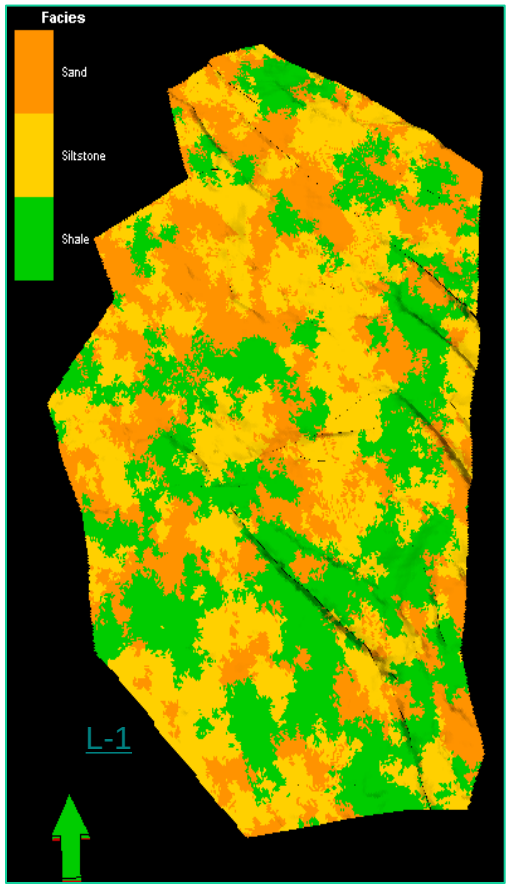
Seismic

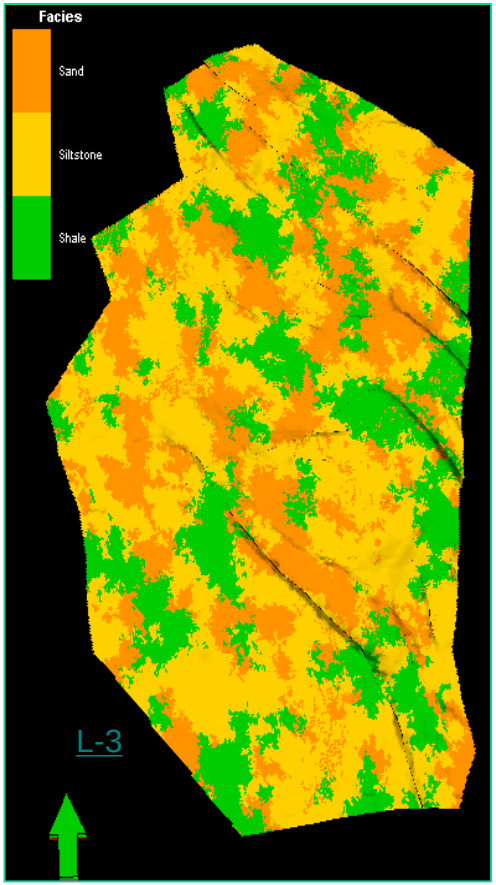
Reservoir in Total Wara Formation

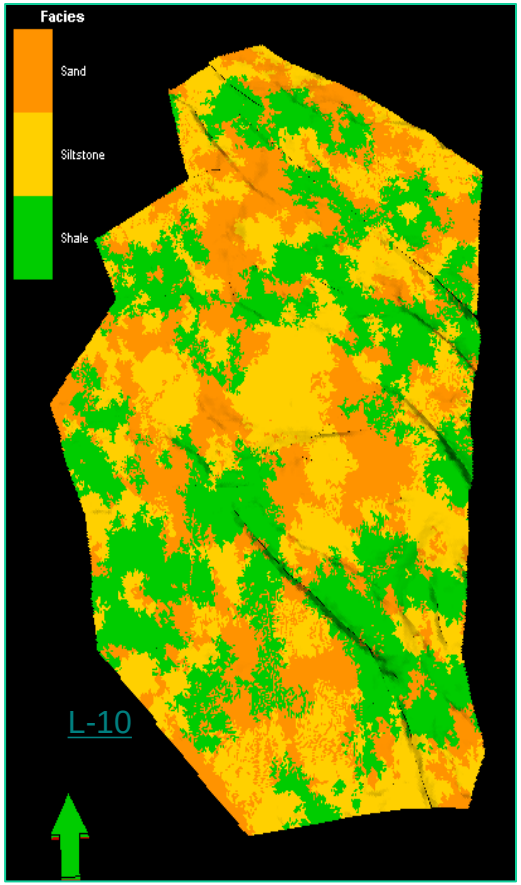


RESERVOIR CHARACTERIZATION

Facies Model – Upper Wara

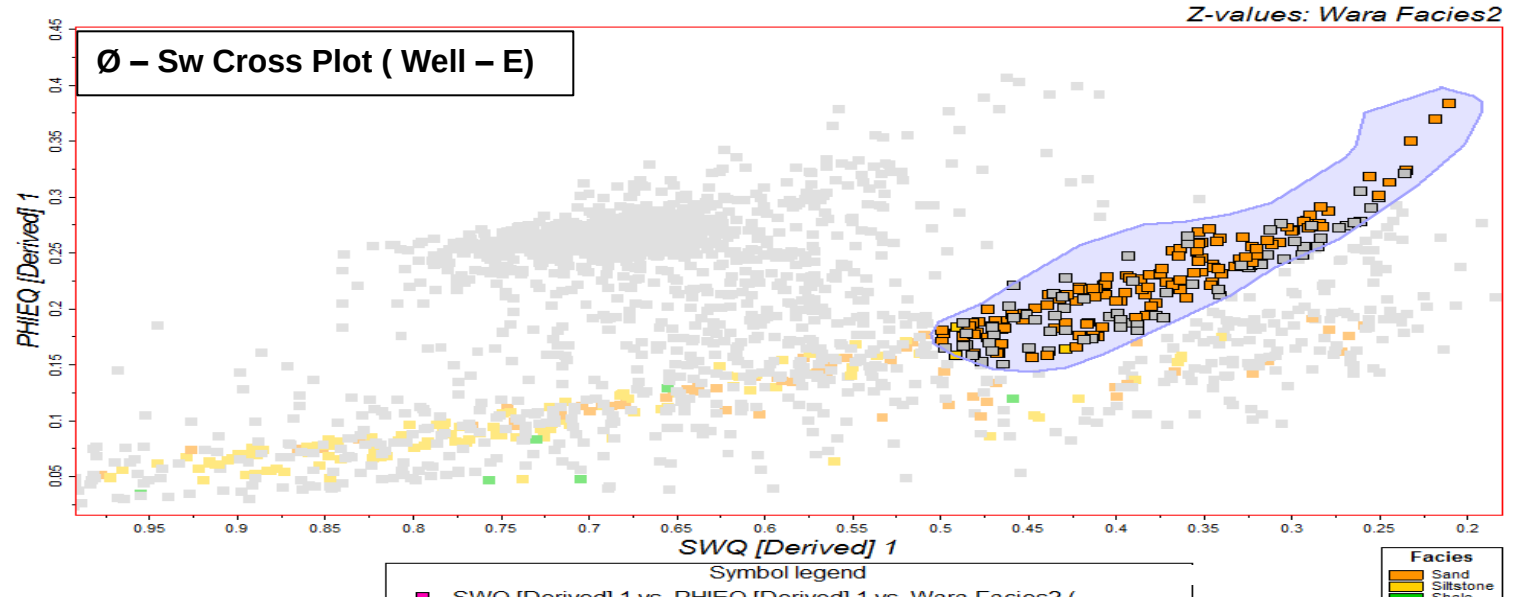


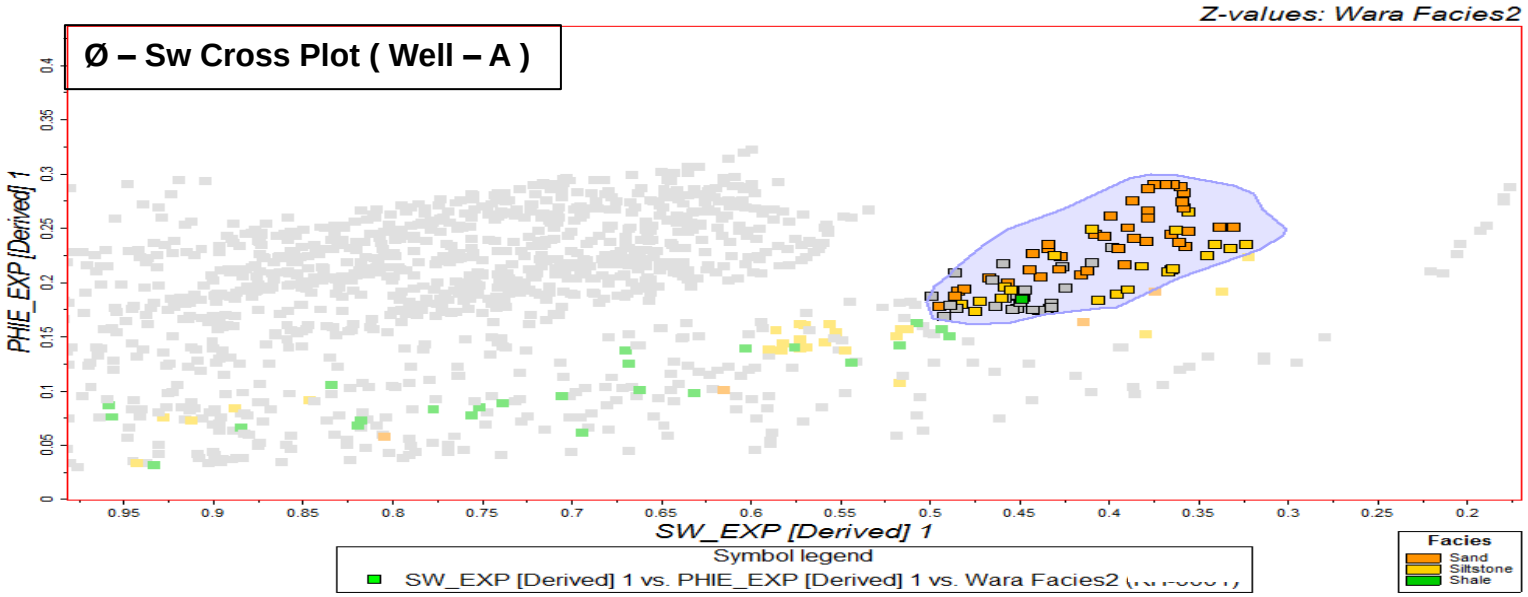




RESERVOIR CHARACTERIZATION

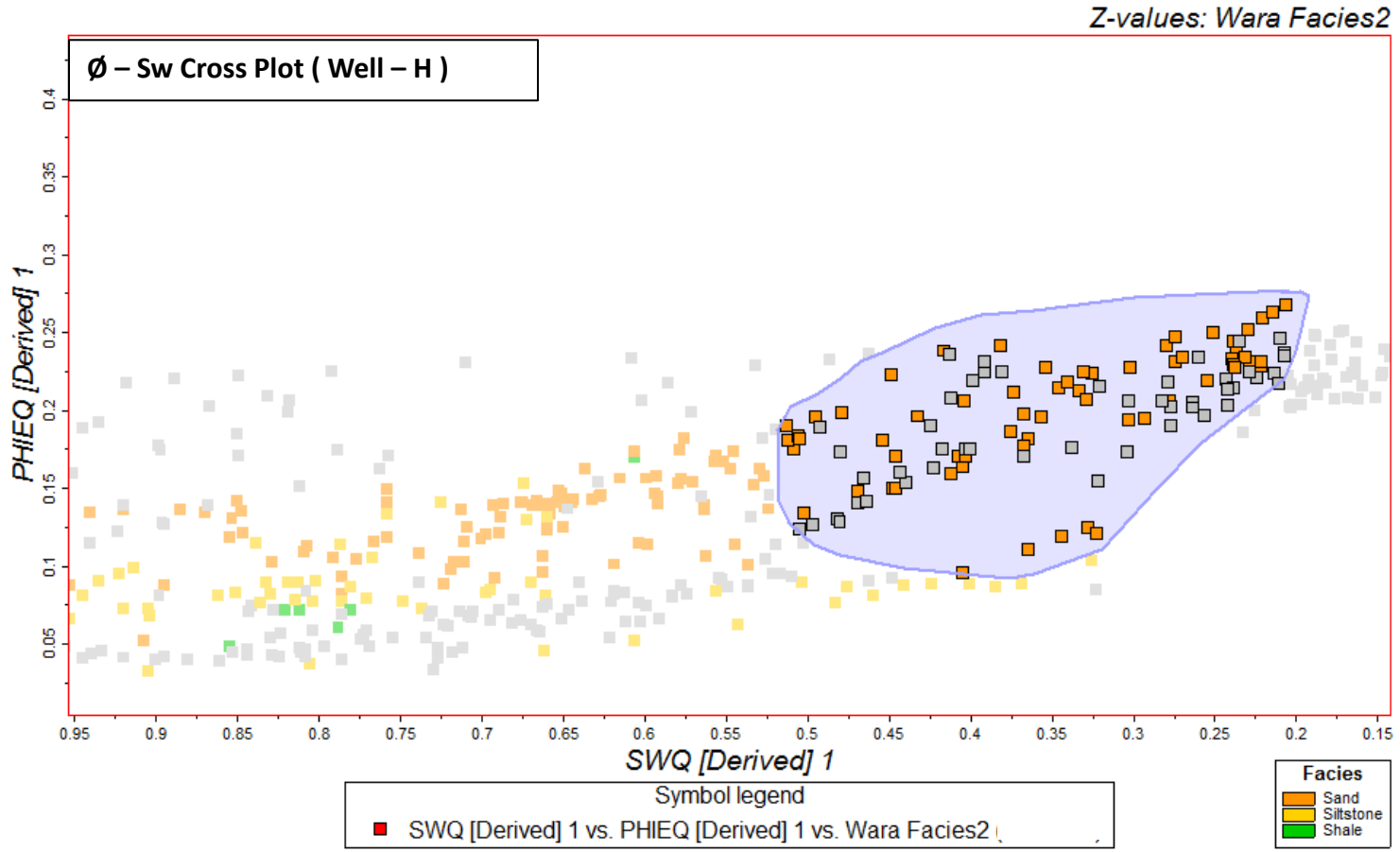
Petrophysics





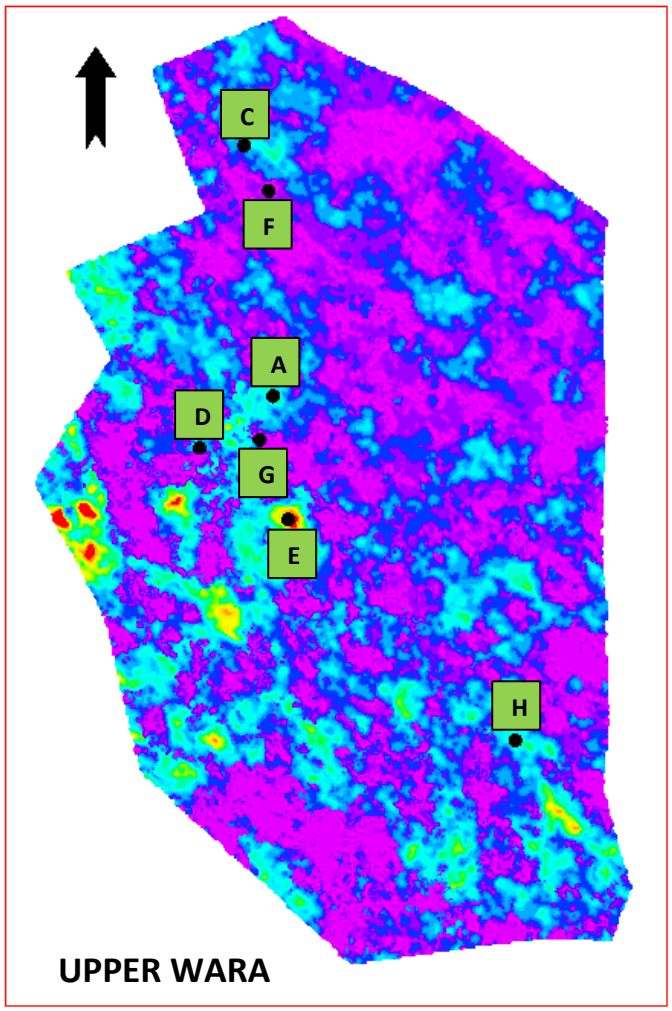
RESERVOIR CHARACTERIZATION

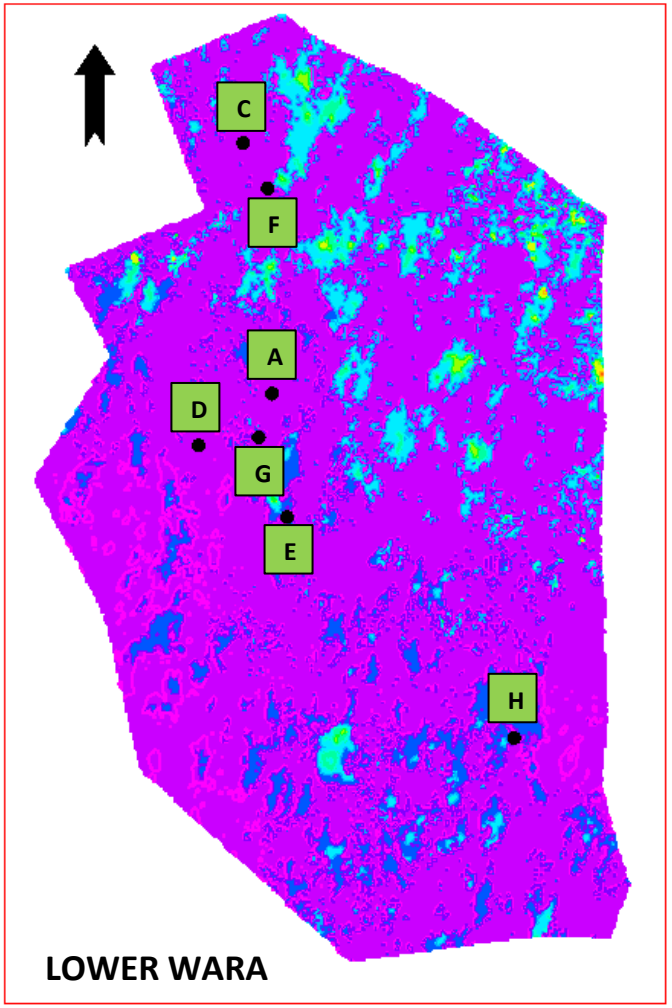
Petrophysics



RESERVOIR CHARACTERIZATION

Net Map Ø> 0.10, Sw < 0.55





CONCLUSIONS

- Enhancement of prospectivity of Wara Formation by integration of Geology, Geophysics and Petrophysics.
- A better picture from PSTM processed 3D seismic using advance technology.
- Analysis on success and failure of earlier exploration phases.
- Evaluation of prospect in different Fault Blocks.
- Delineation of reservoir prone areas.
- Future drillable locations.

WAY FORWARD

Necessity of re-assessment of hydrocarbon prospect by continuous revision incorporating the latest data sets, experience, concepts and technological advancements leading to :

Shaping the Future of Geoscience in the Middle East

ACKNOWLEDGEMENT

1. Ministry of Oil, State of Kuwait

2. Kuwait Oil Company for permitting to publish / present the work.


Thank You