

# **A New Approach to Real Time Acoustic Measurements in North Kuwait Cretaceous Carbonate Formation Evaluation and Characterisation: Case Study\***

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## **Abstract**

The Mauddud reservoir in Raudhatain Field is a giant heterogeneous carbonate reservoir discovered in the 1950s. The field has been on production since 1957, with natural depletion since it has no surrounding aquifer. Overtime, with continuous production there has been a decline in reservoir pressure which affected the field productivity. Horizontal, deviated and highly deviated wells were drilled by Kuwait Oil Company (KOC) in this field with challenges to regulate oil production and early water cut in many horizontal and deviated wells. KOC has started an initiative of installing in-flow control devices (ICD) to optimize completion strategy in horizontal wells of Mauddud carbonate reservoirs. Formations intersected in such wells are heterogeneous in nature and have huge variation in petrophysical properties like porosity, permeability and facies/clast.

It is well established that permeability estimation is a challenging problem due to its heterogeneous nature and success of ICD completion design depends upon accuracy of input data such as formation permeability/mobility, porosity, saturation and pressure. The need for such accurate input data was recognized and subsequently answered by advance acoustic wave measurements. SonicScope is the latest acoustics Logging While Drilling (LWD) tool recently developed by Schlumberger to provide geomechanical properties and mobility. The main innovative features which are exclusive to the tool are real time acoustic slownesses, shear slowness in slow formations, stoneley slowness and mobility or permeability estimation. In addition, it provides source less porosity information along with in situ continuous permeability profile, which provides superior formation evaluation data. Real time sonic data was acquired for the first time in a Raudhatain Mauddud horizontal well. The continuous permeability and porosity profile estimated from in situ acoustic measurements assisted in accurate well placement, detect fractures, pore pressure, geomechanical properties and most important for completion design. The real-time formation porosity can be used together with sonic-derived porosity for more realistic porosity profile. This article provides insight on successful application of innovative field development strategies to optimize production from the Radhatain Mauddud reservoir. It also highlights the importance of real-time acoustic data in estimating mobility for optimum completion design, reservoir characterization and formation evaluation.

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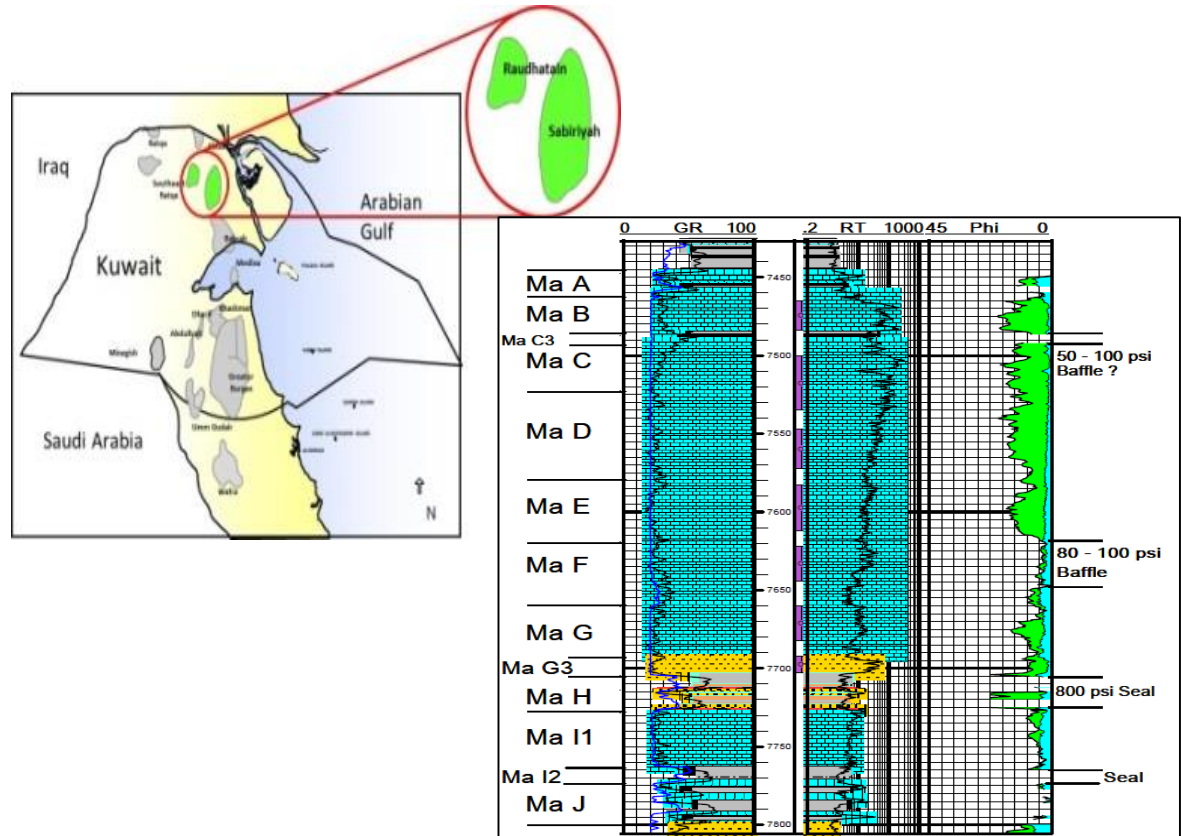
**Schlumberger**

# Agenda

- Introduction
  - Key Challenges
  - Objectives
  - LWD Sonic Measurement
  - Results
  - Conclusions
- 

# Introduction

- Mauddud Reservoir in Raudhatain field is giant heterogeneous carbonate reservoir.
- Field is on production since 1957 with natural depletion.
- Over a time with continuous production, reservoir pressure declines which affect on the productivity.
- Deviated, highly deviated and horizontal wells drilled to regulate oil production and early water cut.
- Forecast is to increase water cut in future.

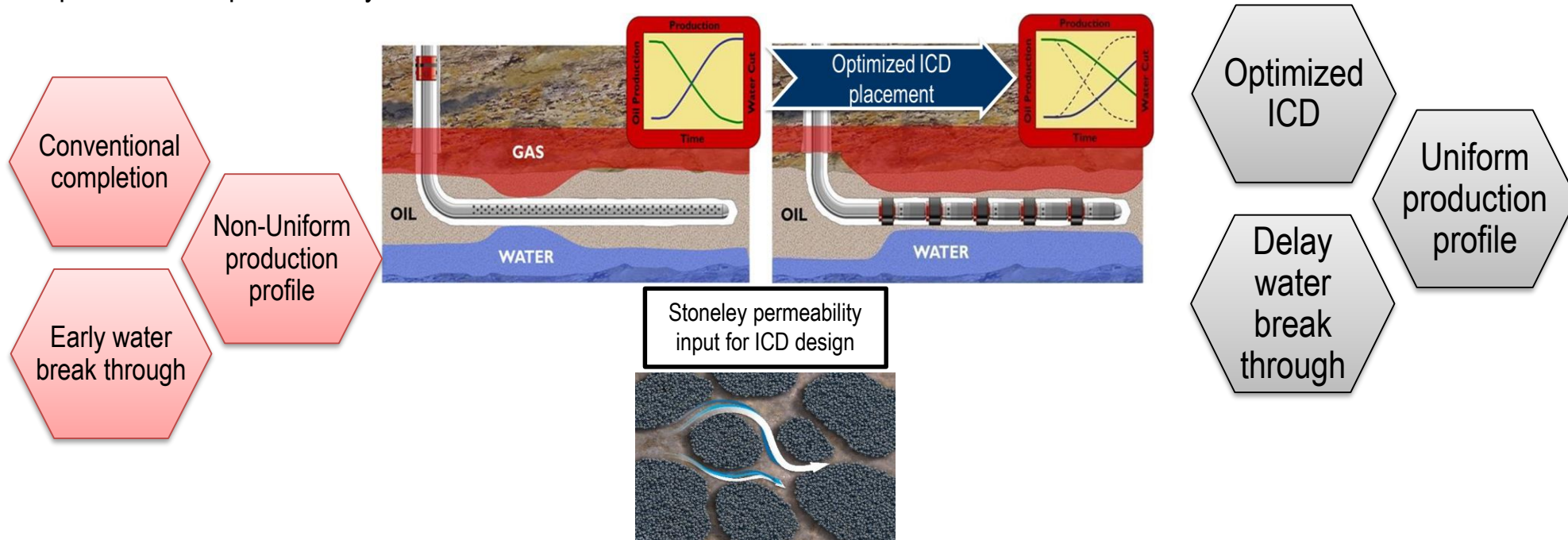


# Key Challenges

- To address future issue
  - Increase in watercut
  - Decrease in oil production
  - Maintenance of reservoir pressure
- Heterogeneous reservoir – variation in the reservoir properties
  - Porosity
  - Permeability
  - Facies/clast
- Permeability estimation is challenging due to heterogeneity

# Key Challenges

- Possess challenges to regulate oil production and early water cut in lots of horizontal and deviated wells.
- To address these issues, started an initiative of installing in-flow control devices (ICD) to optimize completion strategy in horizontal wells from carbonate reservoirs.
- Success of ICD completion design depends upon accuracy of input data such as formation porosity, saturation, pressure and permeability.

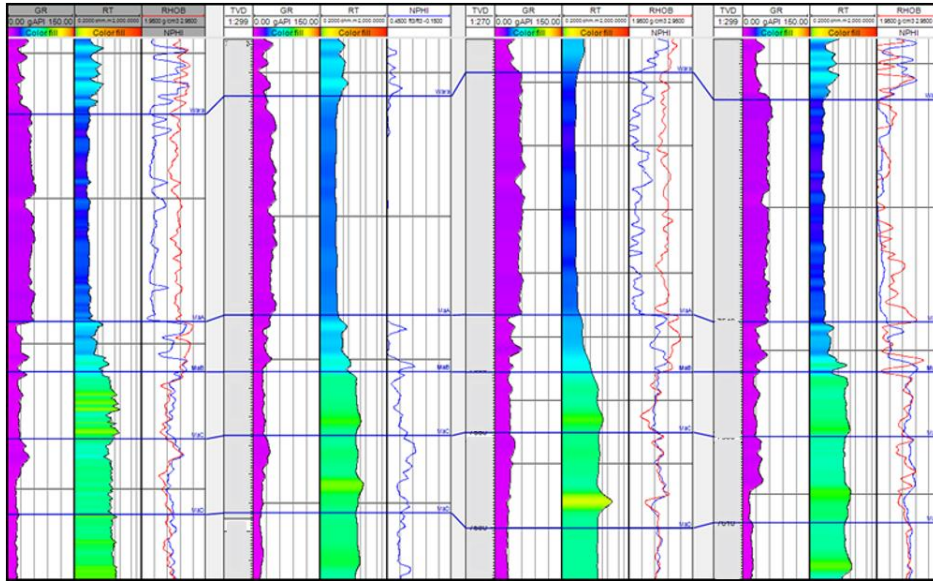


# Objectives

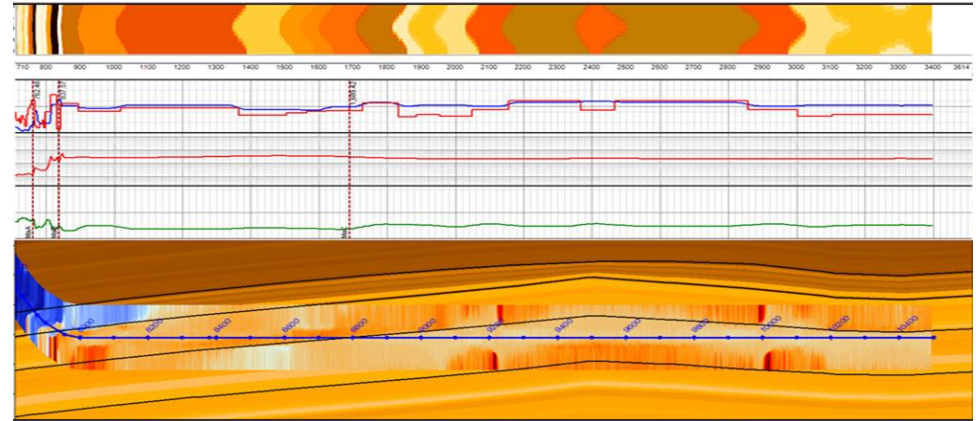
- Geosteer well with optimum criteria
- Evaluate reservoir properties
- Optimize Inflow control devices (ICD) completion designs in horizontal/highly deviated wells

# Methodology

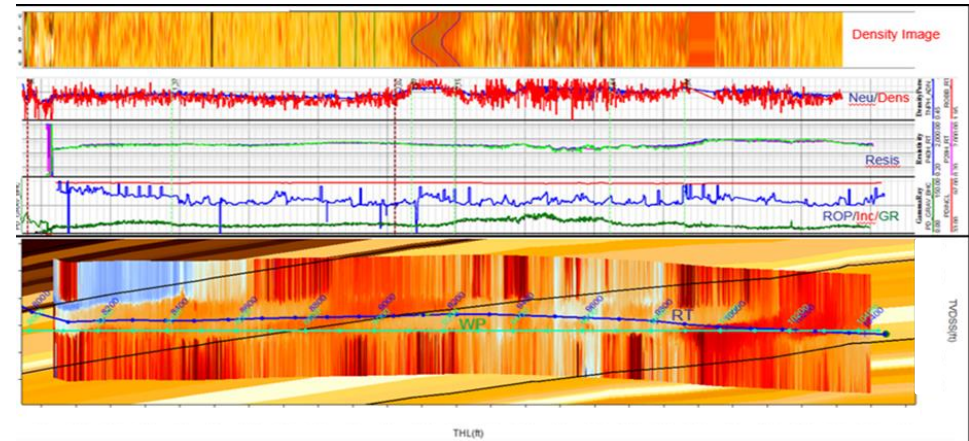
## 1. Offset well correlation:



## 2. Pre-job structural and property model:

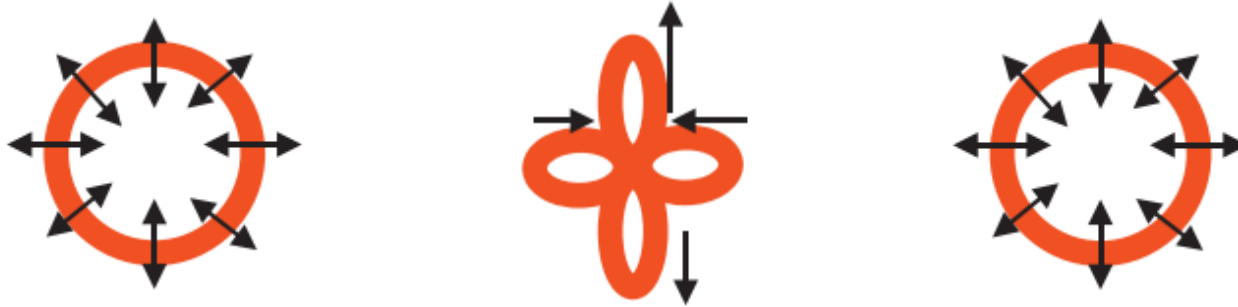


## 3. Pre-job structural and property model :

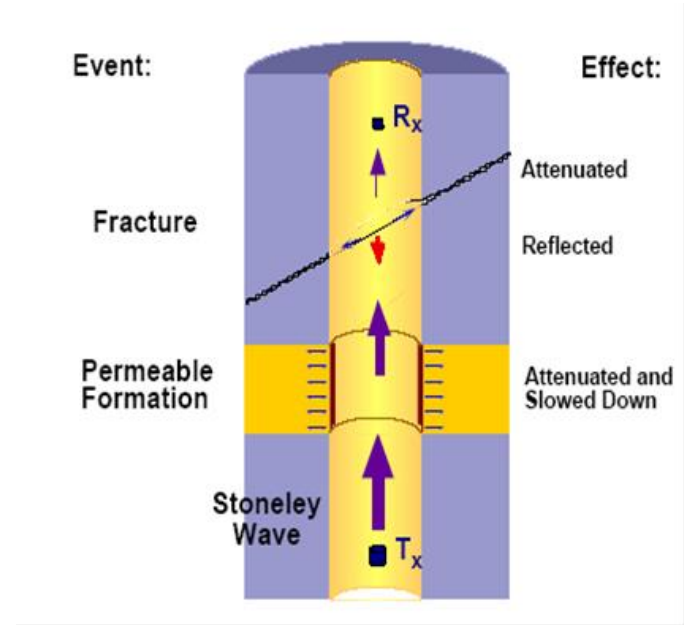




# Methodology



MEASUREMENT	<p>High-frequency monopole for:  <b>compressional and shear slowness measurements in fast formations</b></p>	<p>Quadrupole for:  <b>shear slowness measurements in slow formations</b></p>	<p>Low-frequency monopole for:  <b>Stoneley acquisition</b></p>
APPLICATION	<ul style="list-style-type: none"> <li>• Real-time Porosity</li> <li>• Secondary Porosity</li> </ul>	<ul style="list-style-type: none"> <li>• Rock mechanical properties                      Perforating stability, sanding analysis, Hydraulic fracture height determination, Well bore stability</li> </ul>	<ul style="list-style-type: none"> <li>• Mobility of Invaded zone</li> <li>• Fractures</li> </ul>



# Results

Gamma Ray & Hole Size

Resistivity

Porosity

Borehole Shape

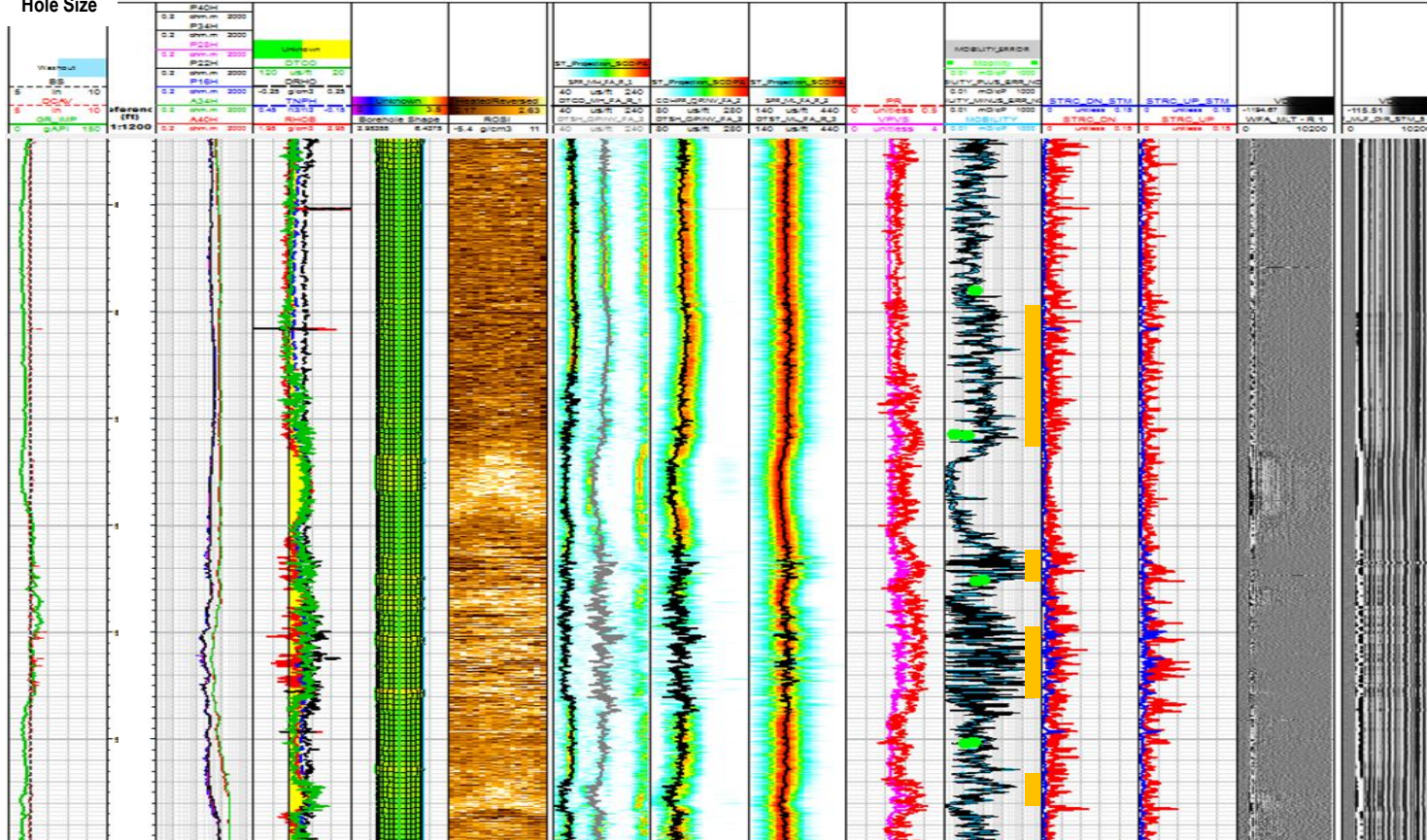
Density Image

Slowness Projection

Poisson's Ratio & VPVS

Permeability

Stoneley Reflection Coefficients



- Well placed in good porosity layers.
- Identified high permeability and fractured intervals.

Optimized intervals for ICD completion design

## Conclusion

- High quality acoustic measurements have proven effective in reducing drilling risk, evaluating formations and characterizing reservoirs, ensuring accurate seismic positioning, and optimizing completion design to enhance production.
- The robust sonic while drilling data for formation evaluation include determination of the ratio of compressional to shear wave velocity ( $V_p/V_s$ ) was applied first time in cretaceous carbonates of Raudhatain water flood reservoir of North Kuwait to provide very useful insight of the heterogeneous carbonate formation, quantitative assessment of rock mechanics, fracture and continuous mobility.
- Being a dynamic water flood reservoir, increase in water cut noticed significant in other wells but with this additional available quantitative data, this well will be completed with ICD completion by optimizing the standard ICD designing program. This will minimize possible early water breakthrough, increase the cum oil rate and sustain the life cycle of this well.