KMS Technologies – KJT Enterprises Inc.

Presentation

Strack, K. – M.

1999

The next paradigm: Integrating borehole & surface geophysical techniques for better reservoir characterization

University of Houston

The next paradigm: Integrating borehole & surface geophysical techniques for better reservoir characterization

1999

K.-M. Strack

KMS99001a

(After AFES, Strack 'Pie in the Sky', 1998)

Presentation challenge: ???

How do convey what I would be doing in the future without -

- **overloading an unknown audience**
- **bragging about my great achievements**
- **knowing future technologies**
- **over promising**

???

Presentation Objective

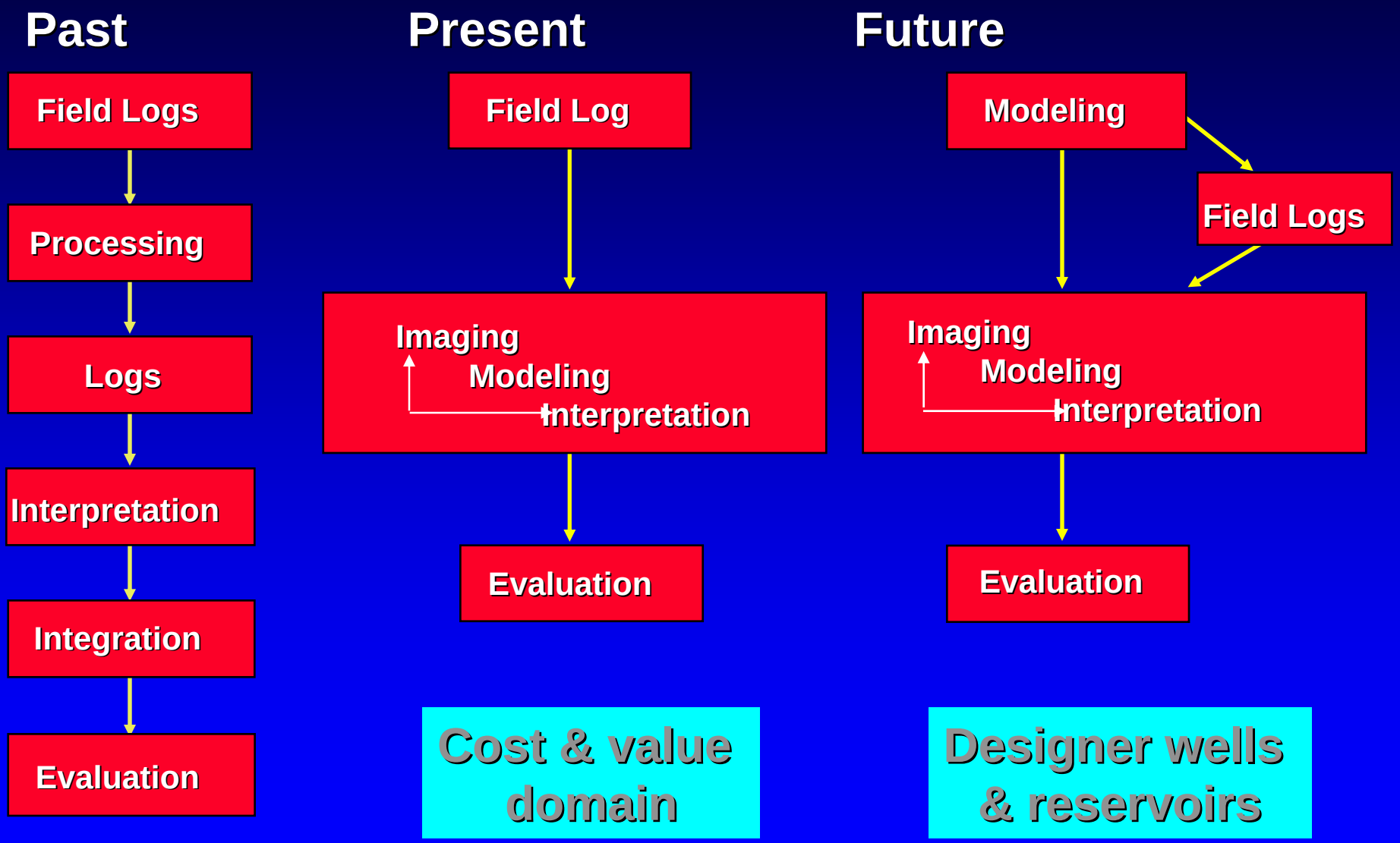
- Display a vision based on data points.
- Tie existing to my own experience.
- Link to AGL/UofH objectives.

…. Or just share my dream

Outline

- **Paradigm Shift**
- **Array tools: The Present (my past)**
- **3D volume integration: The Future**
- **Conclusions**

The Paradigm Shift: log analysis



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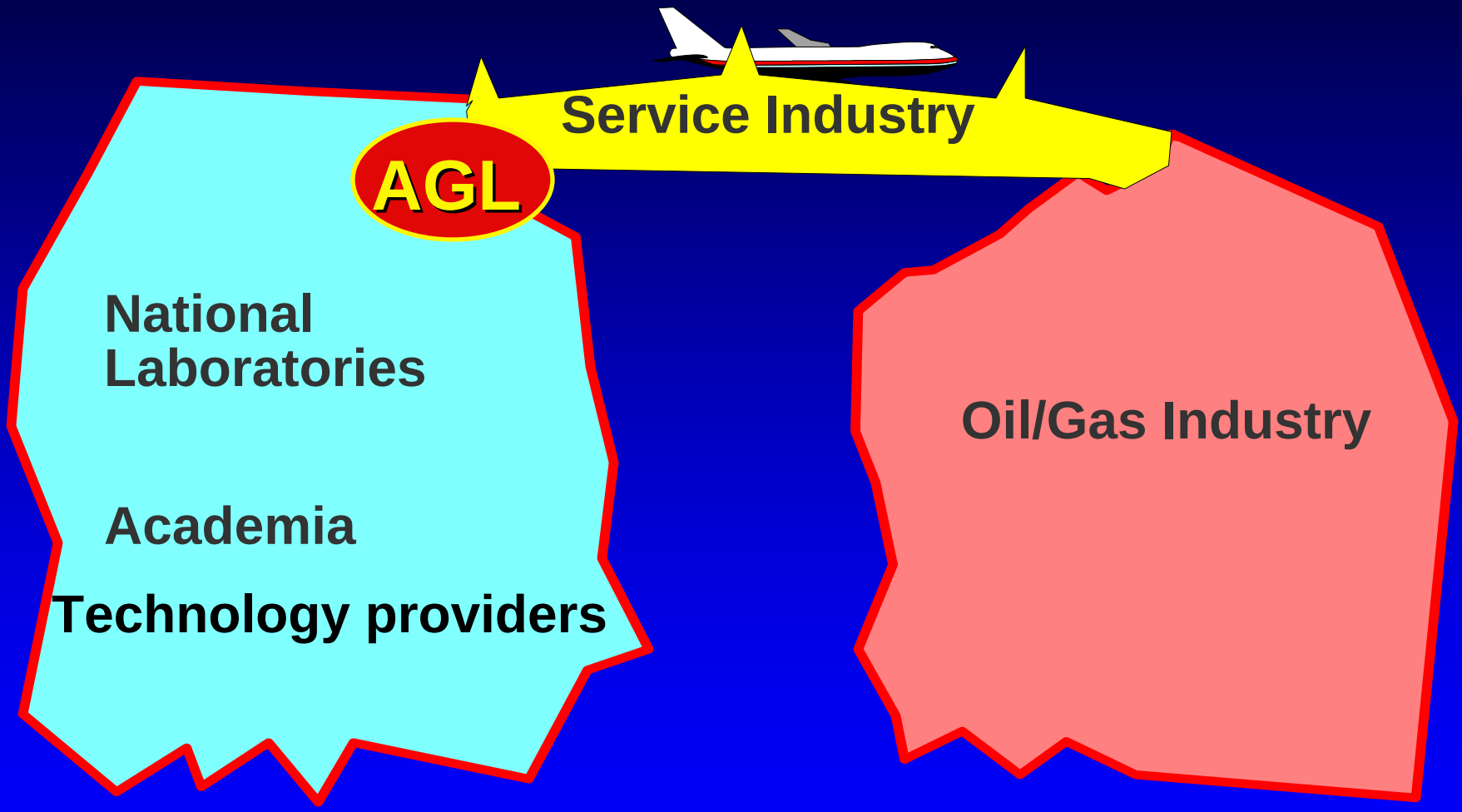
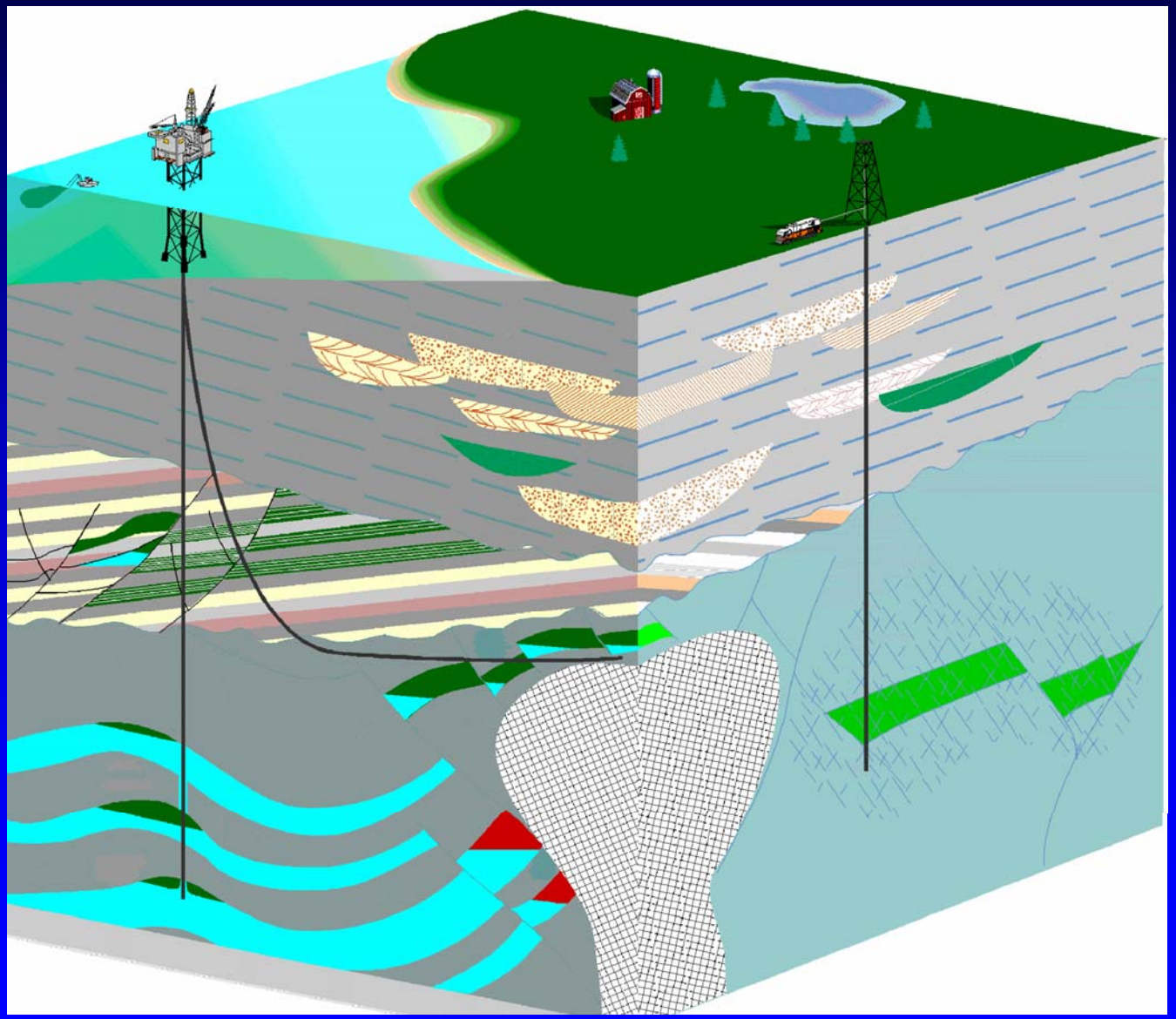
The Paradigm Shift: the industry



The Paradigm Shift: information value



Integration information in the 3 D volume

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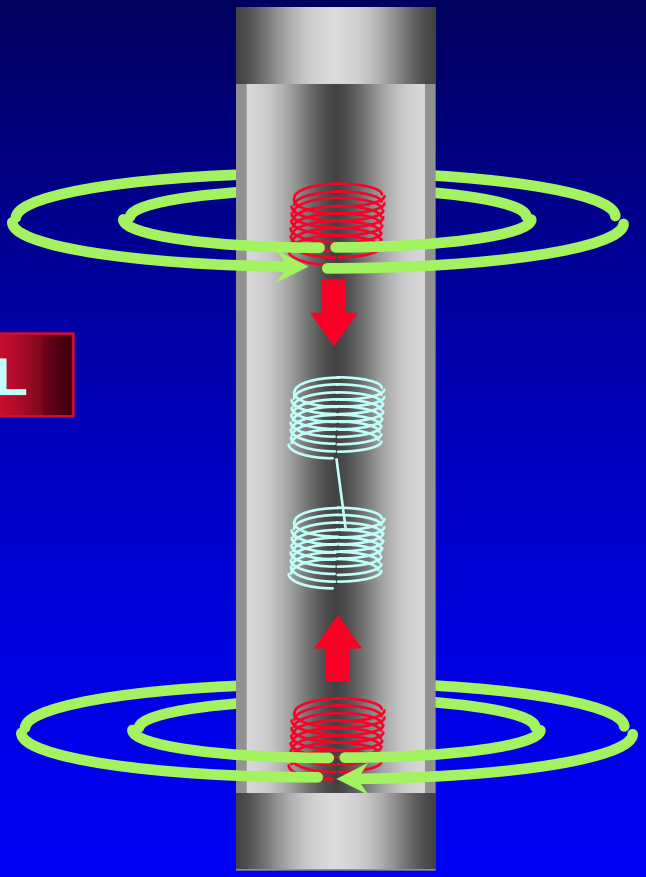
Outline

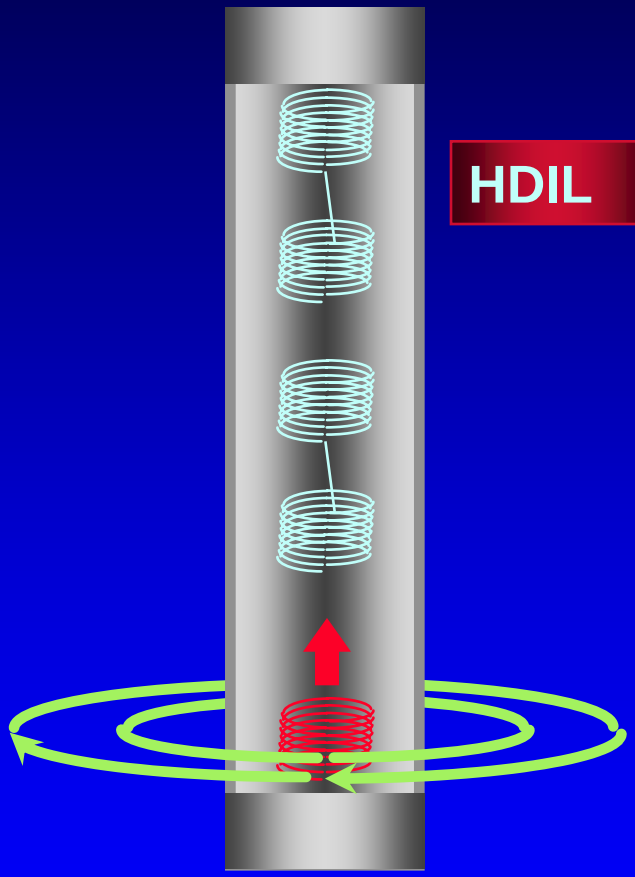
- Paradigm Shift
- Array tools: The Present (my past)
- 3D volume integration: The Future
- Conclusions

Meters vs acquisition systems: Induction



DPIL

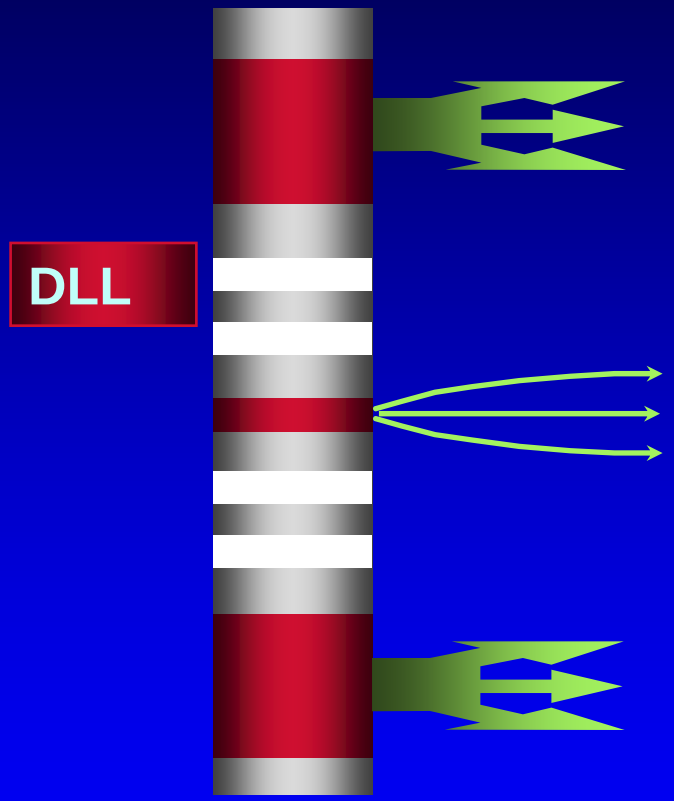
Apparent Rt



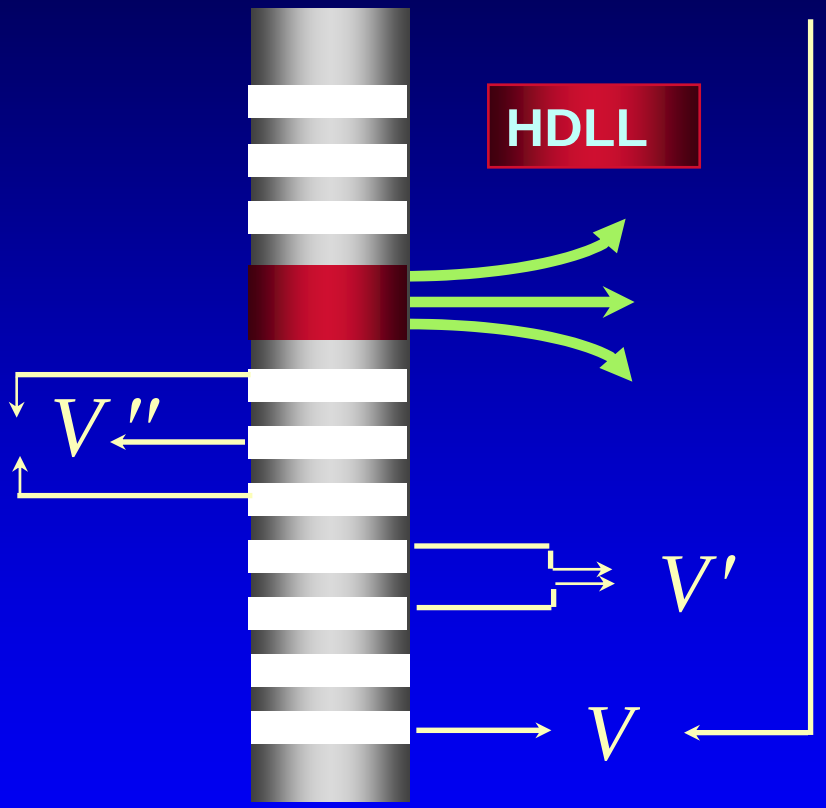
HDIL

Raw Array Data Inversion Rt

Meters vs acquisition systems: Galvanic



Apparent Rt



Raw Array Data Inversion Rt

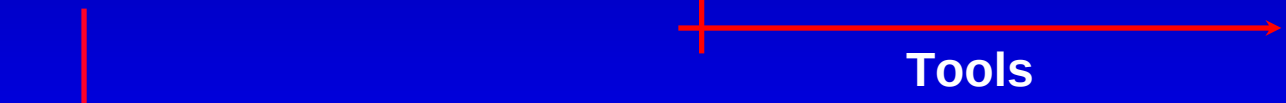
Aray tools:…

- Model based interpretation
- State-of-the art acquisition system (24 bit, high data rates, full waveforms)
- Software processing for improved S/N

Data to Model

Measurements

Initial Guess



Final Model

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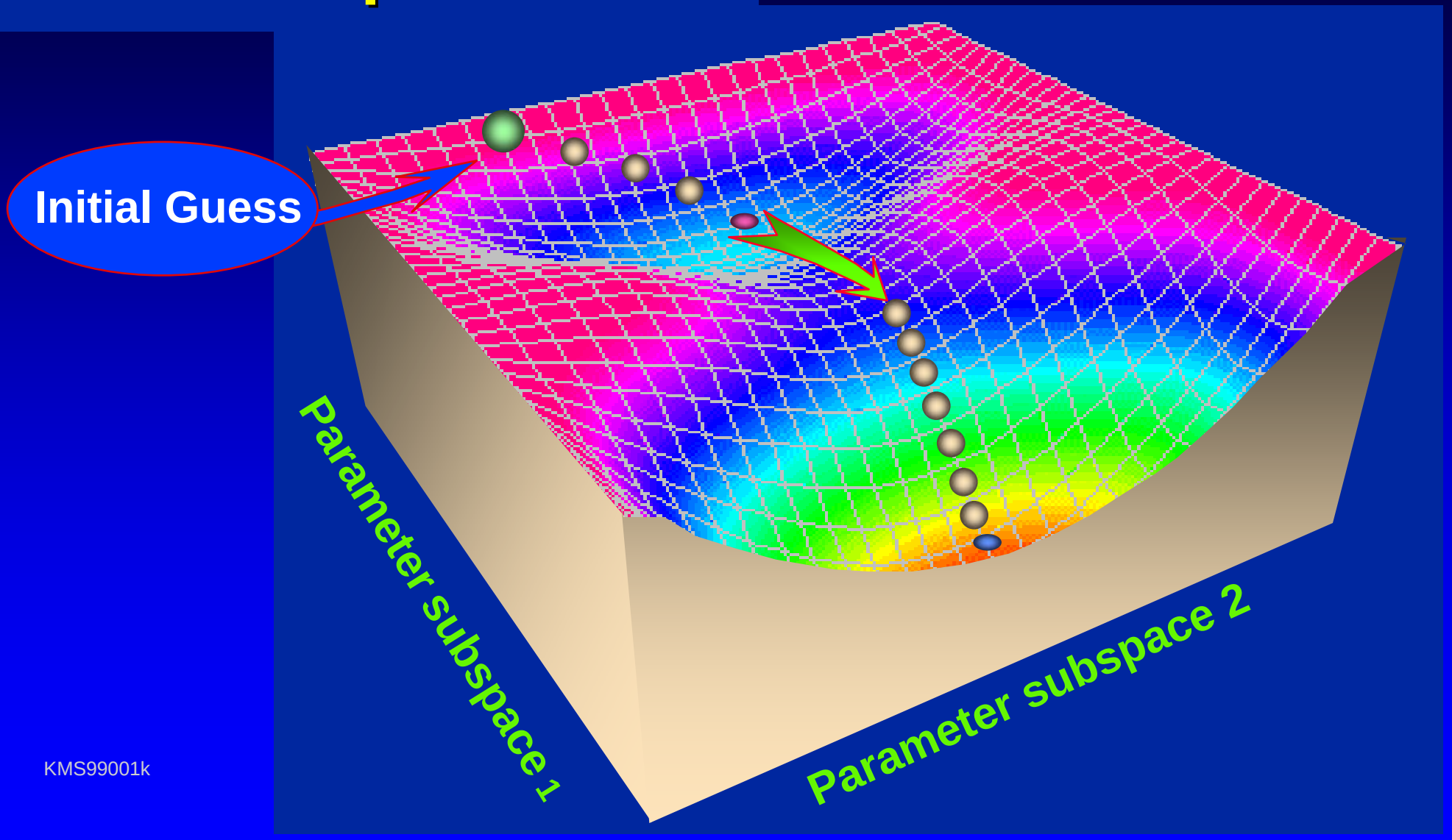
Nonlinear Optimization



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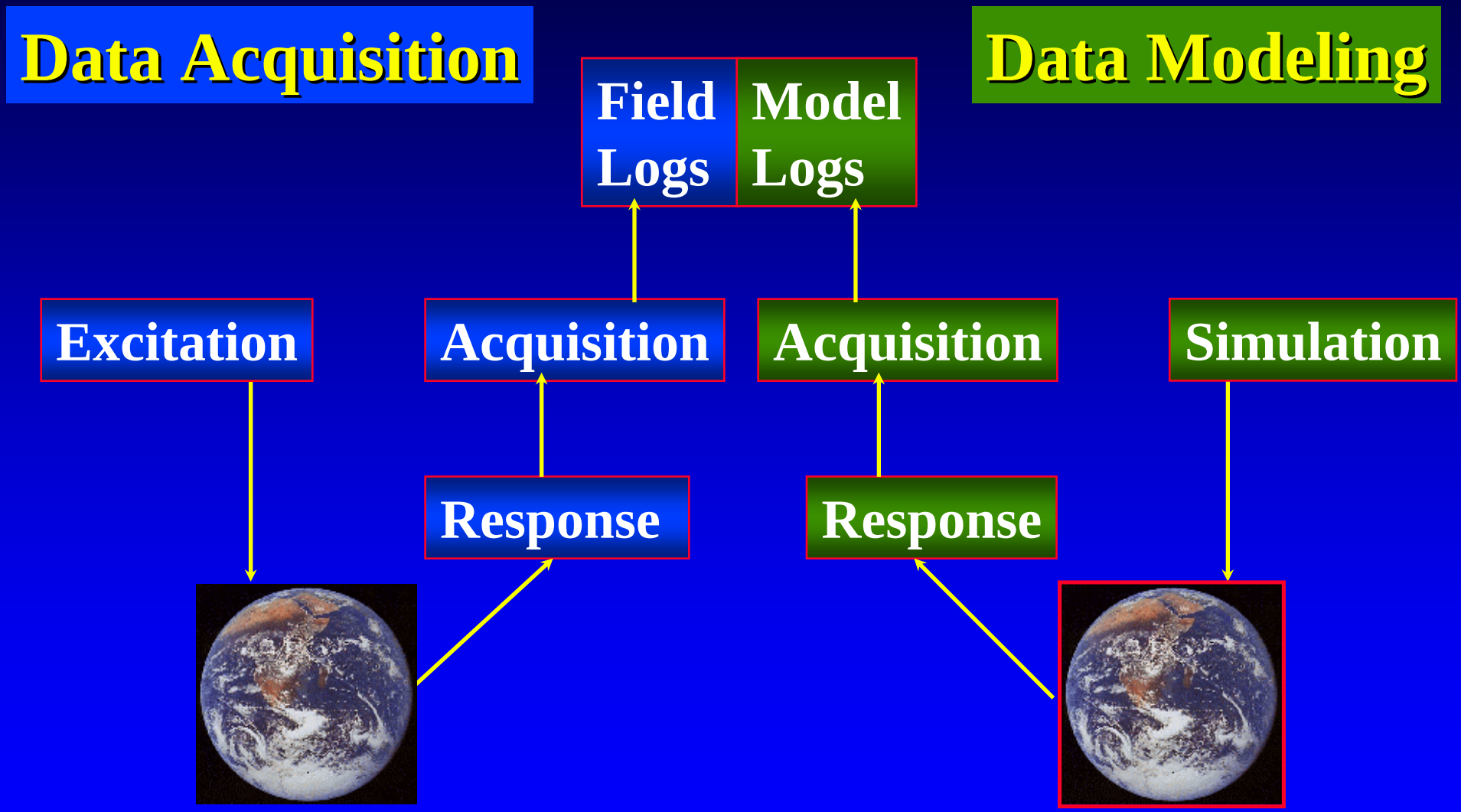
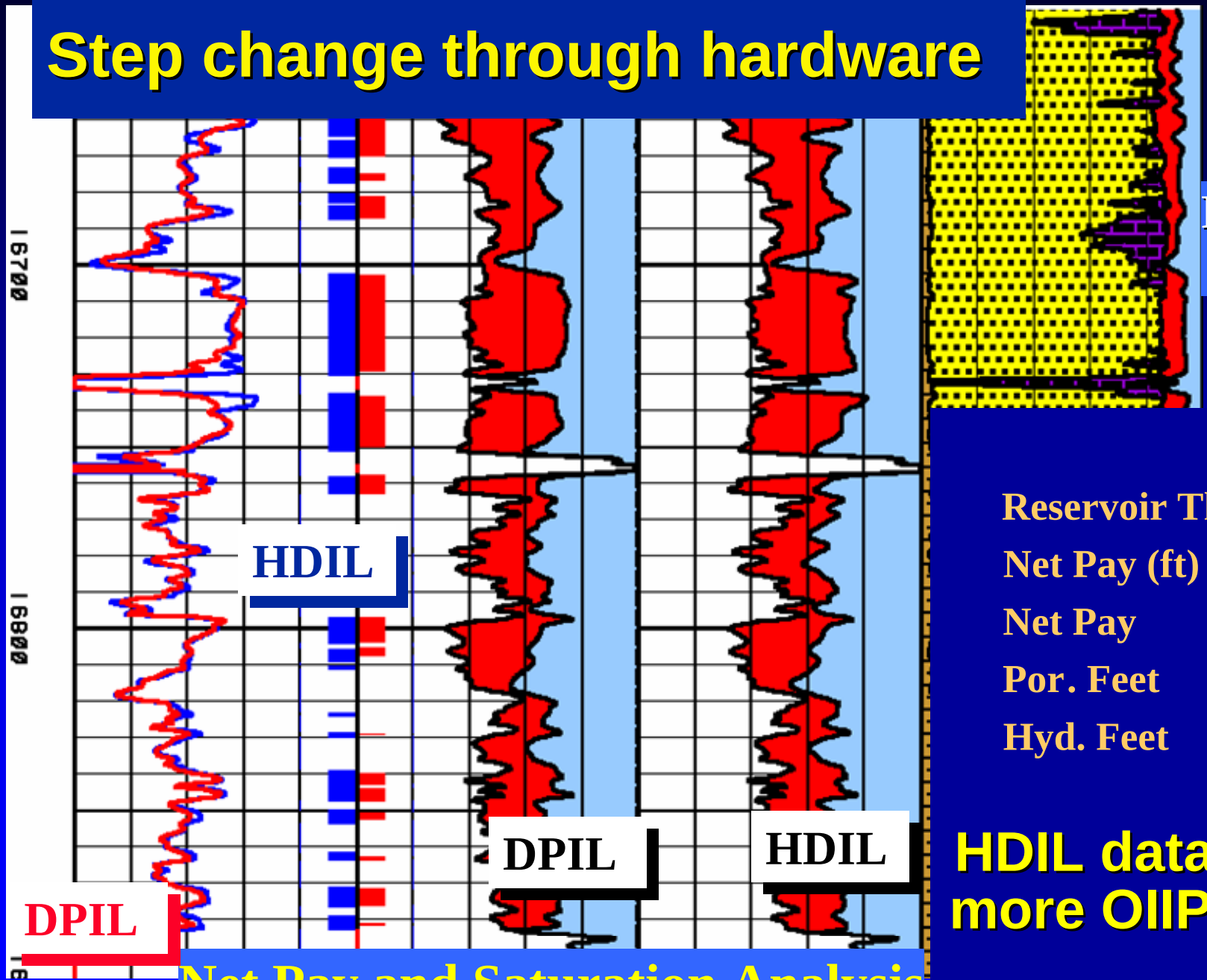
Inversion: Process flow



Step change through hardware



Reserves estimate
DPIL vs. HDIL

	DPIL	HDIL
Reservoir Thickness:		270 ft
Net Pay (ft)	103.6	130.1
Net Pay	38.4%	48.2%
Por. Feet	15.4 ft	18.9 ft
Hyd. Feet	7.4 ft	9.2 ft

HDIL data allowed 24% more OIIP be booked.

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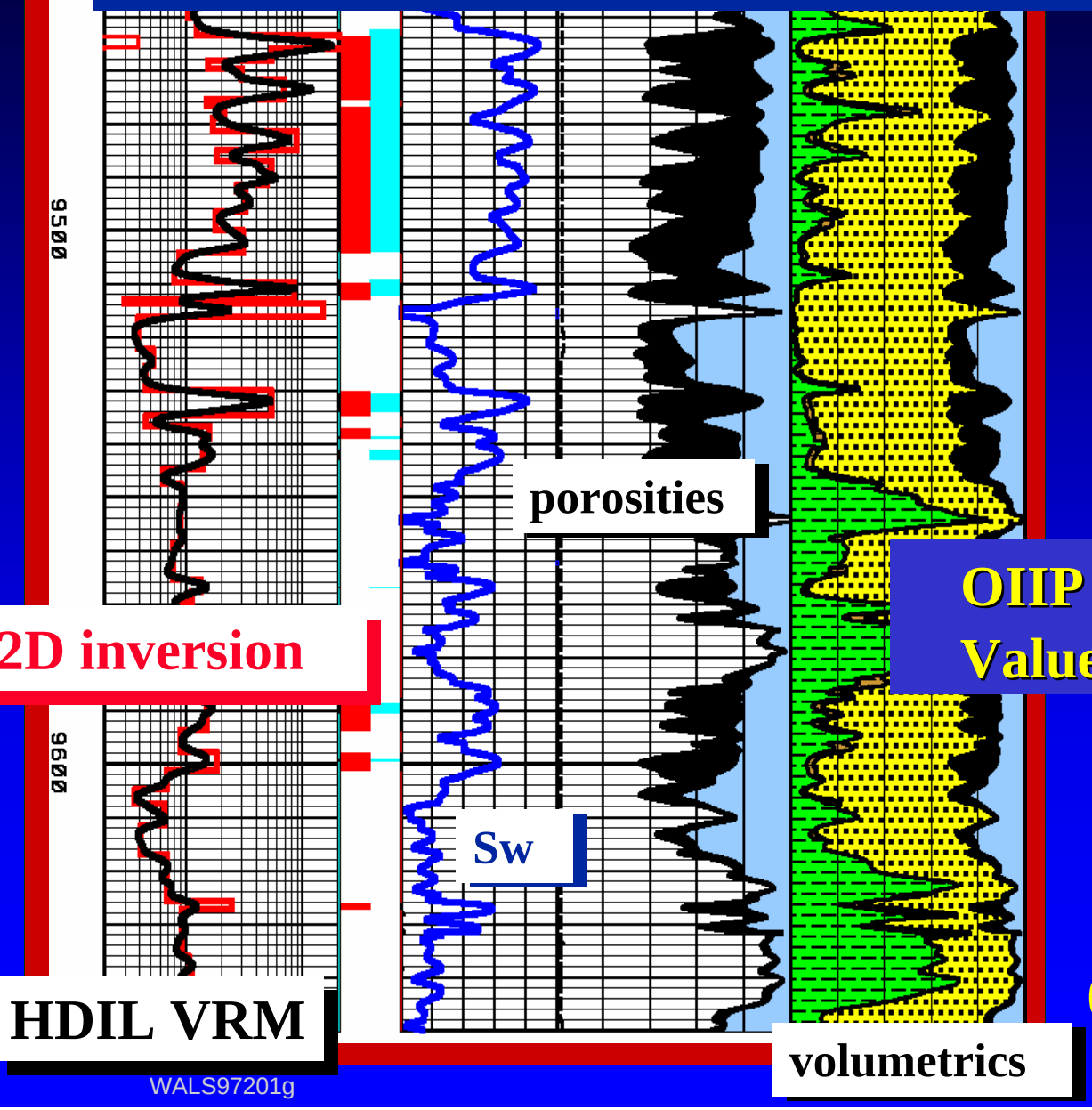
Net Pay and Saturation Analysis

Step change through software



2 ft VRM vs 2D Inversion

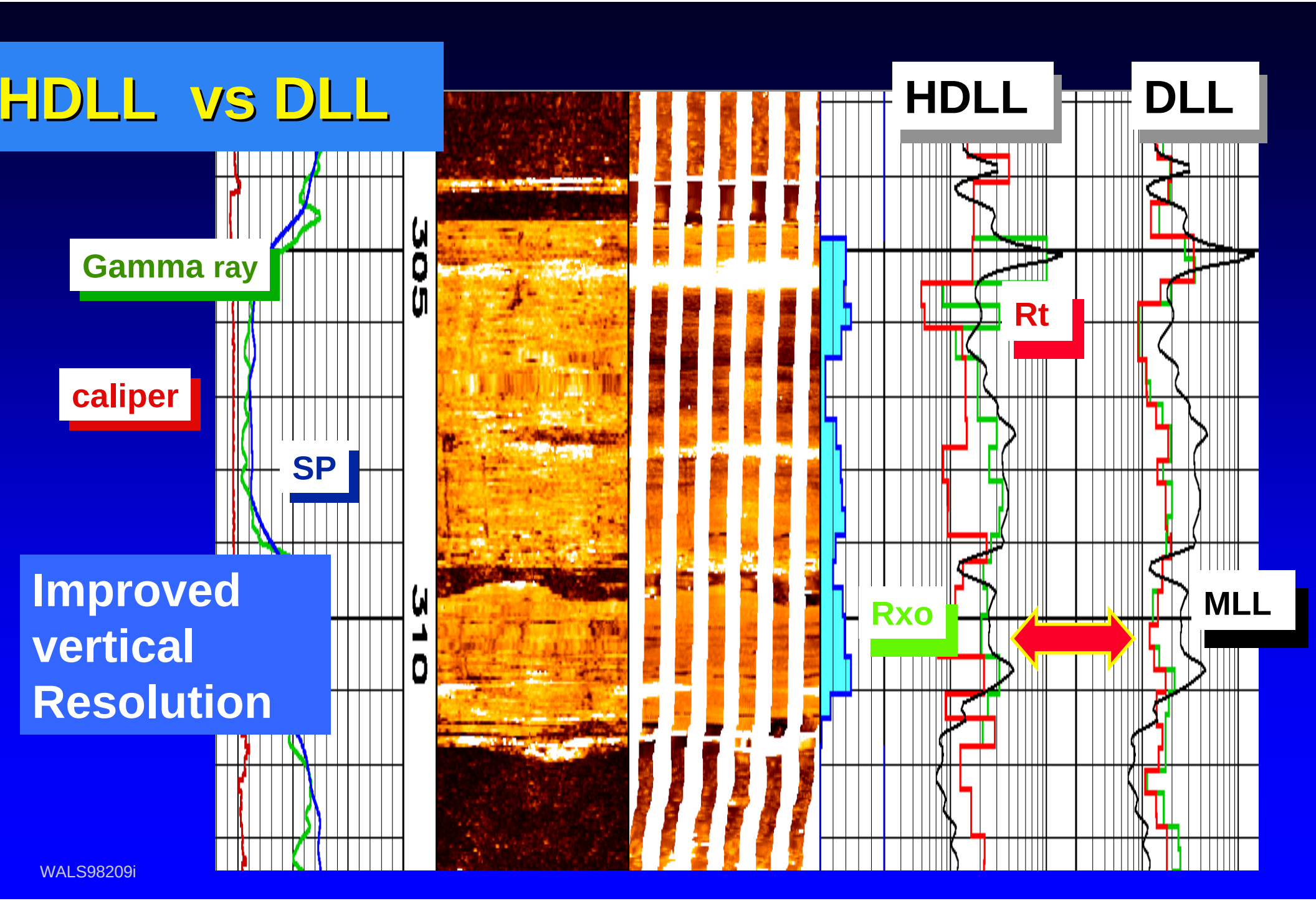
OIIP = (A*h)*Por*(1-Sw)

A= 160 acre
Assume 7,758 API Bbl/acre-foot
1 Bbl = $22

OIIP	**14,912,427 Bbl**	**16,173,193 Bbl**
Value	**328 M$**	**356 M$**

	2 ft VRM Curves	2D Inversion
h	67.00 ft	74.75 ft
Por	25.8%	25.9%
(1-Sw)	69.5%	67.3%

HDLL vs DLL



Improved vertical Resolution

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Outline

- Objectives
- Array tools: The Present
- **3D volume integration: The Future**
- Conclusions

How from Today to 'Pie in the Sky' (10 years)

- Future technology already exists
- Future is a different use of existing components
- Aligned along maximum benefit (economic, technical)
- Virtual computing brings revisiting

Path

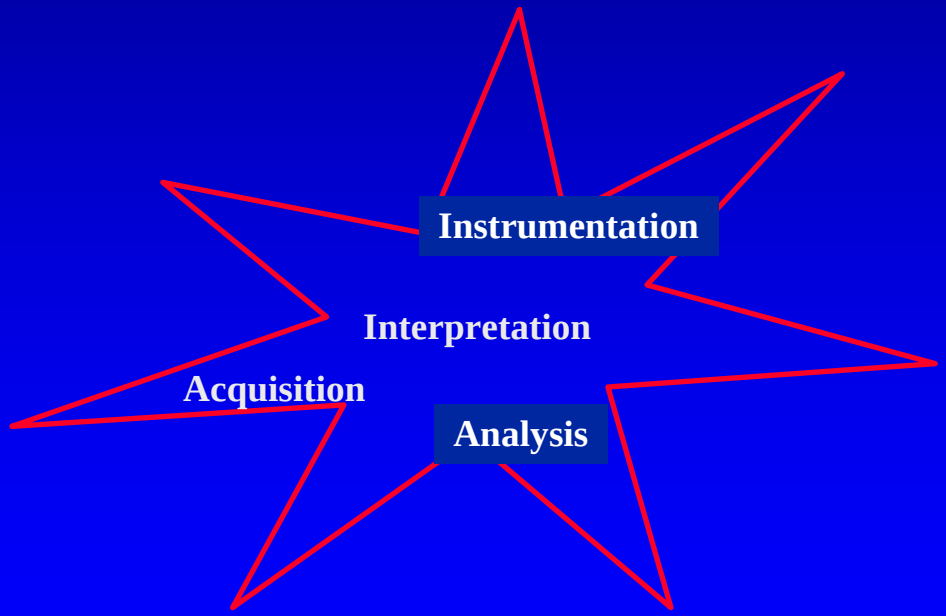
- Identify objectives
- Identify components… delivery vehicle: 3D cube

DeepLook: Vision

Breakthrough

Now → **Vision 2000**

Bypassed production
Mis-positioned wells
Low well productivity
Expensive testing
Reserves uncertainty
Aquifer drive ??



70%+ recovery

Optimal well targeting

Right facilities

Minimum water production

<35% **Pilot Projects** **70%**

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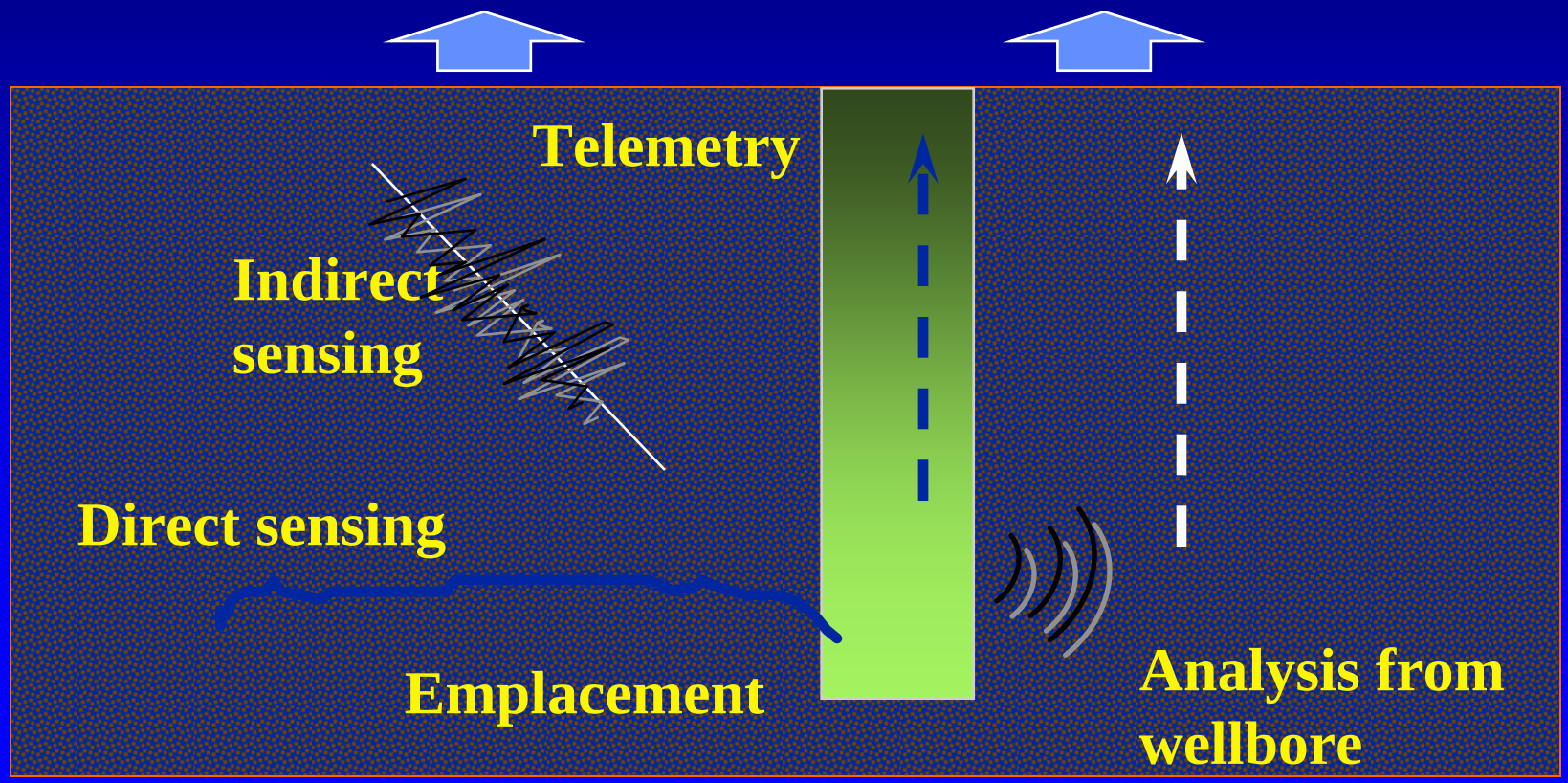
Key Enabling Technologies



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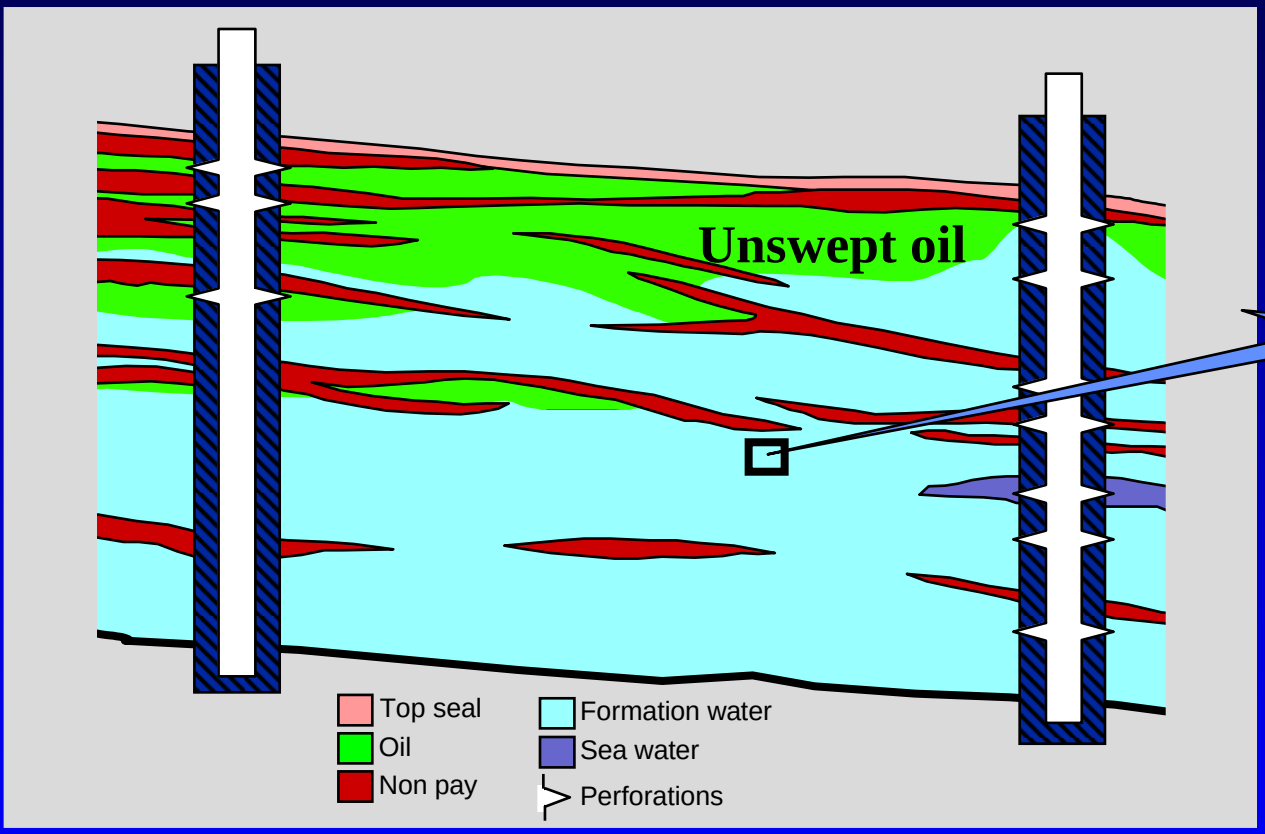
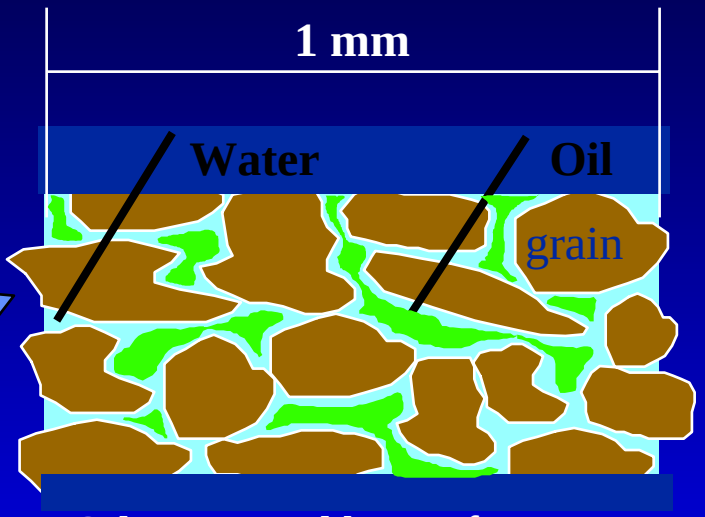
Scope of the Challenge





Oil is trapped by surface tension and structure.

Formation Evaluation Trends

- **Reservoir/production: Drainage**
  - **Measurements:**
    - **NMR (fluids, texture), Susceptibility (mineralogy), Stress & structure (fractures, interwell geology), Horizontal well (guidance, assessment), Through-casing (existing reservoirs)**
  - **Modeling & Inversion (logs and integration)** → **UNCERTAINTIES**
- **Deep investigation techniques: The Next Generation**
  - **Cross-well techniques…selective cases**
  - **Single well/ cross-well seismic**
  - **Single well EM**
  - **Borehole gravity**

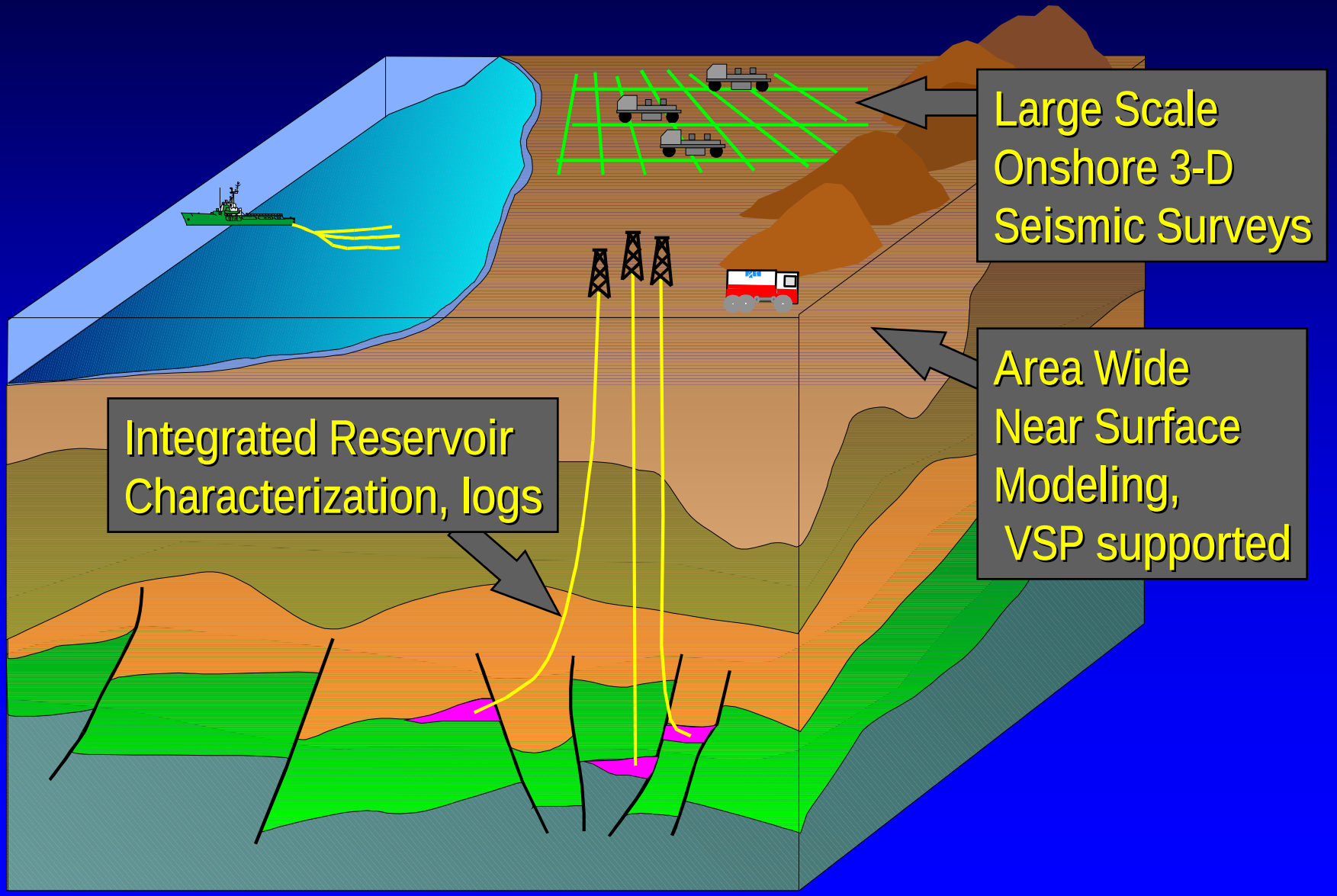
JOINT technology gives answer

Shopping list:

- Optimum use of MWD & wireline
  - MWD: routine and steering
  - wireline: imaging and deep
- Advanced logs: mineralogy, downhole analysis..
- Downhole laboratories & factories

  - tie with SWD to seismic cube

Glue to the Information puzzle



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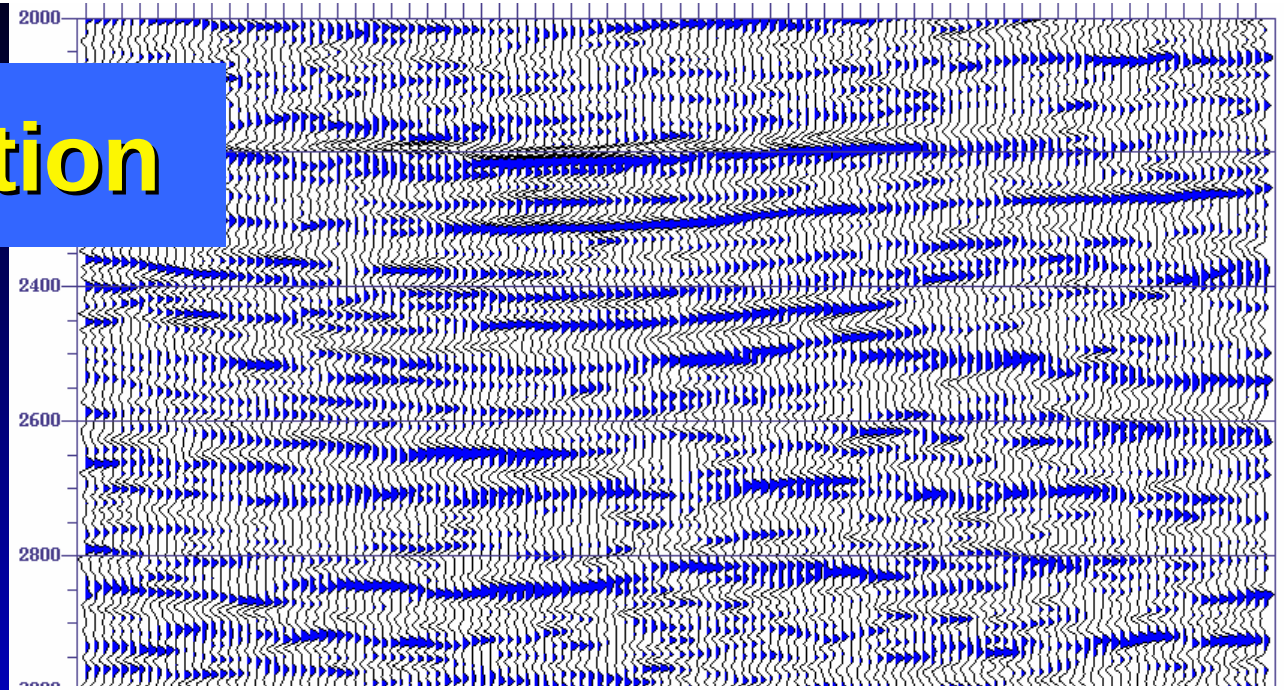
Glue components:

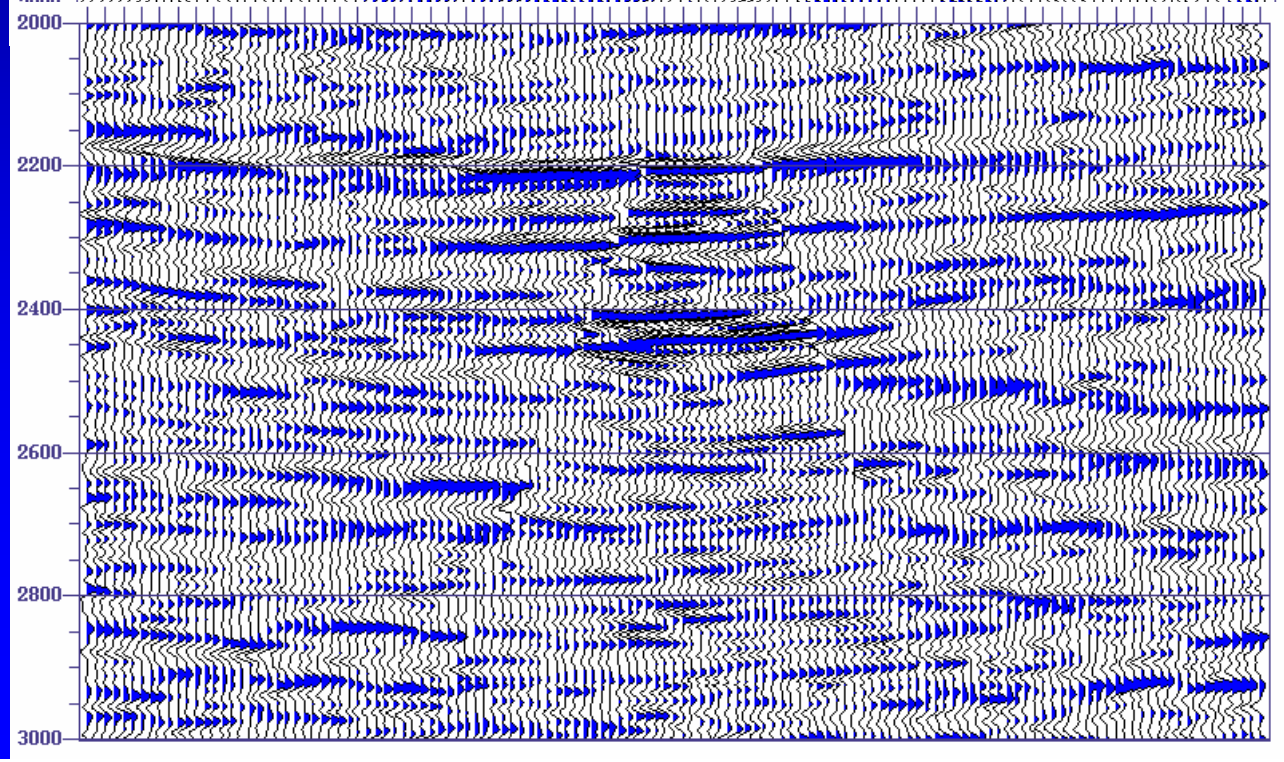
- 3D VSP
- Cross-well seismics
- Hole-to-surface EM
- Borehole gravity
- Sub-seismic fracture mapping
- Geostatistics

3D VSP integration

3D Time
surface seismic migration
processed by ELF



3D VSP Migration
(depth-to-time conversion)
pasted into
surface seismic migration



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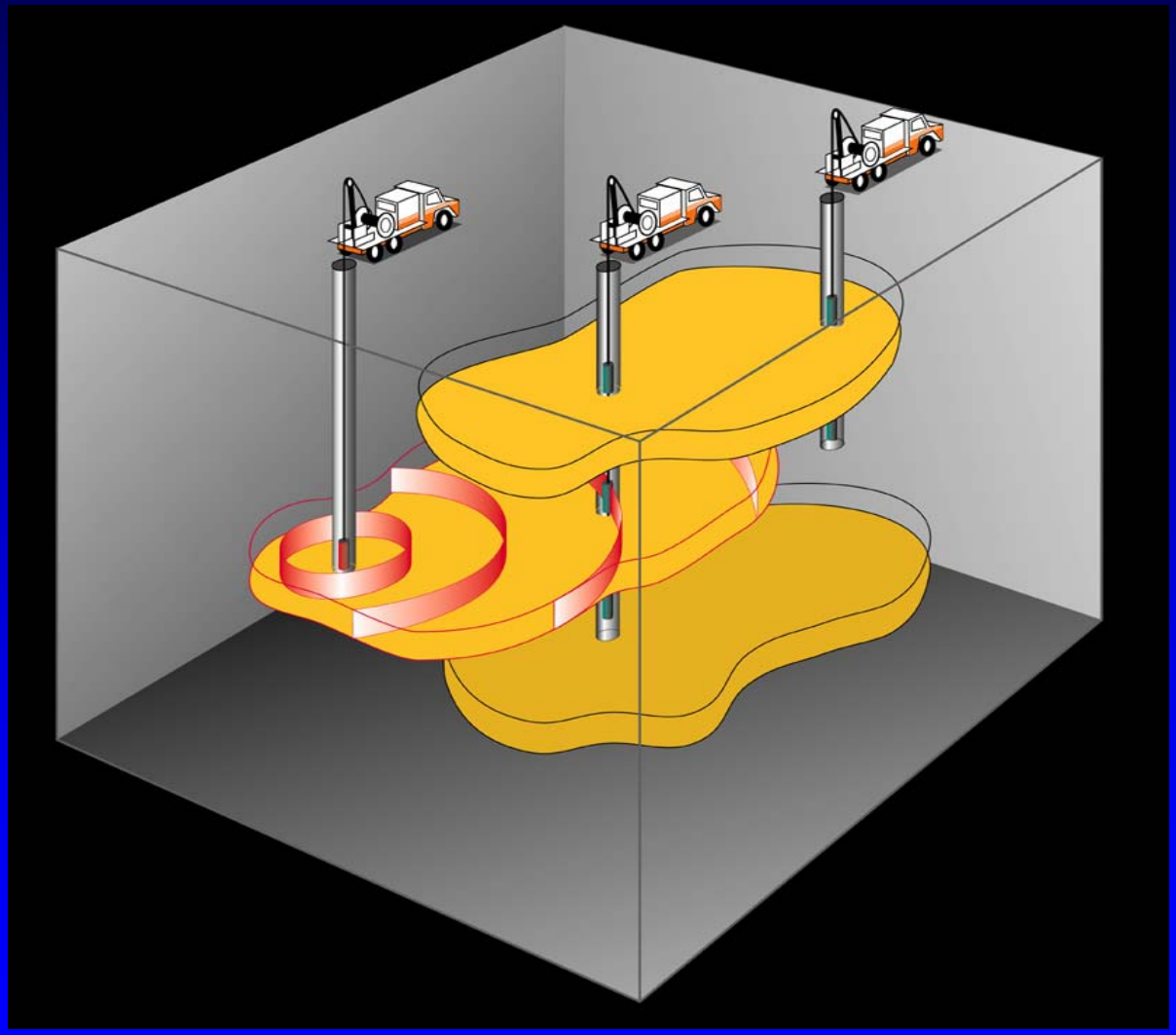
Reservoir Connectivity Mapping (RCM)



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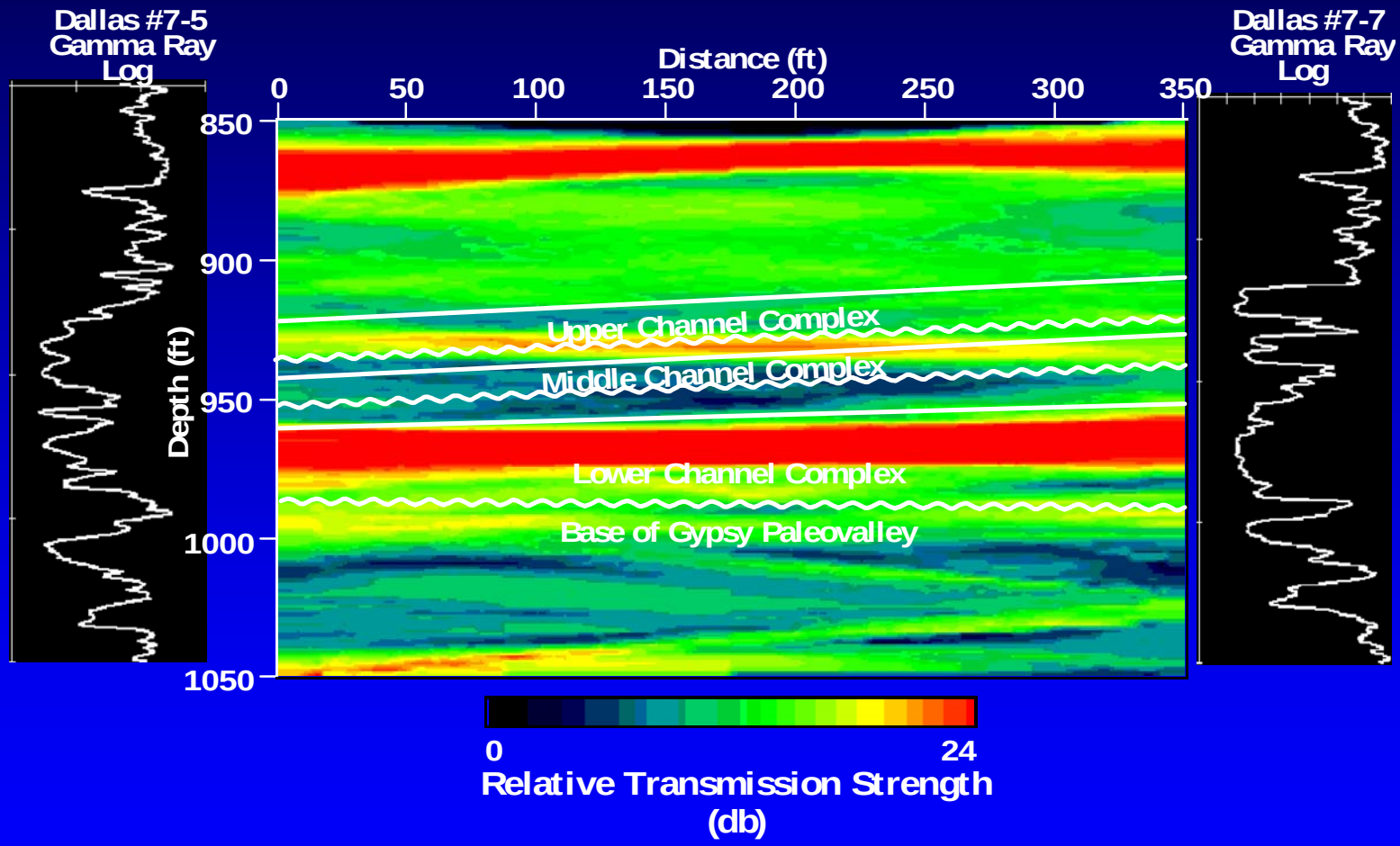
Reservoir Connectivity Map

Gypsy Pilot Site
with pre-survey geologic correlations



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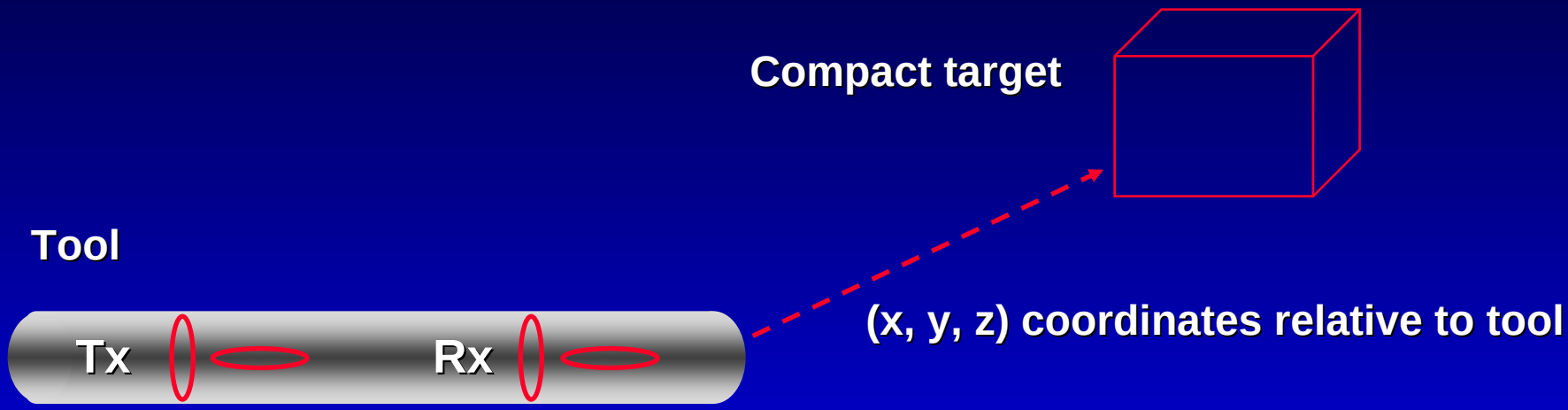
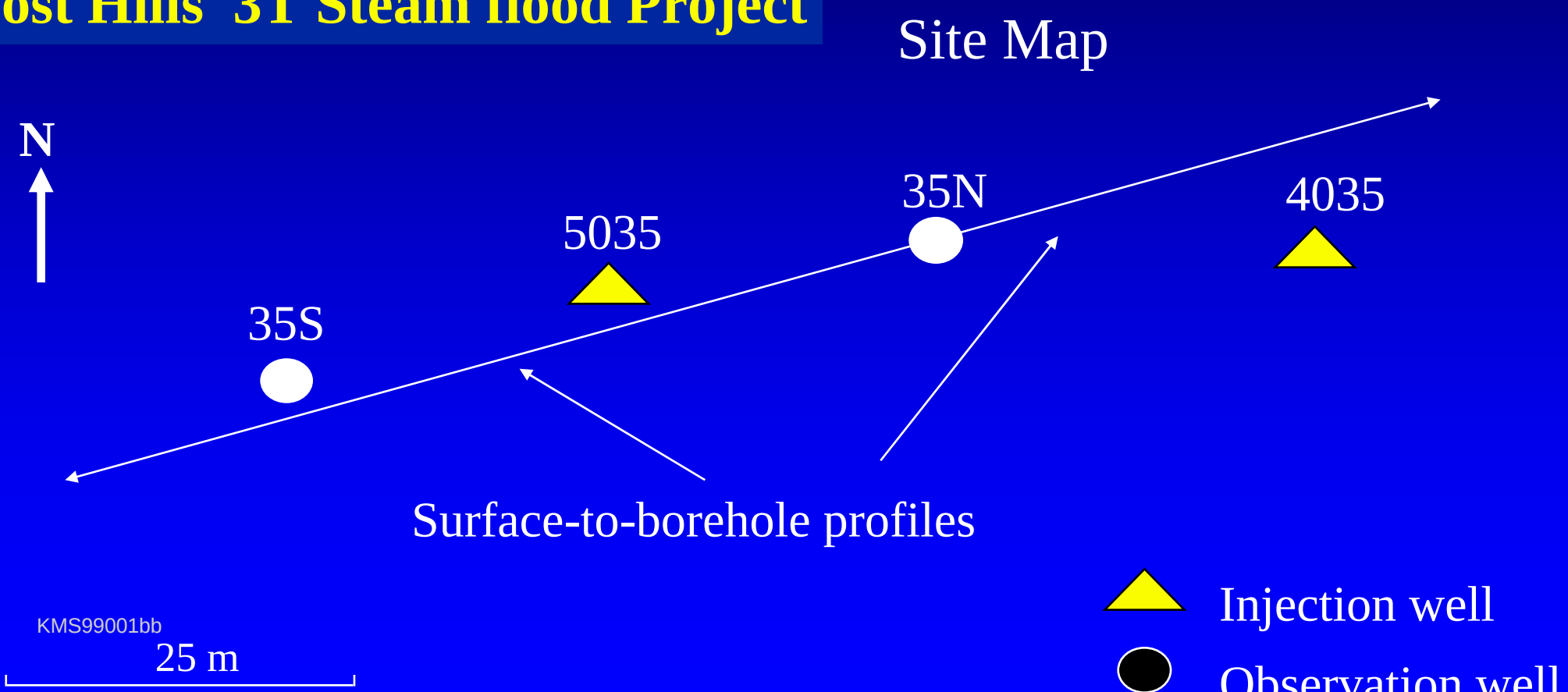
Directional Sensitivity - EM



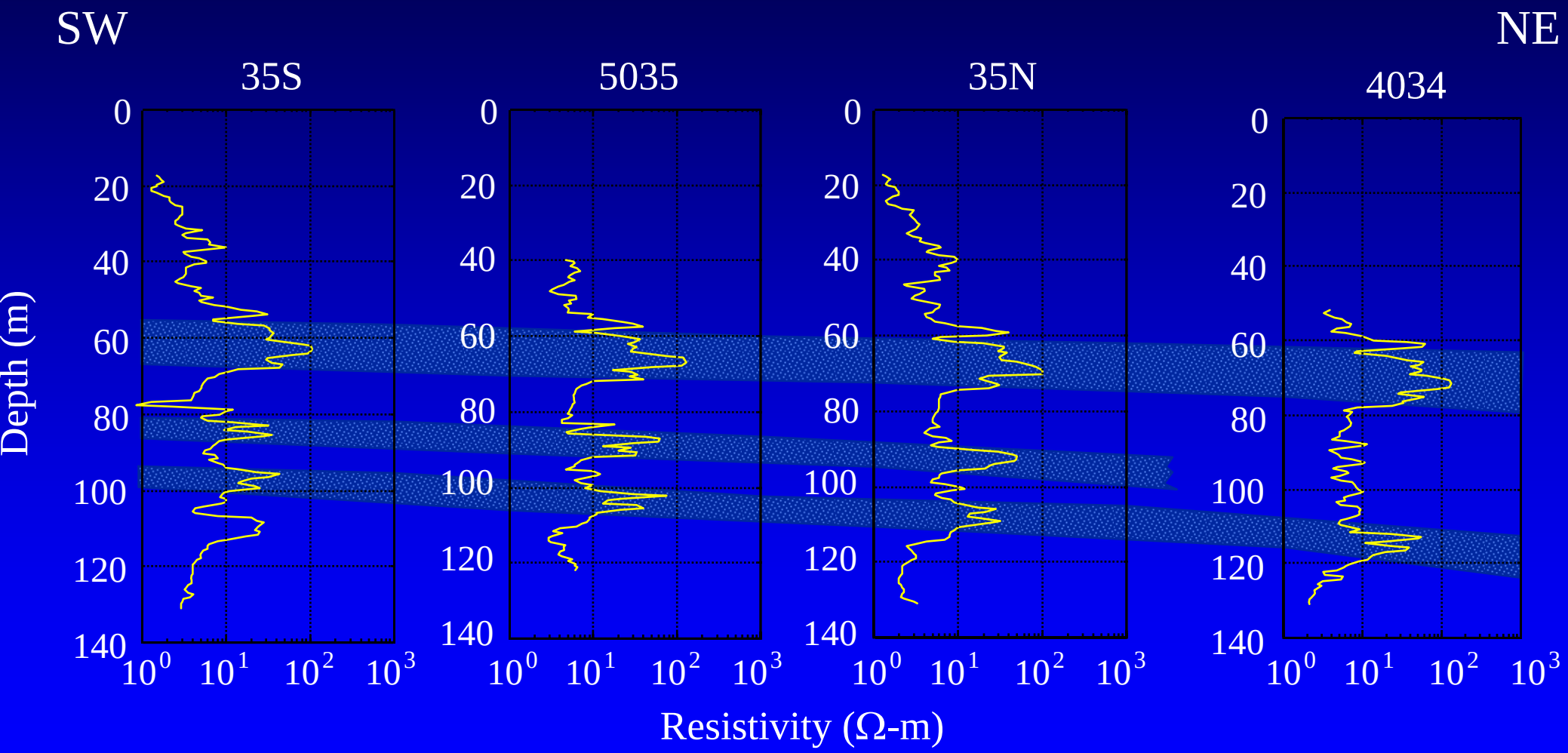
Can pinpoint location of compact target in uniform host, plus sign and magnitude of conductivity contrast

Surface-to-hole EM

Lost Hills 3T Steam flood Project



Borehole Induction Logs



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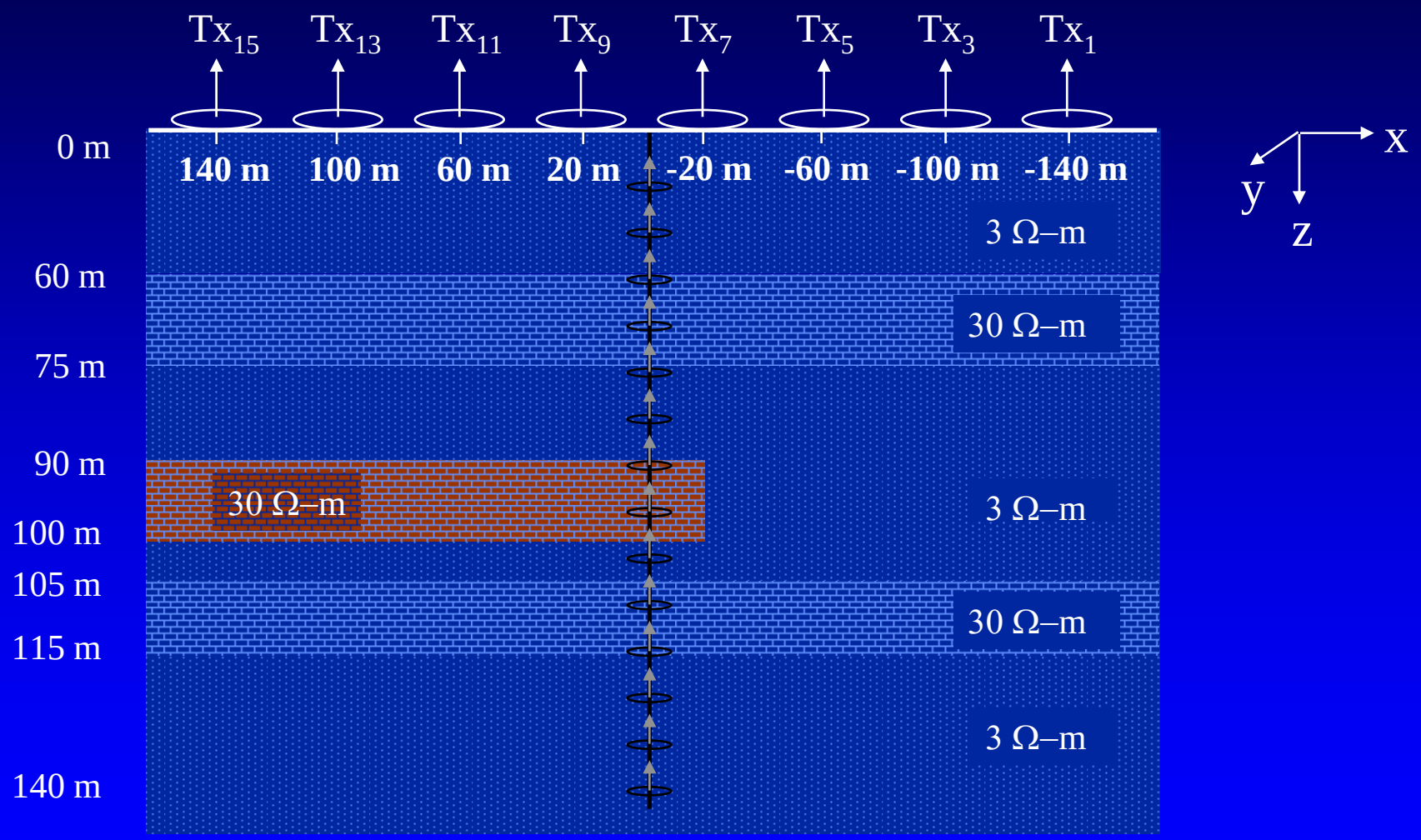
0 m 25 m 50 m 90 m

Oil-Water Contact model - EM



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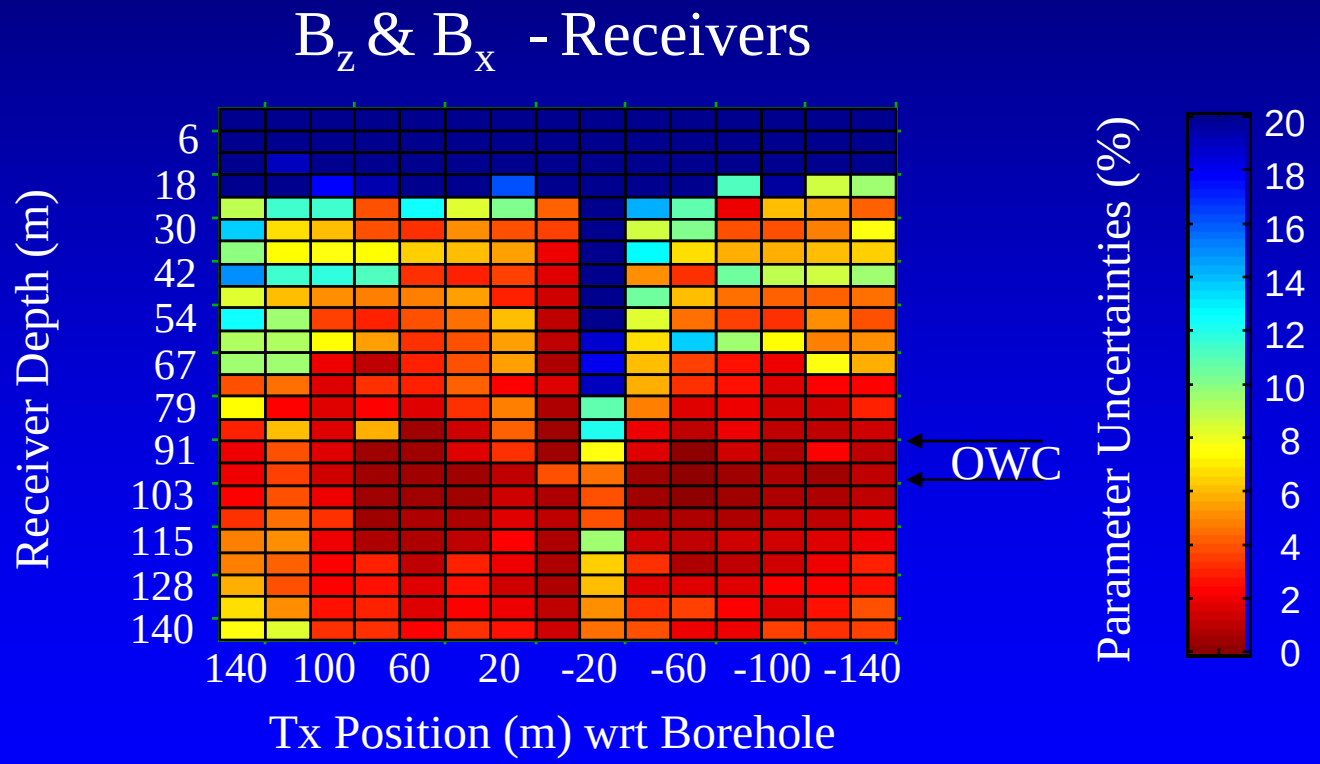
EM - Resolution Analysis - **OWC Model**



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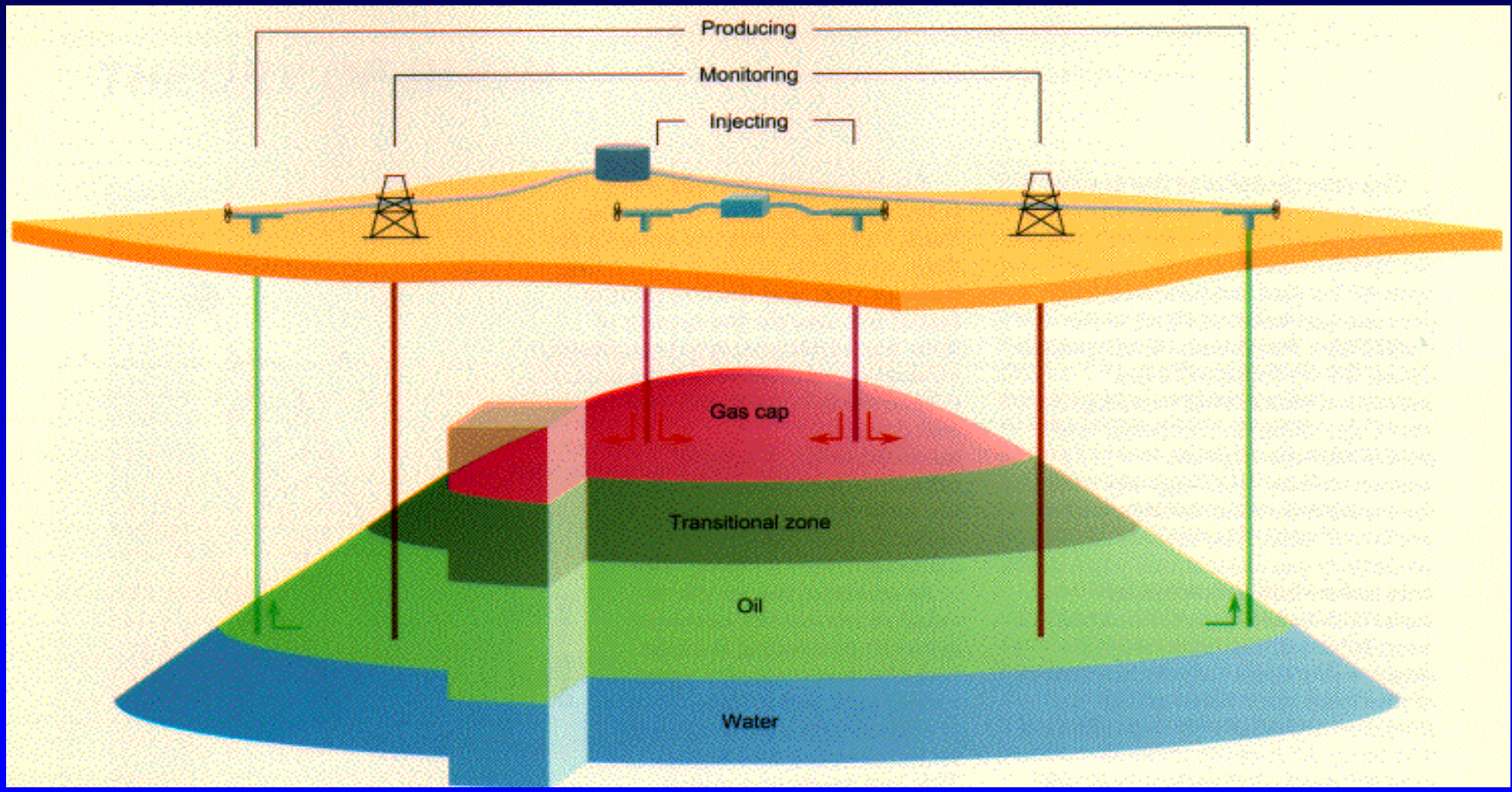
Traditional Oil and Gas production



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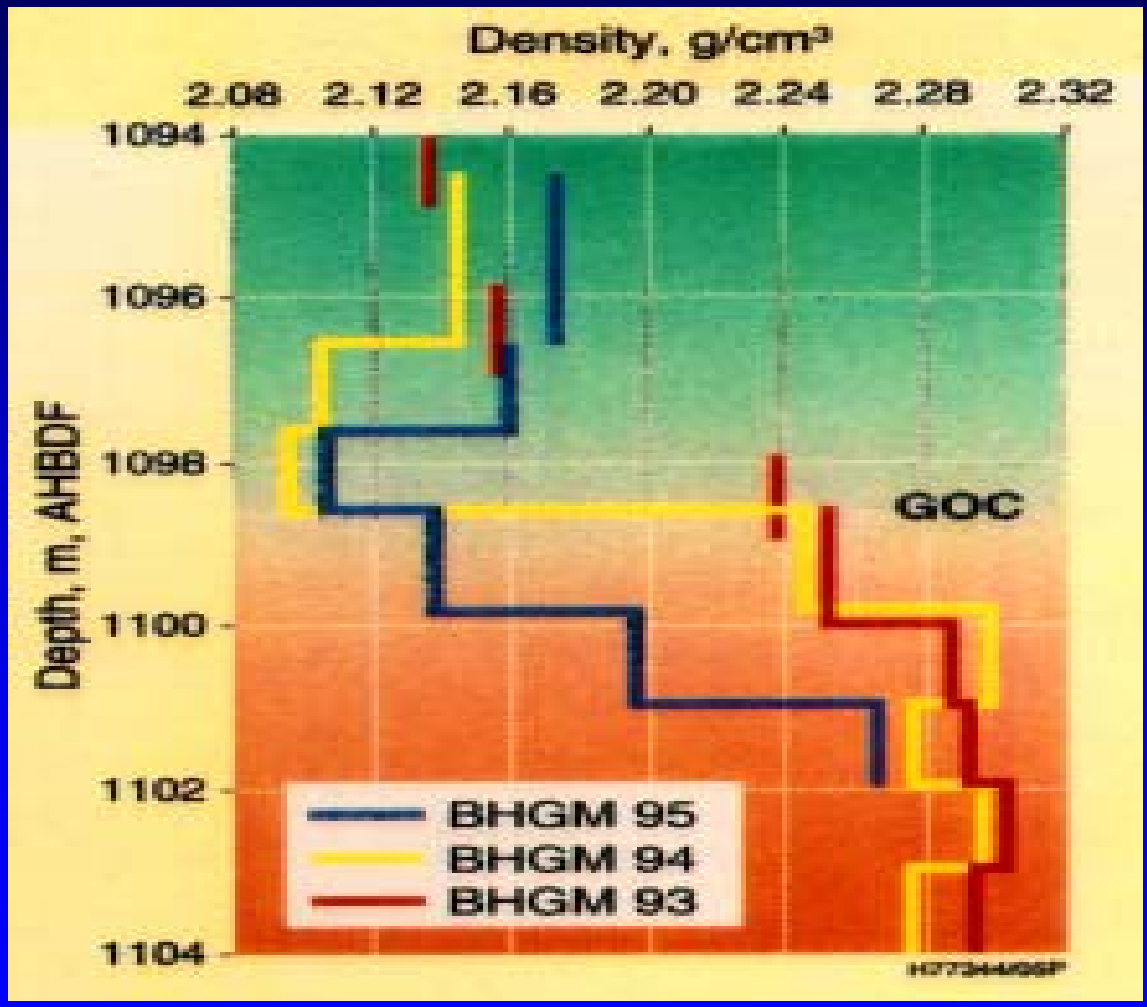
BHGM-Derived Densities for 3
Annual Surveys in the RABI Oil-Rim

Repeat BHGM densities across Rabbi field gas/oil contact in Gabon.

Porosity: 24%,
Gas ρ : 0.082 g/cc,
Oil ρ : 0.780 g/cc.



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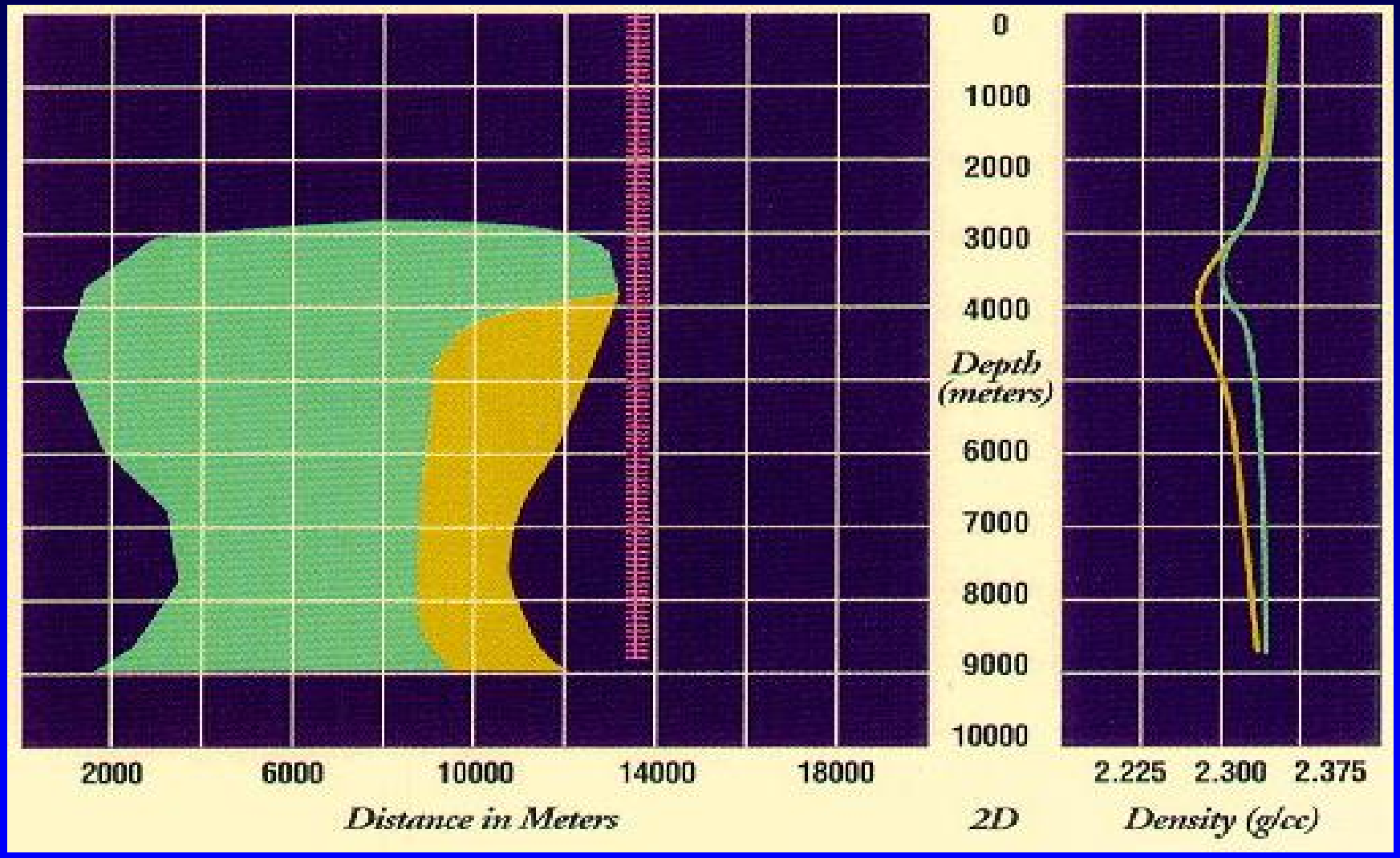
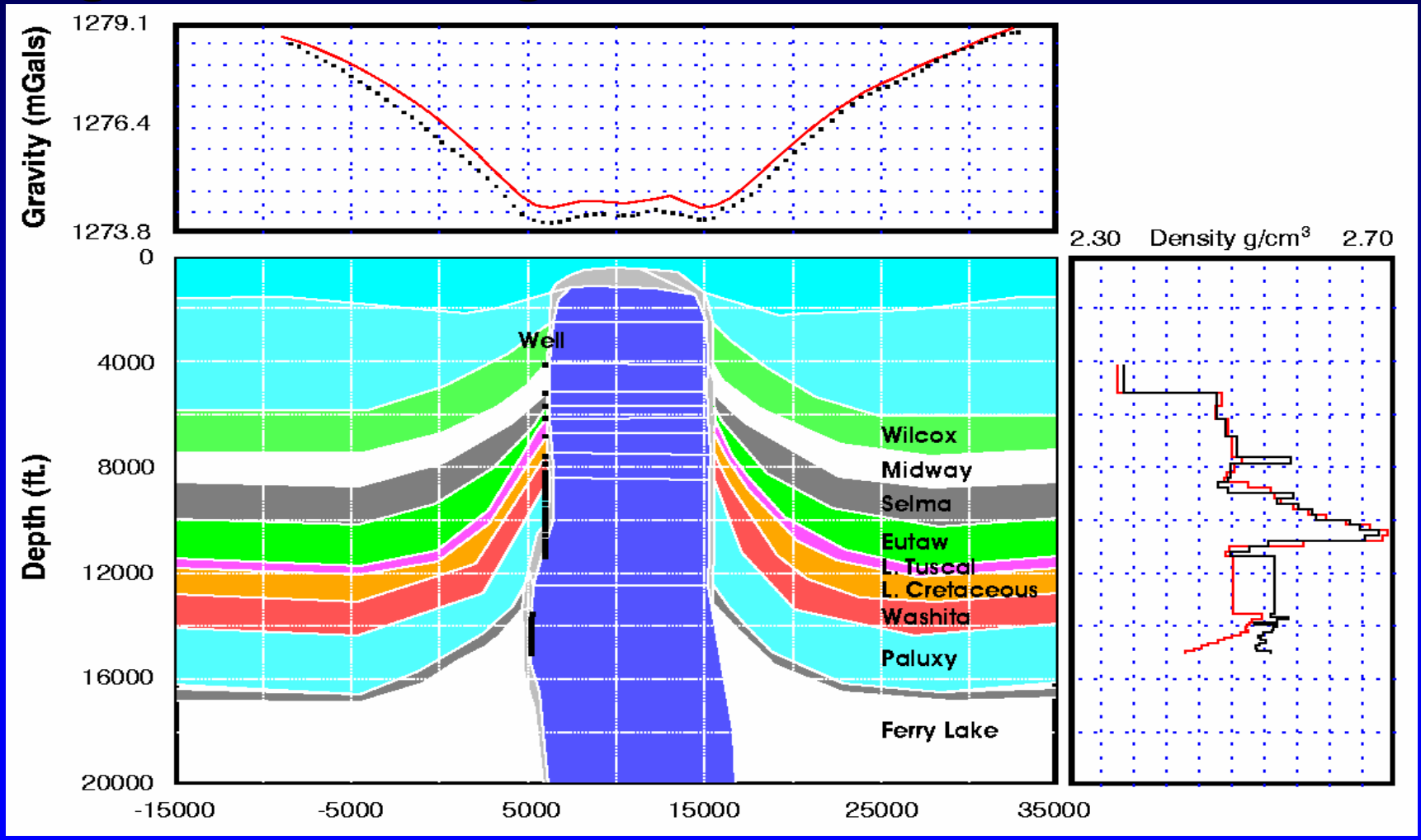
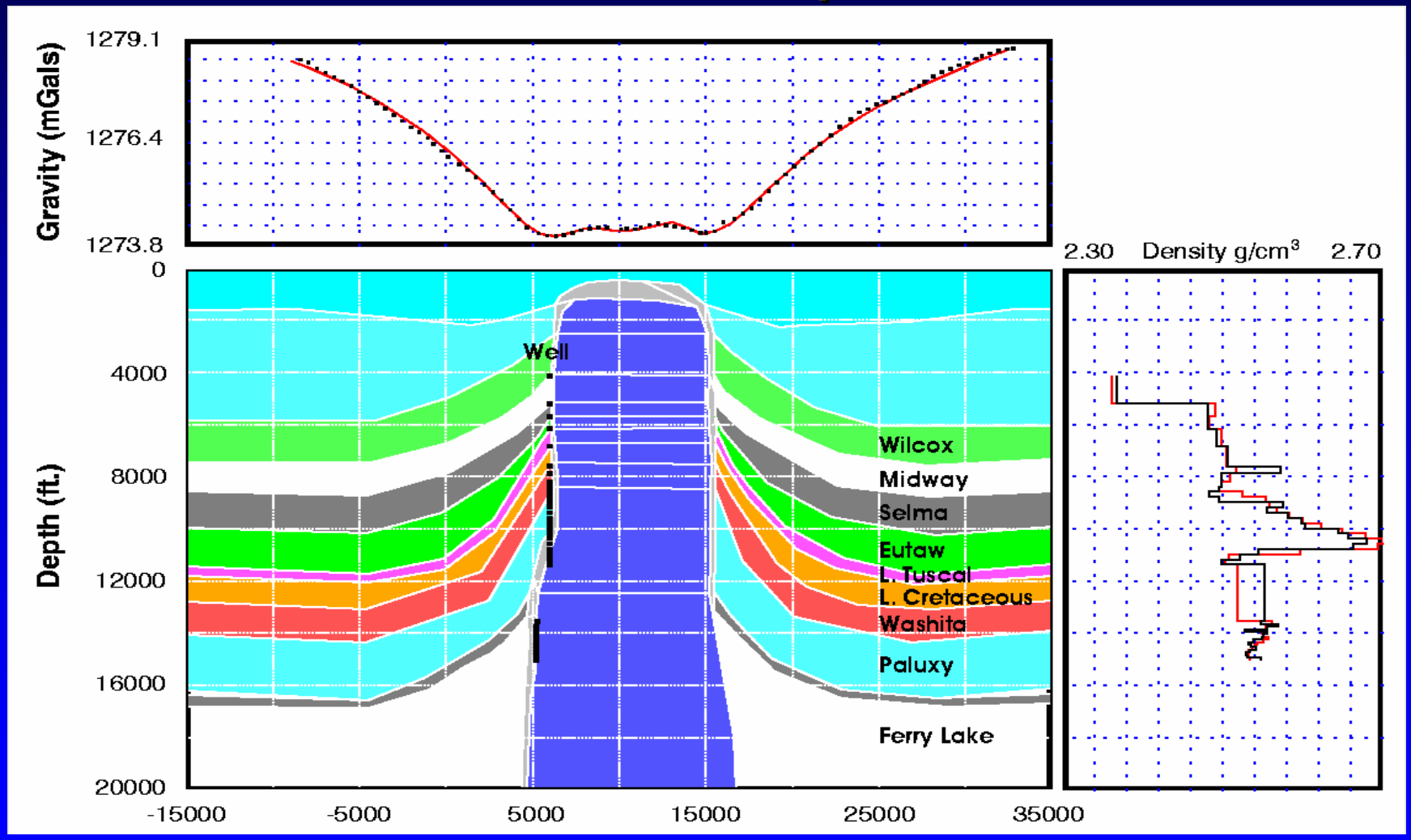
Structural Effect of Salt Overhang



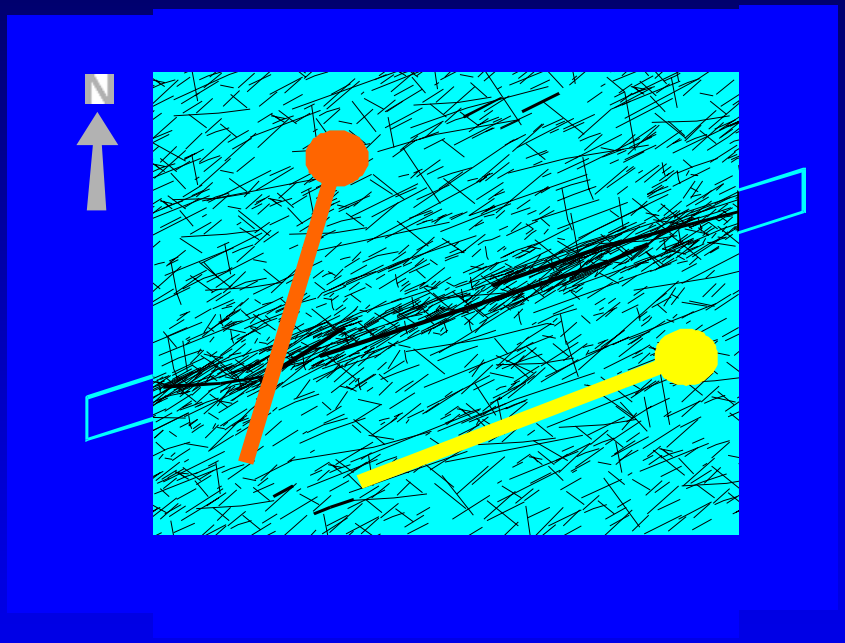
BHGM field (black) & model (red) response to Slight Overhang



Final interpreted Shape of Salt Dome with field and model BHGM responses



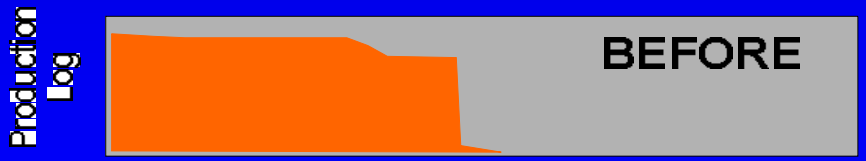
Sub-seismic fractures from STAR

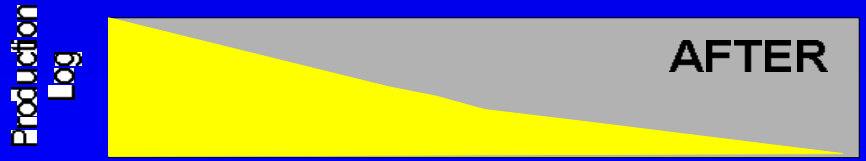


POST-STUDY DRILLING STRATEGY

Avoid 'super fractures' with injectors and producers - ENE well trajectories

Maximize contact with matrix and small fractures - inclined wells





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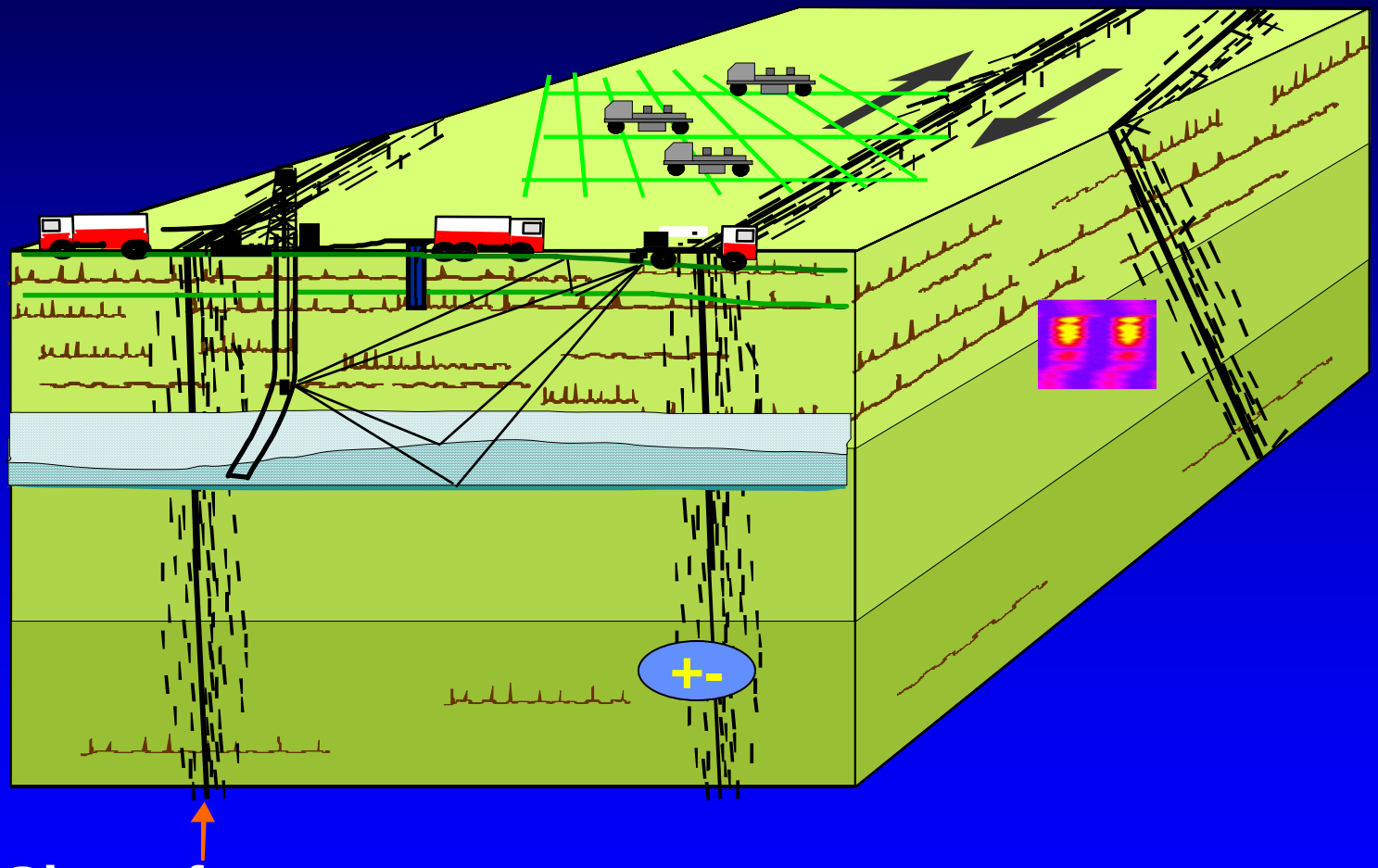
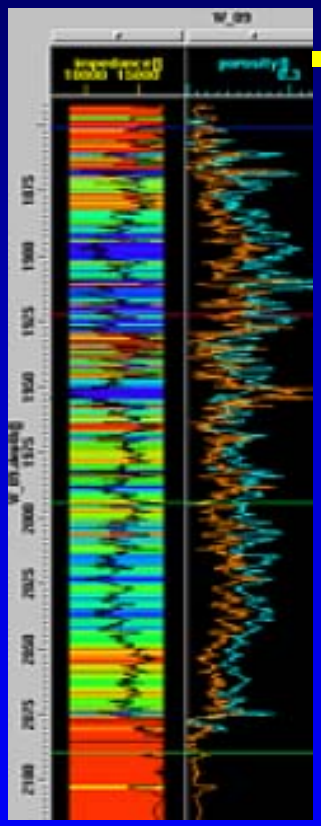
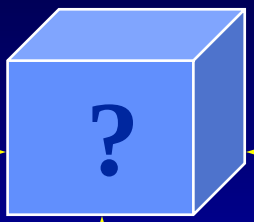
Fractured reservoir example

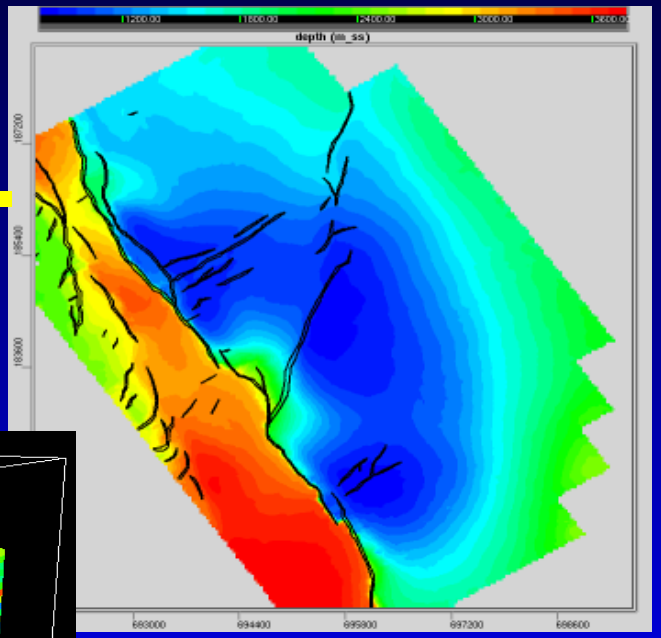


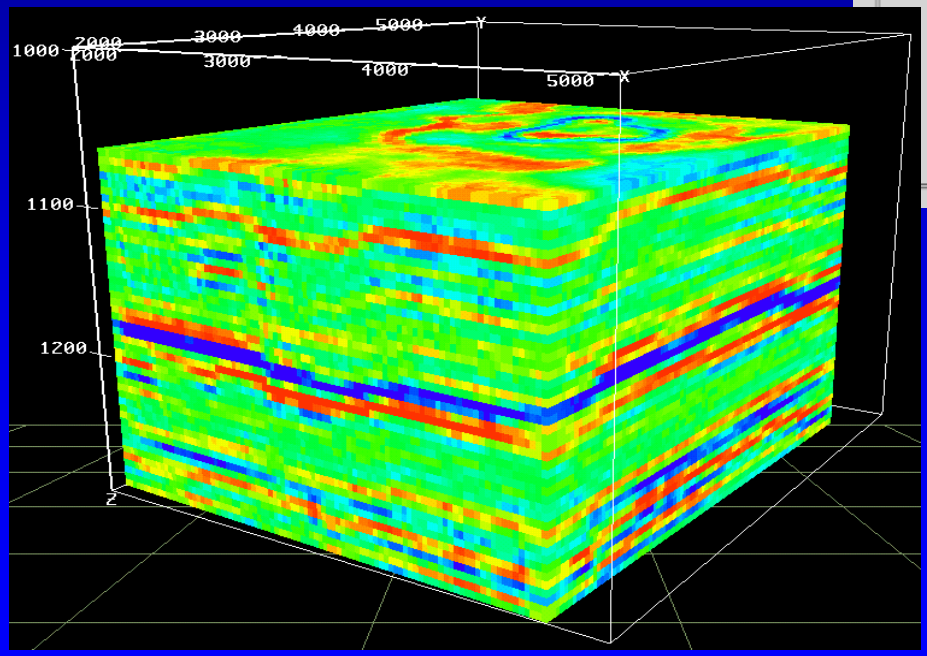
Shear fractures

Creating the 3-D Reservoir Model

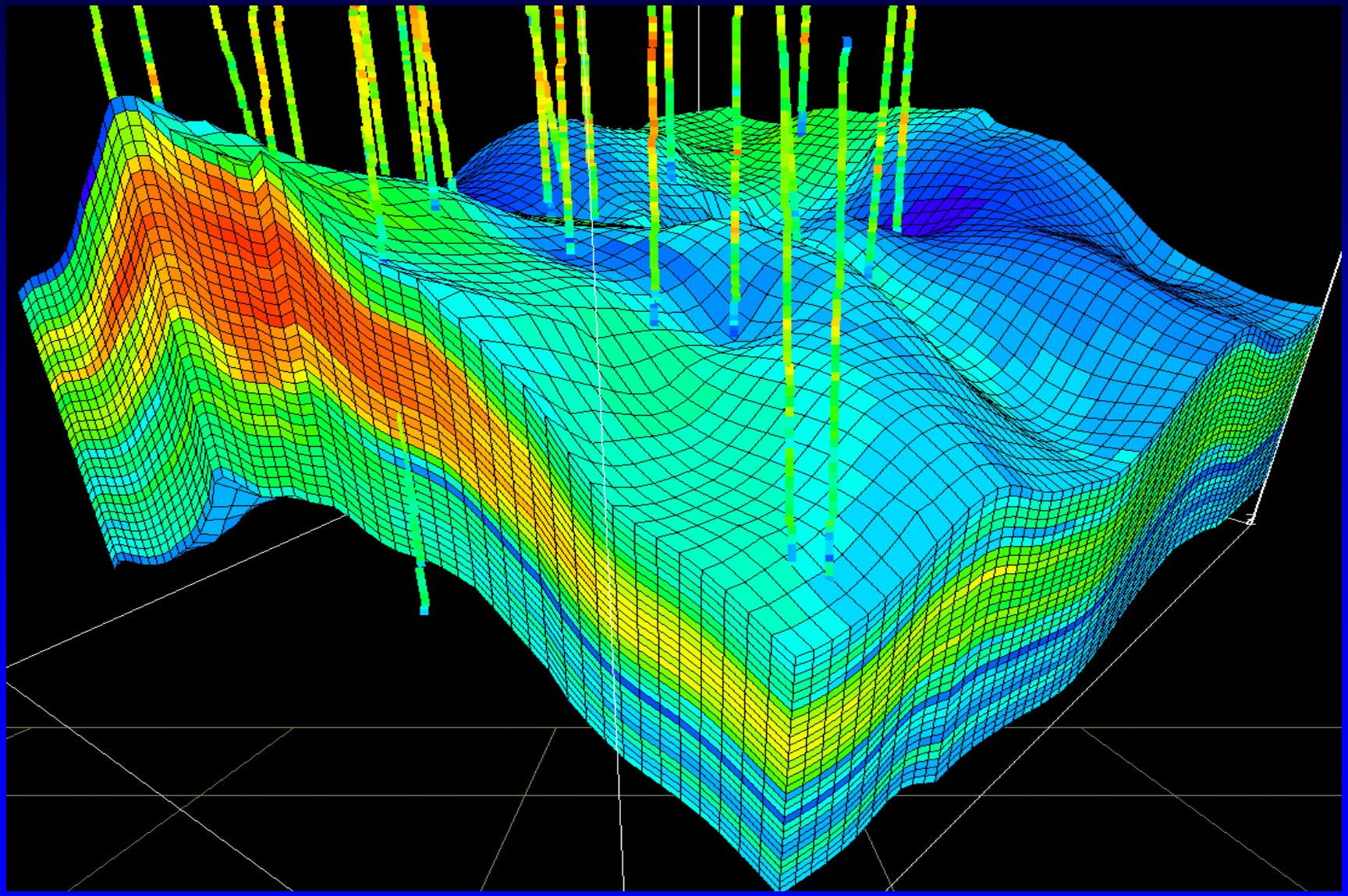








Geostatistically-Derived Porosity Model



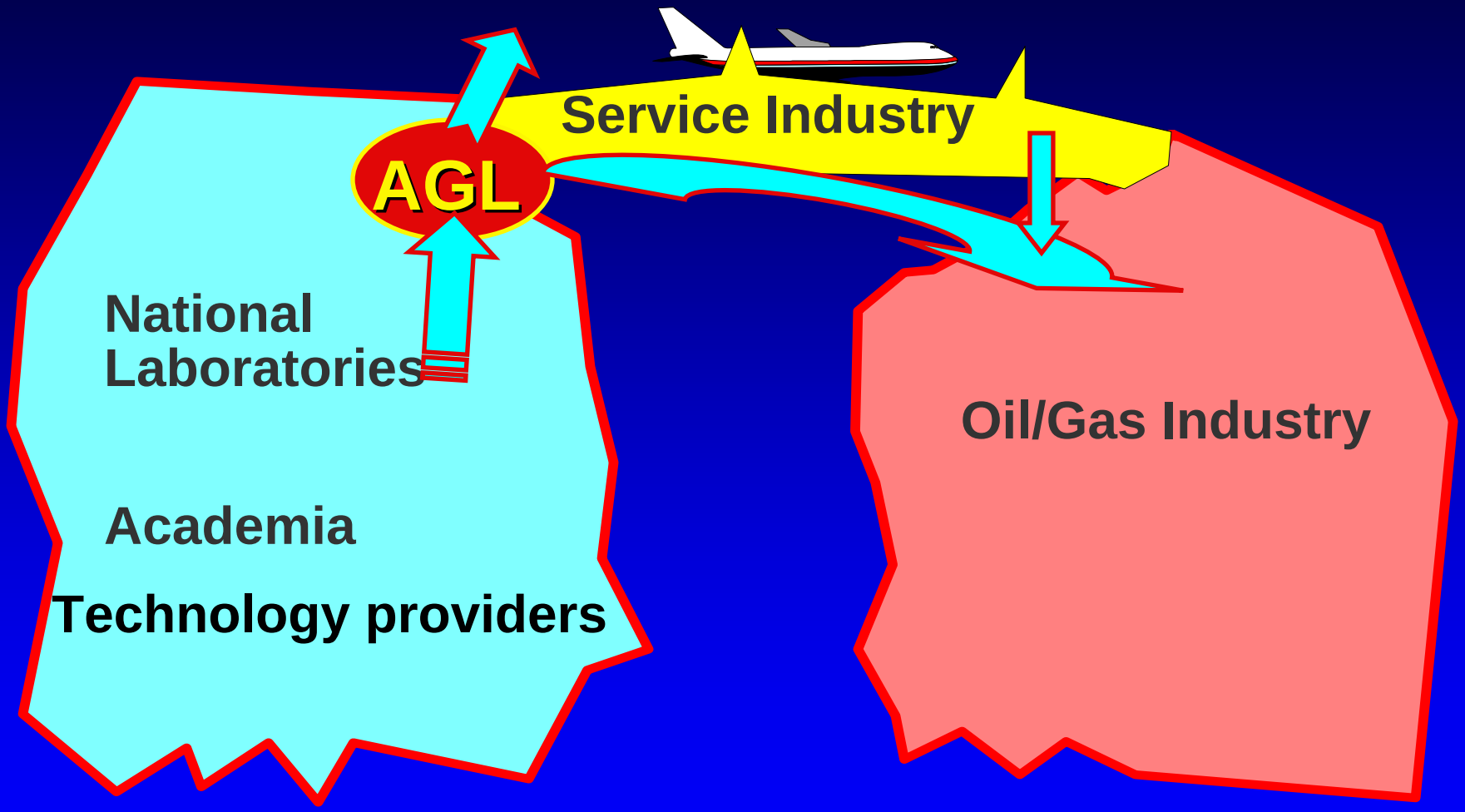
Outline

- Paradigm Shift
- Array tools: The Present (my past)
- 3D volume integration: The Future
- Conclusions

Conclusions

- Advances driven by state-of-the-art
- Economic drive fuels the progress
- Integration provides added value
- General technologies (i.e. computing) will provide environment & continuous changes
- Objective: populations of 3D cube (tie to geology & seismic)

What would I do???



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