PTTEP
Geophysics Technology:
3.1 Reservoir Characterization

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Outline

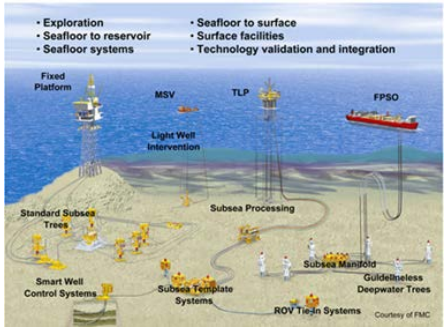
- Oil & Gas Industry Outlook
- Key Reservoir Characterization Technologies

What is the world focusing today?

E & P Focus

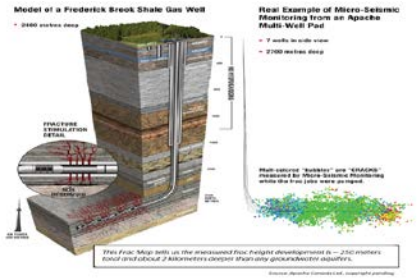
Conventional Oil/Gas

Deepwater



Unconventional Resource

- Heavy Oil/Oil Sands
- Shale Gas/Tight Sands



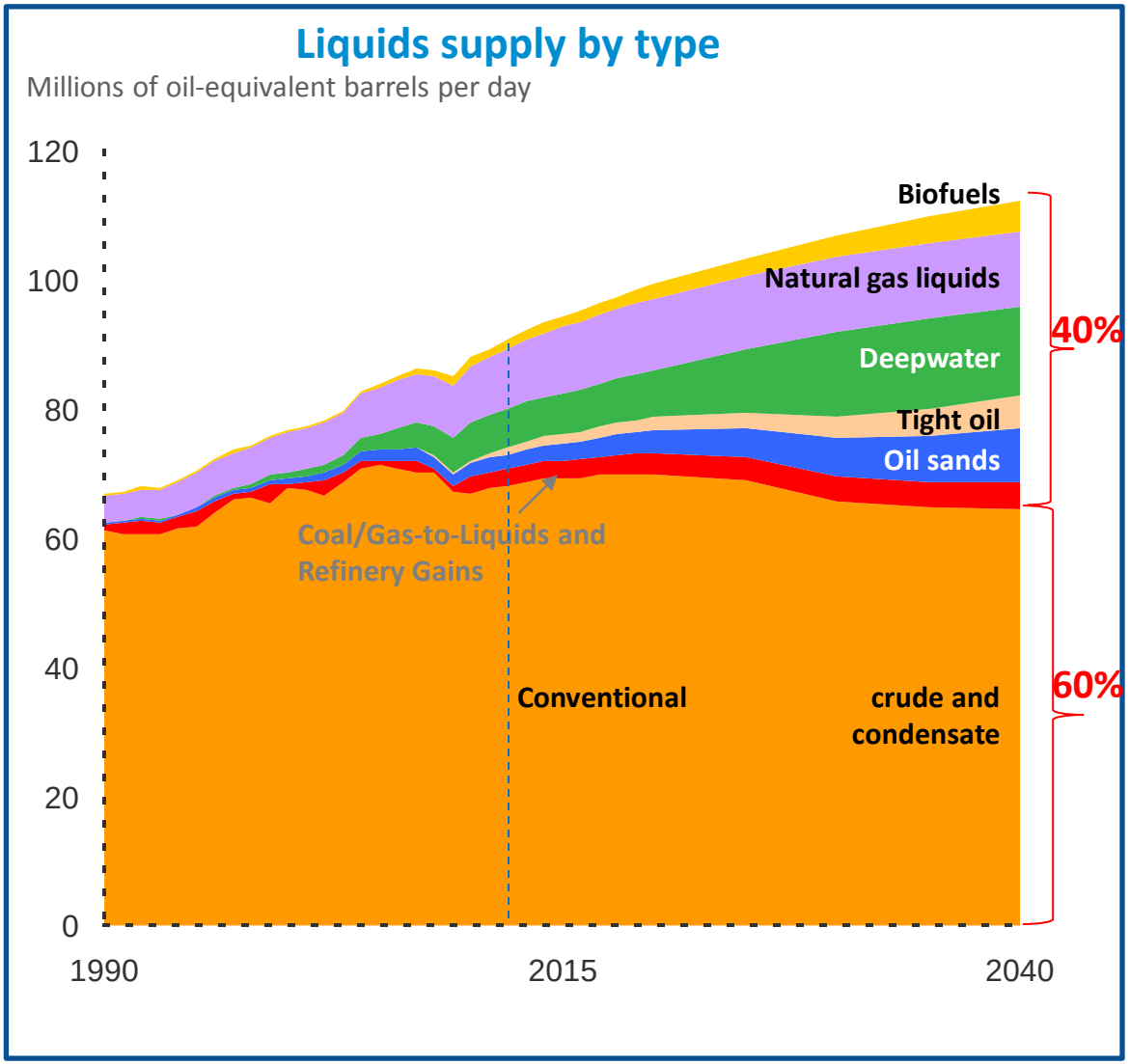
EOR (Enhanced Oil Recovery) Mature Field

Hash Environment

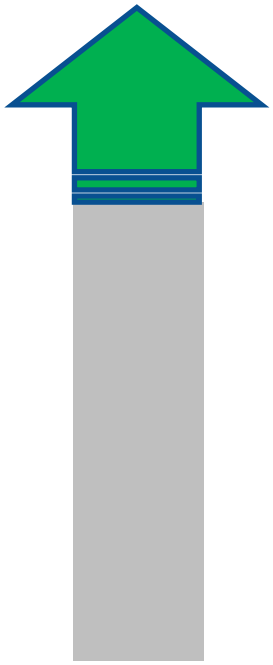
Arctic ice is melting at a record pace, suggesting the region may be ice-free during summer within 30 years. Photograph: Alexandra Kobalenko/Getty

Arctic Exploration

Why they are so focused?



Significant in creasing of Production comes from Unconventional play & Deepwater



Modified from ExxonMobil 2012 Outlook for Energy

Where is PTTEP?: 44 Projects in 12 Countries

Exploration	21
Development	4
Production	19
Total	44

Project Location

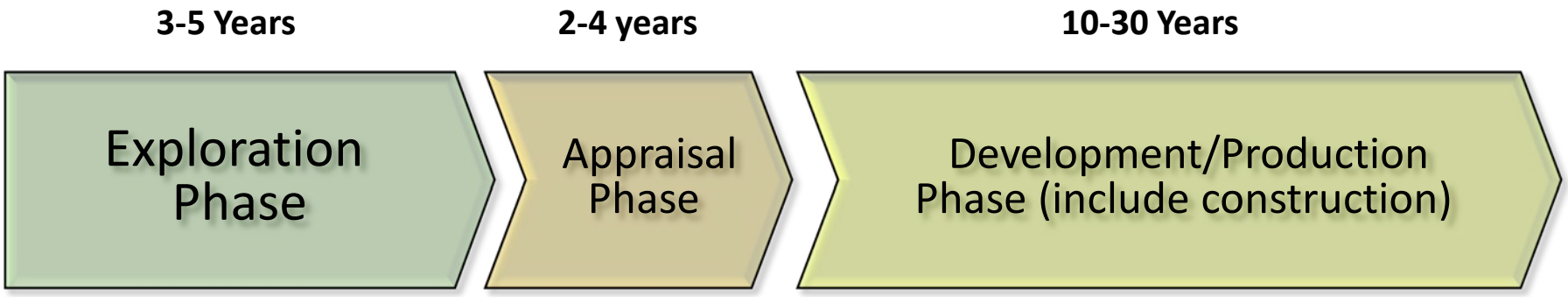
Key
Reservoir Characterization Technologies

Exploration/Production Life-Cycle

3-5 Years	2-4 years	10-30 Years
Exploration Phase	Appraisal Phase	Development/Production Phase (include construction)

Can Res Technology help to shorten Exploration period and prolong Production?

Normal Case



Preferable Case

What are the Key Reservoir Characterization Technologies?

Better Imaging Technology

- Seismic Acquisition Technology
- Seismic Processing/Imaging Technology
- Gravity/Magnetic
- **Electromagnetic**

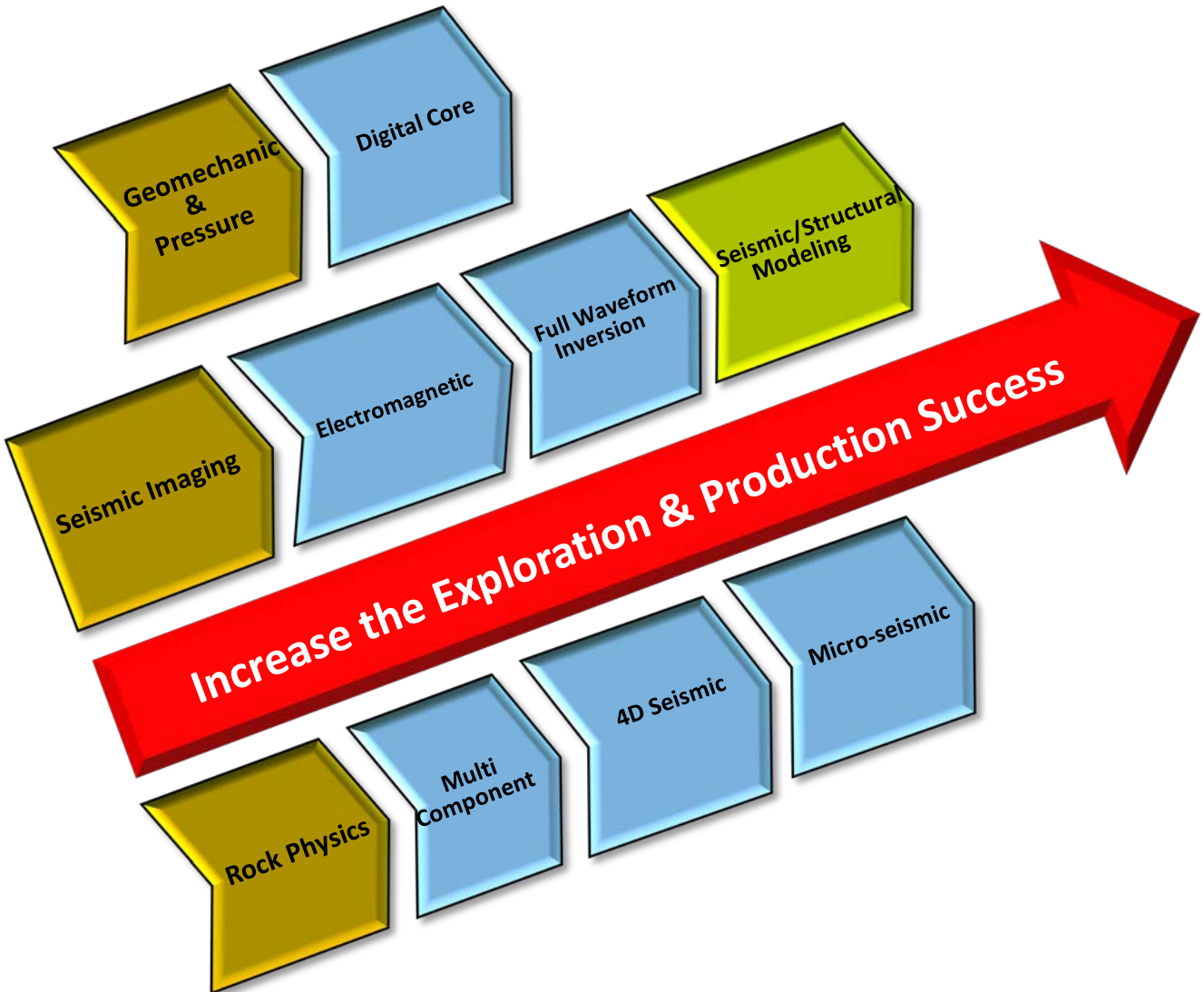
Understanding Geology & Reservoir

- Seismic Interpretation, Subsurface Mapping
- Seismic Sequence Stratigraphy
- **Rock Physics**
- **Direct Hydrocarbon Indicator (DHI)**

Monitoring

- 4D Seismic
- **Micro-seismic, and etc.**

PTTEP: Reservoir Characterization Technologies



- Better Image
- Understand Geology
- Understand Reservoir
- De-Risk Prospect
- Drilling Successful Well
- Add/Monitoring Production

- Increase Exp/App Success
- CAPEX/OPEX Optimization
- Reserves Add
- Increase Production

Micro-Seismic

Micro-Seismic Application

- Hydraulic Fracturing (Direction/Facture propagation)
- Monitoring

Micro-Seismic Application

Raw Data

↓

Preprocessing

↓

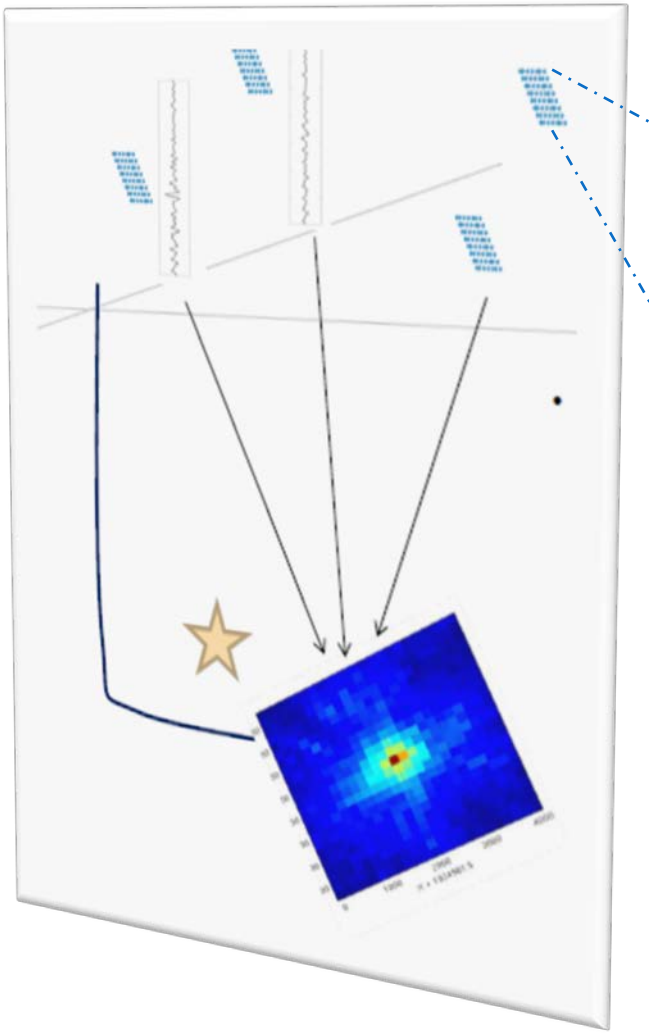
Detection & Location

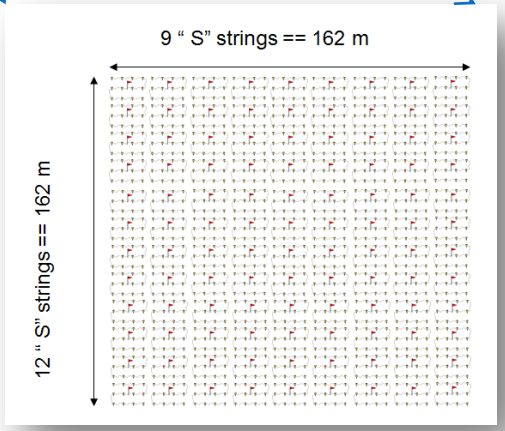
↓

Waveform Inversion

↓

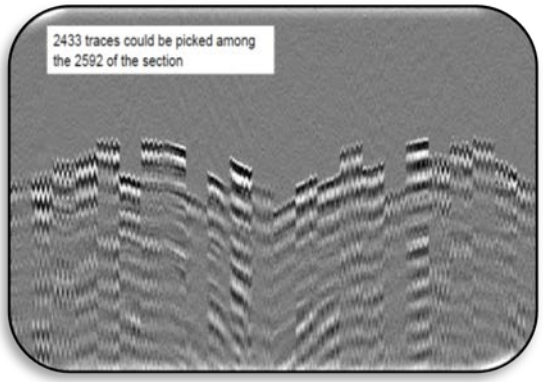
Maps





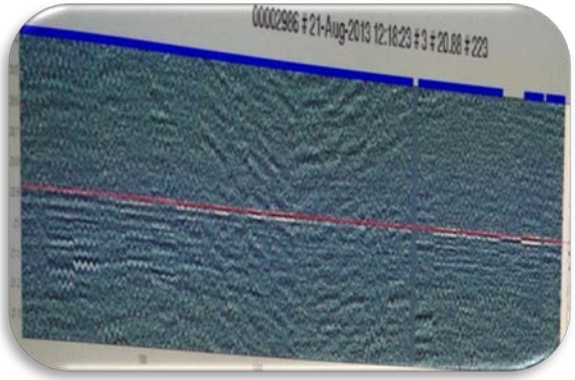
Ref: CGG, 2013

Micro-Seismic Application

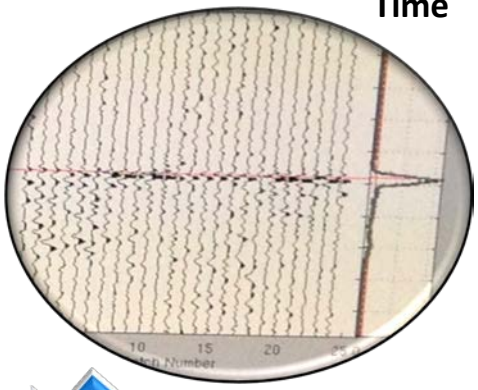


Record:
During Perforation

*



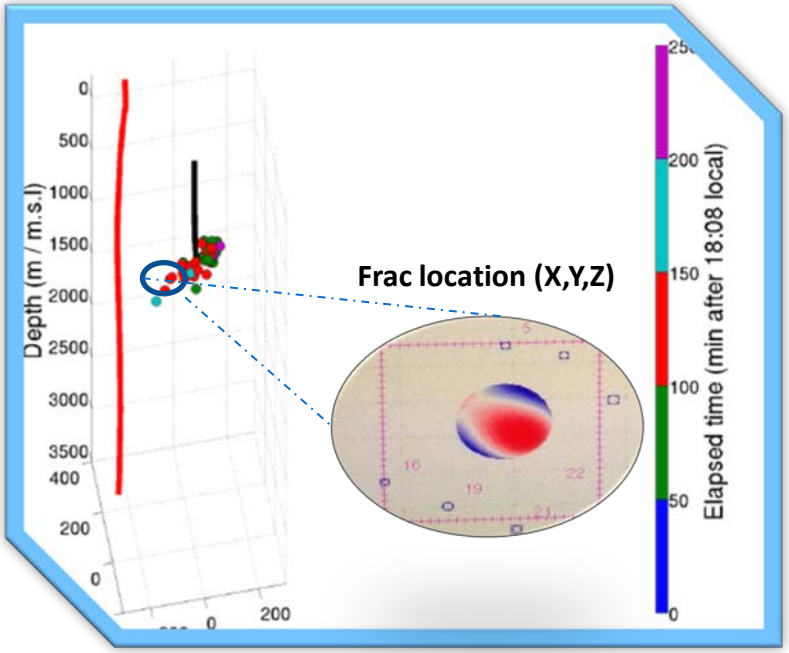
Record:
During Fracturing



Events:
After correlation

Detection:

- **Frac propagation**
- **Frac direction**
- **Frac length/width**



Ref: CGG, 2013

Full Waveform Inversion (FWI)

FWI Application

- Velocity Model for better imaging

FWI Methodology

Phase 1: Data pre-conditioning

=> Multiples and shear waves attenuation

Phase 2: Velocity model building and Migration

=> Iterative migration velocity analysis

Phase 3: Perform 2D FWI and parameter tests

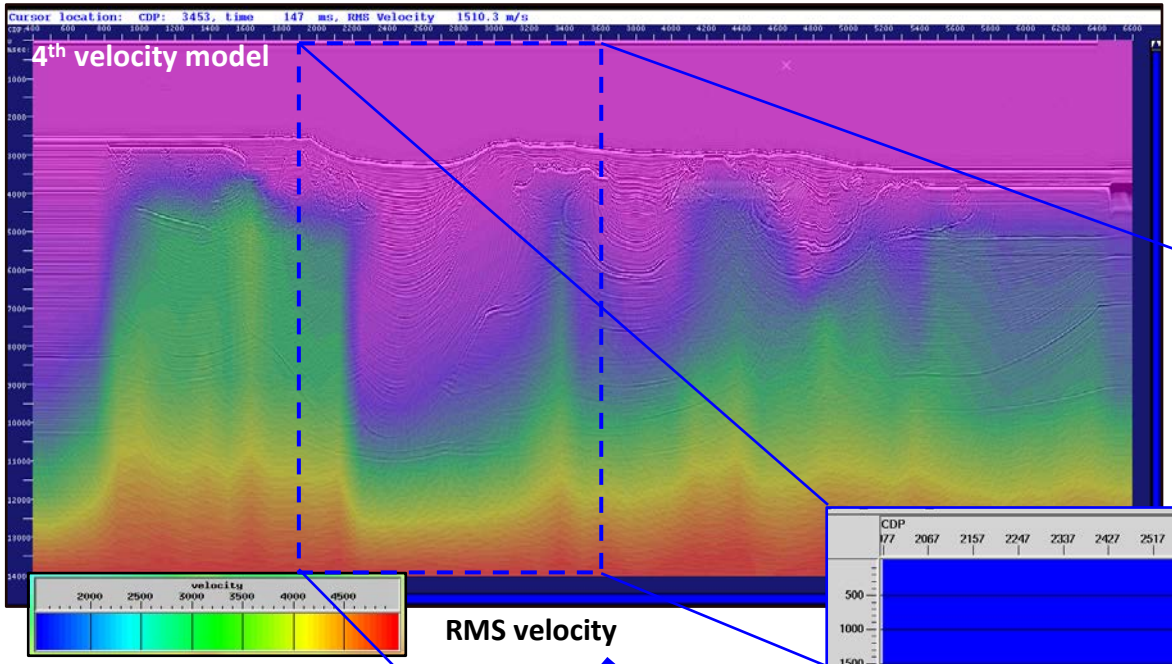
=> Parameterization and final updated velocity model

Phase 4: Comparison and conclusion

=> Comparison of depth migrated sections and conclusion

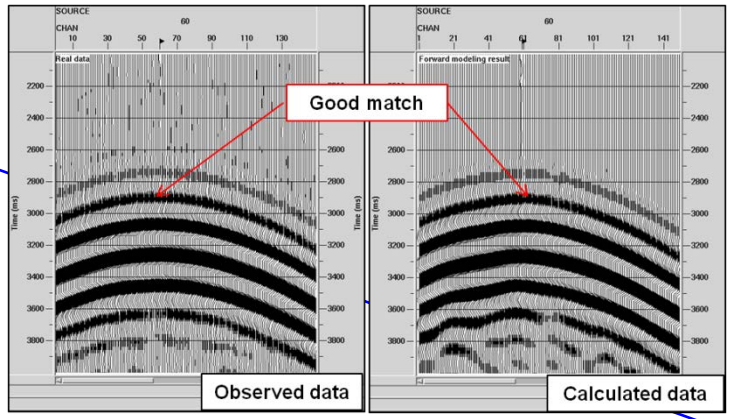
Phansakorn K., 2012

Velocity QC (Initial Model)



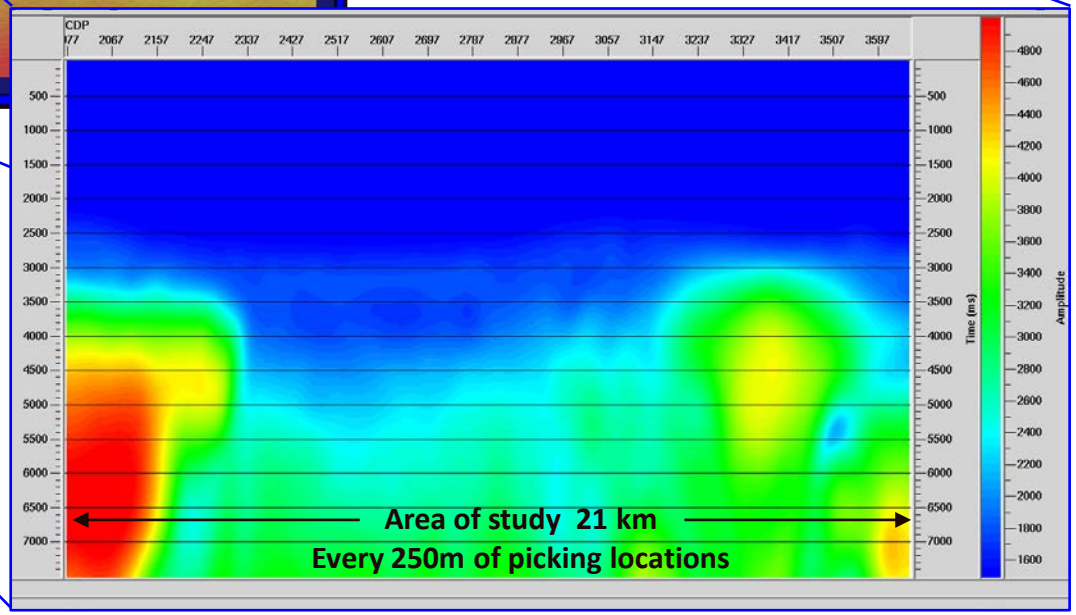
RMS velocity

Making comparison



Dix's equation

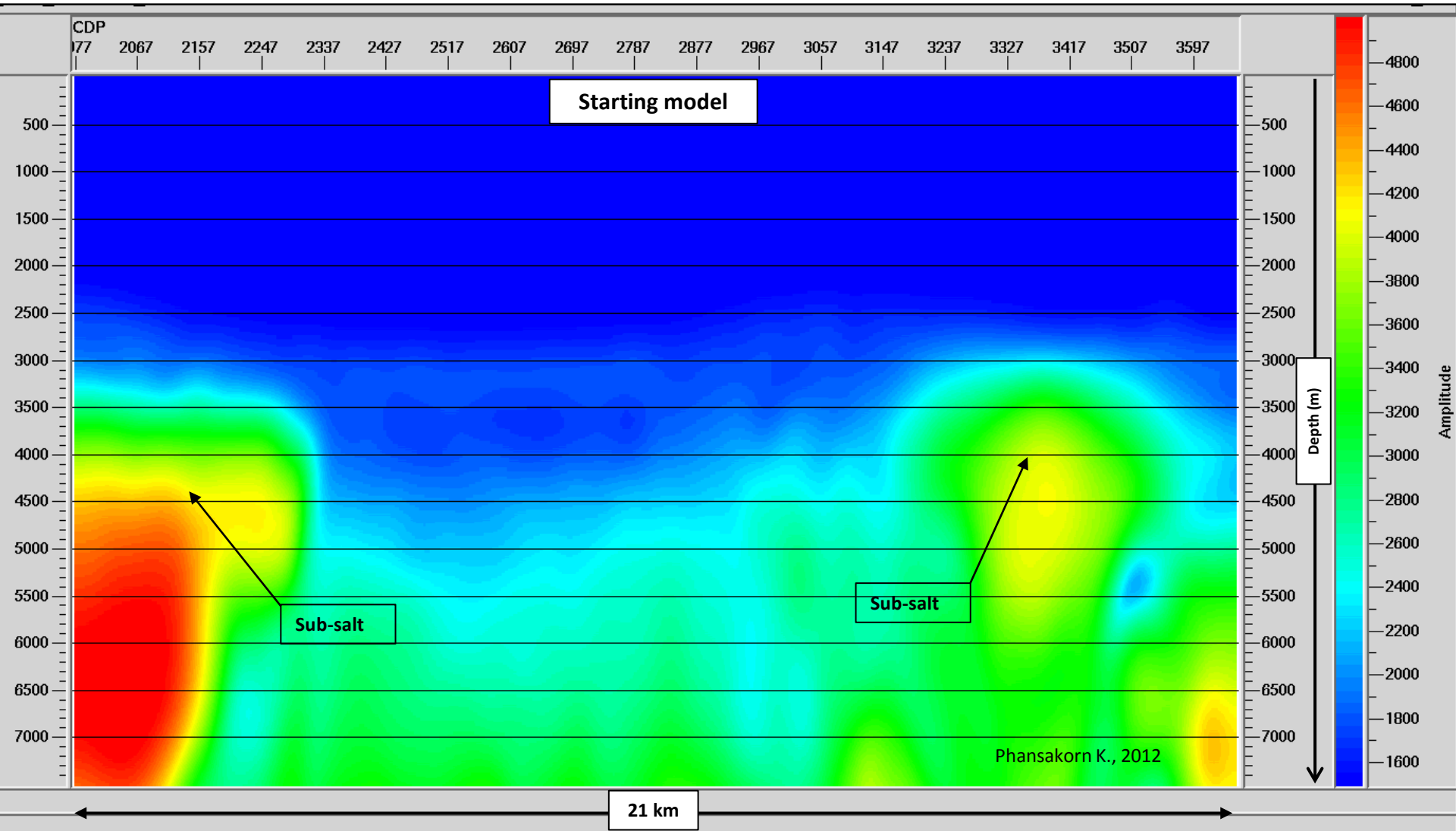
Interval velocity



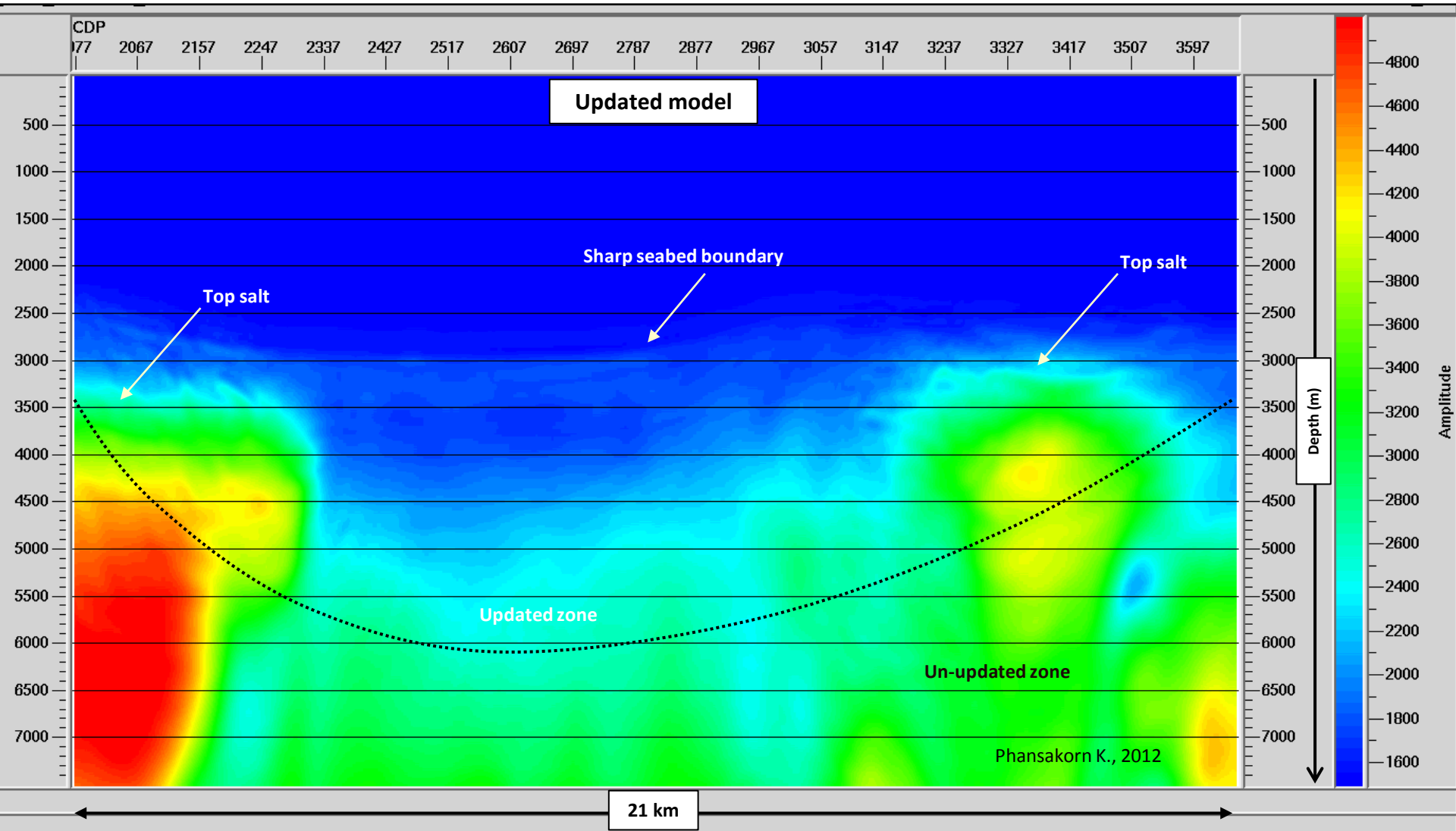
- Synthetic gathers were generated by using starting model (interval velocity)
- Pre-stack migration (time and depth) sections.

Phansakorn K., 2012

Initial Model



Final Result



Electromagnetic

Why EM?

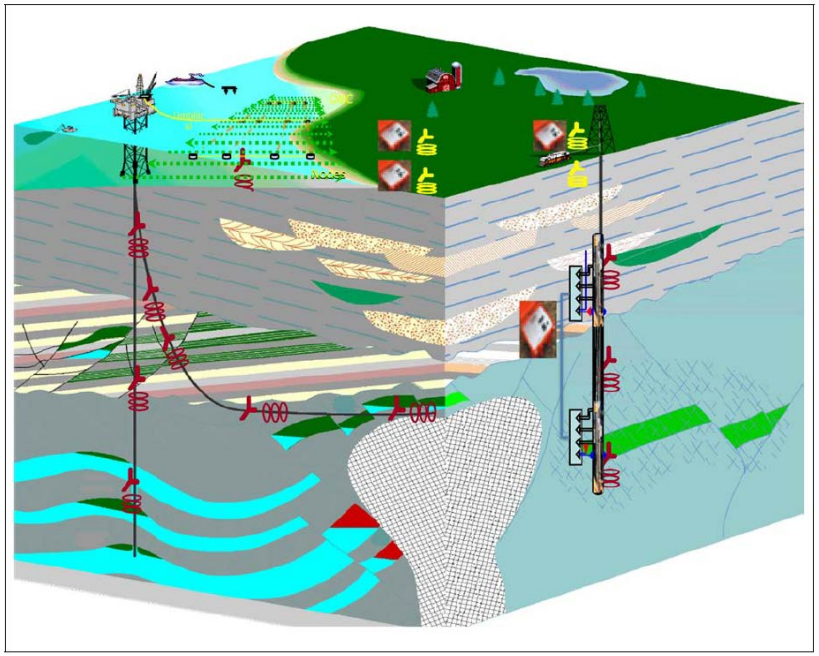
- **Determining composition, boundaries and movement**
- **Best quality data!**
- **Combination of Seismic and EM offer best solution**
- **EM has proven as a valid tool for hydrocarbon detection**

SENSOR CAPABILITY	RESOLVING POWER				
	Distance	Fluid	Surface-to-surface	Surface-to-borehole	Borehole
Seismic	Excellent	Poor	Excellent	Excellent	Ok (more noise)
EM	Ok (5% of depth)	Excellent (water to HC)	Ok	Excellent	Excellent (less noise & distance)
Gravity	Poor	Ok (oil to gas)	Poor	Poor (no source)	Poor (no source)
Strongest Synergy	Seismic	EM/seismic	Seismic/EM/ gravity	Seismic/EM	Seismic/EM/ gravity

Ref: Dr. Kurt Struck-KMS
With permission of WellDynamics

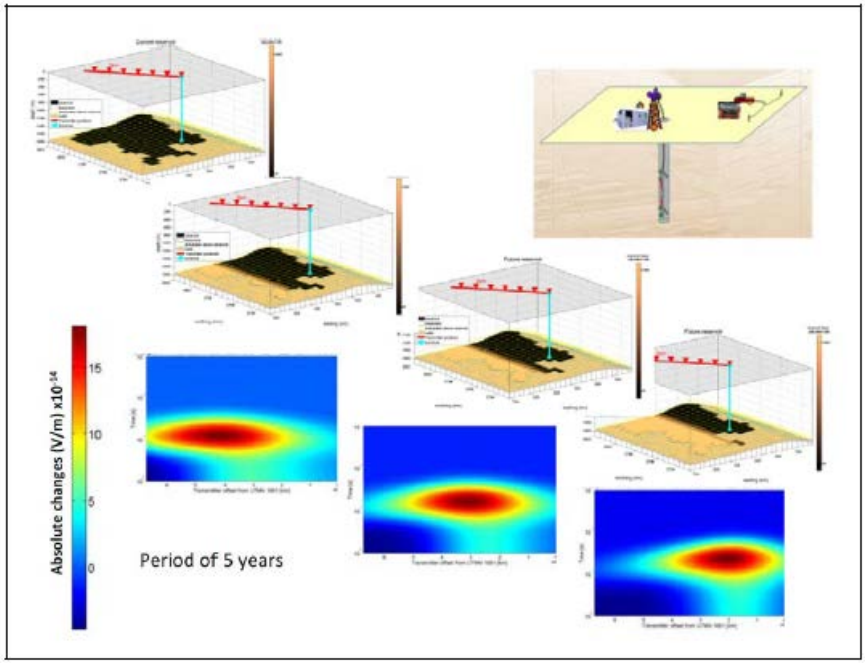
Borehole EM Application

The Full Field Array EM Concept



Sensors placed inside the borehole as well as on the surface (Strack and Aziz, 2012).

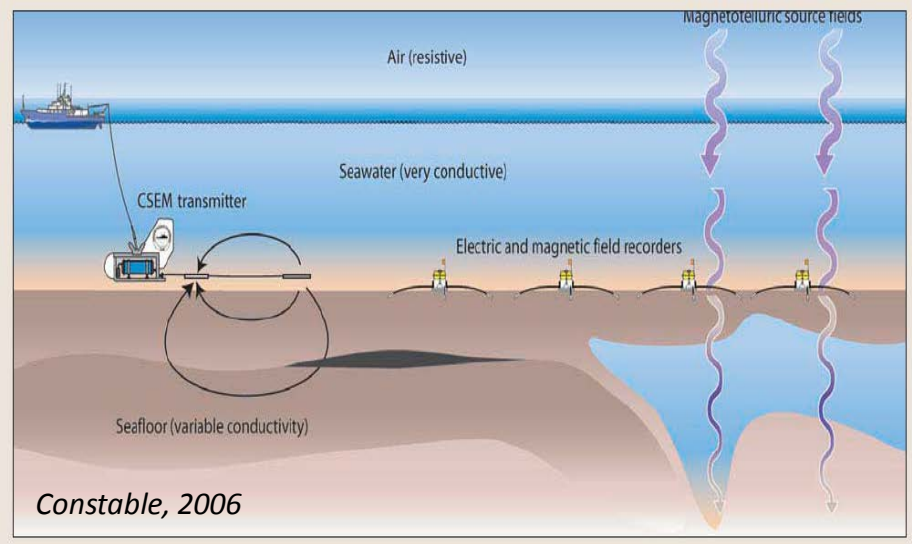
Borehole EM Application: Reservoir Monitoring



A feasibility study in the Middle East: Simulated response of surface-to-borehole EM for 4 time steps over a period of 5 years (Colombo et al., 2010).

Controlled-source Electromagnetic (CSEM)

Marine CSEM Acquisition

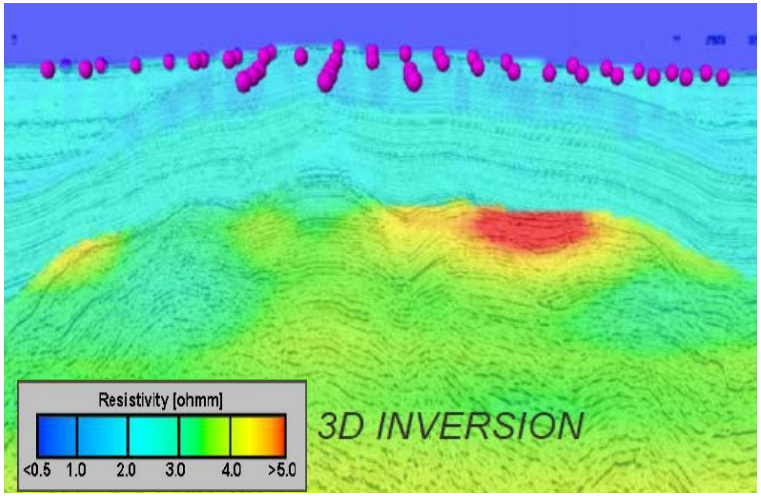


Constable, 2006

- *Transmitter: switching a dc current between the electrodes (0.1-1 Hz) with current 100-1000 A*
- *Seafloor recorders: Measure both primary + secondary EM field*

CSEM Application:

Prospect Delineation



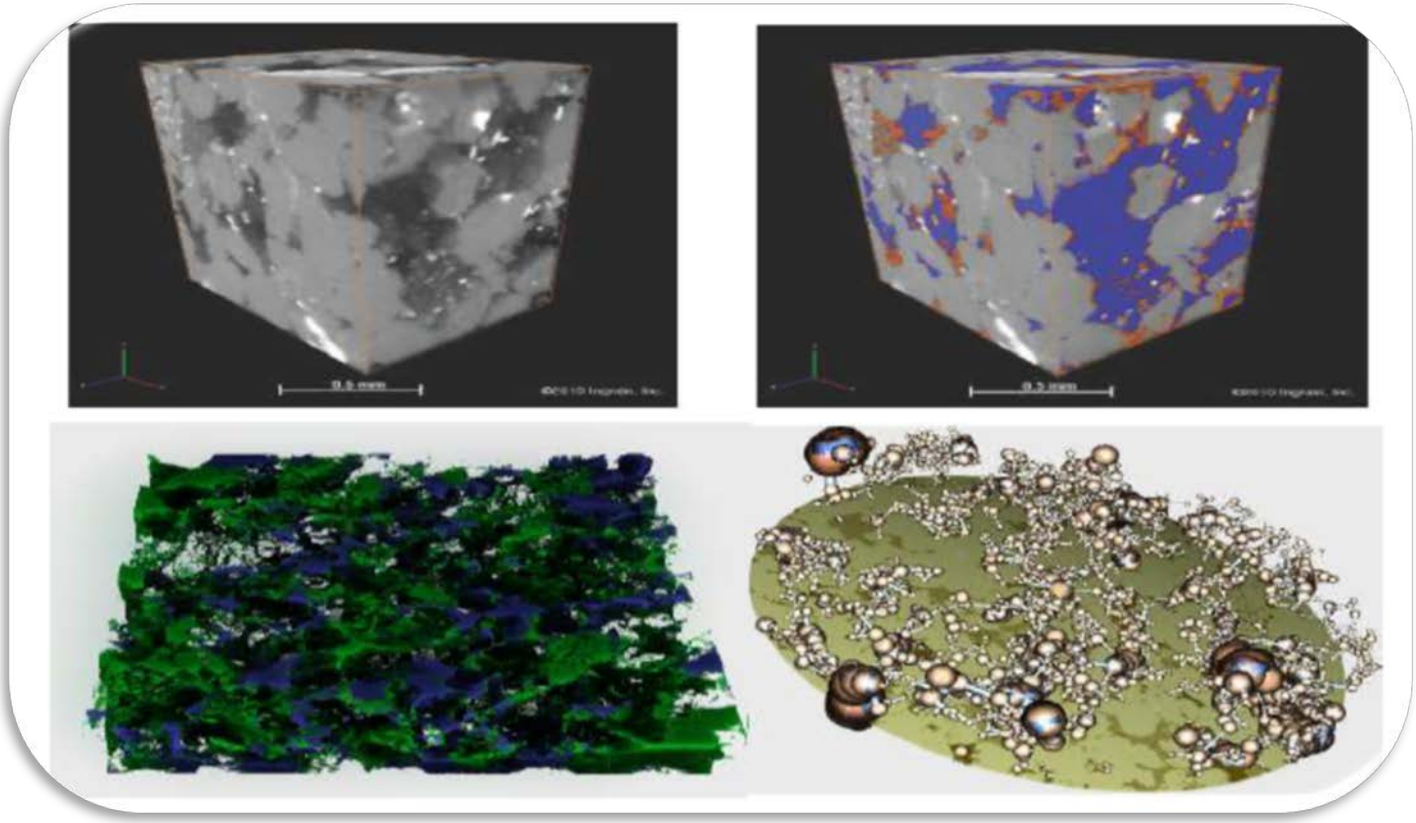
Case study: SE Asia deep water (1800 m) The survey was part of a portfolio ranking campaign to mitigate the drilling risk and associated costs for deepwater frontier exploration (Samohamad et.al, 2010).

Digital Rock

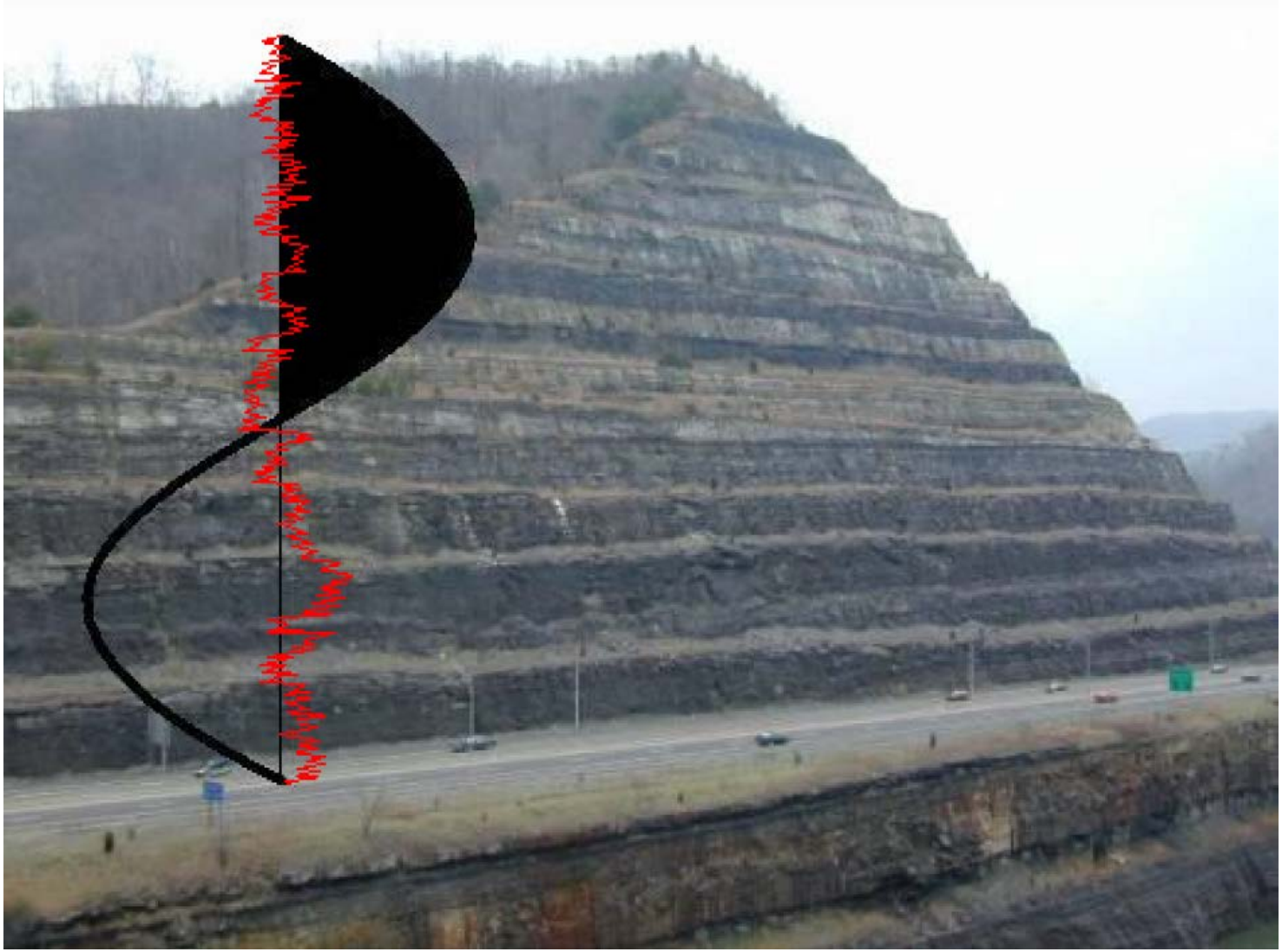
Digital Rock

Application:

- **Digital imaging and computation of rock properties at equivalent quality to laboratory analysis of cores**
- **Paleontology from digital image**
- **Rock Physics**



Reservoir Characterization requires Integration



Ref: Mark Herkommer, Geopressure Workshop, 2012

Integration of Technologies bridging the Gap