



Technologies for Unconventional Resources

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2014 SPE President
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Schlumberger

Outline

Overview of shale

What is shale?

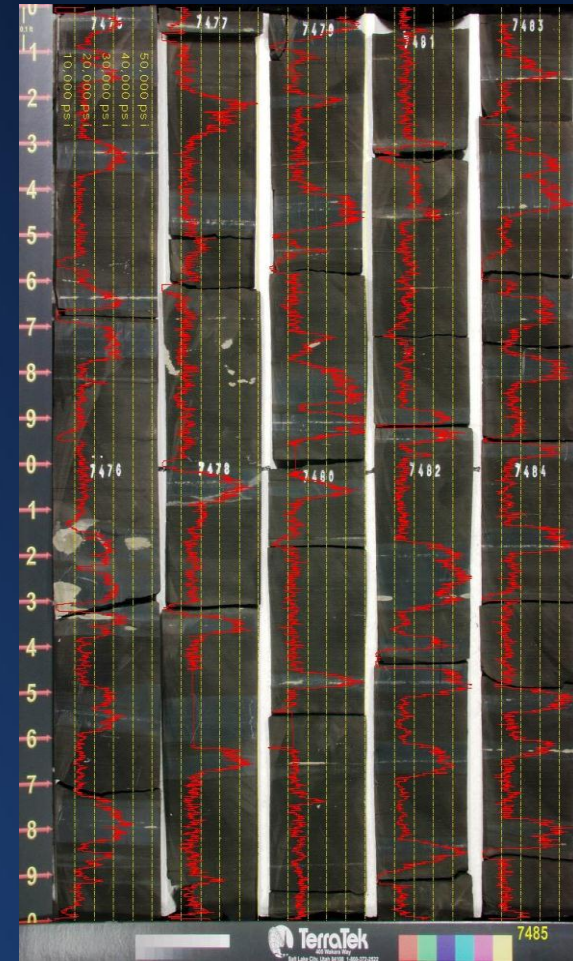
Data required

Technologies making it possible

Subsurface characterization

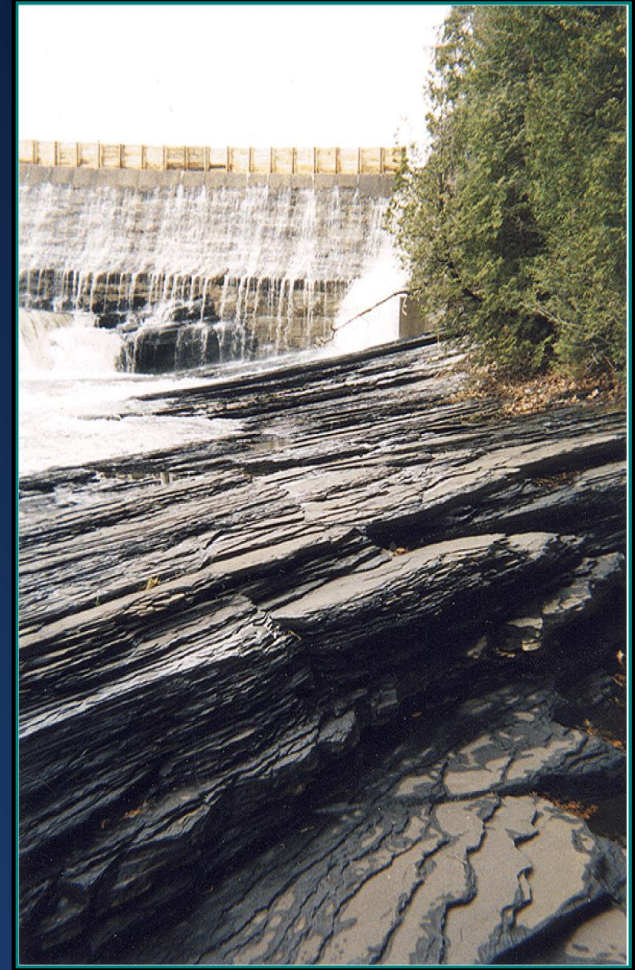
Horizontal Drilling

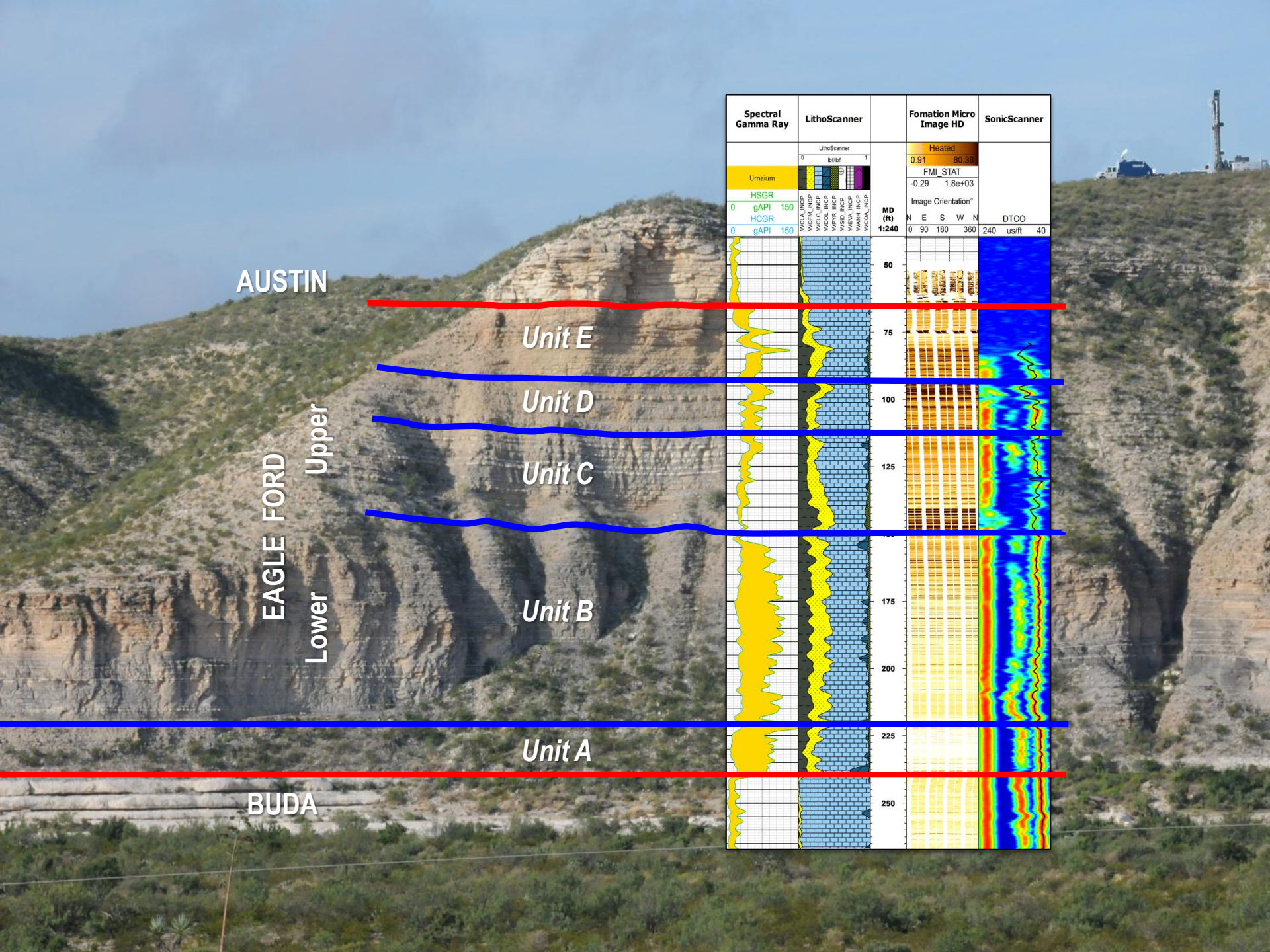
Hydraulic fracturing



What is a Producing Shale?

- Organic rich mudstone – fine grained, low energy, anoxic deposition
- Source rocks to conventional reservoirs
- Hydrocarbon is generated and stored in place, self-sourced reservoir
- Ultra low permeability (nanodarcy)
- Depositional processes control type, quality, abundance and distribution of hydrocarbons
- Shale is the most abundant sedimentary rock
- Not all shales contain enough organic matter, the right thermal maturity, or the right mechanical properties to produce hydrocarbons





AUSTIN

Unit E

Unit D

Unit C

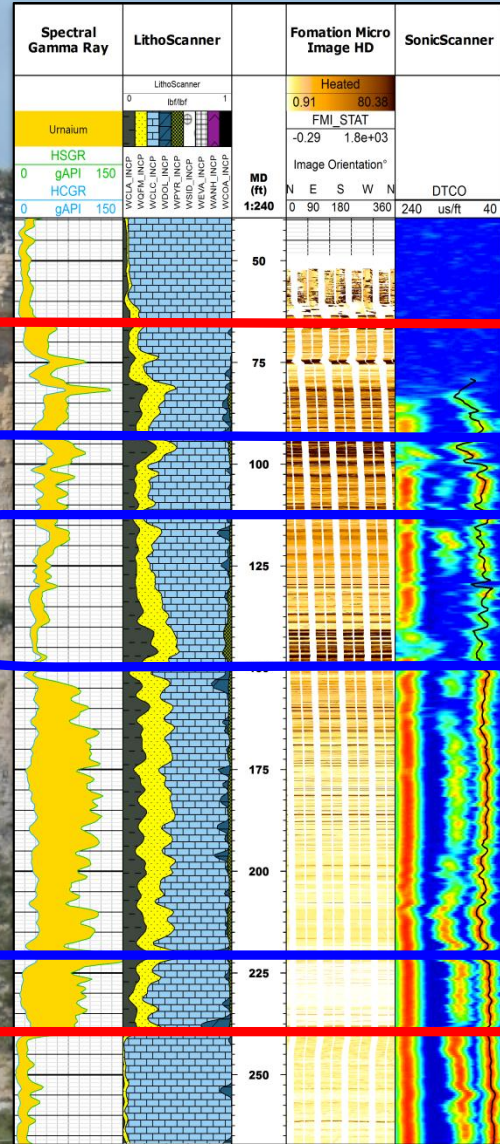
Unit B

Unit A




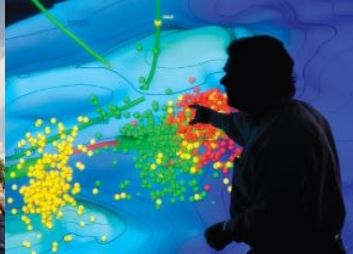

BUDA

Upper

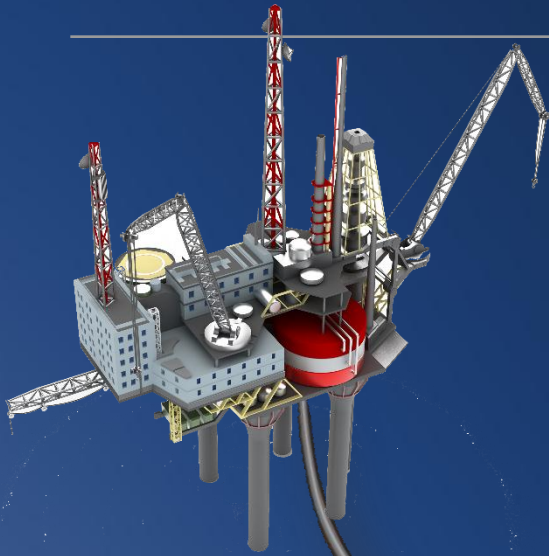
Lower



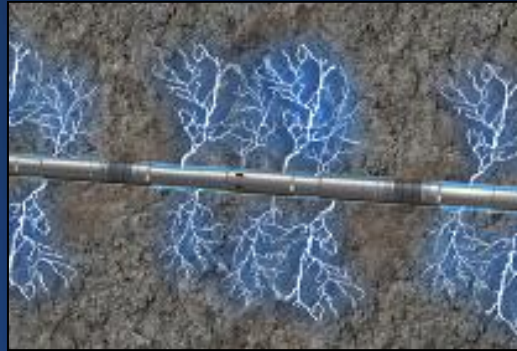
Technologies Required for Economic Shale Gas

Explore	Evaluate	Drill	Complete	Produce
<p>More Data Less Risk</p> <ul style="list-style-type: none"> - Resource assessment - Seismic for UR - Petroleum systems modeling - Integrated core/log/seismic 	<p>More Knowledge Less Uncertainty</p> <ul style="list-style-type: none"> - Petrophysical model - Geomechanics - Defined reservoir quality - Defined completion quality - Characterize PVT 	<p>More Pay Zone Less Rig Time</p> <ul style="list-style-type: none"> - Engineered bit/BHA - Hole cleaning & rugosity - Longer laterals, > ROP - Cuttings and mud logs 	<p>More Reservoir Contact Less Environment Impact</p> <ul style="list-style-type: none"> - Engineered fracture design - Stimulation hardware - Better chemistry - Reduced water/proppant 	<p>More Recovery Less Waste</p> <ul style="list-style-type: none"> - Managed flowback - Optimized production - Coiled tubing interventions - Measured contributions
				

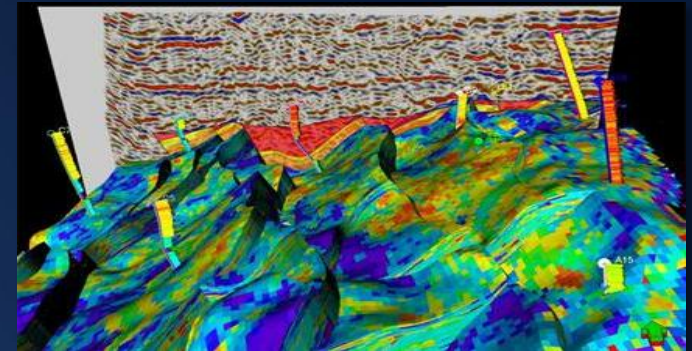
Enabling Technologies for Shale Gas Development



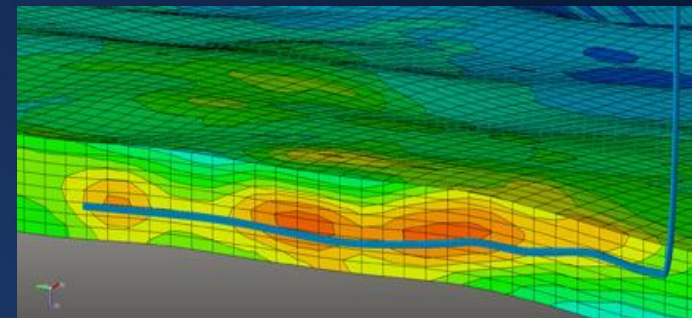
Multistage fracturing



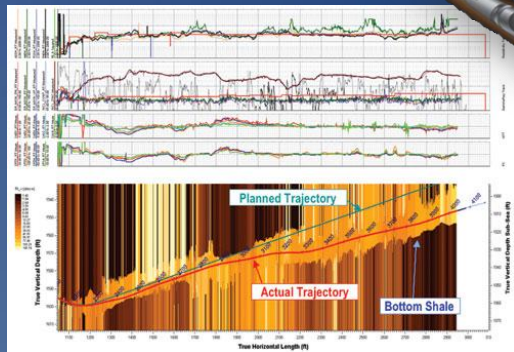
Shared earth model



Horizontal wells



Effective reservoir contact



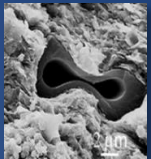
Optimized ROP and well placement

Characterizing Shale Gas Reservoirs

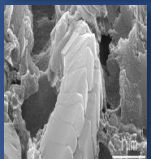
Integration of data at all scales

Matrix						Clay Types				Water		Organic Carbon				
Calcareous	Siliceous	Feldespatic	Sideritic	Phosphatic	Pyritic	Chlorite	Kaolinite	Illite	Smectite	Clay Bound	Small Pore	Oil	Gas	Kerogen	Bitumen	Pyrobitumen

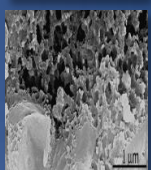
Petrology



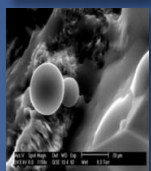
Type II Marine Liptinite



Type II Marine Microalgae

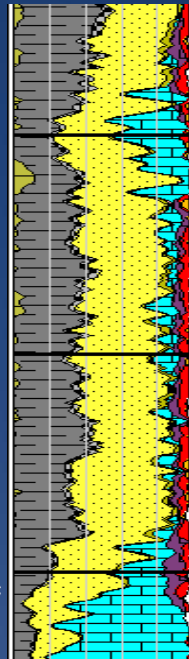


Mixed Amorphous

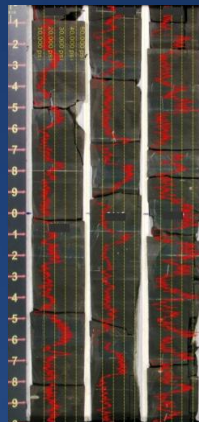


Hydrophobic

Logs

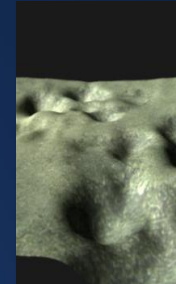
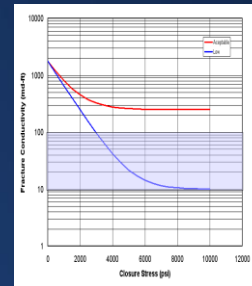


Geomechanics

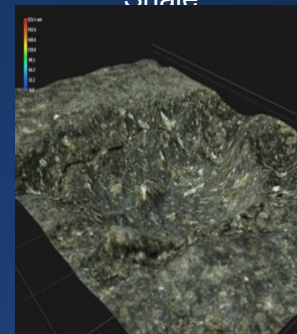


UCS Profile

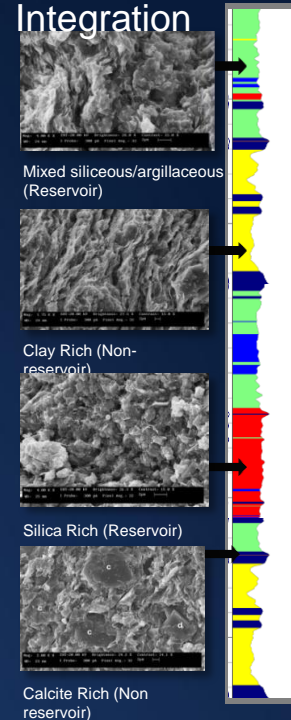
Fluid Sensitivity Fracture Conductivity



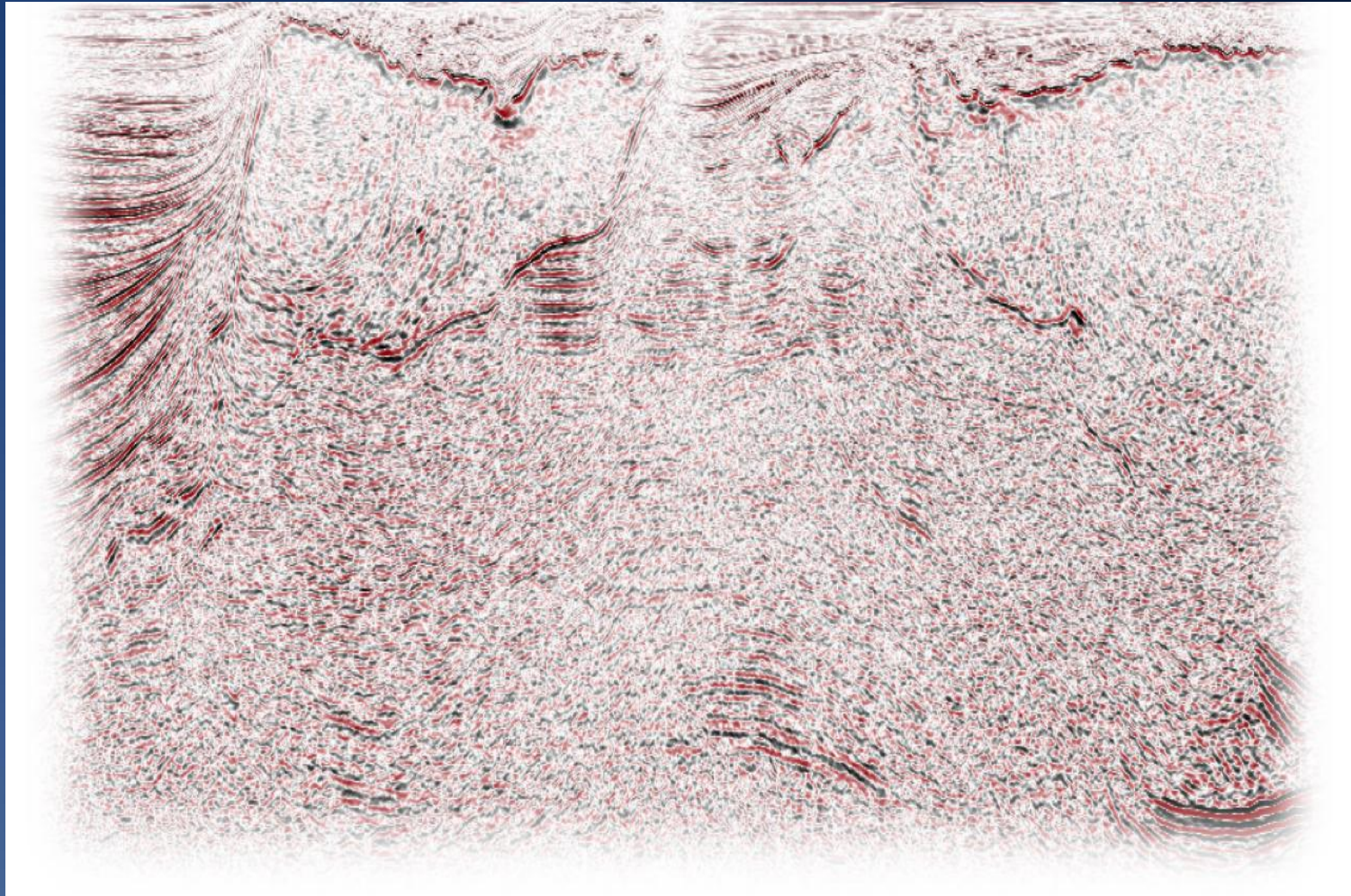
Proppant Embedment in Argillaceous Shale



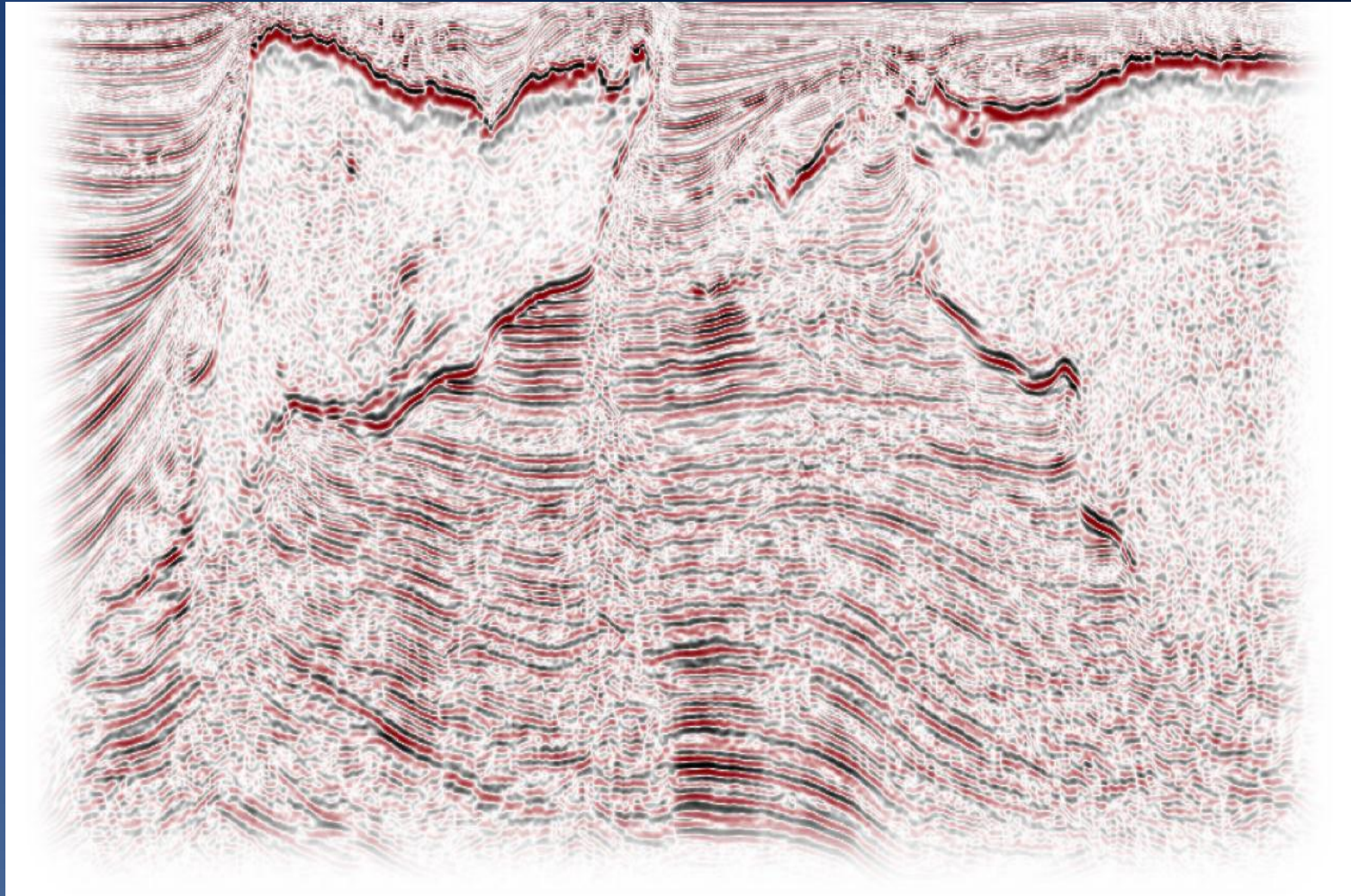
Core to Log Integration

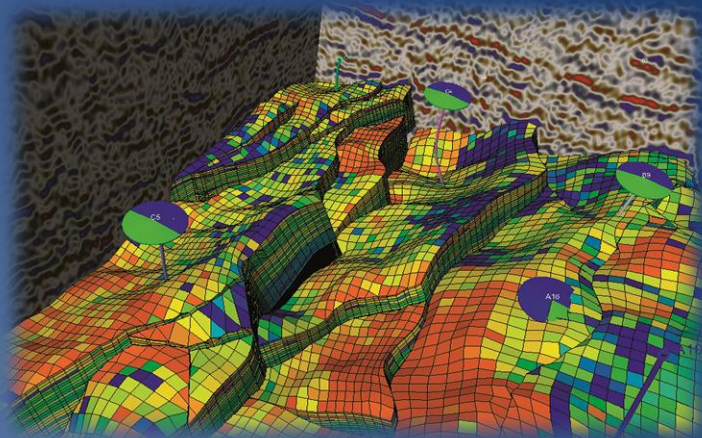
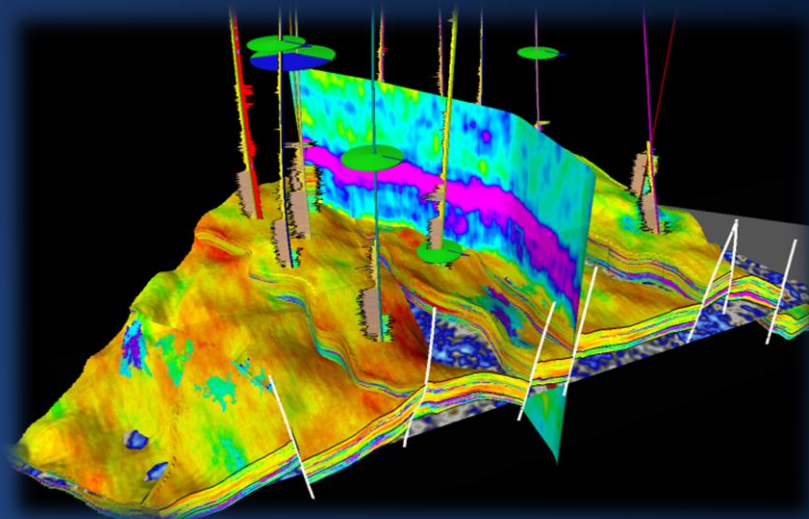
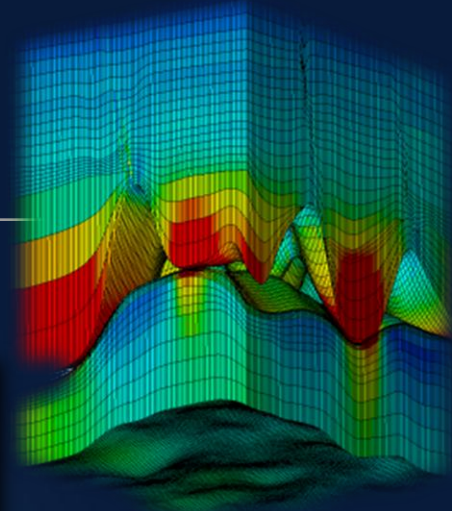
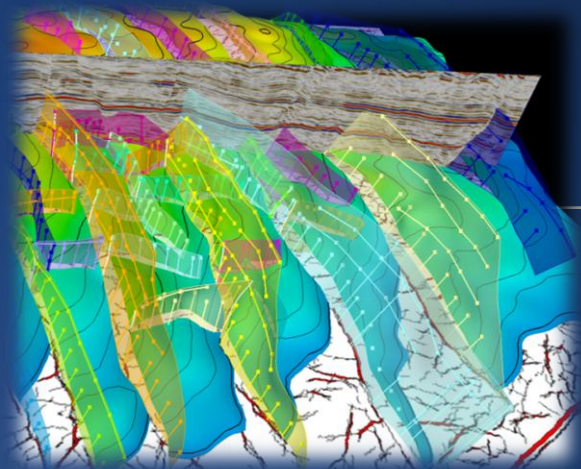


Yesterday

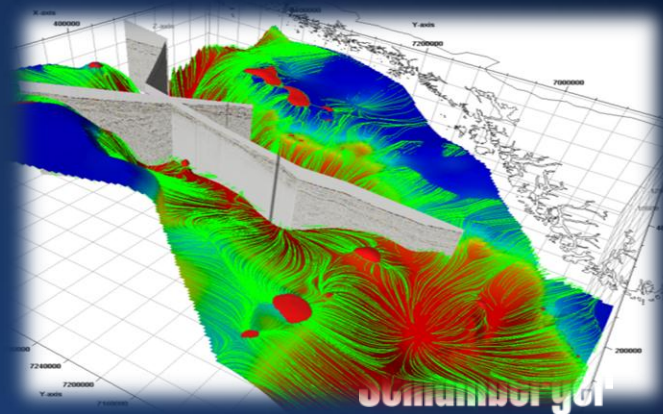


Today





Integrated Earth Model



Technology Challenge - Optimized Drilling and Well Placement

Anticipate and mitigate drilling hazards

- Wellbore stability
- Zonal isolation
- Casing-to-cement integrity
- High pressure formations

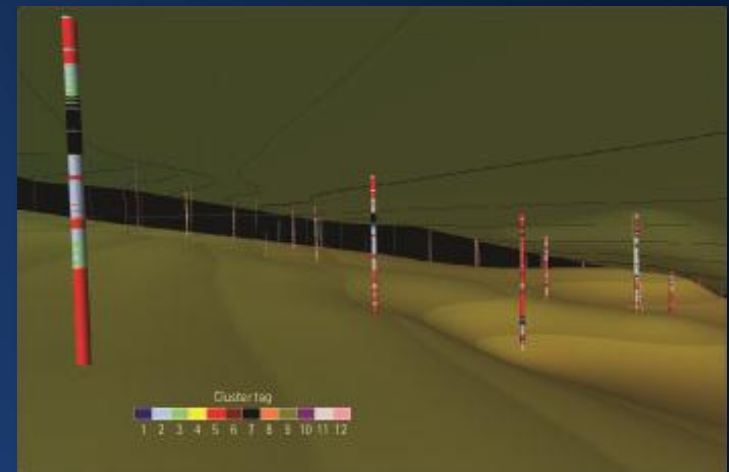


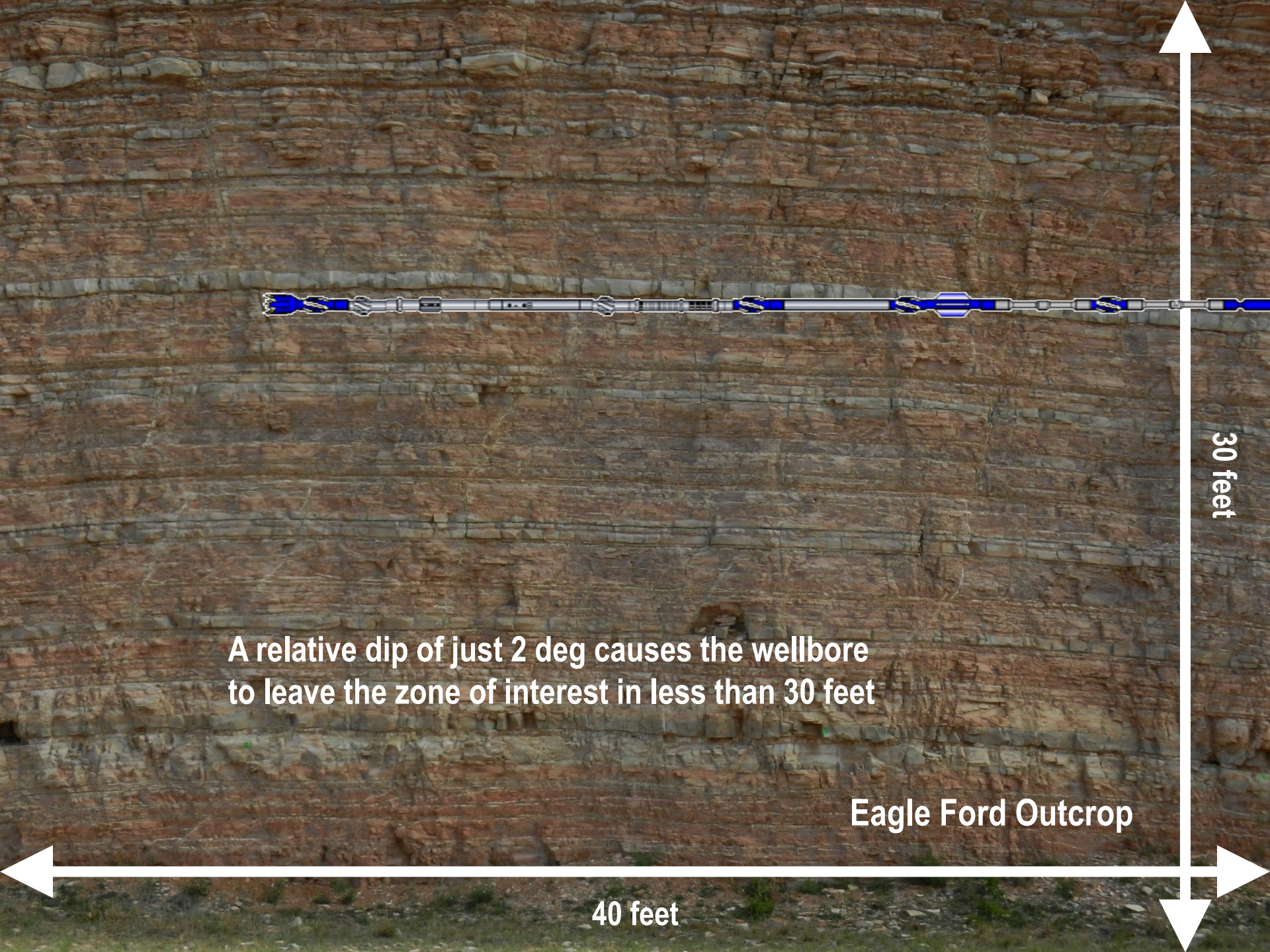
Wellbore placement

- Reliable rotary steerable
- Formation evaluation in real time
- Drilling optimization (look-ahead, look around)
- Maximize reservoir contact—geosteering

Geomechanics and pore pressure prediction

- Manage pore pressure/fracture gradient
- Help eliminate sidetracks
- Optimize complex casing, cementing and completions designs





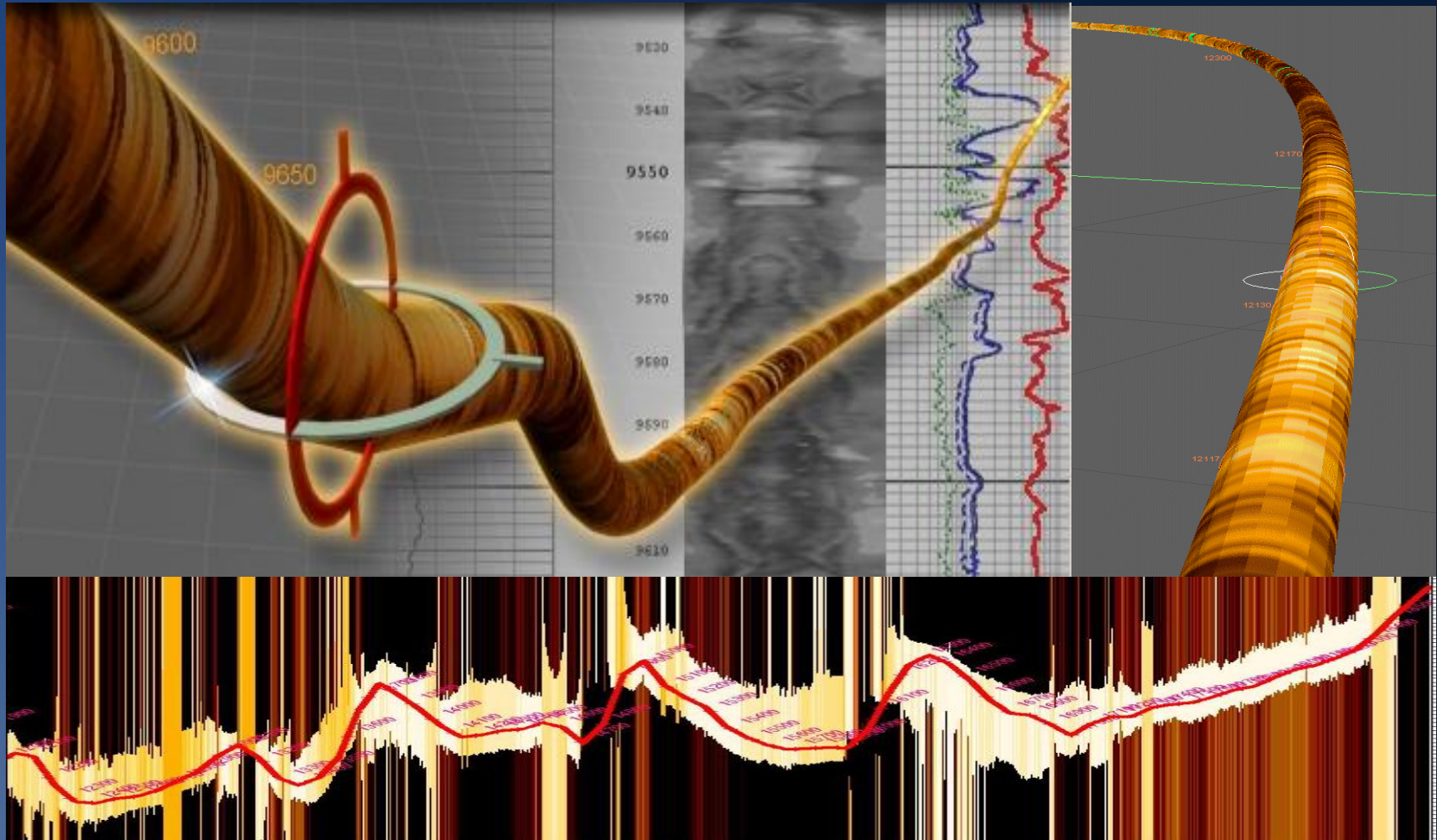
A relative dip of just 2 deg causes the wellbore to leave the zone of interest in less than 30 feet

Eagle Ford Outcrop

30 feet

40 feet

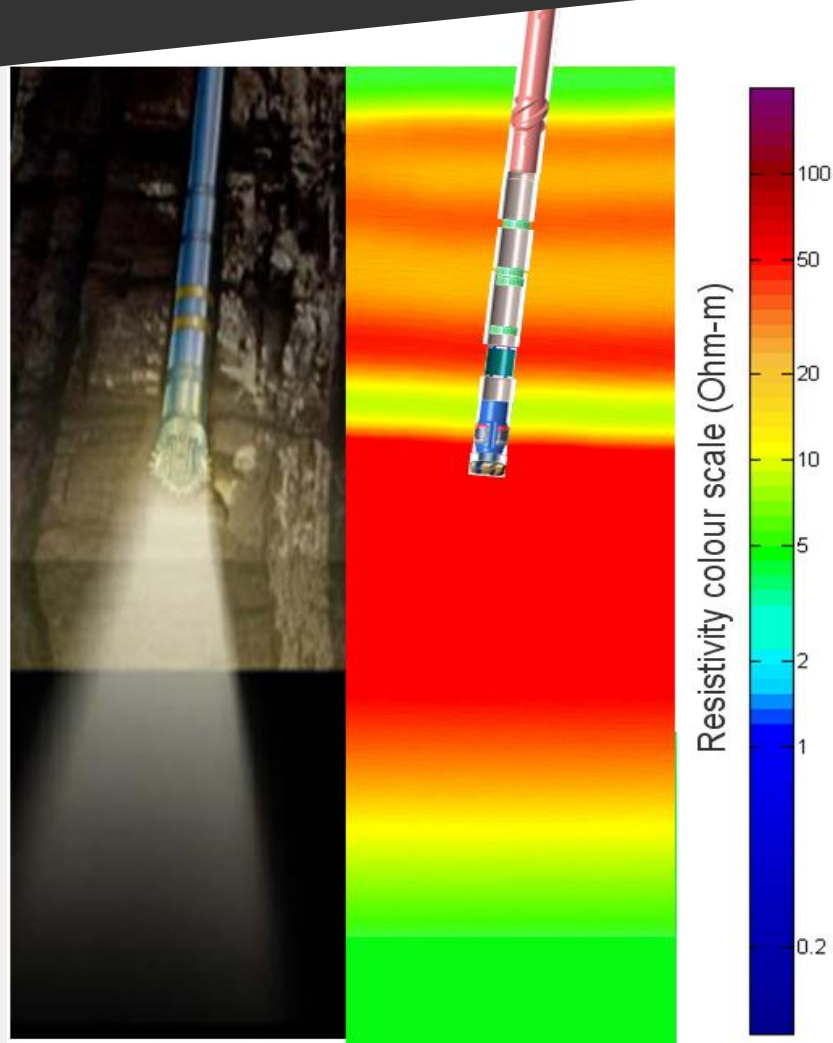
Well Placement – Geological Steering





Statoil

- Resistivity contrast detection from 10–60 ft.
- Drilling risk reduction & production optimization
- Geo-stopping, salt navigation, improved landing



Why Hydraulic Fracturing? Surface area is the key!

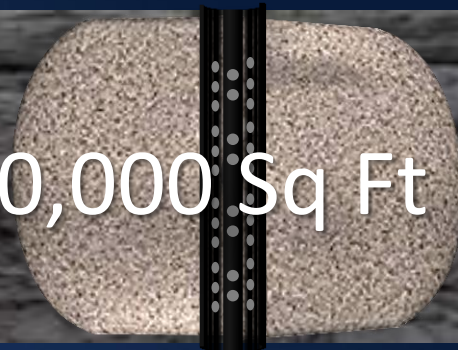
Vertical, Perforated Well



315 Sq Ft

200 Ft High x 6" Wellbore

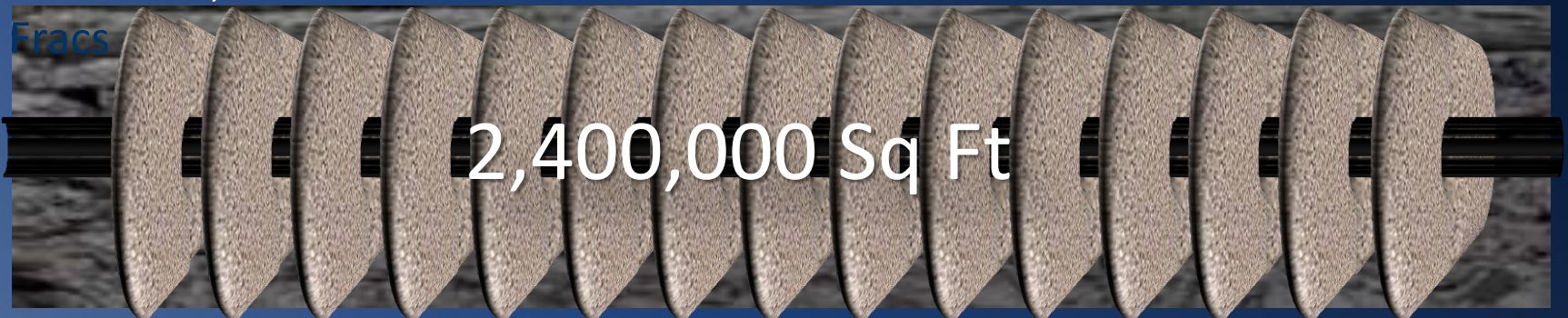
Vertical, Perforated Well with Single Frac



160,000 Sq Ft

200 Ft High x (1) 200 Ft Frac with 2 Wings Each

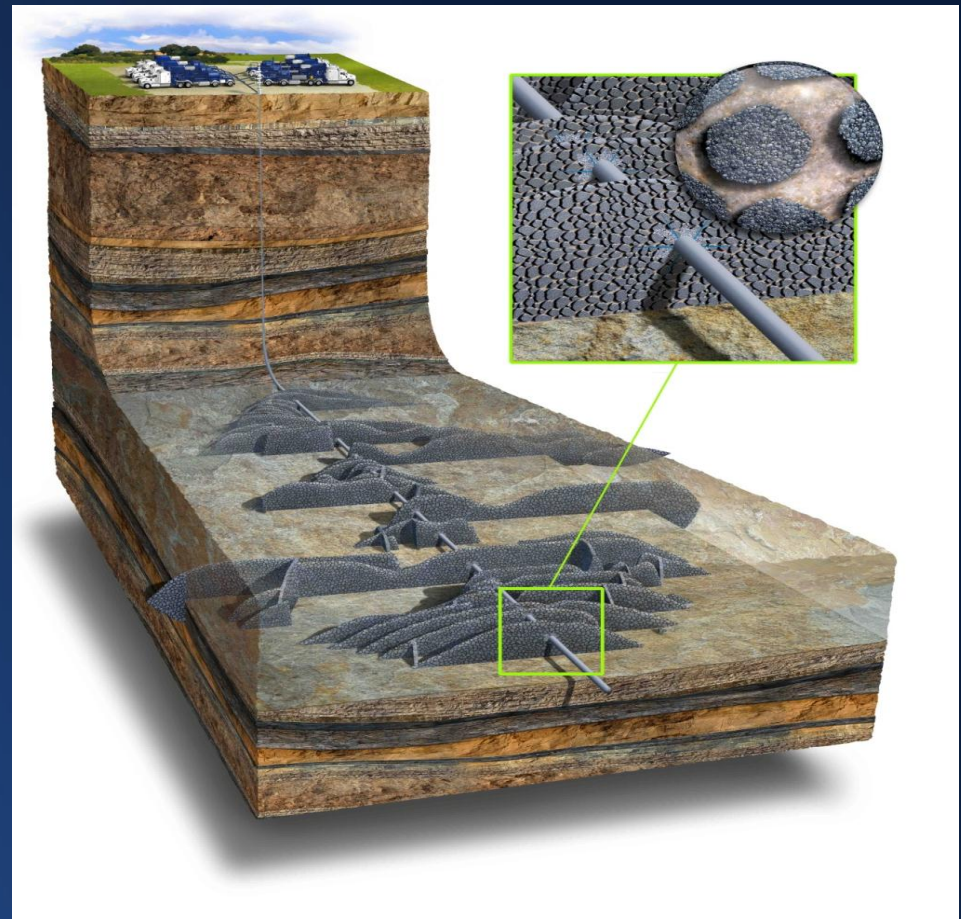
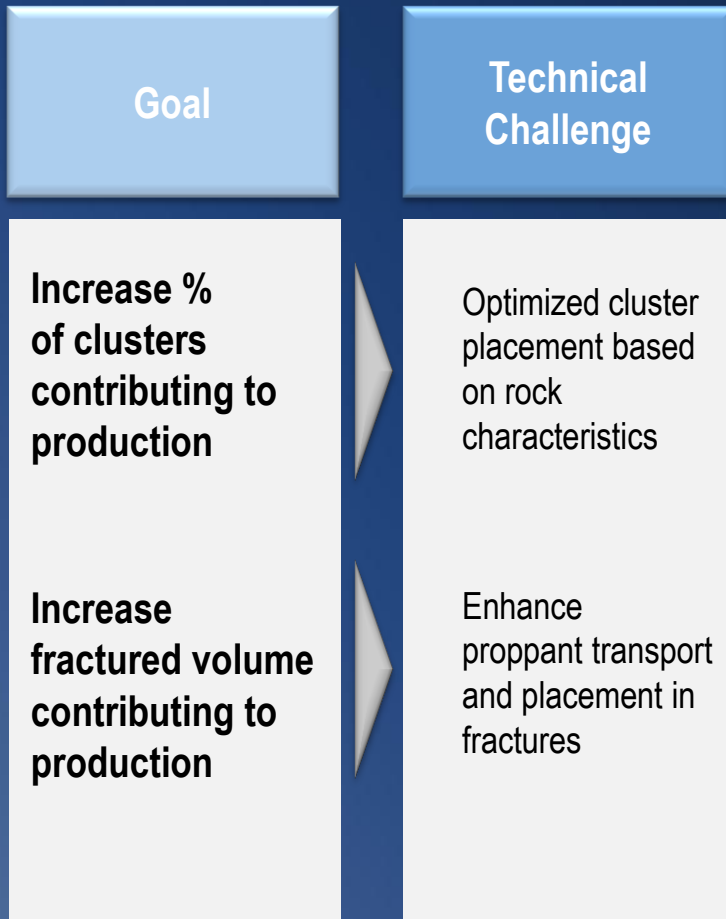
Horizontal, Perforated Well with 15



2,400,000 Sq Ft

200 Ft High x 0.5" Wellbore x (15) 200 Ft Frac with 2 Wings Each

Pioneering Technologies



Microseismic Interpretation

