The challenges of Oil and Gas data interpretation

Horacio Bouzas
Norway Technology Center Manager
Schlumberger Information Solutions

Schlumberger Background

- The world's leading oilfield

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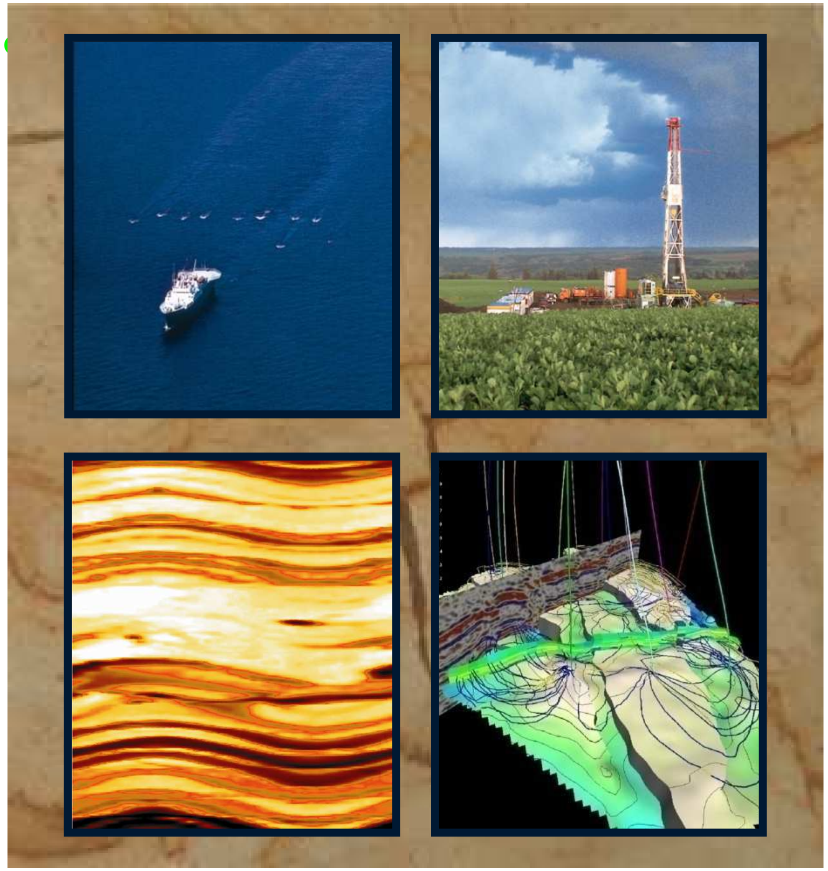
investing more than $800M in research.



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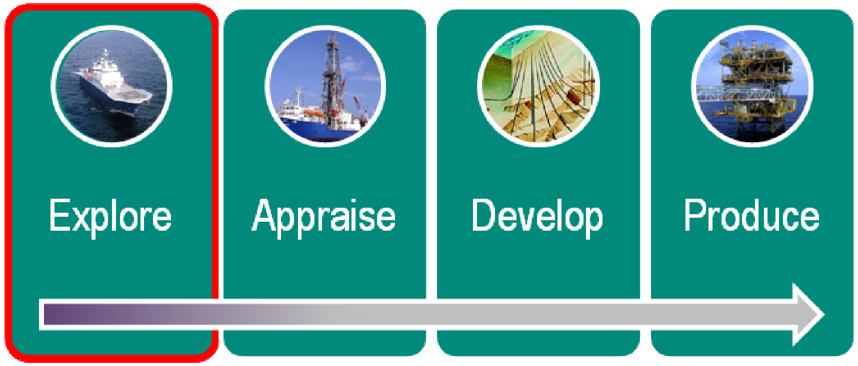
Oil Exploration Lifecycle



Exploration

The initial phase in petroleum operations that includes generation of a prospect, and drilling of an exploration well.

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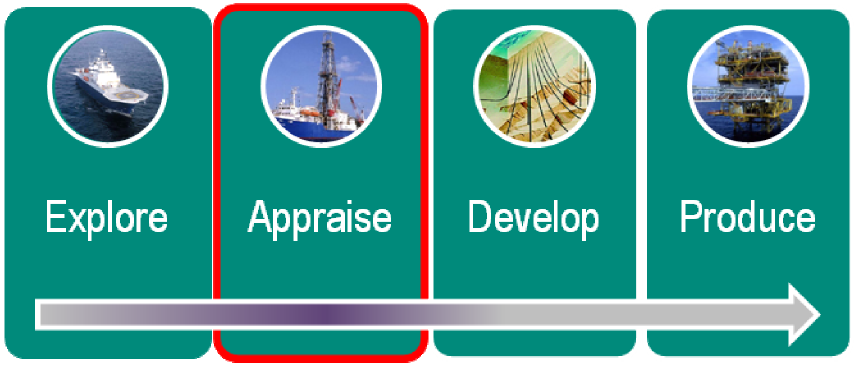
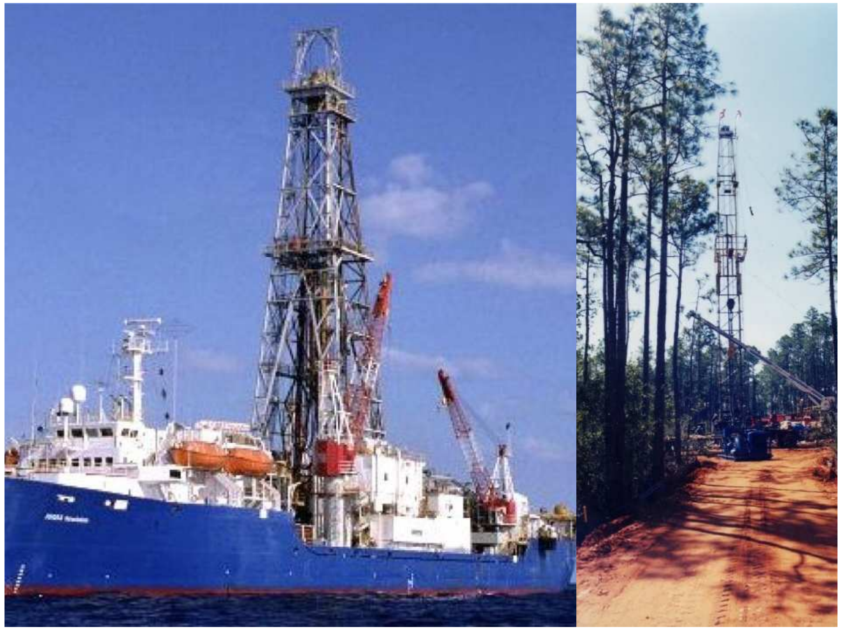
Oil Exploration Lifecycle





Appraisal

The phase of petroleum operations that immediately follows successful exploratory drilling.

During appraisal, delineation wells might be drilled to determine the size of the oil or gas field and how to develop it most efficiently.

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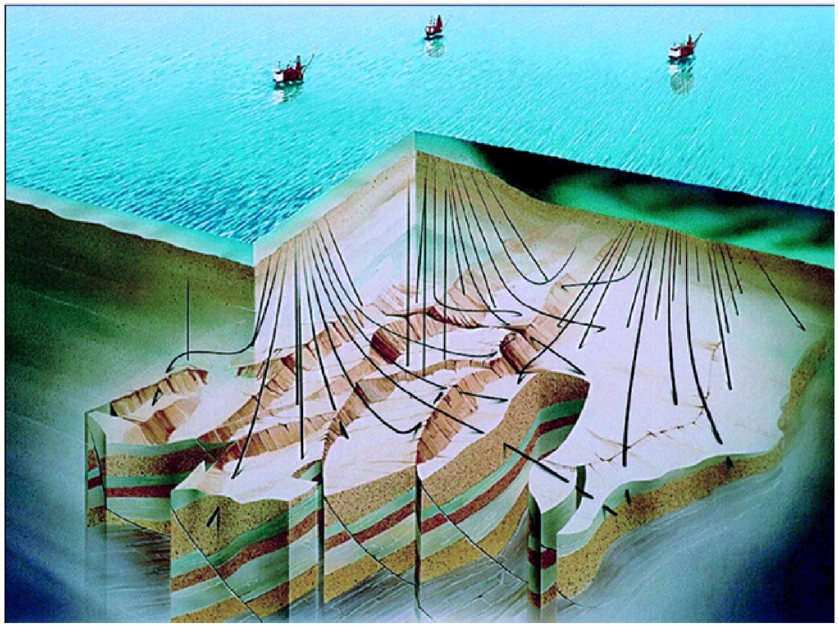
Oil Exploration Lifecycle

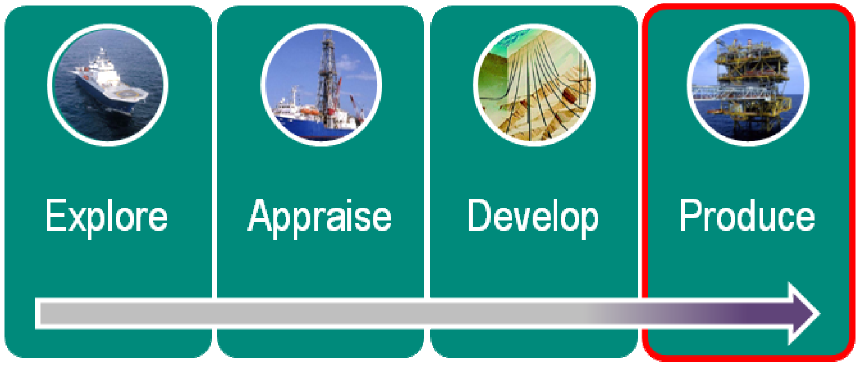


Development

The phase of petroleum operations that occurs after exploration has proven successful, and before full-scale production.

A plan to fully and efficiently exploit the field is created, and additional wells are usually drilled.

Oil Exploration Lifecycle



Production

The phase that occurs after successful exploration and development and during which hydrocarbons are extracted from an oil or gas field.

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What Oil Companies Want to Know…

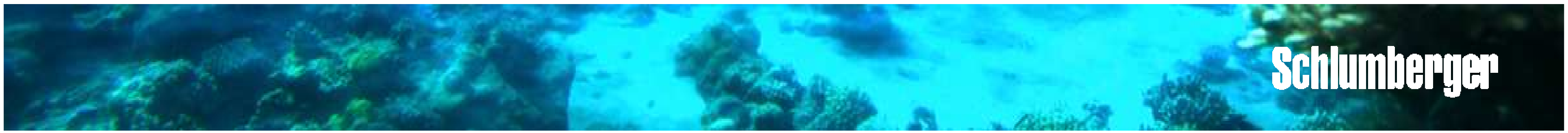
Where is the oil?

How much oil is there?

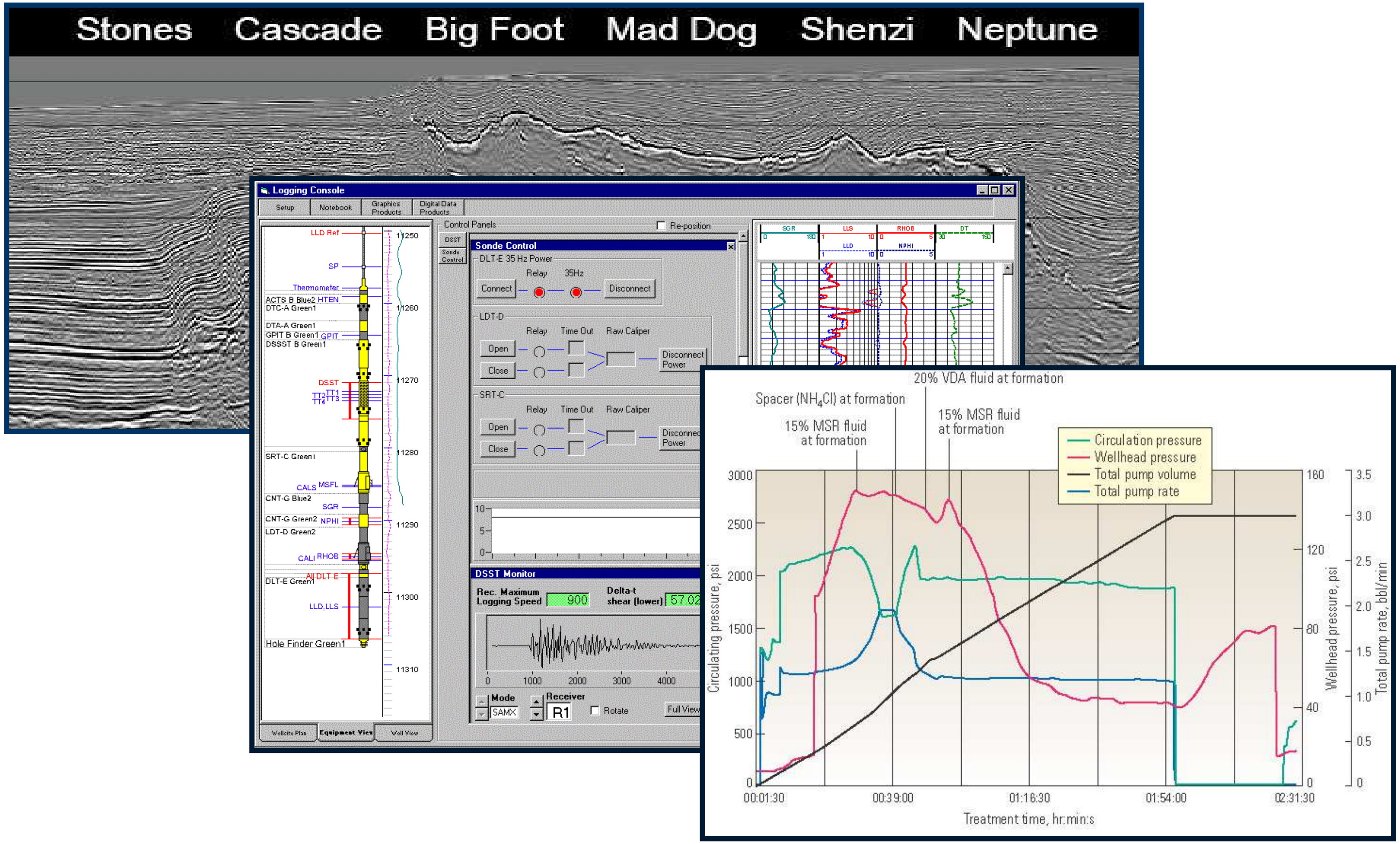
Will it flow?

What's the best way to produce it?

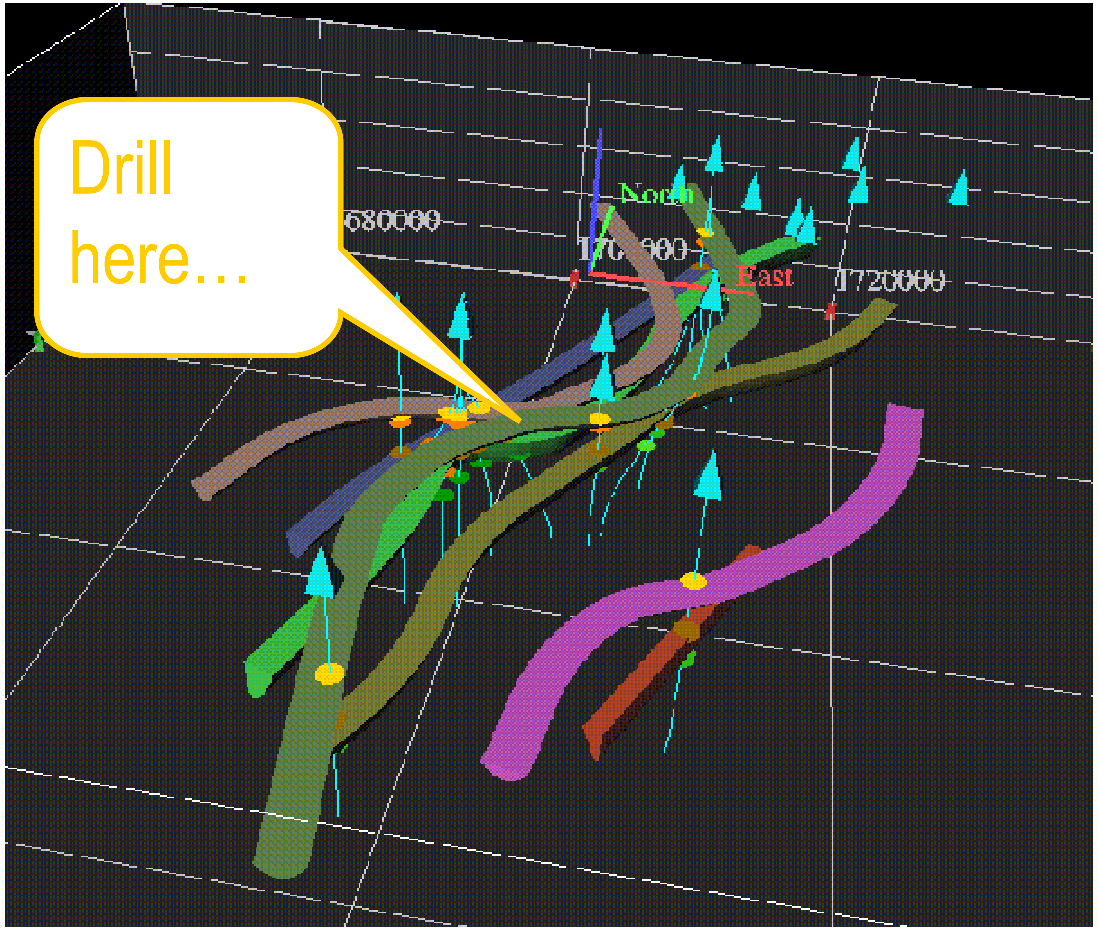
"Can this reservoir profitably produce oil or gas?"



Oil Companies Like Data…



…But Want Insight



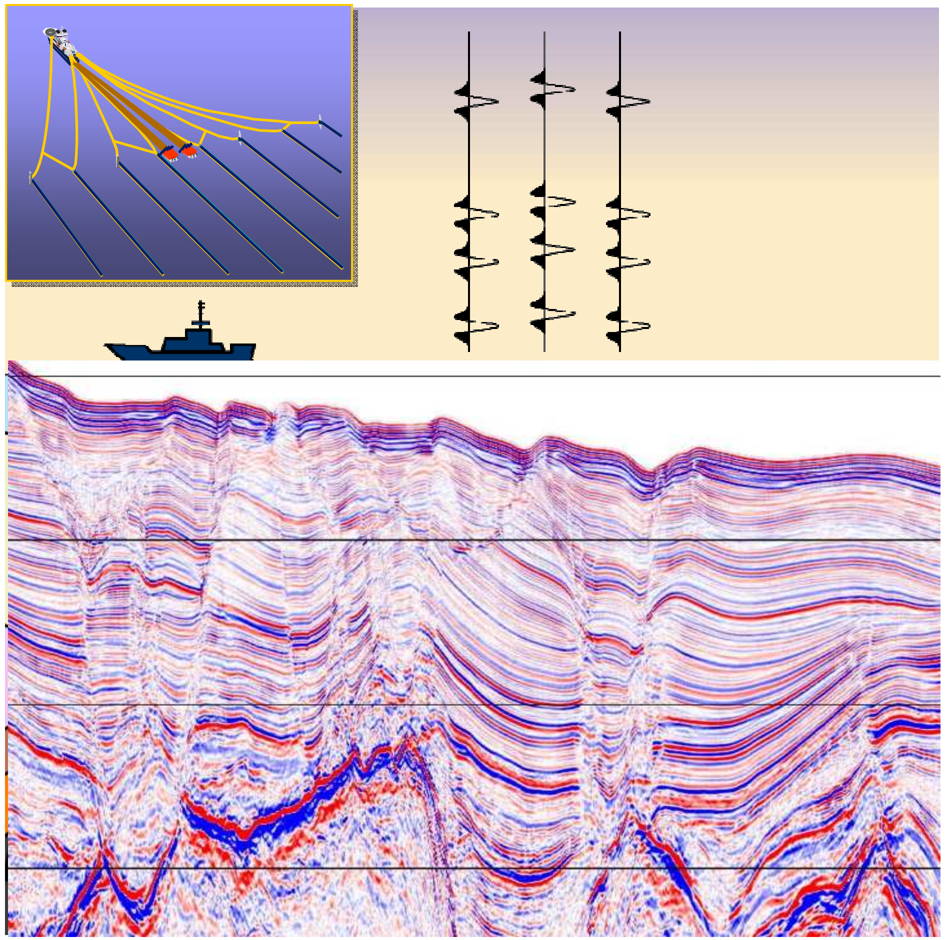
How Oil Companies Find Out…

To answer these questions…

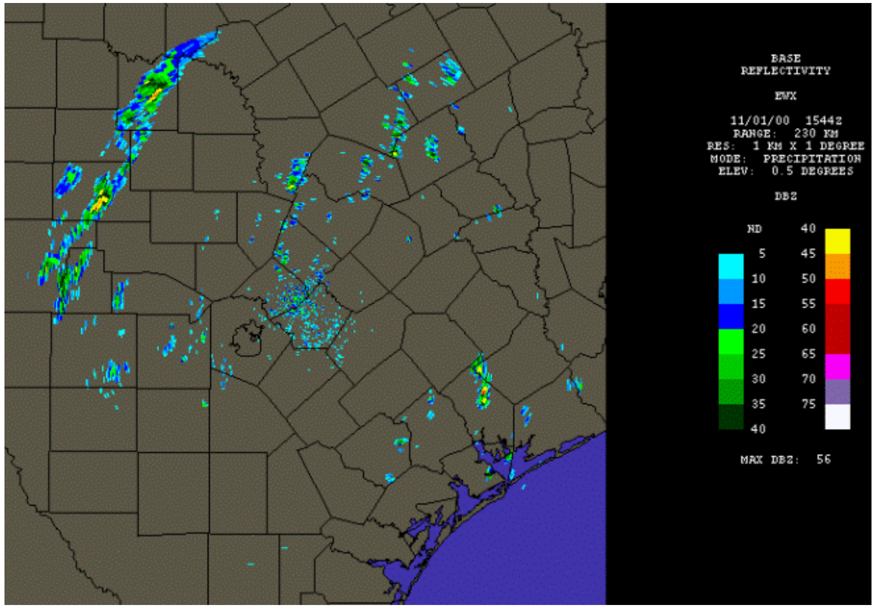
- From *<u>seismic data</u>*, we interpret a structural model.
- From *<u>borehole data</u>*, we interpret physical properties of the rocks
- Integrating the structural model with the physical properties of the rocks, defines a property model.
- The property model is used for fluid flow simulations, financial estimates, drilling planning, etc.

Seismic Data: Acquisition

- Horizons
- Faults
- Structure
- Salt and other bodies
- Amplitude anomalies
- Fluid presence
- Traps
- Rock properties



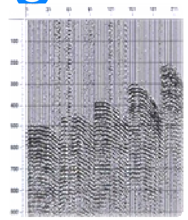
Seismic Data



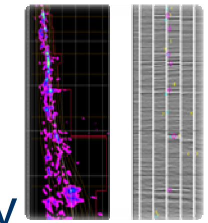
Seismic data is like weather radar.

- Coarse-grained.
- Covers a large volume that we cannot measure in detail everywhere.
- Is a fairly simple measurement.

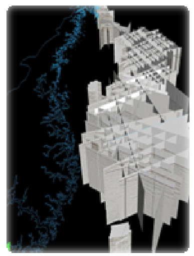
Seismic Data: Characteristics and Processing



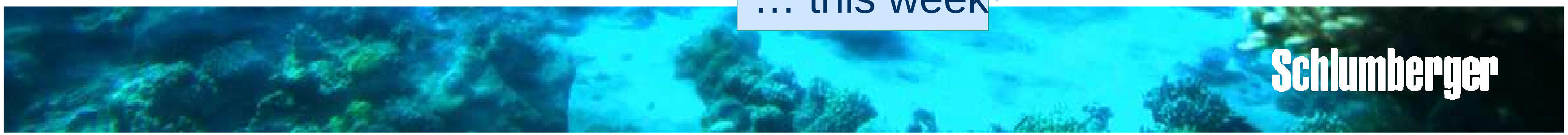
- 500 samples per second per trace
- ~20,000 traces per shot, every 10 seconds
- Up to 160 shots/km^2, 100 – 2,000 km^2 per survey



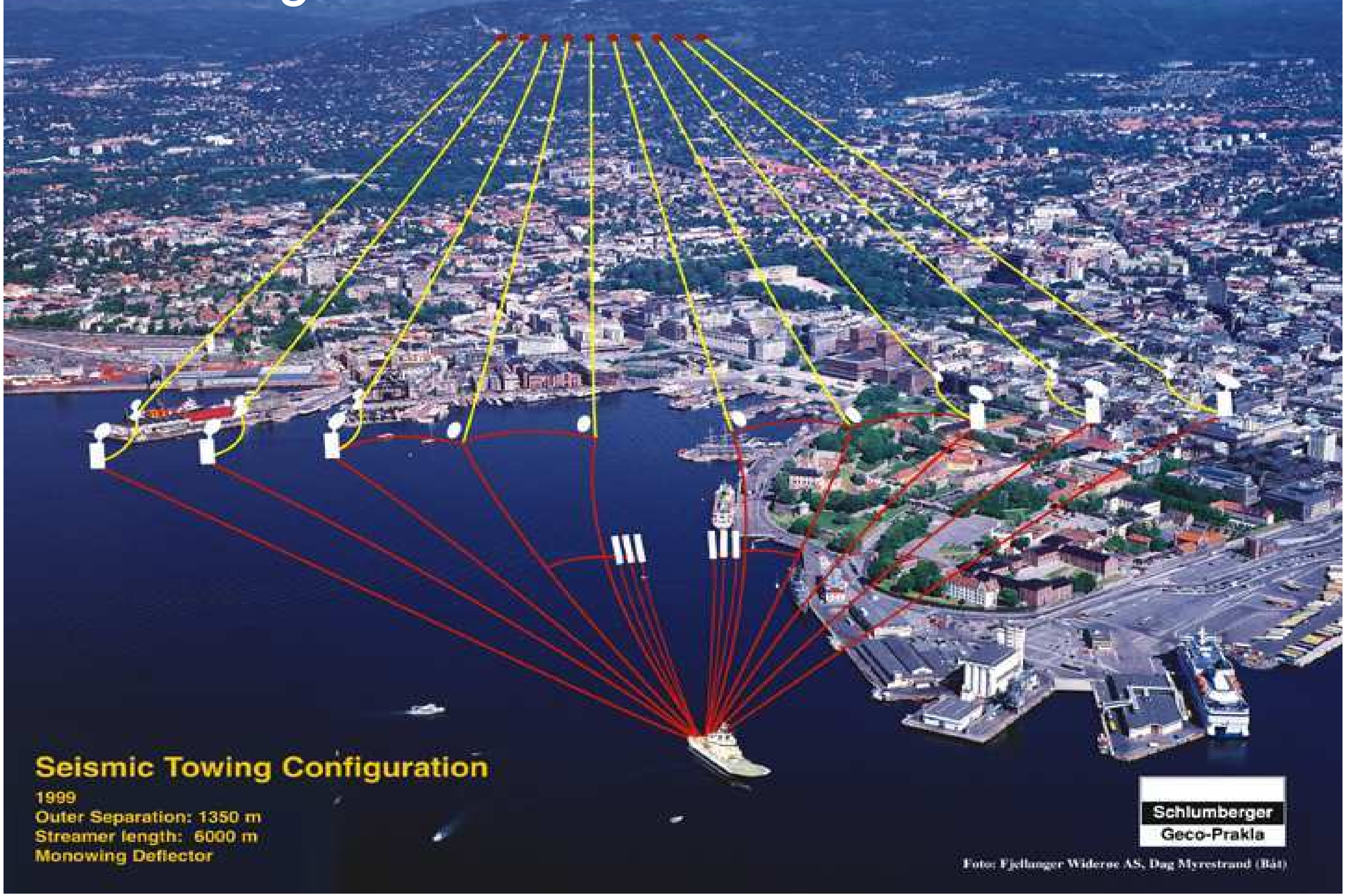
- ~ 45 surveys being processed at any one time
- ~30 separate steps in processing each survey
- Seismic, the largest consumer of computers-worldwid



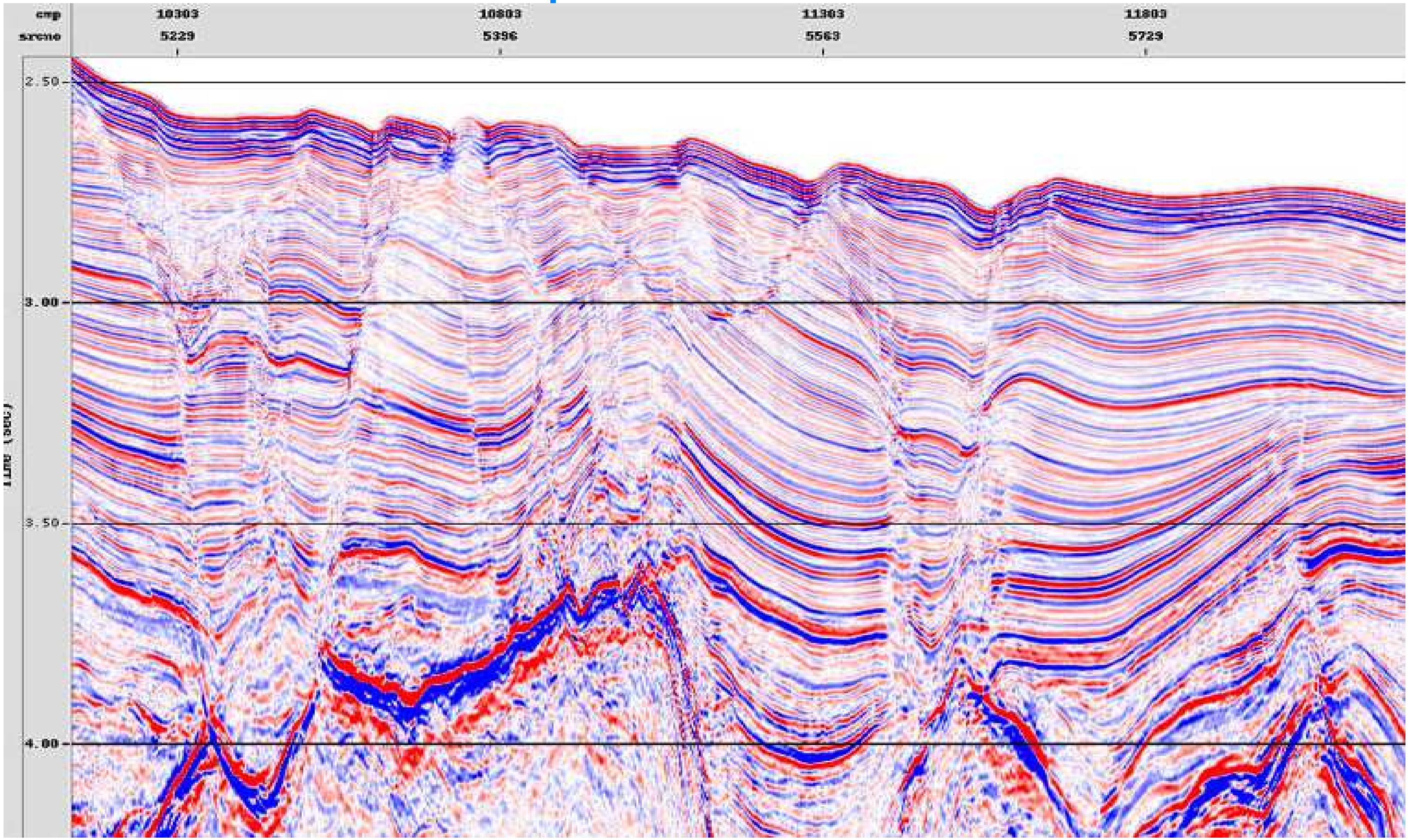
- Online storage: 38 petabytes: ~ 120 million DVDs
- CPU capacity >200TFlops: ~ 90,000 x 3GHz PCs
- … this week



Geco Eagle over Oslo



Seismic Data: Interpretation



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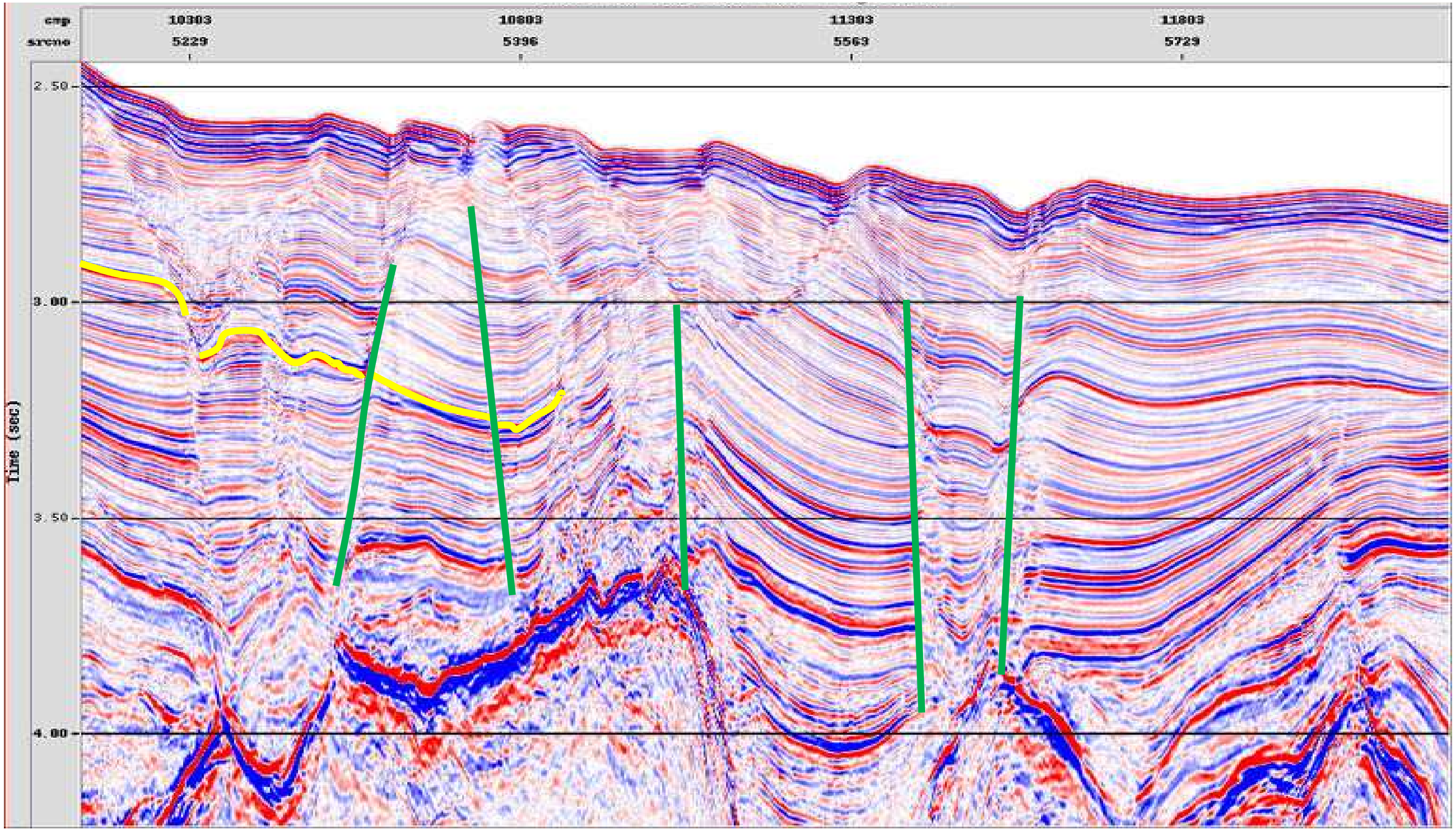
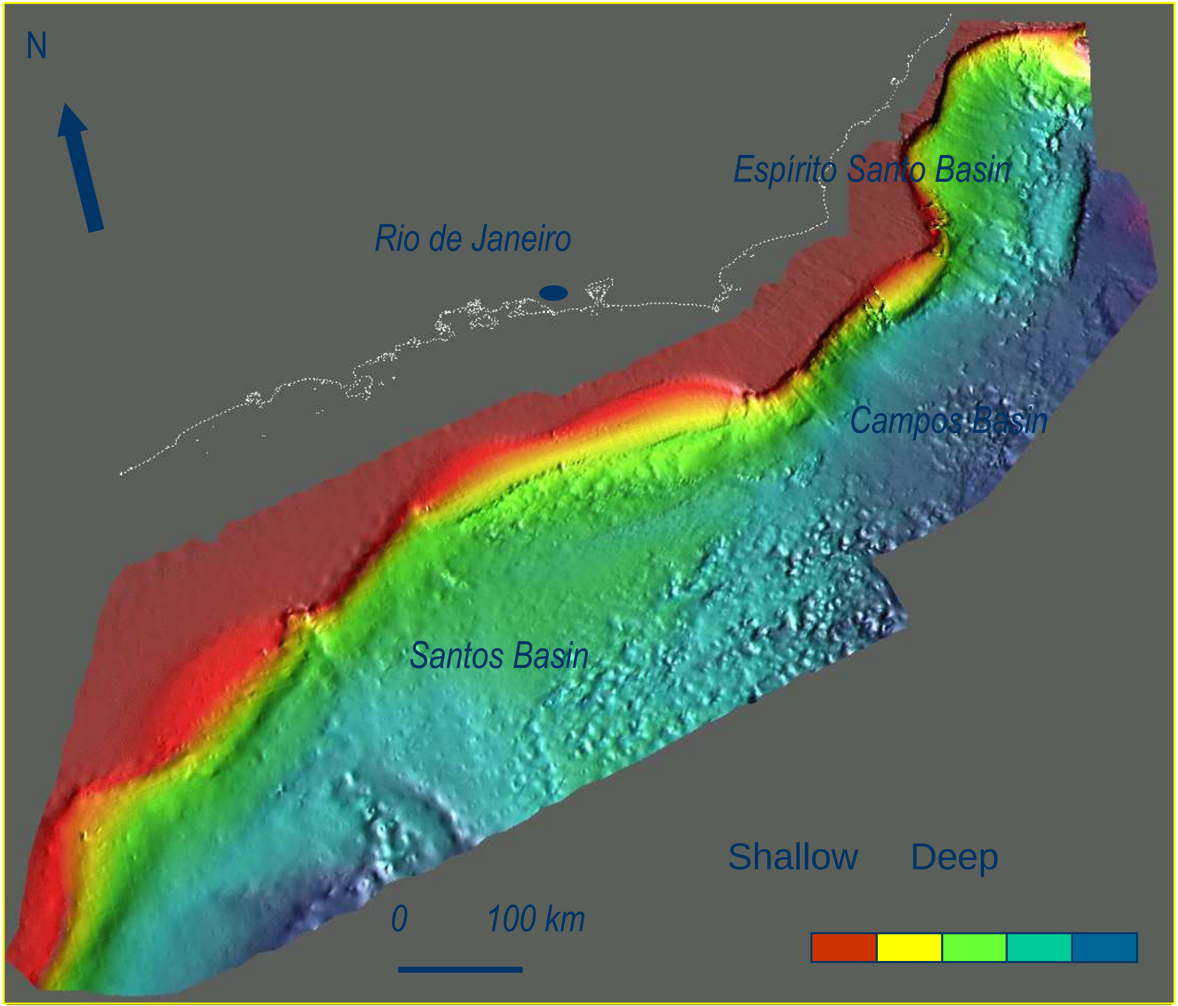


Seismic Data: Interpretation



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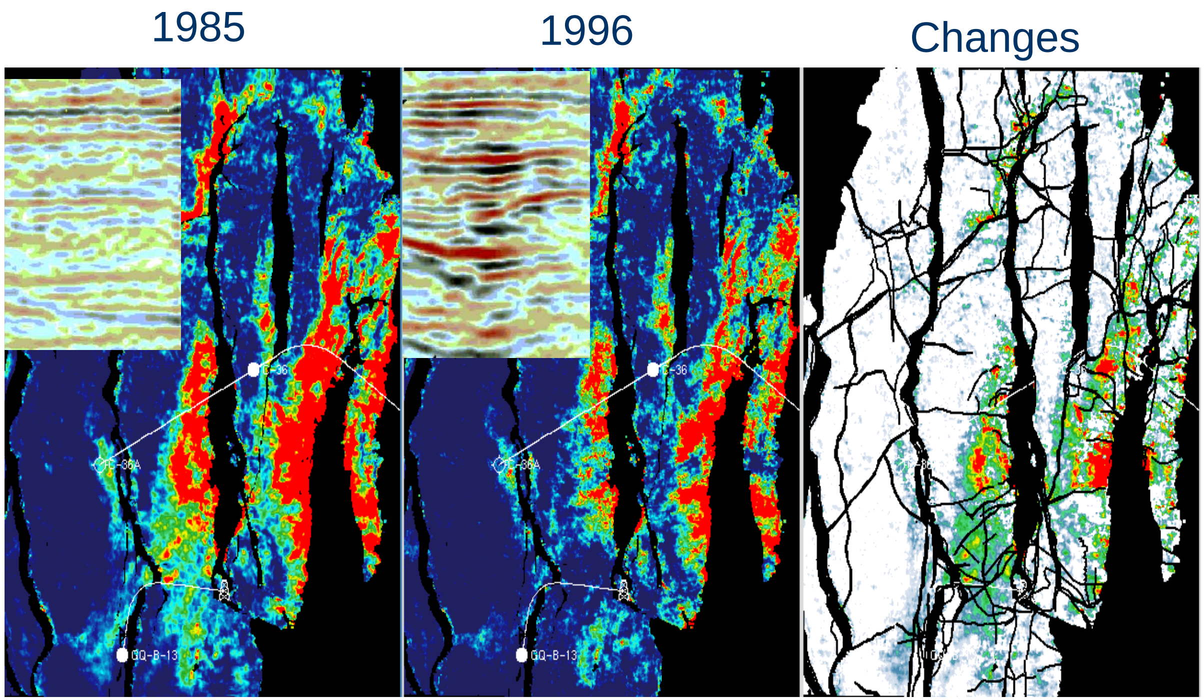
Seismic Data: Time Lapse – Permanent Monitoring



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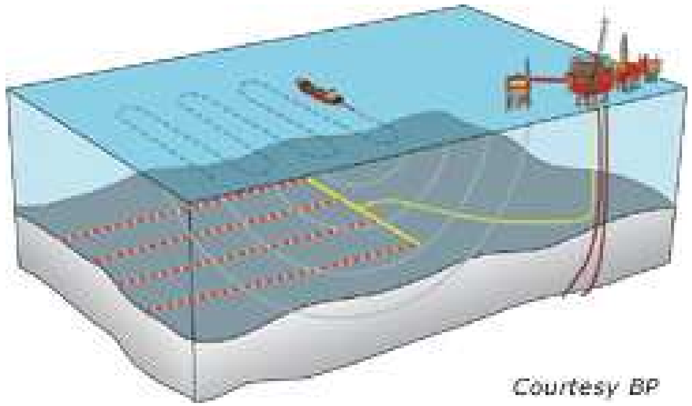
No Change — Significant Change



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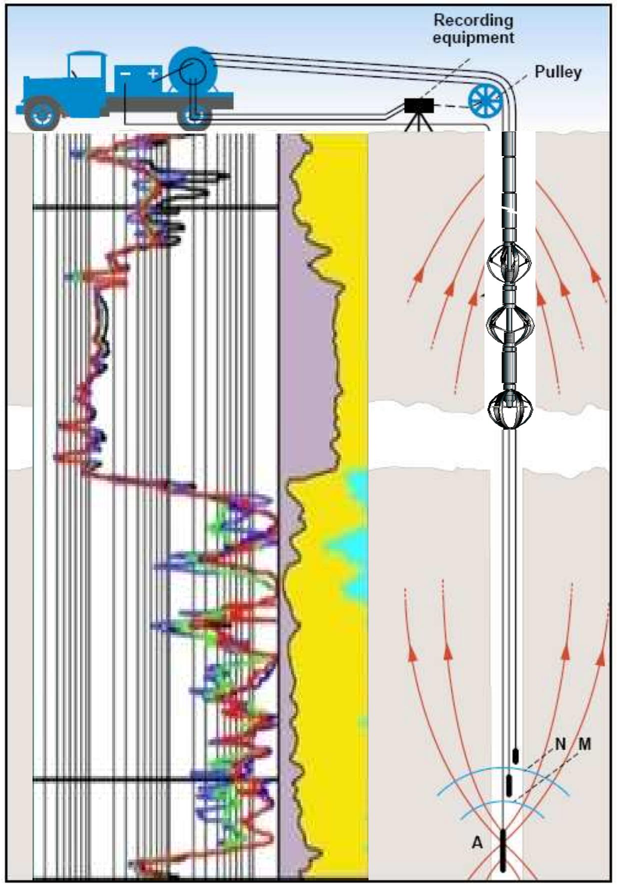
Seismic Data: Challenges

- Acquisition
  - Sampling bandwidth: 100 MB/sec
  - Extremely large amounts of data
  - Multi-component data
- Processing
  - Terabytes of data
  - Algorithmic complexity (physics ⊗ programming)
  - I/O efficiency
- Architecture
  - Scalability
  - Reliability
- Multiple versions!

Borehole Data: Acquisition

- Lithology & Petrophysical Properties
  - Sand/Shale discrimination
  - Porosity (sonic, nuclear)
  - Density (nuclear)
  - Permeability (electrical)
  - Water/Oil/Gas Saturation
- Geomechanical Properties
  - In-situ stresses (sonic)
  - Seismic velocity calibration
- Geology
  - Sub-seismic bedding (electrical, nuclear)



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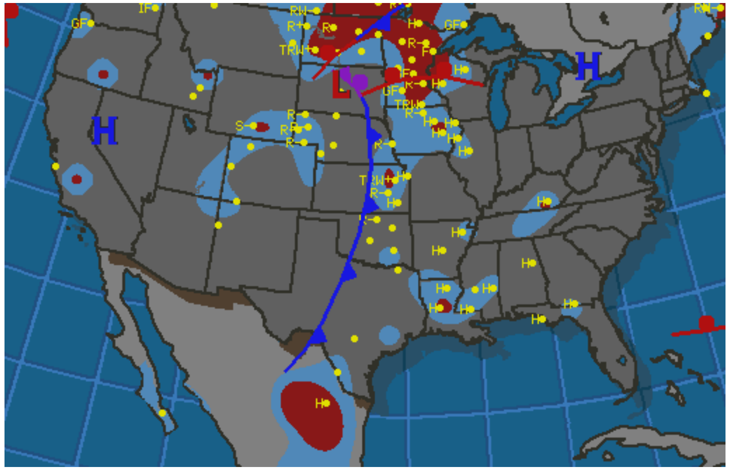
Borehole Data



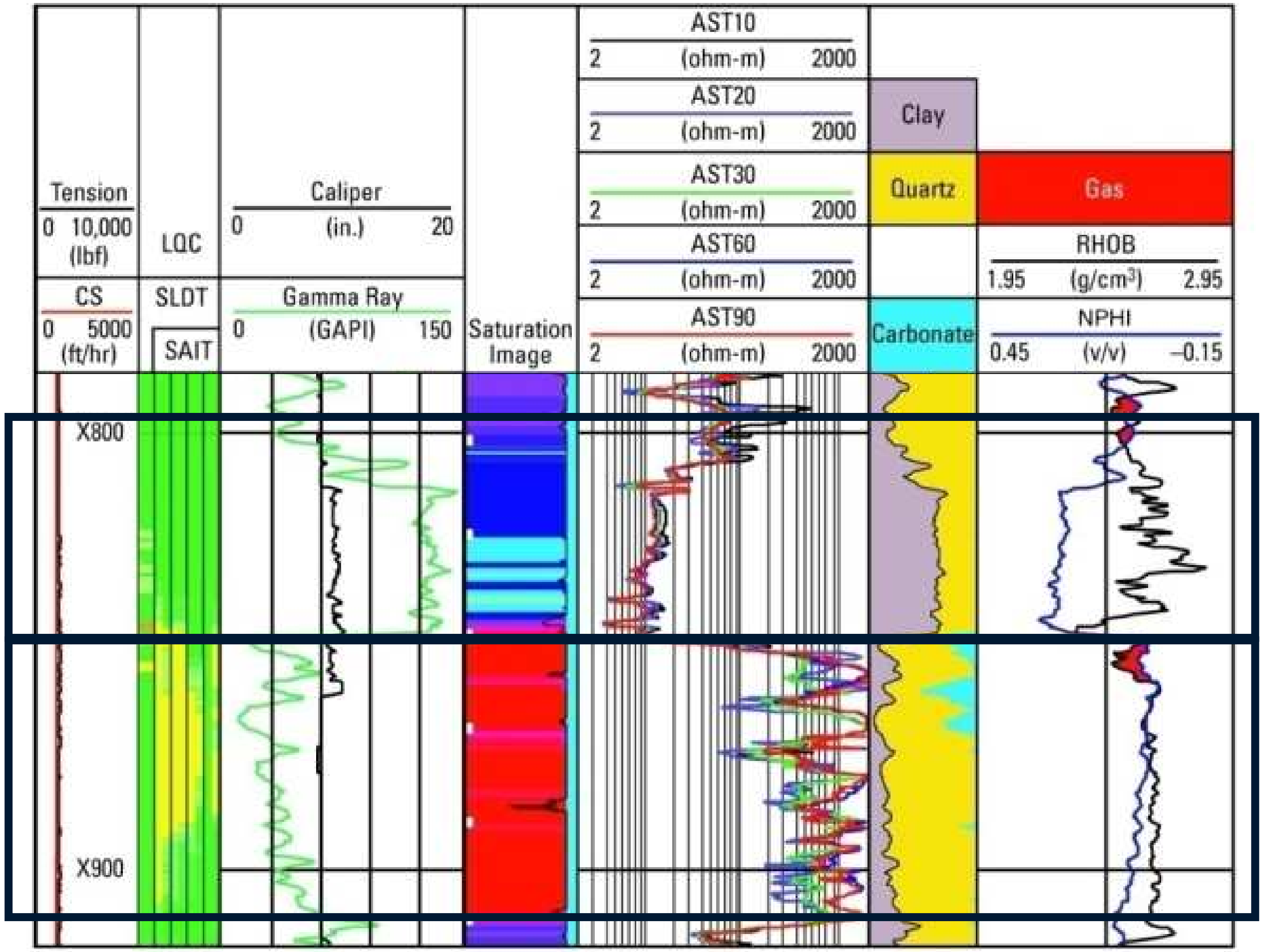
Borehole data is like data from a weather station.

- Lots of precise measurements.
- Sparse areal coverage
- Fronts are like faults—discontinuities between air masses

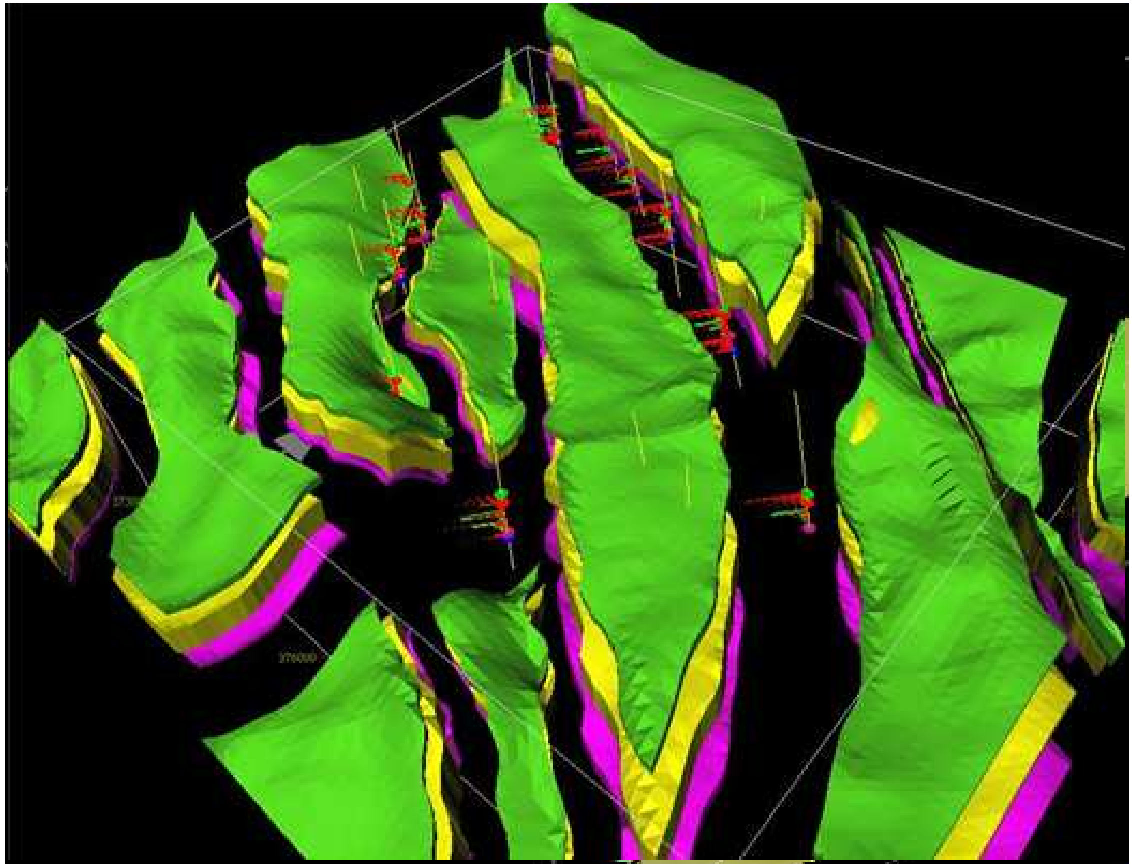
Borehole Data: Interpretation

Shale

HC-saturated sandstone



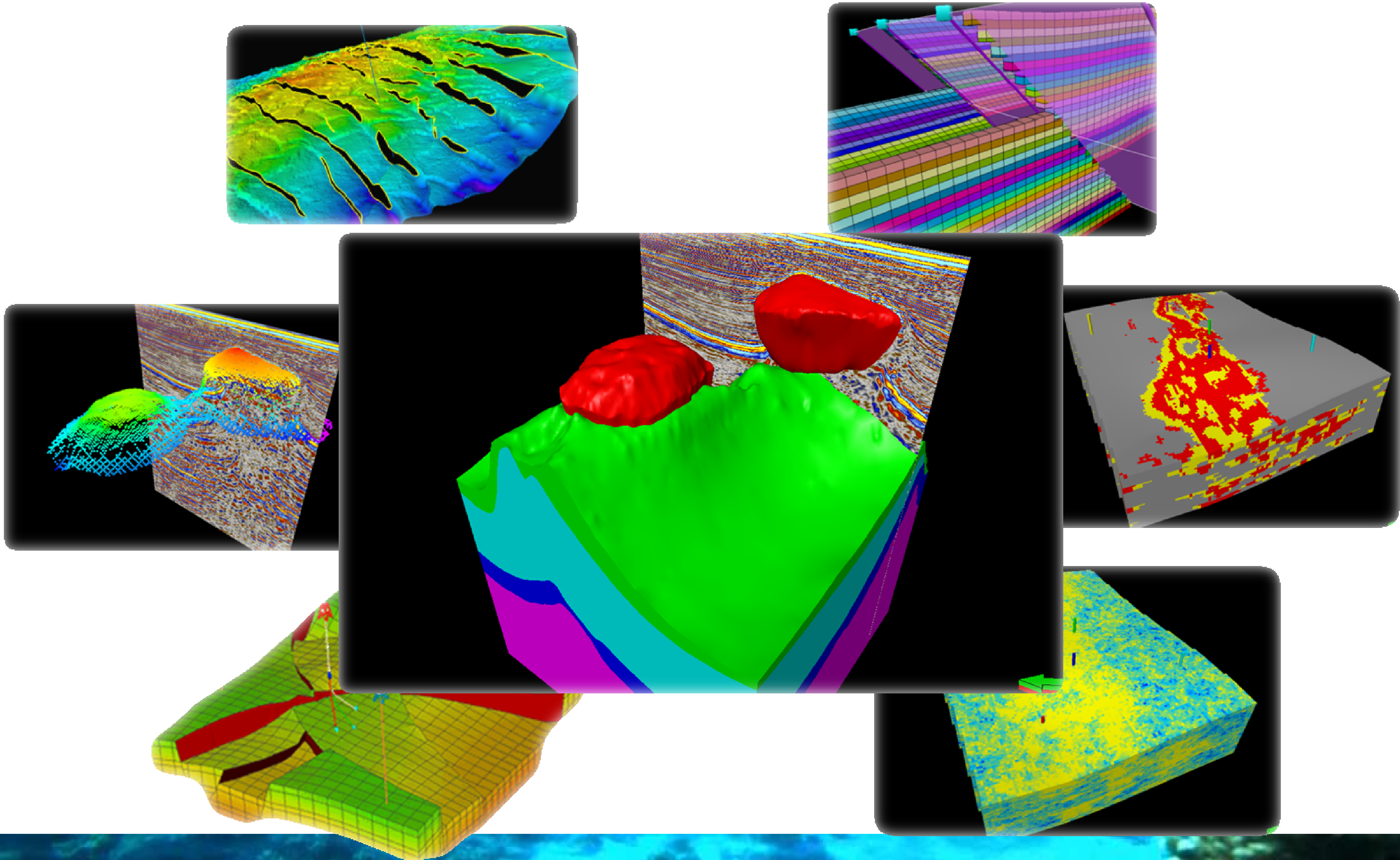
Borehole Data: Interpretation



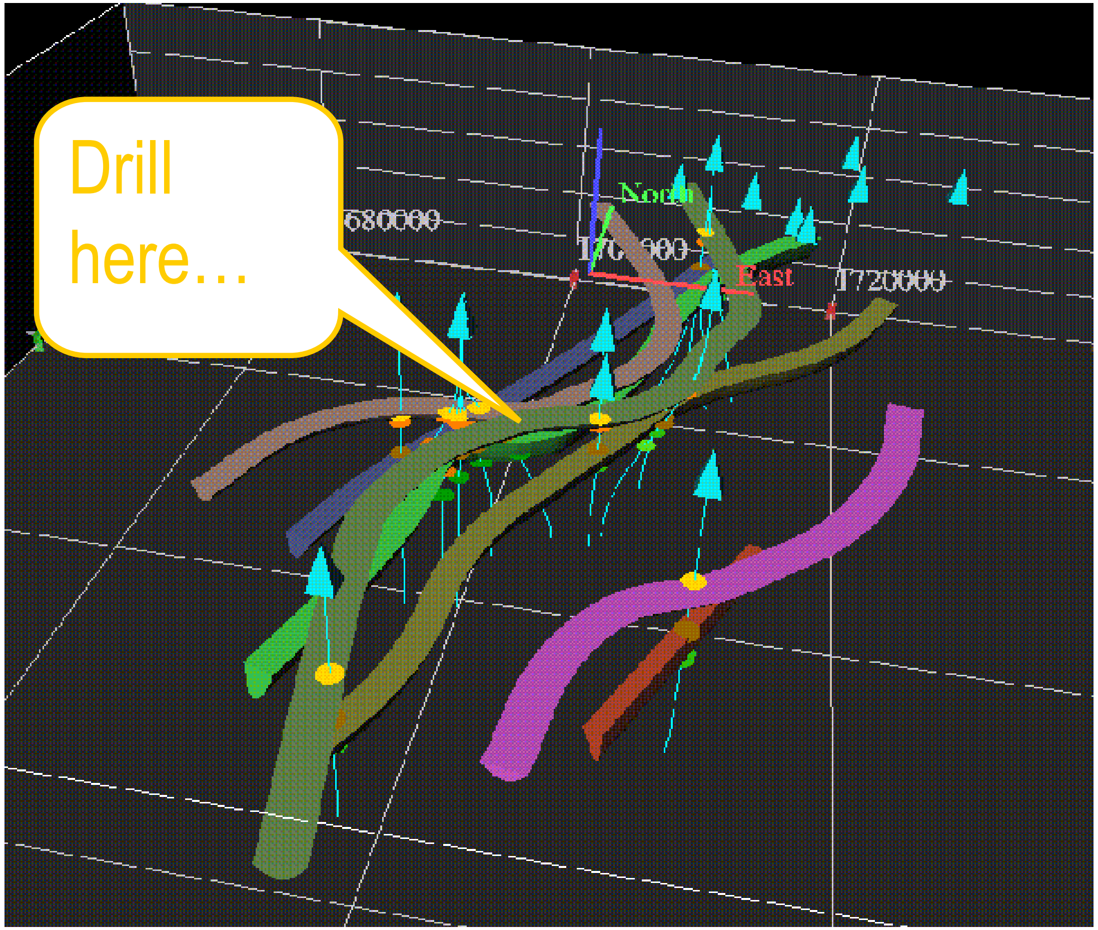
Borehole Data: Challenges

- Acquisition
  - High sampling rate
  - Noise
  - Extremely difficult borehole environments
- Processing
  - Mega to Giga bytes of data
  - Algorithmic complexity (physics ⊗ programming)
  - Disparity in data types
  - I/O efficiency
- Architecture
  - Scalability
  - Reliability

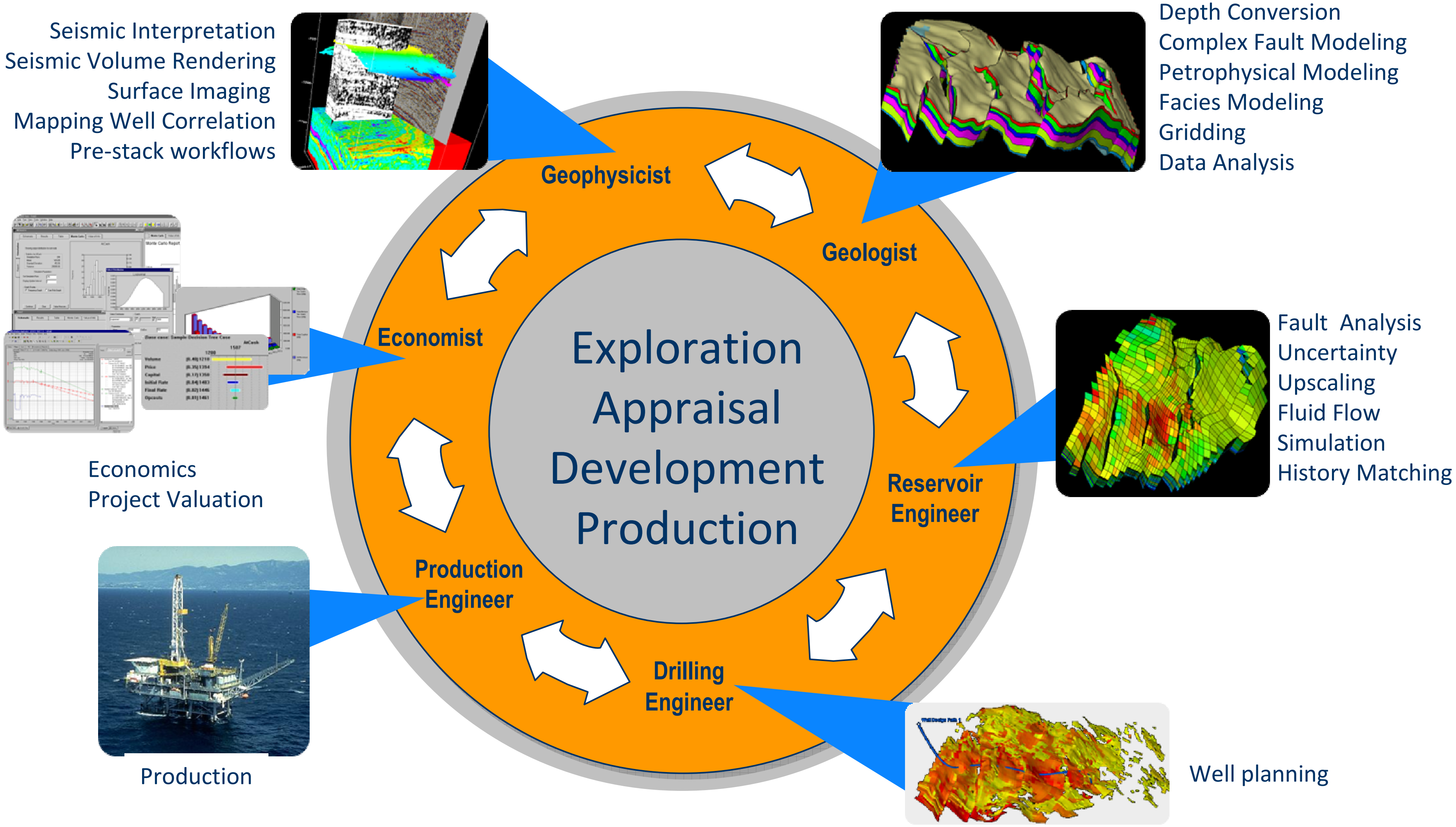
Seismic Data + Borehole Data = Shared Earth Model



Getting to the insight is a multi-disciplinary effort…



Multidisciplinary Data Integration



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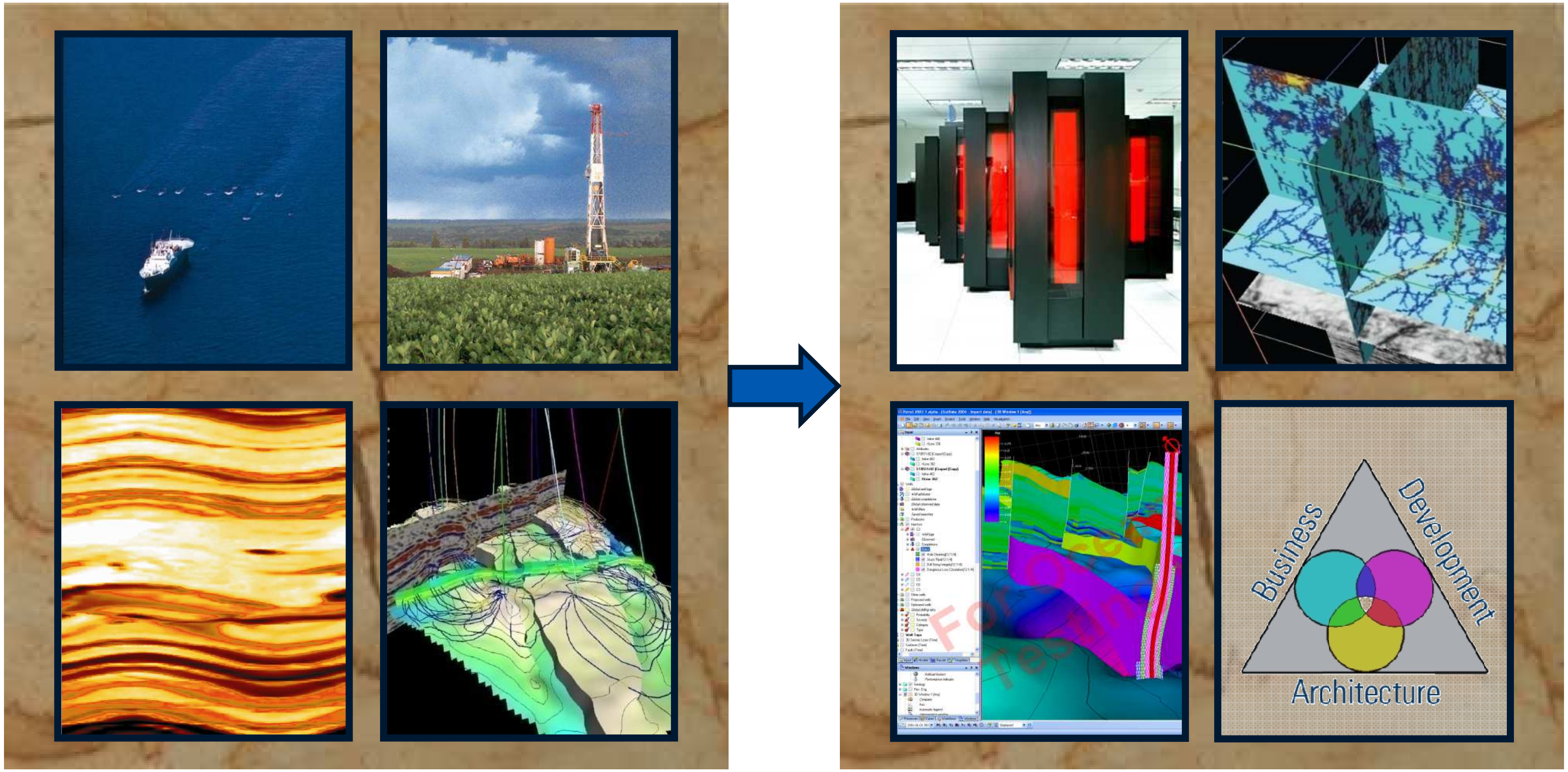
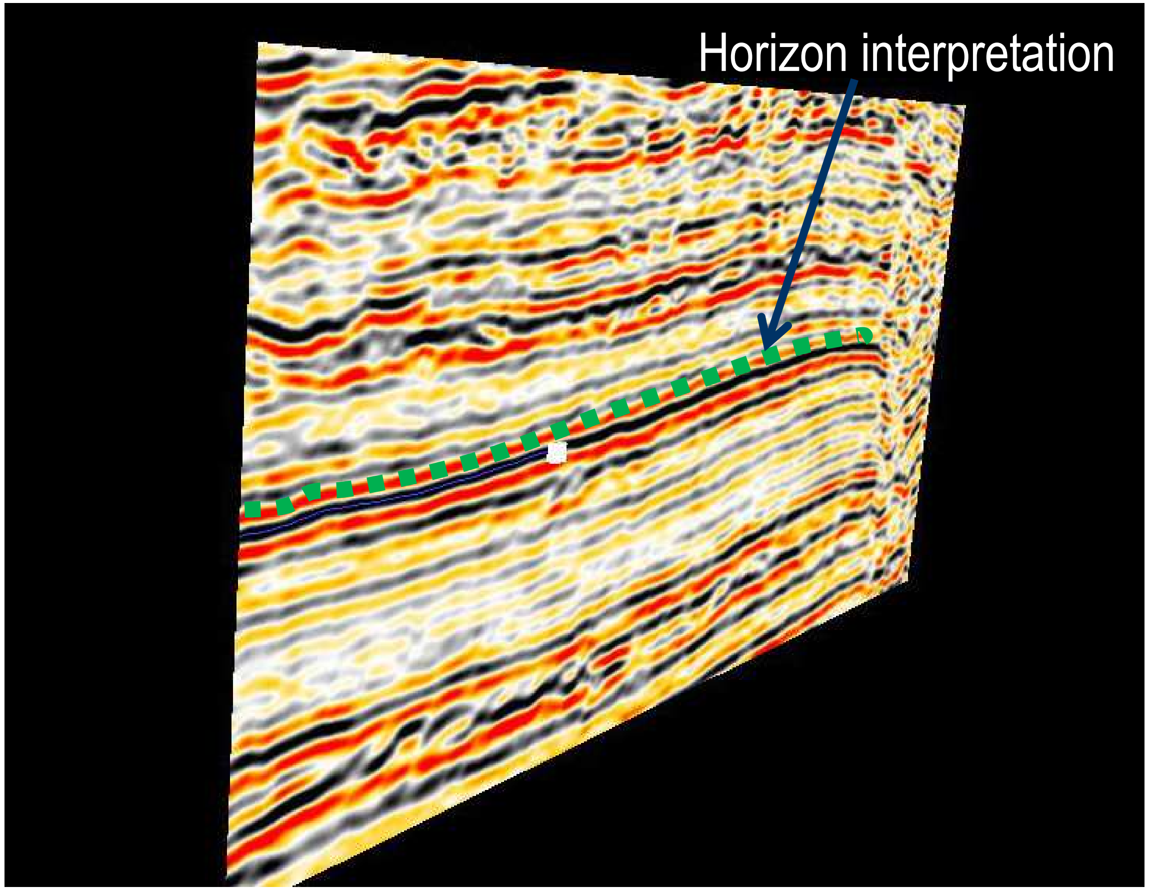
Computer Science Challenges

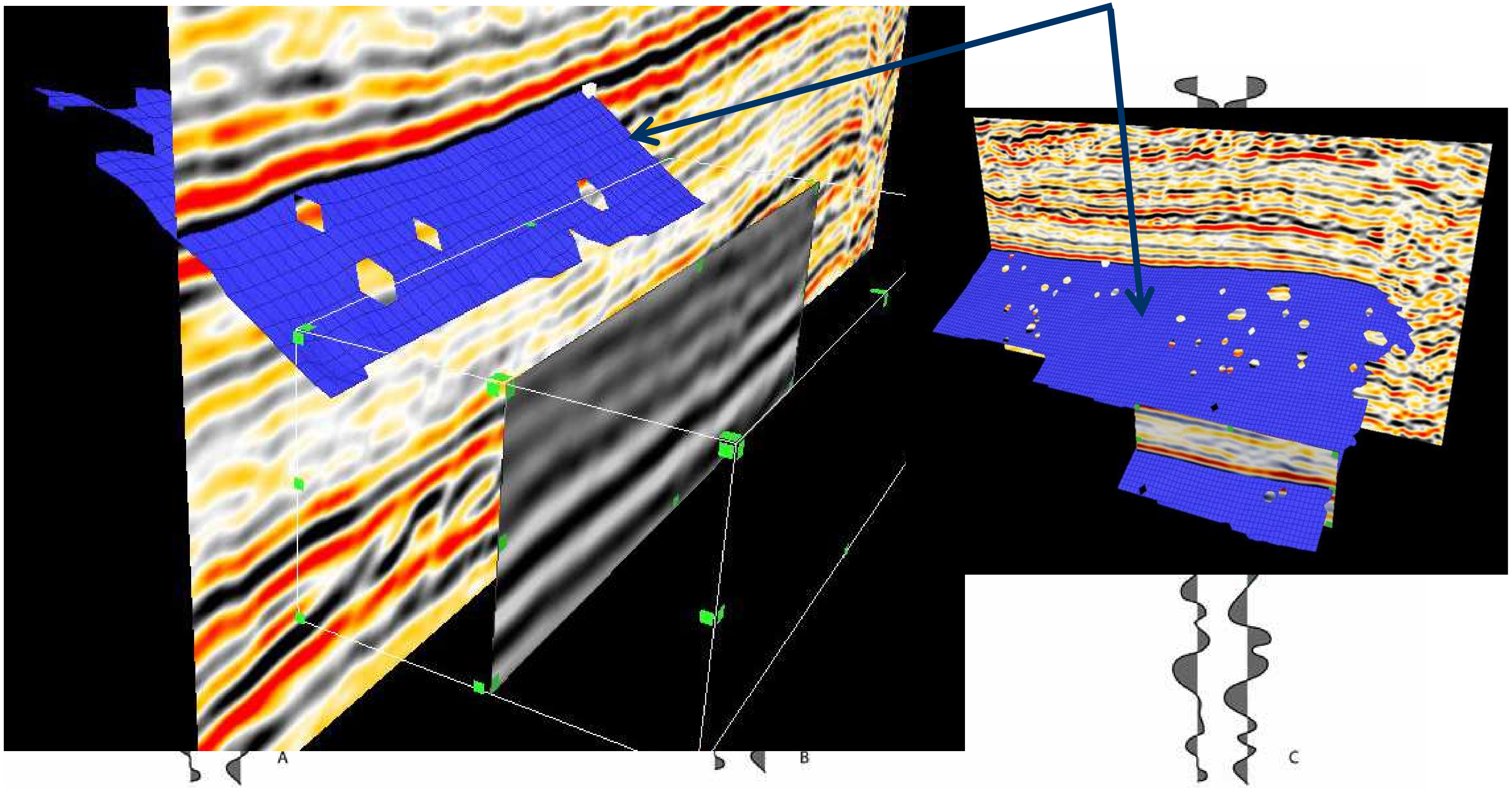


Data Interpretation Challenges: Horizon Detection

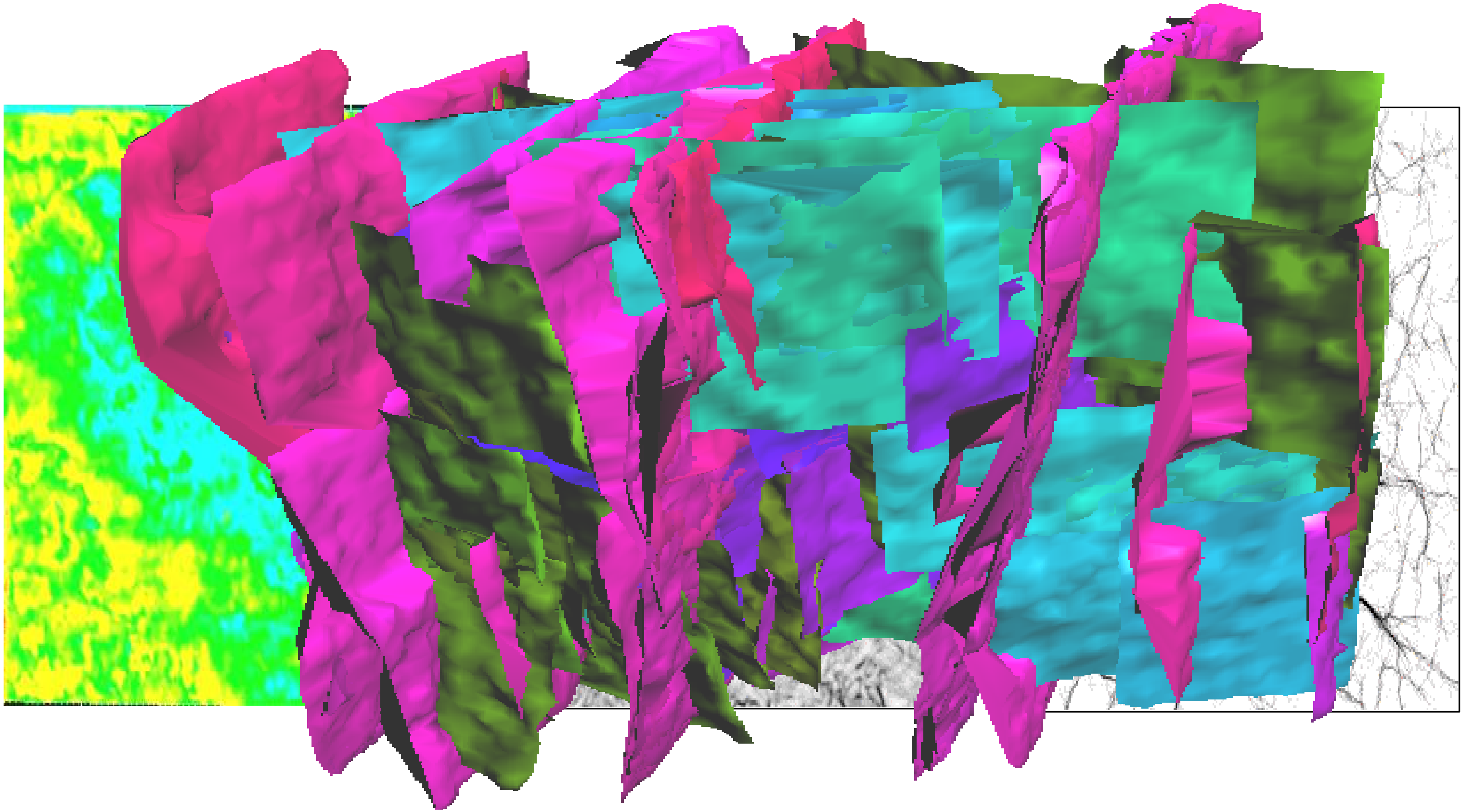


Data Interpretation Challenges: Horizon Detection

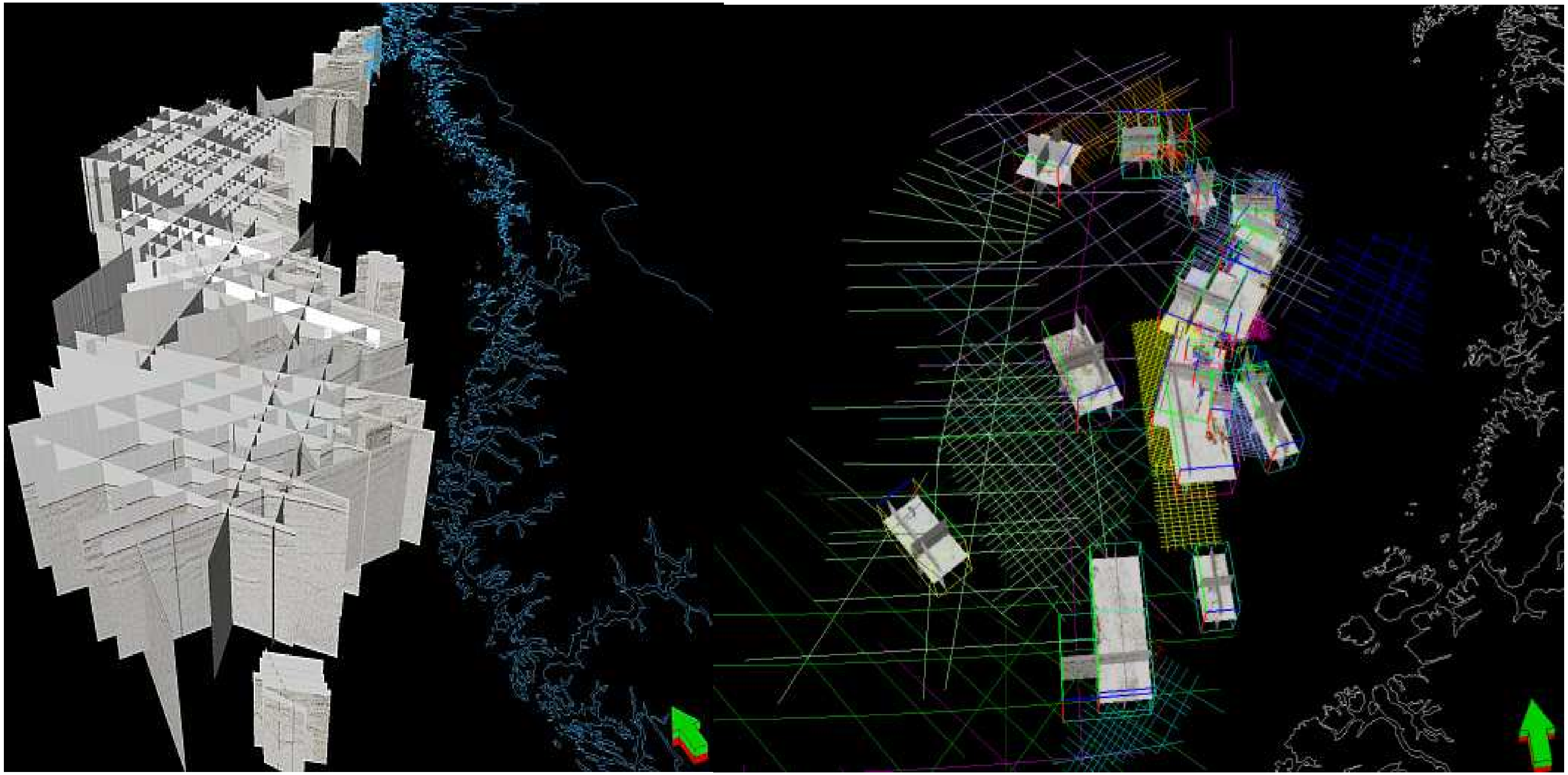
Automatically interpreted and interpolated horizon



Data Interpretation Challenges: Fault Detection



Data Interpretation Challenges: Scalability



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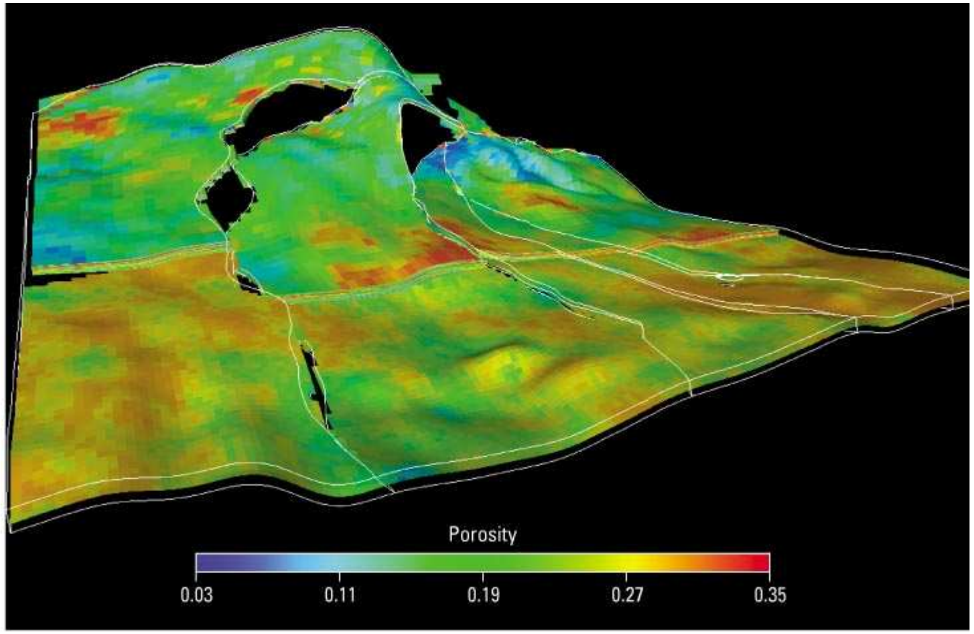
Data Interpretation Challenges: Properties



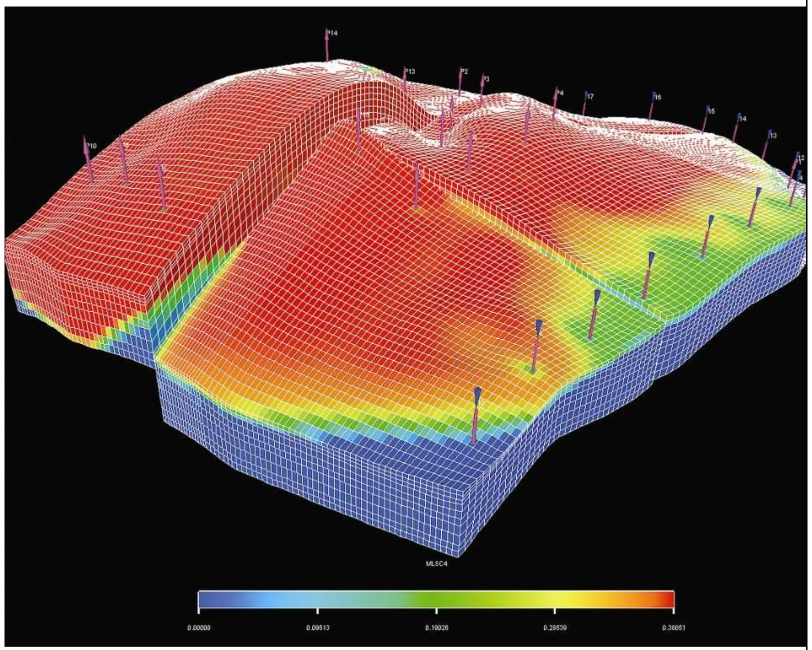
Volumes

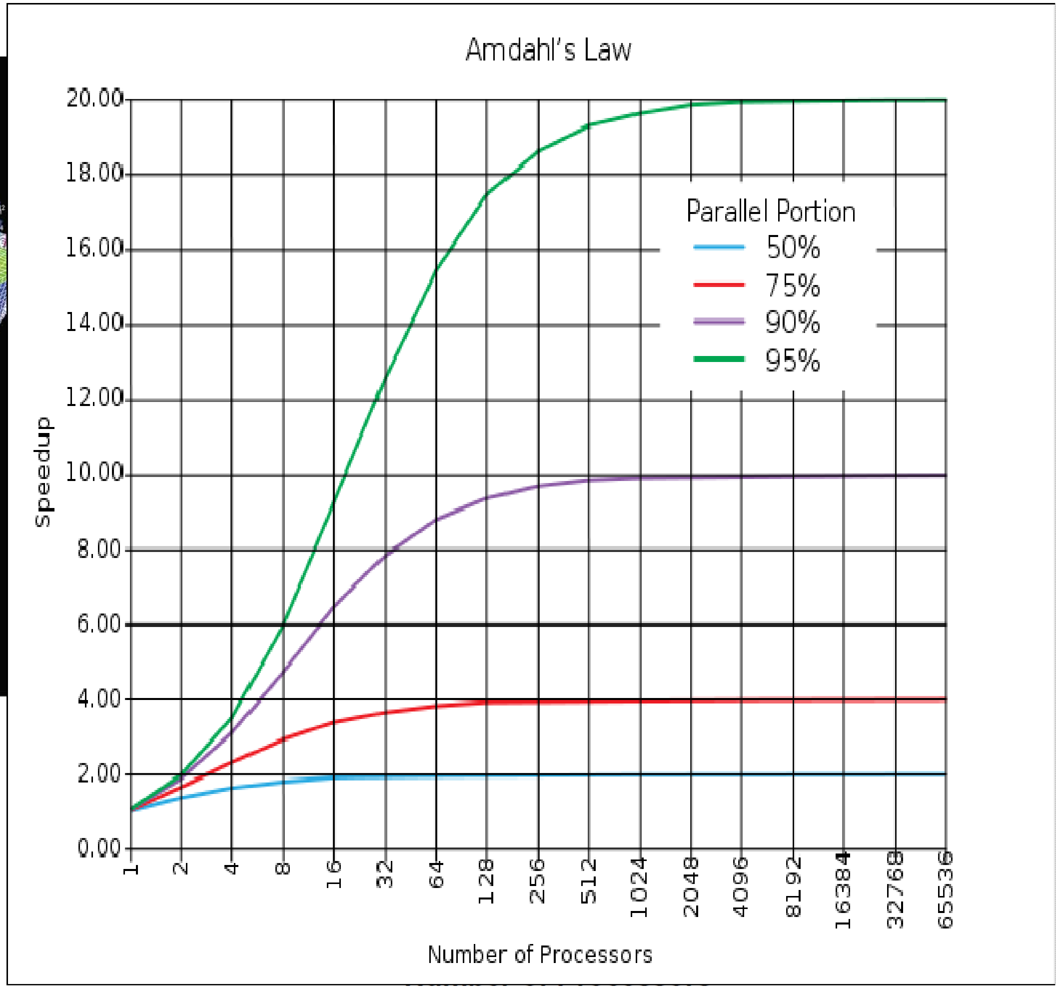
- Cartesian, Corner point
- PEBI, Tetrahedra
- Unstructured

Surfaces

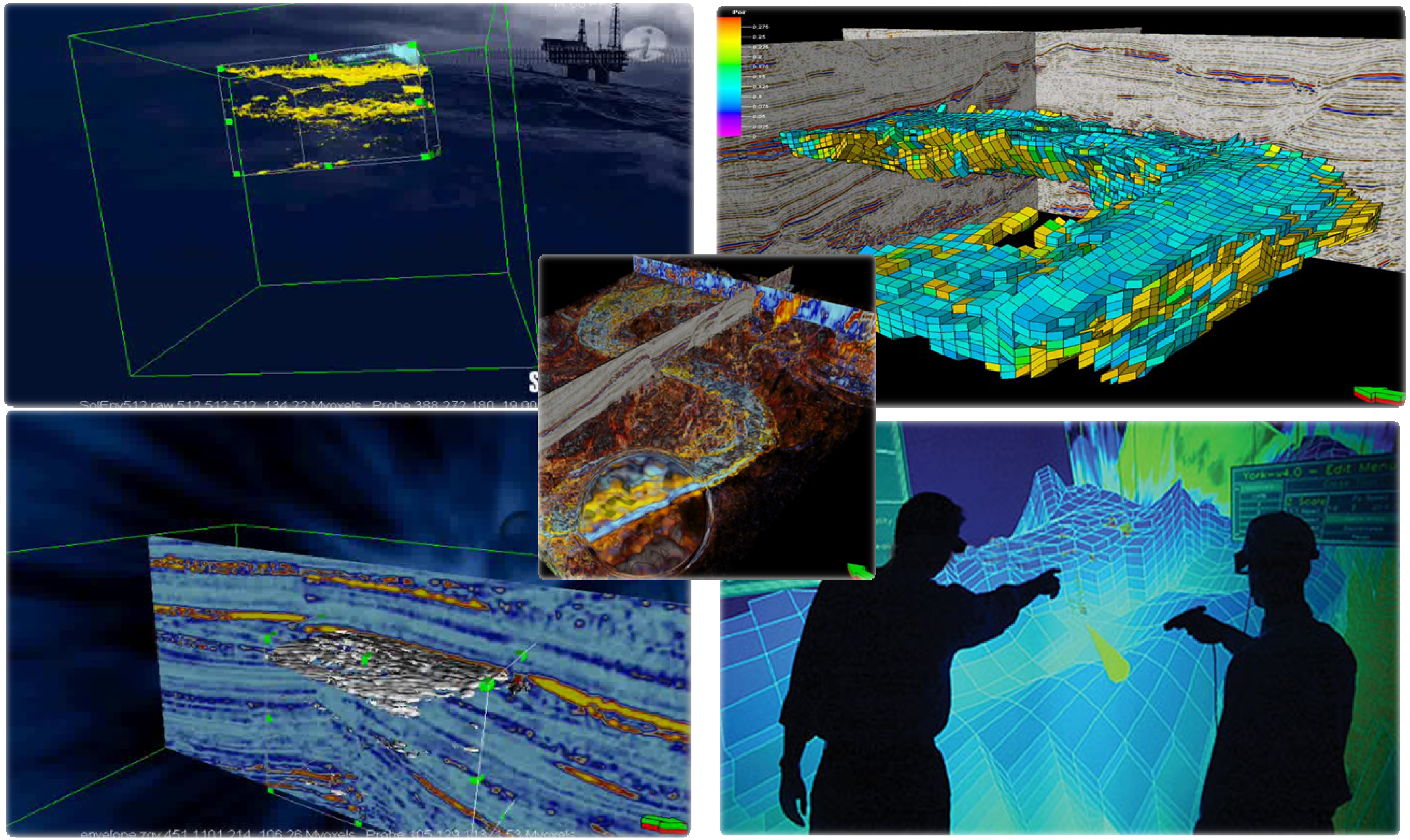
- Height fields: simple and compact, but limited
- Triangle meshes: flexible, but complicated
- Hybrid: best of both, but more complicated

Data Interpretation Challenges: Fluid Flow Simulation





Data Interpretation Challenges: Visualization



Usability

Interpretation requires a computational infrastructure that:

- Makes routine work easy and quick,
- Makes extraordinary work possible (*e.g.,* is extensible)
- Takes advantage of local knowledge and past experience, and
- Allows for experimentation with alternative hypotheses.

Extensibility

Application extensibility requires:

- A robust, secure component framework
- A comprehensive data access API
- Domain API extensibility
- UI extensibility

We want to support *emergent behavior:* allow users to exploit component interactions in unforeseen ways.

Summary of Oil & Gas Data Interpretation Challenges

- Diverse data types
- Extremely large data volumes
- Complex mathematical algorithms
- Enormous range of feature sizes: mm to km
- Complex data structures
- High-performance 3D geometric modeling, visualization and simulation
- What if scenarios and uncertainty management
- Robust calculations and error handling

- Highly efficient parallel computing, need it everywhere!
- Growing functionality and complexity requires extensive software verification
- Growing functionality and complexity requires high developer productivity
- Maintenance and re-engineering of legacy code
- Exponential code base growth
- High performance over the web
- Usability

Thank you!

Questions?

bouzas1@slb.com