The New Paradigms in Oil and Gas Exploration and Production and Implications for The Niger Delta

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By

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The New Paradigms in Oil and Gas Exploration and Production: Implications for Increased Potentials of The Niger Delta

- Introduction
- Current Realities and Challenges
- Future Trends
- Concluding Remarks

Introduction : Strategic Imperatives

Exploration and Exploitation strategies of oil and gas are changing, driven by need for

- Reduction in life cycle evaluation from discovery to first oil/gas
- Cost Reduction
- Lower oil price
- Increasing technological challenges to identify new and by-passed oil and gas

Introduction: Current Realities

- **Exponential increase in Data volume:**
  - higher fidelity of seismic data
  - sophistication of log acquisition from drilling
  - legacy data, interpretation and models

- **Discipline Experts and Teams with ability to analyze data (workflow implementation) and generate models**
  - work in silos, and
  - integration in often limited

- **Increasing need for**
  - greater sophistication of subsurface models
  - consistency of model hierarchies and management of uncertainties
  - integrations of knowledge and skills sets,
  - multi-dimensional analyses and
  - interrogation of large, diversified data types

…. hence the need to evolve new strategies

Introduction: The New Approach in E&P

Designing a New strategy for E&P Teams must be underpinned by:

1. **Knowledge Management** - *"New and robust subsurface concepts and models"*

2. **Technology Applications and Integrated interpretation**

   - *"New Platforms and integration of workflows"*
   - *"Reduction of Interpretation Cycle Time"*

1. **Data Management**

   - *"Managing Big Data"*
   - *"Ability to Sweat information from existing and New Data"*

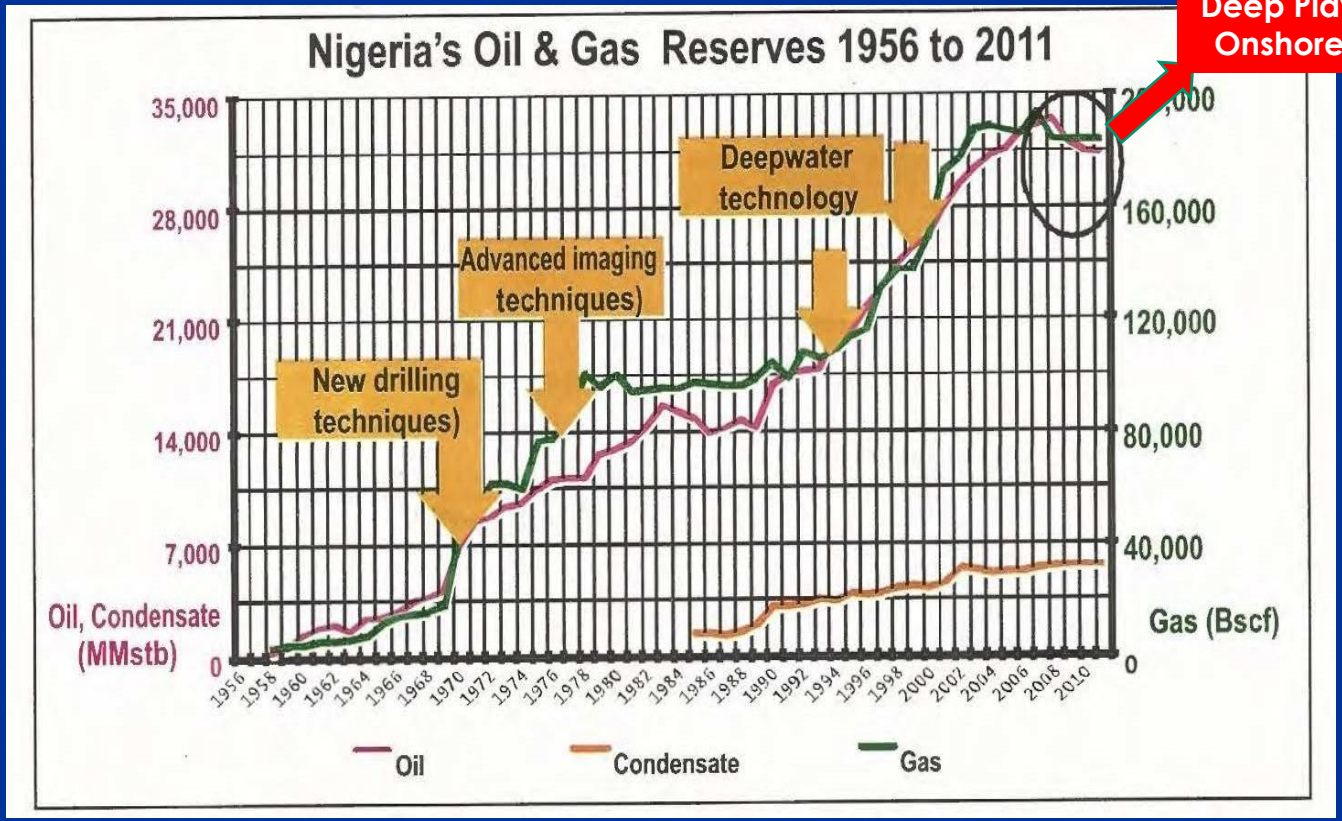
4. **Workflow and Discipline Team knowledge integration**

   - *"from Asset Based teams to Internal and Collaborative"*

5. **People**

   - *Attitudes*
   - *Expertise Skills of the future*

Current Realities: Niger Delta Resource Base



Organic Growth of Reserves

HYDROCARBON	Initially In Place	Ultimate Recovery	Available Opportunities (In Place- UR)	Remaining Reserves
	P1 + P2	P1 + P2		P1 + P2
OIL (MMB)	144,597.36	59,970.10	84,627.0	31,291.28
CONDENSATE (MMB)	12,316.35	6,641.09	5,675.3	5,313.97
ASSOCIATED GAS (BSCF)	235,756.14	131,105.02	104, 651.1	92,945.25
NON-ASSOCIATED GAS BSCF	130,677.00	95,300.09	35,376.9	89,871.42

Source: Osahon, G; In Nigerian Association of Petroleum Explorationists Special Commercial Bulletin Vol 1.11, 2016

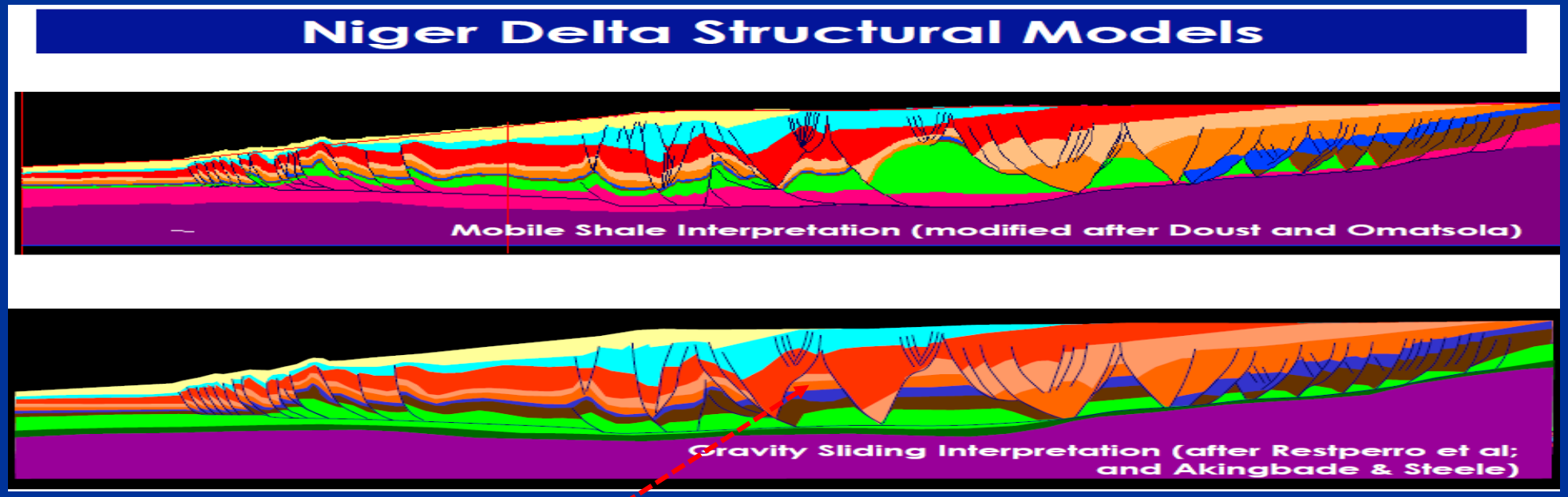
- Over 65Bln Barrels produced and current reserves estimates of ca 35Bln
- Mainly from Conventional play onshore and shallow water
- YTF estimates of ca. 70-75Bboe from onshore deep play and upper slope systems (future reserves addition)
- Ability to realize potential of the undiscovered resources is key and requires new thinking

….. Concepts, technology, Integration and

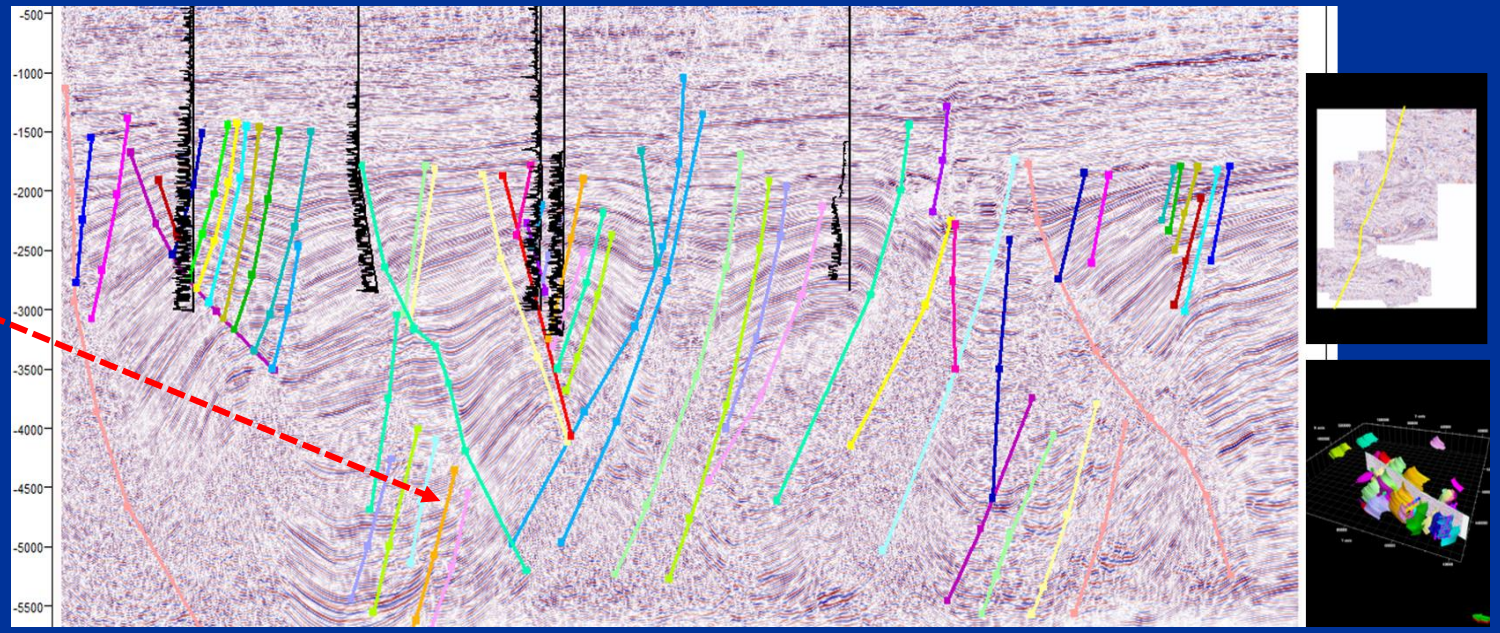
Decoding the "DNA" of the Niger Delta

- **Tectonics and Structural Framework** ➡
  - ➢ Subsidence rates and Delta Evolution
  - ➢ Trapping Configurations
- **Sedimentation and Sand(%) Distribution** ➡
  - Sediment supply
  - Depositional Processes
  - ➢ Delta Evolution
  - ➢ Depositional Setting and Controls
  - ➢ Implications on HC distribution (e.g. sd%)
- **Gross Depositional Environment** ➡
  - Accommodation Space
  - Sediment Supply
  - Structure & Sedimentation
  - ➢ Basin fill histories
  - ➢ Onshore-Offshore linkage
  - ➢ Depositional models and Stratigraphic Architecture
- **Hydrocarbon Occurrence** ➡
  - ➢ Source rock maturity and Fluid Type
  - ➢ HC expulsion and timing
  - ➢ Overpressure

DNA – Structure and Tectonic Framework

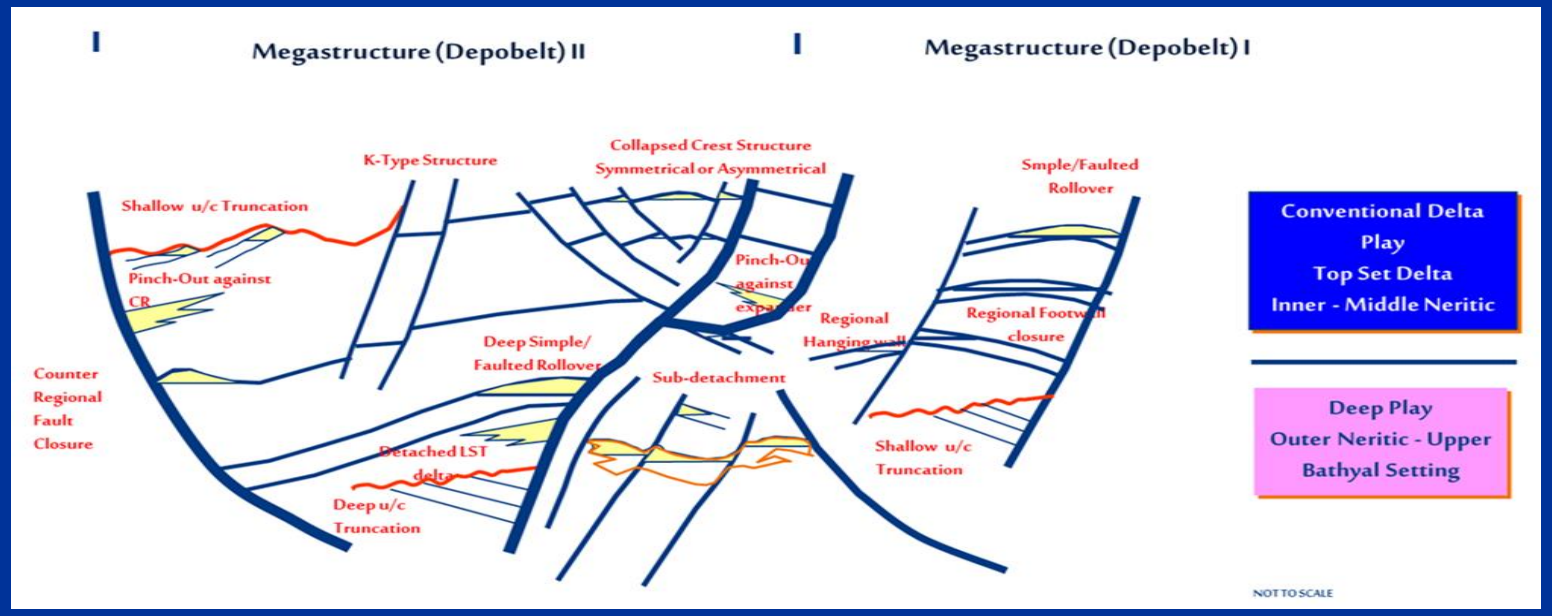


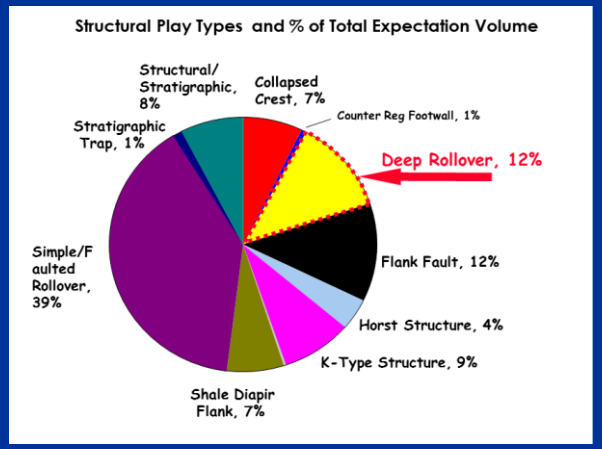
- New tectonic model of gravity sliding has resulted in new play opportunities in the deep, otherwise interpreted as shale diapiric structures

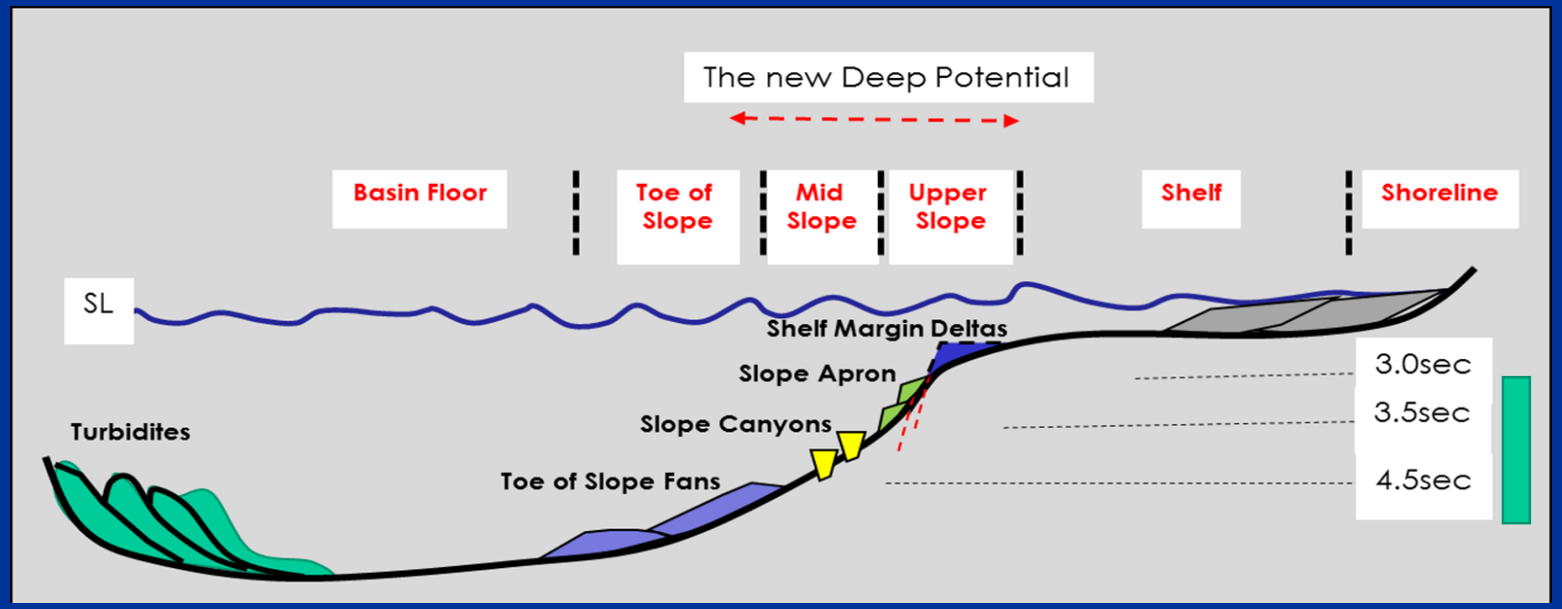


Niger Delta DNA – Tectonics Evolution and Sedimentation

Schematic Framework of megastructures and Trapping Styles



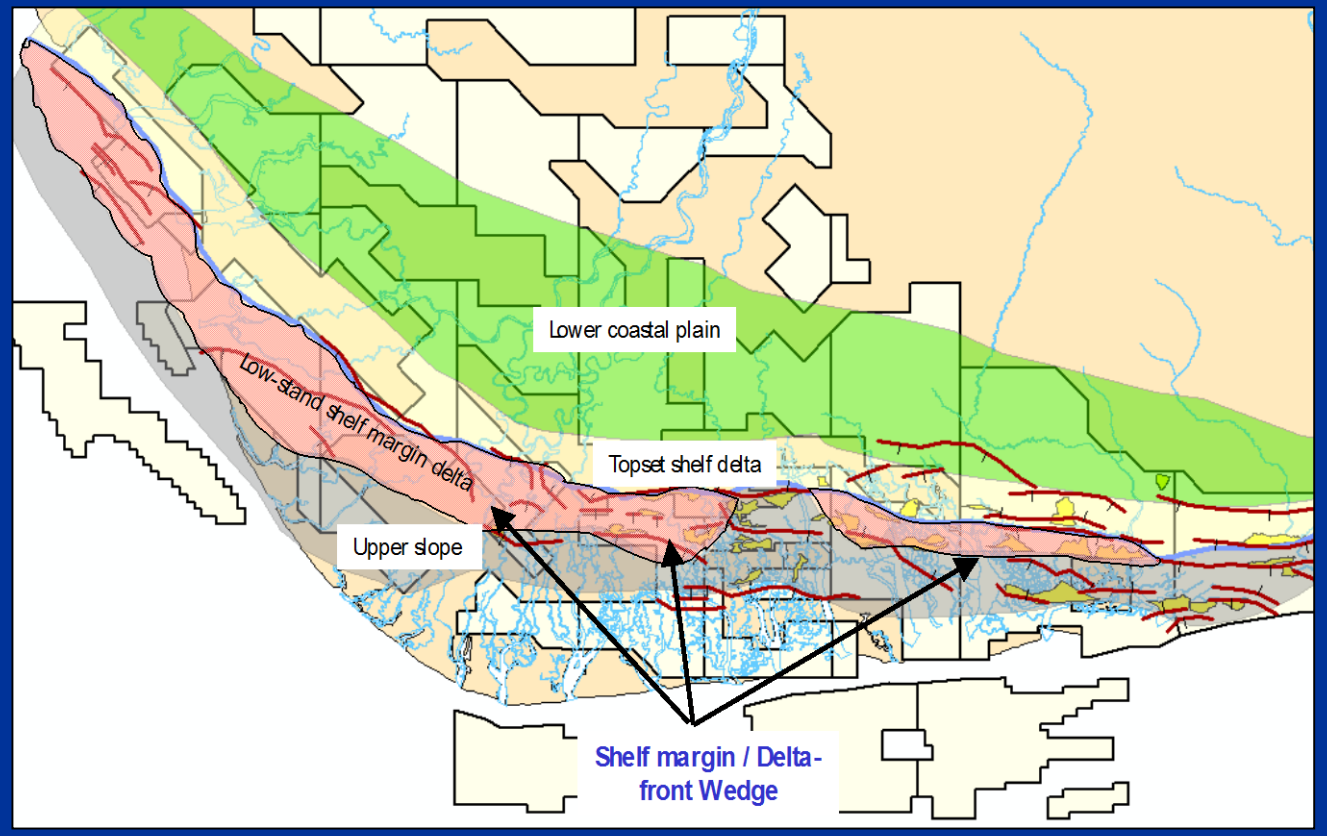




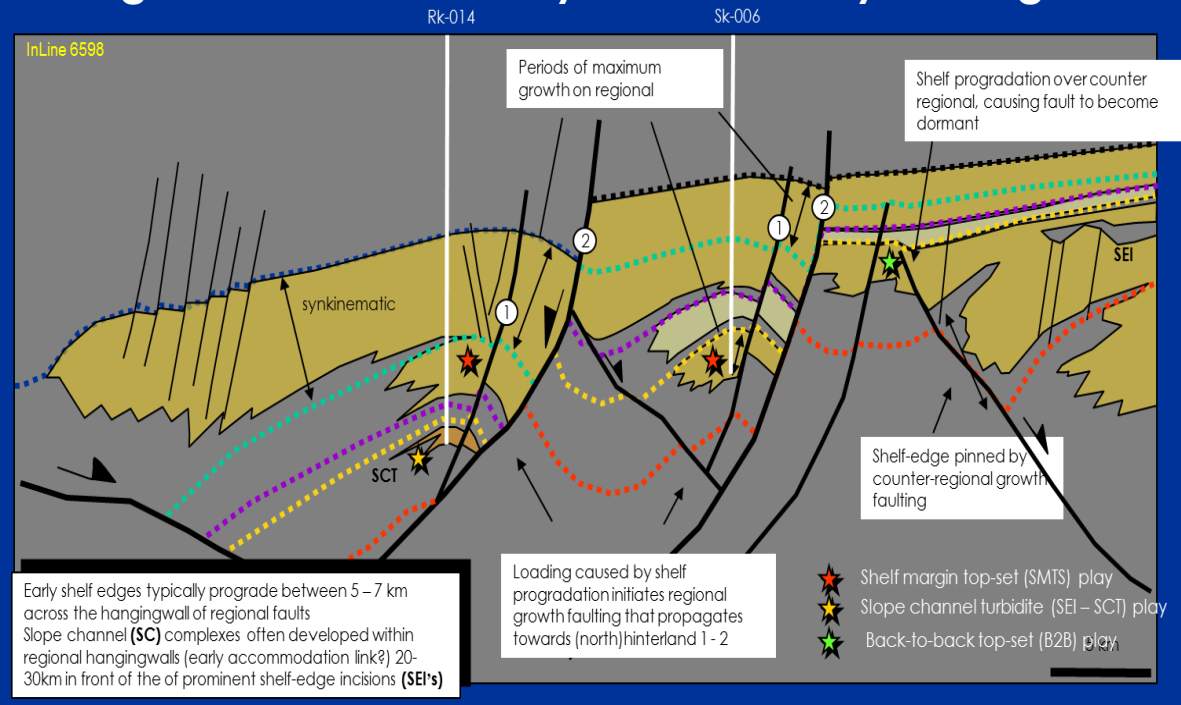
- Trapping styles in the conventional delta mainly structural and constitute ca.90% of the discovered potential
- Onshore-offshore linkage opens new depositional models and geometries of the deeper potential
- **The New Deep play is combination traps (lowstand wedge) and stratigraphic traps (upper-mid-slope aprons, canyons and fans)**
- **Potential to add significant reserves**

Gross Depositional Setting – Lowstand Wedge

Reconstructed Gross Depositional Environment



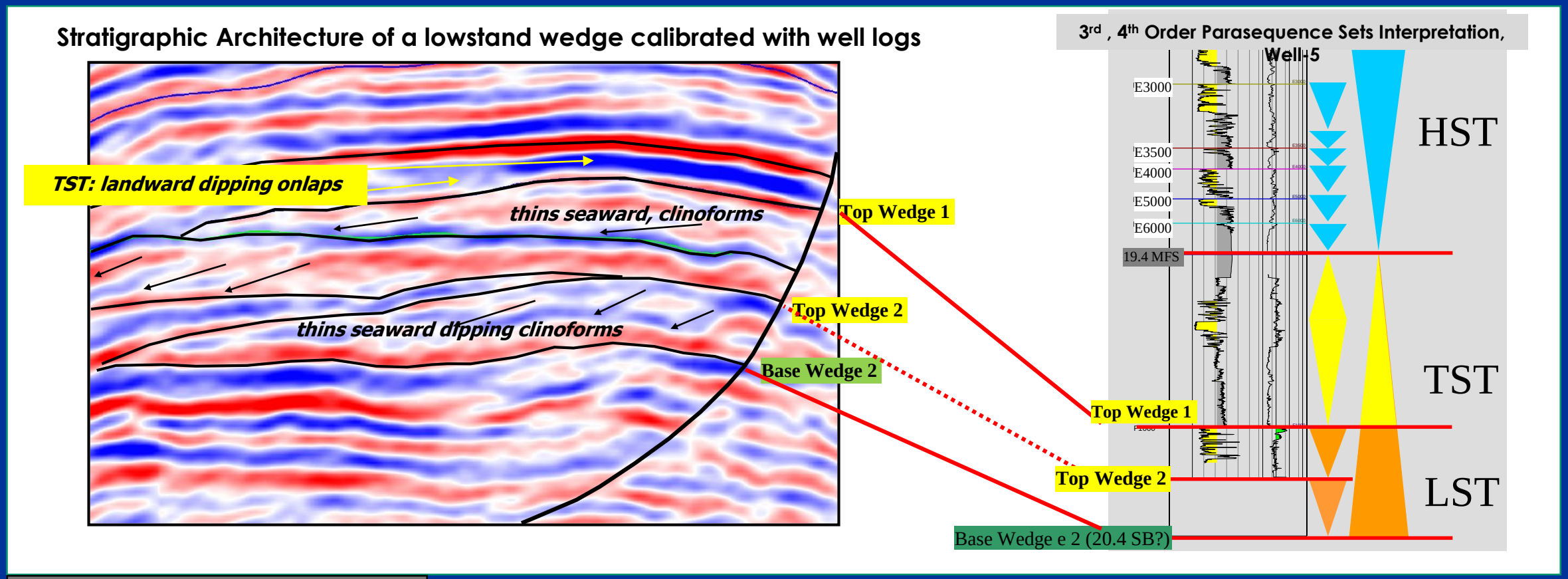
Shelf Margin Growth and architecture of low stand wedge due influence of syn-sedimentary faulting

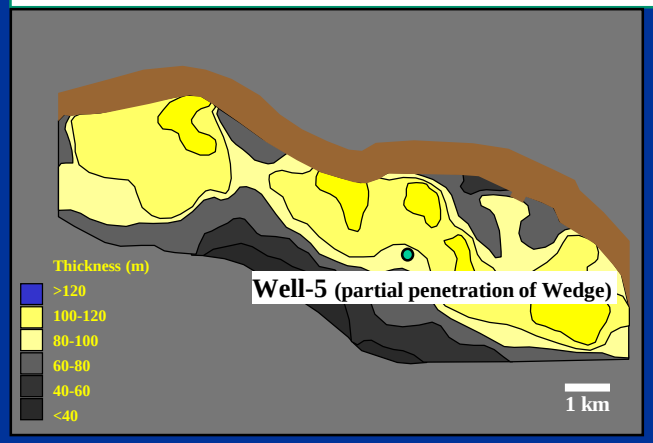


- Lowstand Shelf Margin wedge as defined from regional framework studies
- New play models of the deep untested sequences
- Below current conventional delta

Courtesy SPDC

GDE Characterization of Shelf Margin Deltas

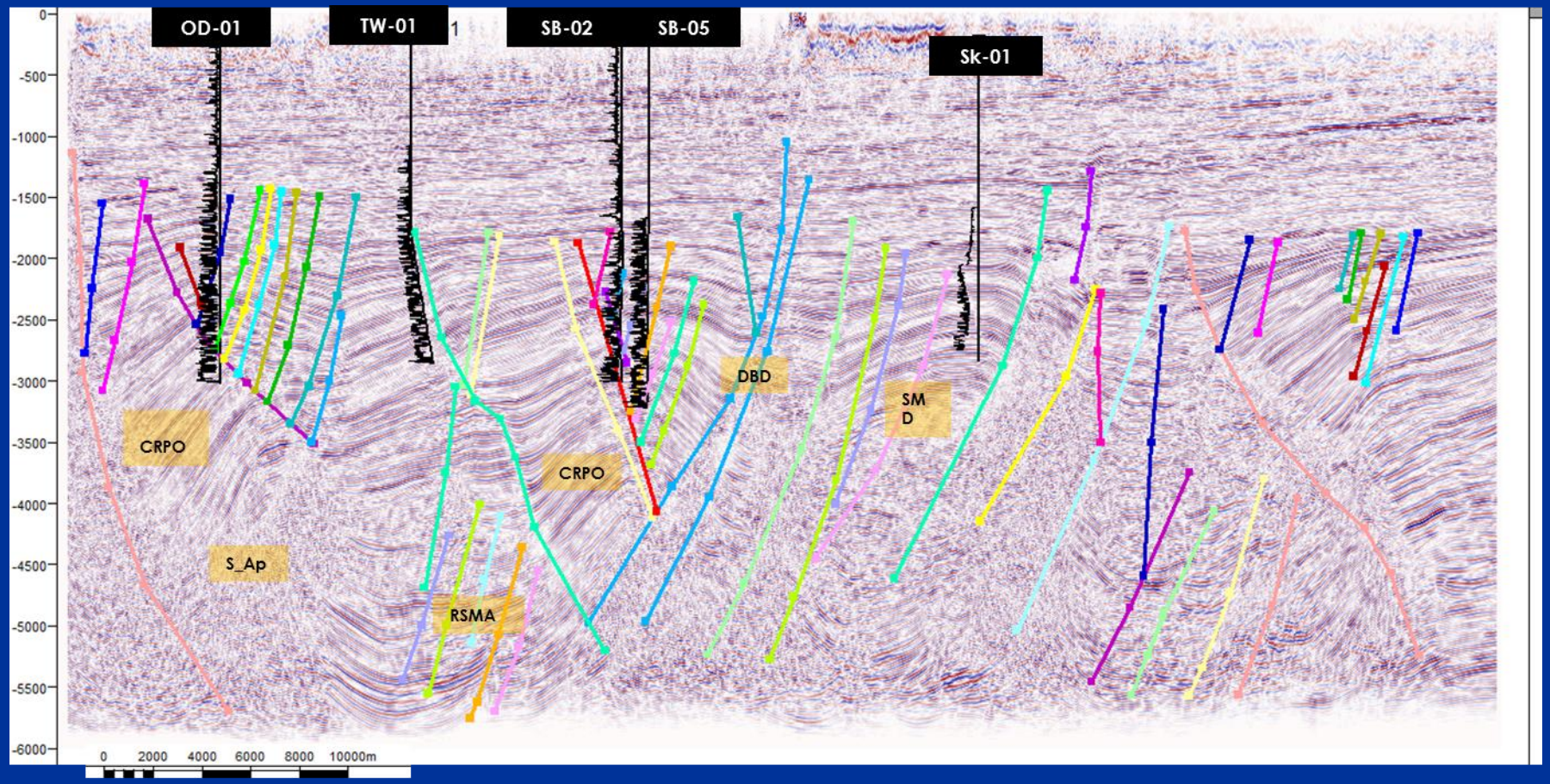


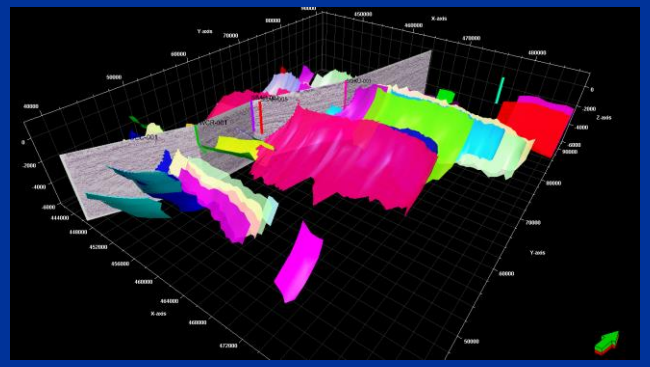


- GDE Models occur at 3rd and 4th order scales
- 3rd and 4th order cycles interpreted from seismic stratigraphy and well log stacking patterns
- Stratigraphic geometry and isopach demonstrate thickening of wedge against bounding fault – increased fault activity during lowstand
- Important for sand% estimation

Courtesy SPDC

Gross Depositional Environments Along A Composite Regional Line and 3D Fault Framework and , Eastern Delta





KEY TO DEPOSITIONAL MODELS:

SMD - Shel margin Delta

DBD – Deep Buried Delta

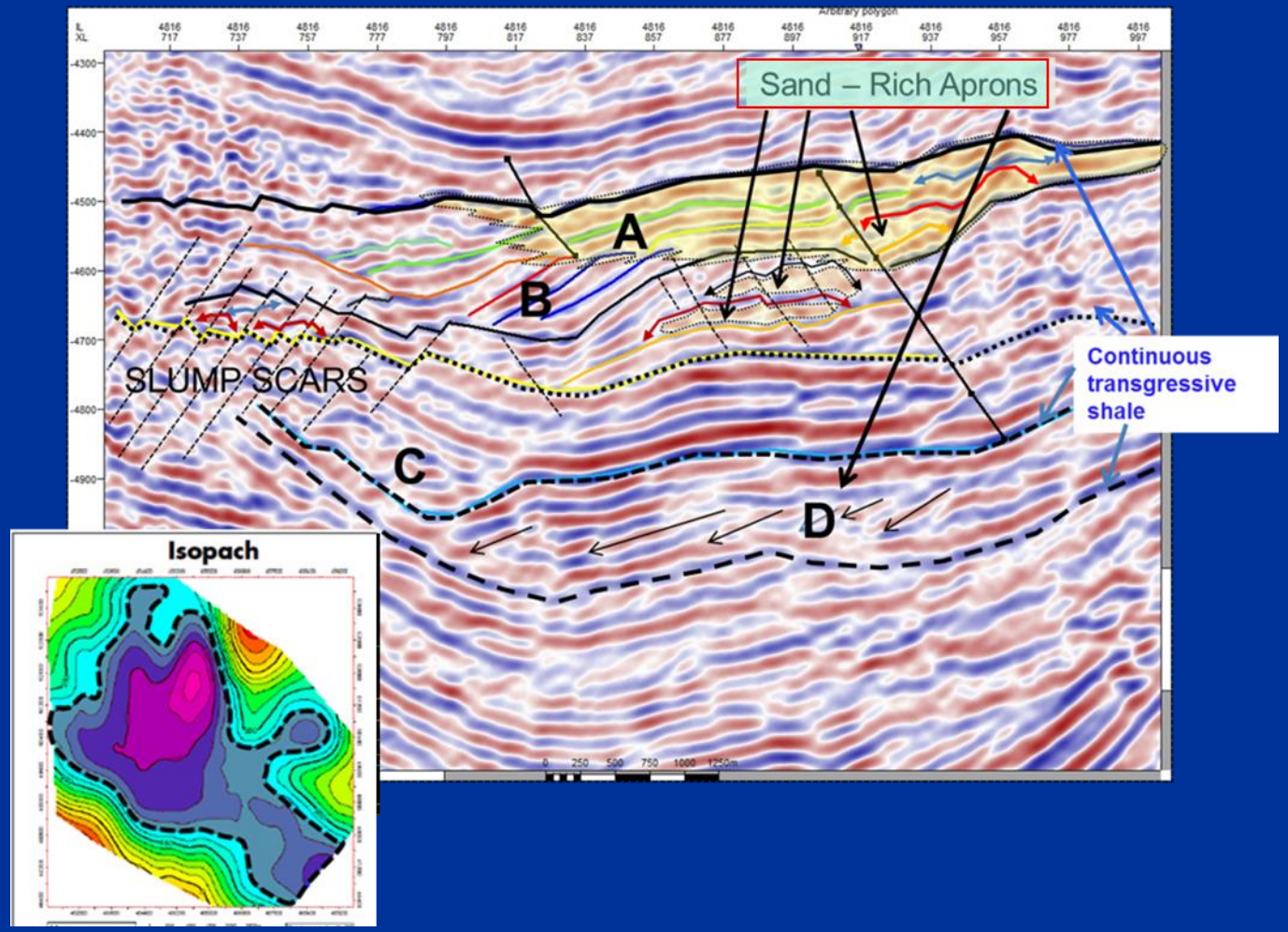
CRPO – Counter Regional Pinch-Out

RSMA - Retrograde Slope Margin Apron

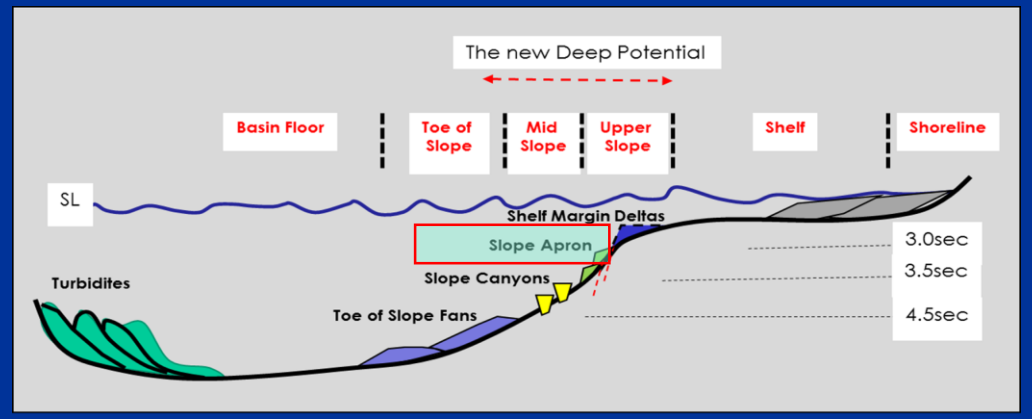
S_Ap - Slope Apron

GDE Characterization of Retrograde Slope Margin

Seismic Facies and geometry - Retrograde Slope Margin (RSM)



- **Stratigraphic Trap**, downdip of erosional features on shelf edge and shelf deltas
- Fore setting of packages suggests isolated lobes with limited lateral continuity
- Overlain by continuous high amplitude reflectors, i.e. shale drapes
- Associated with Rotational Slump cars (RSM), typical of upper slope margin

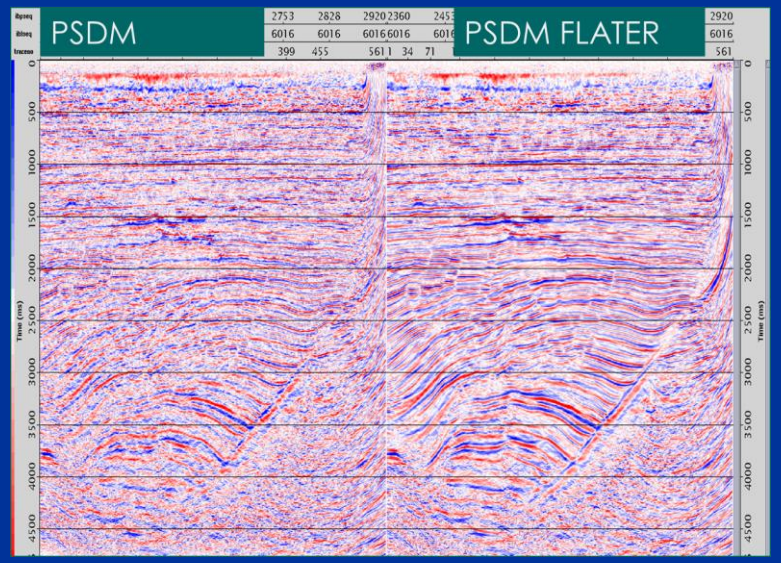


Advances in Seismic Technologies For The Deep Play

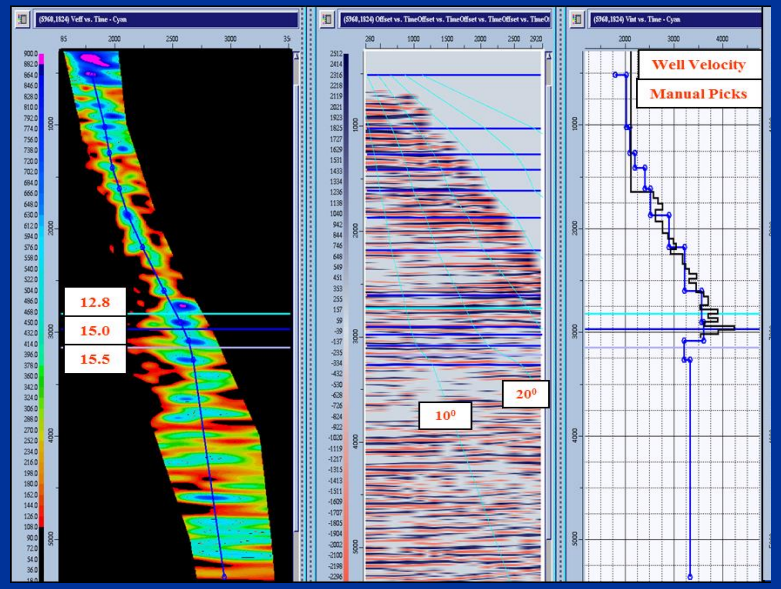
Processing Technologies
- Time migration
- Depth migration
- Merged regional seismic lines

Fault Imaging
- Fault imaging (Flatter*)
- Fault Shadow effects

(Flater is a Shell Proprietary processing software)

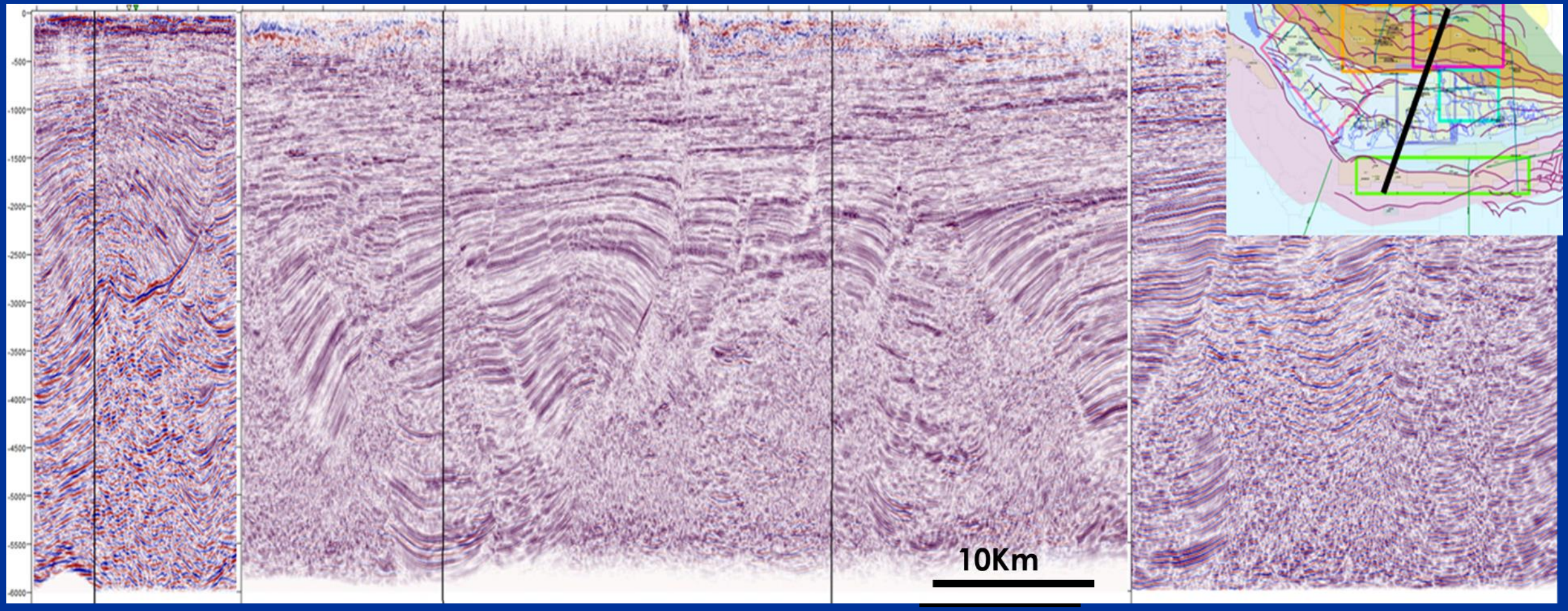


Velocity Modeling
- Overpressure
- True amplitude processing and Phase decomposition (and non-amplitude supported plays)



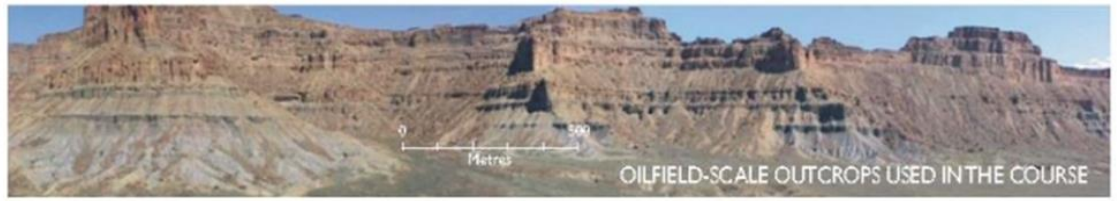
Attribute Analyses, Rock Physics and Inversion

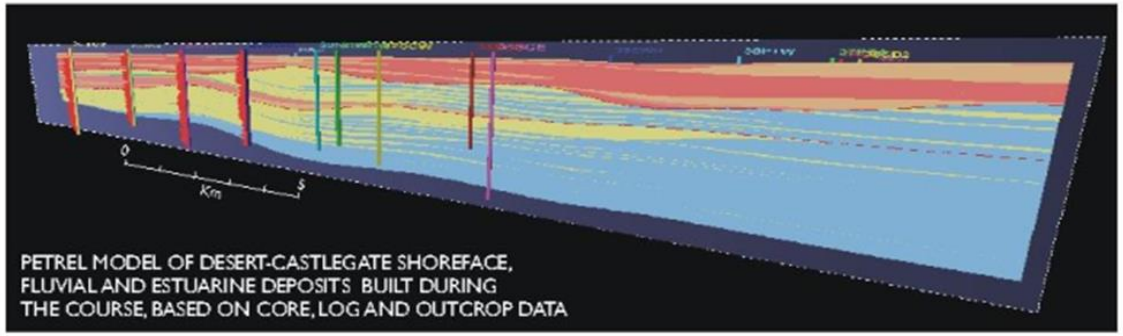
Merged Arbitrary Regional Seismic Profile Across Eastern Niger Delta



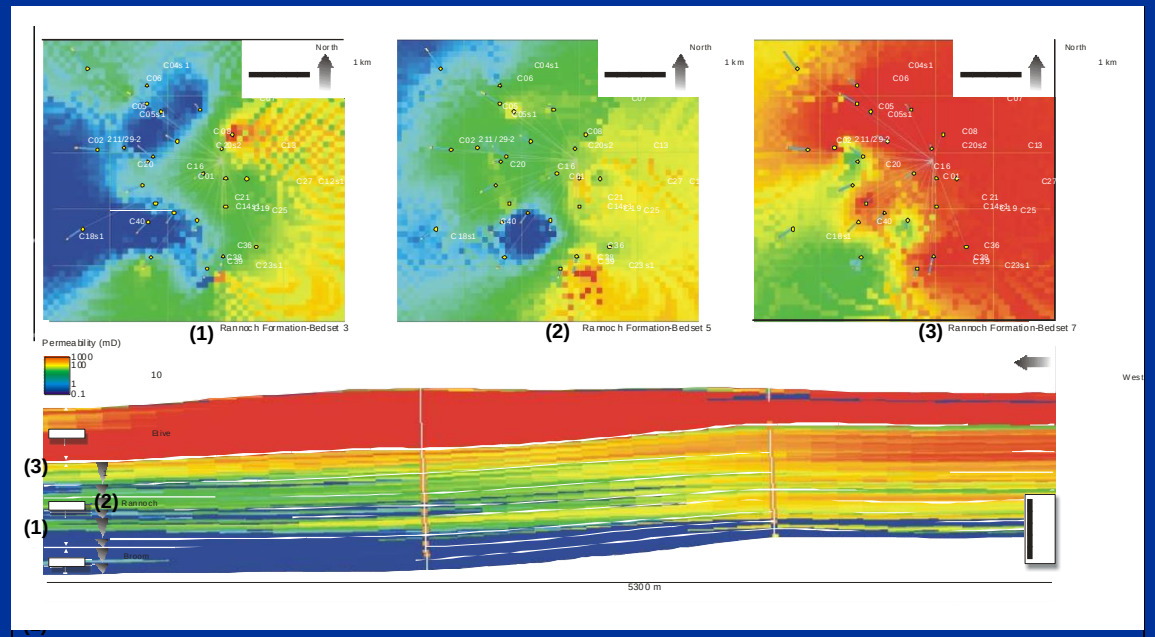
Geophysical Modeling of Stratigraphic Data

Stratigraphic Forward Modeling (**Basin Scale**)





Reservoir Modeling (**Field Scale**)



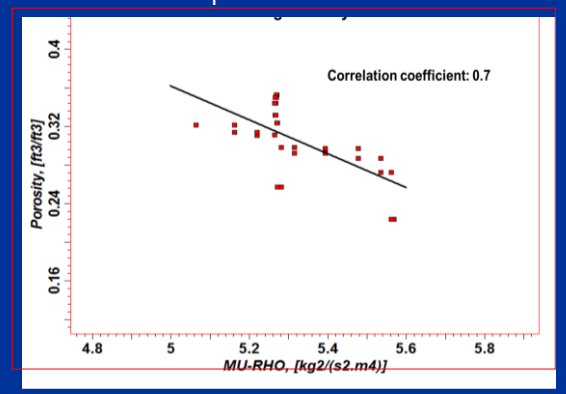
AVO Inversion Attributes & Rock Physics Characterization of Seismic Facies

Reservoir Scale

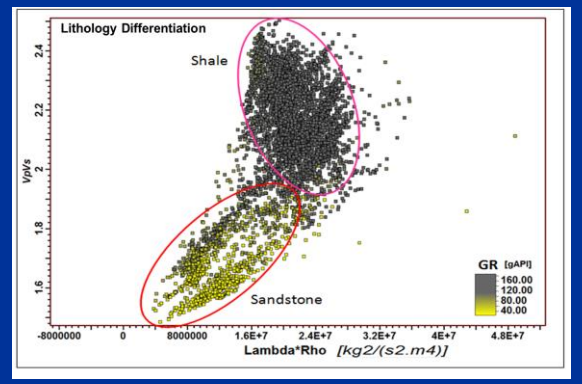
Calibration (1D):
- S-impedance
- Mu-rho
- Lambda-rho

Propagation
- Supervised vs. Unsupervised (AI)

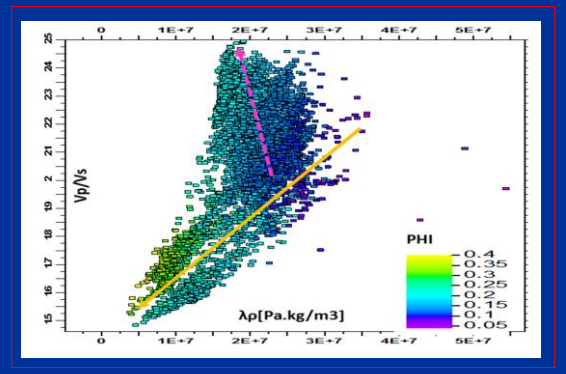
Reservoir Properties



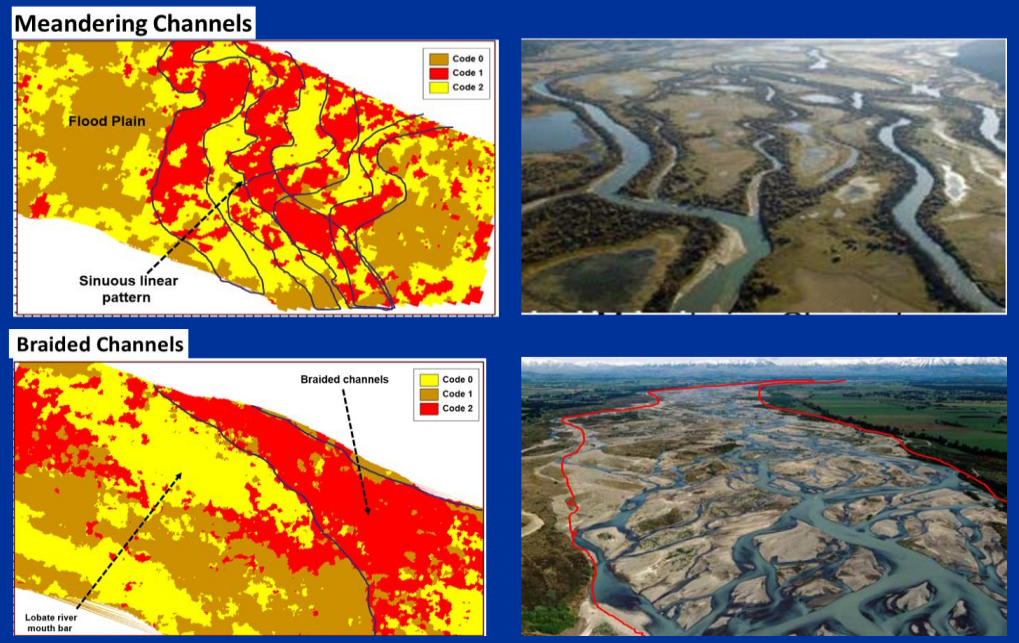
Lithology Differentiation



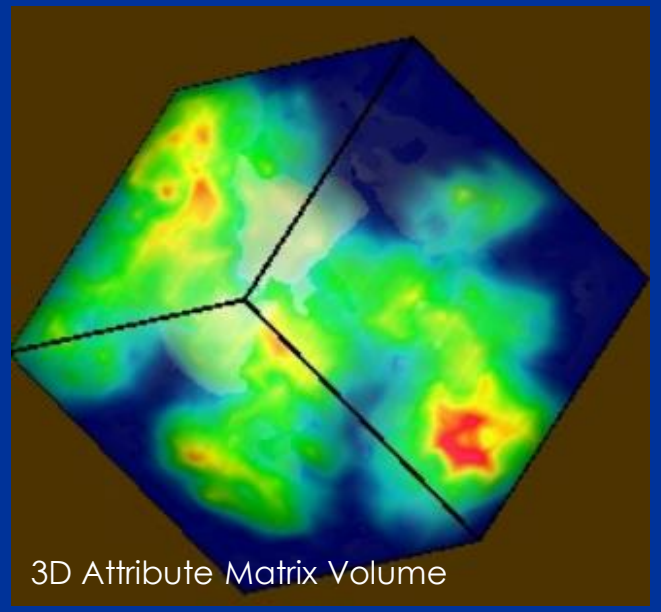
Seismic Inversion & Reservoir Property Trends



2D Depositional Facies From Seismic Inversion and Attribute Analyses (Artificial Intelligence)

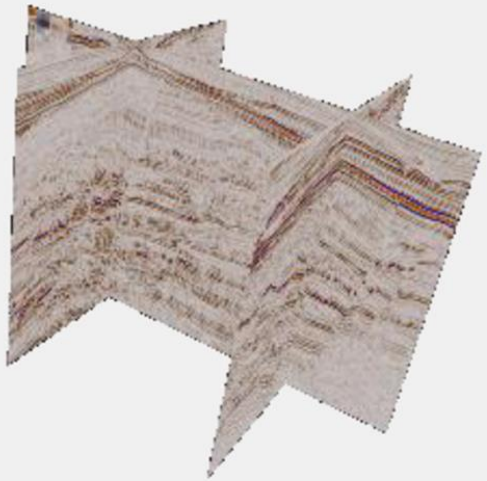


Volume Attributes: Unsupervised Classification

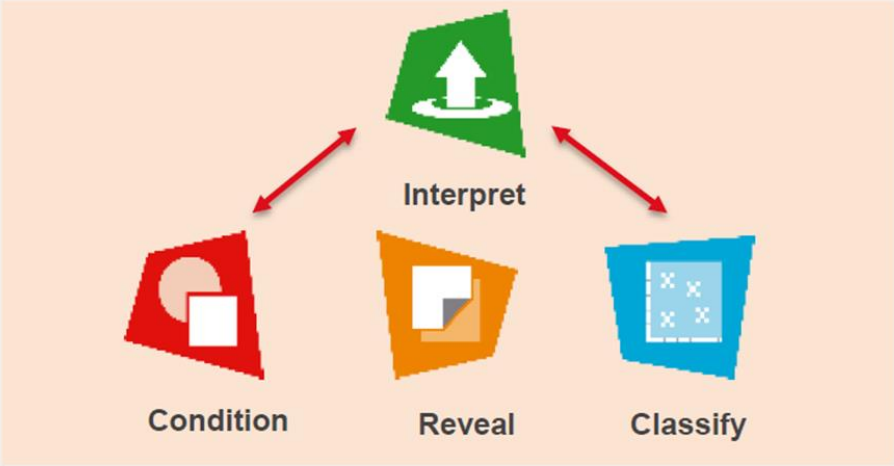


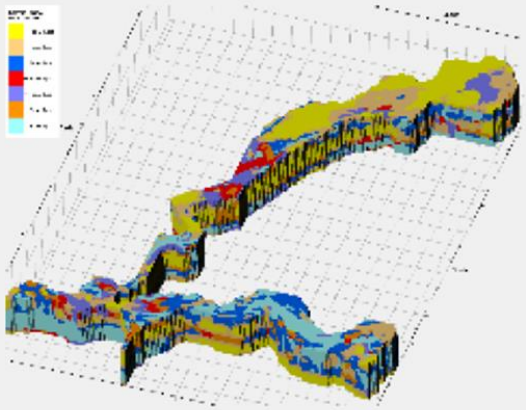
(Source: Bernard Ebere et al., 2016, 2017

Integrated Rock Physics, Structural Modeling and Stratigraphic Data



GeoTeric Workflows

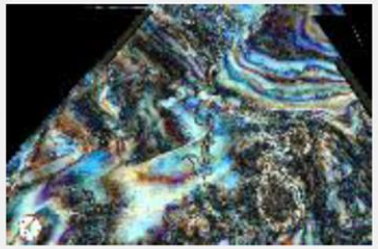




Data Conditioning

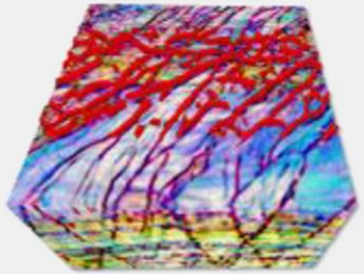
- Noise Removal
- Spectral Enhancement

Stratigraphic Analysis



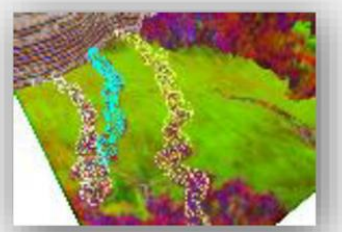
- Standard
- Broadband
- RGB Color Blending

Structural Analysis



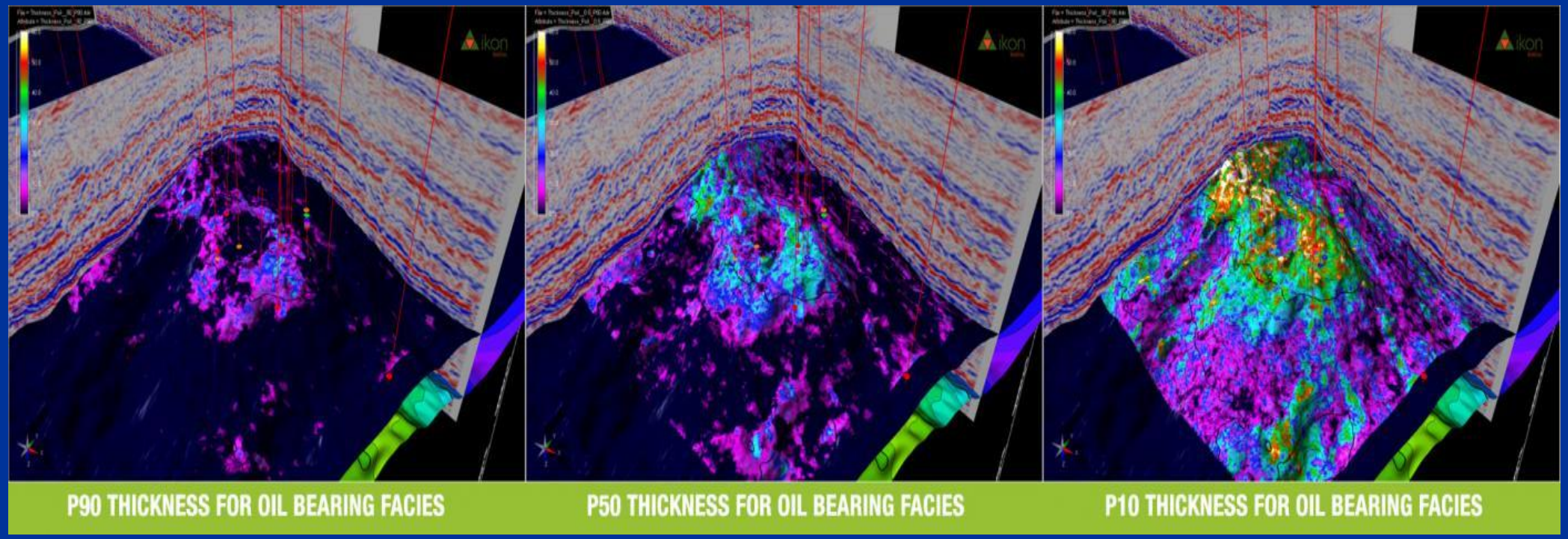
- SO Semblance
- Dip
- Tensor
- CMY & HSV Colour Blend

Interpretation



- Geobody Extraction
- Facies Classification

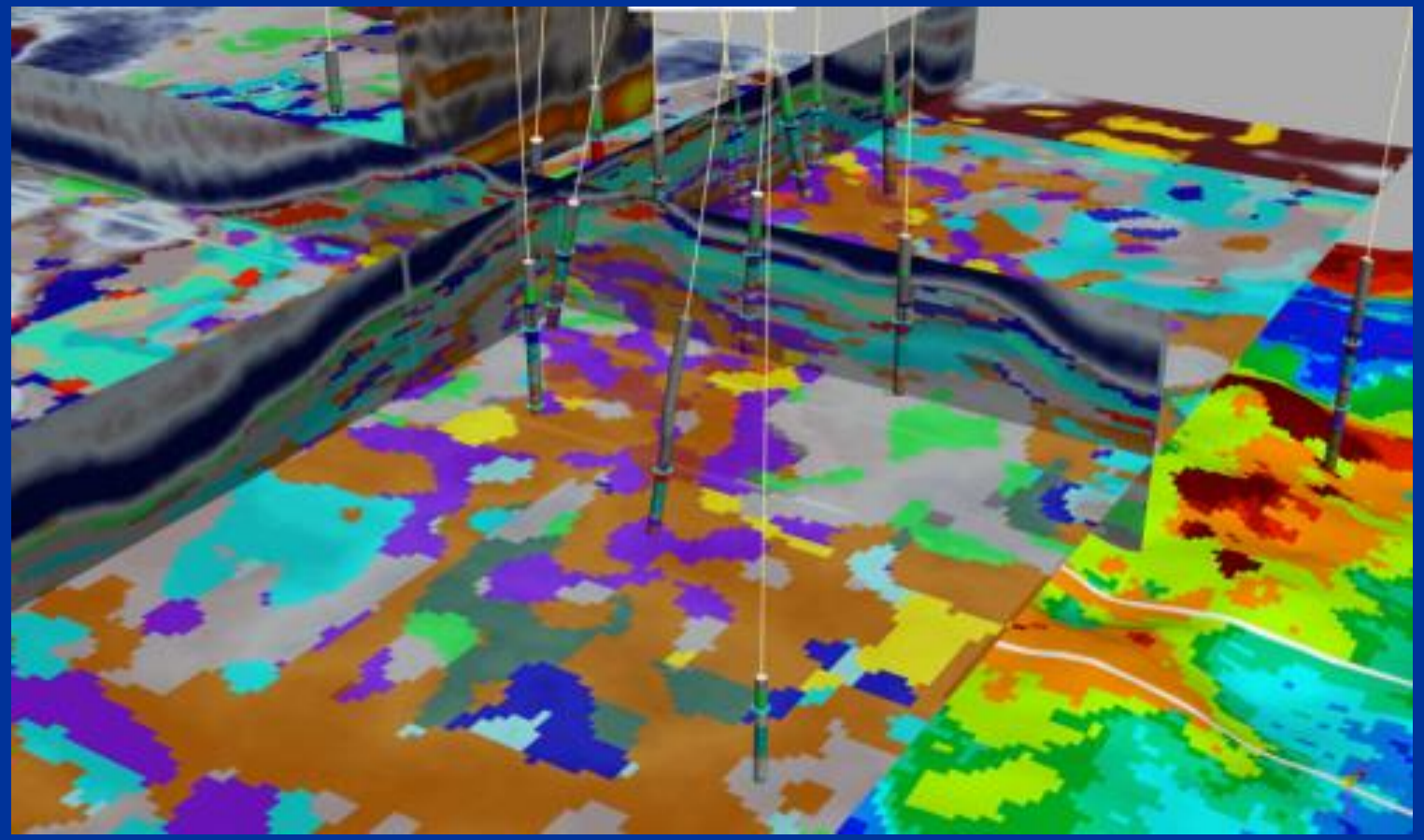
Rock Physics: Scenario Modeling and Uncertainty Analyses of Seismic Inversion



RokDoc Stochastic inversion Ji-Fi technology (Joint impedance and Facies inversion technology (Ji-Fi)

Allows uncertainty analyses in reservoir properties to be taken into account, producing multiple possible geological realizations. (**Source:** ***ikonscience.com***)

Rock Physics and Inversion:
Machine Learning-Based (AI) Rock-Type Classification .



Advanced Seismic Inversion Controlled propagation of log facies calibrated seismic response to predict

- Seismic data and facies from logs to predict facies volumes and their probability of occurrence to improve reservoir characterization

(Source: Paradigm. In: Secrets To Doing Business Successfully In Oil, Gas September 13, 2017)

The New Paradigm: Big Data is now 'A Reality'

Data Management

- More effective **storage and access** of data and management strategies

Advanced Subsurface **Interpretation Tools**

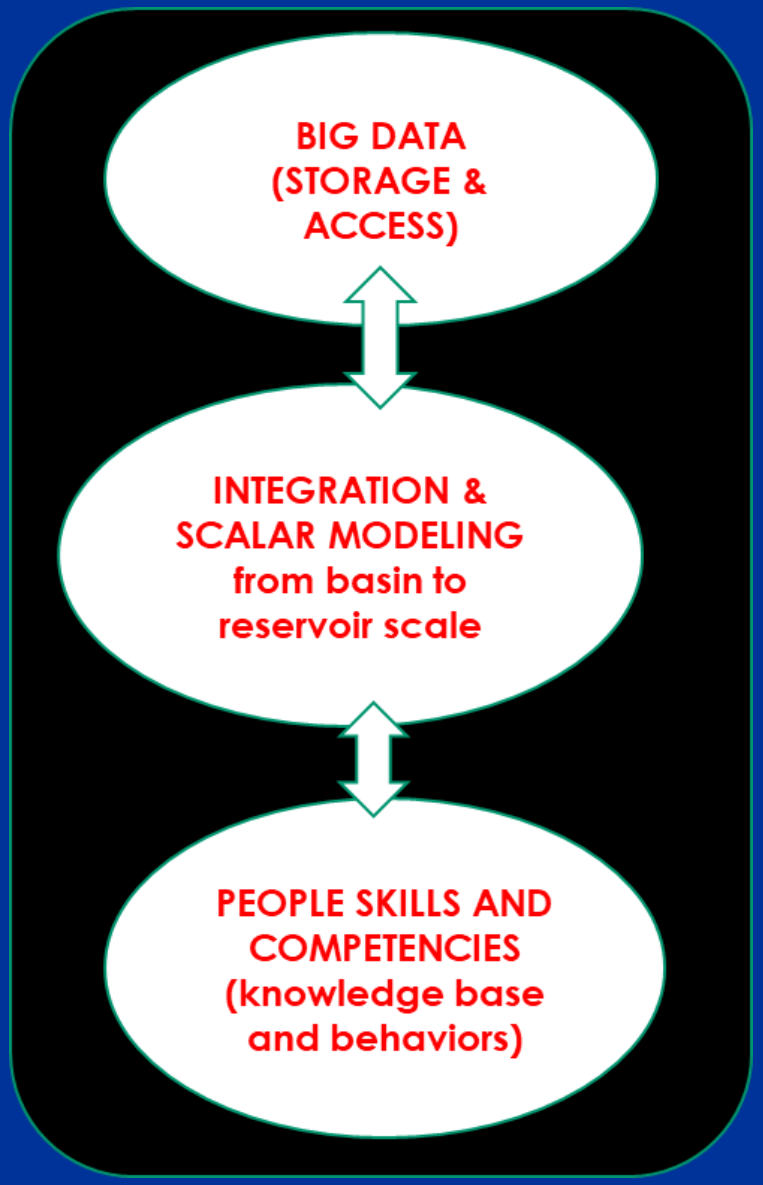
- Robust **Interpretation and Integration platforms** (data, concepts, workflow streams, legacy knowledge)

Collaborative Platform(s)

- integration of different data types and workflows
- Simultaneous and interactive interrogation of data types and
- Scalable and consistent models

People & Knowledge

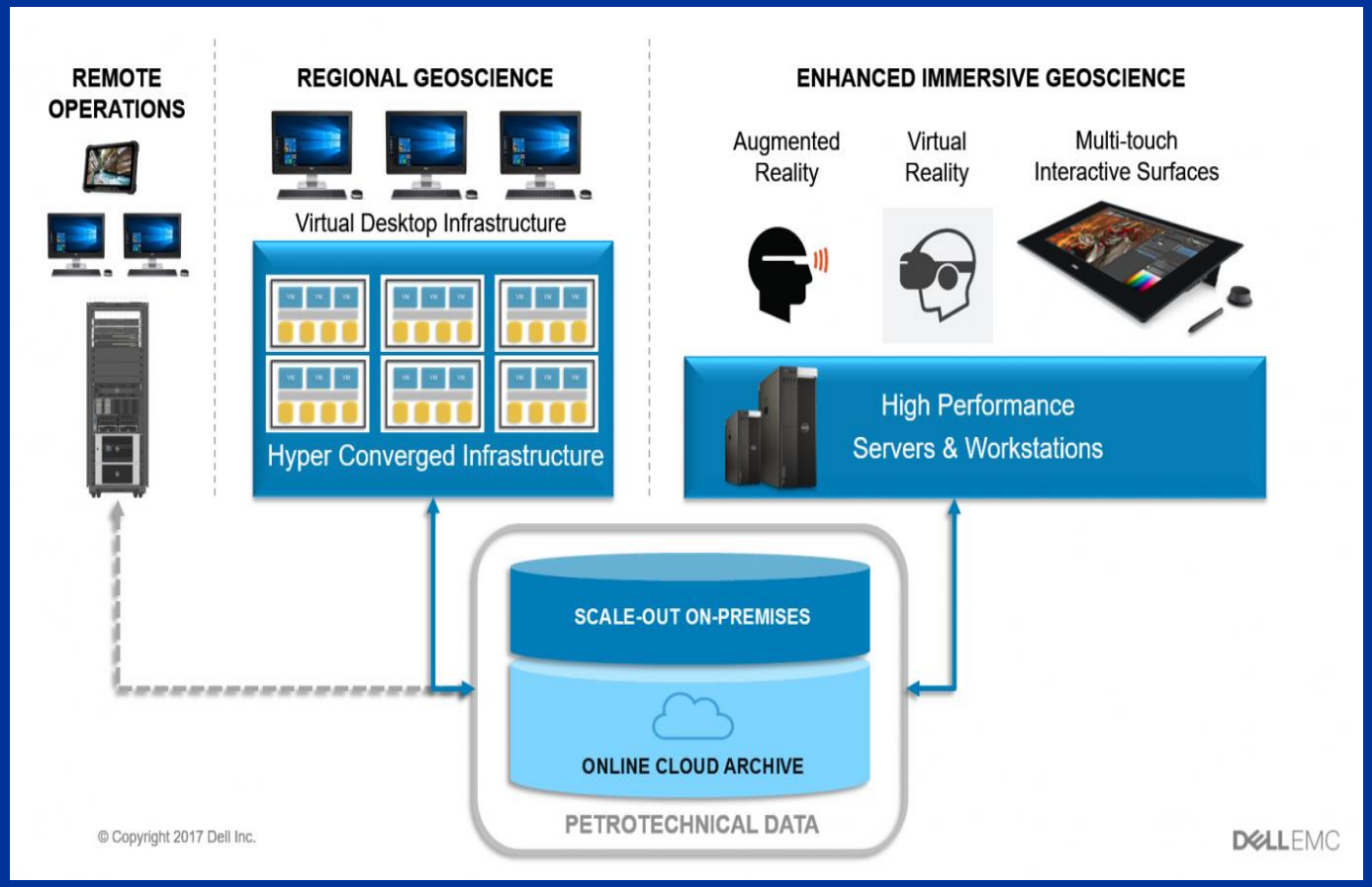
- provide QA of subsurface models
- Adaptation to the New World and acquisition of New Skills



The Transformation in G&G

The Future is more of AI:

- Integrate workflows
- Eliminate errors in interpretation
- Generate more multiple realizations of the subsurface
- Improve uncertainty management and estimation of probabilities to rank model outputs
- Drive Collaboration of experts and teams
- Improve data and knowledge management
- Save costs



Concluding Thoughts

- The evolution of new concepts is key to ensure reserves growth, even in ‘brown’ field basins

- The challenges of ‘big data’, ‘workflow and discipline integration’ required to evolve new concepts, as well as ‘scalable and consistent models’ of the subsurface need new approaches

- Technological Advances of today driven increasingly by AI and fusion of knowledge and skills sets, teams and workflows will be the future, to reduce life cycle evaluation time and realize value quickly

- The Geoscientist of the near future therefore require multi-dimensional skills sets to evaluate multi-component data sets simultaneously, including higher levels of IT capabilities

- A new approach of skills training and development is a must for the E&P professional

Acknowledgements

- SPDC
- Lekoil
- StratKol Consult Ltd. and Colleagues and Sources