

Subsurface Data and Machine Learning

TECHNOLOGY RELIABILITY EFFICIENCY INTEGRATION

Advances and Opportunities for ML/AI for Understanding and Stewarding Subsurface Resources in the Private Sector

Perspectives from Schlumberger

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A Meeting of the Committee on Earth Resources

The National Academies of Sciences, Engineering, and Medicine

June 6, 2019

Washington, DC

Outline

- Digital transformation in the O&G industry
- Subsurface data
- Machine learning
- Concluding remarks

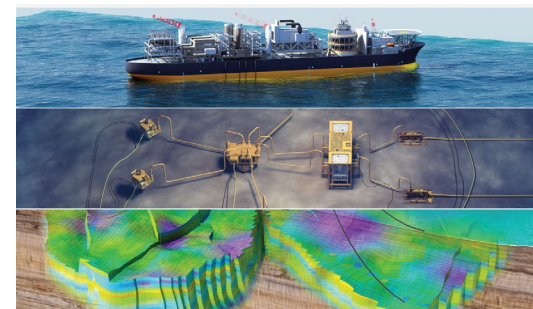
Digital Transformation is Gradually Revolutionizing the Industry

- Leveraging progress across multiple technologies:
 - Sensors (IIOT) - Cloud/Edge – Analytics - Robots - Connectivity

- To improve performance of business and gain operational efficiencies

Industry 4.0 !

- Surface facilities
 - Exploration: Accelerate discovery in cost-effective fashion
 - FDP, optimization of production facilities, environmental monitoring, etc
- Through leveraging subsurface data with ML/AI



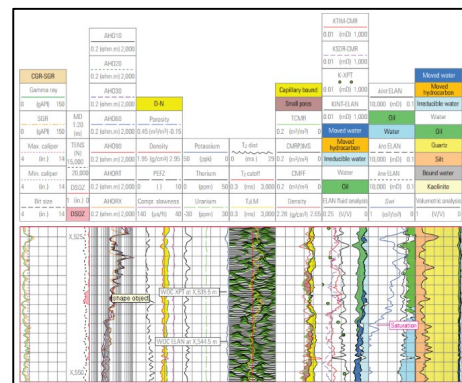
Subsurface Data: *Heterogeneous, Rich*

Data acquired in laboratory and field:

- Images
- Depth & time series
- Geological observations (outcrops)
- Text in well reports; interpretation documents

Multi-physics, multi-scale, diversity in type

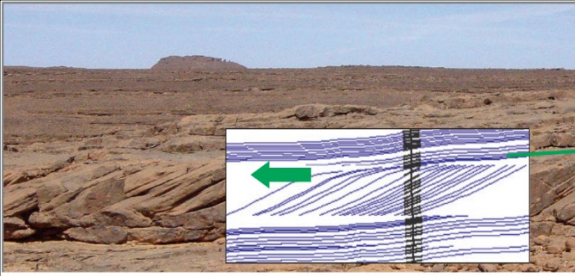
Borehole logs



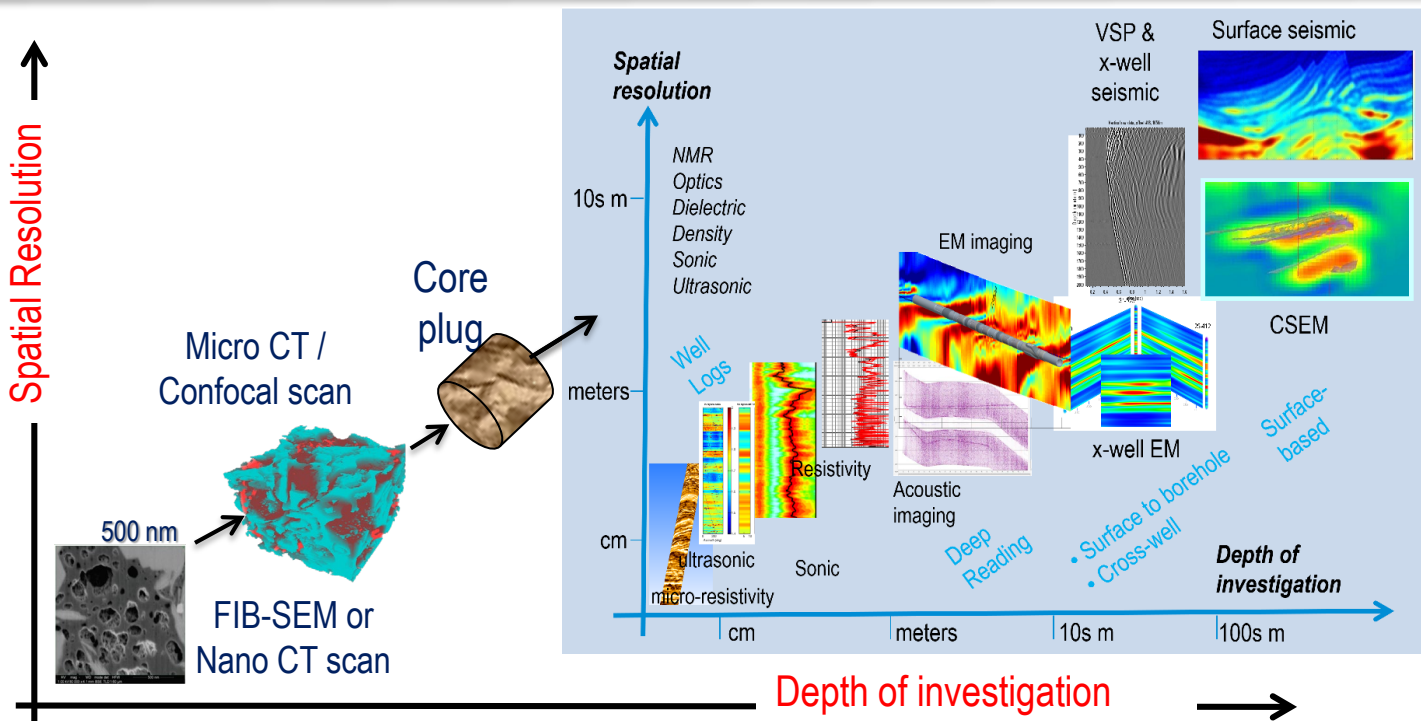
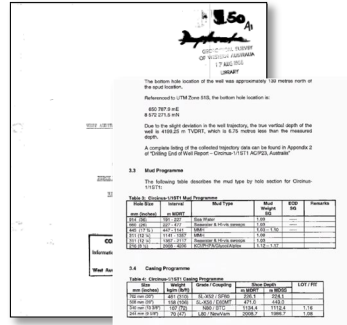
Production/flow log



Geological outcrops – observations



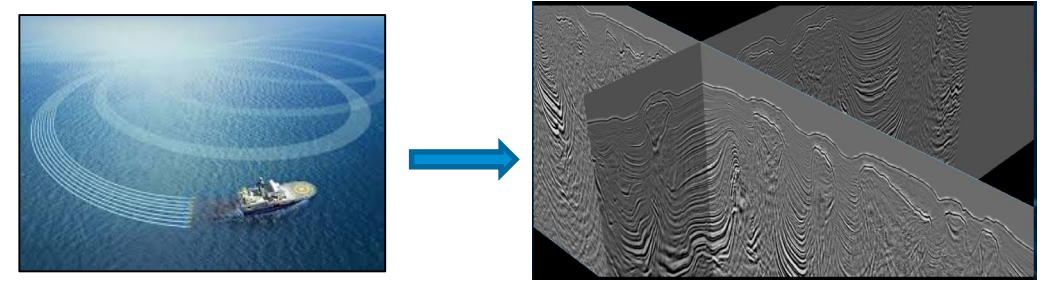
Well report



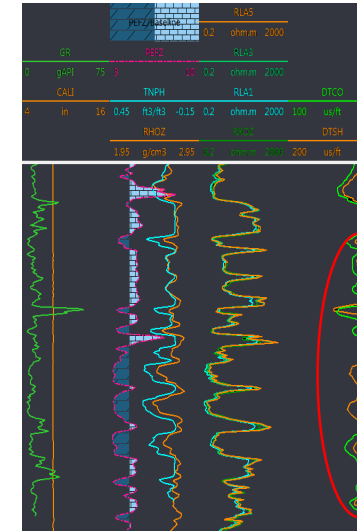
Subsurface Data: *Heterogeneous, Rich, 'Sparse'*

- Seismic
 - Raw: 10s to 100s of TB/job; Image: ~GB
 - Months of processing time to reduce from raw to image
- Well logs:
 - Up to few GB/well
 - Millions of logs in few areas (US, North Sea), sparse in many other places (1 well per several kms)
 - Only very basic logs for most
 - 80% of time spent preparing data (ETL)
 - Poor/diverse quality; Calibration issues;
 - Missing data; Depth matching
- Text data
 - Key to capturing context and labels
 - Inconsistencies in nomenclature, format, etc
 - Present a significant challenge to use

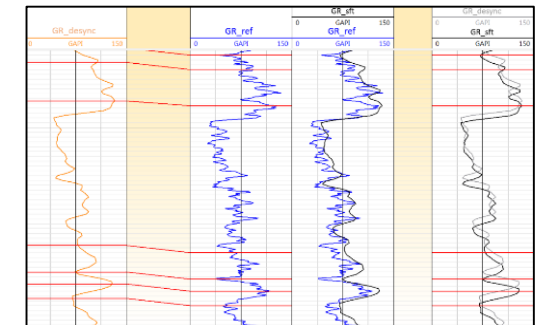
Extreme reduction in data size



Filling missing intervals



Depth matching between logs



* Internet users generate ~2.5 QB (10^{18})/day [x 5 orders]

Subsurface Data

Highly challenging and costly to efficiently curate data !

*“800-pound gorilla –
put your best people on it”*
M. Stonebraker, MIT-CSAIL
June 4, 2019

It requires:

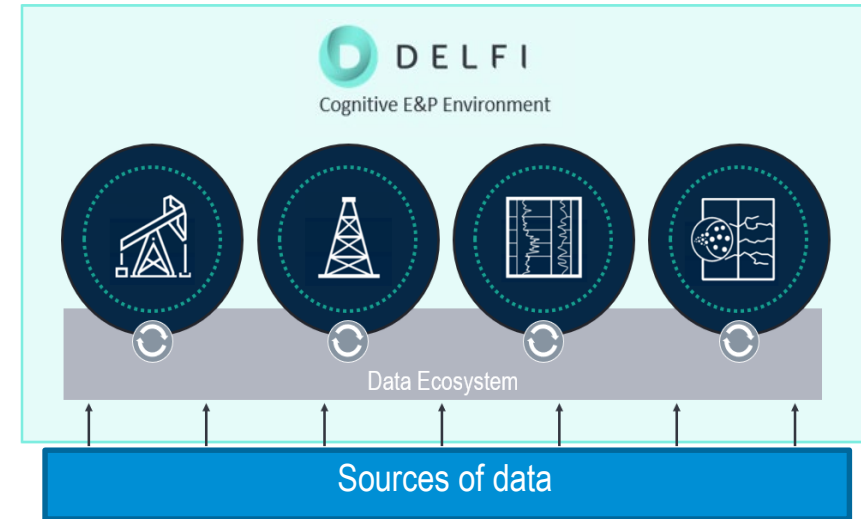
Software architecture and HPC system to orchestrate access to data, access to algorithms to interact with and operate on the data, through a user-friendly experience, that still caters to the requirements of the business/regulators: security; traceability; accessibility/collaboration; scalability, etc

Not only to curate but also to extract value and solve problems

Schlumberger Data Ecosystem - *A Lead in Tackling the Challenges*

■ DELFI: industry E&P data ecosystem

- Secure
- Cloud-based (HPC)
- Collaborative
- Cognitive (ML/AI)
- Open and extensible



Find & Access Data

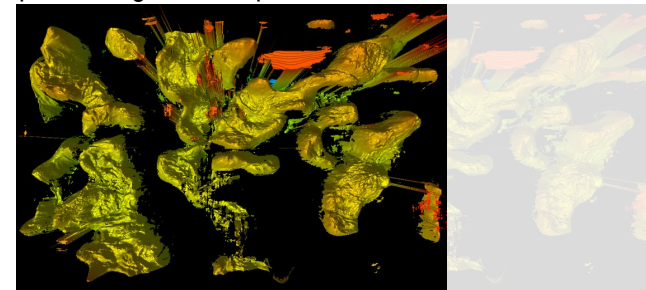
Enable ingestion of data, facilitate discovery of relevant data and bring data seamlessly in context



In partnership with digital technology companies

Integrate Data and Automate Workflows

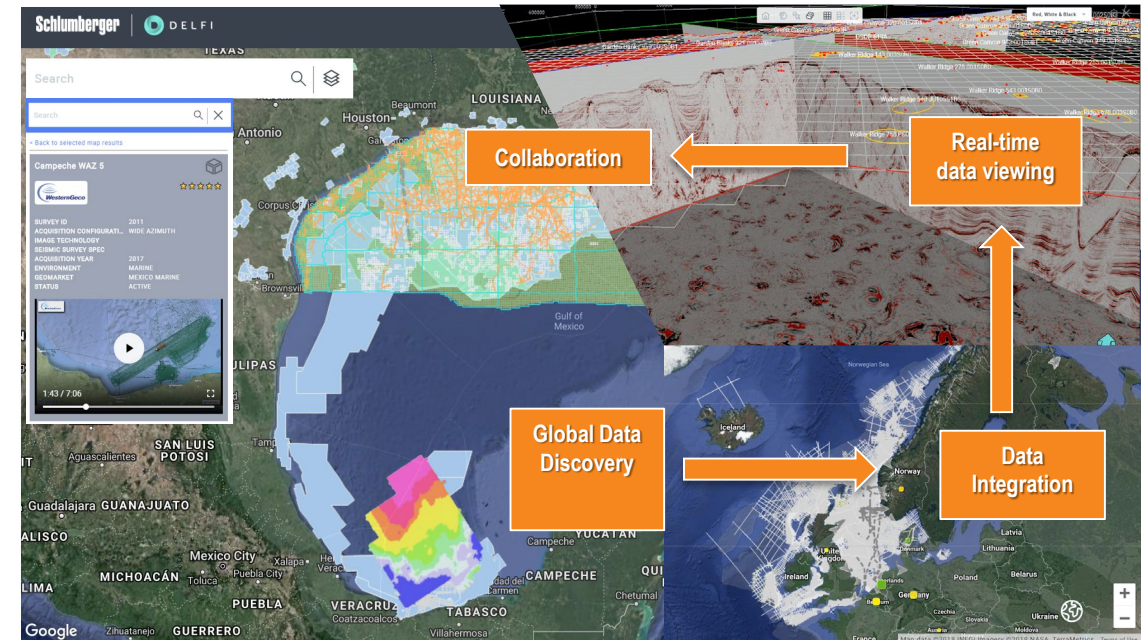
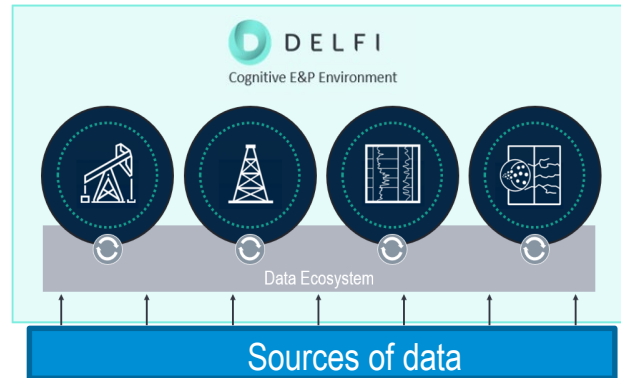
Greatly accelerate Turn-Around Time through automated processing and interpretation workflows



Schlumberger Data Ecosystem - *DELFI*

■ **GAIA: Global Digital Exploration Platform**

- Goal: Accelerate hydrocarbon discovery, screening and ranking of exploration opportunities, through integration of relevant data and automation of workflows
- Uses DELFI* E&P environment to access data available from Schlumberger and other E&P industry data providers



Schlumberger Introduces the GAIA Digital Exploration Platform

Exploration platform powered by advanced digital technologies to accelerate hydrocarbon discovery

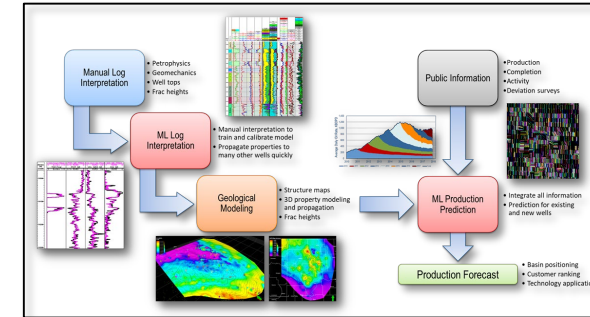
LONDON, June 3, 2019—Schlumberger today introduced the GAIA* digital exploration platform at the 81st EAGE Conference & Exhibition. The GAIA platform enables exploration teams to rapidly discover and access basin-scale data and manage their exploration opportunities.

Schlumberger Data Ecosystem - *DELFI*

■ **GAIA: Global Digital Exploration Platform**

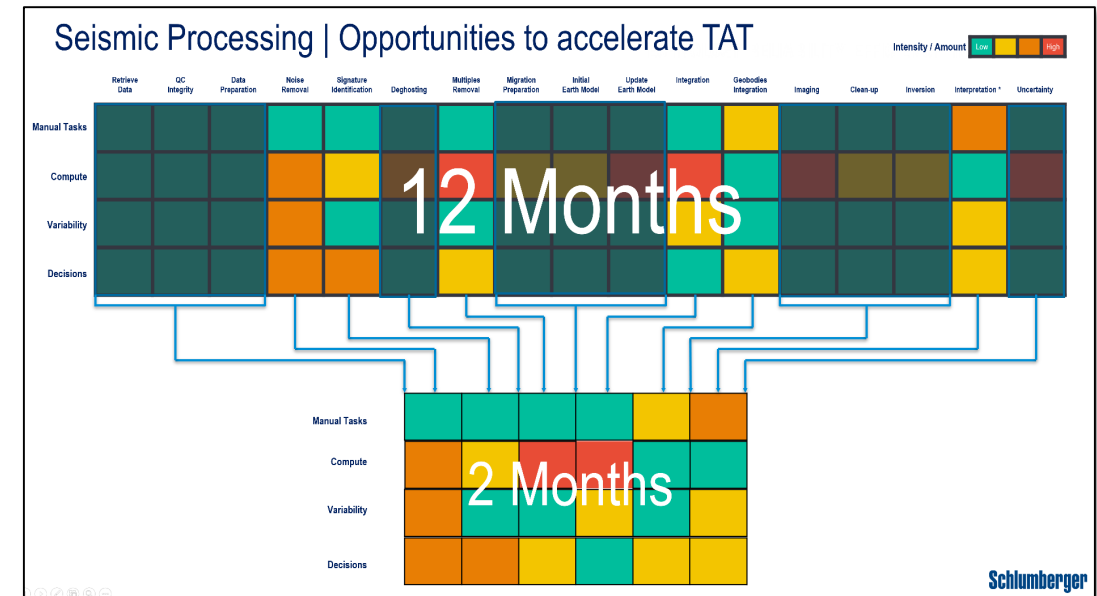
- Accelerating hydrocarbon discovery, screening and ranking of exploration opportunities, through integration of relevant data and automation of workflows

Basin-scale modeling & forecasting



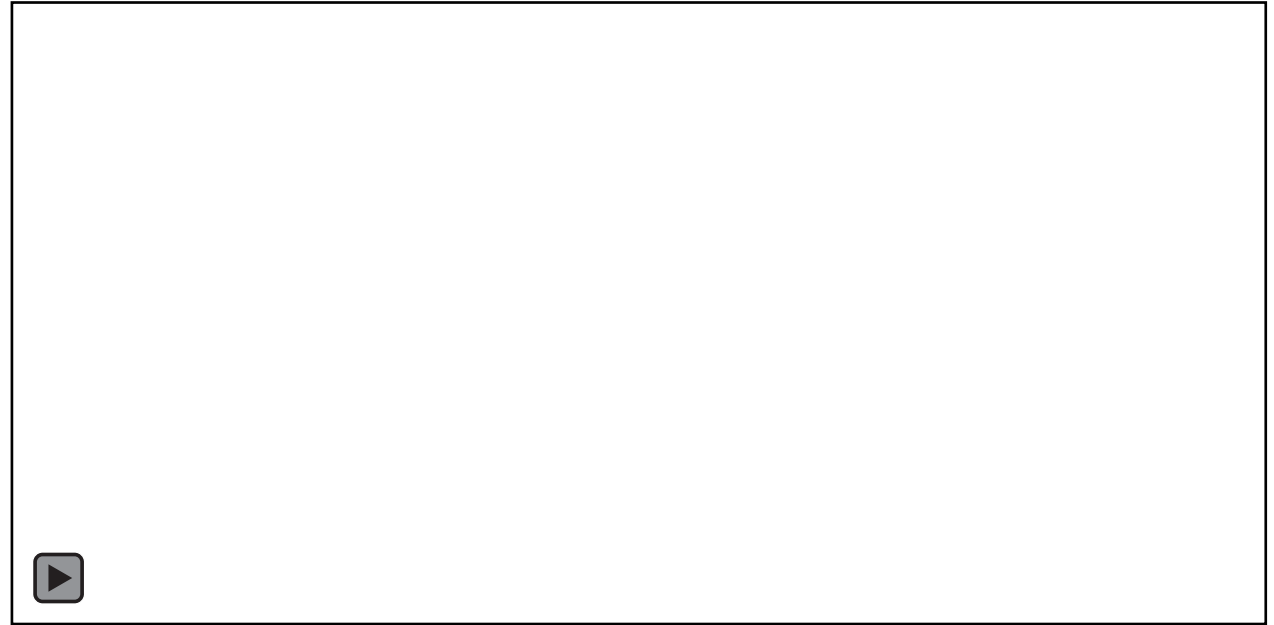
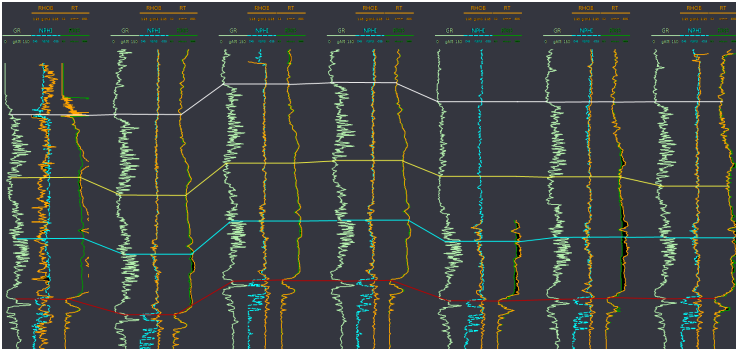
■ **DELFI Seismic processing**

- Accelerating turn-around-time (TAT)



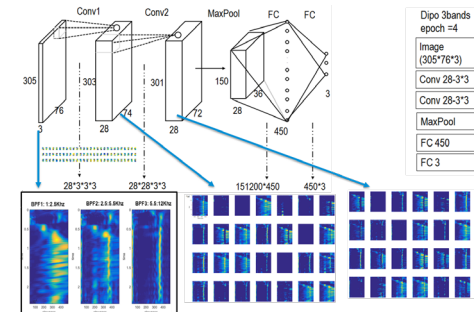
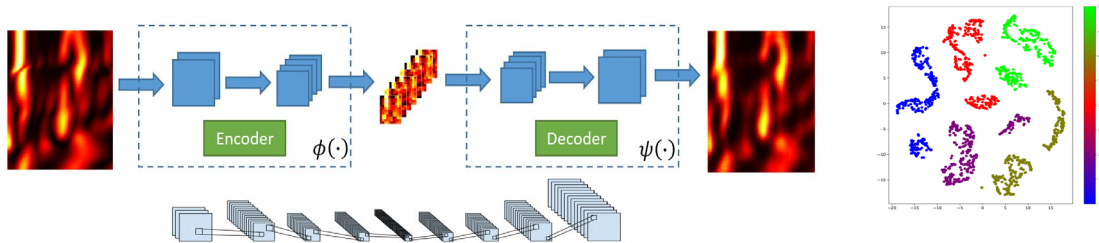
Schlumberger Data Ecosystem - *DELFI*

- ***DELFI Wellbore interpretation***
 - *Example: Well correlation workflow*



Machine Learning – Opportunities

- Supervised learning: e.g., CNN, BNN, GAN, RL
 - Bringing efficiencies to curation, integration and interpretation
- Unsupervised | semi-supervised: AE, VAE, infoGAN
 - Gaining insight to inform better decisions
- Bayesian programming; causal graphical models
 - Enabling cognitivity; ‘augmented intelligence’
- Natural language processing (NLP)
 - Extract interpretation semantics; Adding geological context
- Projects organized around:
 - Business outcomes
 - Partnerships with clients: use case + data
 - Integrated teams: domain + data science



Machine Learning – Challenges & Risks

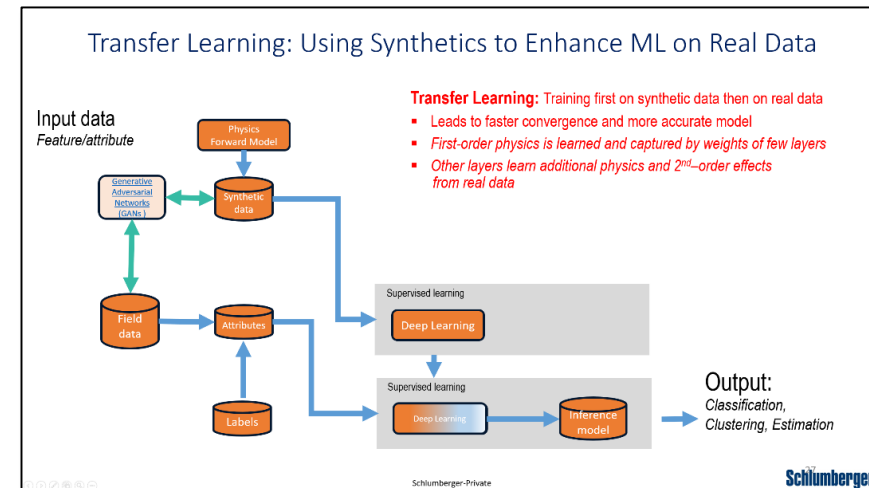
Development

- Curation / structuring (ETL)
- Integration of multi-physics, multi-scale data, multi-types
- Sparsity
- Lack of labels
- Bias
- Interpretability
- Uncertainty quantification

Mitigated by injection physics & domain knowledge

Deployment

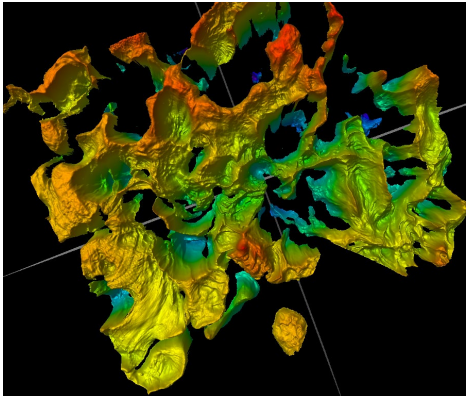
- Model maintenance & updating
- Robustness vis-à-vis
 - Changes in environmental variables
 - Adversarial attacks
- ...



Supervised Machine Learning for Salt Body Picking on Seismic Data

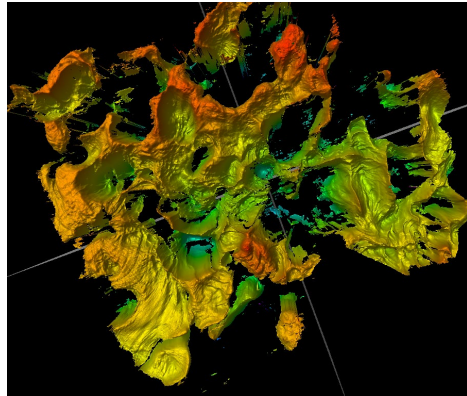
- Leverage ML and autopicking
- Strong integration to geologic model representations
- Some intervention, especially for complex bodies
- Substantial time reduction

User Picks

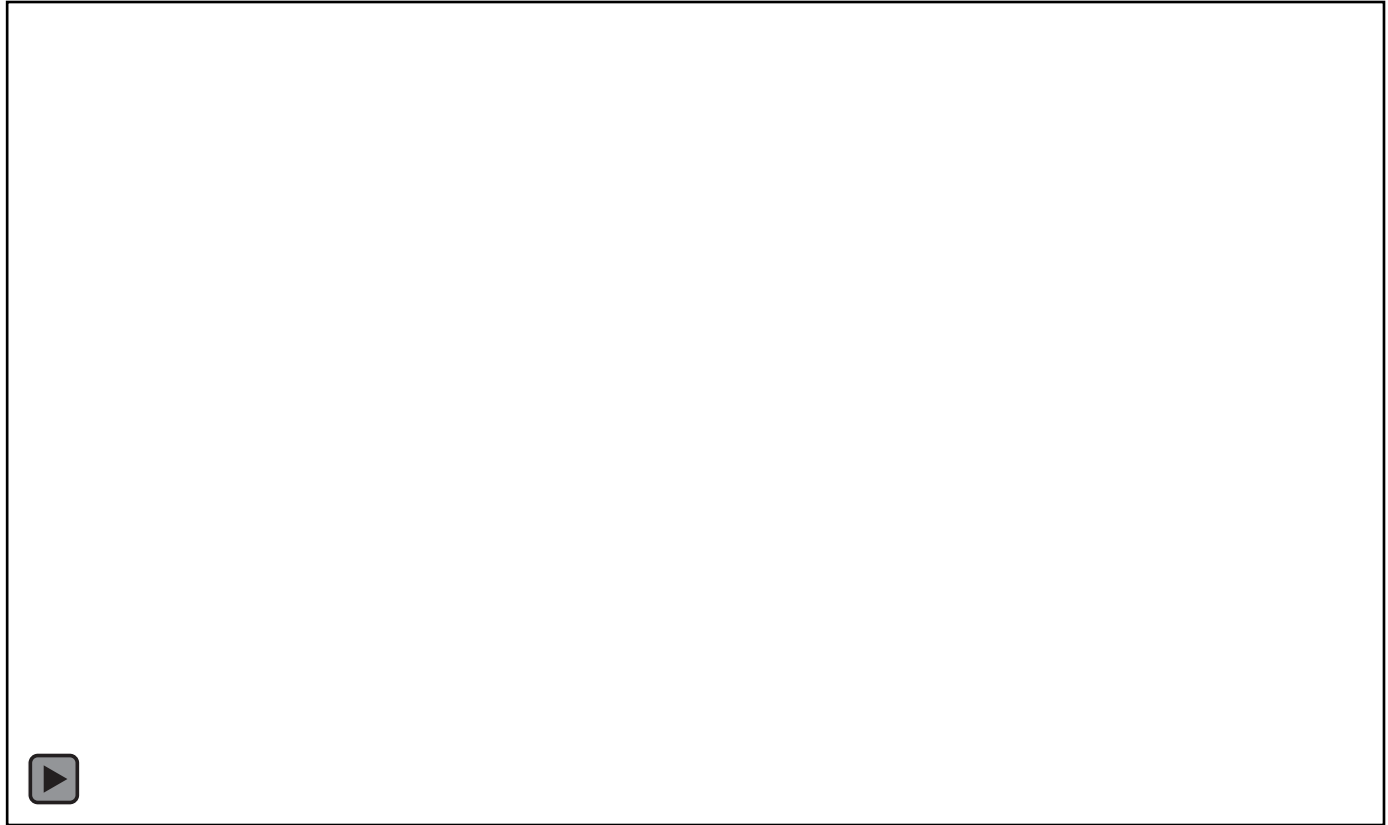


80 days total

Machine Prediction

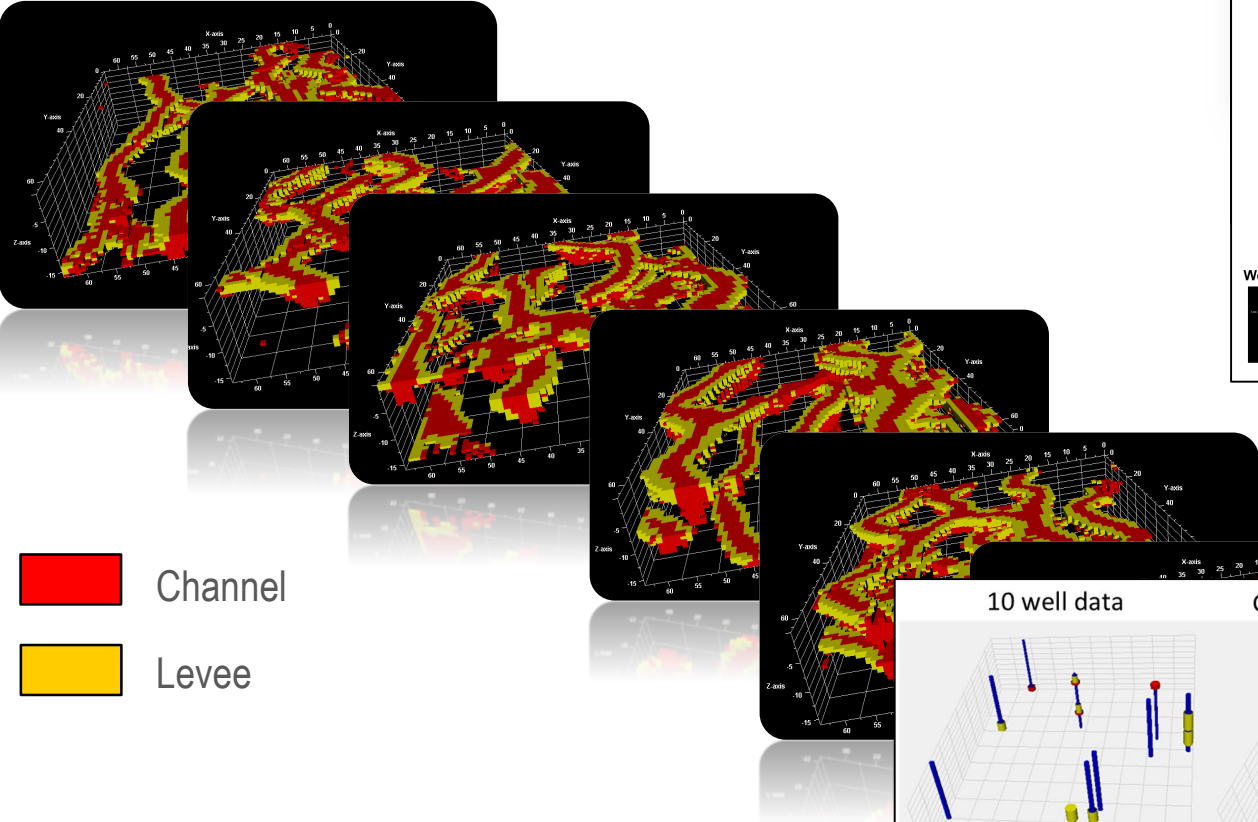


ML Training & Prediction
95% salt picks detected correctly
Few hours & QC 15 days

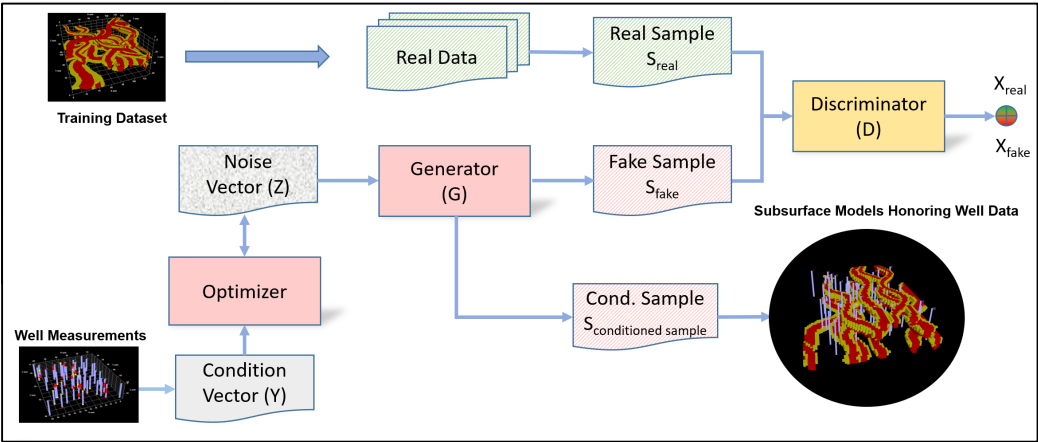


Generative Modeling (GAN) for Subsurface 3D Stratigraphy

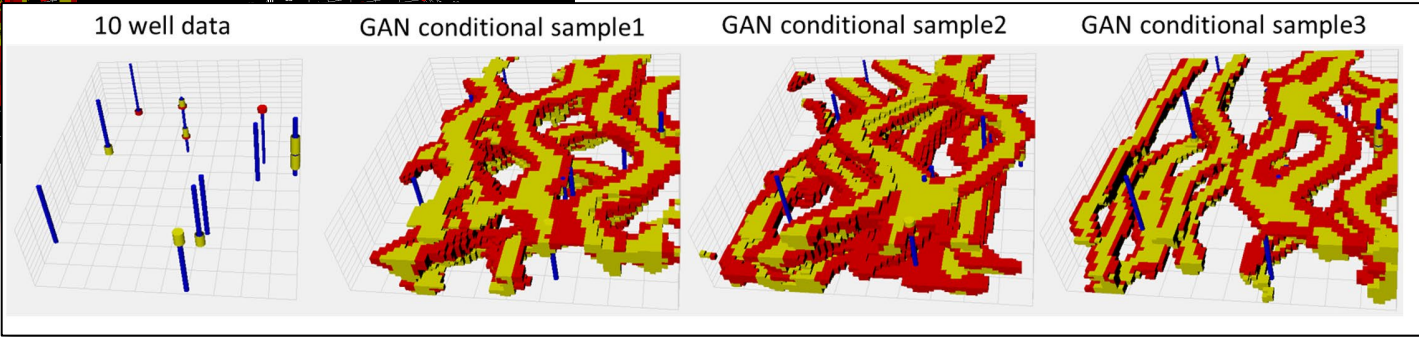
Turbidite Channel-Levee System



Generative Adversarial Networks



Conditioning to well data



Concluding Remarks

- Development in digital technology is transforming the O&G industry
 - Focus on performance efficiencies for gains/cost savings, and
 - Leveraging subsurface data for production optimization and accelerating exploration
- Subsurface data
 - Significant challenges lie toward ML-readiness
 - Requiring comprehensive approach - ecosystem frameworks or platforms
 - Schlumberger is developing and deploying such a framework (DELFI)
- Machine learning
 - Opportunities & challenges abound
 - Early successes encourage adoption, yet
 - Further maturity required to handle data complexity and use case requirements
 - Domain and physics are key enablers; mitigate risks
- Partnerships across the industry to accelerate data projects
- Finally: Great deal of enthusiasm attracting young generation of engineers & scientists at ease with digital and eager to make an impact in a century-old industry

Thank you !

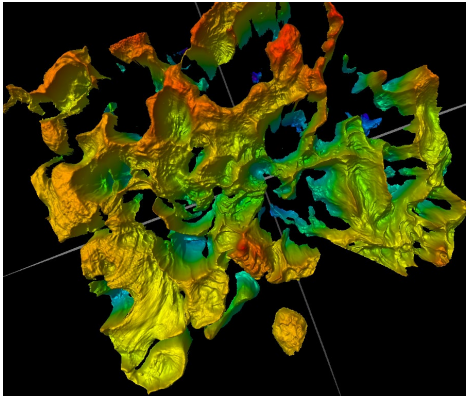
ACKNOWLEDGEMENTS:

- Schlumberger Digital Centers teams
- SLB: A. Belani, J. Smits, D. Pafitis, D. Seabrook, A. Udi, S. Menon, ...
- SDR: S. Bose, P. Tilke, L. Zhu, M. LeFranc, T. Zhang

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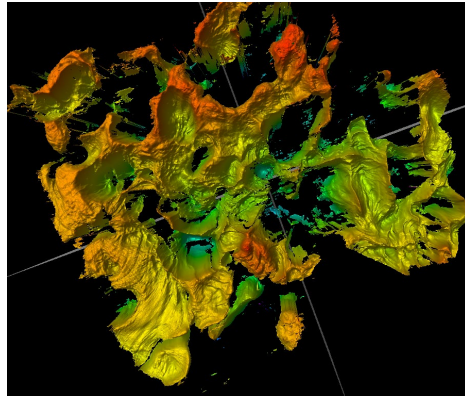
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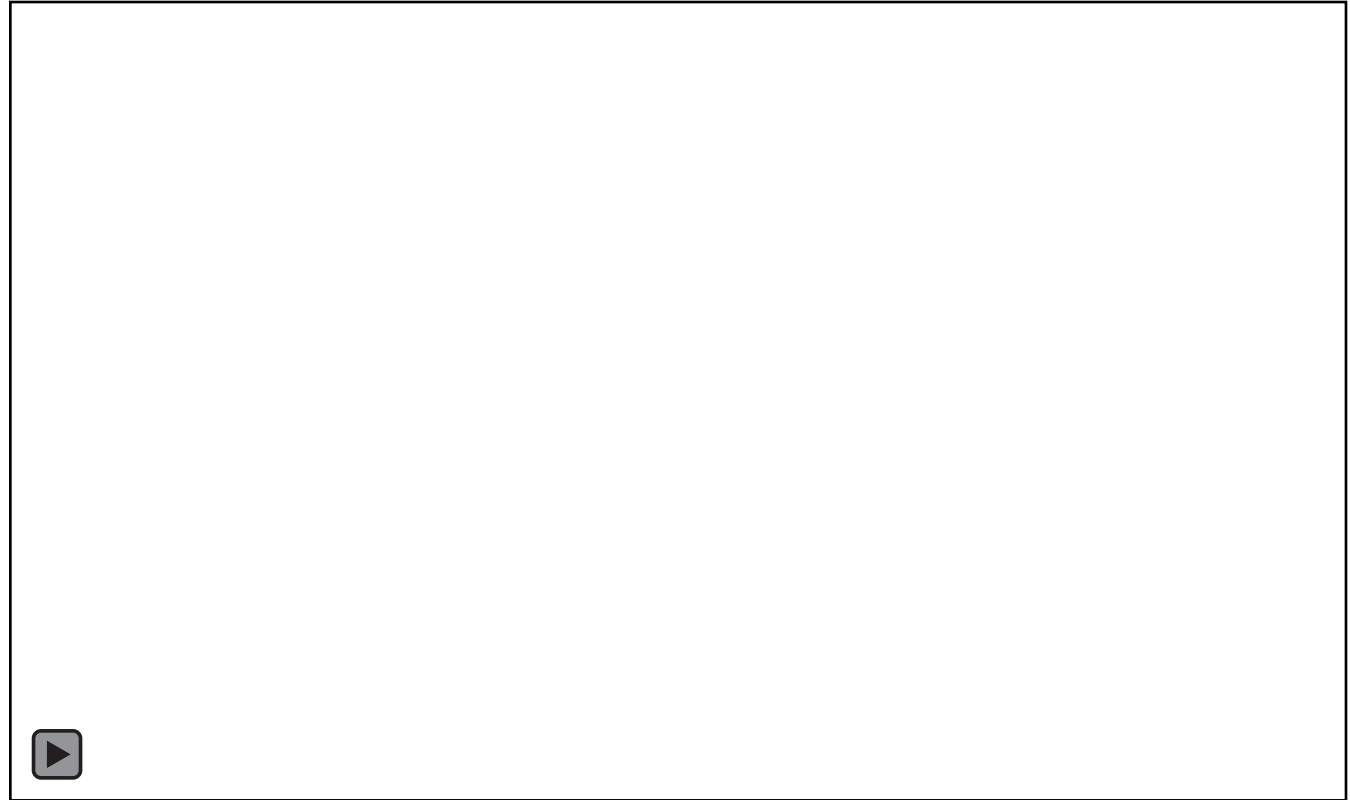


80 days total

Machine Prediction



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Schlumberger Data Ecosystem - DELFI

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