Advanced geomechanical solutions for reservoir life cycle.

HAMID, O., SANAEE, R. and OLUYEMI, G.

2021

IFEDC

IFEDC | 监测技术驱动油气高效开发

Efficient Development of Oil and Gas Driven Surveillance Technology

2021油气田勘探与开发国际会议

International Field Exploration and Development Conference 2021

2021 油气田勘探与开发国际会议
International Field Exploration and Development Conference 2021
2020年9月16日-18日 中国•青岛 16–18 September 2021 in Qingdao, China

Advanced Geomechanical Solutions for Reservoir Life Cycle IFEDC20219784

Speaker:
Osman Hamid

Organization:
Robert Gordon University

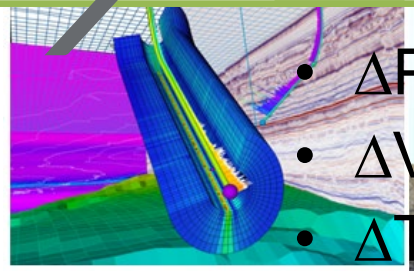
Contents

Introduction to Geomechanics

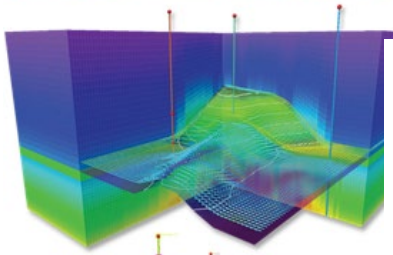
Geomechanics

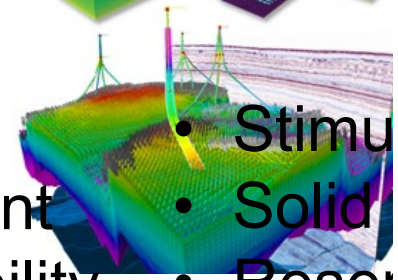
- Geology
- Geophysics
- Petrophysics
- Reservoir

Changes



- ΔP
- ΔV
- ΔT

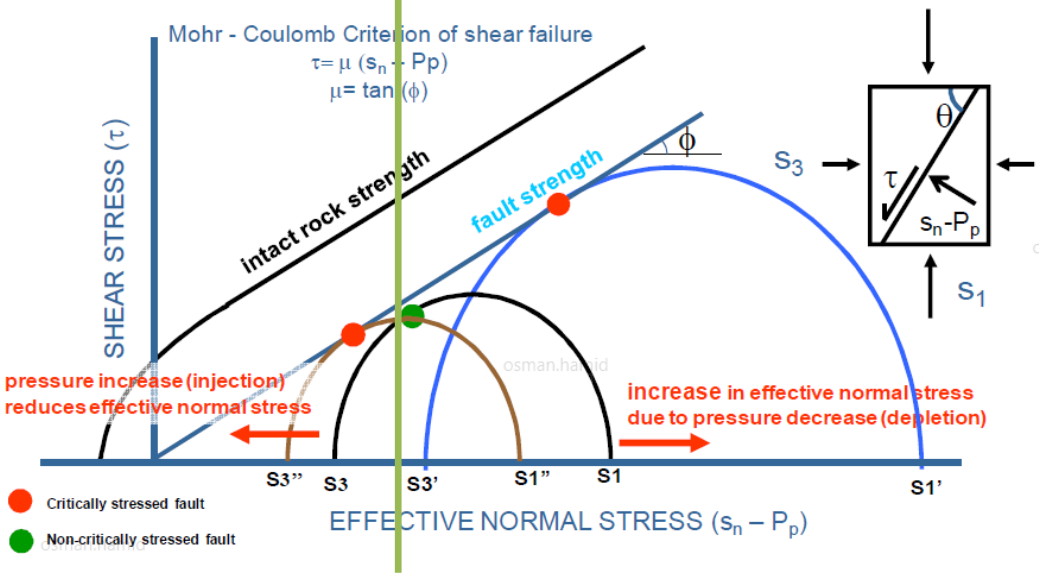




- Stimu
- Solid
- Reser

Geomechanical Analysis

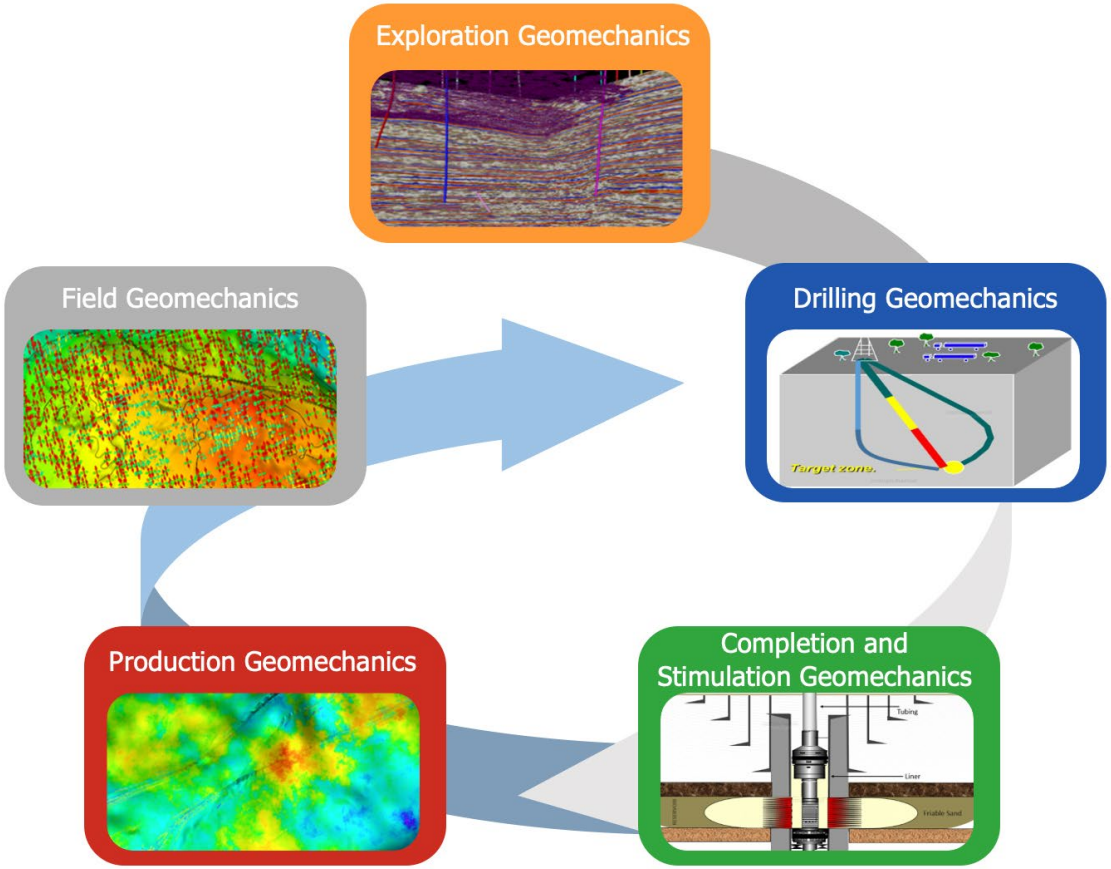
- Rock Failure
- Deformations
- Tensile/Compressive strengths

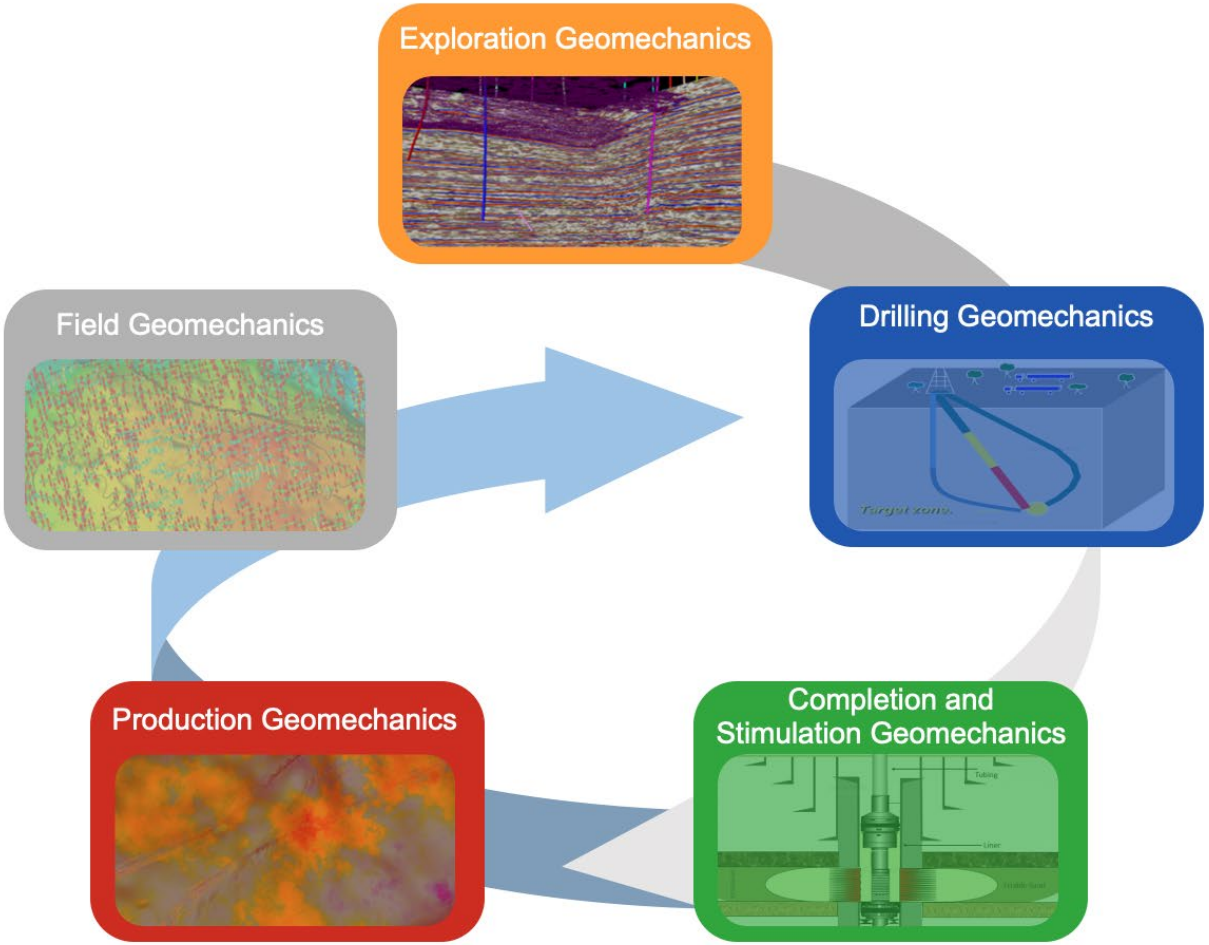


Applications

- Sweet spot
- Well placement
- Wellbore stability

Integrated Geomechanical Workflow



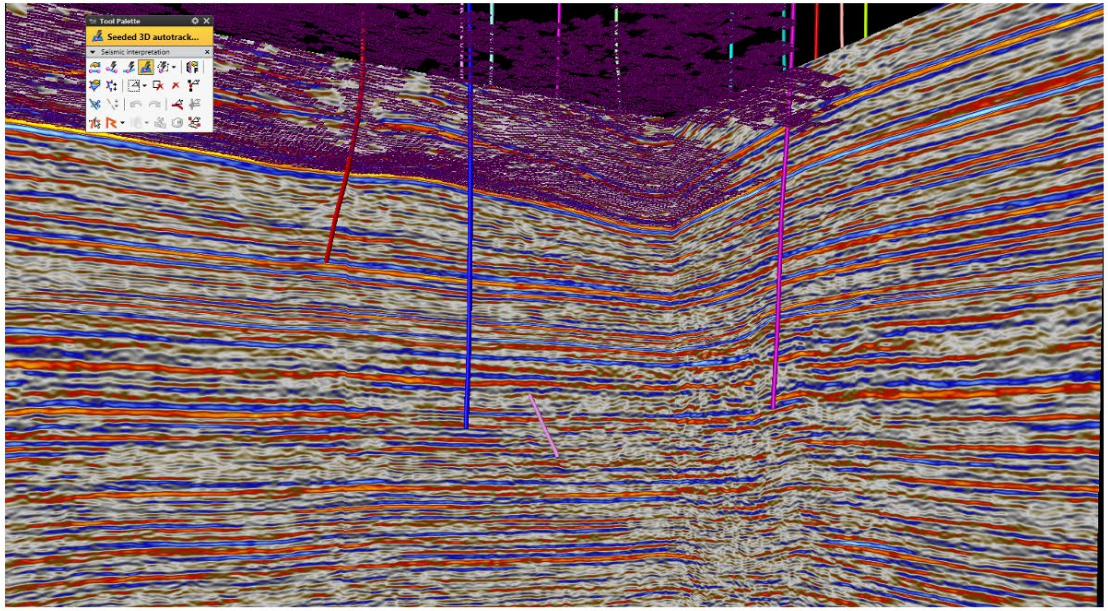


Exploration Geomechanics

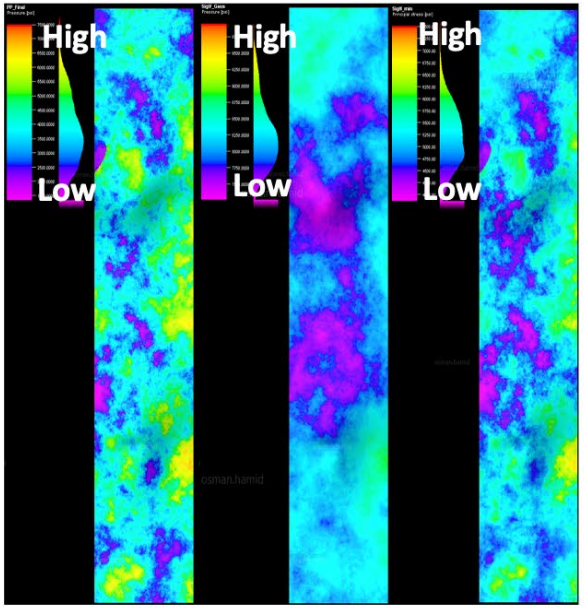
- Stress Regime Characterization
- Reservoir Quality Variation
- Pore pressure Prediction

Exploration Geomechanics

Structural Elements

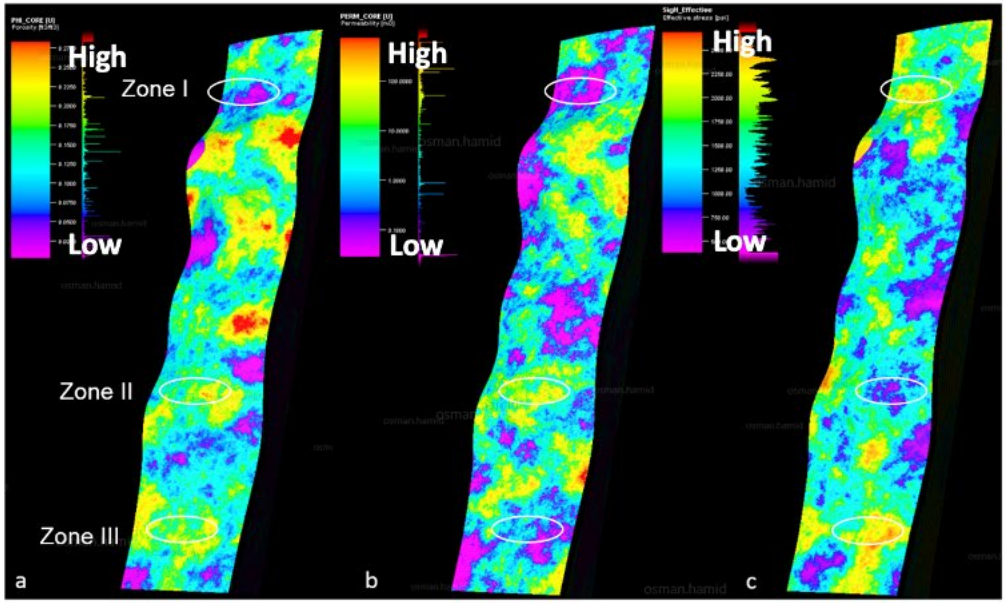


Stresses and pore pressure modeled into 3D space

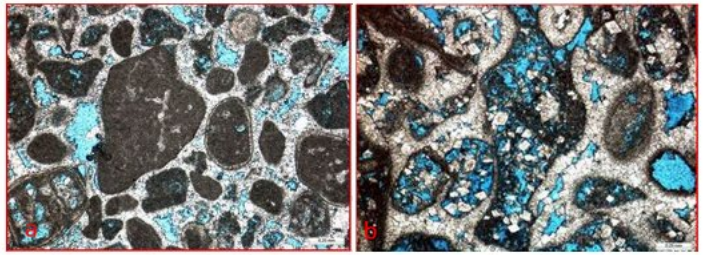


Hamid et al., (2017)

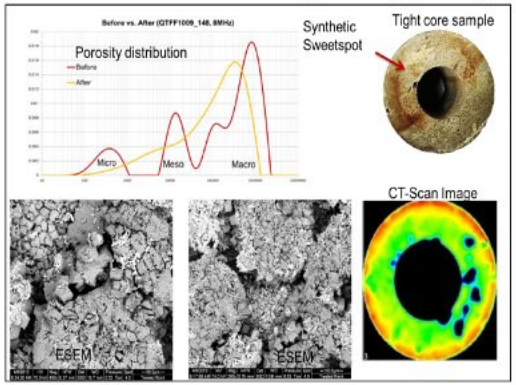
Reservoir Quality Variations



Porosity, permeability and effective stress distributed into 3D space

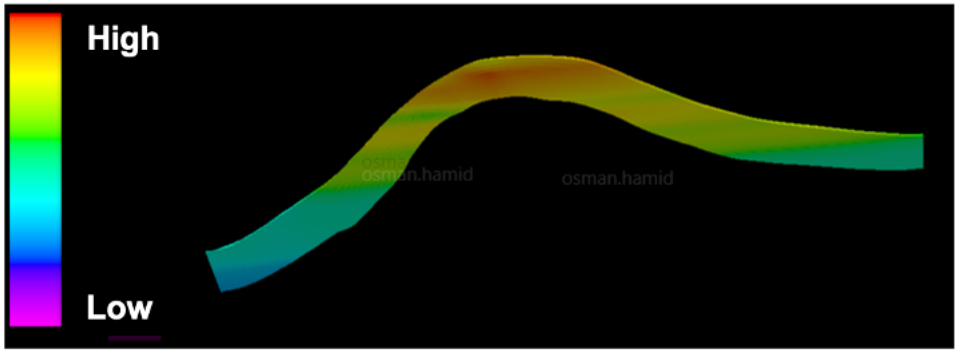


Thin section for both Grainstone and Dolomite and indicates isolated pores (in blue)



Environmental Surface Electro Microscopy (ESEM) shows that microfractures were created using the chemical reactant Hamid et al., (2016)

Pore Pressure Prediction Technology



3D cube of pore pressure

- Pore pressure predication model using Effective stress-Poisson's ratio relationship:

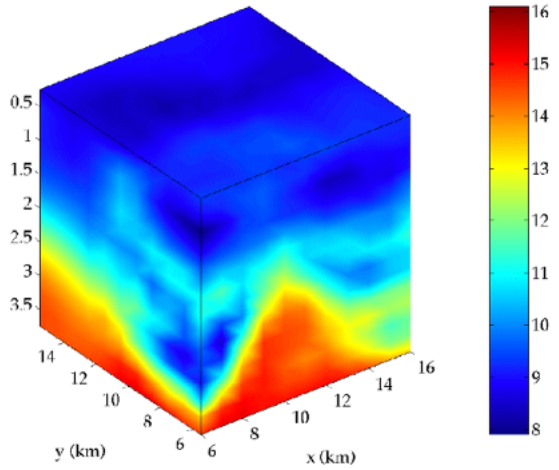
$$\sigma_v^{/} = \mathrm{m} * e^{\mathrm{n}*\vartheta}$$

$$Where\ \vartheta = Poisson'sRatio$$

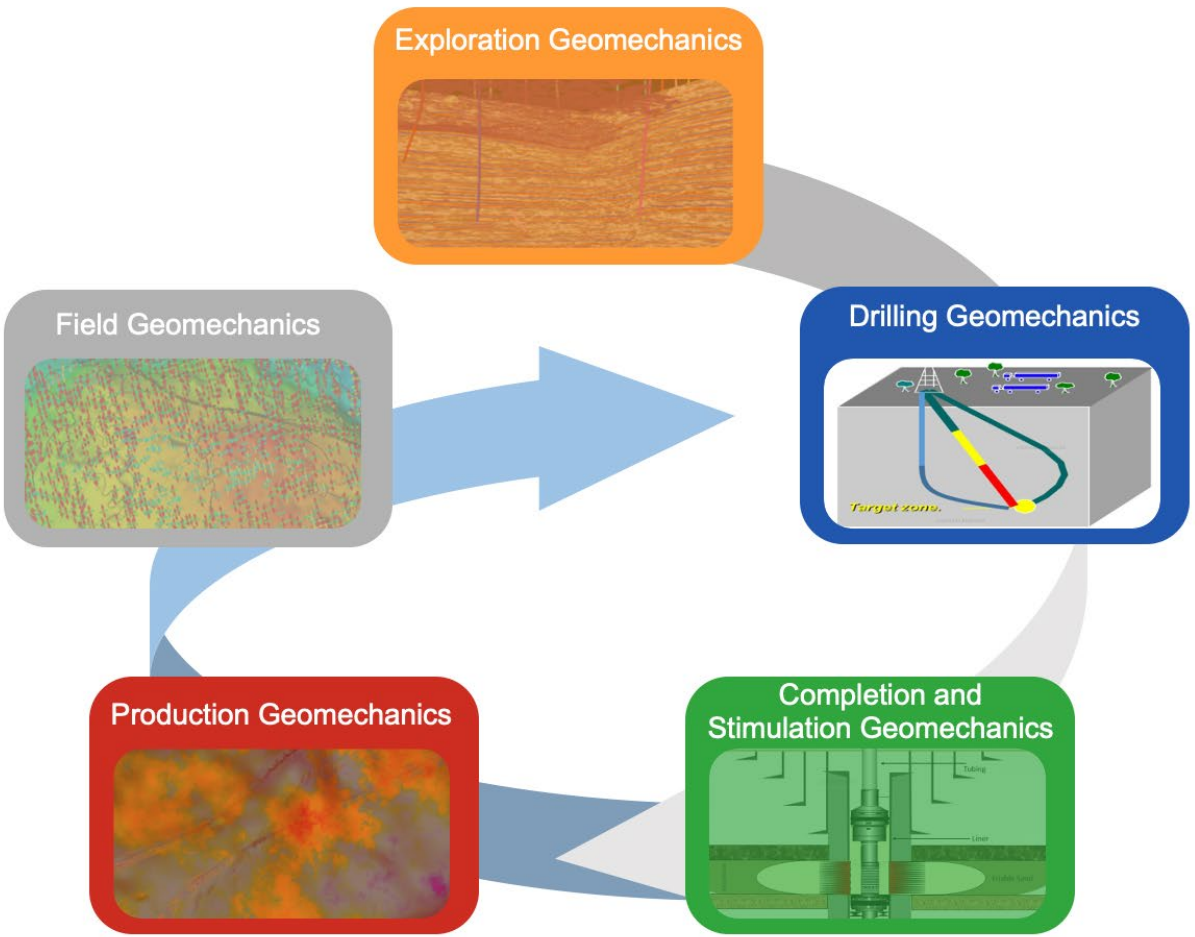
Hamid et al., (2017)

Pore Pressure Prediction

Pore Pressure (ppg) from tomographic velocities



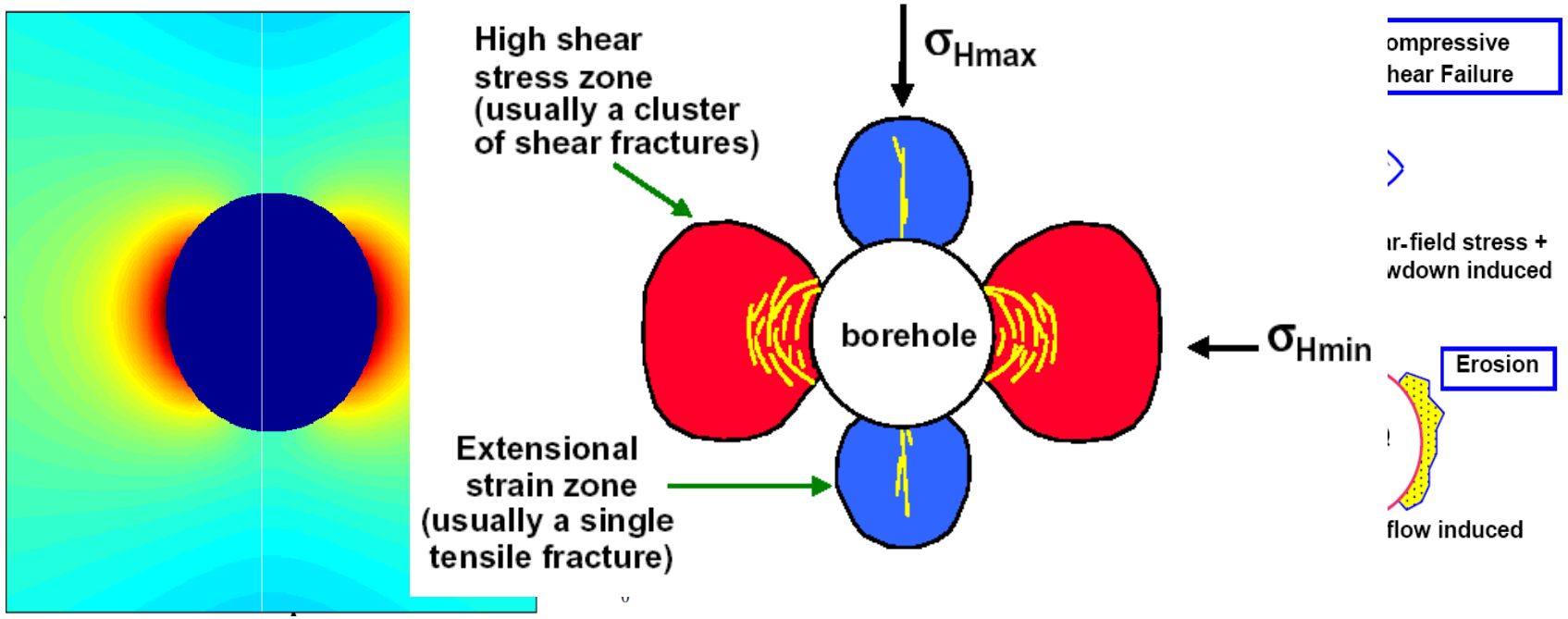
Sayers, C.M., Woodward, M.J. and Bartman, R.C. (2002) *The Leading Edge*, **21**, 188-192.



Drilling Geomechanics

- Wellbore failure
- Global Mud Weight
- Borehole quality

Wellbore Failure Modes

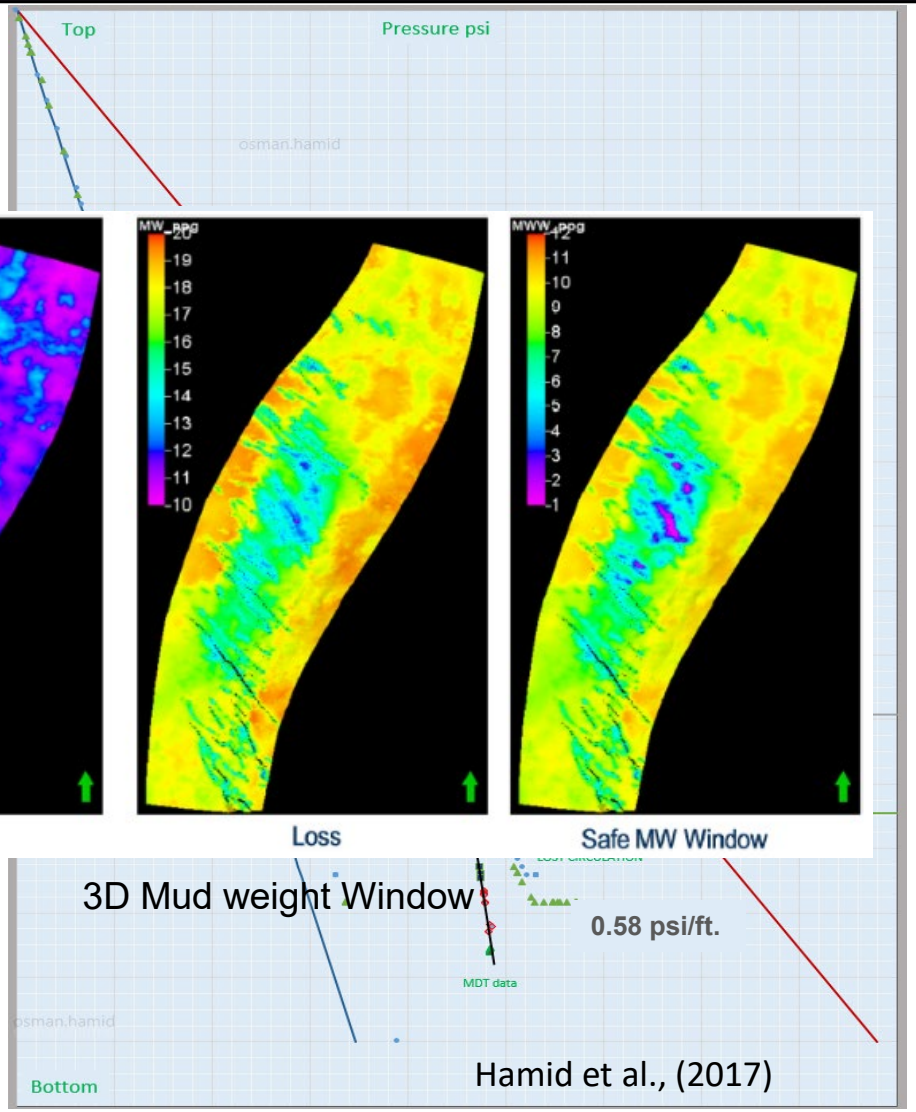


Types of yielding occurring around a vertical wellbore

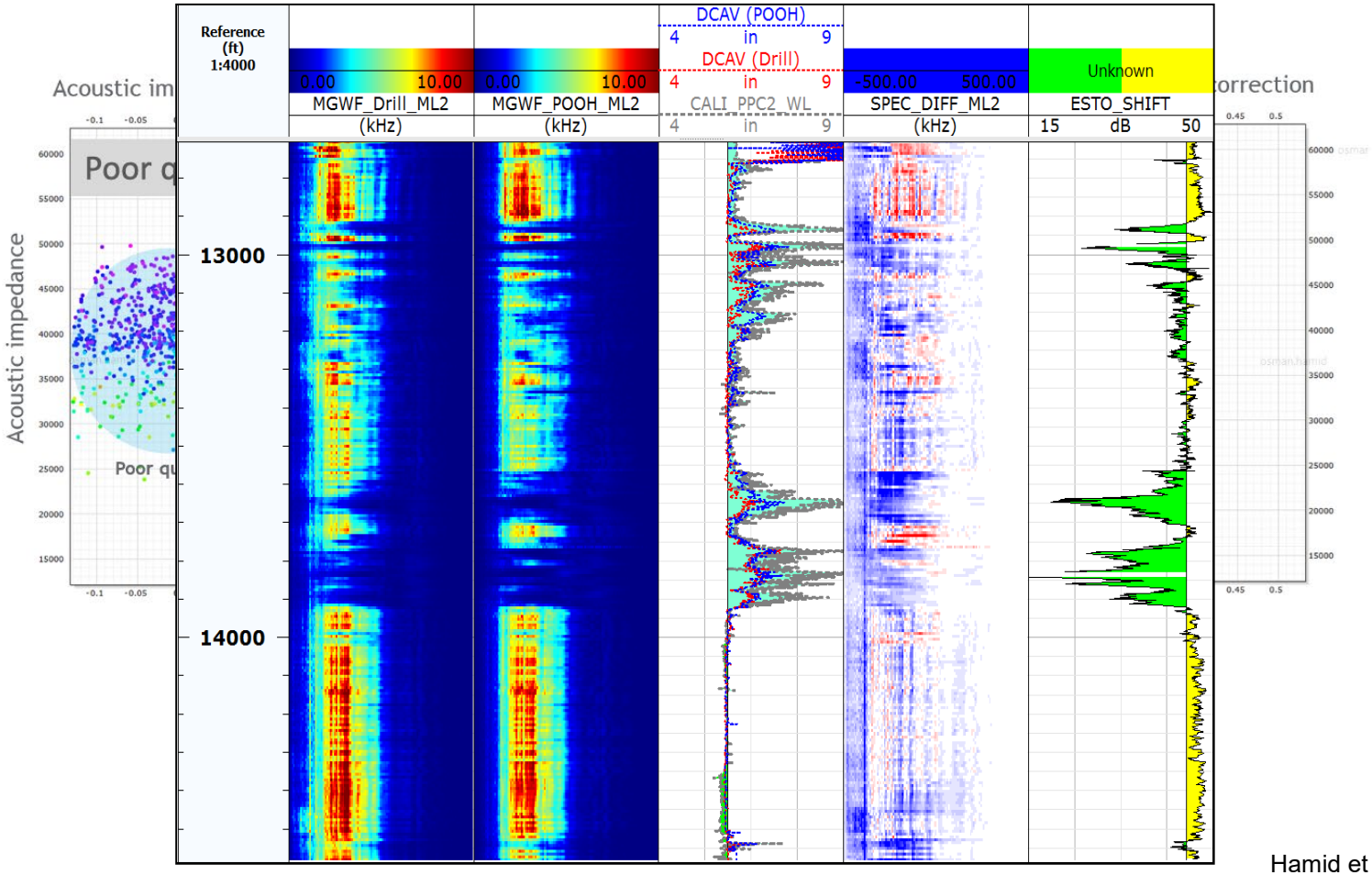
Rock failure mechanisms associated with sand production (after Veeken et al., 1991)

Global Mud-Weight Profile

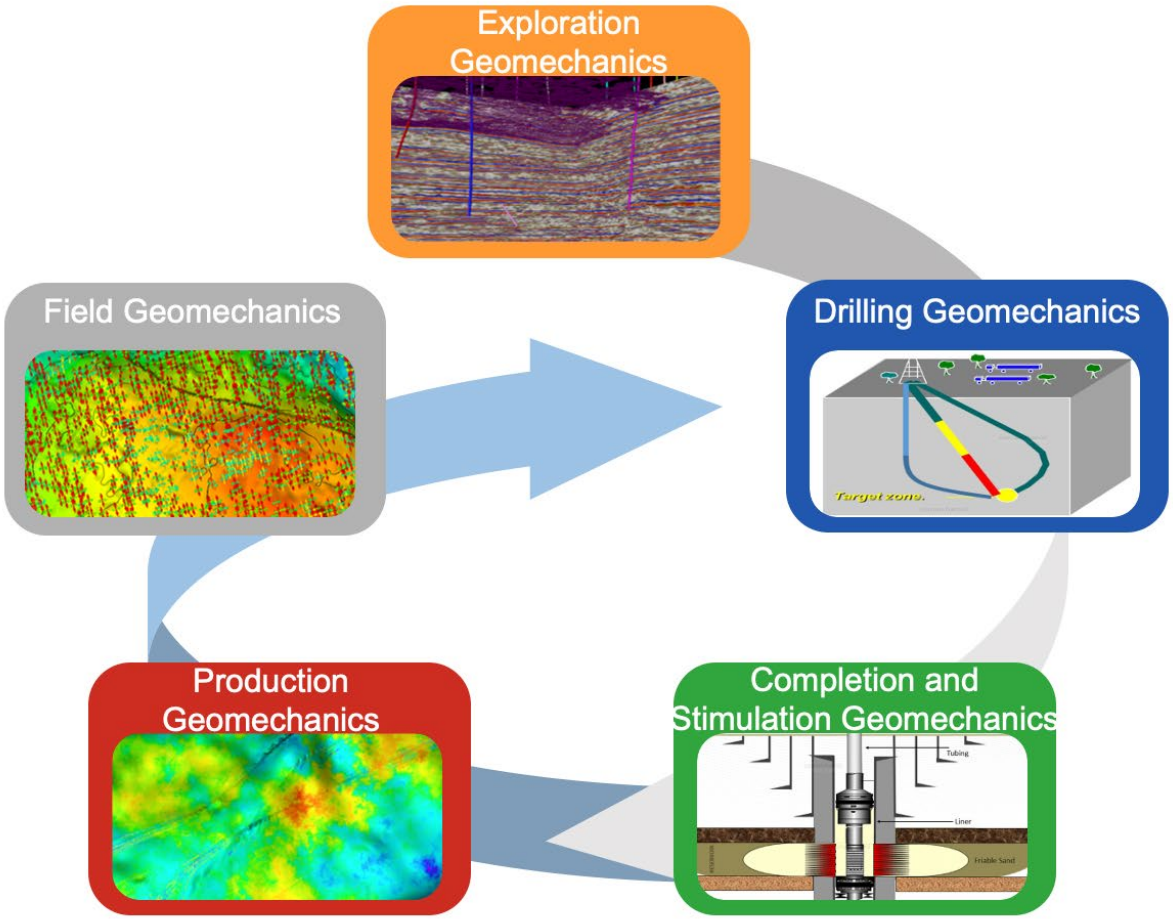
- This plot suggested normal pore pressure regime for the first 5000 FT
- Then the pore pressure gradient increases to 0.48 psi/ft. and 0.52 psi/to till top of high-pressure Carbonate Formation
- High pore pressure up to 0.95 psi/ft. and then decreases at bottom of high-pressure Carbonate Formation



Impact of Wellbore Quality



Hamid et al. 2017

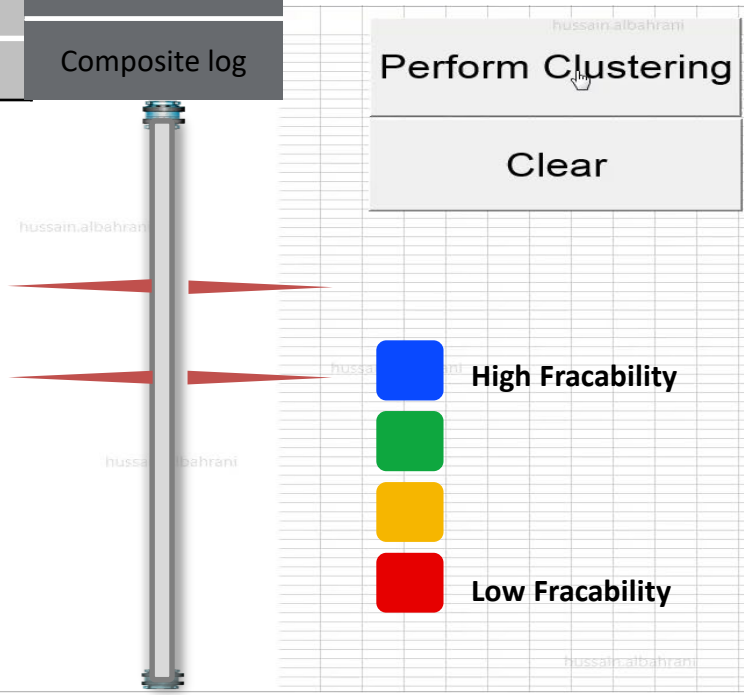


Completion/ Stimulation Geomechanics

- Completion type characterization
- 1D/3D Fracability
- Effect of anisotropy on HF
- Breakdown pressure challenges

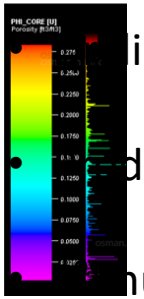
1D Clustering Technology

Inputs									Output
Reservoir Properties				Operational Parameters			Geomechanics		Composite log
DEPTH	PERM	PHI	BHSP	CALI	Wellbore deviation	Perfs OB	Min. Hor. Stress	UCS	



3D Clustering Technology

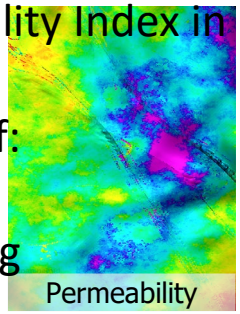
Fracability Index in term of:

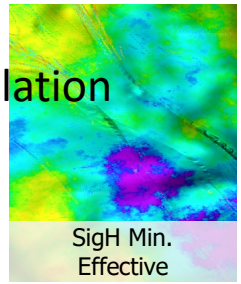


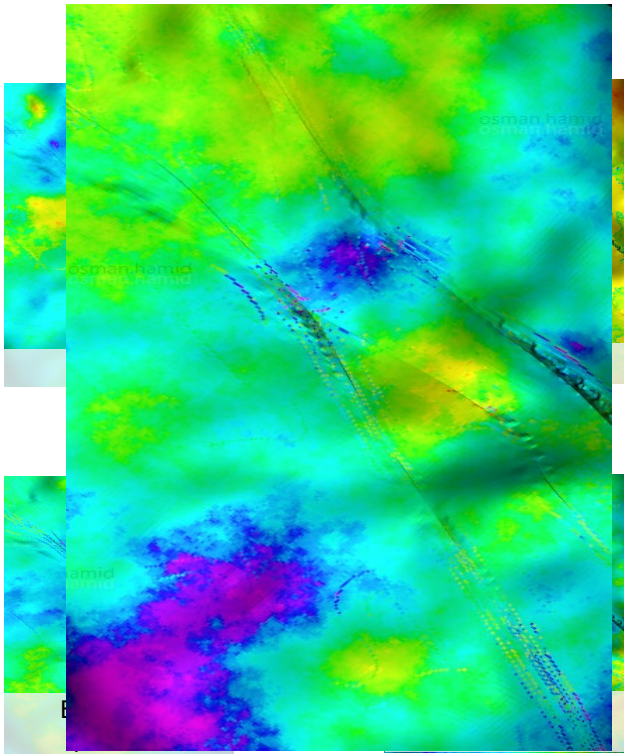
ing

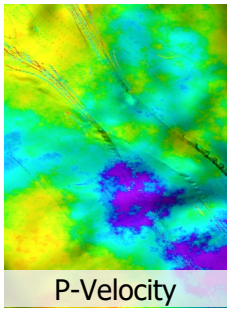
duction

nulation

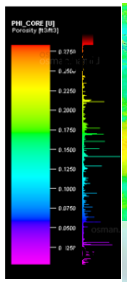


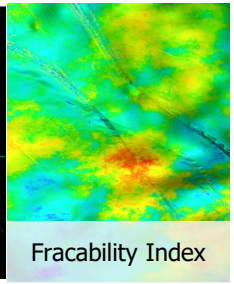






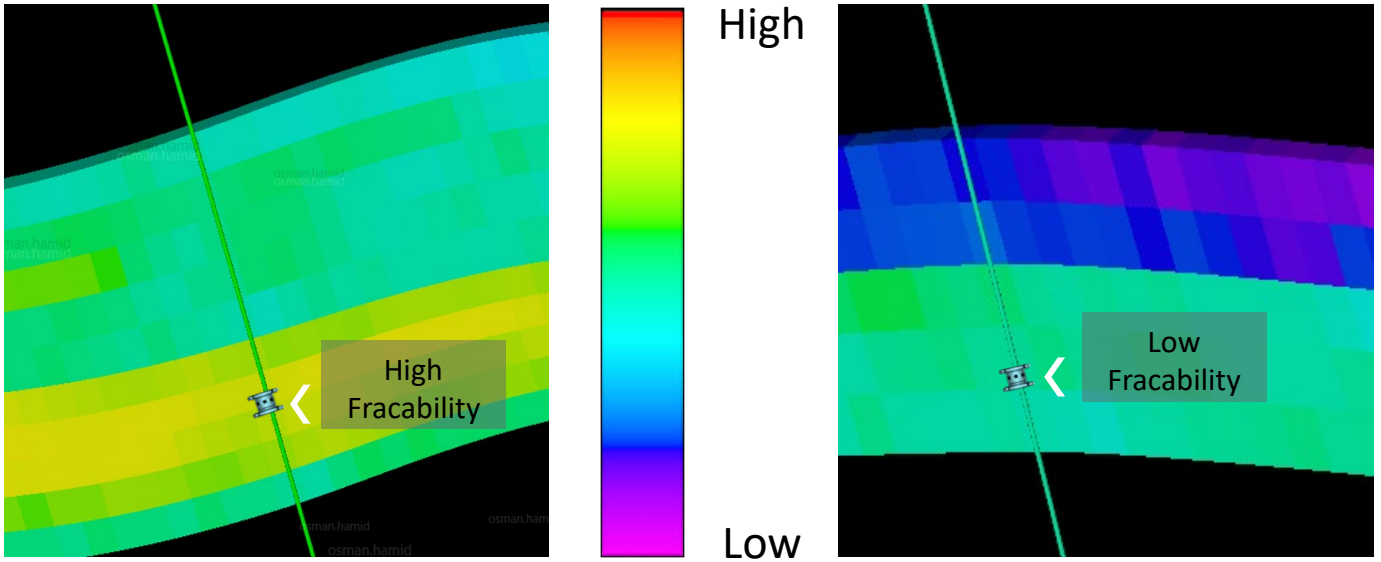
Reservoir Quality



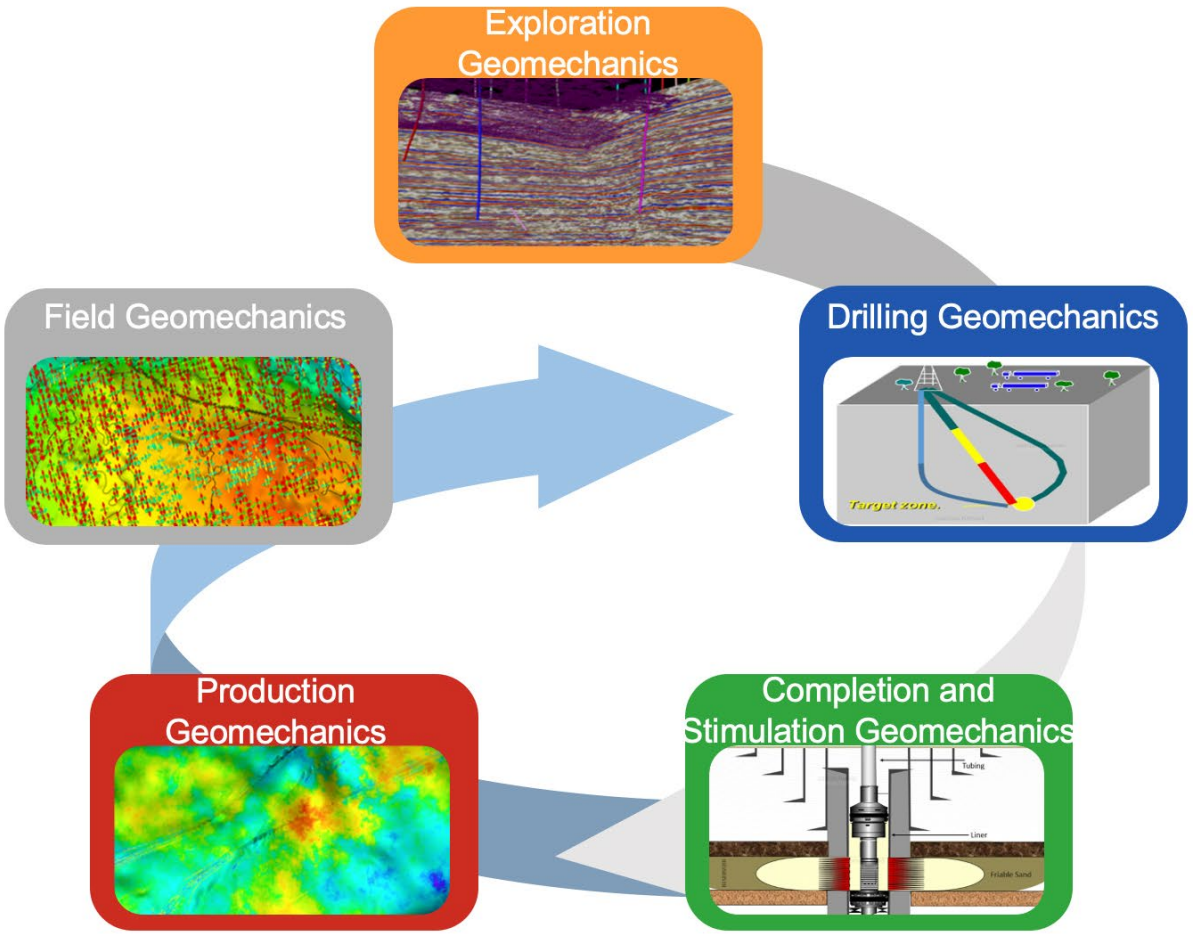


Completion Quality

Fracability Index



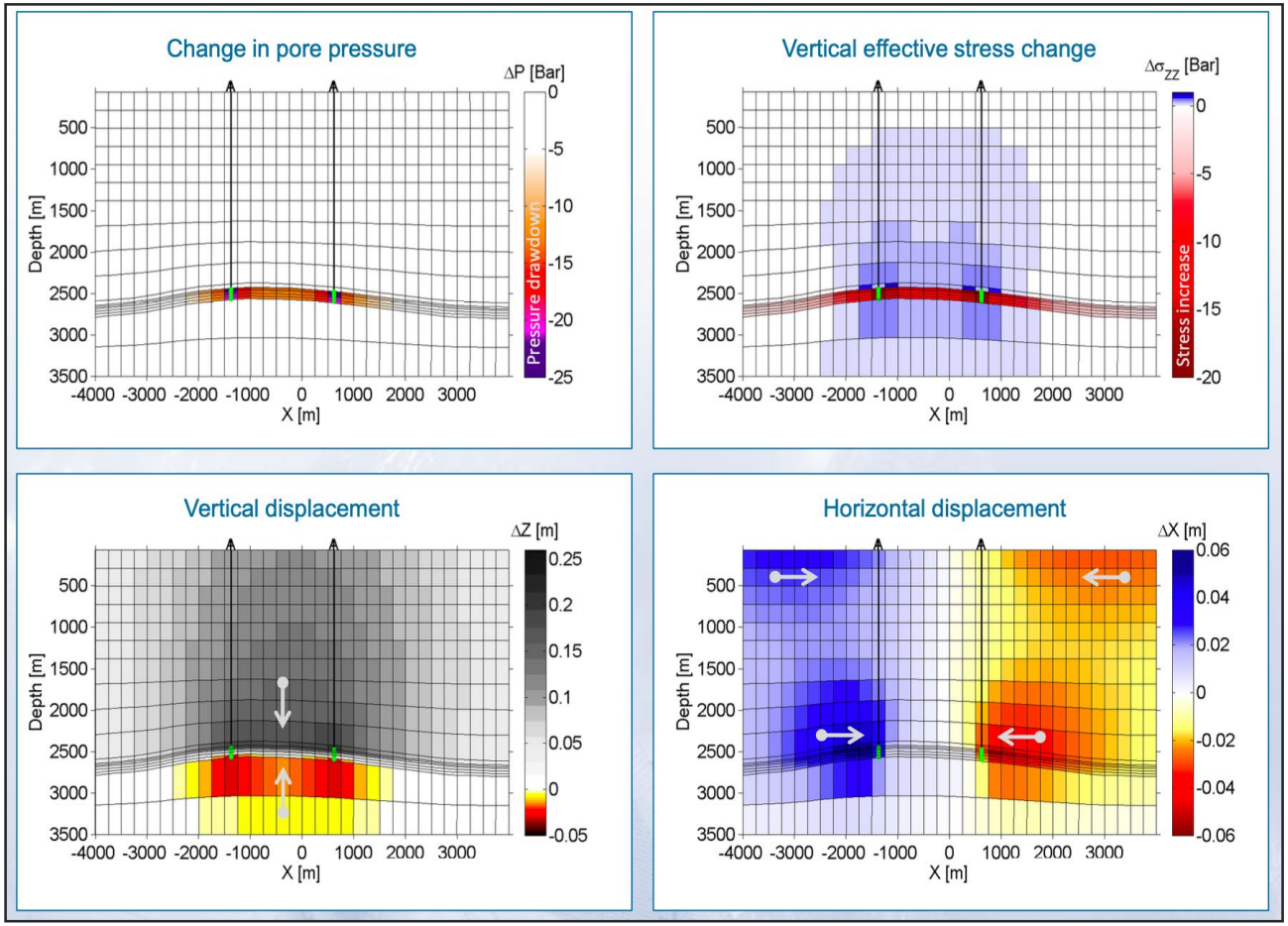
Requires 15K Completion



Production Geomechanics

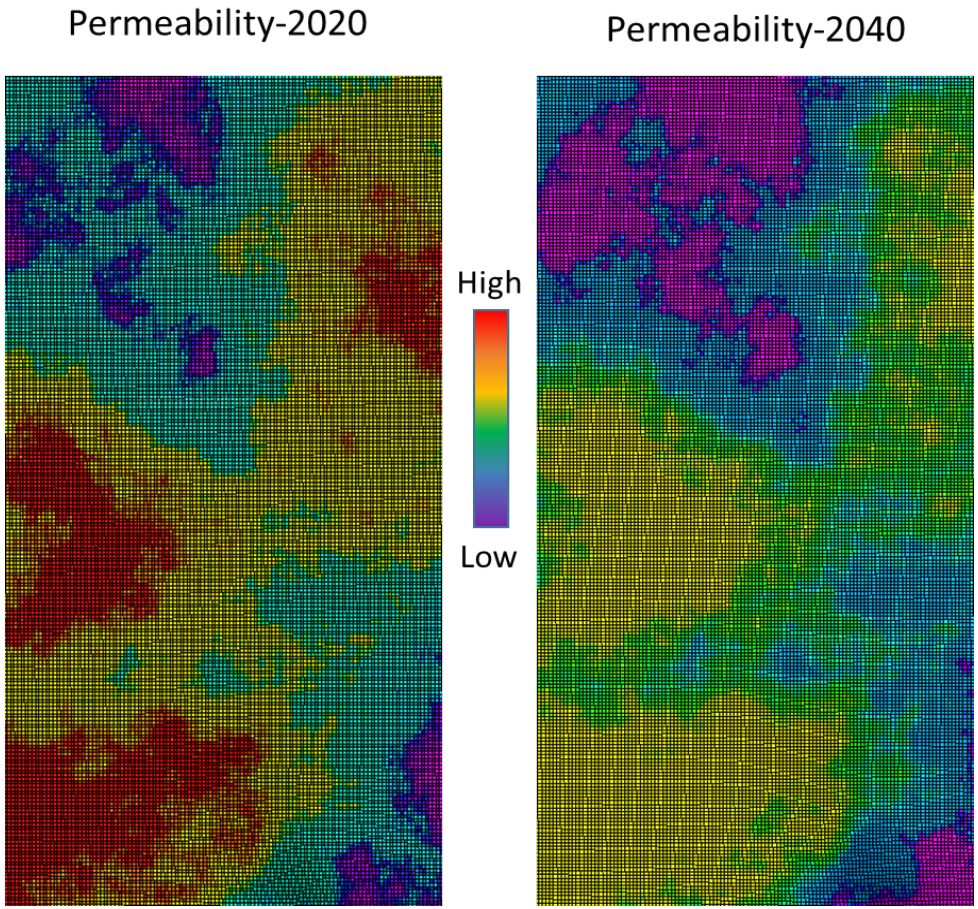
- Elastic and Plastic failure
- Fault and cap-rock integrity
- Casing deformation
- Solid production

Production-Induced Pore Pressure Changes



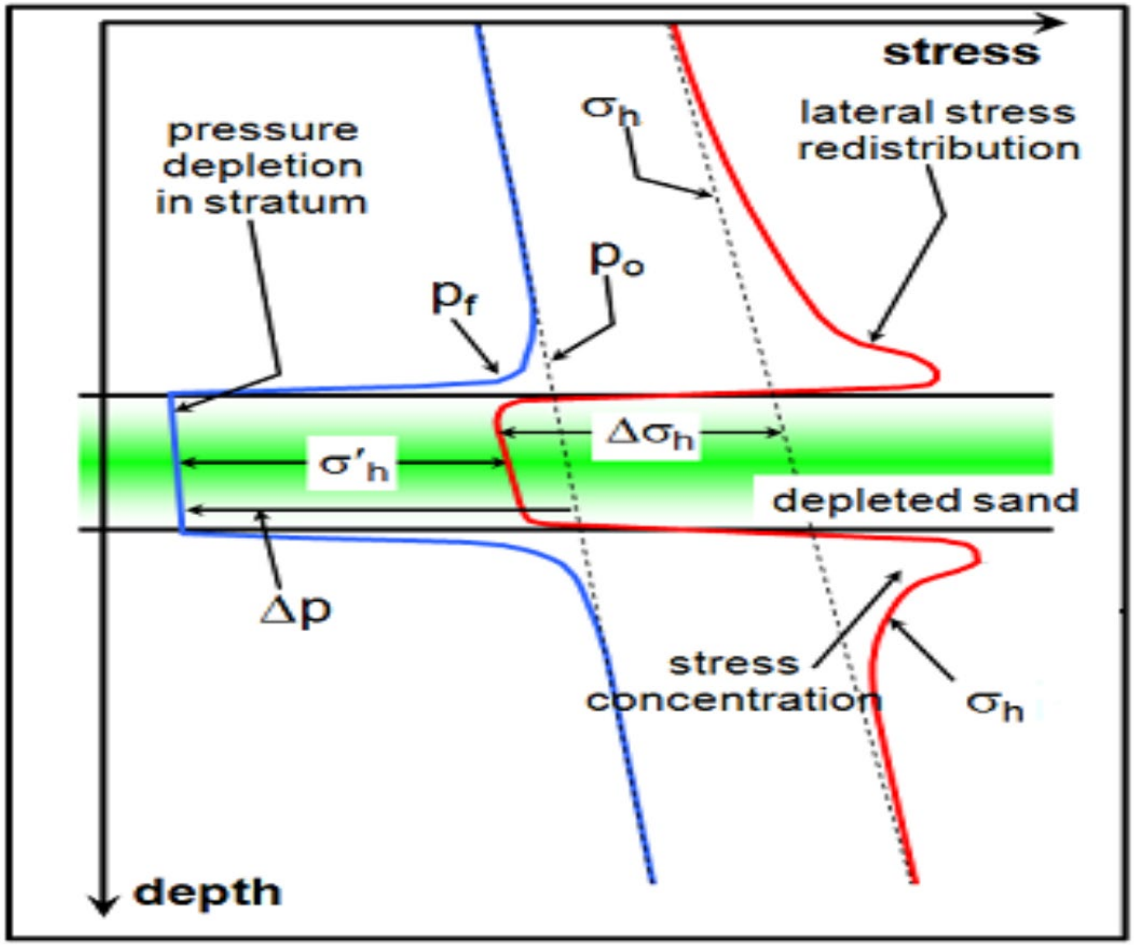
Herwanger and Koutsabeloulis 2011

Stress-Dependent Permeability

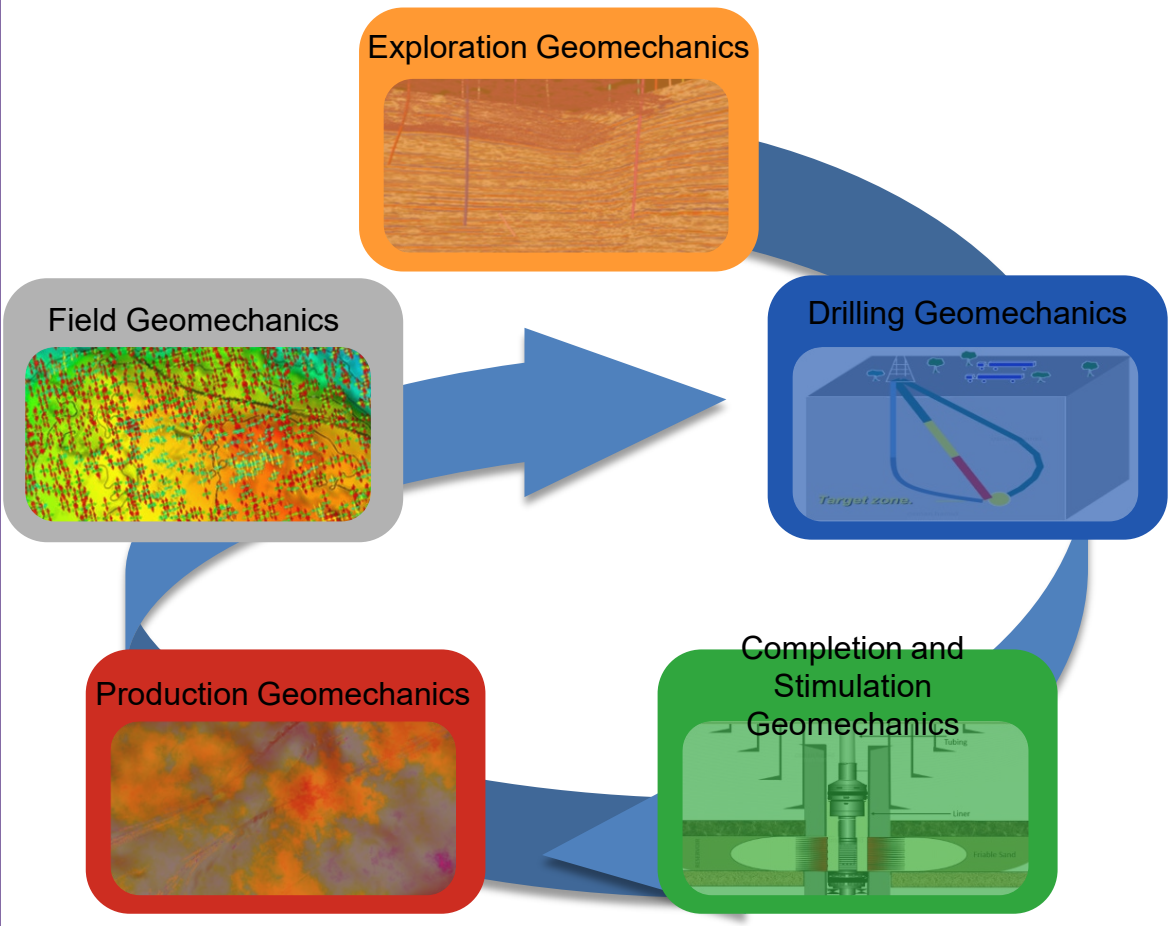


Hamid et al 2018

Stress Redistribution due Depletion



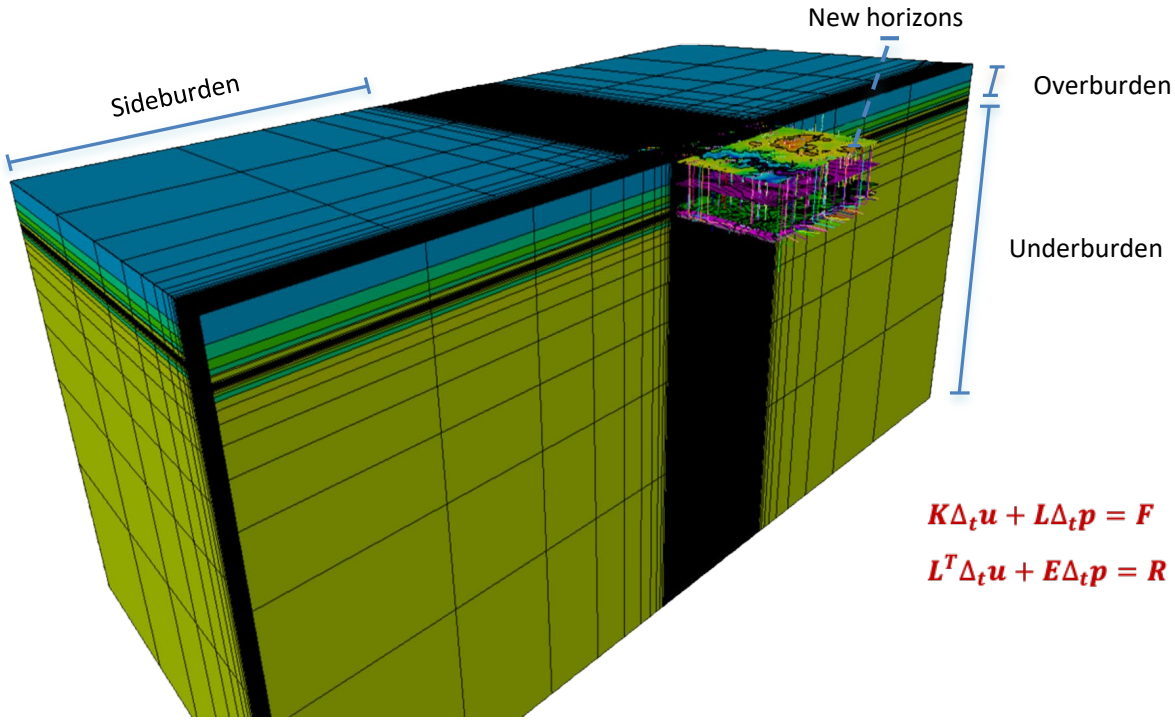
Paul et al 2013



Field Geomechanics

- Porosity and permeability with depletion
- Stress rotation
- History matching

Impact of stress/strain on Elastic and Plastic Deformation

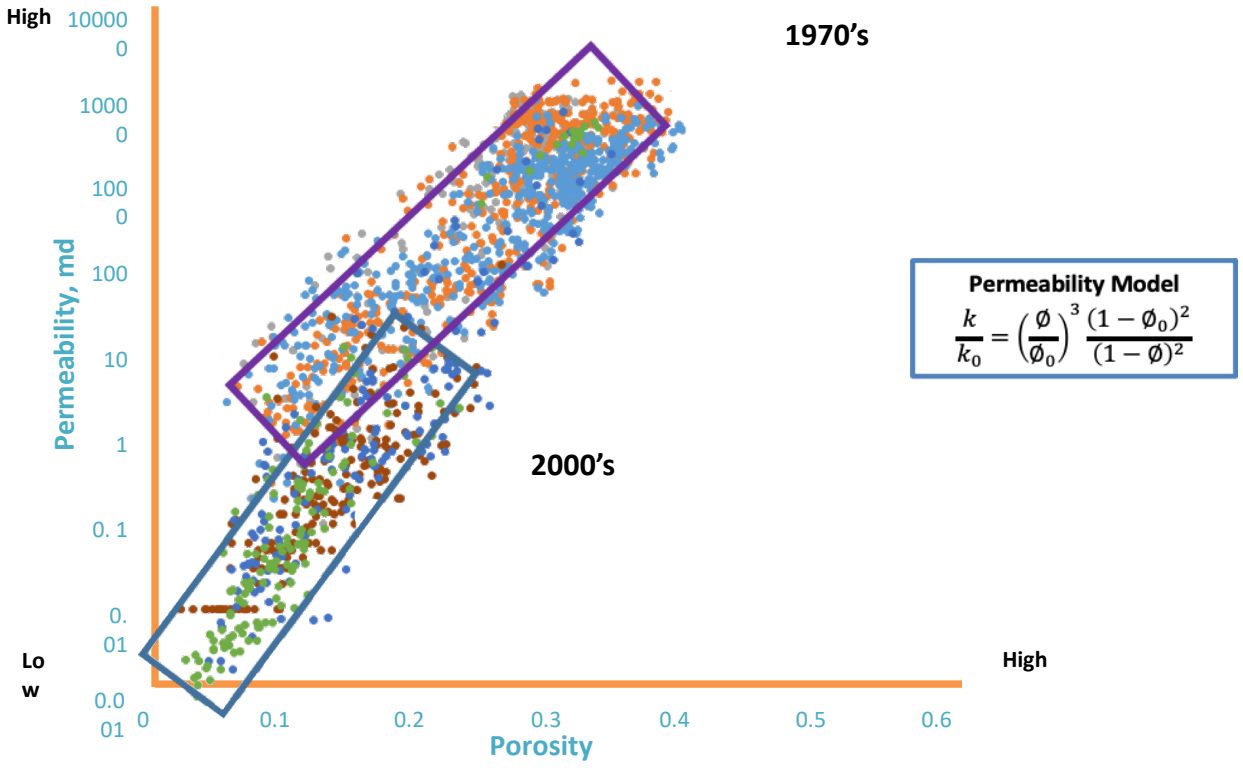


$$K\Delta_t u + L\Delta_t p = F$$

$$L^T\Delta_t u + E\Delta_t p = R$$

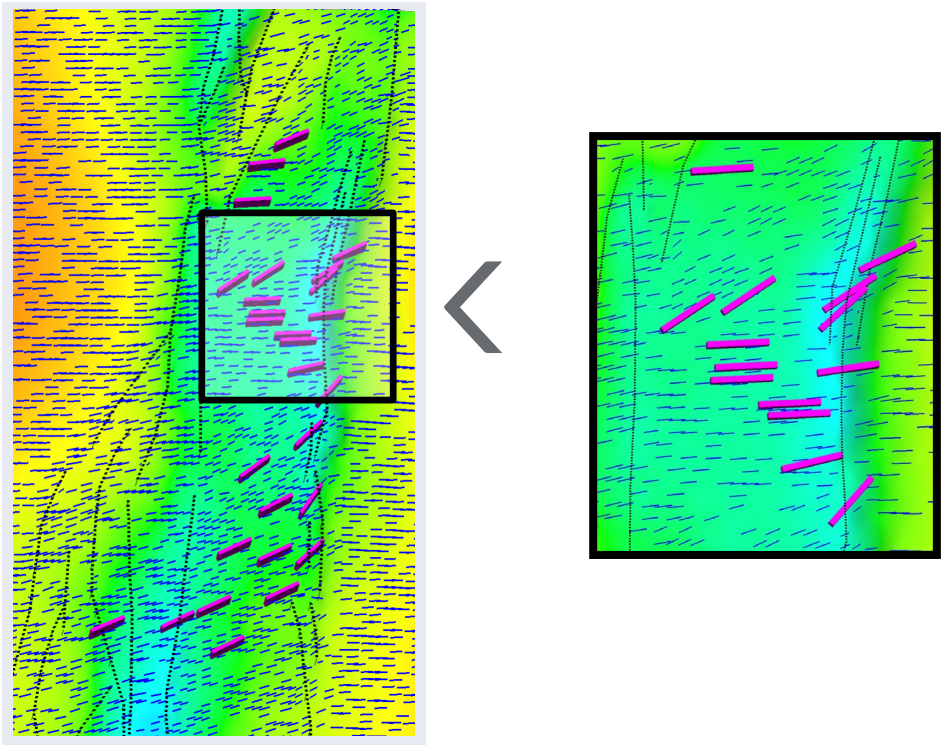
1. 3D/4D Geomechanical modeling
2. Fluid-Flow and Geomechanics coupling
3. Enhanced Oil Recovery projects (injection, water flood) use **4D (dynamic) Geomechanics** to reduce wellbore integrity risks and deliver a higher field recovery factors.

Permeability Changes with Time



Stress Rotation due Reservoir Depletion

Far Field
Maximum Stress



Conclusion

Continuous geomechanical modeling should always be applied to understand the reservoir and precisely place the wells in a better reservoir quality rock with spatial variation in stresses to optimize drilling, completion, stimulation, and to maximize hydrocarbon production

I would like to thanks my Co-authors Dr. Reza Sanaee and Dr. Gbenga Oluyemi

谢谢大家！