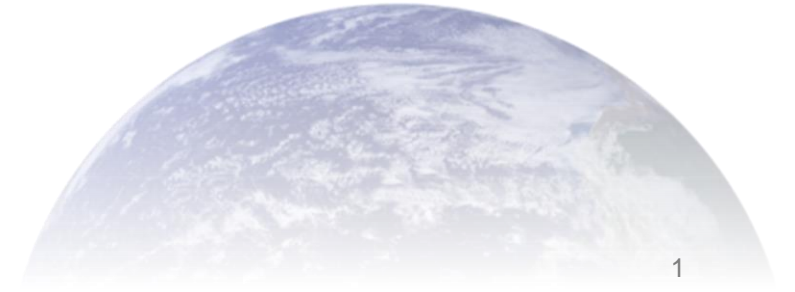


Geomechanical Issues Associated With Large-Scale CO₂ Sequestration in the Gulf of Mexico

Mark D. Zoback
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Co-Director, Stanford Center for
Carbon Storage



Stanford Center for Carbon Storage
November 12, 2020



Geomechanical Issues Associated With *Relatively* Large-Scale CO₂ Sequestration in the Gulf of Mexico

Saline Aquifers

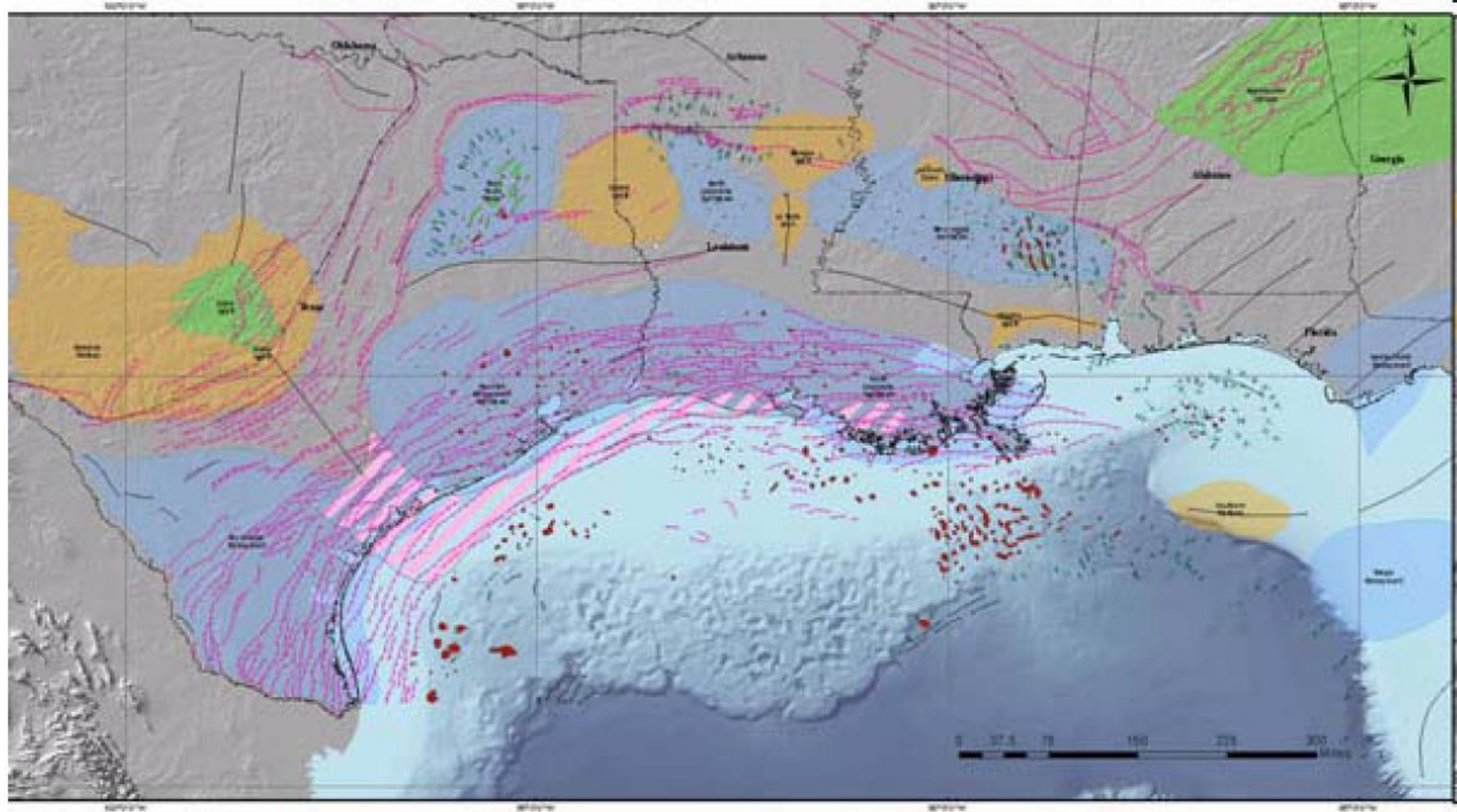
- Composition and Physical Properties of Candidate Reservoirs?
 - *Lithology, Porosity, Permeability, Compressibility?*
- How are Properties Affected by CO₂ Injection?
- What are the Geomechanical Limits on Injection Pressure?

Depleted Oil and Gas Reservoirs

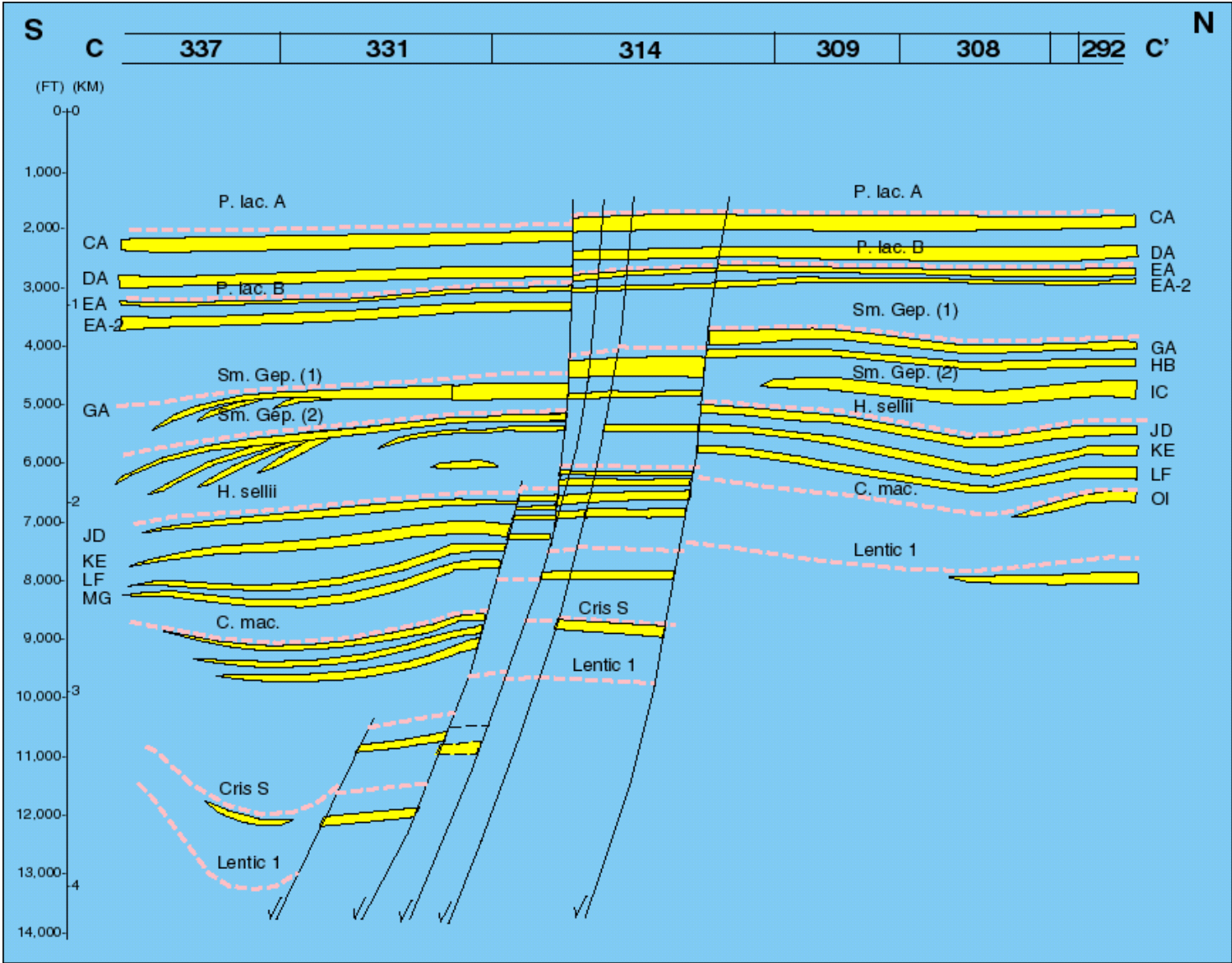
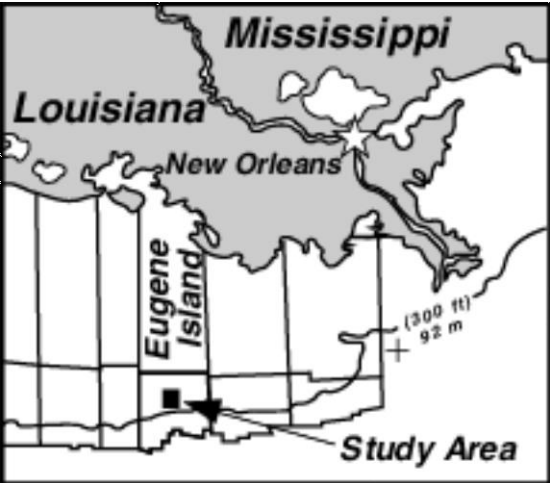
- How did Depletion Change the State of Stress in the Reservoir?
- How did Depletion Change the Physical Properties of the Reservoir?
- How Will the State of Stress Evolve as Pressure Increases Due to CO₂ Injection?

Many of These Issues Need to be Addressed to Carry Out Predictive Simulations

The Gulf of Mexico is an Active Geologic Basin



South Eugene Island Minibasin



(modified from Alexander and Flemings, 1995)

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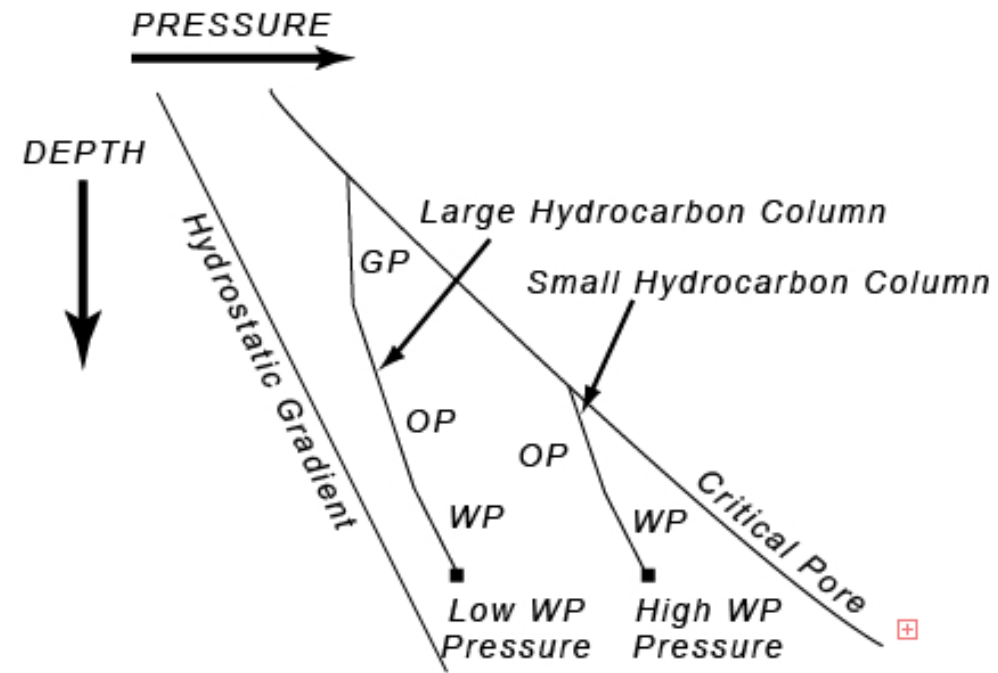
Saline Aquifers

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 - *Porosity, Permeability, Compressibility?*
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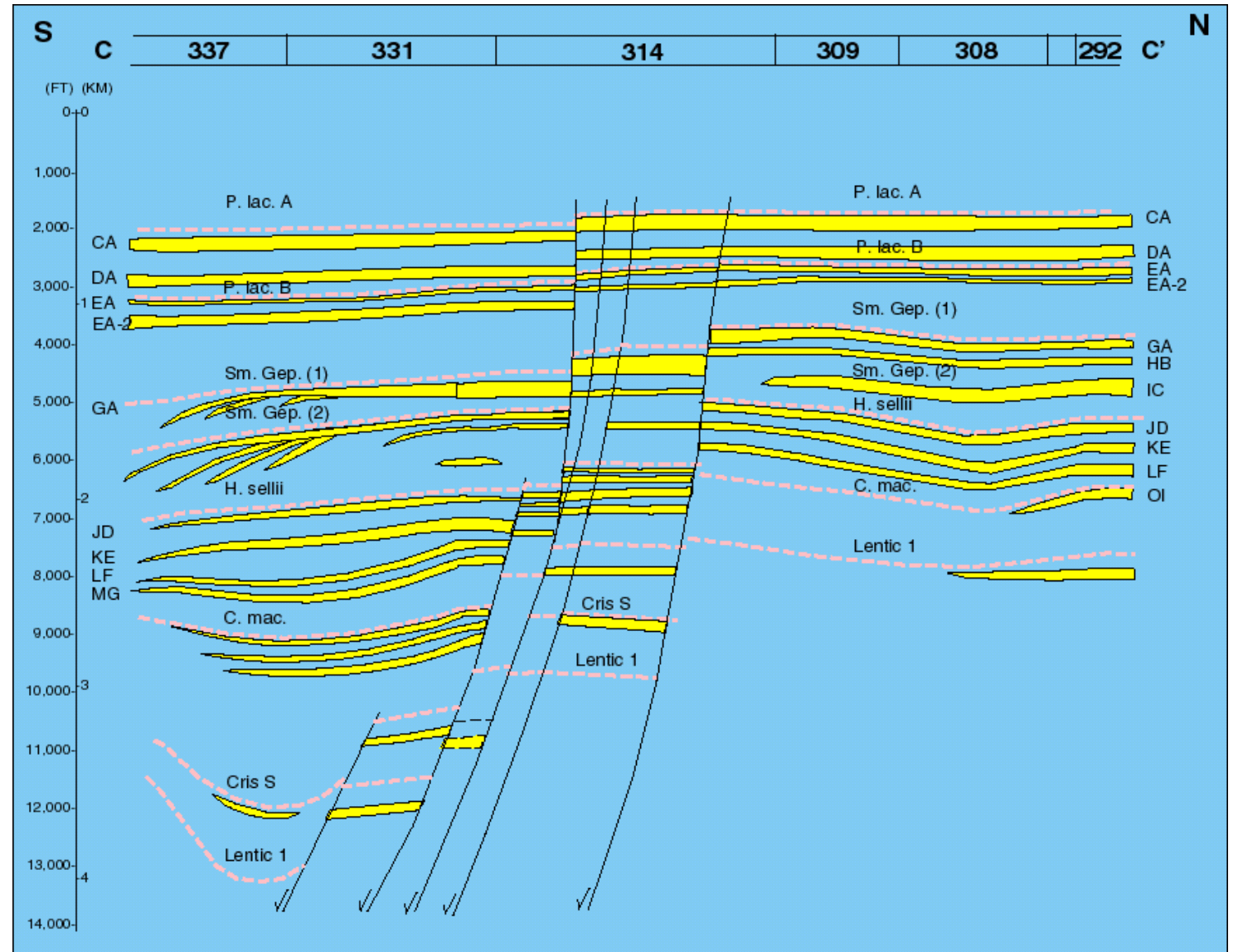
Depleted Oil and Gas Reservoirs

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 - *What was the Stress Path?*
- How did Depletion Change the Physical Properties of the Reservoir?
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 - *Will the Stress Path be Same with Injection as It was With Production?*

Dynamic Limits on Column Heights



Wiprut and Zoback (2002)



Geomechanical Issues Associated With *Relatively* Large-Scale CO₂ Sequestration in the Gulf of Mexico

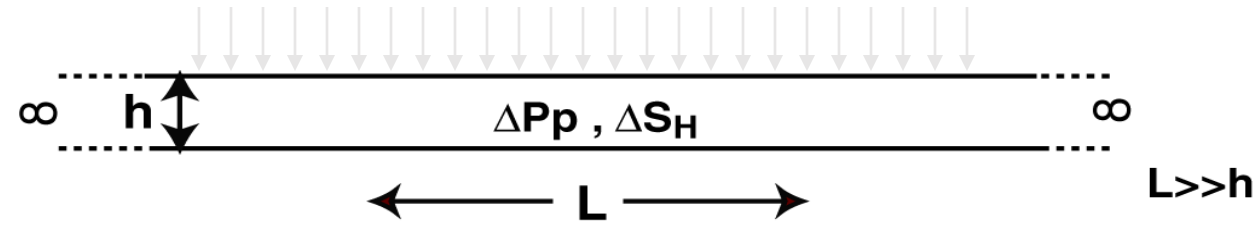
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Stress Path Within a Depleting Reservoir



Using instantaneous application of force and pressure with no lateral strain:

$$S_{Hor} = \left(\frac{\nu}{1-\nu} \right) (S_v) + \alpha P \left(1 - \frac{\nu}{1-\nu} \right)$$

Take the derivative of both sides and simplify

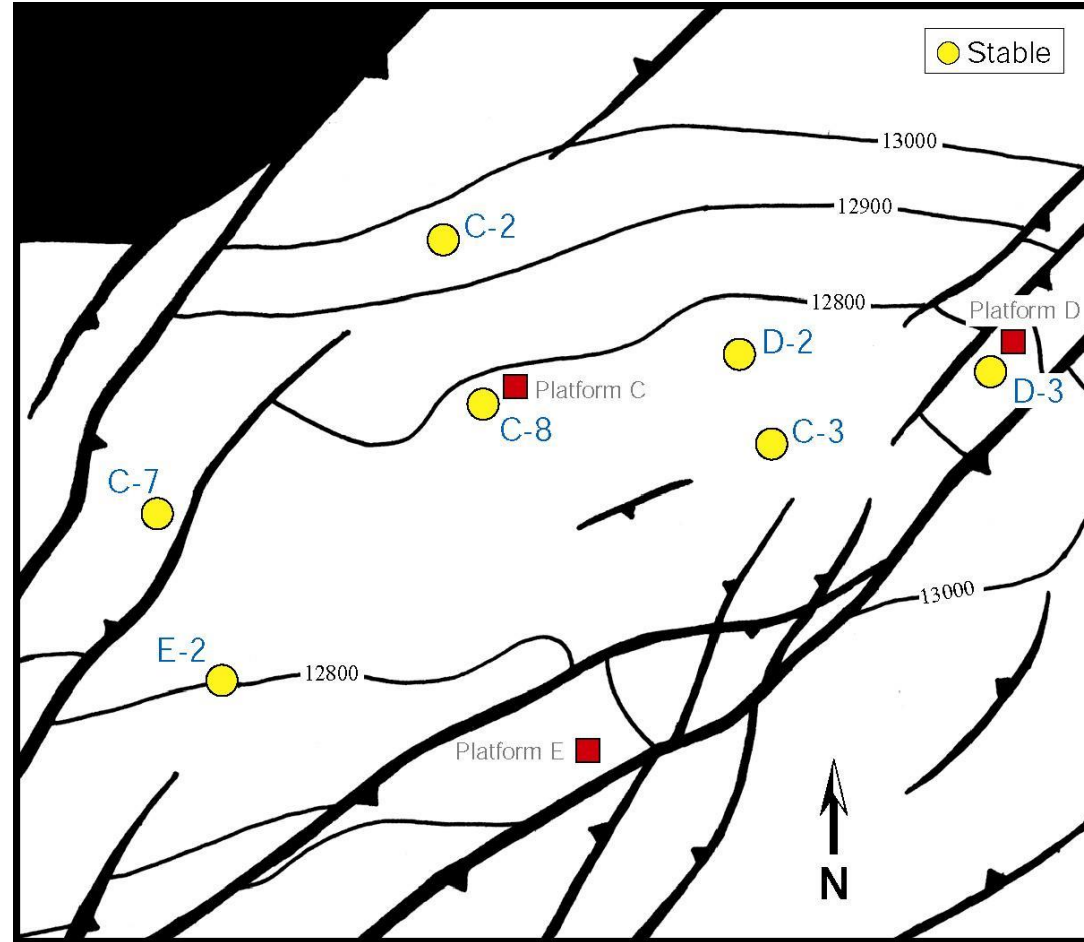
$$\Delta S_{Hor} = \alpha \frac{(1-2\nu)}{(1-\nu)} \Delta P_p \quad \alpha = 1 - \frac{K_b}{K_g}$$

$$\text{if } \nu = 0.25, \alpha = 1 \quad \Delta S_{Hor} = \frac{2}{3} \Delta P_p$$

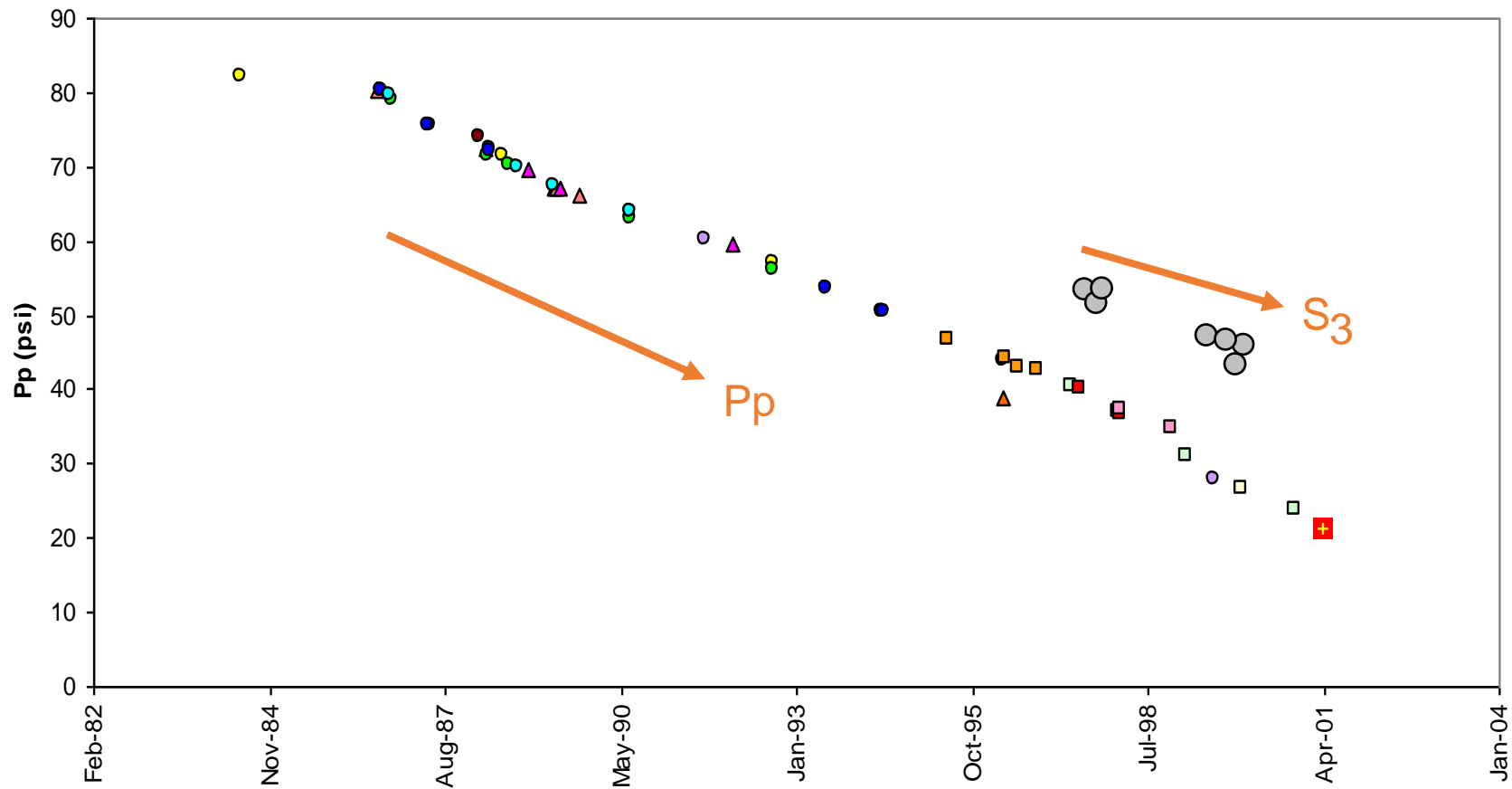
Stress Path is defined as:

$$A = \frac{\Delta S_{Hor}}{\Delta P_p}$$

Gulf of Mexico Field X



Field X Depletion and Stress Path



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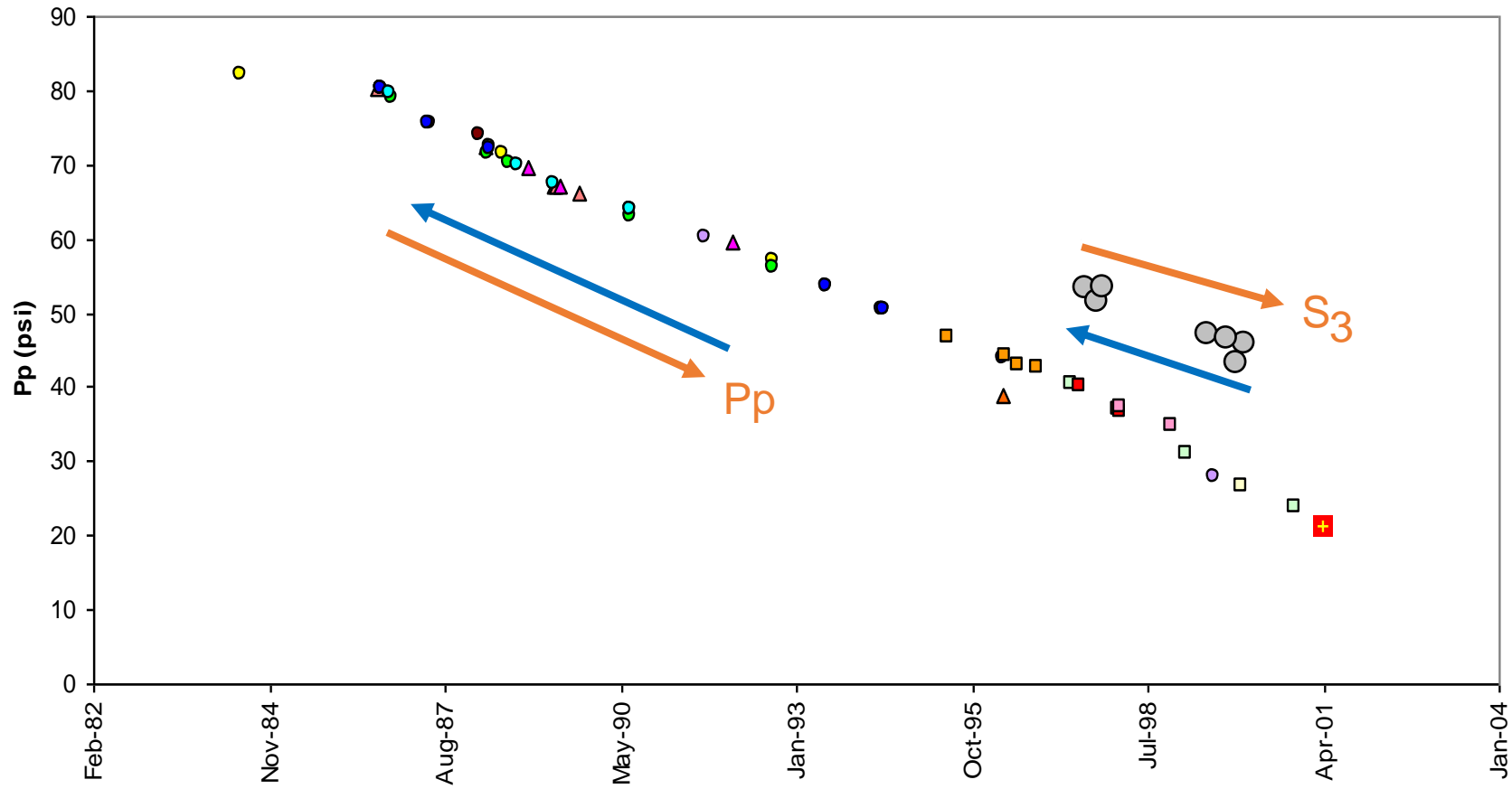
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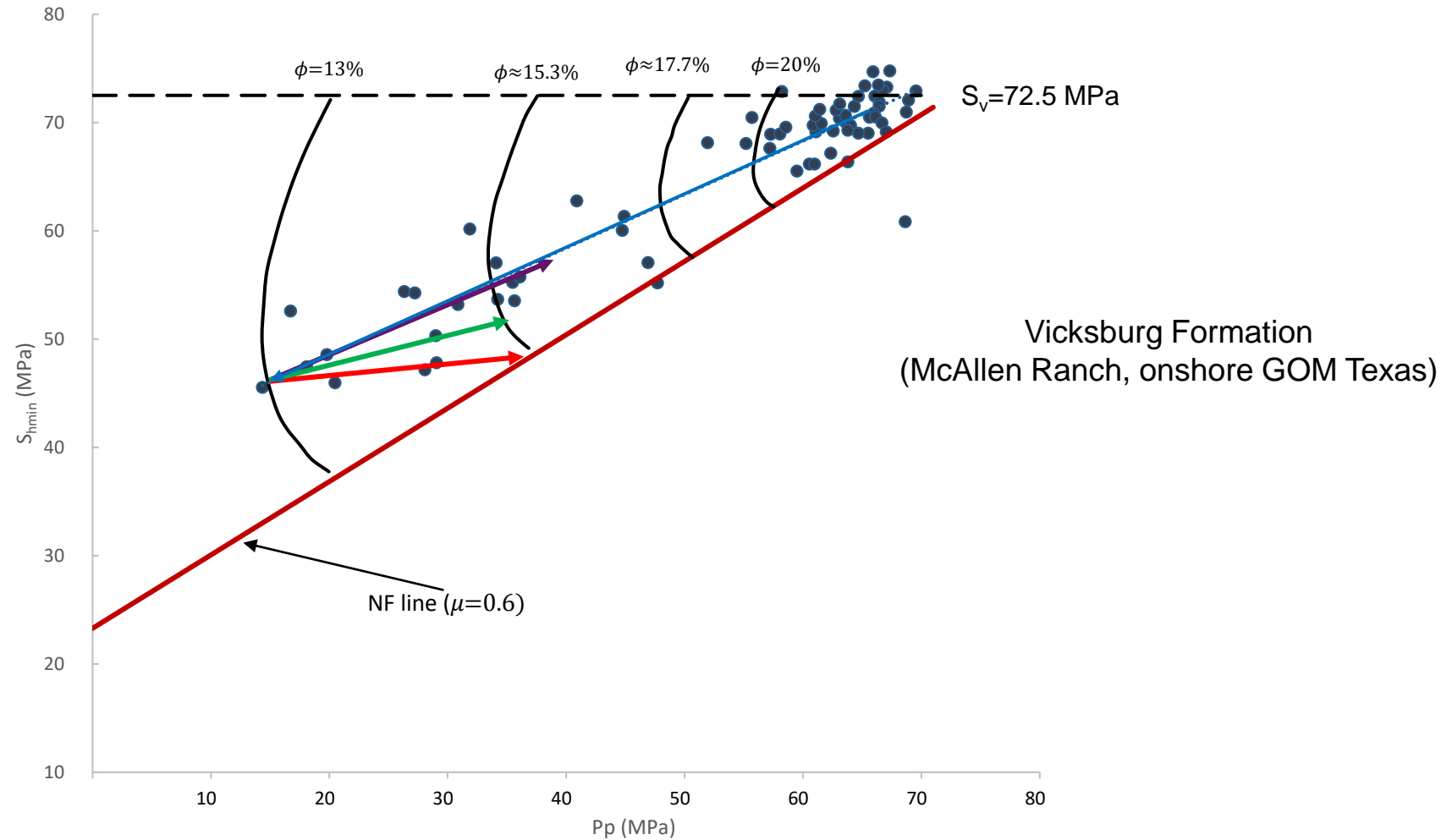
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Field X Depletion and Stress Path Will This be Reversible?



Depletion and Stress Path in Reservoir Space

How do We Manage Injection to Avoid Triggered Faulting?



Irreversible Stress Paths and Fault Re-activation in Ultra-Deep Paleogene (Lower Tertiary) Reservoirs in the Gulf of Mexico

Jeremy Brown and Mark Zoback

