Coupled Passive Margin Stratigraphic Evolution and Fluid Flow
Matthew Wolinsky and Lincoln Pratson
contact: maw@duke.edu

Abstract
We present new approaches to modeling stratigraphic evolution and fluid flow. Fully 2D coupled models can now be used to model dynamic sediment and fluid flow processes in coastal and passive margin systems, including shelf edge failures. Fluid flow models can be used to assess the initiation and mitigation of slope failures.

Key to the Future...
- Stratigraphic data and computer modeling can provide insight into the evolution of sedimentary environments.
- Stratigraphic evolution is strongly affected by climate, sediment supply, and tectonics.
- Sedimentary processes are typically driven by climate, sediment supply, and tectonics.
- Sedimentary processes and environments are affected by climate, sediment supply, and tectonics.
- Coastal Plain: Large contrast between event timescales.
- Shoreface: Large contrast between horizontal and vertical scales.
- Margin systems: Overpressure is mostly around shelf base turbidite fans.
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Shelf edge: 1) Transgression: Rapid sea level rise.
- Shelf edge delta formation.
- Shelf edge delta stabilizes.
- Shelf break: shelf edge delta, turbidite deposition.
- Shelf break: delta backsteps, turbidite deposition ceases.
- Shelf break: transgresses, shelf aggrades and progrades.
- Maximum flood: Slow sea level rise.
- Shelf break: normal regression (progradation).
- Fan head movement determined by presence/absence of mud.

Stratigraphic Modeling
- Stratigraphic evolution is typically driven by migratory depocenters, so is inherently 2D.
- Stratigraphic unit without predefined boundaries.
- Dynamic evolving domain.
- Overpressure, Fluid Flow, Effective Stress: Fluid flow models can be used.
- Shelf edge and shoreline follow sea level rise.
- Presence of shelf prevents deep water sand deposition.
- Shelf edge: delta formation and turbidite fan deposition initiated by sea level fall and occur over an extended period of lowstand.
- This includes early stages of sea level rise.
- Shelf edge stable during fan deposition.
- Fan head movement determined by presence/absence of mud.

Stratigraphic Evolution
- Stratigraphic "memory" of past environments:
- Sedimentary processes and environments:
- Shelf edge failures are strongly affected by overpressure.
- Shelf edge failures cannot capture inherently 2D patterns of overpressure and fluid flow in passive margin systems.

Stratigraphic data structure balances external forcing with feedbacks.
- Shelf edge failures.
- Shelf break: shelf edge delta, turbidite deposition.
- Shelf break: normal regression (progradation).
- Fan head movement determined by presence/absence of mud.

Robust Dynamic Meshing
- Deposition: SedCell → Node → Element
- Erosion: SedCell size constraints automatically bound Element shape quality, error, and conditioning.

Sub-Grid Layering: Effective Conductivity
- Shape quality requires large elements.
- Overpressure centered around shelf break depocenter, which forms flow divide.
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Upper slope most unstable, no access to high conductivity vents.
- Quasi-1D consolidation cannot capture inherently 2D patterns of overpressure and fluid flow in passive margin systems.

Overpressure, Fluid Flow, Effective Stress
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Upper slope most unstable, no access to high conductivity vents.
- Quasi-1D consolidation cannot capture inherently 2D patterns of overpressure and fluid flow in passive margin systems.

Hydrostratigraphy: Local Anisotropy, Confined Aquifers
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.

Overpressure, Fluid Flow, Effective Stress
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Upper slope most unstable, no access to high conductivity vents.
- Quasi-1D consolidation cannot capture inherently 2D patterns of overpressure and fluid flow in passive margin systems.

Conclusions
- Presence of shelf prevents deep water sand deposition.
- Shelf edge delta formation and turbidite fan deposition initiated by sea level fall and occur over an extended period of lowstand.
- This includes early stages of sea level rise.
- Shelf edge stable during fan deposition, while fan head and shoreline follow sea level rise.
- Fan head movement determined by presence/absence of mud deposition on slope.

Sand
Silt
Mud
Age Contours (200 ka)

Overpressure, Fluid Flow, Effective Stress
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Upper slope most unstable, no access to high conductivity vents.
- Quasi-1D consolidation cannot capture inherently 2D patterns of overpressure and fluid flow in passive margin systems.

Hydrostratigraphy: Local Anisotropy, Confined Aquifers
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.

Overpressure, Fluid Flow, Effective Stress
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Upper slope most unstable, no access to high conductivity vents.
- Quasi-1D consolidation cannot capture inherently 2D patterns of overpressure and fluid flow in passive margin systems.

Hydrostratigraphy: Local Anisotropy, Confined Aquifers
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.

Overpressure, Fluid Flow, Effective Stress
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Upper slope most unstable, no access to high conductivity vents.
- Quasi-1D consolidation cannot capture inherently 2D patterns of overpressure and fluid flow in passive margin systems.

Hydrostratigraphy: Local Anisotropy, Confined Aquifers
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.

Overpressure, Fluid Flow, Effective Stress
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Upper slope most unstable, no access to high conductivity vents.
- Quasi-1D consolidation cannot capture inherently 2D patterns of overpressure and fluid flow in passive margin systems.

Hydrostratigraphy: Local Anisotropy, Confined Aquifers
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.
- Hydrostratigraphy: Local Anisotropy, Confined Aquifers.

Overpressure, Fluid Flow, Effective Stress
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Overpressure, Fluid Flow, Effective Stress: Regional anisotropy, confined aquifers vent overpressure.
- Upper slope most unstable, no access to high conductivity vents.
- Quasi-1D consolidation cannot capture inherently 2D patterns of overpressure and fluid flow in passive margin systems.