Thermal and Pore Pressure History of the Haynesville Shale in North Louisiana: A Two-Dimensional Numerical Study*

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Abstract

In North Louisiana, the Upper Jurassic Haynesville shale has a basinward southwest dip and is located at depths ranging from 10,500 ft in the northeast to 14,000 feet in the southwest with local minimums on the Sabine and Monroe Uplifts. Formation thickness ranges from 100 to 400 feet. The shale's pore pressure and temperature history varies across the basin due to local structural highs, lateral changes in basal heat flow, and updip migration of fluid. Using well data, two-dimensional models across the North Louisiana Salt Basin were created to estimate temperature, pore pressure, and fluid flow versus time. Disequilibrium compaction from rapid sedimentation in the low permeability (nDarcy) Haynesville Shale has resulted in significant overpressures ranging from about 7,000 psi to 12,000 psi. Hydrocarbon generation resulted in a maximum pore pressure increase of more than 500 psi at 88 Ma. However, models created with and without hydrocarbon generation produced nearly identical results for present day pore pressure indicating that disequilibrium compaction is the most significant mechanism in generating overpressure. Fluid migration updip to the Sabine Uplift within the Haynesville Shale and underlying Smackover Limestone has resulted in abnormally high fluid pressures on the Sabine Uplift. Model results including lateral pressure transfer are consistent with present-day pore pressures from well test information. While model results do did predict pore pressures in excess of fracture pressures, computed pore pressures are closest to fracture pressures on the Sabine Uplift following uplift and erosion in the mid-Cretaceous.

References Cited

Mancini, E.A., J. Obid, M. Badali, K. Liu, and W.C. Parcell, 2008, Sequence-stratigraphic analysis of Jurassic and Cretaceous strata and petroleum exploration in the central and eastern Gulf coastal plain, United States: AAPG Bulletin, v. 92/12, p. 1655-1686.

Wang, F.P., and U. Hammes, 2010, Effects of petrophysical factors on Haynesville fluid flow and production: World Oil ShaleTech, v. 213/6.

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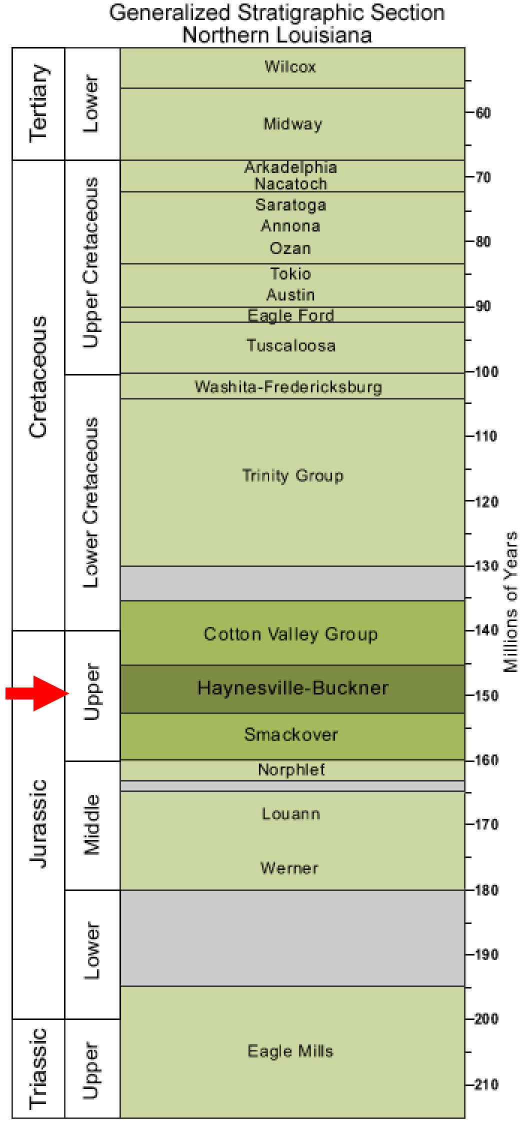
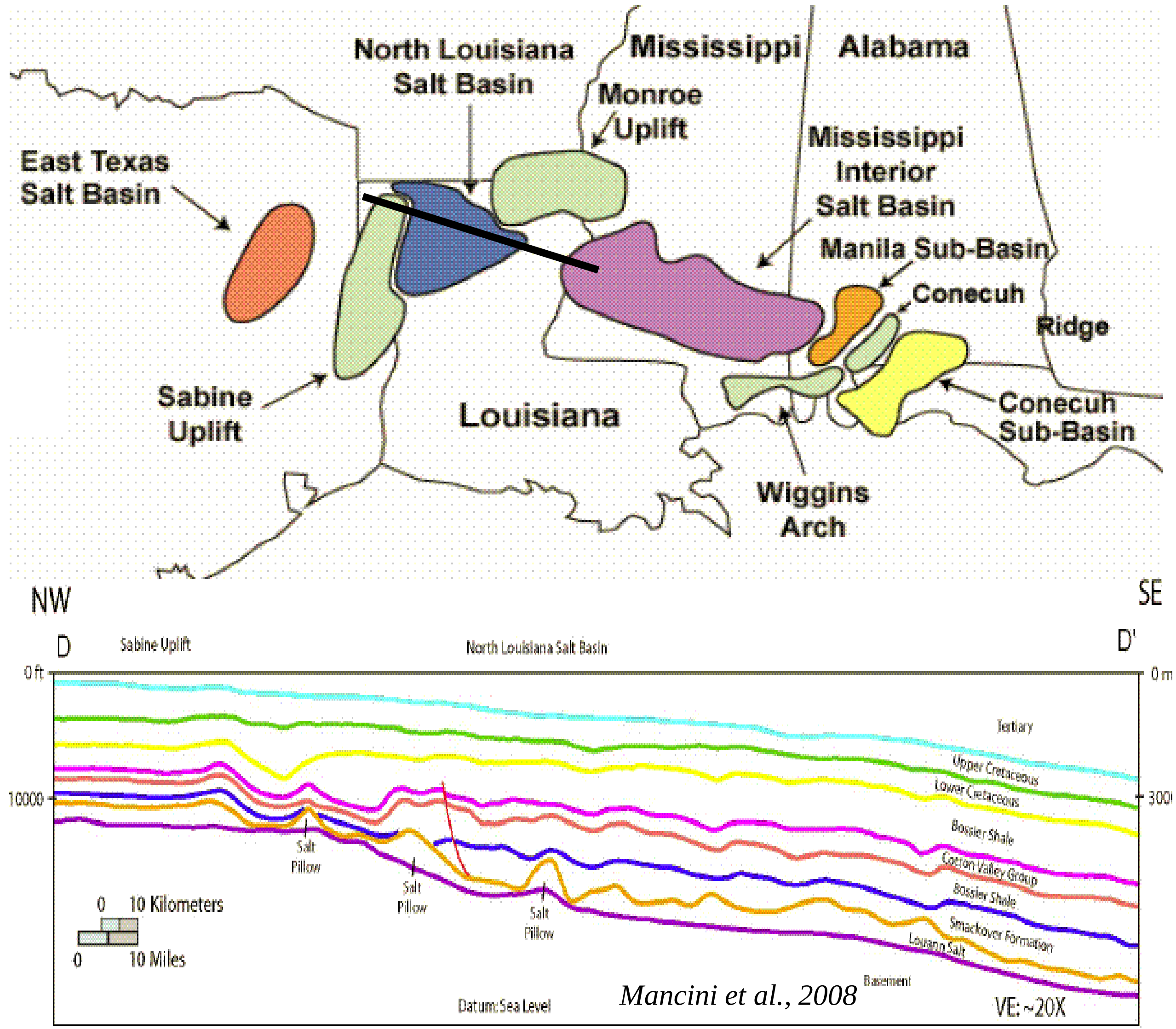
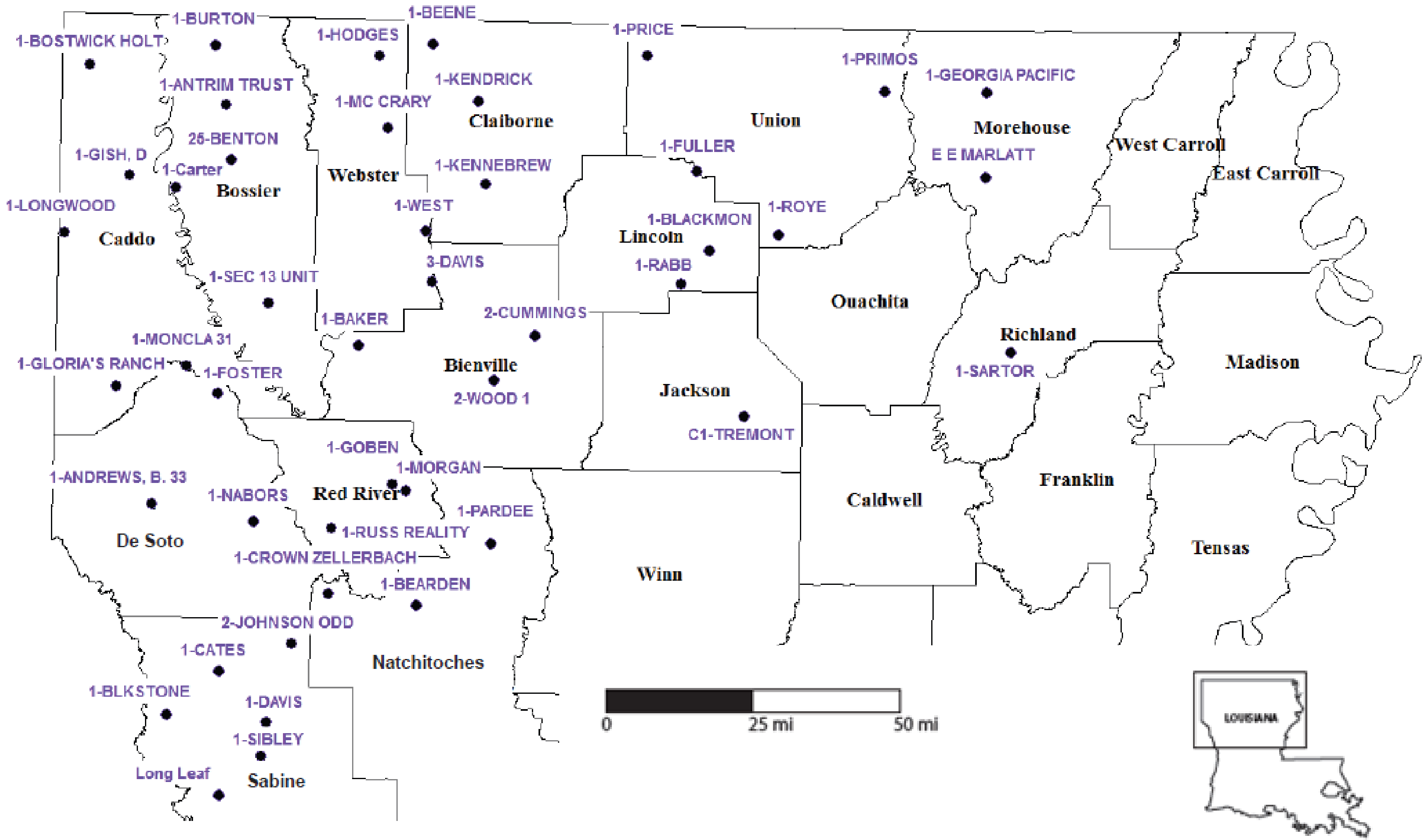
Regional Geology



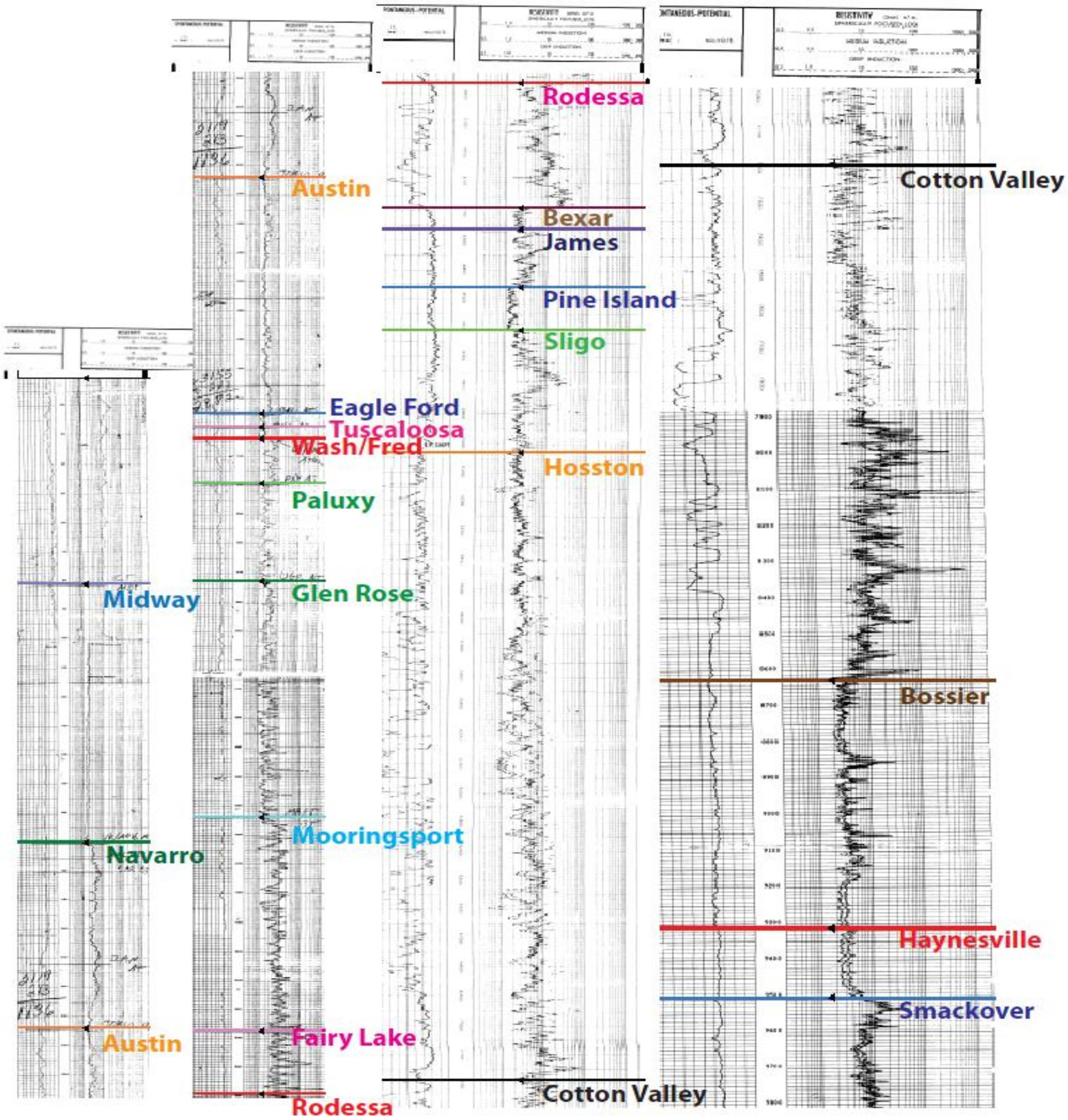


Mancini et al., 2008

Data and Methods

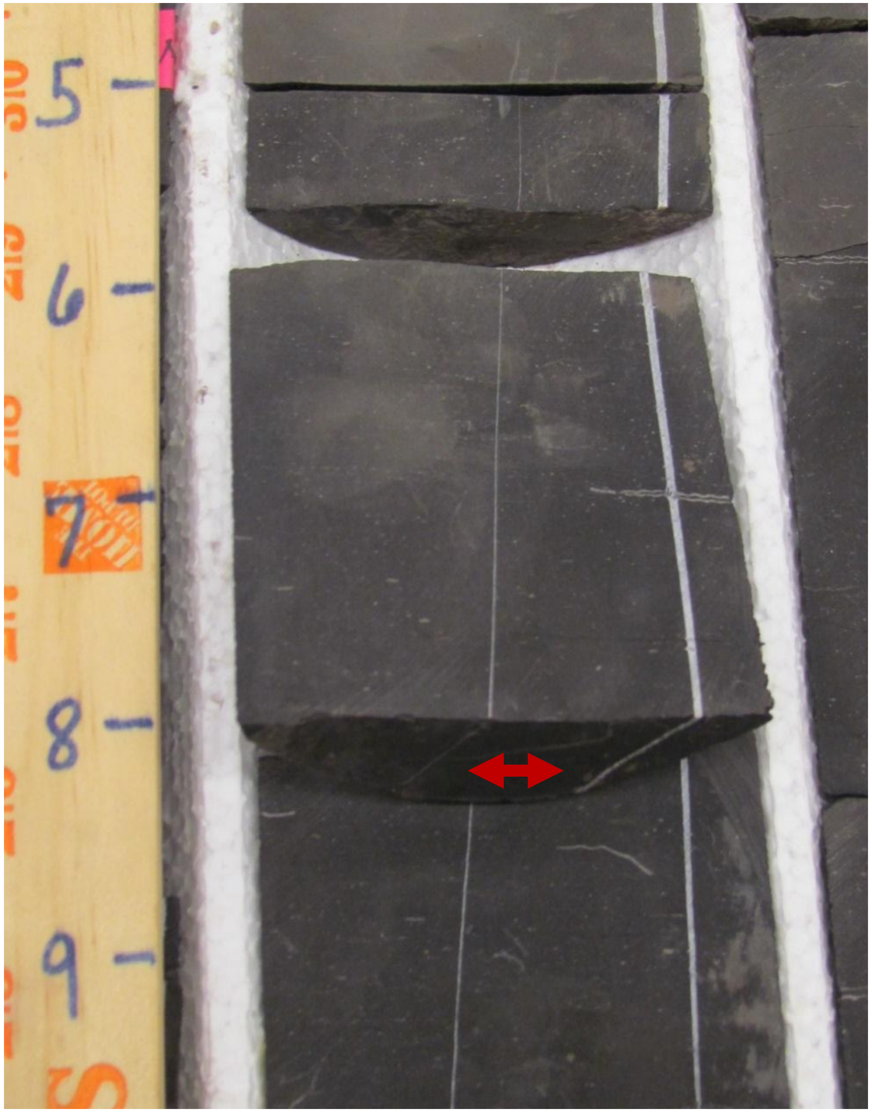


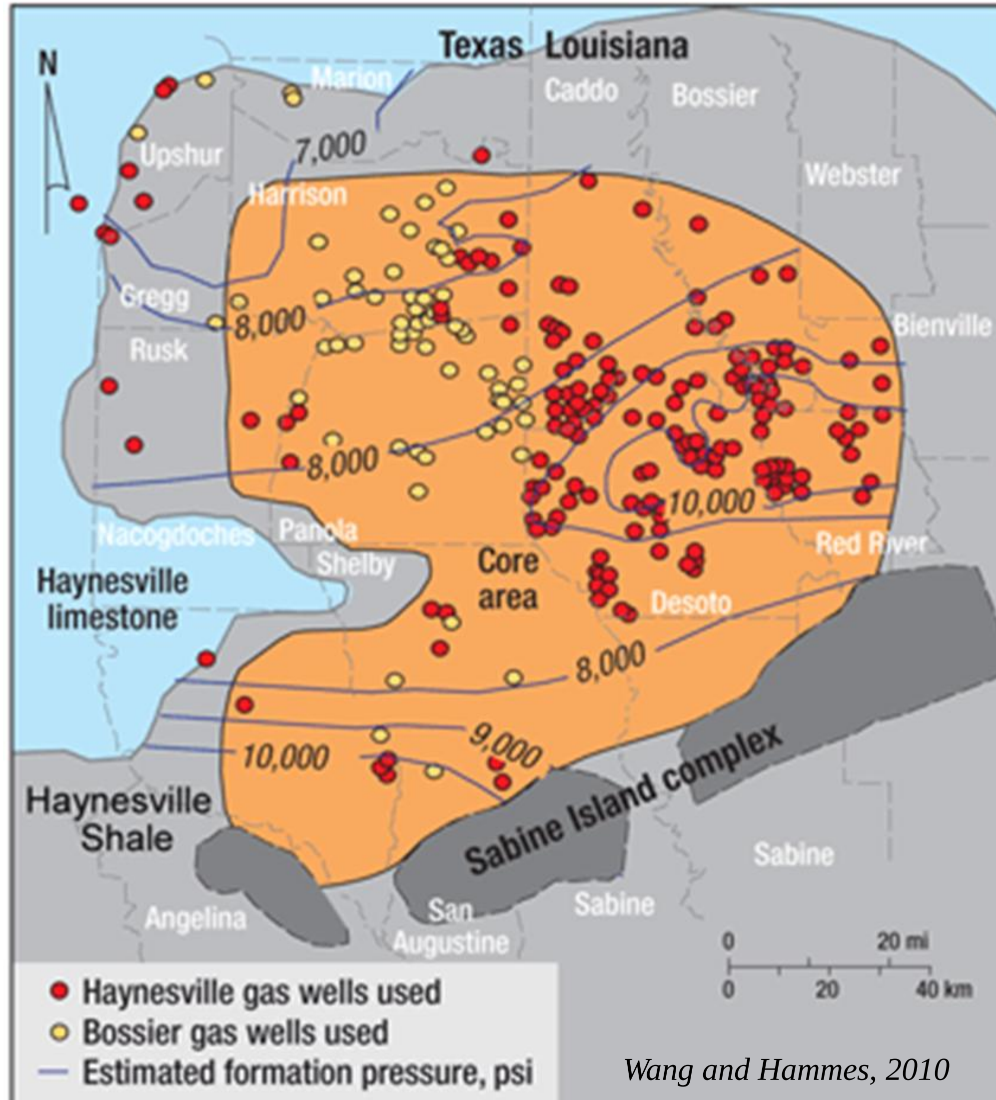
Data and Methods



Layer	Lithology
Tertiary	Shale (typical) 75% Sandstone (typical) 25%
Wilcox	Shale (typical) 75% Sandstone (typical) 25%
Midway	Shale (typical) 75% Sandstone (typical) 25%
Navarro	Limestone (chalk, typical) 60% Sandstone (typical) 25% Shale (typical) 15%
Austin	Limestone (chalk, typical)
Eagle Ford, Wash/Fred undifferentiated	Shale (typical) 40% Sandstone (typical) 30% Limestone (chalk, typical) 30%
Glen Rose	Shale (typical) 40% Sandstone (typical) 30% Limestone (chalk, typical) 30%
Mooringsport	Limestone (shaly)
Ferry Lake	Shale (typical)
Rodessa	Limestone (shaly)
Bexar	Shale (typical)
James	Limestone (shaly)
Pine Island	Shale (typical)
Sligo	Limestone (shaly)
Hosston	Shale (sandy) default κ lowered
Cotton Valley	Shale (sandy) default κ lowered
Bossier	Shale (sandy) default κ lowered
Haynesville	Limestone (chalk, typical) 70% Shale (typical) 30%
Smackover	Limestone (micrite)

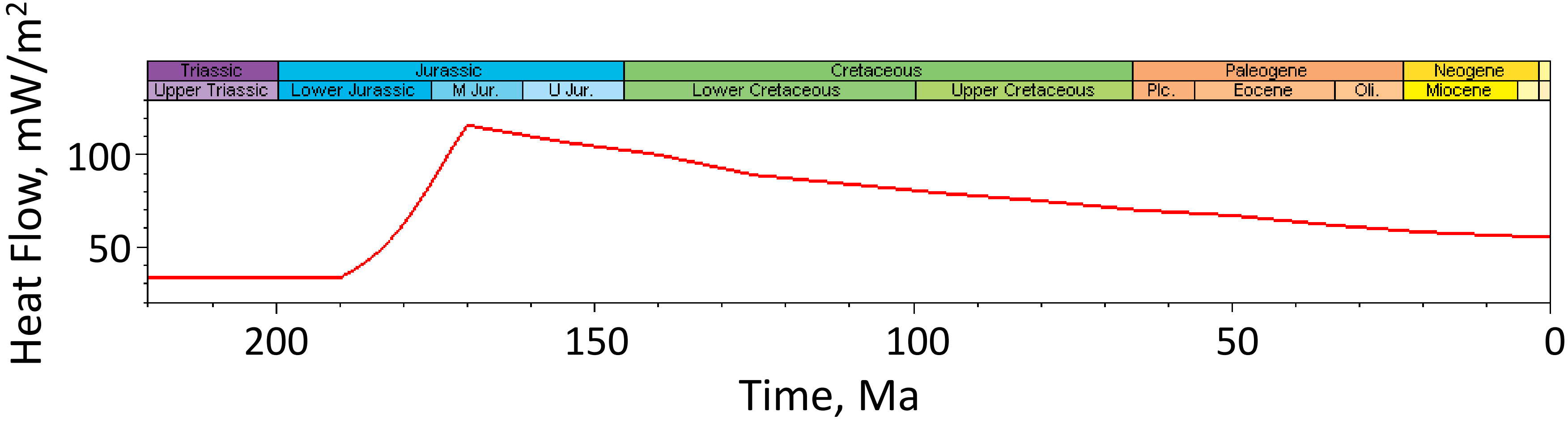
Data and Methods



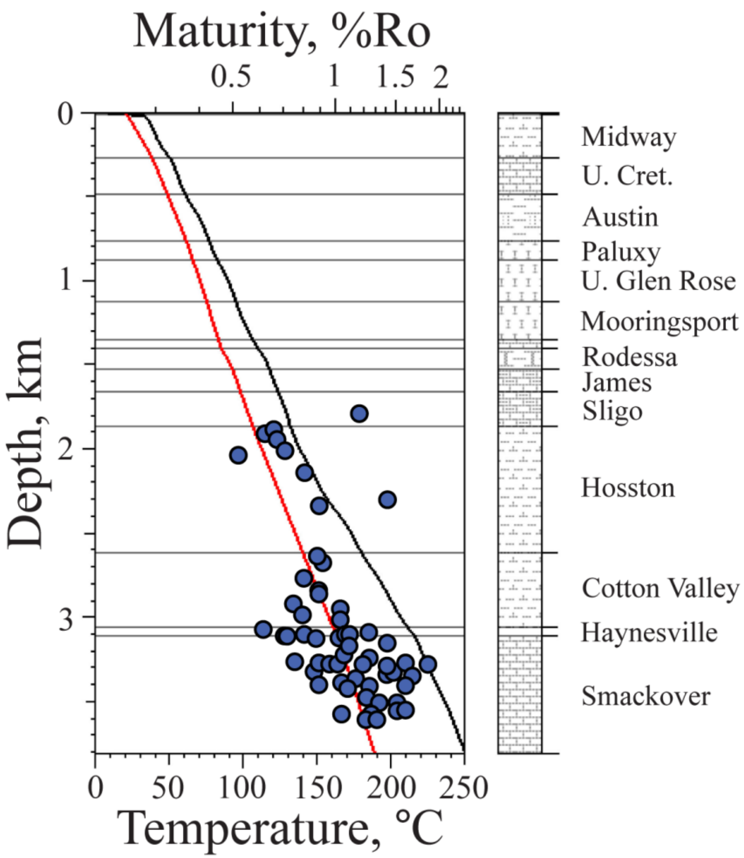


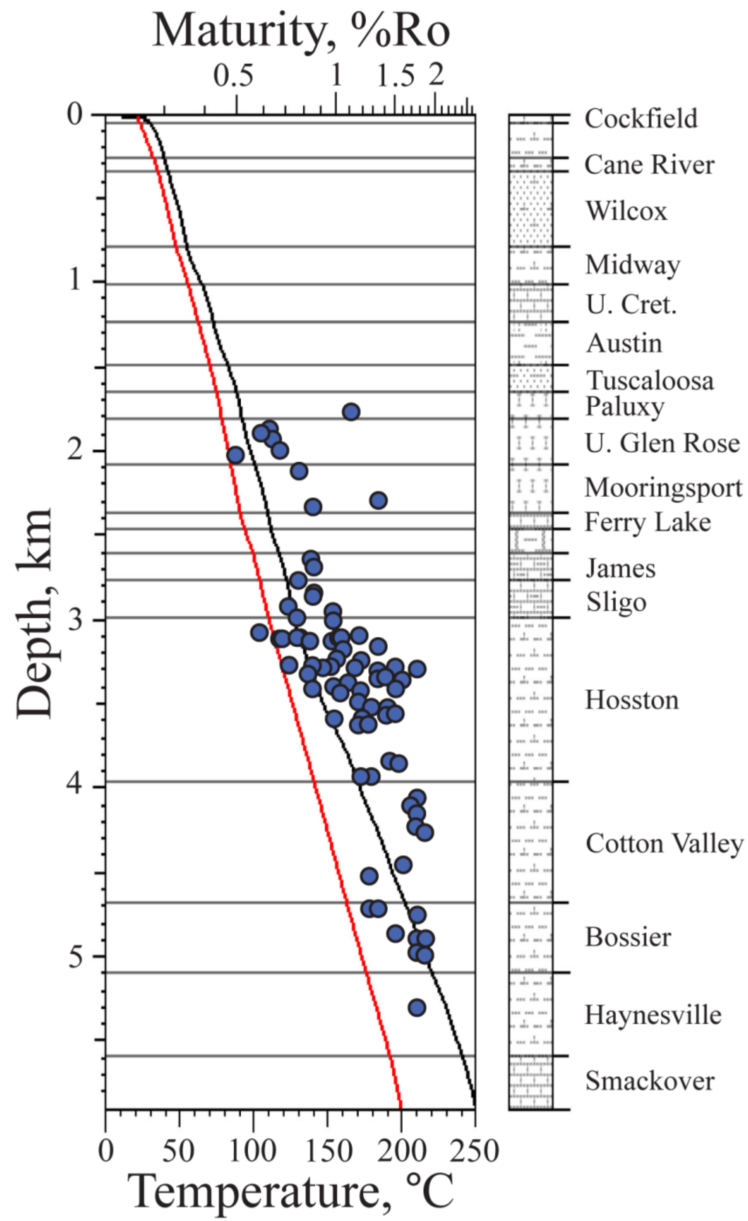
Boundary Conditions:

Paleowater Depths – Shallow
Surface Temperature – Climate and Plate Motions
Heat Flow – β = 1.25 to 2



Prior Results

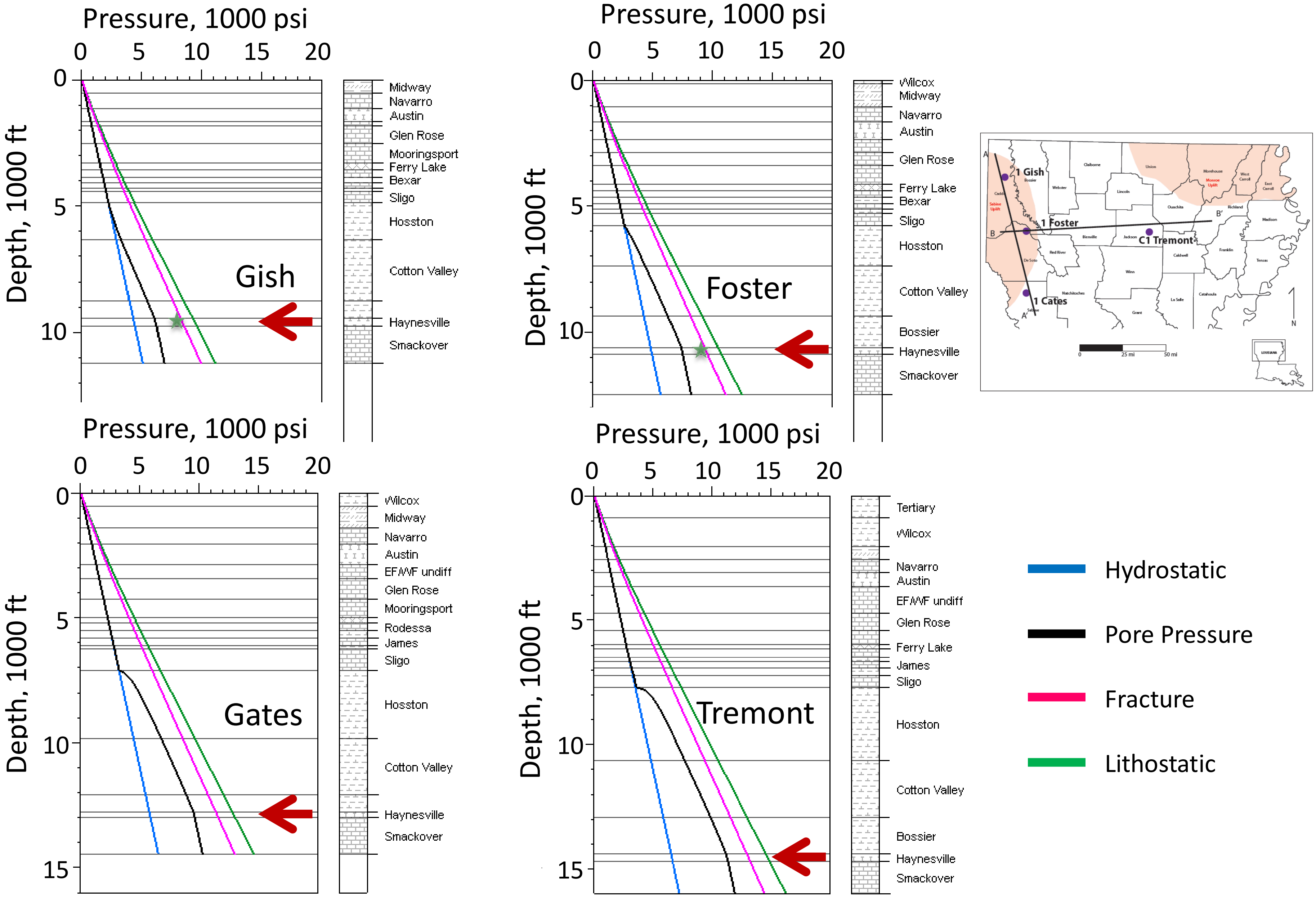




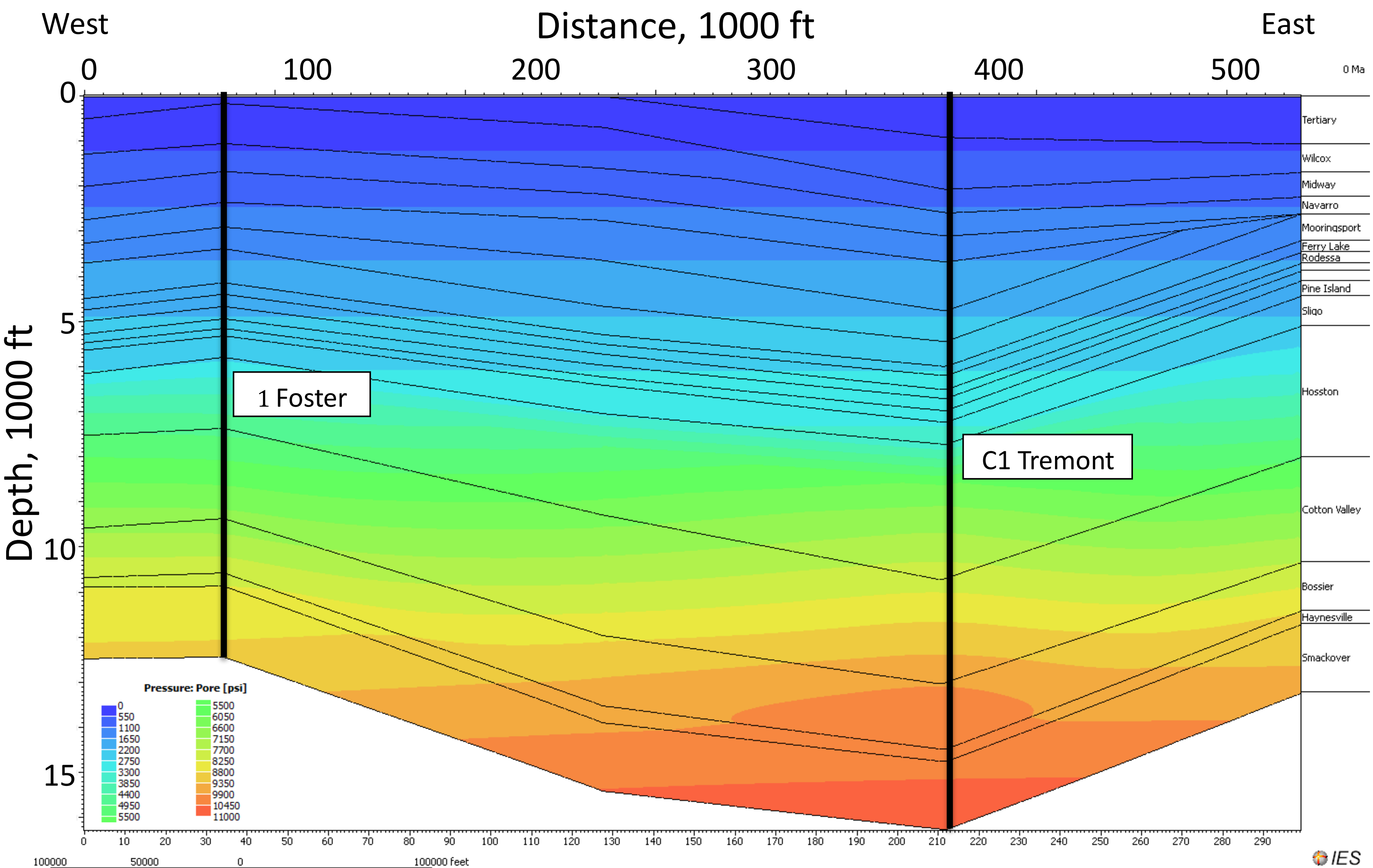
Transformation: 130-100 Ma

Immature->Oil->Wet to Dry Gas

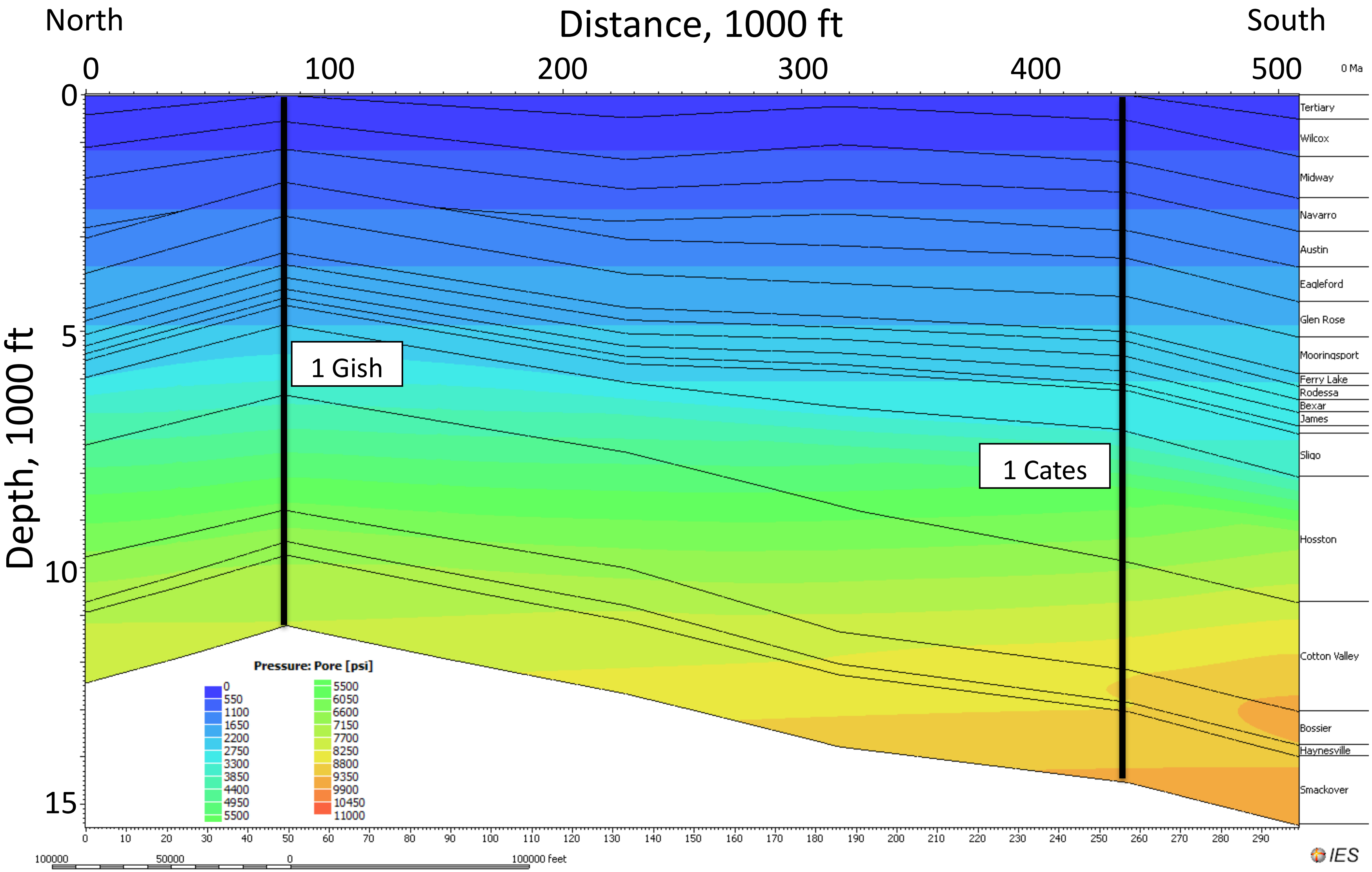
1D Results: Pore Pressure



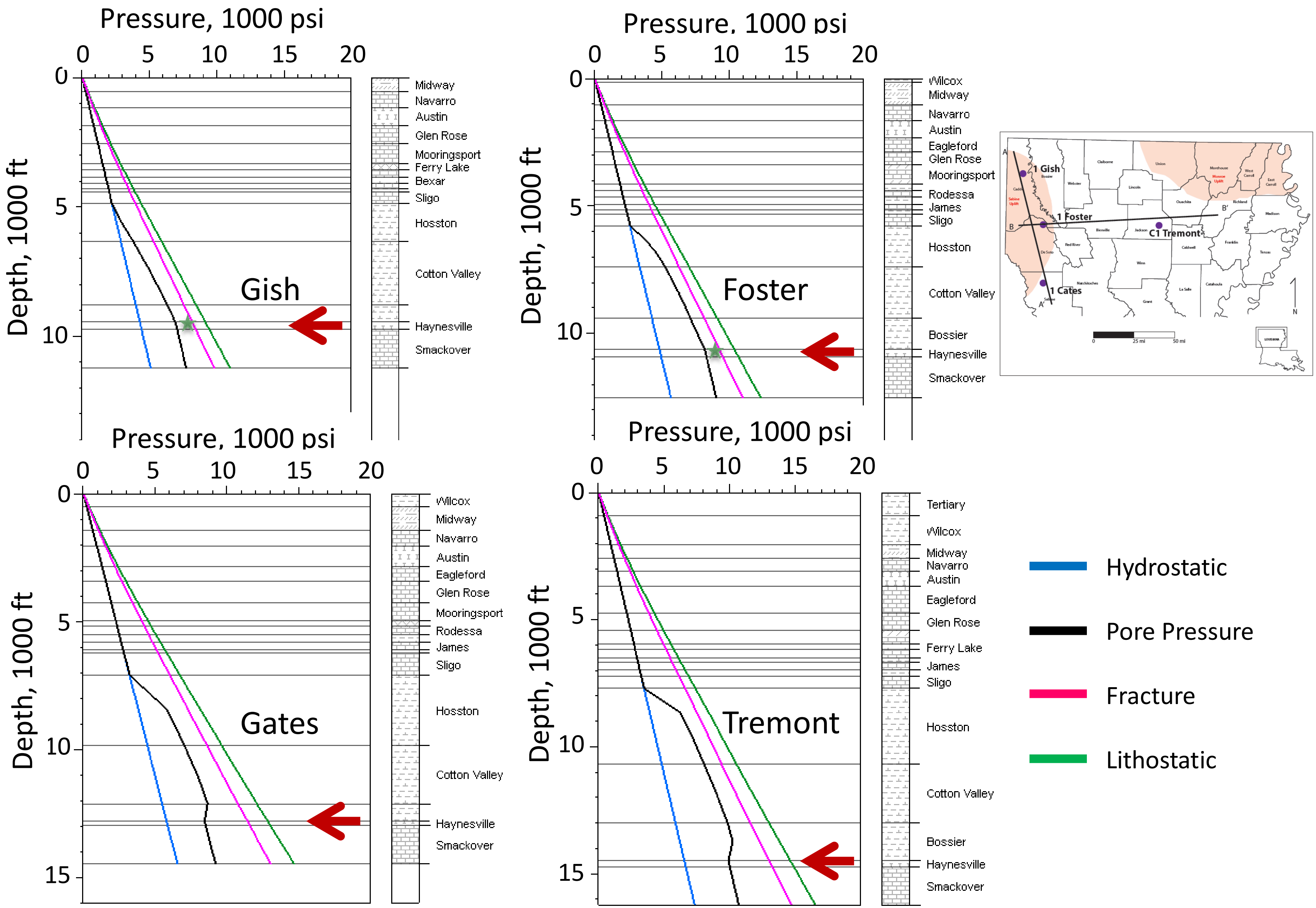
2D Results: Pore Pressure



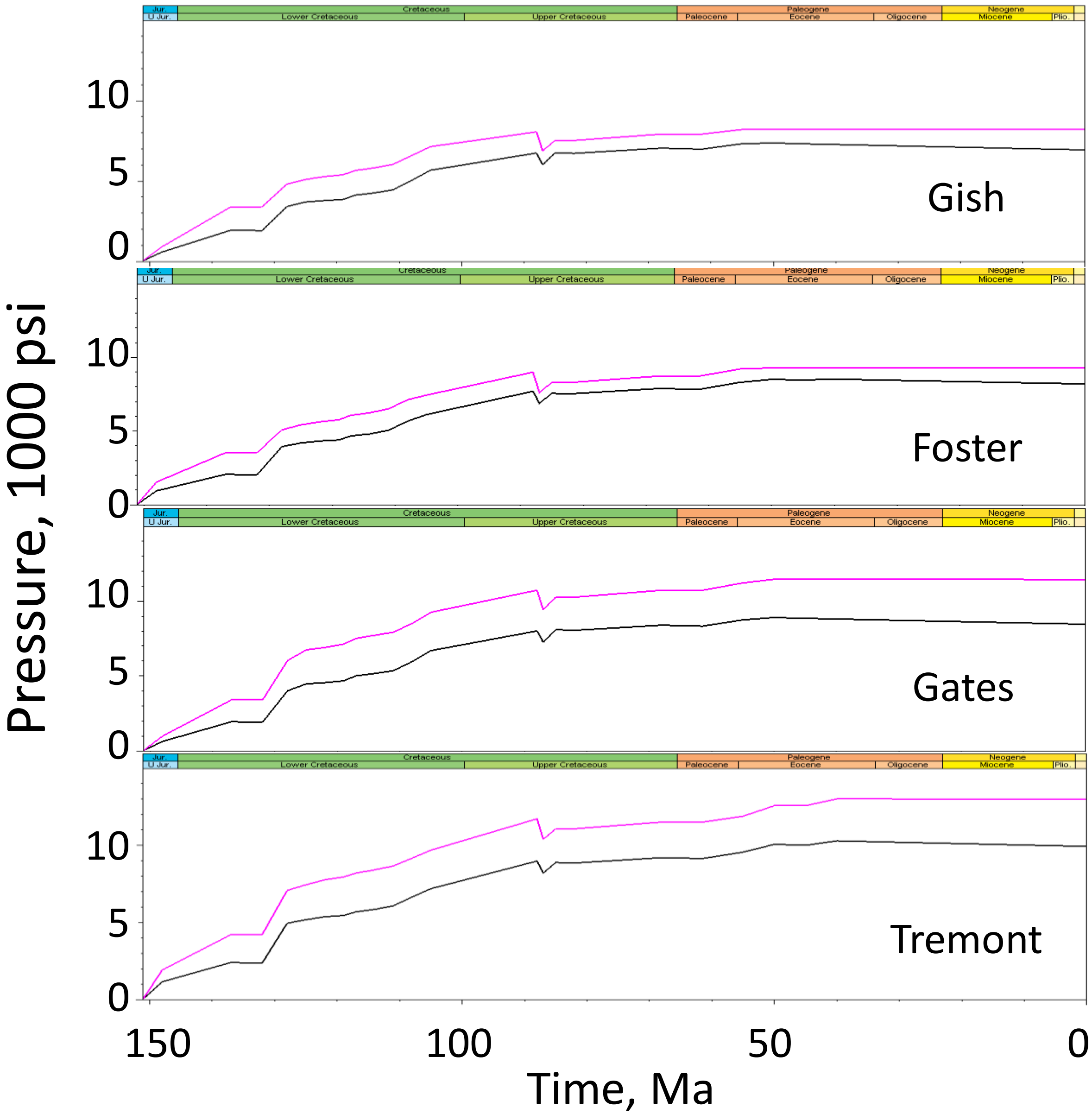
2D Results: Pore Pressure

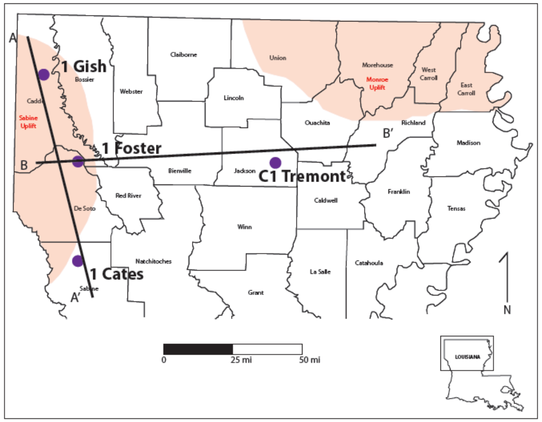


2D Results: Pore Pressure



2D Results: Pore Pressure vs Time

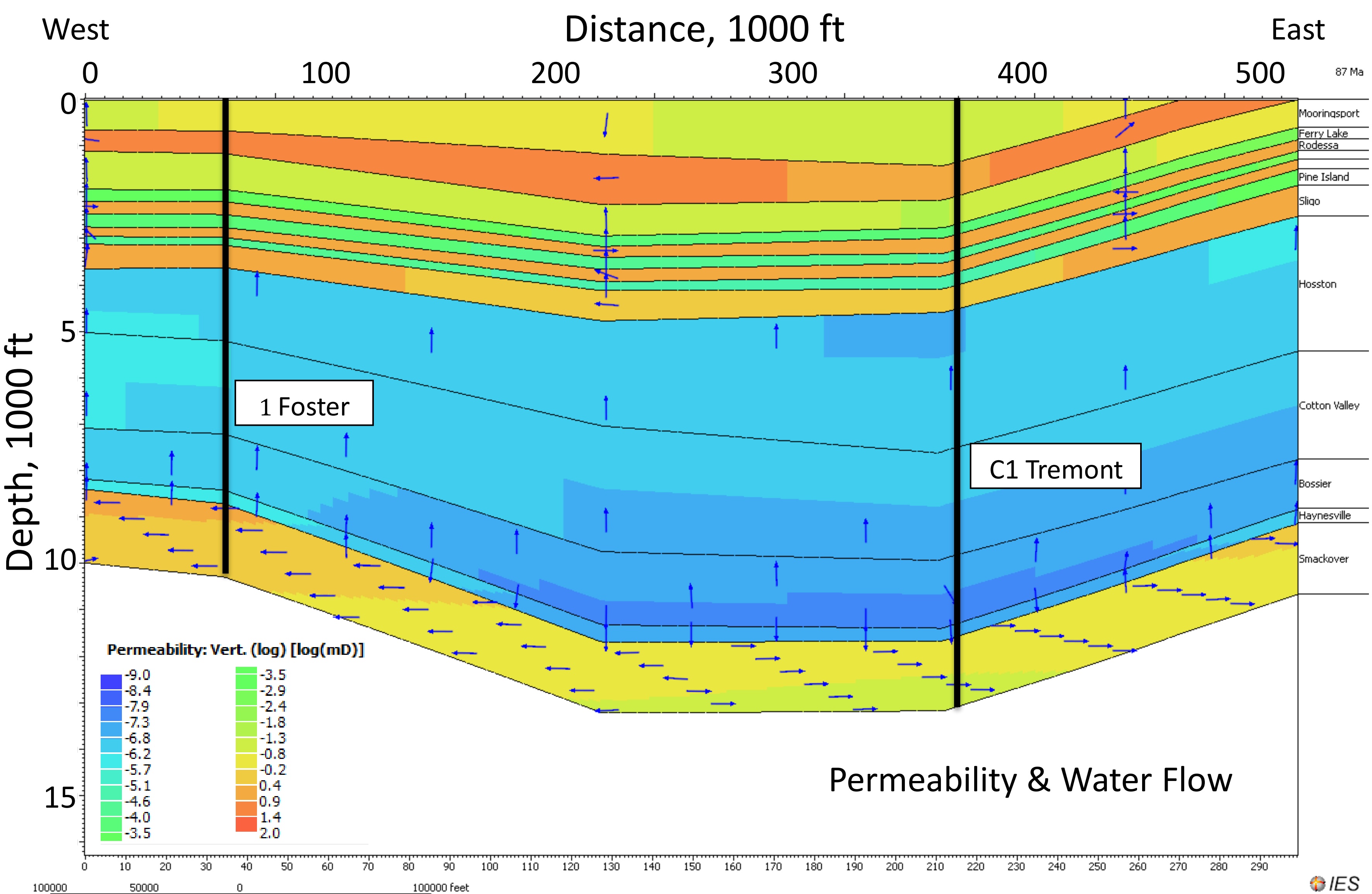




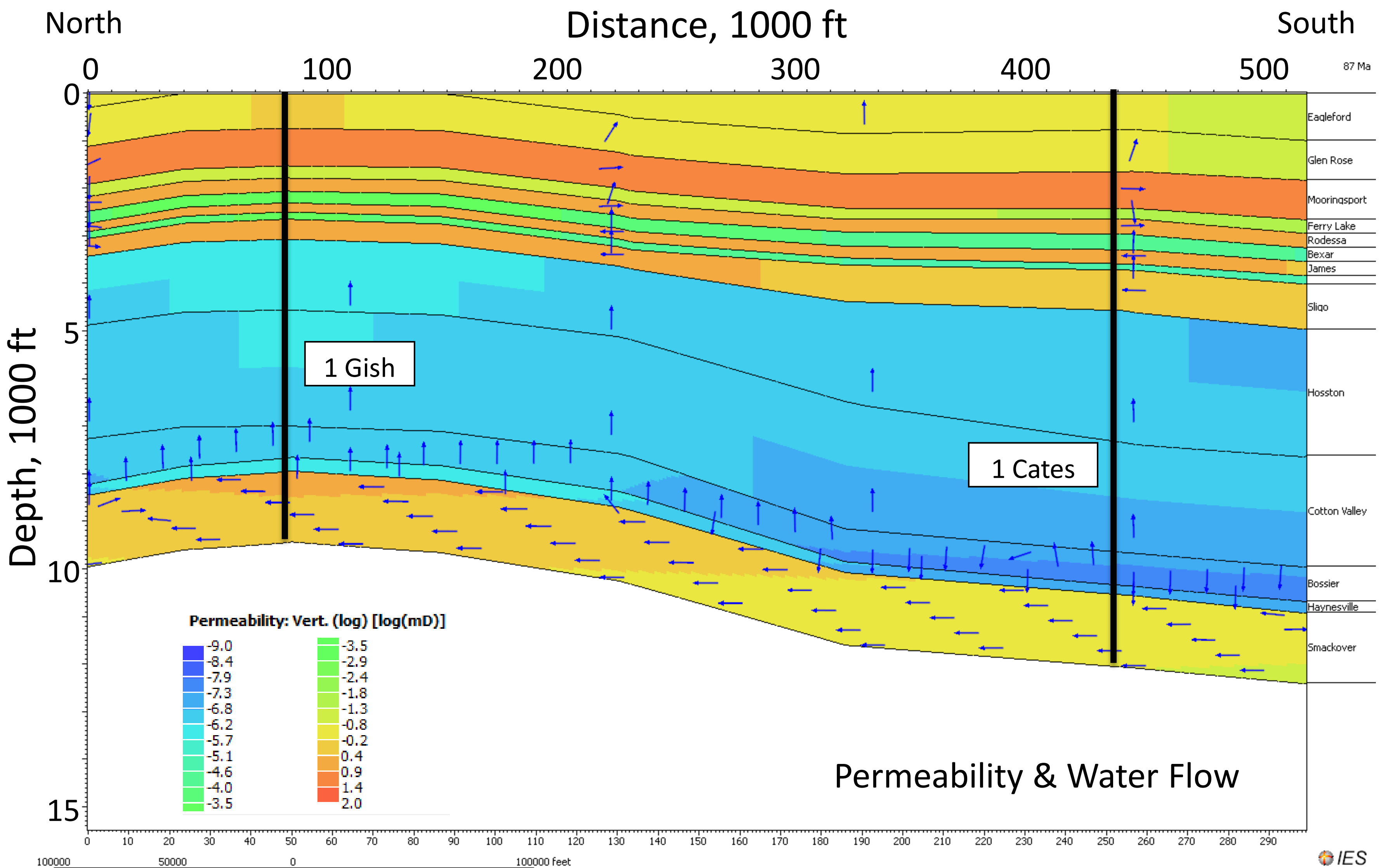
Pore Pressure

Fracture

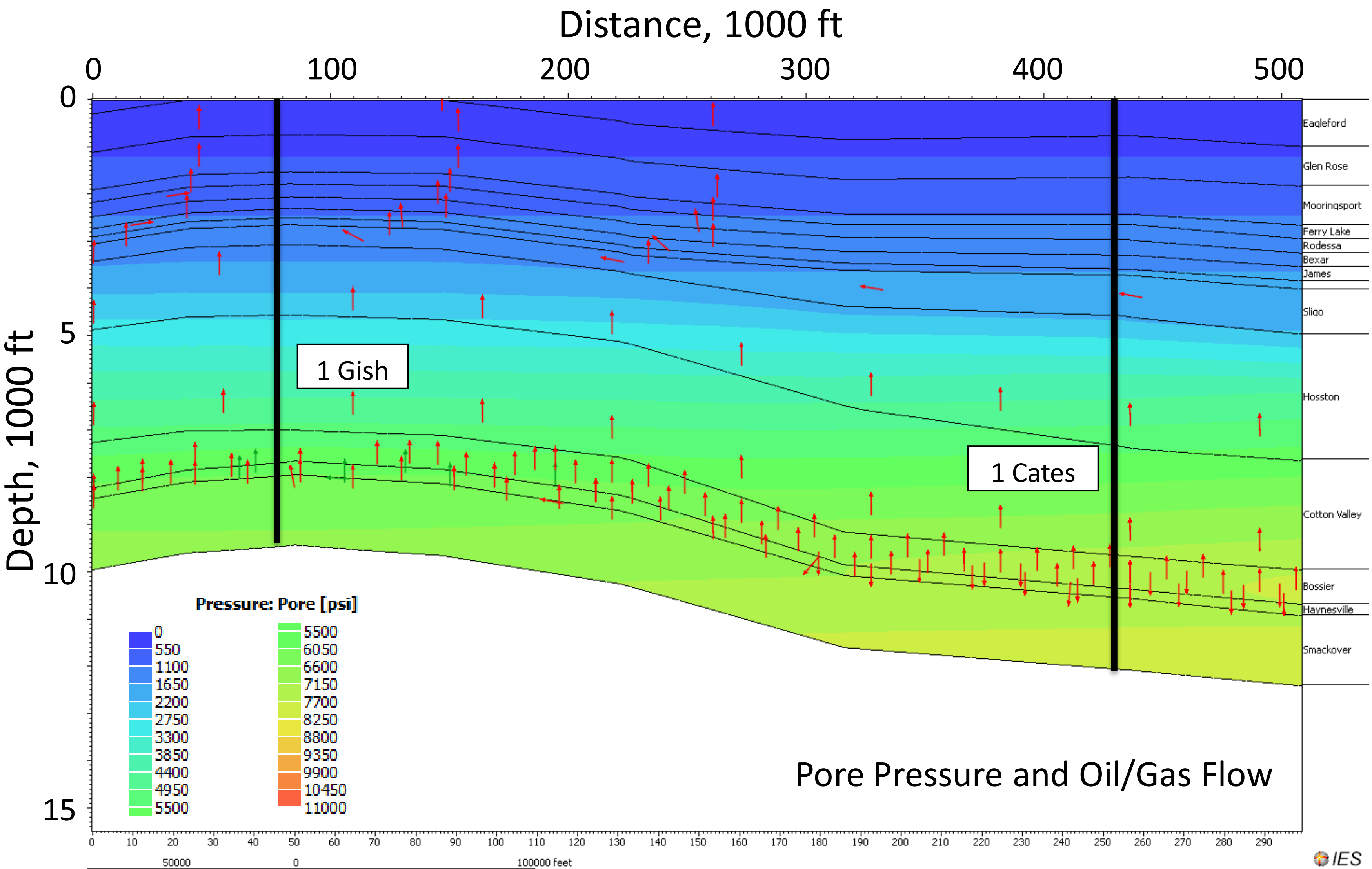
2D Results: mid-Cretaceous



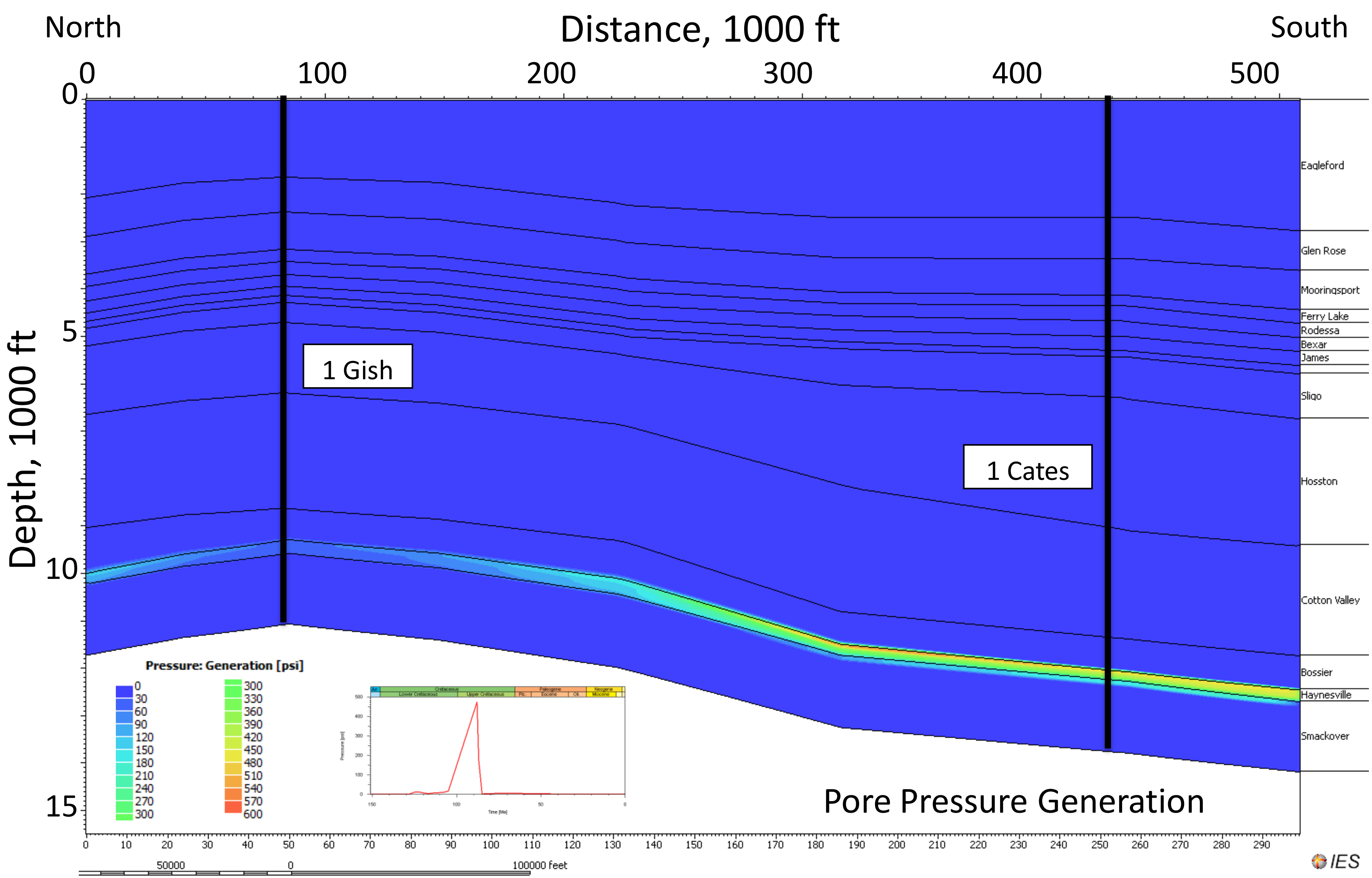
2D Results: mid-Cretaceous



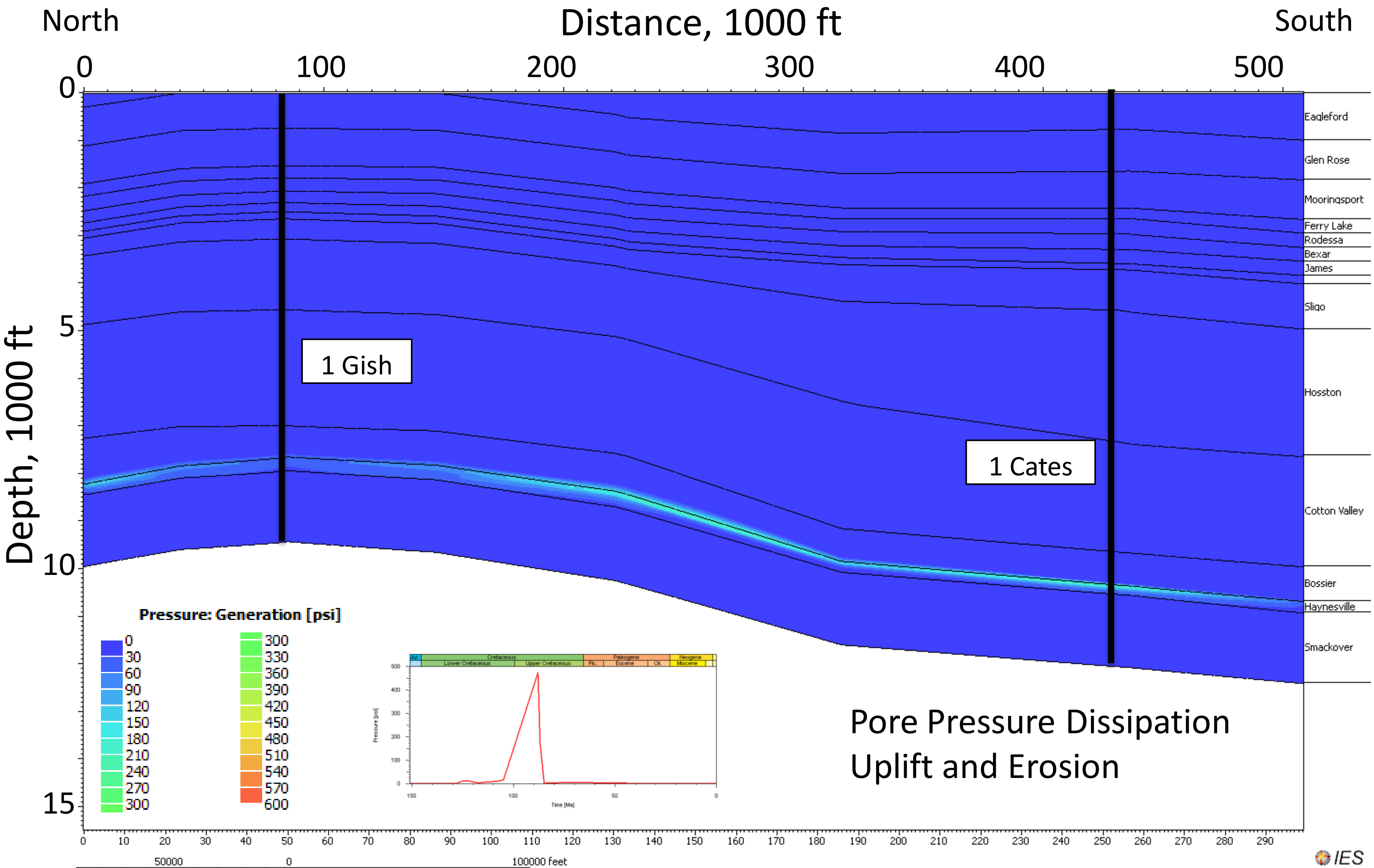
2D Results: mid-Cretaceous



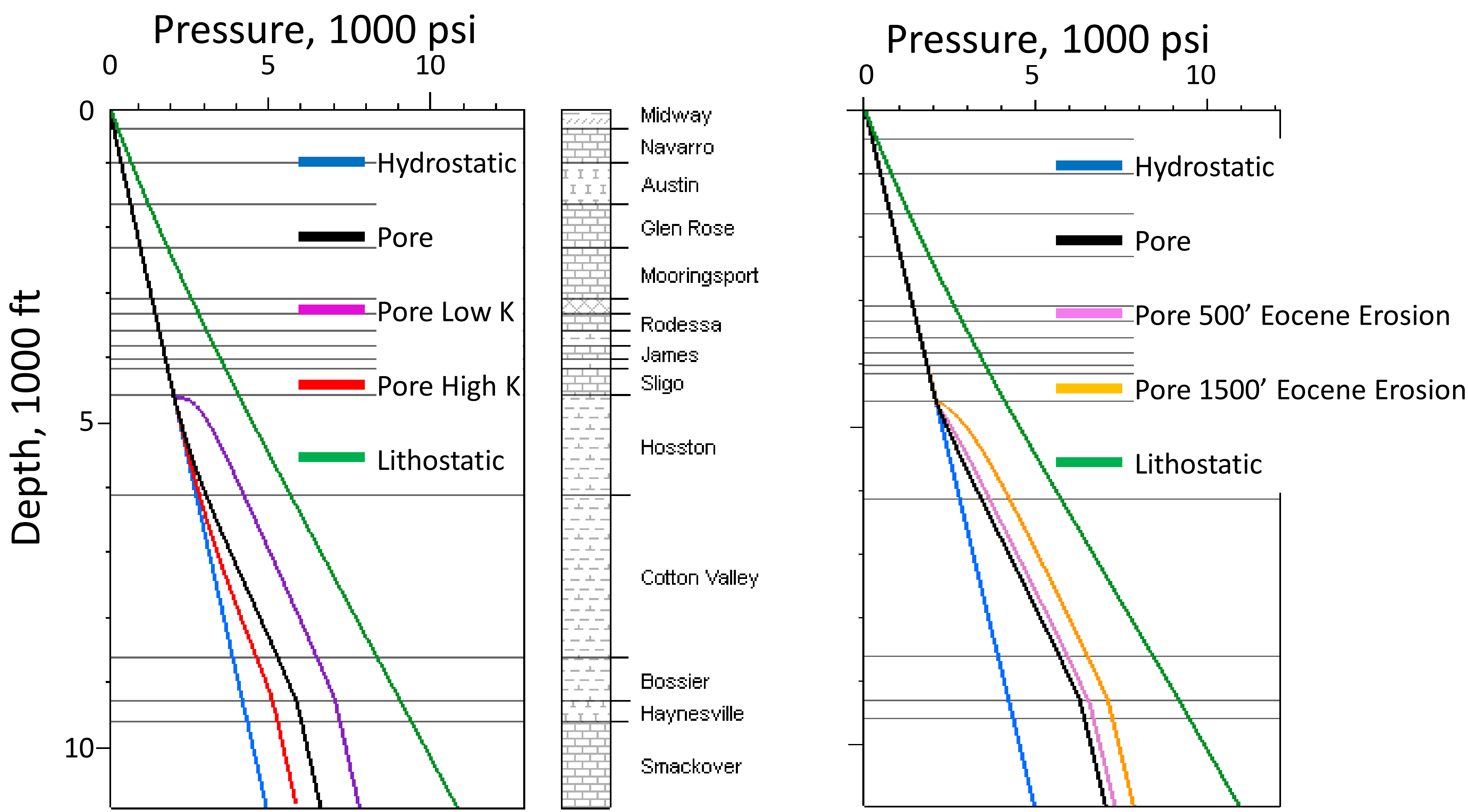
2D Results:– 88 Ma



2D Results: 86 Ma



Sensitivity Analysis



CONCLUSIONS

- Pore pressure and temperature history varies due to local structural highs, lateral changes in basal heat flow, and updip migration of fluid
- Disequilibrium compaction from rapid sedimentation in the low permeability (nD) Haynesville Shale has resulted in overpressures (7000 psi to 12000 psi)
- Hydrocarbon generation resulted in a maximum pore pressure increase of more than 500 psi at 88 Ma
- Disequilibrium compaction is the most significant mechanism in generating overpressure

CONCLUSIONS

- Updip fluid migration within the Haynesville Shale and underlying Smackover Limestone has resulted in higher fluid pressures on the Sabine Uplift
- Model results including lateral pressure transfer are consistent with present-day pore pressures from well test information
- Computed pore pressures are closest to fracture pressures on the Sabine Uplift following uplift and erosion in the mid-Cretaceous.