

# **A Model for Single-Phase Migration of Trenton-Black River Hydrocarbon in the Southern Michigan Basin\***

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## **Abstract**

A model is presented in which hydrocarbons of the southern Michigan Basin Trenton-Black River migrated into existing reservoirs as a single liquid phase. Based on an assumption that southern Michigan once had an overburden of an additional 2,000+ feet that has been eroded away, data is presented demonstrating the likelihood that the gas currently contained in hydrocarbon reservoirs was transported in the liquid phase. Pressure relief owing to overburden removal (and uplift?) after migration allowed the gas cap to form. This model is consistent with, and offered as the best explanation for: 1) presence of a gas cap throughout the southern Michigan Trenton platform; 2) Trenton-Black River gas composition; 3) presence of "perched" water in the oil zone; and 4) presence of "perched" oil in the gas zone.

## **References**

Cercone, K. R., 1984, Thermal history of Michigan Basin: AAPG Bulletin, v. 68/2, p. 130-136

Rullkötter, J., P.A. Meyers, R.G. Schaefer, and K.W. Dunham, 1986, Oil generation in the Michigan Basin: A biological marker and carbon isotope approach: Organic Geochemistry, v. 10/1-3, p. 359-375.

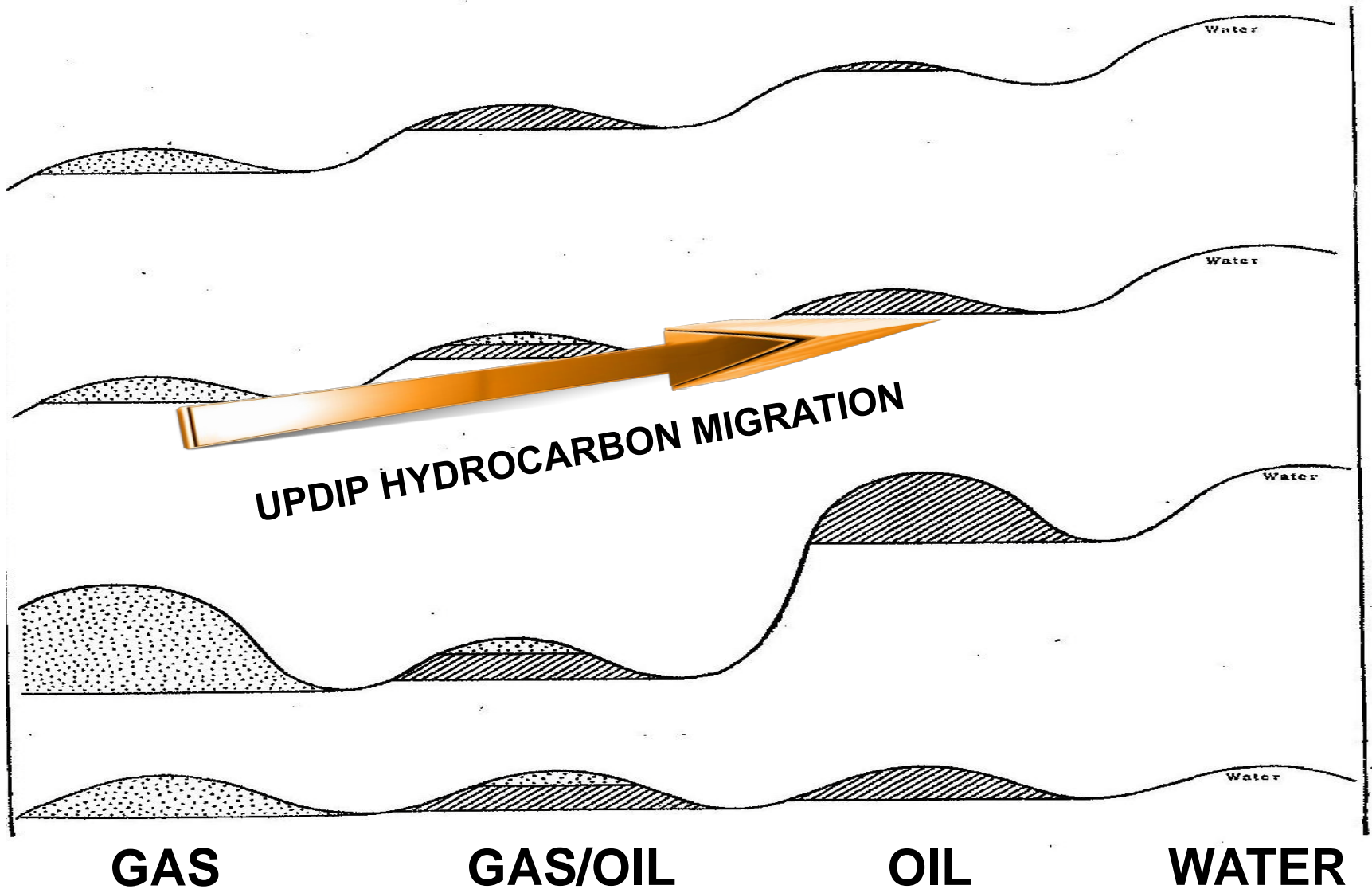
A Model for Single-Phase  
Migration of Trenton-Black River  
Hydrocarbon in the Southern  
Michigan Basin

--Ron DeHaas & Timothy Brock



William Carruthers Gussow  
1908 - 2005

# Differential Entrapment of Hydrocarbon



# CARBONATE FACIES OF THE TRENTON-BLACK RIVER, MICHIGAN BASIN

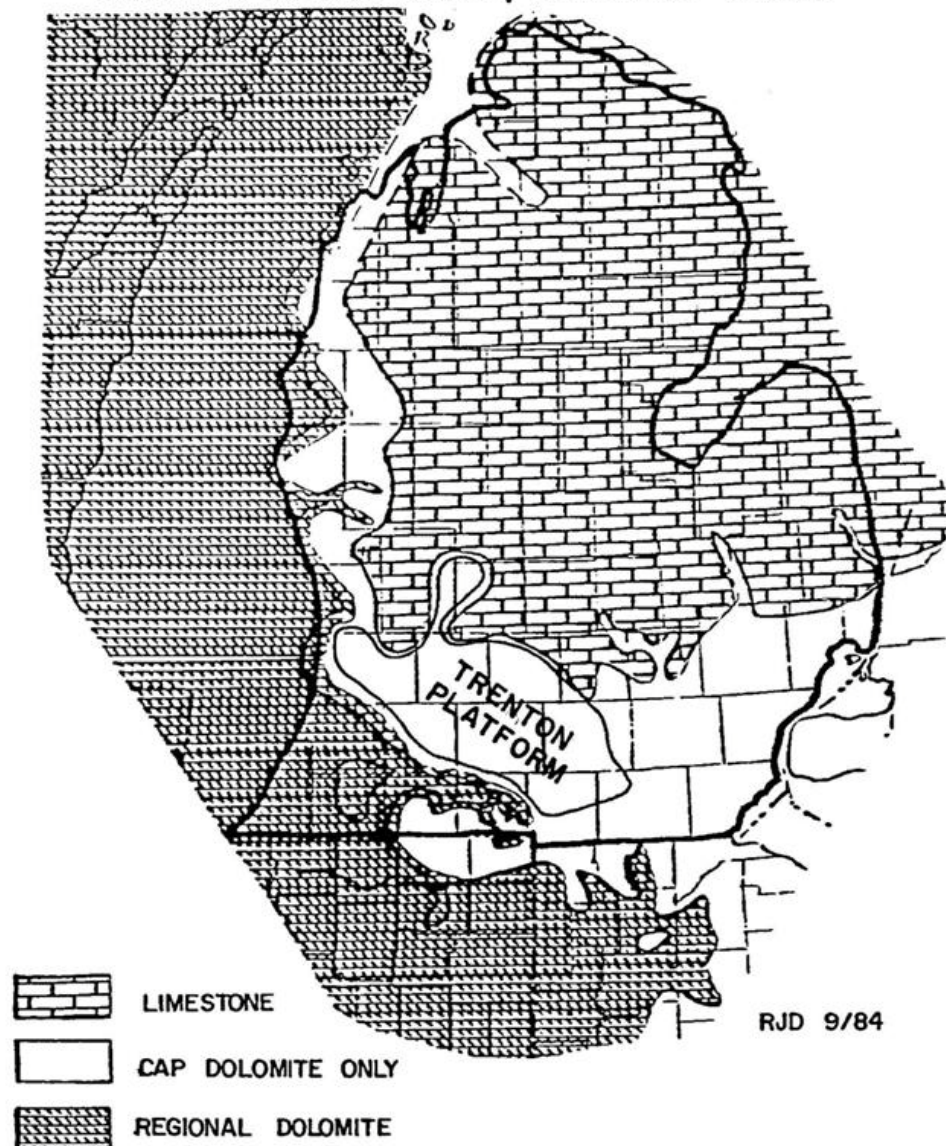
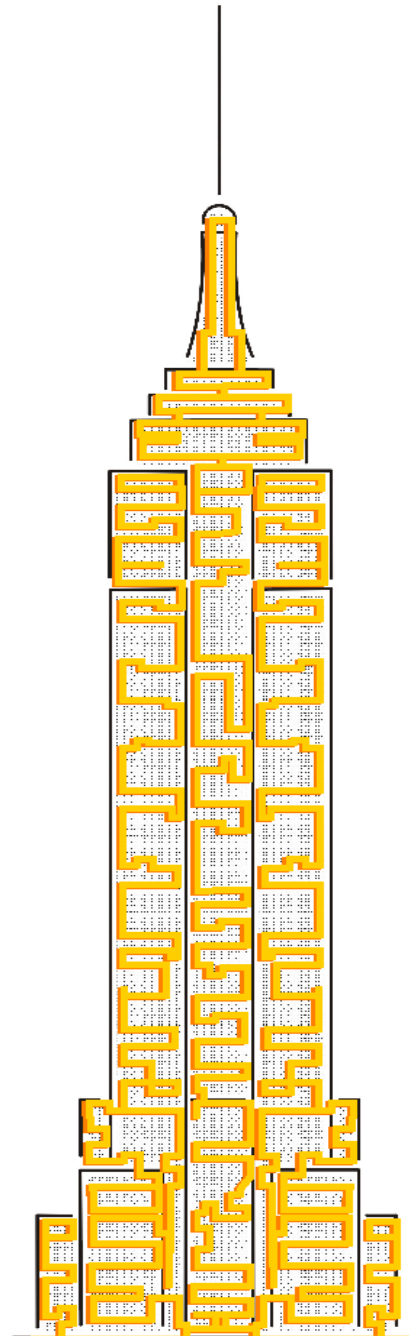
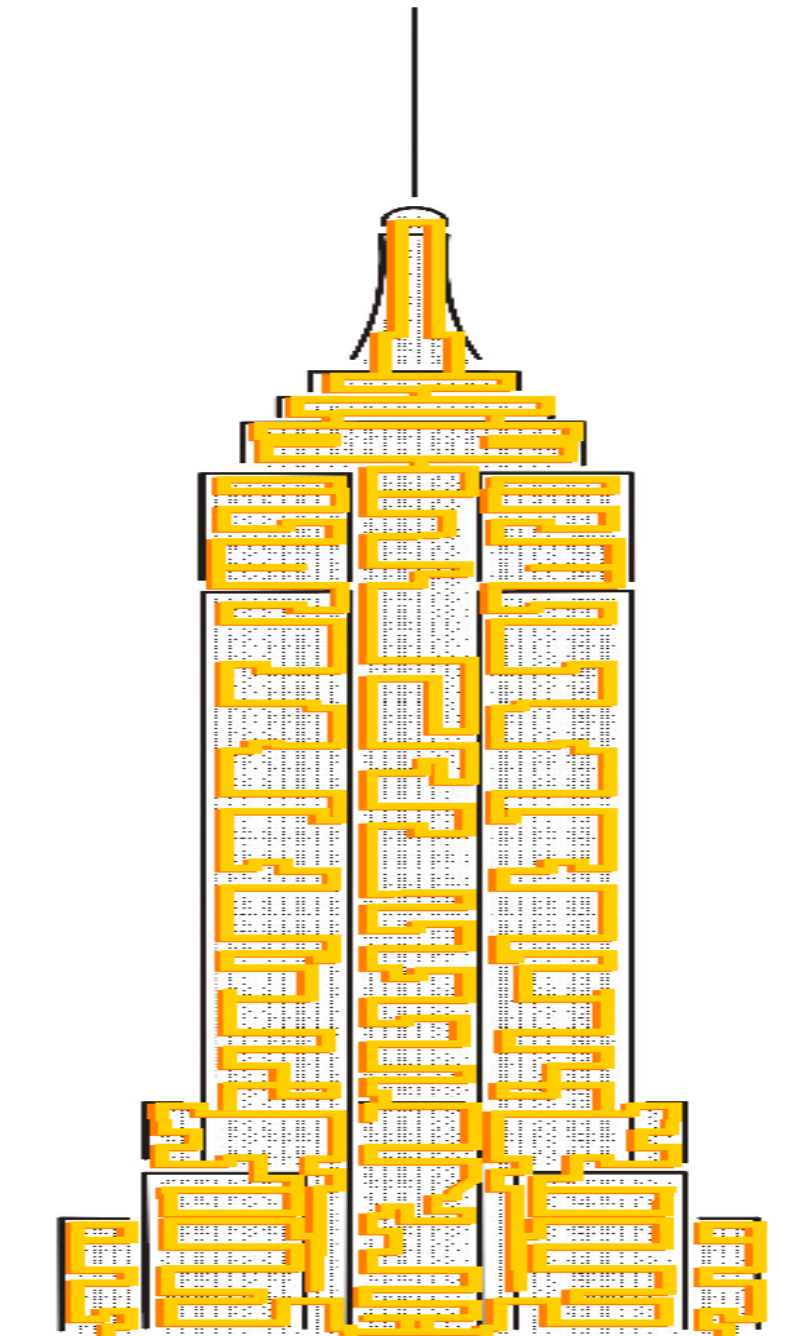


Figure 22—Area where Trenton-Black River caves might be developed.

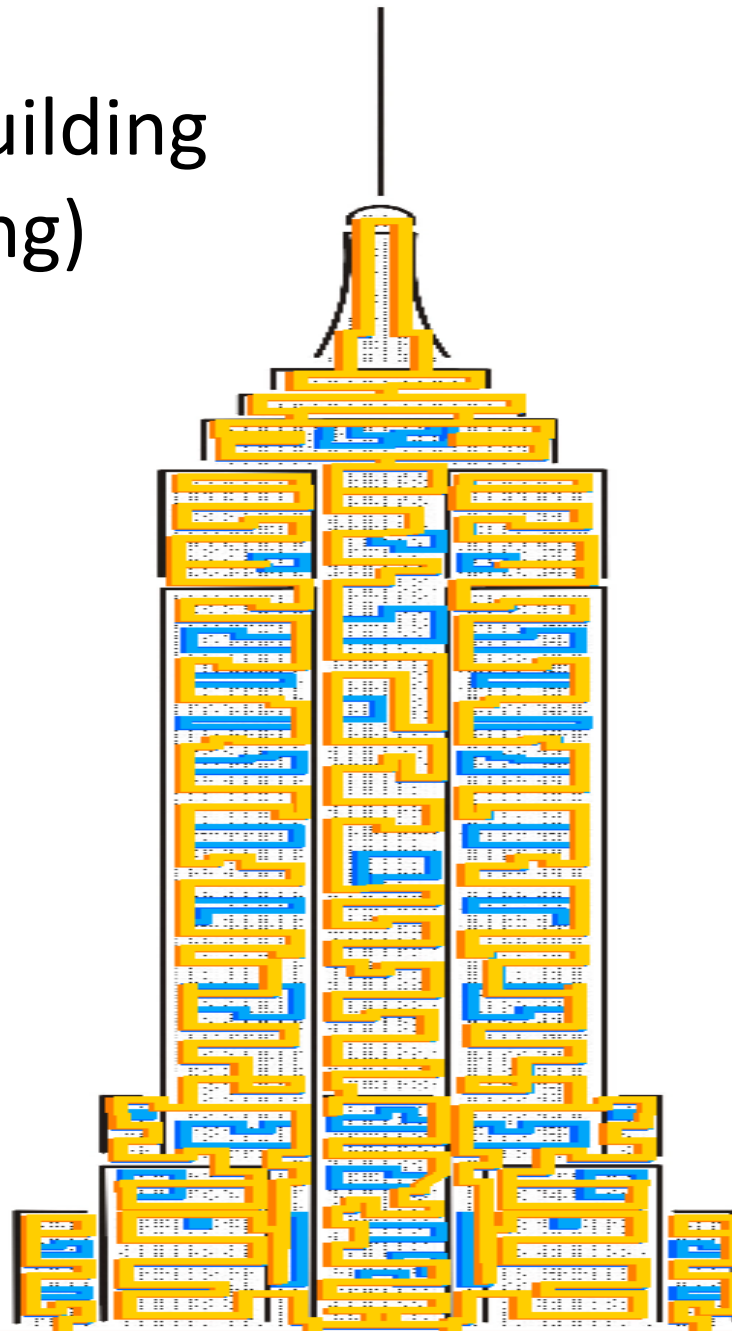
# Empire State Building (1930's Plumbing)



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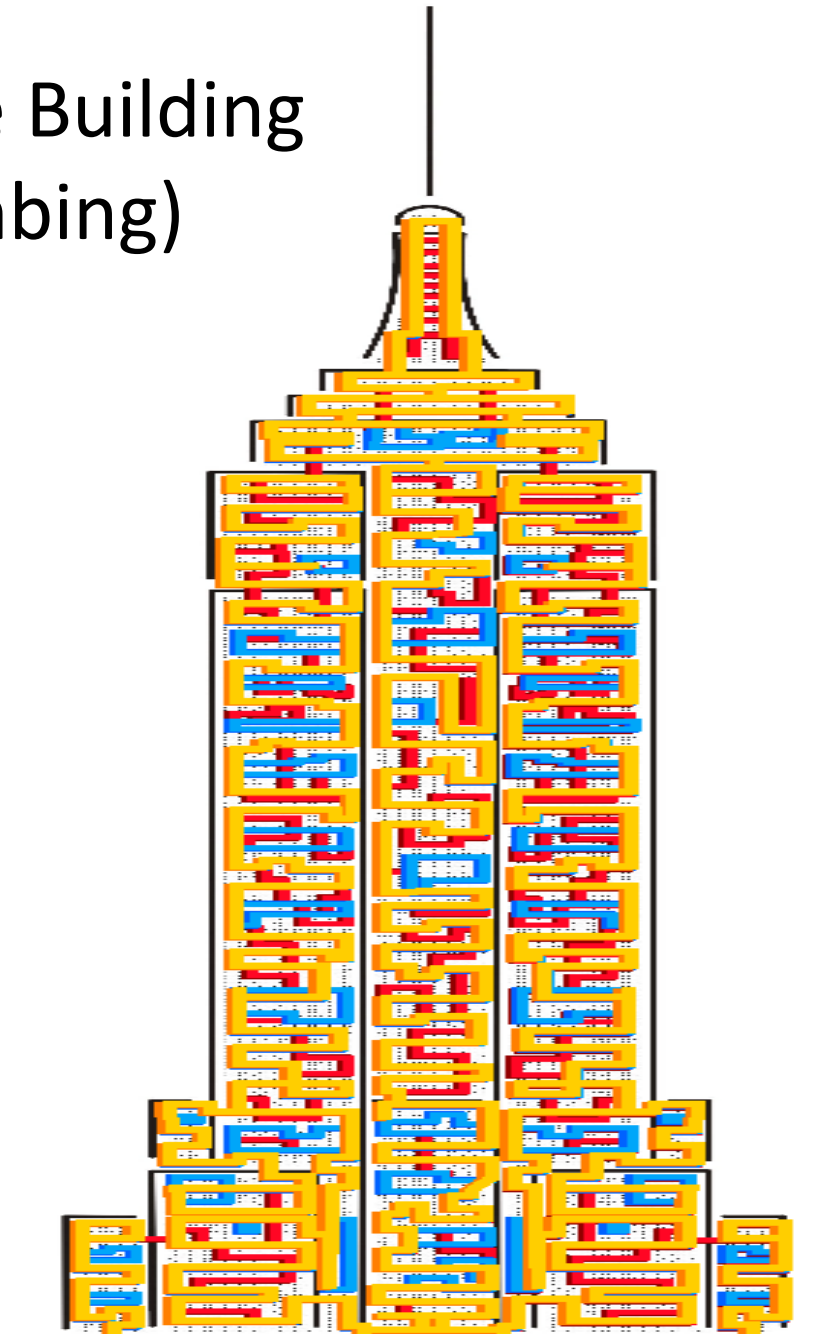


# Empire State Building (1950's Plumbing)

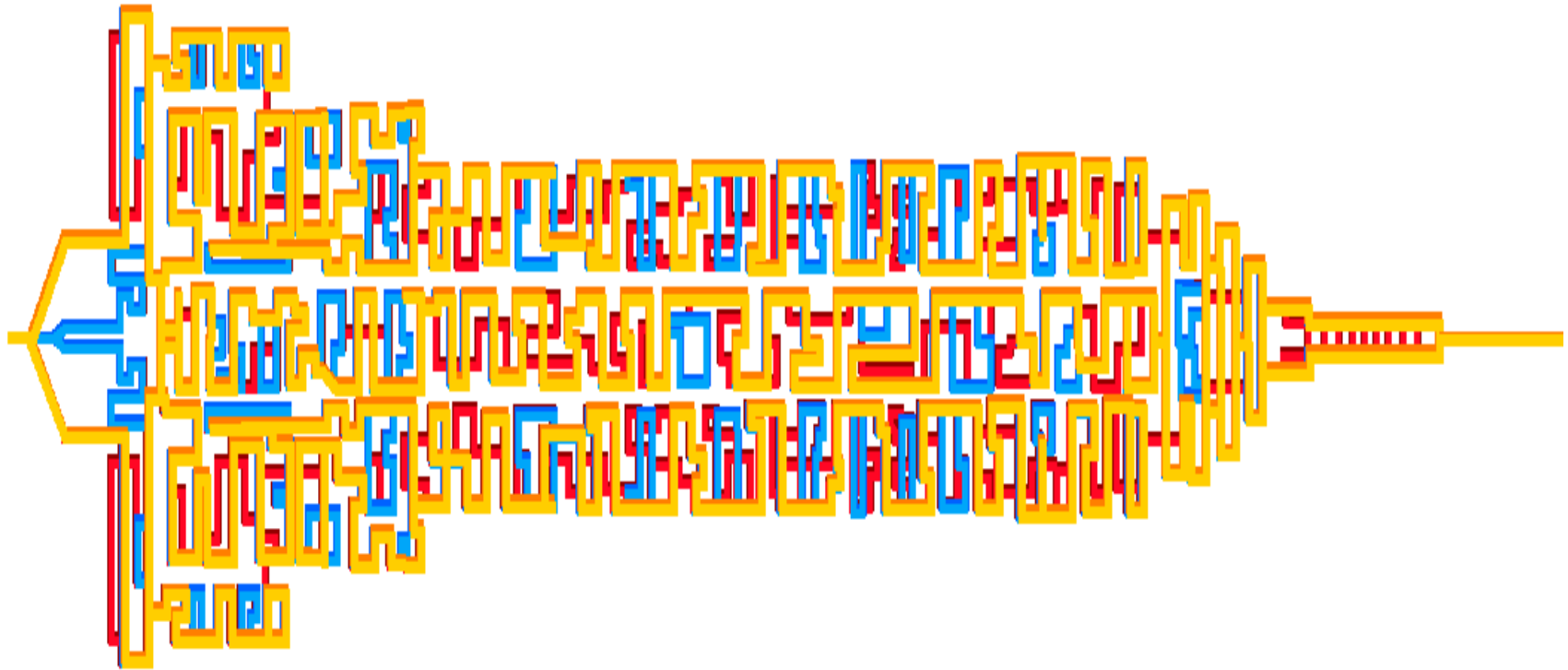




# Empire State Building (1980's Plumbing)



- Empire State Building (1980's Plumbing) turned on its side to illustrate complexity of Trenton-Black River reservoirs in central southern Michigan



So...

**IN LIGHT OF DIFFERENTIAL ENTRAPMENT,  
WHY IS THERE A GAS CAP IN ALL OF THE  
TRENTON-BLACK RIVER RESERVOIRS?**



**MAYBE ALL OF THE HYDROCARBON  
MIGRATED AS A SINGLE LIQUID PHASE?!?**

**How much pressure would it take to  
homogenize Trenton-Black River  
oil and gas?**

**Where would that pressure come from?**

# Evidence for deeper burial

- **Cercone, Karen Rose, 1984, AAPG Bull. v. 68 no. 2 (February, 1984), pp. 130-136:**  
**"Sediment accumulation rates, regional dips, and maturity of Pennsylvanian-age coals suggests that up to 1000 m (3,280 ft) of sediment were removed by erosion..."**
- **Rullkotter, Jurgen, et al., 1986, Org. Geochem. v. 10, pp. 359-375:**  
**"We agree with the conclusion of Cercone... Calculations using kinetic parameters of steroid reactions indicate that oil generation in the Michigan basin requires deeper subsidence of the source rocks in the geological past..."**

# **ASSUMPTIONS FOR HOMOGENIZATION MODEL**

- **Original Albion-Scipio Discovery BHP 1823 psia**
- **Pre-erosion additional overburden 1000 m.**
- **Pre-erosion additional pressure of 1500 psia**

**1823      Albion-Scipio**

**+1500      Additional**

**= 3323 psia original**

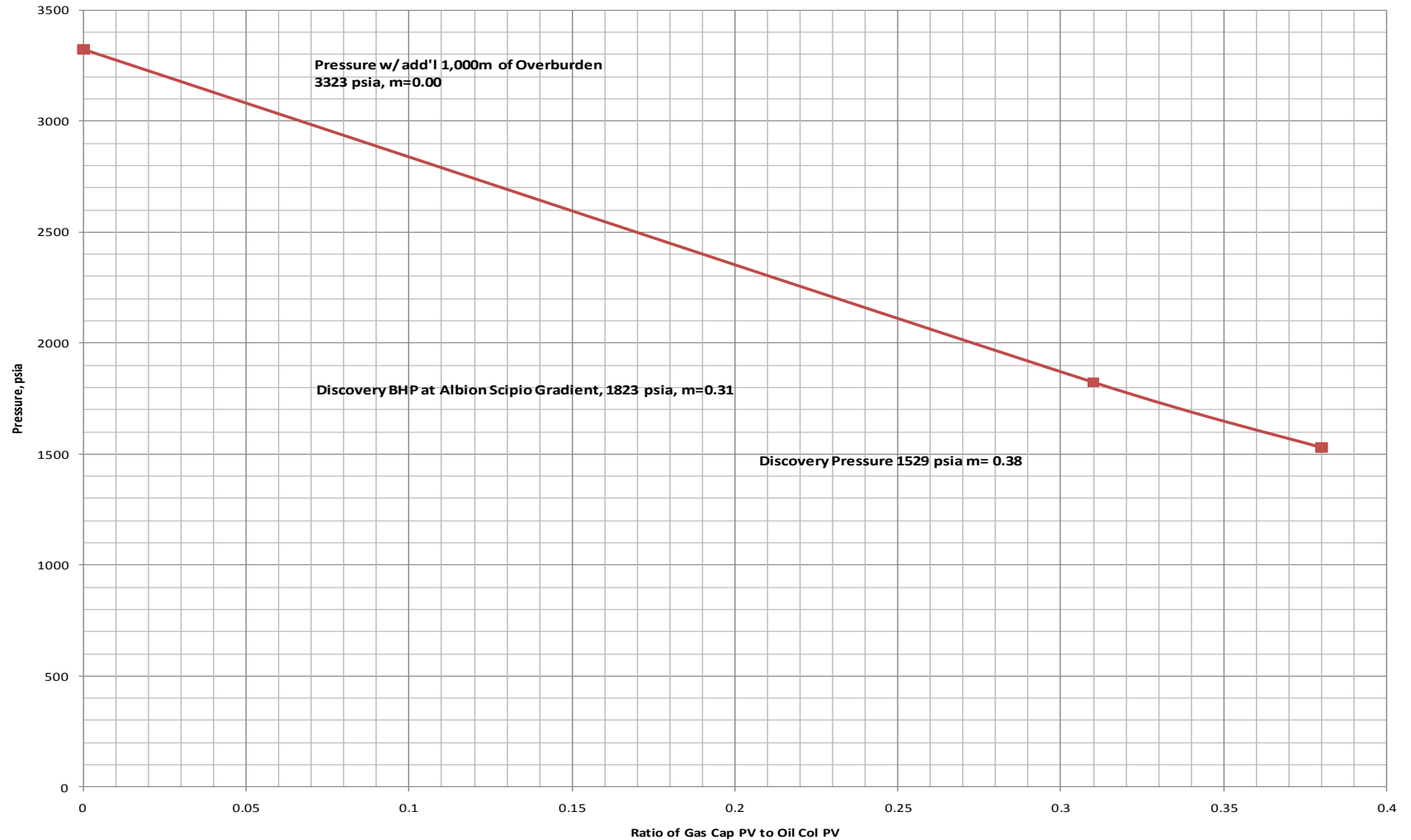
- **Complete homogenization (single liquid oil phase)  
with a bubble point of 3323 psia**
- **Discovery pressure of Stoney Point = 1529 psia**

## **With those assumptions:**

- **What would have happened as the 1000' of overburden was stripped away?**
- **What would be the ratio of gas cap pore volume to oil column pore volume (“m”) at the time of Albion-Scipio discovery?**
- **What would that ratio “m” be at the time of Stoney Point discovery?**
- **Does that match up with known data?**
- **What else could we expect?**

# Theoretical line using known Trenton-Black River oil and gas characteristics and foregoing assumptions

**Stoney Point Field Estimation of Gas Cap Size Due to Regional Depletion and Additional Overburden**





**The predicted “m” value for  
Stoney Point is 0.38**

**Does that match up  
with known data??**

# Stoney Point Field

## Calculation of Gas Cap Size Based on OOIP and Gas Recovery

OOIP, Original Oil in Place	34,000,000 STB	per Knowles, 1991
Boi, Oil Formation Volume Factor	1.285 RB/STB	Calculated using API Gravity, BHT, gas comp & Init BHP
Rsi, Solution GOR (in oil column)	0.556 MCF/STB	Calculated using gas comp & Init BHP
Original Hydrocarbon Pore Volume in Oil	=OOIP*Boi=	$\frac{34,000,000 \text{ STB}}{1.285 \frac{\text{RB}}{\text{STB}}} = 43,697,185 \text{ RB}$
OGIPs, Solution Original Gas in Place	=OOIP*Rsi=	$\frac{34,000,000 \text{ STB}}{0.556 \frac{\text{MCF}}{\text{STB}}} = 18,920,314 \text{ MCF}$
Gp, Gas Recovery to Date (6/2007)	28,600,000 MCF	per IHS Energy
RF, Assumed Gas Recovery Factor	95%	assumed
Estimated OGIP, Original Gas in Place	=Gp/RF=	$\frac{28,600,000 \text{ MCF}}{95\%} = 30,105,263 \text{ MCF}$
OGIPgc, Gas Cap Original Gas in Place	=OGIP-OGIPs=	$30,105,263 \text{ MCF} - 18,920,314 \text{ MCF} = 11,184,949 \text{ MCF}$
Bgl_gc, Gas Formation Volume Factor (gas cap)	1.569 RB/MCF	Calculated using gas cap comp, BHT & Init BHP
Original Hydrocarbon PV in Gas Cap	=OGIPgc/Bgl_gc=	$\frac{11,184,949 \text{ MCF}}{1.569 \frac{\text{RB}}{\text{MCF}}} = 17,551,608 \text{ RB}$
m, Ratio of Gas Cap PV to Oil Column PV	$\frac{=OHCPV_{gc}}{OHCPV_o} = \frac{17,551,608 \text{ RB}}{43,697,185 \text{ RB}} = 0.40$	<b>m = 0.40</b>

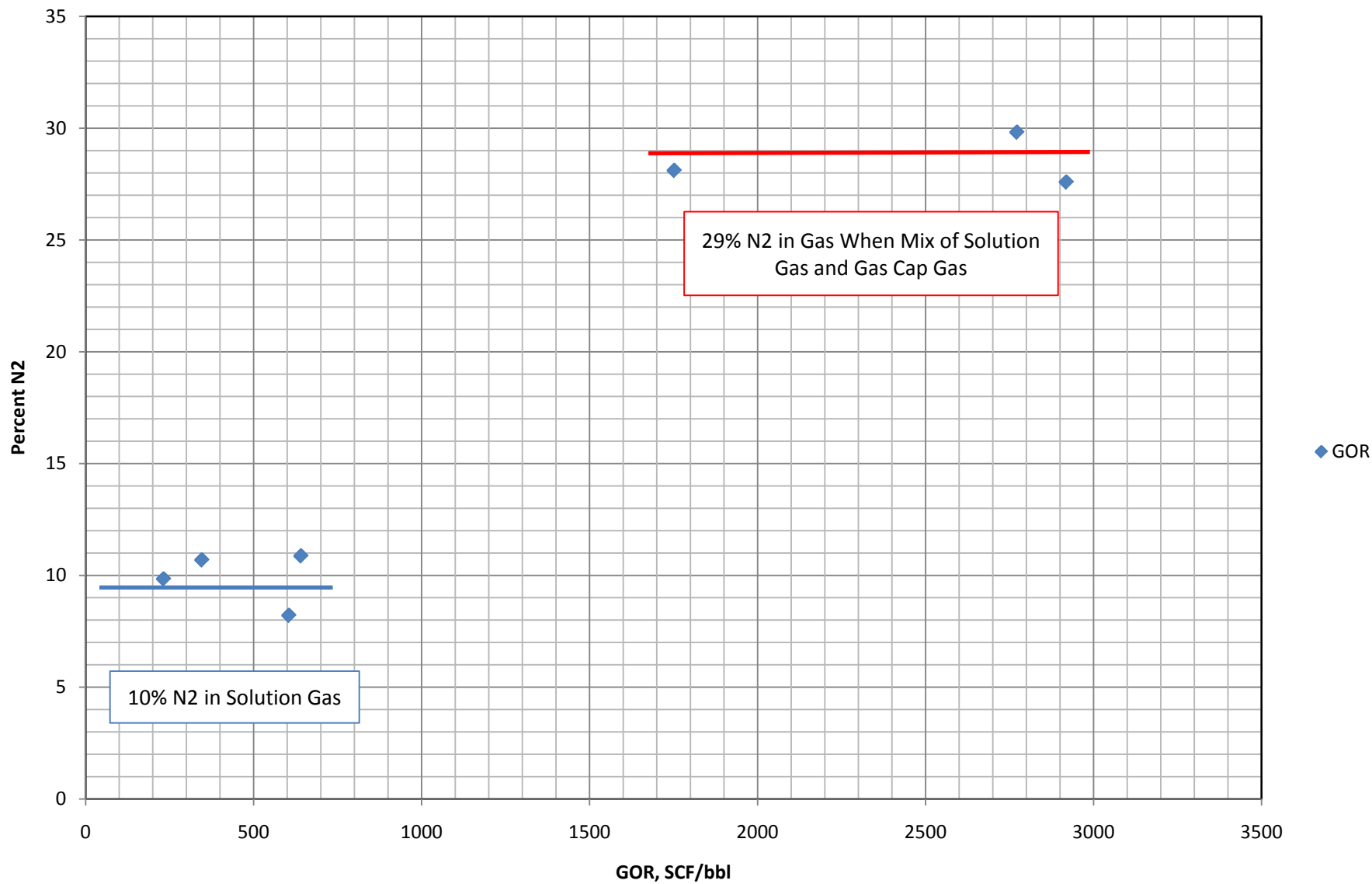
Note: Material Balance approach predicted m = 0.38 by recombining oil column and gas cap to resaturate at a pressure equivalent to additional 1,000m of overburden.

STB = Stock Tank Barrels  
 RB = Reservoir Barrels  
 MCF = 1000 std cubic feet

**What else would we expect to see  
if the hydrocarbon migrated  
as a single liquid oil phase?**

- Preferential concentration of nitrogen in gas cap, but not in solution gas
- Perched oil in the gas cap
- Perched water in the oil column

# Stoney Point Field Nitrogen Content in Gas as it Relates to Produced GOR of Individual Wells

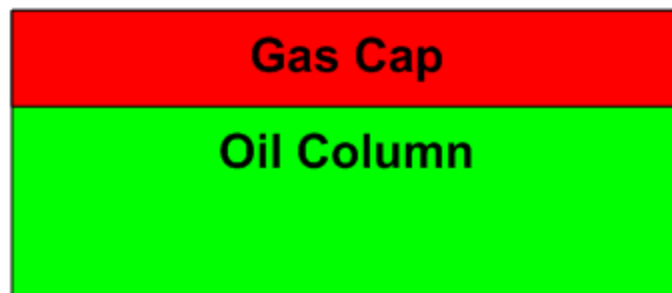


# Results of Recombination Analysis

## Stoney Point Field

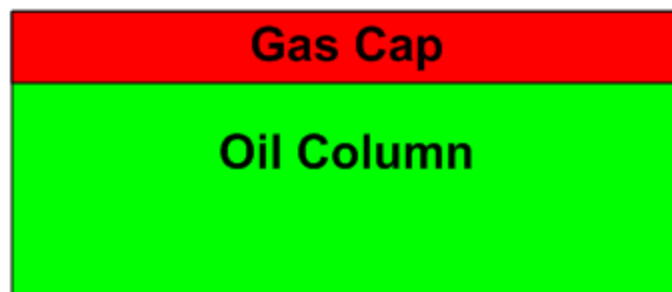
**Stoney Point Field at Discovery:**

- 38' of Gas Cap ( $m=0.38$ ) for every 100' of Oil column



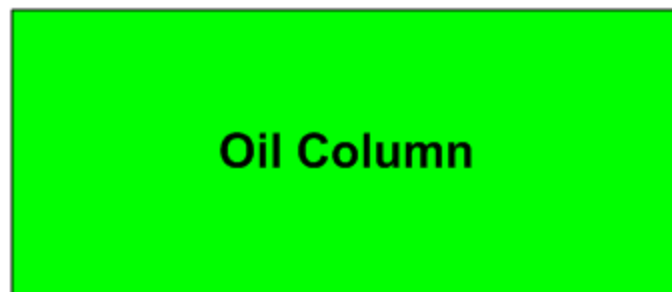
**Stoney Point Field at Albion  
Scipio Discovery:**

- 31' of Gas Cap ( $m=0.31$ ) for every 100' of Oil column



**Stoney Point Field Prior to  
Unloading From Additional  
Overburden:**

- No Gas Cap



# **CONCLUSION:**

**Single liquid oil phase migration of Trenton-Black River oil is consistent with other data (Cercione, 1984), and further explains:**

- ubiquitous gas caps in Trenton-Black River**
  - high nitrogen content in gas cap**
  - perched oil in the gas cap**
- perched water in the oil column**

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[rjdehaas.com/singlephase.pptx](http://rjdehaas.com/singlephase.pptx)**