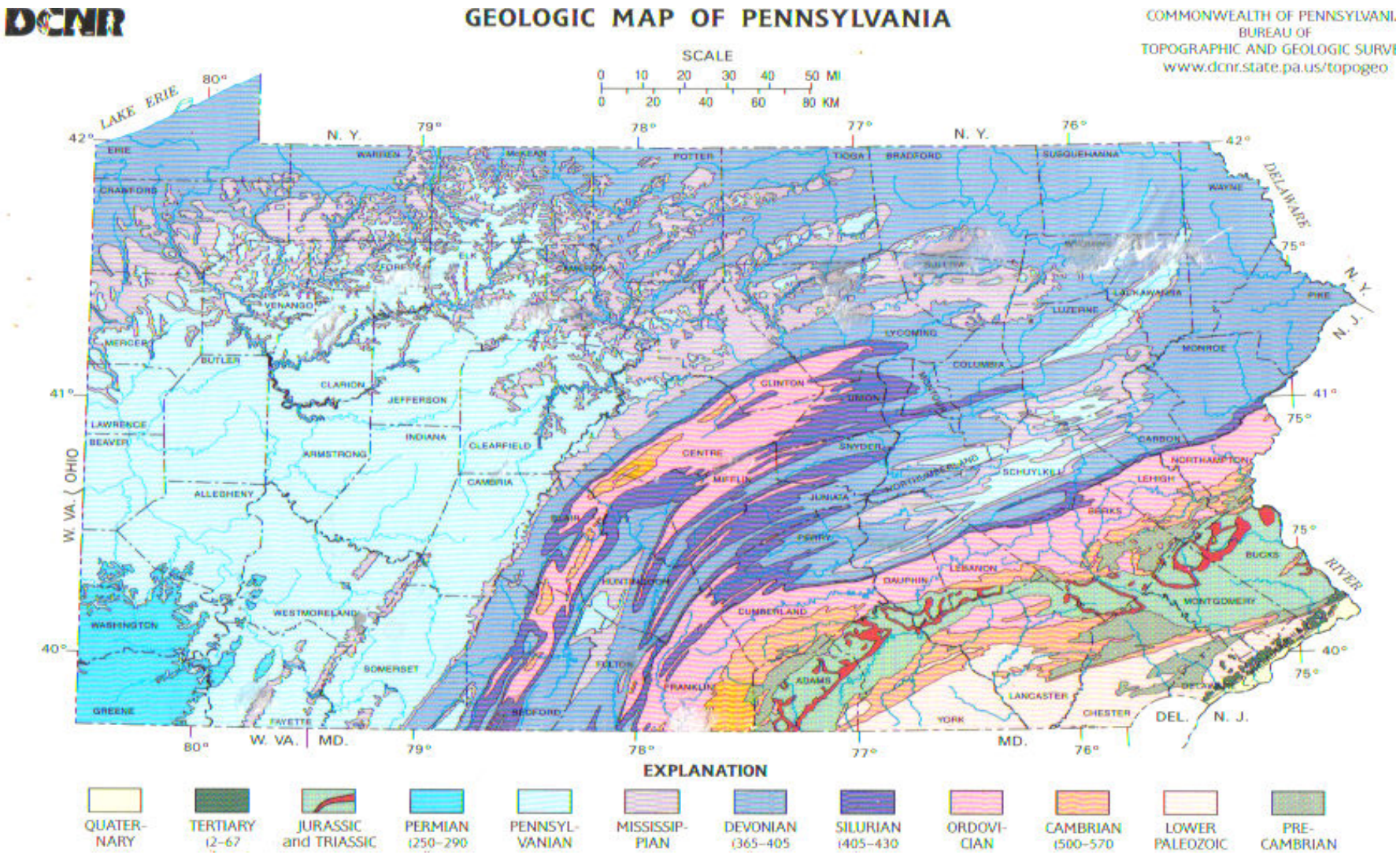
The Depositional Setting of The Marcellus Black Shale



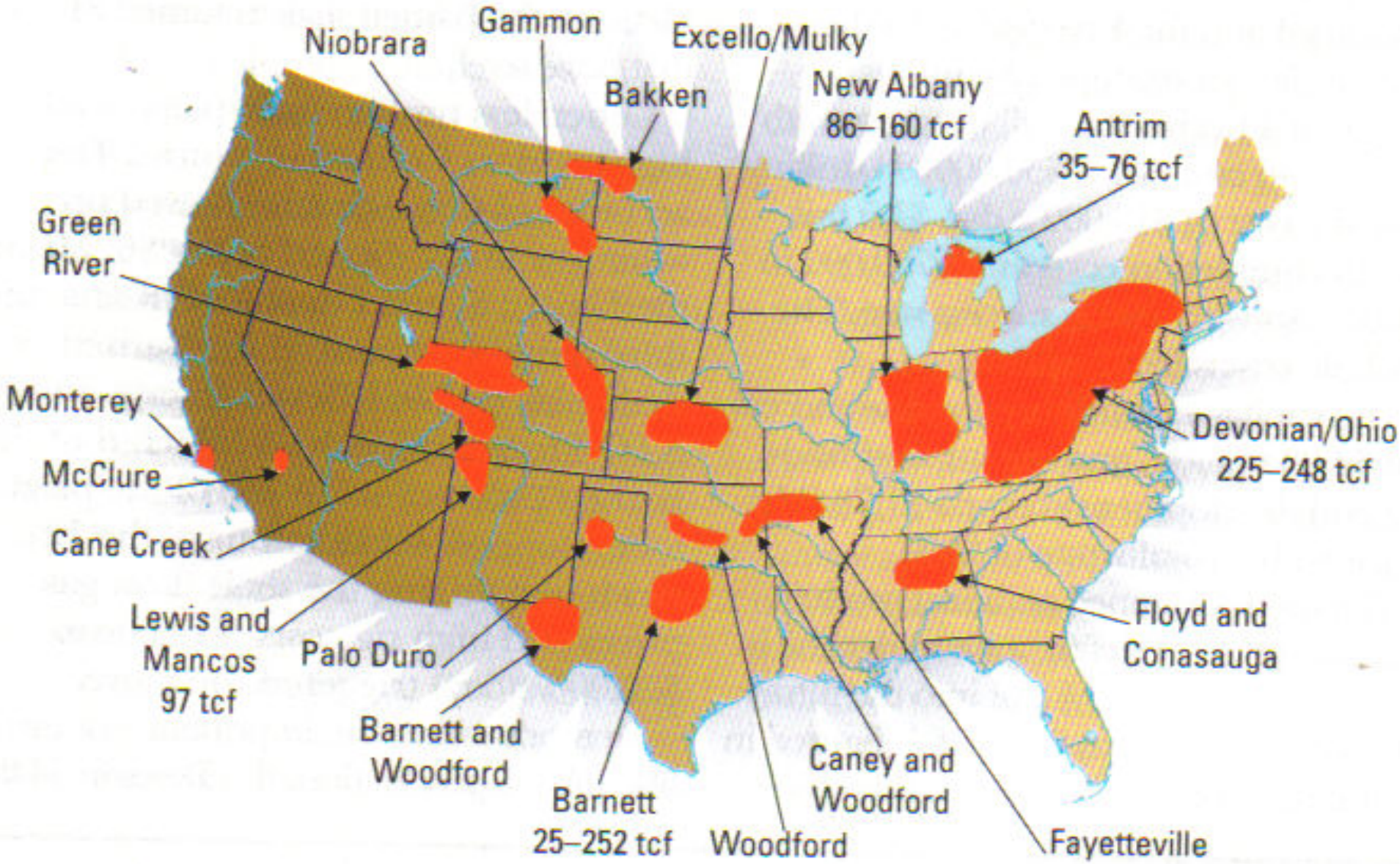
Discussion Points

- Define what is a Resource Play
- History of Shale Plays
- Compare the Tectono-Depositional Setting of the Marcellus Shale in the Appalachian Basin with the Barnett Shale in the Fort Worth Basin
- Implications for Prospecting
- Implications for Development

Resource Play
vs.
Conventional Play

Resource Play		Conventional Play
Low	Geologic Risk	High
High	Engineering Risk	Low
High	Organic Content	Low
High	Reserves/Unit Vol.	Low
	Source/Reservoir	
Identical	Relationship	Remote

Black Shale Resource Plays in North America

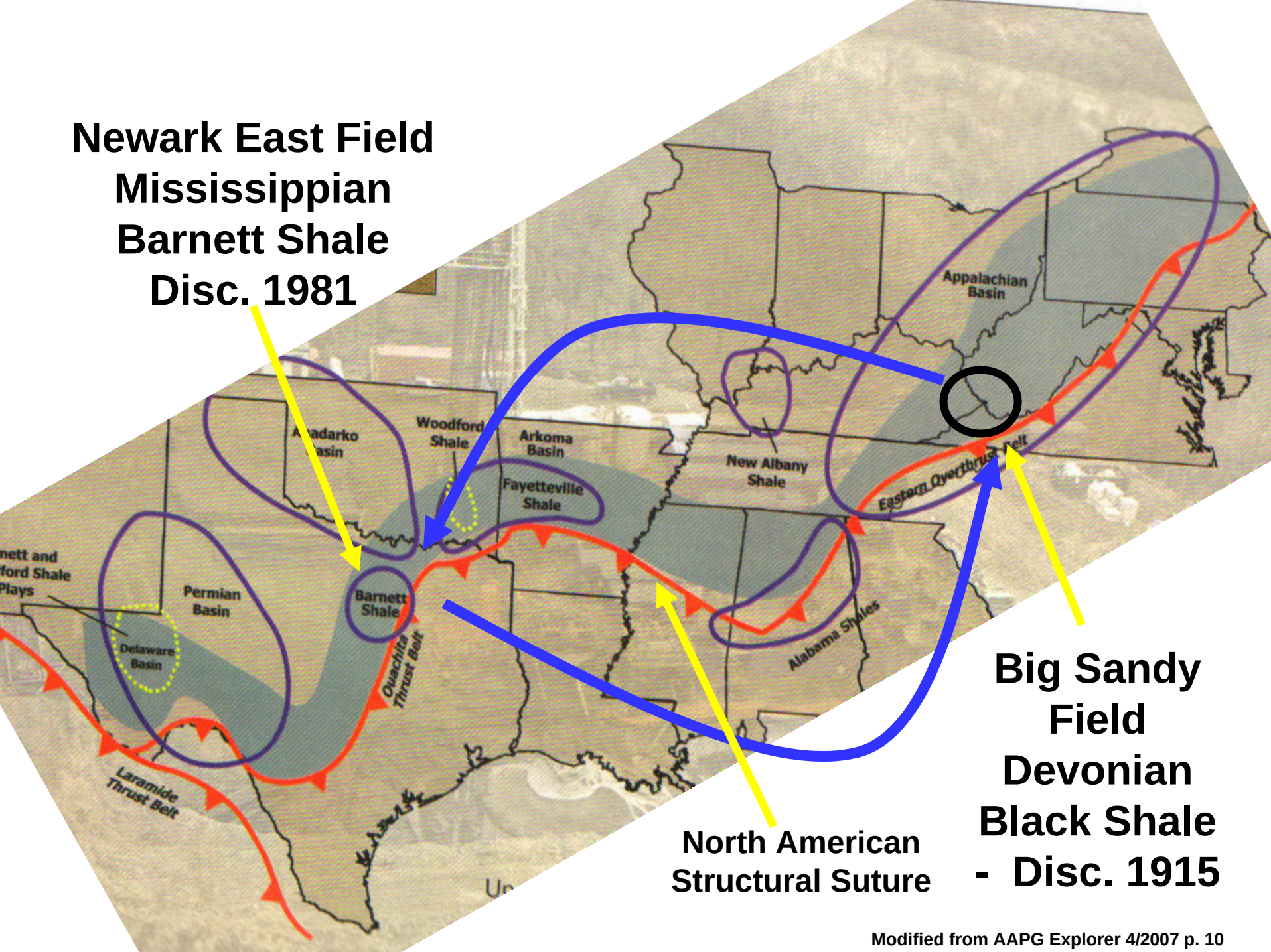


E&P Magazine, 3/2007, p. 77

Gas shale deposits appear in basins from the

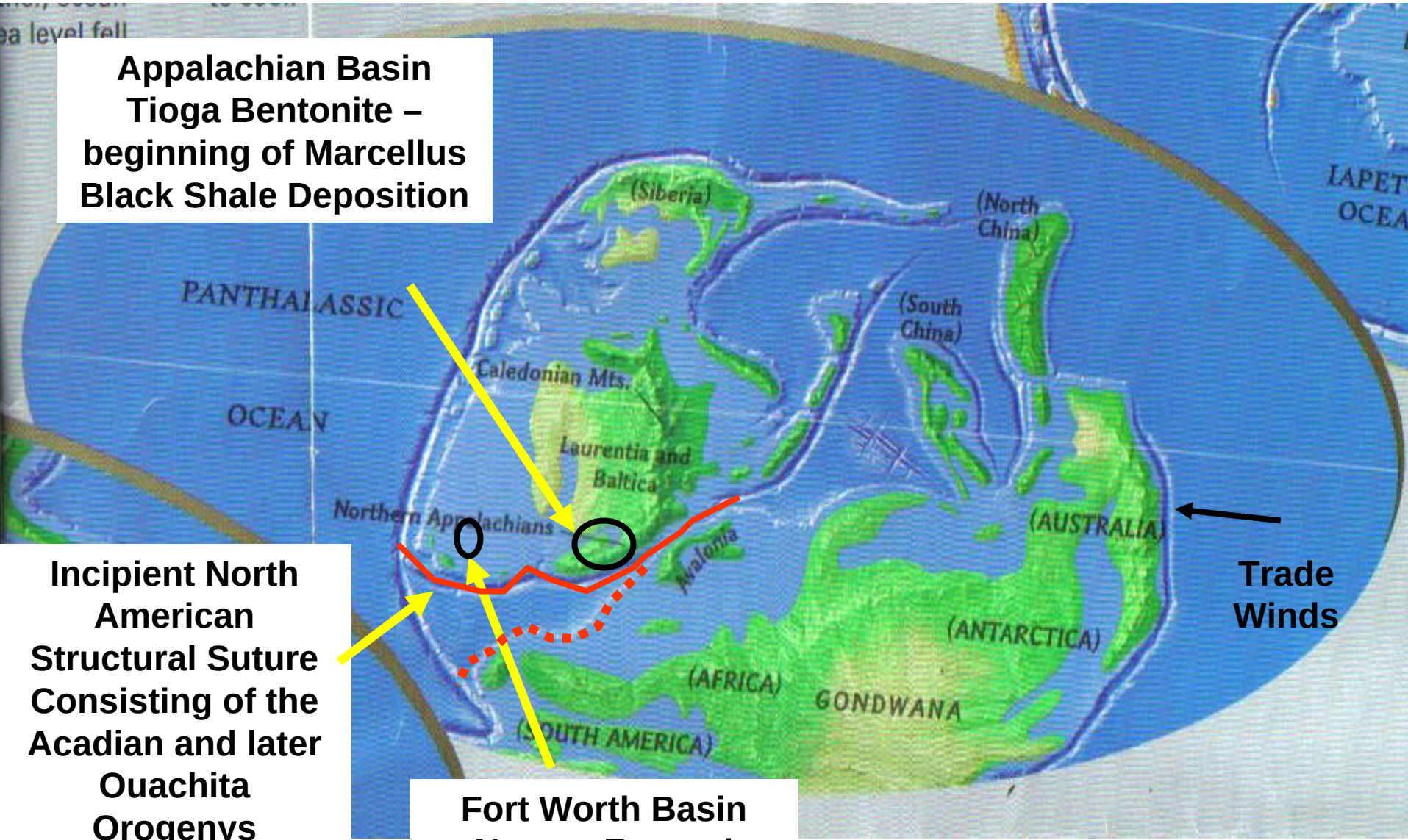
History of Shale Plays

- Big Sandy Field – WV and Kentucky
  - Discovered 1915 - 2.5 TCF of production
  - Natural Fracture System - Maximizes Production
  - Minimal Stimulation
- Newark East Field – Fort Worth Basin
  - Discovered 1982 - 3 TCF of production
  - Induced Fracture System – Maximizes Production
  - Maximum Stimulation



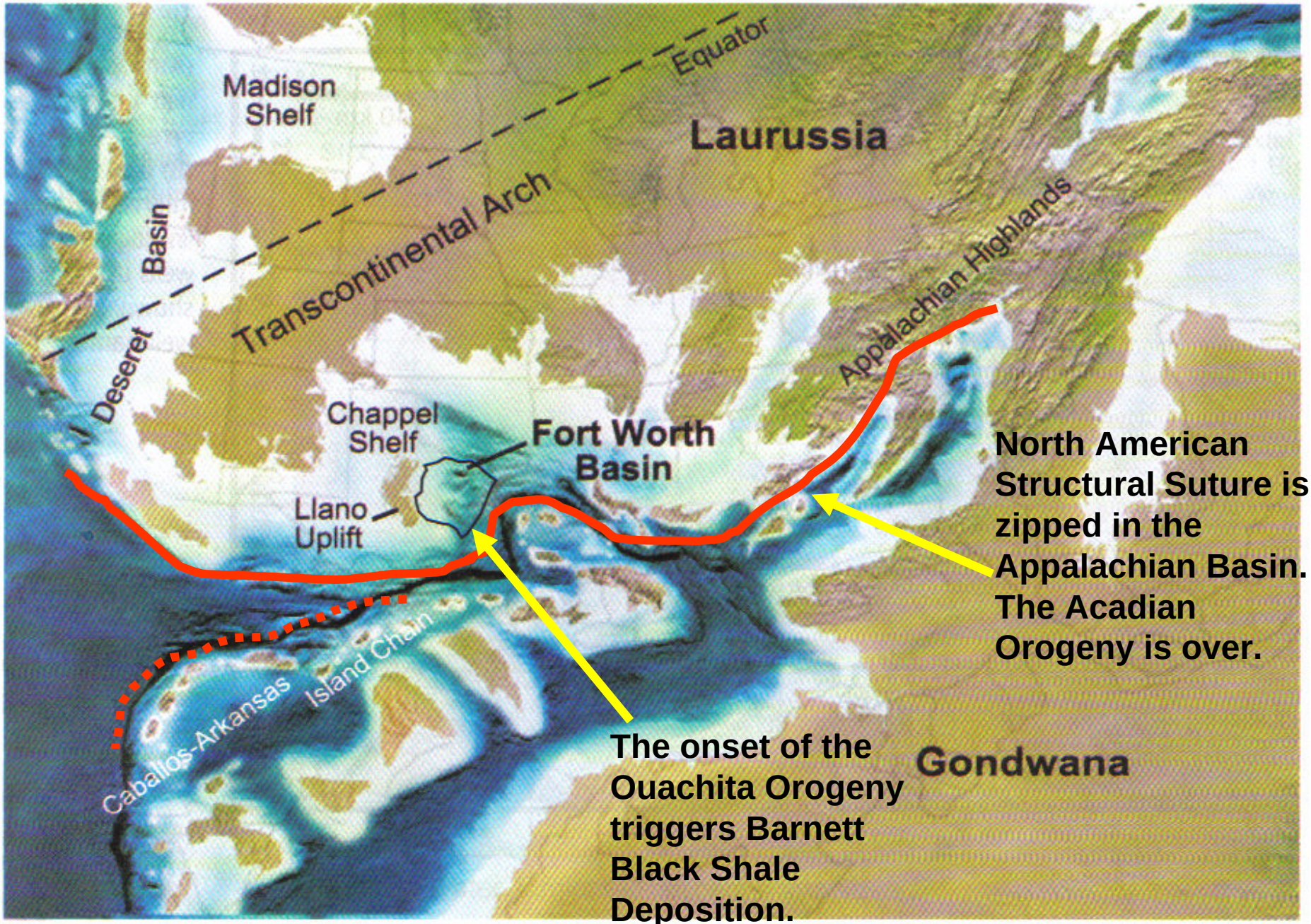
Modified from AAPG Explorer 4/2007 p. 10

Middle Devonian Time – 390 MYA

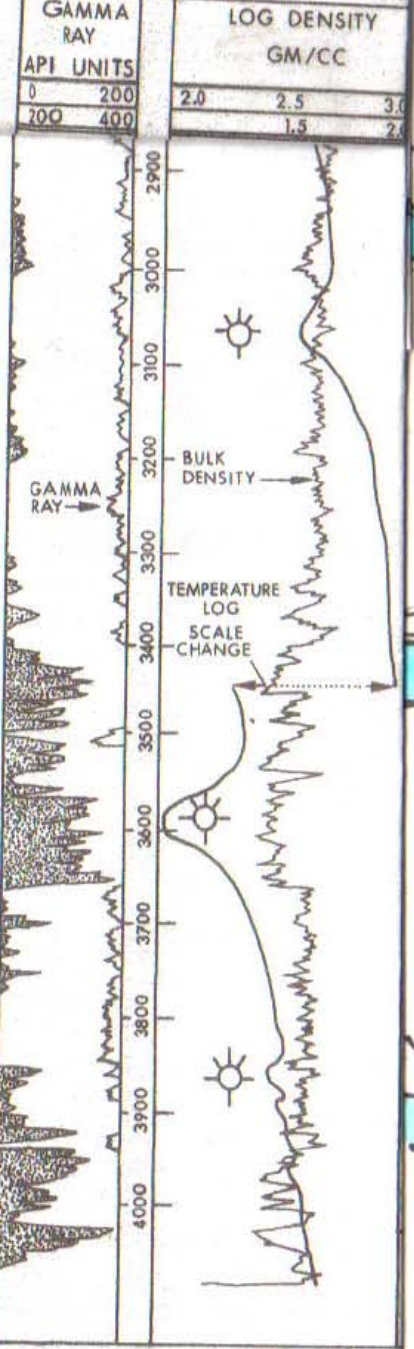


Modified From National Geographic 1998

Early Mississippian 360 MYA



Modified from AAPG Bull. 4/2007, p. 584



WEST

EAST

Ohio Shale

Marcellus Shale

Rhinestreet Shale

PHASE THREE – Erosion of highlands rapidly fills shallowing basin, Trough and Bulge features migrate further west.

Bulge and Trough Migrate West

PHASE TWO–Collision ends and NA Plate rebounds. Deep, Anoxic, Sediment Starved Basin shallows and both Bulge and Trough migrate westward.

Rhinestreet Shale

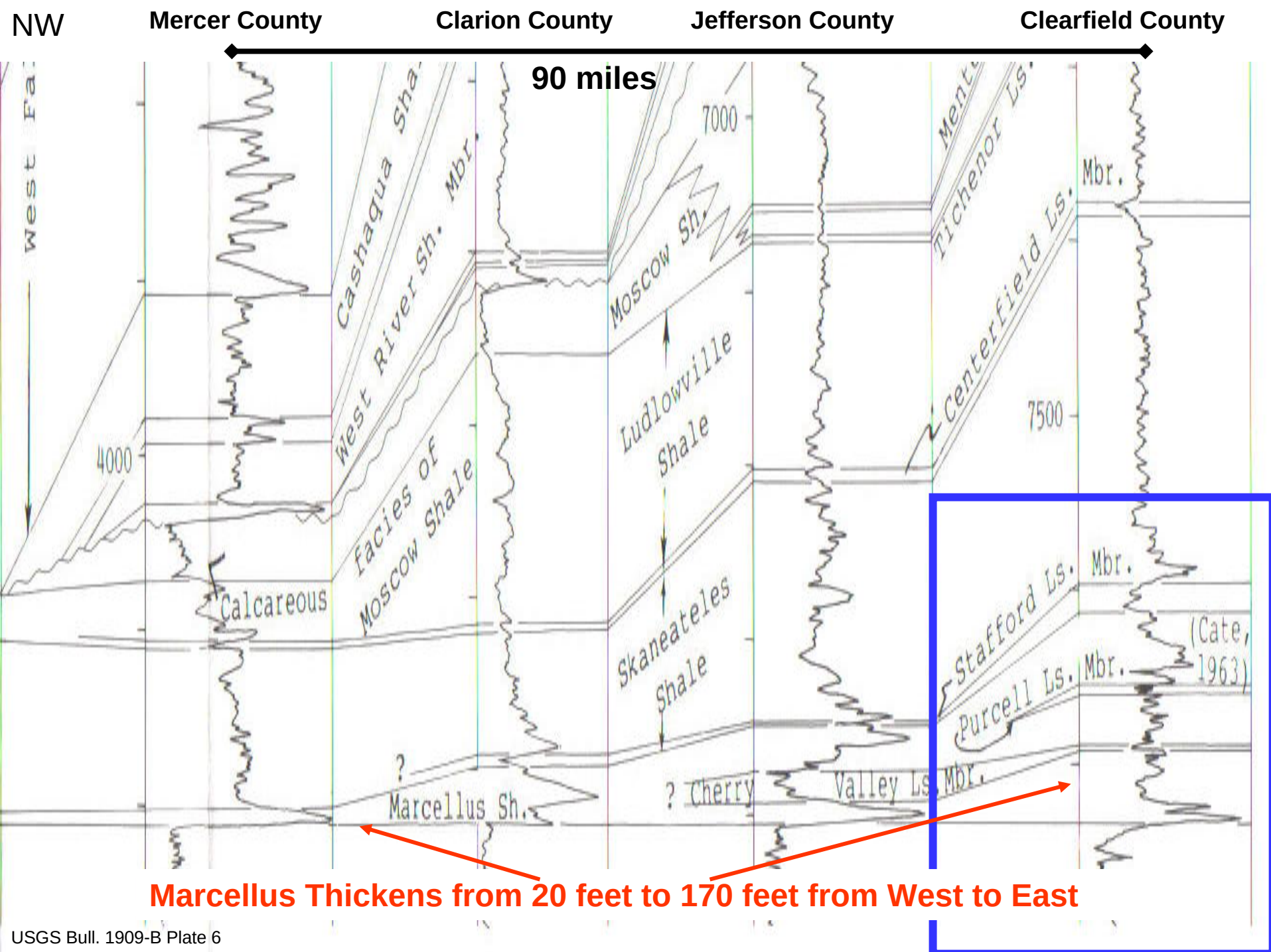
Overriding African Plate

Peripheral Bulge Cincinnati Arch

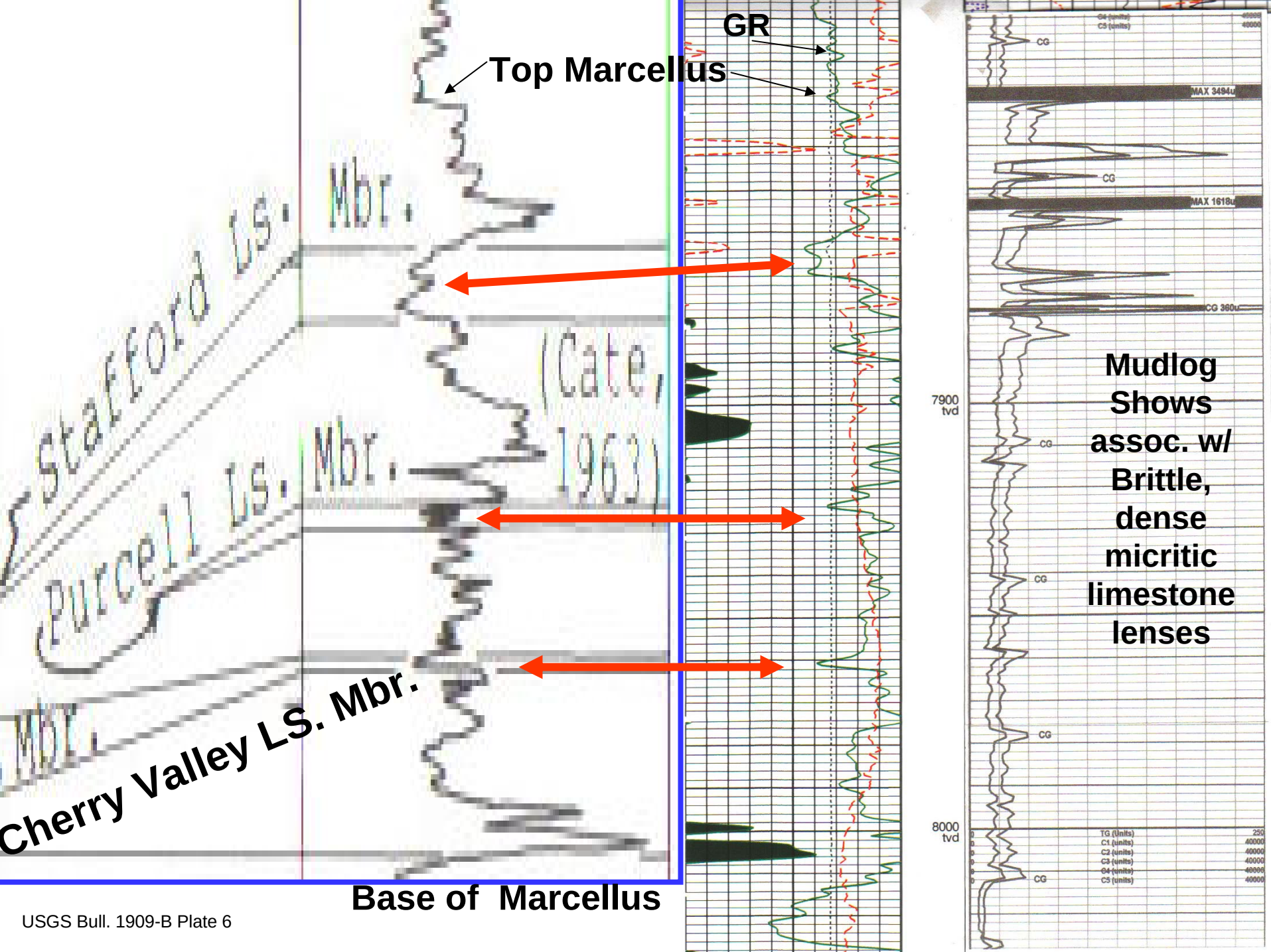
Proximal Trough

PHASE ONE – Initial Collision - African Plate Overrides and Depresses NA Plate – Generating a very Deep, Anoxic, Sediment Starved Basin Termed a Proximal Trough and associated Peripheral Bulge.

Marcellus Shale

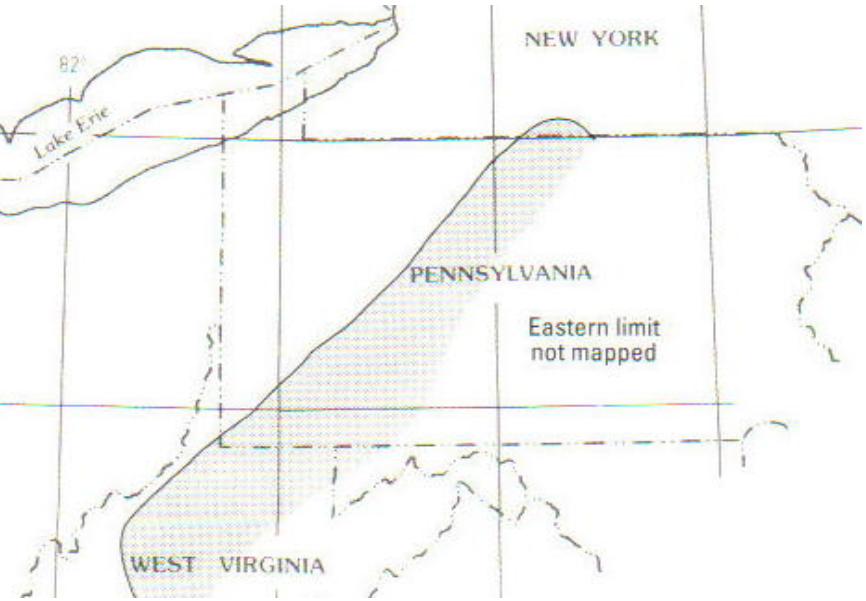


USGS Bull. 1909-B Plate 6

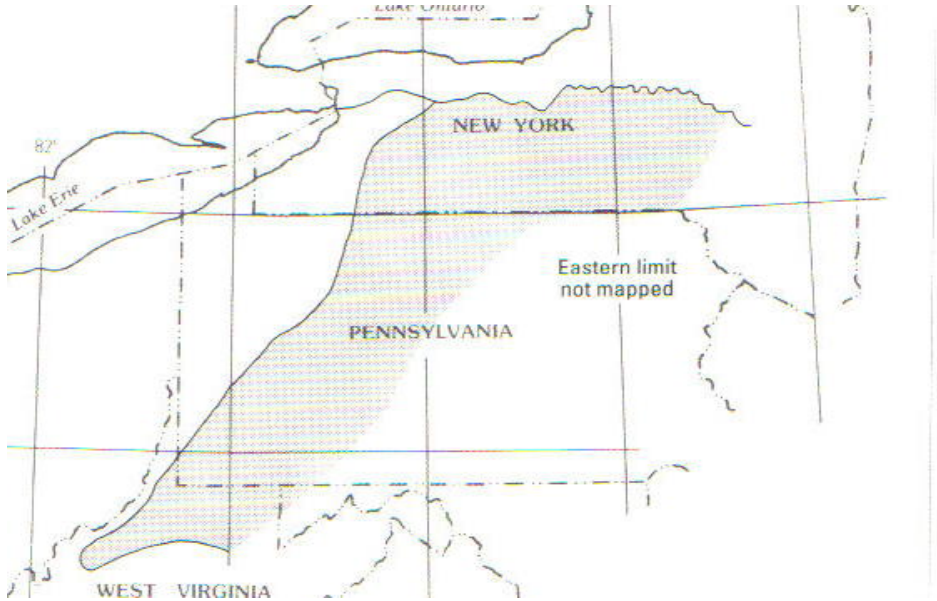


USGS Bull. 1909-B Plate 6

Areal Extent Purcell LS



Areal Extent Cherry Valley LS



USGS Bull. 1909-B Plate 6

Summary: Comparison Between the Marcellus and Barnett Shale Depositional Systems

- **Although separated by 30 my in time, the Marcellus and Barnett Shale were generated by a similar depositional system and tectonic setting.**

- **Both the Marcellus and Barnett Shale were the initial sediments deposited in a very deep, sediment starved, anoxic trough that formed in response to an impinging tectonic plate.**

Implications for Exploration for the Marcellus Shale

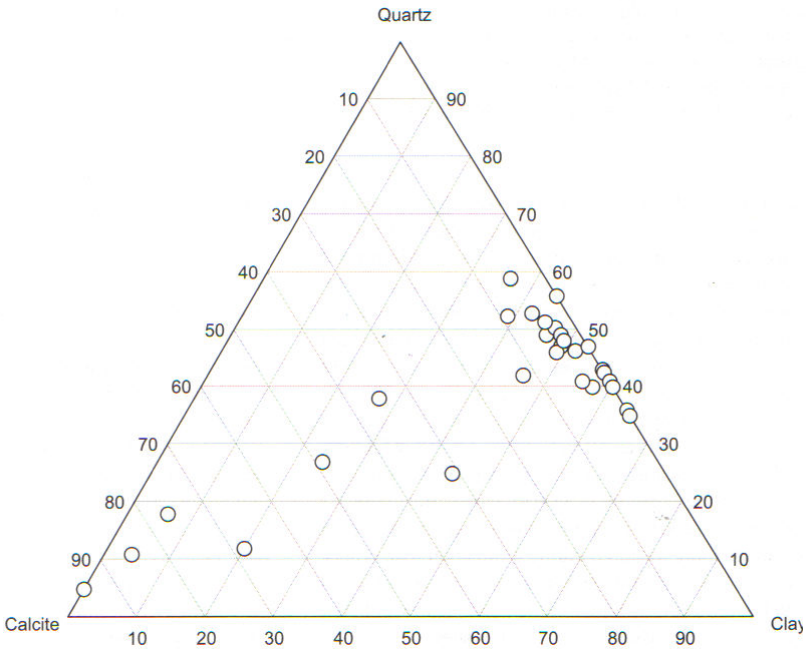
- **In the Appalachian Basin - Head East Towards the Allegheny Front where the Thickest Accumulations of Marcellus Organic Rich Shale were deposited in the proximal trough generated by the earliest phase of the Acadian Orogeny.**

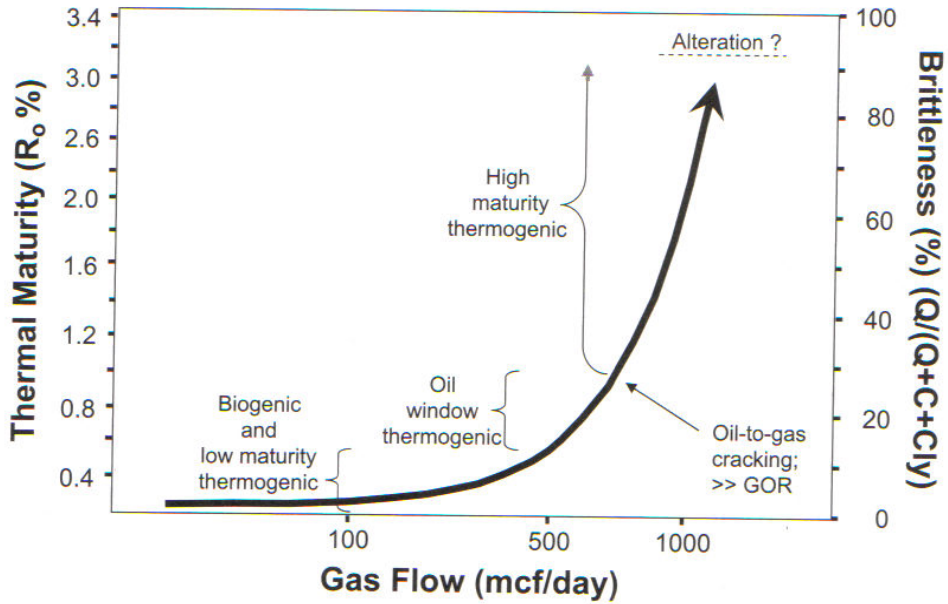
- **Because the Marcellus was deposited early in the collision, the highlands to the east were subdued and less sediment input led to Higher TOC's**

Implications for Development of the Marcellus Shale

- **Maximum Water Depth = Extreme Anoxic Conditions**
  - **Maximum preservation of organic material highest TOC's**
  - **Minimal Bioturbation equals Maximum preservation of silt laminae which increases lateral permeability.**
- **Greater Burial Thickness – Higher Maturity**
- **Ro > 2.0 – Complete Conversion of Organic Material to Natural Gas**
- **Ro > 2.0 increases Porosity by 4%!!**

NEXT STEPS – Mineralogy





- **Marcellus 40% - from cored well in Lincoln county WV**
- **Brittleness (%) (Q/(Q+C+Clay))**
- **Whole Core calibrated to Mineral Identification logs.**

Modified from AAPG Bull. 4/2007, p. 494 & 495