

GEOLOGY OF THE MARCELLUS SHALE IN MARYLAND

**Conventional Appalachian Deep Gas Source Bed and
Unconventional Gas Reservoir**

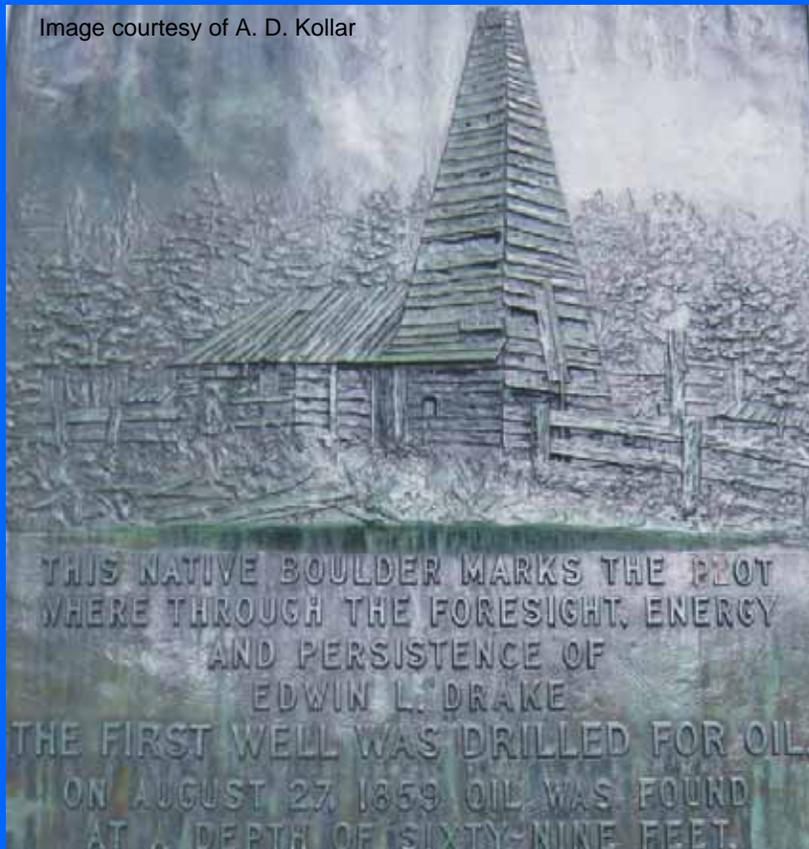


**David K. Brezinski
Maryland Geological Survey
2010**

The Appalachian Basin

Grandfather of the World's Oil and Gas Industry

Image courtesy of A. D. Kollar



1859 - Edwin Drake drills first oil well in Titusville, Pennsylvania.

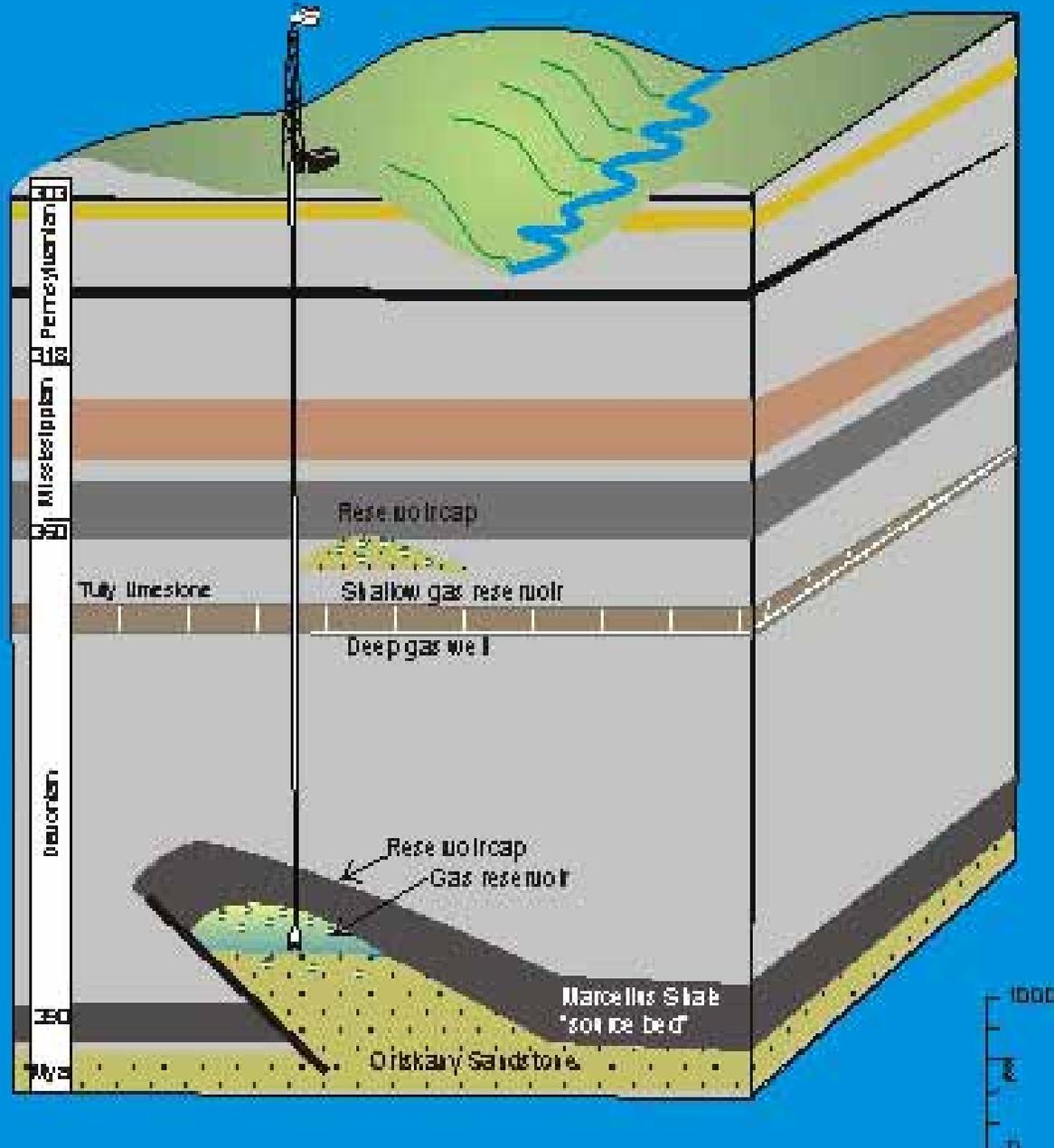
1860 -1901-The Appalachian region becomes the center of the American oil industry.

1901- Spindletop gusher drilled in Beaumont, Texas leads to oil industries migration from the central Appalachians to the Gulf Coast.

2004– Marcellus unconventional gas play begins in Washington Co. PA.

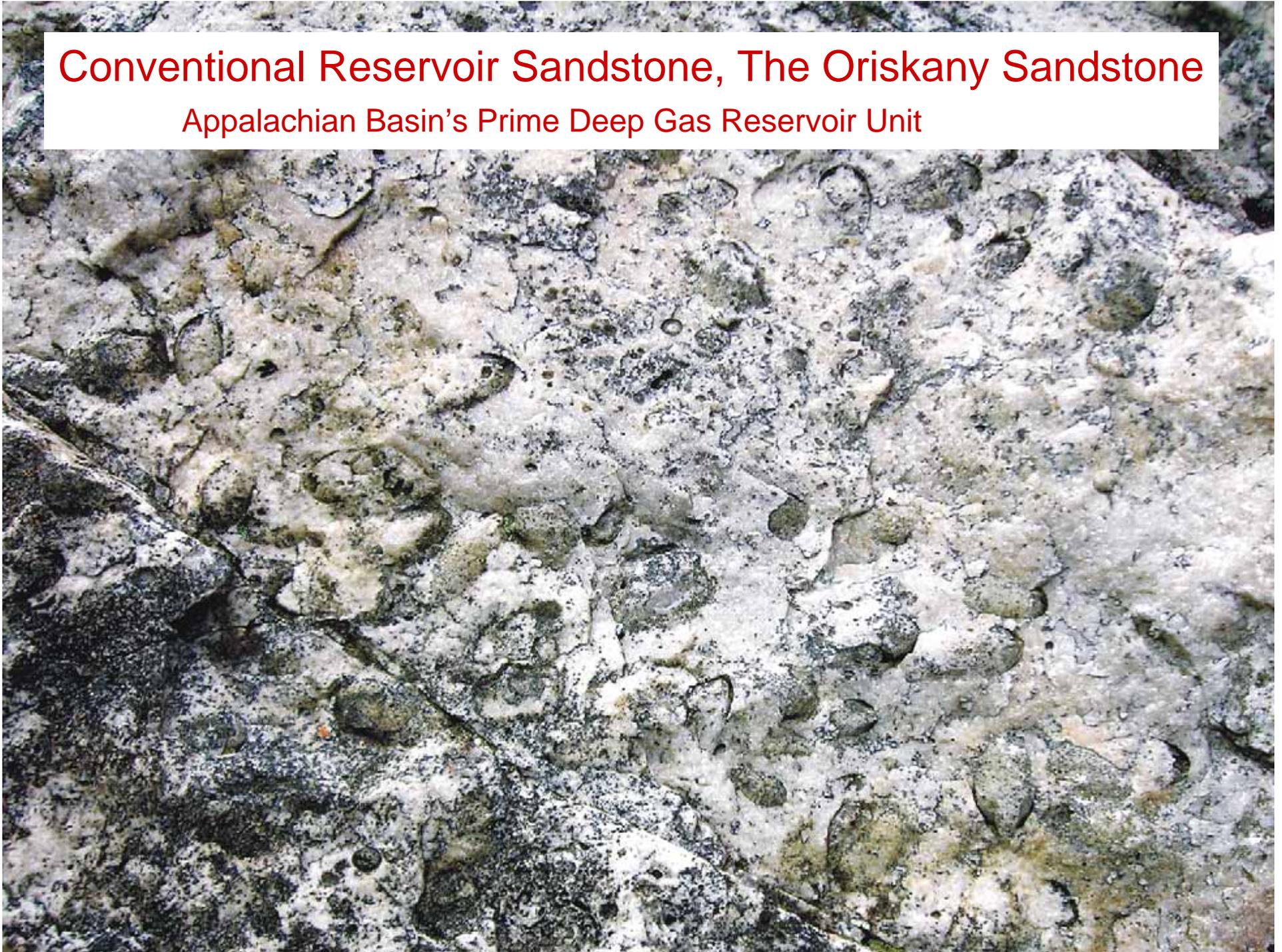
Conventional
versus
Unconventional
Gas Wells

Conventional "deep" Appalachian gas well



Conventional Reservoir Sandstone, The Oriskany Sandstone

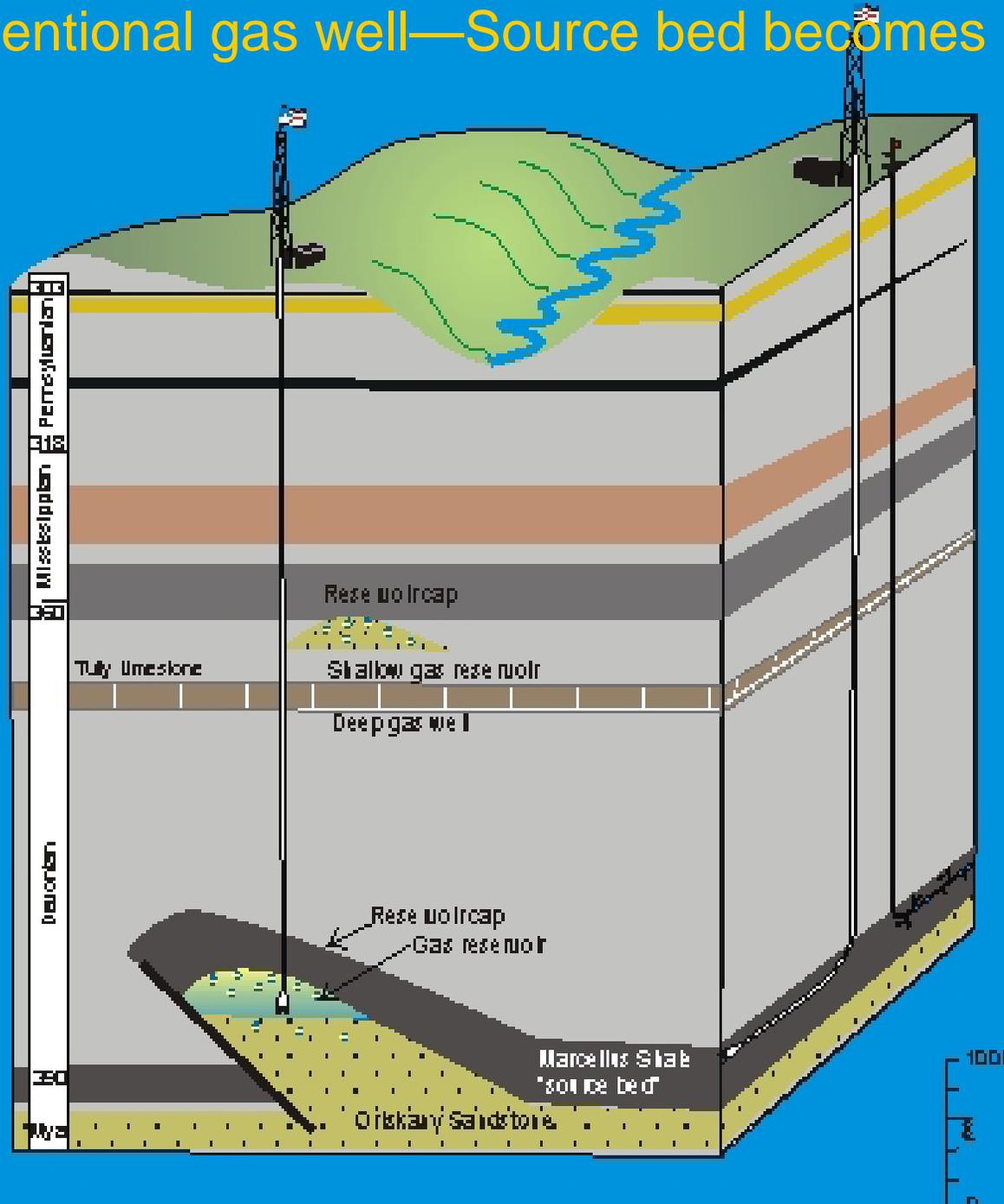
Appalachian Basin's Prime Deep Gas Reservoir Unit



Appalachian Deep Reservoir Seal or Capping Unit
The Marcellus Shale



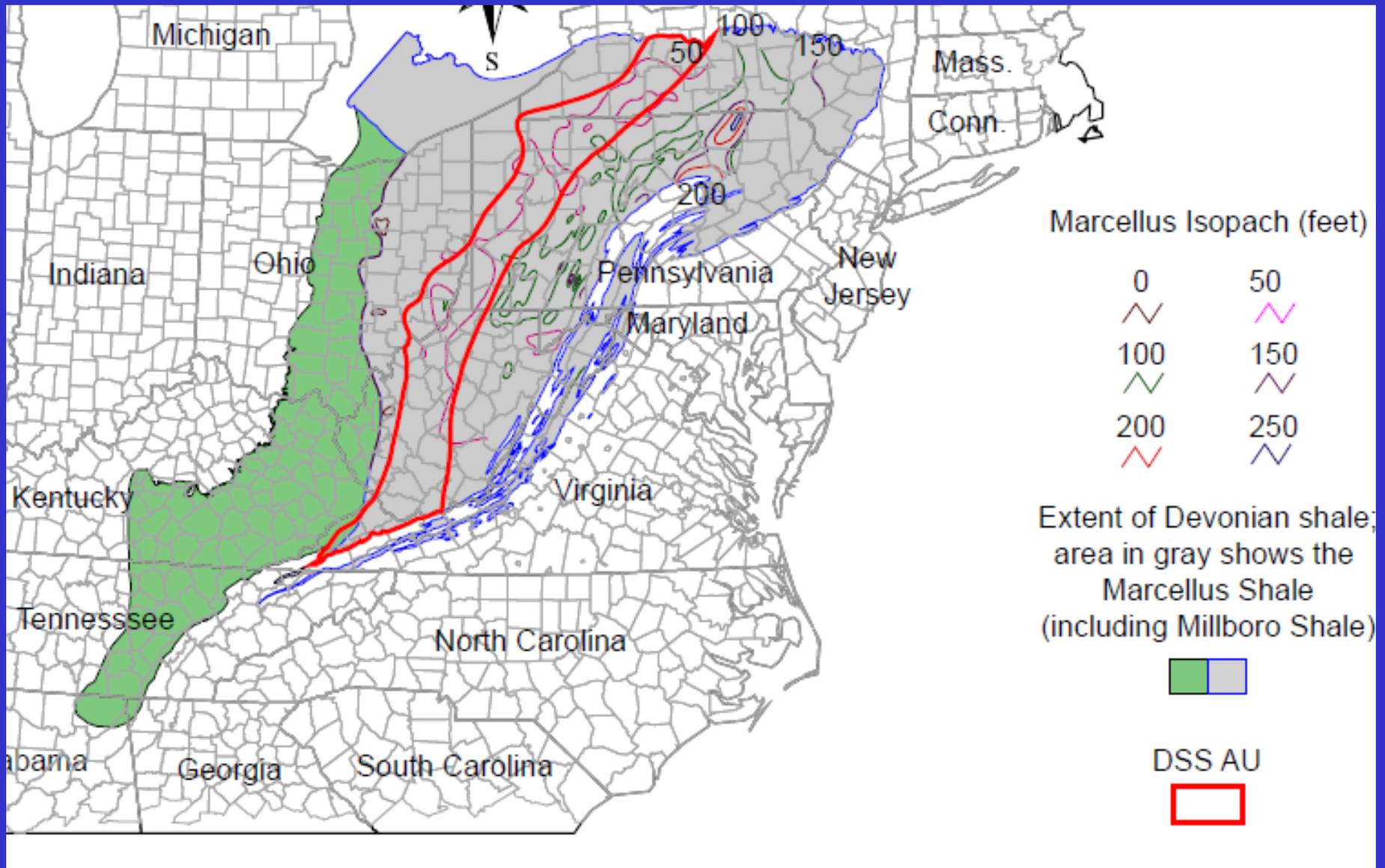
Unconventional gas well—Source bed becomes reservoir too



Key to unconventional drilling: The “downhole mud motor” drilling head



Marcellus Shale- Expansive Gas Reservoir and Source



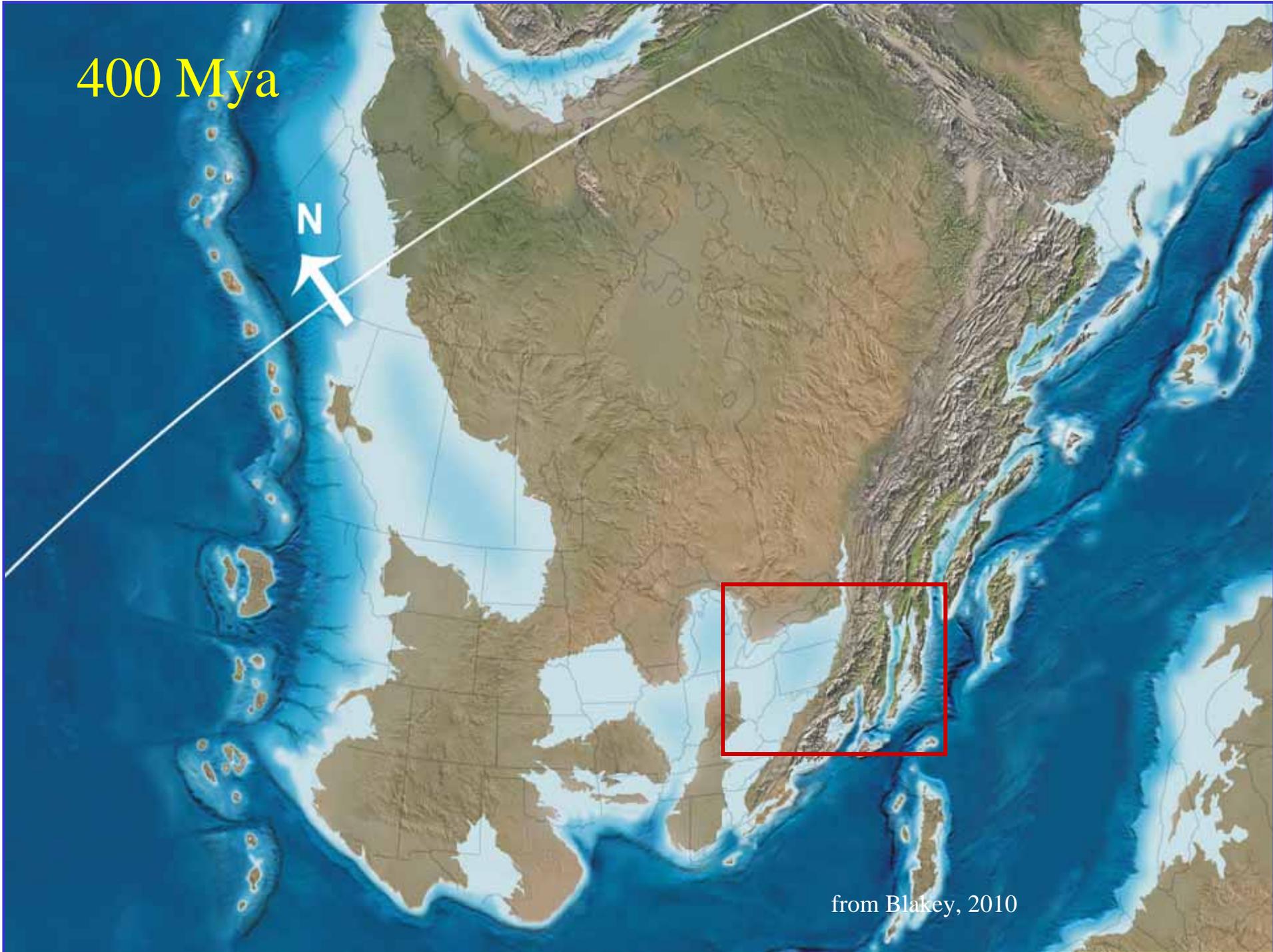
from Milici and Swezey, 2006

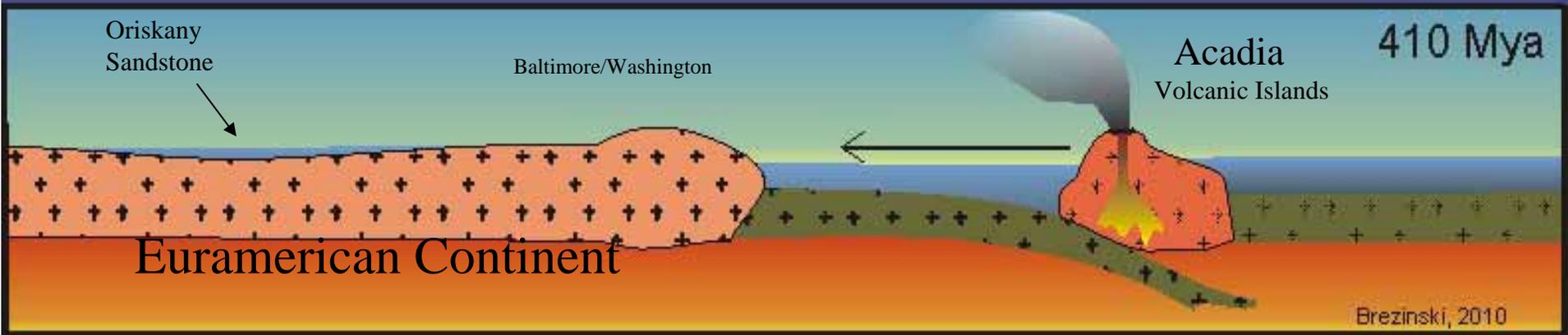
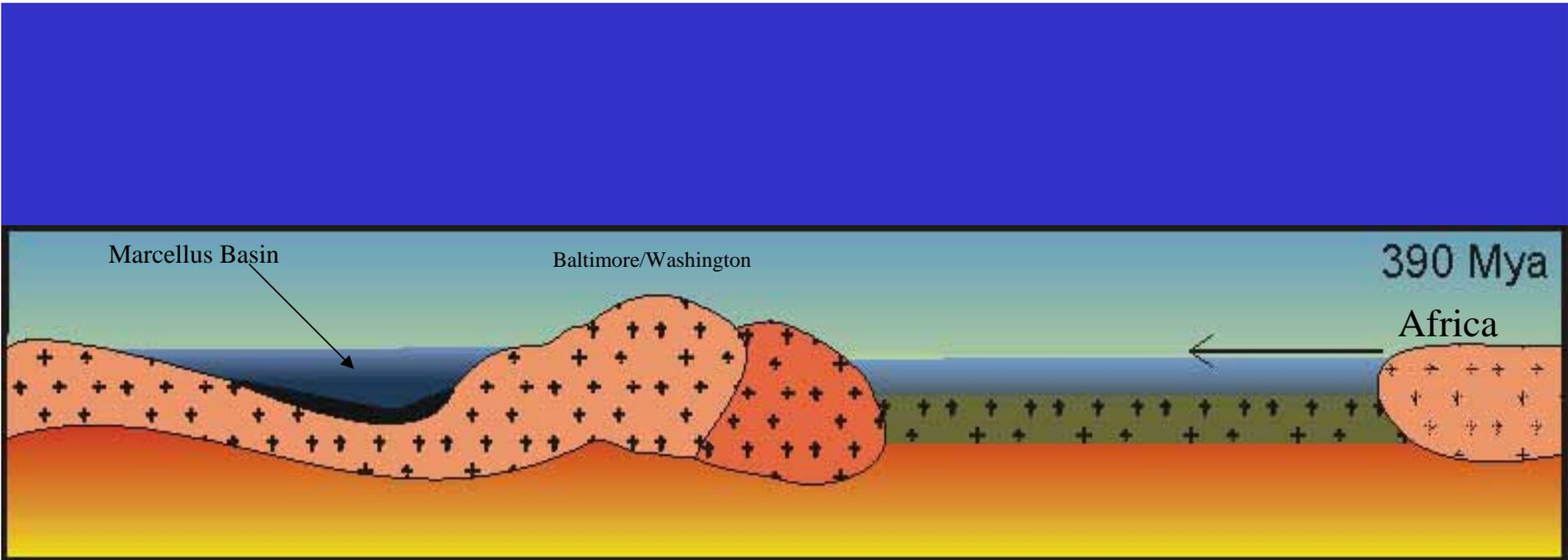
ORIGIN AND STRATIGRAPHY OF THE MARCELLUS SHALE

400 Mya



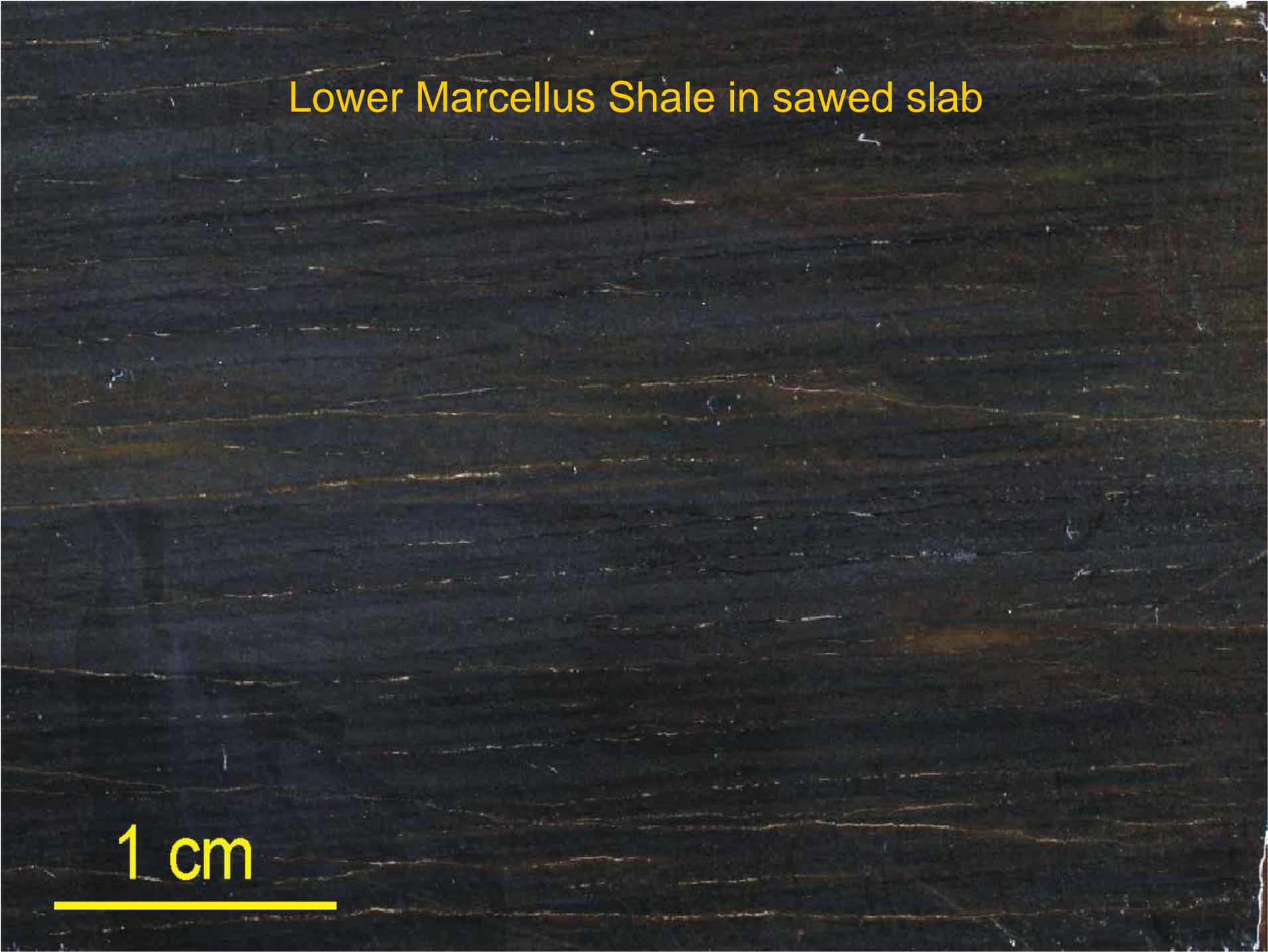
from Blakey, 2010





Lower Marcellus Shale in sawed slab

1 cm



Weathered pyrite, lower Marcellus Shale



Middle Marcellus Shale-Purcell Limestone

Purcell Limestone
Member

lower
Marcellus



Upper Marcellus Shale

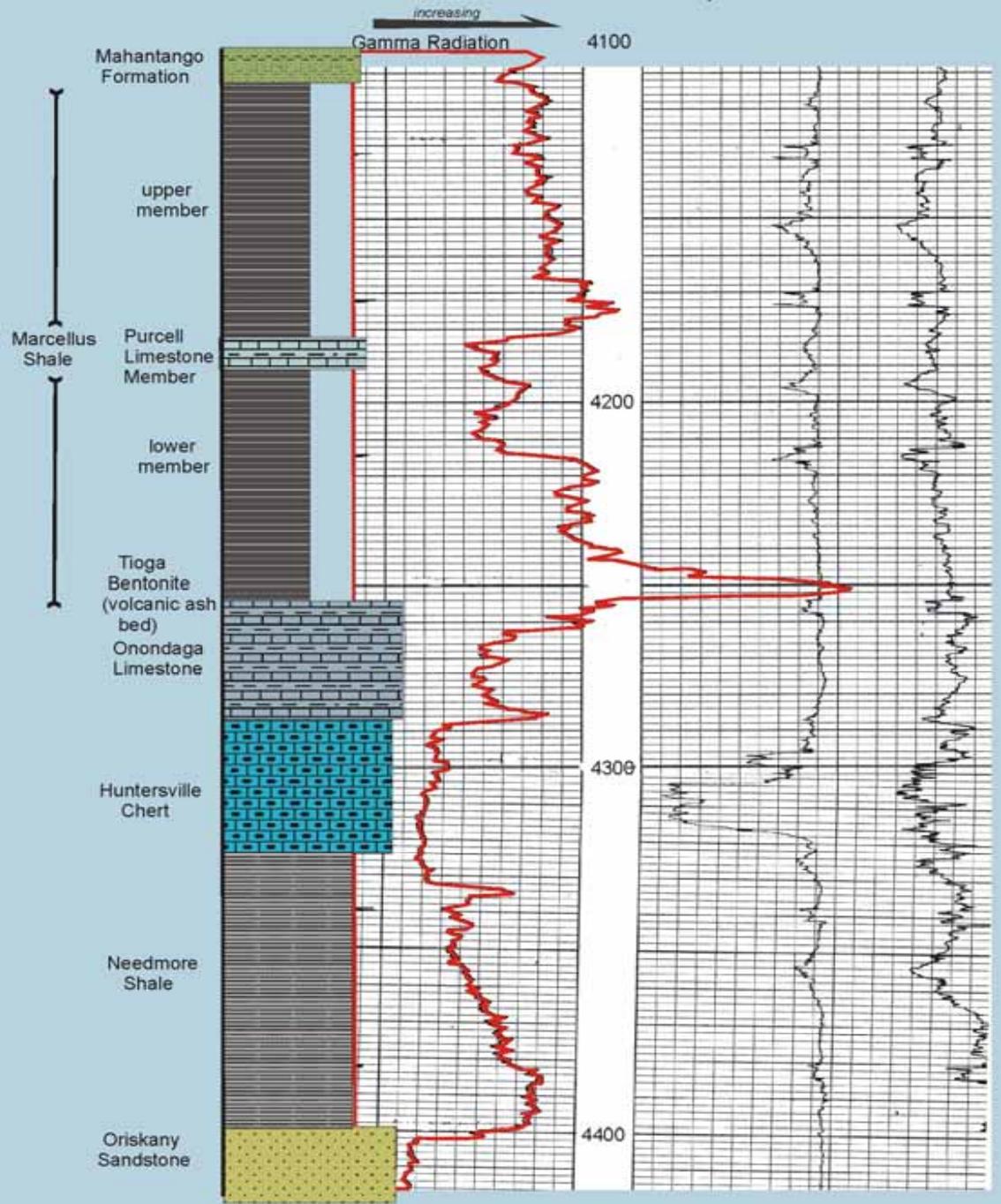


Upper Marcellus Shale in sawed slab

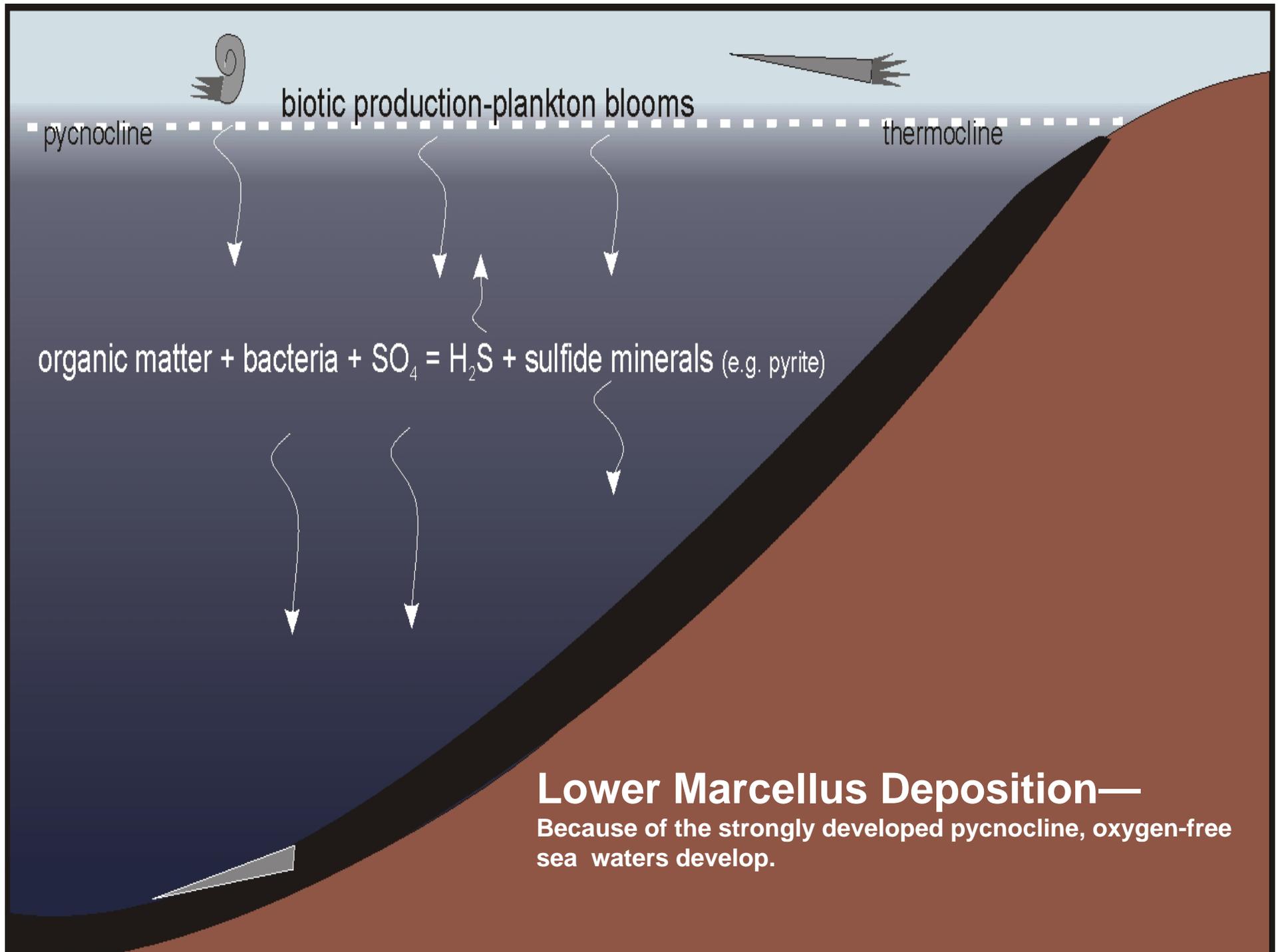
1 cm



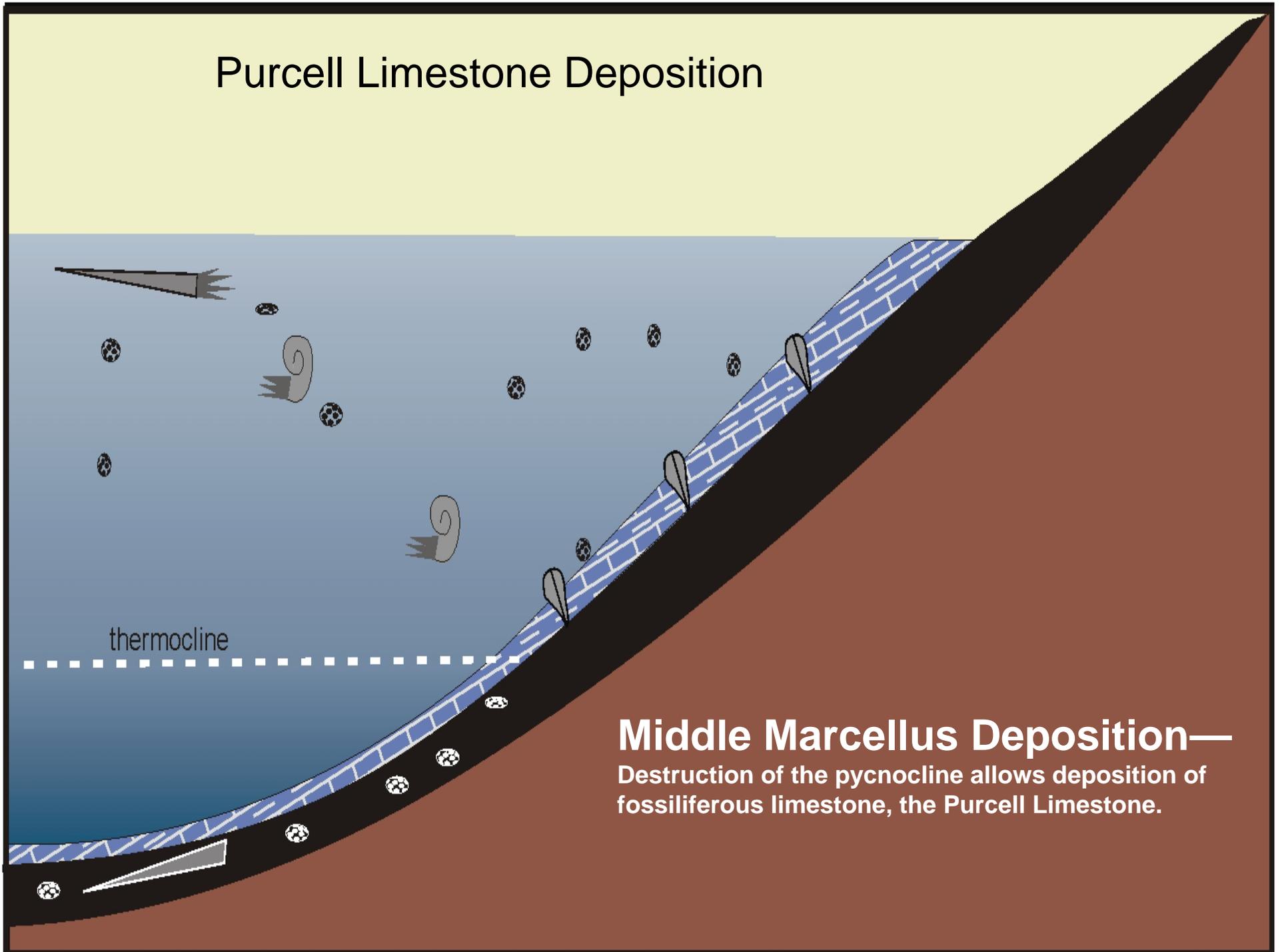
LOTTIE PEACHY #1 (Mtn Lake Park Field)



PRESERVATION AND MATURATION
OF ORGANIC MATTER
IN THE MARCELLUS SHALE

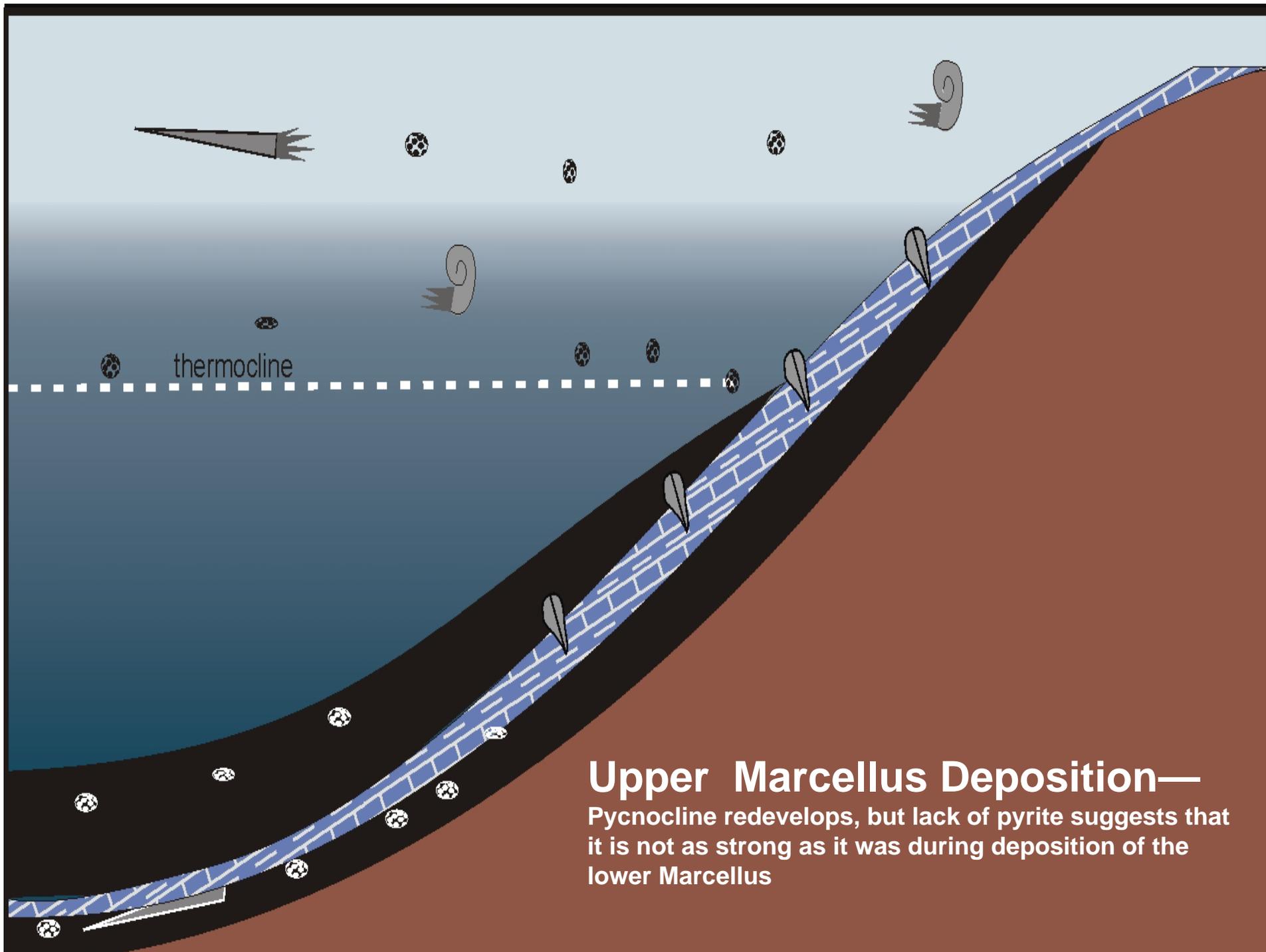


Purcell Limestone Deposition



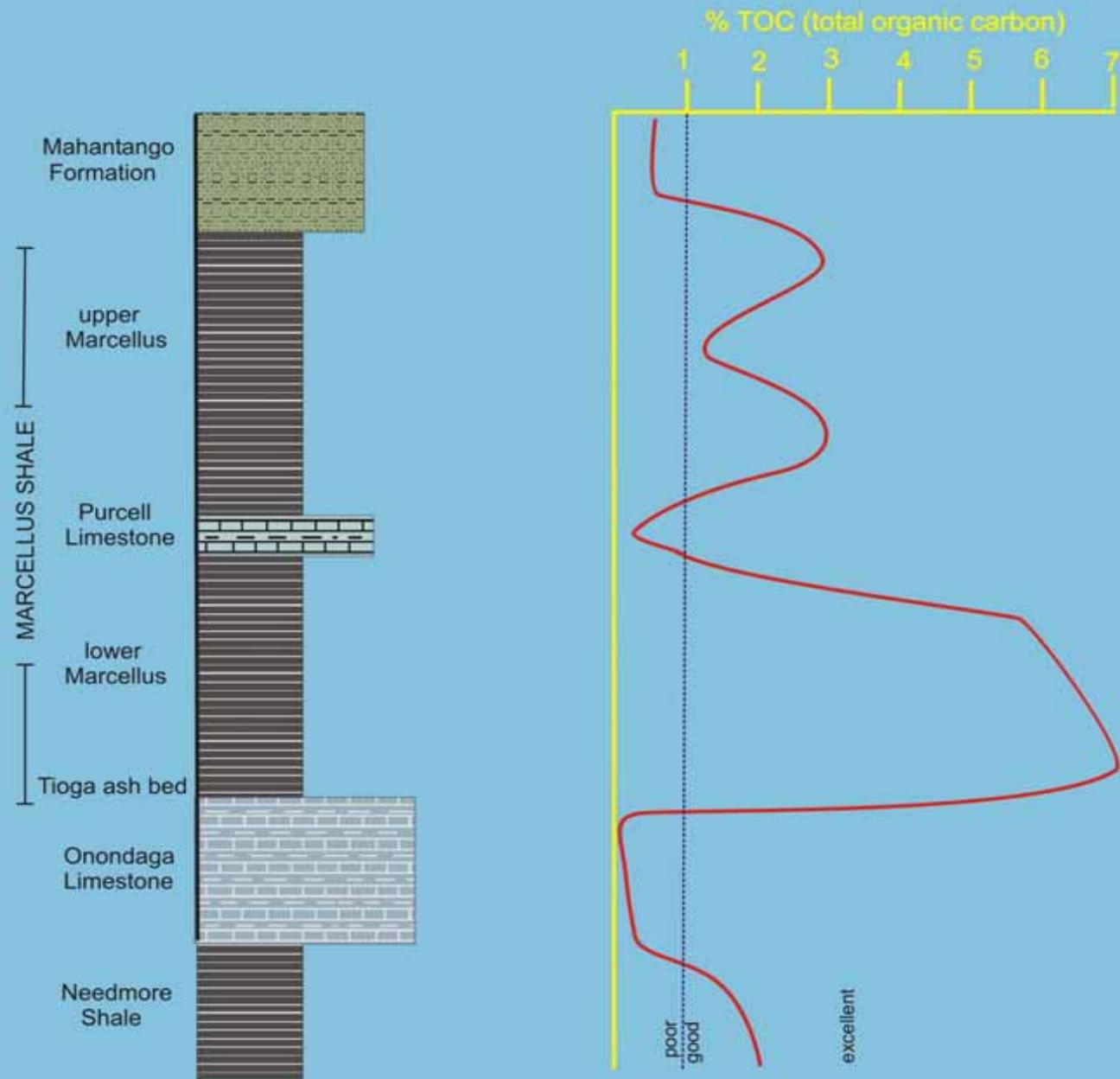
Middle Marcellus Deposition—

Destruction of the pycnocline allows deposition of fossiliferous limestone, the Purcell Limestone.



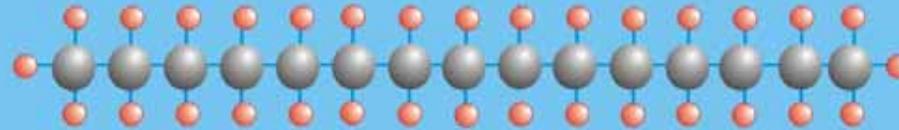
Upper Marcellus Deposition—
Pycnocline redevelops, but lack of pyrite suggests that it is not as strong as it was during deposition of the lower Marcellus

Variations of TOC (total organic carbon) within Marcellus Shale



(TOC from Pennsylvania Topographic and Geologic Survey for Allegheny County, Pennsylvania)

Fatty Acids



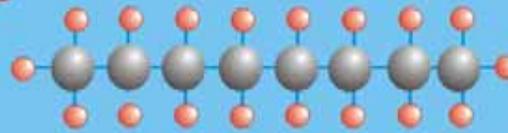
Kerogen ($C_{15}H_{32}$)

Temperature

&

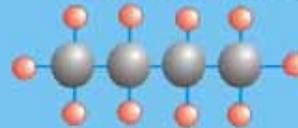
Time

(= depth of burial)

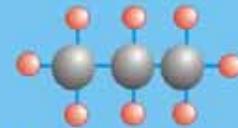


octane (C_8H_{18})

liquid @ room T

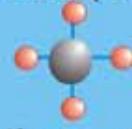


butane (C_4H_{10})



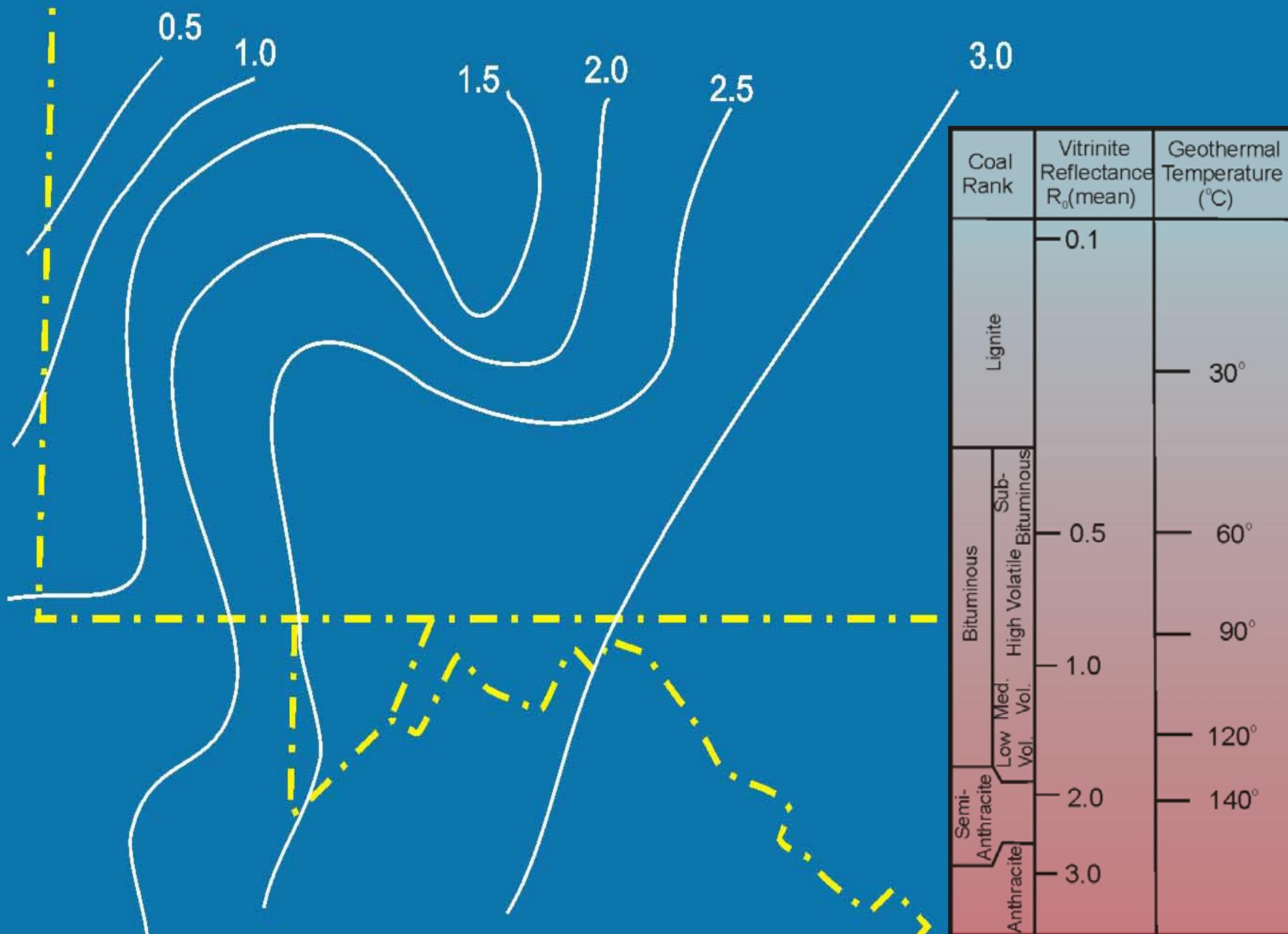
propane (C_3H_8)

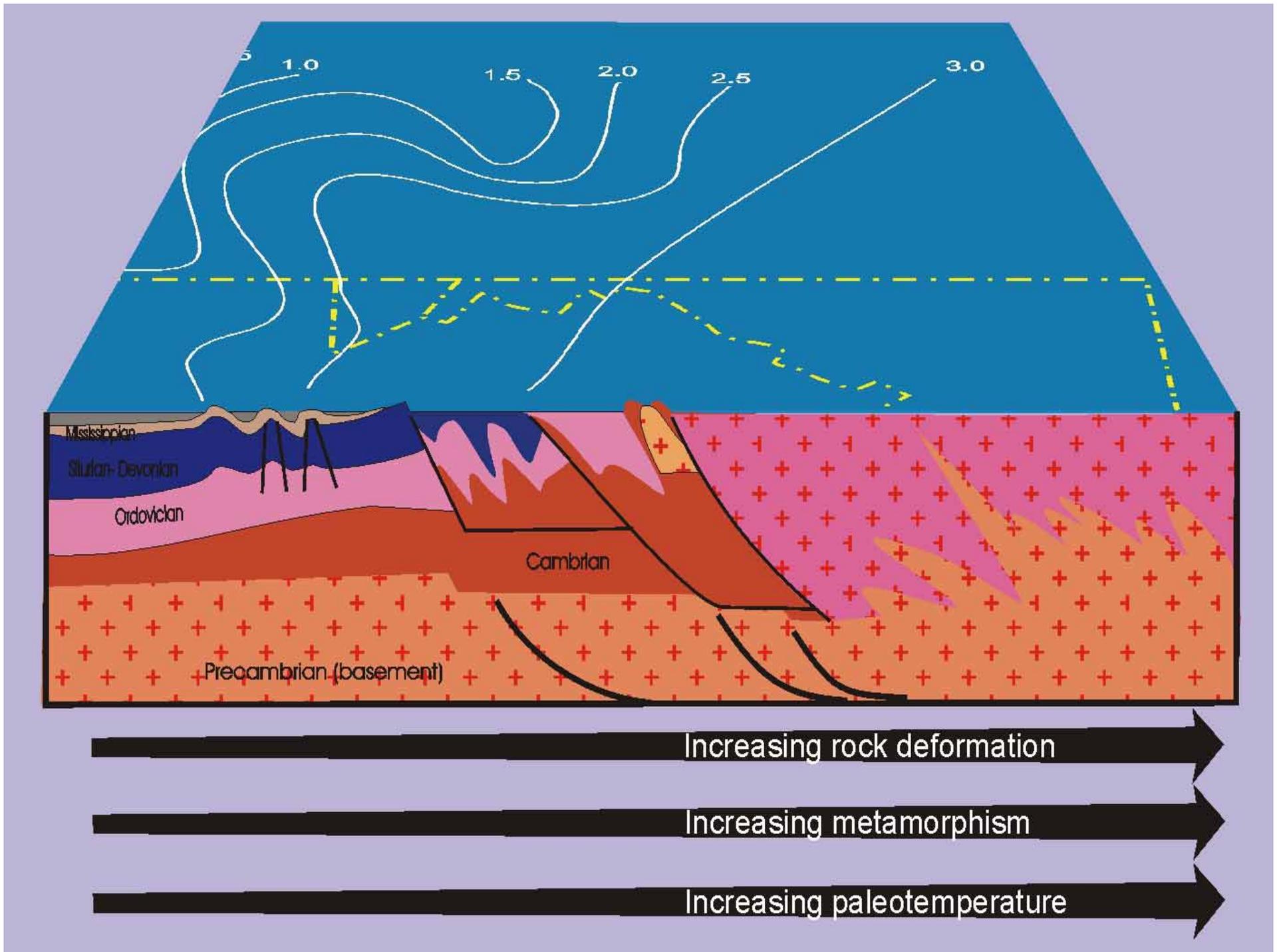
gas @ room T



methane (CH_4)

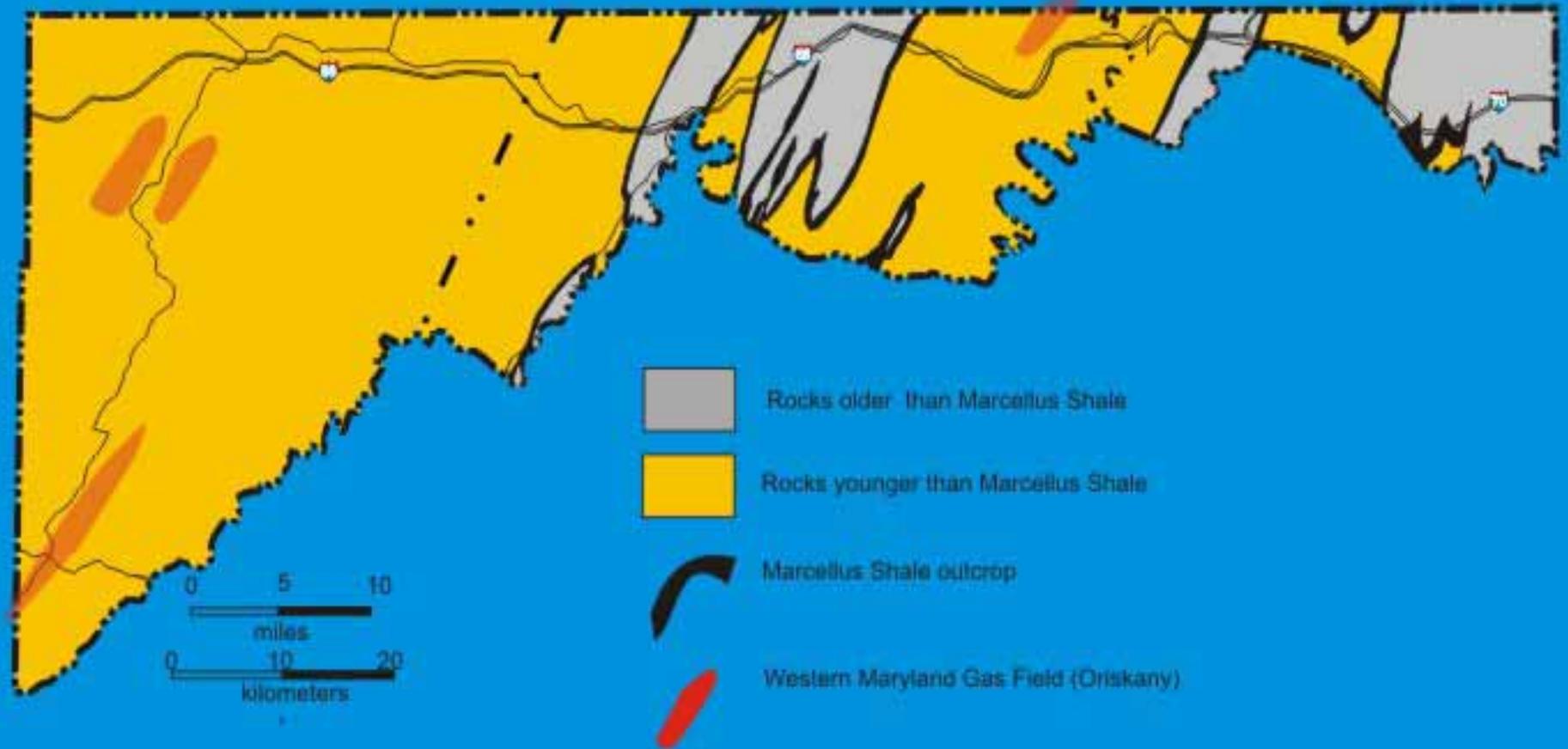
Appalachian Thermal Maturity of Organic Matter (Measured by Vitrinite Reflectance)



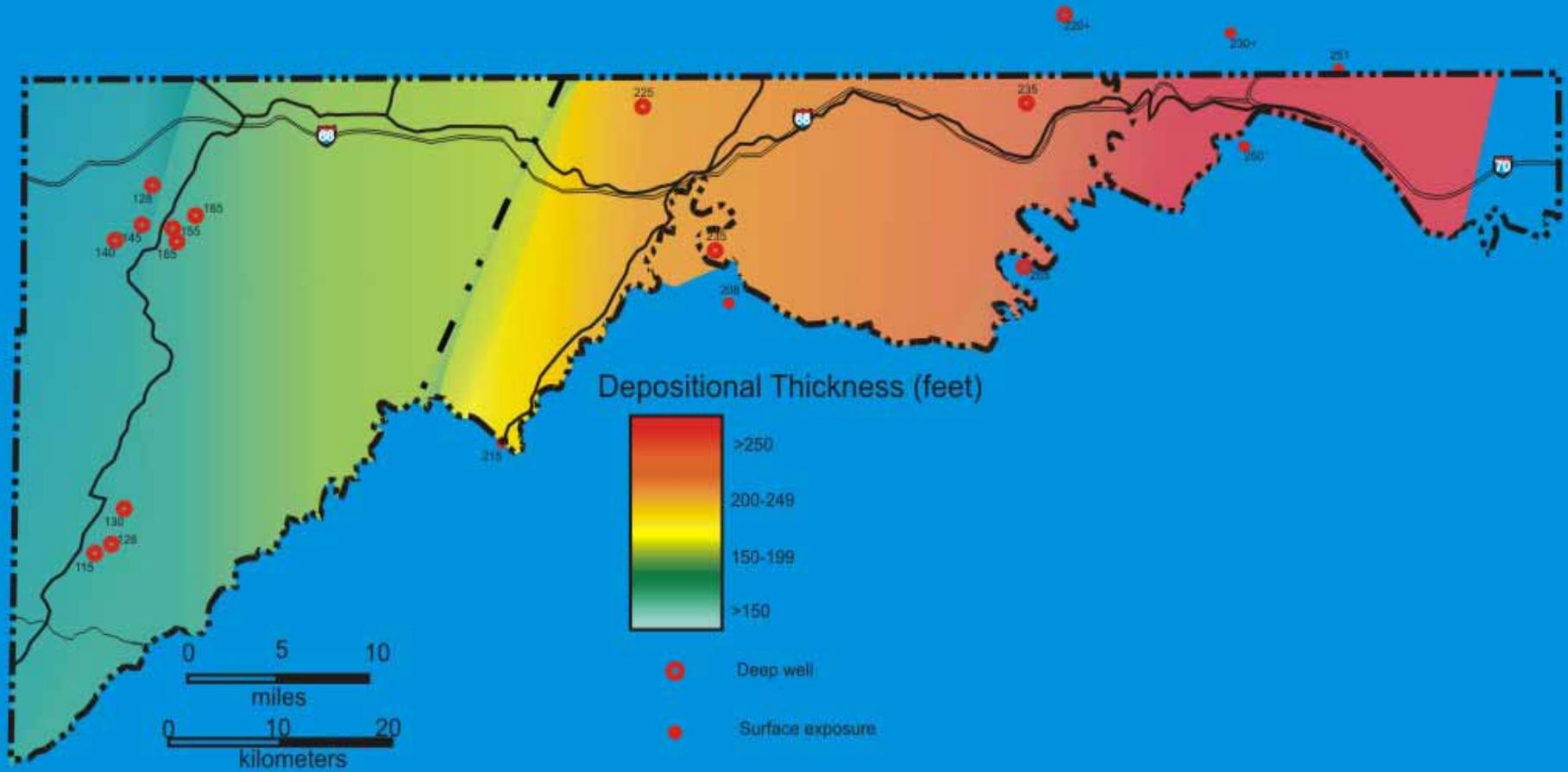


THE MARCELLUS SHALE IN MARYLAND

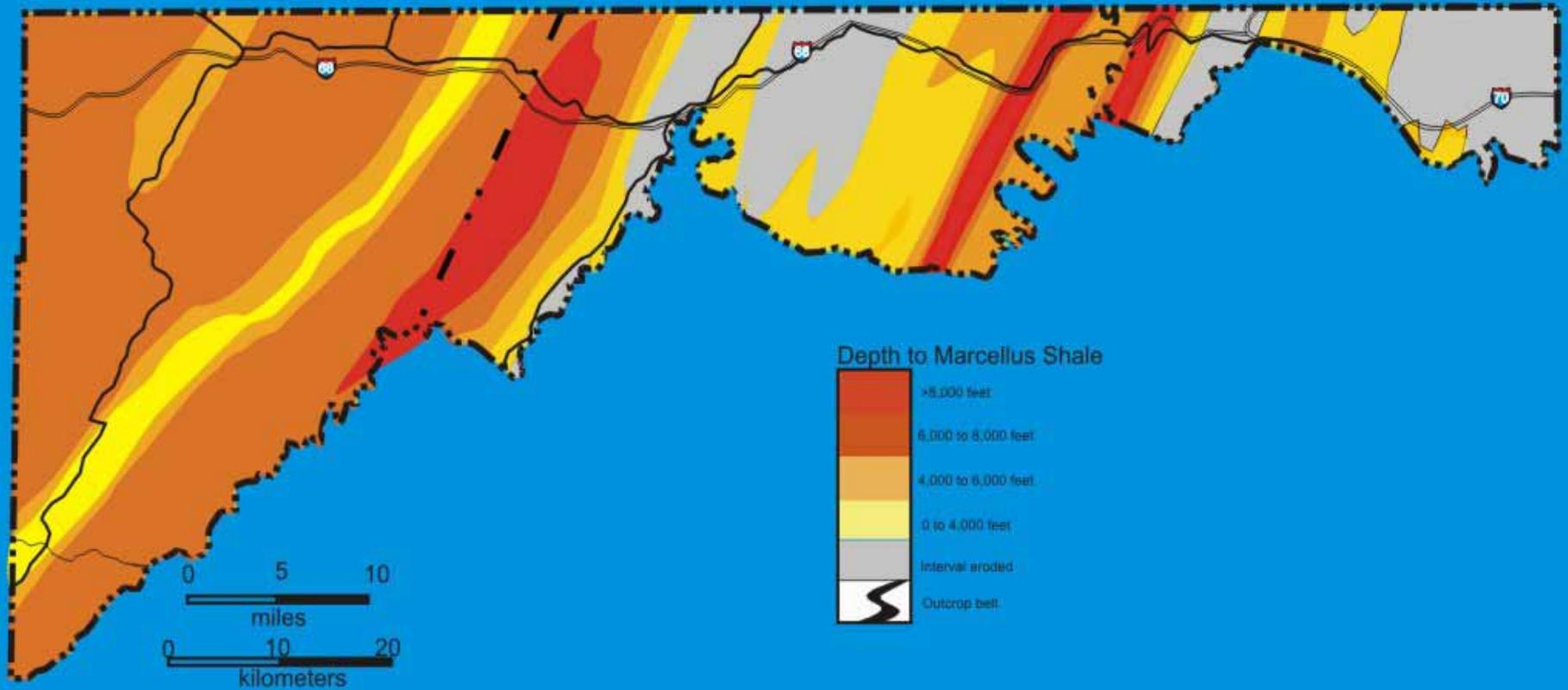
Distribution of the Marcellus Shale in Maryland

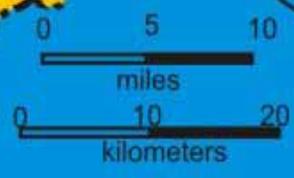
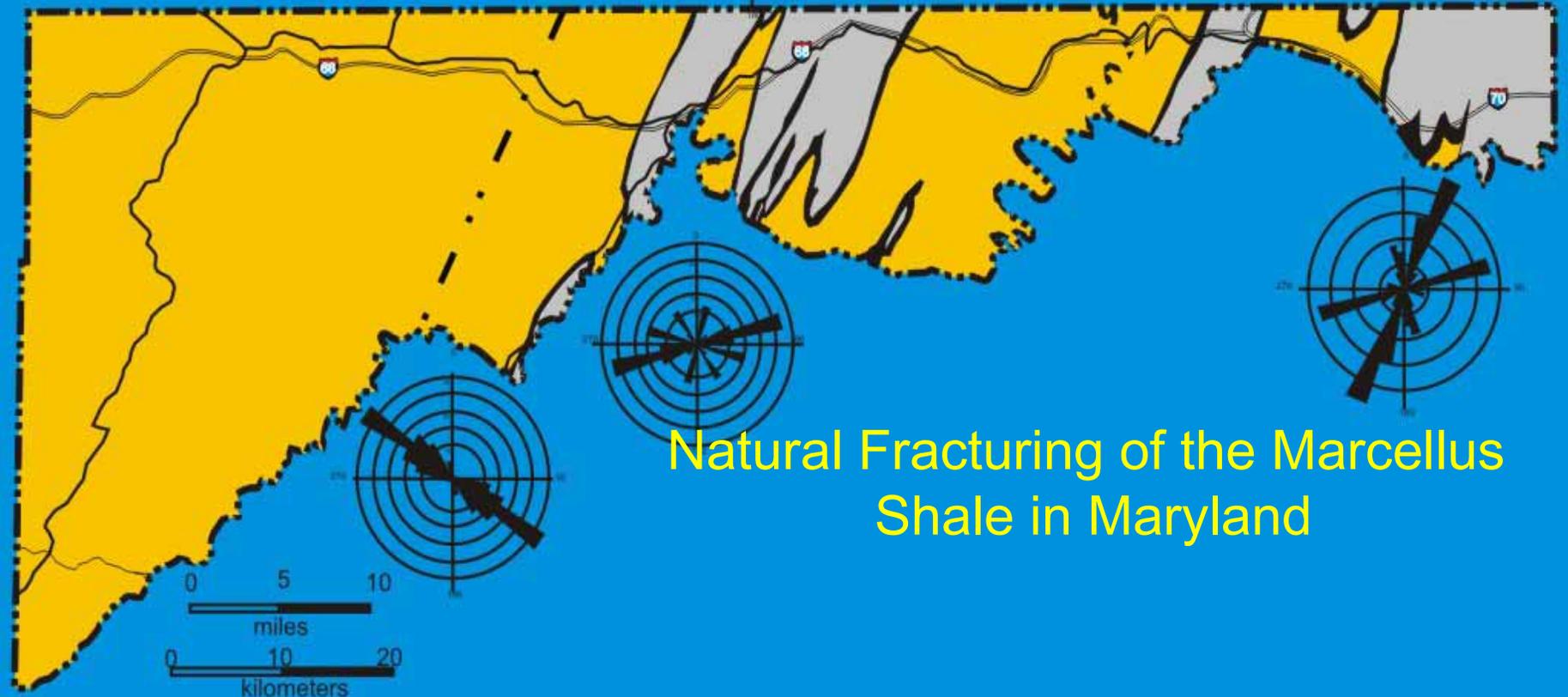


Preliminary Map Illustrating Thickness of the Marcellus Shale in Maryland



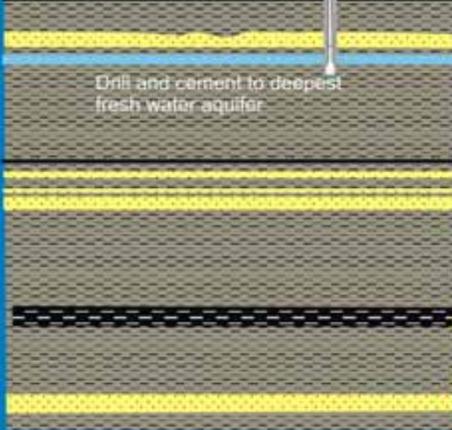
Preliminary Map Illustrating Depth to Marcellus Shale in Maryland





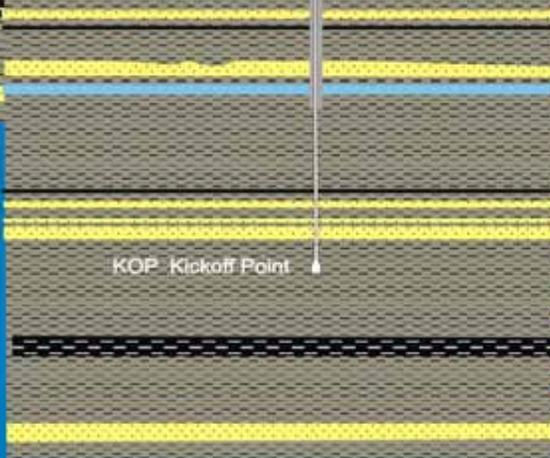
Natural Fracturing of the Marcellus Shale in Maryland

DRILLING FOR THE MARCELLUS SHALE



Drill and cement to deepest fresh water aquifer

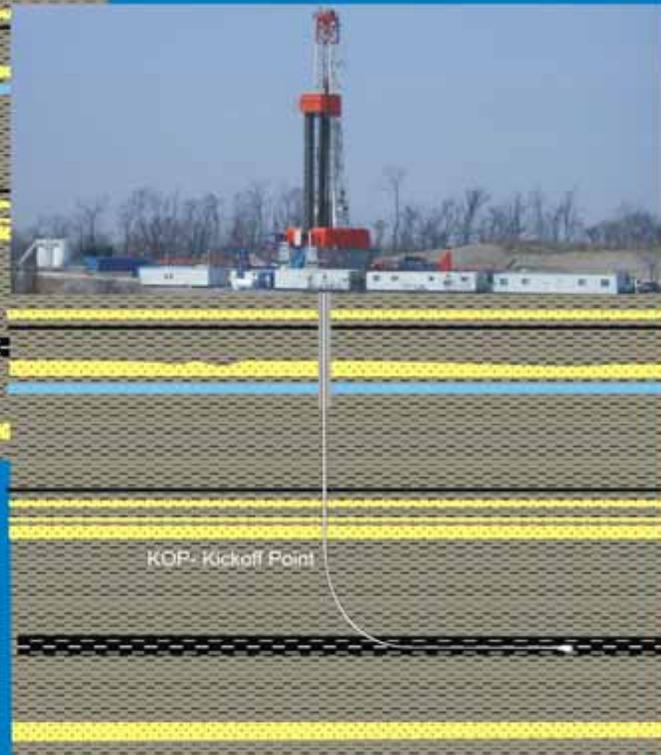
A. Conventional well is drilled to below lowest fresh-water aquifer, then well bore is cased and cemented.



KOP- Kickoff Point

B. Conventional well is continued down to the KOP (Kickoff Point).

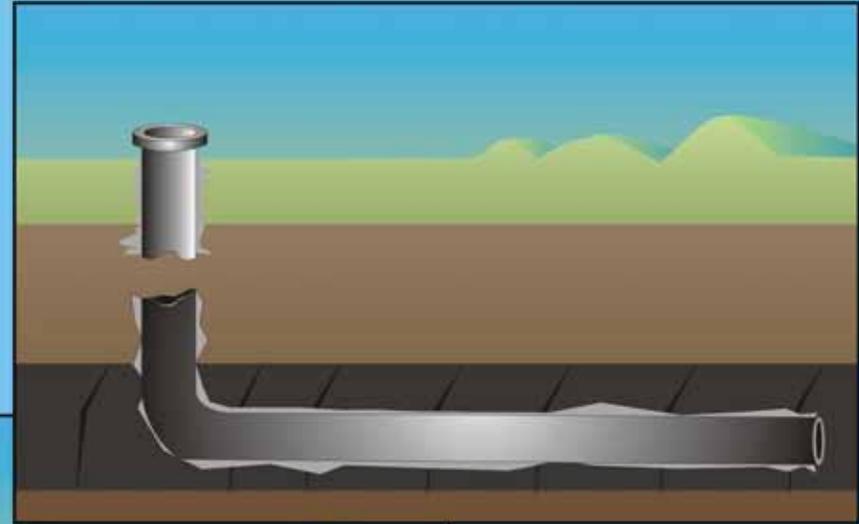
C. Downhole mud motor is inserted in to well bore at KOP, and directional drilling to and into the Marcellus Shale continues.



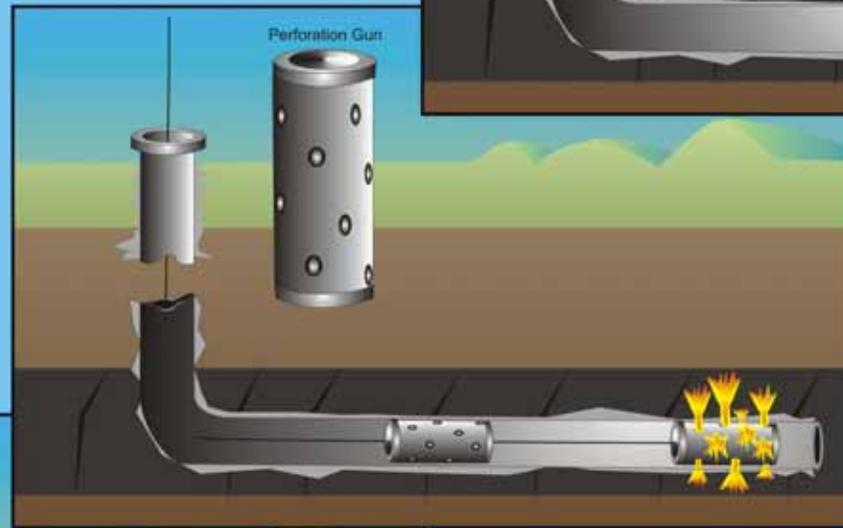
KOP- Kickoff Point

Well Completion

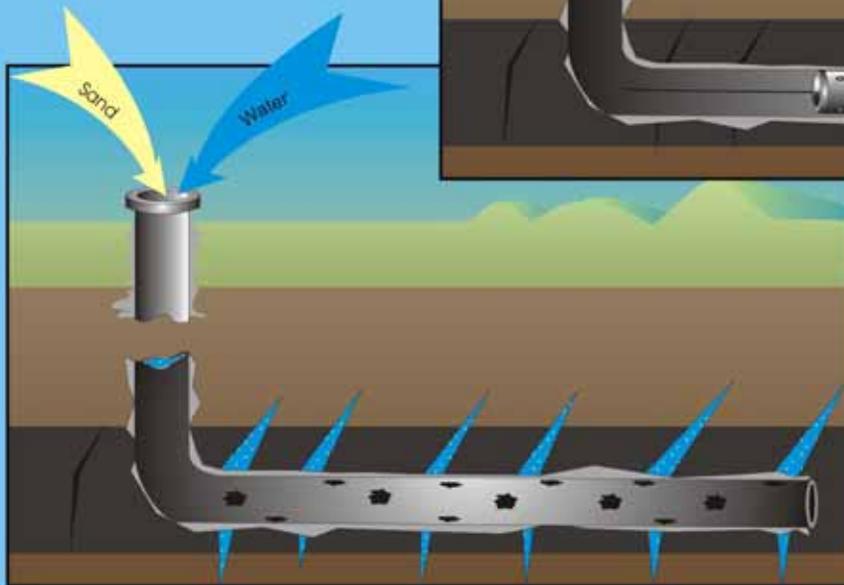
1. Cementing



2. Logging and Perforation



3. Hydraulic Fracturing and Sand Injection



Summary

- The Marcellus Shale is *the* hydrocarbon source bed for most deep Oriskany gas wells in the Appalachian Basin.
- The Marcellus Shale was deposited in an anoxic (oxygen absent) marine basin that was thousands of feet deep.
- The Marcellus Shale can be subdivided into three subunits, the lowermost containing the highest levels of TOC.
- Current estimates of in-place gas is in excess of 500 trillion cubic feet.
- Fracing (fracking) of a Marcellus unconventional wells requires up to 1 million gallons of water per thousand feet of lateral hole.