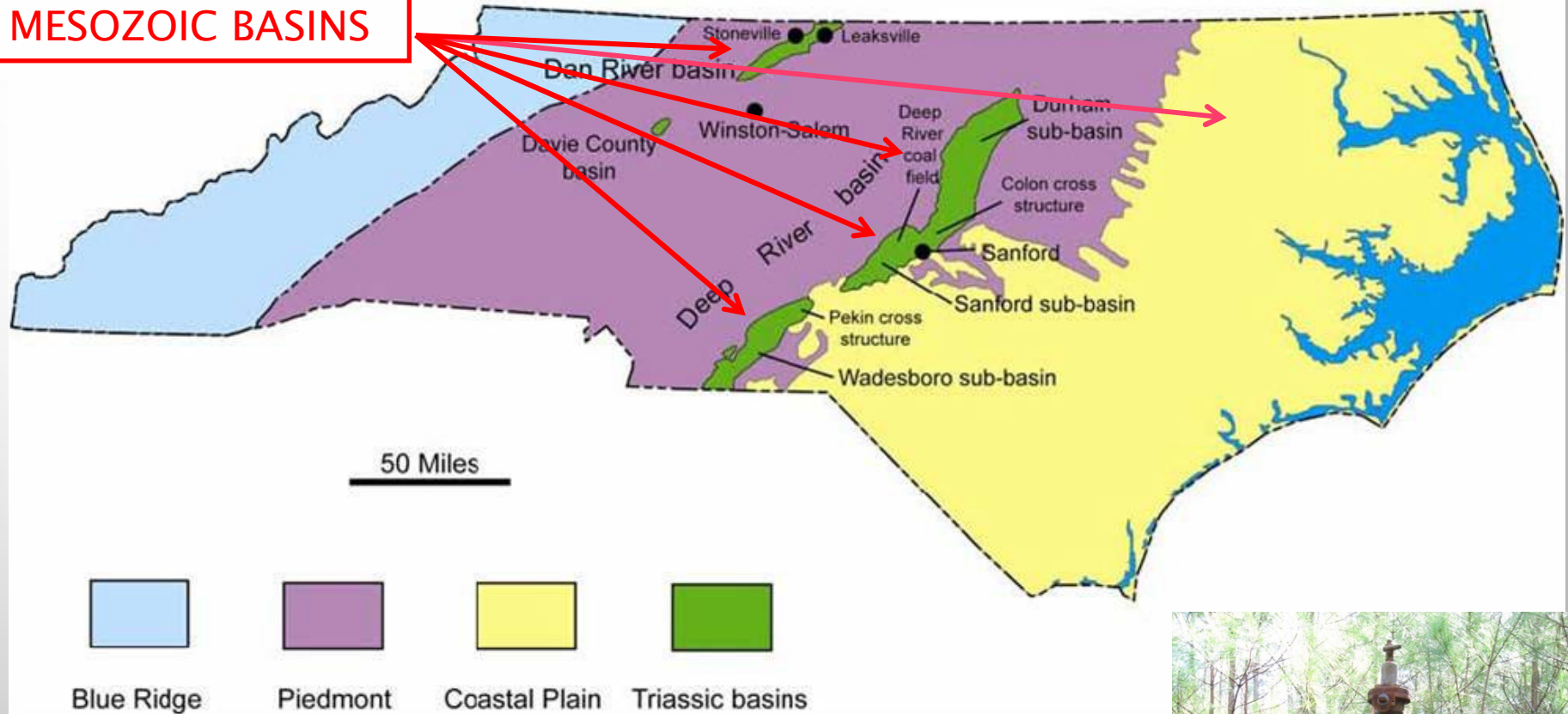


MESOZOIC BASINS



NORTH CAROLINA'S SHALE GAS POTENTIAL: WHO KNEW?

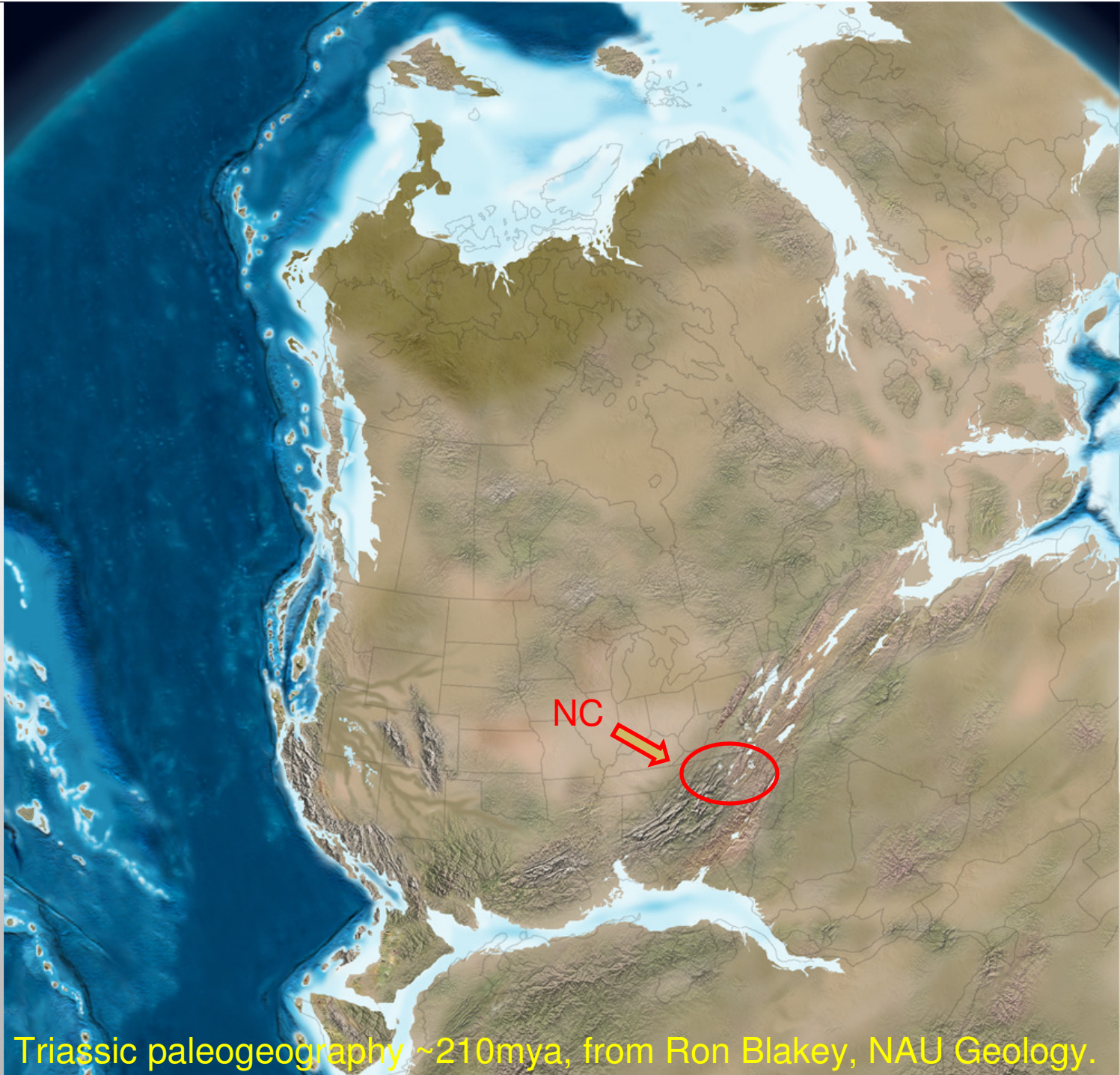
North Carolina Geological Survey



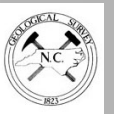
Role of N.C. Geological Survey

- ▣ The 1823 organic act which created the North Carolina Geological Survey (NCGS) tasked us to examine, describe and map the geology, geologic hazards, and mineral resources of North Carolina and publish these findings in NCGS reports and maps.
- ▣ Provide unbiased, impartial and relevant technical information to all parties.
- ▣ The NCGS is the custodian of rock cores, cuttings, geophysical logs, etc.



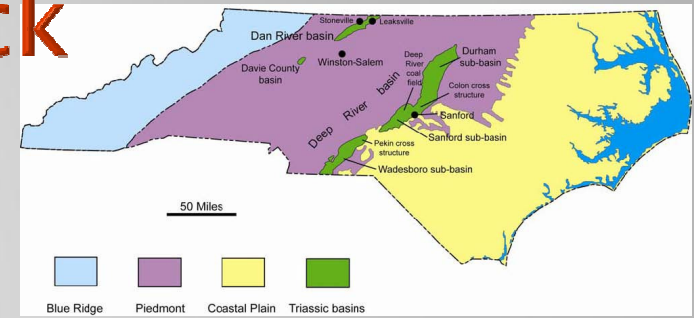


Triassic paleogeography ~210mya, from Ron Blakey, NAU Geology.



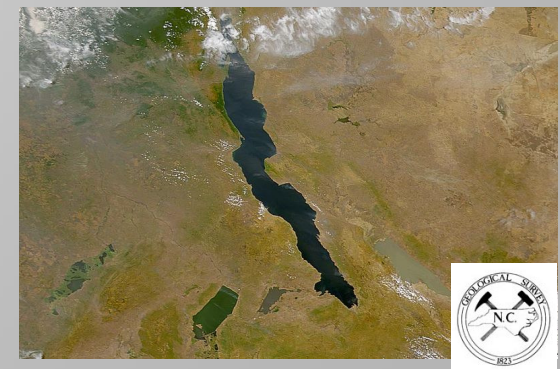


Basin and Source Rock Overview



Map showing the distribution of Mesozoic basins in North Carolina (from Reid and Milici, 2008).

- Deep River Basin – 150-mile-long northeast trending half-graben (rift basin) with a steeply dipping eastern border fault.
- ~7,000 feet of Triassic strata.
- Lake deposits similar to African rift valley lakes.
- ~59,000+ acre prospective area.
- Total petroleum system containing:
 - Source rock
 - Seal
 - Traps / reservoir
- Relatively untested exploration area.

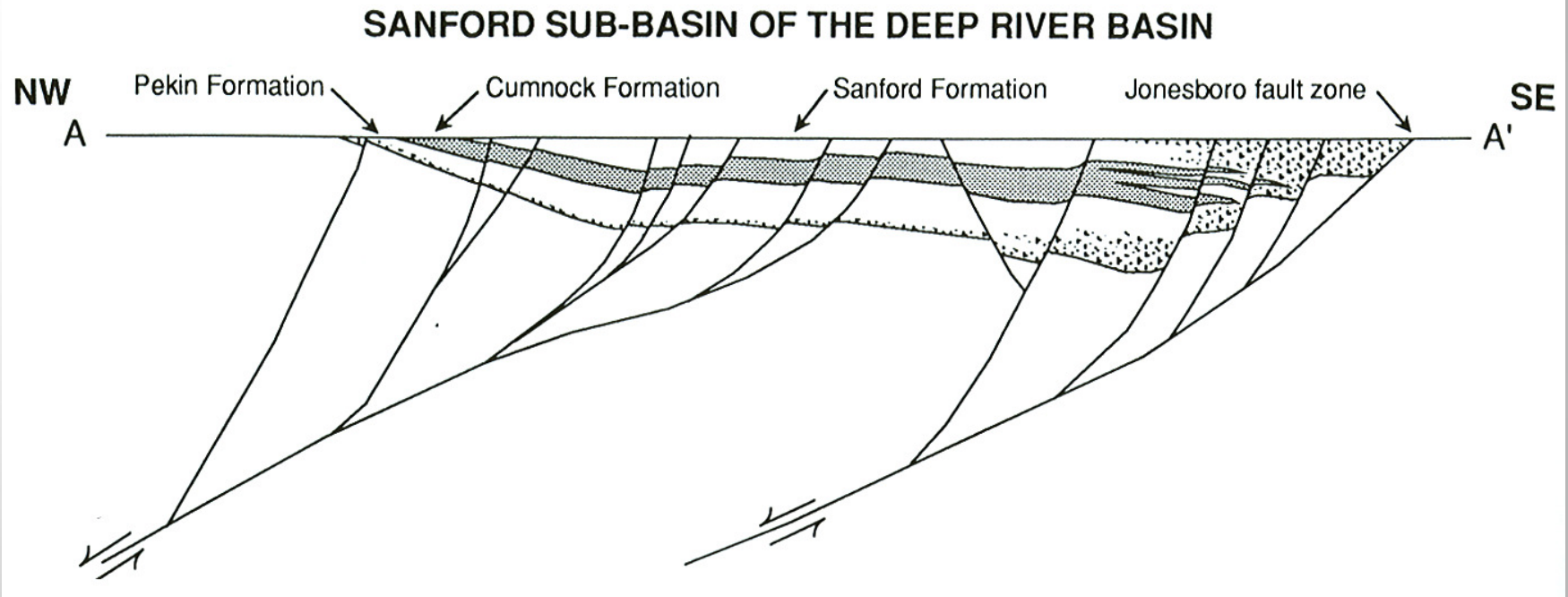


Time line – Deep River Basin

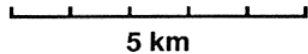
- ▣ 1775 – Revolutionary War era, coal exploration for iron and munitions.
- ▣ 1861 – 1873 – Civil war and post war coal production.
- ▣ 1920's – 1940's – Underground coal mining, exploration; 1925 coal mine explosion (killed 53 workers).
- ▣ 1980's – 1990's – Petroleum drilling (preceded seismic – vertical holes).
- ▣ 2008 – Organic geochemical data published (*Reid and Milici – USGS OFR 2008-1108*). NCGS recognizes thick section of organic shale as a potential gas resource.
- ▣ 2009 NCGS publishes 'Natural Gas and Oil in North Carolina' Information Circular 36.
- ▣ 2009 NCGS Open-File Report 2009-01 (Shale Gas Potential...).
- ▣ 2009 – 2010 Presentations made to interested industry, governmental and environmental groups.
- ▣ 2010 North Carolina Geological Survey / U.S. Geological Survey Resource assessment (currently in progress).

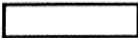





Generalized cross section



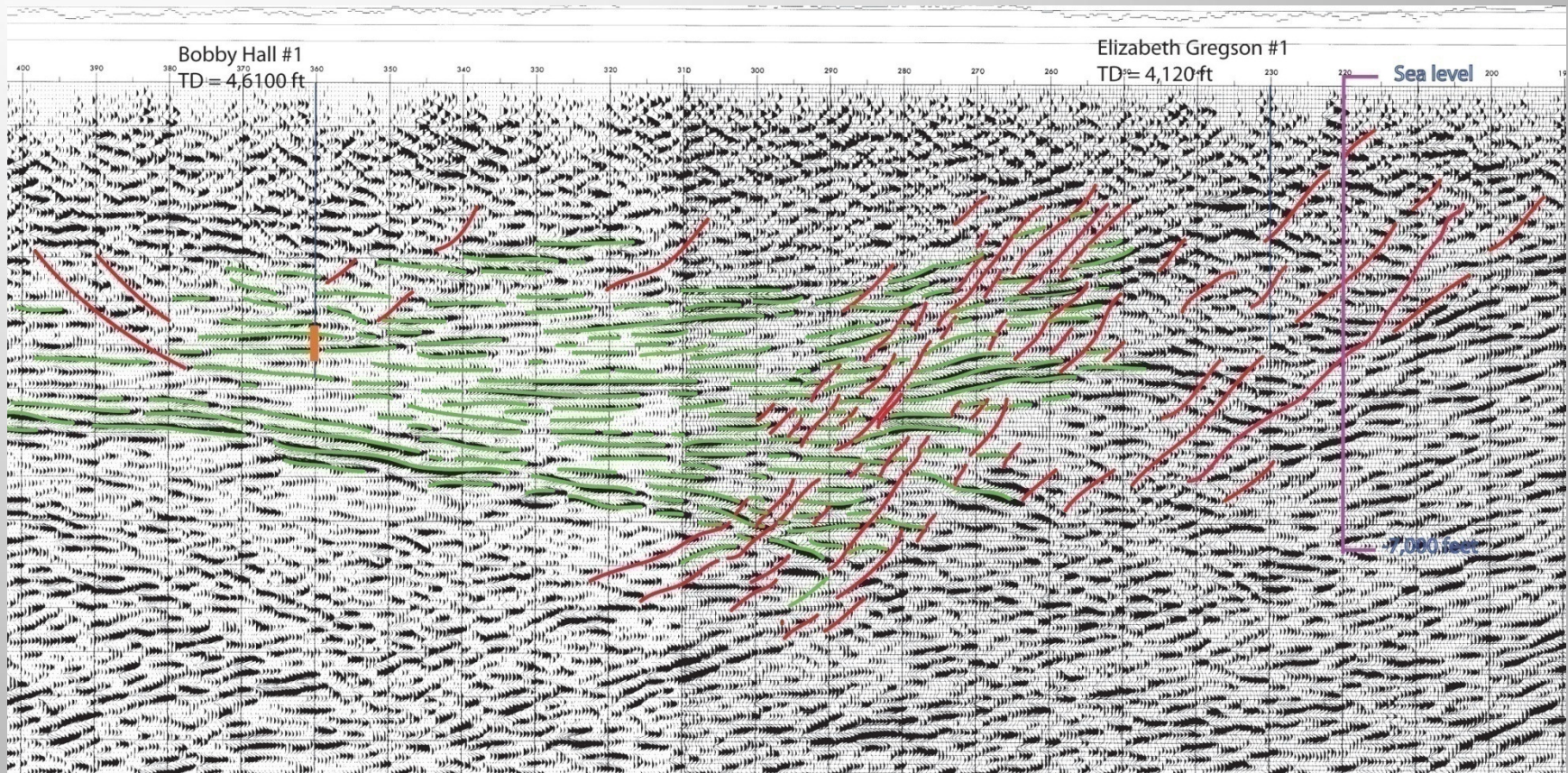
vertical scale = horizontal scale



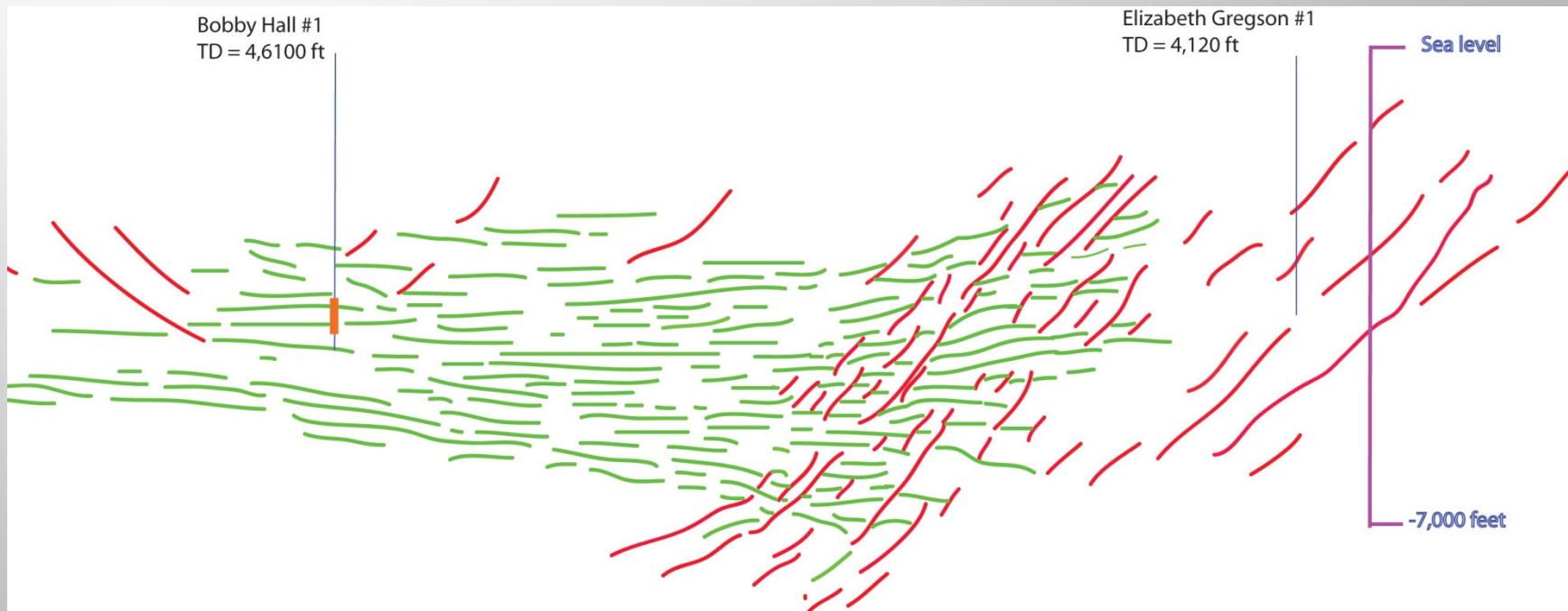
-  Mostly fluvial, red and brown clastic rocks
-  Lacustrine gray and black fine-grained clastic rocks
-  Red, brown, and gray conglomerate and sandstone
-  Major normal faults

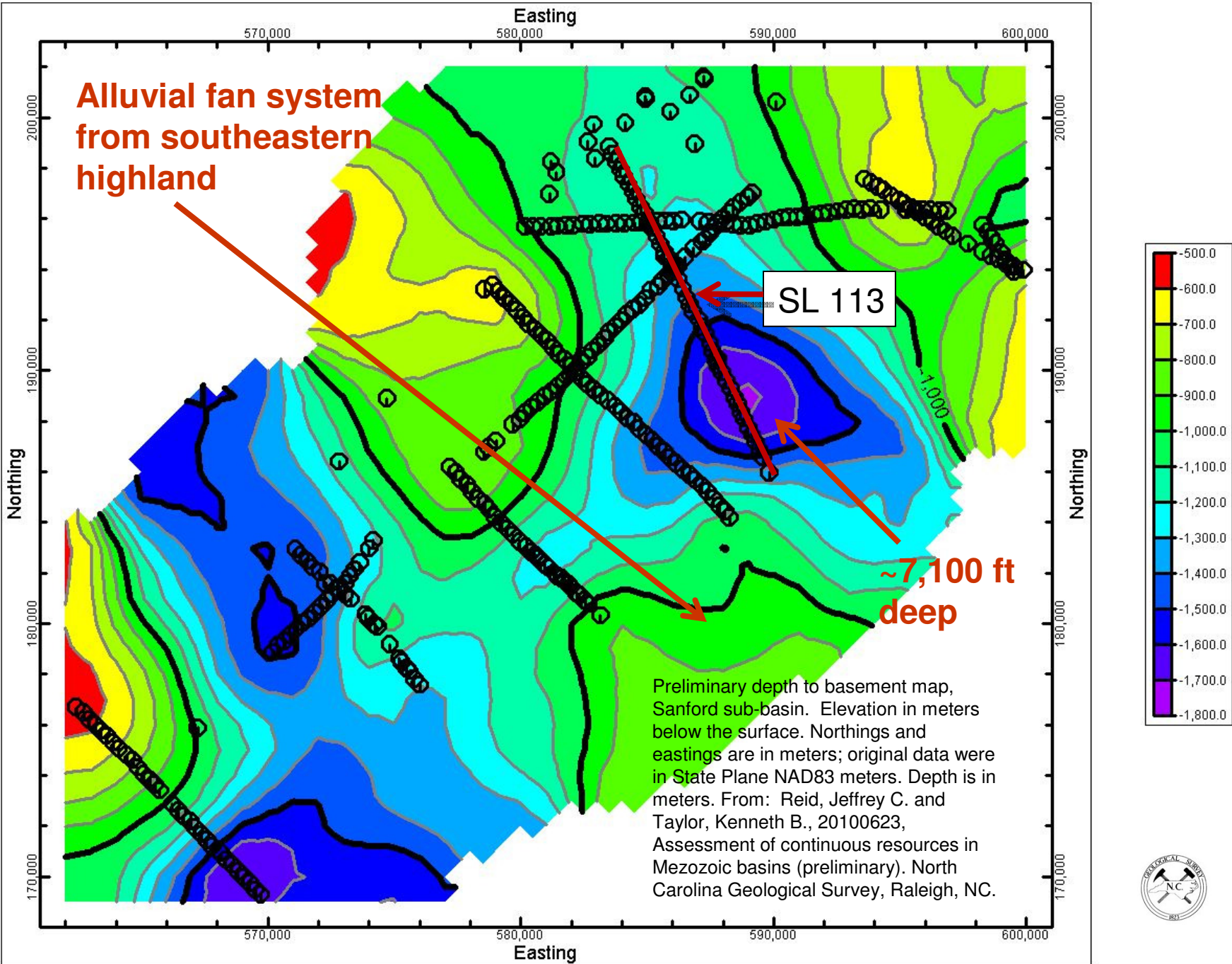


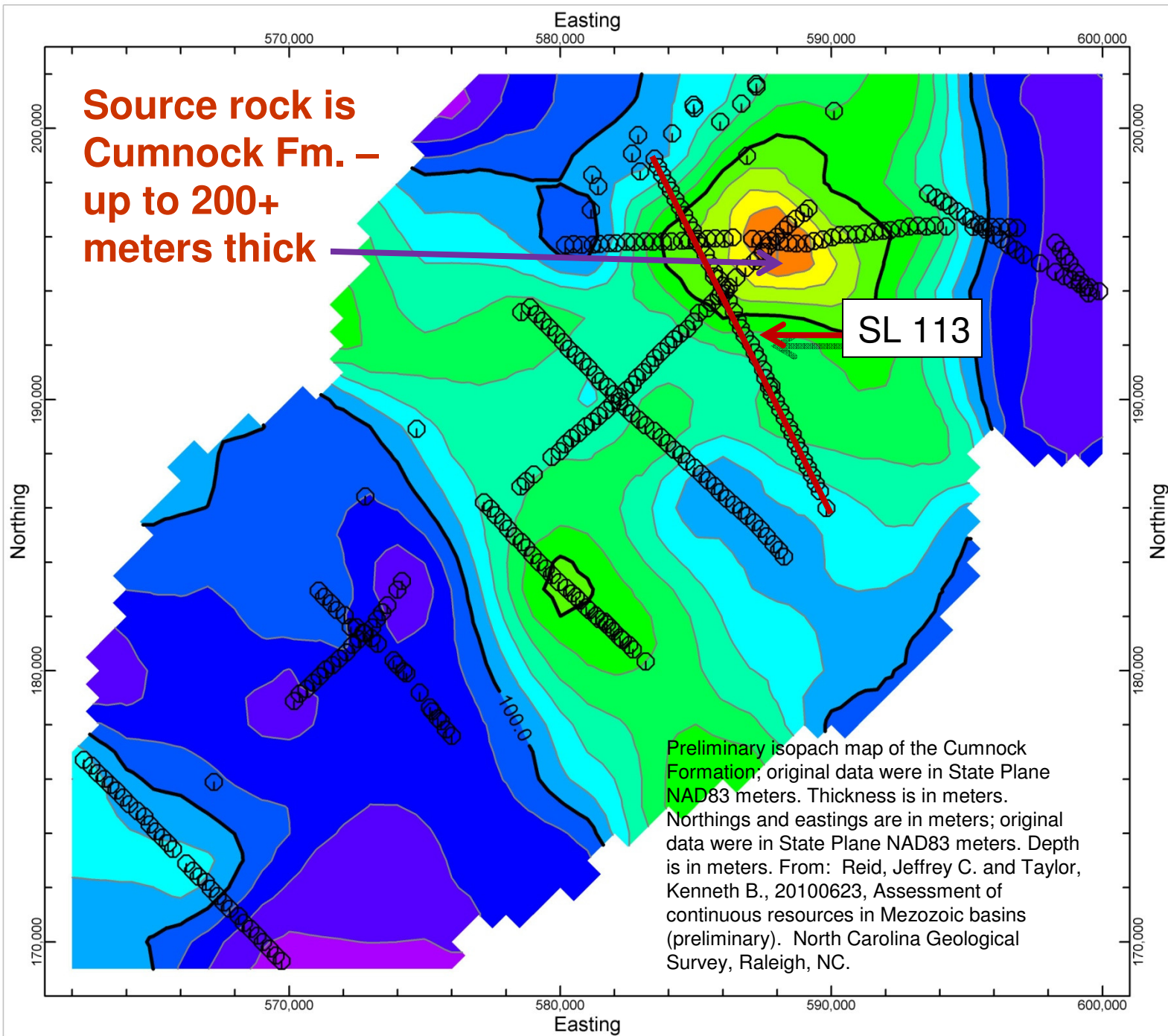
Seismic Line 113



Seismic Line 113







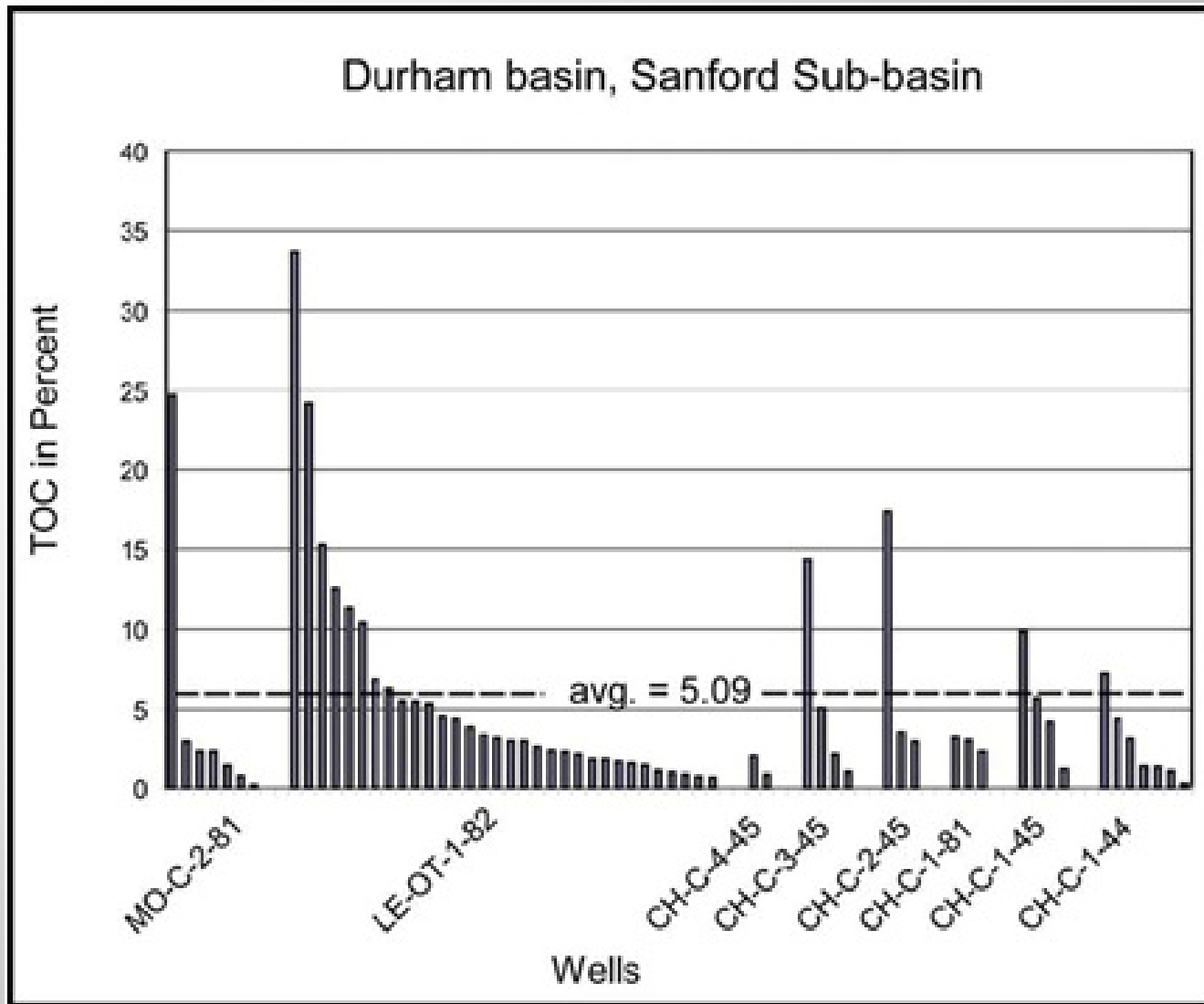
Preliminary isopach map of the Cumnock Formation; original data were in State Plane NAD83 meters. Thickness is in meters. Northings and eastings are in meters; original data were in State Plane NAD83 meters. Depth is in meters. From: Reid, Jeffrey C. and Taylor, Kenneth B., 20100623, Assessment of continuous resources in Mesozoic basins (preliminary). North Carolina Geological Survey, Raleigh, NC.



Organic geochemistry

- ▣ Sediments are predominantly gas prone with some oil shows.
- ▣ TOC data exceeds the conservative 1.4% threshold necessary for hydrocarbon expulsion.
- ▣ Organic matter derived from terrestrial Type III woody (coaly) material and from lacustrine Type I (algal material).
- ▣ Thermal alteration data (TAI) and vitrinite reflectance data (%Ro) indicate levels of thermal maturity suitable to generate hydrocarbons.

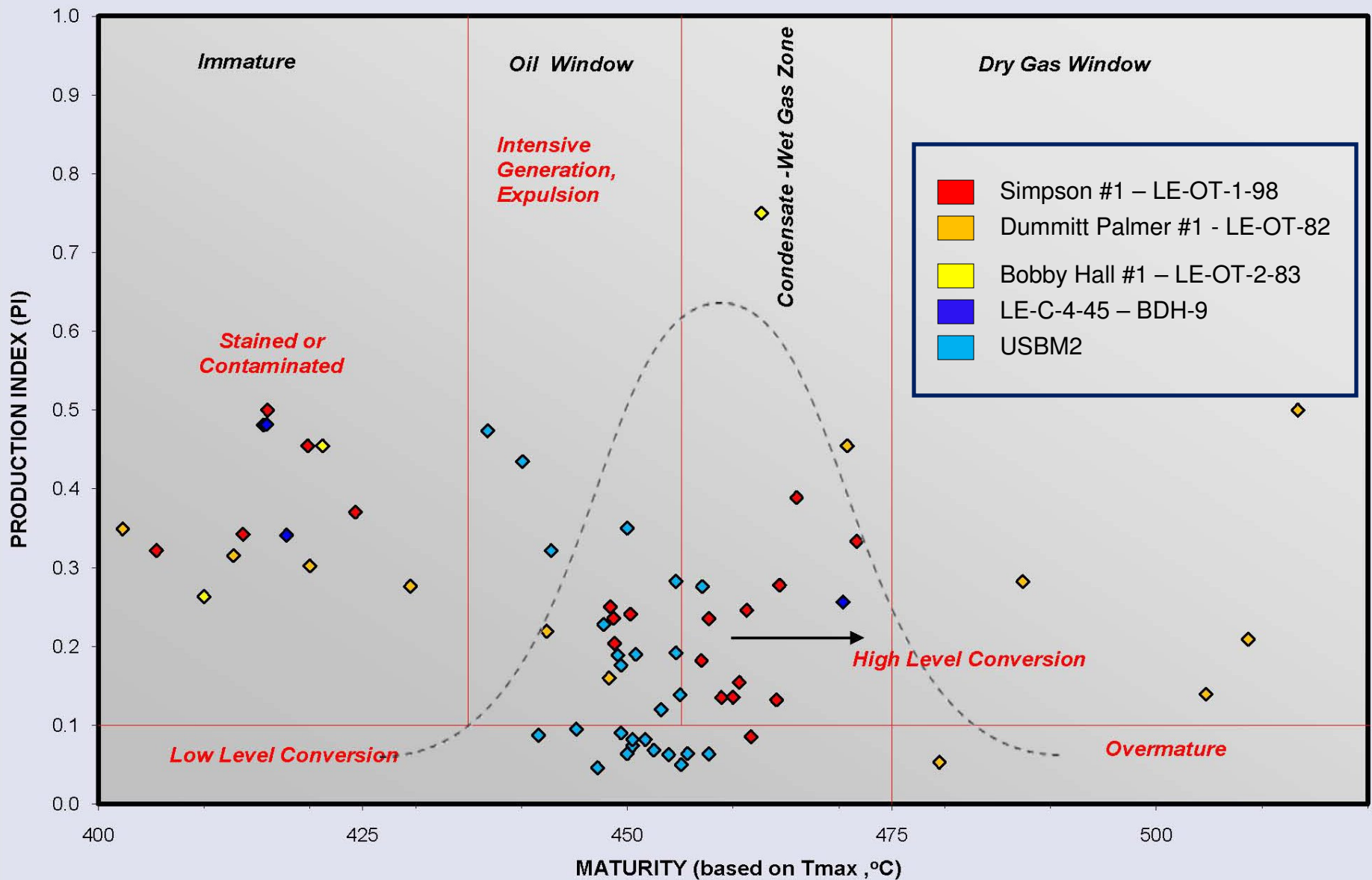


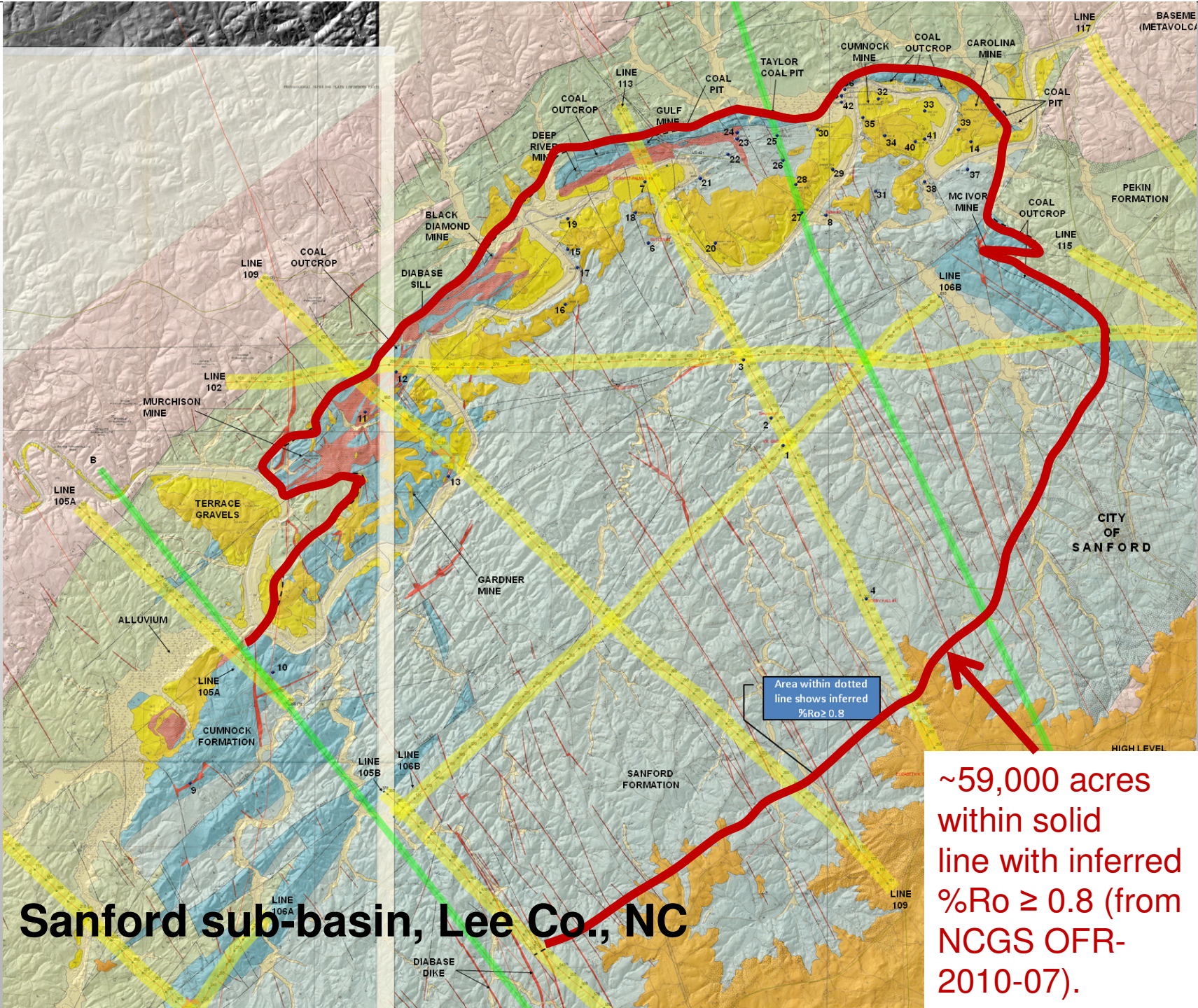


- Distribution of TOC data in wells in the Durham basin
- A threshold of 1.4% TOC is considered necessary for hydrocarbon expulsion
- From Reid and Milici, 2008



Kerogen type and maturity (Tmax) – multiple wells





Sanford sub-basin, Lee Co., NC

~59,000 acres within solid line with inferred %Ro ≥ 0.8 (from NCGS OFR-2010-07).

USGS/NCGS Resource Assessment

- ▣ *Current focus:* Rigorous, science-based assessment of technically recoverable natural gas.
- ▣ *Methodology:* Numerical, conservative approach to be computed by the U.S. Geological Survey.
- ▣ *Completion date:* Winter 2012.
- ▣ *Publication date:* sometime in 2012.



Current technology

- ▣ Current technology allows “shale gas = natural gas” to be recovered from shale formations with a high degree of organic content.
- ▣ Modern exploration and gas production technology, such as horizontal drilling and hydraulic-fracturing, has enabled the extraction of shale gas in similar formations in other states.
- ▣ Unconventional energy resource.



Categories of hydrocarbon occurrence (Schmoker, 1995)

