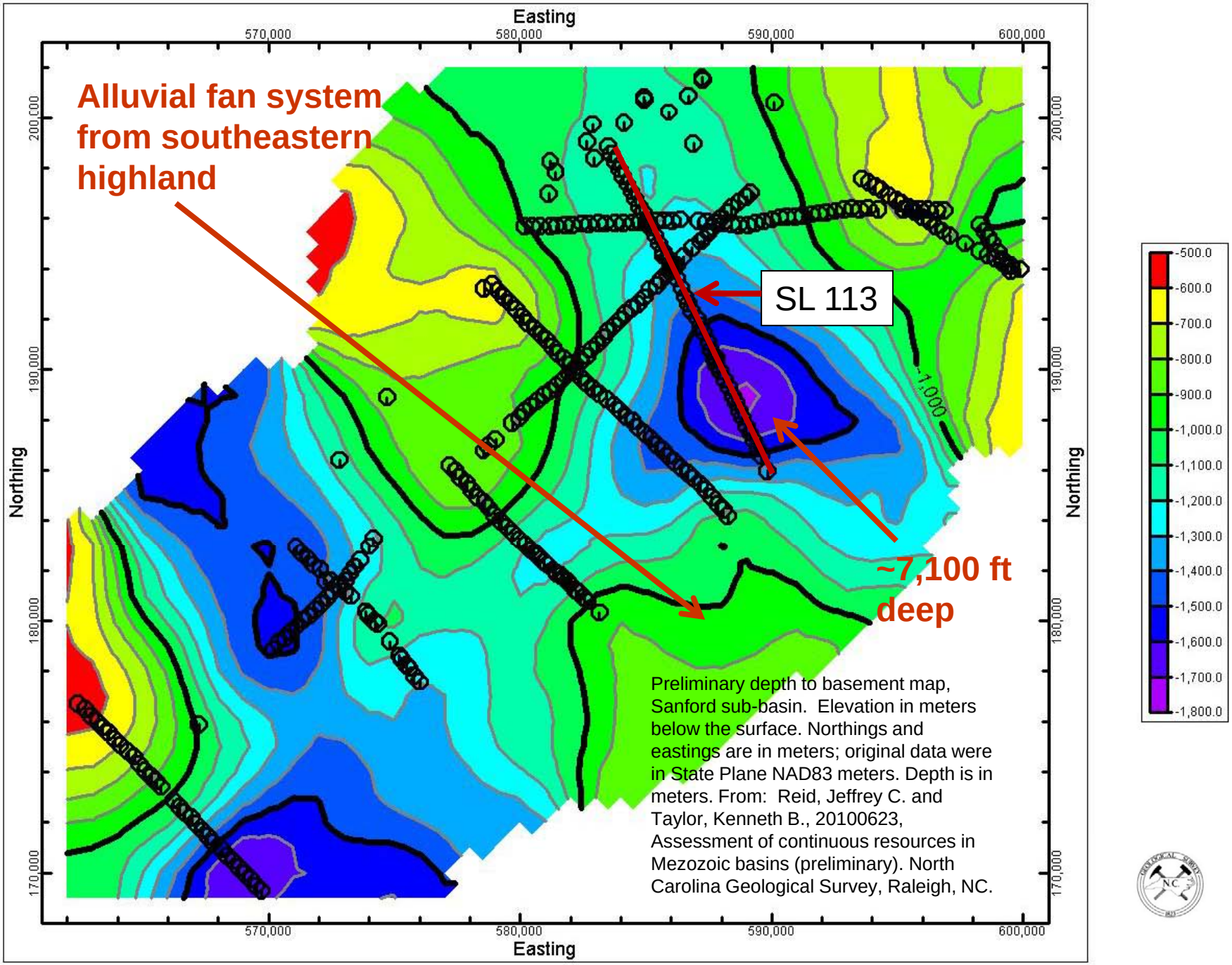
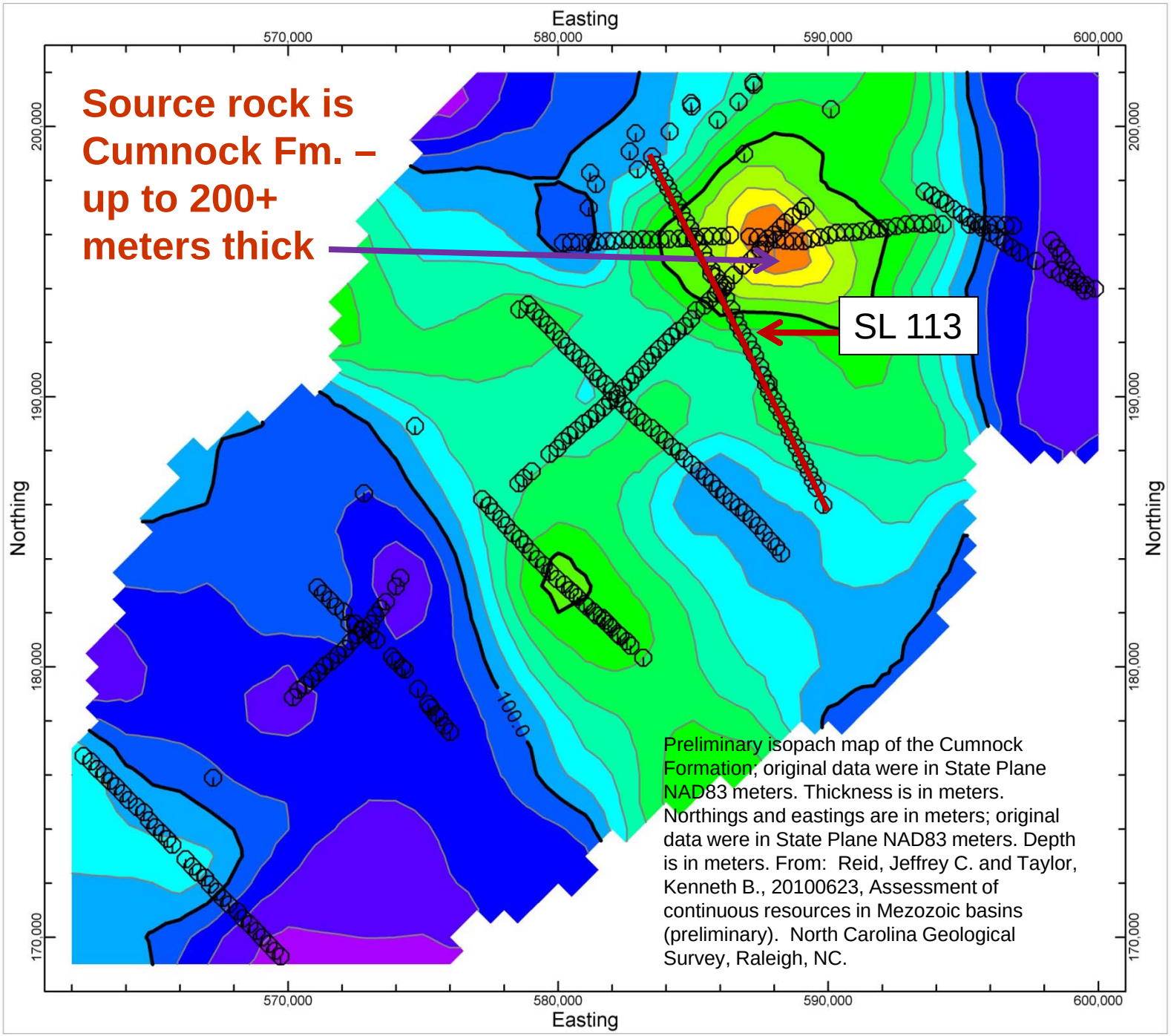
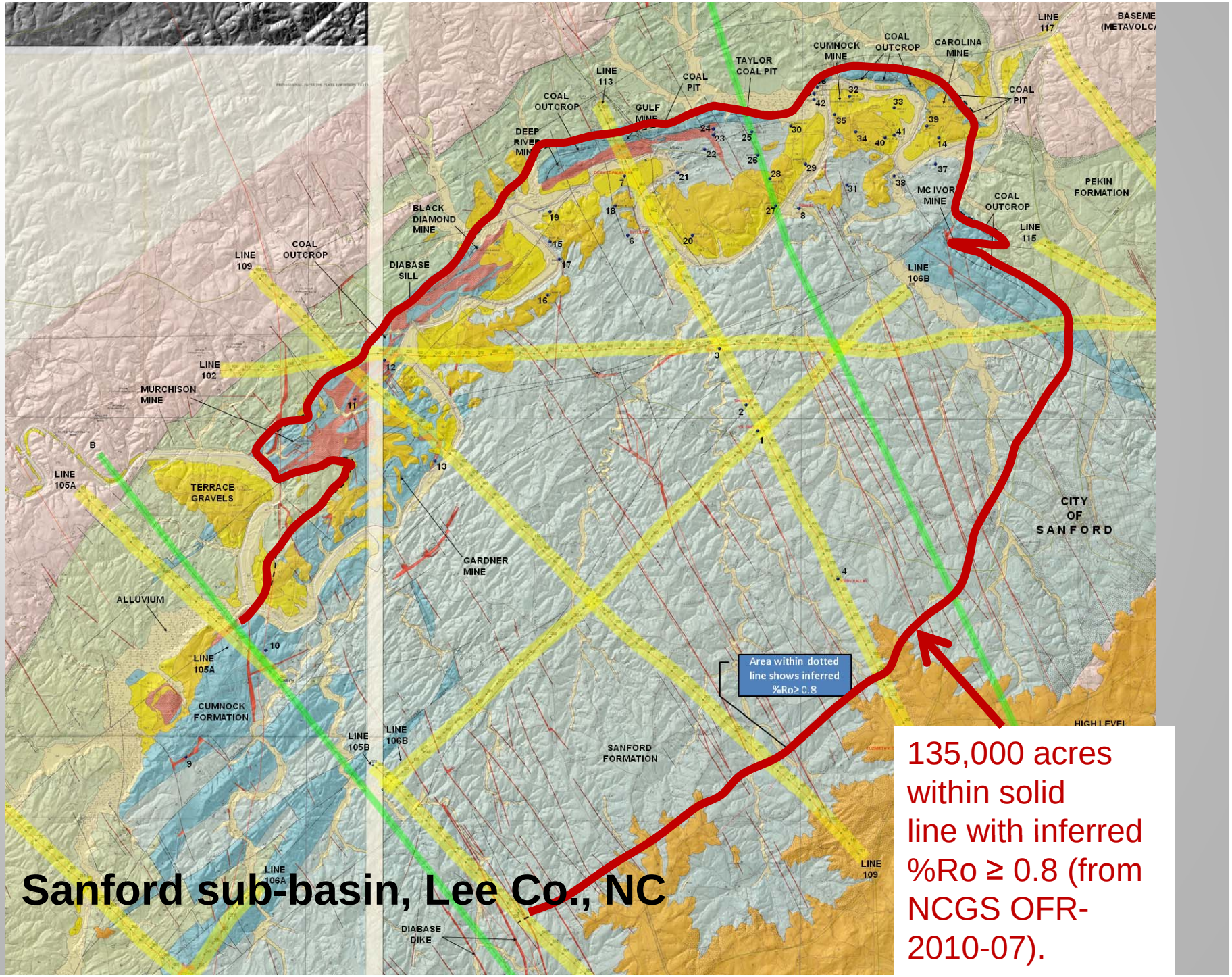


Preliminary depth to basement map, Sanford sub-basin. Elevation in meters below the surface. Northings and eastings are in meters; original data were in State Plane NAD83 meters. Depth is in meters. From: Reid, Jeffrey C. and Taylor, Kenneth B., 20100623, Assessment of continuous resources in Mezozoic basins (preliminary). North Carolina Geological Survey, Raleigh, NC.


Source rock is Cumnock Fm. – up to 200+ meters thick
SL 113
Easting
570,000
580,000
590,000
600,000
Northing
200,000
190,000
180,000
170,000
100.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
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 Mezozoic basins (preliminary). North Carolina Geological Survey, Raleigh, NC.

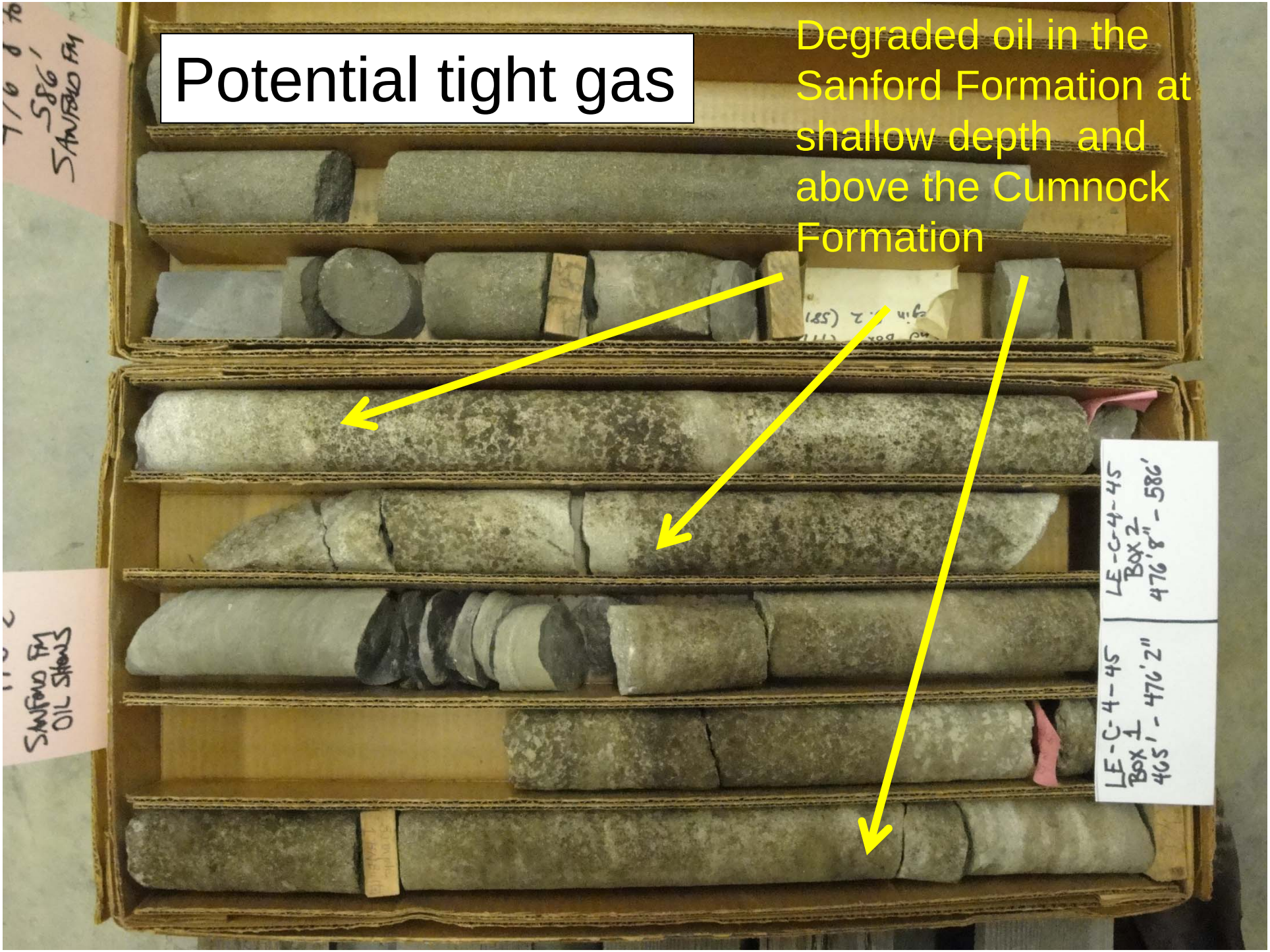
Gas and oil shows

- Eleven of 28 drill holes (including old coal holes) with gas, oil or both and some ‘asphalt’ shows.
- Coal mines with underground oil shows; multiple fatal methane gas mine explosions (mines long closed).
- Two shut-in wells with significant pressure (March 2009) – failed nitrogen frac jobs.
    - Butler #3 (upper left) – with pressure of 900 psi; initial flow rate: unknown;
    - Simpson #1 (lower half) – with pressure of 250 psi; initial flow rate: 3,000 mcfd; settled at 231 mcfd; well flared; and
    - Butler #1 (upper right) – well flared; small amount high paraffin, low flow temp. oil (hand warming) recovered.
- ‘Black band’ rock - <u>nitrogen source rock</u>
    - Nitrogen, phosphorous, oil and iron compounds (local fertilizer);
    - Retorted (1927) produced 3.6 to 12.4 gallons of oil per ton;
    - 18” thick interval between upper and lower Cumnock coal benches (could be packed off); and
    - Formed from carbon and iron-rich muds in coal-forming swamp with restricted accumulation of plant material.

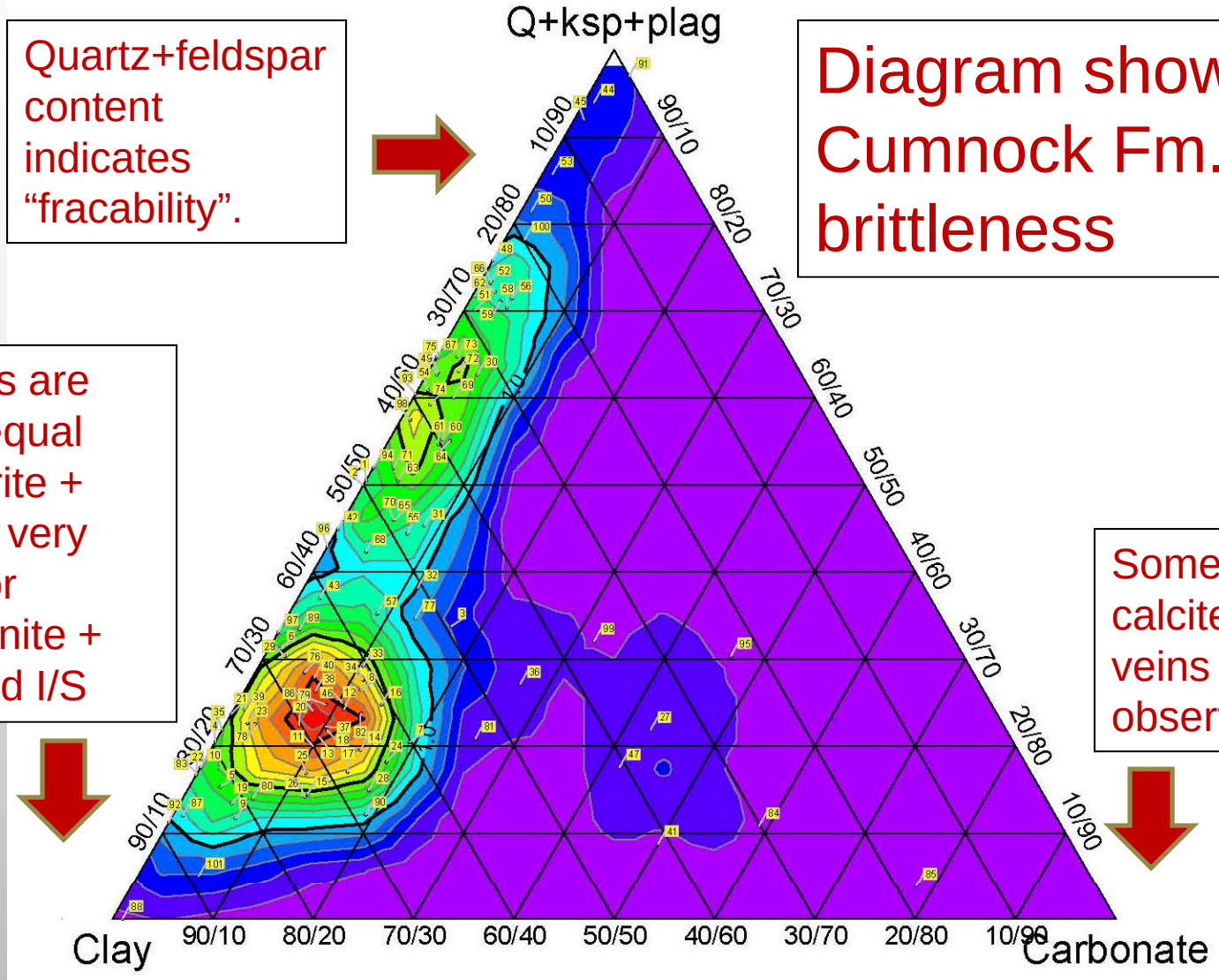


Sanford sub-basin, Lee Co., NC

135,000 acres within solid line with inferred %Ro ≥ 0.8 (from NCGS OFR-2010-07).


Potential tight gas
Degraded oil in the Sanford Formation at shallow depth and above the Cumnock Formation
LE-C-4-45
Box 1
465' - 476'2"
LE-C-4-45
Box 2
476'8" - 586'

(Quartz-ksp-plag) - clay - carbonate
Sanford sub-basin



Quartz+feldspar content indicates "fracability".

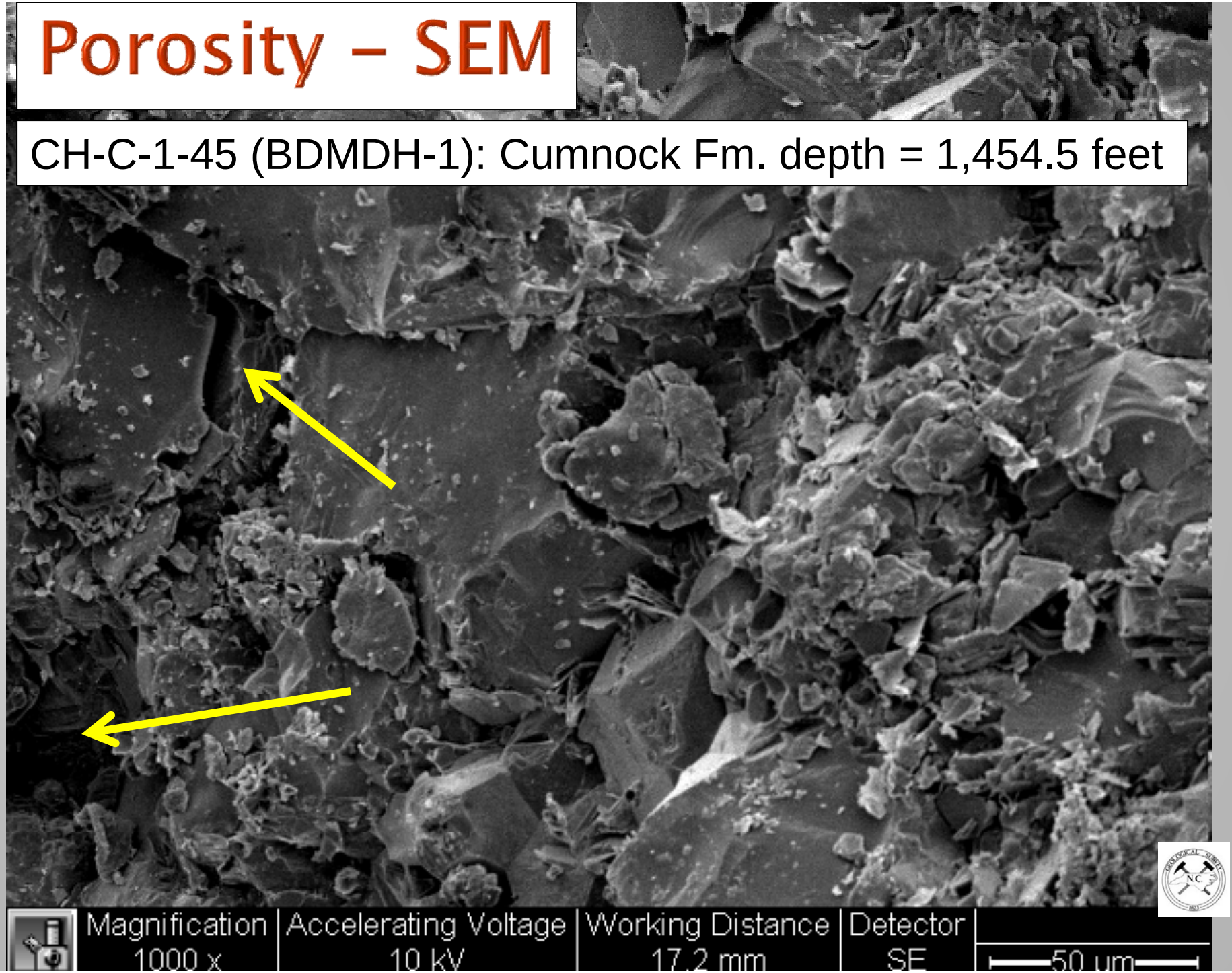
Diagram showing Cumnock Fm. brittleness

Clays are subequal chlorite + illite; very minor kaolinite + mixed I/S

Some calcite veins observed

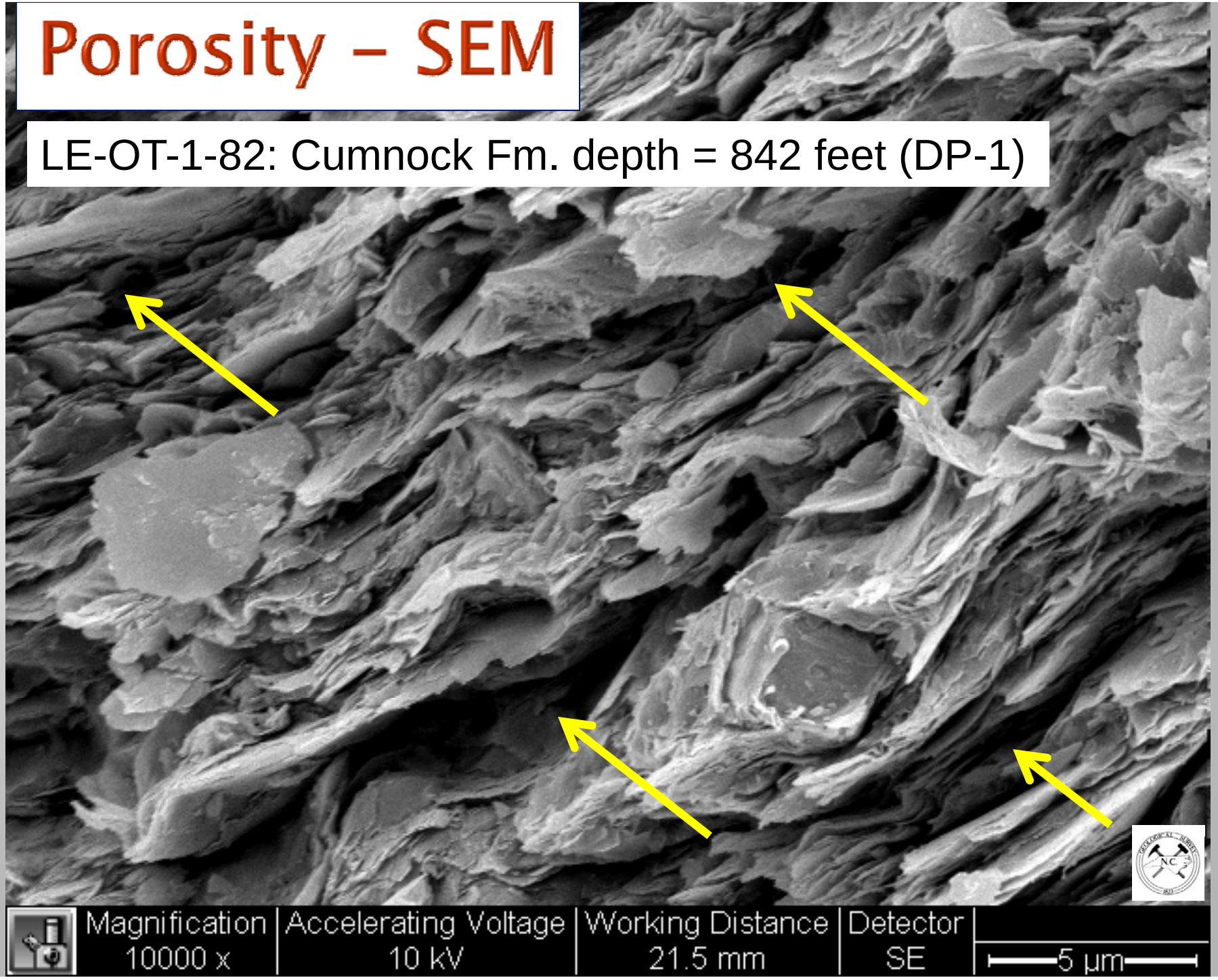
Porosity – SEM

CH-C-1-45 (BDMDH-1): Cumnock Fm. depth = 1,454.5 feet



Porosity – SEM

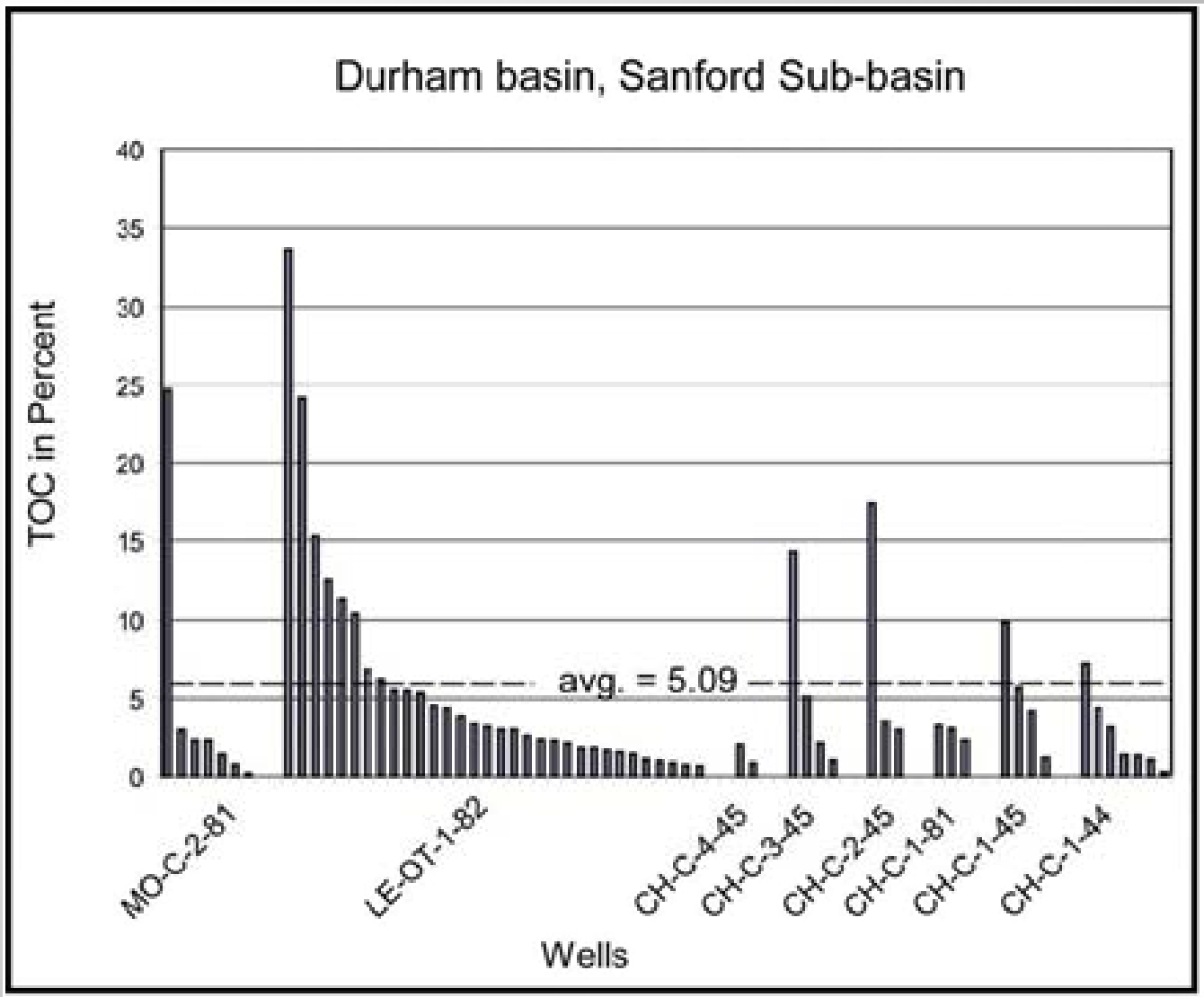
LE-OT-1-82: Cumnock Fm. depth = 842 feet (DP-1)



Organic geochemistry

- Sediments are predominantly gas prone with some oil shows; robust database ~400 analyses.
- TOC data exceeds the conservative 1.4% threshold necessary for hydrocarbon expulsion.
- Organic matter derived from terrestrial Type III woody (coaly) and from Type II material; Type I (algal material) likely present.
- Thermal alteration data (TAI) and vitrinite reflectance data (%Ro) indicate levels of thermal maturity suitable to generate hydrocarbons.

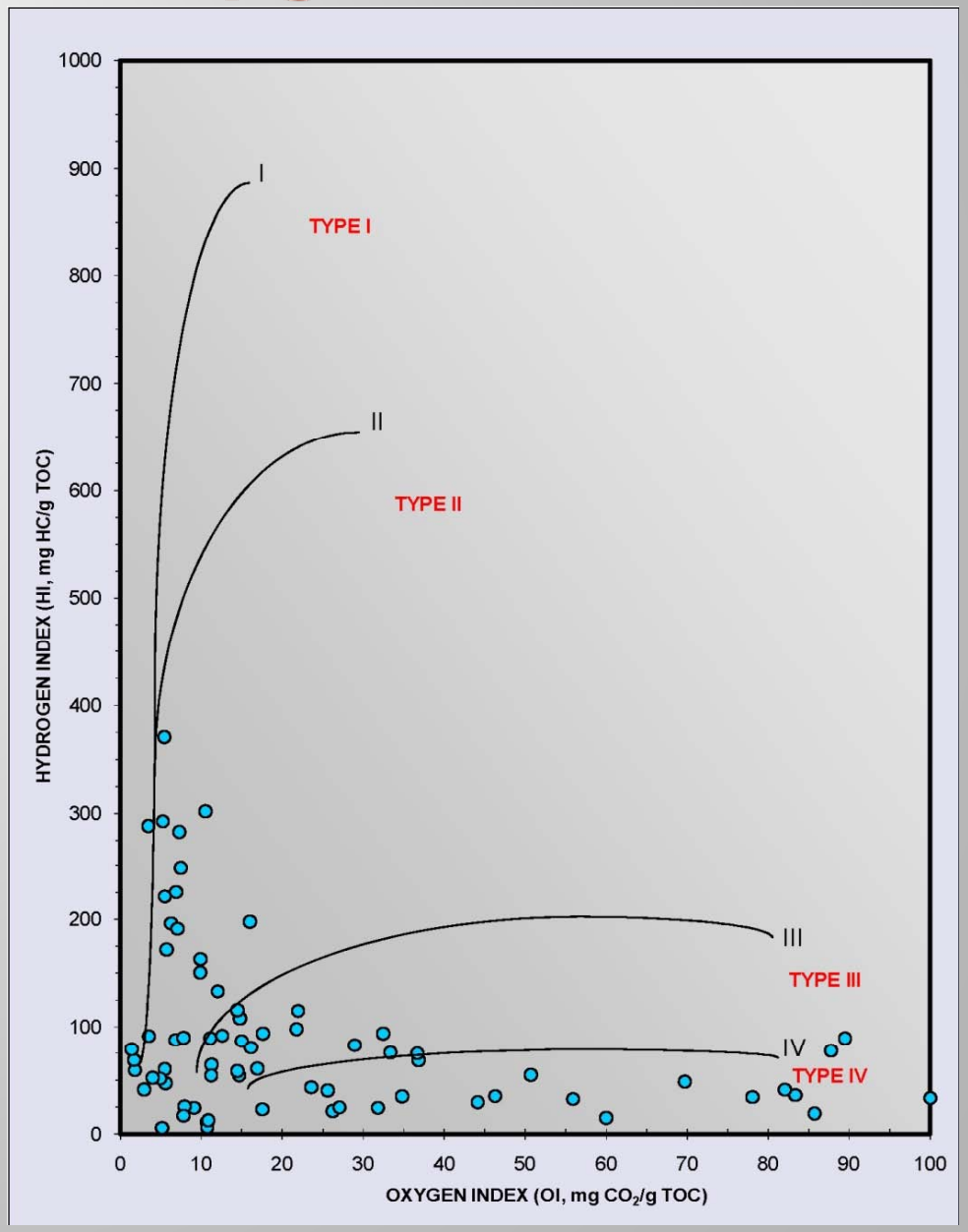
Modified from Reid and Milici (USGS OFR 2008-1108)



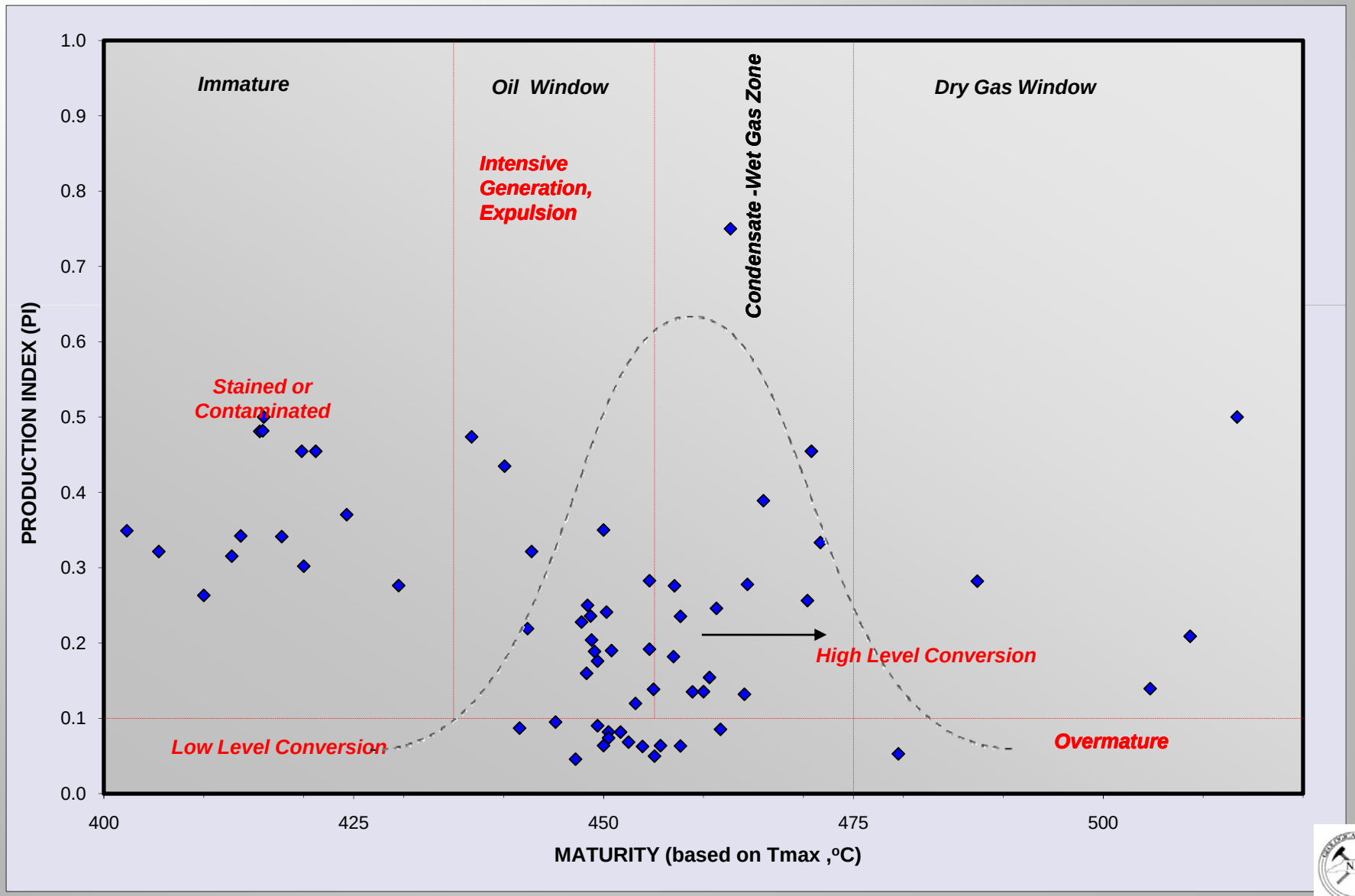
- Distribution of TOC data in wells in the Sanford sub-basin
- A threshold of 1.4% TOC is considered necessary for hydrocarbon expulsion
- From Reid and Milici, 2008

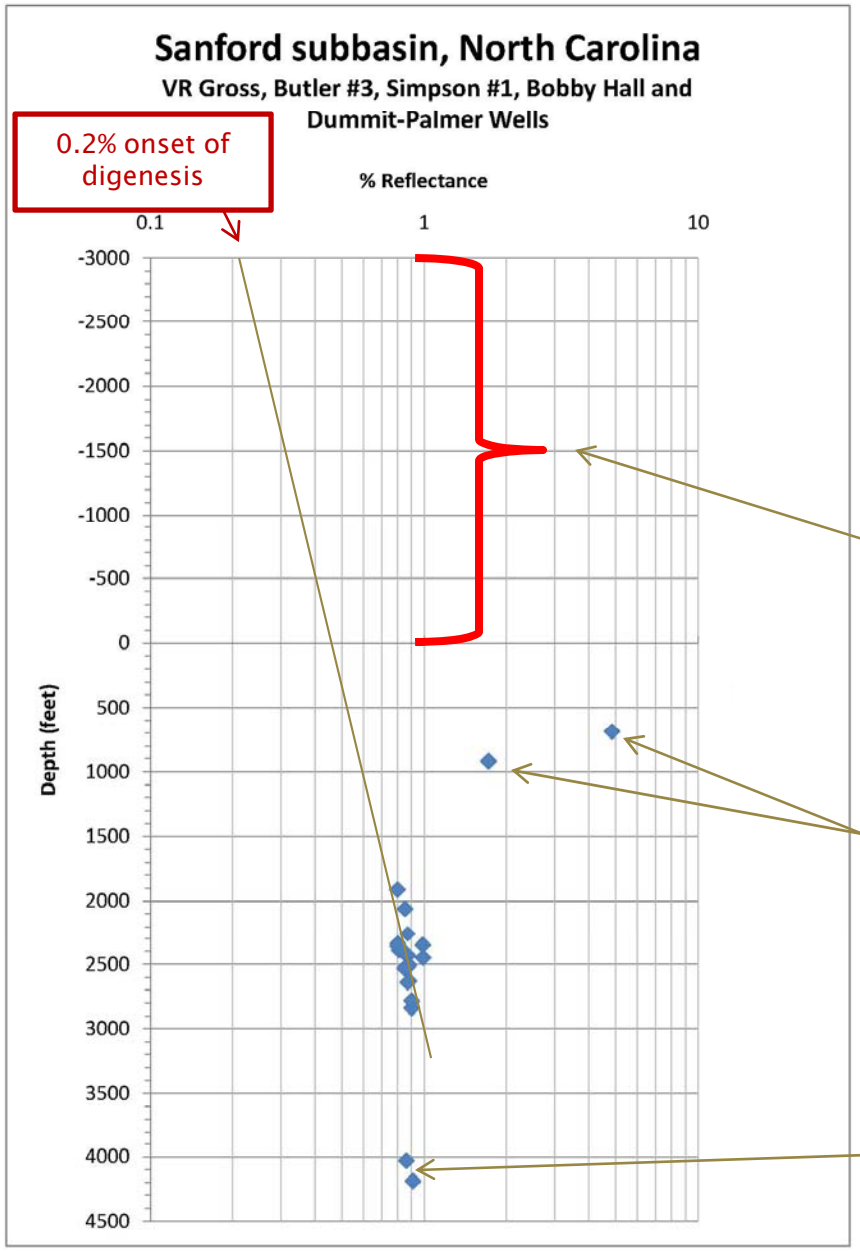
Hydrogen and oxygen indices

- Hydrogen and oxygen indices from Rock-Eval pyrolysis in relation to primary kerogen type.
- The organic material in these formations was derived from Type II and Type III matter; Type I likely present.



Kerogen conversion and maturity (Tmax) – Multiple wells





%Ro – All data, Sanford sub-basin

Estimated maximum erosion is ~3,000 ft

Observed variations are:

- V.R. Groce #1: -1,800 ft
- Butler #3: -1,000 ft
- Simpson #1: -3,000 ft (maximum observed)

Dummitt-Palmer #1 (CBM) – "near dikes" and "overcooked" (updip, basin edge)

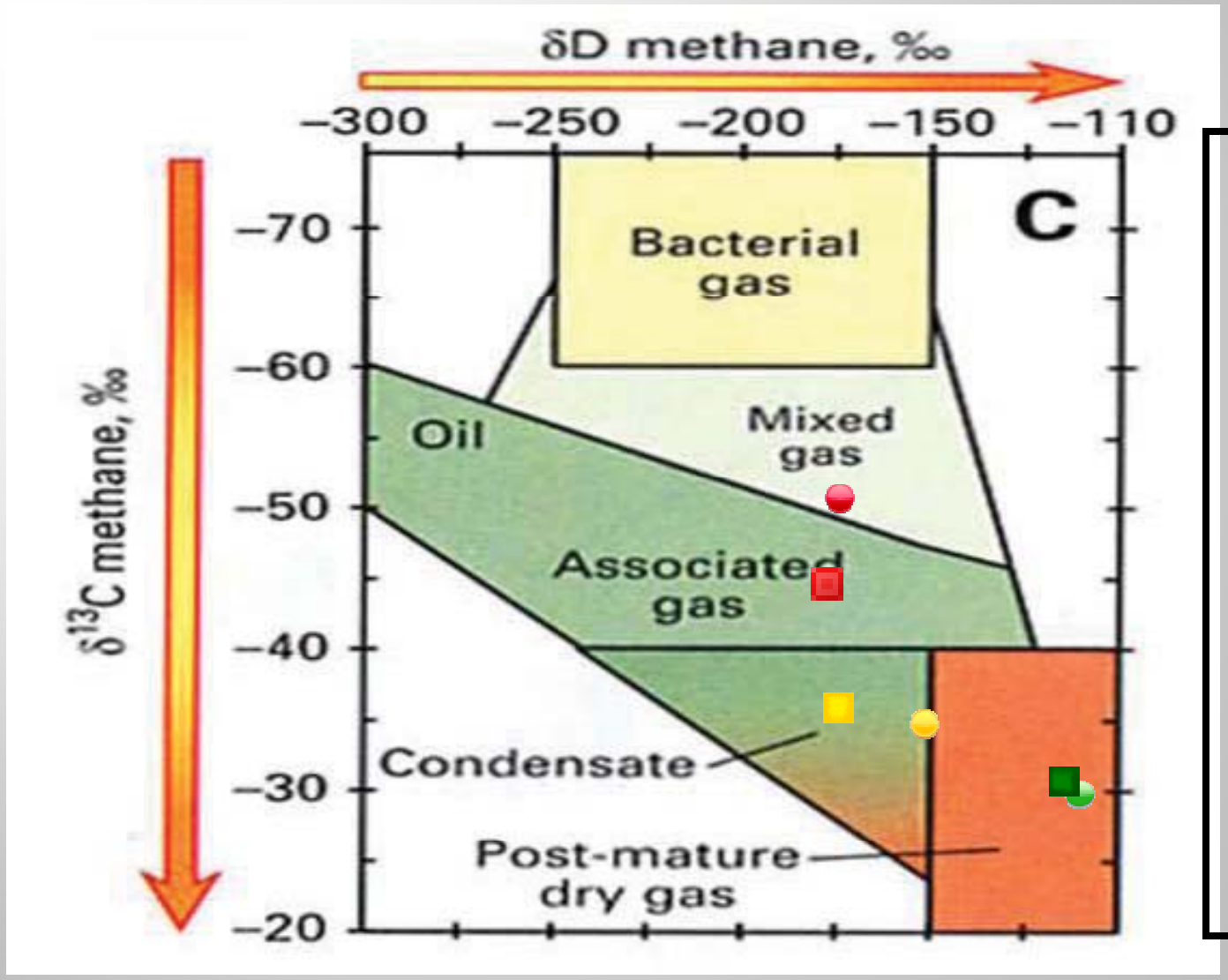
Bobby Hall #1

After Dow, 1977 (method)

Gas composition and BTU (C1 = methane)

Well	PSI	C1 %	N2 %	CO2	C2H6	BTU (Dry)	Comment	ΔN Per mill	ΔC Per mill (C1)	ΔD Per mill (C1)
Butler #3 - 2009	900	48.78	45.60		3.86	605	Small amounts other gases	-3.32	-45.11	-178.5
Simpson #1 - 1998	640-680	70.07	29.603		0.117	712.920				
Simpson #1 - 2009	~250	51.65	45.49		1.89	577	Small amounts other gases	-3.23	-51.41	-174.8
Dummitt-Palmer #1 – 1991 - Cumnock		96.95	2.4	0.24	0.024	986.25				
Dummitt-Palmer #1 – 1991 – Gulf coal		96.40	3.05	0.16	0.27	976.45				
Dummitt-Palmer #1 – 1991 – Black shale		88.40	10.85	0.17	0.30	908.95				

Note – ΔC and ΔD for light gases (ethane, propane, iso-pentane and N-butane along with specific gravity for 2009 analyses – not shown because of space)



***Cross plot of ΔD methane (deuterium** isotopes for methane, ‰) vs. Δ 13C methane (carbon isotopes for methane, ‰) showing fields for bacterial gas, associated gas, postmature dry gas etc., from Ellis et al., 2003. Reprinted with permission from the Oil & Gas Journal (from Janell Edman, RMAG, August 2007).*

Summary

- ~135,000 prospective acres for exploration with inferred %Ro ≥ 0.8.
- Mesozoic rift basin with depth of 7,000+ feet.
- 800-foot thick organic shale section with two coal beds.
- Gas prone section based on organic chemistry and maturation and two shut-in wells with pressure.
- Centrally located in state.
- Environmental and permitting issues.

Acknowledgements

- Support for portions of this work were from the U.S. Geological Survey (NCRDS Cooperative agreement G09AC00381), and
- Seismic Micro-Technology (SMT) for an educational license for the software, 'Kingdom Suite'.
- N.C. Geodetic Survey – LiDAR slides

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