Outline

1. Where we are today – resource assessment results.
2. Legislative charge.
3. Geological glimpses – Total Petroleum System (TPS) and continuous Assessment Unit (AU).
   – Sanford sub-basin, Deep River Basin, and the
   – Dan River-Danville Basin.
4. Public participation, new legislation, and process toward permitting.
North Carolina (USA) Mesozoic rift basin shale gas: A fifth year perspective

- Two continuous composite total petroleum systems (TPS) in N.C.
- USGS assessed 5 of 14 basins (Fact Sheet 2012-3075)
- North Carolina results:
  - Deep River Basin: 1.66 TCF + 83 MMBNGL; and
  - Dan River-Danville Basin: 49 BCF and NGL?
- New N.C. law legalizes horizontal drilling and hydraulic fracturing (SB 820).
- New N.C. process leading to permitting in 2014.
- Geometry: thick shale sequences, with long strike extent => large volume of source rock / reservoir.
East Coast Mesozoic basins: Common characteristics

- Formed: along the continental margin from regional uplift, extension (rifting), and crustal thinning from the early Atlantic opening.
- Rifting: started about 227 mya – Middle Triassic – Carnian time.
- Basin fill (fluvial to lacustrine environments): boulder beds, coarse-grained fluvial to deltaic sandstones, red siltstone, mudstones, gray and black shales.
- Rifting ended: in Jurassic accompanied by regional volcanism and intrusion of diabase dikes and sills (CAMP).
- Source rocks: gray and black shales and coal beds.
- Kerogen: derived from vascular plants and algae => gas and oil.
- Thermal maturation: Wide range from immature to dry gas.
- Potential reservoirs: Continuous accumulations in wide range of lithologies (boulder conglomerates, very coarse sandstones to mudstone, shale and coal).
- Seals (potentially): shale beds interbedded with coarser strata.
Categories of hydrocarbon occurrence
(Schmoker, 1995)

From Milici, Coleman and Reid - 2012
USGS Assessment Methodology
For Continuous-Type Accumulations

1. Based on Geology and Geological Models
2. Identify and Outline Total Petroleum System(s)
3. Total Area and ‘Cell’ Area
   - Drainage Area (Cells)
   - Numbers of Potential Cells of Undrilled Area
4. Historical Exploration and Production Analyses
   - Well-Performance Based – Time and Technology
   - EUR (Estimated Ultimate Recovery)
   - Success/Failure (Historical and Future Success Ratio)
5. Undiscovered, Technically Recoverable Resource
   - Not Economically Recoverable Resource Estimates
   - Not In-Place Resource Estimates
USGS East Coast Mesozoic Basin assessment results: Fact Sheet 2012-3075

<table>
<thead>
<tr>
<th>Total Petroleum System (TPS) and Assessment Unit (AU)</th>
<th>Field type</th>
<th>Total undiscovered resources</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Oil (MMBO)</td>
<td>Gas (RCFG)</td>
<td>NGL (MMBNGL)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F95</td>
<td>F50</td>
<td>F5</td>
<td>Mean</td>
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<tr>
<td>Taylorsville Basin Composite TPS</td>
<td>Gas</td>
<td>516</td>
<td>985</td>
<td>1,880</td>
<td>1,064</td>
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<tr>
<td>Taylorsville Basin Continuous</td>
<td>Gas</td>
<td>99</td>
<td>194</td>
<td>382</td>
<td>211</td>
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<td>Gas AU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Richmond Basin Composite TPS</td>
<td>Gas</td>
<td>363</td>
<td>785</td>
<td>1,698</td>
<td>876</td>
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<tr>
<td>Richmond Basin Continuous</td>
<td>Gas</td>
<td>779</td>
<td>1,527</td>
<td>2,990</td>
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<td>Gas AU</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Newark Basin Composite TPS</td>
<td>Gas</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Deep River Basin Composite TPS</td>
<td>Gas</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas AU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dan River-Danville Basin Composite TPS</td>
<td>Gas</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dan River-Danville Basin Continuous Gas AU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total continuous resources</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,774</td>
<td>3,533</td>
<td>7,056</td>
<td>3,860</td>
</tr>
</tbody>
</table>
Triassic paleogeography ~210mya, from Ron Blakey, NAU Geology.
Triassic paleogeography

From Whitehead and others, May 2011.
U. S. Atlantic Mesozoic Basin Types

Legislative charge

• 2011- Session Law-276 (H.B. 242) – required our department to prepare a draft report on shale gas drilling.

• Session Law 2011-276 (H.B. 242) "§ 113-424. Applicability; effect, SECTION 4. Directs, in part, “...DENR...shall report their (study) findings...(on) the following: (1) Oil and gas resources present in the Triassic Basins and in any other areas of the State....” and report to the N.C. General Assembly by 1 May 2012.

• Law required public hearings – heavily attended by citizens both pro and con.
Sanford sub-basin glimpse

(Reid and Milici, USGS OFR 2008-1108)
## Stratigraphy – Proposed revision

<table>
<thead>
<tr>
<th></th>
<th>Deep River Basin</th>
<th>Dan River Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sub-basins</strong></td>
<td>Wadesboro</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sanford</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Durham</td>
<td></td>
</tr>
</tbody>
</table>

### NEWARK SUPERGROUP

#### Chatham Group

- **Sanford Fm.**
- **Cumnock Fm.**
- **Pekin Fm.**

#### Dan River Group

- **Stoneville Fm.**
- **Eden Mbr.**
- **Dry Fork Mbr.**
- **Walnut Cove Mbr.**
- **Pine Hall Fm.**

### Legends

- Mostly red and tan conglomerate, sandstone, and mudstone
- Mostly grey and black mudstone and sandstone
- Mostly grey and tan sandstone, and red mudstone
- Mostly red, conglomerate, fanglomerate, sandstone, and mudstone
- Coal beds

---

From Olsen, Reid, Kent and Whiteside, 2012 manuscript in preparation

9/13/2012 - 7th Intl. Symposium on Oil & Gas in Western NL

North Carolina (USA) Mesozoic rift basin shale gas: A fifth year perspective: JC Reid and KB Taylor
LiDAR is an important exploration tool – when combined with geologic maps.

Sanford sub-basin, Lee Co., NC
Sanford sub-basin - Structure

SANFORD SUB-BASIN OF THE DEEP RIVER BASIN

NW

A

Pekin Formation

Cumnock Formation

Sanford Formation

Jonesboro fault zone

SE

A'

vertical scale = horizontal scale

5 km

- 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

Generalized lithologies and stratigraphy.
Potential source / reservoir rock - coal

Cumnock Coal Core Box #1
Note: Top of core cannot be determined.

Cumnock Coal Core Box #2

Cumnock Coal Core Box #3

Cumnock Coal Core Box #4
Note: Top of Core cannot be determined.

Coal Cores from the Cumnock Mine (previously known as Egypt Mine), donated by Mr. J. Daniel Butler – February 12, 2010
Potential source/reservoir rock

Figure 30. V.R. Groce #1 well – Selected core from the interval 2422 – 2428 feet and the interval 3038 – 3043 feet depth. This well is located near the center of the Sanford sub-basin. The presence of gray to black shale confirms basinward extent of the lacustrine facies. The well had a number of good petroleum shows.
Potential reservoir rocks

Potential tight gas

Degraded oil in the Sanford Formation at shallow depth and above the Cumnock Formation.

Figure 28. Degraded oil in the Sanford Formation about 300 feet stratigraphically above the Cumnock Formation. The total depth of this hole (BDH-9) is 1425 feet. Cumnock was logged from 723 feet to TD – this also shows the Cumnock to be at least 700-feet thick here. These oil shows plus gas kicks in the well logs suggest the possibility of tight gas. There is a fair amount of porosity in these sands to hold the oil. Gas is not included in the geologic units (GU’s).
Sanford sub-basin, Deep River Basin
Other (brittle minerals) - clays - carbonate (N=101)

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

Mostly quartz+feldspar

Some calcite veins observed
**TOC data distribution**

Distribution of TOC data, Sanford sub-basin, Deep River Basin
(Reid and Milici, USGS OFR 2008-1108)

**TOC Sanford sub-basin = 1.96; N = 353 as of August 2012**

Distribution of TOC data, Dan River-Danville Basin
(Reid and Milici, USGS OFR 2008-1108)
Kerogen type and maturity ($T_{\text{max}}$) – multiple wells: Sanford sub-basin

**%Ro = 1.25%, N = 42 as of August 2012**
%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)
Stratigraphy – Proposed revision

From Olsen, Reid, Kent and Whiteside, 2012 manuscript in preparation

Mostly red and tan conglomerate, sandstone, and mudstone
Mostly gray and black mudstone and sandstone
Mostly grey and tan sandstone, and red mudstone
Mostly red, conglomerate, fanglomerate, sandstone, and mudstone
Coal beds

9/13/2012 - 7th Intl. Symposium on Oil & Gas in Western NL
North Carolina (USA) Mesozoic rift basin shale gas: A fifth year perspective: JC Reid and KB Taylor
Dan River-Danville Basin – Structure

Surface elev.

Sea level

-1,000 ft.

-2,000 ft.

-3,000 ft.

-4,000 ft.

-5,000 ft.

-6,000 ft.

-7,000 ft.

Stoneville Fm. (conglomerate)

Stoneville Fm. (sandstone and mudstone)

Eden Mbr.

Walnut Cove Mbr.

Dry Fork Mbr. (sandstone and mudstone)

Dry Fork Mbr. (conglomerates and sandstone)

Pine Hall Fm. (conglomerate)

Pine Hall Fm. (sandstone and mudstone)

thin coal (North Carolina only)

From Olsen, Reid, Kent and Whiteside, 2012
manuscript in preparation

View to northeast

9/13/2012 - 7th Intl. Symposium on Oil & Gas in Western NL
North Carolina (USA) Mesozoic rift basin shale gas: A fifth year perspective: JC Reid and KB Taylor
• Synthetic gamma-ray study – Eden Mbr. - low count rate.
• ~1,500 feet true thickness, dips 30° NW (to right of image).
• Potential source / reservoir rock.
Eden Mbr. – potential source rock/reservoir
Mostly quartz+feldspar

Eden Mbr. (red squares)

Walnut Cove Mbr. (black triangles)
Dan River-Danville Basin: 2012 %Ro and TOC results – split by Cow Branch member

Ro% = 2.077, n = 25

%Ro = 1.850, n = 23

TOC = 1.384%, n = 42

TOC = 3.553%, n = 122
# U, Th content of the shales

<table>
<thead>
<tr>
<th>Basin</th>
<th>Geologic unit</th>
<th>U ppm (mean, ICP-MS)</th>
<th>U ppm (mean, INAA)</th>
<th>Th ppm (mean by ICP-MS)</th>
<th>Th ppm (mean by INAA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanford sub-basin</td>
<td>Cumnock Fm.</td>
<td>3.176 N = 76</td>
<td>3.365 N = 20</td>
<td>8.72 N = 76</td>
<td>9.427 N = 22</td>
</tr>
<tr>
<td>Dan River – Danville Basin</td>
<td>Cow Branch - Eden Mbr.</td>
<td>16.279 N = 56</td>
<td></td>
<td>12.736 N = 56</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cow Branch - Walnut Cove Mbr.</td>
<td>3.369 N = 78</td>
<td></td>
<td>11.597 N = 78</td>
<td></td>
</tr>
<tr>
<td>Detection limit</td>
<td></td>
<td>0.1 ppm</td>
<td>0.5 ppm</td>
<td>0.1 ppm</td>
<td>0.2 ppm</td>
</tr>
</tbody>
</table>

Black shale average from AGI Data Sheets, 1982: U = 3.7 ppm; Th = 12 ppm
Public participation

• Oct. 10, 2011 – Public meeting in Sanford sub-basin
  – Draft plan of study was presented; the STRONGER process was discussed.
  – Public comment was received as to how the study should be conducted.
  – Comment was received and written comment on the draft outline of the study were accepted through Oct. 18, 2011.

• March 20 and 27, 2012 – Additional public meetings in Sanford sub-basin,
  – Draft findings and recommendations were presented in a public meetings.
  – Meetings were streamed live online, the same information was presented, and public comments were accepted at both meetings, via mail and email.

• April 2, 2012 - Last day to agency received written comments on the draft report.
• April 3, 2012 - Chatham Co. hosted a third meeting; public comments were received.
• STRONGER (State Review of Oil & Natural Gas Environmental Regulations)
  – Reviewed N. C.’s oil & gas regulatory programs in October 2011 at the agency’s request.
  – STRONGER report issued in February 2012.
• DENR study released: URL http://portal.ncdenr.org/web/guest/denr-study
• Extensive legislative debate – spring and summer 2012.
S820 Highlights

• Begins process to create regulations & standards via a ‘Mining and Energy Commission’.
• Three study reports due October 1, 2013
  – Impact on local government and infrastructure (includes fee structure),
  – Local government authority in regulation, and
  – Forced pooling.
• State legislature will vote 2 years hence to approve final rules to allow permit applications.
• Rule-making deadline is October 2014.
• Any contamination is assumed to be from drilling unless proven otherwise. Provides for groundwater supply remedy.
• Mineral rights owner:
  – to be paid 12.5% minimum royalties;
  – deduction of operating expenses not allowed; and
  – 7 day period to back out of lease.
Conclusions

• North Carolina Mesozoic basins contain continuous gas deposits (Deep River Basin, Dan River-Danville Basin).

• With new completion technology, these deposits may become economically recoverable.

• Horizontal drilling and hydraulic fracturing are now legal in North Carolina.

• A process is in place to establish rules and regulation could allow permits as early as 2014 following final legislative approval.
East Coast Mesozoic Basins – not numerically assessed

<table>
<thead>
<tr>
<th>Basin</th>
<th>Type of total petroleum system</th>
<th>Type of assessment unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hartford</td>
<td>Composite</td>
<td>Continuous gas</td>
</tr>
<tr>
<td>North Newark (northern half of Newark basin)</td>
<td>Composite</td>
<td>Continuous gas</td>
</tr>
<tr>
<td>Gettysburg</td>
<td>Composite</td>
<td>Continuous gas</td>
</tr>
<tr>
<td>Culpeper</td>
<td>Composite</td>
<td>Continuous gas</td>
</tr>
<tr>
<td>Delmarva (basins)</td>
<td>Composite</td>
<td>Continuous gas</td>
</tr>
<tr>
<td>Cumberland-Marlboro</td>
<td>Composite</td>
<td>Continuous gas</td>
</tr>
<tr>
<td>Florence</td>
<td>Composite</td>
<td>Continuous gas</td>
</tr>
<tr>
<td>South Georgia</td>
<td>Composite</td>
<td>Continuous gas</td>
</tr>
<tr>
<td>North Florida</td>
<td>Composite</td>
<td>Continuous gas</td>
</tr>
</tbody>
</table>

Source: USGS Fact Sheet 2012-3075
Examples of input EUR data for shale gas and tight gas assessment units (USGS OFR 2012-118)

**Table 1.** Input data for estimated ultimate recovery distributions for United States shale-gas assessment units, values in billions of cubic feet of natural gas. [AU, assessment unit; and EUR, estimated ultimate recovery]

<table>
<thead>
<tr>
<th>AU number</th>
<th>AU name</th>
<th>Province</th>
<th>Year assessed</th>
<th>Minimum EUR</th>
<th>Median EUR</th>
<th>Maximum EUR</th>
<th>Mean EUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>50490161</td>
<td>Haynesville Sabine Platform Shale Gas</td>
<td>Gulf Coast Mesozoic</td>
<td>2010</td>
<td>0.02</td>
<td>2</td>
<td>20</td>
<td>2.617</td>
</tr>
<tr>
<td>50490163</td>
<td>Mid-Bossier Sabine Platform Shale Gas</td>
<td>Gulf Coast Mesozoic</td>
<td>2010</td>
<td>0.02</td>
<td>1</td>
<td>10</td>
<td>1.308</td>
</tr>
<tr>
<td>50580161</td>
<td>Woodford Shale Gas</td>
<td>Anadarko Basin</td>
<td>2010</td>
<td>0.02</td>
<td>0.8</td>
<td>15</td>
<td>1.233</td>
</tr>
<tr>
<td>50670468</td>
<td>Interior Marcellus</td>
<td>Appalachian Basin</td>
<td>2011</td>
<td>0.02</td>
<td>0.8</td>
<td>12</td>
<td>1.158</td>
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<tr>
<td>50490167</td>
<td>Eagle Ford Shale Gas</td>
<td>Gulf Coast Mesozoic</td>
<td>2010</td>
<td>0.02</td>
<td>0.8</td>
<td>10</td>
<td>1.104</td>
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</tbody>
</table>

**Table 3.** Input data for estimated ultimate recovery distributions for United States tight-gas assessment units, values in billions of cubic feet of natural gas. [AU, assessment unit; and EUR, estimated ultimate recovery]

<table>
<thead>
<tr>
<th>AU number</th>
<th>AU name</th>
<th>Province</th>
<th>Year assessed</th>
<th>Minimum EUR</th>
<th>Median EUR</th>
<th>Maximum EUR</th>
<th>Mean EUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>50370661</td>
<td>Mesaverde-Lance-Fort Union Continuous Gas</td>
<td>Southwestern Wyoming</td>
<td>2002</td>
<td>0.02</td>
<td>1.2</td>
<td>15</td>
<td>1.657</td>
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<tr>
<td>50370561</td>
<td>Almond Continuous Gas</td>
<td>Southwestern Wyoming</td>
<td>2002</td>
<td>0.02</td>
<td>0.9</td>
<td>20</td>
<td>1.460</td>
</tr>
<tr>
<td>50200261</td>
<td>Uinta Basin Continuous Gas</td>
<td>Uinta-Piceance</td>
<td>2000</td>
<td>0.02</td>
<td>0.5</td>
<td>40</td>
<td>1.293</td>
</tr>
<tr>
<td>50030161</td>
<td>Tuxedni-Naknek Continuous Gas</td>
<td>Southern Alaska</td>
<td>2011</td>
<td>0.02</td>
<td>0.6</td>
<td>30</td>
<td>1.286</td>
</tr>
<tr>
<td>50620161</td>
<td>Arkoma-Ouachita Foredeep Continuous Gas</td>
<td>Arkoma Basin</td>
<td>2010</td>
<td>0.02</td>
<td>0.6</td>
<td>30</td>
<td>1.286</td>
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<tr>
<td>50350261</td>
<td>Frontier-Muddy Continuous Gas</td>
<td>Wind River Basin</td>
<td>2005</td>
<td>0.02</td>
<td>0.7</td>
<td>15</td>
<td>1.123</td>
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<tr>
<td>50370261</td>
<td>Mowry Continuous Gas</td>
<td>Southwestern Wyoming</td>
<td>2002</td>
<td>0.02</td>
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<td>1.123</td>
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<tr>
<td>50350265</td>
<td>Lance-Fort Union Sandstone Gas</td>
<td>Wind River Basin</td>
<td>2005</td>
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<td>0.6</td>
<td>20</td>
<td>1.110</td>
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<tr>
<td>50370861</td>
<td>Lance-Fort Union Continuous Gas</td>
<td>Southwestern Wyoming</td>
<td>2002</td>
<td>0.02</td>
<td>0.8</td>
<td>10</td>
<td>1.104</td>
</tr>
<tr>
<td>50370761</td>
<td>Lewis Continuous Gas</td>
<td>Southwestern Wyoming</td>
<td>2002</td>
<td>0.02</td>
<td>0.6</td>
<td>15</td>
<td>1.009</td>
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</table>
Figure 1. Cloud plot for United States shale-gas assessment units. Each curve represents one assessment unit and is based on the input data in table 1. Black diamonds indicate the mean value for each curve. [AU, assessment unit; EUR, estimated ultimate recovery; and BCF, billions of cubic feet]
Figure 3. Cloud plot for United States tight-gas assessment units. Each curve represents one assessment unit and is based on the input data in table 3. Black diamonds show the mean value for each curve. [AU, assessment unit; EUR, estimated ultimate recovery; and BCF, billions of cubic feet]
<table>
<thead>
<tr>
<th>Basin name =&gt;</th>
<th>Sanford sub-basin</th>
<th>Deep River</th>
<th>Dan River - Danville (N.C. portion only)</th>
<th>Davie</th>
<th>Burke</th>
<th>Bertie County</th>
<th>Camden’s-Clinton, Martinburg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (surface acres)</td>
<td>146,830 (~99,000 best known)</td>
<td>~208,329</td>
<td>~64,817</td>
<td>~3,932</td>
<td>8,283</td>
<td>Very small from USGS basement magnetics</td>
<td>Moderate size, inferred from USGS basement &quot;quartz&quot; magnetics</td>
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<tr>
<td>Coal present?</td>
<td>Yes</td>
<td>No data</td>
<td>No data</td>
<td>Yes (thin)</td>
<td>No</td>
<td>No</td>
<td>Unknown</td>
</tr>
<tr>
<td>TOC (core and/or cuttings)</td>
<td>1.96, N = 353</td>
<td>No data</td>
<td>No data</td>
<td>3.08 avg.; N = 159</td>
<td>n/a</td>
<td>n/a</td>
<td>Unknown</td>
</tr>
<tr>
<td>%Ro (core and/or cuttings)</td>
<td>1.83; N = 42</td>
<td>No data</td>
<td>No data</td>
<td>1.97 avg.; N = 48</td>
<td>n/a</td>
<td>n/a</td>
<td>No data</td>
</tr>
<tr>
<td>Source rock/reservoir thickness (feet)</td>
<td>up to 800 (Cumneck Fm.)</td>
<td>Likely similar to Sanford sub-basin</td>
<td>Unknown but Cumneck-like rocks present</td>
<td>~425 (Wallow Creek mbr.), ~1,500 (Eden mbr.)</td>
<td>D</td>
<td>D</td>
<td>No organic facies in the single drill hole</td>
</tr>
<tr>
<td>Strike length and width (miles)</td>
<td>~24 x 11</td>
<td>~58 x ~16</td>
<td>~45 x ~10</td>
<td>~277 x 5 (Eden mbr.), ~22 x ~5 (Wallow Creek mbr.)</td>
<td>n/a</td>
<td>n/a</td>
<td>Minute based on USGS magnetic data</td>
</tr>
<tr>
<td>Targets</td>
<td>Shale, CBM, tight gas</td>
<td>Shale, CBM, tight gas</td>
<td>Shale, CBM, tight gas</td>
<td>Shale, tight gas?</td>
<td>None</td>
<td>None</td>
<td>None at present</td>
</tr>
<tr>
<td>USGS assessment type</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Not assessed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shut in wells</td>
<td>2</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well pressures (psig)</td>
<td>900, 250</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geophysical logs available?</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Depth to basement (feet) - from surface</td>
<td>~7,100 (from seismic and drill holes)</td>
<td>~5,500-6,200 (from seismic)</td>
<td>Probably similar to Sanford and Durham subbasins</td>
<td>About 7,400 feet inferred by stepped drilling; possibly deeper</td>
<td>Probably very shallow</td>
<td>200 feet maximum</td>
<td>Unknown</td>
</tr>
<tr>
<td>Shown gas, oil, asphalt, pyrobitumen)</td>
<td>Many (gas, oil, bitumen, pyrobitumen) wells flowed; oil leaks in abandoned coal mines</td>
<td>None reported</td>
<td>None reported</td>
<td>None reported</td>
<td>No organic facies</td>
<td>No organic facies</td>
<td>No organic facies in single drill hole</td>
</tr>
<tr>
<td>Erosion estimates (feet)</td>
<td>~3,000</td>
<td>Probably similar to Sanford sub-basin</td>
<td>Probably similar to Sanford sub-basin</td>
<td>Probably similar to Sanford sub-basin</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Basin buried, post-thermal history unknown</td>
</tr>
<tr>
<td>Tight gas</td>
<td>Maybe</td>
<td>Possibly</td>
<td>Maybe</td>
<td>Maybe</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Leasing (acres)</td>
<td>8,766</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous drilling (gas &amp; Oil)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Previous drilling (coal)</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes (historical)</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Seismic available?</td>
<td>Yes - dynamite source</td>
<td>Yes - vibroseis source</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Core available?</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Cuttings available?</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Paleolake water depth</td>
<td>Shallow - subject to current action</td>
<td>Probably shallow - subject to current action, one shallow water well</td>
<td>Likely shallow - subject to current action</td>
<td>Shallow - subject to current action, one shallow water well</td>
<td>No lake facies present</td>
<td>No lake facies present</td>
<td>No identified organic facies, one shallow water well</td>
</tr>
<tr>
<td>Counties</td>
<td>Lee, Chatham, Moore</td>
<td>Durham, Chatham, Orange, Wake, Granville</td>
<td>Union, Alamance, Richmond, Montgomery</td>
<td>Stokes, Rockingham (continues into Pittsylvania Co., VA)</td>
<td>Davie, Yadkin</td>
<td>Richmond</td>
<td>Bertie, and perhaps others?</td>
</tr>
<tr>
<td>Key citations</td>
<td>Reid and others, 2001; Reid and others, 2009; Reid and Taylor, 2008-2010 - multiple reports</td>
<td>Thayer and Robbins, 1992; Whitehouse, 2010; Stone, 1981; Kirsten in Thayer and others, 1970; Robbins, 1982; Reid and others, 2013; Oliver, Reid, Kent, Whitehouse 2012 in preparation</td>
<td>Thayer, 1970; Deneen, 1982; Weems and others, 2007</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SB 820 - What hath the legislature wrought?

Controversial bill; passed by one vote overriding the Governor’s veto.

PART VII EFFECTIVE DATE

SECTION 7. Sections 4(a) through 4(f), 4(h), and 4(i) of this act are effective when this act becomes law and apply to wells drilled and leases or contracts entered into on or after that date. Sections 1(a) through 1(h), Sections 2(a) through 2(n), Sections 3(a) through 3(d), and Sections 6(a) and 6(b) of this act become effective August 1, 2012. Section 4(g) and Section 5 become effective October 1, 2012, and Section 5 applies to real estate transfers or dispositions occurring on or after that date. All other sections of this act are effective when this act becomes law.

In the General Assembly read three times and ratified this the 21st day of June, 2012.

s/ Walter H. Dalton
President of the Senate

s/ Thom Tillis
Speaker of the House of Representatives

VETO Beverly E. Perdue
Governor

Became law notwithstanding the objections of the Governor at 11:04 p.m. this 2nd day of July, 2012.

s/ Denise Weeks
House of Representatives Principal Clerk
Dan River-Danville Basin glimpse

North Carolina (USA) Mesozoic rift basin shale gas: A fifth year perspective: JC Reid and KB Taylor

(Reid and Milici, USGS OFR 2008-1108)
Drill Hole: USBM DH-2
NCGS No.: CH-C-1-45
Box No.: 118
From: 1423 feet to 1440 feet

Drill Hole: USBM DH-2
NCGS No.: CH-C-1-45
Box No.: 119
From: 1440 feet to 1449 feet
Our 25-year journey

- Dec. 1987 – manuscript completed; on hold – other work assignments (Reid).
- 1998 – Simpson #1 and Butler #3 wells drilled.
- Spring 2010 – leasing starts; ~10,000 acres in the Sanford sub-basin and flurry of inquiries.
- 2010-2012 - Many( 65) presentations to state, local and professional meetings; legislation mulled to update the out-dated 1945 Oil and Gas Act.
- 2011 - NC General Assembly “study bill” Session Law 2011-276 (H.B. 242) to “determine the oil and gas resources present in the Triassic basins and in any other areas of the State....”
- July 2011 - USGS geologic assessment meeting – Denver (Reid and Simons).
- 2011 - DENR study and public comment.
- 2012 – STRONGER review of state regulations.
- 2012 - USGS Assessment released, Fact Sheet 2012-3075.
- 2012 - General Assembly enacts ‘energy bill’ (S820);
  - Overrides Governor’s veto; legalizes hydraulic fracturing and horizontal drilling
  - Mining Commission expanded to Mining and Energy Commission,
  - Members appointed.
### Exploration overview - North Carolina on-shore Triassic lacustrine rift basins

**As of August 15, 2012 - J.C. Reid**

<table>
<thead>
<tr>
<th>Basin name =&gt;</th>
<th>Sanford sub-basin</th>
<th>Durham sub-basin</th>
<th>Wadesboro sub-basin</th>
<th>Dan River - Darville sub-basin (N.C. portion only)</th>
<th>Davie County Once part of Dan River-Darville Basin</th>
<th>Ellerbe County Once part of Wadesboro sub-basin</th>
<th>Bertie County buried basin under CP, no outcrop</th>
<th>Cumberland-Marlboro County buried basin under CP, no outcrop</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size (surface acres)</strong></td>
<td>146,530 (~59,000 best known)</td>
<td>~405,236</td>
<td>~205,809+</td>
<td>~64,817</td>
<td>~3,932</td>
<td>6,283</td>
<td>Very small from USGS basement magnetics</td>
<td>Moderate size; inferred from USGS basement &quot;quiet&quot; magnetics</td>
</tr>
<tr>
<td><strong>Coal present ?</strong></td>
<td>Yes</td>
<td>No data</td>
<td>No data</td>
<td>Yes (thin)</td>
<td>No</td>
<td>No</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>TOC (core and/or cuttings)</strong></td>
<td>1.96; N = 353</td>
<td>No data</td>
<td>No data</td>
<td>3.08 (avg.); N = 159</td>
<td>n/a</td>
<td>n/a</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>%Ro (core and/or cuttings)</strong></td>
<td>1.28; N = 42</td>
<td>No data</td>
<td>No data</td>
<td>1.97 (avg.); N = 48</td>
<td>n/a</td>
<td>n/a</td>
<td>No data</td>
<td>No data</td>
</tr>
<tr>
<td><strong>Source rock / reservoir thickness (feet)</strong></td>
<td>up to 800 (Cummock Fm.)</td>
<td>Likely similar to Sanford sub-basin</td>
<td>Unknown but Cummock like rocks present</td>
<td>~425 (Walnut Cove mbr.), ~1,500 (Eden mbr.)</td>
<td>0</td>
<td>0</td>
<td>No organic facies in the single drill hole</td>
<td>Minute based on USGS magnetic data</td>
</tr>
<tr>
<td><strong>Strike length and width (miles)</strong></td>
<td>~24 x ~11</td>
<td>~58 x ~16</td>
<td>~45 x ~10</td>
<td>~177 x 5 (Eden mbr.); ~22 x 5 (Walnut Cove mbr.)</td>
<td>n/a</td>
<td>n/a</td>
<td>Not assessed</td>
<td>Not assessed</td>
</tr>
<tr>
<td><strong>Targets</strong></td>
<td>Shale, CBM, tight gas</td>
<td>Shale, CBM, tight gas</td>
<td>Shale, CBM, tight gas</td>
<td>Shale, tight gas?</td>
<td>None</td>
<td>None</td>
<td>None at present</td>
<td>Not assessed</td>
</tr>
<tr>
<td><strong>USGS assessment type</strong></td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
</tr>
<tr>
<td><strong>Shut-in wells</strong></td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Depth to basement (feet) - from surface</strong></td>
<td>~7,100 (from seismic and drill holes)</td>
<td>~5,500-6,200 (from seismic)</td>
<td>Probably similar to Sanford and Durham sub-basins</td>
<td>About 4,700 feet inferred by stepped drilling, possibly deeper</td>
<td>Probably very shallow</td>
<td>200 feet maximum</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>Shows (gas, oil, asphalt, pyrobitumen)</strong></td>
<td>Many (gas, oil, bitumen, pyrobitumen); wells flared; oil blebs in abandoned coal mines</td>
<td>None reported</td>
<td>None reported</td>
<td>None reported</td>
<td>No organic facies</td>
<td>No organic facies</td>
<td>No organic facies in single drill hole</td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>Erosion estimates (feet)</strong></td>
<td>~3,000</td>
<td>Probably similar to Sanford sub-basin</td>
<td>Probably similar to Sanford sub-basin</td>
<td>Probably similar to Sanford sub-basin</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Basin buried; past thermal history unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>Leasing (acres)</strong></td>
<td>8,765</td>
<td>8,765</td>
<td>8,765</td>
<td>8,765</td>
<td>8,765</td>
<td>8,765</td>
<td>8,765</td>
<td>8,765</td>
</tr>
</tbody>
</table>
Public participation

• Three public hearings were held in the Triassic Basin. The first was on Oct. 10, 2011, and the draft plan of study was presented; the STRONGER process was discussed; and public comment was received as to how the study should be conducted. Comment was received and written comment on the draft outline of the study were accepted through Oct. 18, 2011.
• Two additional public meetings occurred in March 2012 to discuss the draft report.
• Draft findings and recommendations were presented in a public meetings on March 20, 2012 and on March 27, 2012. Both meetings were streamed live online, the same information was presented, and public comments were accepted at both meetings, via mail and email.
• Chatham County hosted a third meeting on April 2 where public comments were received.
• Written comments on the draft report were accepted through April 2, plus feedback received at the two public meetings.
• DENR requested a nonprofit organization called State Review of Oil & Natural Gas Environmental Regulations (STRONGER) to review of North Carolina’s oil and gas regulatory programs. The STRONGER review process brought together representatives from the state, the oil and gas industry, and public interest stakeholders to evaluate the state’s regulatory programs against STRONGER’s set of national guidelines. STRONGER’s review panel met in late October to gather information about the state’s processes, and issued a report in late February 2012. DENR study located at URL http://portal.ncdenr.org/web/guest/denr-study
STRONGER Review - 2012

• DENR requested a nonprofit organization called State Review of Oil & Natural Gas Environmental Regulations (STRONGER) to review of North Carolina’s oil and gas regulatory programs.

• The STRONGER review process brought together representatives from the state, the oil and gas industry, and public interest stakeholders to evaluate the state’s regulatory programs against STRONGER’s set of national guidelines.

• STRONGER’s review panel met in October 2011 to gather information about the state’s processes, and issued a report in February 2012.
Potential reservoir rocks

<table>
<thead>
<tr>
<th>Drill Hole</th>
<th>NCST-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCGS No.</td>
<td>SO-C-2-81</td>
</tr>
<tr>
<td>Box No.</td>
<td>19</td>
</tr>
<tr>
<td>From</td>
<td>220 feet to 230 feet</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drill Hole</th>
<th>NCST-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCGS No.</td>
<td>SO-C-2-81</td>
</tr>
<tr>
<td>Box No.</td>
<td>20</td>
</tr>
<tr>
<td>From</td>
<td>230 feet to 240 feet</td>
</tr>
</tbody>
</table>

Lower member of the Cow Branch Fm.
S820 Highlights – cont’d

• **Boldface disclosure** that property owners leasing land secure written approval from their mortgage lenders.

• **Groundwater testing:**
  – Energy companies required to test groundwater in a 5,000-feet radius of a drill site before and after drilling.
  – Any contamination is assumed to be from drilling unless proven otherwise. Provides for groundwater supply remedy.