Status of Investigations into the Oil and Gas Resource Potential of the Onshore Lands and State Waters of North Carolina

by James L. Coleman, Eastern Energy Resources Science Center, U. S. Geological Survey, Reston, VA 20192

The U. S. Geological Survey (USGS) is currently conducting an oil and gas resource assessment study of the Mesozoic basins located in the onshore area and state waters of the eastern United States. For this effort, the state waters are those water bodies within the geographic boundaries of a state plus those coastal waters out to the State – Federal management boundary. In the case of North Carolina, this boundary is three miles offshore. This study is part of the long term National Oil and Gas Assessment (NOGA) project of the USGS (http://energy.cr.usgs.gov/oilgas/noga/) to assess the oil and natural gas endowment and the reserve growth potential of the United States, exclusive of Federal waters.

USGS scientists working on the NOGA project examine the occurrence of oil and natural gas in sedimentary basins in the United States. They seek to identify the source rocks for the oil and gas in a basin and the relation between those source rocks and reservoir intervals in known and potential productive fields. Based on the history of oil and gas discovery and production within a basin, the NOGA project scientists estimate the number and size of yet-to-be-discovered, technically-recoverable resource accumulations. These estimations are presented as a range of possible values and are expressed as 5%, 50% (in essence, most likely), and 95% probability values. The NOGA project scientists identify the total petroleum system (or systems)(TPS), which includes all of the genetically related petroleum (both discovered and undiscovered) generated by a source rock, along with the associated reservoir rocks, sealing intervals, and overburden. By incorporating these geological elements in a limited, but mappable, geologic volume, the essential geologic processes of generation, expulsion, migration, entrapment, and preservation of petroleum are associated in time and space (Charpentier and others, 2001).

Within petroleum systems there are one or more assessment units (AU's), which are mappable volumes of rock that encompass the petroleum fluids, reservoirs, and sealing intervals that make up existing and potential future fields. Assessment units are classified as "conventional" (those accumulations that have a readily identifiable hydrocarbon-water contact) or "continuous" (those accumulations that do not have a readily identifiable hydrocarbon-water contact). Conventional accumulations are those types of accumulations with relatively high porosity and permeability and an identifiable structural, stratigraphic, or combination trap geometry. Continuous accumulations are those types of accumulations with relatively low porosity and permeability and a trap geometry that is difficult to identify. Continuous types of accumulations occur in coal bed methane, shale gas, and tight gas sandstone play types (Schmoker, 1999; Schmoker and Klett, 1999). For national consistency, a minimum accumulation size is set at 0.5 million barrels of oil or 3 billion cubic feet of gas. NOGA project scientists may classify

an assessment unit as "hypothetical" if they believe that all of the essential elements of an effective petroleum system may be present, but there are no data to demonstrate clearly that one or more technically-recoverable accumulations above minimum size exist. In this instance, the assessment unit is identified, but no resource volumes are estimated.

The USGS is using these principles to assess the oil and gas resource potential of North Carolina. North Carolina lies within the Blue Ridge, Piedmont, and Atlantic Coastal Plain provinces of the eastern United States. Within the Piedmont and Coastal Plain provinces, narrow Mesozoic rift basins are known to contain elements of a potential petroleum system. These rift basins are present both as exposed features within the Piedmont province and as buried features beneath the Atlantic Coastal Plain. Over the past decades, research by the USGS, the North Carolina Geological Survey, and several petroleum industry companies have found shows of oil and natural gas in wells and outcrop samples in the exposed rift basins of North Carolina. The USGS and North Carolina Geological Survey continue to study these basins, both in outcrop and boreholes, to understand better the potential extent of any petroleum accumulation (Reid and Milici, 2008; Reid and Taylor, 2008). Research on the buried rift basins has proceeded more slowly, because individual boreholes are needed to sample the target subsurface intervals for possible shows of oil or gas. Examination of previously drilled industry boreholes has yielded some valuable information, yet discovery of previously unknown basins by recent drilling is not uncommon. This is evidenced by the recent discovery of a buried rift basin in Bertie Co., NC, in 2004 (Weems and others, 2007).

The trend of these Mesozoic rift basins runs primarily across eastern North Carolina in a generally SW – NE direction (Figure 1). Beneath these basins are metamorphic and

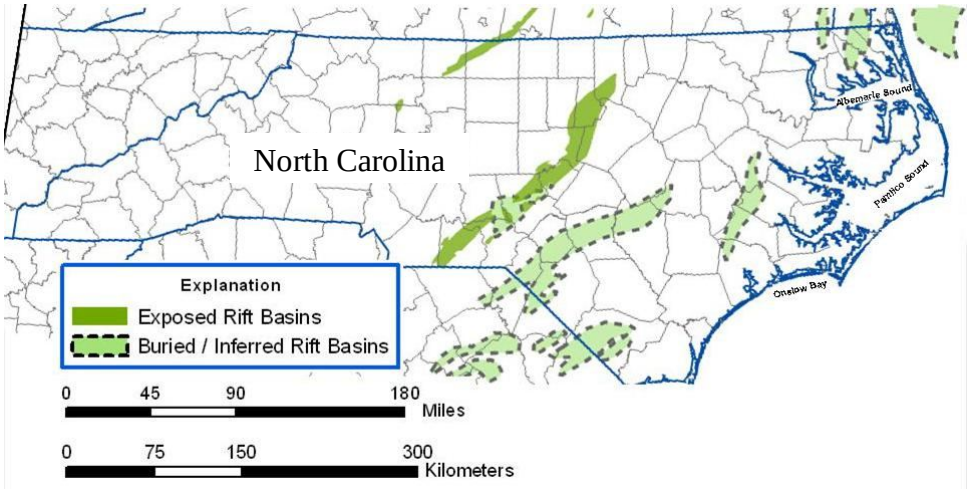

Figure 1. Trend of Mesozoic rift basins in North Carolina (simplified from Benson, 1992; Horton and others, 1991; and Zietz and others, 1984)

igneous rocks that formed during the mountain building events, which formed the Appalachian Mountains. Although some of these rift basins are present offshore of the Atlantic coastline, most are located onshore. Of significance to possible accumulations in state waters, the trend appears to bypass the wetlands, rivers, and bays of Pamlico and Albemarle Sounds and Onslow Bay (Figure 1).

This zone of apparent bypass has been delineated by many wells and some seismic profiling. 120 of the 129 oil and gas exploration wells drilled in North Carolina were drilled within the coastal plain and bays of eastern North Carolina. Of these 120 coastal plain wells, all but one failed to drill through the entire sedimentary section and tag metamorphic or igneous basement at the end of drilling. Only nine of these wells reported shows of oil or natural gas. None were completed as commercial producers.

The relatively paucity of oil and gas shows in eastern North Carolina can possibly be explained by the apparent absence of an effective source rock interval within the drilled, sedimentary section. A petroleum source rock may be present, however, to the east and southeast (offshore), but the migration pathways necessary to charge reservoirs beneath the coastal plain from these potential, deeper source rocks were probably not present at the time of a hypothetical phase of petroleum generation and migration.

Although no commercial accumulations of petroleum have been found to date under the coastal plain and state waters, the suggestion that there might be economic quantities of oil or natural gas present in the eastern part of the state in the vicinity of the nine wells that reported shows deserves an investigation. If it can be determined that the oil and gas shows are valid reports, then the ongoing study will seek to explain the origin of these shows.

References cited:

Benson, R. N., 1992, Map of exposed and buried early Mesozoic rift basins/synrift rocks of the U. S. middle Atlantic continental margin: Delaware Geological Survey Miscellaneous Map Series No. 5. (available online at http://www.dgs.udel.edu/publications/Pubs/MiscMaps/Misc05.pdf).

Charpentier, R. R., T. R. Klett, T. S. Ahlbrandt, and J. W. Schmoker, 2001, Total petroleum system concept for the assessment of undiscovered petroleum resources (abstract): Geological Society of America Earth System Processes – global meeting, June 24 – 28, 2001, Edinburgh, Scotland, U.K. abstracts with program volume (available online at http://gsa.confex.com/gsa/2001ESP/finalprogram/abstract_7267.htm).

Horton, J. W., Jr., A. A. Drake, J., D. W. Rankin, and R. D. Dallmeyer, 1991, Preliminary tectonostratigraphic terrane map of the central and southern Appalachians: U. S. Geological Survey Miscellaneous Investigations Series Map I 2163, one sheet with 15 p. pamphlet (available online at http://pubs.er.usgs.gov/usgspubs/i/i2163).

Reid, J. C. and R. C. Milici, 2008, Hydrocarbon source rocks in the Deep River and Dan River Triassic Basins, North Carolina: U. S. Geological Survey Open-File Report 2008-1108, 28 p. (available online at http://pubs.usgs.gov//of/2008/1108/).

Reid, J. C. and K. B. Taylor, 2008, Tools to evaluate the hydrocarbon potential of the Mesozoic Basins, North Carolina, USA (abstract): American Association of Petroleum Geologists Eastern Section Abstracts with Program (available online at http://www.searchanddiscovery.net/abstracts/html/2008/eastern-pittsburgh/abstracts/reid.htm).

Schmoker, J. W., 1999, U. S. Geological Survey assessment model for continuous (unconventional) oil and gas accumulations – the "FORSPAN" model: U. S. Geological Survey Bulletin 2168, 9 p.

Schmoker, J. W., and T. R. Klett, 1999, U. S. Geological Survey assessment model for undiscovered conventional oil, gas and NGL resources; the seventh approximation: U. S. Geological Survey Bulletin 2165, 7 p.

Weems, R. E., E. L. Seefelt, B. M. Wrege, J. M. Self-Trail, D. C. Prowell, C. Durand, E. F. Cobbs III, and K. C. McKinney, 2007 and others, 2007, Preliminary physical stratigraphy and geophysical data of the USGS Hope Plantation Core (BE-110), Bertie County, North Carolina: U. S. Geological Survey Open-File Report 2007-1251, 163 p. (available online at http://pubs.usgs.gov/of/2007/1251/).

Zietz, I., F. E. Riggle, and F. P. Gilbert, 1984, Aeromagnetic map of North Carolina in color: U. S. Geological Survey Geophysical Investigation Map 958, one sheet.