

# North Carolina Geological Survey

## Information Circular 36

### *Natural Gas and Oil in North Carolina*



## INTRODUCTION

Though natural gas and oil are known to occur in North Carolina, they are not currently produced in the state. Additional work is needed to evaluate their economic value. This report provides an overview of natural gas and oil potential in North Carolina, how natural gas and oil forms, recent interest in both on-shore and off-shore resources, and a summary of the current permit requirements and regulations. North Carolina currently does not produce any natural gas or oil.

Natural gas and petroleum are made up of many hydrocarbon compounds. The simpler hydrocarbons are gases because of their relatively lower molecular weight. The more complex ones are in liquid or solid form.

The first commercial oil well in the United States was drilled in 1859 at Titusville, Pa. Oil was struck at a depth of 69 feet and the well was capable of producing approximately 25 barrels of oil per day.

Between 1925 and 1998, 128 petroleum exploration holes have been drilled in North Carolina. None were commercial. Recent exploration has been focused in Lee and Chatham counties. Two of these exploration wells remain under permit in Lee County but are not in production.

## GEOLOGY

The four requirements to produce natural gas and oil are: 1) source rocks to generate the resource, 2) heat/pressure to mature the resource and its migration, 3) porosity / permeability for movement of the resource, and 4) traps to hold the resource.

### GENERATION OF NATURAL GAS AND OIL

The processes to produce and concentrate hydrocarbon resources are complex and take a long time. Petroleum formation requires that sedimentary deposits containing organic debris be buried at sufficient depths so that they are “cooked” by the Earth’s natural heat over time. With progressively deeper burial, the organic remains are converted to a substance called kerogen. The kerogen, in turn, is converted to natural gas and oil as depths of burial and corresponding temperatures and pressures increase.

The best preservation of organic material occurs in fine-grained sediments that accumulated at the Earth’s surface under reducing conditions (an environment where the amount of oxygen is low). Dark-gray and black shales accumulated under reducing conditions generally contain an abundance of organic matter and have long been recognized by petroleum geologists as potential petroleum source beds. Some carbonate rock strata have proved to be more than adequate sources of natural gas and oil.

## **HEAT/PRESSURE AND MIGRATION**

Once generated, natural gas and oil either remain within the source beds from which they were generated, or they migrate elsewhere in response to differential compaction and to temperature and pressure gradients within the Earth. Migration pathways are difficult to define, but apparently take place along relatively porous beds or fracture zones within the Earth. In general, migration is from areas of relatively high pressure to low pressure and from areas of relatively high temperature to low temperature.

## **POROSITY AND PERMEABILITY**

Geologists recognize two general types of porosity – primary and secondary. Primary porosity consists of the open spaces between grains in the rock that existed at its formation. Secondary porosity consists of open spaces, such as fractures caused by deformation or voids caused by dissolution of soluble rock, induced after the rock formed.

Permeability is the capability of a rock to transmit fluids. Coarser-grained sedimentary rocks are more permeable because they contain larger, more interconnected pores than the finer-grained rocks. Porosity and permeability permit and enhance fluid migration from petroleum source beds to reservoirs and to produce the resource.

## **TRAPS**

Hydrocarbons must be trapped in the Earth, or they will migrate to the surface and escape. Hydrocarbon traps form in many different ways. Folds and faulted rocks form some traps. Others traps are produced by variations in sedimentary deposits.

## **EXPLORATION AND PRODUCTION**

A great deal of natural gas and oil has been discovered by sheer luck since the first commercial oil was discovered in 1859. The geologic processes that cause the localization of petroleum resources will be better understood as petroleum geologists became increasingly adept at finding and exploiting these resources. The most important exploration tool for natural gas and oil is common depth point (CDP) seismic profiling. This method employs energy sources such as explosives, truck mounted vibrators (known as Vibroseis), and air guns in water. Sound waves put into the Earth travel downward through the rock layers and are reflected back to the surface where they are recorded by listening devices. The data are processed by geophysicists and geologists using computer software to produce and interpret the “record sections.” These seismic profiles are cross-sections of the Earth’s subsurface structure and are combined with geologic mapping, exploration drilling and other techniques to evaluate the resource potential.

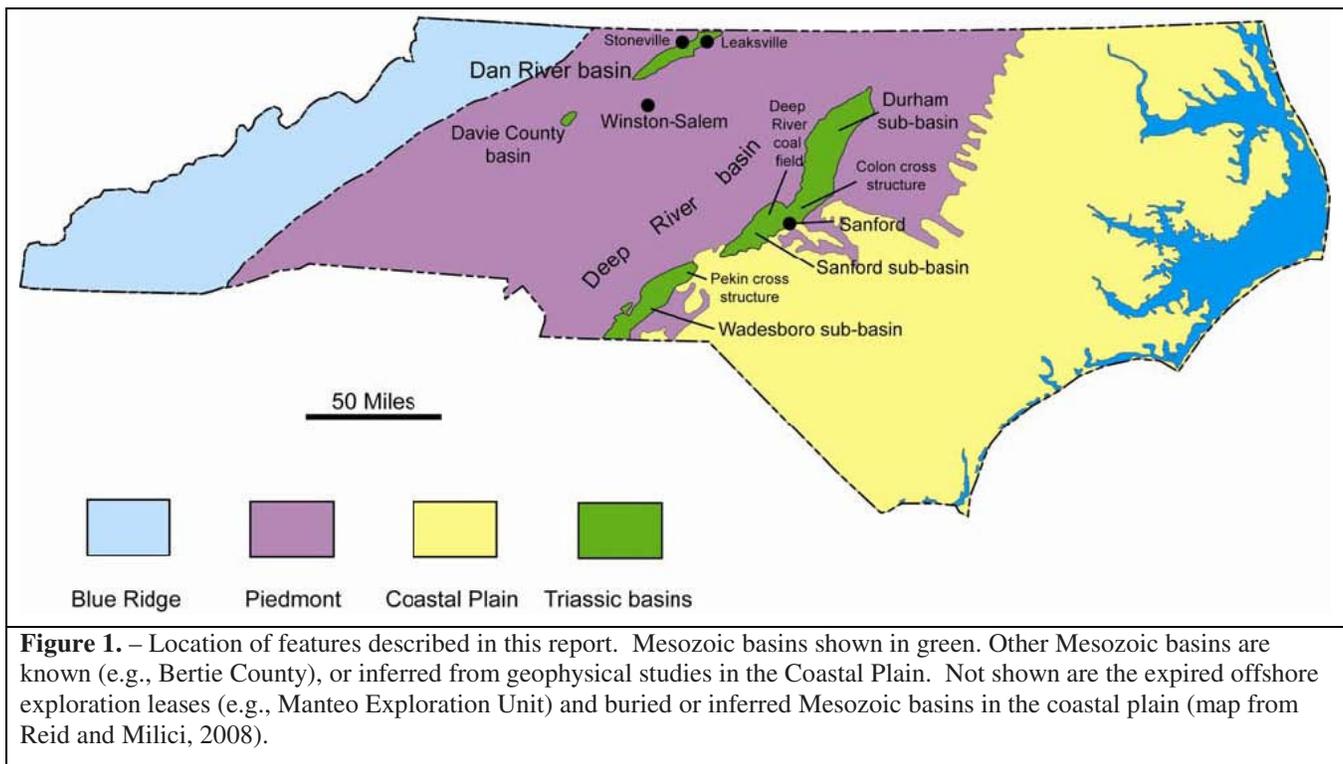
## **OIL AND GAS IN NORTH CAROLINA**

In North Carolina, natural gas and oil can be potentially produced in commercial quantities from two general geologic regions: (1) the Mesozoic basins that are exposed in the Piedmont or lie buried beneath the Atlantic Coastal Plain, and (2) from the Atlantic Outer Continental Shelf (AOCS), which extends eastward from North Carolina’s coastal waters some 50 miles to the edge of the continental shelf.

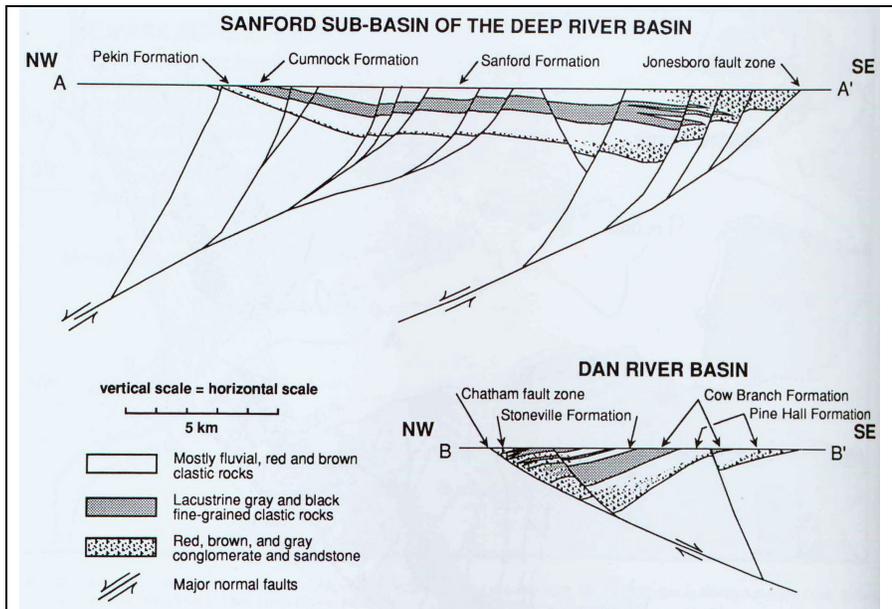
The Atlantic Coastal Plain was explored by drilling but showed limited promise for hydrocarbon production. The Blue Ridge and Piedmont are non-productive because they are composed of non-organic crystalline rocks. The offshore Atlantic Outer Continental Shelf remains prospective and may be tested in the future. The petroleum potential of Paleozoic sedimentary rocks west of the Blue Ridge is unknown.

### MESOZOIC BASINS

Mesozoic sedimentary basins began to form along the eastern seaboard from Florida to Nova Scotia approximately 225 million years ago during the first stages of the opening of the Atlantic Ocean. There has been a recent increased interest in the potential for natural gas production from these basins – particularly in Lee County (Figure 1). Previously, Lee County was the focus of coal and oil exploration.



Mesozoic basins formed by the collapse of the Earth’s crust and were filled by a variety of sediments from erosion of the nearby mountains (Figure 2). Exploration drilling has not yet found commercial natural gas or oil. Exploration drilling records document the presence of natural gas and oil in the Deep River Mesozoic basin, thousands of feet beneath the Earth’s surface (Figure 3).



**Figure 2.** – Generalized cross section of the Sanford sub-basin, Deep River Basin (A-A’) and the Dan River Basin (B-B’). A-A’ shows the Pekin, Cumnock and Sanford Formations and the approximate locations of the Jonesboro and Deep River faults. Cross sections based largely on surface data in the Dan River basin and on seismic profiles and deep drill hole data on the Deep River basin (From Olsen, 1991).

**Figure 3.** – Butler #3 well head, located in Lee County, North Carolina. The well is not in production. Oil and gas shows have been reported from several wells in the Lee County, North Carolina area (Reid and Milici, 2008)

**ATLANTIC OUTER CONTINENTAL SHELF**

The Atlantic Outer Continental shelf, the buried Bertie County Mesozoic basin and other Mesozoic basins are the last major frontier areas for natural gas and oil exploration in North Carolina. The Bertie County Mesozoic basin is known by only one drill hole that did not intersect organic-rich rocks.

At present, there are no Outer Continental Shelf (OCS) natural gas and oil leases offshore of North Carolina. The primary focus in the past was the Manteo Exploration Unit that was approved on May 25, 1990. Following extensive state comment and various legal proceedings, all leases were cancelled. In 2008, President Bush reversed his opposition on off-shore drilling in certain locations. Subsequently, on Oct. 1, 2008, the Congressional moratorium was allowed to expire, allowing all OCS areas to be considered for leasing. The OCS Lands Act Amendments of 1978, however, requires that any area must be included in the 5-Year OCS Leasing Program to be offered for leasing. Three areas off the Atlantic coast, including North Carolina and Virginia are part of the proposed leasing program. On Feb. 10, 2009, the new Interior Department Secretary, Ken Salazar, extended the timeframe for public comment.

In January 2009, the N.C. General Assembly leadership commissioned a study committee to examine the effects of off-shore natural gas and oil exploration.

## **NORTH CAROLINA PERMITTING AND REGULATION PROCESS**

The oil and gas law can be viewed online at URL: <http://www.ncleg.net/gascripts/statutes/Statutes.asp>

### **EXPLORATORY DRILLING FOR OIL OR GAS PERMIT**

**What Activities Require This Permit?** Persons wishing to drill an exploratory well for oil or gas are required to (1) register with the N.C. Department of Environment and Natural Resources (NCDENR), (2) post a bond and (3) submit an application for a drilling permit.

**What Is The Purpose of This Permit?** The permit provides a method by which NCDENR regulates for the protection of the environment.

**Who Issues This Permit?** Division of Land Resources

**How Much Will This Permit Cost?** Prior to any exploration drilling in North Carolina for oil and gas, persons, firms or corporations must register with the NCDENR and furnish bond in the amount of \$5,000, conditioned that any well opened or caused to be opened by an operator shall upon abandonment be plugged in accordance with the rules of NCDENR. Forms for registration and posting of bond may be obtained by application to the director of the Division of Land Resources. Registration, as required by the statutes, shall be by application to the director for a drilling permit upon a form specified by the director, accompanied by a fee of \$50.

**Where Can I Get The Application For This Permit?** Contact the Division of Land Resources

**How Long Will It Take To Review My Application?** There is no set time to review the application.

**Where Do I Submit My Application?** Division of Land Resources, 1612 Mail Service Center, Raleigh, NC 27699-1612

**How Long Is My Permit or License or Certificate Valid?** Drilling permits are valid until completion of the well.

**Legal Authority/Statute Reference:** G.S. 113-378 to 113-415 – “Subchapter V. Oil and Gas Conservation – Article 27”; 15A NCAC 05D – “Subchapter 5D – Oil and Gas Conservation”

### **GEOPHYSICAL EXPLORATION PERMIT**

**What Activities Require This Permit?** Persons conducting geophysical explorations methods, which involve the **use of explosives**, are required to have a permit. By rule, explorations shall mean geological, geophysical and other surveys and investigations, including seismic methods for the discovery and location of oil, gas or other mineral prospects, and which may or may not involve the use of explosives. A permit from NCDENR is required for all seismic exploration work in the area to which these rules are applicable. No such seismic work shall be started without a permit and all such work must be carried out in such manner as may be approved by the NCDENR Secretary.

**What Is The Purpose of This Permit?** The permit provides a method by which NCDENR knows where exploration work is being conducted, places limits on the maximum size, required depth of burial of explosives, time of day shooting can occur, requirements for removal of pipe used in geophysical exploration operations and the minimum distance shot points can be placed near certain features, vessels and bodies of water. The permit process also allows NCDENR to assign a seismic agent to monitor all seismic shooting.

**Who Issues This Permit?** Division of Land Resources

**How Much Will This Permit Cost?** There is no permit fee for the submission of a geophysical exploration permit. No bond is required.

**How Long Is My Permit or License or Certificate Valid?** Permits are limited to a period of six months from date of issue, but may be renewed for not more than two additional 90-day periods at the discretion of the NC DENR Secretary. Applications for renewal may be made in the form of a letter. After the expiration of a permit and any renewals thereof, work may continue or be resumed under any new permit issued or application made as provided in Rule .0106 of Subchapter 5C.

**Legal Authority/Statute Reference:** G.S. 113-378 to 113-415 – “Subchapter V. Oil and Gas Conservation – Article 27”; 15A NCAC 05C – “Subchapter 5C – Geophysical Exploration”

**Where Can I Get The Application For Either of These Permits?** Contact the Division of Land Resources

**How Long Will It Take To Review My Application?** Application for permits for such exploration work must be filed in quadruplicate with NCDENR at least 10 days before issuance of permits and must be accompanied by a detailed map showing the exact area in which the geophysical operations are to be conducted, such area to be shown, where possible, by reference to established coast objects or landmarks. Permittees will also obtain appropriate assent from the lessee if and where the area under investigation is leased, with exclusive exploration privilege, to other than the permittee.

**Where Do I Submit My Application?** Division of Land Resources, 1612 Mail Service Center, Raleigh, NC 27699-1612

**Statewide Contact Information:** Division of Land Resources, 1612 Mail Service Center, Raleigh, NC 27699-1612, Telephone: (919) 733-2423 — Facsimile: (919) 733-0900

**North Carolina Environmental Permit Handbook:** See following URL:  
<http://portal.ncdenr.org/web/csc/start/overview;jsessionid=612312ABEFB4F8572F5CEC38370E792F>

## SUGGESTED ADDITIONAL READING

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## ACKNOWLEDGMENT

Portions of this report describing the origin of petroleum were adapted from Milici and Upchurch (2007). Their willingness to allow its use is greatly appreciated.

Prepared by Dr. Jeffrey C. Reid, PG, CPG; 12 March 2009.

## **FOR FURTHER INFORMATION**

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The North Carolina Geological Survey maintains a core repository containing cores, cuttings, well logs and other materials. Access to this facility is by request to the Chief, North Carolina Geological Survey. Borrowing agreement proposals will be considered.

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