

Gas and Oil

INTRODUCTION

Much of our civilization is based upon one substance, petroleum, which literally means "rock oil". The 20th century will probably be referred to by future generations as the beginning of the age of petroleum. Practically everyone uses gasoline, oil, plastics, diesel and jet fuels, paints, nylon and polyester, asphalt, or other products which are derived from petroleum.

Petroleum, and a closely related substance called natural gas, are composed mostly of two elements - hydrogen and carbon. Substances that contain these two elements are commonly referred to as hydrocarbons. Petroleum and natural gas are made up of many hydrocarbon compounds. The simpler hydrocarbons have a relatively low molecular weight and occur as gases. The more complex hydrocarbons are heavier, generally occur in liquid form, and are capable of being processed into gasoline and lubricating oils.

The first commercial oil well was drilled in America in 1859 at Titusville, Pennsylvania. It struck oil at a depth of 69 feet and was capable of producing approximately 25 barrels of oil per day. The first commercial hydrocarbon well drilled in Virginia struck natural gas in what was to become the Early Grove field, near Bristol. The well was drilled in 1931 in Scott County. Since then, 9,586 wells have been drilled in Virginia in search of oil or gas through 2013. Of these, 7,940 wells produced natural gas and 57 produced oil in 2013. In 2013 alone, 124 gas wells were drilled in Virginia. Many of these gas wells were drilled in search of the

type of gas that is associated with coal beds and is commonly called coal bed methane. The first underground storage field in Virginia was installed in the abandoned Early Grove field in 1990.

SOURCE ROCKS FOR OIL AND GAS

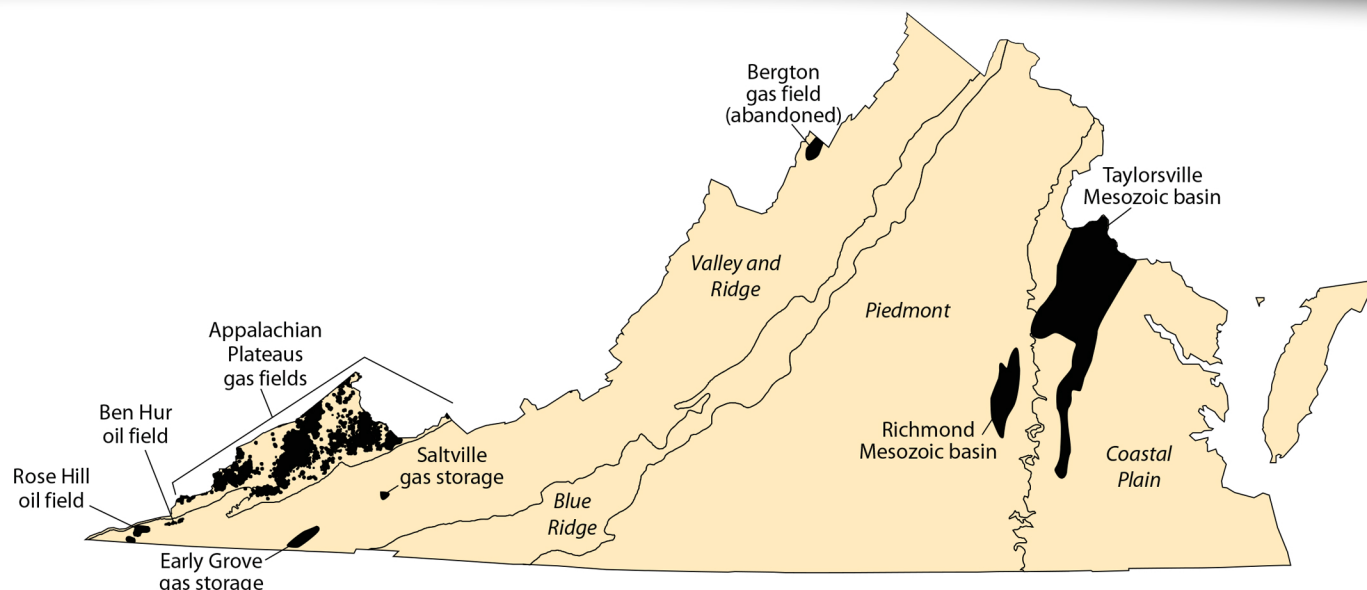
Oil and natural gas occur widely at or near the surface of the earth. The processes which produce and concentrate these hydrocarbon resources are complex and take long periods of time. In general, the

formation of petroleum involves the burial of sedimentary deposits containing organic debris within the earth at sufficient depths so that the deposits are "cooked" by the earth's natural heat. The cooking occurs in stages. As the deposits are progressively more deeply buried by the addition of overlying deposits, the organic remains of any animals and plants that they might contain are converted into

a substance called kerogen. The kerogen, in turn, is converted to oil and gas as depths of burial and corresponding temperatures and pressures increase. Since oxidation tends to destroy the remains of animals and plants, they are usually best preserved in sediments which have accumulated at the earth's surface under reducing conditions (an environment where the amount of oxygen is low). Because of its fine texture, the organic debris is usually transported with the very fine-grained sediments - mud and very fine silt rather than with sand and gravel - and is deposited in relatively quiet waters. As a result, dark-gray and black shales that have accumulated under reducing conditions generally contain an



Early Grove gas field.



abundance of organic matter and they have long been recognized by petroleum geologists as potential source beds. In addition, certain carbonate rock strata have proven to be considerable sources of oil and gas.

MIGRATION

Once generated, oil and gas either remain within the source beds from which they were generated, or they are expelled and migrate elsewhere in response to differential compaction and 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 trends from areas of relatively high pressure to areas of low pressure and from areas of relatively high temperature to areas of low temperature.

POROSITY AND PERMEABILITY

The porosity of rock formations may be of two general types, described by petroleum geologists as primary and secondary. Primary porosity consists of the open spaces in the rock that existed during its formation. This kind of porosity is the open space that exists between the grains within the rock. Secondary porosity consists of open spaces, such as fractures caused by deformation or voids caused by dissolution of soluble rock, which formed in the rock subsequent to lithification.

Permeability is the capability of a rock to transmit fluids. Many factors are involved in the relative permeabilities of strata. In general, coarser grained sedimentary rocks are more permeable because they

contain larger, more interconnected pores than finer-grained sedimentary rocks. Porosity and permeability are important, not only for permitting and enhancing fluid migration from source beds to reservoirs, but also for efficient draining of the reservoirs once they are drilled.

TRAPS

Unless hydrocarbons are trapped somewhere within the earth, they will migrate to the surface and escape into the natural environment. Natural traps suitable for containing hydrocarbons may form in a variety of ways. Commonly, traps exist where sedimentary deposits vary in composition and porosity. Where reservoirs contain water, hydrocarbon accumulations are commonly zoned within the traps. Exsolved gas may occur as a cap at the top of traps, where it overlies accumulations of oil, which in turn floats upon the water that fills pore spaces below. Other traps may form as geologic rock strata are physically folded or faulted during mountain-building events.

EXPLORATION AND PRODUCTION

Ever since the first commercial oil was discovered and produced by the Drake well in 1859, a great deal of oil and gas has been discovered serendipitously - by sheer luck. As the geologic processes that caused the localization of petroleum resources became better understood, petroleum geologists became increasingly adept at finding and exploiting these resources. The most important exploration tool for oil and gas is common depth point (CDP) seismic profiling. This method employs energy sources such as dynamite or truck-mounted vibrators (Vibroseis) on land and air

guns in water. Energy waves sent into the earth travel downward and along rock layers and are reflected back to the surface of the earth where they are intercepted by listening devices. The data are manipulated by geophysicists and geologists who utilize ever-evolving computer software to produce and interpret “record sections”, or seismic profiles, which are cross sections of the earth. Subsurface geologic mapping is accomplished by integrating information from the seismic profiles, exploration test holes, and development wells.

OIL AND GAS IN VIRGINIA

In Virginia, oil and gas are produced or have the potential of being produced in commercial quantities from four general geologic regions: the Appalachian basin in the western part of the state, the Mesozoic basins that are exposed in the Piedmont Physiographic Province, from areas that lie buried beneath the Atlantic Coastal Plain, and from the Atlantic Outer Continental Shelf (AOCS), which extends eastward from Virginia’s coastal waters some 50 miles to the edge of the continental shelf. Some regions, such as the Atlantic Coastal Plain, have been tested by drilling and show limited promise for hydrocarbon production.



Pump jack installed on coalbed methane well operated by CNX Gas Company, LLC, in Buchanan County, VA. Photograph courtesy of the Division of Gas and Oil.

Other regions, namely the areas of the Blue Ridge and Piedmont underlain by hard crystalline rock, are unproductive.

Valley and Ridge and Plateau

The area west of the Blue Ridge is underlain almost entirely by rocks of Paleozoic age (from 570 to 245 million years old). These rocks formed as carbonate and siliciclastic (clay, silt, sand, gravel) sediment accumulated on the ancient continental shelf and margin hundreds of millions of years ago.

Some of the mud and silt that was deposited in these ancient seas accumulated in reducing environments and contain sufficient enough organic matter to be suitable as source beds for hydrocarbons. The most productive source beds in the Appalachian basin of western Virginia are the gray and black shales of Ordovician and Devonian age. Oil production comes from limestone of Ordovician and Mississippian age. Gas production comes from shale and sandstone of Devonian and Mississippian age. Production of oil and natural gas in the Valley and Ridge province is confined to Lee and Scott Counties. Production of oil and gas in the Appalachian Plateau province is currently located in Wise, Dickenson, Buchanan, Russell, and Tazewell counties.

During Pennsylvanian time the Appalachian Plateau area was covered by deltas and coastal swamps. Along these areas, plant life flourished. With the passage of time, plant material accumulated in these areas and was subsequently buried and converted to coal beds. Pennsylvanian age coal beds are the source beds and the reservoir for methane production.

Mesozoic Basins

Sedimentary basins of Mesozoic age occur along the eastern seaboard from Florida to Nova Scotia. The Mesozoic basins began forming approximately 225 million years ago during the first stages of the opening of the Atlantic Ocean.

These basins were traps for a variety of sediments, most of which were produced by the erosion of the nearby mountains. Exploration by drilling has thus far not been successful in finding commercial quantities of gas or oil in these basins. Well records, however, document the presence of gas and oil in both the Richmond and Taylorsville basins, at depths thousands of feet beneath the earth’s surface.

Atlantic Outer Continental Shelf

The Atlantic Outer Continental Shelf and the buried Taylorsville Mesozoic basin are the last major frontier areas for oil and gas exploration in and adjacent to Virginia. To date, most of the exploration by industry has been confined to the northern part of the Taylorsville basin and only one well, Shell 93-1, has been drilled off the coast of Virginia. Thus far the results of drilling have been unproductive, although non-commercial quantities of hydrocarbons have been discovered.

SUGGESTED READING

Averitt, Paul, 1941, Early Grove gas field, Scott and Washington counties: Virginia Division of Mineral Resources Bulletin 56, 50 p.

Bayer, K. C. and Milici, R. C., 1987, Geology and petroleum potential of Mesozoic and Cenozoic rocks, offshore Virginia: Virginia Division of Mineral Resources Publication 73, Parts A-D.

Jacobein, F.H., 1992, Oil and gas well analyses of hydrocarbon potential of Buchanan, Dickenson, and Wise counties, Virginia: Virginia Division of Mineral Resources Open File Report 92-2, 17 p.

Le Van, D.C. and Rader, E.K., 1983, Relationship of stratigraphy to occurrence of oil and gas in western Virginia: Virginia Division of Mineral Resources Publication 43, one sheet.

Miller, R.L. and Fuller, J.O. 1954, Oil and gas well data and geology, Lee County, Virginia: Virginia Division of Mineral Resources Bulletin 71, 383 p.

Nolde, J.E., 1992, Oil and gas well data and geology, Lee County, Virginia: Virginia Division of Mineral Resources Publication 113, 13 p.

Prepared by Robert C. Milici and Michael L. Upchurch;
revised 03/2014.

*Virginia Department of Energy
Geology and Mineral Resources Program
900 Natural Resources Drive, Suite 500
Charlottesville, Virginia 22903*

[http://www.energy.virginia.gov/geology/
geologymineralresources.shtml](http://www.energy.virginia.gov/geology/geologymineralresources.shtml)