4H • ENV • 101

Geology Project Book 3: Advanced

Oklahoma Cooperative Extension Service
Division of Agriculture Sciences and Natural Resources
Oklahoma State University

Oklahoma Energy Resources Board

OSU EXTENSION
4-H YOUTH DEVELOPMENT

Geology Project
Book 3—Advanced

Oklahoma is a state that is geologically diverse and interesting. From the lava-covered mesas at the western tip of the panhandle to the Ouachita Mountains in southeastern corner of the state, the various landscapes make our state a unique place to live. The flatness or hilliness of our own backyard, neighborhood park or family farm are all related to geology.

Geology plays a major role in many important aspects of our lives. From the fuels we use for transportation, farming, industry or heat, to the water we need for drinking and irrigation or the soils that sustain our agricultural industry, geologic resources are critical to our existence.

The geology of Oklahoma is important to our economy. Oklahoma is a leading producer of natural gas and oil. Thousands of Oklahomans rely on the petroleum business for their livelihood. All citizens of our state benefit indirectly by the contributions that oil and natural gas companies and their employees make to education and the arts.

The soils that provide the foundation of Oklahoma's rich agriculture industry are related to the underlying bedrock. Our scenic resources are the result of the interaction of climate and geology over time. The rich rock resources of Oklahoma are mined or quarried to make building stone, cement, monuments and construction material.

The purpose of the 4-H geology project is to increase our understanding of the natural world in which we live. Through learning, we begin to appreciate the importance of this science and the enjoyment it can provide.

Compiled By:

Dr. Jim Puckette, Professor of Geology, Oklahoma State University

Oklahoma Energy Resources Board (OERB)

Editor:

Cathy S. Allen, Assistant Extension Specialist, Oklahoma State University

Reviewer:

Kevin Allen, Associate Professor/Extension Specialist Natural Resource Ecology and Mgmt., Oklahoma State University

Printing of the Geology Project Book is funded by the Oklahoma Energy Resources Board.

Oklahoma State University, in compliance with Title VI and VII of the Civil Rights Act of 1964, Executive Order 11246 as amended, Title IX of the Education Amendments of 1972, Americans with Disabilities Act of 1990, and other federal laws and regulations, does not discriminate on the basis of race, color, national origin, gender, age, religion, disability, or status as a veteran in any of its policies, practices or procedures. This includes but is not limited to admissions, employment, financial aid, and educational services.

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Director of Oklahoma Cooperative Extension Service, Oklahoma State University, Stillwater, Oklahoma. This publication is printed and issued by Oklahoma State University as authorized by the Vice President, Dean, and Director of the Division of Agricultural Sciences and Natural Resources and has been prepared and distributed at not cost to the taxpayer of Oklahoma.

Book 3
Table of Contents

Unit 1
The Geologic History of Oklahoma

Introduction

The landscape of Oklahoma and its rich mineral resources are a result of the state's geologic history. The subtle, smooth hills that are called the Arbuckle and Wichita Mountains were once sharper and much higher mountain peaks.

However, as a result of their great age, they have been reduced in height and smoothed by erosion. The rich geologic history of the state has also resulted in our important supplies of oil, natural gas, coal, building stone and other economically important earth materials.

What is Geology and Geologic History?

Geology is the study of Earth materials, processes and history. This includes Earth materials such as rocks and minerals. Earth processes include volcanoes, earthquakes, mountain building and erosion. The study of geologic history focuses on determining the age of rocks and geologic features. Paleontology, the study of ancient life, and Historical Geology, the study of Earth's geologic history, are specialties or sub disciplines, of geology. The study of fossils is critical to understanding the geologic history of Earth.

What Will I Learn?

In Unit 1, we examine the generalized geologic history of Oklahoma and learn how the present landscape evolved over time. We learn about the locations of the different ages of rocks that outcrop and some of the fossils we should expect to find in these rocks. We also learn how the geologic history impacts our present lives by providing resources that are essential to our lives and important to the economic welfare of the state.

Activities

The following are example activities that relate to the geologic history of Oklahoma:

1. Start a Geology Project Club and define various topics, workshops and exhibits for 4-H'ers to participate in.

2. Give a guided tour of one of the state parks in Oklahoma or lead a guided tour for rock, fossil or mineral collecting.

3. Draw a geologic time line that shows when the major mountain ranges were uplifted and other landscape features formed. Photograph some of these features and prepare an exhibit on Oklahoma's geologic history for the county fair. Explain the great age of these features and how erosion affected their present height and shape.

4. Collect rocks, minerals and fossils and identify them as to the formation of origin and its age. A collection of 30 total rocks, minerals and fossils is recommended as an educational fair exhibit.

5. A self-determined exhibit that could include the degrees of hardness, etc. could also be exhibited.

The Geologic History of Oklahoma

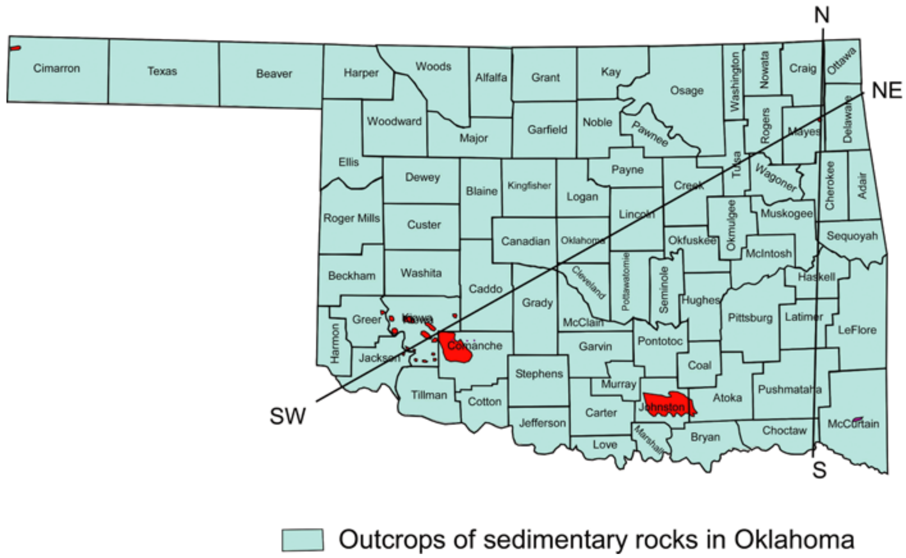
Oklahoma has enjoyed a vast and eventful history. Over millions of years, the surface of Oklahoma has been partially covered by lava, flooded by oceans, experienced mountain building, subjected to extended periods of erosion and covered by vast deltas and peat bogs.

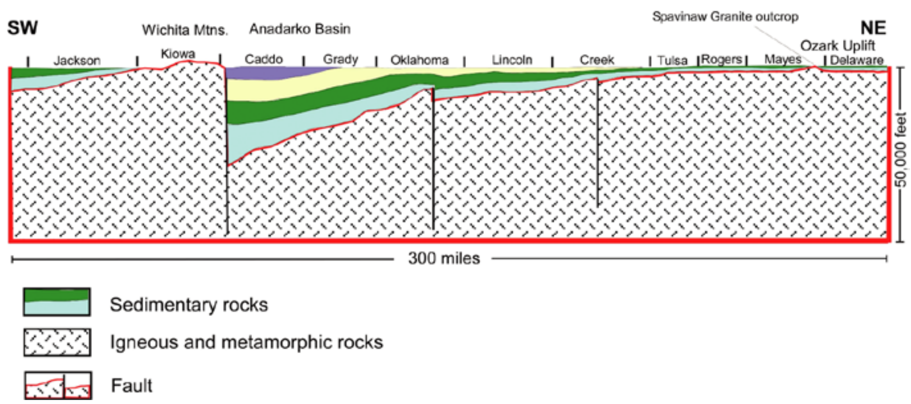
The evidence of Oklahoma's geologic past is reflected in the rock record. The types of fossils we find in the rocks provide clues to the age of the rocks and conditions under which the sediments that formed them were deposited. The sedimentary rocks form a thin layer over much older igneous and metamorphic rocks. These very ancient igneous and metamorphic rocks contain no fossils.

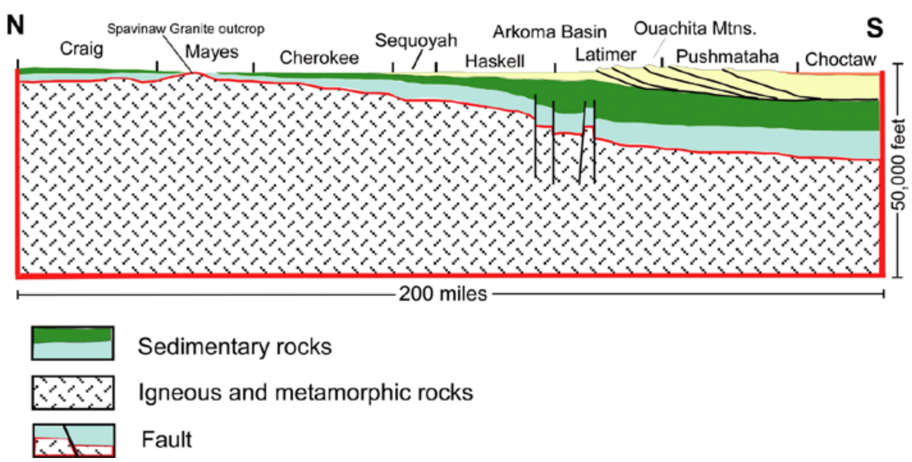
Vocabulary Words

Cambrian – Earliest geologic period of the Paleozoic era of the corresponding system of rocks marked by fossils of every great animal except the vertebrate.

Precambrian - Prior to the earliest geologic period of the Paleozoic era of the corresponding system of rocks marked by fossils of every great animal type except the vertebrate.

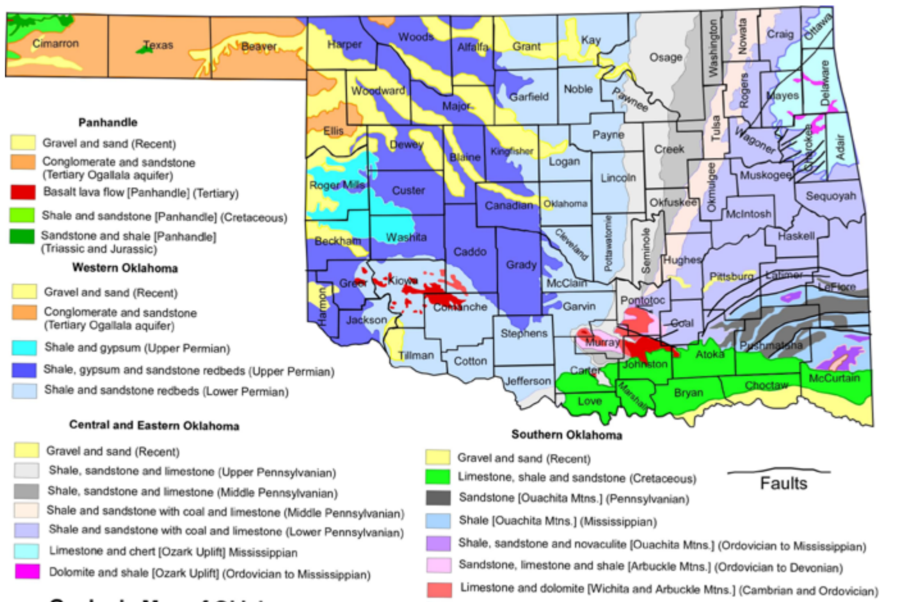






Early Geologic History of Oklahoma

To begin to understand the geologic history of Oklahoma, it helps to begin with a chart of Earth's history that is called the geologic time scale. The geologic time scale provides the framework that is used to separate and classify the rock layers. The following simplified time scale contains the major rock groups that are identified in Oklahoma. The outcrop pattern of these rocks is shown on the map on the following page. The geologic time scale is also shown on the following page.



Geologic Map of Oklahoma
(After USGS, 1960)

Era	Period	Duration	mya			
CENOZOIC	Quaternary	1.8			Lava flows into Oklahoma from Colorado	
	Tertiary	63.7	1.8	Streams cross Oklahoma that begin in Rocky Mountains		Sandstone and gravel: Ogallala aquifer
MESOZOIC	Cretaceous	79	65	Flooding with widespread coastal plains Dinosaur habitat	Rocky Mountains formed	Sandstone and shale in Panhandle; Limestone and shale in southern OK
	Jurassic	62	144			Morrison Formation in Panhandle
	Triassic	42	206			Dockum Group in Panhandle
PALEOZOIC	Permian	42	248	Desert conditions Widespread evaporation		Permian redbeds: shale, gypsum and salt
	Pennsylvanian	33	290	Widespread peat bogs	Wichita, Arbuckle and Ouachita Mountains formed	Pennsylvanian shale, sandstone, limestone and coal
	Mississippian	31	323			Mississippi Limestone
	Devonian	63	354	Continent flooded by deeper ocean		Woodford/Chattanooga shale
	Silurian	26	417	Shallow seas with abundant life		Hunton Group: Limestone and dolomite
	Ordovician	47	443	Shallow seas with abundant life		Simpson Group: Sandstone, shale & limestone Arbuckle Group: Limestone and dolomite
	Cambrian	53	490	Shallow seas with abundant life Volcanism in southern Oklahoma	Crust is split in southern Oklahoma	Timbered Hills Group: Limestone, dolomite & sandstone Colbert and Carlton rhyolites
Precambrian		4057	543	Mostly Igneous and metamorphic rocks		Tishomingo and Spavinaw Granites

Igneous and Metamorphic Basement Rocks

The oldest rocks that outcrop in Oklahoma are granite on the Tishomingo Uplift in Johnston, Coal and Atoka Counties and the Spavinaw Granite in Mayes County. These rocks are classified as Precambrian in age.

The next oldest rocks are Cambrian-age igneous rocks that outcrop in the Wichita Mountains and in the Timbered Hills of the Arbuckle Mountains. Some of these igneous rocks are granite, others are rhyolite (lava) and dark-colored gabbro. The Cambrian lavas formed along an ancient split in the crust that allowed molten rock to flow to the surface.

Sedimentary Rocks

Cambrian and Ordovician

The Precambrian and Cambrian igneous rocks were eroded before the area was flooded by a shallow sea. The first sediment deposited was sand. This sand became a rock layer called the Reagan Sandstone. Following deposition of the Reagan, a series of thick limestone and dolomite formed. These rocks are called the Timbered Hills and Arbuckle Groups and range from Cambrian to Ordovician in age. These rocks are quarried across southern Oklahoma, including Atoka, Carter, Kiowa, Murray, Comanche and Johnston Counties. Deposition of the sediments that formed these rocks occurred in a shallow sea that filled what is called the Oklahoma Basin.

Also during the Ordovician, a sequence of sandstone and shale formed called the Simpson Group. The sandstones in this sequence are almost pure quartz sand and have been mined for silica at Mill Creek in Johnston County and Roff in Pontotoc County.

Deposition of sediments that became limestone and shale capped the Ordovician. A shallow sea flooded the continent during the Silurian and Devonian. Sediments deposited in this sea became the rocks known as the Hunton Group. These rocks contain some of the more interesting fossils found in the state, and include many famous trilobite collecting sites including "White Mound" in Murray County.

During late Devonian and early Mississippian time, the continent was flooded and a dark, organic layer of mud and silt was deposited that became the Chattanooga or Woodford Shale. The same layer of rock is called Chattanooga in northeastern Oklahoma and Woodford in southern and western Oklahoma. This shale bed is very important to the state because it is the premier source rock for oil and natural gas in Oklahoma. Deposition of the Woodford/ Chattanooga was followed by a return to conditions that favored the deposition of carbonate sediments that ultimately became the Mississippian limestones. The Mississippian rocks contain numerous fossils, including crinoids, brachiopods and corals.

Unit 2
Squeezing Out a Few More Drops of Oil: Alternative Recovery Methods

Introduction

The rich mineral resources of Oklahoma have played a major role in our State's history. From its beginning in the roaring oil boom towns in Creek, Seminole, Carter and Osage Counties to the present, the crude oil and natural gas industry has been vital to Oklahoma's economic growth. As oil and natural gas become more difficult to find the industry has become increasingly reliant on technology.

Today the industry is using directional and horizontal drilling and highly engineered fracturing techniques and recovery techniques to produce additional oil and natural gas.

What is an Alternative Recovery Method?

The production of crude oil from a reservoir often involves several stages of crude oil recovery. The initial stage, called primary production, relies on the energy of expanding natural gas or the buoyancy of underlying water to propel the crude oil toward the wellbore and ultimately to the surface. Once a well no longer has the reservoir energy to lift oil to the surface, a pump is installed to raise the fluid. Most pumping wells have the familiar pump jack that is normally associated with oil production. Primary production seldom recovers more than 25% of the crude oil in the reservoir. To recover more of the remaining crude oil, a variety of methods may be used. These are called Alternative Recovery Methods.

What Will I Learn?

In this unit you will learn about secondary and tertiary alternative recovery methods that are used to get more crude oil out of reservoirs. You will learn about the polar water molecule, surface tension and the immiscibility of oil and water. In this unit you will examine how surfactants and polymers are used to help remove crude oil from pores of rock and move it to the wellbore.

Activities

The following are example activities that relate to understanding how alternative recovery methods help recover more oil.

1. Do an experiment that demonstrates the way a surfactant (liquid detergent) reduces the surface tension and breaks larger (cooking) oil globules into smaller ones.

2. Construct a poster that illustrates how different alternative recovery methods are used to increase oil recovery.

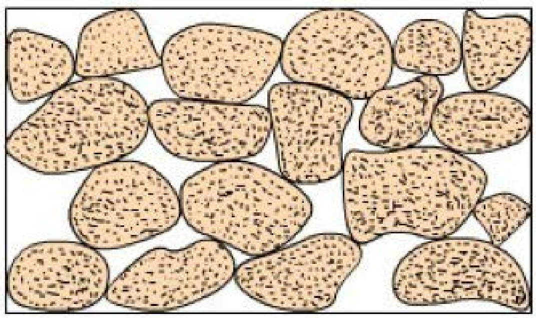
3. Interview a petroleum reservoir engineer to learn the types of alternative recovery methods that have been employed by their company in an Oklahoma oil field.

Getting the Oil Out

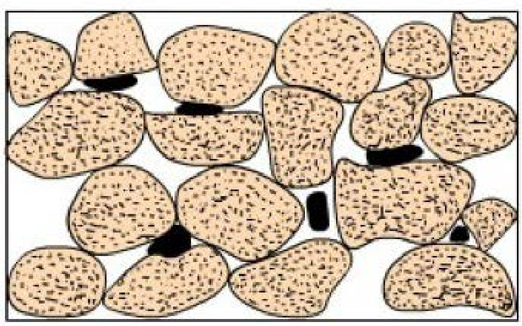
Why Does Oil Stay in the Rock?

Once the natural reservoir pressure no longer moves crude oil from the reservoir to the wellbore, alternative methods must be used to recover the crude oil. Alternative recovery is necessary to effectively produce a reservoir. Reservoirs are rocks that contain voids or pores. Pores are spaces between the grains of sand in a sandstone or cavities in limestone or dolomite. When a well is drilled into a reservoir containing liquids such as petroleum and water, the liquids will move into the well from the pores in the surrounding rock.

When oil is produced, typically less than 25% of the crude oil in the rock is recovered. Some of the crude oil that remains in the reservoir adheres directly to grains by molecular forces. Other crude oil is present as small spheres of globules that can't squeeze through small pore throat apertures that connect the larger pores.



Sand grains and pore network of a typical sandstone reservoir (Courtesy of HbL4u, 2004).

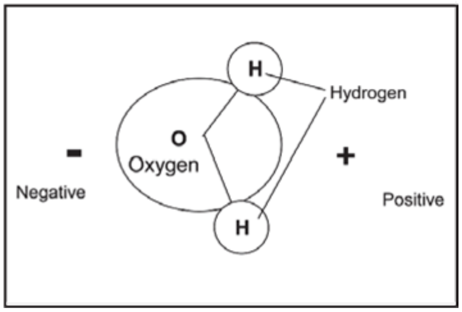


Oil globules that are trapped by the small pore apertures in sandstone (Courtesy of HbL4U, 2004).

Vocabulary Word

Immiscible – Incable of mixing

Water is a Polar Molecule



(Courtesy of Hbl4U, 2004)

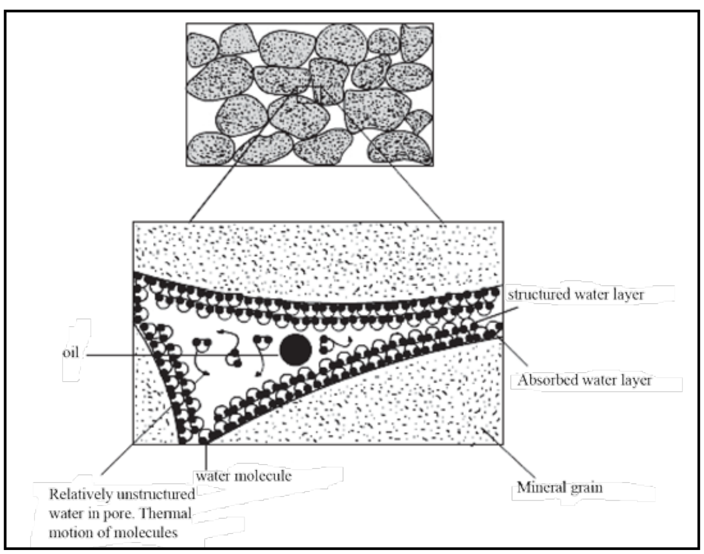
H_2O is a polar molecule. One side of the water molecule (the one with the two hydrogen atoms) is electropositive; the other side (the one with the oxygen atom) is electronegative.

This polarity explains, in part, how H20 molecules interact with each other. The hydrogen (positive) end of one molecule attracts the oxygen (negative) end of another to form a polymer or chain-like structure called liquid water. When hydrogen atoms act as links between water molecules the joining is called hydrogen bonding. The attraction between similar molecules, like water, is called cohesion. The polarity of water also causes it to be attracted to mineral grains, especially electrically charged ones, like clays.

Water Coats the Grains of a Reservoir

In most crude oil and natural gas reservoirs, a thin layer of water coats the grains. The negative end of the water molecule is attracted to electronegative grains, whereas the positive end of the water molecule is attracted to electropositive grains. This process is called adhesion. Most of this water is so firmly attached to the rock that it is never recovered during oil production. This water is called “immovable water” or “bound water.” Reservoirs with a layer of water coating the grains are called water-wet. Some reservoirs have a layer of crude oil coating the grains. These are called oil-wet. If the reservoir is water wet, a thin layer of water typically coats grains, whereas crude oil fills the pores.

Reservoirs containing abundant clay minerals attract and hold large numbers of water molecules. This happens because clay minerals contain strong charges, are very small in size and have high surface area.



Pore containing water and crude oil that is surrounded by grains coated by structured water layers further decrease the size of the pore apertures (Courtesy of HbL4U).

Water and Oil are Immiscible

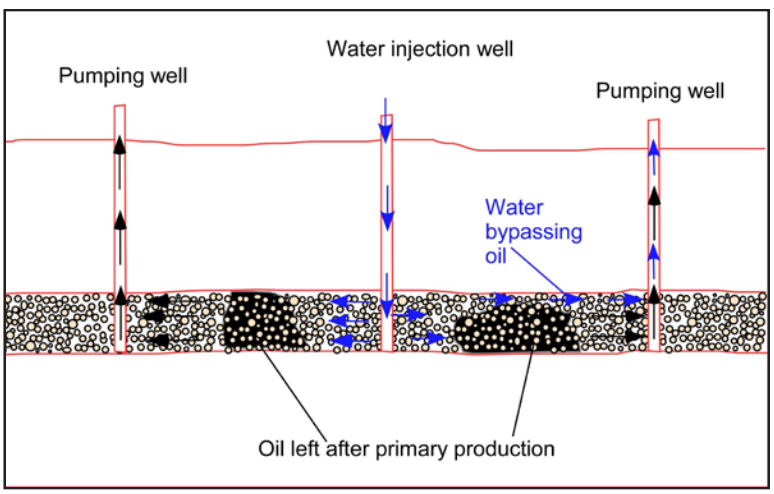
Water and oil are immiscible. This means that they are reluctant to mix. Crude oil globules tend to join together and form larger ones. Surface tension, which is generated by the attraction of oil molecules to other crude oil molecules or the attraction of water molecules to other water molecules contributes to the immiscibility of these two liquids. When two liquids readily mix, they are said to be miscible. Water and most alcohols are very miscible and mix readily.

The formation of crude oil globules reduces crude oil recovery from a reservoir. Relatively large crude oil globules move around in the pore, but can't fit through the pore aperture. Some alternative recovery methods use water to increase reservoir energy and move crude oil to the wellbore. Other recovery methods use chemicals to reduce the surface tension of crude oil, break up the larger globules and make it more miscible.

Alternative Recovery Methods

Secondary Recovery or Waterflooding

The secondary recovery method typically involves the injection of water into a reservoir to increase reservoir pressure and help move crude oil through the reservoir to the well. This process is called waterflooding. One of the problems with this method is that it often leaves crude oil behind. This crude oil is called bypassed oil. Water is less viscous (more liquid and flows easier) than crude oil. As a result it will often move through the reservoir without dislodging crude oil droplets confined to pores.



The basic principle of waterflooding or secondary recovery: Water is pumped into the reservoir to help "flood" or displace oil in the pores and move it toward pumping wells.

Tertiary Recovery

Tertiary recovery includes processes that affect water viscosity, oil surface tension or miscibility. Adding special chemicals called polymers to the water that is injected into the reservoir increases water viscosity. This “thicker” fluid does a better job of picking up oil as it moves through the reservoir.

Adding chemical surfactants to the injected fluid reduces the surface tension of crude oil globules. Surfactants, which are similar to detergents that are used to remove soil particles from clothing, cause larger globules of crude oil to be separated into smaller droplets that will fit through smaller pore apertures. Reducing crude oil immiscibility with water allows the two fluids to mix. Since water flows through the reservoir easier than crude oil, the water will carry the crude oil from the reservoir to the wellbore.

Polymers and surfactants are very effective in increasing crude oil recovery from a reservoir, but they are expensive. Therefore, the volume of crude oil recovered using these methods must be enough to offset the cost of the chemicals.

Special Recovery Techniques

Special recovery methods/techniques such as steam flooding or fire flooding are designed to add heat to the reservoir. These techniques decrease the viscosity of thick crude oil by heating it. Fire floods work by injecting air and setting the crude oil in the reservoir on fire. Some crude oil is consumed, but the heat generated allows additional crude oil to move to the producing wells. Steam flooding involves injecting steam into the reservoirs. One method is called the “huff and puff” method. In this method, the injection and production well are the same. Once steam is injected, the well is not produced. After a period of time, usually hours or a few days, the well is opened and injected steam and crude oil are removed.

References

HbL4U, 2004, Hypothesis-bases Learning, www.hbl.org

Unit 3
Making "Cents" of Oil and Natural Gas Economics in Oklahoma

Introduction

Oklahoma has had a rich history in agriculture and crude oil and natural gas. These two industries make up the majority of the income and employment opportunities in the state. Although Oklahoma has seen a "boom and bust" in the crude oil and natural gas industry, it is still a very vital part of its economic growth.

What Will I Learn?

In Unit 3, you will learn about the economic impact that the crude oil and natural gas industry has on employment in your area and around the state, as well as its contributions to the state from tax collections paid by producers.

Activities

1. Contact your county assessor's office and ask how much ad valorem was collected from crude oil and natural gas equipment in the previous year (and compare it to 5 years ago).

2. Look at census data reports for the crude oil and natural gas industry.

3. Look at the Oklahoma Corporation Commission's Web Site and look at the various production reports that are available to determine the largest producers, county production amounts, intents to drill, completed wells, etc.

4. Make a display of any of these activities to enter in the fair.

5. Identify universities in the state that have energy or geology related programs, visit these universities to see their program and their scholarship opportunities.

Number of Counties with Oil and Natural Gas Production

As of 2011, out of the 77 counties within the state of Oklahoma, all counties with the exception of five (Cherokee, Choctaw, Deleware, McCurtain and Ottawa) have active crude oil and/or natural gas production. In these areas their landscape yields to other types of activities determined by their geography. A variety of reports are available through the Oklahoma Corporation Commission, which is one of the agencies that regulates the activities of the crude oil and natural gas industry. The state is divided into four districts. Each Corporation Commission District has a number of employees who routinely check on the regulatory activities of crude oil and natural gas producers in their area. The various reports available from the Oklahoma Corporation Commission look at a variety of items, including intents to drill, drill spacing, production amounts broken down by county, and top producers for crude oil and natural gas for the previous year. Also, the crude oil and natural gas industry and the Oklahoma Corporation Commission are utilizing the world wide web more and more for forms. This streamlining process is visible on their site. There are a variety of production forms that producers can download. Check these out to get more of a feel for what producers and employees do in their daily duties.

Economic Employment Influence

According to Oklahoma's Oil and Natural Gas Industry Economic Impact and Jobs Report, prepared by the Steven C. Agee Economic Research and Policy Institute and commissioned by the Oklahoma Energy Resources Board (May 2012), labor income (including wage and salary disbursements and self-employment income) grew in 2011, providing a statewide average compensation per job of more than $113,000.

The oil and natural gas industry added almost 12,000 jobs in 2010-2011, with a rebound in oil prices and a temporary rebound in natural gas prices driving a return to self-employment activity in the sector. Labor income grew from $7.6 billion in 2009 to $9.4 billion in 2011, with gains concentrated among the self-employed. Industry wide labor income per job grew by 5.6% to $113,470 in 2011.

The average income from drilling jobs grew to more than $65,000 per job. Direct output from the energy industry in 2011 is estimated to be just more than $35 billion; in total, the industry sparked impacts that are more than $61 billion in output, support 344,503 jobs and generates more than $28 billion in labor income.

To put the impacts in context, in 2011 Oklahoma gross state product was estimated to be approximately $152 billion, state personal income $141 billion, and state employment 2.1 million jobs (full time, part time, wage and salary, and self-employed). Oklahoma oil and natural gas activity in 2011 generated long run economic activity equal to one in every $3 of 2011 gross state product, one in every $5 in state personal income, and just more than one in every six state jobs.

Gross Production Tax

Every producer of crude oil and natural gas pays a tax called gross production. This tax is based upon every mcf of natural gas and every barrel of crude oil that is produced in the state of Oklahoma. This tax is a variable rate. The rate is determined by the average monthly product price as determined by the Oklahoma Tax Commission.

The gross production rate on crude oil is as follows:

- If the average price of Oklahoma oil equals or exceeds $17 per barrel, the tax shall be 7%
- If the average price of Oklahoma oil is less than $17 per barrel, but is equal to or exceeds $14 per barrel, then the tax shall be 4%
- If the average price of Oklahoma oil is less than $14 per barrel, then the tax shall be 1%

The gross production rate on natural gas is as follows:

- If the average price of Oklahoma natural gas equals or exceeds $2.10 per mcf, the tax shall be 7%
- If the average price of Oklahoma natural gas is less than $2.10 per mcf, but is equal to or exceeds $1.75 per mcf, then the tax shall be 4%
- If the average price of Oklahoma natural gas is less than $1.75 per mcf, then the tax shall be 1%

In 2011, the crude oil and natural gas industry paid $964,935,883 in gross production tax. This tax is then distributed to a variety of funds. The chart below shows the distribution and the amounts for FY 2009-FY 2011.

		Gross Production Tax (Crude Oil) Actual Apportionment (Oklahoma Tax Commission)		
Fund (Crude Oil Distribution)	**Statutory Allocation**	**FY-2009**	**FY-2010**	**FY-2011**
General Revenue Fund		$128,931,292	$154,288,977	$233,945,737
County Highways	7.14%	$25,630,243	$28,518,043	$36,267,741
Local School Districts	7.14%	$25,630,243	$28,518,043	$36,267,741
County Bridge and Road Improvement	4.28%	$14,658,963	$14,430,618	$17,655,658
Rural Economic Access Plan (REAP)	4.28%	$7,883,103	$7,883,103	$7,883,103
OK Student Aid Revolving Fund	25.72%	$47,372,299	$47,372,299	$47,372,299
Higher Education Capital Fund	25.72%	$47,372,299	$47,372,299	$47,372,299
Common Education Technology Fund	25.72%	$47,372,299	$47,372,299	$47,372,299
Statewide Circuit Fund			$195,124	$2,522,237
To Counties- CBRIF			$1,365,869	$17,655,658
Total - Crude Oil	100.00%	$344,850,741	$377,316,674	$504,994,310

		Gross Production Tax (Natural Gas) Actual Apportionment (Oklahoma Tax Commission)		
Fund (Natural Gas Distribution)	**Statutory Allocation**	**FY-2009**	**FY-2010**	**FY-2011**
General Revenue Fund	85.72%	$598,340,774	$304,164,072	$275,913,167
County Highways	7.14%	$54,477,942	$25,335,178	$32,481,706
Local School Districts	7.14%	$54,477,942	$25,335,178	$32,481,706
Total - Natural Gas	100.00%	$707,296,658	$354,834,429	$459,941,573

Unit 4
Making Geology or Related Fields a Career

Introduction

As we learned in the last unit, the oil and natural gas industry employs a large number of Oklahomans. In addition, there are other jobs that are created as a result the crude oil and natural gas industry. Some of these jobs are probably quite obvious, however, some of these jobs might be new to you.

What Will I Learn?

In Unit 5, you will learn about the career opportunities available in the crude oil and natural gas industry. In the beginning book, we learned about some common careers related to the crude oil and natural gas industry. In this unit, we will define those careers in terms of what types of education is needed and what types of working conditions are related to that career. Also, we will discuss careers that are very vital to the industry but are not careers that you would commonly think of in relation to the crude oil and natural gas industry.

Activities

1. Find someone in your area that is in one of these career fields and interview them about their job responsibilities, working conditions, advantages and disadvantages, etc.

2. Participate in the 4-H Job Readiness contest, entering into a job related to the crude oil and natural gas industry

3. Prepare a self-determined project that could be a display visually telling about your interview, etc. or other aspect of the crude oil and natural gas careers.

4. Identify colleges in the state that have energy or geology related programs, visit these colleges to see their program and their scholarship opportunities.

Types of Careers

Geologists — Geologists are employed to explore for crude oil and natural gas and to help develop reservoirs. Geologists search for crude oil and natural gas by studying rock formations and using microscopes to examine rocks fragments (cuttings) from wells that are being drilled. Geologists develop surface and subsurface maps to locate oil and natural gas resources. They locate rock layers cropping out on the surface of the ground in order to locate anticlines and domes. Geologists use data from existing wells to make subsurface maps of the reservoir rocks. By matching rock layers between wells, they can draw cross sections to find petroleum traps. Geologists study the physical aspects and history of the earth. They identify and examine rocks, study information collected by remote sensing instruments in satelites, conduct geological surveys, construct field maps, analyze information collected through seismic studies and use instruments to measure the earth's gravity and magnetic field.

Geophysicists — Closely related to geology and often working closely with geologists, geophysicists use the principles of physics, mathematics and chemistry to study not only the earth's surface, but its internal composition, ground and surface waters, atmosphere, oceans and magnetic, electrical and gravitational forces. Geophysicists use three methods of oil exploration: magnetic, gravity and seismic exploration. In magnetic exploration a magnetometer is used to determine the strength of the earth's magnetic field at a specific point on the earth's surface. In gravity exploration a gravity meter, or gravimeter, is used to determine the strength of the earth's gravity at a specific location. The magnetometer and gravity meter are used to locate hidden, subsurface petroleum traps. In seismic exploration, sound is transmitted into the ground by an explosive, such as dynamite, or by a thumper truck. As the sound passes into the subsurface, it is reflected off subsurface rock layers and returns to the surface as echoes. The echoes are detected and recorded at the surface with microphones called geophones, or jugs. The recordings are processed to form a picture of subsurface rock layers.

Geophysicists have been at the forefront of one of the biggest technical advances of the last decade. Three dimensional and four dimentional (3D, 4D) seismic uses advanced computer modeling to develop three and four-dimensional models of the subsurface that have significantly enhanced the industry's ability to locate additional oil and natural gas deposits. Three-D and 4D seismic models are sometimes viewed in huge visualization theaters that make it seem as if you are "stepping into" a subsurface reservoir.

Petroleum Landman — A job largely unique to North America, the petroleum landman is responsible for obtaining permission to drill a well. Before a well may be drilled on private land in the United States or Canada, the land must be leased from the landowner who owns the subsurface oil and natural gas. Permits must be obtained from various government agencies before a well can be drilled. The permit sets forth the requirements for the drilling company to restore the land after the well is drilled and properly plug and abandon nonproductive wells. The petroleum landman is responsible for acquisition or disposition of oil, natural gas or surface interests; negotiation, drafting or management of agreements respecting such interests; and supervision of land administration activities respecting such interests. Petroleum landmen deal directly with farmers, ranchers and other surface owners, and may need to research ownership records in county, state or provincial offices. Good communication, negotiation and research skills, along with some legal knowledge, make a landman successful.

Drilling Engineers — The job of the drilling engineer is to design and implement a procedure to drill the well as economically as possible. The well will confirm the presence of oil or natural gas in the location selected by the geologists and geophysicists. Drilling engineers work closely with the drilling contractor (the operator of the rig and its crews), service contractors and compliance personnel, as well as the other members of his internal team. A drilling engineer must manage the complex drilling operation including both the people and technology. Drilling a well can often cost several million dollars, and the drilling engineer has the responsibility for making certain that costs are minimized while getting all of the necessary information to evaluate the reservoir, protecting the health and safety of workers and any nearby residents and protecting the environment.

Well-Log Analyst — Usually, but not always, an engineer, a well-log analyst takes measurements during drilling or after a well is completed to evaluate the well's production potential. The well-log analyst helps take and analyze core samples. He/she often uses sophisticated electronic, nuclear and acoustical tools that are sent down the well on a wire-line. Information from these tools is sent up the well bore to a computer system on the surface where engineers retrieve and interpret the data. This information helps the petroleum engineer determine if it is financially feasible to drill deeper, produce the well from explored zones of interest or take additional measurements. Working in conjunction with geologist, reservoir and production engineers, the well-log analyst will work with the team to decide where the next well should be drilled.

Production Engineers — Once the well is completed, the production engineer takes over. His/her job is to analyze, interpret and optimize the performance of individual wells. The production engineer is responsible for determining how to bring hydrocarbons to the surface. The production engineer will determine the most efficient means to develop the field considering the viscosity of the crude oil, the gas-to-oil ratio, the depth and type of formation and the project economics. The production engineer is also responsible for developing a system of surface equipment that will separate the oil, natural gas and water. As the field matures, the production engineer will be responsible for exploring additional technologies to enhance production from wells that are declining. In doing so, the production engineer will work closely with reservoir engineers and those in other disciplines to determine the optimal approach for that particular field.

Reservoir Engineers — Reservoir engineers determine the fluid and pressure distributions throughout the reservoir, the natural energy sources available and the methods most useful in recovering the maximum amount of oil or natural gas from the reservoir. The reservoir engineer may develop complex computer-based mathematical programs to model the fluid flow and formation pressures. Reservoir engineers are responsible for estimating the amount of oil or natural gas that can be recovered from a reservoir. Making good estimates of recoverable resources is crucial to a company 's financial position since future recovery is a measure often used by bankers and financial analysts of a company's borrowing power and future worth.

Facilities Engineers— Facilities engineers design and implement all of the supplemental facilities necessary to the separation, processing and transportation of oil and natural gas. They work with production engineers on all of the surface processing equipment for a field. They design and build natural gas processing plants to remove impurities from the gas and prepare it for transportation. They design and build pipelines to move oil, natural gas and produced water around within a field, to processing or disposal facilities and to the point of sale. They also work on large interstate transportation pipelines for oil, petroleum products and natural gas.

Facility engineers design offshore platforms. These enormous structures are built at shipyards and then must be transported to the field where they will be deployed. Offshore facilities must be designed to withstand heavy seas and hurricanes, protect the hundreds of personnel who may work there and assure that all drilling and production operations can take place with the utmost safety. The platform design must consider the number of wells that will be needed for the field, the type and volume of hydrocarbons to be processed, transportation of the oil or natural gas to shore and possible future reuse or abandonment. Designing an offshore platform is one of the greatest and most rewarding challenges that a facility engineer can encounter.

Safety Engineers — Each day, hundreds of thousands of oil and natural gas personnel work around highly flammable materials, sometimes high above the ground or out in the middle of the ocean, yet the oil and natural gas industry has an enviable safety record — one of the best among industries in the U.S. The number of engineers with primary responsibility for safety is expected to continue to grow. Something as simple as the design of a hand-railing on a stair can be crucially important when you're on an offshore platform hundreds of miles from shore. Safety engineers often work as members of project teams, advising on proper handling of chemicals, compliance with applicable regulations, conducting safety drills for personnel, assuring that procedures are documented and a myriad of other tasks designed to assure the safety of industry personnel and any near-by residents.

Environmental/Regulatory Specialists — Environmental and regulatory specialists may have engineering or geology backgrounds, or they may come from one of the many environmental or science disciplines, including biology, hydrology and marine science. They may be lawyers. These personnel are typically part of a project team with responsibility for assuring that all environmental requirements are met. In some companies, they may be charged with developing innovative ways of managing wastes or emissions that will enhance project economics as well as environmental protection. Regulatory specialists often work closely with government oversight agencies to assure that projects are conducted to the satisfaction of the regulator. As oil and natural gas resources are developed in areas far from existing infrastructure, environmental specialists may have significant challenges to overcome to remain in compliance with requirements developed for areas where laboratories (for testing) and disposal sites are readily available. They may also have responsibility for working with indigenous communities and nongovernmental organizations (NGOs). In developed areas, they may have responsibility for community outreach programs.

Chemical Engineers — Individuals with chemical engineering expertise can play many different roles in the oil and natural gas industry. They may work with facility or safety engineers in designing and operating natural gas processing plants or other field facilities. They may work with drilling or production engineers to determine the optimum fluids for use in drilling or stimulation given the subsurface properties. They help production engineers determine how to keep wellbores free from contaminants and control subsurface microbes that could create unpleasant by-products. Many chemical engineers are engaged in research — to develop a better drilling fluid, to improve carrying agents so treatment chemicals can travel further into the reservoir, to devise new ways to control treatment of wastes and emissions to improve environmental performance, to more efficiently remove impurities from natural gas or many other technical challenges.

Petroleum Accountants — In addition to all of the challenges that other accountants face, petroleum accountants must address the valuation of oil and natural gas that will be produced in the future, but represents a corporate asset today. In the U.S. and many other countries, there are unique accounting regulations related to the valuation and reporting of oil and natural gas assets.

Energy Economists — Economists help analyze business conditions and evaluate driving forces in the external business environment. They work with the planning department to prepare price assumptions for the budgeting and planning processes. Economists are also important in estimating exchange rates and identifying critical factors that determine the growth of oil and natural gas consumption. They are often involved in risk assessment, asset valuation and other strategic matters critical to a company's future.

Oil and natural gas companies also need all of the other personnel of any large company — human resources, public relations, information technology, lawyers, administrative assistants and a range of other occupations. Because of their highly technical and well-paid workforce, oil and natural gas companies are typically a good career choice for those in nearly any discipline.

(Special thanks to SPE International for use of this material)

Education

As a rule of thumb, if you are interested in any of these career fields you will need to pursue a four-year degree or bachelor's from a college offering an applicable degree plan for your chosen career. Strong math, science and writing skills are a must. Depending on what career area you are going into, this may be a bachelor's of science or a degree in business.

Taking upper level math and science classes in high school definitely will be a plus when entering into one of these areas, as you will be building upon these concepts in college.

As you prepare to enter your final years of high school, you will want to talk to a counselor in your school about colleges that will offer the degree you will need. Begin working with the counselor to take any additional classes that will be helpful other than the courses required for high school graduation.

The OERB awards scholarships to students at Oklahoma State University, University of Oklahoma and the Univeristy of Tulsa in the areas of energy management, petroleum engineering and geology. To find out more or to apply, log onto www.oerb.com.

Work Conditions

Each of the careers listed above will have varying work conditions. Typically, the following jobs will consist of working with field personnel and individuals inside and outside an office environment. Depending on the career and job responsibilities, more outside or on the site work may be required.

Geologists, geophysicists, petroleum landman, drilling engineers, well-log analysts, production engineers, reservoir engineers, facilities engineers, safety engineers, environmental/regulatory specialists, and chemical engineers.

Typically, petroleum accountants and energy economists spend the majority of their time in office or inside work conditions.

Resources

If you are interested in finding out more about one of these careers one of the best choices is the Internet. Also, there are many professional organizations for engineers, geologists, accountants, etc. Listed are a few of those groups that have organizations in Oklahoma.

Oklahoma Society of Petroleum Engineers
American Association of Petroleum Geologists
Council of Petroleum Accountants Societies
Acquisitions and Divestitures (A&D)
Association of Energy Services Group (AESC)
American Association of Drilling Engineers (AADE)
International Association of Drilling Contractors

University Resources:
University of Oklahoma, Norman, OK.
Oklahoma State University, Stillwater, OK.
Northeastern State University, Tahlequah, OK.
The University of Tulsa, Tulsa, OK.