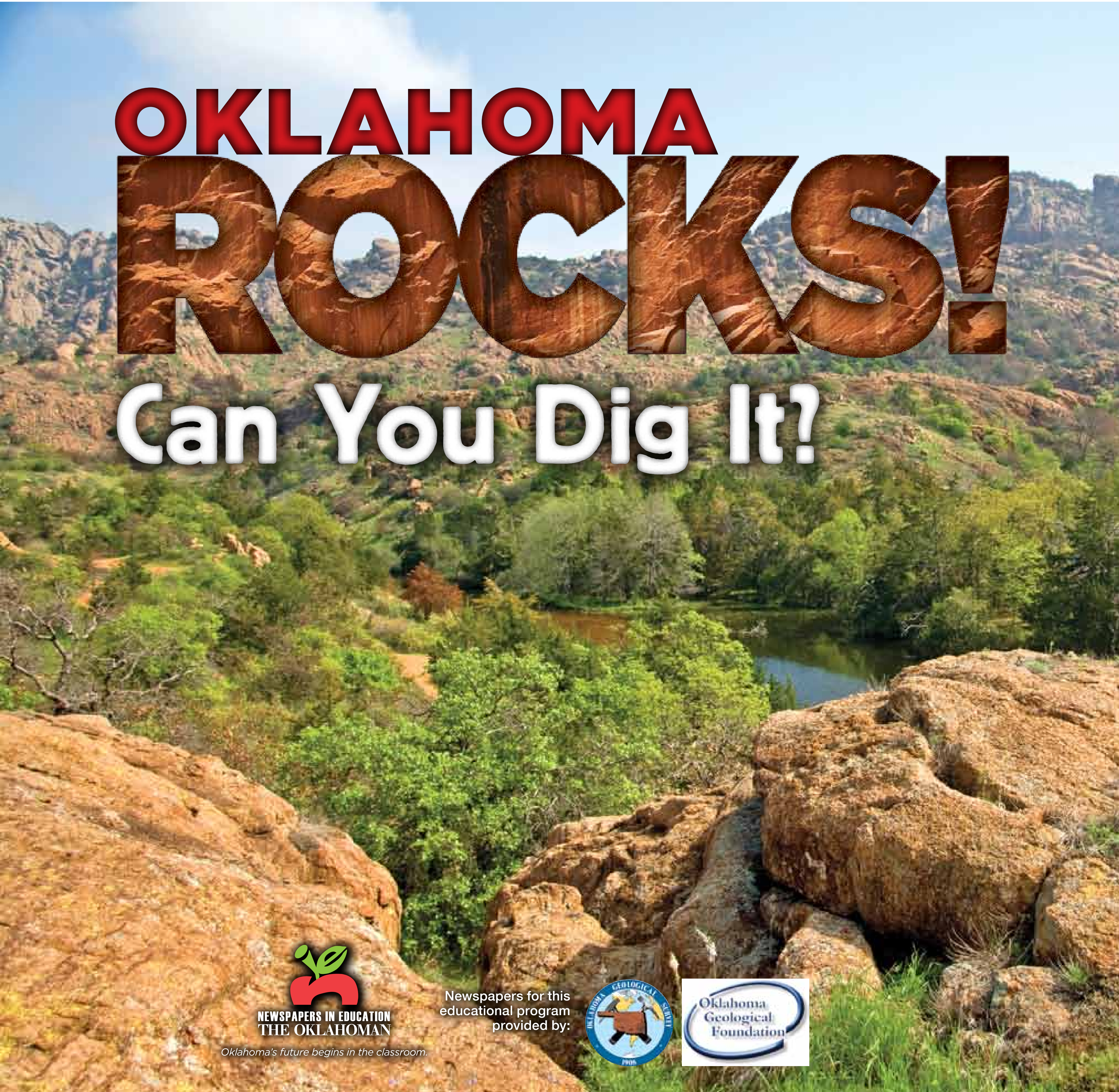
OKLAHOMA ROCKS!

Can You Dig It?



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OKLAHOMA GEOLOGICAL SURVEY 1908

Oklahoma Geological Foundation

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We Love Working in Geology!

When I arrived in Oklahoma in July to take on my new job as Director of the Geological Survey, one of the first things I got asked to do was to support the Oklahoma Rocks program. Most geologists are excited for the chance to talk about rocks, and even about the jobs they do that deal with geology. So helping a program that allows us to reach thousands of students across the state had to be a priority for the Survey.

This issue of Oklahoma Rocks focuses on geological hazards and economic resources in the state, and on what it is like to work as a geologist or an engineer in the earth sciences. Trying to make sure that Oklahomans are not at risk from landslides, earthquakes, sinkholes and excessive amounts of radiation are important tasks for the Oklahoma Geological Survey, and identifying where in the state these hazards exist gets us outdoors to observe some of the most interesting rocks in the world right here in Oklahoma.

You can see them too; they are literally a window into the earth's past. Geologists from many countries have come to see Oklahoma's rocks—especially the ones in the roadcuts through the Arbuckle Mountains along I-35 in south-central Oklahoma.

In this edition of OKLAHOMA ROCKS! we will acquaint you with some geologic principles, and tell you a little about how geologists, seismologists, geological engineers, and others in related career paths study rocks, explore for natural resources, examine natural hazards, and even study the Moon and Mars.

It is our hope that along with providing you information about Oklahoma geology, we will encourage you to take another look at the rocks around you, think about their story, and come away with a better appreciation and understanding of the wonderful planet that we call home.

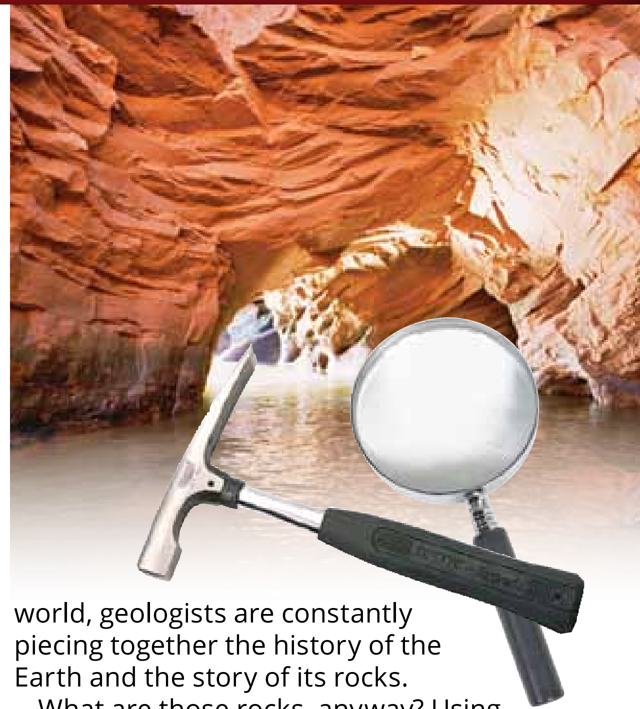
Dr. Jeremy Boak
Director of OGS

Dr. Neil H. Suneson, Geologist, Oklahoma Geological Survey

Have you ever looked at the rocks around you and wondered what they were made of, how they formed, or how they got their interesting layers and folds? If you have, you are going to get some of your questions answered in the next few pages. And if you haven't, look around and take notice of those rocks the next time you drive around Oklahoma!

In Oklahoma, many of us have driven through the Arbuckle Mountains along Interstate 35 north of Ardmore at one time or another, and perhaps we stopped at Chickasaw National Recreation Area or Lake Murray State Park. Maybe we visited Turner Falls Park or just marveled at the rolling hills and vistas along the highway. We probably noticed the high, steep roadcuts through the rocks and possibly wondered why the layers are so tilted. How did those red rocks near the north turnout get folded? What was Oklahoma like in the geologic past?

Geologists who have visited the same places, seen the same rocks, and asked the same questions are like detectives you see on television trying to solve a mystery. They've used their eyes and a variety of tools to study the evidence in the field and in the laboratory. They've studied the rocks outside and inside, under the microscope, using satellite images, on the surface in the roadcuts and beyond. They also have used and compared data collected from underground wells to try to figure out why the Arbuckle Mountains are what they are and how they were so deformed, which is just what you observe when you look at these roadcuts. By studying the rocks and observing their similarities and differences throughout the



world, geologists are constantly piecing together the history of the Earth and the story of its rocks.

What are those rocks, anyway? Using some very simple tools—a hammer, a magnifying glass, and maybe a bottle of hydrochloric acid—geologists know that all the rocks along I-35 are sedimentary. Most are a rock called limestone; a few are shale; and others are sandstone or conglomerate. Because geologists can observe similar rocks forming today, they know the limestone must have been deposited when this part of Oklahoma was covered by an ancient ocean. The conglomerate, in contrast, was deposited by a very fast-moving stream at the foot of some mountains. How can two very different rocks that formed in two very different environments now be so close together?

And how old are those rocks? Old. Very, very old. When we know how old the rocks are we can begin to put together a history of the Arbuckle Mountains. Some important keys for unlocking the age of the rocks are the fossils found in them. Because plants and animals evolve at different rates and in different ways over time, geologists can correlate (match) the rocks in the Arbuckles with same-age rocks elsewhere—even on other continents when similar fossils are found. In addition, because some plants and

Steeply dipping Viola Limestone, looking west on northbound I-35. (OGS Photo)

animals only live in certain places or under certain environmental conditions, geologists can learn something about ancient environments. Part of the story of Oklahoma is that we were submerged beneath a shallow ocean from about 500 to 350 million years ago! We know this because we can see the fossil shells in the rocks.

How can rocks that were under water be mountains? The evidence for the answer to this question lies in the tilted and folded rocks visible not only along the interstate but throughout the Arbuckles. Geologists have spent decades walking these hills, taking notes and measurements, collecting samples, and

making maps to show where the folds and faults are located and when they moved. What role did these earth movements play in the formation of the ancient Arbuckle Mountains, and when did they occur? Only careful and thoughtful collection and examination of the area enables geologists to come up with a theory based on all of the evidence.

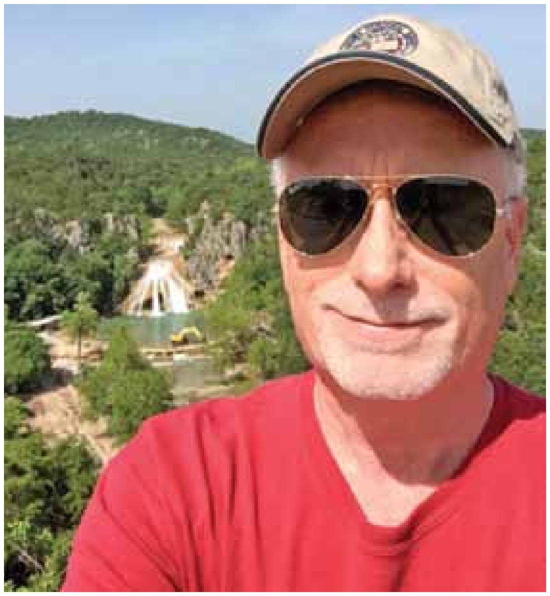
The geologic history of the Arbuckle Mountains, as well as all of Oklahoma, is a fascinating story in itself, but many geologists also use that knowledge for the betterment of humankind. Using all the tools at hand to know what the rocks are and where the faults are is necessary if we are going to understand the potential for landslides or rock-falls, earthquakes, collapse features (sinkholes), and unstable soils. Geological information also helps us safely dispose of solid and liquid industrial wastes; this requires knowing that certain rock properties will prevent harmful chemicals from escaping into the environment.

Aren't some rocks and minerals valuable? Absolutely, and many geologists in Oklahoma spend their careers scouring every bit of data and looking at all the evidence to discover Earth's resources and how to responsibly develop them. We're all familiar with Oklahoma's oil and gas industry, but geologists, and more particularly hydrogeologists, will continue to play a key role in making sure we have enough clean water to drink. Much of Oklahoma's history is tied to the development of its geologic resources—oil and gas, water, lead and zinc in the northeast corner and coal throughout the eastern one-third—and some of these will continue to help drive Oklahoma's economy. The founders of Oklahoma took note of the importance of these resources when they mandated the Oklahoma Geological Survey in the State's Constitution. To paraphrase the

language in the document: The Survey is charged with investigating the state's land, water, mineral, and energy resources and disseminating the results of those investigations to promote the wise use of Oklahoma's natural resources consistent with sound environmental practices.

Geology has many disciplines, such as seismology, geohydrology, engineering geology, biostratigraphy, and other specialties. These professions all work together to help understand and better use, protect and conserve the Earth's resources. Like all good detectives, geologists will leave "no stone unturned" in their quest for a better understanding of the Earth's history and our role in that history.

David Brown, Geologist, Oklahoma Geological Survey

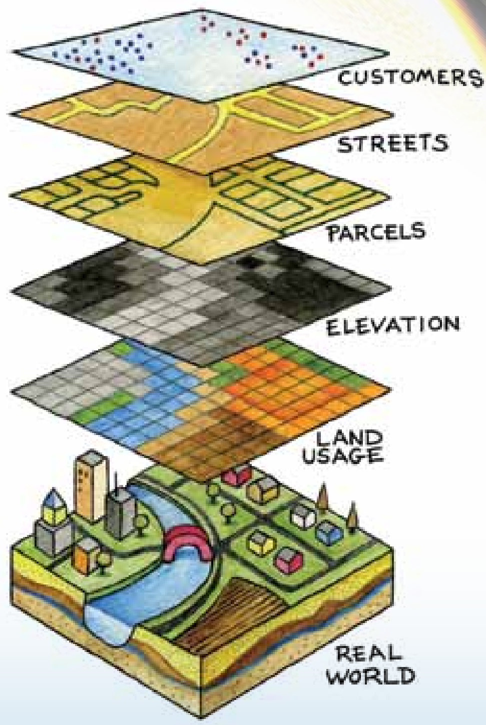


David Brown, OGS geologist, in the field along I-35 in south-central Oklahoma

When I was growing up I loved all things science, but my favorite subjects were astronomy and geology. Since the Earth was so near, and the stars far, I decided to make geology my main field of study; astronomy became a life-long hobby. I also had a fascination with flying and hoped one day to become a lunar astronaut. I became a licensed pilot and while in college I discovered that flying and geology had something in common: maps. Pilots use maps primarily for navigation, but geologists use them for almost everything.

Displaying rock types, fossil locations, or showing the thickness of sand in a subsurface formation are just a few examples of how maps are used in Earth Science. After college, along came a new computer-based technology called Geographic Information Systems, or GIS. GIS analyzes features displayed on a map and is useful for exploring location-based relationships; where and how close things are to one another. I used GIS throughout my petroleum career and continue to use it today as I work in other areas of geologic study.

While I have yet to walk on the Moon, I feel fortunate to be a part of a profession that explores not just the Earth, but the Moon and other heavenly bodies in our solar system. It is an exciting time as we take our search for knowledge to these new and exotic worlds. Rocks have amazing stories to tell us, and using science to interpret those stories is one of the best jobs in the world—and beyond!



Activity

Research a career that a geologist might have. What type of education do you need to work in that career? What would your average pay be per year? What type of companies could you work for? Submit your chosen career summary [1 – 2 pages] to *http://nie.newsok.com/oklahoma-rocks/* for a chance to win an iPad for both you AND your teacher! Submission deadline is January 29, 2016.

Oklahoma has exceptional geologic resources in the form of rocks and minerals. They formed naturally from processes in our geologic past and are found statewide both above and below ground. Natural resources play a significant role in our state's economy and all are important to our society as a whole. Developing these resources takes teamwork among several professional disciplines. Geologists, hydrogeologists, and geophysicists, along with petroleum, geologic and mining engineers, all play a role in this effort.

The Earth's geologic history has been an exciting one, and the same is certainly true for Oklahoma. The seemingly peaceful landscape we see today was anything but peaceful long ago. Igneous rocks formed from hot molten material deep within our crust, and then powerful forces pulled on that crust to the point of nearly ripping the state apart. Later forces caused mountain building – uplifting the rock layers and causing them to bend, fold, and break. Erosion wore the mountains down, redistributing them in layer after layer of new sediment.

Middle Mississippian (340 Ma)

Map by Ron Blakey, Colorado Plateau Geosystems, Inc.

An Interactive Drilling and Well Control Simulator on the University of Oklahoma campus helps drilling engineers perfect their craft as real-life simulations are run.

The tilted and contorted rocks we see today in the Arbuckle Mountains provide evidence of those early and violent processes. One important byproduct of this ancient activity was the creation of a set of naturally occurring assets that we know today as Oklahoma's natural resources.

PETROLEUM

Oklahoma's unique geologic history provided all of the necessary ingredients to produce world-class petroleum resources. Source rocks, such as our famous Woodford Shale, are widespread and contain large amounts of organic matter. Burial beneath other rock layers allowed time, heat, and pressure to chemically alter the organic matter into huge volumes of oil and natural gas. Much of that oil and gas migrated from these source rocks and became trapped in permeable rocks called reservoirs. Geoscientists study rock formations above and below the surface to understand their physical properties and orientations. Engineers analyze the reservoirs and use advanced production and drilling technology to bring the oil and gas to the surface. Oklahoma once led he world in oil production, and OU's Mewbourne College of Earth and Energy, the World's first school of petroleum geology, continues to be a leader in energy science and technology.

NON-PETROLEUM

Our non-petroleum resources in the state are varied and have many uses. Stone, gravel, and shale are all used for construction and road-building projects and for making cement. Limestone and shale are abundant in Oklahoma and are evidence of a time when oceans covered much of our state. Igneous rocks, such as granite from the Arbuckle and Wichita Mountains, are used for constructing buildings and monuments.

Lead and zinc were once mined in far northeast Oklahoma. The state was a top producer of these minerals during the first half of the twentieth century, but mining operations are no longer occurring.

Coal is a special sedimentary rock that formed in and along Oklahoma's ancient peat bogs and swamps. Coal mining was once common in the eastern part of the state and continues today in some locations. Oklahoma coal has supplied fuel for electric power plants for many years.

Other useful resources include gypsum, salt, iodine, and glass sand. Oklahoma is a major contributor to the world's iodine supply and is one of the few producers in the U.S.

WATER

Our most valuable natural resource is water, and having a fresh supply of clean water is essential not only to our quality of living, but to life itself. A hydrogeologist is a scientist who studies water as it moves through rocks. It's important to know how this process works because much of our water supply comes from rocks below the ground.

When water from rain or a river seeps underground, it sometimes accumulates in layers of permeable rocks known as aquifers. Over time, humans can overuse an aquifer to the point of depleting it beyond its ability to continue as a reliable water source. The process of water replenishment and use is a cycle that must

FYI - (http://newsok.com/iodine-production-booming-in-oklahoma-and-only-in-oklahoma/article/5347917/?page=2) a 2014 story about iodine production in Oklahoma.

Activity

Make a list of 5 things that you can do to reduce your own water consumption. Send us your list at *http://nie.newsok.com/oklahoma-rocks/* for a chance to win an iPad for both you AND your teacher! Submission deadline is January 29, 2016.

be understood and monitored. Sometimes humans aren't the problem, but the climate is. Dry seasons or droughts can have disastrous effects on water supplies.

Some aquifers do not refill, or recharge, from natural seepage; or they recharge so slowly that they are considered to be a limited source of supply. The Ogallala Aquifer is such a resource. The Ogallala Aquifer is very large and stretches through the central part of the U.S., including much of western Oklahoma and the Panhandle. It is a major source of water for irrigation and other agricultural uses. Hydrologists keep a close eye on water levels in this part of the state because overuse could lead to farmers not having enough water to sustain their needs.

Our state has a wealth of geologic resources, and it's in our best interest to use them in a way that is responsible without harming ourselves or the environment. If you would be excited to learn about Earth's geologic past and have an interest in science and engineering, then a career exploring and managing Oklahoma's natural resources might be in your future.

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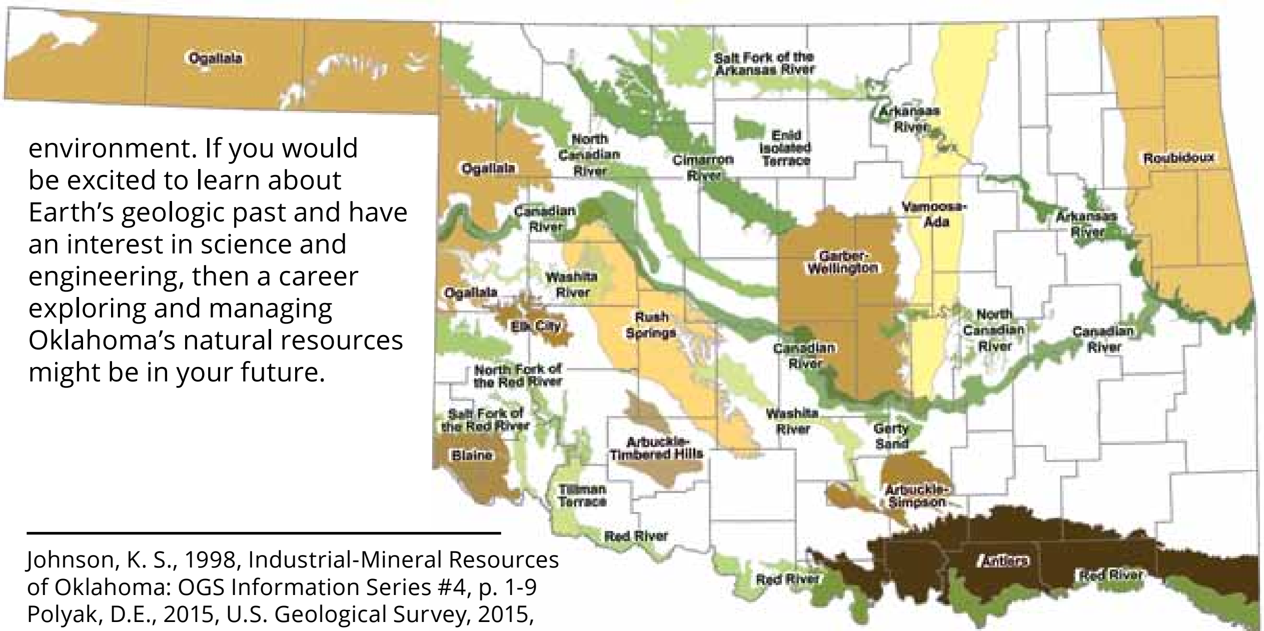


Map showing major aquifers in Oklahoma (Map by the Oklahoma Water Resources Board).

Thomas Stanley, PhD, Geologist Oklahoma Geological Survey

I sometimes tell my students that the science of geology is relatively easy to learn (though difficult to master) because it generally relies on only two basic laws:
1) the law of original horizontality; and
2) the law of superposition.

The second law represents the foundation of age determination in geology, and simply states that provided the layers of rock are not upside down or overturned, then in a sequence of beds, one bed on top of another, the bed on the bottom of the stack <u>must</u> be older than the beds above. (Figure 1)

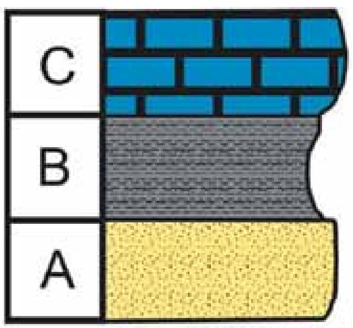


Figure 1. Based of the Law of Superposition, in the vertical sequence of sedimentary rocks as shown, Unit A would have to be the oldest, while Unit C is the youngest.

Looking at Figure 1, in a vertical sequence of rock units (A, B, and C), Unit A would have to be the oldest while Unit C is the youngest. Now, we don't know <u>absolutely</u> how much older Unit A is compared to these other units. It could be a day, a year, a thousand years, ten thousand years, or even a million years older than Units B and C. We can never really know for sure how old something is using the Law of Superposition. For that, we must use other scientific methods such as radiometric dating. However, from our example, we do know that Unit A is <u>relatively</u> older than Units B and C. It also follows that Unit B is relatively older than Unit C.

The example described above is the beginning of relative dating of rocks on the earth's surface, and done by superposition of the strata. Easy, right? It's just common sense.

This method is all well and good when we can see rock layers sitting on top of each other at a single location, as in our example. However, the most common problem we face in geology is where individual beds or sections of rock are far removed from each other (Figure 2). How, then, can we tell the relative ages of rock units in this situation?

All kinds of rocks on the Earth's surface contain the evidence of ancient life. These are called fossils (see fossil pictures). Fossils can be found in all shapes and sizes. From gigantic, vicious dinosaurs like Tyrannosaurus Rex, to very small creatures that one may need a microscope to see, like forams and fusulinids. Fossils also can be found in a wide variety of sedimentary rocks and from a wide variety of locations from across the world. Fossil species that are geologically short-lived, but which can be found in a lot of different countries around the world, are the best to use in determining the relative age of the rocks they are found in. These unique fossils are called index fossils (see Figure 2 and Fossil Pictures).

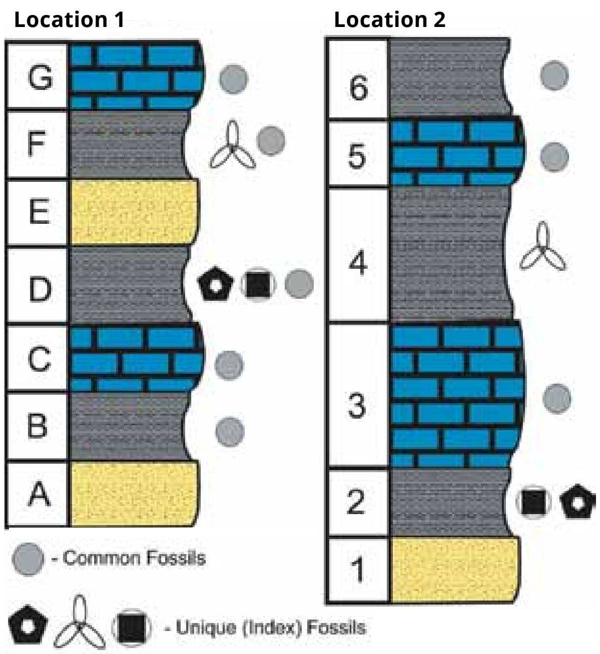
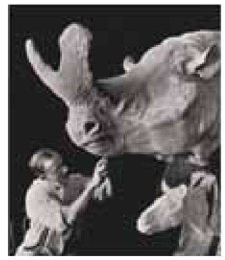


Figure 2. In this example, we have two vertical layers of rock separated by many miles. At first glance, rock layers A, B, and C at location 1 could be the same beds as layers 1, 2, and 3 at Location 2. however, when we look in more detail we find that some rock layers contain unique fossils. That is, they have index fossils that are not found anywhere else above or below these layers. As such, rock layer D at Location 1 and rock layer 2 at Location 2 are the same, or at least formed at the same time. The same goes for layer F and layer 4, which were also formed at the same time. Although there are a lot of common fossils seen at both locations, they cannot be used to tell what horizon is older or younger.

Tyrannosaurus Rex- one of the largest predators from the Cretaceous Period.



Titanothere- one of the first, large mammals that made their appearance after the extinction of the dinosaurs.

Diplosaurus- a plant eating dinosaur from the Jurassic Period.

Mastodon- very much like our modern african elephant, but almost twice as large.

The Monstrosities- the big guys on the left, that is the dinosaurs, can only be found in rocks of Mesozoic age. The big mammals on the right are typical of Cenozoic age rocks. When the dinosaurs went extinct at the end of the Mesozoic it left a lot of open habitat, which was quickly filled by the mammals.

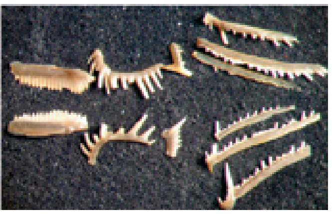
For many decades, geologists from around the world have been collecting and studying index fossils and the rocks they are found in, and one of the results of this painstaking research is the Geologic Time Scale (Figure 3). Essentially, the Geologic Time Scale puts all rocks on Earth into chronological order, from oldest (Precambrian) to youngest (Quaternary). It does this by subdividing geologic history into various segments of time based on the unique fossils found within those intervals. For example, most everyone has heard of the Mesozoic Era, which means 'Middle Life.' The Mesozoic is also known as the Age of Reptiles, because reptile and dinosaur fossils are commonly found in certain sedimentary rocks that formed during that time.

Above the Mesozoic, however, is the Cenozoic Era, which means 'Recent Life.' Rocks of Cenozoic age do not contain any dinosaur fossils (all the dinosaurs went extinct by the Cenozoic), but you will find mammal bones. This is why the Cenozoic is also known as the Age of Mammals.

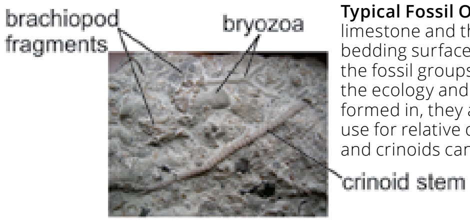
Another example is the Paleozoic, which means Ancient Life. During this time of geologic history, you would find trilobites, which are extinct sea creatures distantly related to the modern horseshoe crab, but you will not find any trilobites from rocks that formed in either the Precambrian, Mesozoic, or Cenozoic.

Trilobites- Abundant in the Cambrian Period, and only found in rocks of Paleozoic Age. They went extinct at the end of the Permian Period.

Fusulinids- Although they are very small and look like grains of rice, these little creatures are excellent index fossils for rocks of Pennsylvanian and Permian age.



Conodonts- These microscopic fossils may look like teeth, but they are really elements of a feeding apparatus of an eel-like animal that tis now extinct. Although they are very small, conodont elements changed very quickly (evolved) through time, and are found in all types of sedimentary rocks all over the world. They are excellent for dating rocks of Paleozoic and lower Mesozoic age. The conodont animal went extinct and the end of the Triassic.



Typical Fossil Occurrence- Look at any limestone and this is what you might see, bedding surfaces chock full of fossils. Although the fossil groups in this picture tell us a lot about the ecology and the environment the rock was formed in, they are too long-living to be much use for relative dating. Brachiopds, bryozoans, and crinoids can all be found in modern oceans.

Crinoid- with head and stem. It looks like a flower, but it's really an animal. We know this because we can still find crinoids living in the ocean.

Brachiopod- an animal similar to clams and oysters. Both the brachiopods and the crinoids (pictured above) were very common during the Paleozoic. Today, however, they are not as common in our oceans.

Ammonoid Cephalopod- distantly related to modern squid. This group went extinct at the same time as the dinosaurs.

Common Fossils of the Paleozoic and Mesozoic- Many fossils are commonly found in a wide variety of sedimentary rocks across many ages, such as the three groups shown above. However, only the ammonoids can be used for relative dating. The other two groups changed too slowly over time.

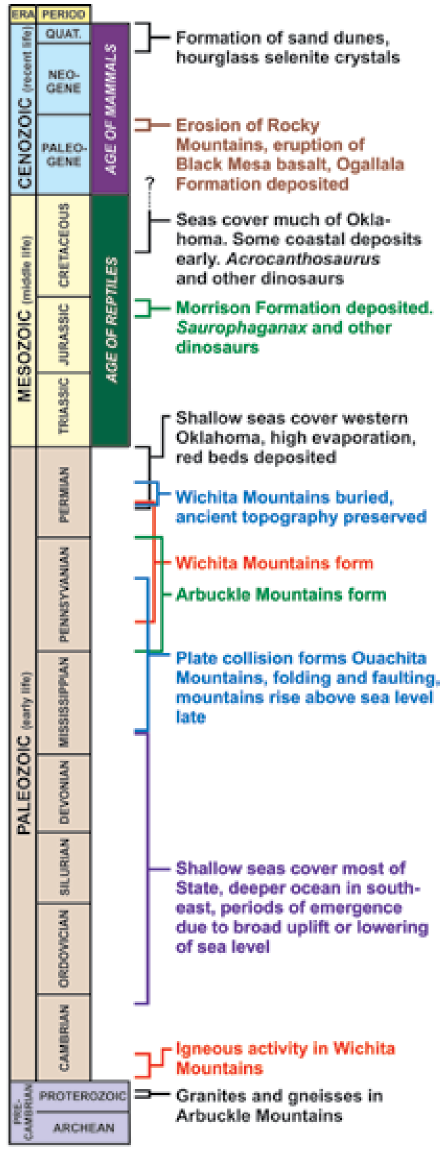


Figure 3. The Geologic Time Scale. Along with the different Eras and Periods shown, there is also a general geologic history of Oklahoma illustrated to the right. The time sale and our geologic history are only made possible by our understanding of fossils and their distribution in sedimentary rocks.

So, we have three major subdivisions of Earth's time separated from each other on the basis of what fossils are found in (or not found in) rocks of those ages.

These major subdivisions of geologic time can be subdivided further. Such as the Mesozoic, which is divided into the Triassic, Jurassic, and Cretaceous Periods. These further divisions are also based of the unique fossils found within each period. For example, Tyrannosaurus Rex can only be found in rocks of Cretaceous age, and not from any other Period, while Diplosaurus (the huge four-legged, plant-eating dinosaur) can only be found in rocks of Jurassic age.

Although not shown, each Period in our Geologic Time Scale is further subdivided into different Stages due to their unique fossil content.

Determining relative time in Earth's history is just one of the many useful applications of fossils that are helpful to geologists.

Okay, you might ask, "So what? Why is knowing the relative ages of rocks so important beyond the historical order of those rocks and the geological events that created them through time?"

The answer is, many economic deposits, such as oil and gas source rocks and reservoirs, and precious, base and industrial minerals, all of which are important to maintaining our civilization, are not found everywhere on the Earth, but are restricted in both time and space. Thus, making it necessary that you know where you are in the Geologic Time Scale to find them. For example, here in Oklahoma, most rocks that contain extensive oil and gas reservoirs happen to only occur in Pennsylvanian-age rocks. So, if we wanted to increase our chances of finding more oil and gas deposits, we would want to begin looking in those rocks of Pennsylvanian age. For that, we need to look at the fossils within the rocks we are examining, and determine what age they belong.

Another example are gypsum deposits. Gypsum is a very important industrial mineral that is primarily used for the manufacturing of sheet rock, also called wall board. Besides oil and gas, gypsum is one of Oklahoma's main export minerals, as we supply much of the country with wall board for interior home construction. The only place to find gypsum deposits in Oklahoma is in the Permian section, and nowhere else. So, it figures if we want to find gypsum deposits, we would have to look in rocks of Permian age, and that means looking at the fossils.

Ultimately then, it is fossils that tell us where to go to find these all important energy and mineral deposits.

Brittany Pritchett, Geologist
Oklahoma Geological Survey

OGS Geologist Brittany Prichett in the OU Conoco Phillips School of Geology and Geophysics x-ray diffraction laboratory.

What kind of rock do I have? Geologists use both simple and complex tools to answer this common question, but first we start by asking: what can I see in my rock?

Rocks are made of one or more minerals and one way they are classified is by the minerals they contain. That's why, when looking at a rock, I first look to see how many minerals the rock contains and then try to figure out what those minerals are. You might think of a mineral as something you find in your breakfast cereal along with vitamins, but to a geologist it has a very specific definition. A mineral is a solid crystalline material that is found in nature and has a specific number and arrangement of atoms. An atom is the smallest component of an element, and all elements are listed on the periodic table. For example, quartz, a mineral made up of silicon and oxygen, has exactly one silicon atom for every two oxygen atoms (SiO_2). Quartz, like any mineral, can occur by itself or be found along with other minerals in a rock, such as granite or sandstone. Knowing what minerals are present is necessary in order to identify any rock.

One of the most important tools a geologist uses is a hand lens, which is a small powerful magnifying glass used to examine crystals, grains, fossils, and other features in a rock. The ability to see these details is critical for mineral identification. At home, try looking at a rock under a magnifying glass. What can you see that you couldn't see with the naked eye? For example, you might find that your gray rock could really contain thousands of tiny black and white minerals when magnified, or that a piece of limestone contains small fossils!

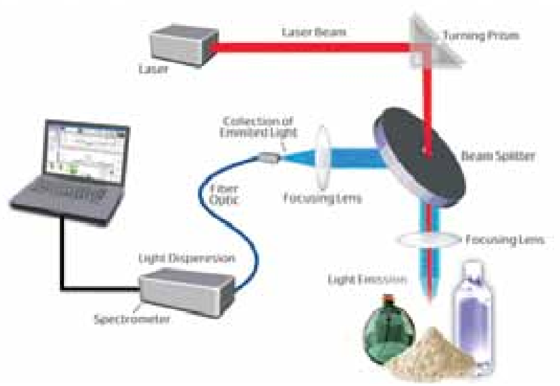
Since the basic properties of each mineral are known, we can figure out what minerals are in a rock by asking the following questions:

- **Color:** **What color does a mineral have? Be careful though; while a useful indicator, color can be misleading as many minerals come in a variety of shades.**
- **Optical Properties:** **Can light pass through the mineral? Does the mineral look metallic?**
- **Magnetism:** **Does a magnet stick to the mineral?**
- **Streak:** **When scraped across an unglazed porcelain tile, what color does the mineral leave?**
- **Hardness:** **All minerals have a hardness. Hardness is measured on a relative scale called the Mohs hardness scale, which ranges from the softest (1, talc) to the hardest (10, diamond). Minerals are tested by scratching them against index minerals and objects, each with a known hardness, to narrow down how hard your mineral is. Can the mineral be scratched by your fingernail, a penny or a nail? What does this tell you?**
- **Shape:** **What shape is the mineral? Is it a flat sheet, rectangle, parallelogram, cube, rhombohedron, octahedron, a sphere, or a blob?**

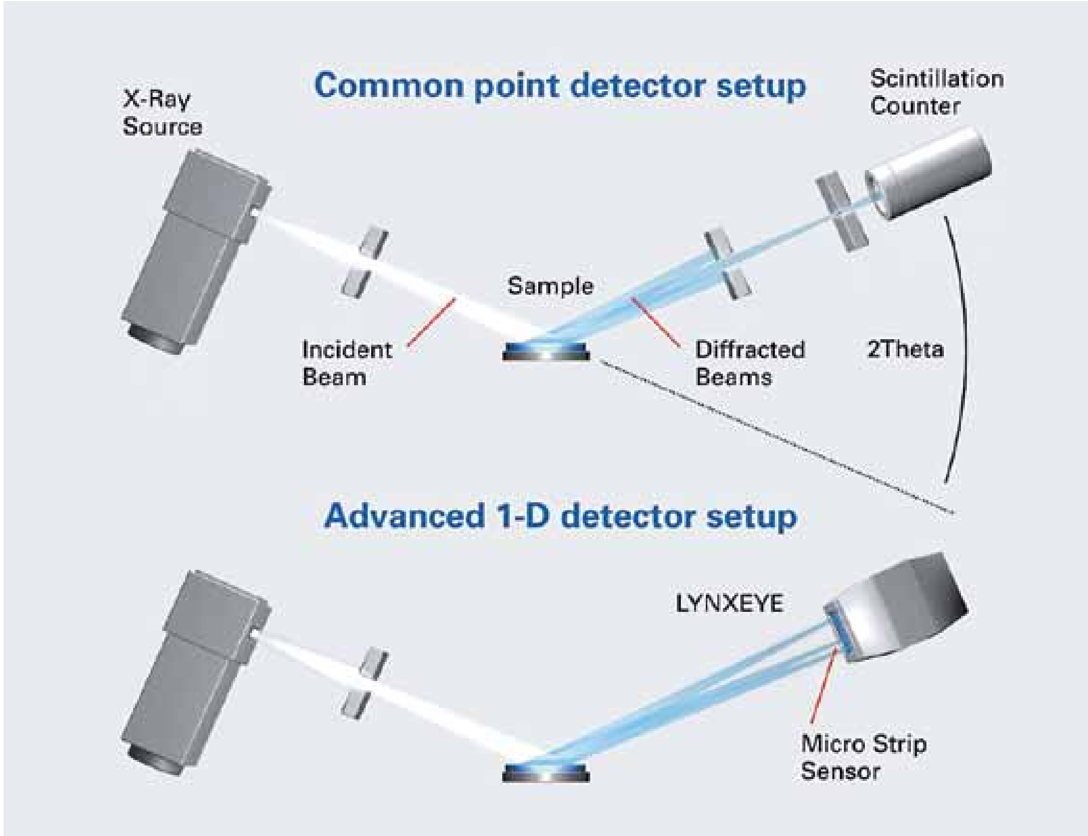
Now that you have the basic tools to identify minerals, you can use that information to figure out what kind of rock you have. Rocks are classified based on the minerals they contain and their texture (crystal/grain size). There are three types of rocks: igneous, sedimentary and metamorphic. Igneous rocks (formed through the cooling of molten rock) are crystalline and can have large or small crystals. Sedimentary rocks are comprised of sediments made of rock fragments, mineral grains, animal and plant parts, rust, and/or precipitates (like salt or carbonate). Metamorphic rocks are identified by the presence of metamorphic minerals and may exhibit foliation (layering and alignment of certain minerals). Geologists ask these questions to help figure out the rock type.

- **Is the rock crystalline? Do I see individual crystals? How big are they?**
- **Do I see individual grains, rock clasts, or fragments? What size are they?**
- **If I put dilute hydrochloric acid on the rock does it effervesce (bubble)? Carbonates, like limestone, bubble when in contact with hydrochloric acid.**
- **Are there any shells or other plant/ animal matter present? If so, what kind?**
- **Is there foliation?**

As a geologist for the Oklahoma Geological Survey, I identify rocks and minerals fairly often using both the simple tools above and more complex tools. At the University of Oklahoma we have many cutting-edge scientific instruments that use basic principles of physics and chemistry. A Raman spectrometer, for instance, examines the bonds of a liquid, solid, or gas by shooting the sample with a laser. A scanning electron microscope scans a sample with a focused beam of electrons to produce an image of the sample up to 500,000 times closer than



regular eyesight! Don't worry though, in our labs we "set phasers to stun". While it might sound destructive, none of these discussed techniques damage the sample rocks.



In my lab, I use x-rays to help figure out what types of minerals are in a rock. I manage the x-ray diffraction lab for the OU Conoco Phillips School of Geology and Geophysics. An x-ray diffractometer shoots x-rays through a crystalline material at varying angles and then measures the intensity of the x-rays sent back at each angle. These intensities and their angles are plotted on a graph to form an XRD pattern. Each mineral has its own distinct pattern. Using sophisticated computer algorithms, we can then compare the XRD pattern against our database of over 50,000 known mineral patterns to model what type of minerals and how much of each are in the rock. We've analyzed rock samples everywhere from Antarctica, to oil wells collected up to 20,000 feet deep in the earth, and also minerals created in a lab! X-ray diffraction is even used on another planet. The Curiosity rover, which landed on Mars in 2012, is equipped with a diffractometer—allowing NASA to identify and quantify the minerals in the Martian soil and rocks!

- **NASA webpage on the CheMin instrument on Curiosity (http://mars.nasa.gov/msl/mission/instruments/spectrometers/chemin/)**
- **Website that walks kids through mineral properties and also has an identification section that asks questions to help identify their mineral http://www.mineralogy4kids.org/mineral-properties**

David Brown, Geologist
Oklahoma Geological Survey

Would you like to have a job that's fun? Well you can in Earth Sciences! Exploring geology and working with our natural resources is not your typical 8 to 5 job, and here's why. First of all, it's not always indoors; in order to understand our resources, you have to go to our resources. You sometimes have to actually stand on the rocks to see what's going on. Geologists often work "in the field" to collect samples and data. They create maps of what they see and use them to put the geologic puzzle together. Let's face it, hiking and climbing on rocks all day isn't a bad way to spend your time.

While outdoor types love this sort of thing, the toys back at the office are fun too. Computer programs that model the Earth almost seem like video games, and nothing can be more scientific than working in a laboratory. Field samples require analyzing and this means using high-tech equipment, such as lasers, to probe their microscopic properties. Engineers aren't left out the fun either. Whether they are drilling wells or mining minerals, they get to use the latest and most advanced technology available. Their language is mathematics, and they use it along with sophisticated computer programs to understand how rocks and fluids behave in harsh subsurface environments.

Earth science professionals have important roles to play in resource exploration and management. If you don't mind having some fun while you work, then maybe this is the career for you.

Fun things to do in an Earth Science job:

OGS Geologist David Brown taking photos of the I-35 rockslide, July 17th, 2015.

Geologist

- **Go see the rocks: Being outdoors and hiking to remote areas are requirements**
- **Measure and collect samples: Rock hammer, compass, and a magnifying hand-lens are standard equipment**
- **Map the rocks: Map reading is a must and drawing skills are required**
- **Model the rock formations with computers: Experience with 3D video games is a plus**
- **Analyze samples in the laboratory: Lab coat, goggles, and using high-tech scientific equipment are required**

Engineer

- **Drill wells: Operate large equipment to drill an approximate 8-inch hole 2-miles down, then hang a right and drill horizontally another 2-miles; without missing your intended target**
- **Produce oil and gas: Use math, chemistry, and specialized tools to extract petroleum from rock formations deep within the Earth**
- **Mine mineral resources: Use powerful equipment to safely extract rock resources from the Earth**
- **Process minerals: Use large equipment to crush and/or combine rock resources for chemical and industrial use**

Hunton Quarry Wall

David Brown, Geologist, Oklahoma Geological Survey

Oklahoma's Geologic Hazards — When geology does not rock!

On June 18, 2015, rocks in the Arbuckle Mountains unexpectedly slid down a hillside and landed on the interstate below. The debris pile included rocks as small as baseballs and boulders as big as cars. Thankfully no one was injured, but a lot of drivers were startled.

Some threats to life and property are related to the geology around us. Geologists study incidents caused by geologic hazards so they can understand how they occurred, but more importantly, predict when and where they might occur in the future, and how to make them less dangerous. The rocks are telling us what could happen. It's up to the geologist to listen.

Here is a partial list of some geologic hazards that can occur in Oklahoma:

LANDSLIDES

Landslides occur when masses of rock or soil can no longer be supported on a hillside or cliff face. The terms rock slide, rock fall, or rock topple may also be used. The types of rock and soil, the slope (gradient) of the terrain, and the fractured state of the rocks all contribute to landslide potential. Layers of shale rock with high clay/mud content are particularly vulnerable to sliding when they are saturated with water. Geologists can identify dangerous slopes on hills using aerial terrain sensing technology, but they must visit the slopes in person to determine the types of rocks involved and to study their orientation.

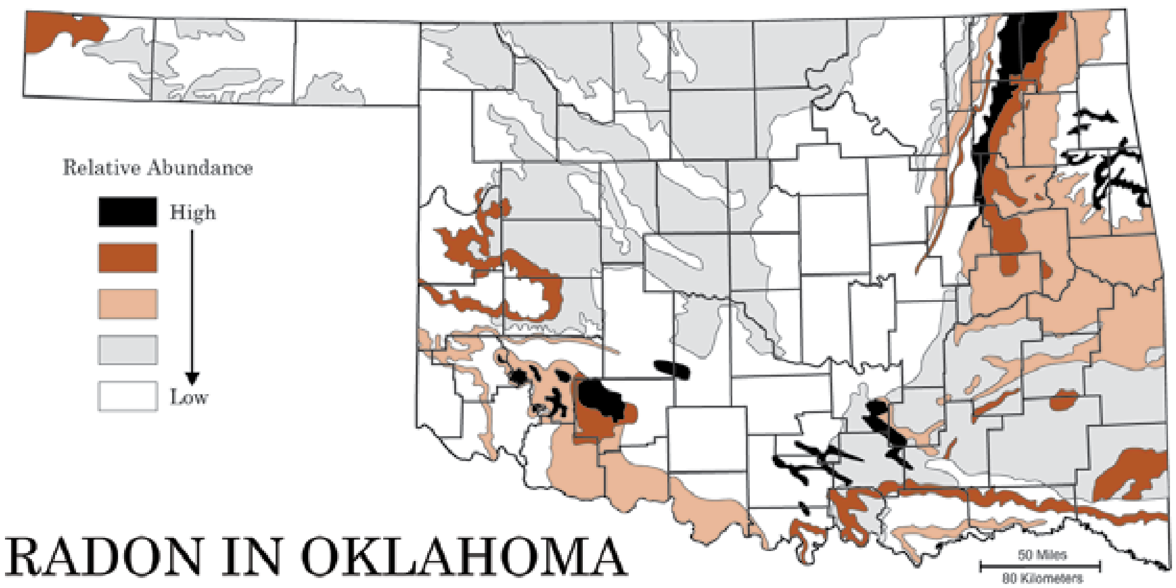
Mark Showell, Latimer County News-Tribune. ODOT workers inspect Highway 82 five miles north of Red Oak where a landslide caused the roadway to collapse.

Rockslide in Arbuckles along I-35. Photo by Jim Anderson, OGS.

Although Oklahoma is not considered to be a mountainous state, it does experience landslides. It's very important that hilly terrain be studied for hazards whenever homes, traffic, or other human activities are located nearby.

EARTHQUAKES

Whenever rocks in the Earth's crust are subjected to unequal pressure, or stress, they sometimes bend. If opposing stresses are large enough, brittle rocks can break, or fracture, sometimes moving past one another along a plane known as a fault. Sudden rock movement along a fault can produce an earthquake with significant amounts of energy being released in the form of seismic waves. Seismic waves can vary in intensity but some are powerful enough to damage or destroy man-made structures. The study of earthquakes is known as seismology and the study of the Earth's crust is known as tectonics. Oklahoma has had a dramatic increase in the number of earthquakes in the last few years and geologists are working to better understand the causes, potential for future occurrence, and possible ways to reduce their number and size.



SINKHOLES

Karst, or karst terrain, forms whenever water dissolves specific rock types such as limestone, salt, or gypsum. It is the same process that creates caves around the world. Pockets of this dissolved rock below the surface sometimes cause the overlying ground to collapse, creating what is known as a sinkhole. Sinkholes can occur without warning and can be large enough to swallow an entire house within minutes. Geologists create maps showing where karst-associated rocks occur to help identify potential sinkhole locations. Some sinkholes are not karst-related but are created by man-made activity, such as mining, or by the removal of soil below the surface by flowing water. There are several sinkholes in the Picher, Oklahoma area that were caused by extensive mining beneath the surface early in the last century. This is also true in coal-mined areas near Krebs, Hartshorne, and Wilburton.

RADIATION

Radiation can pose a potential threat to humans if certain rock types are present. Typically, traces of naturally occurring radioactive minerals, such as uranium, can be found in all rocks; including those in Oklahoma. While our state generally has a low occurrence of radioactive materials, it is possible for higher concentrations to exist in rocks such as granite and dark shales. Radon is an odorless radioactive gas created from the natural breakdown, or decay, of uranium. It sometimes escapes through shallow permeable rocks and can become trapped in homes or buildings. A map has been created to show locations where radon could potentially occur. The map does not actually indicate the presence of radon but is meant to be used as a guide when testing for the gas.

Sinkhole near Picher, in northeast, where sinkholes and mine-collapse features are a result of lead and zinc mining in the Picher field in the early part of the 1900's. Photo by Kenneth V. Luza.

The good news is that Oklahoma has very few areas where radon is a concern. Only about 7% of the state is considered to have a locally moderate to high potential for radon.

Luza K. V., and Johnson, K. S., 2005, Geologic Hazards in Oklahoma: OGS Information Series 11, p. 1-18 (2013). Landslide. Retrieved from ***http://www.eoearth.org/view/article/154157***
http://water.usgs.gov/edu/sinkholes.html
http://www.usgs.gov/blogs/features/usgs_top_story/the-science-of-si...

Activity

Log-in to the online Oklahoman Archives using your classroom log-in by visiting: *http://nieonline.com/theoklahoman/archive.cfm.* Do a search on sinkholes. Using one article that you find answer the following: where was the sinkhole located? Did the sinkhole cause any loss of life or damage to property? Did the article indicate what might have caused the sinkhole? Submit a summary of your article research at *http://nie.newsok.com/oklahoma-rocks/* for a chance to win an iPad for both you AND your teacher! Submission deadline is January 29, 2016.