Name that Tune

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Secondary Pupils

Topic: How oil is found

Topic Overview: To locate oil deposits geologists use seismic technology to map the patterns of rock formations below the surface of the earth. Variations in density affect the way materials reflect sound waves.

Activity Overview: Pupils will investigate how sound waves can be used to locate variations in density and apply this knowledge to understand how geologists use seismic information to locate oil deposits.

Core Experience and Outcome:

SCN 3-17a: Through evaluation of a range of data, I can describe the formation, characteristics and uses of soils, minerals and basic types of rocks.

Learning Intention:
I am learning how sound waves change as a result of passing though different materials due to density

Success Criteria:
I can identify that density affects sound and this is how sonar and other seismic technologies can be used to map hard to see areas.

Resources
"Rock Ages" experiment record

"Oil King" experiment record

Book Reference:
Oil and Natural Gas, pages 28-31

Materials for introductory activity:
- Tuning Fork
- Rocks

Materials per pupil Activity 1:
Colouring pencils/pens
Scissors

Materials per Group Activity 2:
- A cardboard box or other opaque container with cardboard lid
- Sand
- Colouring pens
- Clear drinking straws
- Graph paper
- Small rock samples
- Balloon with water
- Food colouring
- Skewer

Key Vocabulary

Seismic survey – the use of sound waves to create a 'picture' of the subsurface geology.

Fault – a fracture is the rock formation created when one section of the formation moves in relation to another.

Anticline – layers of rock folded upwards by the earth's movement.

Stratigraphic traps – a trap for oil/gas caused by a change in the character of the reservoir rock.

Sea floor spreading - a process that occurs at mid-ocean ridges, where new oceanic crust is formed through volcanic activity and then gradually moves away from the ridge.

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Teacher Information:

Read to pupils from Oil and Natural Gas, pages 28-29:

In the past, finding oil except close to where it seeped visibly to the surface was largely a matter of guesswork and sheer luck. Today, oil prospectors' use their knowledge of the way geology creates oil traps to guide them to areas where oil is likely too occur. They know, for example, that oil is likely to be found in one of the 600 or so basins of sedimentary rock around the world, and it is these basins that oil exploration tends to be concentrated. So far, about 160 basins have yielded oil, and 240 have drawn a blank. Hunting for oil within sedimentary basins might begin by examining exposed rock outcrops for likely looking formations, or scanning satellite and radar images. Once a target area has been located, oil hunters carry out geophysical surveys that use sophisticated equipment to detect subtle clues such as variations in Earth's magnetic and gravitational fields created by the presence of oil.

pages 30-31:

Energy companies are among the highest users of computing power and data of any industry except the military. Exploration specialist use data to interpret geologic structures miles beneath the earth's surface. Engineers can drill through more than five miles of rock to reach resources at extreme depths at high temperatures and pressures. Production engineers bring oil and gas to the surface through miles or production piping, also under extreme conditions, and deliver them through more miles of pipelines to refineries.
Once there, increasingly "heavy" and sulphurous crude oils are refined into useful products. Advanced technologies like satellites, global positioning systems, remote sensing devices and 3-D and 4-D seismic make it possible to discover oil reserves while drilling fewer wells, resulting in a smaller environmental "footprint" and more economical than ever before. The answer to where oil is found? In computers!

Additional Information:

When permeable rocks containing oil and natural gas are moved adjacent to impermeable rocks, the petroleum becomes trapped.

Anticlinal Trap - An anticline is formed when layers of rock are folded upward by earth's movement. Oil and natural gas within the reservoir will tend to migrate to the highest point within the structure. When a cap rock, an overlying layer of impermeable rock, exists above a reservoir rock in an anticline, a trap may form and prevent the upward escape of the oil and natural gas.

Stratigraphic Trap - These geologic features are formed by a change in the character or extent of the reservoir rock. For example, sand can become cemented into impermeable rock at one point in the formation, preventing the upward migration of petroleum from the reservoir rock. Underground water may leach out pockets where oil and natural gas can accumulate, or a permeable, petroleum bearing layer may be "pinched out", tapered to a disappearing edge, and sandwiched between layers of impermeable rock.

Sound waves travel at different speeds through different types of rock. Seismologists use special trucks equipped with high-tech equipment that read the speeds at which sound travels through various types of rocks. Geologists identify rock formations at a prospective drilling site and interpret this information. This helps them to determine if the site could be a good prospect to find oil and natural gas.

One of the most accurate exploration methods is seismic technology. In seismic technology, sound waves created by thumper trucks or explosives detonated either on the earth's surface or underground are recorded by seismographs. Seismographs are similar to instruments used to measure earthquakes. The reflected sound waves are received by geophones, which transmit the sound waves to a seismograph located in a truck. The particular rates at which the sound waves are reflected back create a picture of the underground geology and possible location of petroleum deposits.

Even after the seismic picture is assimilated and analyzed by geophysicists, there is no guarantee of discovering oil or natural gas. At best, the seismic picture can provide only a guess of what lies beneath. Drilling for oil and natural gas is a risky business.

Establishing Prior Knowledge

- How are rocks formed?
- Can you name 3 types of rock?
- What is density?

Concept Introduction

Using a tuning fork, gently strike the fork against a variety of objects around the room. Note variations in sounds produced by different objects. Strike the fork against a variety of rocks. Note variations in sounds produced by different rocks. Discuss with the pupils the differences in the sounds produced from different objects. Ask the pupils why they think there are differences in the sounds produced from different objects and rocks. Ask them how scientists could use this information to help map the rock layers beneath the earth?
Tell the pupils that sound waves are one way that scientist find oil beneath the surface. Over the next few days we are going to explore different ways scientists find oil beneath the earth's surface.

Activity 1: Rock Ages

Place pupils in small groups and read this background information:

During World War II, Germans and Americans began using sonar (sound waves) in warfare. Sound waves emitted from a ship would pass through the water and bounce off solid objects such as other ships, submarines, or the ocean floor. By timing the sound waves and knowing the speed of sound in salt water, sailors could calculate the distance to the foreign object. In this way, the navy could more easily locate enemy targets in the dark.

After the war, geologists looked at some of the data collected from these ships. They discovered that the ocean floor was not flat as most scientists had believed up until that point. A ridge of underwater mountains started to emerge down the centre of the Atlantic Ocean. They also identified numerous volcanic peaks that did not reach the surface. They were curious about these features.

During the 1960's, the Glomar Challenger began a drilling project on the Atlantic Ocean floor. Although it was as tedious process, the drilling pipe and drill bit that were lowered from the floating platform, eventually reached the ocean floor where the drilled rock chips were brought to the surface and studied. Through a variety of dating processes, geologists were able to assign ages to the underwater volcanic rocks that make up the ocean ridge.

In this activity you will make a model of the formation of igneous rocks on an ocean ridge.

Pass out the "Rock Ages" experiment record and have the pupils follow instructions. Following the activity review the seismic technology information with pupils found in the explanation section.

Answers to Assessment Questions:

1. What is the relationship between rock ages and distance from the centre of the ridge? Predict what the ages of the rocks to the far west and east of this rock strip are.

Answer: The farther east or west, the older the rock- 9 mya is the oldest age shown

2. The average speed of sound in salt water is 1,500 meters/second. How long would it take for the sonar wave leaving the ship to get to a depth of 5,000 meter?

Answer: 3.33 seconds

3. What is the age of the rock at that depth?

Answer: 4 million years

4. In order to better show depth, fold the map in half at the slit line and stand it up like a tent.
Make the following predictions:

(a) At the depth of 5500 meters, what is the age of the rock?

Answer: 5 million

(b) How much time would the sonar wave leaving the ship need to reach a 5,500meter depth?

Answer: 3.6 seconds

(c) How much time would the sonar wave leaving the ship need to reach the 6,000 meter depth?

Answer: 4 seconds

5. What do the patterns of rock ages on the mid-ocean ridges tell geologists?

Answer: That there is has been spreading of seafloor at mid oceanic ridges over millions of years. The oldest rock is found farthest away from the ridge; this is evidence for continental drift

Activity 2:

In this activity pupils will work in groups to build a model of an oil reserve and then swap with another group to carry out exploration activities to 'drill' for the hidden oil.

Spilt the pupils into groups of 4 and then pass out the "Oil King" experiment record. Before beginning give each pupil in the group a job from the list below.

Recorder: the pupil who writes down the information from the experiment
Reporter: the pupil t who presents their group's findings to the class
Material Manager: the pupil t who gathers and puts away the materials for the experiment
Clarifier: the pupil who oversees the experiment and ensures their group stays on task.

After completion of the lab, discuss with pupils their findings and what they thought about this activity.

Extension Ideas:

- Task pupils with designing the structure of an oil rig using craft straws and plasticine- you could set specific height and weight bearing requirements and then test the structures strength using a fan.

Home Links

- Challenge pupils to research areas in UK under current exploration using seismic technologies.

Instructions:

Study the attached map of the ocean floor. Notice that the contour lines represent "depths" of water in meters rather that surface contour lines that represent heights above sea level.

Materials:

- Map of Mid- Ocean Ridge
- Scissors

The strip below the map represents different age volcanic rocks that formed along the ocean ridge during the last 9 million years.

1. Cut out the map and the 2 rock strips.

2. Crease the strips along the first line (on both strips). Label this first section on both strips "9 mya." This means that this igneous rock formed 9 million years ago. Now, colour both sections of the 9 million year old rock the same colour on both strips.

3. Fold the second section of the strips of the igneous rock. Colour both matching sections and label these two sections "8 mya." Continue this process until all sections of both the rock strips have been coloured and labelled.

4. Cut along the 2 dashed lines in the Mid Ocean Ridge Map to create 2 slits.

5. Put one rock strip into each slit with the colour showing. You should be able to pull both strips through the slits at the same time in opposite directions to see the seafloor spreading as it did through geologic time. You will pull the "9mya" sections through first all the way down to the newest rock layer which represents to the present.

Assessment:

Answer the following questions on a separate piece of paper.

1. What is the relationship between rock ages and distance from the centre of the ridge? Predict what the ages of the rocks to the far west and east of this rock strip are.

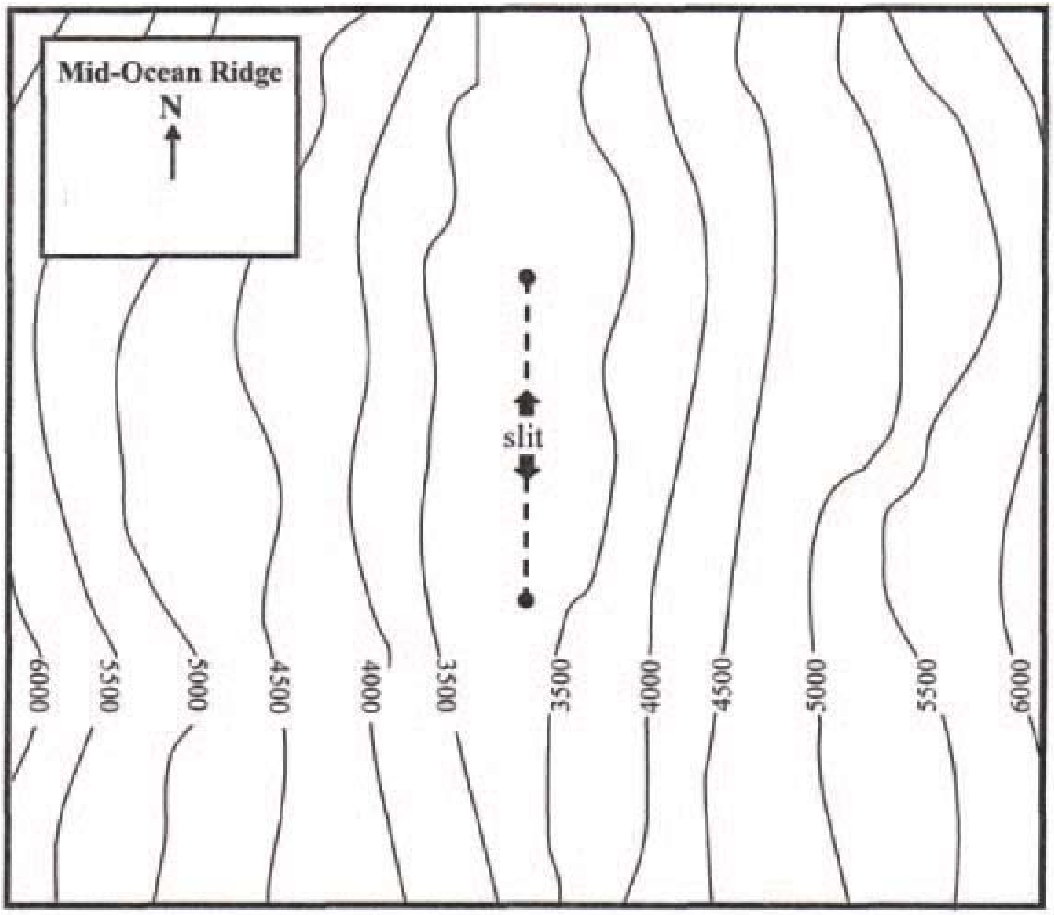
2. The average speed of sound in salt water is 1,500 meters/second. How much time did the sonar wave leaving the ship need to reach a 5,000 meter depth?

3. What is the age of the rock at that depth?

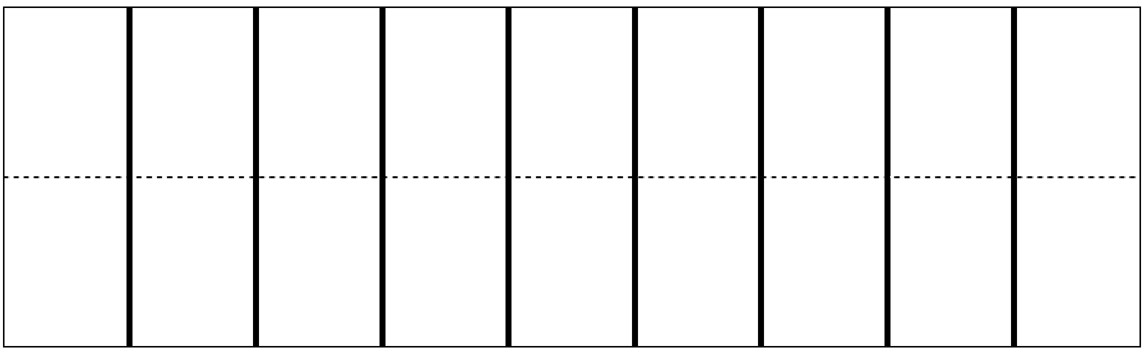
4. In order to better show depth, fold the map in half at the slit line and stand it up like a tent.
Make the following predictions:
(a) At the depth of 5500 meters, what is the age of the rock? (5 million)
(b) How much time would the sonar wave leaving the ship need to reach the 5,500meter depth?
(c) How much time would the sonar wave leaving the ship need to reach the 6,000 meter depth?

5. What do the patterns of rock ages on the mid-ocean ridges tell geologists?

Map of Mid-Ocean Ridge



Cut out map and strips below



Cut along dotted line to create 2 strips

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Oil King Experiment Record

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Materials:

- A cardboard box or other opaque container with cardboard lid
- Sand
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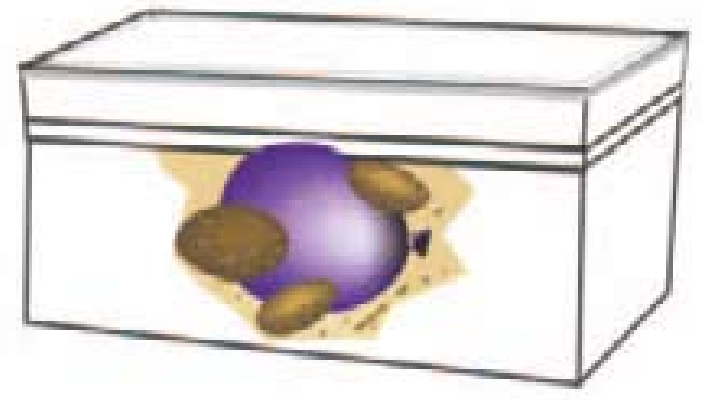
- Small rock samples
- Balloon with water
- Food colouring
- Skewer



Background information:

Since 1970, oil and natural gas have provided more than half of the energy used each year in the United Kingdom to produce electricity, heat, transportation fuels, and many everyday products from balloons to vitamins. Oil and natural gas are forms of petroleum, a word that literally means "rock oil." Petroleum is called a fossil fuel because it is geologically very old and is found in the ground, like fossils. Abundant oil and natural gas form only where conditions in the Earth are just right. Doing this investigation will help you understand how geoscientists identify and explore petroleum-rich reserves. It will also give you an appreciation for the cost of getting petroleum out of the ground.

Instructions:

1. In a small box or opaque container, set up model similar to the one show in the diagram above. Place a small balloon containing coloured water (to represent oil) into the layers. Think carefully about where to place your oil reserves in the model. Putting it in the middle might be too obvious or putting it against the side of the box might be too confusing!
2. After positioning the oil reserve fill the box with sand and a few stones to cover your balloon.
3. Mark the sides of the box "North," "South," "East," and "West." Make a map of your model to show the location of the water-balloon "oil reserve."
4. Place a lid securely on the box and fasten it with masking tape. Exchange your model with another group.
5. With the other group's box, you will model the method used by exploration geologists in the field. You may not move the box, and you may not look inside it. Attach graph paper to the lid of the box. Tap on the box and listen for an area that sounds different. Use the graph paper to record the locations of areas that sound different and seem like good candidates for oil exploration. Probe the box to search for "oil" (the water balloon) in the places you identified.
6. Mark off divisions of one centimetre on a bamboo skewer, beginning at the bottom. Use the bamboo skewer to penetrate the box lid at the location where you think there might be oil.
7. Probe gently though the sand. Look at the skewer for evidence of "oil." This models the drilling process.
8. **Every centimetre of depth that you drill costs £100,000. In addition, each time you move to a new spot to drill, it costs £50,000.**

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Oil King Experiment Record

Secondary Pupils

9. Keep a record of how many cm you drill and how many times you move the skewer to a new spot in the table below, so that you can calculate a total cost for your exploration activities.

	Drill site 1	Drill site 2	Drill site 3	Drill site 4	Drill site 5	Drill site 6	Totals
Depth drilled down (cm)							
Cost of drilling depth							
Cost of each drill site							

Assessment:

1. What was the total cost of your exploration? ___________________________

2. If you were to start over, how would you change your exploration procedure to save money?

3. Compare your results with the group that constructed the model. Look at their map. Was your oil deposit where they said it should be?