UTAH OFFICE OF
ENERGY DEVELOPMENT

Helium

Grade/Subject: 8th grade integrated science

Strand/Standard 8.4.1 Construct a scientific explanation based on evidence that shows that the uneven distribution of Earth's mineral, energy, and groundwater resources is caused by geological processes.

Lesson Performance Expectations:

- Students will construct a scientific explanation concerning the geologic processes that support the formation of helium deposits in Utah and the world.
- Students will focus on the geochemistry associated with nuclear decay that produces helium in granitic rocks and why drilling is used to recover the gas. Granitic rock is a common, coarse-grained, light-colored, hard igneous rock consisting chiefly of quartz used in monuments and for building and commonly referred to as granite.

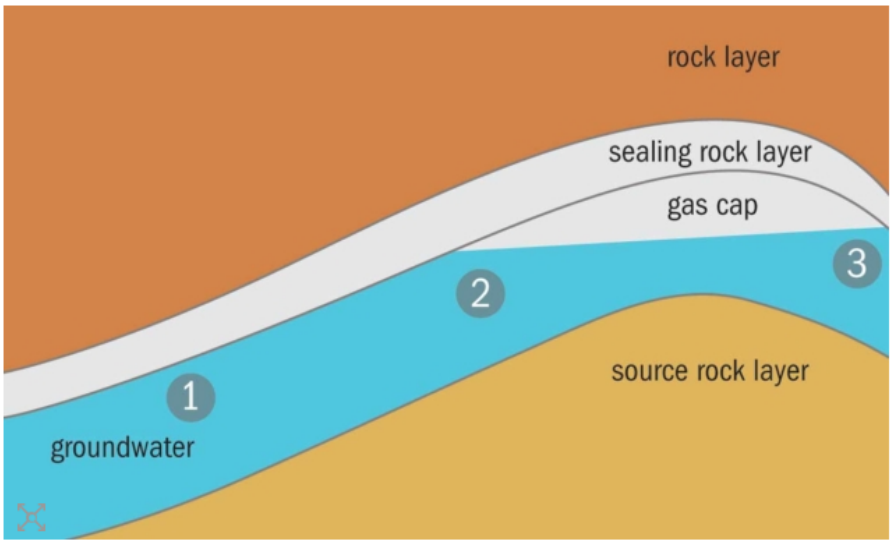
Materials: Students need a computer for each pair or individual student.

Time: 50 minutes

Teacher Background Information:

- Watch this video about helium
- Basic Geology
  - Helium is an element, which means that it cannot be manufactured under normal conditions.
  - Commercial helium concentrations are formed under unusual geologic conditions, often in conjunction with natural gas.
  - Helium often forms in Paleozoic-age rocks from the radioactive decay of uranium and thorium.
  - Helium migrates upward into sedimentary rocks following faults, fractures, and igneous intrusives. Igneous intrusions form when lava flows cool and solidify before reaching the Earth's surface.
  - The atomic radius of helium is so small that it easily moves upward through most of the Earth's layers. Helium can be trapped by non-porous caprock such as halite (rock salt) or anhydrite.
  - Igneous rock is one of the three main rock types, the others being sedimentary and metamorphic. Igneous rock is formed through the cooling and solidification of magma or lava.
- Helium Recovery
  - Helium is typically recovered during natural gas extraction and requires large gas fields to produce substantial quantities.
  - Very little helium is present in Earth's atmosphere. It is such a light element that Earth's gravity cannot hold it. When present at the Earth's surface, unconfined helium immediately begins rising until it escapes the planet. That's why party balloons rise!
- Conservation
  - Shortages of helium have resulted in increased prices, leading to an interest in drilling helium-only wells.
  - The total terrestrial inventory of helium is estimated to be 17,000 trillion standard cubic feet (SCF).
  - Most of this supply is in Earth's atmosphere at a concentration of only 5 ppm.
  - Atmospheric helium is in dynamic equilibrium between the gain of helium diffusing from Earth's crust (as a product of radioactive decay and losses of helium into space.
- Helium Use

    - Helium is most commonly associated with balloons, but industrial uses include military, aerospace, and medical applications.
    - Because it is chemically inert and is a liquid at temperatures near absolute zero, it is used to cool the magnets in MRI machines and air-to-air missile guidance systems.
    - It is a carrier gas for gas chromatography and mass spectrometry.
    - Helium is also used for welding, medical imaging, and making semiconductors.
- Utah Helium R
    - Utah is home to the first well in the United States in which helium extraction was the primary purpose, located in Grand County on land managed by the Bureau of Land Management (BLM).
    - This area is known as the Harley Dome and contains a high helium concentration. Designated as a federal helium reserve in 1934, it contains a mixture of nitrogen and up to 7% helium. Although this well was plugged in 2019, additional development is occurring within the state.



Helium migration: Once released from the source rock, helium and nitrogen can interact with groundwater (1), which carries the dissolved gases as it ascends. When the groundwater contacts a pre-existing gas cap containing methane or carbon dioxide (2), the nitrogen and helium partition out of the groundwater into the gas cap (3).

Source

IACX started producing on-purpose helium in 2013 at the Harley Dome field in Utah.

- The Harley Dome Field is currently producing helium (Source).

Links:

OED Helium Video

https://physicsworld.com/a/on-the-hunt-for-helium/
https://cen.acs.org/articles/95/i30/helium-way.html
NPR The Science of Helium

Student Background Knowledge:

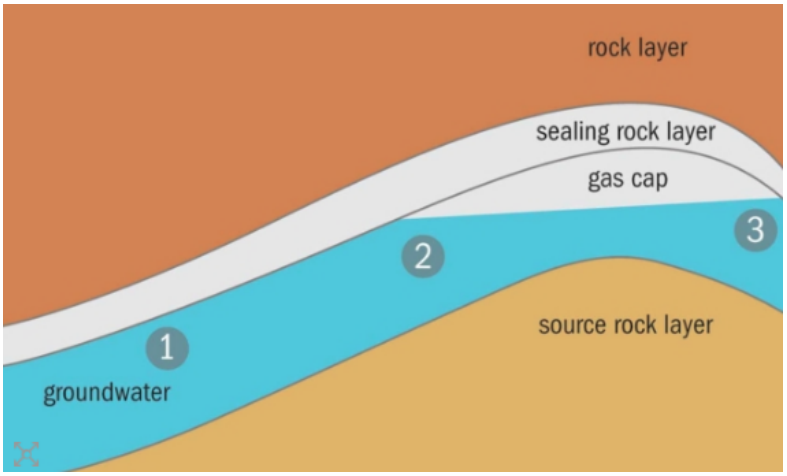
- Students should know the particulate nature of matter and be familiar with the differences between atoms.
- High school students should have a background in radioactive decay.

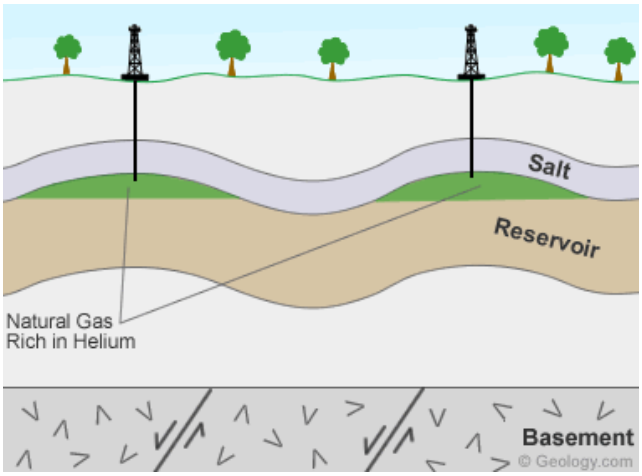
Teacher Step by Step:

1. **Introduce *Phenomenon:*** Bring a helium-filled balloon to class or use a picture of floating balloons.
2. Ask students what they notice about the balloon or balloons pictured on the student sheet. Ask for questions that they have about the phenomenon. You might guide them to ask why helium has not all left Earth.
3. Allow students time to look at the websites. A group of students could divide them up and report to the group about what they find. They should record their findings as evidence.
4. Ask students to write explanations using the CER model (claim, evidence, and reasoning).
5. The difference between the high school product and the 8th grade should be the complexity of the evidence, reasoning, and additional claims.

Assessment of Student Learning.

The below diagram demonstrates a gas cap trapped between source rock and a sealing layer. Helium gas and other gases could be released and captured by a drilling operation.





1. Most geologists believe that the majority of **helium** in natural gas derives from a specific kind of source rock. What characteristic(s) must this source rock layer have to procure helium? Choose all that apply.
    a. It is formed from large crystals.
    b. It is porous and allows gases to flow through.*
    c. It contains radioactive atoms that decay into helium.*
    d. It contains a solid form of helium that evaporates into a gas.

2. What characteristic(s) does the sealing rock layer have? Choose all that apply.
    a. Helium gas cannot pass through it.*
    b. It is less dense than the surrounding rocks.

c. It was formed after the gas cap was created.
d. It is formed from rock containing large crystals.

3. What factors affect the location of the gas cap in the rock formation? Choose all that apply.
    a. Density*
    b. Porosity*
    c. Crystal type
    d. Temperature
    e. Regional geology*

4. What characteristics of helium make it useful in many applications? Choose all that apply.
    a. It is not flammable.*
    b. It has a low density.*
    c. It is non-reactive with other elements.*
    d. It has the ability to “carry” other gases.*
    e. It turns to liquid at extremely low temperatures.*
    f. It can be found in many locations and is abundant in nature.

Extension of lesson:

1. Have students design and perform an experiment to measure the density of helium, using balloons as a source of Helium. Check local stores for these balloons.
2. Have students research and report the various applications of helium.

Using Helium

Name_____

Phenomenon: Helium Balloons

What do you notice?

What questions do you have?

1.

2.

3.

Guiding Questions: What geologic processes are necessary to form helium deposits? Is helium important for anything other than balloons?

Explore: Use the following websites to answer the questions. Report your findings in the CER form:
https://physicsworld.com/a/on-the-hunt-for-helium/
https://www.deseretnews.com/article/865577113/Nations-first-helium-well-planned-for-Utah-may-help-with-worldwide-shortage.html
https://cen.acs.org/articles/90/i29/Helium-Shortage-Affecting-Instrument-Users.html
https://cen.acs.org/articles/95/i30/helium-way.html

Explain:

Claim: Certain geologic processes are necessary to form helium deposits.

Evidence:

Reasoning:

Claim: Helium is important for things other than balloons.

Evidence:

Reasoning: