Earth Science Curriculum
Lesson Plans
Grades 7, 8 & 9

Developed by University of Utah Mining Engineering students for the Utah Mining Association

Piloted and refined by Alpine School District teachers
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Density Separation

<table>
<thead>
<tr>
<th>Topic: Density Calculation</th>
<th>Estimated Length (minutes): 105 minutes</th>
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<tbody>
<tr>
<td>Standard: 1, Students will understand the structure of matter.</td>
<td>Objective: 2, Accurately measure the characteristics of matter in different states.</td>
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</table>

**Description:**
- Calculate the density of various solids and liquids.

**Required Materials/Resources:**
- Activity: Density Calculations
  1. Mineral Samples (quartz, magnetite, pyrite, etc.)
  2. 100 mL graduated cylinders
  3. Scales
  4. Water
  5. Mineral density data sheet, example link
- “Hydrocyclone” (video), link [http://www.youtube.com/watch?v=xijphGyhyQk](http://www.youtube.com/watch?v=xijphGyhyQk)
- “Spiral concentrator” (video), link [https://www.youtube.com/watch?v=QYYxLFrrlE](https://www.youtube.com/watch?v=QYYxLFrrlE)

**Introduction:**
- All matter is made up of atoms that are far too small to see. Atoms are in perpetual motion and the more energy they contain the faster they move. Atoms combine to form molecules. Matter is made up of atoms and molecules that have measurable mass, volume, and density. Density is a measure of the compactness of matter. Density determines the way materials in a mixture are sorted. This property of matter results in the layering and structure of Earth’s atmosphere, water, crust, and interior.

**Discussion:** (Length: 15 minutes)
- Discuss Density, Mass, Volume, and Specific Gravity (ratio of the density of a substance to the density of a reference substance- reference substance is usually water when dealing with liquids, air, and gasses.

**Activity: Density Calculations** (Length: 20 minutes)
- Activity Procedure
  1. Review the concept of density and how it can be calculated by knowing the mass and the volume. The mass is measured on a scale and the volume is the amount of liquid displaced.
  2. Have students measure and write down the mass of mineral samples.
  3. Measure volume by having the students
● Fill their graduated cylinders with 50 mL of water,
● Tilt the cylinder and slide the mineral sample in
  ○ To purchase mineral samples: check out this link: https://www.wardsci.com/store/catalog/searchCategory.jsp?jsessionid=8EDD29B339CA80BD6FDAB13A22E805277?id=PC10356782&searchUrl=/search?isSciedProductListingPage=true&pimId=PC10356782&navAction=pop&navCount=0
● Read the new level on the graduated cylinder and write it down,
● Subtract the new volume from the 50 mL to obtain the volume of the mineral sample.
  4. Have students calculate the density of the samples by dividing the samples mass by their volume giving the units of g/cm$^3$. Note: one mL of water is equal to one cm$^3$.
  5. Instruct students to fill in data chart with the answers that they calculated.

**Assessment:** (Length: 15 minutes)

● Teacher gives the accepted densities values of the mineral samples students measured. For a table of accepted densities check out this link: http://hyperphysics.phy-astr.gsu.edu/hbase/tables/density.html
  ○ Compare students’ experimental densities with the accepted density of the materials used. Discuss reasons for differences, i.e. sources of error when recording data, impurities in the mineral sample, etc.

**Real World Application:** (Length: 15 minutes)

● **Focus on Careers:** Mining Engineers
  ○ **What They Do:** The role of a mining engineer is to identify a resource and optimize its extraction. The knowledge of density helps in both of these aspects, by helping with identifying a mineral resource and separating that resource from the waste.
  ○ **Where They Work:** In mines all around the world! In either surface or underground mines.
  ○ **Education Necessary:** Mining engineers need a four year degree in Mining Engineering and sometimes a Masters.
  ○ **How They Use the concept of Density:** Minerals vary greatly in their individual densities. This is due to the differences in their individual chemical composition and crystal structure. These characteristics lead to metals being denser than nonmetals. This makes density a useful tool for separating and identifying minerals. This concept of density separation is used in the mining/mineral processing world. Some examples of devices used are dense-media drum concentrators, heavy media cyclone, and spiral concentrators. Included is a link to a video showing a simulation of the heavy media hydrocyclone. Below is a short discussion on each of these with visualization.
Dense Media Drum Concentrator

- The heavy particles (pink) settle to the bottom and are carried into an upper tray.
- The less dense particles (green) float and are collected between baffles.

Heavy Media Hydrocyclone

- Particle mixture enters a hydrocyclone at high speed where it is forced to flow around in circles.
- The spinning action spins the larger particles to the outside wall, where the larger particles are forced to spiral down and out through the bottom.
- The fine particles that remain in the center exit through the top, which is a pipe in the top center section of the hydrocyclone.
**Spiral Concentrator**

- A mixture of water and the crushed material enters at the top
- The less dense material flows to the outside of the spiral track as it flows down
- The more dense material is collected on the inside of the track as it flows down
Water and Its Effects

<table>
<thead>
<tr>
<th>Topic: The effects of water</th>
<th>Estimated Length (minutes): 45-60 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard: 1, Students will understand the structure of matter</td>
<td>Objective: 3, Investigate the motion of particles</td>
</tr>
</tbody>
</table>

**Description:**
- Students will learn the impact of expansion and contraction of solid materials on the design of buildings, highways and other structures; including highwalls and mines.

**Required Materials/Resources:**
- **Expansion of Water - Ice can really do that?**
  - A one liter bottle should be filled to the top with water
  - A one liter bottle filled with water and frozen
  - Have another liter bottle filled with water that is unfrozen
  - “Ground Rules-Chapter 4” (Video)
    - [http://www.youtube.com/watch?v=1BYnGWGm-Uc](http://www.youtube.com/watch?v=1BYnGWGm-Uc) (2:07-2:35)

**Introduction:**
- Water affects the design and strength of highwalls
  - The goal is to keep water out of mines
  - Water in mines and highwalls can lead to serious problems, including collapses or failures
  - If water is in a highwall and then freezes, it expands and causes problems
  - A highwall is the portion of a surface coal mine that is the undisturbed material
  - In other words, part of the slope that material has been removed from any portion of a surface mine that has not been excavated
  - A cliff, or highwall, is formed when material is being removed from the mine
  - This area contains either a coal seam in the highwall or underneath it
  - There are many safety concerns when it comes to highwalls
  - Some rules include: do not stand between equipment and a highwall, do not turn your back on a highwall, and you must be at least 30ft away from a highwall if not more.
  - When highwalls fail there are usually signs of warning.
  - These signs include small rocks starting to slide down, then larger rocks, and even cracking noises. When these happen, the highwall is about to fail
What would happen if water got into either of these areas?
Discussion: (Length: 20 minutes)

- What is a highwall (utilize information from the introduction)
- Teach what a highwall is.
  - When the material from a mine is removed, a cliff (highwall) is left
- Water should be kept away from these areas as much as possible
- Water in or around highwalls is very dangerous
- Water reduces the strength of structures that hold the cliff together
- Occasionally water flows out of the highwall, but when water stops it means there is a backup of water, which can weaken the highwall
- When water is backed up and ice forms, the water cannot exit the highwall and there is a water pressure built up; this causes a highwall to fail
Activity: Ice can really do that? (Length: 10 minutes)

- Procedure:
  - The day before class, fill up a one liter bottle to the top with water and freeze it
  - Have another liter bottle filled with water than is unfrozen
  - Discuss the difference between the frozen bottle and the unfrozen bottle
  - Show that the frozen bottle has expanded and caused damage to the bottle
  - Explain why this happened
  - Calculate the density of the ice in the different phases. Compare the densities in the different phases.
  - Explain the possible dangers of frozen water and its expansion
- Watch the “Ground Rules-Chapter 4” Video

Real World Application: (Length: 10 minutes)

What is a highwall?

- A highwall is the portion of the mine that has not been excavated
- When material is removed from the mine, a cliff is left
- Highwalls contain coal seams in them or beneath them
- Highwalls are the areas that are about to be mined
- These areas hold the important material

Rules for Highwalls

- Do not stand between equipment and a highwall
- Do not turn your back on a highwall
- You must be at least 30ft away from a highwall, if not more

Signs of Failing

- When highwalls fail there are usually signs of warning
- Small rocks begin to fall down the highwall
- Then larger rocks begin to fall
- Cracking sounds can be heard coming from the wall
- Then the whole highwall fails
Expanding and Contracting Earth: Intro to Mining Methods

<table>
<thead>
<tr>
<th>Topic: The expansion and contraction of certain materials</th>
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</tr>
</thead>
</table>
| Standard: 1, Students will understand the structure of matter | Objective: 3e. Describe the impact of expansion and contraction of solid materials on the design of buildings, highways, and other structures.  
2d. Describe the relationship between mass and volume as it relates to density. |

Description:
- This lesson plan will describe some basic mining methods and tie in to the expansion and contraction of certain materials that are mined.
- The different mining methods try to take advantage of the fact that materials expand or contract to help extract the desired material in the most efficient and safest way possible.

Required Materials/Resources:

The following videos are helpful for explaining and showing the different kinds of mining methods
- Mining method 1: Video from Caterpillar explaining the longwall mining method (approx 3.5 min) [http://www.youtube.com/watch?v=bXORrVmxwbM](http://www.youtube.com/watch?v=bXORrVmxwbM)
- Mining method 2: Video explaining a bucket wheel excavator (approx 2 min) [http://www.youtube.com/watch?v=oWlcqdPJEPg](http://www.youtube.com/watch?v=oWlcqdPJEPg)
- Mining method 3: Video of various blasts in a mine (approx 4 min) [http://www.youtube.com/watch?v=7fEJcyMNfII&feature=fvwp&NR=1](http://www.youtube.com/watch?v=7fEJcyMNfII&feature=fvwp&NR=1)

Teacher Background:
- Everything in this world is made from materials that come from the earth. Some of these materials are non-renewable. These essential non-renewable resources must be extracted safely and efficiently in order for us to enjoy the wants and needs of our society.
- Different mining methods are used to extract different minerals around the world. The following methods in this outline are just a few.
Discussion: (Length: 15 minutes)

- Materials that are mined experience expansion and contraction

- Method 1: Underground Longwall mining
  - Uses machine called longwall to mine out large regions of coal or other soft rock minerals (see Longwall Video)
  - A machine called a continuous miner, or commonly known as a ‘CM,’ cuts out the entryways (rooms), and leaves the larger area (panel) for the longwall to mine.
  - As the longwall has finished mining out a panel (the 300-800ft by 2-3 mile area), the open space behind the shields caves in. This material is called the gob.

- Method 2: Surface Bucket Wheel Excavator mining
  - Uses machine called Bucket Wheel Excavator to extract soft rock minerals.
  - Is one of the biggest, most efficient ways to mine in the world

- Method 3: Surface Mine Blasting
  - Often times the volume of earth calculated to be in the rock is less when the same volume of rock is blasted and ready to be hauled away by truck and shovel. This is called ‘swell factor.’ Swell factor = \( \frac{h_2 - h_1}{h_1} \) where \( h_1 \) is the assumed height of the face before blasting and \( h_2 \) is the same height after blasting.
  - Simply put, you often have a larger volume of material after blasting has taken place.
  - The swell factor is important when choosing how many and what kinds of trucks and shovels to use to gather and haul the material
  - Blasting is the most efficient form of breaking large rocks into smaller rocks (comminution). The difference between a good blast and a bad blast can be observed. If the blast goes straight up out of the hole, it is a bad blast. If the desired material was removed in a safe and non-chaotic way, it is a good blast. The associated video shows some good blasting examples and bad blasting examples.

Activity: (Length: 20 minutes)

- Dirt in 5 gallon bucket (This activity needs a couple of days of preparation)
- Step 1: Fill bucket about ¼ of the way with dirt.
- Step 2: Add a small amount of water to help dirt become as compact as possible. This may require some downward pressure on the dirt to facilitate the compaction process.
- Step 3: Fill bucket about ½ of the way with dirt.
- Step 4: Repeat step 2.
- Step 5: Fill bucket about ¾ of the way with dirt.
- Step 6: Repeat step 2.
○ Step 7: Finish filling the bucket with dirt.
○ Step 8: Repeat step 2.
○ Step 9: Calculate the density of the dirt.
○ Take the bucket of dirt outside. Activity is done best on concrete. Have the students dump out the contents of the bucket. Then have students fill the bucket back up with the same dirt. Students will realize that compact materials will ‘swell’ and it will be very difficult to put back all of the dirt back into the bucket. Discuss what has happened to the density of the dirt and why this occurred.

Assessment: (Length: 15 minutes)
○ Explain why the dirt did not all fit back in the original bucket (answer must relate to density)

Real World Application: (Length: 5-10 minutes)
○ Some careers associated with mining:
  ■ Mining Engineer, Longwall crew member, survey crew member, continuous miner crew member, planning engineer, mechanical engineer, electrical engineer, geologist, geological engineer
○ The longwall method is currently being used right now in Utah to mine coal
○ Approximately 80% of electrical power in Utah comes from coal
Minerals and Our Everyday Lives

<table>
<thead>
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<th>Topic: Classification Systems</th>
<th>Estimated Length (minutes): 90 minutes</th>
</tr>
</thead>
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<td>Standard: 5, Students will understand that structure is used to develop classification systems.</td>
<td>Objective: 1, Classify based on observable properties</td>
</tr>
</tbody>
</table>

**Description:**

Students will understand that structure is used to develop classification systems. Other goals within this topic include the categorizing of nonliving objects based on external structures, comparison of living, once living and nonliving things, emphasizing the importance of observation in scientific classification and the demonstration of many various methods of classification. As part of learning classification techniques, a discussion on the composition of everyday materials and their sources leads into a lesson on the modern and sustainable mining industry. This discussion can focus on the production, engineering, basic principles or career options within the mining industry.

**Required Materials/Resources:**

- “How coal is formed...” (Video) [http://www.youtube.com/watch?v=TZS2K1ye00A](http://www.youtube.com/watch?v=TZS2K1ye00A)
- “How do they do it?” (Video) [http://www.youtube.com/watch?v=ylkdUuNOJzw](http://www.youtube.com/watch?v=ylkdUuNOJzw)
- “Longwall mining explained” (Video) [http://www.youtube.com/watch?v=bXORrVmxwbM](http://www.youtube.com/watch?v=bXORrVmxwbM)
- “Surface coal mining explained” (Video) [http://www.youtube.com/watch?v=2LQwxTm94Ps](http://www.youtube.com/watch?v=2LQwxTm94Ps)
- “Ground Rules” YouTube Channel [http://www.youtube.com/watch?v=-eP6NP028gQ&list=PL31F52074D345CEA2](http://www.youtube.com/watch?v=-eP6NP028gQ&list=PL31F52074D345CEA2)
- “Minerals Education Coalition” link [http://www.mineralseducationcoalition.org](http://www.mineralseducationcoalition.org)

**Introduction & Discussion** (Length: 30 minutes)

Classification of objects requires a basic understanding of the physical properties that make up those objects in addition to observed characteristics. The main goals within this section include basic classification techniques based on external structure (e.g., hard, soft), comparison of living, once living and nonliving things. Classification begins with objects familiar to the students and understanding what those objects are composed of. Not only will students learn scientific classification techniques but also the composition of everyday objects seen around us. Where do we get these objects? These objectives regarding classification can be met while simultaneously educating about the modern practices seen in the mining industry that provide the necessary resources for modern society. Modern practices of mining focus on providing resources while protecting and improving the environment.
■ **Activity: “Item Classification”**
(Length: 20 minutes)

The goal of this activity is to learn the basics of classification as well as the composition of the objects being classified. The focus should be on the various ways of classifying items i.e. color, shape, texture, size, use etc. There is not one correct way of classification but a discussion of logical methods of classification can be done on the board. The activity can be quickly created using everyday objects from the classroom in which similarities or differences can be found and recorded by the student. Group work is encouraged to enables discussion and cooperation. Following the group work, a classroom discussion of the various classification methods gives each group the opportunity to share their findings and techniques used to classify.

■ **Activity: “That’s in my toothpaste?!?!?!?”**
(Length: 20 minutes)

This activity focuses on the composition of everyday items seen at school and at home. To begin the activity, watch the **“Ground Rules Video – Chapter 3 (1:36)”** which discusses the composition of common minerals and their importance in our daily lives. Following the video, lead a discussion on the composition of common everyday items and the importance of those items in society. The following table is an example of list that can be made of common objects. Additional minerals can be found at the **“Common Minerals and their Uses”** link.

<table>
<thead>
<tr>
<th>Object</th>
<th>Minerals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>Silica sand, limestone, talc</td>
</tr>
<tr>
<td>Cake/Bread</td>
<td>Gypsum, phosphates</td>
</tr>
<tr>
<td>Toothpaste</td>
<td>Calcium carbonate, limestone, fluorine</td>
</tr>
<tr>
<td>Baby Powder</td>
<td>Talc</td>
</tr>
<tr>
<td>Jewelry</td>
<td>Precious and semi-precious stones, gold, silver</td>
</tr>
<tr>
<td>Kitty Litter</td>
<td>Pumice, volcanic ash</td>
</tr>
<tr>
<td>Concrete</td>
<td>Limestone, gypsum, iron oxide, clay</td>
</tr>
<tr>
<td>Pots and pans</td>
<td>Aluminum, iron</td>
</tr>
<tr>
<td>Drinking water</td>
<td>Lime, lime, salt, fluorite</td>
</tr>
<tr>
<td>Medicines</td>
<td>Calcium carbonate, magnesium, dolomite</td>
</tr>
<tr>
<td>Television</td>
<td>35 different minerals</td>
</tr>
</tbody>
</table>
Activity: “It’s all about minerals baby!”
(Length: 20 minutes)

According to the Minerals Education Coalition as of 2014, Americans require **3.03 million** pounds of minerals, metals, and fuel in their lifetime. Each year the number is updated and an illustration known as the “Mining Baby” is created. Below is the illustration created for 2014 itemizing the various amounts of minerals, metals and fuels required by each American. Further discussion can be formed based on what the resources listed around the baby are used for.

Every American Born Will Need...

3.03 million pounds of minerals, metals, and fuels in their lifetime

©2014 Minerals Education Coalition
The Society for Mining, Metallurgy & Exploration Foundation

Learn more at www.MineralsEducationCoalition.org
Activity: “Pencil...mined or grown?”
(Length: 20 minutes)

Following the discussion on minerals in everyday life, focus on the composition of the simple #2 pencil. The goal of this activity is to differentiate between items that are grown vs. mined. Brainstorm with the class items that make up a pencil. Some items are obscure and need to be given and explained to the class. A common list is found below.

<table>
<thead>
<tr>
<th>What is in a Pencil</th>
</tr>
</thead>
<tbody>
<tr>
<td>graphite</td>
</tr>
<tr>
<td>wood</td>
</tr>
<tr>
<td>clays</td>
</tr>
<tr>
<td>soybean oil</td>
</tr>
<tr>
<td>latex</td>
</tr>
<tr>
<td>pumice</td>
</tr>
<tr>
<td>sulfur</td>
</tr>
<tr>
<td>calcium</td>
</tr>
<tr>
<td>barium</td>
</tr>
<tr>
<td>aluminum</td>
</tr>
<tr>
<td>copper</td>
</tr>
<tr>
<td>zinc</td>
</tr>
<tr>
<td>hematite</td>
</tr>
<tr>
<td>limonite</td>
</tr>
</tbody>
</table>

After a list has been created on the board, ask the class to identify whether the item is mined or grown. Divide the class into groups and assign each group an item to research. Provide necessary research tools to each group. Have the research focus on the item’s use(s), where the item is grown or mined and how that item is produced. Each group will be responsible for presenting the research information about their specific item.

Discuss with the class the complicated production process it is to produce a simple pencil. Tally the numbers of countries required to produce a single pencil. Take the time to discuss the production of more complicated items used every day such as televisions, cars, books etc.

Real World Application: (Length: 15 minutes)

After learning about the classification of nonliving, living and once living objects and the necessary minerals used in everyday objects it is important to understand from where and how these minerals are extracted.

Where do these minerals come from and how are they formed? (Example: Coal)

Mineral deposits are formed through varying earth processes and geological events over millions of years. One common example of mineral deposition is the
formation of coal. The deposition of organic material combined with the
tremendous overburden pressure of water or other rock material along with
heat and time help in forming coal. The video, “How coal is formed...” (1:06)
illustrates and describes the formation of coal.

How and why are these minerals extracted? (Example: Coal)
Coal is used to generate over 40% of the world’s electricity and is a vital resource
for large industry. Modern coal mining utilizes a combination of hard work and
heavy equipment to extract the coal. In the video, “How do they do it?” (5:44),
extraction of coal in an underground mine is explained. The video “Longwall
mining explained” (3:26) explains the basics of a longwall and illustrates how a
high volume of coal is removed in such a short amount of time. In addition to
underground coal mines, coal is also mined on the surface of earth using large
trucks and shovels called draglines. In the video, “Surface coal mining
explained” (4:14), a virtual tour of a surface coal mine helps explain the details
that go into creating a successful surface coal mine.

How safe is mining?
Through improvements in modern mining techniques and practices, mining has
become an extremely safe industry. Every mining operation has safety as its
number one value and focus over all others. Safety is something that needs to
be addressed in all aspects of life. Take this opportunity to discuss potential
safety hazards around the classroom as well as at home with the students.

What happens to the land after all the coal has been mined? (Reclamation)
Mines are required by law to have a reclamation plan in place prior to being able
to mine. This requirement helps insure that the land be returned to its original
use after the mining has been completed. In the video, “Surface coal mining
explained” (4:14), reclamation is discussed. Post-mining images of a coal mine
demonstrate the beauty that can be restored as mining has ceased. This is all
part of sustainability and helping maintain the environment around us while
providing the world with its necessary resources.

Career Opportunities in the Mining Industry
- Mining Engineer
- Geologist
- Surveyor
- Geo-technical Engineer
- Environmental Engineer
- Mechanic
- Accountant
- Chemical Engineer
- Biologist
- Metallurgical Engineer
- Industrial Hygienist
Classify This!!!

<table>
<thead>
<tr>
<th>Topic: Categorizing and classifying objects according to a simple system</th>
<th>Estimated Length (minutes): 45-80 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 Grade Standard: 5, Students will understand that structure is used to develop classification systems</td>
<td>Objective: 2, Use and develop a simple classification system</td>
</tr>
</tbody>
</table>

Description:
- In this lesson students will learn how to create a simple classification system for non-living things.

Required Materials/Resources:
- 10 – 12 different common items that students in smaller groups can classify according to the items appearance or structure.
- 5 – 10 simple items to classify as a class
- Examples: shoes, writing implement, paper types, books, office supplies, random rocks, sea shells, balls, etc.

Introduction:
- A basic element of thinking is classification. We place objects and situations into conceptual categories in order to make sense of the world. By doing this we eliminate the need to respond to every object and situation as a completely new experience.
- We classify objects by choosing certain attributes to concentrate on while ignoring others. We cannot take in all attributes at once so we select just a few as being relevant to the task at hand. Classification of data is an important part of all scientific study.

Discussion:  (Length: 10 minutes)
- Define a classification system
  - Discuss how things can be classified. Explain how objects can be classified according to many different properties or characteristics.
  - Discuss how there are multiple ways that objects can be classified and that just because one is different from another it doesn’t make either right or wrong.
  - Give example of multiple ways to classify same set of object.
  - e.g. balls could be classified by size, shape, color, sport type, bounceability, etc.
  - Usually a dichotomous key would work best. For example a set of balls could be split into two groups first base on size, then by color, then by texture, exc.
Discuss the things that we classify everyday without even realizing it. This list could include things such as folders within folder on electronic devices (documents-->school-->science) Groupings students (School-->Grade level--> gender) mailing addresses (country--> state --> city), Facebook Friends (All friends → Close Friends → In a relationship).

**Activity: Developing a classification system** (Length: 10 – 15 minutes)
- As a class, develop a simple classification system on the set of 8 – 12 items. As this classification system is developed be sure to explain the thought process involved in creating the different categories and groups.

**Assessment: Students develop a classification system** (Length: 15 – 20 minutes)
- Split the class up into groups with 4 – 6 students in each.
- Give each group a different set of objects to classify. (whatever you can find in your classroom)
- Have the students within their individual groups create a classification system in a similar manner as it was performed as a class. (10 minutes)
- Have groups rotate (trade object sets) to give students an opportunity to practice proficiency of skill of classification. Rotate as many times as time allows. (5 minutes each)
- Reinforce the fact that classification systems may differ, but that does not mean that one is right and the other is wrong.

**Real World Application:** (Length: 5 minutes)
- Discuss how classification systems are used in many different industries around the world.
- Explain that a major industry that uses classification extensively is the mining and minerals industry.
  - Explain the difference between ore vs. waste as it relates to mining. (Ore is what can be mined to actually be used, waste is what you go through to get to the usable material.) Discuss how this is a classification system and talk about the aspects that may determine whether a rock is ore or waste.
These things that define the classification of ore vs. waste may include things such as color, density, grade, etc.
- Density in relationships with Plate Tectonics - layers of the earth are classified based on their density (the more toward the center of the Earth you go, the more dense the material is)
- Sorting of Earth’s materials by size, density, water speed exc.
- Classification of Stars and Planets.
Name That Mineral

<table>
<thead>
<tr>
<th>Topic: Mineral Identification</th>
<th>Estimated Length: 60 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard: 5, Understand that structure is used to develop classification systems.</td>
<td>Objective: 2b, Develop a classification system based on observed structural characteristics.</td>
</tr>
</tbody>
</table>

**Description:**
- Students will develop a classification system for minerals based on their observed physical characteristics.

**Required Materials/Resources: “Mineral Identification”**
- See Standard 5: Objective 1 for background on important minerals and their uses in society.
- 3-7 different types of minerals. (Ex. Quartz, Hornblende, Pyrite, Graphite, Garnet.)
- Mineral identification kits consisting of: Streak plate, magnet, nail, penny, and a glass microscope slide.
  - [Link to Mineral Identification Kit](http://www.amazon.com/Geosciences-Industries-Mineral-Identification-Kit/dp/B008AK7AQE)
- Mineral Identification Table and Key worksheets. (Provided below)

**Introduction:**
- Minerals are solid, inorganic substances that occur naturally and have specific structures and chemical compositions. Minerals are present in rocks and can be extracted by mining in order to make all of the things we use in our everyday lives.
- You can tell the differences between minerals by looking for certain properties. Because each mineral is unique both chemically and structurally, each has its own set of physical, optical and structural properties, which aid in its identification. Physical properties such as hardness and streak can be tested easily.
- **Color** is often the first property you notice about a mineral, but it may not be the most diagnostic feature. Often color can be misleading because some minerals have a variety of colors. Therefore, it should be used in conjunction with other characteristics.
- **Luster** is a description of the way the surface of a mineral reflects light. The easiest distinction to make is whether a mineral has metallic or non-metallic luster. Metallic minerals will have a luster similar to aluminum foil or jewelry. Non-metallic minerals can be dull or shiny, but they don’t have a metallic look.
- **Streak** is the color of particulate dust left behind when a mineral is scraped across an abrasive surface. Streak color is more reliable than surface color as an indicator. The streak color will be constant, but the surface color may vary.
**Hardness** is a measure of the mineral’s resistance to scratching or abrasion. It is measured using the Mohs Hardness Scale. This is a scale that measures the hardness of minerals relative to each other. The scale ranges from 1 to 10, with 1 being the softest and 10 being the hardest. A mineral should be able to scratch any mineral with a lower hardness number and can be scratched by any mineral or material with a higher hardness number. The following simple tools with known hardness values can be used to determine mineral hardness:

- Fingernail – hardness of 2-3
- Copper penny – hardness of 4-5
- Steel file/nail – hardness of 5-6
- Glass – hardness of 5-6

**Magnetism** identifies specific iron rich minerals. Only a few minerals such as magnetite or pyrrhotite are magnetic. This makes magnetism a very useful identifying feature in limited instances.

These are just some of the properties used to identify minerals. Geologists use many more properties to definitively identify a mineral.

**Discussion:** (Length: 15 minutes)

- Discuss the importance of minerals in our everyday lives.
- Discuss some of the common properties of minerals that can be tested to identify a mineral. These are color, luster, streak, hardness and magnetism.
- Demonstrate how to streak a mineral and have the class tell you what color they observe.
- Demonstrate how to determine the hardness of a mineral sample

**Activity: “Mineral Identification”** (Length: 25-35 minutes)

- The objective of this activity is to identify mineral samples by testing five common properties.
- Divide the class into groups dependent on the number of mineral samples available.
- Hand out Mineral Identification Table and Key to each student or group. (Provided below)
- Hand out one mineral to each group and invite them to use the five physical characteristics to identify each mineral.
- **Color:** Look at the mineral and decide what color(s) are present on the mineral surface. Write the color(s) in the appropriate spot in the Mineral Identification Table.
- **Luster:** Observe how your mineral reflects light. Decide whether your mineral has a metallic or non-metallic luster. Does it look like a metal? If yes, then it has a metallic luster. If it is dull or shiny, but not like a metal, then it has a non-metallic luster.
- **Streak:** Hold the streak plate on the table with one hand. Grasp the mineral in your other hand, press it firmly against the streak plate and pull it towards you to make a streak. If you press too lightly, it will not streak properly. Record

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color of the streak in the streak box on the Mineral Identification Table. If no streak is visible, try using different surfaces of the mineral on the streak plate. If there is still no streak visible record “no streak”.

○ **Hardness:** Conduct a series of tests with hardness tools to identify the hardness range for your mineral. Begin with the softest tool, your fingernail, and proceed up to glass. Each time, evaluate whether your mineral is harder or softer than the hardness tool. If the hardness tool can scratch you mineral, your mineral is softer than that tool. If the mineral can scratch the hardness tool, your mineral is harder than the tool. True scratches will not rub off with your finger. Look up the hardness values of the hardness tools (identified in the introduction) and record whether your mineral is greater than or less that those values in the Mineral Identification Table.

○ **Magnetism:** Hold a bar magnet next to your mineral. Record if the mineral is magnetic.

○ Use the mineral identification key to determine the mineral based on your findings.

○ After 5-7 minutes rotate minerals and repeat steps until each group has identified every sample.

**Assessment:** (Length: 15 minutes)

○ Lead a class discussion about each mineral’s characteristics and invite students to discuss any differences in their findings.

○ Discuss which properties were the most and least helpful in identifying the minerals.

○ Which mineral was the easiest to identify? Why?

○ What additional categories could be used to classify mineral samples?

**Real World Application:** (Length: 5 minutes)

○ **Focus on Careers:** Geologist

○ **What They Do:** Geologists study the Earth and the processes under which it formed.

○ **Where They Work:** Federal, State and Local governments, mining companies, oil and gas companies and environmental agencies are among the many places a geologists can work.

○ **Education Necessary:** A minimum of a four-year degree is needed and a postgraduate degree can provide additional opportunities.

○ **How They Use the concept of Density:** Geologists must identify minerals and their locations in order to extract them for use. Proper mineral identification is one of the first steps in the complicated process of establishing a mine.
Mineral Identification Table

<table>
<thead>
<tr>
<th>Sample</th>
<th>Color</th>
<th>Luster</th>
<th>Streak</th>
<th>Hardness</th>
<th>Magnetic</th>
<th>Mineral Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
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<tr>
<td>4</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Mineral Identification Key

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Color</th>
<th>Luster</th>
<th>Streak</th>
<th>Hardness</th>
<th>Magnetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bauxite</td>
<td>red, brown, yellow</td>
<td>non-metallic</td>
<td>light brown, white</td>
<td>1-3</td>
<td>no</td>
</tr>
<tr>
<td>Calcite</td>
<td>white, colorless, brown, green-black</td>
<td>non-metallic</td>
<td>white</td>
<td>2.5-3</td>
<td>no</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>yellow-gold</td>
<td>metallic</td>
<td>greenish-black</td>
<td>4</td>
<td>no</td>
</tr>
<tr>
<td>Dolomite</td>
<td>white, colorless, pink, brown, gray</td>
<td>non-metallic</td>
<td>white</td>
<td>3.5-4</td>
<td>no</td>
</tr>
<tr>
<td>Feldspar</td>
<td>pink, gray, white, red, green, blue, colorless, black</td>
<td>non-metallic</td>
<td>white</td>
<td>6</td>
<td>no</td>
</tr>
<tr>
<td>Fluorite</td>
<td>white, colorless, purple, pink, yellow, brown</td>
<td>non-metallic</td>
<td>white</td>
<td>4</td>
<td>no</td>
</tr>
<tr>
<td>Garnet</td>
<td>white to dark gray, red</td>
<td>Non-metallic</td>
<td>none</td>
<td>6.5</td>
<td>no</td>
</tr>
<tr>
<td>Hematite</td>
<td>red-brown, gray, black</td>
<td>metallic</td>
<td>reddish-brown</td>
<td>4-6</td>
<td>no</td>
</tr>
<tr>
<td>Hornblende</td>
<td>dark green, black</td>
<td>non-metallic</td>
<td>none</td>
<td>5-6</td>
<td>no</td>
</tr>
<tr>
<td>Magnetite</td>
<td>black</td>
<td>metallic</td>
<td>black</td>
<td>6</td>
<td>yes</td>
</tr>
<tr>
<td>Pyrite</td>
<td>yellow-gold</td>
<td>metallic</td>
<td>greenish-black</td>
<td>6</td>
<td>no</td>
</tr>
<tr>
<td>Pyrrhotite</td>
<td>yellow-gold</td>
<td>metallic</td>
<td>dark gray-black</td>
<td>3.5-4.5</td>
<td>yes</td>
</tr>
<tr>
<td>Quartz</td>
<td>light green, purple, yellow, colorless</td>
<td>non-metallic</td>
<td>white</td>
<td>7</td>
<td>no</td>
</tr>
<tr>
<td>Talc</td>
<td>gray, white</td>
<td>non-metallic</td>
<td>white</td>
<td>1</td>
<td>no</td>
</tr>
</tbody>
</table>
Earth’s Structure and Density

<table>
<thead>
<tr>
<th>Topic: Density and its affect on Earth’s layers</th>
<th>Estimated Length (minutes): 30-55 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard: 2, Examine the effects of density and particle size on the behavior of materials in mixtures.</td>
<td>Objective: 2, Analyze how density affects Earth’s structure.</td>
</tr>
</tbody>
</table>

Description:
- Students will examine the densities of the Earth’s layers and relate density to positioning of Earth’s atmosphere, water, crust, mantle, and core.
- If students have not received instruction on density and its relationship with Earth’s materials see Standard 2: Objective 1 before teaching this lesson.

Resources:
- “Abundance in Earth’s crust” link: http://www.webelements.com/periodicity/abundance_crust/

Introduction:
- The Earth’s layering is directly related to the density of each layer, which reflects the composition of each layer. The Earth is densest at its core (9.9-13g/cm³), where gravity has caused iron rich material to be concentrated.
- Extending outward from the core is the mantle with a density of 3.3-5.7g/cm³ composed of rocks containing olivine, magnesium and iron.
- The next layer is the crust, which has two different types:
  - Oceanic crust consists of cooled iron and magnesium rich rock called basalt. Oceanic crust is thin (5 km) and dense (3.0g/cm³) when compared to continental crust.
  - Continental crust is composed predominantly of granite with a density around 2.7 g/cm³. It is much thicker than oceanic crust, ranging from 10-75 km in depth.
- On top of the crust is the hydrosphere. The layer of the Earth’s water with a density of 1g/cm³.
- Further out from the center of the Earth is the atmosphere with a density of 0.001g/cm³.
- Density of some economic elements mined in Utah.
<table>
<thead>
<tr>
<th>Element</th>
<th>Density</th>
<th>Crustal Abundance</th>
<th>Element uses and information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>8.9 g/cm³</td>
<td>0.00068%</td>
<td>A reddish metallic element that takes on a bright metallic luster and is malleable, ductile, and a good conductor of heat and electricity.</td>
</tr>
<tr>
<td>Gold</td>
<td>19.30 g/cm³</td>
<td>0.00000003%</td>
<td>Very chemically stable precious metal.</td>
</tr>
<tr>
<td>Silver</td>
<td>10.50 g/cm³</td>
<td>0.0036%</td>
<td>Precious metal with high electrical conductivity.</td>
</tr>
<tr>
<td>Iron</td>
<td>7.85 g/cm³</td>
<td>6.3%</td>
<td>A heavy malleable ductile magnetic silver white metallic element, used to make steal.</td>
</tr>
<tr>
<td>Tungsten</td>
<td>19.6 g/cm³</td>
<td>0.000011%</td>
<td>Hard metal with high melting point, used in light bulb filaments and super alloys.</td>
</tr>
<tr>
<td>Beryllium</td>
<td>1.8 g/cm³</td>
<td>0.000019%</td>
<td>A silver gray metal. 1/3 lighter than aluminum, it is the lightest of all metals. Alloymed with copper for electrical connectors and tools. The world’s largest known beryllium resource is in Juab County.</td>
</tr>
<tr>
<td>Zinc</td>
<td>7.1 g/cm³</td>
<td>0.00029%</td>
<td>A bluish white, lustrous metal. Uses include: chemical, agricultural, rubber, and paint industries.</td>
</tr>
<tr>
<td>Uranium</td>
<td>18.9 g/cm³</td>
<td>0.000018%</td>
<td>A radioactive, silvery white, metallic element used to power nuclear power plants.</td>
</tr>
</tbody>
</table>

**Discussion:** (Length: 15 minutes)

- Discuss how density is mass/volume.
  - Discuss everyday items that students are familiar with and invite the students to hypothesize as to their relative densities. (Ex. Brick vs. feathers, oil and water in salad dressing.)
  - Allow students to contrast the weight of similar coins made of different materials—pre-1980 U.S. Lincoln cent (penny) [mostly copper (about 3.1 g)] vs. post-1980 cent [mostly zinc (about 2.5 g)]. With a little practice, many students can distinguish the blindfolded by hefting the two. [The 1943 ‘steel cent’ is the one exception to this composition and was made of zinc-coated steel.]
  - Explain how gravity uses density to naturally sort everything on earth. The most familiar example being the separation of water and air.
- Confirm student’s familiarity with specific gravity and the Earth’s structure and layers.
- Discuss relative amounts of various minerals in the Earth’s crust.
### Activity: (Length: 10 minutes)
- Invite students to hypothesize as to the relative densities of the layers of the Earth’s structure.
- Have students construct a cross section of the Earth including the core, mantle, crust, and atmosphere and list densities of each layer.

### Assessment: (Length: 10 minutes)
- Draw incorrect cross sections on the board and invite students to make corrections based solely on density.
- Provide densities of some minerals and metals mined in Utah and ask students where they would most likely be found.

### Real World Application: (Length: 5 minutes)
- **Focus on Careers:** Geologists, geophysicist and seismologists
- **What They Do:** Geologists, geophysicist and seismologists use the densities of the Earth’s layers to interpret sound waves and help shape the world’s knowledge of the earth below us.
- **Where They Work:** They can work for large corporations or doing research and teaching at a university. They varied aspect of a career in geology is a major draw for a lot of people.
- **Education Necessary:** A bachelor’s degree is generally required, while post graduate degrees are common in research.
- **How They Use the Concept of Density:** They use the density of materials underground to determine the structure of the Earth. Seismic waves (sound waves that traveling through rock) travel differently through materials with different densities. Monitoring seismic waves, human and naturally created, provides seismologists with information on the contents of the Earths subsurface.
Earth as a Cupcake?? 8th Grade Standard 3 Objective 3a

<table>
<thead>
<tr>
<th>Topic: Deposition of rock materials</th>
<th>Estimated Length (minutes): 30-35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard:</td>
<td>Objective: 3a, Describe how the deposition of rock materials produces layering of sedimentary rocks over time.</td>
</tr>
</tbody>
</table>

**Description:**
- The students will understand how the interior of the Earth is researched.

**Required Materials/Resources:**
- A straw, preferably rigid with a large diameter.
- Hostess cupcake or other similar type of snack cake. Snack cakes with filling and frosting work best to represent differing layers.
- A solid, rigid, object that fits in the straw. (pen or pencil)

**Teacher Background:**
- As students may or may not already know, how the layers of the Earth’s crust are formed. In this lesson these processes will be reviewed. The importance of the ordering of the layers and what would have been occurring to create those layers at the time should be emphasized.
- Another major focus of this lesson is explaining how the layers of the Earth are researched and examined. To teach this principle the practice of core drilling must be understood. Many common facts for this particular type of drilling can be found online.
- [http://www.youtube.com/watch?v=a3anE3PEPP8](http://www.youtube.com/watch?v=a3anE3PEPP8)

**Discussion:**
- Review the Earth’s structure:
  (Length: 5 minutes)
  - Display an image showing layering of rocks.
Discuss the process of how rock layers are formed in the crust.
Ask questions to guide students from the layering they can see to what is occurring underground....
  ● Why do you think the layers look the way they do?
  ● What caused the layers to happen?
  ● Which layer would be the oldest?
  ● Why are these layers visible?
  ● Do you think these types of layers happen underground? (use this question to lead into the activity)

○ What the Earth’s crust looks like:
  (Length: 5 minutes)
  ■ Discuss that no one really knows what is far beneath the Earths surface. These observations have never been made, but there is a lot of evidence to the inferences that have been made.
  ■ Discuss the physical depth to which most holes are dug (world record depth is 2,466 meters below the seafloor).
    ○ How many of you have ever dug a hole?
    ○ How deep did you dig?
    ○ So how do we get down thousands of feet?
    ○ Did you see any layers in the hole that you dug?
  ■ Discuss the difference between topsoil and bedrock. Explain that these are part of the crust, but are different layers.
  ■ Discuss the layering involved in the Earth’s crust that we can see above ground has also happened below ground.
  ■ Explain how the layers of the crust are determined when simply digging a hole won’t work. Explain that this is when core sampling must be performed.

○ Core Sampling:
  (Length: 5 – 10 minutes)
  ■ Discuss what core sampling is.
  ■ Discuss how it is performed.
  ■ Expound upon why core sampling is performed.
Example of ICE CORE SAMPLE

EXAMPLE OF HOW CRUST CORE SAMPLE IS TAKEN
EXAMPLE OF CRUST CORE SAMPLE

Activity: Core Sampling  (Length: 10 – 15 minutes)

- Perform a core sample using the straw and snack cake obtained beforehand.
- Activity procedure:
  - Explain that the snack cake will represent a small portion of the Earth’s crust.
  - Ask students what they believe is on the inside of the snack cake.
  - Make it obvious that no one can really know what is on the inside of the cake without either opening it up or taking a sample of the whole thing.
    - Can we easily cut the whole earth in half?
      - another reason why we need core samples
  - Be sure to explain that this sample is independent of any other sample taken previously, i.e. if one of the students has eaten this type of snack cake before.
  - Explain that the straw will represent a core drill and will be used to take a small sample of what is on the inside “beneath the surface” of the snack cake.
  - Push the straw into the snack cake.
  - Remove the straw from the snack cake.
  - Push the “core” out of the straw using the solid, rigid, object obtained beforehand.
  - Explain that the material removed from the straw (the core drill) is representative of what is on the inside of the snack cake.
  - Establish the similarities between this exercise and the Earth’s crust.
Real World Application: Where and why is this performed around the world
(Length: 5 – 10 minutes)

○ After activity is performed and any remaining questions are answered. Explain how and why core sampling is performed around the world.
  ■ Discuss things that geologists or others would possibly be interested in finding in the Earth’s crust. This list may include things such as water, oil, natural gas, gold, etc.
  ■ Discuss how the things we use everyday such as computers, cell phones, televisions, etc. all come from minerals that have been found in the Earth. Explain that most of these minerals were not just lying on the Earth’s surface, but were found by this method shown and discussed today.

References:
World record depth: www.iodp.org/drilling-depth-record-of-scientific-drilling
Magnetic Cereal

<table>
<thead>
<tr>
<th>Topic: Particle separation</th>
<th>Estimated Length (minutes): 50 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard:</td>
<td>Objective:</td>
</tr>
</tbody>
</table>

**Description:**
- Understand the relationship between properties of matter and Earth’s structure. Also observe and describe the sorting of Earth’s materials in a mixture based on density and particle size with different densities, sort materials of different particle size with equal densities.
- Students will learn that some minerals are essential nutrients for human health. They’ll identify essential micro-minerals and macro minerals and confirm the presence of iron in breakfast cereal.

**Required Materials/Resources:**
- Ground Rules film #3 (video) [http://www.youtube.com/watch?v=xmXT1YgfoTA](http://www.youtube.com/watch?v=xmXT1YgfoTA)
- Flaked cereal with iron (Total)
- Nutrition labels and ingredient lists from a variety of cereals
- A strong magnet
- Small Zip lock bags
- Plates and shallow bowls
- Water
- Clear plastic cups
- Plastic straws or stir sticks
- Hand lenses or magnifying glasses

**Introduction:**
- Watch Chapter 3 “Mining and the Modern World” of the Ground Rules film. [http://www.youtube.com/watch?v=xmXT1YgfoTA](http://www.youtube.com/watch?v=xmXT1YgfoTA)
- Discuss the importance of minerals in our daily lives. Minerals have specific properties that make them useful to humans. All minerals come from the Earth’s crust and must be mined.
- Ask the class whether they have ever eaten a mineral? What minerals can we eat? Why do we eat minerals?
- Have the students bring in nutrition labels and ingredient lists from several different brands of cereal. Identify the minerals.
- Minerals only represent about 0.3% of our total intake of nutrients, but they are very important. Without these mineral nutrients, we wouldn’t be able to utilize the other 99.7% of the food we consume.
- Macrominerals are minerals that we require in substantial amounts for proper nutrition. These include **calcium**, **chloride**, **magnesium**, **phosphorus**, **sodium**, **potassium**.
potassium, sodium, sulfur and zinc. Microminerals are minerals that we require only in trace amounts. These include chromium, cobalt, copper, fluorine, iodine, iron, manganese, molybdenum, selenium, silicon and zinc. These minerals can be found in various foods and in supplements.

**Activity:** (Length: 20 minutes)

The objectives of this activity are to determine whether there is actually iron in breakfast cereal and observe separation of minerals.

1. Use a magnifying glass to examine a single flake of cereal closely. Can you see any visible traces of iron? No.
2. Place a few flakes of cereal on the table. Bring your magnet near the flakes and see if they are attracted or repelled by the magnet. You likely will not get a reaction.
3. Fill a plate or shallow bowl with water and float a few flakes of cereal on the surface. Hold the magnet close to the flakes and watch closely for any movement. Any movement that occurs will be slight, so they will need to be patient. With practice, you should be able to make the flakes rotate or move them around the bowl in a pattern.
4. Fill a zip-lock bag half full with cereal. Seal the bag and crush the cereal into a fine powder.
5. Pour enough water into the bag to make a thin cereal paste. It should be about the consistency of thick soup.
6. Pour your cereal mixture into a clear plastic cup.
7. Hold the magnet against the outside of the cup in one location. Stir the mixture gently with a straw or stir-stick (nothing magnetic). After two or three minutes, you should see an accumulation of iron particles on the side of the cup near your magnet. Use a magnifying glass to see the particles better.

**Discussion:** (Length: 15 minutes)

- Why did we use a magnet to test for the presence of iron? Were you able to see the iron in the cereal flake? Why not?
- Why was it easier to move the flakes around when they were floating on the water than when they were on the table? 
  *Friction between the flakes and the table surface was too great to be overcome by the attraction of the iron to the magnet. By floating the flakes on the surface of water, friction was reduced.*
- What step in the mining process was simulated by crushing the cereal into a powder? 
  *This process simulates the crushing process used in mining to extract minerals (such as iron) from the surrounding waste rock.*
- What is the function of iron in the human body? 
  *Iron carries oxygen to the cells and is necessary for the production of energy, the*
synthesis of collagen, and the functioning of the immune system. Iron is found in meat, fish, beans, spinach, molasses, brewer’s yeast, broccoli and seeds. It can also be added to various foods, such as cereal.

**Real World Application:** (Length: 15 minutes)

- Recognition and awareness of where minerals come from. How are these minerals obtained?
- What careers, jobs, equipment, etc. are needed for these activities?
Earth’s Crust and Plate Tectonics

<table>
<thead>
<tr>
<th>Topic: Types of Earth’s crust</th>
<th>Estimated Length (minutes): 35 - 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Science Core, Standard: 2: Students will understand Earth’s internal structure and the dynamic nature of the tectonic plates that form its surface</td>
<td>Objective 3.d: Model tectonic plate movement and compare the results of plate movement along convergent, divergent, and transform boundaries (e.g. - Mountain building, volcanoes, earthquakes, mid-ocean ridges and oceanic trenches)</td>
</tr>
</tbody>
</table>

**Description:**

- Students will be able to model movement along plate boundaries
- Students will be able to describe things formed at these boundaries including ore bodies that lead to deposits that are mined by man.
- **Activity: Plate boundary interactions**
  - Teachers may have a variety of activities that demonstrate how plates move past and into each other. The following activity is offered as a suggestion.

**Required Materials/Resources:** [http://www.youtube.com/watch?v=Wt_jJUnTFhg](http://www.youtube.com/watch?v=Wt_jJUnTFhg)

- Food items are an excellent choice for how to model boundary collisions. Graham crackers or cookies make excellent test subjects. You will need enough of these for students in each class to have several to run together in a variety of ways.
- “Miracle of Copper” (Video) - This video is used at the end of the activity to tie together the idea that ore deposits are one of the geological formation that are created by plate interactions [http://www.oresomereresources.com/media_centre_view/resource/video_miracle_of_copper/category/mining_videos/section/media/parent/](http://www.oresomereresources.com/media_centre_view/resource/video_miracle_of_copper/category/mining_videos/section/media/parent/)

**Introduction:**

- It is assumed that the teacher will have covered the two different types of crust prior to this activity and will have moved on to the different types of boundaries at which plates interact (Subduction zones, Mid ocean ridges, and transform boundaries)
- When the two crusts collide, the Oceanic crust goes under or is subducted under the Continental plate. This is a subduction zone. It is characterized by a trench, and a volcanic island arc or volcanic mountain range. These are have volcanic activity, frequent earthquakes, and are areas where there is a higher probability of mineral/ore deposits.
○ At a mid ocean ridge, plates are spreading apart due to magma rising to the surface and hardening thereby wedging the plates apart. This area has a pattern of earthquakes, volcanoes, and other thermal activity.
○ At a transform boundary, two tectonic plates are grinding slowly past each other. This causes a variety of earthquakes but produces no volcanic activity. Some thermal activity may be present. They are characterized by a series of faults. The best known example of this would be the San Andreas fault in California.
○ Plate interactions cause faults, mountains, and thermal activity
○ Mineral deposits are found near mountains, faults, and thermal activities
○ Plate tectonics can be used help explain ore body deposition.

**Discussion:** (Length: 15-20 minutes)
- Discuss plate tectonics (a theory explaining the structure of the earth's crust and many associated phenomena as resulting from the interaction of rigid lithospheric plates that move slowly over the underlying mantle.)
- Explain granitic/continental plates (continental plates are made mostly of granite)
- Explain basalt/oceanic plates (oceanic plates are made mostly of basalt)
- Describe formations that are created when plates collide (because of all the movement of earth material, minerals form here)
- Explain that these areas that are formed are “hot spots” for mineral deposits and discuss why that is
- Explain that mineral deposits are the sources for the development of mines

**Activity:**
(Length: 10+ minutes)
- This is recommended as a support activity to SAGE interactive questions that students will face at the end of each year.
- As a class or individually have students open up the Phet interactive on tectonics at <http://phet.colorado.edu/en/simulation/plate-tectonics>
- Allow students to make changes to the crust to see how it behaves. As a class, sum up the conclusions that they find from this activity.

**Activity:**
(Length: 15 minutes)
- Hand each student a piece of foam/styrofoam and a block of wood that is about the size of a fist.
- Have the students push these two objects together.
- The sponge should bunch up and move upward against the piece of wood.
- Explain that the wood will be underneath the piece of foam/Styrofoam because of the difference in densities.
- Watch the “Convergent Margin” Video (1:15)
  - [http://www.youtube.com/watch?v=Wt_iJUnTFhq](http://www.youtube.com/watch?v=Wt_iJUnTFhq)
Real World Application: (Length: 15 minutes)

Formation of Ore Deposits

- The mineral deposits are created when these plates collide
- Plate tectonics and their movement create natural formations
- Natural formations include mountains, faults, and thermal activity
- The mineral deposits are located near these formations
- The deposits lead to the development of mines
- These minerals that are mined are used in everyday lives
- Watch the video - “Miracle of Copper” (7:57)