Settling Sediments

Adapted from: SEDIMENTATOR™ Copyright 1996 Janeval Toys, Inc.

Grade Level: Basic/Intermediate

Duration: 40 minutes

Setting: classroom

Summary: Investigating sediment deposition using a Sedimentator that students construct.

Objectives: Students will learn how sediments are deposited in different aquatic environments. Students will be able to distinguish among different sediment types and recognize the rocks produced from sediments.

Vocabulary: chemical weathering, mechanical weathering, sediment, detrital material, soluble material, lithified, compaction, cementation, mature sediments, capacity, competence, suspended load, bed load, dissolved load, bituminous coal, anthracite

Related Module Resources:
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Materials (Included in Module):
- Sand – either fine, playground, or mixed
- Silt/clay from nature
- Cleaned aquarium gravel
- Funnels
- Rulers

Additional Materials (NOT Included in Module):
- 1- 20oz soda-pop bottle with cap per student or pair of students
- Tap water

ACADEMIC STANDARDS: ENVIRONMENT & ECOLOGY

10th Grade
4.1 A Describe the changes that occur from a streams origin to its final outflow.

4.1 B Explain the relationships among landforms, vegetation, and the amount and speed of water.
- Analyze a stream's physical characteristics.
- Explain how the speed of water and vegetation cover relates to erosion.

4.1 C Describe the physical characteristics of a stream and determine the types of organisms found in aquatic environments.
- Describe and explain the physical factors that affect a stream and the organisms living there.
- Identify the types of organisms that would live in a stream based on the stream's physical characteristics.

ACADEMIC STANDARDS: SCIENCE & TECHNOLOGY

7th Grade
3.5A Describe earth features and processes.
- Describe the processes involved in the creation of geologic features (e.g. folding, faulting, volcanism, sedimentation) and that these processes seen today (e.g. erosion, weathering, crustal plate movement) are similar to those seen in the past.
- Distinguish between examples of rapid surface changes (e.g., landslides, earthquakes) and slow surface changes (e.g. weathering)

10th Grade
3.5A Relate earth features and processes that change the earth
- Describe and identify major types of rocks and minerals

12th Grade
3.5A Analyze and evaluate earth features and processes that change the earth
- Apply knowledge of geophysical processes to explain the formation and degradation of earth structures (e.g., mineral deposition, cave formations, soil composition).

BACKGROUND:

Sediments are small bits and pieces of rock. Sediments are a product of the weathering of rocks. There are two types of weathering, **chemical weathering** and **mechanical weathering**. Chemical weathering occurs when water and rocks combine and the chemical make-up of a rock is altered. Mechanical weathering is the physical break down of rocks. This can occur when water freezes in the cracks of rocks and breaks them apart. Mechanical weathering also occurs when water erodes the surfaces of rocks. The rocks become more rounded in shape as sediment is washed away.

Sediment has two sources, either from **detrital material** or from **soluble material**. Detrital material originates from mechanical and chemical weathering

and is transported as solid particles. Only chemical weathering produces soluble material. These materials may enter a waterway in excessive amounts due to human disturbance of land (deforested, plowed, and constructed on). Heavy rainstorms and sudden snowmelts can increase soil and sediment **erosion**, the process of wearing away the earth's surface into the stream. Erosion may increase the sediment load faster than ecosystems can adjust.

Sediments are transported and deposited, creating changes to the landscape. Water is the most common transporter of sediments. When water flows over the landscape there are sediments present in the water. The amount and type of sediment that a stream transports is determined by: the stream's velocity, the composition and texture of the sediment, and the characteristics of the bedrock through which the stream flows. High velocity waters are required to erode and transport large boulders. High velocity is also required to transport small, flat clay particles and mica flakes, because electrical forces on their surfaces cause them to cling to the streambed (Chernicoff, Stanley. Geology. New York: NY, 1995.). Once in the streamflow the fine clay particles remain suspended and are transported long distances.

Mature sediments have a well-rounded shape, very fine particle size (1/16 - 1/8 mm), and the sediments are well-sorted (uniform size of sediments). A stream sorts the particles it carries by depositing them in order of size, the heaviest are deposited first and the lighter sediments are carried to the mouth of the stream. The further particles travel the more mature they become. (*Refer to the grain size sorting charts included in the module for grain sizes, sorting and shape comparisons.*)

The maximum load of sediment that a stream can transport is its **capacity**. Capacity is expressed as the volume of sediment passing a given point on the stream bank in a given amount of time. Capacity is proportionate to discharge: the more water flowing in the channel per second, the greater the volume of sediment that is transported in that time. The diameter of the largest particle that a stream can transport is the measure of a stream's **competence**. Streams transport sediment in different ways, depending on particle size. Very fine solid particles are usually distributed within stream water as a s**uspended load**. Coarse particles that move along the stream bottom form the **bed load**. Other sediment is carried invisibly as dissolved ions in the water, forming the **dissolved load**. There are different classifications of sediment based upon size (see table).

Sediment load is material mixing and moving with the flowing water, making the water muddy. The fine material will eventually settle in the water because of its density and weight, but it can be lifted again from the bottom into the water column during disturbances (high flow rates, dredging, boating, swimming, and water withdrawals for industry or municipalities). When the motion of the water slows or stops, suspended solids settle out of the water in a process called **sedimentation**. The smallest, lightest soil particles stay suspended in the water the longest, and the largest, heaviest settle first. Slow moving or still area in a waterway allows for sedimentation to occur. Pools will have more fine sediment settling than in riffle areas. The mid-channel of a creek (larger substrate size) is usually faster flowing and has larger substrate size as compared to closer

to the shore. In fast water, the small particles do not have a chance to settle out or do not remain at the bottom. High velocity waters erode and transport large boulders, but they also transport small particles, flat clay particles and mica flakes. Higher velocities are sometime required to move clay and silt particles because electrical forces on their surfaces cause them to cling to the streambed. Once in the streamflow the fine clay particles remain suspended and are transported long distances. Whether large or small, deposited stream sediments are described collectively as **alluvium**.

Sediments are also created by plant and animal remains. When a plant or animal decomposes, the pieces of remains can build up over time. This is common is areas such as swamps and marshes where the water is relatively still. Coal is a sedimentary rock that forms from plant remains such as wood, bark, and leaves. The plants that formed the coal in Pennsylvania lived in a warm swampy environment about 300 million years ago. When the plants died they accumulated in the swamps to form peat. The peat was eventually buried deeply enough to undergo heat and pressure to form a rock. Most of the coal found in Pennsylvania is soft coal or **bituminous coal**. Hard coal or **anthracite** is mined in eastern Pennsylvania. Anthracite was subjected to deeper burial and higher temperatures than bituminous coal.

Sediments can be **lithified** (converting sediments into solid rock) through two processes, **compaction** and **cementation**. Compaction occurs when the weight of overlying materials compresses the deeper sediments. Rocks made of silt and clay (i.e. shale) are formed by compaction. Cementation occurs when soluble cementing materials, such as calcite and iron oxide, fill in open spaces in rocks and join the particles together. When the water evaporates the salts and other chemicals are left behind. After sediments have been lithified they are now classified as a sedimentary rock.

Sediments and the Rocks They Form

Particle Size (mm)	Name of Loose Particle	Name of Loose Sediment	Name of Rock Formed
>256	Boulder	Gravel	Conglomerate (if particles are rounded)
64 – 256	Cobble	Gravel	
4 – 64	Pebble	Gravel	Breccia (if particles are angular)
2 – 4	Granule	Gravel	
0.063 – 2	Sand	Sand	Sandstone
0.004 – 0.063	Silt	Silt	Siltstone
< 0.004	Clay	Clay	Shale
	Organic Matter	Organic Matter	Coal

Adapted from: Chernicoff, Geology, 1995. Table 6-1 Detrital Sediments and Rocks.

Sedimentary rocks can provide clues to the past environment in which the rocks formed. Sedimentary rocks may contain fossils or other physical structures that indicate the environment where they formed. Sedimentary rocks are deposited in horizontal layers of rock called **strata** or **beds**. The layers are not always horizontal; this is called **cross bedding**. Most often cross-bedding is found in sand dunes, river deltas, and some stream channel deposits. Graded bedding may occur with in a single layer of rock. Through rapid deposition coarser sediments are on the bottom and fine sediments are on the top. This is typical of rapid deposition by water containing sediments of various sizes. **Ripple marks** are small waves of sand that develop on the surface of a sediment layer from moving water or air. **Mud cracks** indicate that the sediment was alternately wet and dry; they are usually associated with shallow lakes and desert basins. **Fossils** are the remains or traces of prehistoric life. Knowing the types of life forms found in the rocks not only tells us about the environment in which the rock was deposited but they can also help us determine the **relative age** (whether the rock is older or younger than another, no exact age is determined) of the rock.

OVERVIEW:

Students will construct their own Sedimentators and follow the lab procedure to investigate the deposition of sediments in different environments. Students will learn to distinguish between sediment types and recognize the rocks that are composed of different sediments.

PROCEDURE:

Teacher Preparation:

1. Before beginning this activity, collect 20oz plastic soda pop bottles (one for each student or one per pair of students). You may choose to have each student complete their own lab or work together in pairs. You also need to collect or purchase the following:
    - Aquarium gravel (rinsed to remove dust) – various sizes or colors
    - Sand – a more natural, coarse sand tends to work better than play sand. Finer grained sands will settle down in between the aquarium gravel instead of settling on top of it.
    - Silt/clay – the best place to get this is from the banks of a creek or from the bottom of a creek's pool, may be in your soil around the school as well.
    - Potting soil – make sure it is waterlogged for the best results
    - A small piece of leaf – make sure it is waterlogged (get it from a creek not from the grass)

2. When constructing the Sedimentators, the amounts of various sediments can change, but in some cases it will affect how well the process of sedimentation is observed. Do not add too much of any one ingredient; the Sedimentator works better with less, not more. Remember, you can always have students add more if the results are not sufficient. For some bottles, you may want to have different materials or amounts added for comparisons to be made.

3. You may elect to have all sediment materials available for students on their lab tables or distribute them one at a time and have students create their Sedimentators simulataneously. Students may not listen with all materials in front of them. You may have the students follow along with you as you create a Sedimentator.

4. Fill the bottle with 1 inch of the rinsed aquarium gravel. Add 5 to 6 bottle caps full of sand. Next, add ½ cap full of silt/clay and add ½ cap full of potting soil to add a dark organic layer. Fill the bottle with water and close the cap tightly.

5. Place the transparency of the sediment table on an overhead projector for the class to see and begin the lab procedure. Answers to the questions have been provided.

Student Experiment or Activity:

1. Students should obtain their clean 20 oz. pop bottle and a funnel if available.

2. Fill the Sedimentator with 1 inch of aquarium gravel.

3. Add 5-6 bottle caps full of sand total.

4. Add about ½ cap of silt/clay. Do not add too much silt or else it may stay suspended in the water for too long – not allowing you to see sufficient results.

5. You may add ½ cap full of potting soil (waterlogged already) to add a dark, organic layer to your Sedimentator.

6. Now fill your Sedimentator with tap water (not creek water).Tap water helps keep bacteria and algal growth from occurring. If parts of the potting soil float on top of the water, try to eliminate them from the bottle.

7. Cap your bottle and see how it works. Your teacher may check your bottle to see if any additional materials need to be added to make it work better. Use the Student Worksheet to answer questions about your Sedimentator. Once the lab procedure is complete, turn it in to your instructor for evaluation.

DISCUSSION:

What is sediment and what is it made of? *Sediment is any material that settles from water or air. Sediments are made of rock fragments and the remains of plants and animals.*

How did each type of sediment in the Sedimentator form? *The plant remains are formed from rotting plant parts. The sand and gravel are formed from mechanical weathering of rock. The silt and clay are formed from chemical weathering of rock.*

Name two other ways sediments form. *Salts are formed by the evaporation of ocean water. Along the shore seashells are deposited in layers in shallow water.*

In nature, how do sediments move from one place to another? Describe how they move. *Wind and water move sediments. River water carries heavy sediments along the bottom. Light sediments are suspended in the moving water. Volcanic ash and dust can be carried long distances in the air.*

What are the three different groups of rocks? *Igneous, metamorphic, and sedimentary*.

Which group of rock is formed from sediments? *Sedimentary*.

EVALUATION:

- Correctly completed worksheet.
- Discussion questions above can be used for quiz questions.

EXTENSIONS AND MODIFICATIONS:

- Make Sedimentators with varying contents and amounts of sediment sizes to draw comparisons.
- After using the Sedimentators, you may have students sieve the sediments in their Sedimentators to separate out the various particle sizes again.
- Students may examine soil more closely. You may lead an outdoor investigation of soil types. Examine the correlation between sediments and soil. (Soil consists of sediments that have undergone changes at the Earth's surface) Investigate soil horizons and create a soil profile.

NOTES (PLEASE WRITE ANY SUGGESTIONS YOU HAVE FOR TEACHERS USING THIS ACTIVITY IN THE FUTURE):

WORKSHEET: SETTLING SEDIMENTS

Name_____Date_____

Part I Looking at a River Bed or Lake Bottom

1. Predict how the different sediments in the Sedimentator will settle; aquarium gravel, silt & clay, sand, organic matter (potting soil). List them from first to settle to last to settle.

2. Gently shake the Sedimentator to loosen the sediments. Lay the Sedimentator on its side. Observe the water and the sediments close up at eye level for 3 minutes. Repeat.

   - Which type of sediment is floating in the water?

   - Where in the Sedimentator do they eventually settle?

   - List <u>three</u> common environments of deposition and the types of rocks that would be formed.

3. **Draw** what you see on your diagram of the Sedimentator. Using the sediment table overhead transparency, label each type of sediment in your drawing. You may use a ruler to measure the largest sediments.

Part II Looking at the flow of water in a river

1. Pick up the Sedimentator and slightly tilt it up and down very slowly. Continue this motion as you observe the action of the moving water on the sediments.

   - Which sediments float in the moving water? What type of stream "load" is this, dissolved, suspended, or bed?

   - Which sediments move along the bottom? Using a ruler, measure several of the sediments and calculate their average size.

   - How will the sediments change if you continued to tilt the Sedimentator up and down for an extended period of time? What type of weathering process is this?

   - Are the sediments in the Sedimentator mature or immature? Describe the grain size, shape, and sorting of each layer.

   - Explain how substrate changes with stream velocity.

Part III Looking at sediments settling from a river

1. Gently shake the Sedimentator to loosen the sediments. Stand the Sedimentator upright on one end, then flip it over so that it stands up on the other end.

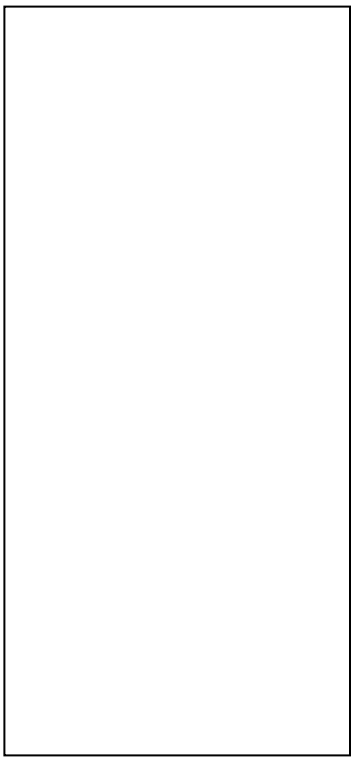
2. Observe the water and the sediments for a few minutes. Repeat steps 1 and 2.

    - What pattern did you observe each time you flipped the Sedimentator?

    - What causes the sediments to settle the way they do?

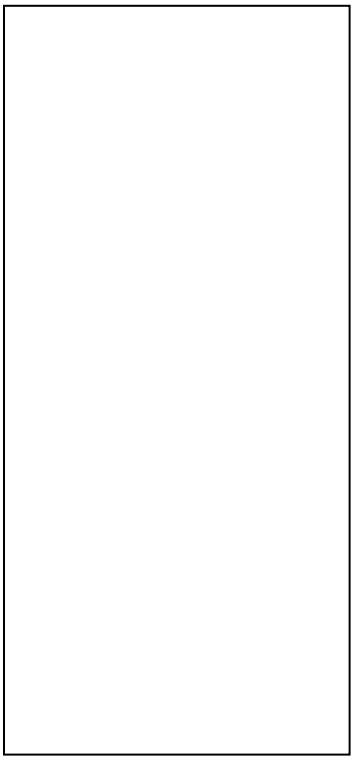
    - What types of sediments settle in the middle of a stream? What types of sediments settle along the shoreline?

    - What would happen if you left the Sedimentator upright overnight? Sketch what you think you would see.



Part IV Looking at sediments that form rocks

1. Leave the Sedimentator standing upright on one end. **Draw** what you see on your diagram of the Sedimentator. Label the sediments on your diagram.



- Which sediments are closely packed?

- Which sediment layer has spaces?

- Which sediments would be compacted? Cemented? Why?

2. Use the information from the sedimentary rock table to find the rocks formed from the sediments in the Sedimentator. On your diagram from Part IV, number 1, write the rock name next to the sediment that forms the rock.

WORKSHEET: SETTLING SEDIMENTS *ANSWERS*

Name_____Date_____

PROCEDURE

Part I Looking at a River Bed or Lake Bottom

1. Predict how the different sediments in the Sedimentator will settle; aquarium gravel, silt & clay, sand, organic matter (potting soil). List them from first to settle to last to settle.

   Aquarium gravel
   Sand
   Silt & Clay
   Organic Matter

2. Gently shake the Sedimentator to loosen the sediments. Lay the Sedimentator on its side. Observe the water and the sediments close up at eye level for 3 minutes. Repeat.

   - Which type(s) of sediment is floating in the water?

     Organic Matter, Silt & Clay

   - Where in the Sedimentator do they eventually settle?

     On the very top layer.

   - List three common environments of deposition and the types of rocks that would be formed.

     Organic matter can be deposited in swamps and marshes where coal may be formed. Silt is deposited in the mouths of rivers where shale can be formed. Salts are deposited in the ocean, evaporites are formed.

3. **Draw** what you see on your diagram of the Sedimentator. Using the sediment table overhead transparency, label each type of sediment in your drawing. You may use a ruler to measure the largest sediments.

Part II Looking at the flow of water in a river

1. Pick up the Sedimentator and slightly tilt it up and down very slowly. Continue this motion as you observe the action of the moving water on the sediments.

   - Which sediments float in the moving water? What type of stream "load" is this, dissolved, suspended, or bed?

     Plant remains, silt & clay float in the moving water. This would be the suspended load in a stream.

   - Which sediments move along the bottom of the sedimentator? Using a ruler, measure several of the sediments and calculate their average size.

     The aquarium gravel and some of the sand moves along the bottom of the Sedimentator.

   - How will the sediments change if you continued to tilt the Sedimentator up and down for an extended period of time? What type of weathering process is this?

     The sediments will become more rounded. The process is physical weathering.

   - Are the sediments in the Sedimentator mature or immature? Describe the grain size, shape, and sorting within each layer.

     The sediments in the Sedimentator are immature. The aquarium gravel is poorly sorted with jagged edges and varying sizes, the sand is more uniform in size, shape and sorting. The silt and clay are hard to see, they look to be uniform also.

   - Explain how substrate changes with stream velocity.

     The heavier sediments settle first as velocity of the stream slows down. The smaller sediments are carried further down the stream until the velocity slows down more and the sediments are no longer able to be carried in the flow of the stream.

Part III Looking at sediments settling from a river

1. Gently shake the Sedimentator to loosen the sediments. Stand the Sedimentator upright on one end, then flip it over so that it stands up on the other end.

2. Observe the water and the sediments for a few minutes. Repeat steps 1 and 2.

   - What pattern did you observe each time you flipped the Sedimentator?

     The sediments settle into layers of different size pieces.

   - What causes the sediments to settle the way they do?

     The sediments settle according to their weight. Heavier sediments settle first.

   - What types of sediments settle in the middle of a stream? What types of sediments settle along the shoreline?

     The more coarse sediments settle in the middle of the stream and the silts & clays settle on the shoreline.

   - What would happen if you left the Sedimentator upright overnight? Sketch what you think you would see.

     The suspended material would settle and form the top layer in the Sedimentator.

Part IV Looking at sediments that form rocks

1. Leave the Sedimentator standing upright on one end. **Draw** what you see on your diagram of the Sedimentator. Label the sediments on your diagram.

- Which sediments are closely packed?

  The plant remains and sand layers are closely packed.

- Which sediment layer has spaces?

  The gravel layer has spaces that are filled with sand, water or air.

- Which sediments would be compacted? Cemented? Why?

  The sand and plant layers would be compacted because the pieces are close together. The gravel has too many large spaces to be compacted. The gravel is cemented by the salts and chemicals from the water.

2. Use the information from the sedimentary rock table to find the rocks formed from the sediments in the Sedimentator. On your diagram from Part IV, number 1, write the rock name next to the sediment that forms the rock.