Rivers Instructional Case: A series of student-centered science lessons

Lesson 2

Rivers, Rocks and Sand!

Summary

Students will be given sediment tubes containing gravel, sand and silt. When the tube is shaken vigorously, the sediments are suspended in the water (representing erosion. When the tube is set down on its end, sediments will deposit on the bottom of the tube (representing deposition). Students will be asked to make a prediction as to which type of sediment will be on the bottom of the tube and why.

Objective

- To increase student understanding of the role of environmental energy in erosion and deposition
- To use prediction as a way to engage students' thinking about the deposition of sediment.
- To engage students in multiple experimental trials to confirm results.

Suggested Timeline

50 minutes

Materials

- Sediment tubes* (sealed plastic tubes pre-filled with sediment and water)
- Student experiment worksheet
- Rivers, Rocks and Sand post-activity assessment probe

*Sediment tubes are inexpensive and are widely available from science education supply companies.

Prep

1. Place one sediment tube for each pair or group of students.
2. Make individual copies of the student worksheet.

Teacher Background Knowledge

In this lesson, students will investigate the role of environmental energy in the erosion (transport) and deposition of sediment. Environmental energy can be defined in many different ways, but in this activity the velocity of the flowing water can be used as a measure of the energy of a river – the higher the flow rate, the higher the energy. Students shaking the sediment tubes add energy to the system (much like a fast flowing river). In a river, *deposition* occurs when the forces responsible for erosion are no longer sufficient to overcome the weight of the particles or friction. When students stop shaking the tube, the energy dissipates. The first particles to settle are the heavy (larger) particles that drop out of the water slurry. As the kinetic energy continues to decrease in the tube, progressively smaller particles will drop out of the water and settle on the accumulated sediment. In this way, sediments may be sorted by size due to changes in the energy of the depositional environment. The observation that larger particles are located at the bottom and become finer as you move upward is known as *graded bedding*. Graded bedding occurs in depositional environments where there is a decrease in energy as time passes.

Although graded bedding represents the sorting of sediments in a single location, sediments may also be sorted by size along the length of the river. Rivers generally originate in more mountainous

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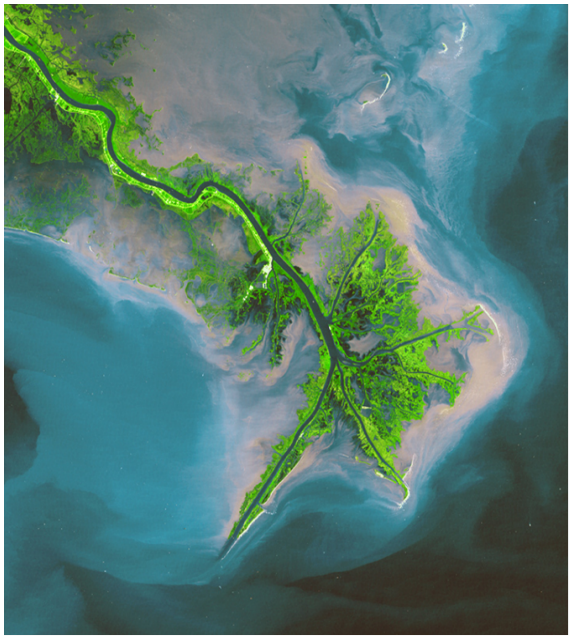

Mississippi River Delta
Source: NASA

Teacher Background Knowledge (continued)

regions where the stream gradient is larger. A higher stream gradient means that the water in a river drops in elevation quickly as it moves down stream.

A steeper gradient is associated with a higher water velocity that results in larger sedimentary particles being transported and deposited. It is common to see a mountain stream with coarse sediments such as boulders and gravel on its banks. As the gradient of the river decreases, the water velocity also decreases. Thus, the size of the particles that can be transported and deposited decreases as the water velocity decreases. Along the length of a river from its high gradient source area to a region with a low gradient near its mouth, sediments are sorted by size. Coarser sediments such as boulders and gravel are common stream deposits in mountainous regions. Near the mouth (end) of a river, sedimentary deposits are commonly composed of finer sediments such as sand, silt and clay. In the assessment probe at the end of this lesson, students should be able to predict that coarser river sediments will be found in the river where it flows in the mountains and that finer sediments such as sand and clay are deposited by the river where it flows through "flatlands" and into the ocean.

Graded Bedding
Source: Newfoundland and Labrador Geological Survey

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Standards [12]

NGSS Performance Expectations: *This lesson supports students in **progressing toward** the NGSS Performance Expectation.*		
MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. [Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.]		
Assessment Boundaries: *Assessment does not include the identification and naming of minerals.*		
In this lesson…		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Cross Cutting Concepts**
Developing and Using Models In this lesson, students are using the sediment tube as a model of how sediment settles with respect to the energy in rivers decreasing as the river channel's characteristics change from river source to river mouth.	**ESS2.A: Earth's Materials and Systems** All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.	**Stability and Change** Students see how the change in river energy affects the sediment patterns. Then, as the model of the river stabilizes, the sediment settles in areas of less energy. Students see that the sediment settles in the same patterns with larger rocks at the bottom and smaller sediment on top.
In this lesson…		
CCSS Mathematics	**CCSS English-Language Arts**	
n/a	CCSS.ELA-LITERACY.W.6.1 Write arguments to support claims with clear reasons and relevant evidence. Students will be constructing explanations to support their claim in how the sediment would change as one goes from the mountains, out to the flatlands, and toward the ocean. Predictions will be justified based on observations from this modeling activity.	

[1] NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, D.C.: The National Academies Press.

[2] National Governors Association Center for Best Practices, Council of Chief State School Officers Title: Common Core State Standards (insert specific content area if you are using only one) Publisher: National Governors Association Center for Best Practices, Council of Chief State School Officers, Washington D.C. Copyright Date: 2010

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Prior Knowledge

In grades 3-5, Students have learned that nearly all of the Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands and the atmosphere.

In lesson 1, the students have formulated questions on river formation, erosion and river movements. They then have used the questions as a way to create predictions on how the moving water will affect the Earth's surface with respect to the placement of new building developments.

Lesson

1. **Predict:** Students will be given a sediment tube with rocks (gravel), sand, fine sand, and other stuff in it. Before your group gets a tube, make a prediction: which will be on the bottom (fine sand, sand, gravel)? Why?
2. After students have made a prediction, give each group a sediment tube. Have students turn the tube upside down and shake it for 30 seconds until all of the rocks and sand are mixed up and moving quickly in the tube. Quickly set the tube down, standing the tube on its end on the table, and have students watch the rocks and sand settle for two minutes. Draw what the tube looks like in the spaces below.
3. Have the students repeat the experiment two more times (for a total of three trials), recording observations each time. Students should have repeated the experiment three times and they should have recorded their observations each time.
4. After the third trial, instruct students to record their observations but to **be very careful not to touch it**! Students should allow the tube to settle for approximately 30 minutes. Students will come back to it in 30 minutes. After the classroom discussion, students will make further observations about the sediment tube.
5. Have students complete the worksheet by recording their observations. When you have made your three diagrams, write a few sentences about your observations.
6. Lead a classroom discussion about the role of energy (water velocity) and the deposition of sediment and the types of environments that you might find more.
    a. Has anybody ever been river rafting before, or seen any movies about river rafting? What's it like to be in the "rapids" versus a slow, flat section of the river? How fast does the water move in each section? What does the water look like?
        i. (Answers: water in the rapids is moving faster than water in wider, slower sections of the river. The water gets churned up and gets "whitecaps" in the rapid section because of turbulence, and is flat and calm in slower, wider sections of the river.)
    b. *People can float in water and be carried by the current. Why is that? Rocks don't usually float, but can rocks be carried by the current in a way similar to things that float? What about sand, or even smaller particles? Can they be carried by water?
        i. (Answers: Buoyancy keeps people floating – objects that are less dense than water will float in water. Rocks aren't usually less dense than water so they don't float, but the water can still exert a force on them and "push" them downstream. Smaller particles are easier for the water to carry along, if the water has enough energy.)
    c. *Solids that are carried by water (like sand and other particles carried by rivers) are known as "suspensions" – can you think of any suspensions in your daily life? Specifically, think about things you drink. What about liquids that are not suspensions?

i. (Answers: some kinds of juice, hot chocolate are suspensions; given enough time, the particles will settle out. Drinking water, cola, and tea are "solutions." Milk is neither a suspension or a solution, since milk solids aren't dense enough to settle out.)

d. *When you shake a suspension that has settled (like a fruit juice smoothie), the particles are re-suspended in the water. What are you adding to the bottle of juice to re-suspend the particles? How is this like a river?
   i. (Answers: You are adding energy to the system in order to re-suspend the particles. This is like a quickly-flowing section of a river, which has very high kinetic energy and can hold a lot of particles without them settling out.)

e. *How is the amount of energy related to the transport of sediment in a river? Where would you expect to find the water carrying more sediment? Where would you expect to find more sediment settling out of the water?
   i. (Answers: the more energy the river has, the more sediment it can transport. Generally this means it transports a lot of sediment in faster-flowing sections, such as in mountains, and deposits its sediment load when the river channel flattens out onto the plains, etc.)

f. *Advanced/VERY optional: What keeps the sediment suspended in the water? Why doesn't it settle out more quickly? And how is that related to skydiving?
   i. (Answers: Friction keeps the sediment suspended in the water. Without friction, gravity would make the sediment settle quickly, but friction exerts an upward force on the sediment particles. Smaller particles have more friction relative to their mass, so they stay suspended longer. This is related to "terminal velocity" in skydiving – where you accelerate only until the downward acceleration from gravity is equal to the upward acceleration of friction on your body. Less massive objects with greater relative surface area have a lower terminal velocity in air too, not just in water.)

7. After the classroom discussion, have students make a final observation about the sediment tube. They should observe more fine material has deposited on top and that there is less suspended material in the water above the sediment

Potential Pitfalls

After you leave the sediment tube for a while, the water gets clearer and you can see the layer of dark material on top of the sand. You may also see the “floaters” that are less dense than water. Be sure to tell students NOT TO TOUCH the sediment tubes while having the sediments settle in the thirty minute period. Any movement will disrupt the deposition of different layers.