A Few Good Materials (Part 1 of 3)
Landforms and Change

This article is the first in a series of three articles (based on presentations at this year's MSTA conference) published in this issue of the MSTA Journal. The presentations and the articles all share a common theme, audience, and emphases.

Landforms

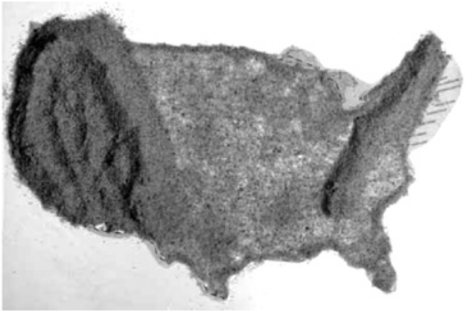
What are landforms? For most of us, it's easier to think of examples than to come up with a definition. If we brainstorm examples of landforms (e.g., mountains, plains, plateaus, valleys, gulleys), we can focus on what they have in common in order to come up with the definition. All of these examples are *natural* (i.e., not made by people), *physical* (i.e., not living, such as a rainforest) features on the *land's surface*. Landforms come in different scales of size, ranging from a gulley and a low ridge on a playground, to a valley and hills in a city, to mountains and plains spanning several states. In this article, we'll first focus on landforms on the largest scale and then show how the same activity and content learning can be done using landforms on the smallest scale - those outside on a playground.

Large-scale landforms define landform regions in the United States. Teachers may recognize the similarity of science and social studies GLCEs (e.g., Describe ways in which the United States can be divided into landform regions; Describe the impact of landforms on patterns of settlement). Thus, landforms provide an opportunity for integrating across the curriculum, with social studies focusing on the *what* and science on the *why* of landforms.

What, then, are the *landform regions* of the United States? Think about the map you have in your head of the United States – not just a political map with state locations, but a physical map with the location of landforms. You can build a model of your mental map with a few good materials - wet sand and a laminated map of the continental United States. The sand is used to build the landforms - just a sprinkling of sand where the land is flat and low (i.e., a plain) and lots of sand where the land is built up to represent mountains, highlands, plateaus, and basin-and-range regions. In making this model, most people include the Central and Coastal Plains, the Appalachian Highlands and the Rocky Mountains (although the Rockies are often placed near the Pacific Ocean instead one-third of the way inland from the ocean). Not as many people have the Pacific Mountains region (including the Cascades and Sierra Nevadas) in their mental map. And almost everyone is missing the landform regions located between the Pacific Mountains and the Rocky Mountains (Figure 2). This huge inter-mountain area is a rugged, built-up region of two plateaus (the Columbia and the Colorado) and the Basin and Range landform region.

Building a model like this allows one's thinking to be made visible, a powerful strategy that can be used for both a pre-assessment of learners' prior knowledge and as an ▶

Figure 2. Incorrect sand model of U.S. landforms



embedded assessment of learning in progress. In this example, sand models of U.S. landforms can reveal misconceptions and gaps that might get in the way of new learning. As you'll see shortly, if you don't know that the Pacific Mountains exist, then you can't explain the rain shadow effect in Arizona. Obviously, then, the next step is to improve the accuracy and completeness of the model by comparing it to a physical map of the United States. This hands-on activity illustrates one of the science process GLCEs, namely using a model to study phenomena that are inaccessible to direct observation - because they are too large for classroom study!

Landforms Change - The Wearing Down

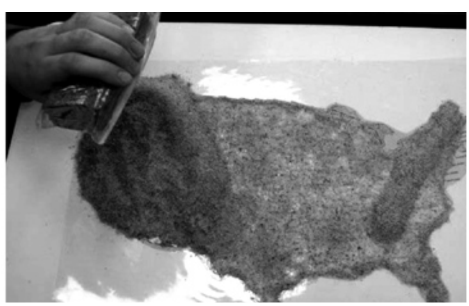
With an accurate sand model of the landform regions (Figure 3), you can explore ways in which these landforms change. For example, you can blow through a straw (one more simple material) to model the wind blowing across the Central Plains and slamming into the western slope of the Appalachians. You'll see particles of sand (i.e., sediments) break away (i.e., weathering) from the mountains and be carried away and deposited in new locations (i.e., erosion). Using the sand model allows you to see these processes of change occur before you even give names to these processes (i.e., weathering is the breaking down of rocks and landforms into sediments; erosion is the carrying away of the sediments).

The weathering and erosion of landforms due to solid water can also be shown with this model. Use an ice cube (another simple material) to represent a glacier moving south from Canada into Michigan. Just sprinkle some sand over Canada on the map (it's a plain). Place the ice cube in Canada and slowly slide it towards the south into Michigan. Let it stop in Michigan so it begins to melt. You'll see particles of sand (sediments) break away from the plain of Canada (weathering) and get carried to and deposited in Michigan (erosion) as the glacier melts.

You can also show landforms changing due to falling rain using a wet sponge to model a moist air mass (another simple material). (We put the wet sponge in a zip-lock snack bag with pin holes perforating one side.) By placing the "air mass" in the Pacific Ocean off the California coast and then sliding it eastward (keep the sponge just a fraction of an inch above the map), you see the air mass hit an obstacle - the Pacific Mountains. The air mass has to rise in elevation. As it rises, it cools and the water vapor in it condenses to liquid water, i.e., clouds. As water droplets collect together, they may have enough mass that the *pulling down* force of gravity will win over the *pushing up* force of the air below and the water will fall as rain. Squeezing the sponge as the air mass moves up the Pacific Mountains lets the rain fall on the western slope, breaking away particles of sand and carrying them downhill (Figure 4).

Figure 3. Correct Sand Model of U.S. Landforms

Figure 4. A moist Pacific air mass meets the Pacific Mountains.



There are several ways in which you can integrate this sand model with other topics in the K-7 science GLCEs and even the social studies GLCES (Figure 5).

Real World Examples

These *few good materials* can easily be used to model landforms (and watersheds) on different scales. For example, you can easily make a sand model of your town or the school playground. While the landforms are on a smaller scale (gulleys instead of plains, small ridges rather than mountains), the same processes of change are occurring. Water and wind are still breaking apart the higher landforms and carrying the pieces (sediments) away to lower areas.

Figure 5. Integration with Other Topics

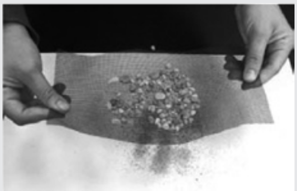
Biomes	Watersheds	Westward Expansion
If you keep moving the now "wrung out" Pacific air mass to the east, when it moves over Arizona, there's very little water left to fall as rain. Thus, Arizona is a desert. Contrast this with the biome found at the same latitude in Georgia. In this case, place the moist air mass in the Gulf of Mexico and move it north. It doesn't run into mountains before it reaches Georgia and so it can drop some of its load of water here. This rainfall makes Georgia a deciduous forest.	A watershed is an area of land that "sheds" all its water to one water body. Thus, all the water running off the land (i.e., the runoff) flows downhill to the same water body, whether a stream, a river, a lake, or an ocean. So in our model, all the sand sloping downhill toward one water body represents a watershed. When rain falls on the western slope of the Pacific Mountains, all the water flows downhill over the sand to the Pacific Ocean. So, all this land from which water flows downhill to the Pacific is the Pacific watershed.	Use the sand map as a guide to re-enacting the westward expansion of the United States in the 19th century. Imagine the pioneers on the Oregon Trail walking with ease across the flat and low Central Plains compared to their trek across the Rocky Mountains. The Columbia Plateau would be a relief (high in elevation but flat) after the Rockies. Imagine then the dismay of discovering a second mountain chain between you and the Pacific. You could make comparisons between climate and the vegetation in the various landform regions.

The Sediments Themselves

The sediments that break away from landforms and rocks and get carried away to new locations come in different sizes. Boulder-sized pieces of mountains break away and then, over time, get broken down themselves into cobbles (stones the size of your fist; think cobblestone roads) and smaller sediments such as gravel, sand, silt, and clay. Familiarity with different Earth materials begins with a kindergarten GLCE, yet teachers often don't have access to some of these different materials. Here we describe a way for teachers to gain access to these Earth materials using *a few good materials* (soil, screen, nylon, coffee filter). Get a sample of soil - any soil. Soil is a mixture of air, water, organic materials (living and dead organisms), and various-sized sediments (rock fragments). Here we'll focus on the rock fragments. Follow the steps below (Figure 6), collecting and labeling the sediments at each step. These homemade materials won't be able to separate the silt from the clay so a sample of clay purchased form a hobby store will be needed. ▶

Figure 6. Sorting sediments: gravel, sand, silt, and clay

Get out the Gravel

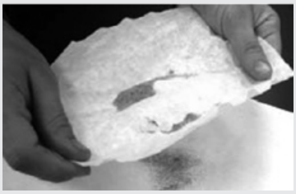


A screen catches the gravel while the sand, silt, and clay pour through.

Sift the Sand

Take the sifted mixture from the previous step and pour it through a nylon hose, shaking gently. Large grains of sand won't pass through, but smaller sediments will.

Save the Silt



Place the smaller pieces on a coffee filter and shake gently. The sand particles won't pass through, but the silt and clay particles will.

Table 1. Sediments

Sediment Type	Gravel	Sand	Silt	Clay
How it looks	large sediment pieces	small particles, but easily visible to the naked eye	small particles barely visible to the naked eye	microscopic particles not visible to the naked eye
How it feels	chunky	gritty	slippery, floury	greasy

Once you have your sediments, observe (meaning use all your senses that are appropriate and safe) the sediments you've separated. You'll be able to tell the difference between gravel, sand, silt, and clay by sight and touch (Table 1). The sand-sized sediments may be different colors, meaning that they are different compositions. Some may be sand-colored, like the quartz sand of the lower Great Lakes. Some may be black in color, like the magnetite sand of the Lake Superior shore or the basalt sand of Hawaii's beaches. Some may even be white, like the gypsum sands of the White Sands of New Mexico. Similarly, your silt sample may be a different color than that sifted out of another soil. Both samples will be the same size sediment, but they may be composed of different materials, giving them different colors.

Landforms Change - The Building Up

Imagine an Earth with only weathering and erosion occurring for hundreds of millions of years. Eventually, all the high places would be weathered down and the low places filled in with their sediments - in short, a smooth, leveled planet. Obviously, there has to be more going on since even after 4 billion years, Earth still has a variety of uplifted landforms. The other half of this story is that Earth's surface is continually being built up. We can use the same materials (sand and a U.S. map) to illustrate (in an abbreviated form) some of the big ideas that explain the build up of Earth's surface, focusing again on the continental U.S., only in this case, going back in time. There is one change needed in the previously used materials - cutting the landform map of the United States into three pieces as shown below (Figure 7).

When we look at a map or a globe of the world, we see a model of the outer layer of Earth. Big pieces of land (continents) are surrounded by vast bodies of water (oceans). If you could drain away all the water in the oceans, you would then see big pieces of land - the ocean floors. This outer layer of Earth is called the crust - just a thin, brittle covering over 4000 miles of Earth materials to the center. This brittleness allows the outer layer to break into about a dozen big pieces, called plates. One plate, called the North American plate, carries the North American continent along with the western half of the Atlantic Ocean. Another plate, the Eurasian plate, carries the Eurasian continent along with the adjacent eastern half of the Atlantic Ocean. Similarly, the African plate carries the African continent and the adjacent Atlantic Ocean. The Pacific plate carries much of the Pacific Ocean.

The crust floats on top of a middle layer of the Earth called the mantle. The rock material that makes up the mantle actually moves vertically within this layer, rising and sinking. It also moves horizontally underneath the overlying crust, carrying the plates along with it. Thus, the plates move, changing position and even direction over millions of years. Most students have noticed evidence of this movement in the close fit of the shapes of South American and Africa.

We'll focus just on the continental United States in our sand model to illustrate how Earth's surface gets built up. Originally, the North American plate was much smaller than it is now. The continental U.S. was only the size of the Central Plains. With our model, we'll start with just the central portion of the laminated map to represent this original plate. Sprinkle some sand on the map to show that it's generally flat and low. At the same geological time, another plate to the east was also a low, flat plain

Figure 7. Map for use in build-up of North American plate

so sprinkle some sand on what will soon become the east coast of the United States. The movement of the mantle crashed these two plates together, uplifting the land to form mountains at the boundary where they met. You can push the two map pieces together so that the edges of the two plates get pushed upward to form mountains - the Appalachians. When the two plates separated later, huge chunks of the other plate got attached to the North American plate, making it larger than it was originally.

Later in time, the western edge of the North American plate experienced similar collisions with other plates, such as the Pacific plate. Each time, land became uplifted and, when the plates later separated, big pieces of the Pacific plate stay attached to the North American plate. Over time, the Columbia and Colorado Plateaus, the Basin and Range region, and the Pacific Mountains got added on to the North American plate through these multiple collisions with other plates. Using the model, push the Pacific plate into the western edge of the North American plate to represented the gradual enlarging of the plate with the build up of the Rocky Mountains and other uplifted areas.

Landforms Change - So Energy's Involved

The two big ideas described in the sections above can be summarized as Earth's surface gets built up, and Earth's surface gets worn down. Both the building up and the wearing ▶

down are examples of change. And whenever matter is changing (in this case, landforms and rocks), energy must be involved. Let's explore this foundational big idea as it's illustrated in both the build up and the breaking down of Earth's surface.

Whenever Earth's surface undergoes weathering, the property of the object (whether a landform or a rock) that's changing is either its size (from big to smaller), or its shape (from angular to rounded), or its texture (from rough to smooth). What causes this change is some other object moving against it, breaking it apart. This other object can be moving air (wind), moving liquid water (rain, river, ocean), or moving solid water (glacier). In each case, the moving object has *mechanical energy* which gets transferred to the landform, breaking it apart. Other moving objects, such as plant roots, and burrowing animals, and humans in agricultural, mining, and construction activities, also transfer mechanical energy to rocks and landforms, breaking them apart.

Erosion, too, illustrates that when matter changes, energy's involved. The carrying away and depositing of sediments is an example of matter changing in terms of location and motion. Once again, in order for the sediments to change, energy must be involved. Erosion, too, requires *mechanical energy* - the energy of moving air (wind) or moving water (runoff, rivers, ocean, glacier)

Just as the breaking down of Earth's surface requires energy, so too does the building up. Mountain building involves Earth materials changing in composition (e.g., changing from sedimentary rock to metamorphic rock), shape, size, texture, and in location and motion. Here the energy involved in changing this matter doesn't come from agents on the surface of Earth; rather it comes from deep within the Earth. Convection currents in the mantle lead to the mantle and the plates moving. Just as moving air and water have mechanical energy, the moving plates have mechanical energy.

A few good materials can go a long way toward promoting understanding of science content and processes when they are coupled with a focus on relevant, meaningful grade level content expectations and integrated with other science content through foundational big ideas. This article has focused on just one of the foundational big ideas, namely, when *matter changes, energy's involved*. The other two articles in this series explore different content in the K-8 science curriculum, but the same foundational big idea can still be used as a framework. With enough practice at looking at the world through this lens, teachers won't have to relegate the topic of energy to the end of the school year, but rather can integrate it into every topic in their science curriculum.

References

American Association for the Advancement of Science. 2001, 2007. Atlas of science literacy, Volume 1. Washington, DC: Author.

Michigan Department of Education, Office of School Improvement. 2009. K-7 Science Grade Level Content Expectations.