LESSON 7: EROSION AND DEPOSITION – FROM WASHES TO CANYONS AT PARASHANT

GEOLOGICAL ADVENTURES AT PARASHANT

EXPLORING THE GEOLOGY OF

GRAND CANYON-PARASHANT NATIONAL MONUMENT

LESSON 7 GUIDE: EROSION AND DEPOSITION - FROM WASHES TO CANYONS AT PARASHANT

OVERVIEW

Students interpret a photograph of gravels and cobbles exposed in Whitmore Wash at the monument. They clip an overhead transparency to a photograph of the sidewall of a wash and draw lines through the longest axes of flattened cobbles, and use the overall pattern of lines to infer the direction of stream flow. Students read about the processes of erosion and deposition that are most prevalent on the monument. In an elaboration activity, students return to the photograph of Whitmore Wash to interpret the percentages of various rock types found in the deposit. After building a class data set using representative square-meter areas of the deposit, they draw inferences about the geology of the mountain range that produced the deposit.

Objectives After interpreting a photo of clast orientations in a wash deposit, reading about processes of erosion and deposition at Parashant, and interpreting the types of rocks exposed in a wash and making inferences about the geology of the mountains from which the deposit came, students will understand:

- Running water orients clasts in streams in ways that enable us to reconstruct the directions of ancient stream flow;
- Erosion is the transport of sediment by wind, water, gravity, and ice, and wears down the land;
- Deposition is the settling of eroded sediment at a lower elevation and builds up the land;
- Running water is the most important agent of erosion in the desert;
- Rocks are broken into smaller pieces over time through chemical and mechanical weathering;
- The composition of rocks in ancient stream deposits provides clues about the existence and nature of ancient mountains.

Concepts Wash, ephemeral stream, clast imbrication, erosion, deposition, mechanical and chemical weathering, mass movement, canyon formation.

Duration Two 45-minute class periods

Audience Students in grades 6 to 9

Materials **Explore Activity** (per group of students)

- a color copy of Worksheet 7.1 (Whitmore Wash Photo)
- overhead transparency
- nonpermanent transparency marker
- clear tape
- ruler

Elaborate Activity (per pair of students)

- a color copy of Worksheet 7.2 (Whitmore Wash Photo)

- a color copy of Worksheet 7.3, 7.4, 7.5, or 7.6 (one per student pair)
- an overhead transparency,
- a nonpermanent transparency marker
- clear tape
- calculator

Extensions **For All Students**

- Arrange for a field trip to a local stream where students can examine clast imbrication, clast shape, and collect rock samples to make inferences about the composition of possible source rocks upstream.
- Take students outdoors to simulate wind erosion, deflation, and the formation of a desert pavement by spreading a bucket of dry sand and gravel out on a plastic tarp and running a strong fan over the sand.

For honors, gifted, and higher grade-level students

- Have students handle data from the activity in the Elaborate portion of the lesson in MS Excel, producing bar graphs or pie charts of clast lithology for the four sectors and the class total.

Resources

- A lucid description of weathering and erosion in desert environments prepared by the USGS is available at http://pubs.usgs.gov/of/2004/1007/erosion.html

ENGAGE

This section describes an experiment conducted by a student in order to engage students in thinking about how the forces associated with running water affect different-shaped particles in streams or washes. Ask volunteers to share ideas. Accept all reasonable ideas and write them on the board. Avoid providing the "right" answer – students will investigate the relationship between stream flow direction and clast orientation (imbrication) in the Explore phase of the lesson. Sample responses to questions are provided for your information below.

1. Students will likely respond that the round rock (A) will roll whereas rushing water will push over or tumble the rock shaped like a discus (B).

2. Accept all reasonable responses. While it is possible for rock B to get lodged in sediment with the arrow pointing upstream, it is far more likely that the arrow will point downstream, allowing water to flow easily over the sloping flat backside of the rock.

EXPLORE

Determining Stream flow Direction

1. Distribute materials to students. Make high quality color copies of Worksheet 7.1 (Whitmore Wash Photo) and laminate to protect them.

Each group will need one copy. Students will need an overhead transparency and a washable transparency marker to do their interpretations. Students will also need clear tape to secure the transparency to the photo, and a ruler to use to draw straight lines through clasts.

2. Help students to understand that the photograph in Worksheet 7.1 is a side view of an older deposit that was exposed by erosion in a wash (dry streambed). Figure 7.2 provides the context view. The light gray gravel at the bottom of the photo is the bottom of Whitmore Wash. As a side note, see how the sediments fine upwards, from coarse boulders at the base of Figure 7.2 to finer brown sand, silt, and clay above the black square. Fining upward sequences are common – as streams lose energy, the coarsest material settles first and becomes progressively finer. The photo was taken in the upper end of Whitmore Wash, where the wash is less than five meters wide. Whitmore Wash widens and deepens with distance, becoming Whitmore Canyon, and eventually joining the Grand Canyon to the south.

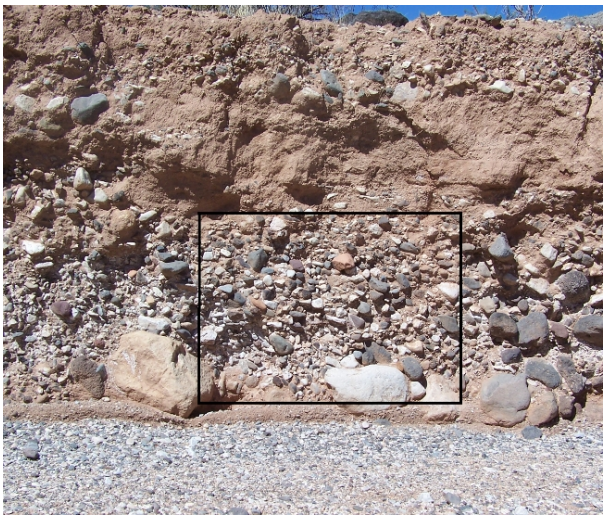


FIGURE 7.2 Rocks exposed in Whitmore Wash at Parashant. The box outlines the area shown in Worksheet 7.1.

3. Remind students how their study relates to the diagram (7.1) and questions in the Engage activity.

4. If you laminate the photographs and use non-permanent markers, the overhead transparencies will not be necessary.

5. This step explains why students are to focus on the elongate rocks in their interpretations. Elongate rocks allow them to explore whether or not flowing water orients rocks in a preferred direction in a stream. Figure 7.1 provides a reference for what is meant by an elongate clast. If you think that students will have difficulty understanding what to do, make an overhead transparency of Worksheet 7.1 and ask students to pick out an elongate rock, and then draw the line down the axis to show them.

FIGURE 1 Sample interpretation of clast orientation for 20 clasts in a wash deposit exposed at Whitmore Wash. All 20 clasts are oriented with the high end pointing to the left.

6. Results will vary depending on the rocks students select, but expect between 90 to 100% of the rocks having a preferred orientation of up and to the left (see Figure 1 above).

7. You could demonstrate the preferred orientation of rocks in a stream by standing four books on end on your demonstration table and gently pushing them over. Ask students what the force of your hand represents (the force of flowing water in a stream). The books will stack on top of each other, and water will flow up the flat back of the books due to their streamlined shapes. Demonstrate how much work is involved to try to flip the books over once they are in this position.

8. Water flow in the older deposit at Whitmore Wash was from right to left.

9. A geologist can use an ancient conglomerate to make inferences about the location of an ancient mountain range that no longer exists by looking at the orientation of the rocks in the conglomerate (to see which direction would have been upstream at the time, assuming that the rocks have not been disturbed).

10. Hold a brief class discussion. If you can project a copy of Worksheet 7.1, students can come to the front of the room to point out particular rocks they want to discuss.

EXPLAIN

Assign for reading during class or as homework (even if the entire activity has not yet been completed). You can supplement the explanation phase of the lesson with a discussion or lecture. Photographs of outcrops of sedimentary rocks, sample of rocks, diagrams of environments of deposition, and photographs of how we use sedimentary rocks as natural resources would be most relevant to the lesson. Photographs of local or regional outcrops would increase the relevance to students.

ELABORATE

1. You will need to make one overhead transparency of Worksheet 7.2 to project to the class (or project the image on a computer) so that they understand how the square they are studying relates to the wash deposit.

Students will need a color copy of Worksheet 7.1 (Whitmore Wash Deposit) as a context photo and a color copy of one of the following: Worksheet 7.3, 7.4, 7.5, or 7.6. Each of the four worksheets is a close-up view of one of the four squares shown in Worksheet 7.2. They will also need a nonpermanent marker, an overhead transparency, and a magnifying glass (to look more closely at rocks in the photo). Students will also need a calculator to calculate percentages of rock compositions.

2. You can project your copy of Worksheet 7.1 (from the Explore activity). Students may note as many as ten different kinds of rocks due to the range of colors. However, there are a variety of colors of limestone and basalt in the photo, and one kind of sandstone, so there are three kinds of rocks in the photo. Light brown soil from the wash deposit coats some rocks, obscuring their identification.

3. Project a copy of Worksheet 7.2 labeled with the types of rocks and help students to see the differences between the colors of basalt, the colors of limestone, the sandstone, and examples of rocks that might be labeled uncertain because they are in shadow or covered with soil.

a. White, light-grey, and light blue-gray rocks labeled A are **limestone**.

b. Medium-grey, dark-grey, black, and reddish-purple rocks labeled B are **basalt**. Some of the basalt rocks have holes (or dimples) made by gas trapped in the lava when it cooled. Basalt is a dark grey rock, but it often weathers into various colors.

c. Orange-red rocks labeled C are **sandstone**. The red color indicates iron between the grains of sand.

4. Point out that worksheet 7.2 shows four squares that correspond to the photos on Worksheets 7.3 to 7.6. The squares allow students to take representative samples of the wash deposit, roughly one square meter each. Assign a quadrant of Worksheet 7.2 to each pair of students. The data from studies of all four squares (as well as duplicate quadrants) can be averaged together. Ask students about the advantages of taking representative samples and averaging, rather than counting every rock in the photo.

5. Have students copy Table 1 into their notebooks. They should add the name of the quadrant you have assigned them to the location section at the top of the table (Upper Left, Upper Right, etc.).

Table 1. Rock Types in Whitmore Wash Deposit

	Location: _____		**Grand Total**	
Rock Type	Number of Clasts	Percent of Total	Number of Clasts	Percent of Total
Limestone				
Basalt				
Sandstone				
Uncertain				
Total				

6. Students count the number of each kind of rock in the square meter sample area assigned to them. Circulate and address student's questions. When they have labeled all the rocks they can see that are longer than 1cm on the photo, they should count each rock type and put the data in Table 1. A sample interpretation is provided in Figure 2 on the next page.

7. Students may need assistance calculating percentages. You can do an example on the board for them.

8. Hold a class discussion in which you record for the class the results for each quadrant. Keep in mind that results are likely to vary between quadrants, and even between duplicate pairs of students assigned to each quadrant. Ask students how they think they should handle differences. The time available for discussion will dictate this to some extent, but the conversation presents a great opportunity to help students to understand the process of science and how to resolve disagreements.

FIGURE 2 Sample interpretation of Worksheet 7.3 - Wash Rocks Upper Left.

As a class, add the data for the four different squares together to find the grand total number of each type of clast. Then calculate the percentage of each rock type represented in the wash deposit.

9. Students will find a slight difference between the amount of limestone and basalt, and a large difference between those two rock types and the amount of sandstone.

10. The purpose of this question is for students to think about the role of chemical and mechanical weathering in changing the composition of rocks as they are transported. The rate at which rocks weather will influence the percentages of rock found in a stream deposit. Basalt is

made of hard, silicate minerals, whereas limestone is made of softer calcite, which dissolves more easily in water.

a. The rocks probably did not travel a great distance because there is a high percentage of limestone in them.

b. Answers will vary, but the ratio of limestone to sandstone is at least 10:1.

c. The ratio of limestone (calcite) to quartz should decrease with distance from the mountain because quartz is more resistant to weathering than calcite, which will be broken down and dissolved.

EVALUATE

Address these questions in a class discussion, assign them for group work, or include them as part of a homework assignment.

1. Chemical and mechanical weathering both break down rock into smaller pieces. Mechanical weathering breaks rock without changing the chemical composition, whereas chemical weathering creates new substances.

2. The orientation of clasts in a stream reveals the direction of stream flow. The clasts will lean over and the high ends will point downstream.

3. Answers will vary. Erosion removes sediment from mountains and transports it down slopes, washes, and canyons. Deposition builds up the land where the sediment settles.

4. Running water is such a major agent of erosion in an arid region like Parashant because there is little vegetation holding the soil in place, so the sediment can be dislodged easily by rainfall. In addition, rainfall comes in intense thunderstorms and when sediment-rich water collects in channels, it has great erosive power.

5. As rocks tumble in a stream, they smash against each other. This is mechanical weathering. The water helps to dissolve the rocks, which is chemical weathering.

6. Quartz is such a major component of the sand found on many beaches because it is one of the most resistant minerals to chemical and mechanical weathering. Other minerals are broken down and dissolved, leaving the quartz sand behind.

7. The farther water travels in a wash at Parashant, the deeper the wash become and the more water the wash can hold, which increases the erosive power of water.

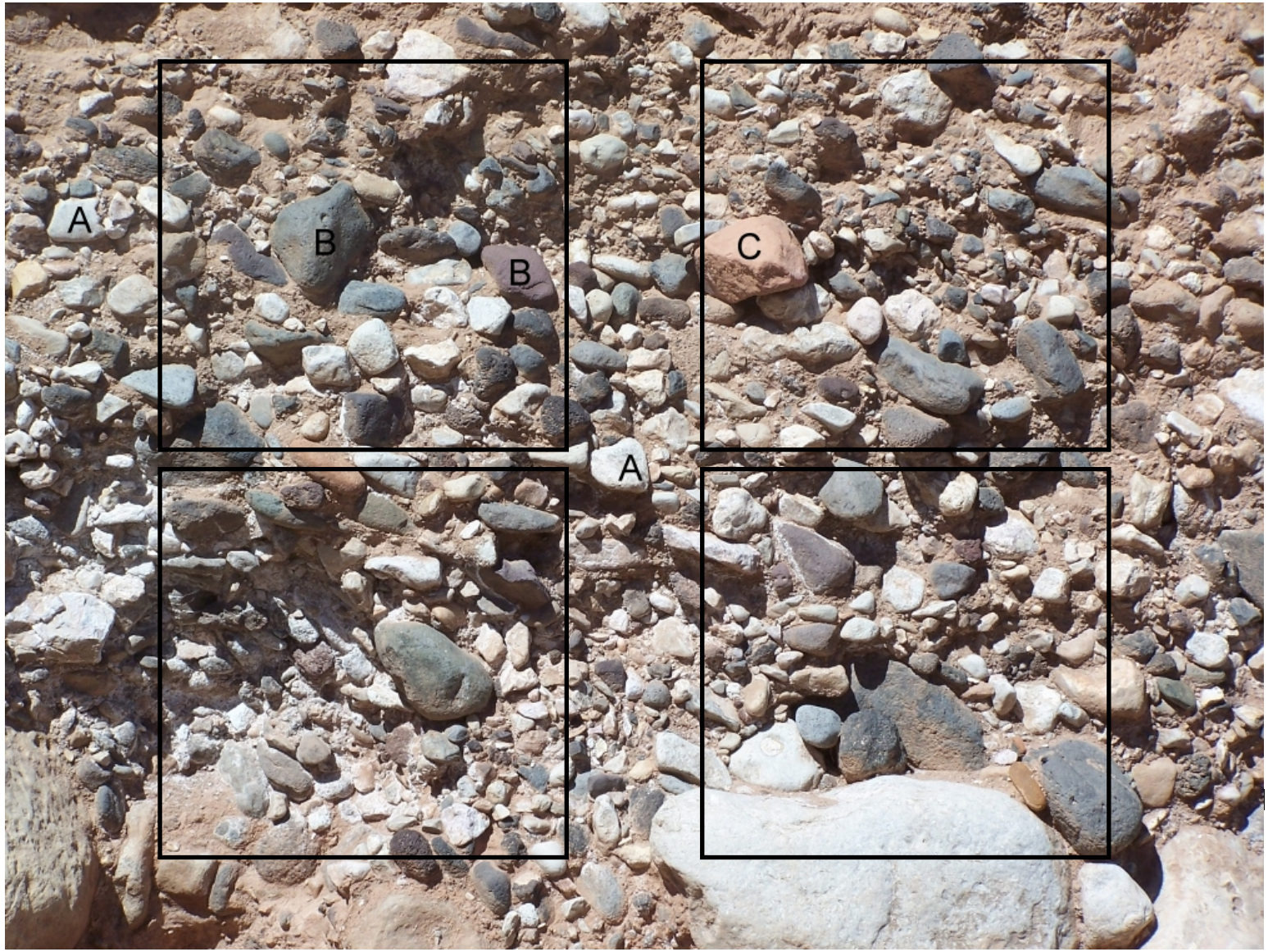
Challenge Question

Expect various interpretations. It appears as though there are a variety of rocks and particle sizes in the conglomerate and that they are less rounded than what

students saw in the rocks in Whitmore Wash. This would mean that the deposit is close to the mountain range from which the rocks came. However, the penny shows that even though a range of sizes is present, the rocks are rather small, especially compared to those exposed at Whitmore Wash, which lends support to the idea that the rocks traveled some distance. A counter argument to this claim about particle size is that the rocks in the conglomerate were transported by a smaller stream, which lacked the energy needed to carry large rocks. If the pebbles were deposited far away, there would be less variety, even greater rounding, and more uniform sizes of sediment particles.

WORKSHEET 7.1 – OLDER WASH DEPOSITS EXPOSED AT WHITMORE WASH

WORKSHEET 7.2 – OLDER WASH DEPOSITS EXPOSED AT WHITMORE WASH



WORKSHEET 7.3 – WASH ROCKS UPPER LEFT

WORKSHEET 7.4 – WASH ROCKS UPPER RIGHT

WORKSHEET 7.5 – WASH ROCKS LOWER LEFT

WORKSHEET 7.6 – WASH ROCKS LOWER RIGHT

LESSON 7: EROSION AND DEPOSITION - FROM WASHES TO CANYONS

ENGAGE

Study Figure 7.1 and its caption. It shows two rocks A and B that a student stuck into the sand in the bottom of a wash (dry streambed) as part of a study on water erosion. Earlier, she had painted an arrow on each rock to show the top of each rock at the start of the study. After she leaves, a thunderstorm occurs that makes water flow down the wash (dotted line) fast enough to move the two clasts.

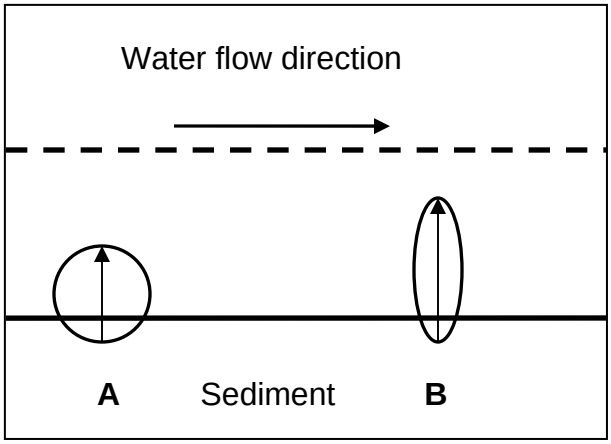


FIGURE 7.1 Diagram of two rocks on the bottom of a wash. The dashed line is level of water during a thunderstorm.

1. Describe what you think the rushing water will do to each rock.

Two weeks after the thunderstorm, the student returns and finds the two rocks in the wash, which is now completely dry. The rocks have moved downstream and the arrow on rock B shows that it was tilted.

2. Do you think she found the arrow at the top of rock B pointing downstream or upstream? Explain.

EXPLORE

Imagine a mountain range that formed so long ago that it weathered and eroded away into a flat plain. No evidence of the mountain exists. Or does it? If we dig into the plain that surrounded the ancient mountain, we might find rocks carried by the streams that eroded the mountain away. Can we use the orientation of the stream rocks to figure out the flow direction of water, and thus, where the mountain used to be upstream? In this activity, you will study rocks exposed in the side of a wash to make inferences about erosion by running water.

Determining Stream flow Direction

1. From your teacher, obtain a color copy of Worksheet 7.1 (Whitmore Wash Photo), an overhead transparency, a nonpermanent transparency marker, clear tape, and a ruler.
2. Worksheet 7.1 shows a side view of rocks exposed in Whitmore Wash at Parashant. The rock and sediment in the photo make up an older wash deposit exposed by erosion of the current wash. Figure 7.2 shows the location of the photo in Worksheet 7.1.

3. When the current wash floods, water flows from right to left across Figure 7.2. Your goal is to find out the direction in which the older wash flowed. To do this, you need to study the orientation of the rocks in that deposit.

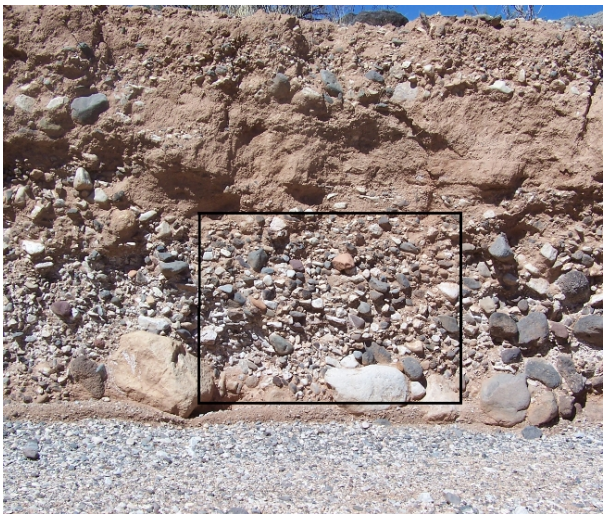


FIGURE 7.2 Rocks exposed in Whitmore Wash at Parashant. The box outlines the area shown in Worksheet 7.1.

4. Place an overhead transparency on top of Worksheet 7.1 and tape it on four sides to keep it from moving.

5. Assume that running water will orient the elongate rocks in a preferred direction as it flows downstream. Running water might also orient the rocks that are more like spheres, but it will be more difficult to see any orientation.

With a nonpermanent marker, draw a line down the middle of the long axis of 20 elongate rocks. Put an arrow on the highest the end of each line (use rock B in Figure 7.1 as a reference). The rocks you pick can be any size, but must be longer than they are wide or tall.

6. Calculate the percentage of rocks pointing up and to the left versus pointing up and to the right (hint: If you have 20 rocks, each rock is 5% of your sample).

7. As you might have predicted from the Engage activity, as water flows over an elongate rock in a wash, the force of the water pushes the rock over. Once the high end of the rock is pointing downstream, it becomes more stable and remains in that position as the water level falls.

8. On the basis of this information and your interpretation, in which direction did water flow in the older deposit at Whitmore Wash – from right to left or left to right?

9. If buried deeply enough for a long time, deposits like the mixture of rocks and sediment exposed at Whitmore Wash form a sedimentary rock called conglomerate. How can a geologist use an ancient conglomerate to make inferences about the location of an ancient mountain range that no longer exists?

10. Share your results in a class discussion.

EXPLAIN

Erosion and Deposition

In the activities, you investigated two processes that change the surface of the Earth – erosion and deposition by running water. **Erosion** is the movement or transportation of sediment due to the action of gravity, wind, water, or ice. Whatever carries the sediment, it eventually settles in a new location at a lower elevation. The settling out of sediment is called **deposition**. Erosion wears down the land and deposition builds up the land in a new place. At Whitmore Wash, floodwaters eroded and carried sediment and exposed older deposits in the walls of the wash.

FIGURE 7.3 This large block of limestone has paused temporarily on its trip downhill under the force of gravity.

Erosion occurs in a number of ways. **Mass movement** is a common form of erosion. Mass movement is driven by gravity, the force that pulls objects towards Earth's center. The higher a rock or sediment is on a slope and the steeper the slope, the more likely it is to move downhill under the force of gravity (see Figure 7.3). Movement can take place quickly, as with landslides, rock falls, slumps, or mudflows, or slowly, as happens with creep. At Parashant, steep slopes are common, making rock falls and landslides the main types of mass movement that erode slopes. In addition, soil forms very slowly in the monument's desert climate, leaving much of the rock and sediment on slopes exposed to erosion.

Wind erosion is the weakest agent of erosion, yet where fine sediments lie at the surface and vegetation is sparse, as in desert regions like Parashant, wind plays a small role. In a process known as **deflation**, wind erosion removes loose finer particles (clay, silt, and sand) and may create dunes where sediment accumulates and leave behind a coarse-grained ground surface called desert pavement (Figure 7.4). In addition, windblown silt and sand collide with and abrade rocks along the ground, which can create spectacular rock sculptures.

FIGURE 7.4 Wind erosion removes finer particles of sediment, leaving a coarse-grained desert pavement behind.

It may surprise you, but running water plays the most important role in eroding the Parashant landscape. After all, Parashant has no permanent streams, only **ephemeral streams** – streams that flow during or immediately after a rain. Its dry, flat-bottomed streambeds are called **washes** (or arroyos and coulees in other regions). An arid region that receives little precipitation during much of the year, Parashant's summer monsoon rains fall as intense thunderstorms. Rains saturate the sediment on slopes, adding weight that makes it more likely to move down the slope under the force of gravity.

Erosion by running water begins with millions of raindrops striking the ground. With little vegetation to hold soil and sediment in place, the force of raindrops dislodges sediment and starts it moving downhill. The mixture of fine-grained sediment and water collects in small channels called rills and gullies higher on the slope. The channels grow larger down slope due to the greater erosive power of sediment-laden water (Figure 7.5). The larger the channel, the more water it can carry and the greater its ability to erode. This creates a self-perpetuating system, widening and deepening washes that lead into canyons farther downstream.

FIGURE 7.5 Canyon forming north of Parashant. Down slope is to the lower right. Note how the canyon becomes wider and deeper over its course, and how smaller channels feed into the larger main channel.

Another important kind of deposit at Parashant and in many mountainous regions is **alluvium**. Alluvium is recent sediment – freshly eroded rock particles in a range of sizes that accumulate on slopes (see Figure 7.7). Alluvium is transported by water and mass movement. Rainfall that soaks into alluvium makes it more likely to flow in a landslide, slump, or debris flow.

FIGURE 7.7 Alluvium covers the slopes along the Grand Wash Cliffs at Parashant to the point where little of the sedimentary rock layers are visible.

Weathering

During their journey from higher to lower elevations, rock and sediment change in size and chemical composition. The reduction in the size of rock is known as **weathering** (Figure 7.8). High on the slopes, rocks are more likely to be angular and have sharp, jagged edges, like the block of limestone shown in Figure 7.3. As rocks tumble on slopes, enter washes, and bounce along the bottom during floods, rocks become smoother and smaller. This physical breakdown of rock into smaller pieces is **mechanical weathering**. The smaller the particle, the more susceptible it becomes to **chemical weathering**, or processes that change the minerals that make up a rock into different substances. For example, the calcite minerals that make up limestone that is so common at Parashant begin to dissolve in water. Minerals dissolved in water help make the ocean salty. The feldspar minerals in basalt weather into fine clay minerals, and the iron silicate minerals in basalt combine with oxygen in the presence of water to form new minerals called oxides. The range of colors in the basalt rocks exposed in Whitmore Wash reflects the variety of iron and manganese oxides formed by chemical weathering.

FIGURE 7.8 Chemical weathering gives the Navajo Sandstone at Parashant its red color. Mechanical weathering disintegrates it into sand, seen at the base of the outcrop.

One of the minerals most resistant to chemical weathering is quartz, which makes up the majority of sandstones and siltstones. By the time sediment completes its journey to the ocean, mechanical and chemical weathering reduces the massive blocks of rock on mountain slopes into clay, silt, and sand-sized particles. As you observed in the photos, the rocks of Whitmore Wash vary greatly in size. They range from meter-sized boulders to fine clay (the brown “dirt” between the rocks). The rocks are slightly rounded, and several kinds of rocks are present. During the journey, the farther sediment travels in a stream, the smaller and rounder it gets, the more uniform in size it becomes, and the higher the overall percentage of quartz. How do you think the rocks at Whitmore Wash will change as they continue their trip to the Colorado River?

ELABORATE

Interpreting Clast Lithology

Think again about the deposit of rocks exposed in the walls of Whitmore Wash. How do the rocks in the wash relate to the types of rocks that made up the

eroding mountain? In this activity, your goals are to interpret the kinds of rocks found in the wash deposit and use this information to make inferences about the rocks found in local mountains.

1. From your teacher, obtain a color copy of Worksheet 7.1 (Whitmore Wash Deposit), a color copy of Worksheet 7.3, 7.4, 7.5, or 7.6, a nonpermanent marker, an overhead transparency with four squares marked as grids, a metric ruler, and a sheet of graph paper.

2. Look closely at Worksheet 7.1. How many different colors of rocks can you see? Record your ideas. Share your ideas in a class discussion.

3. Your teacher will project a copy of Worksheet 7.2 labeled with the main types of rocks.

d. White and light-grey rocks labeled A are limestone.

e. Medium-grey, dark-grey, black, and reddish-purple rocks labeled B are basalt. Some of the basalt rocks have holes made by gas trapped in the lava when it cooled. Basalt is a dark grey rock, but it often weathers into various colors.

f. Orange-red rocks labeled C are sandstone. The red color indicates iron between the grains of sand (the sand grains are quartz, which is clear to white).

4. Worksheet 7.2 also shows four squares that correspond to the photos on Worksheets 7.3 to 7.6. The squares allow you to take representative samples of the wash deposit, roughly $1m^2$ each. The data from studies of all four squares can be averaged together.

5. Copy Table 1 into your notebook.

Table 1. Rock Types in Whitmore Wash Deposit

	Location: _____		**Grand Total**	
Rock Type	Number of Clasts	Percent of Total	Number of Clasts	Percent of Total
Limestone				
Basalt				
Sandstone				
Uncertain				
Total				

6. With your partner, count the number of each kind of rock in the square meter sample area assigned to you. As it will be too difficult to identify the smaller rocks, limit your work to rocks that are at least one

centimeter in length on the photo. You should end up labeling and counting between 50 and 75 rocks.

One way to do this is to tape an overhead transparency onto your worksheet and use a marker to label the rocks L for limestone, B for basalt, and S for sandstone. If you are uncertain about a rock type, label it with a U (for uncertain). Some rocks have a light brown coating of soil, so do your best to identify the type of rock it is.

When you have labeled all the rocks that are at least 1cm long on the photo, count the number of rocks for each rock type and put the data in Table 1.

7. Calculate the percentage of each rock type in your square meter of the deposit. To do this, sum the clasts and write the total at the bottom of Table 1. Divide the number of clasts of each rock type by the total number of clasts, and then multiply the result by 100. Add this data to your data table.

Share your results in a class discussion

8. As a class, add the data for the four different squares together to find the grand total number of each type of clast. Add this to your data table, and then calculate the percentage of each rock type represented in the wash deposit.

9. If the percentages of rock types in the wash are the same as those that made up the mountain before it was eroded, was the mountain made mostly of limestone, basalt, or sandstone? Explain.

10. You observed at least three types of rocks in the Whitmore Wash deposit. Given the percentage of limestone (which dissolves in water and is made of a softer mineral than those in basalt), answer the following questions:

a. Did the rocks in the deposit travel a great distance? Explain.

b. Calculate the ratio of limestone clasts to sandstone clasts (for the four quadrants combined) by dividing the value for limestone by the value for sandstone.

c. Predict how the ratio of percentage quartz to percentage limestone will change as the rocks fall into Whitmore Wash and travel downstream. Explain your prediction.

EVALUATE

1. Compare and contrast chemical weathering and mechanical weathering. How are they similar? How are they different?

2. What does the orientation of clasts in a stream reveal about the direction in which water flows?

3. Give an example of how erosion wears down the land and how deposition builds up the land.

4. Why is running water such a major agent of erosion in an arid region like Parashant?

5. Refer to Figure 7.9. Describe one way that flash floods cause chemical weathering of rock and one way that they cause mechanical weathering of rock.

6. Why is quartz such a major component of the sand found on many beaches? Refer to weathering in your response.

FIGURE 7.9 The person who photographed this flash flood in the Grand Wash at Parashant noted hearing sounds made by boulders tumbling in the water.

7. How does the erosive power of water change with distance at Parashant?

Challenge Question

Refer to Figure 7.10, a photo of an ancient conglomerate. Based on the variety of rocks, the degree of rounding, and the sizes of the particles present, were the sediments deposited close to or far away from the mountain range from which the pebbles were eroded? Explain.

FIGURE 7.10 Clasts in an ancient conglomerate. Penny for scale.