23.2 Shaping the Land

Rivers and glaciers have played major roles in shaping Earth's landscape. Both running water and glaciers alter the land by moving sediment to new locations. You might not be familiar with glaciers, but glaciers move and as they do, they take sediment along with them. An example of how glaciers shape the land is seen in Figure 23.12. You are probably more familiar with how running water such as rivers and streams move sediment.

Moving sediment by water

Factors What factors might affect the amount of sediment that can be carried by running water? The factors include the volume of water, the slope of the land, and how rocky or smooth the land is.

Volume and slope More sediment will be moved if the volume of flowing water is high or the slope is steep. Water volume increases after heavy rains or when snow melts. The steeper the slope, the faster the water and sediment will move over the land (Figure 23.13). Higher water velocity means that larger particles can be moved and more particles can be moved at one time.

Rocky landscapes The presence of rocks in a landscape slows the process of moving sediment. This is because rocks trap sediment. Suspended sediment is likely to travel farther in water running over a smooth bottom. Barriers or rocks can be used by people to stop the transport of sediment and reduce the effects of erosion.

Flowing water carries off sediment of all sizes. The water is cloudy because it is filled with many tiny rock particles.

Photo courtesy of Jim Sammons, Sammons' INK.

Figure 23.12: *The Convict Lake basin in the Sierra Nevada Mountains was carved by glaciers.*

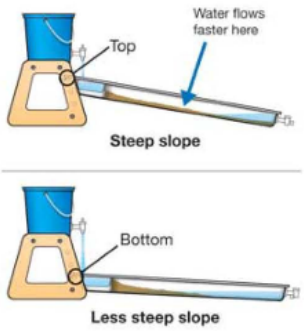


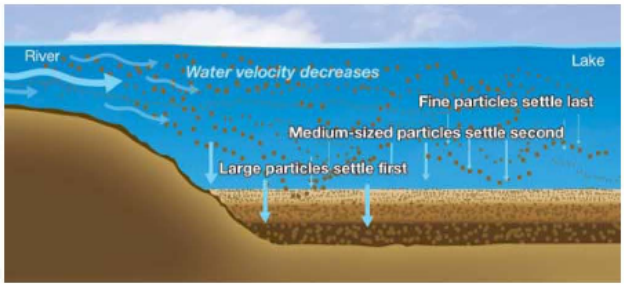
Figure 23.13: *A stream table can be used to model the effects of the slope on how fast water flows and how much sediment is transported.*

Depositing and sorting sediment by water

Deposition As it is moved by water, sediment can be deposited in a variety of places. The process of depositing sediment after it has been moved by water, wind, ice, or gravity is called **deposition**.

Fast versus slow water The steeper the slope of land, the greater the water velocity and energy of flowing water. Both the speed of water and its energy are directly related to the amount of sediment and the size of the particles that can be carried. Fast, high-energy water moves more sediment and bigger rock particles. Slow-moving water moves less sediment and more fine-grained particles.

How sediment is sorted by water During conditions when water is flowing, the size of sediment particles that are deposited depends on the speed at which the water is flowing. As running water slows down, rock particles settle out in order of size from largest to smallest. When a flowing river enters a lake or a pond, the water velocity decreases. Then, the sediment is deposited in order of size in a pattern called **graded bedding**. First, the largest particles settle to the bottom. Next, the medium-sized particles settle. Finally, the smallest, clay-sized particles settle. It's common to find graded bedding in repeating layers, one on top of the other. For example, a stream that flows into a lake might run fast only during thunderstorms. The stream lays down a graded bed of sediment after each storm.



VOCABULARY

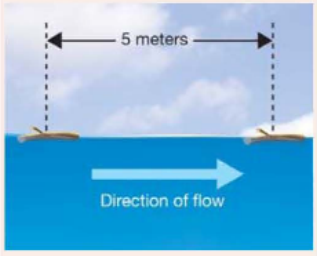
deposition - the process of depositing sediment after it has been moved by water, wind, ice, or gravity.

graded bedding - layers of sediment with the largest particles at the bottom and smallest particles on top; the particles are deposited as flowing water slows down.

SOLVE IT!

River Velocity

You can measure the velocity of a river's surface water using a floating object. For example, a floating twig is timed with a stopwatch as it travels 5 meters. If it takes the twig 10 seconds to travel this distance, what is the water velocity in meters per second?

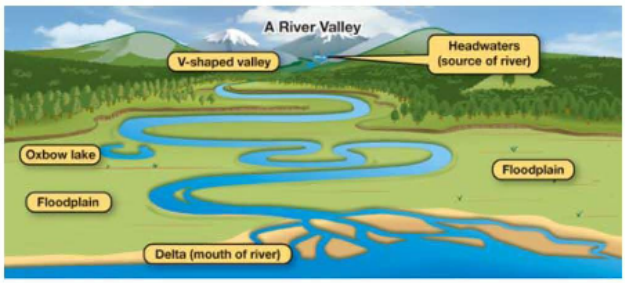


Rivers

What is a river? A **river** is a large, flowing body of water. A **stream** is a small river. The path that a river or stream follows is called a **channel**. A *delta* is the landform associated with the mouth of a river as it flows into an ocean, lake, or another river. The following paragraphs further describe how rivers shape land.

River valleys A river valley is created where rivers erode the land. Rivers tend to cut V-shaped valleys like the one shown in Figure 23.14. A V-shaped valley indicates that the river is fairly young or near its source (called the headwaters). In general, valleys are low-lying land features that are surrounded by higher land features such as hills and mountains. River valleys are changing environments because the amount of water that flows through them changes. The amount of water decreases or increases (even to the point of flooding) based on rain or snow melt.

Floodplains Along the length of the river and toward the mouth (the place where the river meets the ocean), the river widens and forms a floodplain. A **floodplain** is flat land alongside a river that tends to flood. A floodplain also forms over time as the river erodes the land on each of its sides. A floodplain is very good land for growing plants because seasonal flooding of the river deposits nutrients in the soil. However, because flooding occurs regularly, these areas are not ideal for buildings or homes.



VOCABULARY

river - a large body of water that flows into an ocean, lake, or another river.

stream - a small river.

channel - the path that a river or stream follows.

floodplain - flat land alongside a river that tends to flood. A floodplain is usually located at a distance from the headwaters of the river.

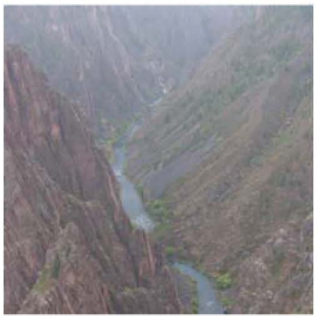


Figure 23.14: *A V-shaped valley cut by a river.*

River meanders

What are meanders?

The diagram of the river valley on the previous page illustrates *S*-shaped curves. These river features are called **meanders** (Figure 23.15). They are formed because water flows at varying speeds in a river. After a meander forms, the speed of water flow varies depending on its position in the channel. The fastest flow is on the outside of each curve, while the slowest flow is on the inside. Fast-moving water erodes sediment. Slow-moving water deposits sediment. The fast-moving water erodes the outside riverbank and at the same time, the slower water deposits sediment on the inside bank. The sediment that settles near the inside bank forms a *point bar*. The point bar adds to the inside of the meander curve and extends it. A channel bar is formed by sediment that is eroded from the riverbank. The extra sediment is too much for the stream to transport, so it is deposited in the channel. Why can't the stream carry this extra sediment? Because the velocity of the water flow is too low.

Moving meanders

Once a river has meanders, the combination of erosion on the outside bank and depositing on the point bar (inside bank) causes the river to shift its course side to side. Sometimes this process causes a meander to become cut off from the river, and it forms a curved lake called an *oxbow lake* (see the river valley diagram on the preceding page).

Photo courtesy Jim Sammons, Sammons' INK.

VOCABULARY

meanders - *S*-shaped curves in a river.

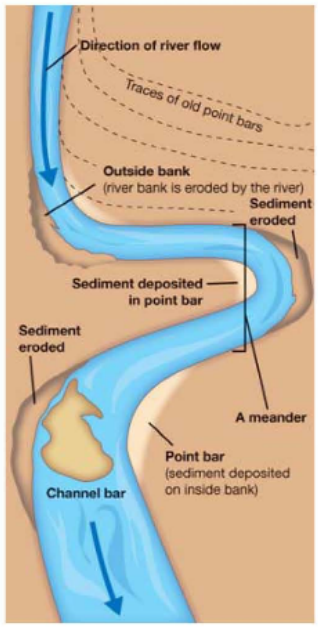


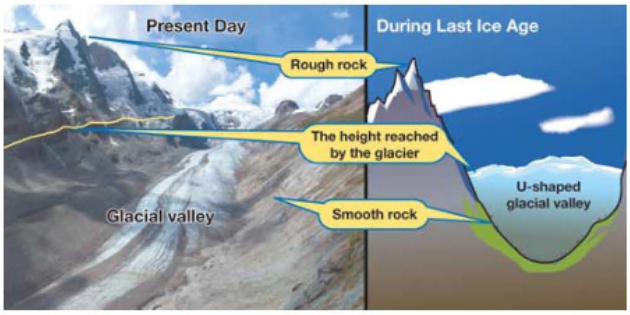
Figure 23.15: *A diagram of a meandering river.*

Glaciers move sediment

What is a glacier? In Chapter 22, you learned that a *glacier* is frozen water found at the poles and on mountaintops as huge masses of ice or ice sheets. A glacier can be many kilometers thick and thousands of kilometers across. A glacier forms on land when snow and ice accumulate faster than they melt. The stages of accumulation can take place over hundreds or thousands of years as snow piles up in the winter and does not entirely melt during the warmer summer months.

Glaciers move As layers and layers of snow accumulate, pressure builds and changes the snow to thick ice. The thick ice becomes so heavy that it becomes plastic and flows (Figure 23.16). *Plastic* means "able to change shape without breaking." Recall that the term *plastic* was also used to describe hot rock in the mantle in Chapter 20. The force of gravity drives the movement of glaciers.

Glacial valleys are *U*-shaped As the ice of a glacier flows down a valley, it grinds the valley floor with pieces of rock caught up in the ice (Figure 23.17). This grinding, or abrasion, smooths the rock it encounters and changes the shape of the valley so that it is *U*-shaped. The highest parts of the ridges surrounding the valley are usually rough because abrasion by the glacier didn't occur that high up. A change from rough to smooth rock is common in glacial valleys and indicates the highest point that the glacier abraded the mountain.



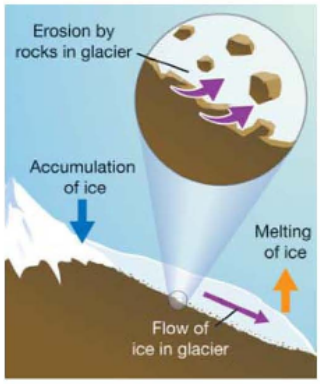


Figure 23.16: *Erosion by a glacier.*

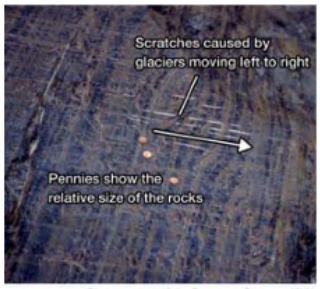


Photo courtesy of Jim Sammons, Sammons' INK.

Figure 23.17: *A glacier passed over this rock, moving from left to right. The scratches were made by rocks caught in the moving ice.*

The effects of ice and glaciers on land and our climate

Glaciers deposit sediment

About 30% of Earth's surface was covered by glaciers 10,000 years ago. As Earth's climate warmed, glaciers melted—except for those near the poles and at higher elevations. The movement, or "retreat," of glaciers toward the poles as the climate warmed and the glaciers melted deposited huge piles of rocks, scratched surfaces of rocks, and eroded valleys and mountaintops. Long Island, in New York, was created by a glacier bulldozing and depositing rocks and sediment as the glacier retreated. Rocky soil in New England is evidence of glaciers moving and depositing rocks and sediment. Retreating glaciers often leave behind large blocks of ice, surrounded by rock and sediment. After the blocks melt, steep-sided depressions are left called *kettle holes*. If these kettle holes extend below the water table, a kettle lake forms. Most of the deep lakes of southern New England are kettle lakes.

Ice and global warming

In Chapter 15, you learned about global climate change and its effects on Earth. Indicators that global climate change is happening include a decrease in the amount of sea ice and permafrost on Earth and the significant retreat of glaciers. One possible side effect of the loss of sea ice is the opening of the Northwest Passage north of Canada. Concerned about this possibility, Canada has recently made policies that state its ownership of the passage should it thaw and become a major channel for shipping goods. *Permafrost* is permanently frozen soil (Figure 23.19). Although the amount of permafrost on Earth is decreasing, another concern worries scientists—the potential release of billions of tons of greenhouse gases such as methane from the frozen ground, which will further increase global warming.

Glaciers and global warming

Interestingly, glaciers are talked about by scientists as having "health." The size of a glacier is determined by the rate at which it accumulates snow and ice near its head, and by the rate of ice loss farther down the glacier. A healthy glacier has a growing, or steady, ice mass balance. Glaciers retreat when the rate of ice loss exceeds the rate of ice gain (Figure 23.18). According to scientists, worldwide glacial retreat has been taking place since 1850 and at a faster rate since 1995 due to global warming. As you read in Chapter 15, a consequence of glacial retreat is increased global sea level as glaciers melt.

Figure 23.18: *The Athebaska Glacier in Alberta, Canada, in retreat.*

Figure 23.19: *Permafrost along the coast of Alaska. This image shows the erosion of permafrost by the ocean.*

Section 23.2 Review

1. What factors affect how much sediment is transported by moving water?
2. What factor causes a river to flow faster?
3. What effect might a steep slope have on the erosion of a hillside? Why?
4. What is deposition?
5. A rainstorm causes a stream to flow faster and deposit more sediment into the lake that already has one graded bed. A week later, another rainstorm occurs. What would the sediment of this lake look like now?
6. Why are floodplains good areas for growing plants? Why are floodplains not good areas for building housing developments?
7. In a meandering river:
   a. Where does the water flow fastest? What happens at this location?
   b. Where does the water flow slowest? What happens at this location?
8. Look at Figure 23.20. Name the feature that the arrow is pointing to in this photograph.
9. Scientists can use a wading rod, a spinning propeller device, and a velocity sensor to measure the velocity of flowing water at any point in the river. Refer to Figure 23.21 and answer the questions below.
   a. Where is the river flowing the fastest?
   b. Where is the river flowing the slowest?
   c. Come up with a hypothesis for why the river is flowing the slowest at this location.
10. What is the difference in shape between a river valley and a valley shaped by a moving glacier?
11. A glacier is a mass of solid ice, yet it flows. Explain why.
12. What type of evidence would indicate that a landscape has experienced erosion by running water? a glacier?
13. Sea ice, permafrost, and glaciers have all been affected by global climate change. Explain why the effects are problematic for people. Do your own research to expand your ability to answer this question.

Photo courtesy of NASA

Figure 23.20: *Question 8.*

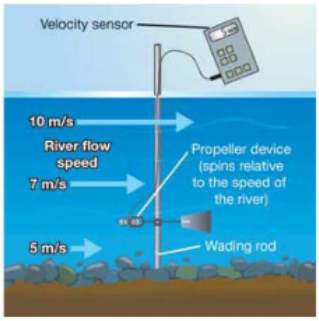


Figure 23.21: *Question 9.*