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Abstract:	Three forces of erosion are water, glaciers and wind. The most powerful erosive force on earth is water which causes erosion in its solid form and as a liquid. Water in its liquid form causes erosion in many ways. Streams from tiny creeks to huge rivers carry tons of eroded earth every year. Oceans and lakes also cause erosion. Water in its frozen form also contributes to erosion. While tiny pockets of ice within a rock can split it into dozens of pieces, huge glaciers can carve out whole valleys and scrape a hilly landscape flat. Wind can sweep away huge amounts of sand, dust, and other bits of earth. INSET: BENEFICIAL EROSION. (Copyright applies to all Abstracts)
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THE FORCES OF EROSION: WATER, GLACIERS, AND WIND

When the wind whips up a dust storm that stings our eyes, its ability to move soil is very clear. But the most powerful erosive force on earth is not wind but water, which causes erosion in its solid form — ice-and as a liquid.

Water in its liquid form causes erosion in many ways. Streams — from tiny creeks to huge rivers — carry tons of eroded earth every year. The size of the eroded material a stream can carry depends on the speed of the stream and how turbulent, or rough, the water is. A fast, turbulent stream can carry large rocks, while a slow, gentle stream carries only smaller particles of sand and clay.

Pulled down by gravity, eroded material eventually settles out of the stream when the stream no longer moves powerfully enough to carry it. A large river may carry its load for hundreds of miles. Some material drops out of the current along the river's floodplain. This is the flat area, on both sides of a river, that is likely to be covered by water when the river floods. At the river's mouth, the place where it joins an ocean or a large lake, the river slows down even further. There it fans out and deposits more material in a broad area called a delta.

Water causes erosion even before it reaches streams. A simple rainstorm loosens soil and carries it off through sheet erosion. The rainwater flows in a thin layer over the surface of the ground until it reaches a ditch or stream. Once in the ditch, the water erodes the channel even more, cutting deeper into the soil or rock it flows through.

In arid, or very dry, regions such as the southwestern United States, many streams swell with rain and melted snow in the spring, then shrink to a trickle by July or August. After the spring rains, it often doesn't rain again until the violent storms of late summer. When fierce summer rains hit the dry soil, most of the water runs off into the nearly dry creek beds. Within minutes of a big rain, this water surges over the stream banks to form flash floods that can wash away

roads, bridges, and cars, as well as tons of soil and rock.

Not all water from rain and melted snow flows over the surface of the land. Some water seeps down into the ground, especially where the land is flat. There it fills the joints and holes within rocks and causes chemical weathering.

Oceans and lakes also cause erosion. Particles such as dust, sand, gravel, and seashells are pushed up onto the beach by incoming waves. Later they wash back into the water on other waves. Over time, the waves create beaches that look much the same from year to year. Dunes are in the same places, and shells washed in by the surf pile up at the same spots. But the individual grains of sand that make up the beach are continually being traded. They wash up onto the beach, help form the landscape, and eventually get whisked away again, to be replaced by other grains of sand from the ocean depths.

Rocky shorelines erode differently from sandy beaches. As the endless motion and power of the water erode softer rock along the shoreline, the remaining erosion-resistant rock forms arches, caves, and chimneylike sea stacks.

Water in its frozen form also contributes to erosion in many ways. While tiny pockets of ice within a rock can split it into dozens of pieces, huge glaciers can carve out whole valleys and scrape a hilly landscape flat.

Glaciers form in areas that don't get warm enough for all the snow that falls to melt. The snow keeps piling up until it is packed so deep and heavy that it turns to ice, just as a snowball does when you squeeze it hard.

The conditions that allow glaciers to form occur in high mountains and near the earth's poles. During the Ice Ages, 15,000 to 20,000 years ago, earth's climate was about 10°F (5.5°C) cooler than it is today. More snow fell during the cold season, and much less snow melted during the warm part of the year. As a result, glaciers didn't develop only in the high mountains and polar regions. They grew until they covered much of the land that is now Canada and the northern United States, as well as northern Europe and Asia, and the southernmost parts of South America.

Glaciers are solid ice, several hundred feet to several miles thick. The tremendous weight of all that ice presses so heavily on the bottom part of the glacier that the ice there changes form. Although it still looks hard and brittle, it softens and begins to flow very slowly. At the same time, ice crystals all through the glacier gradually slip past each other. These small movements carry the glacier downhill.

A glacier moves a few inches to several yards each day. Whenever more snow gathers at its higher, colder end, the added weight helps push the glacier down the mountainside. The leading edge of the glacier is the end that is at a lower elevation where the temperature is warmer. This part of the glacier often starts to melt. If snow is added to the high end of the glacier faster than it melts from the leading edge, the glacier advances. It gets wider and thicker, and its leading edge moves farther downhill. In warmer periods, the glacier melts so fast that the new snow can't keep up. Then the glacier shrinks in width and depth, and retreats up the mountain valley it carved.

Because a glacier is both hard and heavy, it erodes almost everything in its path. It scours rock, scrapes away soil, and even dislodges big rocks and boulders. These in turn scrape up other rocks as the glacier creeps along. The glacier then carries these chunks of earth with it as it flows. When a glacier retreats, the soil, gravel, and rocks it has been carrying fall to the ground. Rocks that are dropped by a glacier are called erratics. Sometimes eroded material piles up into ridges or hills called moraines. The weathered rock left behind can be further eroded by streams, storms, and high winds.

Although wind can't carry boulders or rocks, it can sweep away huge amounts of sand, dust, and other bits of earth. Like water, wind also drops its load of eroded earth when it slows down. It usually deposits fine particles across a wider area than a river does. If the wind slows down at about the same place day after day and year after year, the eroded material it drops

may pile up to form hills or dunes.

Wind moves eroded material in different ways, depending on the size of the particles and the strength of the wind. A strong wind lifts the finest particles, like dust, high in the air. It may haul them hundreds or even thousands of miles. Slightly larger particles, such as fine sand, jump into the air a few feet and fall to earth after traveling a short distance. They may jump again as the wind continues to blow. The same size particles in a lighter wind, or slightly larger particles in a strong wind, roll and tumble along the ground. Larger particles, such as pebbles, stay on the ground but are nudged along by the wind. In these ways, wind can move tons of earth many miles.

Some of the best farmland in the world was created by wind erosion. Over millions of years, wind scooped up fine, dustlike material called loess (LUSS) from deserts and from glacier-scraped mountains. It then deposited layers of loess up to 200 feet (61 m) deep in large areas of the Ukraine, China, Argentina, and the Great Plains of the United States and Canada. Over time, as plants, earthworms, and microorganisms started growing in it, the loess became very fertile soil that people use to grow crops like wheat and corn.

Water, glaciers, and wind all carry eroded material. Eventually, pulled down by gravity, all eroded material conies to rest on the earth again. There it forms new soil or rock. It may form a river delta or a floodplain. Over millions of years, it may help form new mountains by being lifted up by an earthquake or volcano. Then the winds and waters go to work on it again, as erosion continues to whittle away at the earth.

DIAGRAM: MOVEMENT OF ICE CRYSTALS WITHIN A GLACIER

PHOTO (COLOR): Water — the most powerful erosive force no earth

PHOTO (COLOR): Above: This river has deposited eroded material to form a lush floodplain.

PHOTO (COLOR): Right: The rocks on the near bank of this river don't match the rock face on the far bank — a clear sign that the river carried the rocks from upstream.

PHOTO (COLOR): A flash flood can move a great amount of soil. As floodwater rushed across this field (above), it dumped almost 3 feet (0.91 m) of sand along this fence line. The wavy pattern in this dry, sandy streambed (right) was left by rushing water.

PHOTO (COLOR): Top right: Sea stacks off the coast of Oregon

PHOTO (COLOR): Right: The sand on a beach is constantly moved by the waves, even if the beach always looks the same.

PHOTO (COLOR): The icy arm of a glacier cuts through the mountains of Alaska.

PHOTO (COLOR): This field in Maine is littered with glacial erratics.

PHOTO (COLOR): In some places, sand carried by the wind piles up into dunes.

PHOTO (COLOR): Opposite: Dusk settles over glacier-scraped mountains in Montana.

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WRITTEN AND PHOTOGRAPHED BY Cherie Winner

BENEFICIAL EROSION

In many parts of the world, eroded earth carried by rivers forms nutrient-rich soil that

allows people to farm in areas that would otherwise be poor for farming. For centuries, the Nile River flooded the arid lands of northern Egypt every year. With each flooding, the river deposited more than 9 million tons (8.2 million metric tons) — more than half a million dump trucks full — of eroded soil from the mountains of Ethiopia. This rich soil, left on the Nile floodplain and delta, provided excellent farmland.

In 1970, the Egyptian government finished building the Aswan High Dam across the Nile. The government wanted to save water for dry years, prevent damaging floods in wet years, and allow people to farm year-round.

But the dam doesn't just hold back water. It also catches the tons of precious soil that normally helped Egypt's farms to thrive. As a result, farms downstream from the dam no longer receive fresh, fertile soil each year. And without its yearly dose of new soil, the Nile Delta is being eroded by the waves of the Mediterranean Sea. The natural balance between addition and erosion has been destroyed.

Source: Erosion