EXERCISE 10  MASS MOVEMENT

Objective
To recognize the distinctive surface features produced by mass movement and to understand the role mass movement plays in the evolution of slope systems.

Main Concept
The movement of surface material downslope is a universal erosional process. It occurs on the steep slopes of high mountains, on gentle rolling plains, on sea cliffs, and on the slopes of the ocean floor. Mass movement is thus a significant factor in slope erosion and slope retreat.

Supporting Ideas
1. The most important factors influencing mass movement are (a) the saturation of slope material with water, (b) freezing and thawing, (c) the oversteepening of slopes, and (d) earthquakes.
2. The most significant types of mass movement that produce landforms large enough to be seen on aerial photographs and topographic maps are (a) rock falls, (b) debris flows, (c) landslides, and (d) rock glaciers.

Mass movement includes all types of slope failure. Because of its potential for destruction, mass movement has been studied by engineers as well as geologists. As a result, it has been classified in various ways. In this exercise, we will consider four main types that produce features large enough to be seen on aerial photographs and topographic maps.

Rock Falls
Rock falls include the free fall of fragments, ranging from a single grain to huge blocks weighing millions of tons. Small- to moderately sized fragments are commonly broken loose by ice wedging and accumulate at the base of a cliff as a talus cone.

Debris Flows
A debris flow is a mixture of rock fragments, mud, and water that flows downslope as a viscous fluid. Movement can range from a flow that is similar to that of freshly mixed concrete to that of a fluid stream of mud with a velocity nearly equal to that of running water. Debris flows include mud flows composed mostly of fine-grained material, coarse debris involving huge block of rock, and lahars (volcanic mud flows).

Landslides
Although the vague term landslide has been applied to almost any kind of slope failure, a true landslide involves movement along a well-defined slipsage plane, with much of the material moving as a large slump block. The detached block leaves behind a distinct curved incision, or scar. The slippage plane is typically spoon shaped. As the block moves downward and outward, it commonly rotates in such a way that bedding or other identifiable surfaces are tilted backward toward the slippage plane. In the lower part of the slump block, part of the displaced material may move as a debris flow. The characteristic scar, tilting of bedding or other surfaces, and jumbled, poorly drained hillocks formed by previous slides serve to identify terrains that have been modified by landslides.

Rock Glaciers
Rock glaciers are long, tongue-like masses of angular rock debris with pore spaces filled with ice. They resemble a glacier in general outline and form. The surface of a rock glacier is typically furrowed by a series of parallel flow ridges, similar to those in an advancing lava flow. Evidence of movement includes concentric wrinkle ridges, a lobate form, and a steep front. Measurements indicate that rock glaciers move as a body downslope at rates ranging from 2 in./day to 3 ft./yr.

Rock glaciers commonly occur at the heads of glaciated valleys and are fed by a continuous supply of rock fragments produced by ice wedging on the cirque wall. Ice in the pore spaces between the rock fragments presumably is responsible for much of the flow movement. With a continuous supply of rock fragments from above, the weight of the mass increases and causes the mass of ice and rock to flow. Favorable conditions for the development of rock glaciers thus include steep cliffs and a cold climate.

Problems
Answer the questions associated with the photographs on pages 124–126.
1. San Juan Mountains, Colorado

a. List the types of mass movement that you can identify on this photograph.

b. One type of mass movement in this area forms large, tongue-like landforms with a wrinkled upper surface. Map these features and explain how they form.

c. What types of mass movement probably occur in this area but do not produce a major landform?

d. List the geologic conditions in this area that are conducive to mass movement.

2. Mass Movement—British Columbia, Canada

a. What types of mass movement have occurred in this area?

b. What natural geologic conditions exist in this area that would be conducive to mass movement?

c. What effect did this pulse of mass movement have on the geologic processes operating in the valley and on human activity?

d. What evidence suggests that there have been several pulses of movement in the "landslide" areas?

e. Compare and contrast the mass movement in this area with that shown in the photograph above. How are they similar?
3. Lake San Cristobal, Colorado
This area is in the San Juan Mountains of Colorado. The rocks are mostly Tertiary volcanics, with andesites and pyroclastic rocks dominating.

a. What is the origin of Lake San Cristobal?

b. What type of mass movement is the Slumgullion slide?

c. What material most likely is involved in the Slumgullion slide?

d. How thick is the slide debris near the shores of Lake San Cristobal?

e. What was the approximate depth of the lake when it was first formed?

f. Trace the boundaries of the Slumgullion slide on the map, and draw an arrow pointing toward the source, or head, of the slide.

g. What areas might be considered a high risk for future slides? Show these areas on the map with a red felt-tipped pen.
4. Submarine Mass Movement

Submarine mass movements surrounding the islands of Hawaii are among the largest and most fascinating ones on our planet. Several factors are involved in their development. (1) Rift zones commonly develop as flanks of the volcano form major zones of structural weakness. (2) Lava flows that reach the ocean are rapidly quenched by seawater and shattered, producing a steep blanket of unstable volcanic sediment that mantles the upper submarine slopes. Above sea level, the volcanoes develop the classic shield profile of gentle lava flow slopes, whereas below sea level, slopes are substantially steeper. When the volcanoes grow rapidly, they may collapse catastrophically, creating giant landslides and tsunami, or they may fall more gradually, forming slumps.

After volcanism terminates, the volcano continues to subside, and wave-cut terraces and deep river valleys that formed at sea level may be submerged more than 6000 feet. Prominent terraces shown in orange and yellow on this map illustrate the size of the islands in the past.

There are two types of submarine mass movements: (1) Catastrophic landslides, which can carry larger parts of some volcanoes as much as 100 miles across the sea floor. These are characterized by large, angular blocky debris. (2) Slower-moving slump typically develop ridges that parallel the paleocoastlines.

a. What indicates that Maui Lanai, Molokai, and Oahu are part of the same volcanic complex?

b. What type of mass movement is more common around the island of Hawaii?

c. What type of mass movement is most common around the island of Kauai?

d. Where is the largest slide? How big are the largest blocks in this slide?
5. Mass Movement—New Mexico

The small mesa in this area is capped by a layer of basalt. The rock beneath is shale.

a. What type of mass movement occurs in this area? List evidence to support your answer.

b. What geologic factors are necessary for this type of movement to develop?

c. What will eventually happen to the mesa?

d. How is the mass movement debris removed from the base of the mesa?