ARID-CLIMATE LANDSCAPES

Better quality figures can be seen at http://www3.nd.edu/~cneal/PlanetEarth/Lab-Deserts/index.html

MATERIALS NEEDED

- Pencil and eraser
- Colored pencils
- Metric ruler
- Calculator
- Stereoscope (provided by instructor)

INTRODUCTION

The bold, commonly stark, landscapes of arid and semiarid lands contrast with the rounded, more subtle forms of humid regions. Although running water is the principal agent of erosion in arid regions, it commonly is present only after infrequent cloudbursts. Flash floods remove the products of mechanical weathering and mass wasting and leave behind steep banks and cliffs. Plateaus, mesas, and buttes develop from deep erosion of horizontal layers of resistant bedrock. As erosion wears down mountains, alluvial fans form at canyon mouths and, with time, gently sloping erosional and depositional surfaces extend outward from the mountain front. Where strong winds blow and sand is available, dunes of several types may form. In this lab, you will learn to recognize and analyze common arid-climate landforms.

Warm arid and semiarid regions (precipitation, <50 cm/year; see Fig. 8.1) are characterized by sparse vegetation, little water, thin soils, frequent strong winds, and sharp, angular landforms. Mechanical weathering predominates, and sedimentary particles tend to be coarser than in humid regions. Slopes typically are steeper, a requirement for the removal of coarser particles. Even rock such as limestone, which is readily attacked by chemical weathering in humid climates, forms steep cliffs in dry climates.

In spite of the aridity, water is the principal agent of erosion in most deserts. Rain commonly comes as downpours that quickly fill streams and cause flash floods. These floods cause extensive erosion, and sediment is quickly transported down normally dry stream beds and out into valleys before it is deposited. When sediment-choked streams spill out into a valley, they spread out to form numerous interwoven shallow channels called **braided streams** (Fig. 12.1). These braided streams rapidly deposit their sediment to form deposits of sand and gravel. Individual channels have steep, easily eroded banks. Each new flood tends to rework the older sediment and may carve a new main channel among the many secondary ones.

Wind is also an important agent of erosion and transportation in deserts, but it does not move as much material as water does. In fact, large, wind-carved rock landforms are unusual. Sand dunes, however, are common, and demonstrate that wind is an active agent of sediment transport and deposition.

EROSIONAL LANDFORMS

While most landforms in arid and semiarid regions are shaped by running water, the streams in arid regions are different from those in humid climates. Most streams are **intermittent,** carrying water only part of the year. Many, whether intermittent or **perennial,** have braided channels (Fig. 12.1). Deep canyons in dry climates may have near-vertical walls, and box-like cross profiles.

Where rivers traverse and cut into horizontal layers of sedimentary rocks or lava flows, *cliff-and-bench* topography, like that in Figure 12.2, develops. The more resistant layers of sandstone, limestone, or lava form steep cliffs where erosion has cut through them; flat benches develop on their upper surfaces. Less resistant layers of shale form gentler slopes between the benches. The cliff-and-bench topography is developed in a spectacular way on the *Colorado Plateau* of the western United States. This region, in eastern Utah, western Colorado, northwestern New Mexico, and northern Arizona, has sixteen national parks or monuments featuring this scenery, including Grand Canyon and Canyonlands.

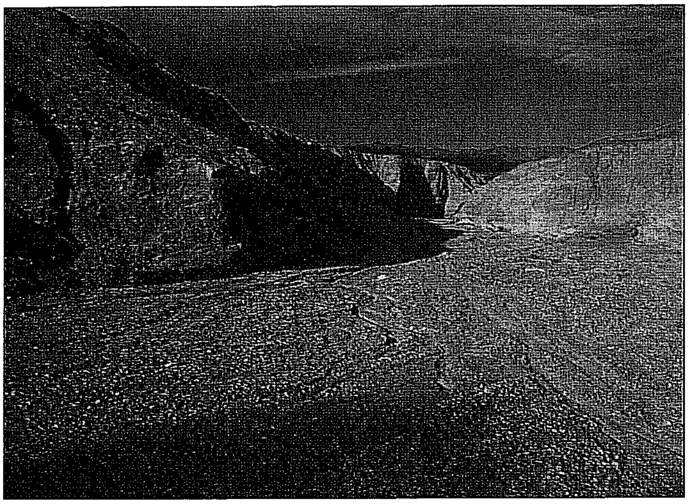

FIGURE 12.1
Upstream view of a dry stream bed in Death Valley National Monument, California, with braided channels and easily eroded banks.

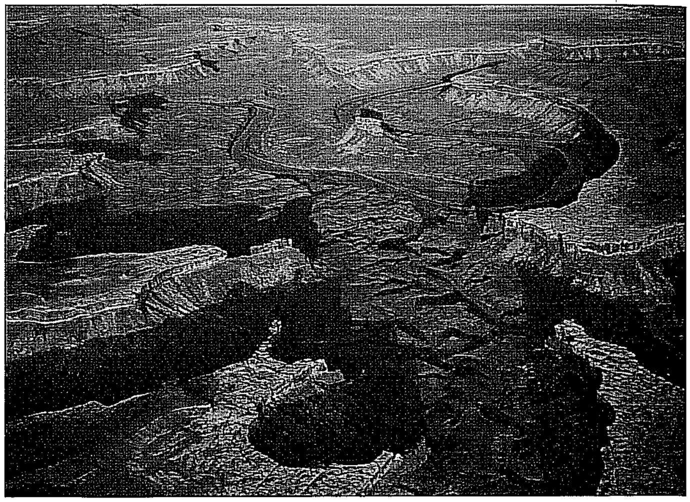

FIGURE 12.2
Cliff-and-bench topography in Canyonlands National Park, Utah, along the Green River.

Plateaus are comparatively flat upland areas that form in regions with nearly horizontal rock layers. Figure 12.3 illustrates several common features developed by the dissection of a plateau. As stream valleys enlarge by lateral and headward erosion, parts of the plateau may be cut off to form mesas. A **mesa** (table, in Spanish) is a generally flat-topped area, bounded by cliffs, that is wider (commonly by quite a bit) than it is high. **Buttes** are smaller, flat-topped landforms isolated by erosion. They are more or less as wide as they are high. **Monuments** (or spires) are slender features that are much higher than they are wide.

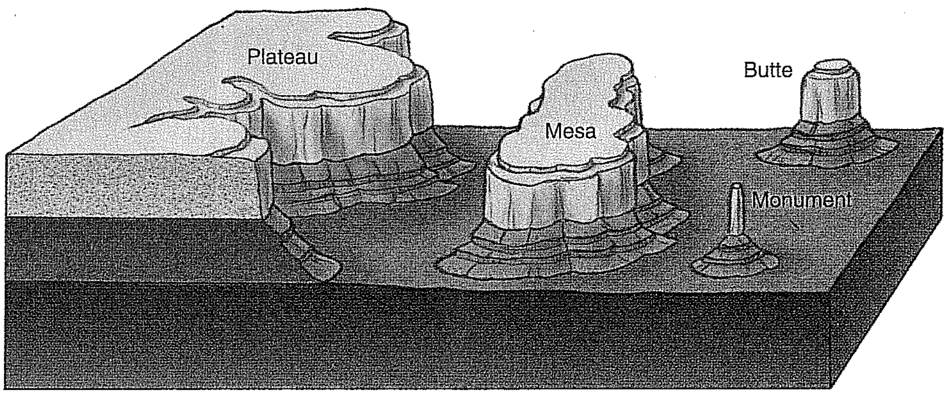

FIGURE 12.3
Characteristic erosional landforms in arid or semiarid areas with horizontal rock layers. Retreat of a plateau leaves mesas, buttes, and monuments as remnants.

Where the bedrock does not consist of horizontal layers of unequal resistance, different erosional landforms develop. In the *Basin and Range* area of the southwestern United States, rugged mountain ranges are separated by wide valleys with flat floors. The mountains were uplifted along steep faults. Although some faults are still active and are readily discernible, others have been obscured by erosion and deposition. Figure 12.4 shows a profile from a mountain into the adjoining valley. A sharp break in slope at the edge of the mountain marks the *mountain front.* The gentle valleyward slope from the mountain front is the **piedmont.** It consists of two parts, the *bajada* and the *pediment.* The bajada is

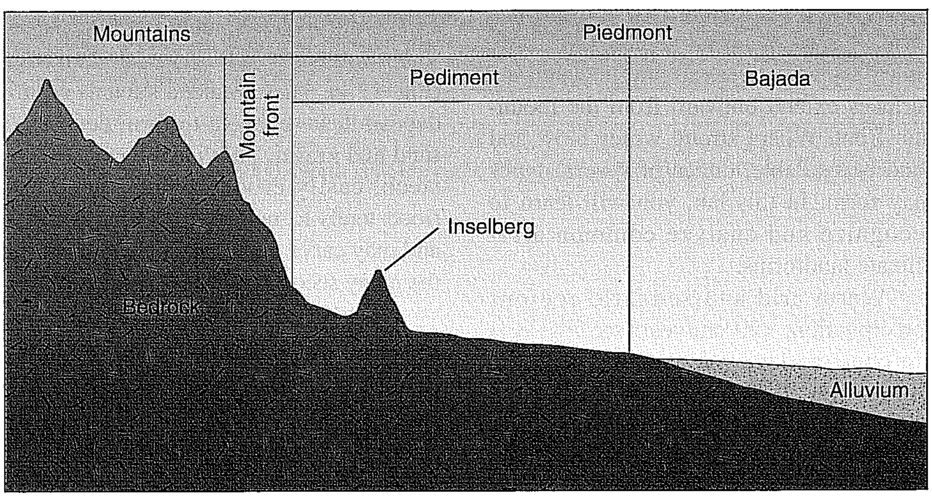

FIGURE 12.4
Profile from mountain into valley, showing the mountain front and the piedmont, with pediment, inselberg, and bajada.

FIGURE 12.5
Two large alluvial fans occur along the base of the Black Mountains in Death Valley National Monument, California. There are two wet playa lakes in the foreground. The white areas are evaporite minerals that were deposited as more extensive playas dried up.

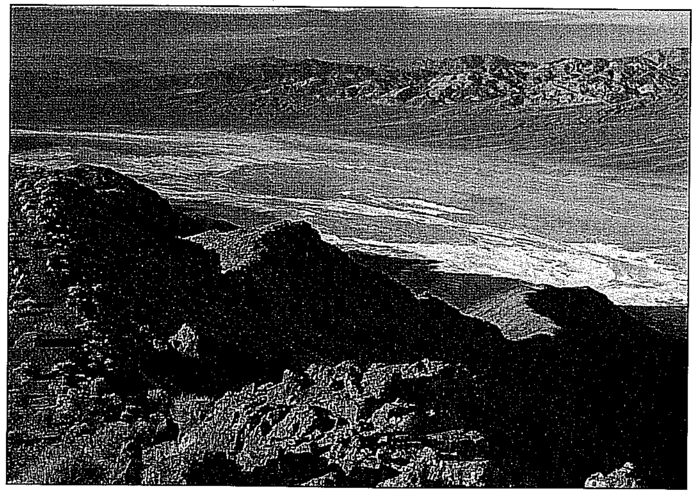

FIGURE 12.6
The dark area in front of the background mountains is a piedmont. The upper part of the dark area is the pediment and the lower part is the bajada, but you would need to be on the ground to map the boundary between them. White areas in the middle of the valley are evaporite deposits. Panamint Range, Death Valley National Monument, California.

formed by deposition, as discussed in the next section. A *pediment* is a gently sloping, erosional surface. It cuts across bedrock, and typically has a thin veneer of sediment on its surface. It is generally thought that a pediment develops as the steep slope at the mountain front retreats under the attack of erosion. The erosional debris is transported across the pediment to the bajada. Erosional remnants, or **inselbergs,** form isolated hills on the pediment.

Depositional Landforms

Water Deposits

Most sediment in arid lands is transported by intermittent streams. In mountainous areas, these streams cut and occupy rock-walled channels, and sediment transport is confined within the rock walls. As the canyons empty into a valley, the stream is no longer confined; it spreads out, losing its capacity to carry sediment. The resulting series of braided stream deposits at the canyon mouth eventually builds up a large **alluvial fan,** like those shown in Figure 12.5. With time, alluvial fans from adjacent canyons coalesce to form a **bajada,** the gently sloping apron of sediment along the mountain front in Figure 12.6. If a pediment is present, the bajada lies basin-ward of the pediment, and together, they form the piedmont at the base of the mountain (see Fig. 12.4).

When an intense rainstorm occurs in arid areas, water runs out of the highlands, down canyons, and across the piedmont. If a pediment exists, much of the water washes across it to the bajada. As it crosses the bajada, a substantial amount of water may soak into the alluvium and become part of the groundwater. But, if it is a real downpour, much water flows out into the valley. If there is no through-going drainage, water may pond to form temporary lakes called **playas** (Fig. 12.6). Evaporation of water from playas results in the deposition of evaporite minerals, such as gypsum or halite.

Wind Deposits

The most obvious wind deposits are sand dunes. They develop from the accumulation of sand-size grains that have been transported by the wind. Grains move by rolling and hopping, and rarely get more than a meter above the surface; many are set in motion by impact from other grains.

Initial deposition generally is caused by an obstacle or irregularity on the surface. Wind velocity decreases after it blows over an obstacle, and some of the sand is deposited on the downwind side; continued deposition produces a dune. Figure 12.7 is a cross section of a dune, showing how a steep, downwind face develops as sand rolls and hops up the windward side and tumbles and slips down the leeward side, forming cross-strata (see Fig. 4.4). As this process continues, the dune migrates downwind.

Differently shaped dunes develop under different conditions. The principal controls are wind velocity, vegetation, and sand supply.

Transverse dunes (Fig. 12.8A) are wave-like ridges of sand perpendicular to the predominant wind direction. They form in areas of abundant sand supply, scarce vegetation, and moderate, unidirectional winds. They are found not only in deserts, but also commonly behind beaches and on barrier islands.

Longitudinal dunes (Fig. 12.8B) are long, narrow ridges of sand parallel to the prevailing wind direction. They form where sand supply and vegetation are meager and winds are strong. Although they parallel the general wind direction,

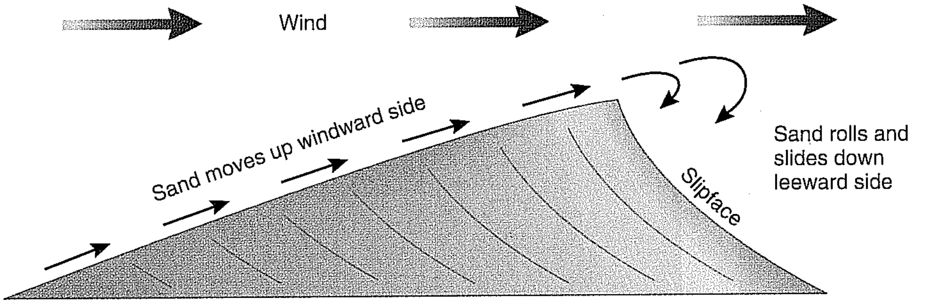

FIGURE 12.7
Cross section of a dune, showing sand moving up the gentle windward slope and falling off the steeper leeward slope.

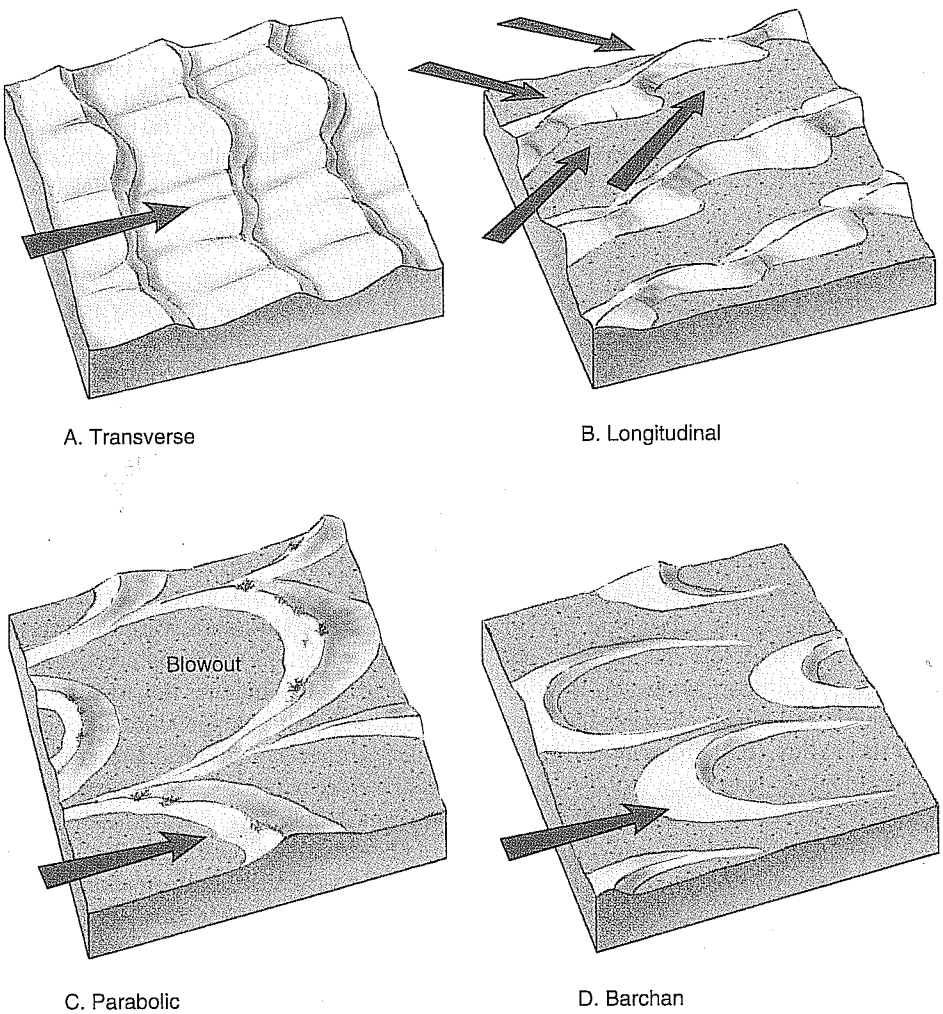

FIGURE 12.8
A. Transverse dunes; B. Longitudinal dunes; C. Parabolic dunes; D. Barchan dunes.
Source: Data from U.S. Geological Survey.

the slip face varies from one side to the other along the axis of the dune, reflecting variations in wind direction.

Parabolic dunes (Fig. 12.8C) are crescent shaped, with the steep slip face on the convex side so that the horns point upwind. They typically develop where vegetation is available to anchor the horns. In many, the area in front of the dune, between the horns, is a **blowout,** a small depression excavated by the wind.

Barchan dunes (Fig. 12.8D) are crescent shaped, like parabolic dunes, but the steep slip face is on the concave side so that the horns of the crescent taper and point downwind. Barchans develop best on barren desert floors where prevailing wind direction is constant, vegetation is scarce, and sand supply is low. They may occur singly or in groups, where they may join to form more complex shapes.

Dune fields may become inactive as conditions change. Vegetation, in particular, acts to stabilize dunes. For example, you can see the crescent shapes of vegetated dunes in the Sand Hills region of Nebraska (Fig. 9.8). However, if patches of vegetation die or are killed by overgrazing or excessive human activity, blowouts develop and active dunes may again migrate over the surrounding landscape.