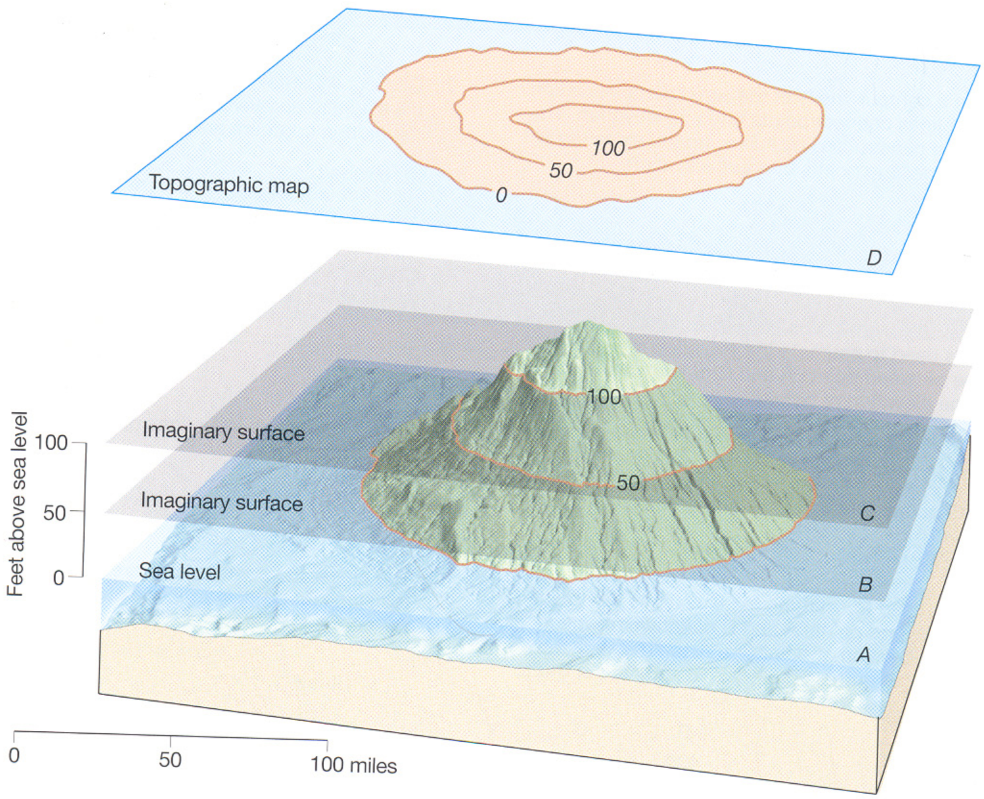
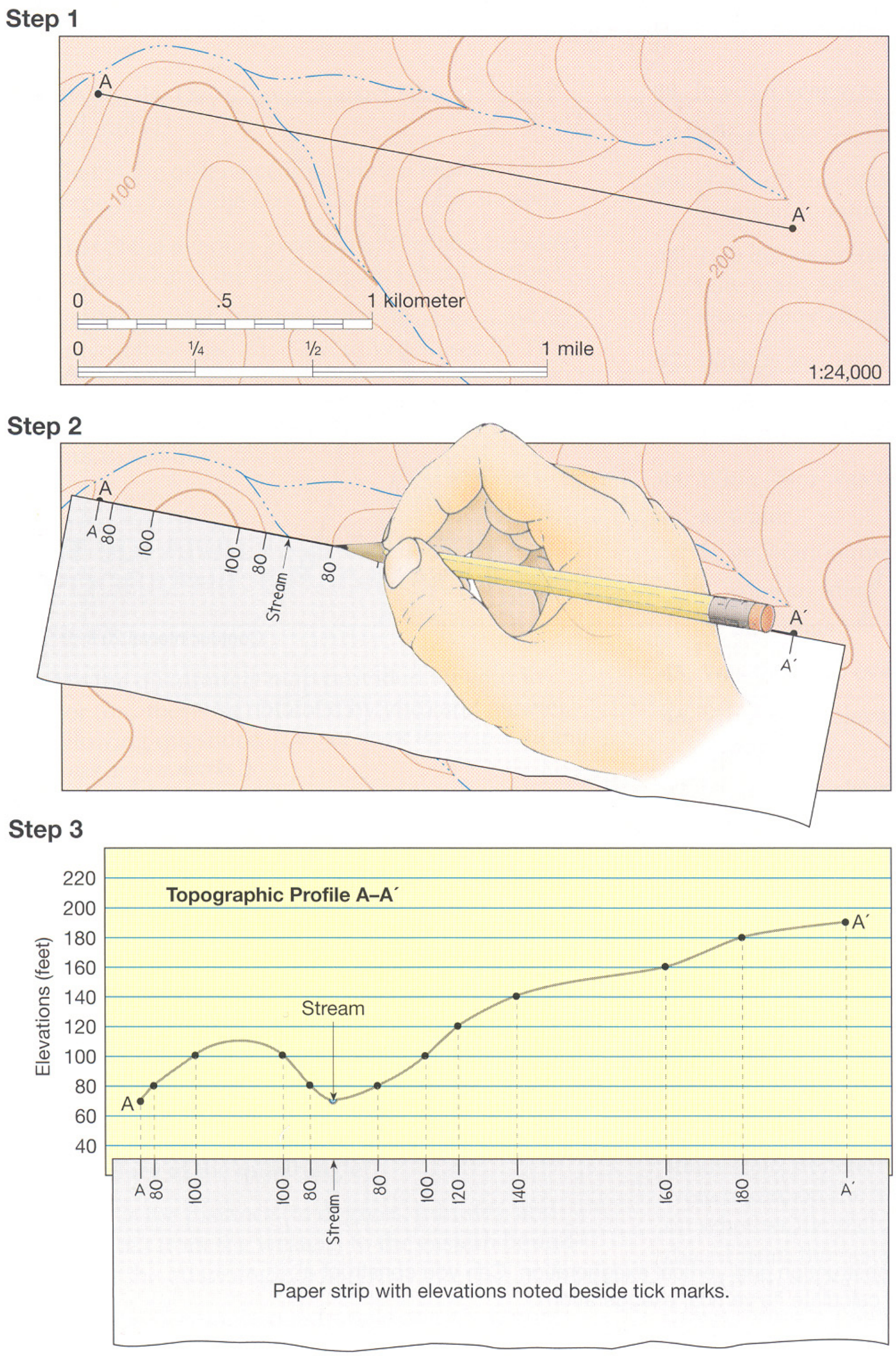


FIGURE 9.5 Topographic map construction. A *contour line* is drawn where a horizontal plane (such as **A**, **B**, or **C**) intersects the land surface. Where sea level (plane **A**) intersects the land, it forms the 0-ft contour line. Plane **B** is 50 ft above sea level, so its intersection with the land is the 50-ft contour line. Plane **C** is 100 ft above sea level, so its intersection with the land is the 100-foot contour line. **D** is the resulting topographic map of the island. It was constructed by looking down onto the island from above and tracing the 0, 50, and 100-ft contour lines. The elevation change between any two contour lines is 50 ft, so the map is said to have a 50-ft *contour interval*. The topographic datum (reference level) is sea level, so all contour lines on this map represent elevations in feet above sea level and are *topographic contour lines*. (Contours below sea level are called *bathymetric contour lines* and are generally shown in blue).

Key Concepts: reading topographic maps, using 2-D maps to model 3-D topography and elevation changes, Contour interval, contour cloasure, elevation



Step 4 Vertical Exaggeration

On most topographic profiles, the vertical scale is exaggerated (stretched) to make landscape features more obvious. One must calculate how much the vertical scale (V) has been exaggerated in comparison to the horizontal scale (H).

The horizontal scale is the map's scale. This map has an H ratio scale of 1:24,000, which means that 1 inch on the map equals 24,000 inches of real elevation. It is the same as a H fractional scale of 1 / 24,000.

On the vertical scale of this topographic profile, one inch equals 120 feet or 1,440 inches (120 feet x 12 inches/foot). Since one inch on the vertical scale equals 1,440 inches of real elevation, the topographic profile has a V ratio scale of 1:1,440 and a V fractional scale of 1/1,440.

The vertical exaggeration of this topographic profile is calculated by either method below:

Method 1: Divide the horizontal ratio scale by the vertical ratio scale.

$$\frac{\text{H ratio scale}}{\text{V ratio scale}} = \frac{1{:}24{,}000}{1{:}1{,}440} = \frac{24{,}000}{1{,}440} = 16.7\times$$

Method 2: Divide the vertical fractional scale by the horizontal fractional scale.

$$\frac{\text{V fractional scale}}{\text{H fractional scale}} = \frac{1/1{,}440}{1/24{,}000} = \frac{24{,}000}{1{,}440} = 16.7\times$$

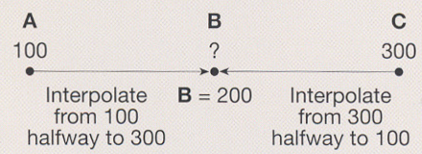
Key Concepts: make sure you can properly scale a map, practice drawing topographic profiles, calculate vertical exaggeration.

FIGURE 9.21 Topographic profile construction and vertical exaggeration. Shown are a topographic map (Step 1), topographic profile constructed along line **A**–**A′** (Steps 2 and 3), and calculation of vertical exaggeration (Step 4). **Step 1**—Select two points (**A, A′**), and the line between them (line **A**–**A′**), along which you want to construct a topographic profile. **Step 2**—To construct the profile, the edge of a strip of paper was placed along line **A**–**A′** on the topographic map. A tick mark was then placed on the edge of the paper at each point where a contour line and stream intersected the edge of the paper. The elevation represented by each contour line was noted on its corresponding tick mark. **Step 3**—The edge of the strip of paper (with tick marks and elevations) was placed along the bottom line of a piece of lined paper, and the lined paper was graduated for elevations (along its right margin). A black dot was placed on the profile above each tick mark at the elevation noted on the tick mark. The black dots were then connected with a smooth line to complete the topographic profile. **Step 4**—*Vertical exaggeration* of the profile was calculated using either of two methods. Thus, the vertical dimension of this profile is exaggerated (stretched) to 16.7 times greater than it actually appears in nature compared to the horizontal/map dimension.

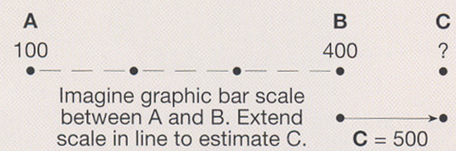
RULES FOR CONTOUR LINES

1. Every point on a contour line is of the exact same elevation; that is, contour lines connect points of equal elevation. The contour lines are constructed by surveying the elevation of points, then connecting points of equal elevation.

2. Interpolation is used to estimate the elevation of a point B located in line between points A and C of known elevation. To estimate the elevation of point B:



3. Extrapolation is used to estimate the elevations of a point C located in line beyond points A and B of known elevation. To estimate the elevation of point C, use the distance between A and B as a ruler or graphic bar scale to estimate in line to elevation C.

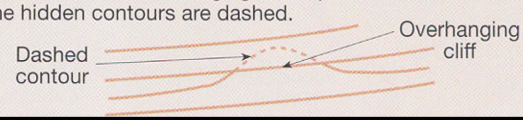


4. Contour lines always separate points of higher elevation (uphill) from points of lower elevation (downhill). You must determine which direction on the map is higher and which is lower, relative to the contour line in question, by checking adjacent elevations.

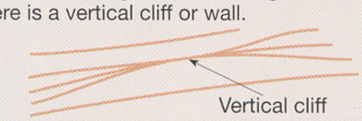
5. Contour lines always close to form an irregular circle. But sometimes part of a contour line extends beyond the mapped area so that you cannot see the entire circle formed.

6. The elevation between any two adjacent contour lines of different elevation on a topographic map is the *contour interval*. Often every fifth contour line is heavier so that you can count by five times the contour interval. These heavier contour lines are known as *index contours*, because they generally have elevations printed on them.

7. Contour lines never cross each other except for one rare case: where an overhanging cliff is present. In such a case, the hidden contours are dashed.



8. Contour lines can merge to form a single contour line only where there is a vertical cliff or wall.

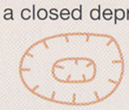


9. Evenly spaced contour lines of different elevation represent a uniform slope.

10. The closer the contour lines are to each other the steeper the slope. In other words, the steeper the slope the closer the contour lines.

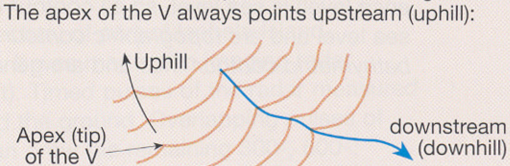
11. A concentric series of closed contours represents a hill:

12. *Depression contours* have hachure marks on the downhill side and represent a closed depression:



See Figure 9.8

13. Contour lines form a V pattern when crossing streams. The apex of the V always points upstream (uphill):



14. Contour lines that occur on opposite sides of a valley or ridge always occur in pairs. See Figure 9.9.

FIGURE 9.6 Rules for constructing and interpreting contour lines on topographic maps.

Key Concepts: make sure you understand how to read the above contour patterns and interpret The landforms associated with them. Very important: using the “law of V’s” to determine stream drainage patterns and drainage divides.

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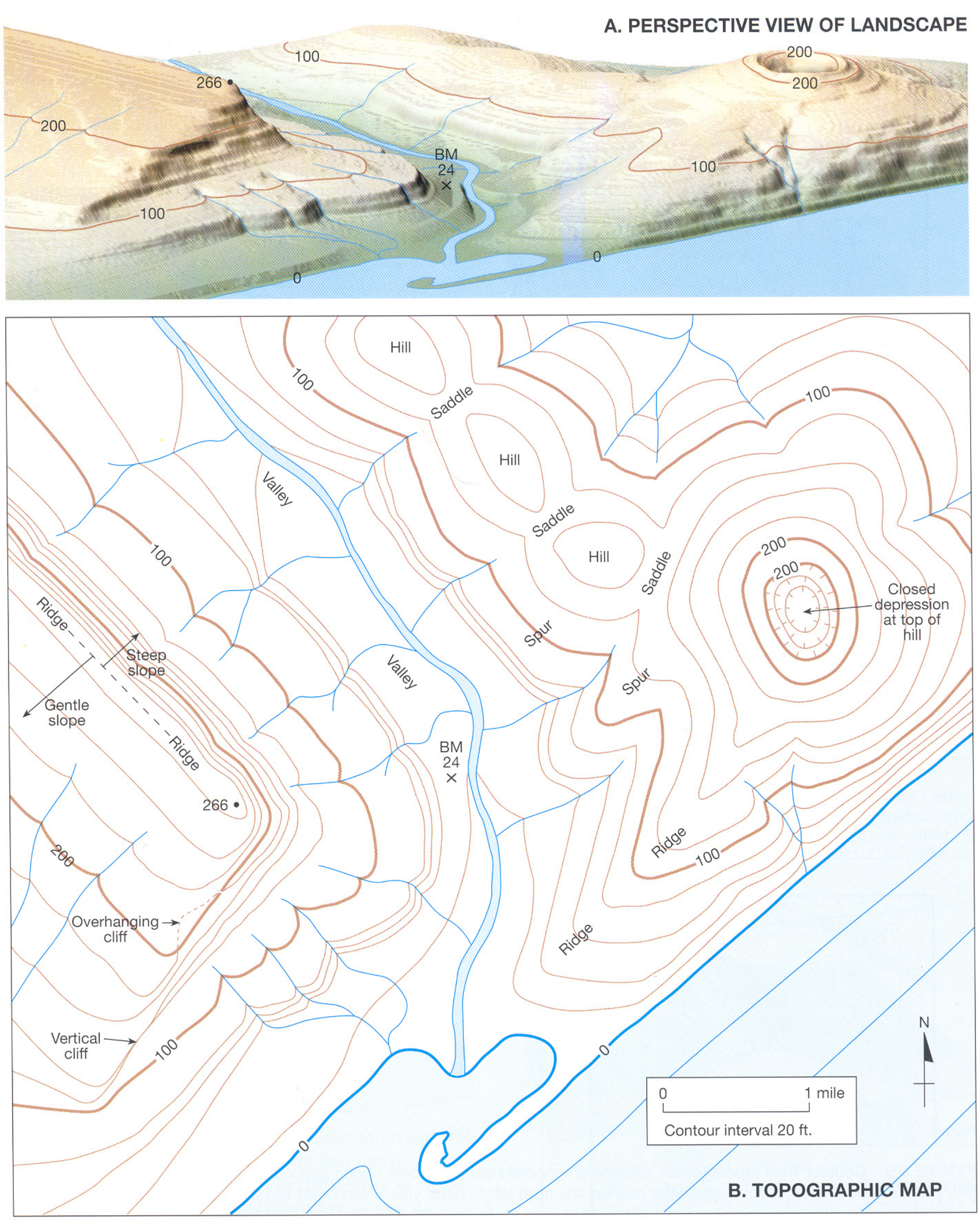


FIGURE 9.7 Names of landscape features observed in perspective view (**A**) and on topographic maps (**B**): **valley** (low-lying land bordered by higher ground), **hill** (rounded elevation of land; mound), **ridge** (linear or elongate elevation or crest of land), **spur** (short ridge or branch of a main ridge), **saddle** (low point in a ridge or line of hills; it resembles a horse saddle), **closed depression** (low point/area in a landscape from which surface water cannot drain; contour lines with hachure marks), **steep slope** (closely-spaced contour lines), **gentle slope** (widely-spaced contour lines), **vertical cliff** (merged contour lines), **overhanging cliff** (dashed contour line that crosses a solid one; the dashed line indicates what is under the overhanging cliff).

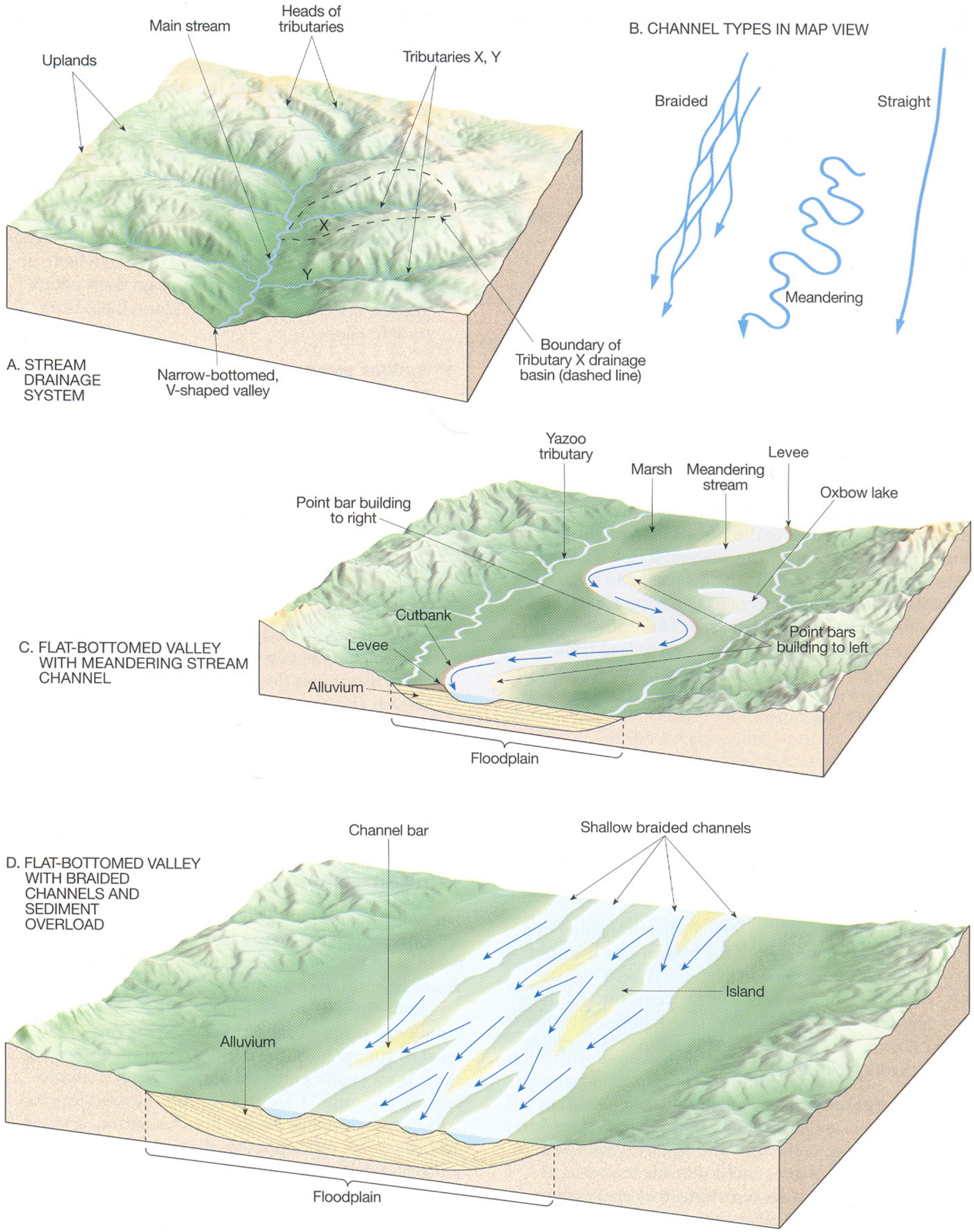
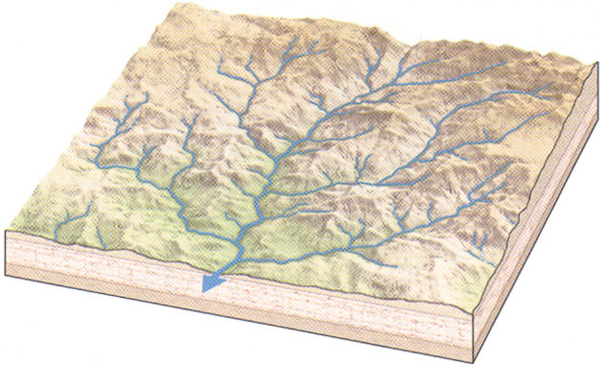
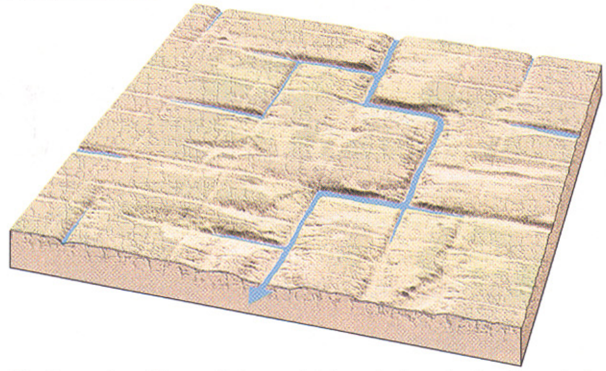


FIGURE 11.1 General features of stream drainage basins, streams, and stream channels. Arrows indicate current flow in main stream channels. **A.** Features of a stream drainage basin. **B.** Stream channel types as observed in map view. **C.** Features of a meandering stream valley. **D.** Features of a typical braided stream. Braided streams develop in sediment-choked streams.

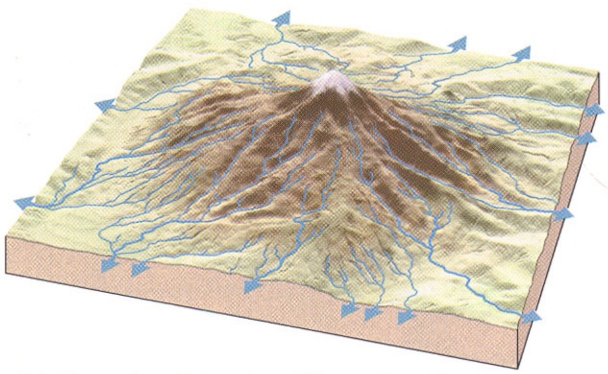
STREAM DRAINAGE PATTERNS



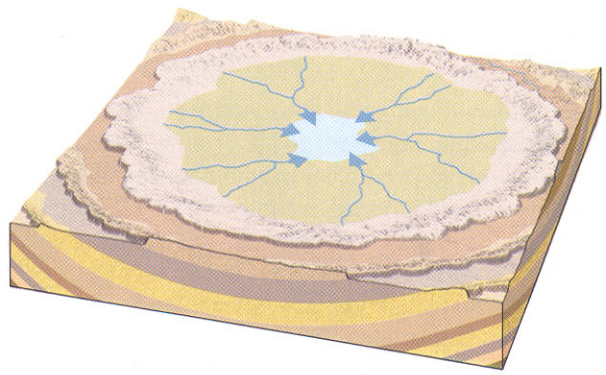
Dendritic: Irregular pattern of channels that branch like a tree. Develops on flat lying or homogeneous rock.



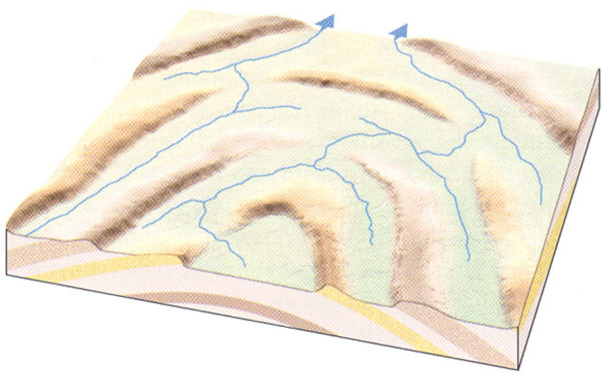
Rectangular: Channels have right-angle bends developed along perpendicular sets of rock fractures or joints.



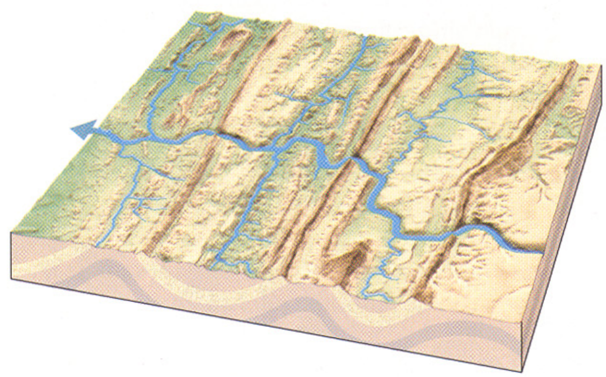
Radial: Channels radiate outward like spokes of a wheel from a high point.



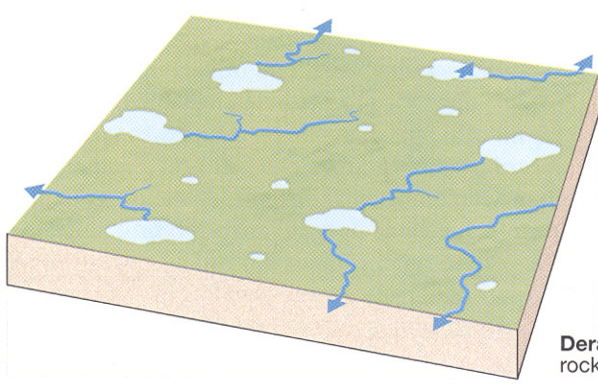
Centripetal: Channels converge on the lowest point in a closed basin from which water cannot drain.



Annular: Long channels form a pattern of concentric circles connected by short radial channels. Develops on eroded domes or folds with resistant and nonresistant rock types.



Trellis: A pattern of channels resembling a vine growing on a trellis. Develops where tilted layers of resistant and nonresistant rock form parallel ridges and valleys. The main stream channel cuts through the ridges, and the main tributaries flow along the valleys parallel to the ridges and at right angles to the main stream.



Deranged: Channels flow randomly with no relation to underlying rock types or structures.

FIGURE 11.2 Some stream drainage patterns and their relationship to bedrock geology.

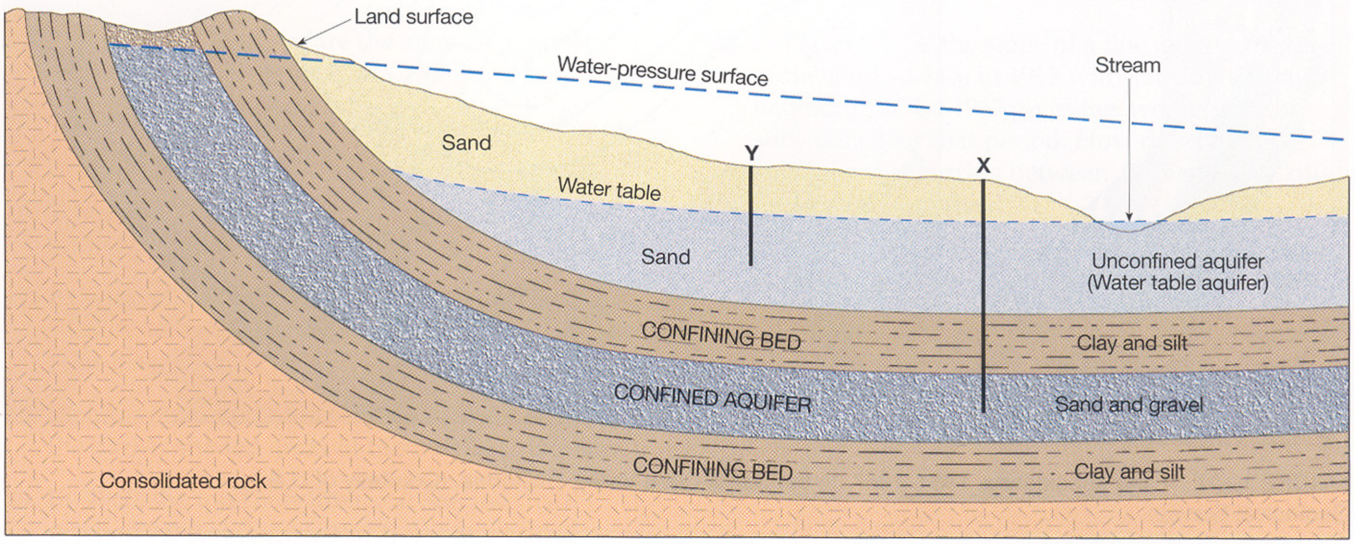


FIGURE 12.10 Geologic cross section illustrating an unconfined (water-table) aquifer and a confined aquifer. Vertical scale is exaggerated.

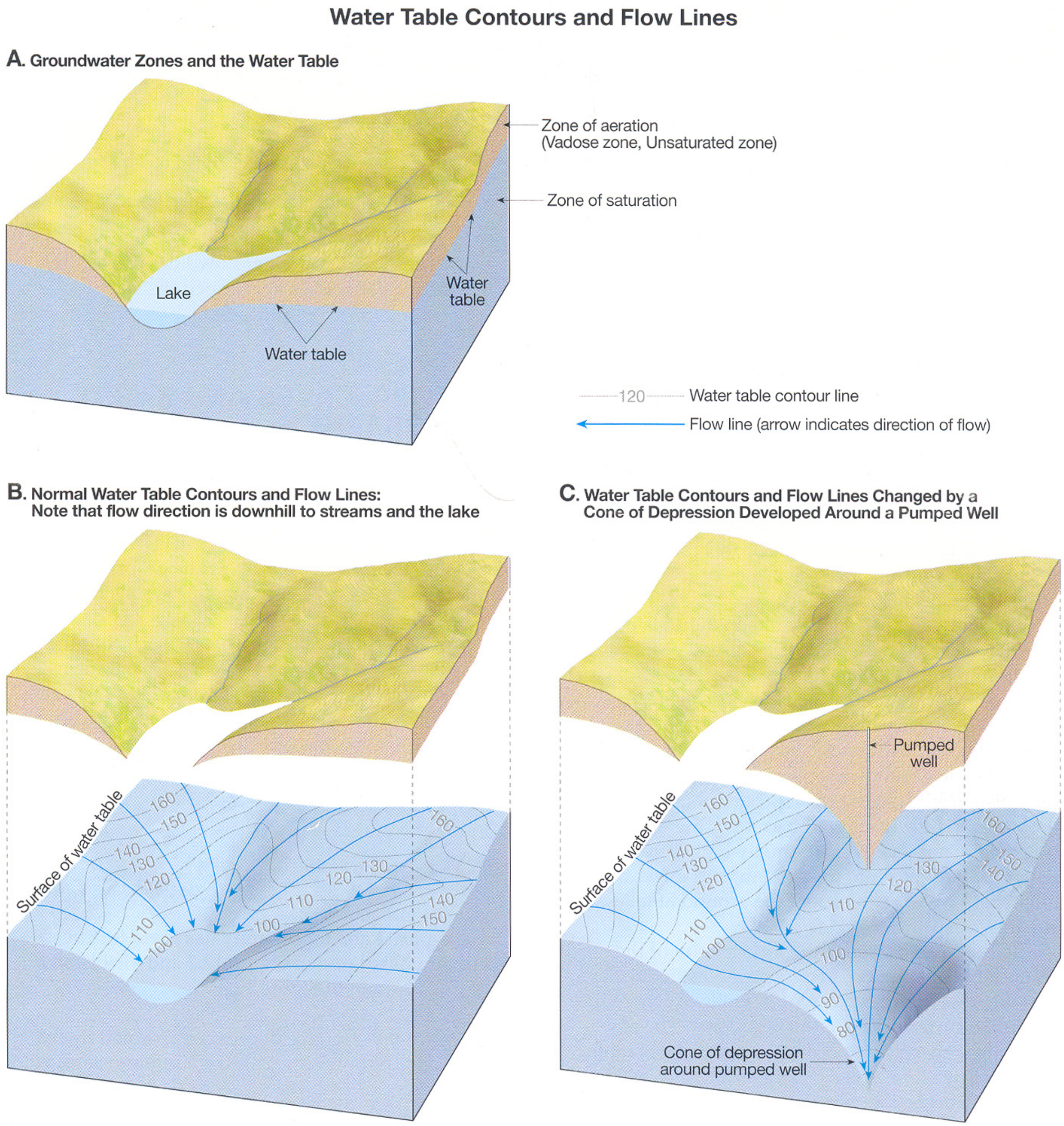


FIGURE 12.1 Water movement through an unconfined aquifer. **A.** Rainwater seeping into the *zone of aeration* (undersaturated zone, vadose zone), where void spaces are filled with air and water. Below it is the *zone of saturation*, where all void spaces are filled with water. Its upper surface is the **water table**. Water in the saturated zone is called **groundwater**. **B.** A water table surface is rarely level. Contour lines (contours) are used to map its topography and identify flow lines—paths traveled by droplets of water from the points where they enter the water table to the points where they enter a lake or stream. **Flow lines** run perpendicular to contour lines, converge or diverge, but never cross. **C.** A pumped well is being used to withdraw water faster than it can be replenished, causing development of a **cone of depression** in the water table and a change in the groundwater flow lines.

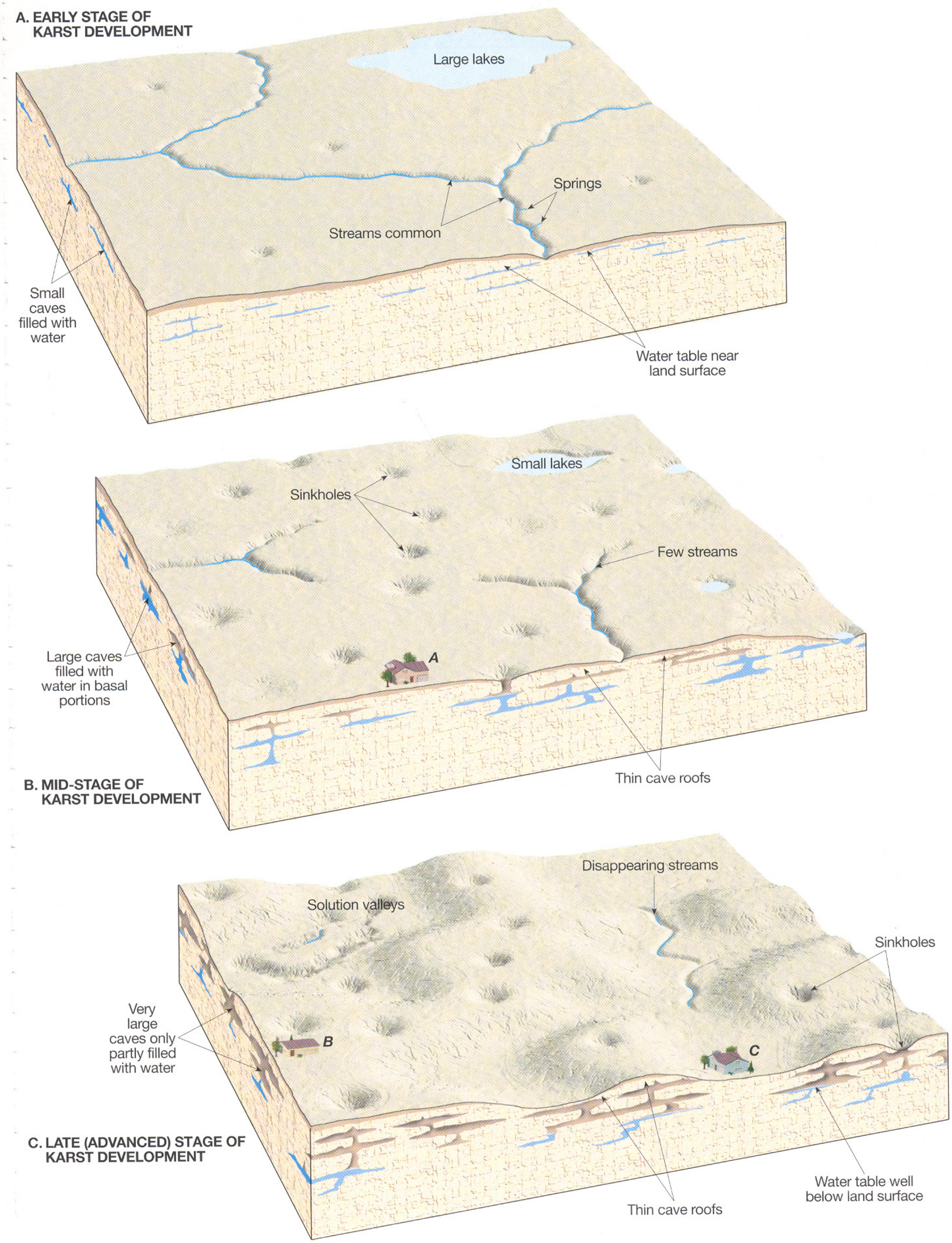


FIGURE 12.2 Stages in the evolution of karst topography, which forms by dissolution of soluble bedrock.

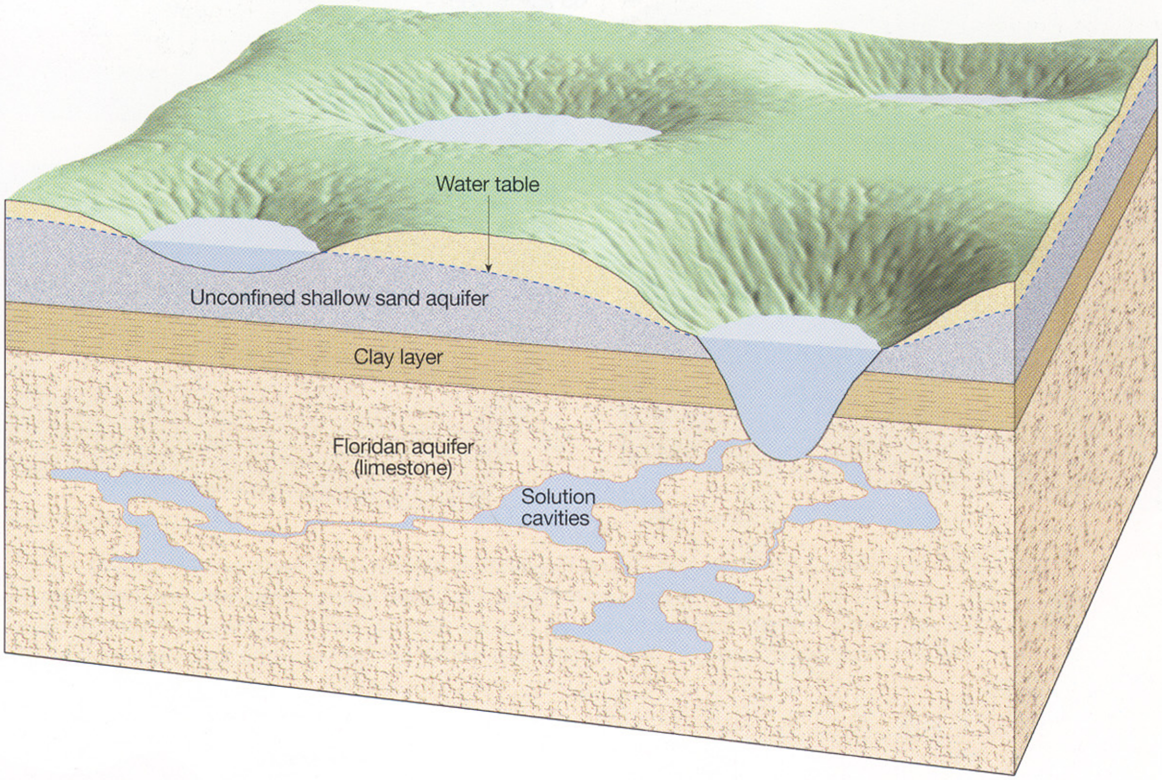


FIGURE 12.7 Geologic cross section showing groundwater distribution in strata underlying the Tampa, Florida, area.

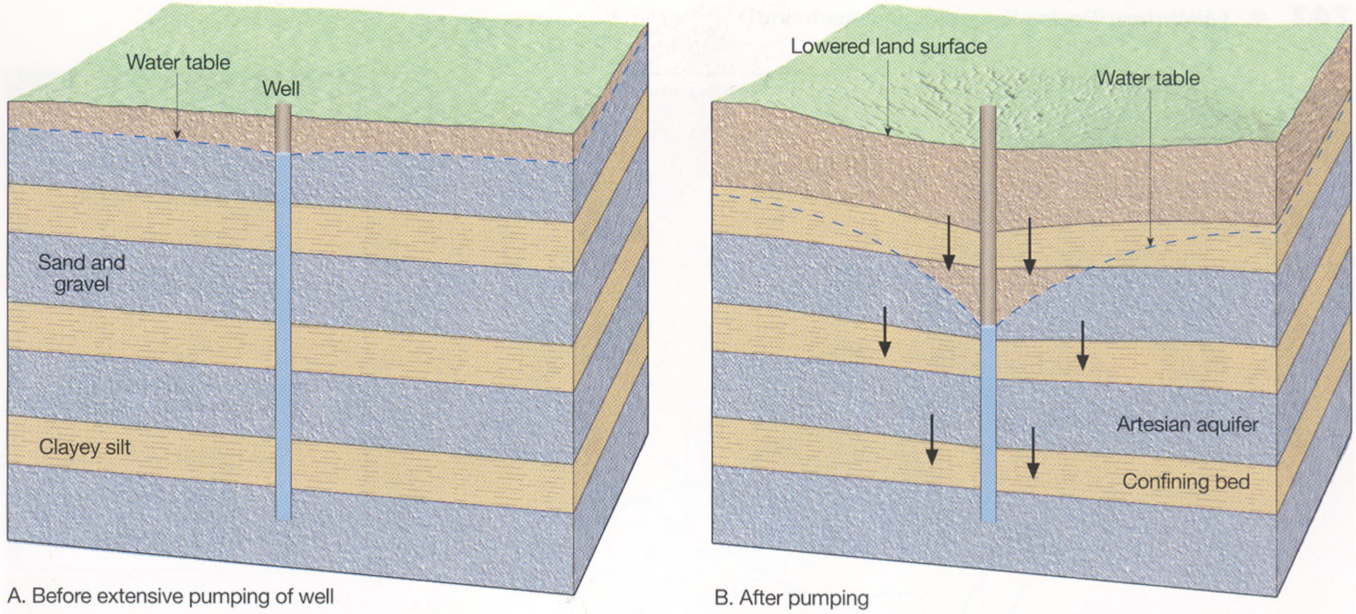


FIGURE 12.9 Before (**A**) and after (**B**) extensive pumping of a well. Note in **B** the lowering of the water-pressure surface, compaction of confining beds between the aquifers, and resulting subsidence of land surface. Arrows indicate the direction of compaction caused by the downward force of gravity, after the opposing water pressure was reduced by excessive withdrawal (discharge) of groundwater from the well.

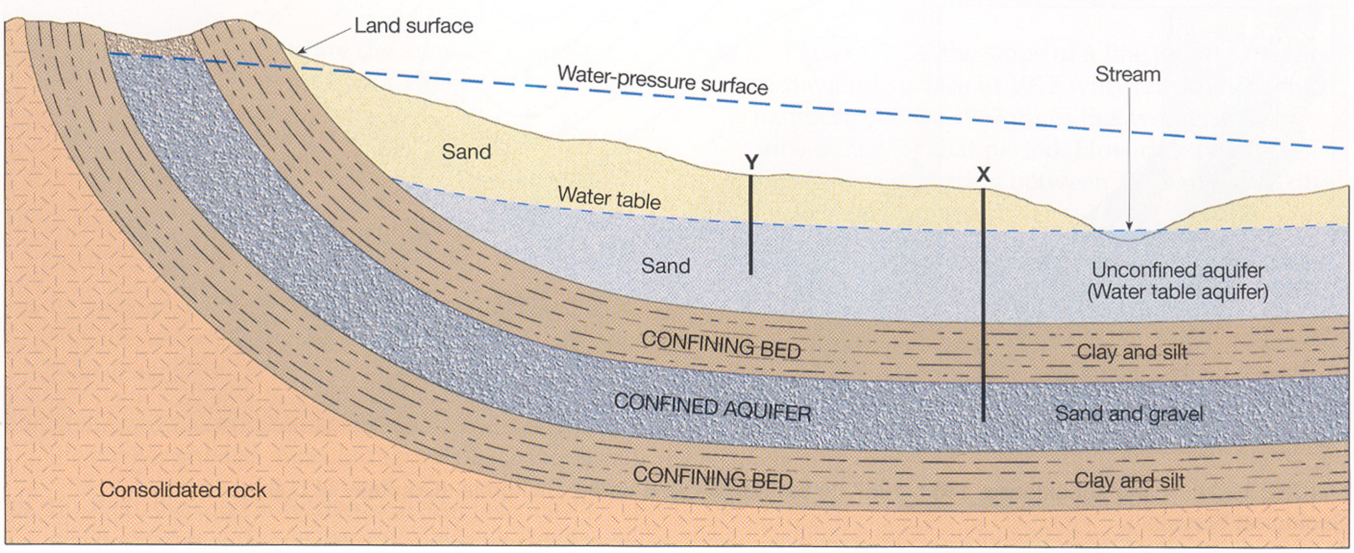
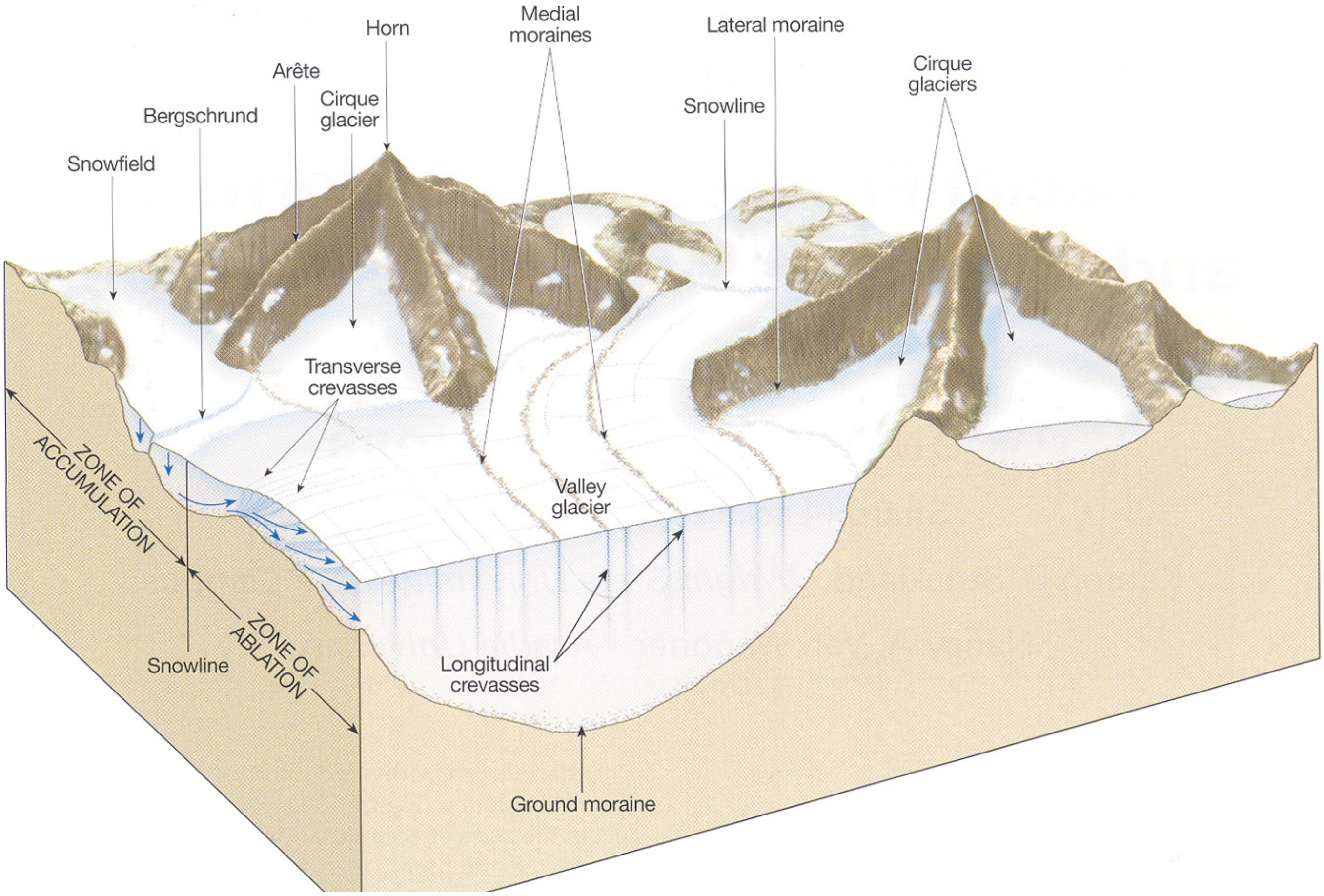


FIGURE 12.10 Geologic cross section illustrating an unconfined (water-table) aquifer and a confined aquifer. Vertical scale is exaggerated.



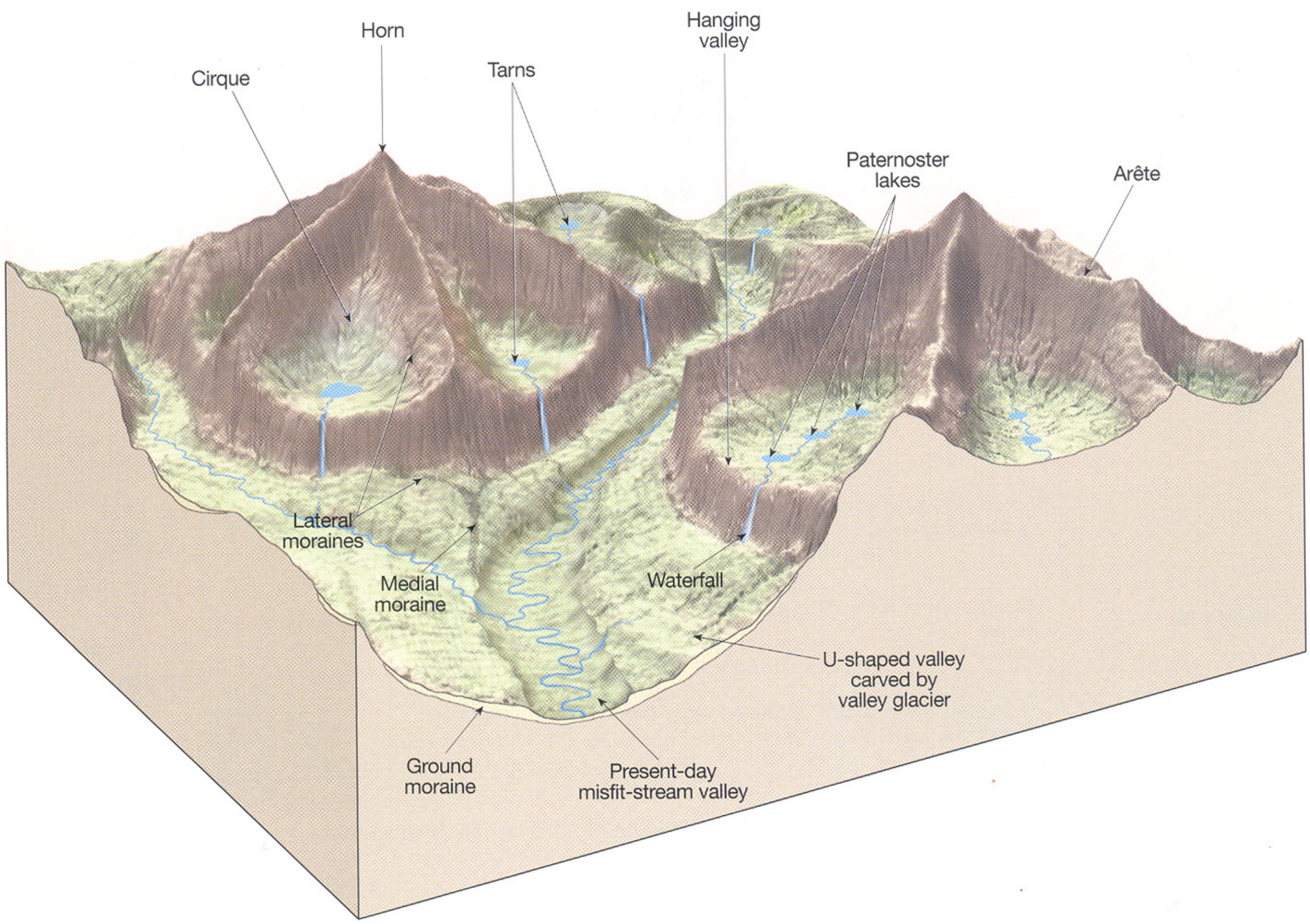


FIGURE 13.2 The same region as Figure 13.1, but showing erosion features remaining after total ablation (melting) of glacial ice.

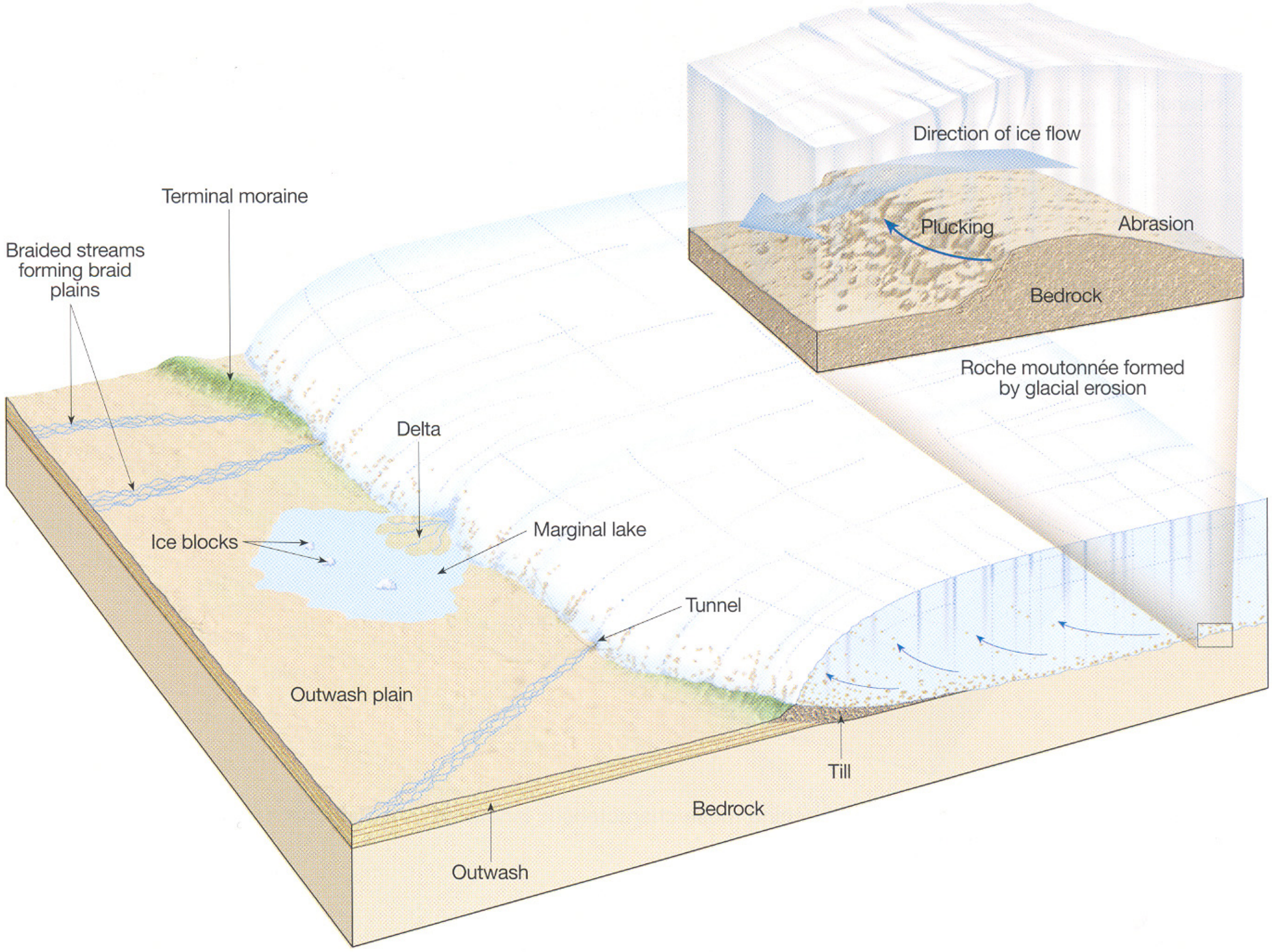


FIGURE 13.6 Continental glaciation produces these characteristic landforms at the beginning of ice wastage (decrease in glacier size due to severe ablation).

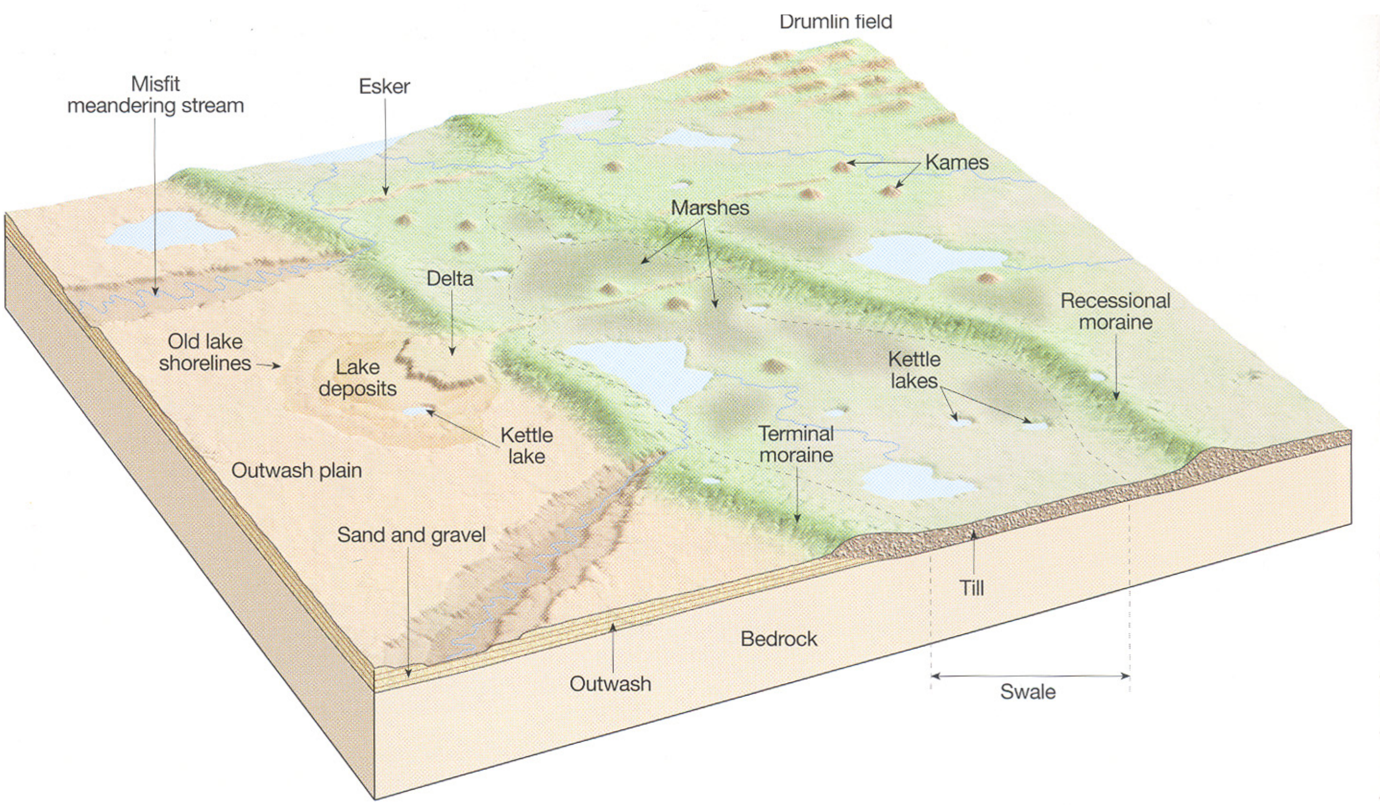


FIGURE 13.7 Continental glaciation leaves behind these characteristic landforms after complete ice wastage. (Compare to Figure 13.6.)

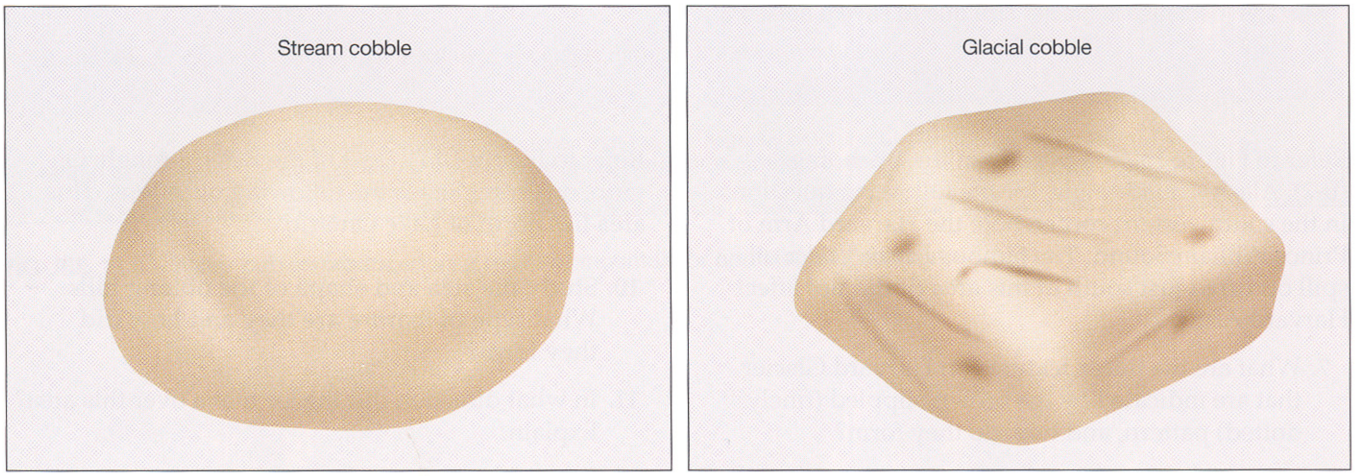


FIGURE 13.8 Note the differences between a stream cobble and a glacial cobble. Stream cobbles are rounded to well-rounded and have smooth surfaces. Glacial cobbles are angular or faceted and have many scratch marks. (A cobble is a clast between a pebble and a boulder in size, 64–256 mm diameter.)

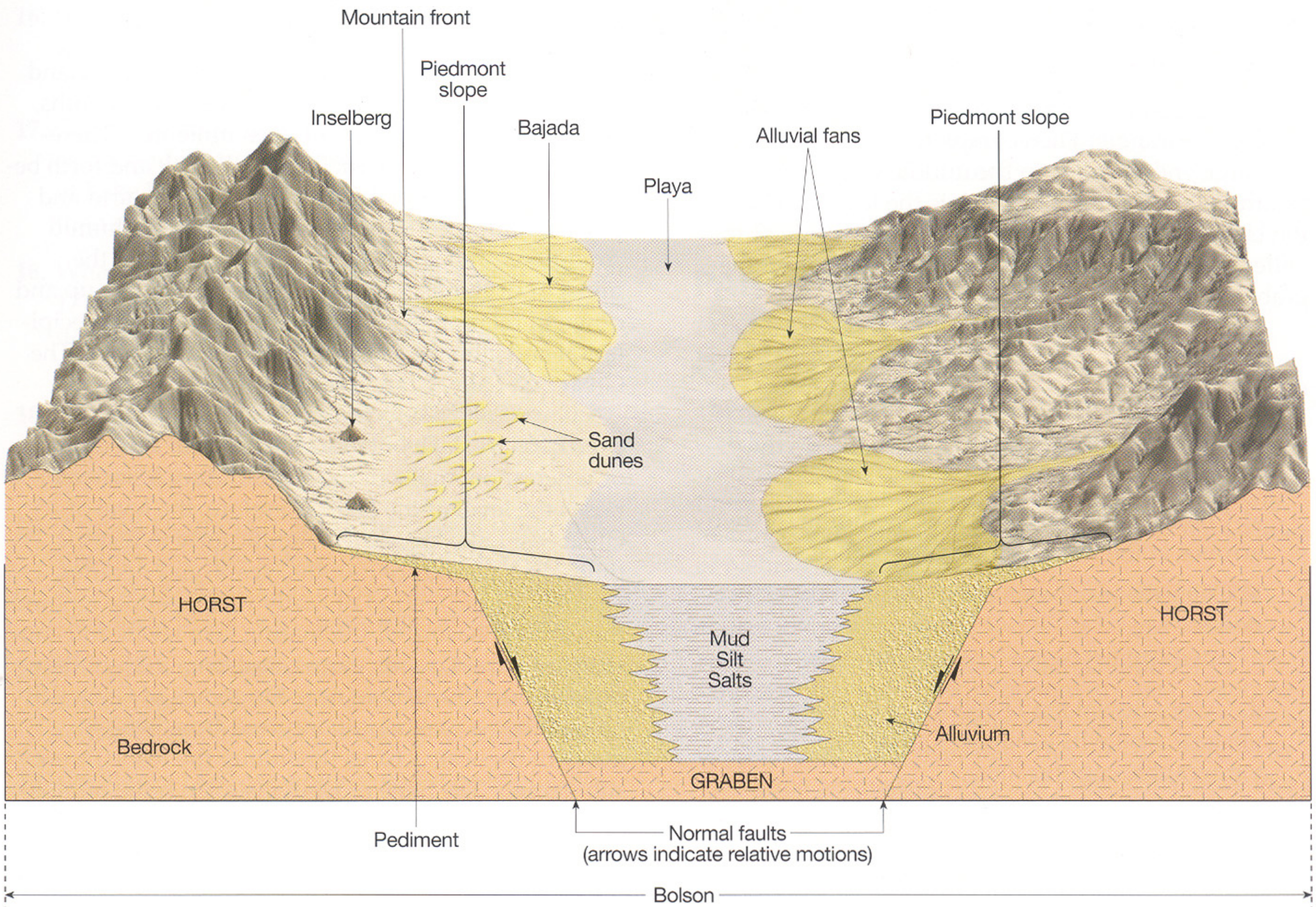
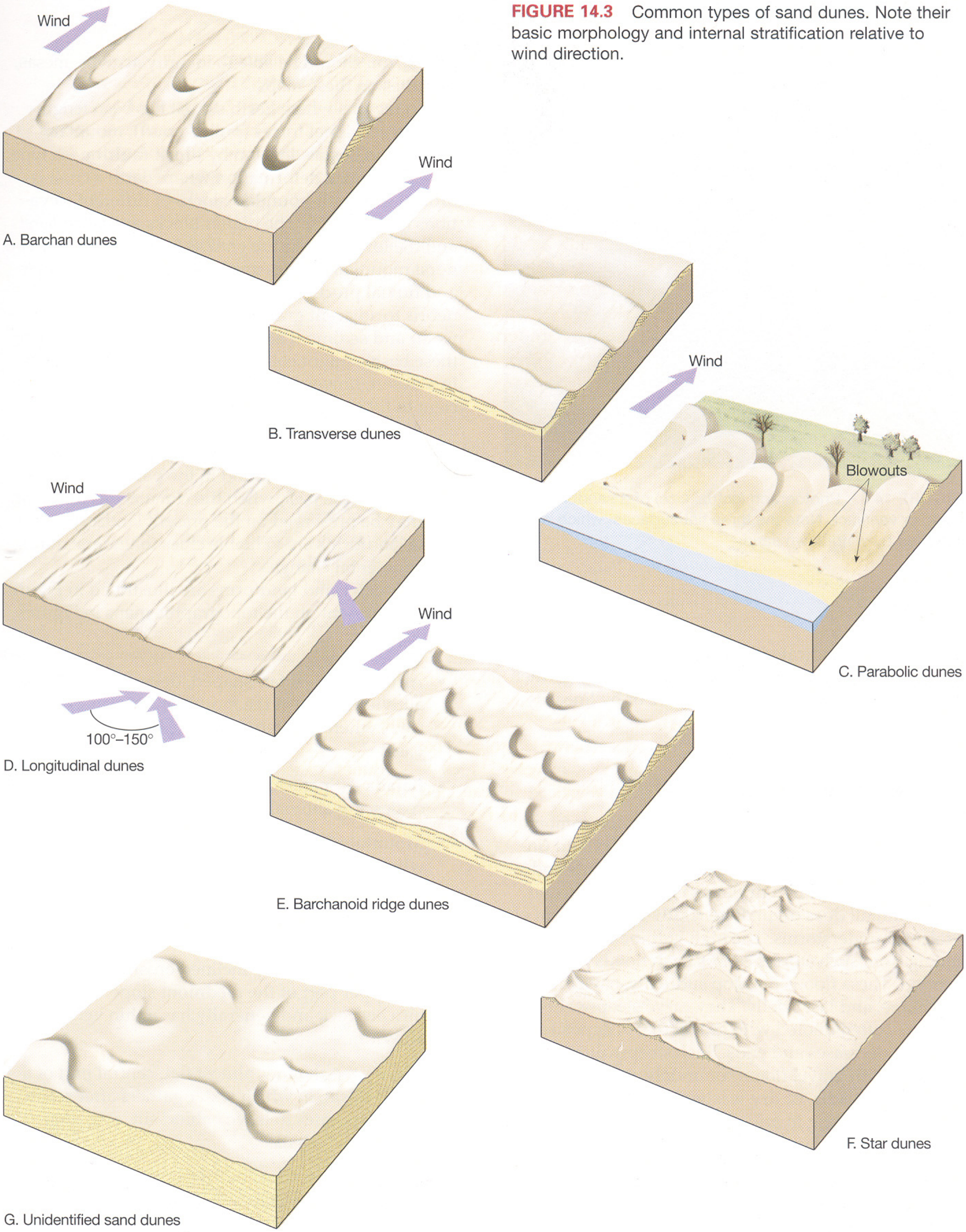


FIGURE 14.7 Typical landforms of arid mountainous deserts in regions where Earth's crust has been lengthened by tensional forces (pulled apart). Mountain ranges and basins develop by **block faulting**—a type of regional rock deformation where Earth's crust is broken into fault-bounded blocks of different elevations. The higher blocks form mountains called *horsts* and the lower blocks form valleys called *grabens.* Note that the boundaries between horsts and grabens are typically normal faults. Sediment eroded from the horsts is transported into the grabens by wind and water. **Alluvial fans** develop from the mountain fronts to the valley floors. They may surround outlying portions of the **mountain fronts** to create **inselbergs** (island-mountains). The fans may also coalesce to form a bajada. In cases where there is no drainage outlet from the valley, the valley is a closed basin or **bolson**.

FIGURE 14.3 Common types of sand dunes. Note their basic morphology and internal stratification relative to wind direction.



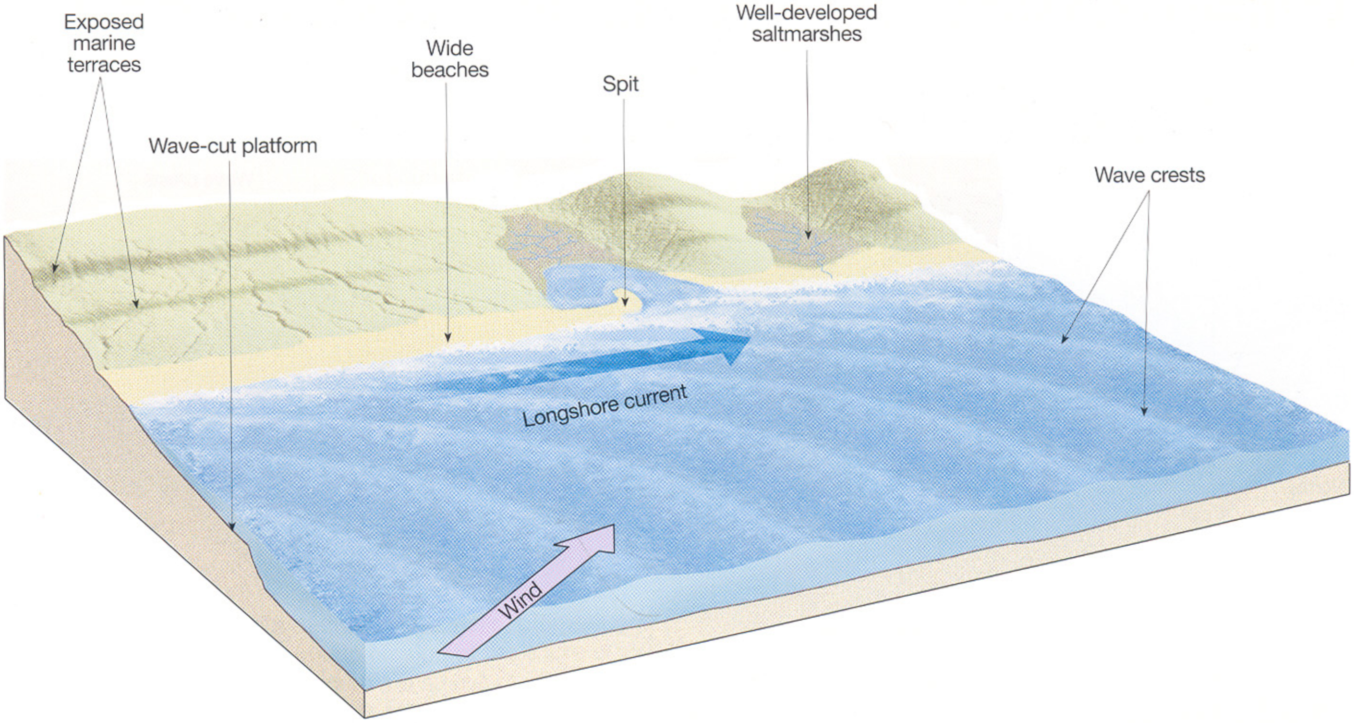


FIGURE 15.1 *Emergent* coastline features. An emergent coastline is caused by sea-level lowering, the land rising, or both. Emergence causes tidal flats and coastal wetlands to expand, wave-cut terraces are exposed to view, deltas prograde at faster rates, and wide stable beaches develop.

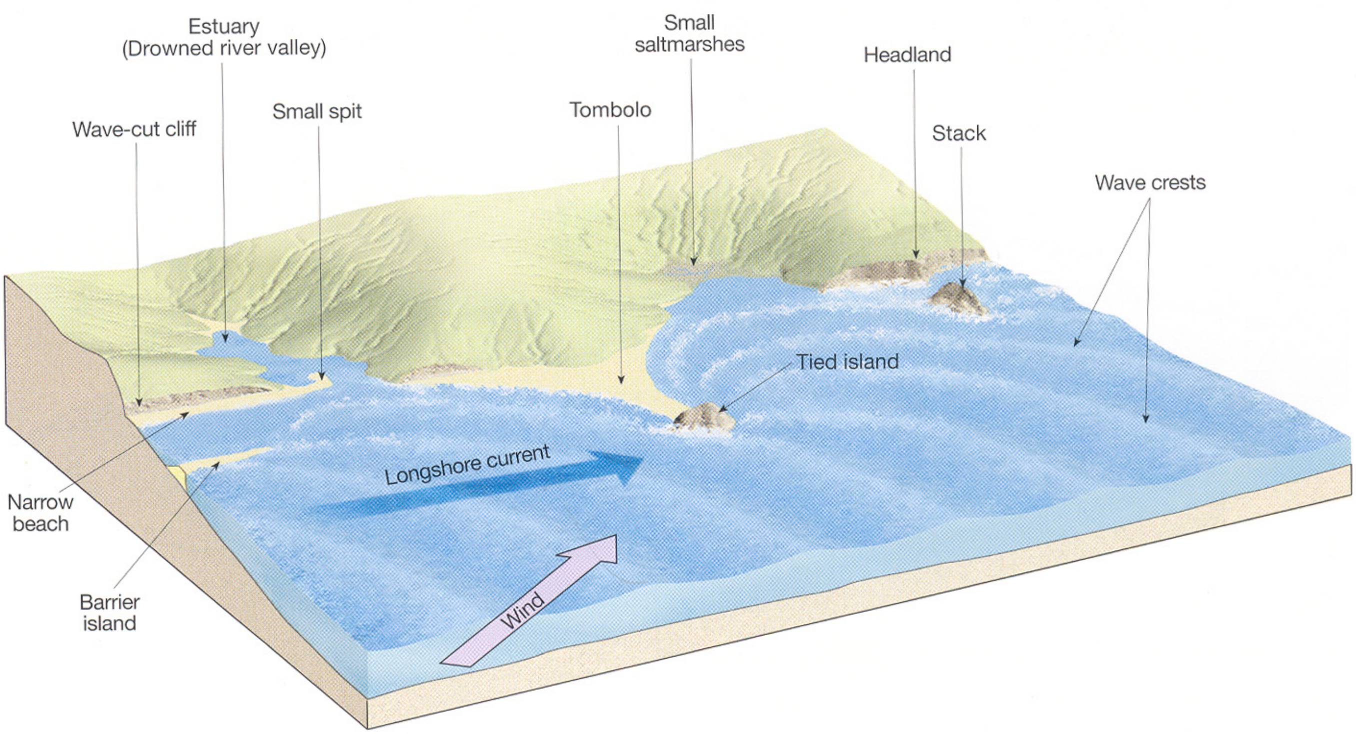


FIGURE 15.2 *Submergent* (drowning) coastline features. A submergent coastline is caused by sea-level rising (transgression), sinking of the land, or both. As the land is flooded, the waves cut cliffs, valleys are flooded to form estuaries, wetlands are submerged, deep bays develop, beaches narrow, and islands are created.

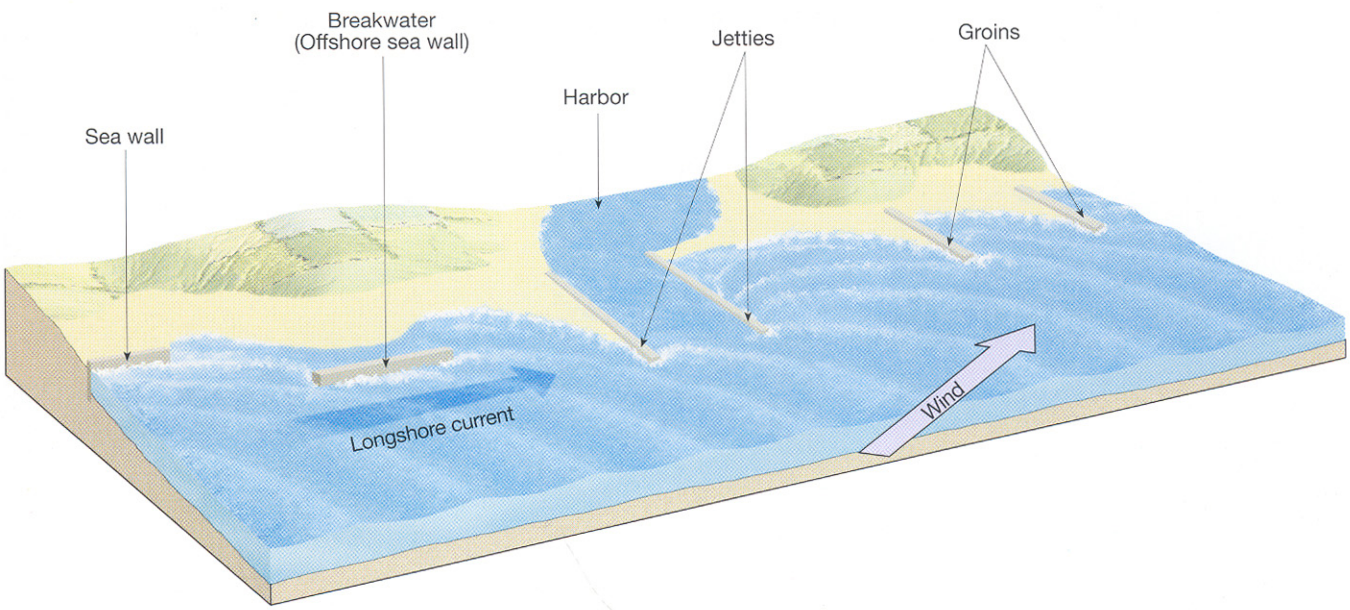


FIGURE 15.3 Coastal structures—sea walls, breakwaters, groins, and jetties. **Sea walls** are constructed along the shore to stop erosion of the shore or extend the shoreline (as sediment is used to fill in behind them). **Breakwaters** are a type of offshore sea wall constructed parallel to shoreline. The breakwaters stop waves from reaching the beach, so the longshore drift is broken and sand accumulates behind them (instead of being carried down shore with the longshore current). **Groins** are short walls constructed perpendicular to shore. They trap sand on the side from which the longshore current is carrying sand against them. **Jetties** are long walls constructed at entrances to harbors to keep waves from entering the harbors. However, they also trap sand just like groins.