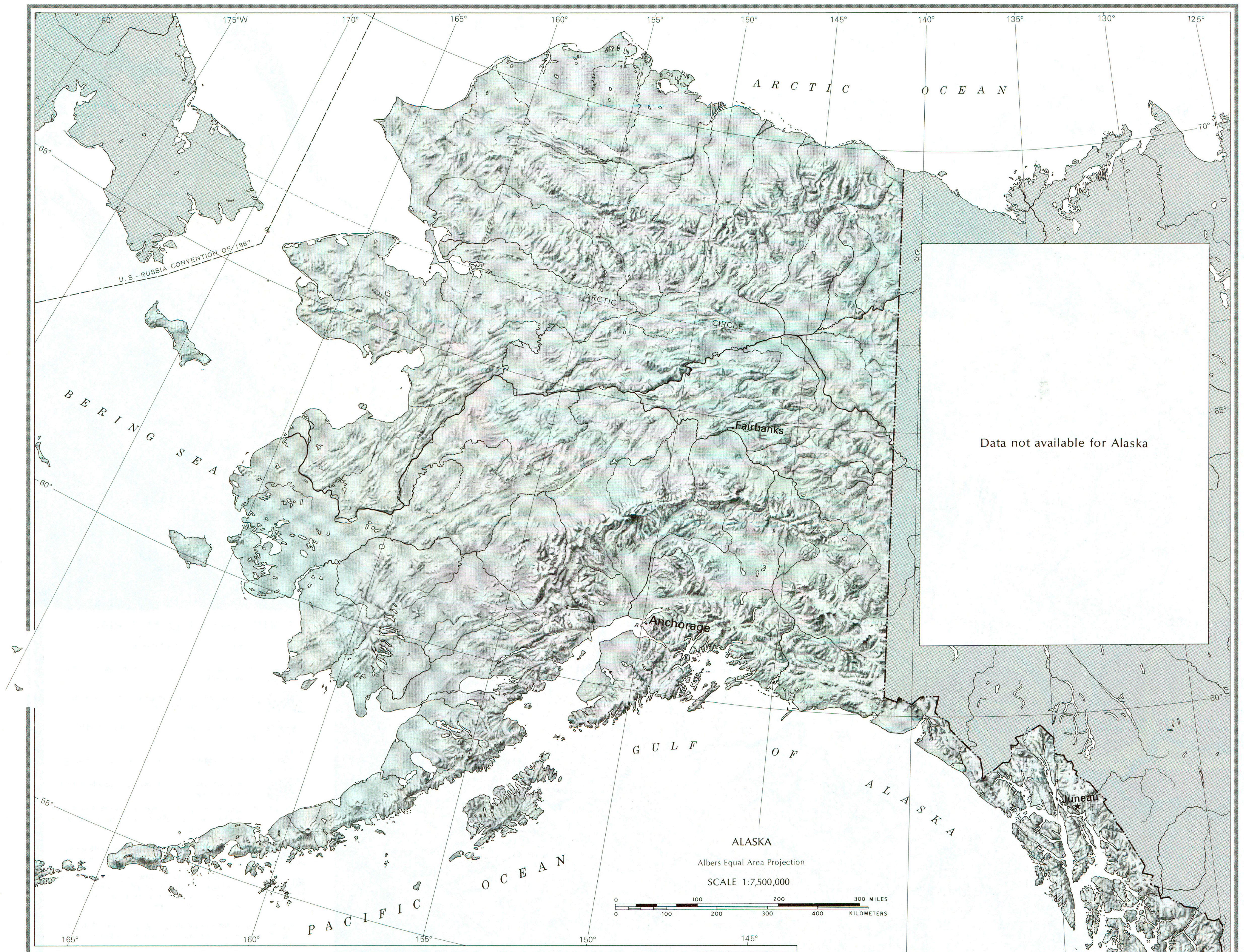

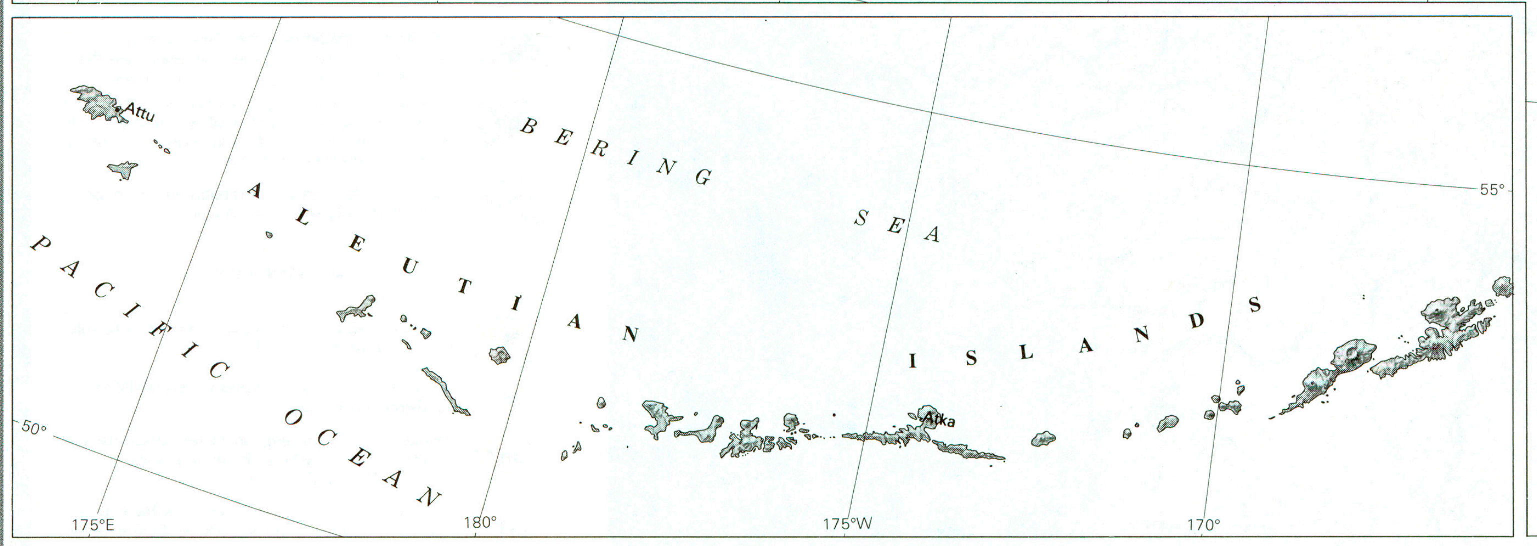

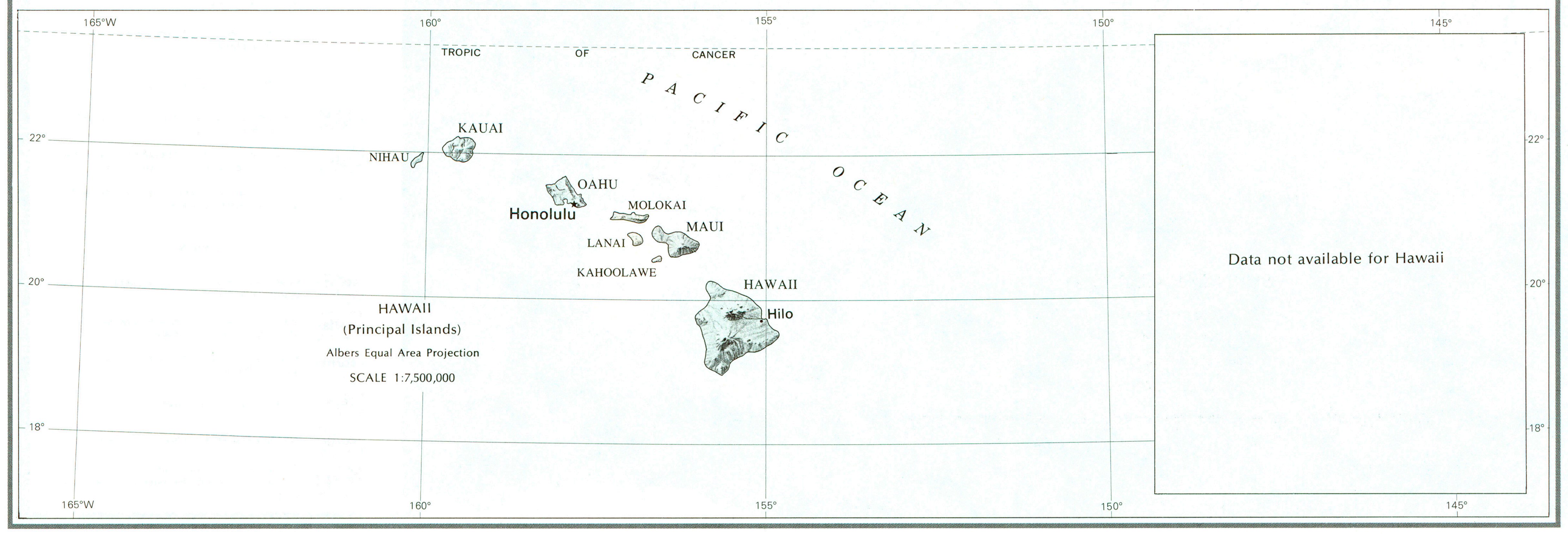

SURFICIAL GEOLOGY OF THE CONTERMINOUS UNITED STATES

By Charles B. Hunt

Surficial materials are those at or near the Earth's surface. They constitute, by far, the largest and most used part of the ground around us. Areas not covered by surficial deposits—bare bedrock—form probably less than 5 percent of our land surface.

Most surficial deposits are composed of poorly consolidated clay, silt, sand, or gravel-sized particles that are produced chiefly by erosion and are transported by and finally deposited by water, wind, or ice, but are also partly produced by the in-situ weathering of bedrock. The major genetic categories are shown on the map by various colors; the principal compositional types in each category are indicated by patterns. Colors, patterns, and letter symbols are given in the explanation which follows this summary description.

Surficial deposits have characteristics important to our environment—water-bearing properties, mineral resources, and suitability as a natural foundation for buildings. They are also susceptible to flooding, erosion, ground subsidence, landslides, and earthquakes.

UNTRANSPORTED MATERIALS

A. **Thick residuum** (saprolite) is material derived by intensive chemical weathering of bedrock or unconsolidated surficial deposits. The parent materials are altered to clay, much of it bright red or yellow, and locally the residuum is thicker than 200 ft.

Residual weathering profiles are most extensive in the Southeastern and South Central United States. They are rare north of the limit of the last (Wisconsin or late Pleistocene) glacial advance (shown as the line tm on the map), because most of the residuum that originally extended into Canada was eroded away by the continental ice sheets. The bulk of the residuum is pre-Wisconsin in age.

The characteristics of a residual profile depend upon the mineralogy and structure of its parent materials. The profiles usually have four layers, which are, from base upward: fresh bedrock; weathered bedrock that is usually moist; clayey saprolite that preserves original rock structures, and a few feet of massive clayey (structureless) saprolite. Saprolites like those in the Southeastern States also occur in the Pacific Northwest, but in the intervening semiarid States, eastward to the 100th meridian, the anciently weathered materials contain much less clay. Throughout the humid regions and above altitudes of about 7,000 ft in arid and semiarid regions, residual materials are acidic (pH less than 7).

B. **Thin, slightly weathered residual deposits** in the arid and semiarid West are alkaline (pH more than 7) and are commonly admixed with transported sediment. They are rarely more than 5 ft thick at their base. They generally have a layer of calcium carbonate (caliche) that, depending on the stage of development, occurs as veinlets, scattered nodules, massive accumulations, or tough layers 1 to 2 in. thick, overlying materials that may contain little calcium carbonate. They are mostly Pleistocene and, locally, late Pliocene in age.

C. **Organic deposits** are most extensive in brackish-water tidal marshes along the Gulf and Atlantic coasts, especially in the Mississippi River Delta. Although not shown on the map, they also occur in estuaries behind longshore bars and barrier beaches. Freshwater organic deposits include fibrous peats developed from grasses and sedges and woody peats developed from fallen and decayed trees. Swamps on the Coastal Plain contain cypress; bogs in the glaciated northeastern and Great Lakes States contain mostly spruce and pine. Other peat deposits, not shown on the map, occur above or near timberline on high western mountains. All are of Holocene or very late Pleistocene age.

D. **Colluvium** is the mantle of surficial materials derived from residuum, bedrock, or unconsolidated deposits that moved slowly downslope by mass wasting or creep, that is, movement due to gravity. Movement can be caused by extra weight, lubrication by saturation with water, frost heaving, wetting and drying of clays, crystallization of salts, growth of roots, burrowing and trampling by animals, falling of trees, and the impact of rain or hail. In many areas, colluvium poses slope stability problems.

Colluvium generally is a chaotic mixture of unsorted, coarse, angular rock fragments and finer grained material. Colluvium may form boulder fields, avalanches of coarse debris, or lag concentrates of boulders from which the fine material has been washed out. Colluvium commonly grades into mudflows composed largely of fine-grained material. Colluvial deposits generally are less than 15 ft thick, but may be much thicker in cones of debris at the base of hillsides. Texture, thickness, and extent depend on the parent rocks, steepness of the hillsides, and climate.

In humid regions such as the Appalachian Mountains and the Pacific Northwest, colluvium may cover 95 percent or more of the hillsides; the subsoils are acidic. In semiarid regions, colluvium may cover 85 to 90 percent of the hillsides. Even in these deposits the subsoil is acidic, except at or near the base of the mountains. In arid regions such as the southern Basin and Range province, colluvium may cover 50 percent of the mountain slopes, most of which have alkaline subsoil.

TRANSPORTED DEPOSITS

Because transported surficial deposits have traveled some distance, they are not only much younger than the underlying bedrock but also are generally unrelated to it.

A. **Shore deposits** are mostly sand, locally gravel, and include some salt- and brackish-water organic materials that are gradational with the residual organic deposits described above. The sand is transported by longshore currents generated by waves breaking obliquely against the shore.

During the Pleistocene, growth of the extensive icecaps caused the sea level to drop as much as a few hundred feet. Subsequent melting of the icecaps has caused the sea level to rise several feet in the last few thousand years. Thus, most shore deposits shown on the map are Holocene.

Sandy shores include broad sandy beaches with associated dunes, longshore bars, and barrier beaches backed by estuaries. Numerous capes, hooks, and baymouth bars are included. Narrow beaches are formed locally from cliffs in easily eroded rocks. Sea islands are irregularly shaped sandy islands. Coral is, in part, live coral but most is sand composed of coral and shellfish fragments. Mangrove swamps are included with coral. Backshore deposits are gradational with residual organic deposits; most are less than 25 ft above sea level and contain shallow ground water.

B. **Glacial deposits** were laid down by two principal types of ice: continental ice sheets such as the icecaps in Greenland and Antarctica, and mountain glaciers developed at high altitudes with low temperatures and high precipitation such as those on Mount Rainier.

During the Pleistocene, two main ice sheets developed in North America. One was east of Hudson Bay (Laurentian icecap), and one to the west (Keewatin). From these centers, the ice spread in all directions and covered most of Canada. In the United States, the ice extended southward to Long Island and to the present locations of the Ohio and Missouri Rivers. The sheets divided into lobes towards the thinned edges. The Driftless section bordering the Mississippi River in Wisconsin and Illinois separated lobes of Wisconsin ice which occupied the basins of Lake Michigan and Lake Superior. The surface of this area is partly covered by deposits of windblown silt (loess). Glacial deposits in New England and New York are thicker and more bouldery than in the Middle Western States, probably because of the very different terrains across which the ice advanced.

There are two principal kinds of mountain or alpine glaciers. The best known glaciers are valley glaciers, which move down valleys from the high summits. Gravel and sand deposited along each side of the ice form lateral moraines, and similar deposits at the lower ends of the ice form end (terminal) moraines. Most of these deposits end at the head of the valley in steep walled basins known as cirques. In the past, other mountain glaciers formed small icecaps across plateaus and flowed off in all directions. Examples are the High Plateaus in Utah and the Grand Mesa and the White River Plateau in Colorado.

The map emphasizes the deposits of the last (late Wisconsin) glaciation. Earlier glaciations (early Wisconsin, Illinoian, Kansan, and Nebraskan) extended farther south in places; these older deposits are mostly covered by loess or other young deposits, but are commonly encountered in excavations. The map exaggerates the extent of their outcrop.

Pre-Wisconsin drift includes ice-laid poorly sorted gravel, sand, silt, as well as well-sorted water-laid deposits of glacial streams and windblown silt (loess). The drift is generally deeply weathered and altered to clay; thickness may exceed 50 ft, locally. The subsoil is acidic and commonly buried by less weathered Wisconsin loess or alluvium.

The terminal moraine, which marks the southern limit of the Wisconsin glacier and northern limit of most residuum, is a hummocky ridge, commonly 25 to 50 ft high, of poorly sorted slightly weathered gravel and sand. It is subdued or absent along about one-quarter of the length of the former ice front. Subsoil is acidic east of the Mississippi River and alkaline west of the 95th meridian.

End moraines were deposited at the front of the Wisconsin ice during stillstands that interrupted the general northward retreat. Some are hummocky ridges of poorly sorted slightly weathered gravel and sand; some were built of outwash off the front of the ice and others of materials scooped into ridges during minor readvances of the lobes.

Till or ground moraine is ice laid, poorly sorted, bouldery, and sandy with numerous scratched (striated) glacial stones. The deposits are generally less than 25 ft thick and are slightly weathered with an acidic subsoil. Bedrock exposures are common.

Ice-laid deposits are mostly sand and silt. They generally form smooth plains on low ground between hummocky end moraines towards the south. In Michigan, Wisconsin, and Minnesota, they form hilly ground pitted with depressions, a terrain referred to as knob-and-kettle topography. Thickness is generally less than 25 ft, but the bedrock is almost entirely covered.

Drumlins are elongate mounds of glacially deposited sand and gravel. They may have a bedrock core and are commonly 50 to 100 ft high. They generally occur in clusters.

Deposits of mountain glaciers are mostly gravel and sand in flat poorly drained floors of U-shaped valleys. They are bounded downvalley by a terminal moraine and at the sides of valleys by lateral moraines that end headward at cirques. The thickness of the deposits is variable, but generally less than 25 ft. Wisconsin deposits are only slightly weathered and eroded; pre-Wisconsin deposits are intensively weathered and eroded. Subsoils are acid.

Some stream channels, especially in the central states are buried under glacial drift commonly 100 ft or more thick. They are important aquifers.

Gravel, sand, silt, and clay, deposited by glacial streams, include small areas of lake deposits. Shown only in hilly Wisconsin glaciated areas, they are the alluvium that extends downvalley from those areas. Thickness is commonly 50 ft and locally much more, especially in New England.

About 1,000 existing perennial snowfields cover 200 square miles on mountain tops in the West. These include local patches of permanently frozen ground, extensively patterned ground due to heaved stones, some peat, and grassy and weedy tundra.

C. **Stream deposits** include alluvium in floodplains along valley bottoms, terraces along valley sides, and alluvial fans at the foot of mountains, especially in the western mountains. Deposits range in texture from clay to boulders. Some alluvial fans grade into mudflows.

In the Western States, many stream deposits contain fossil bones of various mammals and rodents (extinct forms in the Pleistocene deposits) and locally abundant shells of freshwater snails and clams. Weathering is slight, and the subsoil is generally alkaline. In the Eastern States, fossils are scarce because of the acid leaching.

Flood plain alluvium and gravel terraces consist of well-bedded lenticular gravel, sand, and silt. Individual fills are generally 10 to 25 ft thick, but several fills may aggregate more than 100 ft. Ground water in these fills is subject to pollution. Soils are acid in the Eastern and Central States and alkaline in the West; they form much of our best farmland. Most are late Pleistocene and Holocene in age.

Flood plain surfaces are of at least three kinds: (1) flat surfaces built upward by shifting streams overflowing their banks; (2) flat surfaces with natural levees alongside the channel where the overflow of the banks has caused the coarsest sediment to be deposited close to the stream, and (3) surfaces formed of coalescing broad fans at the mouths of side streams supplying a main stream with more sediment than it can transport. At these places, the main stream is likely to be pushed against the far bank opposite the mouths of the tributaries, as the Mississippi is in the 200-mi stretch below Minneapolis-Saint Paul.

Extensive fan gravels at the base of the western mountains cover about half the Basin and Range province and commonly exceed 1,000 ft in thickness. Thinner and less extensive deposits, mostly less than 40 ft thick, may rest on smoothed bedrock surfaces (pediments) sloping from the base of escarpments and mountains. On many fans, the stones are set closely together to form a smooth pavement (desert pavement) with black coating (desert varnish). On pre-Wisconsin fans, rounded gravels disintegrate to form angular rock fragments.

Fan sands lie between gravels upslope and silty beds of flood plains or dried Pleistocene lakes (playas) in the centers of valleys. They are commonly hundreds of feet thick and many deposits have been extensively reworked by wind into sand dunes. The subsoil is alkaline.

Pliocene and older stream deposits are found on the Great Plains. Consisting of mostly sand and gravel, the stream deposits form broad fans apparently deposited by distributaries branching eastward, rather than by trunk streams like those of today. Generally less than 100 ft thick, the surface layers have been generally reworked into Quaternary eolian or alluvial deposits. The rimrocks of older deposits are generally firmly cemented by calcium carbonate (caliche) several feet thick. The surface of the Great Plains is dotted with small depressions, of which many in the south extend down to caliche and have dune sand on the lee side.

D. **Lake Deposits.** During the Pleistocene, lakes were larger and more numerous than they are today. The map shows only the deposits of the three most extensive kinds: (1) late Pleistocene lakes formed by damming of rivers by continental ice sheets (examples around the Great Lakes and in Montana), (2) lakes formed in river valleys over-deepened by ice scour (Finger Lakes in New York and the Connecticut River Valley); and (3) lakes formed in the more than 100 closed basins which are now mostly dry lakes, or playas, in the Basin and Range province.

Other important lake deposits too small to be shown on this map include: (1) depressions in ground moraine (most of Minnesota's 10,000 lakes), (2) sinkholes in soluble limestone or gypsum, especially in Florida where underground drainage causes problems to foundations, (3) deposits along rivers at cutoff meanders and depressions on deltas (for example, the Mississippi River Valley), (4) deposits behind landslides, such as Earthquake Lake in the Madison Range, Montana, (5) deposits behind lava flows or in volcanic craters, (for example, Malheru and Harney Lakes in eastern Oregon and Crater Lake in the Cascade Mountains), and (6) deposits in wind-blown depressions, especially in the southern Great Plains.

E. **Eolian Deposits.** Windblown silt or loess in the Central States was deposited by the westerly winds blowing across desolate mud flats along rivers that were alternately flooded and desiccated because of irregular discharge from melting glaciers. Loess sheets are thinner and finer grained downwind from the river valleys. Some loess was derived from deserts in the Southwest, as in southeastern Utah.

Sand sheets and dunes are common in the deserts of the Southwest. Their thickness is generally less than 30 ft. Dune shapes depend on topography, relative strength of the winds, supply of sand, and vegetation. They may be concave to leeward (barchan), concave to windward (parabolic), transverse, or longitudinal. Some dune fields have all four kinds.

Dunes climb windward slopes and fall on leeward slopes. Sand sheets also develop sand mounds around woody shrubs (coppice dunes), especially on alluvial fans in the Southwest. Most sand sheets have a basal layer of weathered, partly cemented and stabilized older sand. Southwestern sand sheets are mostly late Pleistocene, most dunes are Holocene in age. Along sandy beaches, dunes generally form above the highest beachline (berm). These are Holocene and overlie estuarine deposits.

Loess is early to late Pleistocene in age. Wisconsin loess overlies Wisconsin and older glacial deposits or outwash. It may be moderately weathered, is commonly columnar jointed, and may form cliffs although it is easily eroded. It is generally less than 50 ft thick.

Deeply weathered loess, mostly pre-Wisconsin, is red and yellow clayey silt from 15 to 100 ft thick. It forms prominent bluffs along the east side of the Mississippi and Missouri Rivers. Some sand sheets are found on Pliocene and older stream deposits on the southern High Plains.

MISCELLANEOUS DEPOSITS

Volcanic rocks, mostly basalt, include lava flows, volcanic cones, necks, and fields of scoriae. Mostly Quaternary and late Tertiary in age, they are young enough to retain original structure and shape, so that in the Southwest many are referred to as malpais (Spanish for bad land). Older Tertiary basalt and related rocks are also conspicuous topographically but are more eroded, tilted, and faulted; the lava surfaces usually have been partly covered by silt and sand washed or blown in. Individual lava flows are generally less than 50 ft thick but may aggregate a few hundred feet thick; the flows commonly are interbedded with layers of volcanic ash (tuff).

Bedrock on the Colorado Plateaus is about 75 percent bare rock—mostly sandstone, with some shale, limestone, and metamorphic rocks along canyon walls and hogbacks where the same rocks are steeply tilted. Flat ledges are mantled by loose sand; shale slopes are partly mantled by colluvial debris from the cliffs. In the Basin and Range province, bedrock is about 50 percent bare rock—mostly limestone, with some granite and metamorphic and volcanic rocks. Along the Snake River Canyon, basalt overlies metamorphosed volcanic rocks. In the Rocky Mountains, about 10 to 15 percent of the area shown as colluvium is rock outcrop; in the Appalachian Mountains and in the Pacific Northwest, about 5 percent.

Hot springs shown on this map have water temperatures exceeding 100° F (38° C). They commonly have mounds of travertine; some contain clayey altered rocks.

Clinkers were formed on the northern Great Plains when extensive beds of lignite (coal) ignited spontaneously and burned at the outcrops, altering overlying shale or sandstone to tough red and yellow clinker.

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1984