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Open File 77-232

Surficial geology of the United States

Explanation to accompany the 1/7,500,000 scale map

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1977

This geologic map shows the general distribution of surficial materials -- those at or near the earth's surface. Such materials constitute by far the largest and most used part of the ground around us. Bare bedrock forms only a small percentage of our land surface, probably less than 5 percent. Among the important environmental aspects of surficial deposits are their water-bearing properties, susceptibility to flooding and erosion, susceptibility to such hazards as landslides and earthquakes, suitability for foundations, and use for mineral resources.

Surficial deposits are composed of poorly consolidated materials, produced in part by the weathering of bedrock which leaves layers of residuum; but most are derived by erosion at one place and transported by water, wind, ice, or gravity to another site of deposition. The colors on the map show the major genetic categories of materials; the principal compositional kinds in each category are shown by pattern.

UNTRANSPORTED MATERIALS

A. Thick residuum, or saprolite

Residuum or saprolite is material derived by intensive weathering of bedrock or of unconsolidated surface deposits. The parent materials are altered to clay which locally exceeds 200 feet thick. Colors generally are bright red or yellow.

Saprolite is most extensive in the south-eastern and south-central United States. It is rare north of the limit of the last glaciation, the period of the Wisconsinan glacier (shown as the line, tm, on the map). Presumably these weathered materials originally extended northward into Canada, but were almost completely eroded when overridden by the continental ice sheets. The occurrences show that most saprolite is pre-Wisconsinan in age; some is forming today in the southeastern United States. Present day weathering rates are exceedingly slow.

As brought out in the following, the saprolites differ one from another depending on the mineralogy and structure of the parent materials. Saprolite grades downward into weathered bedrock which in turn grades downward into fresh bedrock. The materials are in four layers: fresh bedrock at the base overlain by weathered bedrock that is usually wet (an aquifer), overlain by clayey saprolite that preserves original rock structures, and capped by a few feet of massive saprolite.

Saprolites like those in the southeastern United States also occur in the Pacific Northwest, but in the intervening semiarid states, eastward to the 100th meridian, the analogous weathered materials average much less clay. Throughout the humid regions and except at altitudes below about 7,000 feet in arid and semiarid regions, residuum is acid with pH less than 7.

Kinds of Saprolitic Residuum

rsh	Micaceous residuum without much quartz; clay, mostly kaolinite.
rgr	Residuum with abundant quartz; much less mica than rsh, but equal in clay.
rga	Clay residuum with little mica or quartz; mostly massive kaolinitic clay.
rls	Red clay, massive clay that is generally kaolinitic.
rlc	Cherty red clay; similar to rls, but with chert relict from the parent rock.
rtr	Residuum on Triassic formations; depths less than most other saprolite, reddish color, largely inherited from parent rock.

U. S. Geological Survey
OPEN FILE MAP 77-232
This map is preliminary and has not been edited for conformity with Geological Survey standards or nomenclature.

rs — Sandy Residuum, derived by intensive weathering of sandstone formations. Sand locally is in dunes.

rc — Clay residuum that swells when wet; developed by weathering of poorly consolidated shale, containing the clay mineral montmorillonite, generally less than 10 feet.

rl — Loam; texture variable, ranging from sand to clay which is mostly the non-swelling clay mineral kaolinite; otherwise similar to rc.

rg — Intensively weathered upper Tertiary and Quaternary gravels; thickness generally less than 30 feet, distribution not completely known.

rph — Phosphatic clay; poorly sorted clay and phosphate pebbles or nodules in sandy matrix. Thickness 10 to 50 feet, commonly overlain by loose sand. Major source of phosphate fertilizer.

rsi — Sandy or silty residuum; probably includes loess. Depth generally less than 10 feet.

B. Thin, slightly weathered residual deposits
Alkaline materials in the arid and semiarid west commonly admixed with transported sediment; rarely more than 5 feet thick; subsoil commonly has a layer of lime carbonate or caliche which, depending on the stage of development, occurs as veinlets, scattered nodules, or as tough layers 1 to 2 inches thick overlying lesser lime zones totalling a few feet thick. The age is mostly Pleistocene and, locally, late Pliocene.

Kinds

ls — Silt on limestone; probably includes considerable loess; extensive bare rock.

ss — Sandy ground; mostly on poorly consolidated sandstone formations

sh — Shaley or sandy ground; on mixed sandstone and shale formations; where shaley, contains considerable swelling clay.

gyp — Sandy gypsiferous ground; many sinks, local dunes; vegetation scanty or lacking where there is much gypsum or other salt.

c — Clayey ground on weathered Permian and/or Triassic red beds.

C. Organic deposits
Organic deposits are most extensive in marshes with salt tolerant grasses in the brackish water tidal zone along the Gulf and Atlantic coasts, especially across the southern part of the Mississippi River delta. Other brackish water wetlands, not shown on the map, occur around estuaries back of longshore bars and barrier beaches. Freshwater organic deposits include fibrous peats developed from grasses and sedges, or woody peats developed from fallen and decayed trees. Swamps on the Coastal Plain are characterized by cypress; those in the glaciated northeastern and Great Lakes states are mostly spruce and pine bogs. Still other peat deposits, not shown on the map, occur above timberline on high western mountains. All these deposits are Holocene or very late Pleistocene in age.

m — Marshes, swamps, or peat deposits; only locally thicker than 12 feet.

gp — Sandy coastal ground with organic layer over a shallow water table, ground water podsols. Although the deposits are Pleistocene, the high water table and associated organic layers are Holocene.

▲ ▲ — Peat deposits; occur in the area covered by the latest (Wisconsinan) glaciers

COLLUVIUM

Colluvium includes the mantle of soil and weathered materials derived from residuum, bedrock, or unconsolidated deposits moving slowly downslope largely due to gravity. The process causing debris to move downslope, known as mass wasting or creep, is initiated by extra weight and lubrication due to saturation by 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 hazardous slope stability problems.

Colluvium generally is a chaotic mixture of coarse angular rock fragments and finer grained materials. Locally the deposits form boulder fields; some are avalanches of coarse debris, and others are lag concentrates of bouldery materials due to washing out of the fine grained sediments that formerly were part of the mixture. Colluvium grades into mudflows composed largely of fine-grained material. Thicknesses generally are less than 10 feet, rarely 25 feet or more, but may grade into thick cones of debris at the base of hillsides. Texture, thickness, and extent depend on parent rocks, steepness of the hillsides, and climate. Although not shown on this small scale map, local outcrops of bedrock form three kinds of patterns: triangular areas bordered by colluvium, bands parallel to the contour where slopes are interrupted by rock ledges, and irregular spotty areas on forested mountains of massive crystalline rocks.

In humid regions, like the Appalachian Mountains and the Pacific Northwest, colluvium may cover 95 percent or more of the ground, and the subsoils are acid. In simiarid mountains, colluvium may cover 85 to 90 percent of the surface, including the summits where frost heaving produces orderly ground patterns. In these areas the subsoil is acid except at or near the base of the mountains. In arid regions, like the southern Basin and Range Province, colluvium may cover 50 percent of the mountain slopes, and most of this colluvium has alkaline subsoil.

Kinds

co/ss, sh	Sandy and stoney colluvium derived mostly from sandstone and shale; fresh rock commonly mixed with weathered materials; thickness mostly less than 25 feet but thickens in colluvial cones at foot of hillsides; boulder fields common.
co/ls	Stoney colluvium on limestone; considerable admixed silt, probably loessial; thickness generally less than 5 feet except at base of steep slopes.
co/m	Stoney colluvium on metamorphic rocks; less silt and clay than in co/ls. Thickness generally less than 5 feet except at base of steep slopes.
co/v	Colluvium on volcanic rocks; blocky where developed on lavas but includes fine grained materials where developed on volcanic mudflows; thickness commonly more than 25 feet in Cascade Range; generally less than 15 feet thick in Southwest.
co/gr	Bouldery and sandy colluvium on granitic rocks.
co/c	Clayey and loamy colluvium; on poorly consolidated rocks on lee side of Pacific Coast Ranges.

TRANSPORTED DEPOSITS

Most surficial deposits are sediments weathered from bedrock in one area and transported by water, wind, ice, or gravity and deposited in another area. Thus, not only are they much younger than the underlying bedrock, they generally are unrelated to it. The deposits are classified according to the mode of transportation by which they were moved to the site of deposition. On the map, the major kinds are distinguished by color.

A. Shore deposits

Mostly sand, locally gravel, and some salt and brackish water organic deposits 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.

Sea level has been rising at an average rate of approximately 6 inches per century, due to melting of the polar ice caps which are remnants of Pleistocene ice caps. The ice was sufficiently extensive during the Pleistocene to remove water from the oceans and to cause sea level to drop a few hundred feet. There has been a rise of several feet in the last few thousand years so that shore deposits shown are Holocene in age. Advance of the sea over the land due to melting of the ice, however, has been interrupted by earth movement, especially along the Pacific coast but to some degree along the Atlantic coast too, and by deposition of deltaic sediments at the mouths of rivers, notably the Mississippi. Most of the submarine mud and sand blanketing the continental shelves are late Pleistocene and Holocene.

Kinds

rks — Bayhead and bayside sand bars separated by rocky headlands

s — Sandy shores. Mostly broad sandy beaches with associated dunes, longshore bars, and barrier beaches backed by estuaries; numerous capes, hooks, and baymouth bars. Local cliffs in easily eroded formation have narrow beaches.

si — Sea Islands. Irregularly shaped sandy islands.

cr — Coral. In part live coral but most is sand composed of coral and other shellfish fragments; includes mangrove swamp.

bm — Backshore deposits. Gradational with residual organic deposits; mostly less than 25 feet above sea level; ground water shallow. Mounds (hammocks) are forested; low areas are marsh or swamp.

B. Glacial deposits

Glaciers are of two principal types: continental ice sheets, like the ice caps at Greenland and Antarctica, and mountain glaciers developed in high altitudes with low temperatures and high precipitation, like Mt. Rainier.

During the Pleistocene, two main ice sheets developed in North America. One was east of Hudson Bay (Laurentian ice cap), and one to the west (Keewatin). From these centers the ice spread in all directions, covering most of Canada and extending southward into the United States to Long Island and to the present locations of the Ohio and Missouri Rivers. Ice sheets do not advance across a broad front, but divide into lobes, especially towards the thinned edges. An example is a driftless area bordering the Mississippi River in Wisconsin and Illinois that separated lobes of Wisconsinan ice occupying the basins of Lake Michigan and Lake Superior. On the map this area is obscured by deposits of loess. Glacial deposits are thicker and more bouldery in New England and New York than in the middle western states, probably because of the very different terrains across which the ice advanced to reach those areas.

Mountain or alpine glaciers are of two principal kinds. Best known are the valley glaciers, which move down valleys from sources on the summits of high mountains. Gravel deposited along each side of the ice forms lateral moraines, and similar deposits at the lower ends of the ice form end, or terminal, moraines. Most of such deposits end headward at steep walled basins known as cirques. In the past other mountain glaciers formed small ice caps across plateaus, and the ice flowed off the plateau in all directions, as for example the High Plateaus in Utah, the Grand Mesa and the White River Plateau in Colorado.

The map emphasizes the deposits of the last (late Wisconsinan) glaciation. Earlier glaciations (early Wisconsinan, Illinoian, Kansan, and Nebraskan) in places extended south of the limit reached by the late Wisconsinan ice, but those older deposits are mostly covered by loess or other young deposits, the older drifts crop out only in scattered locations although commonly encountered in excavations. The map exaggerates the extent of their outcrops.

Kinds

pW — PreWisconsinan drift. Includes ice-laid, poorly sorted gravel, sand, and silt; water-laid, well sorted deposits of glacial streams; and wind blown silt (loess). Generally deeply weathered with rocks altered to clay. Thickness may exceed 50 feet locally. Subsoil acid. Commonly buried by less weathered Wisconsinan loess or alluvium.

tm — Hummocky ridge of poorly-sorted, slightly weathered gravel and sand. Terminal moraine, commonly 25 to 50 feet high, marking the southern limit of the Wisconsinan ice and northern limit of most saprolite. Moraine low or lacking along about one-quarter of the length of the ice front. Subsoil acid east of Mississippi River; alkaline west of the 95th meridian.

em — Other hummocky ridges of poorly-sorted, slightly weathered gravel and sand. End moraines, deposited at front of the Wisconsinan ice during stillstands that interrupted the general northward retreat. Similar to tm. Some ridges built of outwash off the front of the ice; others of materials scooped into ridges by slight readvances of the lobes.

tg — Ice-laid bouldery and sandy deposits (till, or ground moraine). Poorly-sorted Wisconsinan gravel and sand. Numerous glacial erratics. Mostly on hilltops and hillsides and less than 25 feet thick except locally; weathering slight; abundant glacially scratched (striated) stones and bedrock exposure. Subsoil acid.

ts — Ice-laid deposits, like tg but mostly sand and silt. Mostly on low ground between hummocky end moraines; towards south forms smooth plain; northward in Michigan, Wisconsin, and Minnesota forms hilly ground pitted with closed depressions (knob and kettle topography). Weathering slight; few glacial erratics; subsoil acid. Thickness generally less than 25 feet, but bedrock almost entirely covered.

ts/K,T — Thin ice-laid deposits, like ts but thin and discontinuous. Extensive exposure of underlying Cretaceous and Tertiary formations.

d — Drumlins, elongate mounds of glacially deposited sand and gravel; may or may not have bedrock core; generally occur in clusters. Heights commonly 50 to 100 feet. Weathering slight, subsoil acid.

mg — Deposits of mountain glaciers. Mostly gravel and sand forming. Flat, poorly drained ground on floors of U-shaped valleys bounded downvalley by terminal moraine and by lateral moraines at sides of valleys; end headward at cirques. Thickness variable but generally less than 25 feet. Wisconsinan deposits only slightly weathered and eroded; PreWisconsinan deposits intensively weathered and eroded. Subsoils acid.

gal — Stream channels, especially in central United States, buried under glacial drift. These channel deposits, commonly 100 feet or more thick, are important because of their ground water.

w — Gravel, sand, silt, and clay deposited by glacial streams adjacent to or downstream from temporary ice fronts; include small areas of lake deposits. Shown only in hilly Wisconsinan glaciated areas, but these deposits become the alluvium that extends down valley from glaciated areas. Thickness commonly 50 feet and locally much more, especially in New England.

g — Existing perennial snowfields. About 1,000 including some glaciers, cover 200 square miles on mountain tops in Washington, Oregon, California, Idaho, Montana, Wyoming, and Colorado. Local patches of permanently frozen ground; extensive patterned ground due to heaved stones; some peat; grasses and forbes like tundra.

C. Stream deposits

Stream deposits include alluvium in floodplains along valley bottoms, terraces along valley sides, and alluvial fans at the foot of mountains, conspicuously so at the foot of western mountains. Textures range from clay and silt to gravel and boulders. Some alluvial fans grade into mudflows. In western United States the deposits record the late Pleistocene and Holocene climatic changes. South of the glacial border, climates were comparatively wet during the glaciations, and deposition of stream deposits was favored. Conversely, during the interglacial periods, south of the glacial border, climates were drier and the conditions favored erosion and eolian activity.

The chronology of alternate cutting and filling is more completely preserved in western valleys than in the east because slight climatic changes in precipitation in the semiarid regions are, percentage-wise, much greater than in humid regions.

In western United States, stream deposits commonly are fossiliferous, with the bones of various mammals and rodents (extinct forms in the Pleistocene deposits), and locally abundant freshwater snails and clams. Weathering is slight and the ground generally alkaline. In the eastern United States fossils are scarce because of the acid leaching.

Floodplain surfaces are of at least three kinds: 1, flat surfaces built upward by streams overflowing their banks and repeatedly shifting their courses; 2, flat surfaces with natural levees alongside the channel where 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 crowded against the far bank opposite the mouths of the tributaries, as is the Mississippi in the 200 mile stretch below Minneapolis-Saint Paul.

Kinds

al — Floodplain and alluvium gravel terraces. Well bedded gravel, sand, and silt; lenticular bedding. Individual fills generally 10 to 25 feet thick, but the several fills in many valleys may aggregate more than 100 feet. Considerable ground water; subject to pollution. Ground acid in eastern and central United States; alkaline in the west. These deposits form much of our best farm land, both east and west. Age mostly late Pleistocene and Holocene.

fg — Fan gravels. Includes considerable sand and silt. Extensive at base of western mountains, cover about half the Basin and Range Province, and commonly exceed 1,000 feet thick. On Colorado Plateau and in the Basin and Range Province, thinner and less extensive deposits, mostly less than 40 feet thick, rest on smoothed bedrock surfaces (pediments) sloping from base of escarpments and mountains. On old fans (PreWisconsinan) originally rounded gravels disintegrate to form angular rock fragments set closely together to form a smooth pavement (desert pavement) with black coating (desert varnish) on the exposed surfaces. Materials depend on source rocks in the mountains: commonly sandy where source rocks are granitic; bouldery where there were Pleistocene snowfields; blocky where source rocks are metamorphic or well bedded sandstone or limestone; and clayey where source rocks are uplifted, poorly consolidated Tertiary playa deposits.

fs — Fan sands. Mostly a facies between gravels up slope and the silty beds of floodplains or of dried Pleistocene lakes (playas) in the centers of the valleys. Thicknesses commonly hundreds of feet. Extensively reworked by wind into sand mounds and dunes. Ground alkaline.

osg — Pliocene and older stream deposits on the Great Plains. Mostly sand and gravel forming very broad fans apparently deposited by distributaries branching eastward rather than by trunk streams like those of today. Generally less than 100 feet thick. Surface layers generally reworked into Quaternary eolian or alluvial deposits; rim rock of older deposits generally firmly cemented by caliche several feet thick. Plains surfaces dotted with small depressions, dry lakes, many in the south extending down to claiche and having dune sand on lee side.

D. Lake deposits

During the Pleistocene, lakes were greater in size and number than they are today. Of the many kinds of lakes, the map shows only the three extensive kinds; all late Pleistocene in age: 1, those formed in front of the continental ice sheets as a result of rivers being dammed by ice (examples around the Great Lakes and in Montana); 2, those formed in the river valleys overdeepened as a result of scour by the ice (Finger Lakes in New York and the Connecticut River valley); and 3, those formed in the more than 100 closed basins which are now mostly dry lakes, or playas (plyas), in the Basin and Range Province.

Other lake deposits of major environmental importance, but too small to be shown on this map include: 1, depressions in ground moraine, most of Minnesota's 10,000 lakes are this kind; 2, sinkholes in readily soluble formations of limestone or gypsum, especially in Florida where the ground in places is hazardous for foundations because of underground drainage; 3, along rivers at cutoff meanders and depressions on deltas, e.g. the Mississippi River valley; 4, back of landslides, e.g. Earthquake Lake in the Madison Range, Montana; 5, back of lava flows or in volcanic craters, e.g. Malheur and Harney Lakes in eastern Oregon, and Crater Lake in the Cascades; and 6, in depressions due to wind erosion, especially evident on the southern Great Plains where depressions commonly have dunes on the leeward sides.

Kinds

1 Lake deposits. Mostly clay and silt grading shoreward to sand and gravel. Deposits associated with midcontinental glacial deposits are mostly fertile farmland; those in Southwest deserts are mostly alkaline or saline playas. The playa deposits commonly are hundreds of feet thick.

E. Eolian deposits

Silt, or loess, in central United States; attributable to winds from the west blowing across desolate mud flats along the rivers subject to alternate flooding and drying because of irregular discharge from melting glaciers. Loesses thin and became finer grained downwind from the river valleys. Some loess was derived from deserts in the Southwest, e.g. the deposit in southeastern Utah, and probably the silt mixed with coarser materials on the southern Great Plains.

Sand sheets, mostly with dunes, are common in southwestern deserts. Dunes shapes depend on topography, relative strength of the winds, supply of sand, and vegetation. Some are concave to leeward (barchan); others are concave to windward (parabolic); others are transverse; and still others are longitudinal. Some dune clusters have all four kinds. Dunes climb windward slopes and fall on leeward slopes. Sand sheets also develop sand mounds at woody shrubs (coppice dunes), especially on the sand facies of alluvial fans in the Southwest. Most sand sheets have a basal layer of weathered, partly cemented and stabilized sand. Southwestern sand sheets are mostly late Pleistocene, most of the dunes are Holocene. Thickness generally less than 30 feet. Along sandy beaches, dunes generally form above the highest beachline, or berm. These are Holocene and overlie estuarine deposits. The loesses are older and range in age from early to late Pleistocene.

Kinds

s Sand sheets, mostly with dunes or sand mounds at surface. Kind of substrate very important in evaluating environmental aspects of the deposits; may be any

wl kind of bedrock or surficial deposit Wisconsinan loess; overlies glacial deposits or outwash; moderately weathered; columnar jointed and forms cliffs although easily eroded. Thickness generally less than 50 feet.

es Deeply weathered loess; mostly PreWisconsinan; forms prominent bluffs along east side of Mississippi and Missouri Rivers. Mostly red and yellow clayey silt. Thickness to 100 feet in Mississippi and Tennessee, 25 feet in Illinois; less than 15 feet in Wisconsin.

MISCELLANEOUS DEPOSITS

In the Appalachian Mountains and in the Pacific northwest about 5 percent of the area shown as colluvium is rock outcrop; in the Rocky Mountains about 10 to 15 percent of the area shown as colluvium is rock outcrop.