U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

OPEN-FILE REPORT
OFR-03-275

Base from U.S. Geological Survey
1:2,000,000-scale State boundary
Digital Line Graph (DLG) files

Albers Equal-Area Projection

SCALE 1:5 000 000

100 0 100 200 300 400 500 MILES

100 0 100 200 300 400 500 600 700 KILOMETERS

102° West

NOTE
This map is a highly generalized depiction of the geology. Limitations on its use are provided in the "CAVEATS" section of the text.

DESCRIPTION OF MAP UNITS

1) This map shows the sediments and the weathered rock materials at land surface, and the approximate thickness of the entire succession of sediments that overlie bedrock. In most places, especially in areas not covered by glacially-deposited sediment, the uppermost material generally constitutes most (and in places, all) of the total thickness of sediment overlying bedrock. However, where sediment is shown exceeding 100 feet (30m) in thickness, the surficial material mapped at land surface does not necessarily extend downward to bedrock. In many places the uppermost material may be only a few feet thick, but the total thickness of sediment overlying bedrock is much greater. This is especially common in the glaciated area where the peat or loess shown on the map is only a thin veneer that overlies a complex package of other surficial materials which, in places, exceeds 1000 ft (330m) in thickness.
2) Color shades and patterns show thickness variations within each map unit. In the color boxes below, a code indicates sediment thickness, as follows:

P — *Areas where the surficial material does not everywhere cover the underlying bedrock (i.e., where it is discontinuous, or patchy in distribution).*
<100 — *Surficial materials are continuous in distribution, and are generally less than 100 feet thick.*
>100 — *Surficial materials exceed 100 feet in thickness.*

Alluvial sediments (Holocene to Pliocene) -- clay- to gravel-sized sediment, with minor coarser materials, generally moderate- to well-bedded, deposited by perennial and intermittent streams and rivers and by sheetwash flow on uplands. Locally includes associated lake and estuarine sediments. Along perennial streams and rivers, relatively well-sorted sediment underlies floodplains, natural levees, and alluvial terraces that parallel modern or former drainage courses. Alluvial sediments within the glaciated area commonly overlie or are mixed with sediment deposited by water that flowed from the glaciers (see "Glaciofluvial ice-contact sediments", below). On steeper slopes and especially in the arid western U.S., relatively poorly sorted sediment (including debris-flow and debris-avalanche material) underlies alluvial fans and fan piedmonts deposited by intermittent streams. These materials generally form a continuous cover less than 100 feet thick. However in many places, notably in the Mississippi River Valley, in the glaciated area, on the uplands near the Platte River in Nebraska, and in fault-bounded valleys of the western U.S., these sediments may greatly exceed 100 ft in thickness.

Coastal zone sediments (Holocene to Pliocene) -- sediment deposited along the coastal margins of the Atlantic, Gulf of Mexico, and Pacific. Mapped according to sediment texture and environment. These sediments, and any underlying sediments, are generally less than 100 ft thick, forming a continuous cover on underlying rocks (except on Long Island, where the sediments are considerably thicker).

<100 — Generally fine-grained sediment deposited in lagoons, tidal flats, backbarriers, and coastal marshes.

<100 — Generally medium-grained sediment deposited on beaches and dunes, and in shallow marine and related alluvial environments.

Biological sediments (Holocene to middle Pleistocene) -- calcareous materials such as algal mats, marl, oolitic and coralline limestone, and shelly sand, deposited in beach and nearshore environments. These sediments, and any underlying sediments, are generally less than 100 ft thick, forming a continuous cover on underlying rocks. Mapped mostly in South Florida.

<100

Organic sediments (Holocene to late Pleistocene) -- organic-rich muck and peat deposited in poorly drained and swampy areas. These sediments, and any underlying sediments, are generally less than 100 ft thick, forming a continuous cover on underlying rocks. Mapped in the glaciated region and the coastal margins of the Atlantic and Gulf Coast; areas >100 ft thick are found in the glaciated region, but much of that thickness is composed of the underlying glacially-deposited sediment.

<100 >100

Glacial till sediments (late Wisconsinan to pre-Illinoian) -- unsorted material ranging in grain size from clay to boulders, deposited by glacial ice. Includes minor areas of ice-contact and lake sediment. Areas of predominantly clayey, loamy (silty), and sandy till are shown separately on the map. These sediments, and any underlying sediments, commonly form a continuous cover on underlying rocks and may exceed 100 ft in thickness, especially in areas that were occupied by numerous glacial ice lobes (for example, central Michigan, northeastern South Dakota). However, in some areas that are mountainous or near the glacial margin, these sediments are patchy in distribution and bedrock commonly is exposed at land surface.

P <100 >100 — Predominantly clayey till. Mapped mostly in lowlands near the Great Lakes.

P <100 >100 — Predominantly loamy (silty) till, or tills of various textures.

P <100 — Predominantly sandy till. Mapped mostly in the western half of the U.S., and in New England and the Adirondack Mountains.

Glaciofluvial ice-contact sediments (late Wisconsinan to Illinoian) -- mostly sand and gravel with lesser silt, deposited by running water essentially in contact with glacial ice. Includes sediment deposited into water bodies adjacent to the glacial ice margin. These sediments, and any underlying sediments, commonly form a continuous cover on underlying rocks, and may exceed 100 ft in thickness, especially in modern to pre-glacial river channels. Mapped as small areas within the glaciated region in the eastern U.S., notably in eastern Massachusetts.

P <100 >100

Proglacial sediments (late Wisconsinan to pre-Illinoian) -- fine- to coarse-grained sediment derived from material eroded and transported by glaciers. As the ice melted, this material was transported and deposited by glacially-fed streams.

P <100 >100 — Generally fine-grained sediment melted from glaciers and deposited in lakes and marine environments. In the eastern U.S., these lakes are commonly small and related to ice and sediment damming of waters near the margin of the continental glaciers. In the western U.S., these lakes may be considerably larger (e.g., Lake Missoula in western Montana). Includes some areas of glacial till and well-sorted glaciofluvial sediment. These sediments, and any underlying sediments, commonly form a continuous cover on underlying rocks and may exceed 100 ft in thickness.

P <100 >100 — Generally coarse-grained sediment mostly deposited in terraces, river floodplains, buried valleys, and as sheet deposits during intervals when glacial ice was melting. In the northwest U.S., includes coarse-grained flood sediments from the breaching of glacial Lake Missoula. Includes fine-grained deposits, especially in slackwater areas. In places, interfingers with alluvial sediments. These sediments, and any underlying sediments, commonly form a continuous cover on underlying rocks and may exceed 100 ft in thickness. Common in glaciated region and the Pacific Northwest.

Lacustrine and playa sediments (Holocene to Pliocene) -- fine- to coarse-grained sediment and evaporite salts deposited in mostly undrained basins by perennial and ephemeral lakes in the arid western U.S.

<100 — Lacustrine sediments. Generally well sorted and well bedded material ranging in grain size from clay to coarse gravel, deposited in perennial to intermittent lakes commonly in undrained valleys of the Great Basin. Because these lakes mostly are a response to lower evaporation and increased precipitation rather than to the melting of glaciers, much of the sediment is derived from stream erosion. Locally includes material deposited in playas, mudflats, salt flats, and adjacent saline marshes. Generally interbedded with playa sediment deposited during drier climatic periods; commonly intertongues upslope with sediment deposited by alluvial fans. These sediments, and any underlying sediments, commonly form a continuous cover less than 100 feet thick along valley margins, and may exceed several hundred feet in thickness in long-lived sedimentary basins.

<100 — Playa sediments. Fine-grained sediment and evaporite salts deposited in ephemeral lakes in the centers of undrained basins. Includes material deposited in playas, mudflats, salt flats, and adjacent saline marshes. Generally interbedded with eolian sand and with lacustrine sediment deposited during wetter climatic periods; commonly intertongue upslope with sediment deposited by alluvial fans. These sediments, and any underlying sediments, commonly form a continuous cover less than 100 feet thick, and may exceed several hundred feet in thickness in long-lived sedimentary basins.

Eolian sediments (Holocene to Pleistocene) -- silt- and sand-sized sediment deposited by wind. These sediments, and any underlying sediments, commonly form a continuous cover on underlying rocks and generally do not exceed 100 ft in thickness.

<100 >100 — Mostly loess (a silty material deposited by winds near the glacial margin). Includes minor areas of alluvium and colluvium. Loess forms a thin cover over much of the central United States, but is shown on this map only where it is thicker than 20 ft.

<100 >100 — Mostly dune sands. Notably thick in the Nebraska Sand Hills.

<100 — On Southern High Plains in Texas and Oklahoma, the eolian sediments are somewhat different in texture and origin from typical dune sands or loess, forming a complex silty to sandy sediment. In general, the eolian sediments are more sandy in the west or southwest and more silty and clayey in the east or northeast.

Mass-movement sediments (Holocene to Tertiary) -- poorly sorted and stratified sediment ranging from clay to boulders in size; may contain organic material. Formed by weathering and breakdown of underlying rock in areas of steep to moderate slopes. The weathered and broken material has undergone some downslope transport and has been deposited as colluvium, landslides, talus, and rock avalanches. In places, this map unit includes the following: residual materials, especially on lower slopes; alluvial sediments; and fine-grained eolian sediments (loess) overlying the colluvium. In the eastern U.S., the unit has been subdivided to indicate where these other constituents occur. These sediments generally are patchy in distribution, especially on steeper slopes where rock can be found exposed amongst these sediments. However, in many areas they do form a continuous cover and, locally in some debris flows and slope failures, they exceed 100 feet in thickness.

P <100 — Mostly colluvial sediments.

P — Colluvial and alluvial sediments.

P — Colluvial sediments and loess.

P — Colluvial sediments and residual material.

Residual materials (Holocene to Tertiary) -- these materials formed by the partial chemical dissolution and physical disintegration of bedrock; they include the modern soil profile and extend downward to unweathered rock. Depending on the source rock, these materials can be generally fine- to coarse-grained, and commonly are poorly sorted. Unlike mass-movement sediments, these materials were not transported. In places, this map unit includes alluvial and colluvial sediments. This material is generally less than 10 ft (3m) thick and, in many places, is patchy in distribution. Particularly in mountainous areas, exposed rock can me more commonly be found than residual material.

P — Residual materials developed in igneous and metamorphic rocks.

P <100 — Residual materials developed in sedimentary rocks.

P — Residual materials developed in fine-grained sedimentary rocks (e.g., shale) that contain smectite (a clay mineral responsible for "swelling soil").

P <100 — Residual materials developed in limestone and other carbonate rocks.

P — Residual materials developed in alluvial sediments. Mapped mostly on the Atlantic and Gulf coastal margins, adjacent to Coastal zone deposits.

P <100 — Mostly residual materials developed in bedrock, with lesser sheetwash alluvial sediments.

P <100 — Mostly residual materials developed in bedrock, with lesser colluvial sediments.

Volcanic rocks (Holocene to Pliocene) -- ranges from generally coarse-grained sediment to rocks, formed by volcanic eruptions. Includes dominantly volcanic sediment reworked from original depositional setting by fluvial processes. Character is largely dependent on magma composition: silicic eruptions produce domes and ash-flow tuffs, andesitic eruptions along the western plate boundary produce large stratovolcanoes, and basaltic eruptions produce cinder cones and sheet-like flows. Generally between 10 and 100 ft (3 and 30m) thick, except in stratovolcanoes and in the Snake River Plain region (southern Idaho), where stacked basalt flows may be hundreds of feet thick.

<100

EXPLANATION OF MAP SYMBOLS

Contact between major sediment classes (e.g., between Residual and Mass-movement)

Contact between minor sediment classes (e.g., between clayey till and loamy till)

DISCUSSION

INTRODUCTION

The Earth's bedrock is overlain in many places by a loosely compacted and mostly unconsolidated blanket of sediments in which soils commonly are developed. These sediments generally were eroded from underlying rock, and then were transported and deposited. In places, they exceed 1000 ft (330 m) in thickness. Where the sediment blanket is absent, bedrock is either exposed or has been weathered to produce a residual soil. This map shows the sediments and the weathered, residual material; for ease of discussion, these are referred to here as "surficial materials." Certain areas on this map include a significant number of rock outcrops, which cannot be shown at the scale of the map; this is noted in the "Description of Map Units" section.

Most daily human activities occur on or near the Earth's surface. Homeowners, communities, and governments can make improved decisions about hazard, resource, and environmental issues, when they understand the nature of surficial materials and how they vary from place to place. For example, are the surficial materials upon which a home is built stable enough to resist subsidence or lateral movement during an earthquake? Do these materials support a ground water resource adequate for new homes? Can they adequately filter contaminants and protect buried aquifers both in underlying sediments and in bedrock? Are they suitable for development of a new wetland? Where can we find materials suitable for aggregate?

The USGS National Cooperative Geologic Mapping Program (NCGMP) works with the State geological surveys to identify priority areas for mapping of surficial materials (for example, in areas of complex and poorly understood deposits of various sediment types, where metropolitan areas are experiencing rapid growth). To help establish these priorities, a modern, synoptic overview of the geology is needed. This map represents an overview of our current knowledge of the composition and distribution of surficial materials in the conterminous United States*. The best available map has been a highly generalized depiction at 1:7,500,000-scale (about 120 miles to the inch), prepared for the USGS National Atlas (Hunt, 1979; 1986).

This map is compiled at a slightly more detailed scale (about 80 miles to the inch) than Hunt (1979; 1986). We used digital methods, which enabled us to rapidly incorporate the variety of source maps available to us. State-scale geologic maps from the western United States were brought directly into this map, without expending the time needed to resolve interpretive differences among them. Therefore, abrupt changes in surficial materials are indicated along many State boundaries. This of course is an artifact of our compilation technique, and a limitation on its utility. However, this approach supports the basic premise of the map -- to provide an overview of surficial materials, and to identify areas where additional work may be needed in order to resolve scientific issues that can, in turn, lead to improved mapping.

* The map covers only the conterminous U.S. because similar geologic information in digital form was not readily available for Alaska and Hawaii.

ACKNOWLEDGMENTS

This map was funded by the USGS National Cooperative Geologic Mapping Program. Geologic maps and digital files that were used to create this map are listed in the "References and Compilation Sources" section. David R. Soller (for the eastern States) and Marith C. Reheis (for the western States) compiled and generalized the map units from the source materials. Darren VanSistine (for the western States) and David R. Soller (for the eastern States) performed the digital processing of map data. Nancy R. Stamm and David R. Soller prepared the final, printed product. The compilers thank Russell W. Graymer and Van S. Williams (USGS) for their critical reviews of this map.

GENERAL DISTRIBUTION OF SURFICIAL MATERIAL TYPES

Surficial materials can be classified according to their age, texture, composition, and environment of deposition or formation. The environment of deposition is particularly helpful in understanding differences among these materials. For example, the texture, internal structure, and thickness of materials transported and deposited by glaciers are markedly different from residual materials developed in place, in bedrock. A highly generalized graphical depiction of the sediment texture and depositional environment of map units is shown in Figure 1.

The map shows broad, regional differences in the nature of materials at land surface. To help identify different units on the map, small index maps showing the general distribution of each unit are provided; this technique was adapted from: Miles, C., compiler, 2003, Geologic shaded-relief map of Pennsylvania: Pennsylvania Bureau of Topographic and Geologic Survey Map 67, scale 1:500,000. In the Atlantic and Gulf coastal zones, clayey to sandy materials have been deposited in beach, lagoonal, nearshore, and related environments. Inland, broad areas especially in the southern, central, and western parts of the Nation are covered by thin residual materials weathered from the underlying bedrock, and "mass-movement" (landslide and hillside creep) sediments mostly derived from residual materials that have been slightly transported downslope and redeposited. In many places, the residual and mass-movement materials are patchy or absent and bedrock is exposed, especially on hillslopes. For large areas of the midwest, these and other materials are blanketed by windblown sediments, especially on the uplands. Coarse- to fine-grained alluvial and lake sediments are commonly found in major river valleys throughout the Nation, in low-lying areas of glacial-age lakes (e.g., surrounding the Great Salt Lake, Utah), and in internally drained valleys in the Great Basin of the western U.S. In the northeast and north-central United States, glacial ice caused the accumulation of extensive and thick deposits (in places exceeding 1000 ft) of till and associated glacial lake and stream sediments; these materials support a rich agricultural and industrial infrastructure.

METHODOLOGY

The compilation of this map began with an inventory of available source maps. We used maps that met the following criteria: were statewide or larger in area; showed surficial materials at land surface (or could be interpreted to derive such information); and were Geographic Information System (GIS) files in ArcInfo format. For the conterminous U.S. east of 102 degrees West Longitude, we used a 1:2,500,000-scale recompilation (Fullerton and others, written commun.) of the "Quaternary Geologic Atlas of the United States" series (U.S. Geological Survey, Map I-1420, scale 1:1,000,000). That recompilation contained more than 150 different types of surficial materials. For the conterminous U.S. west of 102 degrees West Longitude, we used published statewide geologic maps, which mostly were at 1:500,000-scale. Those maps emphasized the bedrock geology, although they also showed some of the major unconsolidated units such as alluvium in major river valleys and large deposits of lake sediment. Significant interpretation therefore was required in order to identify the appropriate residual surficial material developed in each mapped bedrock unit.

The disparity in information content among source maps argued for a broad classification with few units. We began with a simple classification based on that of the British Geological Survey (McMillan and Powell, 1999). For the eastern source map (Fullerton and others, written commun.), each of the 150 map unit descriptions were interpreted and manually parsed into various attribute fields in a spreadsheet. Attributes included: unit name, dominant sediment texture, geologic age, environment of deposition, and thickness. After using these attributes to classify the map units, the map was displayed and evaluated and, iteratively, a revised classification emerged that adequately displayed and highlighted the broad variations in surficial materials. This classification emphasizes sediment texture and depositional environment.

Parsing into sediment texture and depositional environment fields was especially challenging because the map unit descriptions were in many cases quite lengthy and complex, and contained information about several different surficial material types. For example, in southwestern North Dakota a unit on a source map is named "Loamy disintegration residuum, sheetwash alluvium, and colluvium on sandstone, siltstone, mudstone, claystone, shale, and lignite" -- this map unit contains three different major types of surficial material and a variety of bedrock lithologies that provide sources for the surficial material. We classified the unit as "Mostly residual materials developed in bedrock, with lesser sheetwash alluvial sediments".

For each source map in the western part of the Nation, unconsolidated units were assigned to the appropriate category in our classification, and bedrock units were assigned to the surficial materials category most appropriate to their rock composition; for example, a sedimentary rock unit predominantly comprised of limestone was assigned to the category "Residual materials developed in limestone and other carbonate rocks". These source maps then were appended into a single digital map file of the western States, and additional source information for lake and eolian deposits was added (see "General References" under Part 3 of "References and Compilation Sources" section).

We combined the eastern and western GIS map files into a single Postscript file and, using Adobe Illustrator, produced this map without an accompanying GIS database. However, at some future time a GIS database may be prepared.

Sediment thickness estimates were derived from various sources. For the glaciated area and adjacent alluvial valleys mostly in the eastern part of the map, thickness contours from Soller and Packard (1998) were generalized. Elsewhere in the east, sediment thicknesses were derived from the source map unit descriptions. In the west, sediment thicknesses were obtained from source maps and also by generalizing to map units the known thicknesses of local areas. Sediment thickness is shown by stippled patterns and variations in color intensity.

CAVEATS

This map is a highly generalized depiction of surficial materials for the conterminous United States. It is intended solely as an overview of existing knowledge, as an educational tool, and as a guide to support discussions on where additional geologic mapping might be needed. Because of its generalized unit descriptions, regional scale, and incomplete integration across the map area (as discussed below), this map is not intended for decisionmaking at the local scale.

Many of the processes that create surficial materials (especially those involving wind or mass movement of materials) tend to vary over small distances, and so the delineation of map areas large enough to be visible at the scale of this map (1 inch on the map equals about 80 miles on the ground) is highly problematic. To improve map legibility and comprehension, a classification system was required that assigned the many complex units on source maps into units much more broadly and simply defined.

In some cases, units on source maps could not be readily assigned to our classification. As an example, a geologic unit found mostly in the southeastern U.S. is a residual material that developed mostly in metamorphosed sedimentary rocks and, to a lesser extent, in sedimentary rocks. Rather than define a new map unit, we decided to classify it as "Residual materials developed in sedimentary rocks" to distinguish it from "Residual materials formed in igneous and metamorphic rocks". As another example, the source map for New York and New Jersey classified a unit as "Ice-contact deposits and glacial lake deposits -- A complex of ice-contact sand and gravel and glacial lake sediments." This unit could not readily be assigned in our classification to either a coarse- or a fine-grained unit. Therefore, we decided to assign it to a genetically-related unit, glacial till, whose texture ranges from coarse to fine. This decision certainly is imperfect, and illustrates the difficulties in reinterpreting source map information.

A further challenge is presented where map units from different source maps abut. When compiling a map from numerous published sources, many instances occur where, especially along the edges of adjoining source maps, the materials are described and mapped in different ways. Normally, these inconsistencies can be resolved by additional field mapping or through discussions with the geologists who created the source maps, and this is an especially effective approach when mapping at a relatively detailed scale. Lacking such avenues for resolution, units shown on adjacent source maps could not always be reconciled. Therefore, this map shows numerous instances where different map units meet along straight lines, commonly at state or latitude boundaries. For example, in North Dakota, a map unit extends westward where it seems to correspond to a unit from the adjacent source map. However, on that adjacent map, the surficial materials were not shown; there, it must be assumed that the bedrock is exposed and has been weathered to produce residual materials. The residual materials that are inferred from that map are classified differently than the materials described on the map to the east, hence there appears to be a sharp discontinuity in surficial materials. Because this map is an overview, essentially a "snapshot" of current knowledge that can be represented at a national scale, these inconsistencies are retained to indicate what is actually known about the materials, and to indicate where additional mapping may be beneficial.

Regarding the thickness of these surficial materials, scant information at a regional or national scale is available, except within the glaciated area. In most places, this is not a significant problem because these materials generally fall within our lower thickness category (<100 ft). However, for large expanses of alluvial and lacustrine materials (for example, in the Mississippi River Valley, the Platte River Valley, and in internally drained valleys of the western United States), thicknesses may exceed 100 ft, even where not so indicated on the map.

In most places, especially in areas not covered by glacially-deposited sediment, the uppermost material generally constitutes most (and in places, all) of the total thickness of sediment overlying bedrock. However, where sediment is shown exceeding 100 feet in thickness, the surficial material mapped at land surface does not necessarily extend downward to bedrock. In many places the uppermost material may be only a few feet thick, but the total thickness of sediment overlying bedrock is much greater. This is especially common in the glaciated area where the peat or loess shown on the map is only a thin veneer that overlies a complex package of other surficial materials which, in places, exceeds 1000 ft in thickness. Please refer to the "Description of Map Units" section for further information.

SUMMARY

A detailed understanding of the Earth's blanket of sediment and weathered bedrock is critical to our society, because nearly all human activities occur on or within these materials. This level of understanding is now being gained through detailed mapping by the State geological surveys and the USGS. In support of that work, this map provides a rapid, preliminary regional compilation; it does not offer information useful for local decisions, but instead serves to illustrate for educational and planning purposes the general nature and distribution of the Nation's surficial materials at land surface. Perhaps most significantly, the map is intended to highlight regional differences in the mapping of these materials. The compilers hope the map will thereby serve a useful purpose, by helping to guide further mapping efforts.

DEVELOPED IN SITU — TRANSPORTED AND DEPOSITED

GRAIN SIZE — COARSER — FINER

Residual materials developed on igneous and metamorphic rocks
Residual materials developed on sedimentary rocks
Residual materials developed on unconsolidated alluvial deposits
Residual materials developed on sedimentary rock
Mass-movement deposits
Coastal zone deposits
Coastal zone deposits
Alluvial deposits
Predominantly clayey till
Predominantly loamy (silty) till
Predominantly sandy till
Glaciofluvial ice-contact deposits
Proglacial deposits
Proglacial deposits
Eolian deposits (loess)
Eolian deposits (dune sands)

Figure 1. The general texture and transport history for various depositional environments in our classification of map units. The figure is intended only to acquaint the reader with the general characteristics, similarities, and differences among the map units, and should not be used as a definitive guide to a map unit's characteristics. To simplify the presentation, not all map units are shown here.

GEOLOGIC TIME SCALE

PERIOD	EPOCH	AGE	
QUATERNARY	Holocene		
	Pleistocene	late	Wisconsinan
			Sangamonian
		middle	Illinoian
			Yarmouthian
		early	pre-Illinoian
TERTIARY (part)	Pliocene	late	
		early	

Time scale modified from:
a) Hansel, A.K., and Johnson, W.H., 1996, Wedron and Mason Groups: Lithostratigraphic reclassification of deposits of the Wisconsin Episode, Lake Michigan Lobe Area: Illinois State Geological Survey Bulletin 104, 116p.;
b) Sibrava, V., Bowen, D.Q., and Richmond, G.M., editors, 1986, Quaternary glaciations in the northern hemisphere: Report of the International Geological Correlation Programme, Project 24: Pergamon Press, New York, 514 p.; and
c) Remane, J., compiler, 2000, International Stratigraphic Chart: International Union of Geological Sciences, <http://www.stratigraphy.org/>.

Absolute ages are not provided here, but as a general frame of reference the Pleistocene Epoch occurred between about 1.81 million to about 10,000 years before present.

REFERENCES AND COMPILATION SOURCES

1. General references:

Hunt, C.B., 1986, Surficial deposits of the United States: Van Nostrand Reinhold Company, New York, 189 p.

Hunt, C.B., 1979, Surficial geology of the conterminous United States: U.S. Geological Survey, National Atlas of the United States of America, scale 1:7,500,000.

McMillan, A.A., and Powell, J.H., 1999, BGS Rock Classification Scheme, Volume 4, Classification of artificial ground and natural superficial deposits -- applications to geological maps and datasets in the UK: British Geological Survey Research Report, RR 99-04, 61 p.

2. Compilation sources for eastern United States (east of 102 degrees West Longitude):

Fullerton, D.S., Bush, C.A., and Pennell, J.N. (U.S. Geological Survey), written commun., Surficial deposits and materials in the eastern and central United States (east of 102 degrees West Longitude): U.S. Geological Survey unpublished database derived from map series "Quaternary Geologic Atlas of the United States, USGS map I-1420", one ArcInfo file, scale 1:2,500,000. [Printed map derived from this database is available as: Fullerton, D.S., Bush, C.A., and Pennell, J.N., 2003, Map of surficial deposits and materials in the eastern and central United States (east of 102 degrees West Longitude): U.S. Geological Survey Geologic Investigations Series Map I-2789, scale 1:2,500,000.]

Kolfield, K.E., and Muhs, D.R., [n.d.], Mid-continental USA gridded maps of loess thickness: World Data Center-A for Paleoclimatology, Data Contribution Series, NOAA-NGDC Paleoclimatology Program, Boulder, CO., <http://www.hgo-jema.mgp.de/bgr_prentice/projects/dirmap/>.

Mason, J.A., 2001, Transport direction of Peoria Loess in Nebraska and implications for loess sources on the Central Great Plains: Quaternary Research, v. 56, p. 79-86.

Soller, D.R., and Packard, P.H., 1998, Digital representation of a map showing the thickness and character of Quaternary sediments in the glaciated United States east of the Rocky Mountains: U.S. Geological Survey Digital Data Series, DDS-38, ArcInfo files, scale 1:1,000,000, <http://pubs.usgs.gov/dds/dds38/>.

Swinehart, J.B., and Diffendal, R.F., Jr., 1989, Geology of the pre-dune strata, *in* A. Bliord and C. Flowerday, eds., An atlas of the Sand Hills: Conservation and Survey Division of the University of Nebraska, Resource Atlas, no. 5, p. 29-42.

3. Compilation sources for western United States (west of 102 degrees West Longitude):

Arizona

Richard, S.M., Reynolds, S.J., Spencer, J.E., and Pearthree, P.A., 2000, Geologic map of Arizona: Arizona Geological Survey Map 35, scale 1:1,000,000. [Used a slightly modified unpublished digital version of this map.]

California

Bedford, D.R. (U.S. Geological Survey), written commun., digital file showing geology of California, *digitized from* Jennings, C.W., Strand, R.G, and Rogers, T.H. (compilers), 1977, Geologic map of California: California Div. Mines and Geology Map GDM 2, scale 1:750,000. [Some information in this file is found in: Bedford, D.R., Ludington, Steve, Nutt, C.M., Stone, P.A., Miller, D.M., Miller, R.J., Wagner, D.L., and Saucedo, G.J., 2003, Geologic database for digital geology of California, Nevada, and Utah - an application of the North American Data Model: USGS Open-File Report 03-135, 35 p., <http://geopubs.wr.usgs.gov/open-file/of03-135/>.]

Colorado

Green, G.N., 1992, The digital geologic map of Colorado in ArcInfo format: U.S. Geological Survey Open-File Report 92-507, ArcInfo file, <http://pubs.usgs.gov/of/1992/of92-0507/>. [*digitized from* Tweto, Ogden, 1979, Geologic map of Colorado: U.S. Geological Survey, scale 1:500,000.]

Idaho

Johnson, B.R., and Raines, G.L., 1996, Digital representation of the Idaho state geologic map: a contribution to the Interior Columbia River Basin Ecosystem Management Project: U.S. Geological Survey Open-File Report 95-690, ArcInfo file, <http://wrgis.wr. usgs.gov/open-file/of95-690/>. [*digitized from* Bond, J.G., and Wood, C.H., 1978, Geologic map of Idaho: Idaho Bureau of Mines and Geology, scale 1:500,000.]

Kansas

Ross, J.A., compiler, Geologic map of Kansas: Kansas Geological Survey Map M-23, ArcInfo file, scale 1:500,000.

Montana

Raines, G.L. and Johnson, B.R., 1996, Digital representation of the Montana state geologic map: a contribution to the Interior Columbia River Basin Ecosystem Management Project: U.S. Geological Survey Open-File Report 95-691, ArcInfo file, <http://pubs.usgs.gov/of/ 1995/ofr-95-0691/>. [*digitized from* Ross, C.P., Andrews, D.A., and Wilkind, I.J., 1955, Geologic map of Montana: U.S. Geological Survey, scale 1:500,000.]

Soller, D.R., and Packard, P.H., 1998, Digital representation of a map showing the thickness and character of Quaternary sediments in the glaciated United States east of the Rocky Mountains: U.S. Geological Survey Digital Data Series, DDS-38, ArcInfo files, scale 1:1,000,000, <http://pubs.usgs.gov/dds/dds38/>.

Nebraska

Belohlavy, Francis (Conservation and Survey Division, Univ. of Nebraska - Lincoln), written commun., Digital map of soil parent materials (interpreted as bedrock types, alluvium, etc.) assembled by querying STATSGO data (from USDA Nat. Res. Conserv. Serv.), see <http://www.nrc.state.ne.us/databank/metadata/stgo_doc.html>.

Nevada

Bedford, D.R. (U.S. Geological Survey), written commun., digital file showing geology of Nevada, *digitized from* Stewart, J.H. and Carlson, J.E., 1978, Geologic map of Nevada: U.S. Geological Survey, scale 1:500,000. [Information about any modifications of the published map are found in: Bedford, D.R., Ludington, Steve, Nutt, C.M., Stone, P.A., Miller, D.M., Miller, R.J., Wagner, D.L., and Saucedo, G.J., 2003, Geologic database for digital geology of California, Nevada, and Utah - an application of the North American Data Model: USGS Open-File Report 03-135, 35p.,<http://geopubs.wr.usgs.gov/open-file/of03-135/>.]

New Mexico

Green, G.N., and Jones, G.E., 1997, The digital geologic map of New Mexico in ArcInfo format: U.S. Geological Survey Open-File Report 97-52, ArcInfo file, <http://pubs.usgs.gov/of/1997/ofr-97-0052/>. [*digitized from* Anderson, O.J. and Jones, G.E., 1994, Geologic map of New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-File Report 408 A, B, scale 1:500,000.]

North Dakota

Clayton, Lee, 1980, Geologic map of North Dakota: U.S. Geological Survey Special Map prepared in cooperation with North Dakota Geological Survey, scale 1:500,000. [Used an unpublished, digital version of this map.]

Soller, D.R., and Packard, P.H., 1998, Digital representation of a map showing the thickness and character of Quaternary sediments in the glaciated United States east of the Rocky Mountains: U.S. Geological Survey Digital Data Series, DDS-38, ArcInfo files, scale 1:1,000,000, <http://pubs.usgs.gov/dds/dds38/>.

Oklahoma

Cederstrand, J.R., 1996, Digital geologic map of Cimarron County, Oklahoma: U.S. Geological Survey Open-File Report 96-372, ArcInfo file. [*digitized from* Sapik, D.B., and Goemaat, R.L., 1973, Reconnaissance of the ground-water resources of Cimarron County, Oklahoma: U.S. Geological Survey Hydrologic Investigations Atlas HA-373, scale 1:125,000.]

Cederstrand, J.R., 1996, Digital geologic map of Texas County, Oklahoma: U.S. Geological Survey Open-File Report 96-379, ArcInfo file. [*digitized from* Wood, P.R., and Hart, D.L., Jr., 1967, Availability of ground water in Texas County, Oklahoma: U.S. Geological Survey Hydrologic Investigations Atlas HA-250, scale 1:125,000.]

Oregon

Walker, G.W. and MacLeod, N.S., 1991, Geologic map of Oregon: USGS, ArcInfo file, scale 1:500,000, <http://geology.wr. usgs.gov/docs/geologic/or/oregon.html>.

South Dakota

South Dakota Geological Survey, in prep., Geologic map of South Dakota; preliminary version obtained from Nancy Shock, USGS Central Publications Group, Denver, CO.

Texas

Barnes, V.E., editor, 1992, Geologic Map of Texas: Texas Bureau of Economic Geology, scale 1:500,000. [Quaternary units on the map were generalized and then digitized.]

Utah

Bedford, D.R. (USGS), written commun, digital file showing geology of Utah, *adapted from* Hintze, L.F., Willis, G.C., Laes, D.Y.M., Sprinkel, D.A., and Brown, K.D., 2000, Digital geologic map of Utah: Utah Geological Survey Map 179DM, CDROM. [Information about modifications of the published map are found in: Bedford, D.R., Ludington, Steve, Nutt, C.M., Stone, P.A., Miller, D.M., Miller, R.J., Wagner, D.L., and Saucedo, G.J., 2003, Geologic database for digital geology of California, Nevada, and Utah - an application of the North American Data Model: USGS Open-File Report 03-135, 35 p., <http://geopubs.wr.usgs.gov/open-file/of03-135/>.]

Washington

Raines, G.L., and Johnson, B.R., 1996, Digital representation of the Washington state geologic map: a contribution to the Interior Columbia River Basin Ecosystem Management Project: U.S. Geological Survey Open-File Report 95-684, ArcInfo file, <http://wrgis.wr.usgs.gov/open-file/of95-684/>. [*digitized from* Hunting, M.T., Bennett, W.A., Livingston, V.E., Jr., and Moen, W.S., 1961, Geologic map of Washington: Washington Division of Mines and Geology, scale 1:500,000.]

Wyoming

Green, G.N., and Drouillard, P.H., 1994, The digital geologic map of Wyoming in ArcInfo format: U.S. Geological Survey Open-File Report 94-425, ArcInfo file, <http://pubs.usgs.gov/of/1994/ofr-94-0425/>. [*digitized from* Love, J.D. and Christiansen, A.C., 1985, Geologic map of Wyoming: U.S. Geological Survey, scale 1:500,000.]

General references

Kerwin, M.W. (U.S. Geological Survey), written commun., digital file showing pluvial lakes of the western U.S. Information mostly derived from:
Reheis, Marith, 1999, Extent of Pleistocene lakes in the western Great Basin: U.S. Geological Survey Miscellaneous Field Studies Map MF-2323, <http://pubs.usgs.gov/mf/1999/mf-2323/>.
Mifflin, M.D., and Wheat, M.M., 1979, Pluvial lakes and estimated pluvial climates of Nevada: Nevada Bureau of Mines and Geology Bulletin 94, 57 p., scale 1:1,000,000.
Snyder, C.T., Hardman, G., and Zdenek, F.F., 1964, Pleistocene lakes in the Great Basin: U.S. Geological Survey Miscellaneous Investigations Map I-416, scale 1:1,000,000.

Locke, H. (Montana State University), and Smith, L. (Montana Bureau of Mines and Geology), written commun., digital files from U.S. Forest Service showing the maximum extent of Glacial Lake Missoula.

Muhs, D.R. (U.S. Geological Survey), written commun., digital file showing surficial sands of the western U.S. Information mostly derived from:
Muhs, D.R., and Zarate, Marcelo, 2001, Late Quaternary eolian records of the Americas and their paleoclimatic significance, *in* V. Markgraf, ed., Interhemispheric Climate Linkages: Academic Press, San Diego, p. 183-216.
Muhs, D.R., and Holliday, V.T., 1995, Evidence of active dune sand on the Great Plains in the 19th century from accounts of early explorers: Quaternary Research, v. 43, p. 198-208.
Thorpe, J., and Smith, H.T.U., 1952, Pleistocene eolian deposits of the United States, Alaska, and parts of Canada: National Research Council Committee for the Study of Eolian Deposits, Geological Society of America, scale 1:2,500,000.

United States Forest Service, [n.d.], Glacial Lake Missoula and the Channelled Scablands: A digital portrait of landforms of the last ice age, Washington, Oregon, northern Idaho, and western Montana: U.S. Department of Agriculture, United States Forest Service, Northern Rockies Region, scale 1:2,000,000.

SURFICIAL MATERIALS IN THE CONTERMINOUS UNITED STATES

David R. Soller and Marith C. Reheis, compilers

2004

This map is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards. Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.

USGS science for a changing world