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SCIENTIFIC INVESTIGATIONS MAP 2823
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SURFICIAL GEOLOGIC MAP OF THE SOUTHWEST MEMPHIS QUADRANGLE, SHELBY COUNTY, TENNESSEE, AND CRITTENDEN COUNTY, ARKANSAS

By
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2004

Base from U.S. Geological Survey 1965; revised 1993
1927 North American Datum (NAD 27)
Projection and 1,000-meter grid: Transverse Mercator, zone 15
10,000-foot ticks: Tennessee Coordinate System

SCALE 1:24 000
CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology mapped by Moore and Diehl in 2000
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SUMMARY

The predominant surficial deposits in the quadrangle are loess and alluvium. The loess (Ql), which is a wind-deposited layer of silt and clayey silt that covers the upland, is 4.5–16 m thick. In the valleys, sandy river alluvium (Qal), 10–35 m thick, underlies the Mississippi River and its floodplain; silty creek alluvium (Qa), 1–10 m thick, underlies the tributary stream floodplains. No evidence of prehistoric liquefaction (sand boils or sand dikes) or slumping was observed in any mapped deposits. Pebbly sand deposits, probably less than 50 years old, are 0.5–3 m thick and make up the point-bar deposits in the perennial channel of Nonconnah Creek. These are included in unit Qa.

DESCRIPTION OF MAP UNITS

Artificial fill (late Holocene)—Brown (7.5YR 5/4) silt to clayey silt, generally obtained from loess deposits. Locally, unit contains minor amounts of chert pebbles and sand where excavations locally cut the underlying gravel (“Lafayette Gravel,” QTg). Buildings or concrete and asphalt surfaces of roadbeds, airport runways, and other structures cover the artificial fill, which is presumed (not verified) to be compacted to engineering specifications. Fill beneath railways is pebble-size, angular, crushed crystalline igneous rock and limestone ballast; aggregated thickness estimated to be about

1 m. Thickness of artificial fill is estimated to be 0.5–2 m under paved surfaces (not exposed) and 1–5 m under highway access ramps

River alluvium (Holocene and late Pleistocene)—White (10YR 8/2), very pale brown (10YR 8/4), fine- to medium-grained quartz and chert (10 percent of total sand) sand; 2–5 percent heavy minerals with green olivine(?) and pyroxene(?). Deposit is unconsolidated, friable, and distinctively planar bedded and cross bedded. Planar beds are 1–2 m thick. Inclined dune foreset beds, which locally include sand-size granular humic material, are common. Laterally discontinuous sets of cross beds, 5–25 cm thick, alternate with planar beds. Locally, gray (7.5YR N5) clay beds are intercalated with sand beds. Locally, strong-brown (7.5YR 5/8) oxidized zones envelop the plastic, gray clay beds. Vertical chambers (1–2 cm in diameter) resembling animal burrows and sparse collapse structures (20–30 cm in diameter) are present. Sparse thick laminae of clay granules and pebbles are present. Maximum observed thickness was 6 m in a sand pit; base of unit not exposed. Thickness of unit estimated to be 10–35 m based on cross sections of Autin and others (1991, Plate 7), who depicted gravelly sand at base of this unit

Creek alluvium (Holocene and late Pleistocene)—White (10YR 8/1) and very pale brown (10YR 8/4) silt and locally interbedded gray (10YR 5/1) clay; laminated and very thin bedded; contains lenses of very fine grained and fine- to medium-grained quartz and chert sand. Upper meter or two is silty and reworked by wind and sheetwash. Unit is approximately 80 percent silt, derived from loess by erosion and deposition of creeks in quadrangle. Unit includes minor, local silty lacustrine and fan deposits and probable local, buried bog deposits. Probable bog deposits are inferred from sinuous contour lines suggestive of abandoned meandering channels on floodplain of Nonconnah Creek depicted on early 1900’s USGS topographic maps that predate channel dredging operations. A few kilometers east (in the Southeast Memphis 7.5-minute quadrangle), Delcourt and others (1980) collected fossils from a measured stratigraphic section in this map unit consisting of interbedded clay, silt, and sand. Fossils included ankle, skull, whole teeth, and tusk fragments of the extinct American mastodon (Mammut americanum); and fossil seeds, pollen, leaves, bark-covered logs, and beetle remains (Brister and others, 1981). These fossils suggest a cool climate of the last major continental glacial episode (late Wisconsinan glaciation). Delcourt and others (1980) obtained carbon-14 isotope dates of 23–17 ka on the fossil wood.

This map unit includes both modern and older alluvium. Modern alluvium is present only on point bars and in stream channels and is mostly medium-grained sand, and some very fine to very coarse sand that includes lenses of granules and chert pebbles. In contrast, older alluvium (late Pleistocene to Holocene) under the floodplain of Nonconnah Creek is mostly silt and minor clay beds that contain lenses of sand and pebbly sand.

The natural meandering channels of some streams have been straightened by dredging (Simon and Hupp, 1992). For example, most of Nonconnah Creek in the map area has been dredged; Cane Creek (northeastern part of quadrangle) and parts of Cypress Creek (south-central part of quadrangle) are concrete-lined, straight ditches or conduits. Much of Nonconnah Creek is flanked by silty and sandy spoil (only spoil thicker than about 4 m was mapped as unit af). Base of unit not exposed. Thickness 1–10 m

Terrace deposit (late Pleistocene)—Brown (7.5YR 5/4) mostly silt, clayey silt, and silty very fine to fine quartz sand. The unit is Nonconnah Creek alluvium, compositionally similar to, but slightly older than, unit Qa. Unit underlies a terrace, which is a relict floodplain. Silty sheetwash alluvium, perhaps admixed with thin loess a meter or less thick, mantles unit. A terrace origin is inferred from the nearly level surface and general altitude of unit, which is about 2 m higher than floodplain of Nonconnah Creek (Qa) and lower than loess-covered (Ql) hilly upland south of creek. Base of unit not exposed. Thickness estimated to be 2–6 m

Loess (late Pleistocene)—Brown (7.5YR 5/4) and light-brown (7.5YR 6/4) clayey silt. Calcareous, porous, and massive. Undisturbed uppermost 0.2–0.5 m of unit is oxidized, dark-brown (7.5YR 4/4) clayey silt; plastic when wet and hard when dry. This part commonly contains vertical prismatic soil structures 3–5 cm wide and 20–30 cm long and is a partial or entire B horizon of a relict soil. In eastern and northern parts of quadrangle, however, this soil commonly has been mixed with underlying silt by earth-moving machinery. Parks and Lounsbury (1975) reported the following grain-size data for loess in the Memphis area: clay (<0.002 mm) 20–25 percent; silt (0.06–0.002 mm) 70–75 percent; and sand (2.0–0.06 mm) <5 percent. Hwang and others (2000) reported clay 19 percent, silt 76.3 percent, and sand 4.7 percent. Loess is cohesive and generally stands in 4- to 5-m-high exposures. Bare slopes of loess erode readily, forming small gullies 0.5–1 m apart. In much of quadrangle, unit has been excavated to various depths for construction projects and gravel pits. Elsewhere, loess uniformly mantles a stream-dissected upland surface on older alluvial sands, clayey sands, and pebbly sands of unit QTg.

Origin of the loess is tied to the midcontinental ice sheet. In late Pleistocene time (pre-late Wisconsinan and late Wisconsinan glacials), when the Laurentide ice sheet covered land north of the present Ohio and Missouri Rivers, voluminous glacial valley-train deposits washed southward down the Mississippi River alluvial valley. From these deposits prevailing winds picked up and carried silt mainly eastward, depositing it on uplands that include the Memphis area. Stratigraphic studies in western Tennessee (Rodbell and others, 1997) suggest that loess deposition was episodic, based on recognition of soil-separated loess units. Loess in this quadrangle is probably mostly Peoria Loess (Leverett, 1898). Although other named units may be present, we recognized only one undifferentiated loess unit in the field. Thicknesses observed in exposed deposits in quadrangle range from 4.5 to 5.5 m. Drill-hole logs indicate thickness as much as 16 m

Gravel ("Lafayette Gravel" of Hilgard, 1892, early Pleistocene and Pliocene?)—Shown in cross section only. Mostly concealed under loess (Ql) and alluvium (Qa). Unit locally exposed in spoil and banks of small gravel pits. Ferruginous, weathered upper 1–2 m of unit observed in gravel pits and stream cutbanks is mottled, strong-brown (7.5YR 4/6), brown (7.5YR 5/4), and red (2.5YR 4/6), fine- to coarse-grained sand; chiefly chert and minor quartz pebbles and granules, subrounded to subangular. Some chert pebbles contain minute biogenic skeletal debris (spines?, spicules, foraminifers). Gravel layers are lenticular, occur at top of unit, and are interbedded with medium-grained, subangular to subrounded quartz sand, commonly in a red (2.5YR 5/8) sandy clay to clayey sand matrix that is 3–5 percent of unit by volume. Firm; moderately well cemented by clay minerals, hydrous iron oxide(?), manganese oxide(?), and silica. Locally present are abundant vertical, roughly cylindrical (2–20 cm in diameter), iron oxide-cemented sand structures (root casts?, burrows?). Locally, gravel is overlain by brownish-yellow (10YR 6/8) silt that contains root casts 1–2 mm in diameter and tens of centimeters long. Vesicles 0.5 mm in diameter are common.

Age of unit is uncertain. Previous workers referred to similar, topographically high, widespread graveliferous deposits in the Mississippi Valley region as Orange Sand, Lagrange, Upland Gravel, Lafayette Gravel, Citronelle, or the Upland Complex (Autin and others, 1991, p. 554). Unit overlies Tertiary bedrock and is 3–27 m thick based on interpretations of drill-hole data

Bedrock (Tertiary)—Shown in cross section only. Interbedded sand, silt, clay, and lignite; loosely consolidated. Probably Eocene Jackson Formation or upper part of Eocene Claiborne Group (Kingsbury and Parks, 1993). Unit not exposed in map area, but encountered in most borings

Contact—Solid where relatively certain; dashed where less certain

Drill-hole locality and identification number

INTRODUCTION

The map locates surficial deposits and materials. Mapping them is the first step to assessing the likelihood that they could behave as a viscous liquid (liquefy) and (or) slump during strong earthquakes. This likelihood depends partly on the physical characteristics of the surficial deposits (Youd, 1991; Hwang and others, 2000), which are described here. Other possible uses of the map include land-use planning, zoning, education, and locating aggregate resources. The Southwest Memphis quadrangle is one of several quadrangles that were mapped recently for these purposes (fig. 1).

The City of Memphis lies within the upper Mississippi embayment, which is seismically active (Schweig and Van Arsdale, 1996) and near the New Madrid Seismic Zone (NMSZ) (fig. 2). Proximity to the NMSZ raises concerns that if earthquakes as strong as those that occurred near New Madrid, Mo., in 1811–1812 were to occur again, life and infrastructure in Memphis would be at risk (Hamilton and Johnston, 1990). The evidences suggestive of a seismic risk for the Memphis Southwest quadrangle are: (1) probable earthquake-induced liquefaction features (sand dikes) exist in Wolf River alluvium inside Memphis city limits (Broughton and others, 2001), (2) severe damage in the area of present-day Memphis was caused by an 1843 earthquake in the NMSZ, near Marked Tree, Ark. (Stover and Coffman, 1993), and (3) in the mid-continent, earthquake energy waves travel long distances outward from their source, compared to distances of wave transmission from earthquakes of comparable magnitude in California (Johnston and Kanter, 1990; Tuttle and Schweig, 1996).

The Southwest Memphis quadrangle is located on loess-covered bluffs and uplands east of the Mississippi River. The loess (Ql), mostly the Peoria Loess (Leverett, 1898), covers alluvial sand and gravel of late Tertiary to early Pleistocene age (QTg) that, in turn, overlies the uppermost, soft sandstone of the Clairborne Group (middle Eocene; Tb). The Peoria Loess was deposited widely in the midcontinent region during the late Wisconsinan glaciation and during the coeval aggradational phase of the Mississippi River, 25,000–14,000 years B.P. (Knox, 1996, p. 265). Generally westerly winds deflated copious volumes of silt from the outwash that covered the floodplain and carried it onto the uplands. Subsequently, tributaries to the Mississippi River have eroded some of the loess and redeposited it as silty alluvium (Qa).

The main inaccuracies of the map are our generalized depiction of artificial fill and manmade drainageways, and our interpretations of stratigraphy using drill-hole data previously collected by others. These subjects are discussed in the “Methods” section.

METHODS

Mapping was based on field observations, analysis of color aerial photographs (scale 1:24,000, flown in 1997), topography, and drill-hole data. Grain sizes were estimated using a comparative chart using nomenclature of the modified Wentworth grade scale (American Geological Institute, 1982). Colors of materials were determined by comparison to Munsell Soil Color Charts (Munsell Color, 1973). Geologic ages of the surficial geologic deposits are based on relative and absolute dating techniques and on previous work (Hilgard, 1892; McKay, 1979; Delcourt and others, 1980; Brister and others, 1981; Saucier, 1987; Autin and others, 1991). Relative dating assumes that older deposits are higher than modern stream level and that the soils on them are more fully developed than those on the lower, younger deposits. Radiocarbon-dated fossil material in alluvium of Nonconnah Creek in the adjacent quadrangle to the east (Moore and Diehl, 2004) provides a geochronologic datum (see Qa).

Large areas of the quadrangle have been altered by construction. As a result, the shape of the land surface in such areas differs from that depicted on the topographic base map (1993) and aerial photographs. The artificial fill (af), whose thickness is estimated in cross section, was mapped separately because we speculate that its potential for liquefaction differs from that of the undisturbed geologic deposits. Also it affects risk assessment because it commonly supports buildings and roadways. However, engineering properties of the fill and of the other deposits depicted on the map were not measured. Most artificial fill, except gravelly ballast under railways, is reworked loess (Ql).

Boundaries between map units shown on the geologic cross section were interpreted from drill-hole data. Depths to those boundaries were obtained from drill-hole data in the Shelby County Subsurface Database of the Ground Water Institute (GWI), University of Memphis (http://gwidc.gwi.memphis.edu/website/introduction). Those boundaries were "picked" previously by other geologists using a process that involved interpreting drillers' logs and borehole electrical logs (Ank Webbers, USGS, oral commun., 2000). We used those stratigraphic assignments with little or no modification.

The locations of drill holes on the map and cross section have inherent errors. Locations of some holes in the GWI database were determined in the field by previous workers using a global position system; other holes were located using maps and addresses. Most drill-hole locations probably are plotted within a few meters to a hundred meters or more of the actual drill site (Brian Waldron, GWI, written commun., 2002).

Plotting the elevations of drill holes in the cross section was more problematic. Elevations of the tops of drill holes recorded in the GWI database (derived from the National Elevation Dataset, NED; Gesch and others, 2002) differed from elevations of the land surface at drill sites as determined by the topographic map. We plotted the latter in the cross section. This required a re-projection of drill-hole locations (from state plane coordinates in the GWI database) to a Transverse Mercater projection, followed by plotting of the new drill-hole locations on the Southwest Memphis 7.5-minute topographic quadrangle.

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Figure 1. Locations of quadrangles for which the geology has been mapped recently as part of the National Earthquake Hazards Reduction Program of the USGS.

Figure 2. New Madrid and Wabash Valley seismic zones, showing earthquakes as circles. Red, earthquakes that occurred from 1976 to 2002 with magnitudes >2.5, located using modern instruments (University of Memphis). Green, earthquakes that occurred prior to 1974. Larger circle represents larger earthquake. Modified from Gomberg and Schweig (2002).