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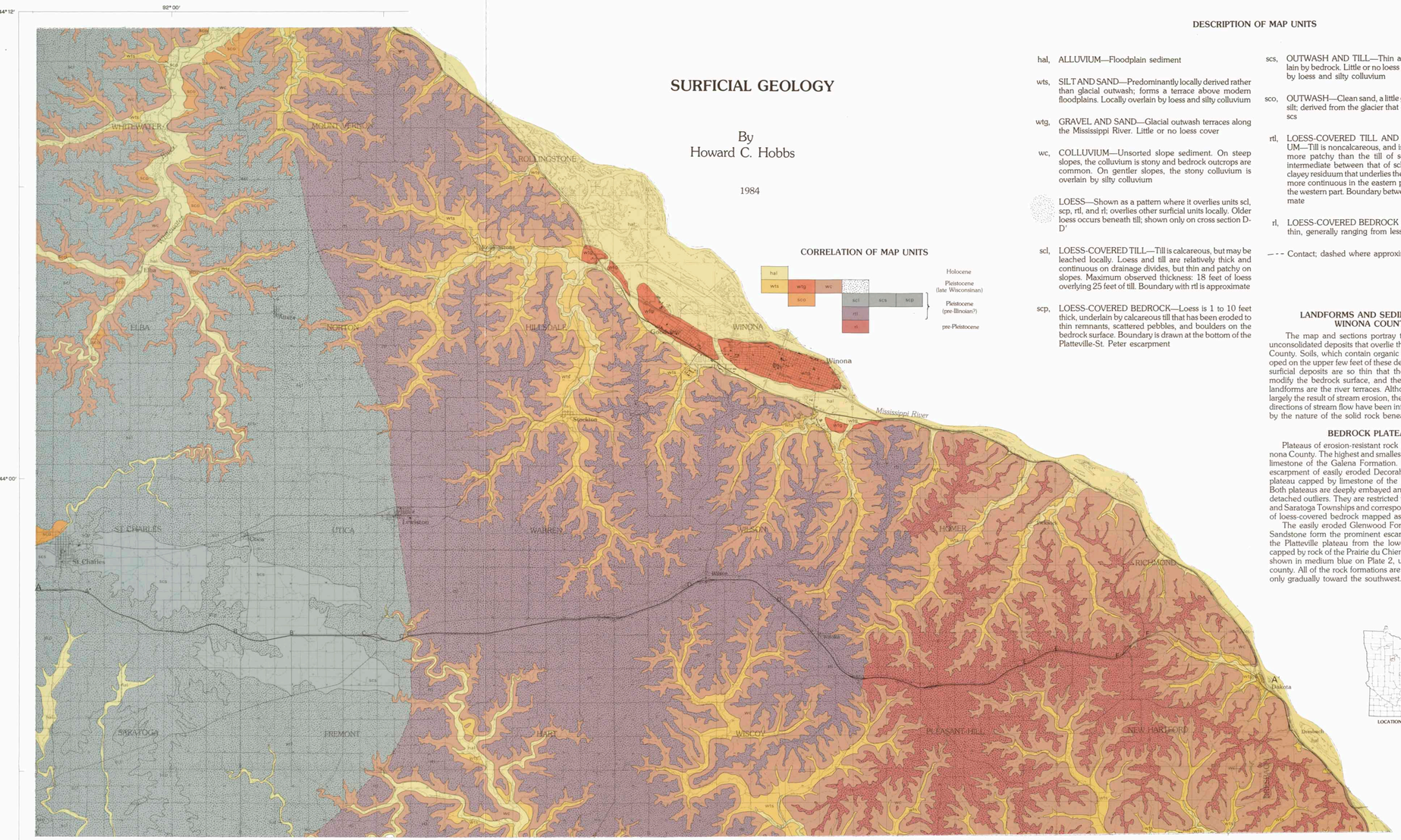

SURFICIAL GEOLOGY

By
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1984

CORRELATION OF MAP UNITS

DESCRIPTION OF MAP UNITS

hal, ALLUVIUM—Floodplain sediment

wts, SILT AND SAND—Predominantly locally derived rather than glacial outwash; forms a terrace above modern floodplains. Locally overlain by loess and silty colluvium

wtg, GRAVEL AND SAND—Glacial outwash terraces along the Mississippi River. Little or no loess cover

wc, COLLUVIUM—Unsorted slope sediment. On steep slopes, the colluvium is stony and bedrock outcrops are common. On gentler slopes, the stony colluvium is overlain by silty colluvium

LOESS—Shown as a pattern where it overlies units scl, scp, rtl, and rl; overlies other surficial units locally. Older loess occurs beneath till; shown only on cross section D-D'

scl, LOESS-COVERED TILL—Till is calcareous, but may be leached locally. Loess and till are relatively thick and continuous on drainage divides, but thin and patchy on slopes. Maximum observed thickness: 18 feet of loess overlying 25 feet of till. Boundary with rtl is approximate

scp, LOESS-COVERED BEDROCK—Loess is 1 to 10 feet thick, underlain by calcareous till that has been eroded to thin remnants, scattered pebbles, and boulders on the bedrock surface. Boundary is drawn at the bottom of the Platteville-St. Peter escarpment

scs, OUTWASH AND TILL—Thin and calcareous; underlain by bedrock. Little or no loess cover. Locally overlain by loess and silty colluvium

sco, OUTWASH—Clean sand, a little gravel, and thin beds of silt; derived from the glacier that deposited scl, scp, and scs

rtl, LOESS-COVERED TILL AND BEDROCK RESIDUUM—Till is noncalcareous, and is generally thinner and more patchy than the till of scl. Loess thickness is intermediate between that of scl and rl. The sandy to clayey residuum that underlies the till is much thicker and more continuous in the eastern part of the area than in the western part. Boundary between rtl and rl is approximate

rl, LOESS-COVERED BEDROCK RESIDUUM—Loess is thin, generally ranging from less than 1 to 5 feet

Contact; dashed where approximate

LANDFORMS AND SEDIMENTS OF WINONA COUNTY

The map and sections portray the different kinds of unconsolidated deposits that overlie the bedrock in Winona County. Soils, which contain organic material, have developed on the upper few feet of these deposits. In general, the surficial deposits are so thin that they merely mantle or modify the bedrock surface, and the only wholly surficial landforms are the river terraces. Although the landscape is largely the result of stream erosion, the depth of erosion and directions of stream flow have been influenced or controlled by the nature of the solid rock beneath.

BEDROCK PLATEAUS

Plateaus of erosion-resistant rock underlie much of Winona County. The highest and smallest of these is capped by limestone of the Galena Formation. It is separated by an escarpment of easily eroded Decorah Shale from a lower plateau capped by limestone of the Platteville Formation. Both plateaus are deeply embayed and erosion has created detached outliers. They are restricted to parts of St. Charles and Saratoga Townships and correspond roughly to the area of loess-covered bedrock mapped as scp.

The easily eroded Glenwood Formation and St. Peter Sandstone form the prominent escarpment that separates the Platteville plateau from the lowest plateau, which is capped by rock of the Prairie du Chien Group. This plateau, shown in medium blue on Plate 2, underlies much of the county. All of the rock formations are relatively flat, sloping only gradually toward the southwest.

Weathering of the bedrock surfaces has created a sandy to clayey residuum that thickens toward the east. In the western part of the county, its distribution is patchy, and it is generally less than 5 feet thick. East of a line passing through Wilson, however, it forms a continuous cover over bedrock on the drainage divides, and reaches 100 feet in thickness where it fills sinkholes. Complex mixing and interbedding indicate some transport and redeposition of the residual material. Rock of the Galena and Platteville Formations weathers to brown clay that contains thin, partly leached clasts of limestone. The Decorah Shale becomes greenish-gray clay. Rocks of Prairie du Chien Group weather to reddish-brown cherty clay. However, the Oneota residuum exhibits a somewhat redder color and contains more chert and quartz, and the lower part of the Shakopee Formation breaks down to a loose, iron-stained sand with variable clay content and to fragments of cemented sandstone.

The Effects of Glaciation

Although the Pleistocene is commonly called the Great Ice Age, it encompasses numerous glaciations and intervals of warmer climate that occurred between about 2 million years ago and about 10,000 years ago. When heavy snowfall and low summer temperatures produced major ice caps, glaciers flowed southward and covered much of northern North America. The flowing ice scoured the land surface and plucked up soil and boulders. When the ice later melted, the unsorted debris carried by the ice was left behind. These deposits are called till. Meltwater streams sorted out and transported some of the material away from the ice front. As stream velocity decreased, particles of sand and gravel were deposited as outwash. Some silt and clay were deposited in quiet backwater areas within the outwash sequence, but most of the fine material was carried outside the area. Some of the silt-size material in outwash plains was picked up by winds and deposited over adjacent areas as loess. All of these sediments resulting from glaciation are present in Winona County.

Loess mantles most of the plateau surfaces. It consists of unbedded brownish silt loam; unoxidized exposures are gray but rarely seen. The loess is commonly more than 10 feet thick along drainage divides in the western part of the county, and thins to less than a foot near the edges of the deep valleys. In general, it is thinner in the eastern part of the county. The loess was originally calcareous, but the carbonate component has been leached to a depth of 5 to 8 feet.

Most of the till in the county is less than 10 feet thick. In many places, the till has been eroded by slopewash and stream erosion, and only a line of pebbles remains above the bedrock under the loess. The till is generally thickest along drainage divides, and thin or absent on the upper rims of valleys.

Two types of till occur in Winona County. One is a component of unit rtl. It is thickest in the area around Wilson; elsewhere it is generally thinner and more patchy in distribution than the till of scl. It ranges in texture from clay through clay loam and sandy clay loam to sandy loam. Almost all samples of this till contain less silt than the till of the other type. The igneous rock fragments in both tills are basically the same, both in amount and rock type, although the pebbles in rtl appear to be more weathered on the average. Carbonate rock fragments are lacking; fragments of chert and sandstone from the bedrock residuum are common locally. No unoxidized, unleached till of this type was observed.

The second type of till is well exposed in the St. Charles area, where the loess is thin or absent (unit scs), and is a component of map units scl and scp. It is chiefly loam to clay loam, and contains scattered pebbles, cobbles, and boulders. It is gray and calcareous where unoxidized and unleached; however, where exposed at the surface, it is commonly brown and noncalcareous. The dominant rock types observed in the very coarse sand (1-2 mm) fraction are igneous and metamorphic rocks, chiefly granite—rock types typical of the Canadian Shield. Rock types typical of northeastern Minnesota, such as basalt, rhyolite, and agate, are more common in the pebble than in the sand fraction, but are a relatively minor component. Where unleached, this till also contains sand grains, pebbles, and cobbles of limestone and dolomite. Thick outwash (sco) from this glacial event was deposited in the Whitewater River valley and its north, middle and south forks. Because this outwash occurs almost at river level, the valley must have been about as deep then as it is today.

The tills in Winona County are of unknown age, but are believed to be much older than glacial deposits at the surface in most of Minnesota. Pioneer geologists recognized a "drift-less area" in southwestern Wisconsin and adjacent parts of Minnesota, Iowa, and Illinois where glacial deposits or "drift" were not thought to occur. Though later studies have shown that parts of the original driftless area were indeed glaciated, the core of it apparently never was covered by ice. Neither till nor glacial erratics were observed in Winona County east of the area mapped rtl. Had till ever been deposited in the area mapped rl and subsequently removed by erosion, the residuum should have been largely removed, as well, as is the case in the western part of the county.

Both tills were not observed in the same place, and thus they could be variants of the same till sheet. The differences between them could be accounted for by the local incorporation of residuum in the eastern part of the same ice sheet. However, the distribution of the rtl unit and the lack of outwash in valleys that drained its area suggest that considerable erosion occurred after it was deposited. By contrast, the Whitewater River appears to be little deeper now than it was when the outwash (sco) was deposited. Furthermore, the till of scl is thicker and less leached than the till of rtl. Thus on balance, it seems likely that the two till types represent separate glacial events. Loess observed under the younger till may have been deposited during an intervening, less extensive glaciation.

Between deposition of the second till and the late Wisconsinan glaciation, the till sheets were leached, in places all the way through, and their surfaces were eroded, removing any hummocks and lake basins that may have existed.

Glaciation during late Wisconsinan time had a marked effect on Winona County, though the ice margin was about 50 miles to the west. Dust from outwash plains formed a mantle of loess over the landscape. Water freezing in cracks broke loose chunks of rock from valley walls. Processes such as soil flow over permafrost appear to have stripped off the pre-Wisconsinan soils before deposition of the late-Wisconsinan loess, and in the area mapped scs, to have stripped most of the loess away as well. At about the same time, the Mississippi valley was filling up with outwash derived from glaciers upstream. The consequent rise in base level caused all the tributary streams to backfill in order to maintain their gradient. The material that the streams were carrying was largely silt, derived directly and indirectly from the loess.

VALLEY LANDFORMS AND SEDIMENTS

The deep dissection of the Prairie du Chien surface probably began after deposition of the till of rtl. As long as the Mississippi flowed on rock of the Prairie du Chien Group, downcutting was slow and the surrounding countryside could not be deeply dissected. Once the river had cut into the soft Jordan Sandstone and underlying rocks, downcutting became more rapid. Between periods of downcutting, the valley was probably backfilled by glacial outwash at times, or by interglacial river sediments. The tributaries deepened when the Mississippi deepened, and backfilled when it backfilled.

Valley sides are steep and mantled by unsorted slope sediment (colluvium) composed of angular rock clasts in a silty to sandy matrix. On the upper slopes, the clasts are dolomite from the Prairie du Chien in a silty matrix derived from loess on the plateau. Farther downslope, the matrix is sandy from the breakdown of the Jordan Sandstone. Below that, the colluvium contains increasing amounts of Franconia and St. Lawrence clasts. In general, the slopes are steepest and the colluvium thinnest on the Prairie du Chien Group, and rock is exposed in many places. On the lower, more gently inclined slopes, this coarse colluvium is mantled by a silty colluvium that contains few rocks.

As the remnants of the last glaciers melted, northward drainage was blocked by the retreating ice, and an enormous volume of glacial lake water spilled south into the Mississippi valley. This stream, called Glacial River Warren, eroded a channel in the outwash down to the present floodplain level or somewhat lower. The highest remnant of the outwash surface prior to River Warren's entrenchment is extensively preserved on the Wisconsin side of the Mississippi, but has been largely eroded away on the Winona County side. Lower terraces, like those at Winona and Goodview, were eroded by the early stages of River Warren but were not cut down all the way to the modern floodplain level. The outwash of these terraces (unit wtg) consists chiefly of rounded pebbles and sand, indicative of much reworking by ice and water.

Terraces along the Whitewater River (unit sco) are chiefly outwash sand from the glacial advance that deposited the till of units scl, scp, and scs. Similar outwash is present under the silt of unit wts in the terraces of Rollingstone Creek, and probably occurs in the terraces of Rush and Pine Creeks in Hart and Fremont Townships, as well.

Terraces mapped wts are largely silt, overlying and interbedded with sand. The silt is reworked loess and the sand is from local bedrock. Gravel is present in small amounts, occurring chiefly as subangular to subrounded dolomite pebbles. The hillside edges of the terraces are commonly mantled by silty colluvium.

Postglacial Events and Sediments

Downcutting into the outwash along the Mississippi valley by River Warren allowed downcutting to propagate up the tributaries. In some valleys, such as Wiscoy valley, downcutting has just begun, and practically the whole valley bottom is terrace. In others, such as Rush Creek, terraces are few and small. This difference is related to the size and erosive power of the stream compared to the size of the valley it occupies, and also to the distance upstream from the Mississippi.

Alluvium is present in the floodplains and channels of modern streams. The floodplain deposits are chiefly silt and clay in the Mississippi valley and silt in the tributary valleys. The channel deposits are largely sand in the Mississippi Valley and thin sand over a layer of pebbles and cobbles in the tributary valleys.

The boundary between alluvium (hal) and terrace deposits (wts) is marked by steep scarps as high as 70 feet in the lower reaches of Mississippi tributaries. The scarps diminish upstream, because the modern stream gradient rises more rapidly than the terrace surface, as shown at the eastern edge of the section along I-90. In the upper reaches of most streams whose valleys head in the Prairie du Chien, there is no scarp, and the whole valley bottom is mapped wts.

Most of the postglacial (Holocene) period has been a time of leaching, soil formation, and slow rates of erosion. However, once the land was plowed, erosion increased dramatically, chiefly by gully formation. Floods increased in frequency and severity, and silty alluvium was deposited on floodplains to thicknesses approaching 10 feet. The introduction of soil conservation practices has greatly decreased the rate of erosion. Streams are now cutting into the flood deposits and will eventually reestablish their equilibrium more or less at the presettlement level.

ACKNOWLEDGMENTS

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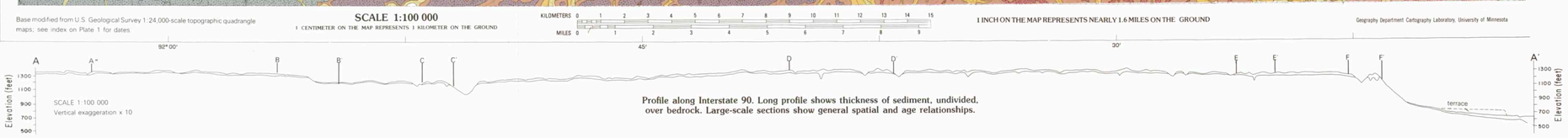
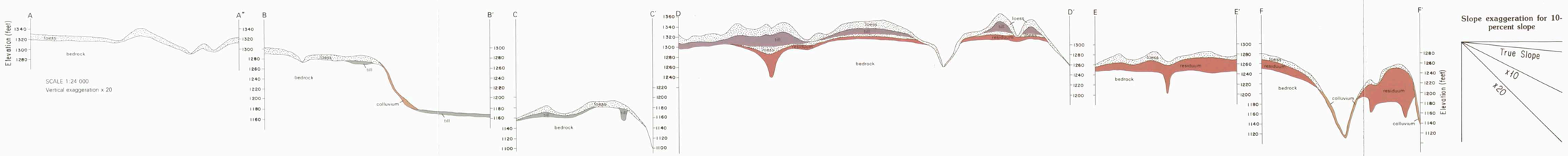


Profile along Interstate 90. Long profile shows thickness of sediment, undivided, over bedrock. Large-scale sections show general spatial and age relationships.



Slope exaggeration for 10-percent slope

GEOLOGIC ATLAS OF WINONA COUNTY, MINNESOTA