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QUATERNARY STRATIGRAPHY

By

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2006

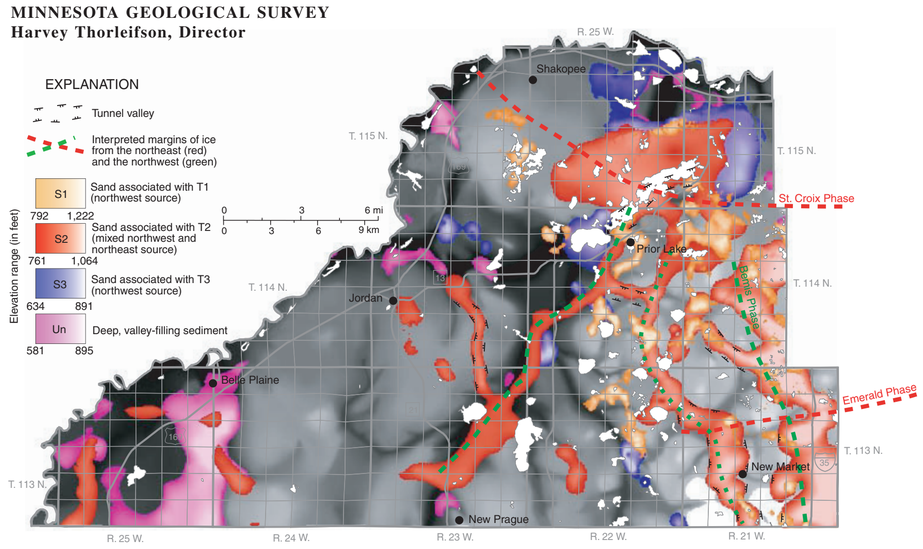


Figure 1. This complex figure includes several stacked images and interpretations. A gray-scale, two-dimensional version of the bedrock surface (similar to Fig. 6B) showing bedrock topography underlies the entire diagram. Superimposed on top of the bedrock surface are the various modeled sand layers that occur at different depths but are associated with distinct glacial events that affected the county. With all of these images stacked in this way, it is easy to see that the sands have been deposited primarily in pre-existing channels on the bedrock surface (Fig. 6B), such as the one south of Belle Plaine. A portion of S2 also seems to fall within a segment of the main bedrock valley north of New Prague. It also becomes apparent that much of S3 sand underlies the large concentration of S2 sand. The location of this large stack of sand corresponds to the St. Croix moraine—a terminal position of the Superior lobe about 20,000 years ago (Fig. 4). Finally, the locations of well established glacial landforms such as the Bemis moraine and the St. Croix moraine, as well as some more speculative features—ice margins and tunnel valleys—are indicated. The presence of these features is interpreted based on the distribution of buried sands as indicated by the model.

GEOLOGIC HISTORY

The surficial sediment in Scott County was deposited about 14,000 years ago by the last major ice lobe to cross this region—the Des Moines lobe. Prior to this, ice crisscrossed the region numerous times in the last two million years, eroding the sediments left from the previous advances and depositing new material. The succession of these deposits can best be illustrated using a series of diagrams that portray the distinct sediment layers that remain in the subsurface (Figs. 2-6).

Underlying the glacial debris in Scott County is sandstone and dolostone that was laid down much earlier, nearly 500 million years ago. During that time, a shallow sea covered much of North America, including parts of Minnesota (Fig. 6A). Over the next 200 million years, sediments were deposited in that sea. These deposits were buried and eventually became the bedrock that is exposed in places along the Minnesota River in the Twin Cities metropolitan area, and throughout southern Minnesota (see Plate 2).

Between 300 and 2 million years ago, southeastern Minnesota was largely high and dry and the land surface was eroded by wind and rain. There is little geologic record in this region of events that occurred during this time. It is not until the last 2 million years that the depositional history is again recorded in sediments. At this time, glaciers crossed the landscape and eroded the bedrock surface even more, and left deep valleys across the region that is now Scott County (Figs. 6B, C).

Figure 6B is a digital elevation model of the bedrock surface generated from depth to bedrock data compiled from water well records, cutting samples, and drill core. The landscape represented by this digital elevation model reflects the surface as it would appear if the cover of glacial sediments were stripped away; the vertical scale has been exaggerated by a factor of 10, and the surface is tilted slightly to the north. A cross-sectional slice through the surface (Fig. 6C) illustrates how the surface would appear if viewed edge-on along the southern border of the county (line D-D' on the index map in Fig. 7).

The most notable features on this bedrock surface are the deep valleys that crisscross the county (Figs. 1, 6B). The deepest valley, in the southwestern corner of the county, follows a line from the county border, north to the Minnesota River valley at Belle Plaine. Bedrock units exposed in the walls of these deep valleys range in age from Paleozoic rocks as old as about 500 million years, to rocks deposited during the Mesoproterozoic era—approximately 1,100 million years old. A narrow valley extends northeast from New Prague to Prior Lake, and finally northeast to the Minnesota River valley. A tributary valley extends from the Minnesota River valley roughly east to Prior Lake, where it enters the northeast-trending valley.

Just above the bedrock surface in isolated patches throughout the county, there are pockets of glacial debris of unknown source and age (unit Un on cross sections). These materials are typically observed filling the deepest valleys, with the largest concentration in the bedrock valley south of Belle Plaine (Fig. 1). Little is known about the age and origin of these materials. Drillers' logs provide limited information, identifying them only as mixed sand and clay. It is possible that these materials were deposited by ice that advanced into this region prior to the major ice advances that began about 2 million years ago.

Covering these isolated patches of sand and clay is a discontinuous unit (unit T3 on Fig. 5C). T3 is described by well drillers as predominantly "blue clay," and less commonly as "sandy clay." This material has been described informally as the "old gray till," and is exposed to the east in Dakota, Goodhue, Mower, Rice, and Steele Counties. The "old gray till" has been correlated to the Pierce Formation in Wisconsin—a pre-Wisconsin glacial sediment—and likely contains deposits from several advances (Fig. 5A). The overall sediment is compact, clayey loam with rock fragments indicative of a northwest source, including granite, gneiss, limestone, and dolostone. However, the distinctive gray shale that is common in other deposits from the northwest is lacking and allows us to distinguish these gray tills from the younger Des Moines lobe till. The three-dimensional model shows how this sediment has filled the bedrock lows and drapes thinly onto the bedrock surface in places (Figs. 5B, C). It is likely that these sediments at one time covered much of the region (Fig. 5C), then were eroded by subsequent glacial advances (Fig. 3C).

Sands that were deposited in valleys associated with unit T3 are labeled S3 in the model (Figs. 1, 5B). These sands occur in isolated patches, schematically drawn in cross section as channel-shaped, mostly in bedrock valleys in the eastern half of the county (Figs. 5C, 7). These isolated patches of sand are likely erosional remnants of sand bodies that at one time filled the valleys. There is also a large concentration of sand (S3) in the northeastern corner of the county (Fig. 1). The location of this deposit is significant in that it indicates that the material may have been derived from a northeast source and deposited by the Superior lobe.

At times throughout the ice age, ice advanced from the northeast through the Superior basin. This ice deposited material that contains characteristic red rock fragments that were eroded from the deposits of red sandstone in the Lake Superior basin. There is evidence to suggest that Superior lobe ice crossed the area of Scott County more than once. Remnants of very old, red deposits are exposed in places along the Minnesota River valley. There may be places within Scott County where isolated patches of old Superior lobe sediment are preserved, but they are not easily identified, nor are they separated in this model.

In the southeastern corner of the county, Johnson (1998) interpreted various geomorphic features as marking the extent of the Superior lobe during the Emerald Phase of advance—20,000 to 25,000 years ago (Fig. 1). Although there is no evidence of the Emerald margin west of the St. Croix moraine, the trend of geomorphic features can be traced through Dakota County and into the easternmost portions of Scott County. It is in this area where thick accumulations of sand (unit S2) have been modeled (Fig. 1). In gravel pits along Interstate 35, red Superior lobe deposits are found very near and at the surface. South and east into Rice and Dakota Counties, channels of sand have been mapped under thin surface sediments (Meyer and Lusardi, 2000). These channels extend north into Scott County and may have originated as tunnel valleys related to the Emerald Phase of the Superior lobe but lie beyond the Emerald ice margin (Fig. 1).

About 20,000 years ago, Superior lobe ice again advanced into this region (Fig. 4). The most notable feature from this advance is the St. Croix moraine. It is a complex moraine that extends from St. Paul to Walker, Minnesota. Although the St. Croix moraine crosses the very northern corner of Scott County (Figs. 1, 4), there is little evidence at the surface to indicate its presence. Subsequent advance of the Des Moines lobe has eroded and/or covered the moraine in this area. In the subsurface, however, there are clues that help us unravel the complex glacial history.

Large concentrations of sand—unit S2—have been identified at elevations between 761 and 1,064 feet (232 to 324 meters). In places, these S2 sands overlie sands attributed to S3 (at elevations between 634 and 891 feet [193 to 272 meters]; Figs. 1, 7). Some of this material can be attributed to the Superior lobe, as northeast-source sand and gravel is being mined below northwest, shale-bearing sand and gravel in deep gravel pits just south of Prior Lake. It is likely that the lower portions of S2 were deposited by the Superior lobe during the St. Croix phase and earlier (Fig. 1).

Material shown as unit T2 on the cross sections (Figs. 3B, C, 7) also likely includes sediments from more than one glacial advance. Based on drillers' logs, this appears to be all one unit described as blue clay or sandy clay. There are areas of sand recorded as well. Cuttings indicate that the bulk of material making up T2 is a gray-brown pebbly loam with rock fragments of northwestern source material, including granite, gneiss, limestone, dolostone, and abundant gray shale; and northeastern rock types such as basalt, greenstone, and red sandstone. Deep exposures in gravel pits in the eastern part of the county have layers of red sediment in places underlying the "blue clay."

The bulk of unit T2 was deposited by ice from the northwest. Just like the Superior lobe, the Des Moines lobe advanced across this region several times. At its furthest extent, northwest ice advanced beyond Scott County to what has been called the "extra-Bemis," or Moland position (Patterson and Hobbs, 1995). About 14,000 years ago, Des Moines lobe ice was at the edge of the county, forming the Bemis moraine. The modeled distribution of sand bodies associated with T2 indicates that the ice from the northwest paused several times in Scott County, long enough to develop ice-marginal meltwater channels that in places made use of preexisting depressions such as tunnel valleys of the Superior lobe, and the deep bedrock valley north of New Prague (Fig. 1).

The final phase of the Des Moines lobe covered the county with a relatively uniform blanket of shale-rich till—a mixture of sand, silt, and clay (T1 and associated sand, S1; Figs. 2B, C). Although the texture varies from place to place, there is little to distinguish this surface unit from the various buried ones for the purpose of this three-dimensional model.

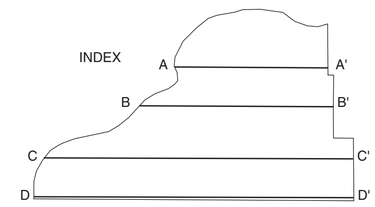
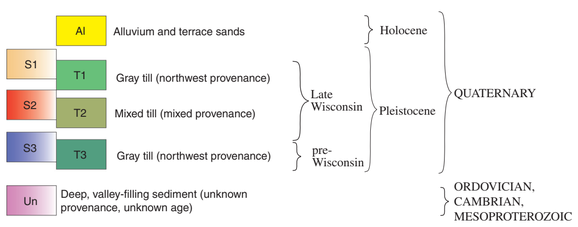


Figure 7. Series of cross section diagrams based on the surfaces generated by the three-dimensional model. The location of each cross section is shown on the index map (above). Section D has been split to show the depositional history of materials across the county as shown in Figures 2C, 3C, 5C, and 6C. The complete cross section along line D-D' is shown in Figure 1C. A magenta line represents the bedrock surface; a black line represents the land surface.

CORRELATION OF ALL UNITS



DESCRIPTION OF STRATIGRAPHIC UNITS

Al **Alluvium**—Silty clay loam to gravelly sand, deposited in modern river channels and along terraces adjacent to the Minnesota River valley.

S1 S2 S3 **Outwash** (undifferentiated)—Sand, gravelly sand, and cobble gravel, moderately to poorly sorted; crossbedded to flatbedded; interbedded in places with unsorted sediments (till, cobbles, and boulders).

T1 **Gray till** (northwest provenance, Wisconsin age)—Sandy loam to clay loam, pebbly, unsorted, with scattered cobbles and rare boulders; characteristic gray shale clasts generally compose from about 25 to greater than 50 percent of the very coarse (1-2 mm) sand fraction; includes rare lenses of stratified sediment. Likely contains deposits from more than one ice advance.

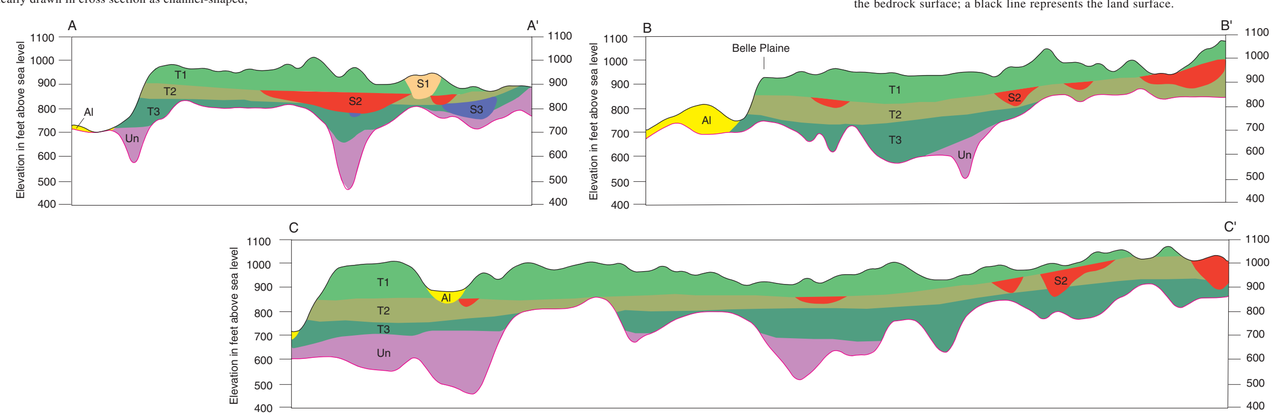
T2 **Mixed till** (mixed provenance, Wisconsin age)—Loam to sandy loam, pebbly, unsorted, with cobbles and boulders; generally less than 25 percent shale in the very coarse (1-2 mm) sand fraction. Inclusions of reddish-brown sediment indicate mixing with Superior provenance sediment. Likely contains deposits from more than one ice advance from different directions.

T3 **Gray till** (northwest provenance, pre-Wisconsin age)—Loam, pebbly, unsorted, with cobbles and rare boulders. Includes lenses of sorted sand and gravel in places.

Un **Unknown deposits** (unknown provenance, unknown age).

BUILDING THE THREE-DIMENSIONAL MODEL

Unlike the bedrock units, which are generally laterally consistent in thickness and lithology, the overlying unconsolidated Quaternary deposits in Scott County vary greatly in character and extent. Sand bodies that provide water for one well may be discontinuous over distances of less than a mile, making the construction of a three-dimensional geologic model difficult. In order to address this problem, water well drillers' descriptions, along with more detailed information on unconsolidated deposits where available, were used to identify glacial till contacts over a series of closely spaced cross sections. Till contacts associated with sand bodies or oxidized layers, typically reported by drillers as changes from sand and gravel to clay, or as changes in color, were plotted on individual cross sections and then compared with neighboring cross sections. Using the cross sections to establish a county-wide stratigraphic till sequence allows for the connection of individual sand bodies to one another in a geologic model. The link between sand and till deposits is illustrated in the cross-sections depicted on this plate (Fig. 7). Deposition of till is followed by the recession of glacial ice, resulting in deposition of sand and gravel meltwater from the receding glacier. These sand bodies are then buried by the next glacial advance, and the process is repeated. Interpreted geologic contacts between tills, or sand and tills, were used to create continuous surfaces that link similar units between cross-sections. These surfaces were then iteratively modified until they adequately represented the stratigraphic interpretation for the majority of water well data. The resulting geologic model does not represent or "capture" all sand bodies. Many Quaternary wells exist in the water well database that, according to the model, are not finished in sand. Sand bodies were connected in a manner that seemed reasonable in the context of the interpreted stratigraphic framework. Therefore, the surfaces and cross-sections that are generated by the model will not necessarily match the more detailed interpretations shown on the surficial and bedrock geologic maps. The model should be used as a guide and does not preclude site specific inspection of individual well logs.



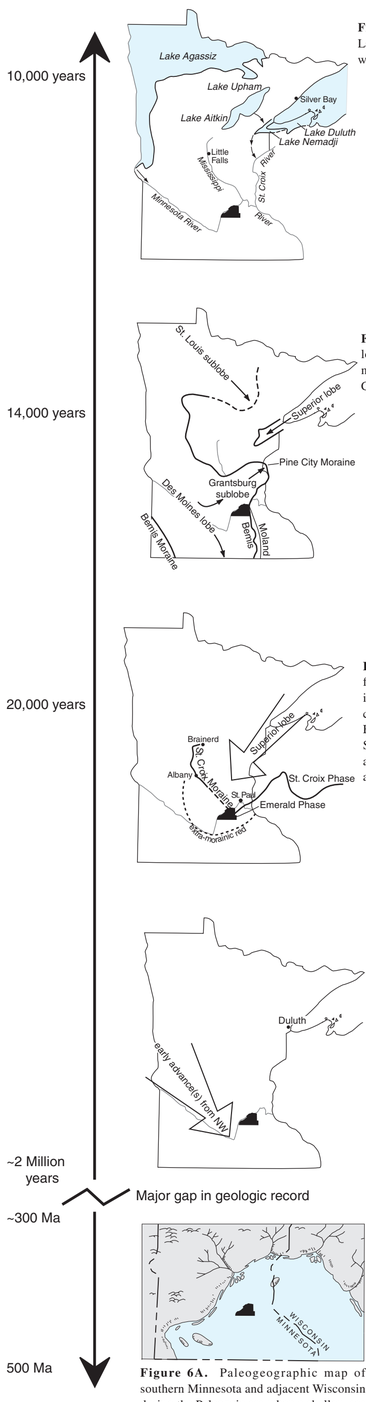
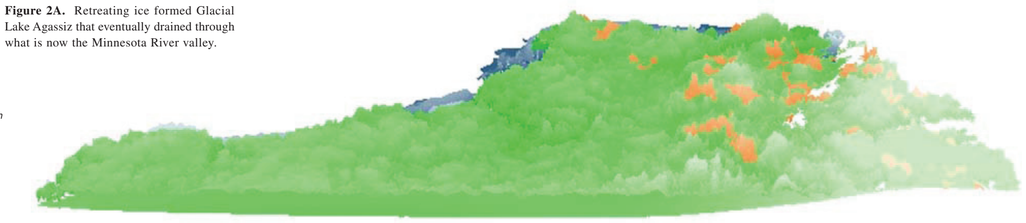
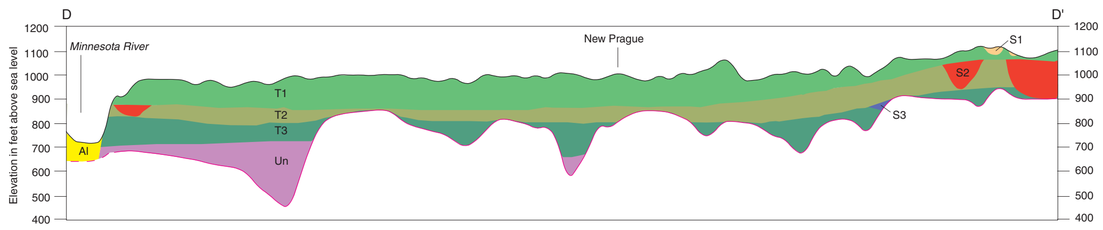


Figure 2A. Retreating ice formed Glacial Lake Agassiz that eventually drained through what is now the Minnesota River valley.



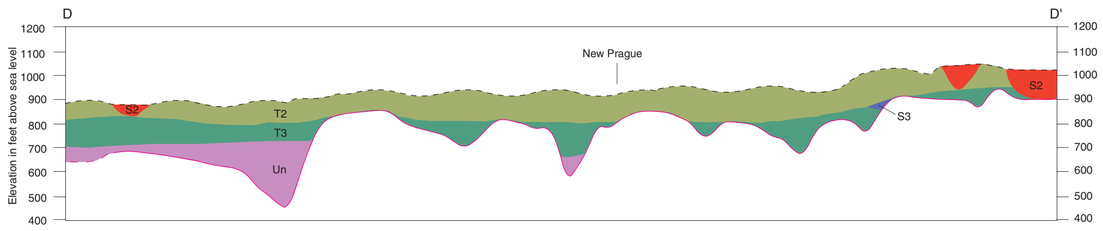
B. Three-dimensional model of the T1 surface and associated sands (S1). Vertical exaggeration x10. These sediments were the last to be deposited in this area before the ice retreated completely. These deposits form the present land surface across Scott County. Note the incision of the Minnesota River valley, carved by the draining of Glacial Lake Agassiz. In this view, fluvial deposits are visible across the northern edges of the county—shown in shades of blue.



C. Cross section showing the edge-on view of T1, associated sands (S1), and older units (Un) along line D-D' (shown on index map in Fig. 7). Note the deep Minnesota River valley that was carved by Glacial River Warren when Glacial Lake Agassiz drained.

Figure 3A. Advance of the Des Moines lobe from the northwest forming the Bemis moraine along the eastern edge of Scott County.

B. Three-dimensional model of the T2 surface and associated sands (S2). Vertical exaggeration x10. May include sand deposited by the Superior lobe during an earlier advance.



C. Cross section showing the edge-on view of T2, associated sands (S2), and older units (Un) along line D-D' (shown on index map in Fig. 7).

Figure 4. Advance of the Superior lobe from the northeast. At its furthest extent, it is likely that Superior lobe sediments covered all of Scott County. Positions of the Emerald and St. Croix margins are indicated. Superior lobe deposits are poorly preserved and may be included in the surface modeled as T2 (see Figs. 3B, C).

REFERENCES

Johnson, M.D., 1998, Ice-margin positions of the Superior lobe during Late Wisconsinan deglaciation, *in* Patterson, C.J., and Wright, H.E., Jr., eds., Contributions to Quaternary studies in Minnesota: Minnesota Geological Survey Report of Investigations 49, p. 7-13.

Meyer, G.N., and Lusardi, B.A., 2000, Surficial geology of the St. Paul 30 x 60 minute quadrangle, Minnesota: Minnesota Geological Survey Miscellaneous Map M-106, scale 1:100,000, 1 pl.

Patterson, C.J., and Hobbs, H.C., 1995, Surficial geology, pl. 3 *of* Hobbs, H.C., project manager, Geologic atlas of Rice County, Minnesota: Minnesota Geological Survey County Atlas C-9, pt. A, scale 1:100,000.

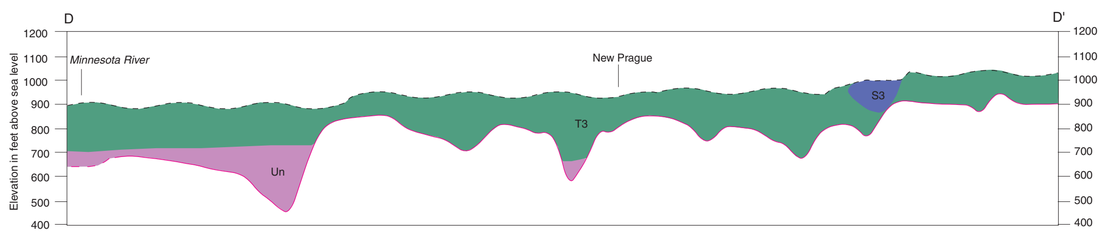
Runkel, A.C., 1996, Geology of Whitewater State Park, Minnesota: Minnesota Geological Survey Educational Series ES-9, 22 p.

Every reasonable effort has been made to ensure the accuracy of the factual data on which this map interpretation is based; however, the Minnesota Geological Survey does not warrant or guarantee that there are no errors. Users may wish to verify critical information; sources include both the references listed here and information on file at the offices of the Minnesota Geological Survey in St. Paul. In addition, effort has been made to ensure that the interpretation conforms to sound geologic and cartographic principles. No claim is made that the interpretation shown is rigorously correct, however, and it should not be used to guide engineering-scale decisions without site-specific verification.

Edited by Lori Robinson

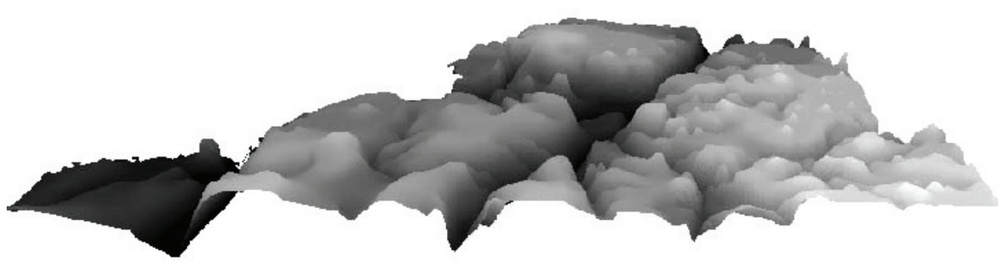
Figure 5A. Early advances of ice from the northwest deposited glacial sediment and associated sand and gravel in somewhat continuous layers across the landscape. These deposits, combined in the model as unit T3 and associated sands, S3, are not preserved everywhere across the county.

B. Three-dimensional model of the T3 surface and associated sands (S3). Vertical exaggeration x10.

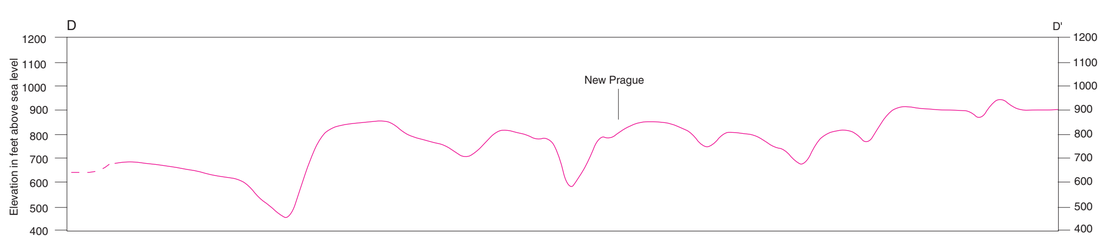


C. Cross section showing the edge-on view of T3, associated sands (S3), and older units (Un) along line D-D' (shown on index map in Fig. 7).

Figure 6A. Paleogeographic map of southern Minnesota and adjacent Wisconsin during the Paleozoic era when a shallow sea covered much of North America (modified from Runkel, 1996). These rocks are flat-lying, but their surface is dissected by deep valleys.



B. Three-dimensional model of the bedrock surface. Vertical exaggeration x10.



C. Cross section showing the bedrock surface along line D-D' (shown on location map in Fig. 7).

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