HYDROGEOLOGIC SETTING EAST OF A LOW-LEVEL RADIOACTIVE-WASTE DISPOSAL SITE NEAR SHEFFIELD, ILLINOIS

By J. B. Foster, George Garklavs, and G. W. Mackey

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ILLUSTRATIONS

CONVERSION FACTORS

Multiply inch-pound unit	by	To obtain SI unit
	Length	
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	0.4047	hectare
	Flow	
foot per second (ft/s)	0.3048	meter per second (m/s)

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ABSTRACT

Core samples from 45 test wells and 4 borings were used to describe the glacial geology of the area east of the low-level radioactive-waste disposal site near Sheffield, Bureau County, Illinois.

Previous work has shown that shallow ground water beneath the disposal site flows east through a pebbly-sand unit of the Toulon Member of the Glasford Formation. The pebbly sand was found in core samples from wells in an area extending northeast from the waste-disposal site to a strip-mine lake and east along the south side of the lake. Other stratigraphic units identified in the study area are correlated with units found on the disposal site.

The pebbly-sand unit of the Toulon Member grades from a pebbly sand on site into a coarse gravel with sand and pebbles towards the lake. The Hulick Till Member, a key bed, underlies the Toulon Member throughout most of the study area. A narrow channel-like depression in the Hulick Till Member is filled with coarse gravelly sand of the Toulon Member. The filled depression extends eastward from near the northeast corner of the waste-disposal site to the strip-mine lake.

INTRODUCTION

The U.S. Geological Survey began a study of the hydrogeology of the Sheffield low-level radioactive-waste disposal site in 1976. During the study, a pebbly-sand unit of the Toulon Member of the glacial Glasford Formation of Pleistocene age was found to underlie 67 percent of the waste-disposal site. The presence and extent of the pebbly sand prompted a further investigation, begun in 1981, to study the hydrogeology of the area east of the site. The information in this report can be used to extend the hydrogeologic system from the site to the eastern hydrologic boundaries, which are the lake and the tributary to Lawson Creek. This investigation was accomplished in cooperation with the U.S. Nuclear Regulatory Commission and the Illinois Department of Nuclear Safety. The waste-disposal site is located on 20 acres of rolling terrain 3 miles southwest of the town of Sheffield, Bureau County, Illinois (fig. 1).

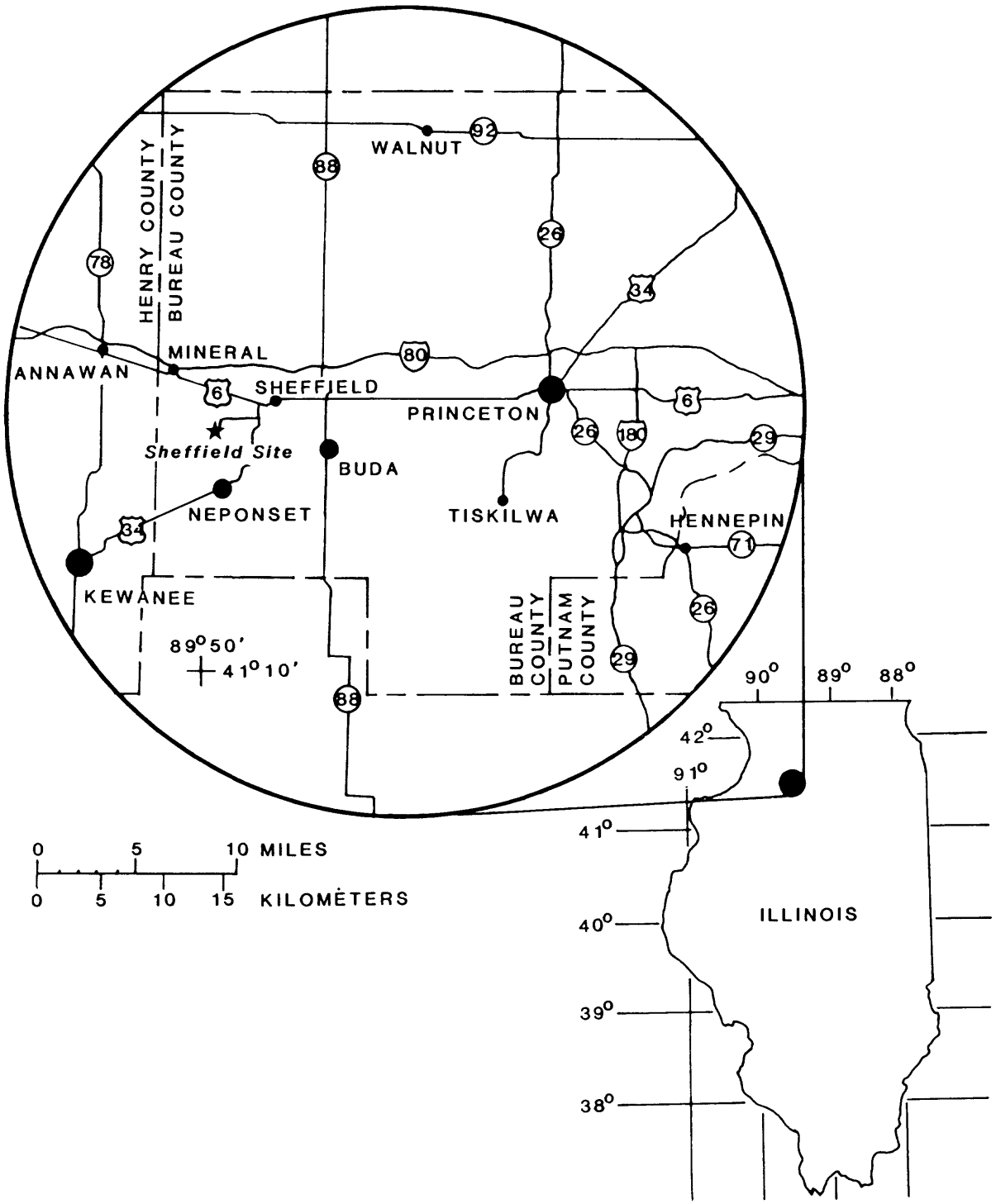


Figure 1.--Location of Sheffield low-level radioactive-waste disposal site.

Twenty-one test wells were drilled (wells 560-574 and 602-607) to obtain geologic and hydrologic data (Foster, Garklavs, and Mackey, 1984). An additional 24 test wells and 4 borings were drilled during another investigation to determine the extent of tritium migration east of the site (wells and borings 577-584, 586-601, 608-611). Location of wells and borings are shown in figure 2. Surficial electrical earth resistivity and shallow geothermic methods of geophysical investigation were conducted by the Illinois Department of Energy and Natural Resources, State Geological Survey Division, in the area to the east of the waste-disposal site (Larson and others, 1983). This geophysical investigation found resistivity and temperature anomalies that indicated a narrow, east-trending, coarse-grained, water-bearing deposit in the Toulon Member of the Glasford Formation.

The waste-disposal site is referred to in this report as the site. It includes the 20-acre waste-disposal area and adjacent land bordered on the east by the north-south township road. The area east of the road is referred to as the study area. The study area includes the area bounded by the township road on the west, strip-mine lake on the north, the boundary line on the south, and the east end of the lake (fig. 3).

Purpose and Scope

The purpose of this report is to describe the hydrogeologic setting of the area immediately east of the Sheffield waste-disposal site. The scope of the report is to describe the areal extent, thickness, and lithology of the glacial deposits of the study area and to correlate these deposits with deposits found on the site.

Acknowledgments

The authors appreciate the cooperation and technical support from the U.S. Nuclear Regulatory Commission. We are particularly grateful to David L. Siefken for his suggestions and technical support.

The Illinois Department of Nuclear Safety provided radiometric analyses of water samples. We are especially grateful to David Ed and James Blackburn for their assistance in coordinating the analytical work.

The authors also thank Keros Cartwright and Thomas M. Johnson of the Illinois State Geological Survey for coordinating laboratory analyses of core samples. The assistance of the late John Hower, former Chairman, Department of Geology, University of Illinois at Urbana, in directing analyses of cores is greatly appreciated.

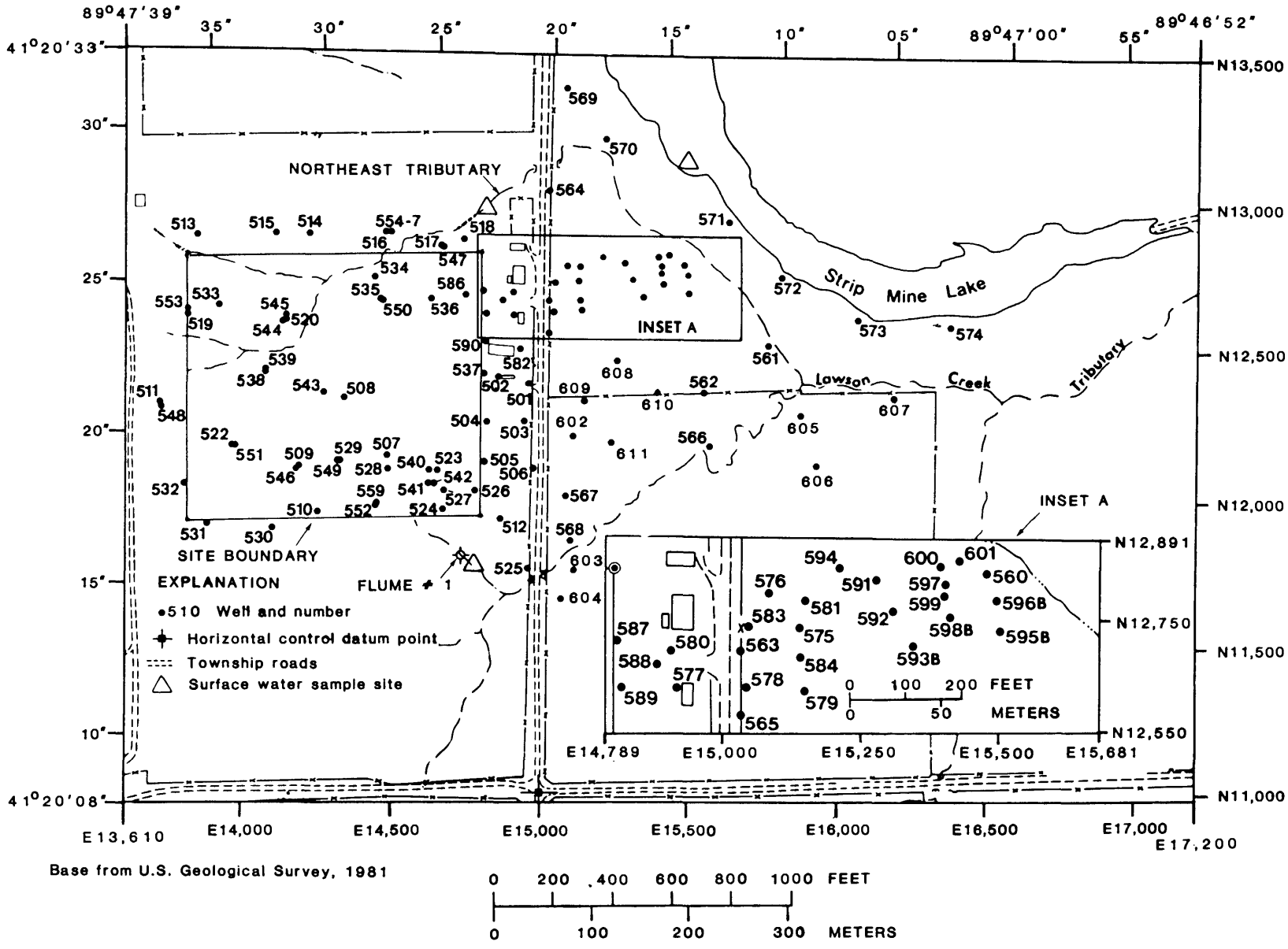


Figure 2.--Location of U.S. Geological Survey test wells and borings.

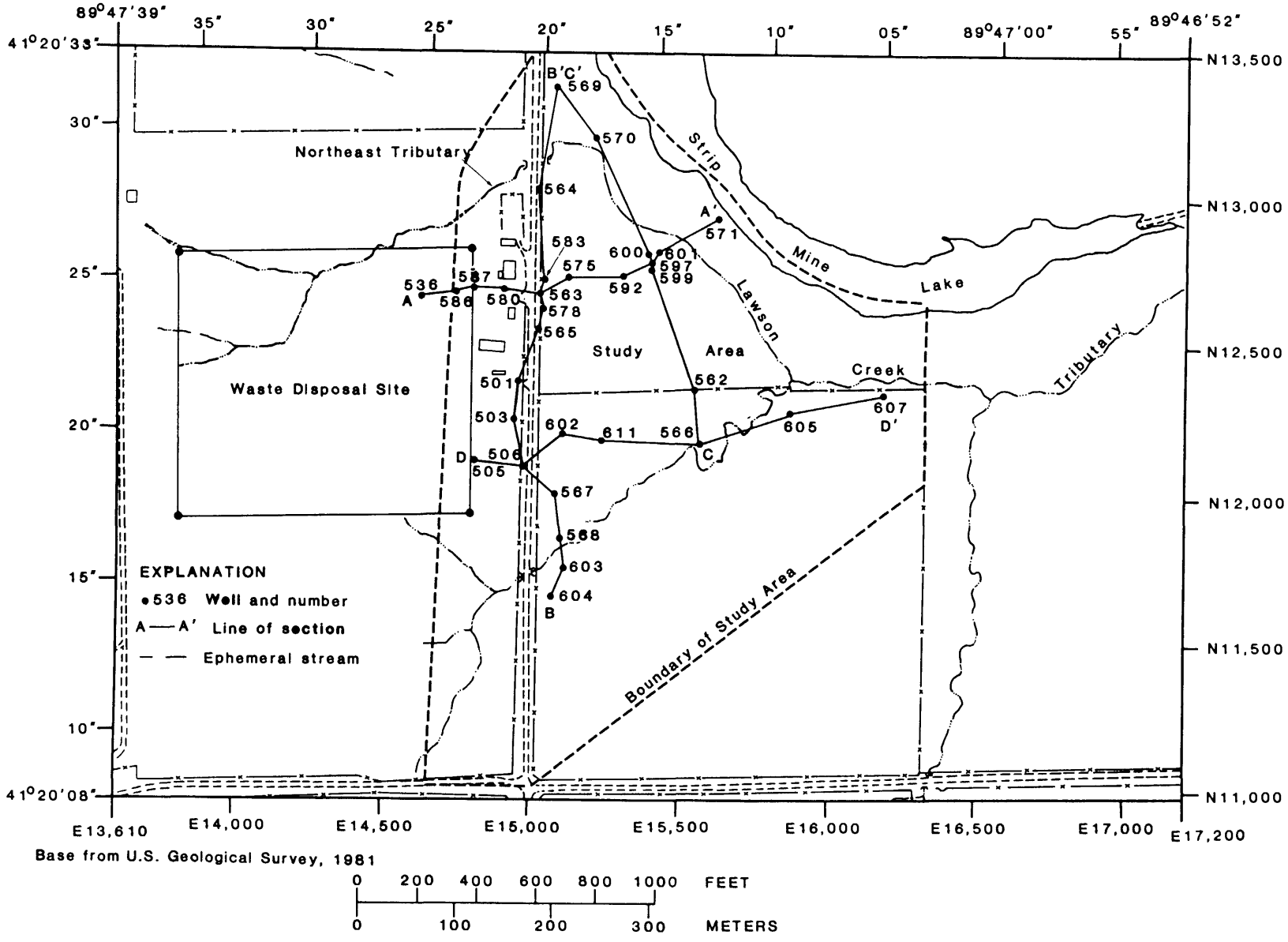


Figure 3.--Waste-disposal site, study area, drainage, and lines of section.

HYDROGEOLOGIC SETTING

The Sheffield site and adjoining lands are in an area of rolling terrain. Surficial glacial deposits of Pleistocene age overlie Pennsylvanian shale. The shale is approximately 450 feet thick. Glacial deposits range in thickness from 10 to 80 feet and average 55 feet (fig. 4).

The glacial materials encountered in test wells in the study area were correlated by texture and mineralogy with units in the rock-stratigraphic classification system of the Illinois State Geological Survey (Willman and Frye, 1970, p. 12). Each lithologic unit was characterized by its percentage composition of sand, silt, and clay by plotting grain-size percentages on the trilinear classification diagram developed by Shepard (1954). Rock-stratigraphic units in the study area were correlated with units identified on the waste-disposal site by Foster and Erickson (1980). The stratigraphic nomenclature used in this report is that adopted by the Illinois State Geological Survey and does not necessarily follow the usage of the U.S. Geological Survey.

Quaternary age outwash, composed of sand and gravel, underlies much of the site and extends eastward to the strip-mine lake. A narrow channel-like deposit of sand and gravel, roughly defined in areal extent by the wells shown in inset A of figure 2, acts as a principal flow path for ground water moving eastward from the site. Variability in the lithology of other glacial deposits strongly influences the direction and velocity of ground-water flow.

Although sand deposits are present in the southern part of the study area--roughly bounded by wells 567, 602, and 566--they are generally unsaturated. Till underlying the sand in this area rests directly on Pennsylvanian bedrock and is partially saturated. Only the lower portions of the till are saturated; therefore, fractures or coal seams in the bedrock are considered probable pathways for ground-water flow.

Ground-water flow boundaries in the study area are the strip-mine lake to the east, the tributary to Lawson Creek to the south, and strip-mine spoil material to the north. The western boundary of the flow system lies to the west of the waste-disposal site.

Rock stratigraphy, areal extent, lithology, and degree of saturation of the geologic units encountered in the study area are discussed in the following sections.

Pennsylvanian System

Desmoinesian Series

The Carbondale Formation of the Desmoinesian Series of the Pennsylvanian System underlies the glacial deposits. Core samples from wells that penetrated the Carbondale Formation showed weathered shale composed of silty clay and clayey silt. Coal and coal fragments were also found in the weathered

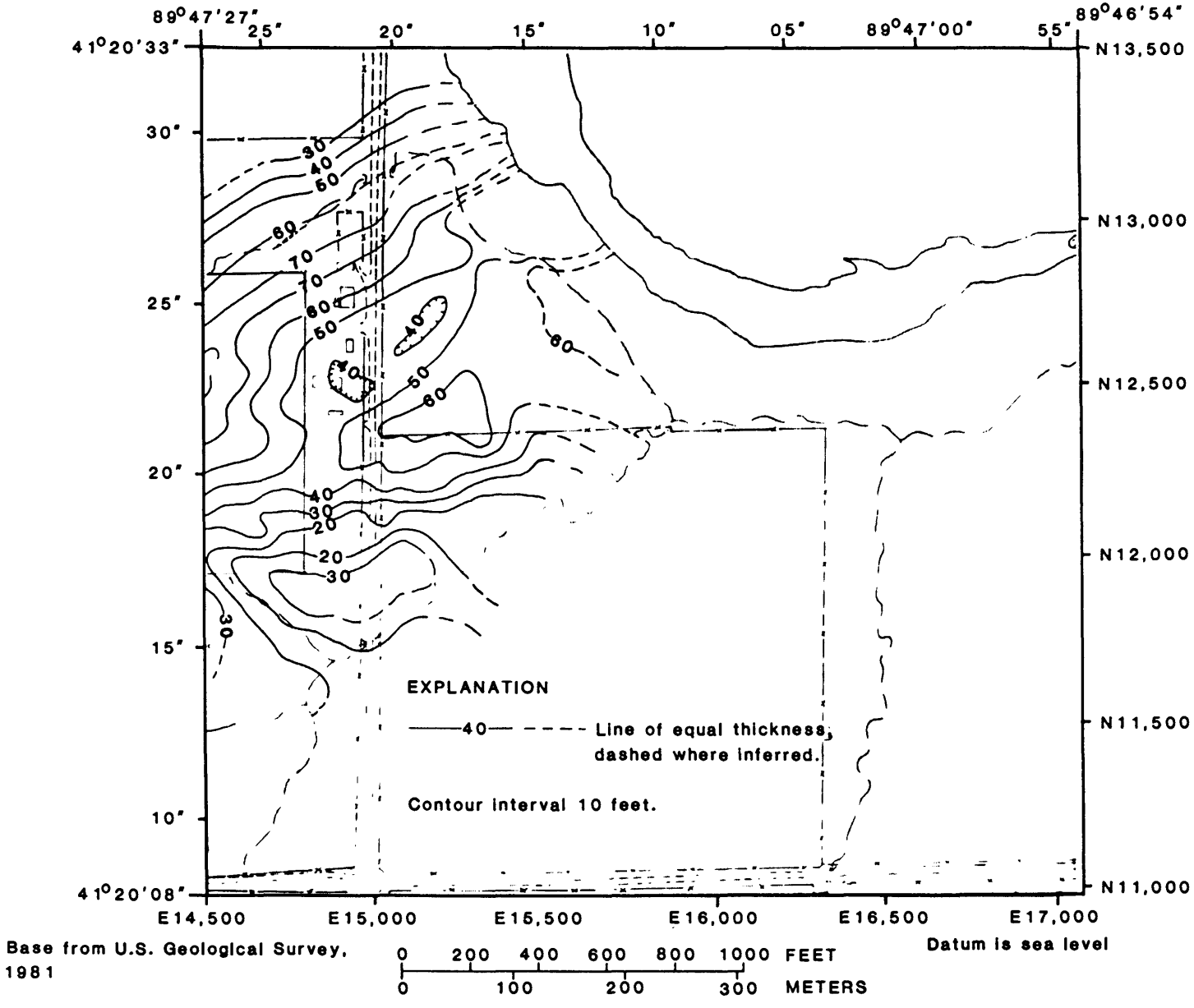


Figure 4.--Thickness of glacial deposits.

shale. Shale was penetrated in wells 566, 569, 577-579, 603, 608, 609, and 611 on the site and in the study area. In well 560, the altitude of the top of the shale is below 667 feet, and in well 574, below an altitude of 664 feet above sea level. The configuration of the top of the shale bedrock (fig. 5) generally follows the present surface topography. Silurian, Ordovician, and Cambrian dolomites and sandstones underlie the Pennsylvanian rocks (Willman and others, 1975, p. 36, 47, 87, and 169).

The shale bedrock forms a topographic high near the southeast corner of the site. The surface of the bedrock generally slopes to the northeast in the study area. The bedrock has been eroded in some areas leaving valley-like depressions in its surface.

The weathered bedrock surface that underlies the Pleistocene deposits in the study area generally acts as a barrier for movement of shallow ground water to the deeper regional aquifer. Nevertheless, the bedrock may influence ground-water movement in the glacial deposits. In the area roughly bounded by wells 567, 602, and 611, the saturated zone consists of the weathered bedrock surface and the lower portion of the Hulick Till Member. The overlying pebbly sand and silt, though more permeable, are unsaturated. Fractures and coal seams in the bedrock are considered conduits for ground-water flow in this area.

Quaternary System

Pleistocene Series

Glasford Formation

Duncan Mills Member.--The oldest Pleistocene deposits in the area are a sequence of lacustrine and outwash sediments assigned to the Duncan Mills Member of the Glasford Formation. The Duncan Mills Member overlies bedrock in and adjacent to the site, but is not found in the eastern area. The location nearest to the study area where the Duncan Mills Member is found is at well 505. The relative stratigraphic position of the Duncan Mills Member is shown in figure 6.

The Duncan Mills Member consists of silty clay interbedded with silt, clayey silt, and pebbly-sandy silt layers. The lower part of the deposit consists of clayey silt strata ranging from 1 to 18 inches in thickness. The upper part consists of rhythmite deposits consisting of finely laminated silts and silty clays. Where present, the Duncan Mills Member is saturated.

Hulick Till Member.--The Hulick Till Member of the Glasford Formation is penetrated by test wells throughout the site and study area. The Hulick Till Member overlies bedrock and the Duncan Mills Member where it is present. The Hulick Till Member is not present in the study area along parts of the channel of Lawson Creek Tributary, where it has been eroded and the channel filled with alluvial deposits.

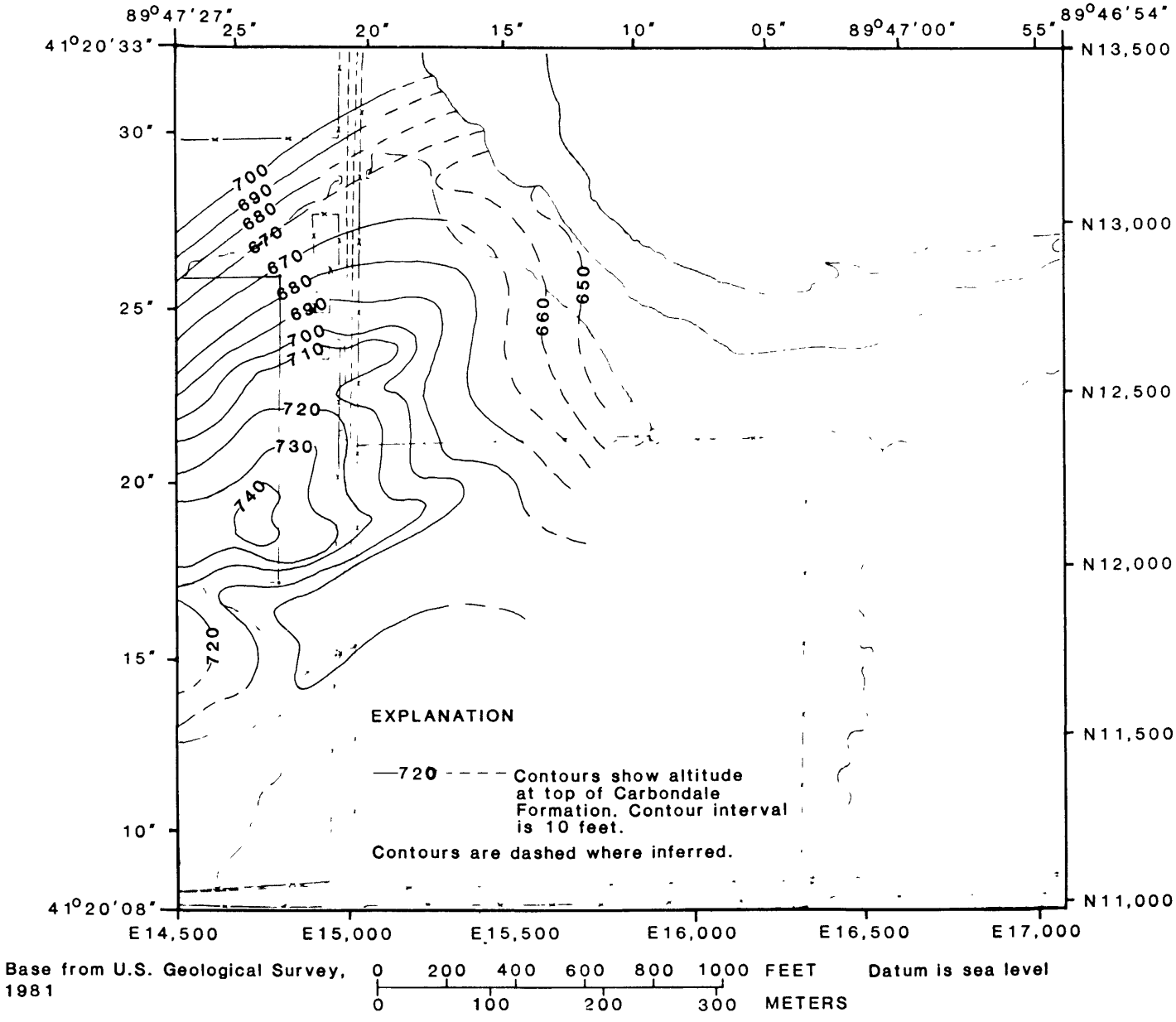


Figure 5.--Altitude of top of Carbondale Formation.

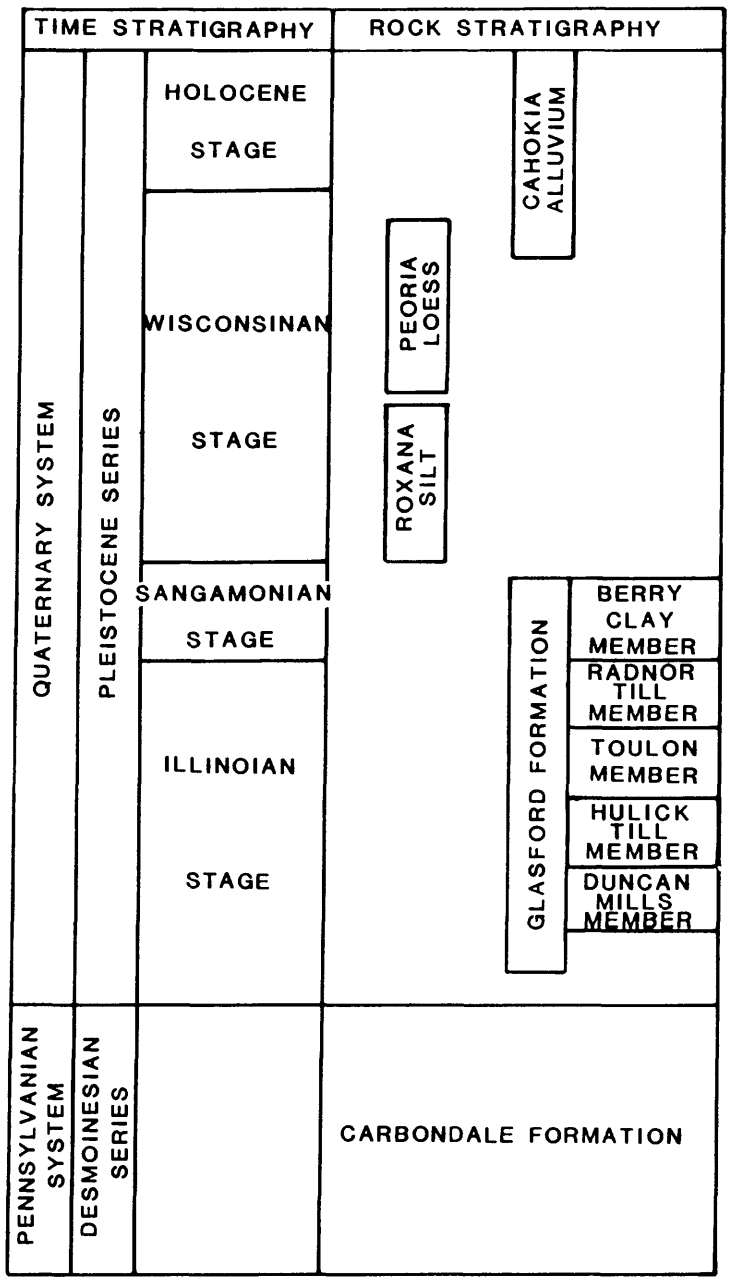


Figure 6.--Illinois State Geological Survey geologic-time classification system in relation to rock stratigraphic classification system (modified from Willman and Frye, 1970).

The Hulick Till Member ranges in thickness from 0.5 to 49 feet in test wells that penetrated the till in the study area. The till is comprised of sand, silt, and clay; the typical grain-size distribution is 26 percent clay, 28 percent sand, 40 percent silt, and 6 percent gravel. Slight areal and stratigraphic differences in mineralogy and grain-size distribution reflect differences in source-area mineralogy (Foster, Erickson, and Healy, 1984).

The Hulick Till Member is saturated throughout its areal extent, with the exception of the area near wells 578 and 584. Although the till is saturated, low hydraulic conductivities of glacial tills, which generally range from about 3.3×10^{-6} to 3.3×10^{-12} feet per second (Freeze and Cherry, 1979), indicate that they are barriers to ground-water flow where bounded by more permeable materials such as pebbly sand and sandy silt.

Toulon Member.--A channel-like outwash deposit of the Toulon Member of the Glasford Formation underlies 67 percent of the site and extends east to the strip-mine lake (fig. 7). The Toulon Member overlies the Hulick Till Member in most of the study area (figs. 8-11). In the southern half of the site, the Toulon is overlain by Radnor Till Member and in the northern area by the Peoria Loess. The Toulon Member consists of two lithologic units. The first is lacustrine-like silt-clay with some sand and gravel lenses. The second is a pebbly-sand unit which grades from a moderately sorted pebbly, silty sand in the site to a well sorted pebbly sand throughout most of the study area. The pebbly-sand unit generally overlies the silt-clay unit in the study area. The pebbly-sand unit of the Toulon Member ranges from less than 1 to 35 feet in thickness in the study area (fig. 12).

The pebbly-sand unit of the Toulon Member is partly saturated throughout most of the study area. East, along the strip-mine lake, the sand is fully saturated. The pebbly sand is unsaturated in the vicinity of the bedrock high near the southeast corner of the site, and along a ridge-like structure extending from well 578 to test boring 596B. A shallow depression in the underlying Hulick Till Member, about 5 feet deep, is filled with gravelly, pebbly sand. The gravelly, pebbly sand-filled depression provides a conduit for ground-water flow from the northeast corner of the site east-northeast to the strip-mine lake (fig. 10).

Radnor Till Member.--The Radnor Till Member of the Glasford Formation is distinguished from Hulick Till Member by differences in clay mineralogy and sand content. The greatest areal extent of the Radnor Till Member is in the southern half of the site although it was found in a small area in the northwestern part of the site and near the lake in an area outlined by wells 561, 571, 572, 573, and 574. Near the lake it ranges from 2 to 8 feet in thickness. It consists of clayey silt and gravel-sand-silt-clay. The ranges in grain-size distribution in different samples vary from 0 to 4 percent gravel, 4 to 20 percent sand, 50 to 68 percent silt, and 27 to 28 percent clay. The Radnor Till Member is unsaturated in the study area.

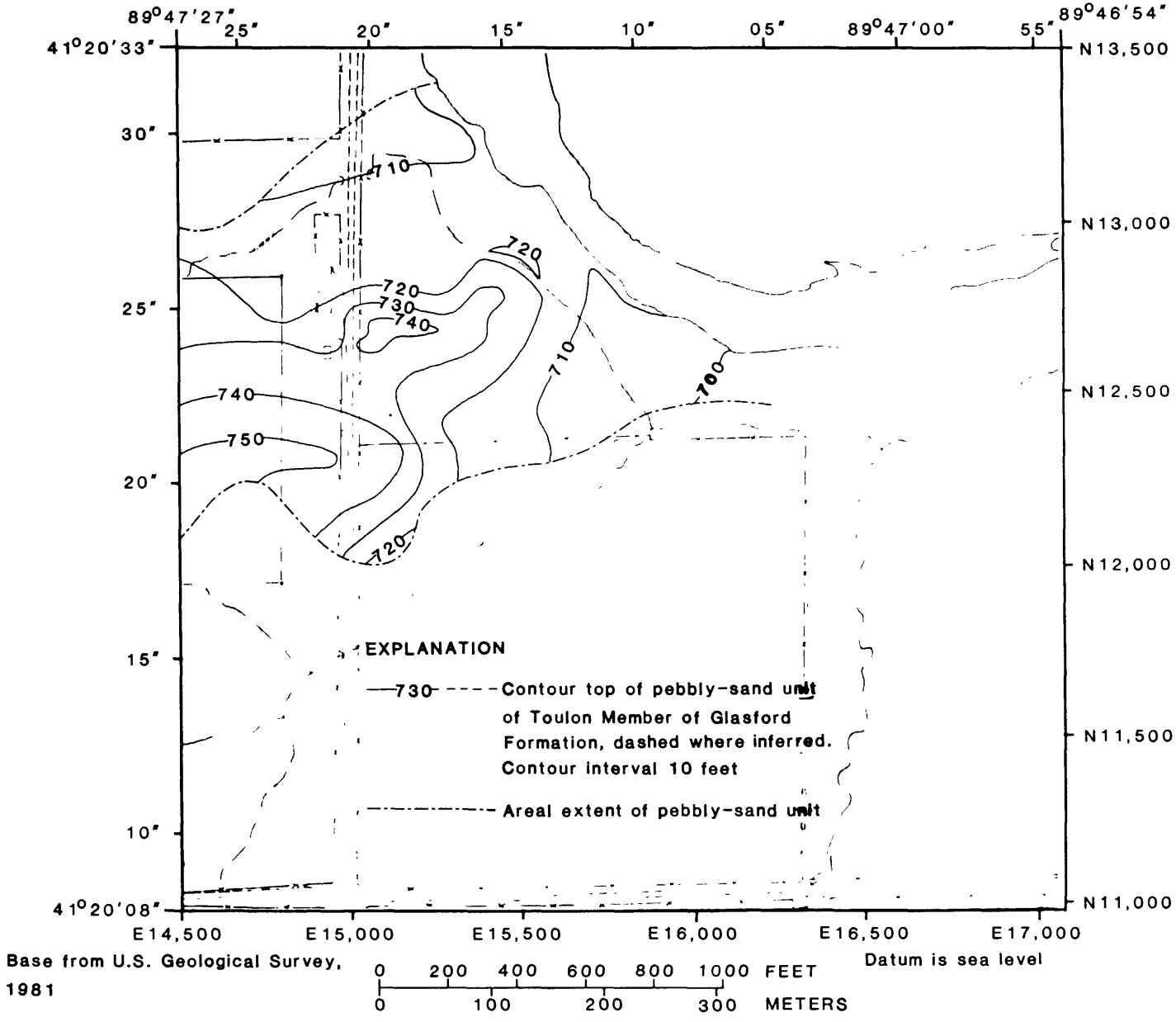


Figure 7.--Areal extent and altitude of top of pebbly-sand unit of Toulon Member of Glasford Formation.

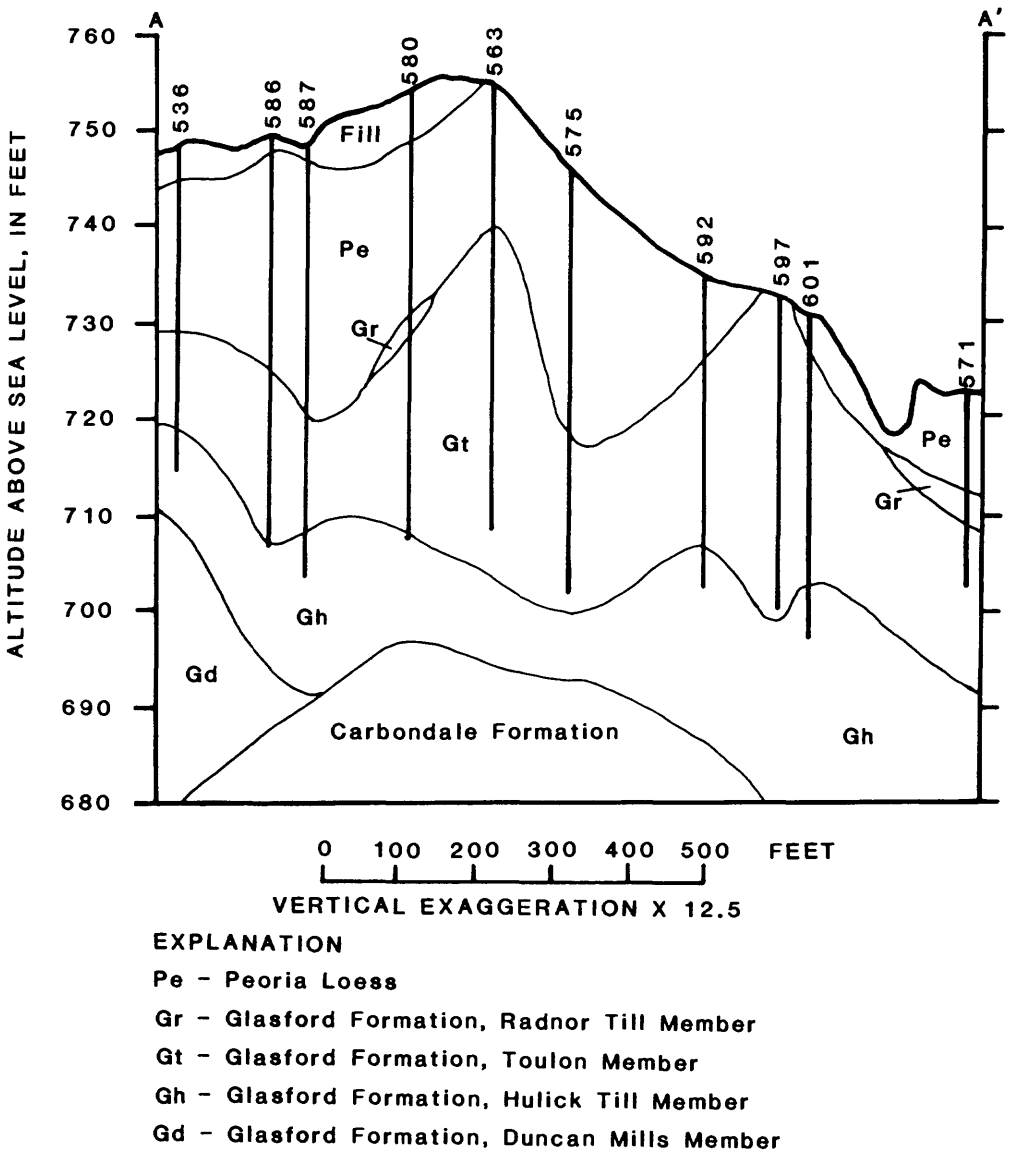


Figure 8.--Geologic section A-A'.

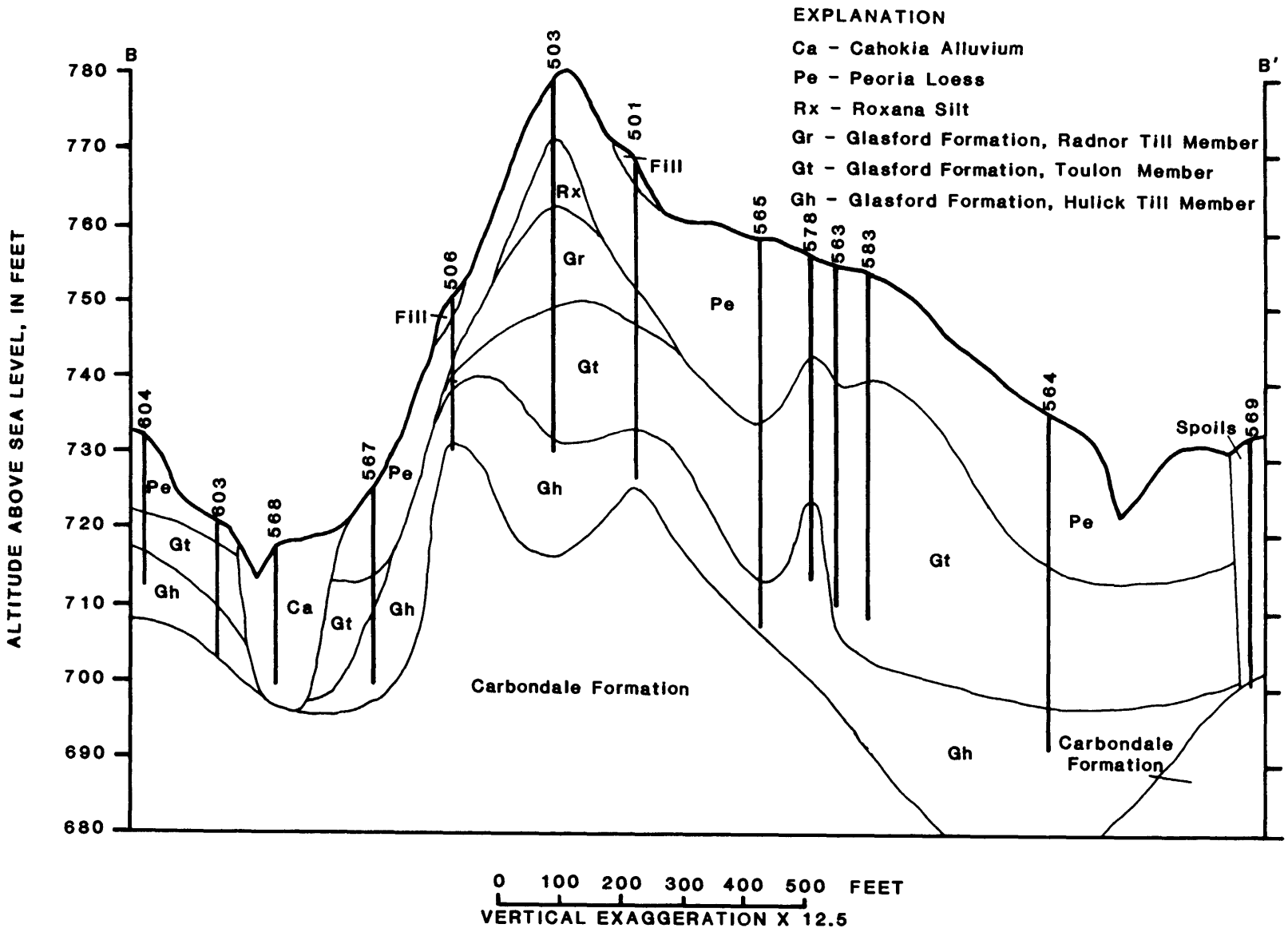
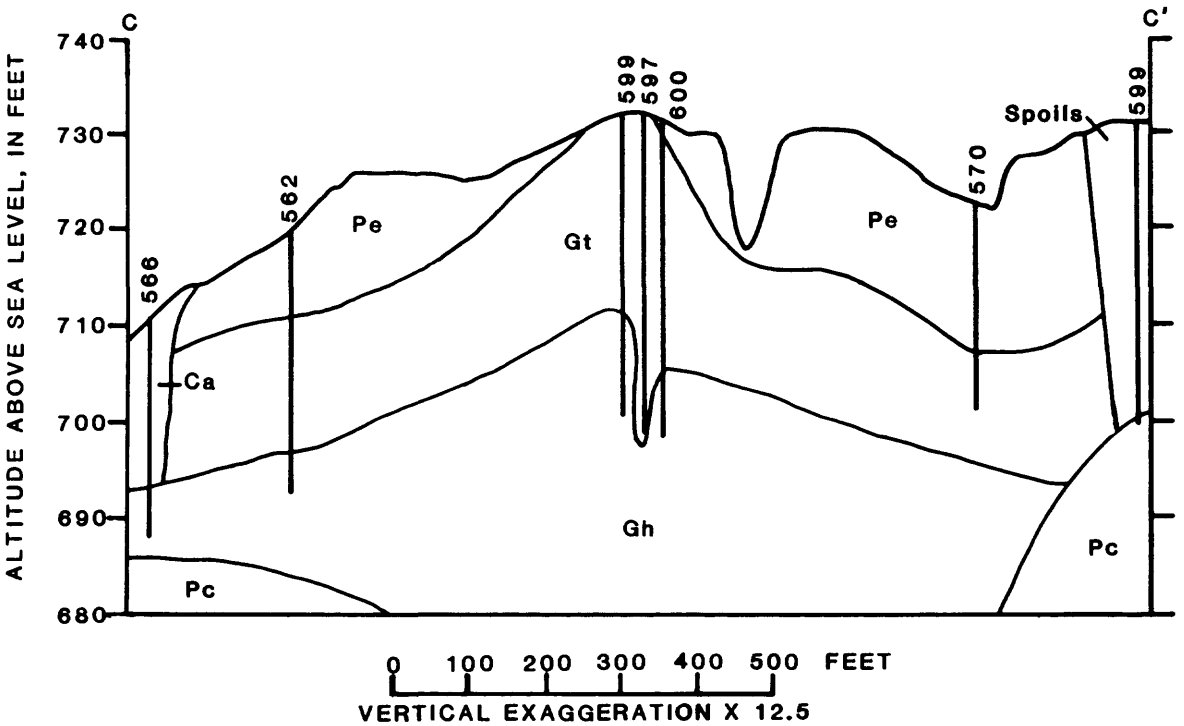


Figure 9.--Geologic section B-B'.



EXPLANATION

Ca - Cahokia Alluvium

Pe - Peoria Loess

Gt - Glasford Formation, Toulon Member

Gh - Glasford Formation, Hulick Till Member

Pc - Carbondale Formation

Figure 10.--Geologic section C-C'.

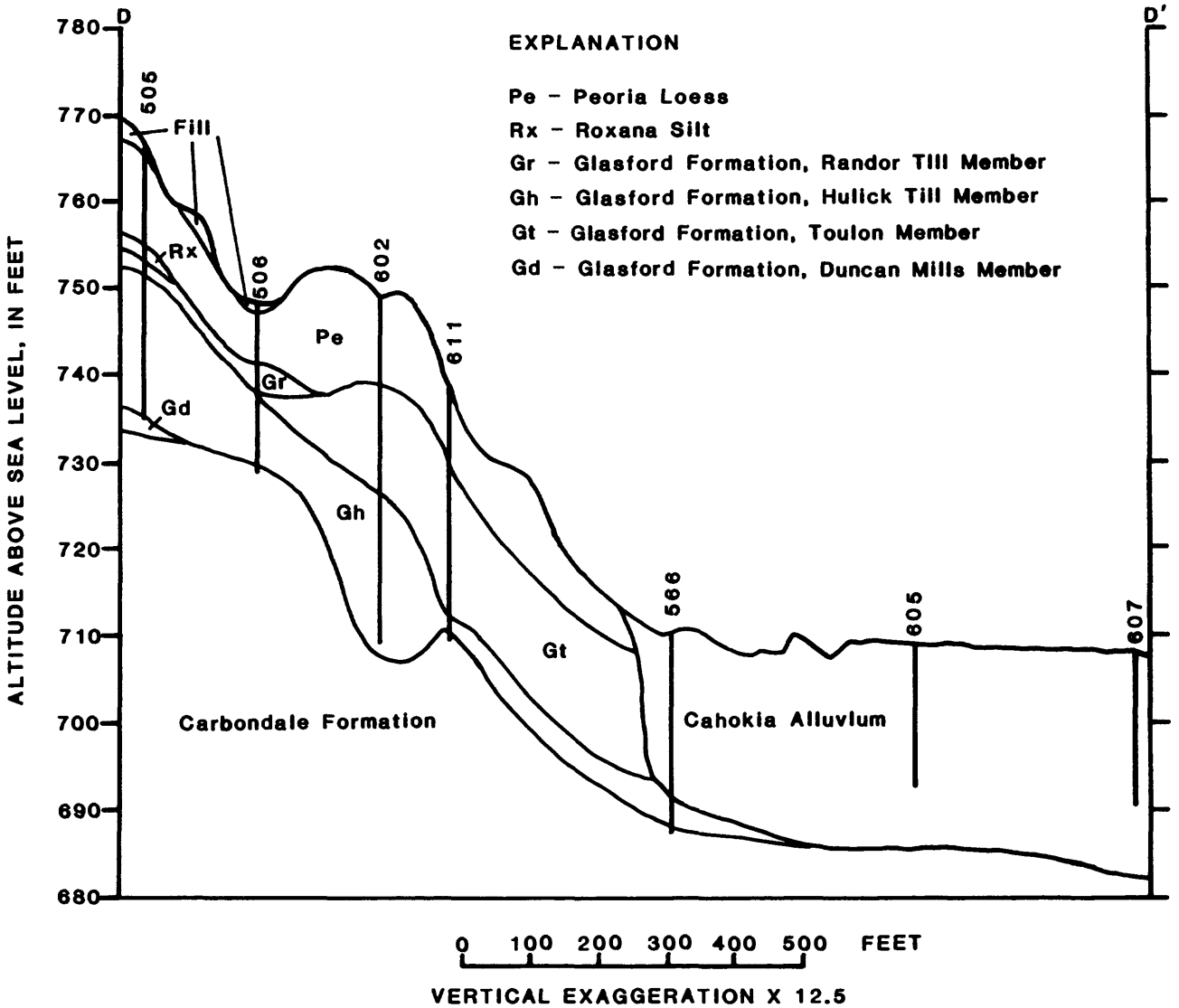


Figure 11.--Geologic section D-D'.

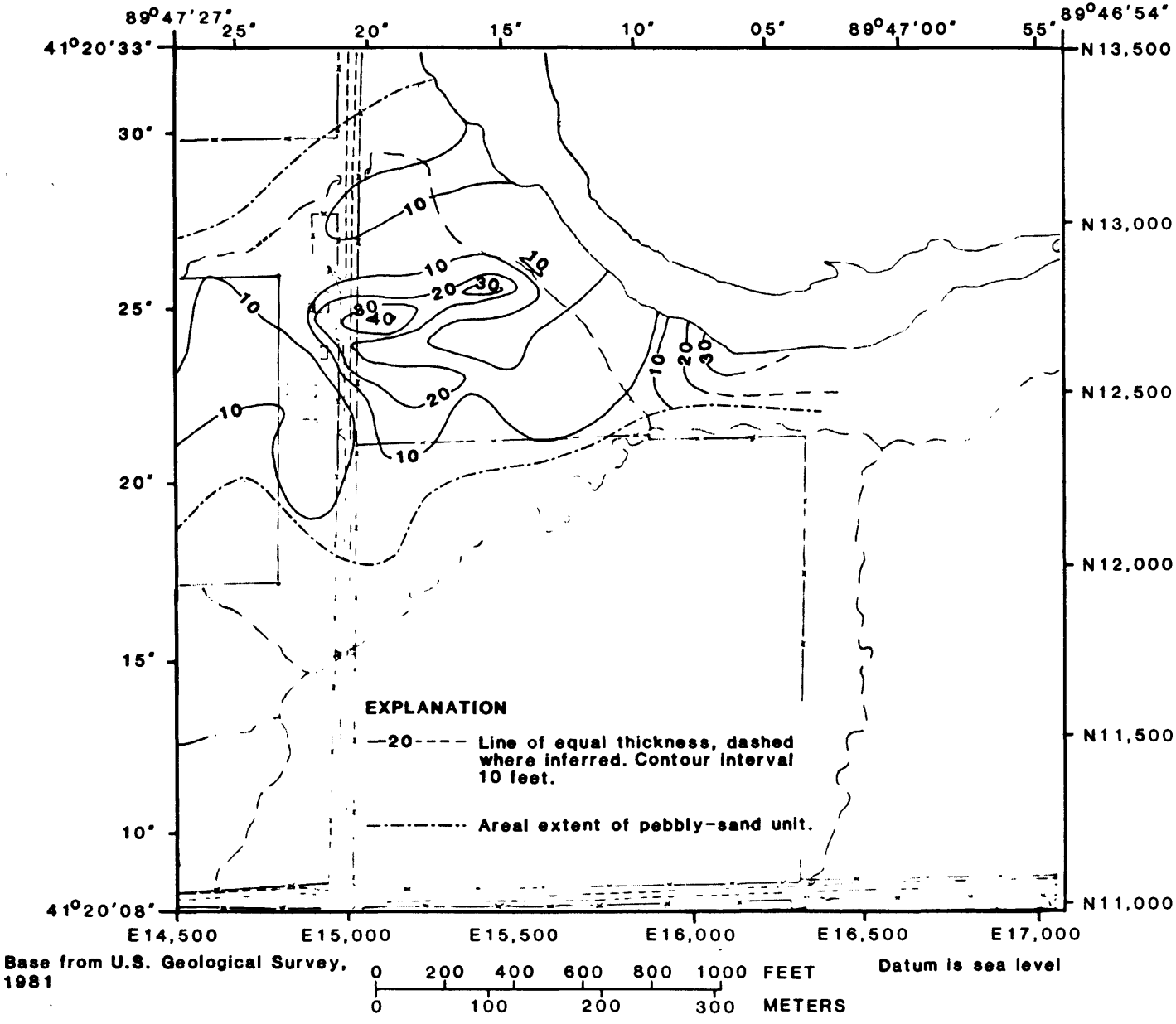


Figure 12.--Areal extent and thickness of pebbly-sand unit of Toulon Member of Glasford Formation.

Roxana Silt and Peoria Loess

During the Wisconsinan Stage ice did not cover the Sheffield site area, but aeolian silts were transported from along the Mississippi River (Willman and Frye, 1970, p. 36), and sands from nearby outwash deposits. Lower Wisconsinan aeolian silts are assigned to the Roxana Silt. Middle to upper Wisconsinan aeolian silts are assigned to the Peoria Loess.

Peoria Loess covers the entire site and study area except for the stream channels. The stream channels are filled with alluvial material derived from material that was eroded from higher ground. The loess ranges in thickness from 2 to 30 feet on the disposal site, with the thicker accumulations found near the northern and western boundaries. The loess ranges from 1 to 28 feet in thickness in the study area. The Peoria Loess is unsaturated in the study area.

Roxana Silt is not found in the study area. It is found near the eastern boundary of the site where it is penetrated by wells 503, 504, and 505.

Cahokia Alluvium

The Cahokia Alluvium was deposited during the Wisconsinan and Holocene Stages of the Pleistocene Series. It consists of clayey, silty-sand, and is found in the valley of Lawson Creek Tributary. The Cahokia Alluvium ranges in thickness from 19.5 to 24.5 feet. It is derived from reworked glacial deposits found in the study area. The Cahokia Alluvium is saturated in the southern part of the study area along the stream valley.

Modern Soil

A soil cover is developed in the upper part of the Peoria Loess and assigned to the Modern Soil (Willman and Frye, 1970, p. 89). The soil is mostly clayey silt and, where present, ranges in thickness from 2 to 9 feet. Most of the soil has been removed by ground clearing and by erosion in the area directly east of the site between the township road and the intermittent stream. The soil is unsaturated in the study area.

Coal-Mine Spoil

Test well 569 penetrated 42 feet of coal-mine spoil, which extends from land surface to the top of the shale bedrock. The spoil was emplaced when the area was stripped for coal in the early 1950's. Spoil is present in the area north of a line extending west from the lake between wells 570 and 569 and west of the township road. There are insufficient data to describe the degree of saturation in the spoil.

SUMMARY

The glacial geology of the site and study area consists of a complex system of interbedded and interfingering deposits. The stratigraphic units present, from oldest to youngest, including the bedrock are: Carbondale Formation; Duncan Mills Member; Toulon Member, Hulick Till Member, and Radnor Till Member of the Glasford Formation; Roxana Silt; Peoria Loess; and Cahokia Alluvium. Recent units include the Modern Soil and coal-mine spoil.

The bedrock is the Carbondale Formation of the Desmoinesian Series. It is composed of weathered shale with some coal.

The Duncan Mills Member of the Glasford Formation is found only in the site. It consists of silty clay interbedded with silt, clayey silt, and pebbly-sandy silt layers.

The Hulick Till Member of the Glasford Formation underlies most of the study area. It lies unconformably on the Carbondale Formation. The Hulick Till Member consists of a mixture of sand, silt, and clay with some gravel layers.

The Toulon Member of the Glasford Formation lies unconformably on the Hulick Till Member. In some areas, such as near wells 578, 580, and 592 the Toulon Member lies directly on the Hulick Till Member. A shallow depression in the underlying Hulick Till Member is filled with a gravelly, pebbly-sand of the Toulon Member. This depression extends from the northeast corner of the site eastward across the study area, providing a ground-water conduit. The Toulon Member consists of silt, sand, silty-sand, and sand and gravel.

The Radnor Till Member of the Glasford Formation is present only in the southern part of the study area and near the strip-mine lake. It overlies the Toulon Member where both units are present. The Radnor Till Member consists of clayey silt, and a mixture of gravel, sand, silt, and clay.

The Peoria Loess covers the entire study area except in stream channels where it has been eroded. The Peoria Loess consists of silt and fine sandy-silt.

The Cahokia Alluvium is found in the valley of Lawson Creek Tributary. It consists of clayey, silty-sand. The alluvial material drains the southeast corner of the site.

Modern soil covers the site and study area except where it has been removed during construction of trenches and replaced with fill material. In the cleared area directly east of the site, much of the soil has been removed either during clearing of the ground or by subsequent erosion. In the area north of well 570, the glacial materials were replaced with spoil when that area was stripped for coal.

Pleistocene deposits in the study area are saturated to varying degrees. In the area of wells 567, 602, and 611, the weathered bedrock surface and overlying Hulick Till Member are saturated. Although the Hulick Till Member is also saturated, the greater hydraulic conductivity of the pebbly-sand unit of the overlying Toulon Member suggests that the till is a barrier to groundwater flow. Where present, the Toulon Member usually is partially saturated. It is unsaturated in the vicinity of wells 567, 602, and 611, and in the area from well 578 to test boring 596B. No units overlying the Toulon Member are saturated.

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