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THE PLEISTOCENE STRATIGRAPHY AND GEOMORPHOLOGY OF CENTRAL-SOUTHERN WISCONSIN AND PART OF NORTHERN ILLINOIS[1]

by

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ABSTRACT

In south-central Wisconsin and north-central Illinois six mappable till units have been differentiated. The differentiation is based on texture, clay mineralogy, soil profiles, gross lithology, and areal field mapping. Two till units of Woodfordian age, the Tiskilwa and Haeger Members, can be traced from northern Illinois into southern Wisconsin near Lake Geneva in Walworth County. The Marengo Moraine and the Darien-West Chicago Moraine, which are associated with the Tiskilwa and Haeger Members respectively, can also be correlated across the state line. Four pre-Woodfordian units are present west and south of the prominent Woodfordian Johnstown and Darien Moraines. The Capron Member is correlated with its equivalent in northern Illinois. The Clinton Member which is overlain by a remnant paleosol and which was formerly thought to correlate with the Argyle Till Member in Illinois, is shown to overlie the Allens Grove Member, the Wisconsin equivalent of the Argyle Till Member. The Clinton Member, Allens Grove Member, and the underlying Foxhollow Member are newly recognized and described lithostratigraphic units. The Foxhollow Member, found only in the subsurface, is the lowermost till recognized in southern Wisconsin and correlates with a yet unnamed unit in northern Illinois.

INTRODUCTION

Early studies by Chamberlin (1877, 1878, 1883, 1894), Leverett (1899), and Alden (1904, 1918) in southern Wisconsin and northern Illinois formed the basis for classification of glacial deposits in the Midwest. Chamberlin (1883) recognized that the glacial deposits near Lake Michigan were less weathered than those farther west. He assigned the older, more visibly weathered deposits to the First Glacial Epoch and the younger, less severely weath-

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[1] This manuscript was prepared while lithostratigraphic nomenclature and convention were evolving. The text has been changed to be consistent with present usage but the figures and table have not. All named units labelled "till" should be considered "Members" in Wisconsin and "Till Members" in Illinois--Editor

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ered material to the Second Glacial Epoch. The Second Glacial Epoch was renamed the East Wisconsin by Chamberlin in 1894, and this name was changed to the Wisconsin Glacial Stage by Leverett in 1899. Alden (1904, 1918) extended Chamberlin's work by mapping glacial deposits in greater detail in central, southern and eastern Wisconsin.

This study focuses upon a part of southern Wisconsin originally mapped by Chamberlin (1883), Alden (1904, 1918), and Bleuer (1970, 1971). It was undertaken because mapping of glacial deposits and stratigraphic correlations were not made, or did not match well at the Wisconsin-Illinois state line (fig. 1). When Alden (1904, 1918) mapped southeastern Wisconsin, he proposed that the Delavan Sublobe of the Lake Michigan Glacial Lobe flowed southward and southeastward depositing the Genoa, Darien, and Elkhorn Moraines (fig. 2). In northern Illinois, detailed studies of glacial deposits established the existence of the West Chicago Moraine (Willman and Frye, 1970), which, although supposedly deposited by the same ice advance, could not be correlated with any of Alden's moraines in Wisconsin (fig. 2). Recognizing this discrepancy, Leighton and Ekblaw (1932), Thwaites (1937), Leighton and Willman (1953), and Thwaites (1956) suggested that, contrary to Alden's mapping, the West Chicago Moraine of northern Illinois was continuous with the western portions of the Darien Moraine (figs. 3 and 4). However, except for some work by Black (1958) these studies have been based more on inference than on field evidence.

Bleuer (1970, 1971) mapped the older glacial materials to the west and correlated them, for the most part, with stratigraphic units previously mapped in northern Illinois. He suggested that the Capron Member, which contains the surface till on the Capron Ridge in Illinois, continues northward into Wisconsin. The sandy-loam surface till between the Capron Ridge and the Sugar River in Wisconsin was correlated with the Argyle Till Member of north-central Illinois. However, there was no detailed sampling program to thoroughly document these correlations. Bleuer also encountered several problems with these correlations, finding that the physical characteristics of the presumed Argyle till in Wisconsin did not match well with those of the surficial Argyle Till Member in northern Illinois. A summary of correlations of units in this area is given in table 1.

PLEISTOCENE STRATIGRAPHY

In Illinois, the pre-Woodfordian (Altonian) age materials are grouped into one rock-stratigraphic unit called the Winnebago Formation (Kempton and Hackett, 1968; Willman and Frye, 1970) (fig. 5). The Winnebago Formation consists of till, silt, peat, and outwash reaching at least 120 m in thickness in northeastern Illinois. It is comprised of three members; from oldest to youngest they are the Argyle Till Member, the Plano Silt Member, and the Capron Till Member. The Farmdalian substage, which separates the Altonian from the Woodfordian Substage, is represented by the Robein Silt. Deposits of the Woodfordian Substage are included in the Wedron Formation and consists of till, outwash, silt, and peat. In northeastern Illinois, the Wedron Formation contains six till members, which are the Esmond, Tiskilwa, Malden, Yorkville, Haeger, and Wadsworth till Members (fig. 4).

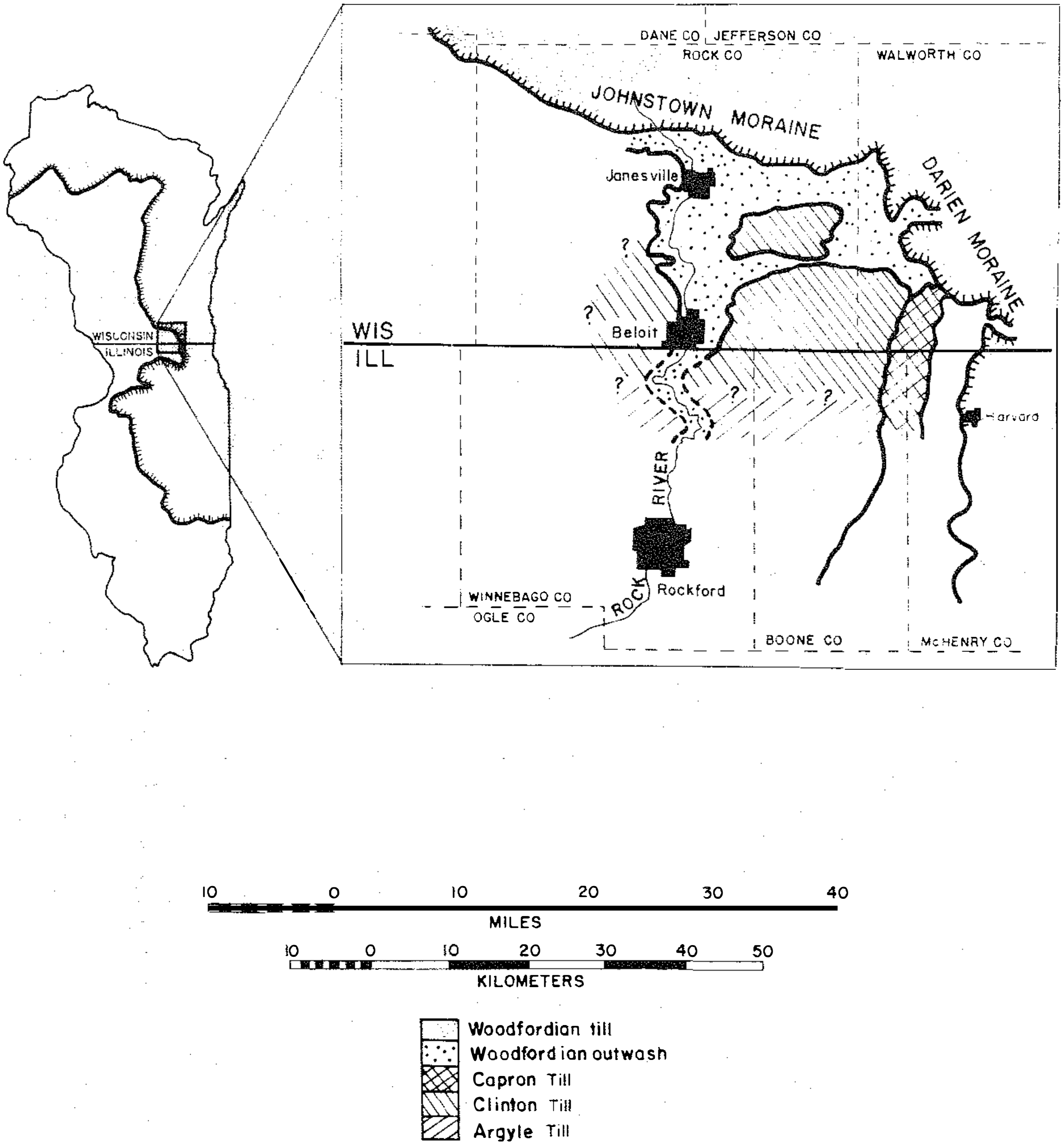

FIGURE 1.--Location of the study area, major physiographic features, and distribution of surficial units. Present Woodfordian till boundary corresponds closely to Chamberlin's boundary of the second glacial epoch. (Adapted from Chamberlin, 1883; Alden, 1904, 1918; Willman and Frye, 1970; Bleuer, 1970).

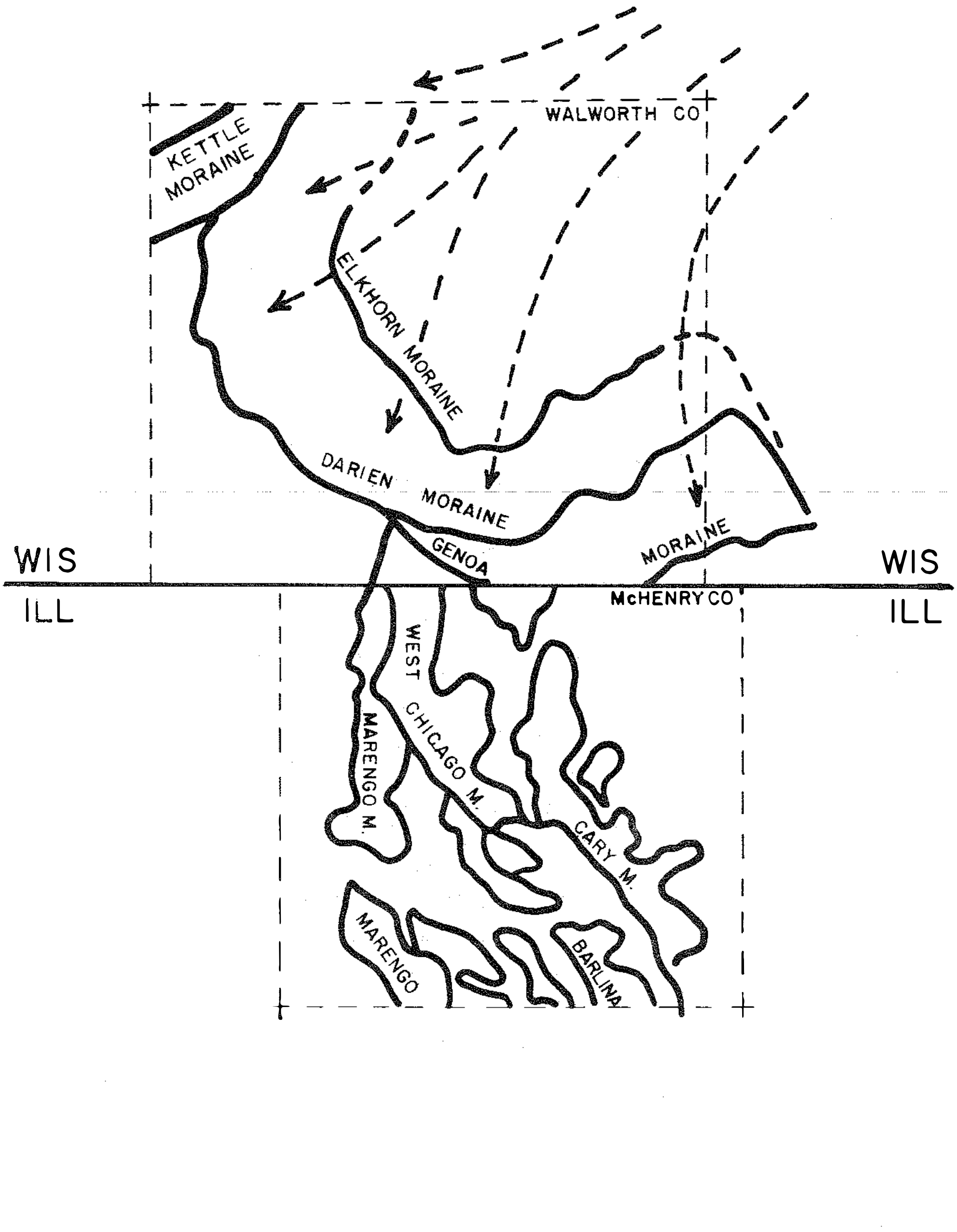

FIGURE 2.--Generalization of the Woodfordian moraines as mapped by Alden (1904) in Walworth County, Wisconsin and by Willman and Frye (1970) in McHenry County, Illinois.

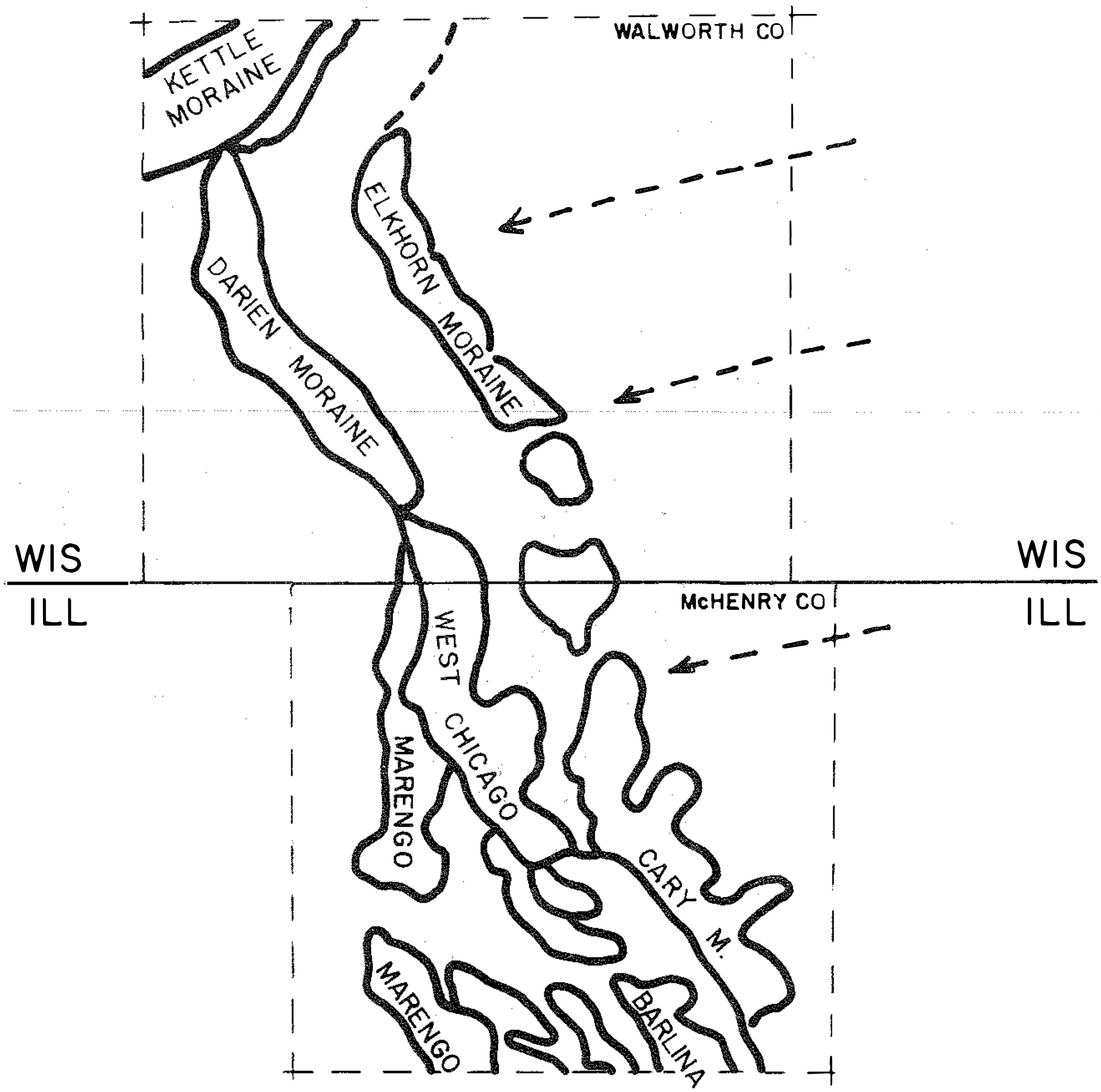

FIGURE 3.--Correlation of the Woodfordian moraines of Walworth County, Wisconsin and with those of McHenry County, Illinois.

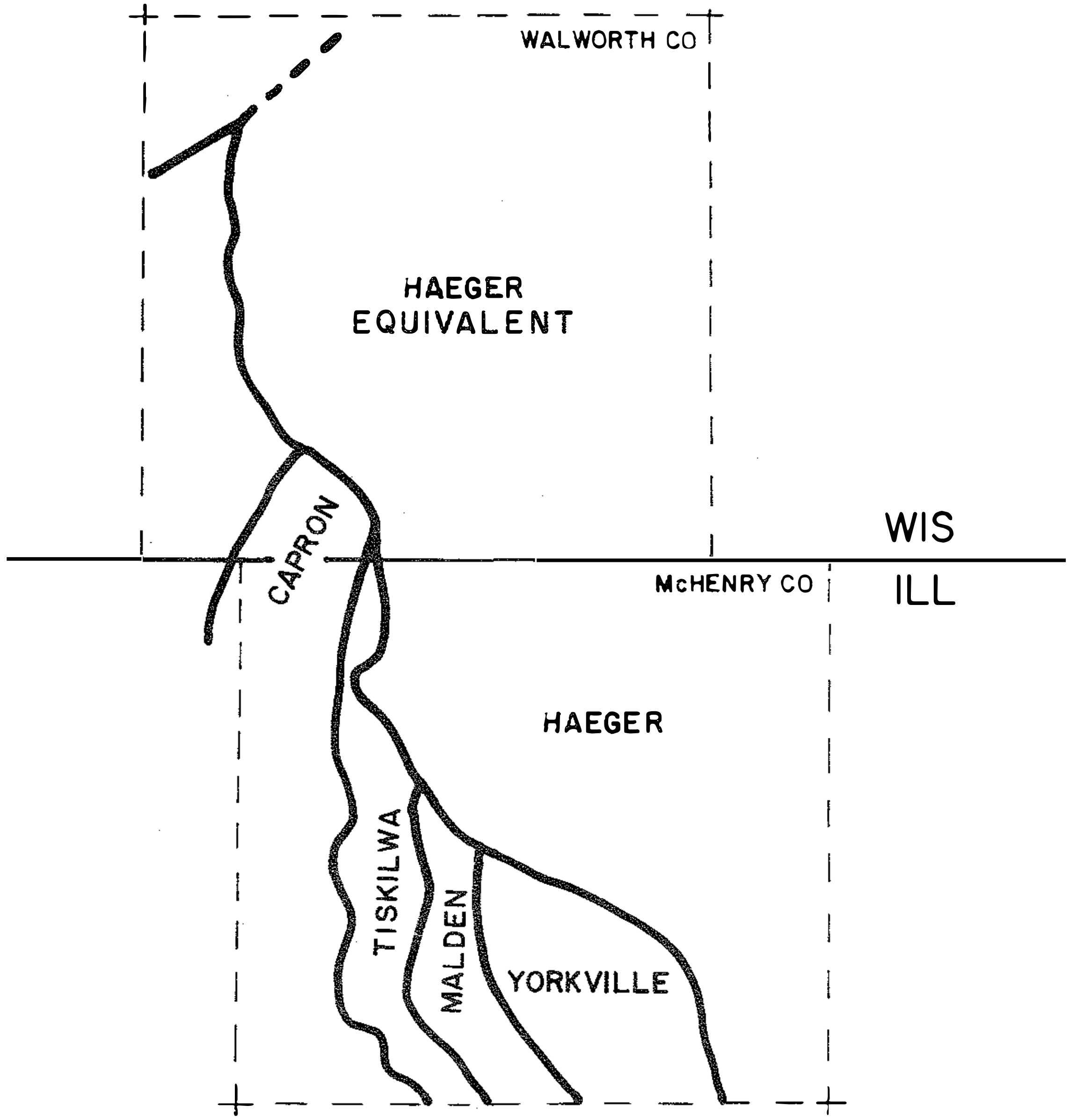

FIGURE 4.--Correlation and distribution of units in Walworth County, Wisconsin and McHenry County, Illinois.

C14 AGE	STAGE	SUBSTAGE	FORMATION	MEMBER	TYPICAL COMPOSITION
12,500	WISCONSINAN	Woodfordian	Wedron; Peoria Loess; Richland Loess		
				Wadsworth Till	Gray (insufficient data)
				Haeger Till (outwash)	Yellowish gray G 50-40-10 CM 15-60-25
				Yorkville Till	Gray G 10-52-38 CM 2-77-21
				Malden Till (outwash)	Gray-yellowish gray G 35-45-25 CM 4-76-20
				Tiskilwa Till (Lee Center Till)	Reddish gray G 37-38-25 CM 8-67-25
				Esmond Till	Gray-yellowish gray G 24-43-33 CM 3-76-21
			Morton Loess		Silt, thin clay beds
22,000		Farmdalian	Robein Silt		Silt, organic silt, peat
28,000		Altonian	Winnebago; Roxana Loess	Capron Till	Pinkish-brown G 25-43-32 CM 29-58-13
34,000±				Piano Silt	Organic silt, silt, peat
44,000±				Argyle Till	Pinkish-gray G 54-31-15 CM 23-62-15
				Unnamed Till	
75,000±	SANGAMONIAN		Glasford		
	ILLINOIAN				

EXPLANATION

G 50-40-10
Grain size, percent sand-silt-clay

CM 15-60-25
Clay minerals, percent montmorillonite-illitechlorite plus kaolinite

FIGURE 5.--Classification of Plesistocene stratigraphic units in northeastern Illinois with radiocarbon age and typical properties of the tills. (From Kempton and Gross, 1970).

TABLE 1.--Glacial stratigraphy in south-central Wisconsin as used by Bleuer (1970, 1971), as redefiend here, and as correlated with the stratigraphy in northern Illinois.

ILLINOIS	WISCONSIN	WISCONSIN
(Willman, 1975)	(Bleuer, 1971)	(This report)
Capron Till	Capron Till	Capron Till
unnamed till	Argyle Till	Clinton Till
Argyle Till	Janesville till	Allens Grove Till
unnamed till		Foxhollow Till

WOODFORDIAN GLACIAL GEOLOGY

The Tiskilwa Member

The early Woodfordian Tiskilwa Member, named from its type section near Tiskilwa, Illinois (Willman and Frye, 1970), consists of pink, silty-sand to sandy-silt till. The Tiskilwa Till Member in Illinois composes the prominent Marengo Moraine, a north trending feature characterized by rolling topography. Less than 2 km north of the Wisconsin-Illinois state line the Marengo Moraine is overlapped by outwash and the Wisconsin equivalent of the younger Haeger till Member of the Darien Moraine (fig. 4). Large channels filled with valley-train outwash deposits cut through the Marengo Moraine and contribute to the abrupt disappearance of the moraine north of the state line.

The Tiskilwa Member in Wisconsin is exposed at the surface or beneath a veneer of the younger, surficial Haeger Till Member equivalent in south-central Walworth County, Wisconsin. In this area, the oxidized Tiskilwa till is characterized by a light brown color (7.5YR 6/4); where unoxidized, the color is dark reddish gray (5YR 4/2). Grain-size analyses of 35 samples averaged 39 percent sand, 39 percent silt, and 22 percent clay.

The rolling topography of this unit is evident at the surface even where it has been covered by younger till and outwash. The overlying equivalent to the Haeger Till Member is very thin and locally absent; landforms composed of the Haeger till equivalent are limited to locally irregular morainic deposits.

The Equivalent of the Haeger Till Member in Wisconsin

The sandy, gravelly till within and behind the Darien and West Chicago Moraines correlates with the late Woodfordian Haeger Till Member in Illinois, named for Haeger's Bend in McHenry County, Illinois (Willman and Frye, 1970). The equivalent of the Haeger Till Member in Walworth County, Wisconsin is highly variable in thickness and character. The till is generally thin (less than 8 m), sandy and gravelly and varies from brown (10YR 5/4) to light brown (7.5YR 6/4) in color. There appear to be several phases within the Wisconsin equivalent of the Haeger Till Member distinguishable by local differences in texture and color. These differences are probably the result of local changes in source material or glacial regime. Although its clay mineralogy is similar to that of the underlying Tiskilwa Member, the Haeger equivalent is generally much coarser and less pink. In the Darien Moraine, the till is sandy, gravelly, reddish-brown to yellowish-brown and contains about 65 percent sand, 27 percent silt, and 8 percent clay; it is interbedded with deposits of sand and gravel. Behind the Darien Moraine, the till is generally less than 3.3 m thick and is commonly absent. The surface till behind the moraine contains an average of about 54 percent sand, 36 percent silt, and 10 percent clay and is well exposed in gravel pits near Lake Geneva where it overlies a thick outwash unit. In some areas the ice overrode substantial amounts of outwash that contributed sand and gravel to the till. Where the ice overrode the Tiskilwa Member, the drift acquired more fines and a reddish color.

Near the state line in Wisconsin, the Darien Moraine consists largely of sand and gravel with some gravelly, sandy, reddish brown till. East of the moraine, the underlying Tiskilwa Member is covered by a thin, discontinous, sandy, gravelly till with approximately 51 percent sand, 39 percent silt, and 10 percent clay virtually identical in character to the Haeger Till Member of the West Chicago Moraine in Illinois.

In summary, stratigraphic correlations based on field mapping and laboratory data confirm the continuity of the Darien Moraine in Wisconsin with its equivalent in Illinois, the West Chicago Moraine (fig. 3). Till units in both the Marengo and Darien Moraines in Wisconsin also are continuous across the state line and correlate with the Tiskilwa and Haeger Till Members in Illinois (fig. 4).

PRE-WOODFORDIAN GLACIAL GEOLOGY

The only major study west of the Woodfordian moraines in southern Wisconsin since Alden (1918) was made by Bleuer (1970, 1971). Bleuer mapped the pre-Woodfordian glacial materials in southern Wisconsin, but he did not directly trace the units across the state line into Illinois with a detailed sampling program.

Bleuer (1970, 1971) equated the surficial till between the Capron Ridge and the Sugar River south and west of the Woodfordian moraines with the Argyle till Member in northern Illinois. He encountered several problems with this correlation. The physical characteristics of the surficial till in his area of mapping did not match well with those of the surficial Argyle Till Member in northern Illinois. Bleuer (1970) noted that the typical pinkish or salmon color (7.5YR 6/4) of the Argyle Till in Illinois was not necessarily characteristic of the surficial till in south-central Wisconsin.

Textural analyses performed on 125 samples from numerous localities indicated that the surficial till in southern Wisconsin is significantly sandier than the surficial till in northern Illinois. The surficial till in Wisconsin averages 61 percent sand, 27 percent silt, and 12 percent clay, whereas the Argyle Till Member in Illinois averages 53 percent sand, 35 percent silt, and 12 percent clay. On the basis of shale pebbles and clay mineral data, Frye and others (1969, p. 6) suggested that the surficial Argyle till in northern Illinois was deposited by the Green Bay Lobe from the northeast. However, drumlinoid forms, till distribution, and Silurian dolomite pebbles in the till of central-southern Wisconsin support the suggestion that the Argyle till was deposited by the Lake Michigan Lobe as it advanced from the east (Bleuer, 1971).

Texture, clay mineralogy, color, and pebble lithology served as a basis for distinguishing and classifying pre-Woodfordian units in this study (table 2). Heavy mineral and carbonate content were found by Bleuer (1970) not to be useful in making stratigraphic correlations.

Closely spaced sampling and traverses across the state line were used to help solve correlation problems in portions of the area of older till outside the Woodfordian moraines. As a result, a new stratigraphic framework was established that contains the newly named surficial Clinton Member overlying at least two other units, the Allens Grove Member and the Foxhollow Member. While the Argyle till was previously thought to continue north as a surficial till, from Illinois into southern Wisconsin, it can now be shown that the Clinton Member overlies the Allens Grove Member and that the Allens Grove Member found in the subsurface in southern Wisconsin is instead the stratigraphic equivalent of the Argyle Till Member of Illinois. The third unit, the Foxhollow Member, underlies the Allens Grove Member and represents a previously unrecognized stratigraphic unit.

Foxhollow Member

The Foxhollow Member, a new lithostratigraphic unit, is stratigraphically the oldest and lowermost till unit recognized in the study area. Where sampled, this unoxidized, gray, clayey silt till averages 44 percent sand, 37 percent silt, and 19 percent clay. It generally contains a larger number of pebbles and cobbles than any of the other pre-Woodfordian tills in the study area and ranges in color from silver to brownish gray to purplish gray. The Foxhollow Member differs from the other pre-Woodfordian age tills in this area by its lower ratio of light-to-dark-colored dolomite in the 1 to 2 mm (coarse sand) size fraction (less than 0.8:1); whereas the Allens Grove Member typically has a ratio between 0.8:1 and 1.3:1, and the Clinton Member typically has a ratio greater than 1.3:1. Of all the tills in southern Wisconsin, the Foxhollow contains the smallest average amount of illite. X-ray diffraction analyses of the less-than 2 micron clay fraction indicated large amounts of calcite and dolomite and consistently more dolomite than calcite.

In some places, the sand-sized fraction of the Foxhollow till contains small quantities of wood, but no significant amounts could be retrieved. This is the only till known to contain wood in this area outside of the Capron Ridge and the Woodfordian moraines. One of the best sample localities at which wood fragments were found in the Foxhollow till was a test hole drilled approximately 5 km east of Beloit on the east side of a country road, north of old Wisconsin highway 15 in the center of the NE¼SE¼NE¼ sec. 33, T. 1 N., R 13 E. Alden (1918, p. 140) also reported finding organic material at a number of localities in the area.

The Foxhollow Member generally occurs in the subsurface and typically is confined to preglacial or early glacial bedrock valleys where it was protected from erosion during later glacial events. Consequently, the Foxhollow Member is almost totally defined from subsurface sampling.

Allens Grove Member

The Allens Grove Member, which overlies the Foxhollow Member, is named for the village of Allens Grove in Walworth County, Wisconsin. Its type section is on the west side of a borrow pit along State Highway 15 in the

TABLE 2.--Compositional summary of the Pre-Woodfordian tills in Central-southern Wisconsin. Amounts shown are averages, except where noted.

UNIT	TYPICAL COMPOSITION			
	G^{H}_{L}	C	R	N
Capron Till, sandy phase	41^{44}_{37}-35^{36}_{33}-24^{27}_{23}	28-61-11	—	3
Capron Till, silty phase	27^{31}_{24}-38^{40}_{36}-35^{40}_{29}	28-61-11	—	2
Clinton Till	61^{69}_{57}-27^{34}_{15}-12^{29}_{24}	26-60-14 45-45-10	>1.3:1	85
Allens Grove Till	53^{56}_{47}-35^{43}_{27}-12^{22}_{3}	26-61-13 39-47-14	0.8-1.3	40
Foxhollow Till	44^{48}_{39} 37^{46}_{24} 19^{32}_{9}	28-53-19	<0.8:1	22

G = Grain size, percent sand (2-.062mm), silt (.062-.004mm), clay (<.004mm)
H = Highest value, L = Lowest value

C = Clay minerals, percent montmorillonite-illite-chlorite plus kaolinite

R = Ratio of light colored to dark colored dolomite sand grains

N = Number of samples analyzed

NW¼SE¼SW¼ sec. 32, T. 2 N., R. 15 E., 0.8 km east of Allens Grove and approximately 4 km west of the Capron Ridge.

At the Allens Grove type section, a sequence of 11 samples were collected from the outcrop face and from the subsurface using a power auger (fig. 6). At the top of the section below 1 m of loess is 0.6 m of a yellowish-red (5YR 4/6 to 4/8), weathered, truncated B horizon formed on 8 m of Clinton till. A 1 m thick bed of sand separates the Clinton Member into two parts that are lithologically the same. A second sand and gravel layer 1.5 m thick, and 6.4 m below the top of the section separates the Clinton till from the underlying Allens Grove till. The stratified layer contains coarse gravel and cobbles; some reach 11 cm in diameter. The till of the Allens Grove Member is hard, very well compacted, and is brown and light brown to yellowish and light yellowish brown (7.5YR 5/4 to 6/4 to 10YR 5/4 to 6/4) in color. The amount of compaction in the Allens Grove till here, as well as several roadcuts west of sampling location 663 and east of Turtle Creek, may be the result of incorporation and compaction within or beneath glacial ice.

The base of the Allens Grove Member is not exposed. A nearby auger hole penetrated another 2 m of Allens Grove Member before encountering a 14 m section of gray, lacustrine silt. Beneath the silt is a firm, compact, gray (5YR 5/1) till identified as Foxhollow.

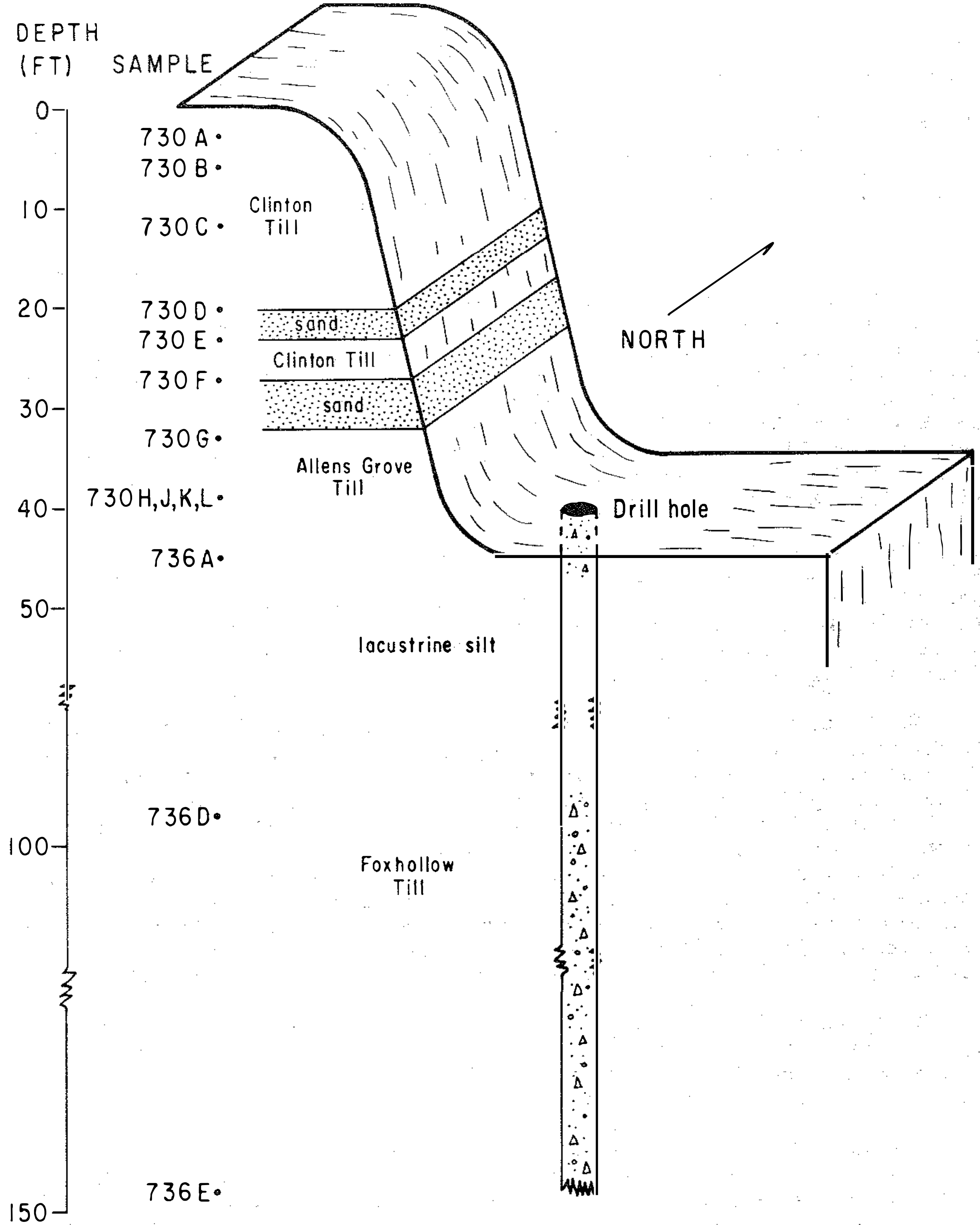

FIGURE 6.--Diagrammatic sketch of the Allens Grove Member type section (NW¼SE¼SW¼ sec. 32, T. 2 N., R. 15 E., Walworth County, Wisconsin).

The texture, clay mineralogy, ratio of light to dark colored sand-sized dolomite, and stratigraphic position support correlation of the Allens Grove Member in Wisconsin with the Argyle Till in Illinois. Samples of the Argyle till, at the Cherry Valley Section, (SE¼SE¼SW¼ sec. 30, T. 44 N., R. 3 E., Boone County, Illinois), an important reference section of the Illinois Geological Survey as well as a stop made on the 1965 INQUA field trip (Frye and Willman, 1965) near Rockford, Illinois, have a texture, clay mineralogy, and ratio of light-to-dark-sand-size dolomite similar to that of the Allens Grove till. For additional evidence supporting this correlation, see section entitled Wisconsin-Illinois Stratigraphic Correlations.

Clinton Member

With the possible exception of an area west of Janesville, the surficial Clinton Member extends throughout nearly all the rolling upland areas west of the Capron Ridge and the Woodfordian Moraines within the study area. The sandy, pebbly, light yellowish brown (10YR 6/4) Clinton Member is named from its type section in a roadcut and adjacent drillhole along the Beloit-Milwaukee Road (State Highway 15), 3.3 km northeast of Clinton, Wisconsin. Formerly correlated by Bleuer (1971) with the Argyle Member, the Clinton Member can be demonstrated to be a separate, distinct unit stratigraphically above the Allens Grove Member and below the Capron Member.

The clay of the Clinton Member is mineralogically similar to that of the Allens Grove and Capron Members; it averages 26 percent montmorillonite, 60 percent illite, and 14 percent chlorite plus kaolinite. However, the Clinton Member is distinguished by a sand-silt-clay content averaging 61 percent, 27 percent, 12 percent and by a light-to-dark dolomite ratio in the sand-sized fraction of greater than 1.3:1 (table 2).

The Clinton till in some places has a pinkish cast similar to that of the Argyle till. Its chroma varies with lighting condition and moisture content. The pinkish cast may be due to incorporation of material from the underlying Allens Grove till, as is indicated by very small inclusions of pink clay in the Clinton till matrix. However, the sandy, buff-colored Galena-Platteville Dolomite beneath much of the area probably had a great influence on forming the composition of the Clinton till. In several pits dug for bridge pilings along Wisconsin Highway 15 near Clinton, large amounts of sandy, weathered Galena-Platteville dolomite were found beneath the Clinton Member. As ice which deposited the Clinton till moved over the dolomite and sand, much of the weathering material could have been incorporated into the Clinton till matrix.

Weathering of the Clinton till has produced a paleosolic B horizon that persists beneath the loess on the flatter uplands. Removed from the steeper slopes by erosion, this paleosol may still exist along the footslopes of hills beneath loess and colluvial deposits.

The upper 6.7 m of the Clinton Member is exposed in the face of the road cut at its type section and was sampled at approximately 0.3 m intervals. The lower 8.2 m were explored by using a power auger. The sandy, buff-colored Clinton Member is overlain by 1.8 m of loess (fig. 7). The loess is an oxidized, light yellowish-brown (10YR 6/4) silt, is noncalcareous throughout, and has no observable bedding.

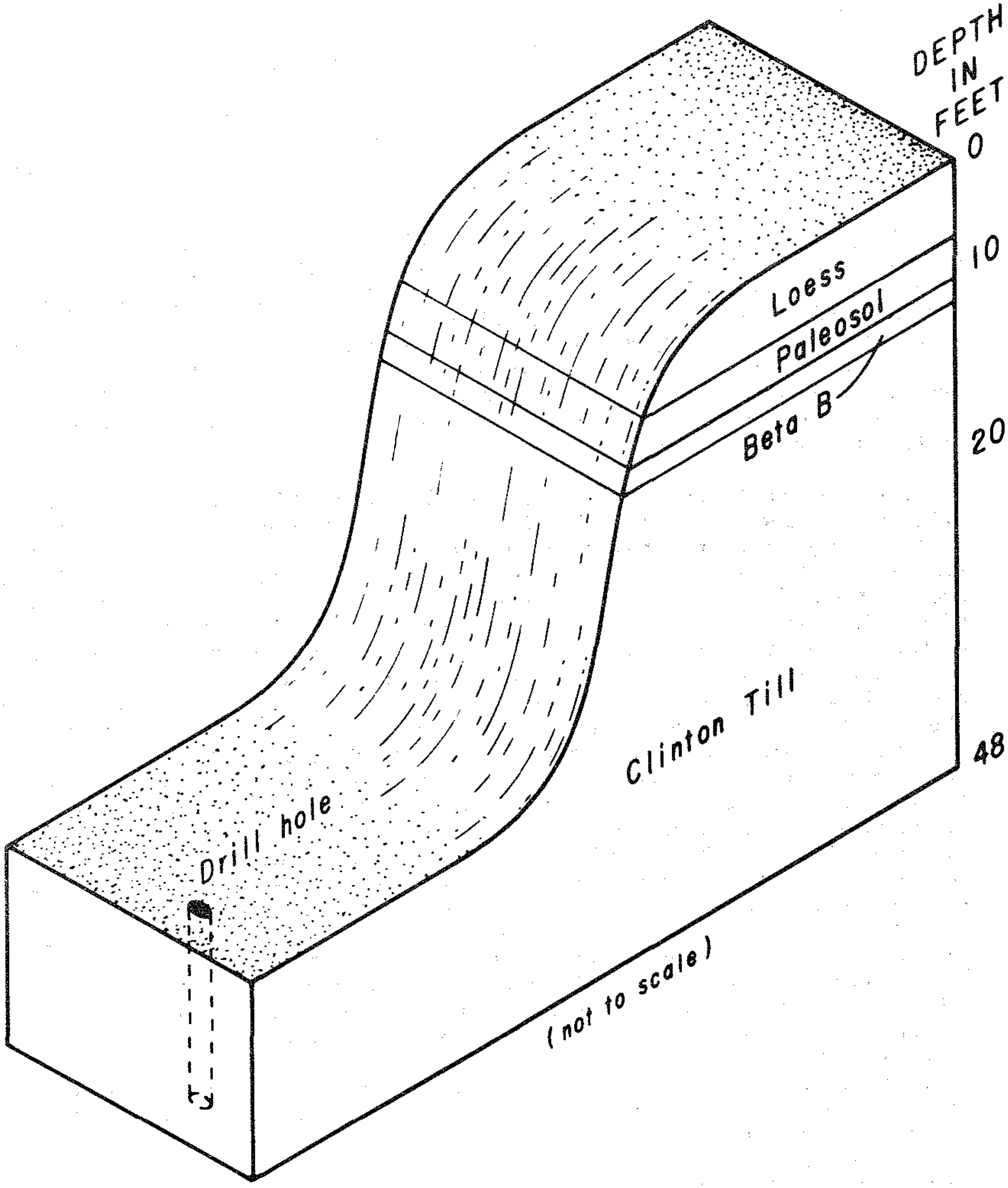

FIGURE 7.--Diagrammatic sketch of the Clinton Member type section. (NW¼SW¼ sec. 3, T. 1 N., R. 14 E., Rock County, Wisconsin).

In composite profile from the type section of the Clinton Member (fig. 8), an illuviated B2t horizon occurs below the A1 horizon in the loess. A significant decrease in silt with a reciprocal increase in sand 1.8 to 2.1 m below the top of the section marks the contact between the loess and the Clinton till. Except for a sample from the basal portion of the Clinton till at a depth of 13.1 m which contained slightly less sand, eleven samples between 2.7 m and 11.6 m depth contained nearly the same amount of sand. Apparently the upper part of the underlying Foxhollow Member was incorporated into the base of Clinton Member when the former was overridden by the advancing ice sheet.

In situ weathering of the Clinton till before the deposition of the Peoria Loess produced a reddish-brown to light-reddish-brown (5YR 4/4 to 6/4) B horizon in the upper 1.7 m of the Clinton Member. Clay-percentage data indicate that illuviation also took place in the B horizon as well as in the brown (7.5YR 4/4) beta B, a zone developed immediately below the Bt horizons.[5] There is an overall gradual increase in clay content upward from the unweathered till through both the beta B and B horizons. The profile is leached to the base of the beta B horizon. No soil structure is evident in the highly weathered, sandy paleosol.

Clay minerals in the less-than-2 micron fraction of 8 samples in the Clinton type section were analyzed by X-ray diffraction (fig. 9). Representative X-ray patterns from various parts of the type section are shown in figure 9. The presence of dolomite, calcite, chlorite, and montmorillonite are represented by sharp, well-defined peaks in sample 17. In the lower parts of the Clinton Member in its type section, both dolomite and calcite are present in relatively large amounts. The calcite peak decreases in intensity from sample 17 up to sample U. Calcite has been leached from the profile in sample P, while dolomite still remains. In samples M and H, which are from the beta B and the B horizons respectively, both calcite and dolomite were removed by weathering. Flattening and reduction of the chlorite plus kaolinite peak and the illite peaks upwards through the profile are concomitant with a broadening of the montmorillonite and mixed layer peak (near 5.4° 2Θ). The third-order (003) chlorite peak, a very sensitive indicator of weathering (Willman, Glass and Frye, 1963; Glass, 1976, oral communication), decreases in intensity and clarity upward through the profile as the influence of surficial weathering increases. The persistence of an artifact chlorite (001) peak at 6.1° 2Θ in sample H, the paleosol (fig. 9), may be due to aluminum integrades (Glass, 1976, oral communication), vermiculite, or both. Chlorite should have been removed by weathering at this point. The X-ray pattern of sample H exhibits characteristics of the most severe weathering and represents a horizon for which calculations of clay-mineral percentages are impractical. Illite and chlorite peaks in this sample are much smaller, and peaks reflecting montmorillonite and mixed-layer clay minerals (near 5.4° 2Θ) are larger. The location of the peak near 5.4° 2Θ instead of at 5.1° 2Θ suggests that the expandable clay may have had a chlorite parent material (Glass, 1976, oral communication).

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[5] In calcareous sediment, a secondary zone of clay accumulation occurs in the leached zone directly above the contact with the underlying calcareous sediment. Both clay and organic matter, which gives the beta B its characteristic brown color, accumulated here as the result of (1) a change in porosity and permeability, and (2) a change from leached to calcareous material (Bartelli and Odell, 1960).

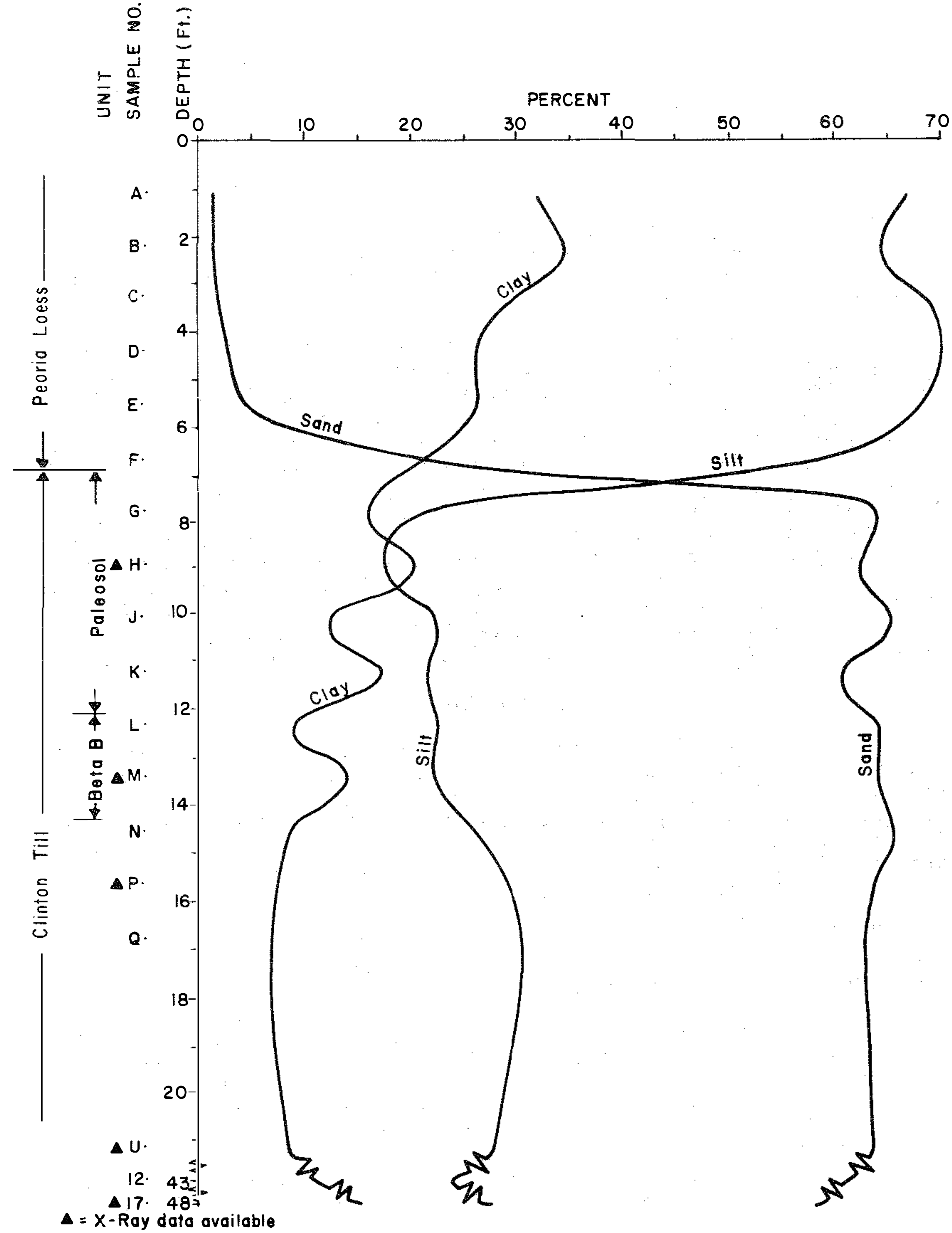

FIGURE 8.--Grain-size distribution in samples from the Clinton Member type section and stratigraphic positions of samples selected for x-ray analysis.

Effects of weathering on a profile can also be observed by changes in the diffraction intensity (DI) ratio (William, Glass, and Frye, 1963). The DI ratio is a comparison of the glycolated 10 nm illite peak with the glycolated 7.2 nm kaolinite plus chlorite peak. Kaolinite is a stable mineral and any change in the DI ratio is the result of a change in the amount of chlorite or illite. Chlorite is the first mineral affected by the weathering process and the DI ratio increases accordingly. With sufficient continued weathering, the illite begins to alter and the DI ratio drops. Alteration of illite in Woodfordian till has not been observed, whereas alteration of illite extends into the B2 horizon in Altonian age tills (Willman, Glass, and Frye, 1963). In the Clinton Till profile, the DI ratio increases upward through sample U and then decreases from sample U through sample H. This change at sample U represents alteration of illite below the paleosolic B horizon and supports the conclusion that a great degree of weathering has occurred in the upper part of the Clinton Till.

At the base of the type section for the Clinton Member a second till unit represented by sample 21 (fig. 9) contrasts sharply with the overlying Clinton Member. The Clinton till, with sand percentage in the upper 50s and 60s overlies a till with a sand content of 43.5 percent (sample 21). The X-ray patterns for sample 21 also exhibit a smaller ratio of calcite-to-dolomite than overlying samples, suggesting that it correlates with the Foxhollow Member, although more data are needed to support this conclusion. In the Vermiculite Index (VI)[6], a weathering index that is used to compare the glycolated 10 nm illite peak to the glycolated 14 nm chlorite peak, there is a break between samples 17 and 21. The VI is less than 50 in the upper sample (17) and larger than 145 in the lower sample (21). This difference, along with the less intense 5.4 nm peak in sample 17, and the broad 5.4 nm peak in sample 21, substantiates the stratigraphic boundary determined from the textural break and suggests correlation of this unit with the Foxhollow Member.

Capron Member

Overlying the Clinton Member and overriden by the Woodfordian glacier that formed the Darien Moraine near Lake Geneva, Wisconsin, is a small ridge of red clayey till that trends southward into Illinois. The till composing this ridge was correctly correlated by Bleuer (1970, 1971) with the Capron Till Member of the Capron Ridge in Illinois. Woodfordian outwash from the Lake Michigan Lobe marks the eastern surficial border of the till and the occurrence of the distinctly sandier Clinton Member defines its western limit.

The Illinois State Geological Survey recognizes a silty phase and a sandy phase in the Capron Till Member (Frye and others, 1969). Both phases have been observed in the Capron Ridge in Wisconsin, although in places the difference in texture is often less than that reported in the Capron Ridge in Illinois. Several samples collected by Bleuer (1970) from the Capron Ridge had compositions intermediate between the two phases. One Illinois boring (Northeastern Illinois Planning Commission test hole NPC-12, in the NE¼NE¼ sec. 7, T. 40 N., R. 6 E. Kane Co.; open-file report at the Illinois State Geological Survey) contains till with sand percentages grading upward from 20

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6 The VI measures the ratio of the peak heights of the 10 nm and the 14 nm peak. The $>$ or $<$ sign signifies whether the 14 nm peak is greater than ($>$) or less than ($<$) the 10 nm peak. The numerical value is a relative size indicator and is unitless.

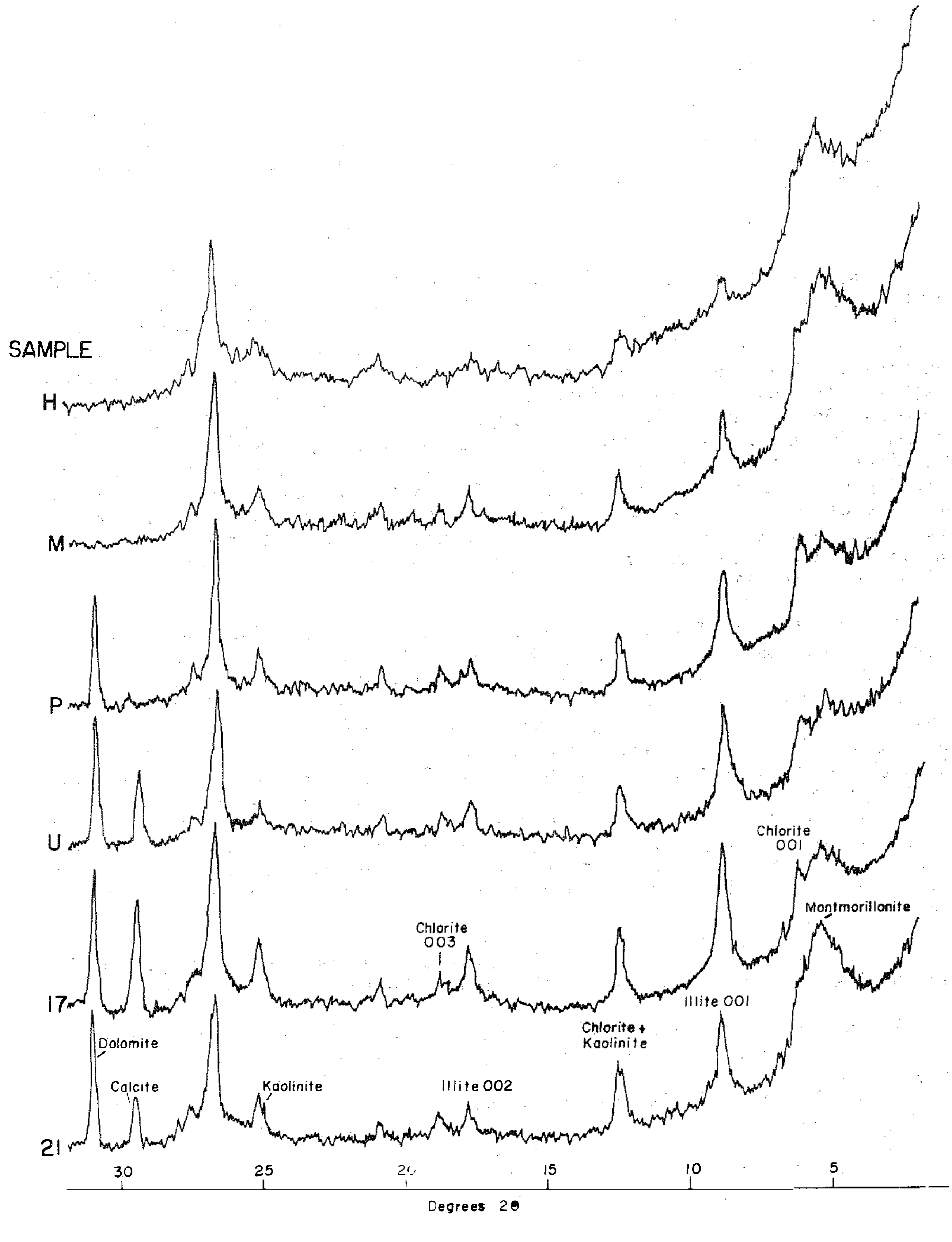

FIGURE 9.--X-ray diffraction patterns of glycolated samples from the Clinton Member type section.

to 36 percent over a vertical distance of 5 m. At all sites sampled during this study, the sandier unit of the Capron equivalent lies above the siltier one. The lower part of the Capron till sheet may contain finer material derived from the underlying sediment or the upper part may represent ablation till. In adjacent Winnebago County, Illinois, incorporation of pre-existing material into younger deposits by glacial ice resulted in overlying material acquiring some of the characteristics of the overridden deposit (Kempton and Gross, 1970, p. 68). Examples of this in Winnebago County include the Esmond Till Member, which acquired some of the characteristics of the underlying Argyle Till Member, and the Malden Till Member which incorporated some of the underlying Tiskilwa Till Member.

WISCONSIN-ILLINOIS STRATIGRAPHIC CORRELATIONS

Except by inference, very little work has been completed to base glacial stratigraphic correlations between Wisconsin and Illinois. In this study, correlations were established by tracing the stratigraphic units from one state to the other. The relationship of the Argyle, Clinton, and Capron Members is shown on a cross section extending from a point about 4.8 km southeast of Hunter in Boone County, Illinois, to a point near the northeast corner of Boone County (fig. 10). A profile of the Beaverton Section (ILL 5 on fig. 10), described in detail by Frye and others, (1969) which has the Farmdale soil developed in the Argyle till, and the Northeastern Illinois Planning Commission's cored test hole NPC-1 on the Capron Ridge, are included on the cross section (fig. 10). Part of this cross section, as evidenced by the great thickness of unconsolidated deposits in test hole NPC-1, lies over the Troy bedrock valley. The total depth of NPC-1, although not fully presented here, is 144 m.

The NPC-1 core (fig. 11) contains the most complete sequence of stratigraphic units. Beneath the surficial Peoria Loess lies the sandy phase of the Capron Till Member which, in turn, overlies the sandy, yellow-brown Clinton Member. A layer of silty sand and gravel outwash separates the Clinton Member from the pink to gray-brown Argyle Member below. Beneath the Argyle is a less sandy till (T1) characterized by a sand percentage in the low to upper 40s. Although the stratigraphic position of till T1 supports its correlation with the Foxhollow Till, the consistently higher illite content of T1 does not. Below till T1 is a thick outwash sequence. Under the outwash is a till designated T2, which possibly corresponds with the Sterling Till of Illinoian age. Still lower in the section is a massive lacustrine deposit underlain by another till (T3) which may correlate with the Ogle Till, also of Illinoian age.

The Capron Till mantles the Clinton Member to the western margin of the Capron Ridge. West of that margin the Clinton Member is at the surface.

In the Beaverton Section (ILL 5 fig. 11), the Clinton Till is absent and 1 m of Peoria Loess overlies 4.6 m of Argyle Till Member. Developed on the Argyle Till Member and below the loess is 0.6 m of Farmdale Soil (Frye and others, 1969). From field observations, the Farmdale Soil is visibly less developed than the paleosol on the Clinton till in Wisconsin. This may indicate that the Argyle till, at least at the Beaverton section, was not exposed to subaerial processes as long as the Clinton till or that a thin cover of Clinton till was removed from atop the Argyle till during the late Altonian

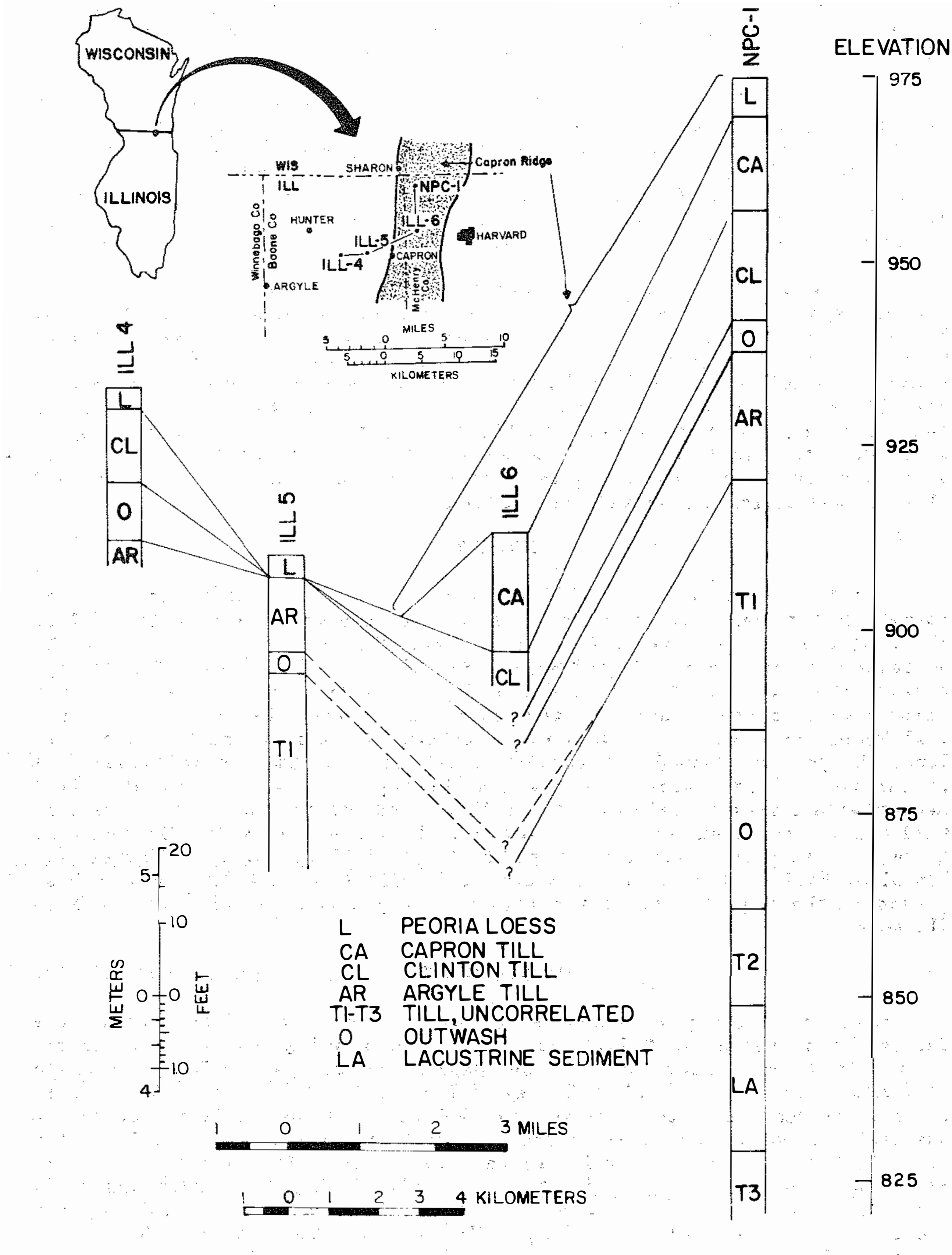

FIGURE 10.--Cross section across a part of northern Illinois showing the stratigraphic relations of glacial materials.

when the Capron till was deposited. The Argyle till is separated from till T1 below by a 1-m thick bed of sand and gravelly sand. The Argyle till is distinguished from T1 by differences in clay mineralogy and texture.

West of the Beaverton section, test hole ILL 4 contains sandy Clinton till resting on outwash that overlies the Argyle till. Separation of these tills was based partly on the difference in their grain size and the presence of an intervening outwash layer. Clay mineralogy also helps to distinguish these tills; not only do their DI ratios differ, but the difference in chlorite (003) peaks for the two tills indicates that the lower unit is much more severely weathered than the upper unit.

The cross section shown on figure 10 provides the basis for defining the stratigraphic relationships between the Clinton and Allens Grove Members. Instead of forming the surface till in both northern Illinois and southern Wisconsin, the Clinton Member overlies the Allens Grove (Argyle in Illinois) Member in southern Wisconsin and extends at least a short distance into northern Illinois. Although not presented here, additional data from test holes and outcrops in both Wisconsin and Illinois support these correlations and compliment the cross section (see Fricke, 1976). Further mapping needs to be done to better define the surficial extent of the Clinton Member in northern Illinois and define its westernmost margin.

SUMMARY

Six till units are included among the Pleistocene units that can be correlated between Illinois and Wisconsin. The Woodfordian age Haeger till of the West Chicago Moraine in Illinois is traceable into Wisconsin where the equivalent of the Haeger Till Member forms the Darien Moraine. The Marengo Moraine and the associated Tiskilwa Member are overlapped by the Darien Moraine a short distance north of the state line. Capron Ridge and the Capron Till Member extend from Illinois into southern Wisconsin where they are overlapped by younger outwash and the Darien Moraine. In the area of older till to the west of the Darien Moraine and the Capron Ridge, the Clinton Till Member with a remnant paleosol formed locally on its surface is the surficial till unit. The Allens Grove Till Member, which lies below the Clinton Till Member in Wisconsin, correlates with the Argyle Till Member in Illinois. The Foxhollow Till Member is the lowermost till unit recognized in southern Wisconsin in the sequence and correlates with a yet unnamed till in northern Illinois.

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