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Absence of Altonian Glaciation in Illinois

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Illinois was free of glacier ice from about 130,000 to 25,000 yr B.P. Deposits of this time interval in northeastern Illinois, represented by core samples from test-hole ISGS S-30, are composed of leached, nonglacigenic, stratified, or pedoturbated silty sediments that typically are organic-rich and pedogenically modified. These deposits overlie the Sangamon Soil, which is identified by its stratigraphic position, soil morphology, and distinct alteration products in the clay-mineral fraction, including a variably swelling vermiculite-like phase and a randomly interstratified kaolinite/10 Å phase. The regional extent of these deposits suggests that if Altonian ice existed in the Lake Michigan basin, it did not extend westward beyond the cuesta of Silurian dolomite that rims the southwestern shore of Lake Michigan.

INTRODUCTION

No direct evidence indicates that northeastern Illinois was glaciated between the wasting of late Illinoian ice prior to 130,000 yr B.P. and the arrival of the Woodfordian ice margin about 25,000 yr B.P. Deposits of that time interval are present at sites in central and northeastern Illinois and typically are pedogenically altered colluvium (Robein Silt) with a significant eolian component that overlies the Sangamon Soil. Radiocarbon ages from Robein Silt in northeastern Illinois range from about 25,000 to >50,000 yr B.P. (Table 1) The Sangamon Soil is interpreted to have developed during parts of oxygen-isotope stage 5 (Follmer, 1983), dated from about 130,000 to 70,000 yr B.P. (Martinson *et al.*, 1987). Earlier studies concluded that the northern region was glaciated during part of Altonian time (e.g., Willman and Frye, 1970).

Early stratigraphic studies of Pleistocene deposits in Illinois (Leverett, 1888; Horberg, 1953) recognized that the Wisconsinan and Illinoian glacigenic sediments are separated by a soil complex. Studies by Leighton and Willman (1950), Shaffer (1956), Kempton (1963), and Willman and Frye (1970) suggested that Altonian-age Roxana Silt, a deposit dominated by loess along the Illinois and Mississippi River valleys, is genetically related to several glacigenic deposits that were included in the Winnebago Formation in northern Illinois. Most of the Roxana was deposited between 45,000 and 31,000 yr B.P. (McKay, 1979). Radiocarbon ages and recognition of Sangamon Soil profiles beyond the limit of Woodfordian glaciation have indicated that the Winnebago tills are of Illinoian age (Kempton *et al.*, 1985; Curry and Krumm, 1986; Follmer, 1986). This study demonstrates that Robein Silt and Sangamon Soil extend discontinuously eastward beneath Woodfordian glacial deposits to the cuesta of Silurian dolomite along the western rim of the Lake Michigan Basin (Fig. 1).

Figure 2 compares the informal time divisions of Richmond and Fullerton (1986) with the chronostratigraphic units of Willman and Frye (1970). The former, developed for the purpose of correlations across the United States, is based on the estimated astronomical ages of correlated marine oxygen-isotope stages. The latter, developed for use in Illinois, is based mostly on radiocarbon ages, lithostratigraphy, and pedostratigraphy.

As a product of a detailed investigation of

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TABLE 1. List of Radiocarbon Ages

Site	Radiocarbon age	Lab No.	Material	References
Athens North Quarry	22,170 ± 450	ISGS-534	Wood	Follmer *et al.*, 1986
	25,170 ± 200	ISGS-536	Wood and muck	
	38,920 ± 1100	ISGS-654	Peat	
	41,770 ± 1100	ISGS-684	Washed organics	Follmer, 1983
	35,750 ± 620	ISGS-870	Organic silt loam	Follmer *et al.*, 1986
	37,100 ± 1200	ISGS-883	Organic silt loam	
Monticello	22,850 ± 290	ISGS-422	Organic silt loam	Liu and Coleman, 1981
	34,290 ± 840	ISGS-490	Organic silt loam	
	37,950 ± 700	ISGS-423	Organic silty clay	
ISGS S-30	26,100 ± 390	ISGS-1593	Organic silt loam	Curry *et al.*, 1988
	41,000 ± 3100	ISGS-1594	Organic silt loam	
ISGS F-4	27,150 ± 340	ISGS-1294	Organic silt loam	Kempton *et al.*, 1987
	38,600 ± 3200	ISGS-1295	Organic loam	
NIPC-19	25,300 ± 2100	I-2783	Muck	Wickham *et al.*, 1988
NIPC-3	35,000 ± 2500	W-1450	Organic silt loam	Kempton and Hackett, 1968
	38,000 ± 3000	I-847	Organic silt loam	
NIPC-8	25,600 ± 800	I-849	Muck	Kempton and Hackett, 1968
Oak Crest Bog	24,830 ± 350	ISGS-1039	Organic silty clay	McKenna, 1985;
	37,900 ± 1300	ISGS-1073	Peat	Meyers and
	43,800 ± 2700	ISGS-1069	Peat	King, 1985;
	47,400 ± 2400	ISGS-744	Peat	Liu *et al.*, 1986
Fox River Stone Co.	35,300 ± 1400	ISGS-1275	Wood	B. Fisher, pers. commun.
	>37,000	ISGS-1320	Organic silty clay	
Woodland Landfill	26,980 ± 400	ISGS-1113	Muck	B. Fisher, pers. commun.

the geology of a county-size area in northeastern Illinois, samples from test-hole ISGS S-30 indicate that a sequence of stratified and pedogenically altered deposits occur between Woodfordian and Illinoian glacigenic diamictons. The borehole site is 25 km east of the limit of the Woodfordian glaciation and 72 km west of Lake Michigan (Fig. 1). In other boreholes and outcrops in this area, lack of a continuous sequence representing the time interval under consideration has made correlations difficult. At most sites in northeastern Illinois, Robein Silt and Sangamon Soil occur only sporadically beneath the Wedron Formation (Wickham *et al.*, 1988); Roxana Silt rarely is observed. Glacigenic diamicton of definite Altonian age has not been identified in Illinois.

SITE STRATIGRAPHY AND METHODS

The stratigraphic succession at borehole ISGS S-30 is in Figure 3; the interval of interest is in Figure 4. Samples from core ISGS S-30 were rotary cuttings from depths of 30.69 to 40.39 m and continuous split-spoon samples from depths of 40.69 to 42.54 m. Samples were logged and subsampled for clay mineral, particle size, radiocarbon, and organic carbon analysis. All sub-Wedron units (A through D) are leached of carbonate minerals.

Particle-size distribution. Samples were

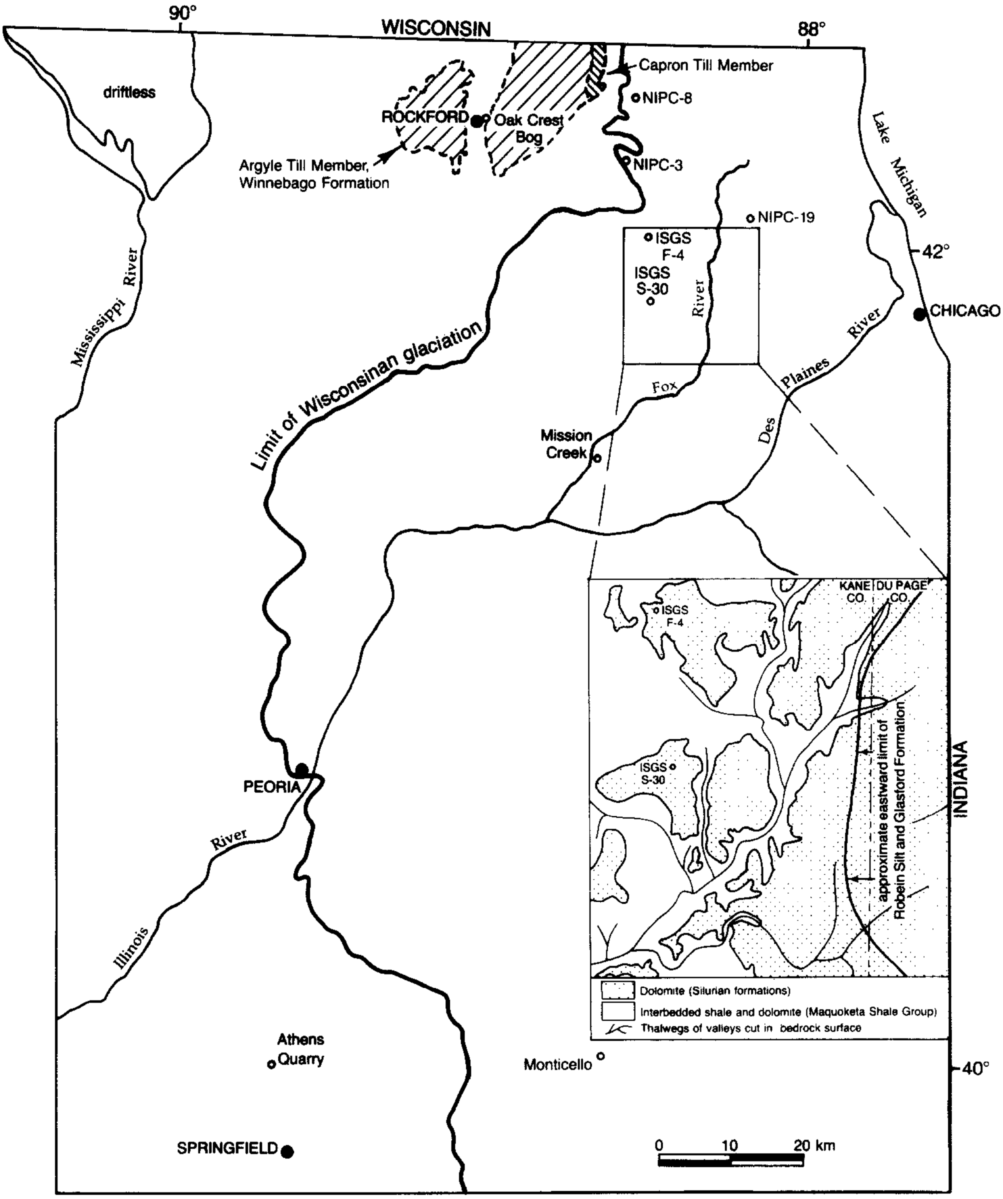


FIG. 1. Map showing location of sites. Shading shows approximate extent of Winnebago Formation (after Kempton *et al.*, 1985). Inset shows approximate westward limit of cuesta of Silurian dolomite (stippled) and eastward limit of Robein Silt and Berry Clay in Kane and Du Page Counties.

analyzed with a Sedigraph after dispersion with sodium hexametaphosphate. The gravel and sand fractions were analyzed by wet sieving. Textural classes are in USDA terminology.

Clay-mineral analysis. The <2-μm fraction of eight samples spaced about 22 cm apart along the core was separated by centrifuge, suctioned onto mullite tiles, and given the following treatments: (1) ethylene glycol solvation; (2) Mg^{2+} saturation, and subsequent solvation with glycerol; (3) Mg^{2+} saturation plus heating to 375°C for 2 hr; and (4) heating to 550°C for 13 hr. The samples were X-rayed with a Siemens diffractometer with a Ni filter and Cu*K*α

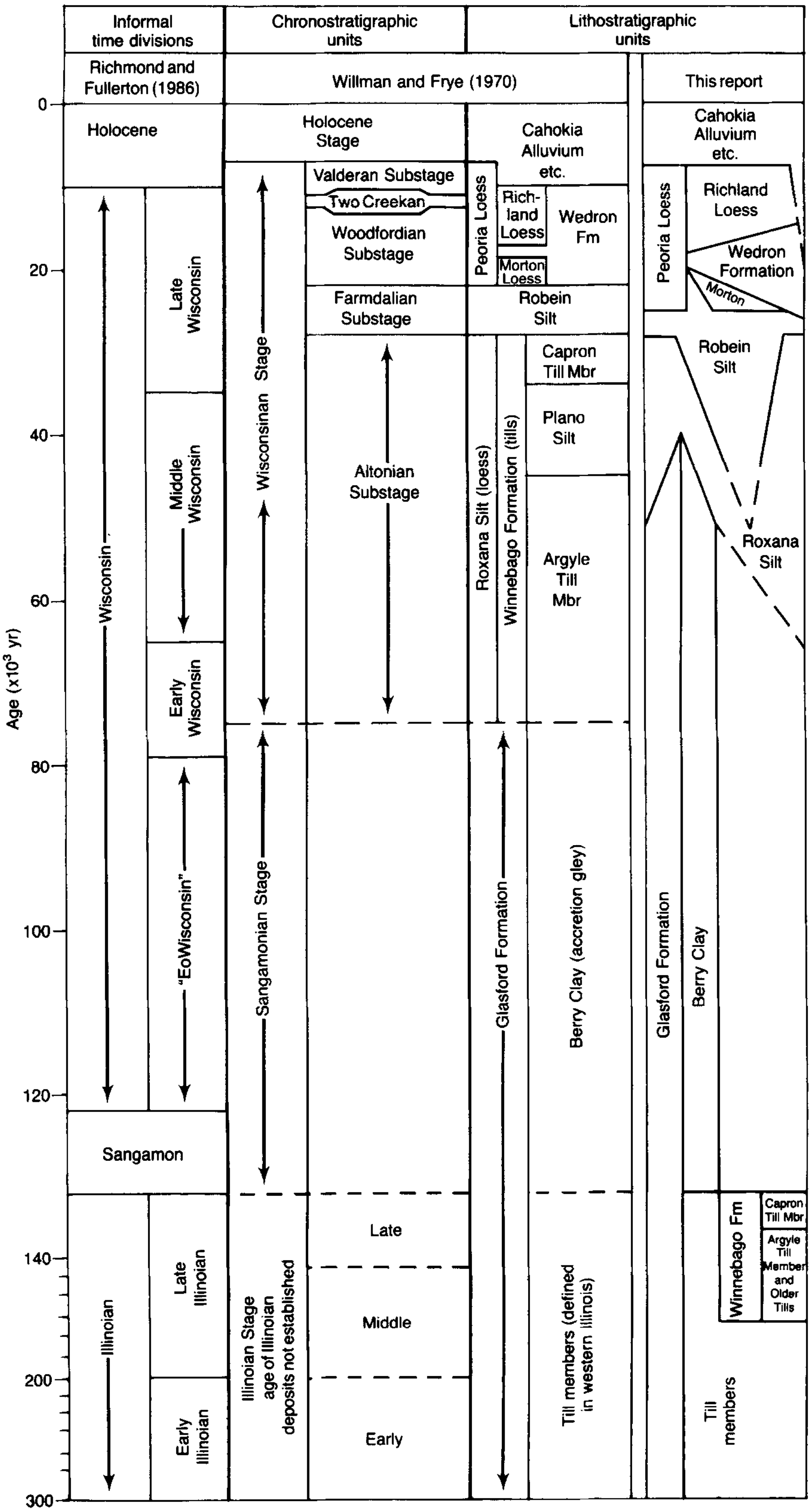
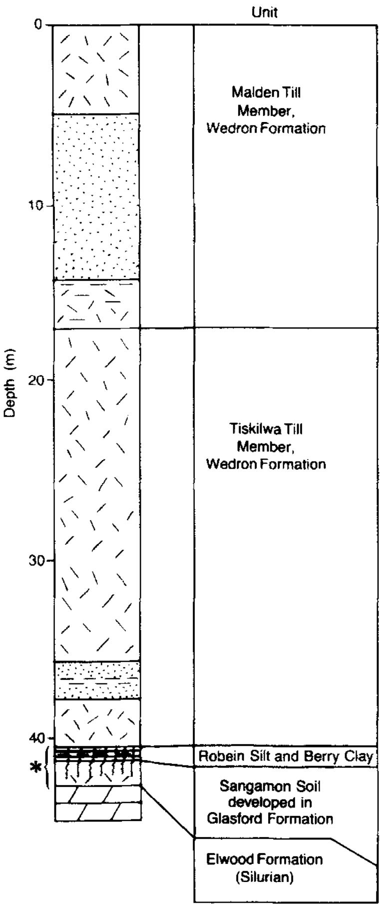


FIG. 2. Informal time divisions of Richmond and Fullerton (1986), and chronostratigraphic and lithostratigraphic units of Willman and Frye (1970).



*interval shown in Figure 4

FIG. 3. General stratigraphy of test-hole ISGS S-30.

radiation. Typically at the Illinois State Geological Survey, only ethylene glycol solvated samples are X-rayed to evaluate clay mineralogy for lithostratigraphic correlation (Frye *et al.*, 1960; Wickham *et al.*, 1988). In this case, the other treatments were also done to evaluate mineralogic details of the weathered materials, such as presence of unexchangeable interlayer material in vermiculite-like phases, the presence of a randomly interstratified kaolinite/10 Å phase, and behavior of "heterogeneous swelling material" (Willman *et al.*, 1966) that is diagnostic of relatively well-drained Sangamon Soil profiles. X-ray diffraction analyses of three representative samples are shown in Figure 5.

RESULTS

Units A through D are characterized by their distinctive colors, stratification, organic matter content, textures, and clay-mineral assemblages (Table 2; Figs. 4 and 5). Unit A (40.39 to 40.69 m in depth) was not sampled by the split-spoon method; rotary cuttings provided disturbed samples of fibrous peat that had a high organic carbon content (15.2%). Peat fragments from this interval yielded a Farmdalian ^{14}C age of 26,610 ± 390 yr B.P. (ISGS-1593). Small sample size did not allow clay-mineral or particle-size analyses.

Unit B is 30 cm thick and carbonaceous. At the top is brown silt loam 9 cm thick that is relatively deficient in organic carbon (0.6%). Beneath it is organic-rich silty clay bed 1 cm thick and brown silt loam 19 cm thick that has a relatively high organic carbon content (4.6%) and yielded a ^{14}C age of 41,000 ± 3100 yr B.P. (ISGS-1594). At the base of unit B is another thin, organic-rich, silty clay bed. Unit B has a particle-size distribution and medium silt (16–31 μm)/course silt (31–63μm) ratios greater than

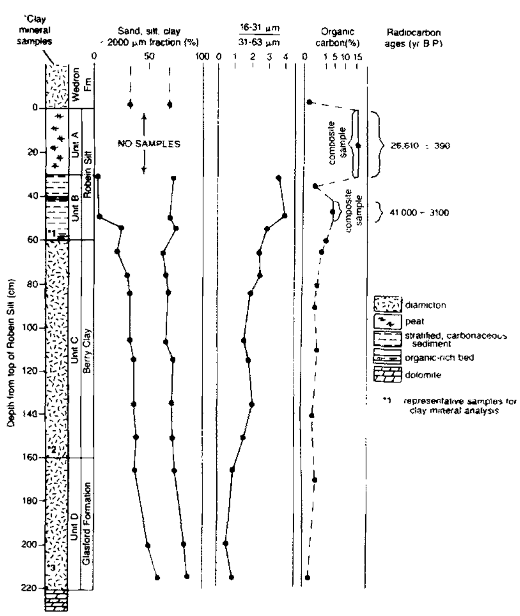


FIG. 4. Detailed stratigraphy and lithologic parameters of test-hole ISGS S-30.

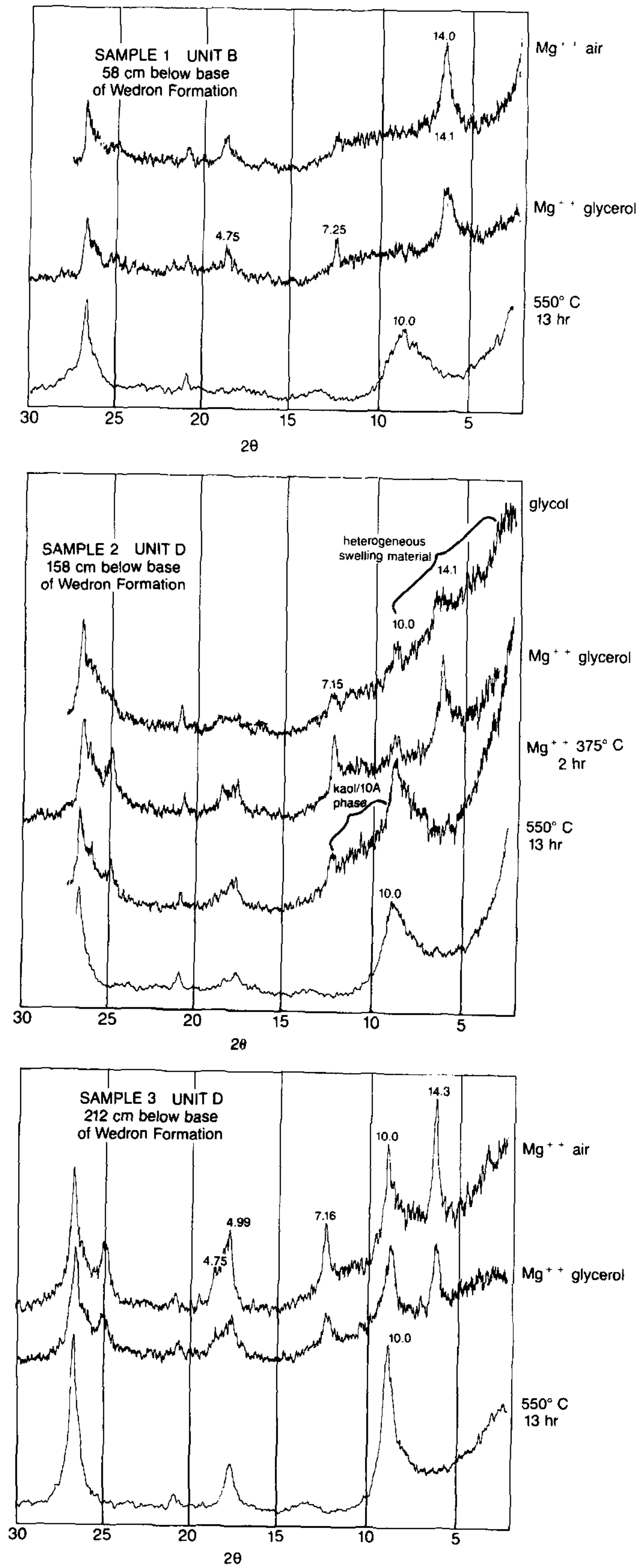

SAMPLE 1 UNIT B
58 cm below base
of Wedron Formation
14.0
14.1
4.75
7.25
10.0
Mg⁺⁺ air
Mg⁺⁺ glycerol
550° C
13 hr
30
25
20
15
10
5
2θ
SAMPLE 2 UNIT D
158 cm below base
of Wedron Formation
heterogeneous
swelling material
14.1
10.0
7.15
kaol/10A
phase
10.0
glycol
Mg⁺⁺ glycerol
Mg⁺⁺ 375° C
2 hr
550° C
13 hr
30
25
20
15
10
5
2θ
SAMPLE 3 UNIT D
212 cm below base
of Wedron Formation
14.3
10.0
4.99
4.75
7.16
10.0
Mg⁺⁺ air
Mg⁺⁺ glycerol
550° C
13 hr
30
25
20
15
10
5
2θ

TABLE 2. PARTICLE-SIZE ANALYSES OF UNITS B, C, AND D FROM TEST-HOLE ISGS S-30

Depth from top of Unit A (cm)	Unit	>2000 μm (based on total sample)	<2000 μm 2000–63 μm (sand)	63–4 μm (silt)	<4 μm (clay)	16–31 μm / 31–63 μm
		percent	percent	percent	percent	
35	B	0.0	1.3	66.3	32.4	3.6
48	B	0.0	2.7	62.3	35.0	3.8
54	B	0.6	23.0	46.6	30.4	2.8
65	C	0.2	19.0	39.5	41.5	2.4
72	C	0.3	28.1	34.5	37.4	2.4
83	C	2.1	28.7	33.4	37.9	1.9
107	C	7.9	30.0	34.4	34.6	1.5
114	C	4.8	35.3	34.9	29.8	1.8
135	C	4.2	34.8	32.2	33.0	2.1
150	C	24.1	35.5	33.0	31.5	1.6
166	D	3.6	32.0	42.9	25.1	0.8
197	D	2.7	45.8	35.2	19.0	0.5
215	D	4.2	54.3	25.9	19.8	0.9

three (Table 2; Follmer, 1982) that indicate the material is derived from loess.

The clay minerals in unit B include at least one swelling 2:1 phase with properties similar to macroscopic crystals of vermiculite (Walker, 1961). After Mg^{2+} saturation, most of the clay minerals have a *d*-spacing of about 14.0 Å and they only partly expand with subsequent glycerol solvation (sample 1, 58 cm below the top of Robein Silt in Fig. 5). That phase may be partly high-charge smectite, but its composition cannot be confirmed without data to determine layer charge. The phase does not completely collapse to 10 Å with K^+ saturation or after heating to 550°C. Rich (1968) suggested that such behavior indicates the presence of interlayer aluminum– or iron–hydroxy complexes.

Units C and D have pedogenic characteristics such as subangular blocky structure and common clay coatings. The units are separated by several sand-filled tubules and one krotovina beneath a loose gravelly horizon at the top of unit D. Also, there are subtle changes in grain size and differences among the clay minerals in the two units.

X-ray diffractometer traces characteristic of samples from the B horizon of the Sangamon Soil (Willman *et al.*, 1966) were observed in units C and the upper part of unit D (sample 2, 158 cm below the top of Robein Silt in Fig. 5). These characteristics include high intensity in the lower-angle region (<9° 2θ) of ethylene-glycol-solvated samples (the "heterogeneous swelling material" of Willman *et al.*, 1966) and much less illite than in the leached and oxidized sample 3 lower in unit D. The cation-exchange treatments show that the swelling material generally behaves like the hydroxy-interlayered vermiculite in the sample above, but sample 2 has more collapsible material.

Another characteristic of the Sangamon Soil in sample 2 (Fig. 5) is a randomly interstratified kaolinite/10 Å phase. This is indicated by a small but notable increase in background from about 8.8° 2θ to about 11.8° 2θ before and after Mg^{2+} saturation

FIG. 5. X-ray diffractograms of the <2 μm fraction of selected samples shown in Figure 4. Samples were oriented on mullite tiles and X-rayed with CuKα radiation with a Ni filter.

and the 375°C heat treatment. The 375°C heat treatment shows that intensity of the kaolinite/10 Å phase is not due to second-order reflections of the heterogeneous swelling material. This phase has been noted in other well-drained paleosols (Hughes and Glass, 1987).

The X-ray diffraction data for sample 3 (212 cm below the top of Robein Silt in Fig. 5) show that the illite (001) peak at about 10 Å is relatively sharp and there are no chlorite or carbonate materials. This indicates the diamicton is oxidized and leached but otherwise not affected by pedogenesis (the "CL-zone" of Frye *et al.*, 1960). Diffractograms of the 550°C heat treatment show that the vermiculite does not have as many hydroxy interlayers as are present in the samples higher in the core because it collapses more completely to 10 Å. The vermiculite in this sample in part probably is an alteration product of chlorite, detected by X-ray diffraction in a subsample 7 cm below sample 3.

Both the clay-mineral and textural data indicate mixing by pedoturbation of units B and D to form unit C, which is 100 cm thick. In unit C, there is upward decrease in the heterogeneous swelling material and the mixed-layer kaolinite/10 Å phase relative to illite. Moreover, the medium silt (16–31 μm)/coarse silt (31–63 μm) ratio is intermediate between those in units B and D (Table 2), indicating incorporation by pedoturbation of admixed eolian-derived material rich in medium silt (Follmer, 1982).

DISCUSSION

Nonglacial deposits beneath the Wedron Formation or Peoria Loess have been identified at several sites in northern Illinois, including ISGS S-30 (Fig. 6). The entire sequence, which includes Farmdalian and Altonian organic sediments, colluvium, or loess overlying the Sangamon Soil, is represented at a few sites: Monticello (Liu and Coleman, 1981), Oak Crest Bog (McKenna, 1985; Meyers and King, 1985), and Athens Quarry (Follmer *et al.*, 1986). At other sites, such as Mission Creek (Willman and Payne, 1942, p. 302; Fig. 6) where a nonglacigenic Farmdalian to Sangamonian sequence would be anticipated but the ^{14}C chronology and pedogenic character of the sediments have not been determined. The nonglacial deposits are present at least as far north as test-hole NIPC-8 (Kempton and Hackett, 1968) and as far east as NIPC-19 (Wickham *et al.*, 1988), 30 km west of Lake Michigan (Fig. 1).

Deposits between Woodfordian and Illinoian deposits typically have been correlated with Robein Silt, Roxana Silt, and Berry Clay, but this correlation has been tenous in northeastern Illinois for three reasons. First, the deposits generally are less than 1 m thick, and all units seldom are present in a stratigraphic section. Second, subsurface samples usually are taken at 1.5-m intervals, and the thin deposits probably often are missed or only partly sampled. Third, radiocarbon ages cluster in two groups: 42,000 to about 32,000 yr B.P. (Altonian) and 27,500 to 25,000 yr B.P. (Farmdalian). Early correlations (Kempton and Hackett, 1968; Willman and Frye, 1970) suggested that the Capron Till Member of the Winnebago Formation was deposited during the time interval between the two clusters of ages. The organic-rich colluvium or loess that yielded the Altonian ^{14}C ages was named Plano Silt (Willman and Frye, 1970). The Plano now is considered to be the lower part of the Robein Silt (Curry and Kempton, 1985; Fig. 2). The Capron Till Member probably is Illinoian in age because it is present 17 km east of test-hole NPC-8 (Fig. 1) which has a stratigraphy in the interval of interest similar to that of test-hole ISGS S-30 (Kempton and Hackett, 1968; Fig. 6).

Figure 7 is a cross section across parts of Kane and Du Page Counties, Illinois, showing that the Robein Silt and Glasford Formation are truncated by the Wedron Formation in the eastern part of the region. Other data indicate that Robein Silt and Berry Clay are present to the north beneath

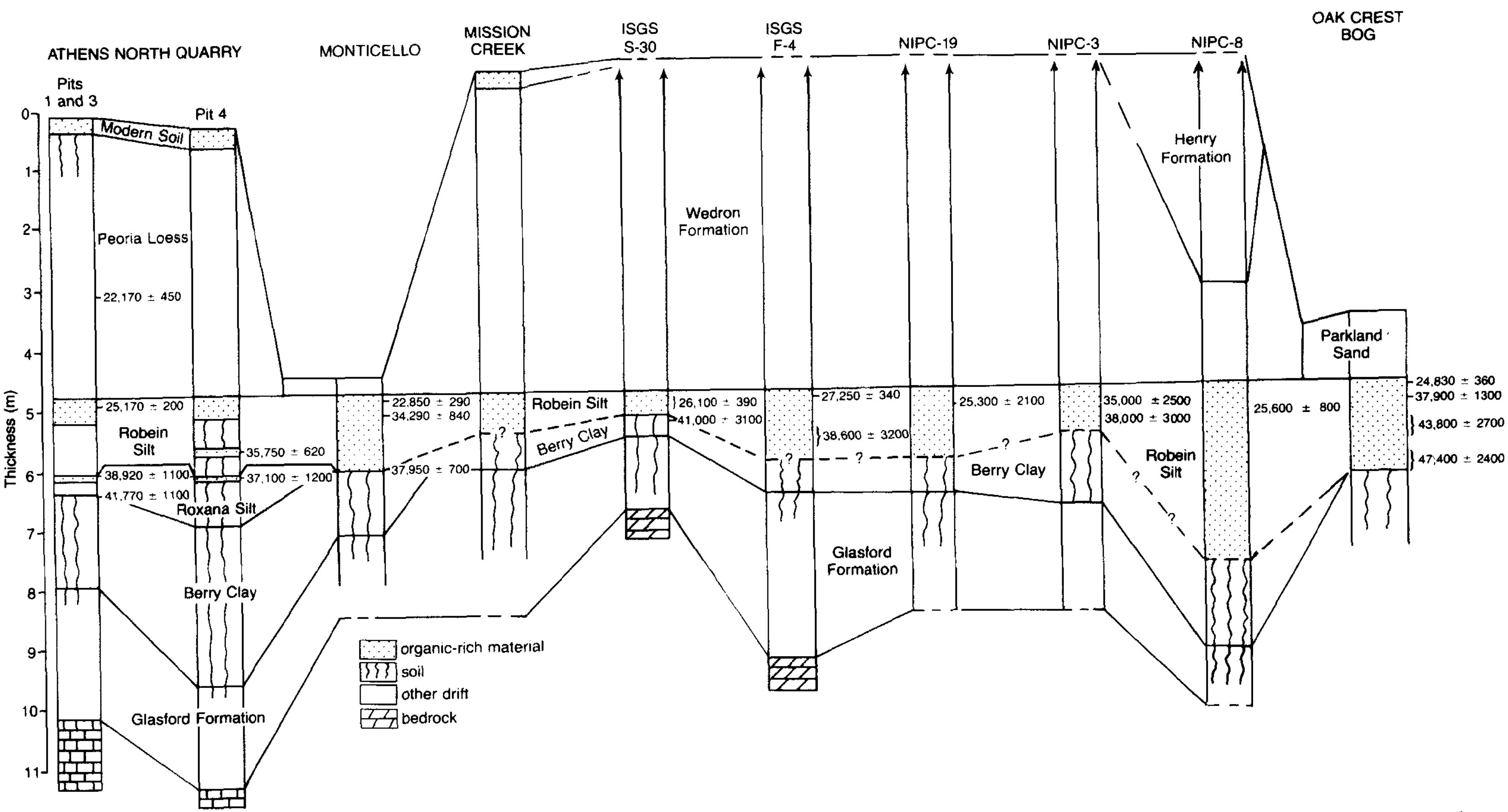


FIG. 6. Correlation of lithostratigraphic units from localities in central and northern Illinois (see Fig. 2 for site locations), including Athens North Quarry (Follmer, 1983; Follmer *et al.*, 1986), Monticello (W. H. Johnson, unpubl. data; Liu and Coleman, 1981), Mission Creek (Willman and Payne, 1942), ISGS S-30 (Curry *et al.*, 1988), ISGS F-4 (Kempton *et al.*, 1987), NPC-19 (Wickham *et al.*, 1988), and Oak Crest Bog (McKenna, 1985; Meyers and King, 1985). Datum is top of Robein Silt.

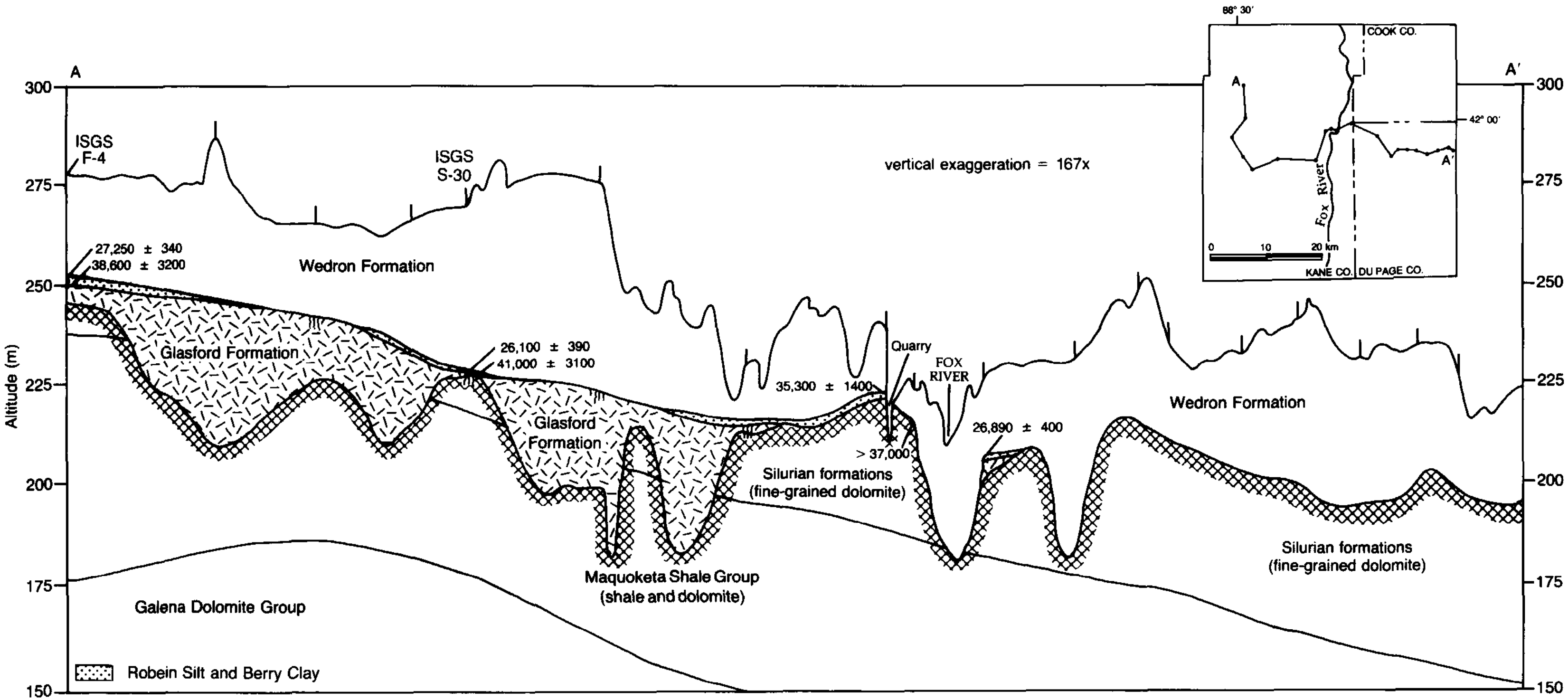


FIG. 7. Section across parts of Kane and Du Page Counties, Illinois, showing eastward limit of Robein Silt, Berry Clay, and Glasford Formation. Radiocarbon ages from several borings and one quarry highwall are included. Tick marks along ground surface indicate locations of water wells and test-holes. Inset shows location of section line.

the Wedron Formation in northern Illinois and southern Wisconsin. If Altonian glaciation occurred in the Lake Michigan Basin, it did not extend as far south and west as Kane County, Illinois.

The Robein Silt, Roxana Silt and Berry Clay are difficult to differentiate where they are thin owing to pedoturbation and colluviation. Typical Robein Silt (Willman and Frye, 1970, pp. 64–65) has structures indicative of colluviation, such as thin-bed stratification (Follmer and McKay, 1986). Typical Roxana Silt is massive (Willman and Frye, 1970) and commonly it has small-scale pedologic structures. These characteristics are often ambiguous; for example, evidence of colluviation is lacking at the type section of the Robein but is present in Athens North Quarry and other sections (Follmer *et al.*, 1986). Roxana Silt is rare in northeastern Illinois because the principal source area, the Illinois River Valley (a former course of part of the Mississippi River) is not in that region (McKay, 1979). Berry Clay is redeposited diamicton (accretion gley) and both it and the Robein Silt are colluvium. Their textures are largely inherited; Berry Clay is sandy (especially at the base) and Robein Silt is silty. Where Roxana Silt does not intervene, the lithologic basis for separating the Berry Clay and Robein Silt is lacking.

For practical purposes, units A, B, and C (Fig. 4) constitute a single lithostratigraphic unit. Elements of Robein Silt, Roxana Silt, and Berry Clay can be distinguished by interpretation of the laboratory data, but the units are thin and difficult to separate by observing the core. A formation that embraces all nonglacigenic sediments between the Wedron and Glasford Formations may be practical, but definition of a new unit is beyond the scope of this report. In the present lithostratigraphic classification (Fig. 2), units A and B are correlated with Robein Silt because of their silty texture and ^{14}C ages, but they in part may be Roxana Silt; unit C is Berry Clay because the clay mineral and textural data indicate it is weathered, pedoturbated diamicton mixed with eolian-derived medium silt. Unit D is a truncated Sangamon Soil profile that includes part of the B-horizon developed in the Glasford Formation.

The time interval during which Sangamonian pedogenesis occurred in Illinois is inferred. Sangamon Soil probably began to develop in the type area earlier than 130,000 yr B.P., the beginning of marine oxygen-isotope stage 5 according to the chronology of Martinson *et al.* (1987). The rate of pedogenic alteration of Illinoian deposits lessened considerably during initial deposition of the Altonian Roxana Silt, possibly as early as 75,000 yr B.P. (Frye *et al.*, 1974; Follmer, 1983). Although the latter estimated ages have no chronometric basis in Illinois, the oldest Roxana is older than 42,000 yr B.P. (McKay, 1979).

SUMMARY

Altonian-age glacigenic sediment has not been identified in northeastern Illinois. The absence of till between the Illinoian-age Glasford Formation and Woodfordian-age Wedron Formation is documented in test-hole ISGS S-30, 25 km up-ice of the limit of Woodfordian till and 72 km west of Lake Michigan (Fig. 1).

The stratigraphic record from ISGS S-30 is particularly significant because the Glasford to Wedron sequence appears to be complete; at other sites the absence or truncation of parts of this sequence limit the reliability of correlation and interpretation. Lateral tracing of interglacial deposits beneath the Wedron Formation indicates that glacigenic sedimentation did not occur in Illinois from before 130,000 yr B.P. until encroachment of the Woodfordian ice margin about 25,000 yr B.P. However, the presence of Roxana Silt and equivalent deposits in western Illinois and elsewhere in the North American midcontinent suggests that Altonian glaciation did occur in the Great Lakes region (Eyles and Westgate, 1987; Winters *et al.*, 1988) or in the Missouri and Mississippi River drainage basins (Dreeszen, 1970; Flemal *et al.*, 1972).

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