LITHOSTRATIGRAPHIC DESCRIPTION AND CLASSIFICATION OF LOESS-STRATIGRAPHIC UNITS IN WISCONSIN

by

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This lithostratigraphic classification is herein informally proposed for use in the State of Wisconsin.

Moist Munsell colors are used throughout. Textures and other descriptive criteria follow the terminology of the Soil Survey Staff (1975).

KIELER FORMATION

Source of the name.--Kieler, Wisconsin is the source for the name.

Type Section.--The type section located at the same site as the type section of the Rountree Formation in the Rosemeyer Farm Quarry (Knox and others, 1990) located on an interstream divide in the SE1/4, NW1/4, SW1/4, NE1/4 Sec. 14, T. 3N., R. 1W. approximately 1.6 km east of Platteville, Wisconsin (Fig. 1).

Reference Sections.--The reference sections include core hole sites CR3, GT6, and GT7 of Leigh (1991)(Figs 2-7). These core sites also constitute the reference sections for the various members of the Kieler Formation, and their precise locations and descriptions are given with this description of the Kieler Formation. Core samples of these reference sections are available at the University of Wisconsin Department of Geography. The reference sections are provided to illustrate variability that exists within the Kieler Formation and to illustrate how members of the Kieler Formation differ from similarly named lithostratigraphic units in Illinois and elsewhere.

Description of Unit.--The Kieler Formation consists largely of loess and reworked loess that typically occurs on uplands, terraces, and valley margins, especially on the uplands along the Mississippi River valley. Peoria loess makes up the majority of the Kieler Formation. The Kieler Formation consists primarily of massive silt and silt loam that ranges in color depending on the drainage conditions and pedogenic alteration at any given site. In most places (well drained settings) it is typically yellowish brown to light yellowish brown (10YR 5/4 to 10YR 6/4). In poorly drained settings it is typically greyer in color. The unweathered part of the Kieler Formation commonly is calcareous, containing up to 15 percent carbonate minerals, and dolomite is generally more abundant than calcite. Unweathered parts of the Kieler Formation are generally massive, but may include beds of silty sediment that are thinly laminated and stratified. The Kieler Formation typically does not include distinct beds of sand or clay like those that are characteristic of fluvial and lacustrine deposits. In addition, it does not include fining-upward sequences of gravel, sand, and silt or any sedimentary structures that are characteristic of fluvial deposits. Stone lines and thin beds of sand can occur in the Kieler, but they are not ubiquitous features. The Kieler Formation ranges in thickness from several centimeters to 15 to 20 meters. It is generally coarsest textured and thickest near large river valleys, and it becomes finer and thinner with distance from the valleys. In landscape settings immediately adjacent to large river valleys the sand content may be as much as 50 percent, and at sites more than 20 km from large river valleys the Kieler is more clayey (up to 25 percent clay in the unweathered state). On hillslopes it typically includes clasts of the local rock material that occur in a massive silty matrix. Paleosols typically bound separate members of the Kieler Formation, which are distinguished on the basis of stratigraphic position, color, texture, and structure, and chemical characteristics. At present, four members are named within the Kieler Formation. These include, from oldest to youngest, the Wyalusing, Loveland, Roxana, and Peoria Members.

Nature of contacts.--The Kieler Formation is generally the surface deposit and it abruptly overlies the Rountree Formation, Paleozoic rock, and to a lesser extent other Pleistocene deposits including till and lacustrine sediment.

Differentiation from other units.--The Kieler Formation is differentiated from other units by its typical massive structure and abundant silt. It does not typically contain isolated beds of gravel, sand, or clay, and the macro-stratification of the Kieler does not include fining-upward sequences or beds of gravel, sand, and silt, or any sedimentary structures that are typical of fluvial deposits. The Kieler Formation is distinguished from other surficial sediments by its abundant percent of silt (more than 50 %). Massive sandy deposits that contain more than 50 percent sand are not included in the Kieler

Formation.

Regional extent and thickness.--The Kieler Formation is the surface deposit over most of the uplands in the Driftless Area and it is fairly extensive on till surfaces that predate the late Wisconsinan (see Hole, 1968). It is thickest (up to 20 m) and most noticeable within 25 km of large rivers of southwestern Wisconsin. However, it occurs as a thin deposit throughout much of the state (see map of Hole, 1968). The occurrence of the Kieler Formation in the landscape is primarily restricted to upland interstream divides and hillslopes. However, in some valley bottoms it may occur on Pleistocene terraces and as late Pleistocene hillslope and alluvial fan deposits at valley margins. The Kieler Formation also occurs as the fill in cutoff valley meanders in southwestern Wisconsin. The Peoria Member makes up the vast majority of the Kieler Formation.

Origin.--The Kieler Formation originated as loess that was blown from river floodplains (and possibly lake plains) that were subaerially exposed during the Pleistocene. Subsequent to its eolian deposition as loess it has undergone mass wasting and limited fluvial transport processes that have redistributed it on various parts of hillslopes.

Age.--Most of the Kieler Formation is composed of the Peoria Member which ranges in age from 25 ka to 12 ka. It is likely that most of the Kieler is younger than the Brunhes-Matuyama magnetostratigraphic boundary because Jacobs (1990) found that the oldest parts of upland loess-derived sediment had normal remanent magnetism. Reworked parts of the Kieler could be as young as 10 ka.

Correlation.--The Kieler Formation correlates lithostratigraphically and chronostratigraphically with all Pleistocene loess-derived Formations of the Illinois State Geological Survey (Willman and Frye 1970) and with other Pleistocene loess deposits in the Midwest (Ruhe, 1976). The classification of the Kieler Formation differs from Illinois and elsewhere because separate lithostratigraphic units that are Formations in Illinois, and other states, are members of the Kieler Formation. For example, the Loveland, Roxana, and Peoria Members of the Kieler Formation correlate respectively with the Loveland Silt, Roxana Silt, and Peoria Loess Formations of the Illinois State Geological Survey (Willman and Frye, 1970). The creation of the Kieler Formation and the drop in rank of the Peoria, Roxana, and Loveland units to members is needed because the pre-Peoria members are not mappable at the scale of geologic mapping practiced in Wisconsin. In addition, name changes, based on whether the lithostratigraphic unit overlies or underlies glacial till of a certain age, is not practiced in Wisconsin as it is in Illinois with the Richland Loess and Morton Loess Formations (Willman and Frye, 1970).

Description of Type Section.--The Kieler Formation is described by Knox and others, (1990, pp. 64, 65) at the type section of the Rountree Formation as the Peoria and Roxana Formations. However, in this formal classification the Peoria and Roxana are considered members of the Kieler Formation.

At the type section the Peoria Member extends from the surface to 2.23 m depth and consists of dark yellowish brown (10YR 5/4) silt loam that averages 76 percent silt, 23 percent clay, and less than 1 percent sand in the basal calcareous part and becomes more clayey and darker colored (10YR 4/4 to 10YR 4/3) upward through the weathering profile. The basal Peoria (1.90 to 2.23 m) is calcareous and has thin beds of brown silt loam that were probably eroded from the underlying Roxana. The Peoria Member abruptly overlies the Roxana Member.

At 2.23 to 2.35 m the Roxana Member is a dark brown (10YR 4/3) silty clay loam. The Roxana has moderate coarse platy structure and is noncalcareous. Charred plant fragments are common in the Roxana, which has a gradational lower boundary with the Rountree Formation. The lower boundary of the Kieler Formation is characterized by a mixed zone (2.35 to 2.59 m) that has features that are transitional from the Roxana Member to the underlying Rountree

Formation. The mixed zone is considered part of the basal Roxana Member of the Kieler Formation and has a clear boundary at the top of the Rountree Formation.

The Rountree Formation (2.59 to 4.65 m) consists of dark brown 7.5YR 4/3) to reddish brown (5YR 5/3) clay. Two subdivisions are recognized in the Rountree Formation and include an upper reddish brown (5YR 4/3) clay with strong angular blocky structure (2.59 to 3.10 m) and a lower dark brown to strong brown (7.5YR 4/4 to 7.5YR 4/6) clay with strong angular blocky structure. The clay content in the upper part ranges from 50 to 60 percent in the upper part and from 60 to 80 percent in the lower part. A noncalcareous lens of yellow (2.5Y 8/8) silt occurs in the lower part of the Rountree Formation at 4.16 to 4.27 m and angular fragments of chert are common in both units. Metallic black coatings of manganese occur in the lower part. The Rountree Formation abruptly overlies brownish yellow (10YR 6/6) weathered sandy dolomite of the Galena Formation at 4.65 m.

Description of Reference Sections in Wisconsin.

CORE CR3:

Core CR3 is located approximately 1 kilometer northwest of Bridgeport, Wisconsin on the center of the north line of the NE 1/4, NW 1/4 Sec. 10, T. 6N, R. 6W, on the Bridgeport 7.5-minute quadrangle in Crawford County, Wisconsin. The core-hole is on the crest of the drainage divide 4 meters south of the south edge of the blacktop road and in line with a windbreak of larch trees on the north side of the road (see Figs. 2 and 3).

DEPTH CM	HORIZON	DESCRIPTION
PEORIA MEMBER		
0-18	A	10YR 3/1 sandy silt loam, compressed weak medium granular, clear boundary.
18-28	A/B	10YR 3/1 and 10YR4/4 sandy silt loam, moderate medium subangular blocky, noncalcareous gradual boundary.
28-90	Bt	10YR 4/6 sandy silt loam, weak medium subangular blocky, noncalcareous, very thin clay coats on ped faces, diffuse boundary.
90-130	BC	10YR 5/5 sandy silt loam, weak very coarse subangular blocky, noncalcareous, gradual

		boundary.
130-192	C1	10YR 5/4 sandy silt loam, weak very coarse subangular blocky to massive, noncalcareous, gradual boundary.
192-230	C2	2.Y 5/2 silt loam, mottled with abundant large and medium 10YR 5/6 mottles, some mottles follow root casts as "pipestems", massive, noncalcareous, abrupt boundary.
230-275	C3	2.5Y 5/2 at top grading to 2.5Y 6/4 at base silt loam, mottled with common large 10YR 5/8 well rounded "pipestems" with concentric Mn rings, massive, calcareous, gradual boundary.
275-660	C4	2.5Y 6/4 coarse silt loam to silt, massive, calcareous, abrupt boundary.
660-696	C5	10YR 5/4 silt loam with many thin lenses of 2.5Y 6/4 and 5YR 5/4, few 10YR 4/2 lenses at the base, massive to thinly laminated, few specks of charcoal, slightly calcareous, abrupt boundary.
PEORIA MEMBER		
ROXANA MEMBER		
696-717	2EB1b	10YR 4/5 silt loam, moderate medium platy breaking into compressed moderate fine to very fine granular, noncalcareous, few specks of charcoal, gradual boundary.
717-750	2EB2b	10YR 4/4 silt loam, moderate medium platy parting to moderate fine granular, noncalcareous, few specks of charcoal, diffuse boundary.
750-779	2EB3b	10YR 5/4 silt loam strong fine platy breaking into moderate medium granular, noncalcareous, clear boundary.
ROXANA MEMBER		
LOVELAND MEMBER		
779-793	3Ab	10YR 4/3 silt loam, compressed moderate to strong medium to coarse granular, few silt coats on ped faces, noncalcareous, Mn stains abundant toward the top, gradual boundary.
793-825	3Bt1b	10YR 4/4 silty clay loam, strong fine subangular to angular blocky, moderately thick clay coats on ped faces, and faint silt coats on ped faces, noncalcareous, gradual boundary.
825-866	3Bt2b	7.5YR 4/6 ped interior with 7.5YR 4/4 thick continuous clay coats on ped faces, silty clay loam to silty clay, strong angular

		blocky, noncalcareous, gradual boundary.
866-925	3Bt3b	10YR 4/5 silt loam, strong coarse platy, parting to strong fine angular blocky, thin discontinuous clay coats, noncalcareous, diffuse boundary.
925-945	3BCb	10YR 5/4 silt loam, moderate coarse platy, noncalcareous, diffuse boundary.
945-1025	3C1b	10YR 5/4 at top to 2.5Y 6/4 at base, silt loam, mottled with many large 10YR 5/6 mottles, weak very coarse platy, noncalcareous, clear boundary.
1025-1080	3C2b	10YR 5/4 silt loam, massive, noncalcareous, thinly bedded with lighter and darker colors of silt loam, clear boundary.

LOVELAND MEMBER

WYALUSING MEMBER

1080-1245	4EBb	10YR 4/4 silt loam, moderate to strong fine platy structure with silt coats capping ped faces, noncalcareous, few nodules of Mn, ped structure becomes gradually stronger with depth, clear boundary.

WYALUSING MEMBER

DIAMICTON

1245-1355	4BWb	10YR 4/4 loam to sandy loam with pebbles scattered throughout, strong fine platy with silt coats on ped faces, becomes coarser with depth, abrupt core refusal at 1355 cm.

CORE GT6:

GT6 is located 30 meters south of Adams Lane and 4 meters east of the eastern edge of the driveway to Lester Hill's house on the center of the north line of the NW1/4, NW1/4, Sec. 3, T. 2N., R. 1E. on the Balltown 7.5-minute quadrangle in Grant County, Wisconsin (see Figs. 4 and 5).

DEPTH CM	HORIZON	DESCRIPTION
PEORIA MEMBER		
0-20	Ap	10YR 4/2 silt loam, moderate medium subangular blocky, noncalcareous, clear boundary.
20-40	Bt1	10YR 4/5 ped exterior and 10YR 4/6 ped interior silt loam, strong medium subangular blocky, moderately thick clay coats on ped faces, noncalcareous, gradual boundary.
40-85	Bt2	10YR 4/4 ped exterior and 10YR 4/5 ped interior silt loam, moderate coarse subangular blocky moderately thick clay coats on ped faces, noncalcareous, gradual boundary.
85-115	Bt3	banded 10YR 4/4 and 10YR 5/4 silt loam with silt coats on ped faces, thin discontinuous clay coats, noncalcareous, clear boundary.
115-159	BC	10YR 5/4 silt loam, weak very coarse subangular blocky to massive, noncalcareous, clear boundary.
159-330	C1	2.5Y 5/5 silt, mottled with common medium, 2.5Y 6/2 mottles, massive, calcareous, gradual boundary.
330-415	C2	2.5Y 5/4 silt, massive, calcareous, clear boundary.
415-435	C3	2.5Y 5/3 silt, massive, calcareous, clear boundary.
435-457	C4	thinly bedded 2.5Y 5/3 silt and 10YR 4/3 silt loam, common fine iron oxide coats in pores, few specks of charcoal in the darker beds, noncalcareous, a 1cm thick 7.5YR 4/6 iron crust is at the base, very abrupt boundary.
PEORIA MEMBER		
ROXANA MEMBER		
457-477	2BAb	10 YR 4/4 (with faint reddish hue) silt loam, compressed fine granular, faint silt coats on ped faces, few small specks of charcoal, noncalcareous, gradual boundary.

477-560	2EBb	10YR 4/4 silt loam, moderate fine platy becoming strong fine platy with depth, very distinct white silt coats on ped faces that are more well expressed with depth, few specs of charcoal, clear boundary
ROXANA MEMBER		
ROUNTREE FORMATION		
560-580	3Bt1b	10YR 4/4 ped interior with 10YR 3/3 clay coats on ped exterior, silty clay loam, white silt coats along vertical cracks, moderate medium platy, moderately thick clay coats on ped faces, few Mn stains on ped faces, pod of fecal pellets noted at 570 cm, noncalcareous, gradual boundary.
580-622	3Bt2b	10YR 3/3 silty clay loam, strong medium angular blocky, thick clay coats on ped faces, noncalcareous, few chert pebbles, gradual boundary.
622-652	3Bt3b	10YR 4/4 silty clay, moderate fine to medium angular blocky to subangular blocky, thick clay coats on ped faces, abundant black Mn mottles, noncalcareous, abrupt boundary.
652-710	3Bt4b	10YR 3/2 silty clay mixed with 10YR 6/6 crumbly dolomite, silty clay has moderate fine subangular blocky structure, silty clay is noncalcareous, very abrupt boundary.
710-711+	R	dolomite bedrock, very abrupt core refusal.

CORE GT7:

GT7 is located in the shallow roadside ditch on the center of the south line of the SE1/4, SE1/4, Sec. 25, T.8N., R.1W., on the Muscoda 7.5-minute quadrangle in Grant County. The hole was located 0.1 miles west of E.J Connery's mailbox, 3 meters south of a large cedar fence post on the north side of the road (see Figs. 6 and 7).

DEPTH CM	HORIZON	DESCRIPTION
PEORIA MEMBER		
0-16	Ap	10YR 4/2 silt loam, gravelly from road gravel, strong coarse granular, noncalcareous, abrupt boundary.
16-57	Bt1	10YR 4/4 heavy silt loam, strong medium subangular blocky, moderately thick clay coats on ped faces, few light grey silt coats on ped faces, noncalcareous, gradual boundary.
57-115	Bt2	10YR 5/4 silt loam matrix, moderate coarse to very coarse subangular to angular blocky, moderately thick 10YR 5/3 clay coats on ped faces, common fine 10YR 5/8 mottles, noncalcareous, clear boundary.
115-199	BC	2.5Y 6/4 to 10YR 5.5/4 silt loam, weak very coarse prismatic, common fine 10YR 5/8 mottles, few 10YR 4/4 clay coats on ped faces, noncalcareous, clear boundary.
199-224	C1	2.5Y 6/4 silt loam, massive, calcareous, few 10YR 5/8 mottles, few Mn mottles around root casts, gradual boundary.
224-263	C2	2.5Y 6/2 silt loam, massive, calcareous, clear boundary.
263-286	C3	2.5Y 6/2 with thin beds of 10YR 4/4 silt loam, massive, calcareous, abrupt boundary.
PEORIA MEMBER		
ROXANA MEMBER		
286-312	2BC1b	10YR 4/3 silt loam, massive, abundant specks of charcoal, noncalcareous, clear boundary.
312-351	2BC2b	10YR 5/3 silt loam, massive weak compressed granular structure, noncalcareous, structure becomes more well expressed toward the base, clear boundary.

351-387	2AEb	10YR 4/3 silt loam, moderate medium platy parting to moderate medium granular, common light silt coats on ped faces which become more apparent toward the base, noncalcareous, gradual boundary.

ROXANA MEMBER

LOVELAND MEMBER

387-399	3Ab	10YR 4/3 silty clay loam, strong fine subangular blocky, striking light grey silt coats on ped faces, pods of fecal pellets, clear boundary.
399-426	3Bt1b	10YR 5/4 silty clay loam matrix with thick 10YR 4/2 clay coats on ped faces, also 7.5YR 4/4 clay coats beneath the 10YR 4/2 clay coats, strong medium to coarse subangular blocky, noncalcareous, gradual to diffuse boundary.
426-455	3Bt2b	10YR 5/6 silty clay loam with thick 7.5YR 4/4 clay coats on ped faces, strong coarse subangular to angular blocky, noncalcareous, clear boundary.
455-502	3Bt3b	7.5YR 5/6 silty clay with moderately thick 7.5YR 4/6 clay coats on ped faces, noncalcareous, clear boundary.

LOVELAND MEMBER

ROUNTREE FORMATION

502-594	4Btb	7.5YR 5/6 clay, many Mn stains, becomes 10YR 6/8 toward the base, and is 5YR 4/6 in the top 20 cm, noncalcareous, very abrupt boundary.
594-595	R	dolomite bedrock.

WYALUSING MEMBER

Source of the name.--Wyalusing State Park is the source for the name. One can view the type section northward across the mouth of the Wisconsin River from scenic overlook on the north edge of Wyalusing State Park .

Type section.--The type section is core-hole site CR3 of Leigh (1991) (Figs. 2 and 3) located near the mouth of the Wisconsin River approximately 1 km northwest of Bridgeport, Wisconsin on the center of the north line of the NE 1/4, NW 1/4, Sec. 10, T. 6N, R. 6W, in the Bridgeport Township of Crawford County, Wisconsin. The core-hole is on the crest of the drainage divide 4 m south of the south edge of the blacktop road and in line with a windbreak of tall larch trees on the north side of the road (Fig. 2).

Description of unit.--The Wyalusing Member is lithologically similar to the Roxana Member, but is lower in its stratigraphic position. The Wyalusing Member underlies the Loveland Member and is typically composed of unbedded yellowish brown (10YR 5/4) to brown (10YR 4/3) silt to silt loam that has been slightly to moderately altered by pedogenesis. Weak to moderate platy to blocky pedogenic structure is typical. Known sections of the Wyalusing Member are not calcareous. Pedogenic features typically include nodules of iron and manganese compounds and weak to moderate platy or blocky structure. Evidence of clay illuviation in the form of argillans is not typical. Like other loess-derived units the Wyalusing Member typically contains 75 to 90 percent silt, less than 5 percent sand, and less than 25 percent clay. The mineralogy is mostly quartz and feldspar in the silt fraction, and clay mineral x-ray diffraction patterns suggest that there are abundant mixed-layered clay minerals present. The Wyalusing Member is lithologically similar to the Roxana, except that the Wyalusing lacks charred plant material and is in a lower stratigraphic position than the Roxana.

Nature of contacts.--The lower contact is generally gradational with the underlying material and may include a mixed zone between the two units. The base of the mixed zone should be considered as the base of the Wyalusing Member. The upper boundary of the Wyalusing Member is typically abrupt with overlying Loveland Member in terms of texture and color characteristics.

Differentiation from other units.--The Wyalusing Member is differentiated from other silty units by its stratigraphic position and color. It directly underlies the Loveland Member and has weak expression of pedogenesis. The Wyalusing Member is darker colored than the overlying Loveland Member and may include more iron and manganese nodules that the overlying Loveland Member. Unlike the Roxana, the Wyalusing silt has not been found to contain charred plant material.

Regional Extent and Thickness.--The Wyalusing Member is a subsurface unit with a very limited regional extent. It has been found in very stable landscape positions such as flat interfluves and cutoff valley meanders that have escaped erosion during the late Quaternary. Less than 10 percent of 60 coring sites of Leigh (1991) on upland interstream divides have encountered the Wyalusing Member.

Origin.--The Wyalusing Member was probably deposited as loess that was blown from floodplains of major rivers, including the Mississippi and Wisconsin River. Like all members of the Kieler Formation, the original loess has probably been reworked by hillslope and pedologic processes.

Age.--There are no finite ages for the Wyalusing Member but the stratigraphic position (beneath the Loveland Member) suggests that it is Illinoian or older. Jacobs (1990) found that loess-derived sediment beneath the Loveland Member had normal remanent magnetism, which suggests that the Wyalusing Member postdates the Brunhes-Matuyama magnetic polarity reversal at circa 790 ka. If the Wyalusing Member is pre-Illinoian, then it may correlate with the Wolf Creek Formation of Iowa, which has normal remanent magnetism.

Correlation.--The Wyalusing Member may correlate with other pre-Loveland deposits of the midcontinent, but insufficient chronologies are available to allow accurate correlations.

Description of type section.--See the description reference section CR3 included in a discussion of the Kieler Formation above.

LOVELAND MEMBER

Source of the name.--Loveland, Iowa is the source for the name. The Loveland Member was initially named by Shimek (1909) as the Loveland joint clay. The type locality was later listed by Kay and Graham (1943, p. 64) and included additional lithofacies other than loess. Mickelson (1949) proposed that the name "Loveland" be restricted to the loess. An excellent description of the history of the "Loveland" is provided by Bettis (1990, pp. 53-54).

Type Section.--The type locality was listed by Kay and Graham (1943, p. 64) as Sec. 3, Rockford Township, T. 77 N., R. 44 W., Pottawatamie County, Iowa. The type section was destroyed in 1957. Daniels and Handy (1959) described a replacement section located in a borrow pit in the center of Sec. 3, T. 77 N., R. 44 W. just northeast of Loveland, Iowa in Pottawatamie County.

Reference Sections.--The reference sections in Wisconsin for the Loveland Member are core-hole sites CR3 and GT7 of Leigh (1991) (Figs. 2, 3, 6, 7), which are described above as reference sections in the discussion of the Kieler Formation.

Description of unit.--The Loveland Member is similar to the Peoria Member in terms of its color and texture. In the unweathered state it is a yellowish brown (10YR 5/4) to light brownish grey (2.5Y 6/2) unbedded silt to silt loam. The Loveland Member typically has a well developed paleosol at its top and the associated pedological characteristics are generally noticeable throughout its thickness. The paleosol typically exhibits a brown (7.5YR 4/4) to yellowish brown (10YR 4/4) Bt-horizon matrix with brown (7.5YR 4/4) clay coats on ped faces. Strong angular blocky ped structures typify the top of the Btb horizon. No calcareous sections of the Loveland Member have been recognized in Wisconsin.

<u>Nature of Contacts.</u>--The lower contact of the Loveland Member is generally abrupt with the underlying material in terms of its color and texture. Like other loess units, the basal part of the Loveland Member may be somewhat mixed with the underlying material. The upper boundary of the Loveland Member may be gradational with the basal part of overlying units due to pedogenic effects, or it may be abrupt due to erosional truncation. The upper boundary is typically associated with the solum of a well developed paleosol (Sangamon Soil).

<u>Differentiation from other units.</u>--The Loveland Member is differentiated from other loess units based on its stratigraphic position, texture, and color. It directly underlies the Peoria Member or the Roxana Member and typically has a well developed paleosol with and argillic horizon developed in the upper part. The Loveland Member is generally lighter colored than the underlying Wyalusing Member and overlying Roxana Member. The Loveland contains coarser silt than the Roxana, but the Loveland typically has more clay than the bounding units because of illuvial clay enrichement (Figs. 3 and 7).

<u>Regional extent and thickness.</u>--The Loveland Member is a subsurface deposit in the modern landscape. Less than 20 percent of more than 60 core sites located on upland interstream divides include the Loveland Member. It is likely that the Loveland Member was much more extensive in the past, but that it has been eroded from most parts of the modern landscape. The Loveland Member is typically less than 3 m thick and it has been found to be from several centimeters up to 3 m thick. The thickest known sections of Loveland Member are located on the uplands close to major rivers including the Mississippi and Wisconsin River.

<u>Origin.</u>--The Loveland Member probably originated as loess that was deflated from river floodplains that were exposed during the Illinoian.

Age.--There are no finite dates from the Loveland Member in Wisconsin. Amino acid racimization studies of Loveland in Arkansas and correlative units in Illinois indicate an Illinoian age (Clark et. al., 1989), as do well established stratigraphic relationships (Johnson, 1986). Thermoluminescence ages for the Loveland and its correlatives along the Missouri and Mississippi River are contradictory. In the Mississippi Valley thermoluminescence ages for Loveland and its correlatives generally fall between 70 ka and 85 ka (Pye and Johnson, 1988: Forman and others, 1992) whereas at the Loveland type section in western Iowa thermoluminescence ages for the Loveland are between 170 ka and 120 ka (Forman and others, 1992).

Correlation.--The Loveland Member correlates with the Loveland Loess Formation of Iowa (Kay and Graham, 1943; Daniels and Handy, 1959) and the Loveland Silt Formation and Teneriffe Silt Formation of Illinois (Willman and Frye, 1970).

Description of Type Section.--See Daniels and Handy (1959).

Description of Reference Sections.--See the description of the reference sections CR3 and GT7 (Figs. 2, 3, 6, 7) in the above section that discusses the Kieler Formation.

ROXANA MEMBER

Source of the name.--Roxana, Illinois is the source for the name.

Type Section.--The type section is the Pleasant Grove School Section, a borrow pit in the bluff of the Mississippi River 4 miles southeast of Roxana, Illinois in the SW1/4, NE1/4, SE1/4, Sec. 20, T. 3 N., R. 8 W., Madison County, Illinois. The exact location of the original type section has been destroyed by borrowing activities, but the Roxana may still be exposed in other parts of the borrow pit.

Reference Sections.--The reference sections in Wisconsin for the Roxana Member include the type section of the Kieler Formation and core-hole sites CR3, GT6, and GT7 described above as reference sections in a discussion of the Kieler Formation (Figs 2-7).

Description of unit.--The Roxana Member is typically composed of brown (10YR 4/3) to dark yellowish brown (10YR 4/4) silt to silty clay loam that is noncalcareous and has weak to moderate pedogenic expression. A pink to red hue is noticeable in sections of Roxana Member that have not been, or have only slightly been, altered by pedogenesis. The Roxana Member is invariably buried by the Peoria Member, and it typically overlies a very well developed paleosol (Sangamon Soil), till, rock, or the Rountree Formation. Pedogenesis associated with the underlying stratigraphic unit generally extends upward across the lower boundary of the Roxana Member. Charred flecks of plant material (including *Picea* and *Larix* wood), typically smaller than 5 mm, are conspicuous fossils in the Roxana Member. Pedogenic features typically include platy structure, silt coats on ped faces, rootlets and pores, and nodules of iron and manganese. Evidence of clay illuviation, such as the presence of argillans, is not a typical characteristic of the Roxana Member.

Like the Peoria Member, the Roxana Member typically contains 75 to 90 percent silt, less than 5 percent sand, and less than 25 percent clay. However, the Roxana Member is invariably finer than in the overlying Peoria because the frequency distribution of the silt (2 to 63 lm) is finer than in the overlying Peoria Member at any individual site (Figs. 2-7). In addition, the Roxana Member typically has a coarsening-upward trend throughout its thickness. The Roxana Member becomes finer with increasing distance from major river valleys such as the Mississippi and Wisconsin River valleys. The mineralogy is made up primarily of quartz and feldspars, and heavy minerals account for less than 5 percent by weight. Clay minerals predominate in the less-than-2 um fraction and primarily include mixed layer clay minerals and lesser amounts of kaolinite. Illite, which exhibits a distinct 001 d-value of 1.0 nm, is not generally recognized, or it is indistinct. Therefore, the diffraction intensity ratio (DI ratio = 1.0 nm intensity divided by the 0.7 nm intensity) is generally less than 1. Carbonate minerals are generally absent from the Roxana. However, the Hegery-1 section of Leigh et al. (1989) included a small amount of calcite and dolomite in the Roxana Member, indicating that it probably had a calcareous parentage and was subsequently leached of carbonate minerals.

Nature of Contacts.--The lower contact is generally gradational with the underlying material and typically includes a mixed zone between the two units (Leigh et. al., 1989) where sedimentary structures have been obscured by pedogenesis. The mixed zone typically contains clasts of sediment that resemble sediment in the underlying stratigraphic unit. The mixed zone near the base of the Roxana Member generally does not show any distinct bedding like that of the basal mixed zone in the Peoria Member. Lack of bedding occurs because bedding features that may have formed were obscured by pedogenesis. The base of the mixed zone should be considered to be the base of the Roxana Member because that probably represents the initial accumulation of the lithic material that is included in the Roxana Member. The upper boundary of the Roxana Member is typically quite abrupt with the overlying Peoria Member and is easily distinguished because the basal Peoria Member is lighter colored than the Roxana and the Peoria Member is generally calcareous and bedded with thin beds of brown Roxana-like silty sediment. In rare instances the upper part of the Roxana Member contains an organically enriched A-horizon that is correlative with the Farmdale Soil of Follmer (1983).

Differentiation from other units--The Roxana Member is darker colored than the overlying Peoria Member and is typically not calcareous. It commonly has a characteristic "chocolate brown" color. The Roxana Member overlies a well developed paleosol that has an argillic horizon, or the Roxana is very unlike the material that underlies it. The modal diameter of silt particles, detected from Coulter Counter analyses, in the Roxana Member is characteristically finer than the overlying Peoria Member and the underlying Loveland Member. Charred plant fragments (including *Picea* and *Larix* wood) that are generally smaller than 5 mm are conspicuous fossils in the Roxana Member. The diffraction intensity ratio of clay minerals in the Roxana Member is characteristically less than 1, distinguishing it from the underlying Loveland Member and the overlying Peoria Member. The Roxana Member is not known to occur as a surface deposit and is invariably found beneath the Peoria Member. Although the Roxana Member often contains a basal mixed zone, thin bedding and stratification, are not characteristic of the Roxana like they are of the Peoria.

Regional Extent and Thickness--The Roxana Member is a subsurface formation. The Roxana Member probably covered most of the landscape throughout the Driftless Area and on top of any till surfaces that are older than 50 ka. However, its modern occurrence is quite restricted to stable landscape positions that have not favored erosion, such as wide and flat upland interstream divides, terrace remnants, and cutoff valley meanders. The Roxana may range from several centimeters to 2 m in thickness. The thickest known sections of the Roxana Member in Wisconsin are less than 1.5 m thick and are typically found within 2 km of the bluffs of the Mississippi and Wisconsin River valleys. Somewhat thicker sections (1.5-1.7 m) have been found in northwestern Illinois (Leigh, 1991). Like the Peoria Member, the Roxana Member generally becomes thinner with increasing distance from major rivers.

Origin.--The Roxana Member was probably deposited as loess that was blown from river floodplains that were exposed during the middle Wisconsinan (50 to 27 ka) (Leigh, 1991). Textural fining trends that are associated with distance from the major rivers support the idea of an eolian origin along with the fact that it is texturally and mineralogically different from the underlying units, eliminating the possibility that it is a deposit from hillslope processes. It is probable that the Roxana Member originated as loess that was blown from floodplains of meltwater streams that were linked to the terminus of middle Wisconsinan ice sheets. Following its deposition as loess, the Roxana was subject to reworking by hillslope and pedologic processes.

Age.--Numerous accelerator-mass-spectrometer (AMS) radiocarbon ages indicate that the age of the bulk of the Roxana Member is between 55,000 ^{14}C yr B.P. and 27,000 ^{14}C yr B.P. at sites near the Mississippi River valley bluffs (Leigh, 1991; Leigh and Knox, 1993).

Correlation.--The Roxana Member of Wisconsin correlates with the Roxana Silt Formation of Illinois (Willman and Frye, 1970), the Pisgah Formation of Iowa (Bettis, 1990; p. 55), and the Gilman Canyon Formation of Nebraska (Dreeszen, 1970). It is the "lower Wisconsin loess" of Ruhe (1976).

Description of Type Section.--The type section of the Roxana is described by Willman and Frye (1970, p.187) as the Roxana Silt of the Pleasant Grove School Section.

Description of reference sections--See the type section of the Kieler Formation and reference sections CR3, GT6, and GT7 (Figs. 2-7) of the Kieler Formation above.

PEORIA MEMBER

Source of the name.--Peoria, Illinois is the source for the name. The name was first used formally by Willman and Frye (1970) for the Peoria Loess Formation in Illinois.

Type Section.--The type section is the Tindall School Section of Willman and Frye (1970, pp. 65-66, 188-189) located south of Peoria, Illinois in the west bluff of the Illinois River, SW1/4, SW1/4, NE1/4, Sec. 31, T. 7N., R. 6E., Peoria County, Illinois.

Reference Sections.--The reference sections in Wisconsin for the Peoria Member include the type section of the Kieler Formation and core-hole sites GT6, GT7, and CR3 (Figs 1-7). Locations and descriptions of these sites are provided above in the discussion of the Kieler Formation.

Description of unit.--The Peoria Member, in the unweathered state, is typically composed of calcareous, unbedded, light brownish grey (2.5Y 6/2) to yellowish brown (10YR 5/4) silt to silt loam. The color varies depending on drainage conditions and pedogenic history of a site. The upper 2 to 3 m of the Peoria Member are typically oxidized and noncalcareous due to pedogenesis associated with the modern soil. The unweathered Peoria Member typically contains 75 to 90 percent silt, less than 5 percent sand, and less than 25 percent clay. Unusually abundant sand (up to 30 percent by weight) occurs at sites that are very near the probable source areas for the loess of the Peoria Member. Distinct facies assemblages are apparent in the Peoria Member. Massive silty facies are the most common, but on hillslopes and in certain depositional settings the silty sediment may be thinly bedded and include clasts from juxtaposed and subjacent stratigraphic units. The Peoria Member generally becomes finer and thinner with increasing distance from former loess source areas such as the Mississippi and Wisconsin River valleys. The Peoria Member is composed predominantly of quartz and feldspar, and heavy minerals generally account for less than 5 percent by weight. Clay minerals predominate in the less-than-2-micron size fraction and are mainly composed of smectite with lesser amounts of illite, chlorite, and kaolinite. The diffraction intensity ratio (DI ratio = 1.0 nm intensity divided by the 0.7 nm intensity) of clay minerals in the Peoria Member is generally greater than 1. Carbonate minerals (dolomite and calcite) typically make up 10 to 15 percent by weight of calcareous parts of the Peoria Member, and dolomite is generally the dominant carbonate mineral. Snail shells occur infrequently within the basal 50 cm of the Peoria member. Thin bedding and stratification of silty sediment is usually most apparent near the lower contact, where the interbedded sediment resembles material that is like the underlying stratigraphic unit.

Nature of Contacts.--The lower contact of the Peoria Member is usually quite abrupt with underlying Paleozoic rock, Rountree Formation, Roxana Member, fluvial sediments, till, or a well developed paleosol. The lower contact can easily be distinguished where the Peoria Member is calcareous because the underlying stratigraphic units are generally not calcareous. The basal meter of the Peoria Member (or thin units of Peoria Member) are generally mixed with the underlying material and evidence of mixing becomes less apparent with increasing height above the lower contact. Evidence of mixing typically consists of thin bedding and stratification or a poorly sorted matrix that includes clasts of the underlying stratigraphic unit. The base of the mixed zone marks the base of the Peoria Member.

Differentiation from other units--The Peoria Member is generally lighter colored than underlying stratigraphic units. The basal part of thick sections of the Peoria Member (more than 3 m thick) are typically calcareous, whereas underlying lithostratigraphic units are typically not calcareous. Clay minerals distinguish the Peoria Member from other loess-derived deposits because the diffraction intensity ratio is generally greater than 1 and smectite is more abundant in the Peoria Member than in most underlying stratigraphic units.

Regional Extent and Thickness--The Peoria Member is the surface deposit over most of the uplands in the Driftless Area of southwestern Wisconsin and on till surfaces throughout much of the state (see Hole, 1968). The Peoria Member ranges from several centimeters up to 10 meters in thickness. Thin units of the Peoria Member (less than 50 cm) are usually mixed with the underlying material. The thickest Peoria Member is found along the bluffs of the Mississippi River where it is commonly is 6 to 8 m thick. The Peoria Member generally becomes thinner with increasing distance from the Mississippi Valley and other river valleys and lake plains that may have been deflationary source areas for the loess of the Peoria Member (see map by Hole, 1968). In any given upland setting the Peoria Member is typically thickest on the widest and flattest interfluve divides and becomes thinner as interfluve divides become narrower and hillslopes become steeper.

Origin.--The Peoria Member originated as loess that was blown from river floodplains (and possibly lake plains) that were exposed during the last part of the Wisconsinan. Thinning patterns and textural fining trends that are associated with distance from the major river valleys provide strong evidence for an eolian origin along with the fact that the Peoria Member typically has a massive structure and is found on upland divides. It is most likely that the Peoria Member was blown from floodplains of proglacial streams that were linked to the terminus of late Wisconsinan ice sheets. Subsequent to eolian deposition as loess, the sediment of the Peoria Member was, in some cases, retransported primarily by hillslope processes.

Age.--Snail shells located 25 cm above the base of Peoria Member in the GT6 reference section yielded an accelerator mass spectrometer ^{14}C age of 24,250 +/-970 yr B.P. (GX-15888-AMS), and charred plant fragments located 10 to 15 cm below the boundary between the Peoria Member and Roxana Member yielded an accelerator mass spectrometry ^{14}C age of 29,290 +/- 380 yr B.P. (AA5801). In addition, other radiocarbon ages from near the top of the Roxana Member (Leigh, 1991) indicate a minimum age of about 27 ka for the Roxana. These ages bracket the base of the Peoria Member at bluffside locations at around 25 ka in Wisconsin and correlate well with the basal age of 25 ka for the Peoria Loess indicated by McKay (1979) and Hogan and Beatty (1963). Deposition of Peoria Member probably ceased at approximately 12 ka as suggested by local and regional stratigraphic relationships and radiocarbon ages (McKay, 1979).

Correlation.--The Peoria Member correlates with the Peoria Loess Formation of Illinois (Willman and Frye, 1970) and the Peoria Loess Formation of Iowa (Bettis, 1990). In addition, it correlates with the informal Peoria loess stratigraphic unit that is widely referenced in the midcontinent of the United States.

Description of Type Section.--The type section of the Peoria Member is described by Willman and Frye (1970, pp. 188-189) as the Peoria Loess Formation at the Tindall School Section.

Description of the Reference Sections in Wisconsin.--See the type section of the Kieler Formation and reference sections CR3, GT6, and GT7 (Figs. 1-7), which are discussed above as part of the Kieler Formation.

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FIGURE CAPTIONS

Figure 1. Location of the type section of the Kieler Formation (and Rountree Formation) in Grant County, southwestern Wisconsin. Area shown is 4.5 km wide; contour interval 10 feet. (U.S. Geological Survey, Platteville, Wisconsin quadrangle, 7.5-minute series, topographic, 1952.)

Figure 2. Location of core site CR3 of Leigh (1991), which is the type section of the Wyalusing Member of the Kieler Formation in Crawford County, southwestern Wisconsin. Area shown is _._ km wide; contour interval is 20 feet. (U.S. Geological Survey, Bridgeport, Wisconsin quadrangle, 7.5-minute series, topographic 19__.)

Figure 3. Physical and chemical characteristics of core site CR3. The radiocarbon age is 31,000 +/- 480 (AA-5796).

Figure 4. Location of core site GT6 of Leigh (1991), which is a reference section for members of the Kieler Formation in Grant County, southwestern Wisconsin. Area shown is _._ km wide; contour interval is 10 feet. (U.S. Geological Survey, Balltown, Wisconsin quadrangle, 7.5-minute series, topographic 19__.)

Figure 5. Physical and chemical characteristics of core site GT6. The radiocarbon ages shown are (1) 24,250 +/- 970 (GX-15888), (2) 29,290 +/- 380 (AA-5801), (3) 28,640 +/- 410 (AA-6371), and (4) 45,200 +/- 2650 (AA-5422).

Figure 6. Location of Core site GT7 of Leigh (1991), which is a reference section for members of the Kieler Formation in Grant County, southwestern Wisconsin. Area shown is _._ km wide; contour interval is 20 feet. (U.S. Geological Survey, Muscoda quadrangle, 7.5-minute series,

topographic 19__.)

Figure 7. Physical and chemical characteristics of core site GT7. Radiocarbon ages shown are (1) 26,950 +/- 300 (AA-5798), (2) 18,830 +/- 330 (GX-15891), and (3) >47,000 (AA-5799).

Fig 1

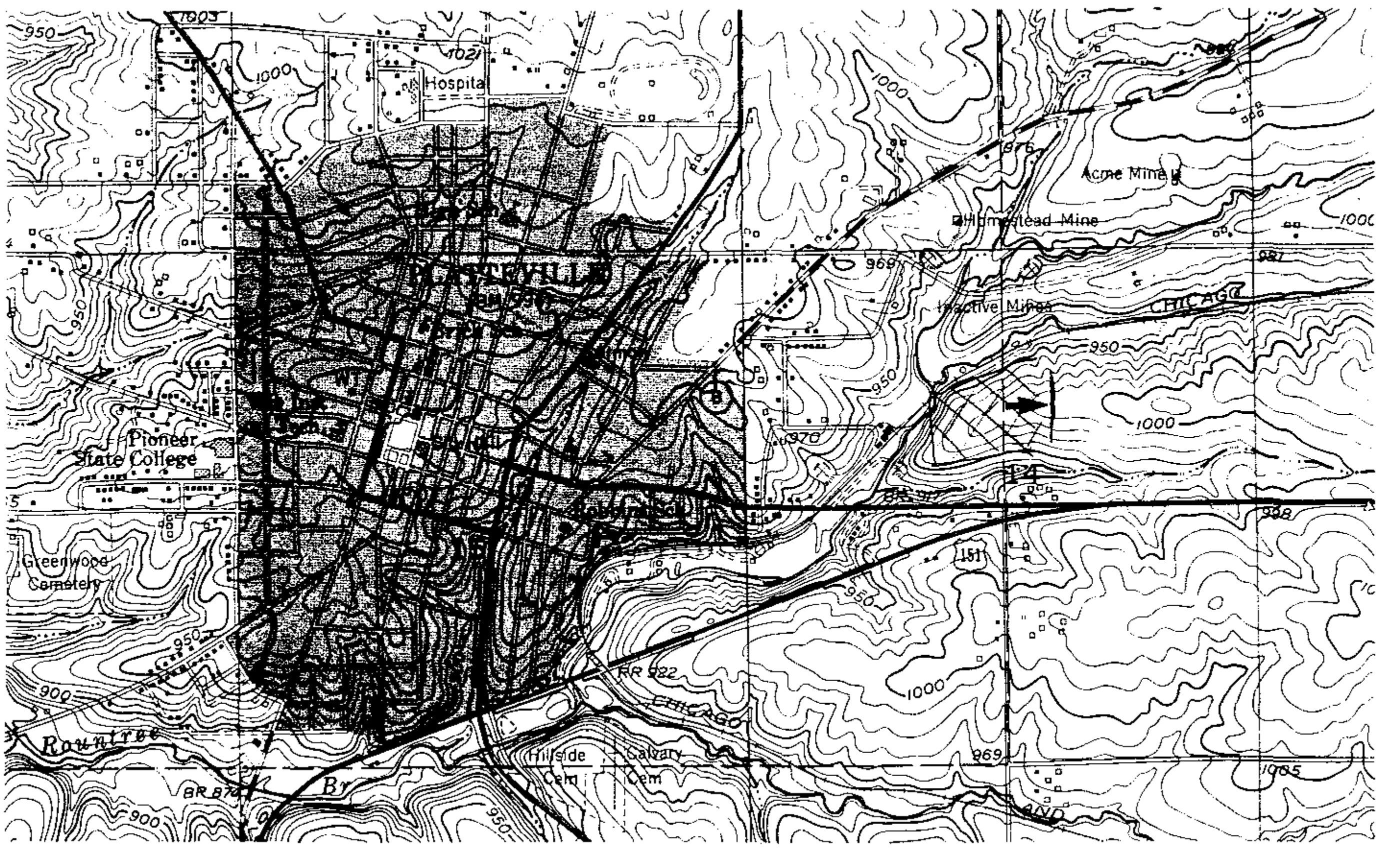


Figure A1. *Location of the type section of the Rountree Formation (arrow) in Grant County, southwestern Wisconsin. Area shown is 4.5 km wide; contour interval 10 feet. (U.S. Geological Survey, Platteville, Wisconsin, quadrangle, 7.5-minute series, topographic, 1952.)*

APPENDIX:

ROUNTREE FORMATION (NEW)

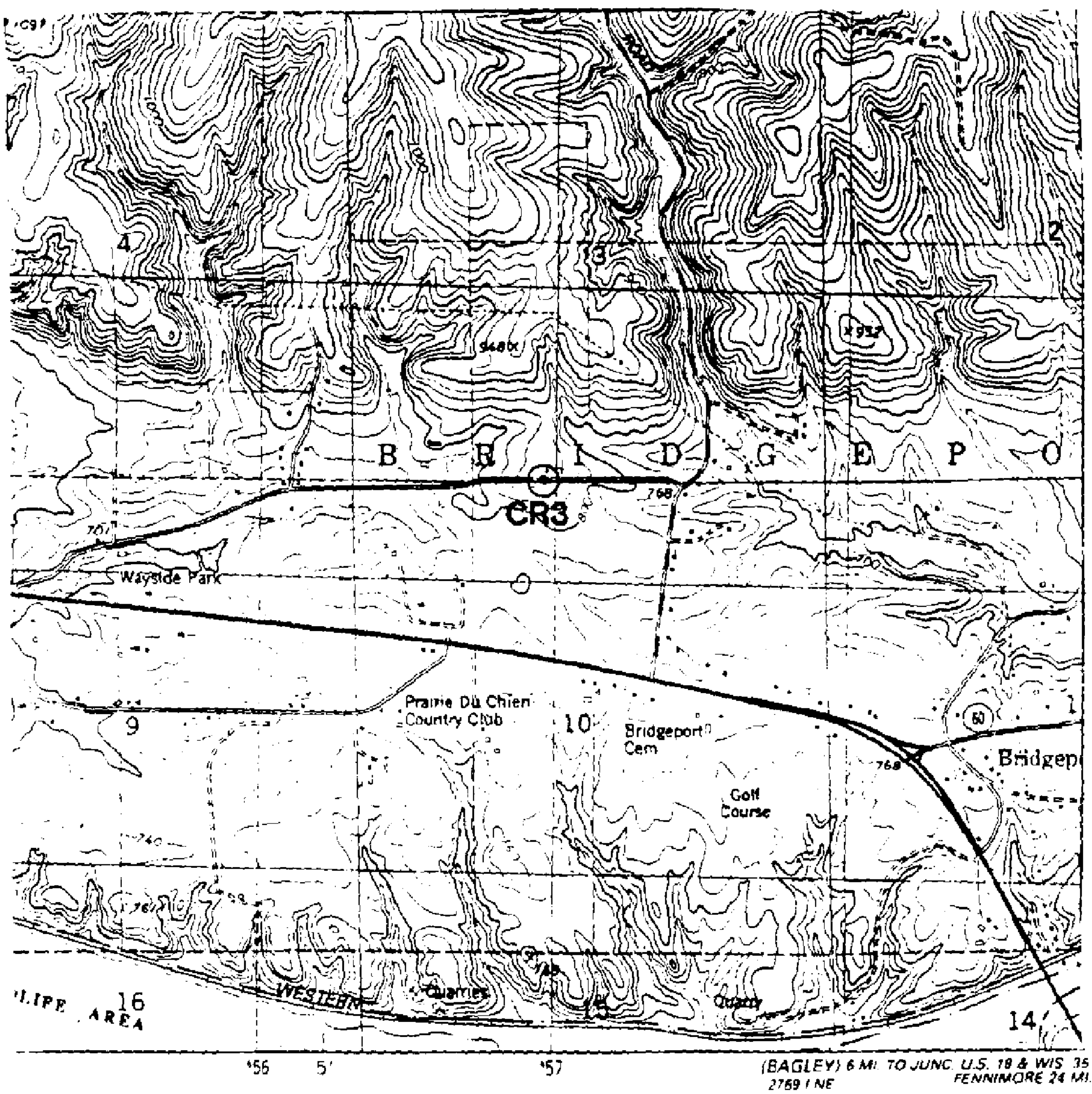
James C. Knox, David S. Leigh, and Tod A. Frolking

Source of name

section is a west-facing exposure at the east edge of the quarry and located at the crest of the interfluve. This site has been previously identified as the Rosemeyer Farm Quarry (Knox and Maher, 1974). At this site, loess of the Peoria and Roxana Formations overlies the red clay of the Rountree Formation, which in turn overlies cherty dolomite of the lower member of the Galena For-

CORE CR3:

Core CR3 is located approximately 1 kilometer northwest of Bridgeport, Wisconsin on the center of the north line of the NE 1/4, NW 1/4 Sec. 10, T. 6N, R. 6W, on the Bridgeport 7.5-minute quadrangle in Crawford County, Wisconsin. The core-hole is on the crest of the drainage divide 4 meters south of the south edge of the blacktop road and in line with a windbreak of larch trees on the north side of the road (see map below).



Core CR3 / Bridgeport Section

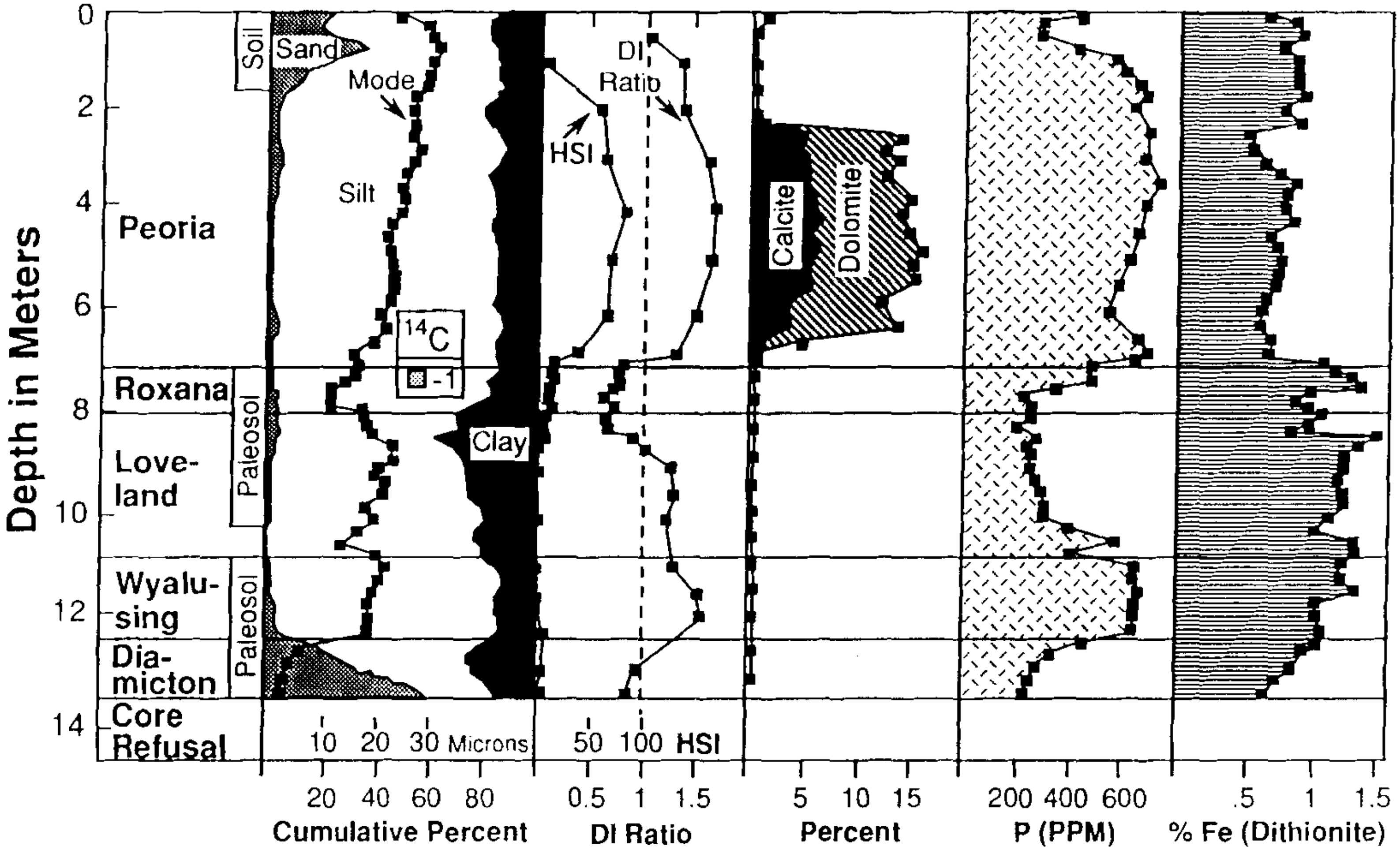


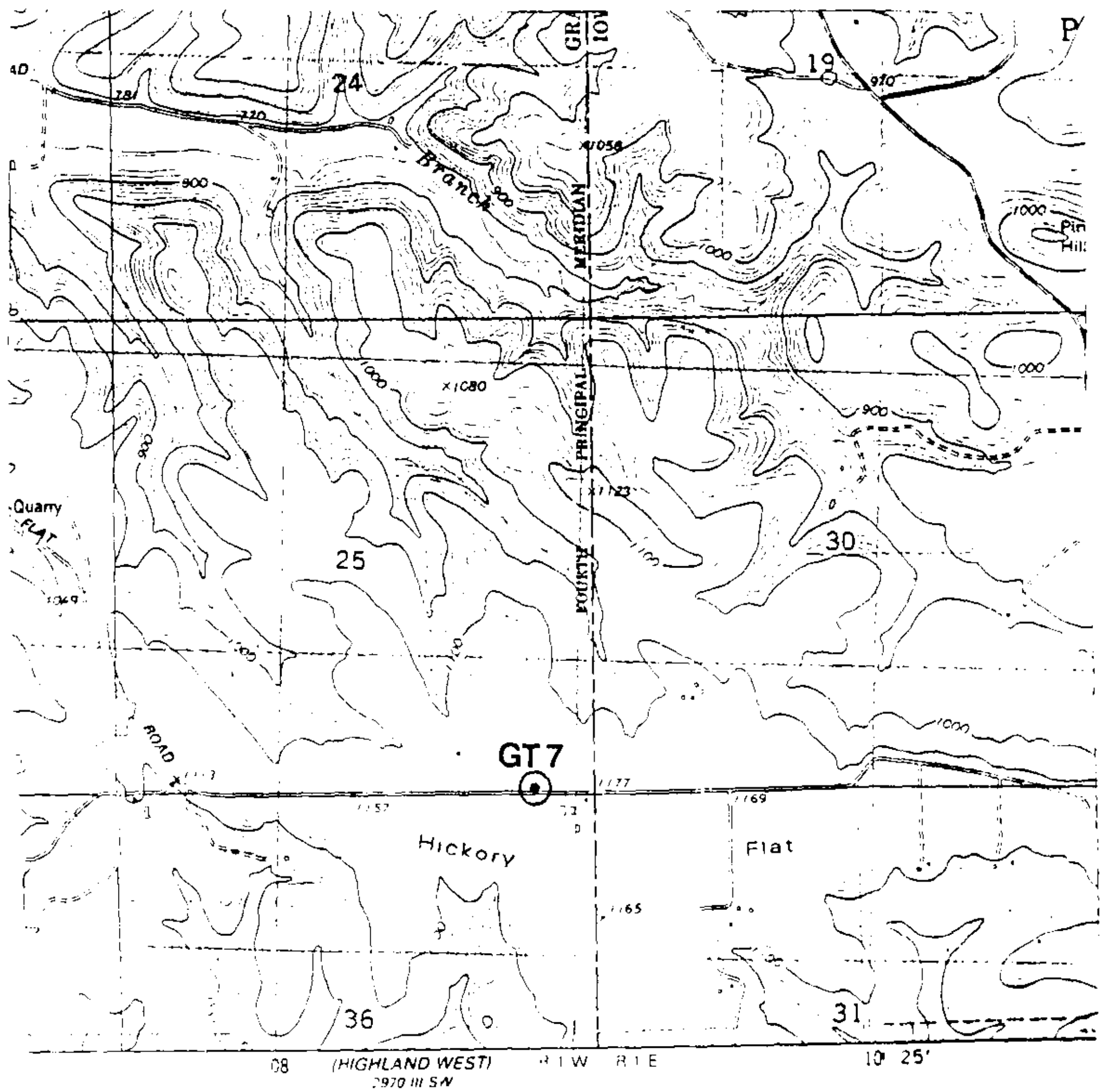
Fig 3

CORE GT6:

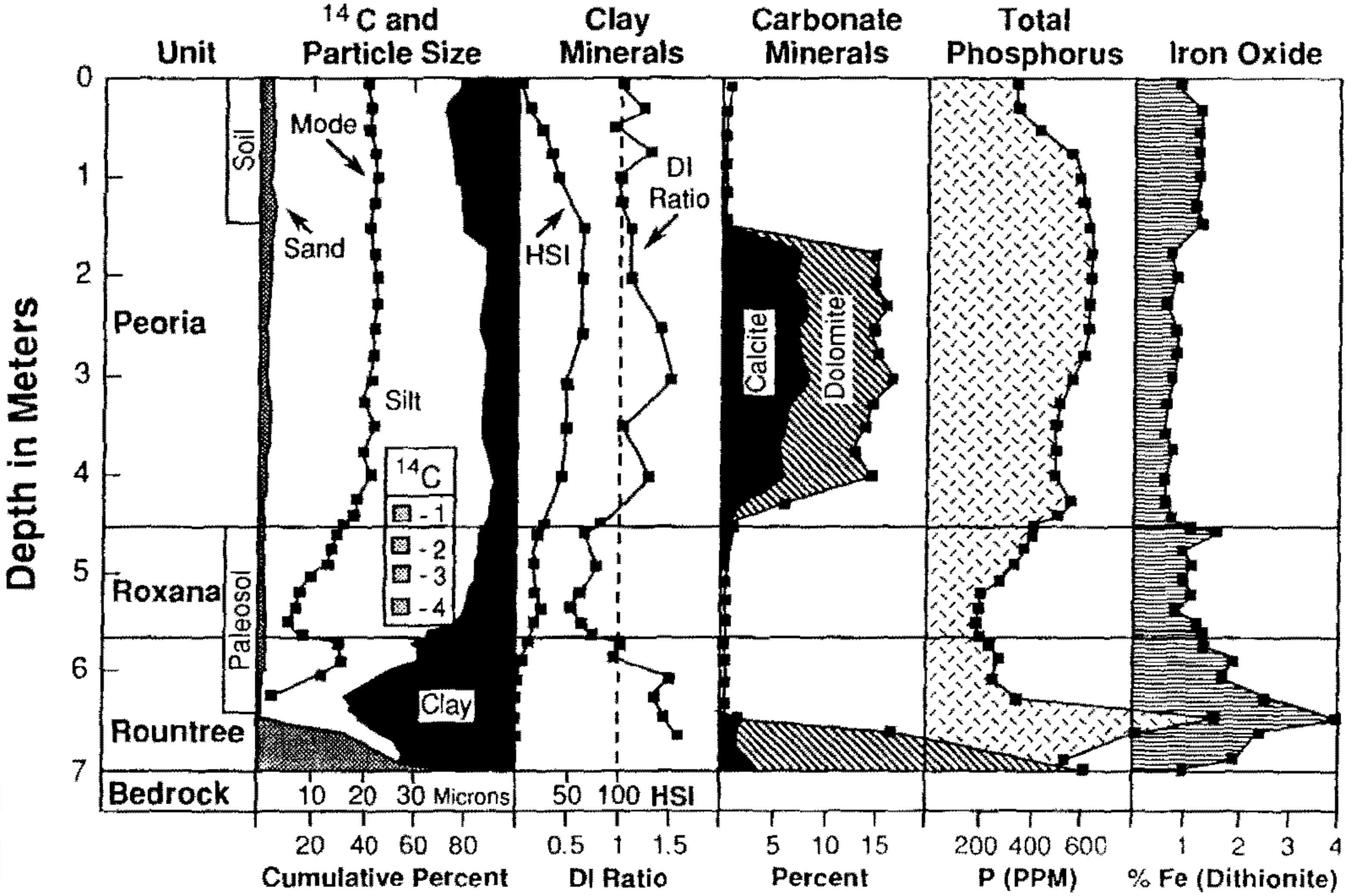
GT6 is located 30 meters south of Adams Lane and 4 meters east of the eastern edge of the driveway to Lester Hill's house on the center of the north line of the NW1/4, NW1/4, Sec. 3, T. 2N., R. 1E. on the Balltown 7.5-minute quadrangle in Grant County, Wisconsin (see map below).

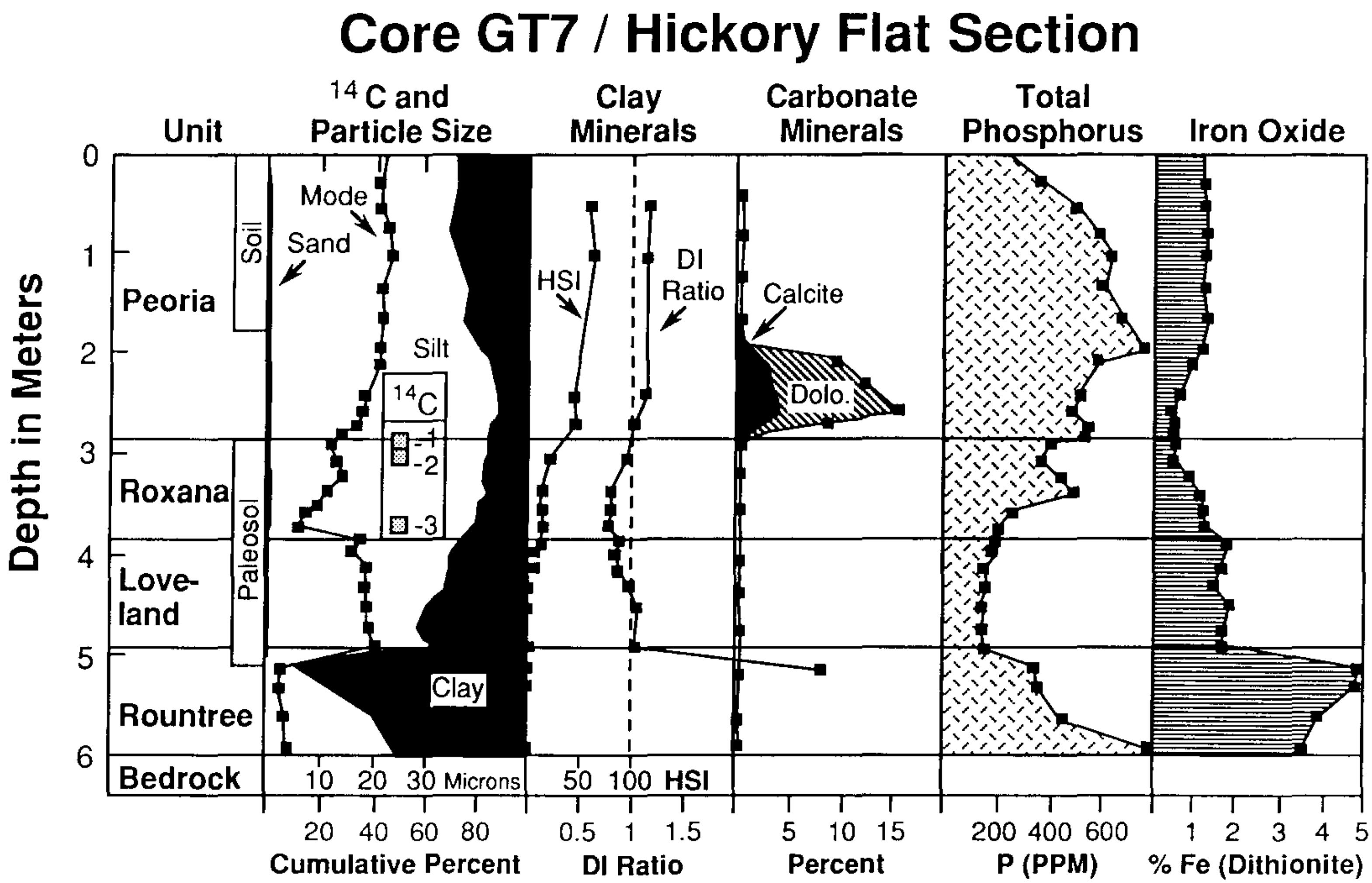
CORE GT7:

GT7 is located in the shallow roadside ditch on the center of the south line of the SE1/4, SE1/4, Sec. 25, T.8N., R.1W., on the Muscoda 7.5-minute quadrangle in Grant County. The hole was located 0.1 miles west of E.J Connery's mailbox, 3 meters south of a large cedar fence post on the north side of the road (see map below).



Core GT6 / Adams Lane Section





Core GT7 / Hickory Flat Section
Unit
14 C and Particle Size
Clay Minerals
Carbonate Minerals
Total Phosphorus
Iron Oxide
Depth in Meters
0
1
2
3
4
5
6
Peoria
Roxana
Love-land
Rountree
Bedrock
Soil
Paleosol
Mode
Sand
Silt
Clay
14C
-1
-2
-3
HSI
DI Ratio
Calcite
Dolo.
10 20 30 Microns
50 100 HSI
20 40 60 80
Cumulative Percent
0.5 1 1.5
DI Ratio
5 10 15
Percent
200 400 600
P (PPM)
1 2 3 4 5
% Fe (Dithionite)