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Contents

Organization of the Lexicon

In this book, formations and their members are arranged by age, from oldest to youngest. For a quick lookup by formation name, refer to the following:

Formations by name

Kieler Formation

James C. Knox, David S. Leigh, Peter M. Jacobs, Joseph A. Mason, and John W. Attig

Source of the name. The village of Kieler, Grant County, Wisconsin.

Location and description of type section. An interstream divide approximately 1.3 km (0.8 mile) south of Kieler. It is located in the SW¼ SE¼ sec. 9, T. 1 N., R. 2 W., Grant County, an area shown on the Kieler 7.5-minute quadrangle (fig. 126).

Three of the four members of the Kieler Formation—the Peoria, the Roxana, and the Loveland—are exposed at the type section (fig. 127). The Peoria Member extends from the surface to a depth of 4.1 m. It consists of yellowish-brown (10YR 5/4) silt loam in the upper oxidized zone to light brownish-gray (10YR 6/2) to pale brown (10YR 6/3) silt loam in the lower zone where chemical reduction has occurred. The less-than-2 mm fraction averages less than 1 percent sand, 78 percent silt, and 22 percent clay.

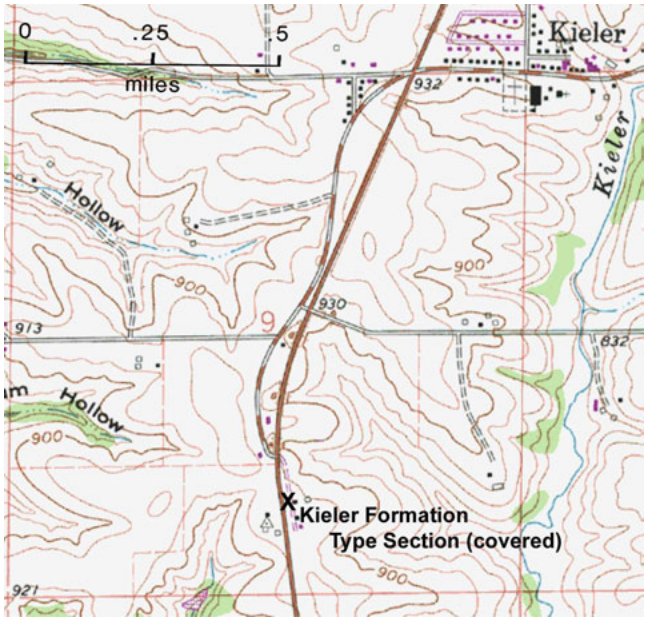

Figure 126. Part of the Kieler 7.5-minute quadrangle showing the location of the type section of the Kieler Formation. This locality also serves as a reference section for the Loveland, Roxana, and Peoria Members.

Calcite is leached to a depth of 2.0 m at the type section. Thin beds of brown silt loam (probably eroded from the underlying Roxana Member) are commonly interstratified in the basal section of the Peoria Member as shown in figure 127. The Peoria Member sharply overlies the Roxana Member.

The Roxana Member extends from a depth of 4.1 to 4.7 m and averages less than 1 percent sand, 76 percent silt, and 24 percent clay. The unit commonly contains charred plant fragments. The Roxana Member is a brown to dark brown (10YR 4/3) non-calcareous silt loam in which the Farmdale Geosol is formed (Follmer, 1983). The Roxana Member has been truncated by post-depositional erosion at the site, and the remaining unit is characterized by a massive to weak blocky structure representative of pedogenic B-horizon development. The basal Roxana Member grades into the underlying Sangamon Geosol developed in the Loveland Member of the Kieler Formation.

The Loveland Member extends from a depth of 4.7 to 6.1 m. The silty clay loam of the Loveland Member is non-calcareous throughout. The solum of the Sangamon Geosol extends across the entire thickness of the Loveland Member. The Sangamon Geosol A horizon is exceptionally well preserved except for minor color loss and overprinting with weak subangular blocky structure. This overprinting was caused by burial and pedogenesis during formation of the Farmdale Geosol in the overlying Roxana Member. Nonetheless, the paleo-A horizon in the Sangamon Geosol is dominated by granular structure and is relatively dark brown (10YR 4/3) in comparison with the underlying lighter brown (7.5YR 4/4 to 5/4) B horizon of the Sangamon Geosol. The Sangamon B horizon displays strong, medium, subangular blocky pedogenic structure. The Loveland Member averages less than 1 percent sand, 63 to 69 percent silt, and 31 to 37 percent clay. The

Loveland Member overlies the lighter colored and more strongly weathered Rountree Formation with a sharp contact.

Highly weathered silty clay at a depth of 6.1 to 6.6 m underlies the Kieler Formation at the type section. This unnamed silty clay traditionally has been recognized as an upper member of the Rountree Formation (Knox and Maher, 1974; Knox and others, 1990; Jacobs and others, 1997). Its placement within the Rountree Formation is controversial because it is typically composed of 40 to 50 percent silt, suggesting a strong contribution from loess sources. At the Kieler Formation type section, the unit averages 1 percent sand, 51 percent silt, and 48 percent clay. The high clay content of the unit probably is a result of several processes, including eolian accretion, particle-size reduction associated with intense weathering, and long-term mixing with underlying clayey residuum. Occasional inclusions of clastic fragments from underlying bedrock provide evidence that the unit is derived in part from, or mixed with, weathered sediment from the underlying bedrock. Although the unnamed silty clay is pedologically continuous with the residuum of the basal Rountree Formation, the typical browner color (7.5YR 4/3 versus 7.5YR 4/4 to 4/6) and characteristic pervasive clay coatings on the fine subangular blocky structure of the upper Rountree Formation unit differentiate it from the basal Rountree Formation unit. While evidence of a strong loess contribution to this unit supports the idea that it may better fit as a lower member of the Kieler Formation, the high percentage of clay is the principal basis for placement of this sediment within the upper

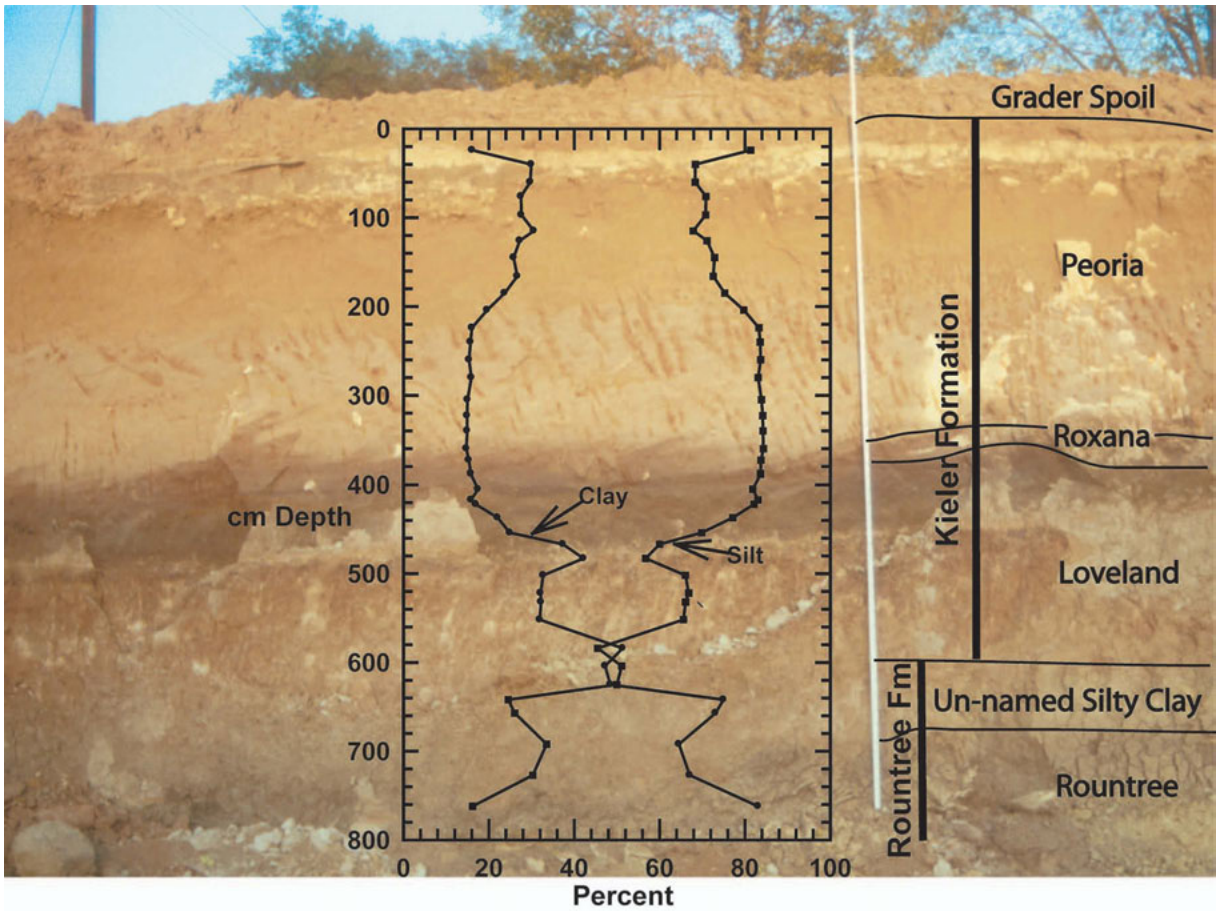

Figure 127. Kieler Formation type section near Kieler, Wisconsin. The Kieler Formation consists largely of loess and reworked loess at upland sites, but on steep hillslopes and basal hillslopes where colluvial activity has been very important, its composition can include a wide range of clast sizes and its thickness can vary from a few tens of centimeters to several meters (fig. 128). Photo: J.C. Knox.

Rountree Formation. Evidence of loess deposition before the Illinoian Glaciation has been documented elsewhere in the region, but post-deposition erosion and weathering have destroyed evidence of early Quaternary loess deposition at most sites (Jacobs and Knox, 1994).

Description of unit (summarized from Leigh, 1991). The Kieler Formation consists largely of loess, reworked loess, and colluvium found on uplands, terraces, and valley margins. Its presence is most extensive in the Driftless Area of southwestern Wisconsin where four named members are recognized, in addition to a few locally restricted and unnamed units deposited before the Illinoian Glaciation (see Knox and others in the introduction to this publication, for historical background and geologic framework). The named members from oldest to youngest are: Wyalusing, Loveland, Roxana, and Peoria Members. The Wyalusing and Loveland Members are thought to have been deposited during the Illinoian Glaciation, while radiocarbon ages quantitatively show that the Roxana and Peoria Members were deposited during the middle to the last part of the Wisconsin Glaciation (Leigh and Knox, 1994). Sediment of the Peoria Member makes up the majority of the Kieler Formation.

The Kieler Formation consists primarily of massive silt and silt loam. Color differs as influenced by 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 grayer in color. The unweathered part of the Kieler Formation is commonly calcareous and contains up to 15 percent carbonate minerals; 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 sediment. 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 are present in the Kieler Formation, but they are not ubiquitous features.

The Kieler Formation ranges in thickness from several centimeters to 20 meters. The coarsest textures and thickest deposits are generally found 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; at sites more than 20 km (12.5 miles) from large river valleys, the unweathered Kieler Formation is more clayey (up to 25 percent clay). On hillslopes it typically includes clasts of the local bedrock set in a massive silty matrix (fig. 128). Paleosols typically bound separate members of the Kieler Formation, which are

Figure 128. Example of basal hillslope colluvial phase of the Kieler Formation located in the SW¼NW¼ sec. 18, T. 2 N., R. 1 W., an area on the Dickeyville 7.5-minute quadrangle. Here, angular carbonate cobbles and boulders are embedded in silt, all mass wasted from upper hillslope positions. The colluvial phase commonly is dominated by silt of the Peoria Member, but its thickness varies from very shallow on steep slopes to very thick on gentle slopes or at basal hillslope positions. Photo: J.C. Knox.

distinguished on the basis of stratigraphic position, color, texture, structure, and chemical characteristics (see specific member descriptions for details). Isolated remnants of loess-derived sediment pre-date the Illinoian Glaciation. Such remnants suggest that the earliest Kieler Formation sediment was initially more extensive on the landscape, but weathering and erosion removed most of this sediment. Further description of Kieler Formation units is presented in Jacobs and others (1997).

Nature of contacts. The Kieler Formation is generally at the surface. It sharply overlies the Rountree Formation, bedrock, and other Pleistocene sediment.

Differentiation from other units. The Kieler Formation is differentiated from other units by its massive structure and abundant silt. It does not typically contain isolated beds of gravel, sand, or clay, and the macro-stratification of the Kieler Formation does not include fining-upward sequences or beds of gravel, sand, and silt, or any sedimentary structures that are typical of fluvial deposits. Massive sandy deposits containing 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 uplands in the Driftless Area of southwestern Wisconsin, and it is fairly extensive elsewhere on till surfaces that predate the last part of the Wisconsin Glaciation (MIS 2) (Hole, 1950). It is thickest (up to 20 m) and most noticeable within 25 km (15.5 miles) of large rivers of southwestern Wisconsin. However, it occurs as a thin deposit throughout much of the state. The Peoria Member makes up the vast majority of the Kieler Formation. The occurrence of the Kieler Formation in the landscape is most prevalent on upland interstream divides and hillslopes. The Kieler Formation also occurs in some valley bottoms, on Pleistocene terraces, and within late Pleistocene hillslope and alluvial fan deposits along valley margins. The Kieler Formation also is present in cut-off bedrock valley meanders in southwestern Wisconsin.

Origin. The massive silt that dominates the Kieler Formation originated as loess blown from river floodplains and lake plains. The massive silt also was derived from sparsely vegetated periglacial landscapes and the floodplains of the sediment-laden streams that drained those landscapes.

Age and correlation. It is likely that most of the Kieler Formation is younger than the Brunhes-Matuyama magnetostratigraphic boundary formed about 790,000 cal. yr B.P. because older loess units deposited before the Illinoian Glaciation have normal remanent magnetism, as observed on upland interfluves in the central Driftless Area (Jacobs, 1990). An AMS radiocarbon age of 24,250 ± 970 ^{14}C yr B.P. (29,076 ± 1041 cal. yr B.P.) on snail shells was obtained for a stratigraphic horizon 25 cm above the base of the Peoria Member at a site 30 km (18.6 miles) north of the Kieler Formation type section (Leigh and Knox, 1993). The Peoria Member is the thickest member of the Kieler Formation, so most of the Kieler Formation was deposited between 25,000 to 12,000 ^{14}C yr B.P. (approximately 30,000 to 14,000 cal. yr B.P.) (Knox, 1989; Forman and others, 1992).

The Kieler Formation correlates lithostratigraphically and chronostratigraphically with all Pleistocene loess-derived formations of the Illinois State Geological Survey (the Loveland Silt, Roxana Silt, and Peoria Loess Formations of Willman and Frye, 1970) and with other Pleistocene loess deposits in the Midwest (Ruhe, 1976; Forman and Pierson, 2002; Bettis and others, 2003; Busacca and others, 2004). In states other than Illinois, loess lithostratigraphic units also are classified as individual formations. In Wisconsin, the Kieler Formation was created and the Peoria, Roxana, and Loveland units were reduced in rank to members because pre-Peoria members are insufficiently extensive to be mappable units in Wisconsin.

Previous usage: First used informally by Leigh (1991). Formalized in this publication.

Kieler Formation: Wyalusing Member

David S. Leigh and James C. Knox

Source of the name. Wyalusing State Park, Grant County, Wisconsin. The type section is visible northward across the mouth of the Wisconsin River from the scenic overlook on the north edge of Wyalusing State Park.

Location and description of type section. A core site (CR-3 of Leigh and Knox, 1994) on the crest of the drainage divide on a terrace of the lower Wisconsin River, approximately 1 km (0.6 mile) northwest of Bridgeport, Wisconsin. The core site is 4 m south of the south edge of Ward Road and in line with a windbreak of tall larch trees on the north side of the road. It is located on the center of the north line of the NE¼NW¼ sec. 10, T. 6 N., R. 6 W., Crawford County, an area shown on the Bridgeport 7.5-minute quadrangle (fig. 129). This type section also serves as the reference section for the Loveland, Roxana, and Peoria Members of the Kieler Formation. Sediment properties at the site are summarized in figure 130.

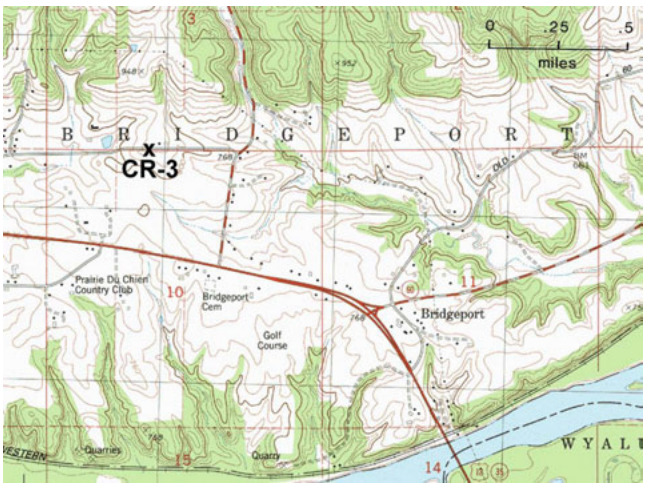

Figure 129. Part of the Bridgeport 7.5-minute quadrangle showing the location of the type section (core site CR-3) for the Wyalusing Member. This locality also serves as a reference section for the Loveland, Roxana, and Peoria Members.

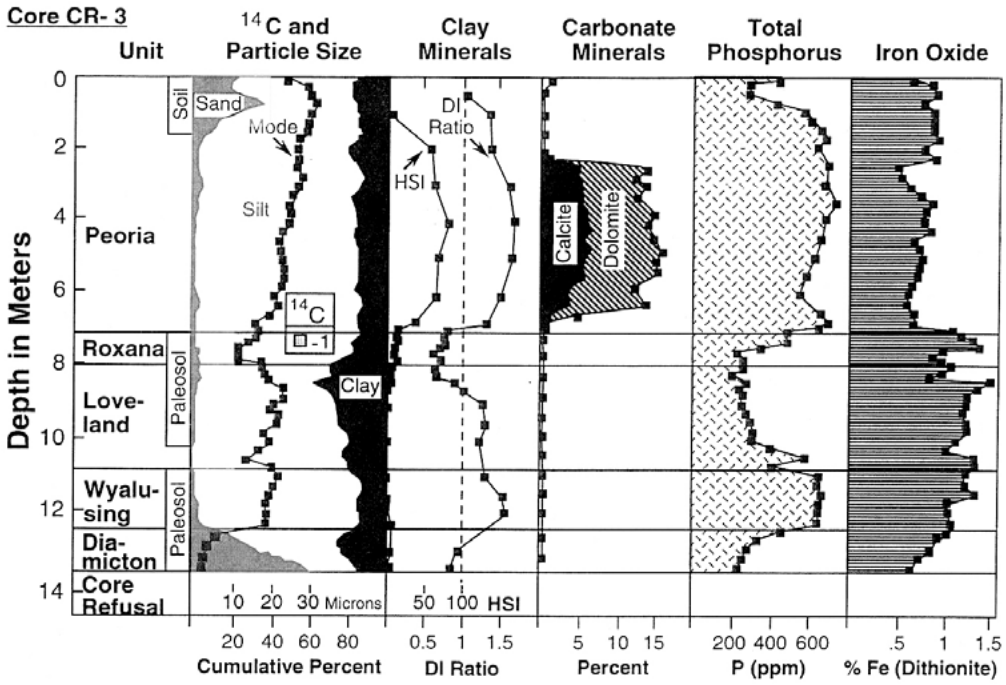

Figure 130. Sediment properties at the reference section for the Wyalusing, Loveland, Roxana, and Peoria Members of the Kieler Formation (core site CR-3). From Leigh (1994).

Kieler Formation: Wyalusing Member

Description of unit. 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 less than 5 percent sand, 75 to 90 percent silt, 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 Member, except that the Wyalusing Member lacks charred plant material and is in a lower stratigraphic position.

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 the base of the Wyalusing Member. The upper boundary with the Loveland Member is typically sharp because of texture and color differences.

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 and may include more iron and manganese nodules than the overlying Loveland Member.

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 escaped erosion during the late Quaternary. Fewer than 10 percent of 60 upland coring sites of Leigh and Knox (1994) encountered the Wyalusing Member.

Origin. The Wyalusing Member probably was deposited as loess blown from floodplains of major rivers, including the Mississippi and Wisconsin Rivers. Like all members of the Kieler Formation, the original loess probably has 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 was deposited before or during the Illinoian Glaciation. The Wyalusing Member has normal remanent magnetism, which suggests that it postdates the Brunhes-Matuyama magnetic polarity reversal at about 790,000 cal. yr B.P. (Jacobs, 1990).

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

Previous usage: The name was first used by Leigh (1991) and Leigh and Knox (1994). Formalized in this publication.

Kieler Formation: Loveland Member

David S. Leigh and James C. Knox

Source of the name. Loveland, Iowa.

Location and description of type section. The type locality listed by Kay and Graham (1943, p. 64) was in sec. 3, T. 77 N., R. 44 W., Rockford Township, Pottawattamie County, Iowa. This type section was destroyed in 1957, and a replacement section was established in a borrow pit a short distance northeast of Loveland, Iowa (Daniels and Handy, 1959). It is in the center of sec. 3, T. 77 N., R. 44 W., Pottawatamie County, an area shown on the Missouri Valley (Iowa/Nebraska) and Loveland (Iowa/Nebraska) 7.5-minute quadrangles (fig. 131). The type section is mainly on the Missouri Valley 7.5-minute quadrangle. See Daniels and Handy (1959) for detailed description of the type section.

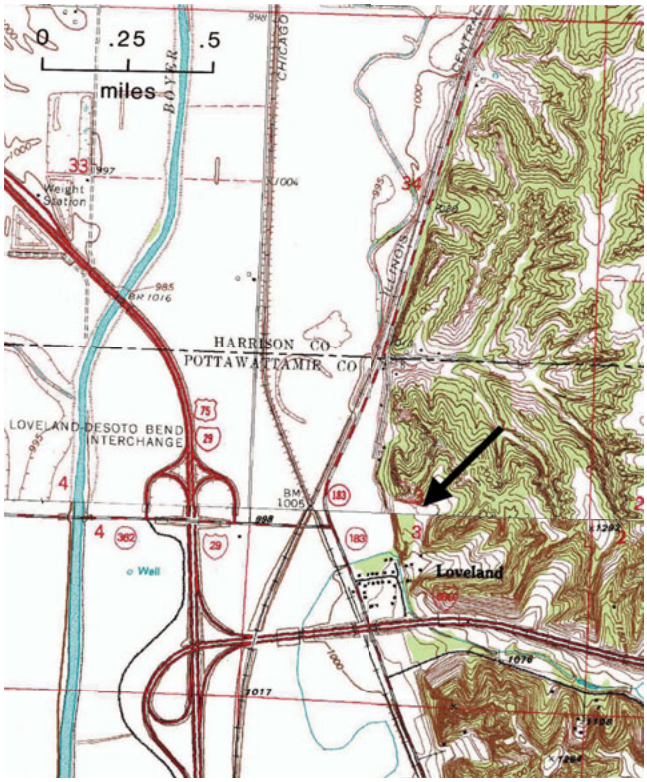

Figure 131. Parts of the Missouri Valley and Loveland 7.5-minute quadrangles (Iowa/Nebraska) showing the location of the type section of the Loveland Member.

Location and description of reference sections. Three reference sections for the Loveland Member are located in Wisconsin. (1) The type section of the Kieler Formation also serves as a reference section for the Loveland Member. It is located in the SW¼ SE¼ sec. 9, T. 1 N., R. 2 W., Grant County, an area shown on the Kieler 7.5-minute quadrangle (figs. 126, 127). See full outcrop description in the Kieler Formation description. (2) The type section of the Wyalusing Member also serves as a reference section for the Loveland Member. Core site CR-3 is located on the center of the north line of the NE¼NW¼ sec. 10, T. 6 N., R. 6 W., Crawford County, an area shown on the Bridgeport 7.5-minute quadrangle (figs. 129, 130). (3) Core site GT-7 is located in a shallow roadside ditch along the south line of the SE¼SE¼ sec. 25, T. 8 N., R. 1 W., Grant County, an area shown on the Muscoda 7.5-minute quadrangle (fig. 132).

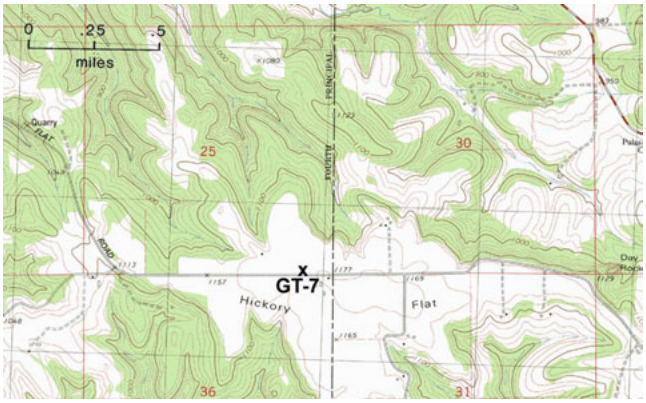

Figure 132. Part of the Muscoda 7.5-minute quadrangle showing the location of reference section 3 (core site GT-7) of the Loveland Member. This locality also serves as a reference section for the Roxana and Peoria Members.

Sediments in reference sections 2 and 3 are summarized in figures 130 and 133, respectively, and core samples of these reference sections are available at the University of Wisconsin–Madison Department of Geography. The reference sections illustrate variability within the Loveland Member and illustrate how it differs from similarly named lithostratigraphic units in Illinois and elsewhere.

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-gray (2.5Y 6/2) unbedded silt to silt loam. The unit averages 2 percent sand, 62 percent silt, and 36 percent clay at the Kieler type section. 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 coatings 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.

Nature of contacts. The lower contact of the Loveland Member is generally sharp 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 sharp because of erosional truncation. The upper boundary is typically associated with the solum of the Sangamon Geosol.

Differentiation from other units. The Loveland Member is differentiated from other loess units by its stratigraphic position, texture, and color. It directly underlies the Peoria

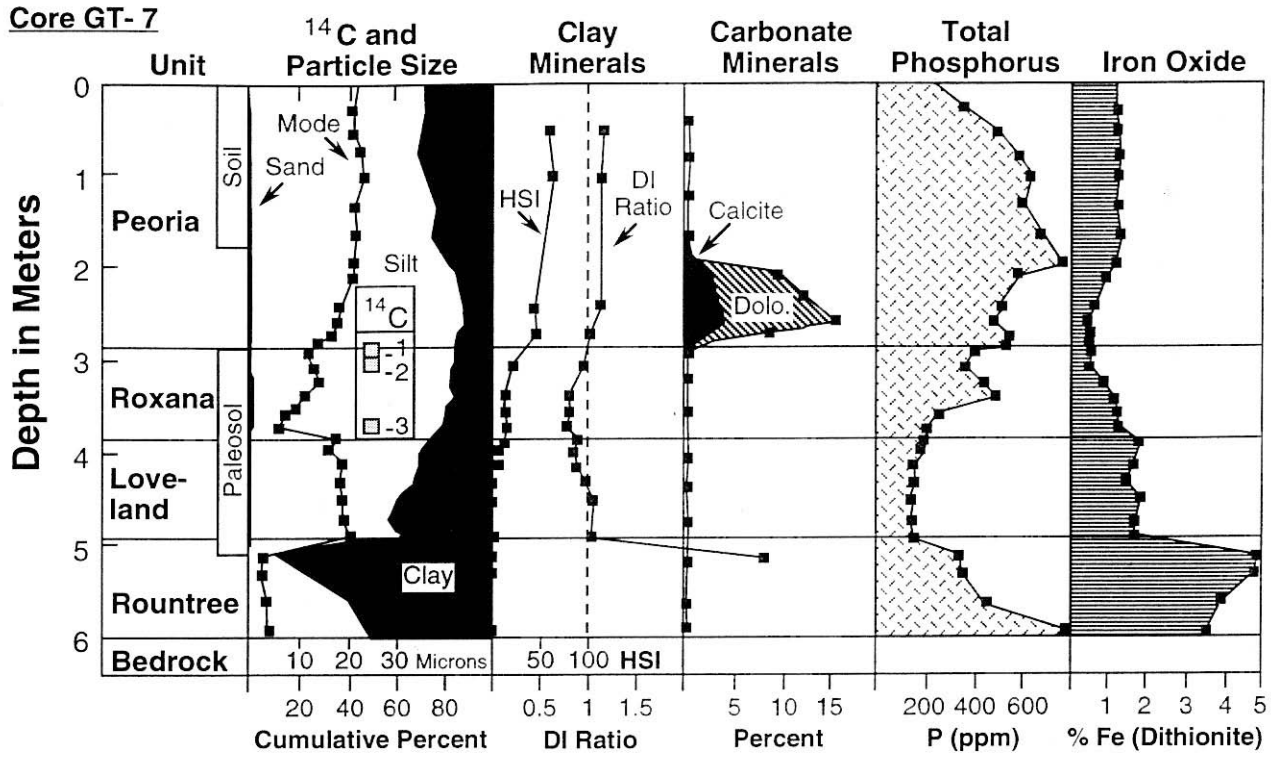

Figure 133. Sediment properties at the reference section for the Loveland, Roxana, and Peoria Members (core site GT-7). From Leigh (1994).

Member or the Roxana Member, and typically the upper part of the Loveland Member has a well-developed paleosol with an argillic horizon. The Loveland Member is generally lighter colored than the underlying Wyalusing Member and overlying Roxana Member. The Loveland Member contains coarser silt than the Roxana Member, but the Loveland Member typically has more clay than the bounding units because of illuvial clay development.

Regional extent and thickness. The Loveland Member is a subsurface deposit in the modern landscape. Fewer than 10 percent of the core sites (more than 60 sites) located on upland interstream divides in southwestern Wisconsin have encountered the Loveland Member. The Loveland Member probably was much more extensive in the past, but it has been eroded from most parts of the modern landscape. The Loveland Member ranges in thickness from several centimeters to 3 m. The thickest known sections of Loveland Member are located on the uplands close to major rivers including the Mississippi and Wisconsin Rivers.

Origin. The Loveland Member probably originated as loess that was deflated from river floodplains and sparsely vegetated uplands that were exposed during the Illinoian Glaciation (MIS 6–8) (Mason and others, 2007).

Age and correlation. There are no finite dates from the Loveland Member in Wisconsin. Amino acid racemization age studies of Loveland loess in Arkansas and correlative units in Illinois indicate deposition during the Illinoian Glaciation (Clark and others, 1989), as do well-established stratigraphic relationships (Johnson, W.H., 1986). Thermoluminescence ages for the Loveland Member and its correlatives along the Missouri and Mississippi Rivers are contradictory. In the Mississippi Valley, thermoluminescence ages for the Loveland Member and its correlatives generally fall between 70,000 and 100,000 cal. yr B.P. (Forman and others, 1992; Forman and Pierson, 2002; Markewich and others, 1998; Pye and Johnson, 1988), whereas at the type section in western Iowa, thermoluminescence ages for the Loveland Member average 135,000 ± 20,000 cal. yr B.P., but age estimates range from 130,000 to 180,000 cal. yr B.P. (Forman and others, 1992; Forman and Pierson, 2002).

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).

Previous usage: An excellent description of the history of the Loveland Formation is provided by Bettis (1990, p. 53–54). The Loveland Member was initially named as the Loveland joint clay (Shimek, 1909). The type locality was later listed by Kay and Graham (1943, p. 64) and the unit included additional lithofacies other than loess. Mickelson (1949, 1950) proposed that the name "Loveland" be restricted to the loess. The name was subsequently used by Leigh (1991) and Leigh and Knox (1994) in Wisconsin. It is formalized as the Loveland Member of the Kieler Formation in this publication.

Kieler Formation: Roxana Member

David S. Leigh and James C. Knox

Source of the name. Roxana, Illinois.

Location and description of type section. A borrow pit in the bluff of the Mississippi River 6.4 km (4 miles) southeast of Roxana, Illinois. The exact location of the original type section has been destroyed by excavation activities, but the Roxana Member may still be exposed in other parts of the borrow pit. It is located in the SW¼NE¼SE¼ sec. 20, T. 3 N., R. 8 W., Madison County, Illinois, an area shown on the Wood River 7.5-minute quadrangle (fig. 134). The type section of the Roxana Member is described by Willman and Frye (1970, p. 187) as the Roxana Silt of the Pleasant Grove School section.

Location and description of reference sections. Four reference sections for the Roxana Member are located in Wisconsin. (1) The type section of the Kieler Formation also serves as a reference section for the Roxana Member. It is located in the SW¼ SE¼ sec. 9, T. 1 N., R. 2 W., Grant County, an area shown on the Kieler 7.5-minute quadrangle (figs. 126, 127). See full outcrop description in the Kieler Formation description. (2) The type section of the Wyalusing Member also serves as a reference section for the Roxana Member. Core site CR-3 is located on the center of the north line of the NE¼NW¼ sec. 10, T. 6 N., R. 6 W., Crawford County, an area shown on the Bridgeport 7.5-minute quadrangle (figs. 129, 130). (3) Reference section 3 of the Loveland Member also serves as a reference section for the Roxana Member. Core site GT-7 is located in a shallow roadside ditch along the south line of the SE¼SE¼ sec. 25, T. 8 N., R. 1 W., Grant County, an area shown on the Muscoda 7.5-minute quadrangle (figs. 132, 133). (4) Core site GT-6, 30 m south of Adams Lane and 4 m east of the eastern edge of a house driveway, along the north line of the NW¼NW¼ sec. 3, T. 2 N., R. 4 W., Grant County, an area shown on the Balltown (Iowa/Wisconsin) 7.5-minute quadrangle (figs. 135, 136).

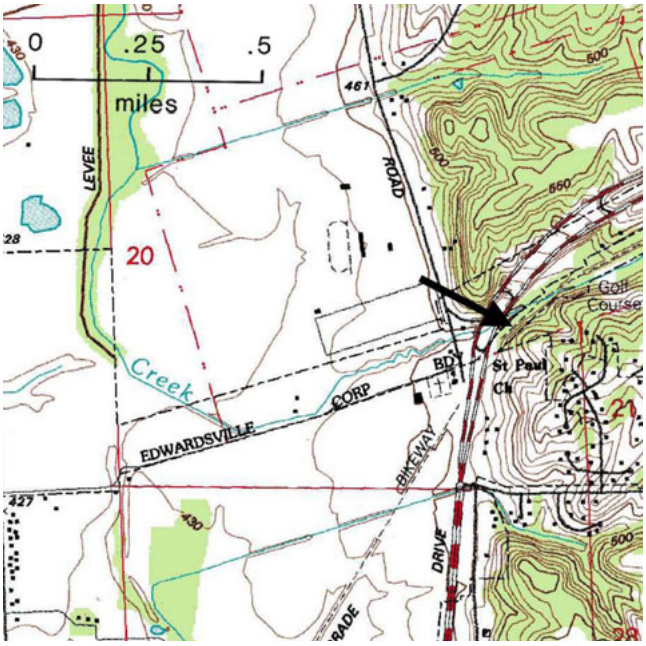

Figure 134. Part of the Wood River (Illinois) 7.5-minute quadrangle showing the location of the type section of the Roxana Member.

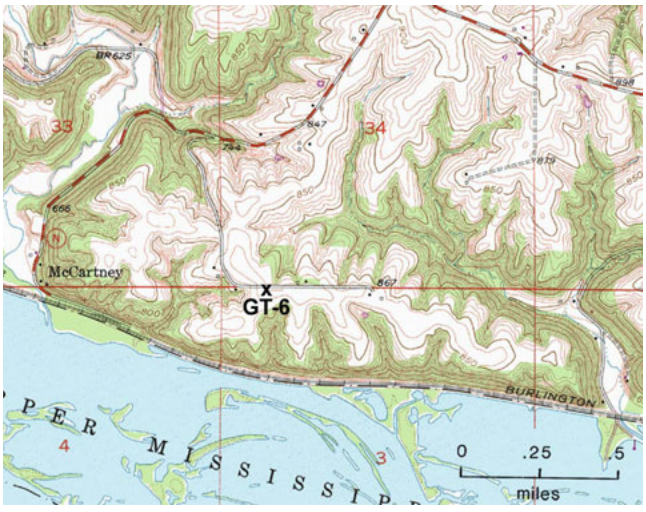

Figure 135. Part of the Balltown (Iowa/Wisconsin) 7.5-minute quadrangle showing the location of reference section 4 (core site GT-6) of the Roxana Member. This locality also serves as a reference section for the Peoria Member.

Sediments in reference sections 2, 3, and 4 are summarized in figures 130, 133, and 136, respectively, and core samples of these reference sections are available at the University of Wisconsin–Madison Department of Geography. The reference sections illustrate variability within the Roxana Member and illustrate how it differs from similarly named lithostratigraphic units in Illinois and elsewhere.

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 the 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 Geosol), till, rock, or the Rountree Formation. Pedogenesis associated with the underlying stratigraphic unit generally extends upward across the lower boundary of the Roxana Member. Pedogenic features typically include platy structure, silt coats on ped faces, rootlets and pores, and nodules of iron and manganese. The Roxana Member rarely shows evidence of clay illuviation, such as the presence of argillans. Charred flecks of plant material (including *Picea* and *Larix* wood), typically smaller than 5 mm, are conspicuous fossils in the Roxana Member.

Like the Peoria Member, the Roxana Member typically contains less than 5 percent sand, 75 to 90 percent silt, and less than 25 percent clay. However, at the Roxana Member type section, the sediment averages 2 percent sand, 69 percent silt, and 29 percent clay. The Roxana

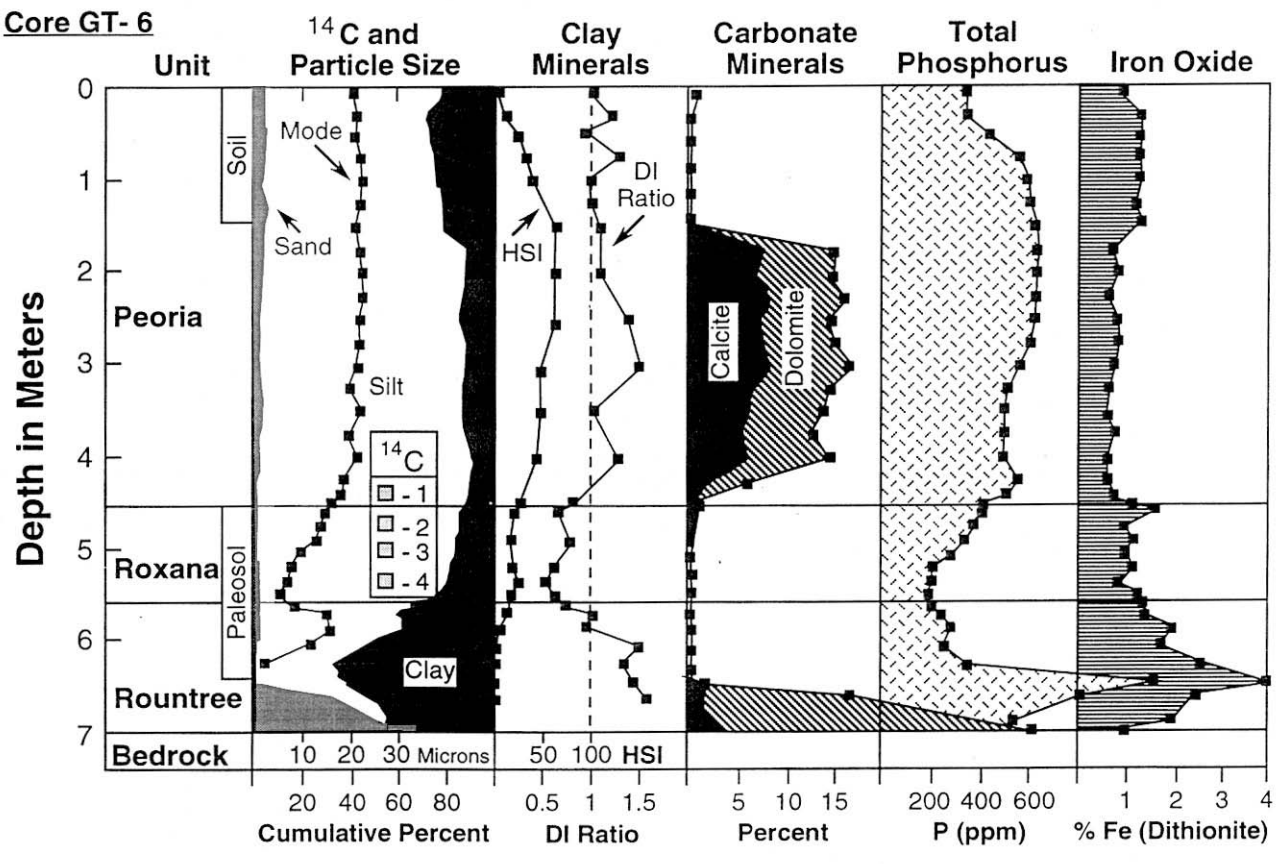

Figure 136. Sediment properties at reference section 4 for the Roxana and Peoria Members (core site GT-6). From Leigh (1994).

Member is typically finer than the overlying Peoria Member because the frequency distribution of the silt (0.002 to 0.063 mm) is finer grained than in the overlying Peoria Member at any individual site. In addition, the Roxana gradually becomes coarser towards the top of the member. 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-0.002 mm fraction and primarily include mixed-layer clay minerals and lesser amounts of kaolinite.

The clay mineralogy diffraction intensity ratio (DI ratio = 1.0 nm intensity divided by 0.7 nm intensity) provides a measurement of weathering, where lower numbers suggest more weathering. The DI ratio for the Roxana Member at the Kieler Formation type section near Kieler, Wisconsin is typically 0.7 to 0.8. By comparison, the DI ratio for the overlying Peoria Member averages between 0.9 and 1.0 and the DI ratio for the underlying Loveland Member typically ranges between 0.8 and 1.0 (Jacobs and others, 1997). Although the Roxana Member typically does not contain carbonate minerals, it does contain minor amounts of calcite and dolomite at the Hegery-1 core site, located in the lower Wisconsin River valley near Port Andrews, where it is preserved in relatively greater thickness than elsewhere. This preservation indicates a calcareous component probably also existed elsewhere, but has since been removed by weathering (Leigh and others, 1989).

Nature of contacts. The lower contact generally grades into the underlying material and typically includes a mixed zone between the two units where sedimentary structures have been obscured by pedogenesis (Leigh and others, 1989). The mixed zone commonly contains sediment clasts 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. Pedogenesis may have obscured any bedding initially present in the unit. The base of the mixed zone is defined as the base of the Roxana Member because the basal sediment includes the initial accumulation of the lithic material that comprises the Roxana Member. The upper boundary between the Roxana Member and the overlying Peoria Member is typically sharp. However, in places the basal Peoria Member is inter-stratified with thin beds of eroded brown Roxana Member. In rare instances the upper part of the Roxana Member contains an organically enriched A-horizon that is correlative with the Farmdale Geosol described by Follmer (1983).

Differentiation from other units. The Roxana Member is darker colored than the overlying Peoria Member and is typically not calcareous, unlike the Peoria Member. It commonly has a characteristic chocolate brown color. The Roxana Member either overlies a well-developed paleosol that has an argillic horizon or a material completely dissimilar to the Roxana Member. The modal diameter of silt particles, detected from electronic particle counting (Coulter Counter) analyses, indicates that the Roxana Member is characteristically finer grained than the overlying Peoria Member and the underlying Loveland Member. Charred fragments of spruce and larch, generally smaller than 5 mm, are common in the Roxana Member. The DI ratio of clay minerals in the Roxana Member (0.7 to 0.8) is characteristically lower than the underlying Loveland Member (>0.8) and the overlying Peoria Member (>0.8). The Roxana Member does not occur as a surface deposit and is commonly 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 Member.

Regional extent and thickness. The Roxana Member is a subsurface formation in Wisconsin. The Roxana Member probably covered most of the landscape throughout the Driftless Area and adjacent areas on top of glacial deposits deposited more than 50,000 ^{14}C yr B.P. (56,000 cal. yr B.P.). However, its modern occurrence is quite restricted to stable landscape positions that have not favored erosion, such as wide, flat upland interstream divides, terrace remnants, and cutoff valley meanders. The Roxana Member ranges in thickness from several centimeters to 2 m in the upper Mississippi Valley. 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 valley bluff margins of the Mississippi and Wisconsin River valleys. Somewhat thicker sections (1.5 to 1.7 m) are located in northwestern Illinois (Leigh, 1991). Like the Peoria Member, the Roxana Member generally thins with increasing distance from major rivers.

Origin. The Roxana Member was deposited as loess blown mainly from exposed river floodplains during the middle part of the Wisconsin Glaciation, 27,000 to 50,000 ^{14}C yr B.P. (32,000 to 56,000 cal. yr B.P.)(Leigh, 1991). An eolian origin is supported by particle size fining away from the major rivers. In addition, the differences in grain size and mineralogy compared to the underlying units indicate that the Roxana Member was not deposited by hillslope processes. Following deposition, hillslope and pedologic processes reworked the Roxana Member.

Age and correlation. A radiocarbon age of 29,400 ± 700 ^{14}C yr B.P. (33,634 ± 618 cal. yr B.P.) was determined for spruce charcoal collected from the Roxana Member in a road cut near the Kieler Formation type section (Hogan and Beatty, 1963). Numerous accelerator-mass-spectrometer (AMS) radiocarbon ages indicate the bulk of the Roxana Member was deposited between 27,000 and 55,000 ^{14}C yr B.P. (32,000 to 60,000 cal. yr B.P.) at sites near the Mississippi River valley bluffs (Leigh, 1991; Leigh and Knox, 1993).

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). The Roxana Member correlates with the "lower Wisconsin loess" of Ruhe (1976).

Previous usage: The name was first used by Leigh (1991) and Leigh and Knox (1994) in Wisconsin. Formalized here as the Roxana Member of the Kieler Formation.

Kieler Formation: Peoria Member

David S. Leigh and James C. Knox

Source of the name. Peoria, Illinois.

Location and description of type section. The type section is the Tindall School Section in the west bluff of the Illinois River to the south of Peoria, Illinois. It is located in the SW¼SW¼NE¼ sec. 31, T. 7 N., R. 6 E., Peoria County, Illinois, an area shown on the Glasford 7.5-minute quadrangle (fig. 137). The type section is described by Willman and Frye (1970, p. 65–66, 188–189) as the Peoria Loess Formation.

Location and description of reference sections. Four reference sections for the Peoria Member are located in Wisconsin. (1) The type section of the Kieler Formation also serves as a reference section for the Peoria Member. It is located in the SW¼ SE¼ sec. 9, T. 1 N., R. 2 W., Grant County, an area shown on the Kieler 7.5-minute quadrangle (figs. 126, 127). See full outcrop description in the Kieler Formation description. (2) The type section of the Wyalusing Member also serves as a reference section for the Peoria Member. Core site CR-3 is located on the center of the north line of the NE¼NW¼ sec. 10, T. 6 N., R. 6 W., Crawford County, an area shown on the Bridgeport 7.5-minute quadrangle (figs. 129, 130). (3) Reference section 3 of the Loveland Member also serves as a reference section for the Peoria Member. Core site GT-7 is located in a shallow roadside ditch along the south line of the SE¼SE¼ sec. 25, T. 8 N., R. 1 W., Grant County, an area shown on the Muscoda 7.5-minute quadrangle (figs. 132, 133). (4) Reference section 4 of the Roxana Member also serves as a reference section for the Peoria Member. Core site GT-6, 30 m south of Adams Lane and 4 m east of the eastern edge of a house driveway, along the north line of the NW¼NW¼ sec. 3, T. 2 N., R. 4 W., Grant County, an area shown on the Balltown (Iowa/Wisconsin) 7.5-minute quadrangle (figs. 135, 136).

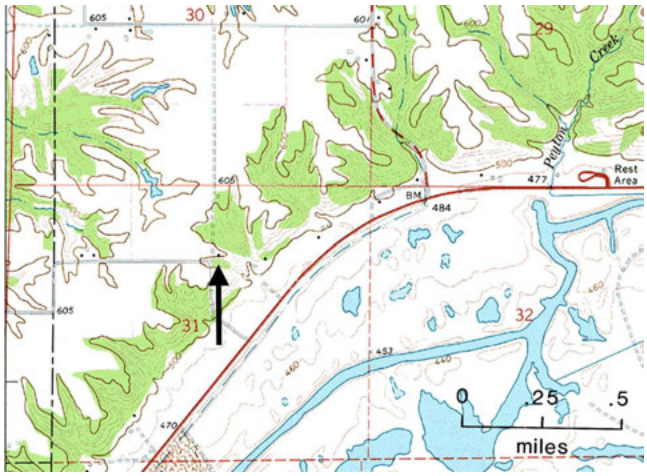

Figure 137. Part of the Glasford (Illinois) 7.5-minute quadrangle showing the location of the type section of the Peoria Member.

Sediments in reference sections 2, 3, and 4 are summarized in figures 130, 133, and 136, respectively, and core samples of these reference sections are available at the University of Wisconsin–Madison Department of Geography. The reference sections illustrate variability within the Peoria Member and how it differs from similarly named lithostratigraphic units in Illinois and elsewhere.

Description of unit. In its unweathered state, the Peoria Member typically is composed of calcareous, unbedded, light brownish-gray (2.5Y 6/2) to yellowish-brown (10YR 5/4) silt to silt loam. Drainage conditions and pedogenic history of a site influence the color of the unit. The upper 2 to 3 m of the Peoria Member typically is oxidized and noncalcareous due to pedogenesis associated with the modern soil. Unweathered Peoria Member typically contains less than 5 percent sand, 75 to 90 percent silt, and less than 25 percent clay. The unweathered Peoria Member at the Kieler type section averages 1 percent sand, 83 percent silt, and 16 percent clay. Sand is unusually abundant (up to 30 percent by weight) at sites close

to former floodplain source areas for the Peoria Member. Distinct facies assemblages are apparent. Massive silty facies are the most common, but on hillslopes and related colluvial settings, the silty sediment may be thinly bedded and include clasts from juxtaposed and subjacent stratigraphic units. The Peoria Member generally fines and thins with increasing distance from former loess source areas such as the Mississippi and Wisconsin River valleys (Leigh and Knox, 1994), although sparsely vegetated uplands during periglacial conditions also were sediment sources for the Peoria Member (Mason and others, 1994; Schaetzl and others, 2009). The Peoria Member contains predominantly quartz and feldspar, and heavy minerals generally account for less than 5 percent by weight. Clay minerals predominate in the less-than-0.002 mm 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 mass of calcareous parts of the Peoria Member, and dolomite is generally more abundant. In places snail shells are present in the basal 50 cm of the Peoria Member. Thinly bedded silty sediment is usually most apparent near the lower contact, where the interbedded sediment may contrast sharply with sediment of the underlying stratigraphic unit.

Nature of contacts. The Peoria Member is present at the surface. The lower contact of the Peoria Member is usually quite sharp with the underlying materials (Paleozoic rock, Rountree Formation, Roxana Member, fluvial sediment, till, or a well-developed paleosol). The basal meter of the Peoria Member (or thin units of Peoria Member) is generally mixed with the underlying material; evidence of mixing becomes less apparent with increasing distance from the lower contact. Evidence of mixing typically consists either of interstratifications with underlying older Kieler Formation units or a poorly sorted matrix that includes clasts of the underlying stratigraphic units. The base of this 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 (more than 3 m) of the Peoria Member is 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 (indicating less weathering), 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 many other landscape surfaces throughout much of the state (Hole, 1950). The Peoria Member ranges in thickness from several centimeters to 10 m. Thin sediment of the Peoria Member (less than 50 cm thick) is usually mixed with the underlying material. The thickest Peoria Member sediment accumulated along the bluffs of the Mississippi River where it is commonly is 6 to 8 m thick. The Peoria Member generally thins with increasing distance from the Mississippi Valley and other river valleys and lake plains that were deflationary source areas for the loess of the Peoria Member (see map by Hole, 1950). 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 mainly was blown from exposed river floodplains, exposed lake plains, and sparsely vegetated periglacial land surfaces during the last part of the Wisconsin Glaciation (MIS 2). Strong evidence for an eolian origin includes thinning patterns and textural fining trends away from major river valleys, a typically massive structure, and the location on upland divides. Peoria Member sediment was extensively reworked by mass wasting processes during (or shortly after) deposition (Knox, 1989; Mason and Knox, 1997).

Age and correlation. Snail shells located 25 cm above the base of the Peoria Member in the GT-6 reference section yielded an accelerator mass spectrometer age of 24,250 $\pm$ 970 ^{14}C yr B.P. (29,076 ± 1041 cal. yr B.P., GX-15888-AMS), and charred plant fragments located 10 to 15 cm below the boundary between the Peoria Member and the underlying Roxana Member yielded an accelerator mass spectrometry age of 29,290 $\pm$380 ^{14}C yr B.P. (33,661 ± 409 cal. yr B.P., AA5801). In addition, other radiocarbon ages from near the top of the Roxana Member (Leigh, 1994; Leigh and Knox, 1993) indicate a minimum age of about 27,000 ^{14}C yr B.P. (32,000 cal. yr B.P.) for the Roxana Member. These ages suggest that the base of the Peoria Member at bluff-side locations was deposited about 25,000 ^{14}C yr B.P. (30,000 cal. yr B.P.) in Wisconsin. This date correlates well with the basal age of 25,000 ^{14}C yr B.P. (30,000 cal. yr B.P.) for the Peoria Loess in Illinois reported by McKay (1979) and by Hogan and Beatty (1963). Deposition of Peoria Member probably ceased at approximately 12,000 ^{14}C yr B.P. (14,000 cal. yr B.P.) as suggested by local and regional stratigraphic relationships and radiocarbon ages (McKay, 1979; Bettis and others, 2003).

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 (Bettis and others, 2003; Forman and Pierson, 2002; Busacca and others, 2004).

Previous usage: The name was first used formally by Willman and Frye (1970) for the Peoria Loess Formation in Illinois. The name was subsequently used by Leigh (1991) and Leigh and Knox (1994) in Wisconsin. Formalized as the Peoria Member of the Kieler Formation in this publication.