Geologic Overview, Description of Map Units, and Correlation Chart

for the Surficial Geologic Materials Maps of the Letts Quadrangle, Iowa and the Blanchard Island Quadrangle, Illinois - Iowa

Geological Survey Bureau
Open File Report 94-1

Iowa Department of Natural Resources
Larry J. Wilson, Director
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Prepared by

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Background

The Letts, Iowa and Blanchard Island, Illinois-Iowa 1:24,000-scale geologic quadrangles cover an area from 41° 15' to 41° 22' 30" N latitude and 91° to 91° 15' W longitude. The area encompasses two geomorphic regions: 1) loess-mantled uplands of central eastern Iowa and central western Illinois, and 2) the Mississippi River Valley.

Prior geologic mapping in the area consists of mapping of the Des Moines 4° X 6° Quadrangle at a scale of 1:1,000,000 (Hallberg et al., 1991) and 1:100,000-scale landform maps produced for cultural resource surveys in the Mississippi River Valley (Benn et al., 1988). The latter use a mixture of lithologic and chronologic units and do not define map units using formal stratigraphic procedures.

Brief Geologic History

The oldest exposed deposits in the map area are Early and Middle Pennsylvanian terrigenous clastics of the Eastern Interior (or Illinois) Basin (Isbell, 1985; Hammer et al., 1985; Leary and Trask, 1985). These mudstones, siltstones, coals, and thin sandstones crop out intermittently along the base of the eastern Mississippi Valley bluff in Illinois. The Pennsylvanian rocks fill channels cut into Devonian marine carbonates and shale.

This area was glaciated several times during the early and middle Pleistocene and a thick sequence of Pre-Illinoian glacial tills and intercalated fluvial and eolian deposits cover the bedrock. These deposits are included in the Wolf Creek and older Alburnett formations (Hallberg, 1980a) but are undifferentiated on the accompanying cross-sections. An important local buried sand and gravel aquifer is present 100 to 200 feet below the land surface within Pre-Illinoian deposits in the western half of the Letts Quadrangle. Most private and municipal water wells in this area draw water from this buried Pre-Illinoian sand and gravel.

The last glacier to directly affect this area advanced from the Lake Michigan Basin in the early Illinoian (ca. 300,000 ka) and deposited the Kellerville Till Member of the Glasford Formation (Willman and Frye, 1970; Hallberg, 1980b). As the glacier entered eastern Iowa, sandy outwash accumulated along the ice margin. The glacier overrode the outwash, which is now exposed in short, steep tributary valleys and along the western valley wall of the Mississippi River in Iowa. This early Illinoian sand and gravel discharges groundwater to seeps in the upper reaches of short, steep tributaries along the western wall of the Mississippi Valley. The maximum extent of the Illinoian glaciation was approximately 9 km west of the map area. When the glacier had retreated into Illinois east of the map area, outwash (Pearl Formation) was transported southwestward in meltwater channels to the ancestral Iowa/Cedar Valley.

During the Sangamon Interglacial, which followed the Illinoian, soils formed across the landscape, an integrated drainage network developed, and a thick alluvial fill (beneath the Early Phase High Terrace) accumulated in the Iowa/Cedar Valley. During this interglacial, the Ancestral Mississippi River flowed north and east of the map area through the Princeton Bedrock Valley and down the Lower Illinois Valley to the St. Louis, Missouri vicinity (Anderson, 1968; Willman and Frye, 1970). A tributary to the Ancestral Iowa/Cedar Valley probably occupied the present location of the Mississippi River Valley in the map area during the Sangamon Interglacial.

Two loess sheets were deposited during the Wisconsinan in this part of the Upper Mississippi River Basin. The Roxana Silt accumulated between about 50,000 and 25,000 B.P. and was subsequently modified by formation of the Farmdale Soil (Leigh and Knox, 1993; Johnson and Follmer, 1989; Follmer, 1983). Shortly after 22,000 B.P., Peoria Loess began to accumulate on uplands. At that time an extensive upland erosion surface was developing across the northern Mid-continent (Ruhe, 1969; Hallberg et al., 1978; Kemmis and Bettis, 1992). Eolian sand sheets and dune fields were active in eastern Iowa along the margins of the erosion surface, and these were eventually buried by Peoria Loess, which continued to accumulate until about 12,500 B.P.

About 21,000 B.P. outwash from Lake Michigan Lobe glaciers blocked the Ancestral Mississippi Valley and flow was diverted into a tributary of the Ancestral Iowa/Cedar Valley, forming the present course of the Mississippi Valley through the map area (Anderson, 1968). Between about 20,000 and 11,000 B.P. the Mississippi and Iowa/Cedar valleys acted as meltwater channels for glaciers in the upper parts of their basins. During this period sandy and gravelly outwash (Henry Formation of Illinois and Noah Creek Formation in the Iowa/Cedar Valley) aggraded the valleys, and two major terrace fills accumulated. Downcutting events that formed these terraces occurred at an earlier date in the Iowa/Cedar Valley than in the Mississippi Valley and, as a result, the upper Late Wisconsinan terrace of the Iowa/Cedar Valley (Late Phase High Terrace) is loess-mantled, while the upper Late Wisconsinan terrace in the Mississippi Valley (Savanna Terrace complex) lacks loess. Entrenchment to the Holocene flood plain level in both the Mississippi and Iowa/Cedar valleys occurred between about 10,500 and 10,000 B.P. (Benn et al., 1988). In the Mississippi Valley this was coincident with the overflow of Glacial Lakes Agassiz and Duluth into the Minnesota and St. Croix valleys, respectively.

Alluvial fills of the DeForest Formation accumulated in valleys during the Holocene (Bettis, 1990; Bettis et al., 1992). The Mississippi River attained an island-braided pattern similar to its Historic pattern about 10,000 B.P., and shortly after 10,000 B.P. the channel shifted from a position along the western valley margin to the eastern valley margin. Between 9,000 and 6,000 B.P. the channel gradually moved westward, then settled into approximately its present channel belt about 6,000 B.P. (Benn et al., 1988). Colluvial aprons and alluvial fans (DeForest Formation, Corrington Member) prograded the Mississippi and Iowa/Cedar flood plains between about 8,500 and 2,500 B.P. Alluvial fans emanating from large tributaries such as Copperas and Eliza creeks continue to prograde in the Historic period. The present islands in the Mississippi channel began to emerge about 3,500 B.P. and have continued to form. Construction of the lock-and-dam system in the 1930's had only a minor flooding effect on this part of the valley since it is in the upper reach of a pool (Pool 17), but the levee system has promoted increased flood heights and accumulation of thick post-settlement alluvium (DeForest Formation, Camp Creek Member) channelward of the levees.

The accompanying correlation diagram depicts relationships among the map units of the surficial geologic materials maps and the lithologic units that are present beneath the

land surface. Surficial materials map units are indicated along the top row of the diagram, and the successions of lithologic units, to the first bedrock aquifer, that occur beneath the map units are depicted in the corresponding column. The numbered lithologic units and accompanying patterns correspond to those of cross-sections associated with the surficial materials maps.

DESCRIPTION OF MAP UNITS

Holocene

Qdm8 ALLUVIUM (DeForest Formation, Camp Creek Member) -- Grayish brown and brown sandy and loamy deposits in close proximity to the Mississippi River channel that became emergent after completion of the lock-and-dam system in the 1930's. Usually noncalcareous and 2 to 6 meters thick. Fines overlie moderately well sorted, poorly to well stratified, coarse to fine feldspathic quartz sand and pebbly sand channel deposits of the Henry Formation that are more than ten meters thick. Blanchard Island Quadrangle only.

Qdm7 ALLUVIUM (DeForest Formation) -- Grayish brown and dark brown loam, silt loam, clay loam, and linear-trending sands in the Mississippi channel belt and islands channelward of the artificial levee of the Mississippi River. Contains many small inclusions of organic deposits (Qdw). Sands are poorly to moderately well sorted, poorly to well stratified, medium to fine feldspathic quartz sand, often interbedded with thin loamy beds. Usually calcareous at depth. Three to five meters thick. Upper 1.0 to 2.0 meters is brown to grayish brown, well stratified silt loam, loam, or sandy loam of the Camp Creek Member (Historic). Fines overlie moderately well sorted, moderately to well stratified, coarse to fine feldspathic quartz sand and pebbly sand channel deposits of the Henry Formation that are more than ten meters thick. Blanchard Island Quadrangle only.

Qdm6 ALLUVIUM (DeForest Formation) -- Grayish brown and brown loam, silt loam, clay loam, and linear-trending sands in former Mississippi River channel belt. Contains many small inclusions of organic deposits (Qdw). Sands are poorly to moderately well sorted, poorly to well stratified, medium to fine feldspathic quartz sand, often interbedded with thin lenses of loam. Usually calcareous at depth. Two to four meters thick. Upper 0.5 to 2.0 meters is grayish brown and brown, well stratified silt loam, loam, or clay loam of the Camp Creek Member (Historic). Fines overlie moderately well sorted, moderately to well stratified, coarse to fine feldspathic quartz sand and pebbly sand channel deposits of the Henry Formation that are more than ten meters thick. Blanchard Island Quadrangle only.

Qdm5 ALLUVIUM (DeForest Formation) -- Grayish brown and brown loam, silt loam, clay loam, and linear-trending sands in former Mississippi River channel belt. Contains several small inclusions of organic deposits (Qdw). Sands are poorly to moderately well sorted, poorly stratified, medium to fine feldspathic quartz sand, often interbedded with thin lenses of loam. Usually calcareous at depth. Two to three meters thick. Upper 0.5 to 1.0 meter is grayish brown to brown, poorly to well stratified silt loam and clay loam of the Camp Creek Member (Historic).

Fines overlie moderately well sorted, moderately to well stratified, coarse to fine feldspathic quartz sand and pebbly sand channel deposits of the Henry Formation that are more than ten meters thick. Blanchard Island Quadrangle only.

Qdm4 ALLUVIUM (DeForest Formation) -- Grayish brown and brown loam, silt loam, clay loam, organic-rich loam, and linear-trending sands in former Mississippi River channel belt. Sands are poorly to moderately well sorted, poorly stratified, medium to fine feldspathic quartz sand, often interbedded with thin lenses of loam. Contains less than 0.5 meter thick mantle of grayish brown to brown, poorly stratified to massive silt loam and clay loam of the Camp Creek Member (Historic). Usually calcareous at depth. One to three meters thick. Fines overlie moderately well sorted, moderately to well stratified, coarse to fine feldspathic quartz sand and pebbly sand channel deposits of the Henry Formation that are more than ten meters thick. Blanchard Island Quadrangle only.

Qdm3 ALLUVIUM (DeForest Formation) -- Dark gray to brown loam, silt loam, clay loam and organic-rich alluvium in former Mississippi River channel belt. Noncalcareous and two to four meters thick. Fines overlie moderately well sorted, moderately to well stratified, coarse to fine feldspathic quartz sand and pebbly sand channel deposits of the Henry Formation that are more than ten meters thick. Blanchard Island Quadrangle only.

Qdm2 ALLUVIUM (DeForest Formation) -- Dark gray to brown loam, silt loam, clay loam, and sandy loam alluvium on former islands in abandoned Mississippi River paleochannel systems. One to two meters thick. Fines overlie more than ten meters of moderately well sorted, moderately to well stratified, coarse to fine feldspathic quartz sand and loam channel deposits and near-channel deposits of the Henry Formation. Thin beds of reddish brown Glacial-Lake-Duluth-source silty clay are present near the base of the fines in parts of this map unit.

Qdm1 ALLUVIUM (DeForest Formation) -- Dark gray to brown loam, silt loam, and clay loam alluvium in abandoned paleochannel systems of the Mississippi River. Two to four meters thick. Overlies moderately well sorted, moderately to well stratified, coarse to fine feldspathic quartz sand and pebbly sand channel deposits of the Henry Formation that are more than ten meters thick. Ten to thirty centimeter thick beds of reddish brown silty clay laminae derived from Glacial Lake Duluth are present near the base of the fines in parts of this map unit.

Qds ALLUVIUM (DeForest Formation) -- Grayish brown to yellowish brown sandy loam, loam, and silt loam natural levee and crevasse splay deposits. Massive to well stratified with local cut and fill sequences in crevasse channels. Calcareous at depth. One to five meters thick. Thickest along western margin of map unit. Underlain by deposits of map units Qdm3 and Qdm4. Blanchard Island Quadrangle only.

Qdc1 ALLUVIUM (DeForest Formation, Corrington Member) -- Grayish brown to yellowish brown sandy loam and pebbly sand alluvial fan deposits. Channel gravels present in apex areas of some fans. Present beneath large, low-angle alluvial fans fed by moderate-size perennial tributaries along the margins of the

Mississippi Valley and its major tributaries. Usually contains several upward-fining sequences, sometimes capped with paleosols. Massive, becoming weakly to moderately stratified and calcareous at depth. Two to eleven meters thick and overlies older Holocene alluvium.

Qdc2 ALLUVIUM AND COLLUVIUM (DeForest Formation, Corrington Member) -- Grayish brown to yellowish brown loamy and pebbly loam alluvial and colluvial deposits. Present beneath alluvial fans and colluvial slopes along the margins of the Mississippi Valley and its major tributaries. Channel gravels present in apex areas of some fans. Contains multiple upward-fining sequences, each capped with a paleosol. Massive, becoming weakly to moderately stratified near base. Calcareous at depth. Two to eleven meters thick and overlies older Holocene alluvium.

Qdy ALLUVIUM (DeForest Formation) -- Dark gray to yellowish brown loam, silt loam, clay loam, sandy loam, and organic-rich alluvial deposits in meander belts of active and former anabranch channels of the Mississippi River. Massive to well stratified. Ranges from two to five meters in thickness and overlies moderately well sorted, moderately to well stratified, coarse to fine feldspathic quartz sand and pebbly sand channel deposits of the Henry Formation that are more than ten meters thick.

Qdw LAKE AND MARSH DEPOSITS (DeForest Formation) -- Black to gray peat, muck, and other organic-rich lacustrine and paludal deposits in abandoned channels of the Mississippi River. Three to eleven meters in thickness and overlying poorly to moderately well sorted, moderately to well stratified, coarse to fine feldspathic quartz sand and pebbly sand channel deposits of the Henry Formation that are more than ten meters thick.

Qdn ALLUVIUM (DeForest Formation, Gunder and Corrington members) -- Grayish brown to yellowish brown loam, silt loam, and sandy loam alluvial deposits overlying poorly to well sorted, massive to well stratified, coarse to fine feldspathic quartz sand and pebbly sand of the Noah Creek Formation. DeForest Formation deposits are one to three meters thick. Underlying Noah Creek Formation extends to a depth of more than ten meters. Letts Quadrangle only.

Qdhn ALLUVIUM (DeForest Formation) -- Dark gray to yellowish brown loam and sandy loam overlying poorly to moderately well sorted, massive to well stratified, coarse to fine feldspathic quartz sand, pebbly sand, and gravel of the Henry Formation (in Illinois) or Noah Creek Formation (in Iowa). Holocene alluvium up to three meters thick overlying Henry and Noah Creek formations that extend to depths of five to ten meters.

Late Wisconsinan

Qp LOESS (Peoria Loess) -- Gray to yellowish brown wind-blown silt to silt loam derived from the Mississippi and Iowa\Cedar valleys. Massive, jointed, and leached. Three to seven meters thick. Overlies either Farmdale Soil developed in leached, brown to dark gray Roxana Silt, clayey dark gray to reddish brown

Sangamon Soil developed in glacial till or sandy alluvium of the Glasford Formation, or eroded, compact, yellowish brown to dark gray loamy glacial till of the Glasford Formation. Letts Quadrangle only.

Qps LOESS (Peoria Loess) -- Gray to yellowish brown wind-blown silt to silt loam, and well sorted, medium to fine feldspathic quartz sand derived from the Mississippi and Iowa\Cedar valleys. Massive, jointed, and leached. Sands range from absent to three meters in thickness and are most common in lower half of unit. These appear to be part of a discontinuous, full glacial dune field and sand sheet. Organic-rich silt, sand, and thin peats are discontinuously present in some interdune depressions within the sandy zone. Three to seven meters thick. Overlies either the Farmdale Soil developed in leached, brown to dark gray Roxana Silt, clayey dark gray to reddish brown Sangamon Soil developed in loamy glacial till or sandy alluvium of the Glasford Formation, or eroded, compact, yellowish brown to dark gray glacial till of the Glasford Formation.

Qptl LOESS (Peoria Loess) -- Gray to yellowish brown wind-blown silt to silt loam grading downward to poorly to moderately well sorted, moderate to well stratified, coarse to fine feldspathic quartz sand alluvium. Wind-blown silt five to seven meters in thickness, massive, jointed, leached and derived from Iowa\Cedar and Mississippi valleys. Underlying alluvium extends to a depth of greater than ten meters and is the alluvial fill beneath the Late Phase High Terrace of the Iowa\Cedar Basin. Letts Quadrangle only.

Qpth LOESS (Peoria Loess) -- Gray to yellowish brown wind-blown silt to silt loam. Five to seven meters thick, massive, jointed, leached, and derived from the Iowa\Cedar and Mississippi valleys. Overlies the Farmdale Soil developed in leached, brown to dark gray, 1.0 to 1.5 meter thick Roxana Silt, or peat grading downward into Roxana Silt. Beneath the Roxana Silt is the Sangamon Soil developed in fine-grained early Wisconsinan to late Illinoian alluvial fill beneath the Early Phase High Terrace of the Iowa\Cedar Basin. Letts Quadrangle only.

Qpr LOESS (Peoria Loess) -- Gray to yellowish brown wind-blown silt to silt loam and interbedded eolian sand. Five to nine meters thick, massive, jointed, calcareous at depth, and derived primarily from the Mississippi Valley. Overlies the Farmdale Soil developed in leached, brown to reddish brown, 1.5 to 2.0 meter thick Roxana Silt. The Sangamon Soil is beneath the Roxana Silt and is developed in silty and sandy grading downward to gravelly valley train outwash of the Pearl Formation (Illinoian). Pearl Formation deposits are more than four meters thick. Occurs beneath the high loess-mantled terrace along Copperas Creek in Illinois. Blanchard Island Quadrangle only.

Qe SLACKWATER DEPOSITS (Equality Formation, Plum River Member--new) -- Gray, yellowish brown, and reddish brown well stratified to laminated silt, clay, and fine to medium feldspathic quartz sand. Seven to twelve meters thick, calcareous, and derived from both local tributary valleys and the Mississippi Valley. Contains beds of reddish brown silty clay derived from the Superior Basin. These deposits have a facies relationship with deposits in map unit Qhs.

Underlies the Savanna Terrace in tributaries of the Mississippi Valley. Blanchard Island Quadrangle only.

Qhs OUTWASH SAND AND PEBBLY SAND (Henry Formation, Sabula Member--new) -- Yellowish brown to gray, moderately to well sorted, massive to well stratified, coarse to fine feldspathic quartz sand and pebbly sand with zones of gravel at depth. Calcareous at depth. Mantled with late Wisconsinan and Holocene dunes and eolian sand sheet of variable thickness (0-5 meters) composed of well sorted, massive to poorly bedded, medium to fine feldspathic quartz sand derived from reworking of the outwash. Outwash is more than ten meters thick in the map area, but localities are present south of the map area where gray, compact, calcareous loamy glacial till occurs between five and seven meters below the top of the alluvium. The alluvium of this unit has a facies relationship with slackwater deposits of map unit Qe. Underlies the Savanna Terrace complex in the Mississippi Valley. Blanchard Island Quadrangle only.

Qhm1 OUTWASH SAND AND PEBBLY SAND (Henry Formation, Muscatine Member--new) -Yellowish brown to gray, moderately to well sorted, massive to well stratified, coarse to fine feldspathic quartz sand and pebbly sand. Calcareous at depth. Mantled with low Holocene dunes and sand sheet of variable thickness (0-1.5 meters) composed of well sorted, massive, medium to fine feldspathic quartz sand derived from reworking of the outwash. Outwash is more than ten meters thick in the map area, but localities are present south of the map area where gray, compact, calcareous loamy glacial till is present between five and seven meters below the top of the alluvium. Contains zones of gravel at depth. Underlies the Kingston Terrace complex in the Mississippi Valley.

Qhm2 OUTWASH SAND AND PEBBLY SAND (Henry Formation, Muscatine Member--new) Yellowish brown to gray, poorly to well sorted, massive to well stratified, coarse to fine feldspathic quartz sand and pebbly sand with thin gravel lenses within two meters of the land surface. Calcareous at depth. Mantled with Holocene sand sheet of variable thickness (0-1.5 meters) composed of well sorted, massive, medium to fine feldspathic quartz sand derived from reworking of the outwash. Outwash is more than ten meters thick. Occurs beneath southwestward-trending late Wisconsinan to early Holocene overflow channels on the Kingston Terrace complex.

Qn OUTWASH SAND AND PEBBLY SAND (Noah Creek Formation) -- Yellowish brown to gray moderately to well sorted, massive to well stratified, coarse to fine feldspathic quartz sand and pebbly sand with gravel zones at depth. Calcareous at depth. Mantled with late Wisconsinan and Holocene dunes and sand sheet of variable thickness (0-4 meters) composed of well sorted, massive, medium to fine feldspathic quartz sand derived from reworking of the outwash. Outwash more than five meters thick. Underlies the Low Terrace of Iowa\Cedar Basin; correlates with outwash beneath the Kingston Terrace complex in the Mississippi Valley. Letts Quadrangle only.

Complexes (Holocene and Pleistocene)

Qpsd ALLUVIUM, LOESS, SAND, GLACIAL TILL (DeForest, and Glasford formations, Peoria Loess) -- Silt loam, sand, clay loam, and loam. Complex composed of materials that correlate with those in map units Qp, Qps, Qdhn, Qptl, and Qpth and outcrops of yellowish brown to dark gray, loamy, compact, leached or calcareous Illinoian glacial till (Glasford Formation, Kellerville Member) and clayey or loamy Sangamon Soil along steep sideslopes and narrow tributary valleys. Holocene slumps and debris flow deposits are common. Letts Quadrangle only.

Qgwa ALLUVIUM, LOESS, SAND, GLACIAL TILL (DeForest, Glasford, Pearl, Wolf Creek and Alburnett formations, Peoria Loess, and undifferentiated Pennsylvanian rocks in Illinois) -- Silt loam, sand, clay loam, and loam. Also includes a few small areas shallow to siltstone, mudstone, and coal along the margin of the Mississippi Valley in Illinois. Complex composed of materials that correlate with those in map units Qp, Qps, Qdhn, Qpr and, in Illinois, Pu. Also contains outcrops of brown to dark gray, loamy, compact, leached or calcareous Illinoian and Pre-Illinoian glacial till and clayey or loamy paleosols along steep sideslopes and narrow tributary valleys. Holocene slumps and debris flow deposits are common.

Pennsylvanian

Pu LITHIFIED SHALLOW MARINE AND FLUVIAL DEPOSITS (Caseyville, Abbott and Spoon formations) -- gray, pyritic silty shale and carbonaceous shale, with thin, pyritic coal, mudstone, and fine to very fine grained, quartzarenite to feldspathic litharenite sandstones and micaceous sandstones. Poor exposures of undifferentiated Caseyville, Abbott, and Spoon formations with slumped Quaternary deposits. Present in narrow, steep, unstable outcrops along eastern wall of the Mississippi Valley in Illinois. Blanchard Island Quadrangle only.

Other Map Units

ml Made land. Ranges from locally derived fill to fill dominated by concrete and brick rubble. Blanchard Island Quadrangle only.

pits Gravel pits in map units Qhm and Qhms. Usually located in areas where pebbly sand or gravel lenses are present. Underlain by sand, pebbly sand, or gravel of the Henry Formation to depths greater than ten meters. Blanchard Island Quadrangle only.

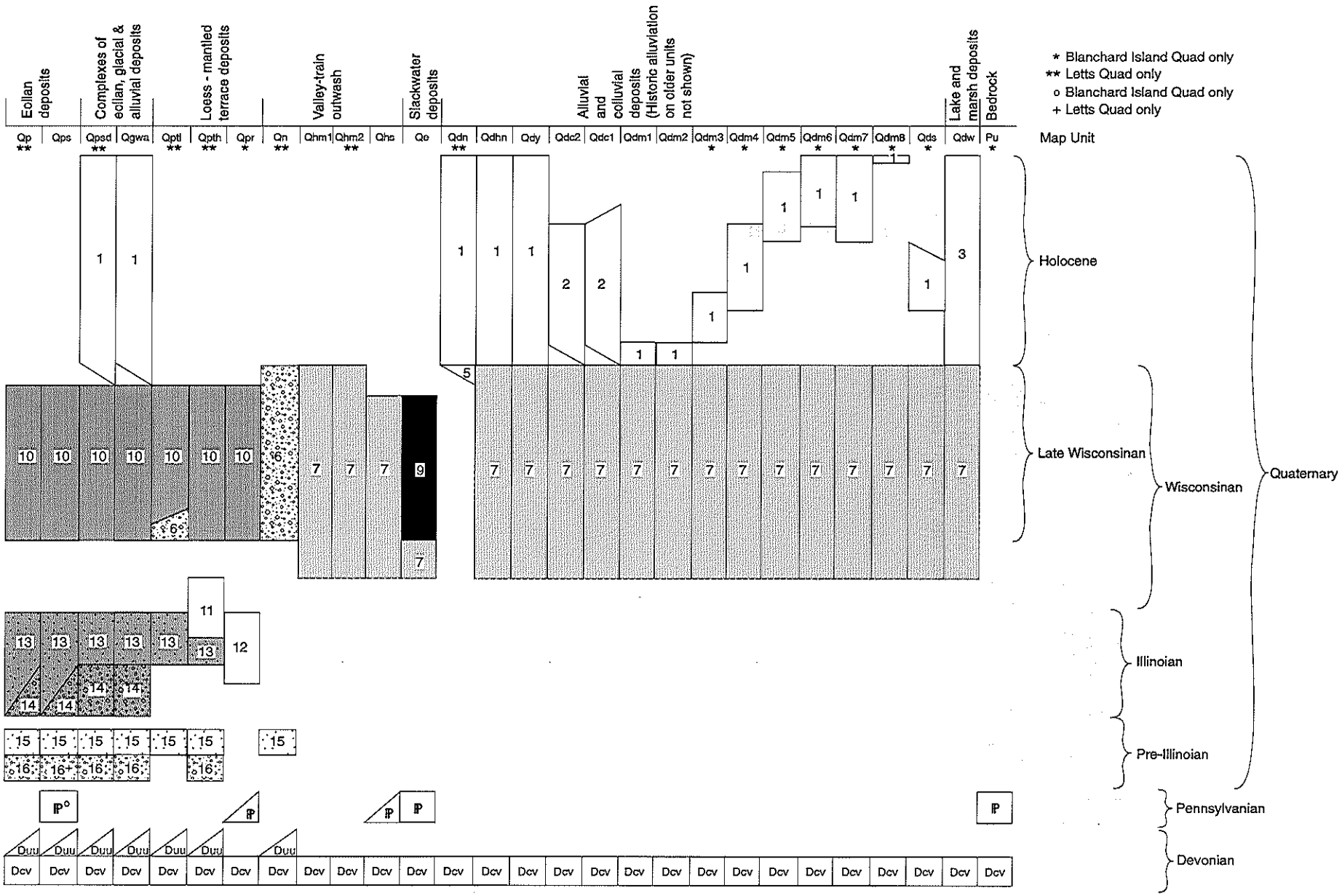

Figure 1. Correlation of Map and Cross-Section Units: Letts, Iowa and Blanchard Island, Illinois-Iowa 7.5' Quadrangles.

REFERENCES

Anderson, R. C., 1968, Drainage evolution in the Rock Island area, western Illinois and eastern Iowa. In: The Quaternary of Illinois, R. E. Bergstrom (editor), University of Illinois College of Agriculture Special Publication 14, p. 11-18.

Benn, D. W., Bettis, E. A. III, and Vogel, R. C., 1988, Archaeology and geomorphology in Pools 17 and 18 Upper Mississippi River. Center for Archaeological Research Report 714, Southwest Missouri State University, Springfield, 389 p.

Bettis, E. A. III (editor), 1990, Holocene alluvial stratigraphy and selected aspects of the Quaternary history of western Iowa. Midwest Friends of the Pleistocene Field Trip Guidebook, 197 p.

Bettis, E. A. III, Baker, R. G., Green, W. R., Whelan, M. K., and Benn, D. W., 1992, Late Wisconsinan and Holocene alluvial stratigraphy, paleoecology, and archaeological geology of east-central Iowa. Iowa Department of Natural Resources, Guidebook Series No. 12, 82 p.

Kemmis, T. J., and Bettis, E. A. III, 1992, Quaternary geology of Conklin Quarry. Iowa Department of Natural Resources, Guidebook Series 13, 41 p.

Follmer, L. R., 1983, Sangamon and Wisconsinan pedogenesis in the Midwestern United States. In: The Late Pleistocene, Porter, S. C. (editor), Vol. 1 of Late Quaternary Environments of the United States, Wright, H. E. Jr. (editor), University of Minnesota Press, Minneapolis, pp. 138-144.

Hallberg, G. R., 1980a, Pleistocene stratigraphy in east-central Iowa. Iowa Geological Survey, Technical Information Series 10, 168 p.

Hallberg, G. R. (editor), 1980b, Illinoian and pre-Illinoian stratigraphy of southeast Iowa and adjacent Illinois. Iowa Geological Survey, Technical Information Series 11, 206 p.

Hallberg, G. R., Fenton, T. E., Miller, G. A., and Lutenegger, A. J., 1978, The Iowan Erosion Surface: An old story, an important lesson, and some new wrinkles. In: Anderson, R. (editor), 42nd Annual Tri-State Geological Field Conference Guidebook, pp. 2-1 to 2-94.

Hallberg, G. R., Lineback, J. A., Mickelson, D. M., Knox, J. C., Goebel, J. E., Hobbs, H. C., Whitfield, J. W., Ward, R. A., Boellstorf, J. D., Swinehart, J. B., and Dreeszen, V. H., 1991, Quaternary geologic map of the Des Moines 4° X 6° Quadrangle, United States. U. S. Geological Survey, Miscellaneous Investigations Series, Map I-1420.

Hammer, W. R., Anderson, R. C., and Schroeder, D. A., 1985, Devonian and Pennsylvanian stratigraphy of the Quad Cities Region Illinois-Iowa. Great Lakes SEPM 15th Annual Field Conference Guidebook, Augustana College, Rock Island, IL, 129 p.

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