GEOLOGY OF THE UNIVERSITY OF IOWA CAMPUS AREA, IOWA CITY

A Walking Tour Along the Iowa River

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GEOLOGY OF THE UNIVERSITY OF IOWA CAMPUS AREA, IOWA CITY

with A Walking Tour Along the Iowa River

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cover photo: Devonian limestone exposed at the Sanders Quarry in the 1890s (Stop 5 on N. Dubuque St.). Workmen quarried building stone for use in Iowa City and surrounding communities in Johnson County. Photo by Professor Samuel Calvin, State Geologist (original negative in the Sam Calvin photograph collection, Department of Geology, University of Iowa).

SUMMARY OF THE GEOLOGIC HISTORY OF THE IOWA CITY AREA

by Brian J. Witzke

Exposures of Devonian, Pennsylvanian, and Quaternary strata are accessible in the Iowa City area and are the main focus of this guidebook. The significance of these exposures to interpreting portions of the geologic history of the area is discussed in subsequent sections of this guidebook. However, additional information on the geologic history of the area can be obtained from well penetrations in Iowa City and adjacent areas. In Iowa City, we stand on top of a sequence of sedimentary rocks approximately 850 meters (2800 ft) in thickness. The stratigraphic sequence of these rocks records the historical succession of deposition and erosion in the area. Precambrian metamorphic and igneous rocks occur beneath the sedimentary rock sequence, forming the surface of the "basement" complex. Only a few deep wells in eastern Iowa have encountered "basement" rocks, but these wells provide important clues concerning the nature and composition of the upper portion of the thick continental crust.

Iowa presently occupies a position within the North American continental interior commonly termed the "stable craton." This area has not experienced major moutain-building or volcanic activity for about one billion years. Although an area of relative tectonic stability, a complex history of broad-scale folding, which created a series of basins and arches, and faulting, characterizes structural development during Iowa's last 600 million years (the Phanerozoic).

Precambrian Rocks

No wells have penetrated the Precambrian surface in Iowa City or Johnson County. Nevertheless, a general picture of the complex Precambrian history has emerged through interpretations of geophysical and well data from nearby areas of Iowa. Rocks comprising the basement surface over much of eastern Iowa have been informally included in the "Iowa Plutonic Complex." This poorly understood Precambrian terrane underwent multiple episodes of igneous and metamorphic activity. No Archean rocks (greater than 2500 million years old) have been recognized in eastern or southern Iowa, and much or all of the Precambrian crust under Iowa City is probably of Proterozoic age. The crust beneath Iowa City was apparently part of an Early Proterozoic land mass that collided with older Archean/Early Proterozoic continental crust to the north during the Penokean Orogeny (1850 million years ago), thereby joining the accreting North American continent.

Prior to 1640 million years ago, southeastern Iowa occupied a position close to a passive trailing continental margin. At that time, thick sequences of quartz sandstone and shale were deposited along this margin. These sediments were subsequently deformed and metamorphosed to varying degrees during an orogenic episode related to subduction and/or collision along the former continental margin about 1640 million years ago (Dott, 1983). The Baraboo Quartzite of Wisconsin and the Sioux Quartzite of northwestern Iowa are preserved remnants of these sediments. Similar red quartzites have been encountered in wells in Washington County about 40 km (25 mi) southwest of Iowa City (Anderson and Ludvigson, 1983), and reported at Cedar Rapids. Red quartzites also may occur locally beneath Johnson County. Monzonite in Jackson County, east-central Iowa, has been dated at 1487 million years, recording another episode of plutonic activity in eastern Iowa.

Late Proterozoic (Keweenawan) igneous activity and sedimentation is documented in the Midcontinent Rift System, which extends from Lake Superior to Kansas and cuts across Iowa from the north-central to southwestern portion of the state. About 1000 to 1200 million years ago, intrusive/extrusive mafic igneous activity and sediment accumulation accompanied rifting of the continental crust. Sediments continued to accumulate following cessation of igneous activity. Subsequent uplift of the central portion of the former rift system was accompanied by development of deep flanking basins filled with clastic sediments. The extent of Keweenawan plutonic activity and sedimentation in eastern Iowa remains unknown. In general, the Late Proterozoic in eastern Iowa was probably marked by extensive erosion of the continental crust. The highly resistant red quartzites became topographically accentuated as less resistant granitic and metamorphic rocks were differentiallly eroded. Prior to Cambrian deposition, the eroded Precambrian surface in eastern Iowa probably had about 300 m (1000 ft) of topographic relief.

Cambrian History

Several wells in Iowa City penetrate the upper portion of the Cambrian stratigraphic sequence (fig. 1), and the complete Cambrian sequence above the Precambrian basement has been penetrated in nearby wells in eastern Iowa (Washington County and Cedar Rapids). Cambrian strata comprise the lower portion of the Sauk Sequence (Sloss, 1963). Widespread deposition of Sauk Sequence rocks occurred over large areas of the continental interior, marking the oldest episode of Phanerozoic marine sedimentation. Cambrian deposition was apparently initiated in eastern Iowa during the late Middle or early Late Cambrian about 530 million years ago, as a seaway advanced into the state from the present-day southeast. Iowa occupied a position near the equator at that time.

The oldest Cambrian rocks in Iowa are assigned to the Mt. Simon Sandstone. The Mt. Simon in eastern Iowa is characterized by a sequence of fine- to coarse-grained quartz sandstone with minor shale, and typically ranges from about 100 to 365 m (325-1200 ft) in thickness. This thick sandstone interval buried most of the irregular Precambrian basement surface, but is locally absent above paleotopographic highs on the basement surface. Subsequent Late Cambrian marine deposition is recorded by a stratigraphic sequence which includes, in ascending order (fig. 1): 1) Eau Claire Formation, 85 m (280 ft), glauconitic sandstone, siltstone, and shale; 2) Wonewoc Formation, 25 m (80 ft), sandstone; 3) Lone Rock Formation, 55 m (180 ft), glauconitic shale, siltstone, and dolomite; 4) St. Lawrence Formation, 55 m (180 ft), dolomite; and 5) Jordan Sandstone, 45 m (150 ft), sandstone and sandy dolomite.

Terrigenous clastic sediments in the Cambrian sequence were derived from uplands along the Wisconsin Dome and Precambrian Shield areas. Carbonate rocks were deposited in the shallow seas when the influx of terrigenous clastic sediments was reduced. Primitive invertebrate organisms lived in this ancient sea, and trilobites and brachiopods have been found in well cuttings and rock cores from eastern Iowa.

Post-Mt. Simon Cambrian rocks generally thicken toward the southeast in Iowa along a north-south axis of thickening termed the Hollandale Embayment. Iowa City lies near the axis of this embayment. Water-bearing sandstones and dolomites in the upper portion of the Cambrian sequence, especially the Jordan Sandstone, form a significant part of the widely utilized Cambro-Ordovician aquifer of eastern Iowa (fig. 1). Deep wells in Iowa City

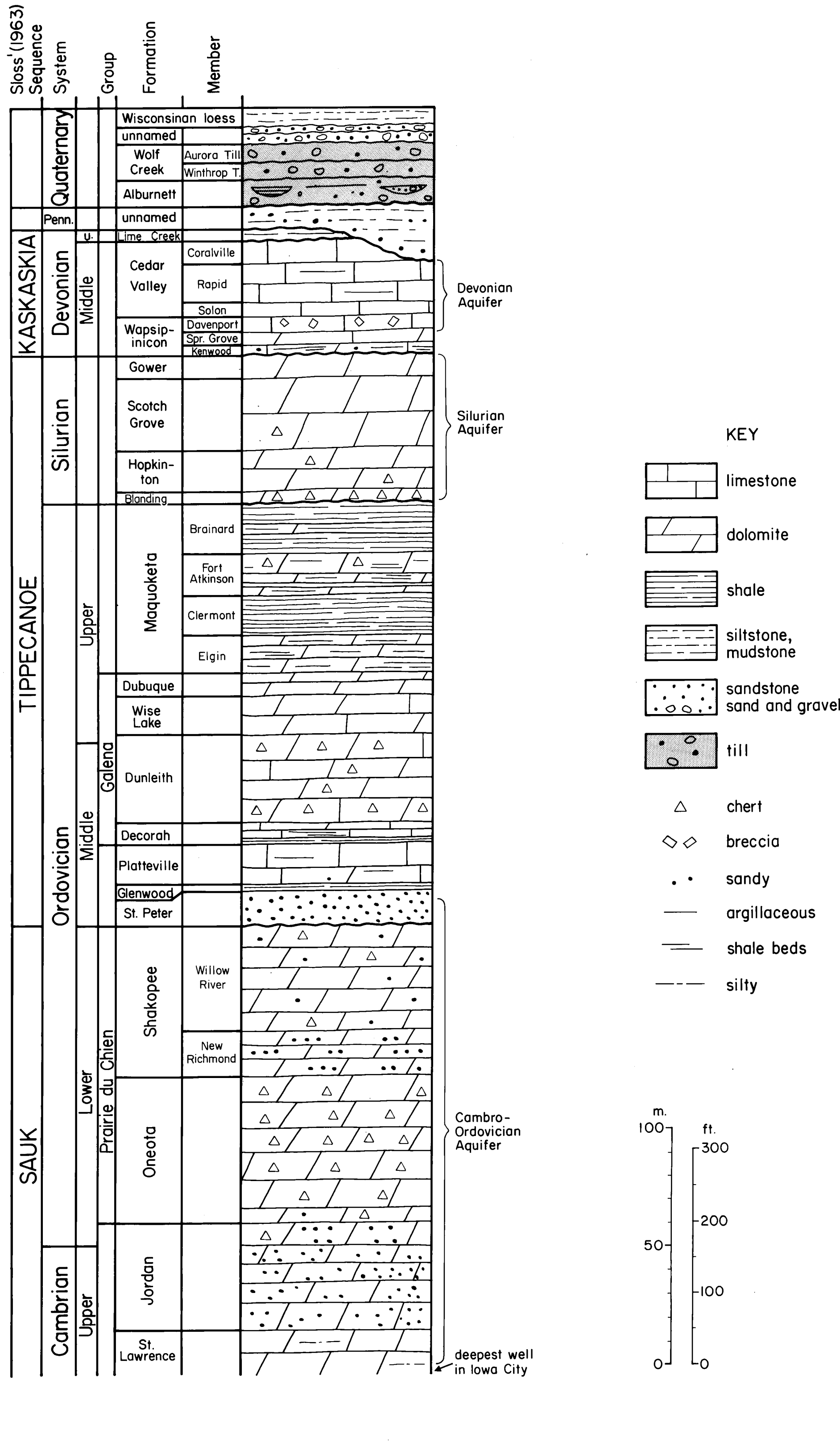


Figure 1. Generalized Upper Cambrian through Quaternary stratigraphic sequence in Iowa City. Upper Devonian through Quaternary interval is a composite section.

and Coralville have utilized this groundwater resource for municipal and other purposes.

As interpreted from bedrock exposures in the Upper Mississippi Valley, the Cambrian-Ordovician boundary is placed within the upper portion of the Jordan Sandstone interval. Although minor disconformities are noted within the Cambrian-Lower Ordovician sequence of eastern Iowa, essentially uninterrupted deposition spanned the Cambrian-Ordovician boundary in the state. The Lower Ordovician Prairie du Chien Group records the continuation of Sauk Sequence deposition in eastern Iowa.

Ordovician History

Strata of the Lower Ordovician Prairie du Chien Group represent the upper portion of the Sauk Sequence in Iowa. Prairie du Chien strata in Iowa City include cherty dolomite in the lower portion (Oneota Formation), sandy dolomite and sandstone in the middle portion (New Richmond Member), and sandy and cherty dolomite in the upper portion (Willow River Member) (fig. 1). The Prairie du Chien Group averages 130 m (425 ft) in thickness in Iowa City. These Lower Ordovician strata were deposited in an extensive shallow seaway that covered much of the North American continental interior. Following the withdrawal of the Sauk seaway from Iowa, the area was subjected to a prolonged period of subaerial erosion that lasted about 20 million years. Karst developed and valleys were incised on the Prairie du Chien surface during this erosional episode.

Seaways once again advanced into Iowa from the present-day southeast during the Middle Ordovician, marking the initiation of Tippecanoe Sequence (Sloss, 1963) deposition in the area. Iowa occupied a position in low southern latitudes at that time. A widespread sheet of sandstone, the St. Peter Sandstone, was deposited in the midcontinent area coincident with this marine transgression. The St. Peter Sandstone, an exceptionally pure quartz arenite derived from eroded Sauk and Keweenawan sandstones in the Wisconsin area, averages about 14 m (45 ft) thick in Iowa City (fig. 1). Younger Middle Ordovician stratigraphic units in Iowa City include, in ascending order (fig. 1): 1) Glenwood Shale, 3 m (10 ft); 2) Platteville Formation, 16 m (54 ft), fossiliferous shale, limestone, and dolomite; and 3) Decorah Formation, 10 m (33 ft), fossiliferous shale, limestone, and dolomite. The Decorah shales thicken to the northwest in Iowa, toward their source areas on an ancient eroding land surface along the Transcontinental Arch (Minnesota, northwest Iowa).

An extensive sheet of relatively pure carbonate rocks was deposited in a seaway that spread across the continental interior during the late Middle and early Late Ordovician. These rocks include most of the Galena Group in Iowa (Witzke, 1983a). This depositional episode has been termed "the greatest inundation in North American history" (Ross, 1976, p. 91). In Iowa City this sequence of carbonate rocks is subdivided, in ascending order (fig. 1): 1) Dunleith Formation, 36 m (120 ft), dolomite, minor limestone, part very cherty; 2) Wise Lake Formation, 17 m (55 ft), dolomite, minor limestone; and 3) Dubuque Formation, 9 m (30 ft), dolomite.

Shale and argillaceous carbonate was deposited in eastern Iowa during the latter half of the Late Ordovician, and this rock sequence is assigned to the Maquoketa Formation. Shale prograded into eastern Iowa at that time from the rising Taconic Mountains in the eastern United States. The Maquoketa Formation averages 72 m (235 ft) thick in Iowa City, where it is subdivided into four members (fig. 1). The Middle and Upper Ordovician seas supported a diversity of life, and trilobites, crinoids, brachiopods, bryozoans, and graptolites have been recognized in well cuttings and rock cores from Johnson County. The seas withdrew from Iowa near the close of the Late Ordovician, and an erosional surface developed on the Maquoketa shales.

The thickest accumulations of Lower Ordovician Prairie du Chien rocks in Iowa are noted in the southeast portion of the state, and Iowa City occupies a position along a north-south axis of Sauk Sequence thickening termed the Hollandale Embayment. Structrual reorganization occurred following the withdrawal of the Early Ordovician seas, and the former structural low in southeast Iowa became part of a structural high (the northern extension of the broad Northeast Missouri Arch). Middle and lower Upper Ordovician rocks in eastern Iowa thicken to the northeast, generally coincident with the northern extension of the Hollandale Embayment. A broad basin in eastern Iowa began to develop during deposition of Galena and Maquoketa strata (East-Central Iowa Basin). Iowa City occupied a position along the southwestern margin of this ancient basin.

Silurian History

The Silurian seas advanced into eastern Iowa from a present-day easterly direction, beginning the final episode of Tippecanoe Sequence (Sloss, 1963) deposition in the area. Iowa occupied a position between about 20° and 30° south latitude at that time. Earliest Silurian shallow marine sedimentation was restricted to ancient valleys eroded into the Maquoketa shales of east-central and northeast Iowa. As the seaway expanded to the west and southwest, a widespread sheet of carbonate rocks (Blanding Formation) was deposited across most of the state, burying the eroded surface of Upper Ordovician rocks. The Blanding Formation, a cherty dolomite sequence, represents the oldest Silurian rock unit in Iowa City (fig. 1). The Hopkinton and Scotch Grove Formations (fig. 1) were deposited in open-marine, clear-water environments inhabited by a great diversity of organisms. Fossils of green algae, sponges, stromatoporoids, corals, brachiopods, bryozoans, nautiloids, crinoids, and trilobites have been identified in rock cores of the Hopkinton-Scotch Grove interval in Johnson County. Crinoid- and coral-rich carbonate mounds ("reefs") are locally developed in the upper Scotch Grove Formation (e.g., Palisades-Kepler State Park, Linn County).

As the seaway began to withdraw from the continental interior during the Late Silurian, eastern Iowa became part of a restricted embayment (Witzke, 1983b). Faunal diversity declined as salinities increased, and laminated carbonates were deposited in the area. The laminated dolomite sequence, locally containing brachiopod-rich carbonate mound facies, is assigned to the Gower Formation. The Gower Formation is the youngest Iowa rock unit included in the Tippecanoe Sequence. Gower Formation strata are exposed in northeastern Johnson County along the Cedar River (fig. 2). The rock in that area was quarried during the mid-to-late 1800s, and was utilized for grave markers and building stones in Iowa City.

Following the withdrawal of the Late Silurian seas, eastern Iowa was subjected to a prolonged period of erosion that lasted about 35 million years. Gower and Scotch Grove strata were eroded in Johnson County prior to burial by Middle Devonian sediments, and Devonian rocks variably overlie the Gower and Scotch Grove Formations in Iowa City. The Silurian sequence was completely eroded farther to the south in Iowa, where Middle Devonian strata lie directly on an eroded surface of Ordovician rocks.

The Silurian dolomite sequence averages about 67 m (220 ft) thick in

Iowa City. The porous and fractured character of these rocks permits the utilization of this sequence as an aquifer in the Iowa City area, as well as in other areas of eastern Iowa. Numerous wells in the Iowa City area pump water from the Silurian aquifer for university, rural, and residential uses. Silurian rock units thicken to the northeast from Iowa City, toward the center of the East-Central Iowa Basin. Iowa City occupies a position along the southern margin of this ancient basin.

Devonian History

A portion of the Devonian stratigraphic sequence, the upper interval of the Cedar Valley Formation, is well exposed along the Iowa River in Iowa City. Older Devonian stratigraphic units (Wapsipinicon and lower Cedar Valley strata) are present in the subsurface beneath Iowa City, and are well exposed in areas north of Iowa City. Younger Devonian rock units occur in the subsurface south and west of Iowa City (fig. 2). Iowa occupied a position in southern latitudes during the Devonian.

Following a prolonged period of Late Silurian and Early Devonian erosion, seas once again advanced into the state during the early Middle Devonian (late Eifelian), this time from the present-day north. This seaway spread across northeast Iowa and occupied portions of the East-Central Iowa Basin area to the south, marking the initiation of Kaskaskia Sequence (Sloss, 1963) deposition in the area. However, rocks of this age are absent beneath Iowa City, which apparently remained emergent at that time. Later expansion of the seaway during the Middle Devonian (Givetian) is documented by deposition of Wapsipinicon Formation strata across eastern Iowa. The Wapsipinicon Formation in Iowa City is subdivided into three members which include, in ascending order (fig. 1): 1) Kenwood Member, 4 m (13 ft), argillaceous dolomite, shale, dolomitic limestone, in part sandy; 2) Spring Grove Member, averages about 6 m (20 ft), dolomite, laminated and petroliferous; and 3) Davenport Member, averages about 7.5 m (25 ft), micritic limestone, part highly brecciated. The Wapsipinicon Formation is an unfossiliferous carbonate and shaly carbonate sequence deposited in restricted marine environments. The Wapsipinicon includes economic evaporite deposits (gypsum-anhydrite) in southeast Iowa, indicating that hypersaline environments characterized much of Wapsipinicon deposition. Portions of the Wapsipinicon carbonate sequence in Iowa City and at many other localities in eastern Iowa are highly brecciated, especially the Davenport and Spring Grove Members. These breccias apparently formed by evaporite solution-collapse processes, as the included evaporite units dissolved coincident, in part, with lower Cedar Valley deposition. The Davenport breccias are exposed in the Conklin Quarry northwest of Iowa City, and can also be examined at exposures along the Coralville Reservoir near Lake MacBride State Park.

The highly fossiliferous limestones of the Cedar Valley Formation were deposited during the late Middle Devonian (Givetian) as open-marine seaways expanded across large areas of the central midcontinent. The classic Cedar Valley sequence in the Iowa City area is subdivided into three members which include, in ascending order, the Solon, Rapid, and Coralville. These members derive their names from localities in the Iowa City and Solon areas of Johnson County. The Cedar Valley sequence reaches thicknesses in excess of 33 m (110 ft) in Iowa City.

A general interpretation of Cedar Valley deposition developed by Kettenbrink (1973) is briefly summarized here, although alternative models and ideas have been, and will continue to be, presented. Limestones in the Solon Member

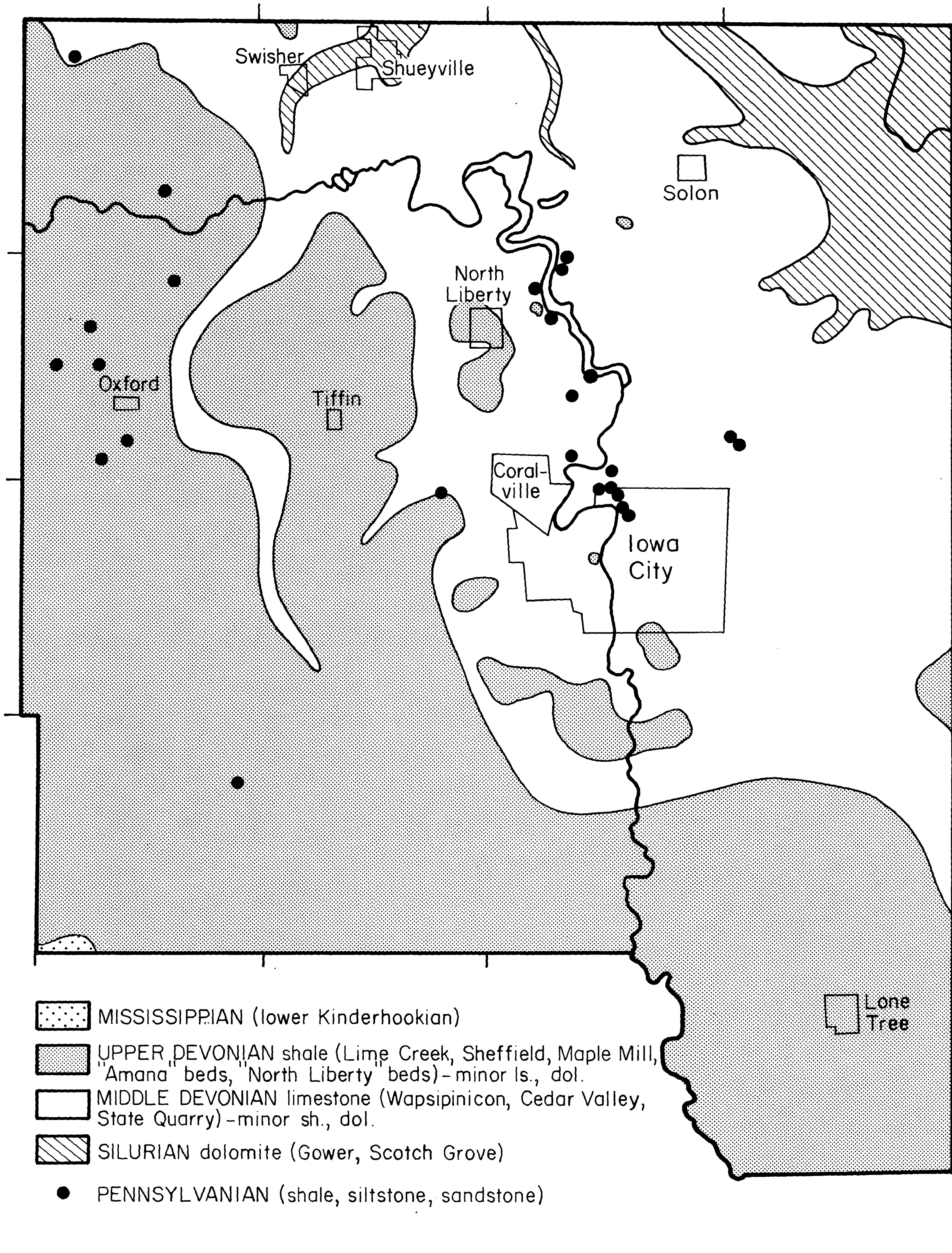


Figure 2. Bedrock geologic map of Johnson County. Tick marks along margins correspond to township and range boundaries (6 mile spacing).

Member are primarily skeletal calcarenites containing a diversity of invertebrate fossils. Crinoid debris and brachiopods are characteristically the dominant skeletal grains. These limestones were deposited during transgression of the Cedar Valley seaway, generally in agitated marine environments above effective wave base. The Rapid Member is dominated by argillaceous skeletal calcilutites containing a diversity of fossils, especially brachiopods, echinoderms, and bryozoans. The abundance of carbonate mud in the Rapid suggests that deposition generally occurred below effective wave base. As interpreted by Kettenbrink (1973), the Rapid Member accumulated during the maximum transgressive (deepest water) phase of Cedar Valley deposition. Lower Coralville strata in Johnson County are characterized by coral- and stromatoporoid-rich skeletal calcarenites, suggesting a return to shallower-water deposition above effective wave base. The upper Coralville Member is characterized by a sequence of limestones deposited in restricted marine and supratidal environments, documenting further shallowing of the Cedar Valley sea. As the seas withdrew from the Iowa City area, the Cedar Valley limestone surface was subjected to subaerial erosion. Coralville and Rapid strata were eroded over large areas of southeastern Iowa prior to their burial by Upper Devonian shales.

The State Quarry Limestone is found in areas of Johnson County lying unconformably above the Rapid or Coralville Members. Although not recognized in Iowa City, the State Quarry Limestone is well exposed to the north in the Coralville Reservoir area, where building stone blocks were quarried during the mid-to-late 1800s. Blocks of State Quarry Limestone can be seen in the Old State Capitol on campus, as well as in other buildings in Iowa City. The State Quarry Limestone is dominated by skeletal calcarenites, typically containing a preponderance of brachiopod and echinoderm grains. The State Quarry represents a marine channel facies that is incised into underlying Cedar Valley rocks. It has been interpreted to be a tidal channel sequence, deposited contemporaneously with upper Coralville strata outside the channel areas (Watson, 1974).

Fracture porosity is developed in the Middle Devonian carbonate rocks in Iowa City to varying degrees, enabling groundwater to flow through the stratigraphic interval. Shallow water wells have been developed in the Middle Devonian limestones in the Iowa City area. These strata form the productive portion of the Devonian aquifer in the region (fig. 1).

Upper Devonian shales overlie an eroded surface of Middle Devonian limestone over large areas of Johnson County (fig. 1), but these shales are not well exposed anywhere in the county. The Upper Devonian shale sequence reaches thicknesses to 82 m (270 ft) in southwestern Johnson County. The basal Upper Devonian shale unit in Johnson County is usually assigned to the Lime Creek Formation, although it has been informally labelled the "Amana beds" or "North Liberty beds" within the county by some geologists. The Lime Creek, where covered by younger shale units, varies between 7.5 and 33.5 m (25 and 110 ft) in thickness in Johnson County. It is a light green-gray calcareous shale sequence with interbedded argillaceous dolomite. It commonly includes abundant megaspores near the base. An exposure of Lime Creek shale about 1.5 m (5 ft.) thick was discovered in the 1950s on the University of Iowa campus "in an excavation below the Hillcrest Dormitory addition facing Riverside Drive," where it overlies "an irregular surface of the Coralville member" (Dow, 1959, p. 59). An abundant Upper Devonian conodont fauna was recovered from this shale (ibid.); this exposure is no longer visible.

In portions of western and southern Johnson County, the Lime Creek shales are overlain by an interval of light green-gray, light gray, and brown laminated shale, commonly containing abundant megaspores. This interval is usually assigned to the Sheffield Formation, although exact correlations are unclear. This shale interval in overlain in turn by a light- to dark-gray shale sequence assigned to the Maple Mill Shale. The Sheffield-Maple Mill sequence reaches thicknesses to 52 m (170 ft) in the county. The Upper Devonian shale interval in Johnson County is part of a widespread shale package that covers extensive areas of the eastern and central United States, and was apparently derived, in part, from source terranes on the rising Acadian Mountains in the eastern United States. The Upper Devonian shales grade into carbonate-dominated facies to the northwest in Iowa.

The early phases of Middle Devonian deposition in eastern Iowa were strongly influenced by structural patterns first developed during the Silurian in the East-Central Iowa Basin area. Structural reorganization during the late Middle and early Late Devonian is evidenced by: 1) the development of a regional unconformity in southeast Iowa (and broad areas of the eastern and south-central U.S.), and 2) the westward shift of the area of maximum subsidence from eastern Iowa to central Iowa, which marked the development of the Late Devonian Iowa Basin. Late Middle and early Late Devonian carbonate deposition prevailed in central and north-central Iowa, coincident with the development of a subaerial erosion surface in southeast and east-central Iowa. Following the withdrawal of the Late Devonian seas from Iowa, a relatively brief period of erosion ensued.

Mississippian History

Mississippian rocks are absent in Iowa City, although Early and Middle Mississippian seas undoubtedly covered the Iowa City area. Mississippian rocks are present in the southwest corner of Johnson County (fig. 2) and are well exposed south and west of the county. Iowa occupied a position in low southern latitudes during the Mississippian. The Lower Mississippian sequence in eastern Iowa includes limestones, dolomites, and siltstones. Extensive Middle Mississippian open-marine carbonates were deposited across much of the continental interior. At times when the seaway shallowed, restricted marine carbonates and evaporites were deposited, including economic deposits of gypsum in southern Iowa. Lower and Middle Mississippian rocks form the upper portion of the Kaskaskia Sequence (Sloss, 1963) in Iowa.

A prolonged period of Late Mississippian erosion, which lasted about 20 million years, removed vast amounts of older Paleozoic strata in eastern Iowa. Broad uplift of the Wisconsin Dome and Arch resulted in erosional beveling of Ordovician, Silurian, Devonian, and Mississippian strata to the northeast in eastern Iowa before the initiation of Early Pennsylvanian sedimentation. Major movements along the Plum River Fault Zone in east-central Iowa occurred prior to Pennsylvanian fluvial deposition in the area.

Pennsylvanian History

Pennsylvanian fluvial rocks are well exposed in Iowa City and are discussed in greater detail in subsequent sections of this guidebook. The sub-Pennsylvanian erosion surface in eastern Iowa includes incised paleovalleys and paleokarst. During the initial phases of Pennsylvanian deposition, the valleys and karst openings were infilled with fluvial and other nonmarine sediments. Iowa occupied a position in tropical equatorial latitudes at that time. Spores recovered from paleokarst fills north and east of Iowa City (Hiawatha, Linn County; Atalissa, Muscatine County) are of Early

Pennsylvanian (Morrowan) age. Early Pennsylvanian fluvial deposition is also documented in the Quad Cities area (Caseyville Formation), where fossiliferous mudstones, siltstones, and quartz sandstones are well exposed. Pennsylvanian deposits in Johnson County have not been precisely dated, although it is reasonable to suggest that some of them may be Lower Pennsylvanian.

Widespread nonmarine Middle Pennsylvanian deposition is documented in Iowa. The included strata are asssigned to the Cherokee Group or Spoon Formation in eastern Iowa. The Pennsylvanian sandstones in Iowa City are compositionally similar to those in the Spoon Formation of the Quad Cities area, possibly suggesting a Middle Pennsylvanian age. The Middle and Upper Pennsylvanian sequence in southern and western Iowa includes cyclic repetitions of nonmarine and marine units. These cyclic patterns of sedimentation were a response to the repeated rise and fall of sea level, probably related to the waxing and waning of continental glaciers in the southern hemisphere (Gondwanaland). Although only the basal nonmarine deposits are presently preserved in Johnson County, Iowa City undoubtedly was covered repeatedly by Middle and Late Pennsylvanian seas. Later erosion extensively stripped most Pennsylvanian deposits from the area. Pennsylvanian rocks are included within the Absaroka Sequence of Sloss (1963).

Pennsylvanian deposits in Iowa City reach thicknesses to 24 m (80 ft). A variety of Pennsylvanian rock types are recognized in Johnson County, including shale, mudstone, siltstone, sandstone, and conglomerate. The strata are commonly carbonaceous to varying degrees, and thin seams of coal have been recognized. Plant macrofossils recovered in Johnson County confirm their Pennsylvanian age. Outliers of Pennsylvanian strata are scattered in Johnson County (fig. 2), where they variably overlie Middle Devonian limestone or Upper Devonian shale.

Maximum thicknesses of Pennsylvanian rocks in Iowa occur in the southwestern portion of the state. This region is included within the Forest City Basin, a structural feature that developed during the Pennsylvanian. Eastern Iowa occupies a position across a broad structural saddle that separates the Forest City Basin to the west and Illinois Basin to the southeast.

Late Paleozoic, Mesozoic, and Cenozoic History

No deposits of Permian, Triassic, Jurassic, Cretaceous, or Tertiary age have been identified in Johnson County, and this interval of time, about 280 million years long, was apparently dominated by extensive erosion in eastern Iowa. Thick sequences of rocks of this age accumulated in areas west of Iowa, and Jurassic and Cretaceous strata are also known from portions of western Iowa. Permian seas undoubtedly spread into portions of Iowa, but subsequent erosion removed all evidence of Permian strata from the state. Seaways encroached into Iowa from the west during the Late Jurassic, and evidence of evaporitic nearshore environments are preserved in the Fort Dodge area, where economic deposits of gypsum are mined. However, pre-mid-Cretaceous erosion removed most evidence of Jurassic deposition in the state.

Cretaceous strata are preserved in portions of western and northern Iowa, but no deposits of this age are known in east-central or southeast Iowa. Base levels rose in the fluvial systems of Iowa coicident with eastward transgression of the Cretaceous sea. Fluvial sediments aggraded in the westward-flowing stream systems at that time across much of Iowa. As the seaway expanded eastward across the state during the Late Cretaceous, marine shales and chalks accumulated. The seaway spread as far east as southeast Minnesota, and it is not unreasonable to suggest that Iowa City also was covered by the Cretaceous sea during times of maximum transgression. However, a prolonged period of Tertiary erosion removed all evidence of Cretaceous marine deposition in eastern Iowa.

Eastward-flowing fluvial systems were sites of deposition during portions of the Tertiary in areas immediately west of Iowa. Although a few reworked Tertiary fossils have been found in Iowa, little evidence of Tertiary deposition remains in the state. However, beginning about 2.5 million years ago, continental glaciers advanced from the north into the state, leaving a complex stratigraphic record. Seven or more major glacial advances are recorded in the Iowa Quaternary stratigraphic sequence, and continental glaciers covered Iowa City on more than one occasion. The Iowa Quaternary was marked by episodes of both deposition and erosion. Glacial tills, alluvium, and lacustrine and eolian deposits are known in the Quaternary sequence of Iowa. Erosion surfaces and paleosols developed repeatedly during periods of non-deposition. The Quaternary stratigraphy of the Iowa City area is discussed in more detail in a later section of this guidebook.

The geologic history of the Iowa City area is both complex and fascinating. Geologists have been investigating the geology of Iowa for only 150 years, and many discoveries await further study. Only through further study will a more complete picture of the geologic history of Iowa emerge. Professional and amateur geologists alike can contribute to the ongoing task of unravelling and interpreting the many clues contained in Iowa's rock record.

HISTORY OF GEOLOGICAL INVESTIGATIONS OF DEVONIAN AND PENNSYLVANIAN STRATA IN IOWA CITY

by Brian J. Witzke

The location of the Territorial Capitol was selected in 1839 on the present-day site of the University of Iowa, and the newly established settlement was named Iowa City by previous legislative decree. Iowa City was selected as the site of the Territorial Capitol, not only because of its central position within that portion of the Iowa Territory reliquished by the Sacs and Foxes, but also because of the availability of natural building stone along the Iowa River. Limestone strata ("marble") were examined by appointed territorial commissioners in 1839 in the picturesque valley of the Iowa River near the capitol site. It was apparent that limestone quarries could be developed in Iowa City to provide building stones for the construction of the Capitol Building and to supply the town with lime and building materials.

Quarrying activity in Iowa City had commenced by 1840, when the cornerstone of the Capitol was laid. Limestone blocks shaped with a hammer were widely used for "for cellar walls, foundations, and all ordinary masonry" in the early construction of Iowa City (Calvin, 1897, p. 95). A quarry area along the east bank of the Iowa River in Iowa City, in the vicinity of the present-day President's House, is shown on the 1854 map of the city (fig. 3). The area, known then as the "Public Quarry," was the site where blocks were quarried for the early phases of construction of the Territorial Capitol (Stop 4 of this guidebook).

Studies of the Devonian Cedar Valley Formation

David Dale Owen investigated the geology in portions of eastern Iowa between the late 1830s and 1850, the first geological survey of the area. He (1852, p. 86) recognized Devonian limestone at Iowa City "forming a mural exposure of from thirty to forty-five feet" in thickness. Near the base of the exposure Owen (ibid.) identified a limestone interval "studded with fossil corals," and he listed a number of coral and stromatoporoid taxa from these beds. He suggested that the "whole mass must have been an ancient coral reef" (ibid.). He had earlier labelled the coralline beds at Iowa City the "Acervularia-Lithostrotion coral reef." Owen (1852, p. 86) recognized "a seam, three inches thick, of an earthy, carbonaceous substance, a kind of coal or humus" above the coralline beds; he also found beds containing abundant gastropods in the upper portion of the limestone sequence. Owen termed the Devonian limestones in Iowa City and other areas of eastern Iowa the "Limestone of Cedar Valley." McGee (1891, p. 319) designated a formal stratigraphic name for the sequence of Devonian limestones in eastern Iowa, stating that he would "recur to the designation originally proposed by Owen, and rechristen the entire series of calcareous Devonian sediments . . . the Cedar Valley limestone."

The James Hall survey of Iowa (1858) also investigated the Devonian strata at Iowa City. Whitney (in Hall, 1858, p. 263-264) stated that Devonian rocks, which were correlated with the Hamilton Group of New York, "are well exposed in the neighborhood of Iowa city, where there are numerous quarries which have been opened" that supply "a durable building stone." He (ibid.) recognized limestones at Iowa City which are "crowded with fossils, especially corals";

Hall and Whitney listed and described corals and stromatoporoids from these exposures.

Louis Agassiz visited the University of Iowa in 1866 and delivered a lecture entitled "Coral Reefs of Iowa City." Shortly after Agassiz' lecture, coral-rich accumulations were encountered during the construction of a mill along the Iowa River northwest of Iowa City. The new town near the mill site was named Coralville for these coral accumulations (Zawistowski, 1971, p. 5).

The White survey of Iowa (1870, p. 188) also recognized abundant corals in the limestones at Iowa City, in particular the colonial rugosan "Acervularia Davidsoni" (now referred to Hexagonaria). White referred the Devonian exposures in Iowa City to the "Hamilton Limestone." Calvin (1883) also noted coralline accumulations and identified other fossils in the limestones at Iowa City. The coral-rich beds at Iowa City were commonly referred to as the "Acervularia Davidsoni reef" in the late 1800s. Subsequent studies by Samuel Calvin (1890, 1897), professor and State Geologist, and his student G. F. Thompson (1898), further refined the Devonian stratigraphy and identified numerous fossils from exposures in the Iowa City area.

Some early residents of Iowa City were quick to realize the aesthetic qualities of the coral-bearing limestones in the area. Owen (1852, p. 79) noted that the coralline limestones have an "appearance of great beauty, when highly polished." The limestones take a "fine polish and make beautiful cabinet specimens" (White, 1870, p. 188). Artisans crafted these limestones into curios and paperweights for sale in the local "marble shops." The polished rocks were marketed under the names "Iowa marble," "Iowa City marble," and "Birds-eye marble" (ibid.; Owen, 1852, p. 79; Whitney in Hall, 1858, p. 264; Calvin, 1897, p. 99). Even though the term "Iowa marble" was listed in the U.S. Geological Survey's Lexicon of Geologic Names, "the term is in reality a petty trade-name of local curiosity vendors" (Keyes, 1934). Polished specimens of different coralline fossils were marketed under various names: Hexagonaria corals were "the common 'birds eye' of the marble shops," Favosites corals were termed "fish egg" marble, and massive stromatoporoids were known as "wavy marble" (Calvin, 1897, p. 99). The term "Bird-eye Marble" appears on the 1854 map of Iowa City in the Public Quarry area (fig. 3). The "Iowa marble" was first marketed in the 1840s and 1850s, and Calvin (ibid.) noted in the late 1890's that "the annual value of the product is not inconsiderable."

Studies of the Devonian limestones in Iowa City advanced during the 1900s. Keyes (1912, 1913) proposed a formal subdivision of the Devonian strata exposed in the Iowa City area, defining the Rapid, Coralville, and Lucas Members of the "Senecan series." The Lucas, named after the township that includes Iowa City, was defined to include the dense gastropod-bearing limestones in the upper part of the Iowa City section above the coral-and stromatoporoid-rich beds. The term Lucas was found to be preoccupied for a stratigraphic unit in the Michigan Basin, and Keyes (1931, p. 318) proposed the term "Hutchinson limestone" to replace it, "from the well known quarry on the west side of the Iowa River at Iowa City" (Stop 3 in this field guide). However, the term Hutchinson was also found to be preoccupied for a stratigraphic unit in Kansas. Stainbrook (1935, 1941a) reorganized the stratigraphic terminology of Keyes and included the "Hutchinson limestone" within an expanded Coralville Member. In 1941 he also redefined the Rapid Member, which he had originally termed the the Littleton Member in 1935, to include strata assigned by Keyes to the lower Coralville and upper Solon Members. Stainbrook's (1941a) stratigraphic definitions have been adopted subsequently by all geologists studying the Cedar Valley Formation. Although the term "Hutchinson limestone" is no

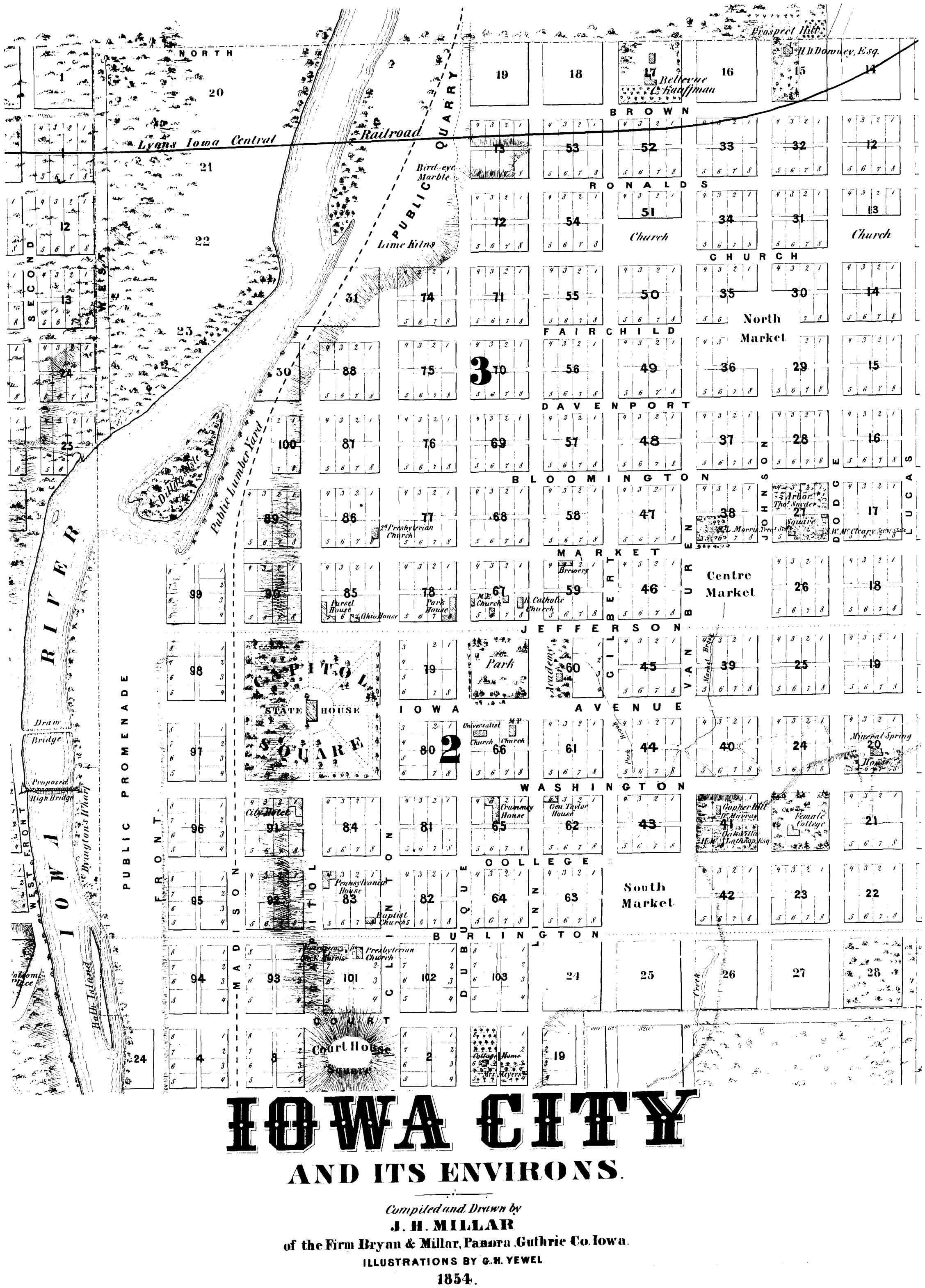


Figure 3. 1854 map of Iowa City. Lime kilns and "Bird-eye Marble" noted in the Public Quarry area (Stop 4). Full map may be purchased at Old Capitol.

longer used, "this portion of the Coralville is lithologically distinct and easily separated from the calcarenites below . . .it might be useful to follow Keyes in recognizing this portion of the section as an additional member" (Kettenbrink, 1973, p. 49).

Merrill Stainbrook extensively studied the stratigraphy and paleontology of the Cedar Valley Formation in eastern Iowa, including the Iowa City area. His faunal subdivision of the three members of the Cedar Valley remain in use today, and are utilized to subdivide portions of the Iowa City Devonian sequence in later sections of this guidebook. Stainbrook's (1938a, 1938b, 1940a, 1941b, 1942, 1943a, 1943b) studies of the Cedar Valley brachiopod fauna, including many specimens from Iowa City, are essential references for all students of Middle Devonian paleontology. Additional paleontologic and biostratigraphic studies of fossils collected from Cedar Valley strata in the Iowa City area also deserve mention: algae and foraminifera (Kettenbrink, 1973), chitinozoans (Dunn, 1959), corals (Stainbrook, 1940c; Pitrat, 1962), trilobites (Walter, 1924), echinoderms (Thomas, 1920; Calhoun, 1983), and conodonts (Downs and Youngquist, 1950; Klapper and Ziegler, 1967; Klapper in Glenister and Rexroad, 1968; Klapper, 1975). Several fossil groups represented in the Cedar Valley biota of Iowa City remain poorly studied, especially the bryozoans, stromatoporoids, and spores.

Modern studies of Cedar Valley stratigraphy, petrography, and deposition form a critical basis for much of the information presented in this guidebook. Excellent exposures of the Cedar Valley Formation are accessible in operating quarries in the Iowa City area; the Klein Quarry section west of Iowa City was described by Michael and Welp (1957), and the Conklin Quarry near Coralville was the focus of petrographic and depositional studies by Kettenbrink (1973; also Kettenbrink and Heckel, 1975). Zawistowski (1971) included information about Cedar Valley stratigraphy in the Iowa City area as part of his more detailed investigation of the coralline biostromes in the Rapid Member. The thin coal layer within the Coralville Member of campus was described by Dow (1960). Bisque and Lemish (1959) investigated the insoluble residues and magnesium content in the Cedar Valley, including the Conklin Quarry section near Iowa City.

Studies of Pennsylvanian Geology

Pennsylvanian exposures in Iowa City were first mentioned by Owen (1852, p. 87) who noted a brown "coal sandstone" on the north edge of the city. Likewise, Whitney (in Hall, 1858 p. 264) identified "limited patches of rock belonging to the Coal measures" (i.e. Pennsylvanian) in Iowa City and observed "coal plants" within these strata. McGee (1891, p. 309) described "irregularly stratified gray and brown sandstones, yielding impressions of Carboniferous plants" which "occur in a water-carved depression in the Cedar Valley limestone mid-height on the bluffs in the northern part of Iowa City." Calvin (1897, p. 80-83) also discerned the geometry of the Pennsylvanian sequence in northern Iowa City, and recognized that it occupies an "old valley" more than 24 m (80 ft) in depth incised into the Cedar Valley limestones. He described exposures of thinly laminated, shaly sandstone and sandstone in the area, which locally contain pyrite nodules, "a thin layer of coal," and plant fossils. The Pennsylvanian exposures in Iowa City were referred to the "Des Moines Series" by Kay et al. (1935).

The Pennsylvanian sandstone near the old Terrill Mill (Stop 6 in this guidebook) was "extensively quarried for building stone, but their tendency to discoloration and to split into thin laminae on weathering led to their disuse" (Calvin, 1897, p. 82). "In the early development of the city a number of houses were built of the laminated, shaly sandstone" (p. 98). Although the sandstone building blocks tended to weather in an unacceptable manner, a number of buildings in Iowa City constructed in the 1840s and 1850s remain standing today. Quarrying of the Pennsylvanian sandstone in Iowa City presumably ceased during the mid 1800s.

Dow (1959, p. 62) suggested that the shaly and silty micaceous sandstones in Iowa City represent "a beach or shallow ocean deposit." These strata, described in a later section of this guidebook, are now interpreted to be of fluvial origin.

THE DEVONIAN STRATIGRAPHIC SEQUENCE EXPOSED IN IOWA CITY

By Brian J. Witzke

Strata included in the upper Rapid and Coralville Members of the Middle Devonian Cedar Valley Formation are accessible in the valley of the Iowa River in the University of Iowa campus area. The bulk of the exposures are the remains of quarries operated during the last century, although Devonian limestone also has been excavated during sewer, road, and building construction in more recent years. Upper Devonian Lime Creek shales were once exposed in excavations for Hillcrest Dormitory, but are no longer visible. A generalized cross-section of the stratigraphic sequence in the campus area (fig. 4) illustrates the general subdivisions and gross relationships of upper Rapid and Coralville strata. The characteristic features of each subdivision within the Cedar Valley sequence will be summarized in this section. Devonian limestones are cut out by Pennsylvanian strata in the northern exposures, and are unconformably overlain by Pleistocene till or Upper Devonian shale across most of the campus area (fig. 4). Devonian strata are gently folded in the campus area, with up to 9 m (30 ft) of structural relief noted on specific stratigraphic datums.

The Rapid Biostromes

Coralline biostromes occur in the lower part of the upper Rapid Member in the Johnson County area; these were included in the upper portion of the "*Pentamerella* beds" by Stainbrook (1941a). The Rapid biostromal strata generally are not exposed in the campus area but have been recognized in the bed of the Iowa River below the Burlington Street dam during periods of low water, and sewer excavations near the Iowa Memorial Union in 1979 also encountered the Rapid biostromes. They are well exposed in the Conklin Quarry northwest of town. Two biostromes occur within this portion of the Rapid Member and form a widespread and easily traceable unit throughout the Johnson County area. The lower biostrome averages 40 cm (1.3 ft) in thickness and is an argillaceous skeletal calcilutite to calcarenite containing disordered accumulations of corals and stromatoporoids (Zawistowski, 1971; Kettenbrink, 1973). The basal portion is glauconitic (ibid.). The lower biostrome is dominated by encrusting and massive stromatoporoids, and colonial rugose corals (*Hexagonaria*) and favositid corals are also conspicuous. Some of the coral heads are abraded and overturned and are commonly encrusted by stromatoporoids (Zawistowski, 1971). Crinoid debris, algae, alveolitid and solitary rugose corals, and fish debris also occur, although whole brachiopod shells are rare to absent (ibid.). The lower biostrome is separated from the upper biostrome by about 1 m (3 ft) of crinoidal and brachiopodal argillaceous skeletal calcilutite.

The upper biostrome averages about 90 cm (3 ft) thick in the area. It is a skeletal framework of corals and stromatoporoids in a matrix of argillaceous skeletal calcilutite and calcarenite. Colonial rugose corals (*Hexagonaria*) dominate the coralline fauna, but, unlike the lower biostrome, coral heads are only rarely overturned (ibid). Solitary rugose corals (Pitrat, 1962) and ramose favositid corals also make up a significant portion of the upper biostrome. Massive favositid corals and stromatoporoids occur in the upper biostrome, but are proportionately less abundant than in the lower biostrome (Zawistowski, 1971). Additional fossils include alveolitid corals,

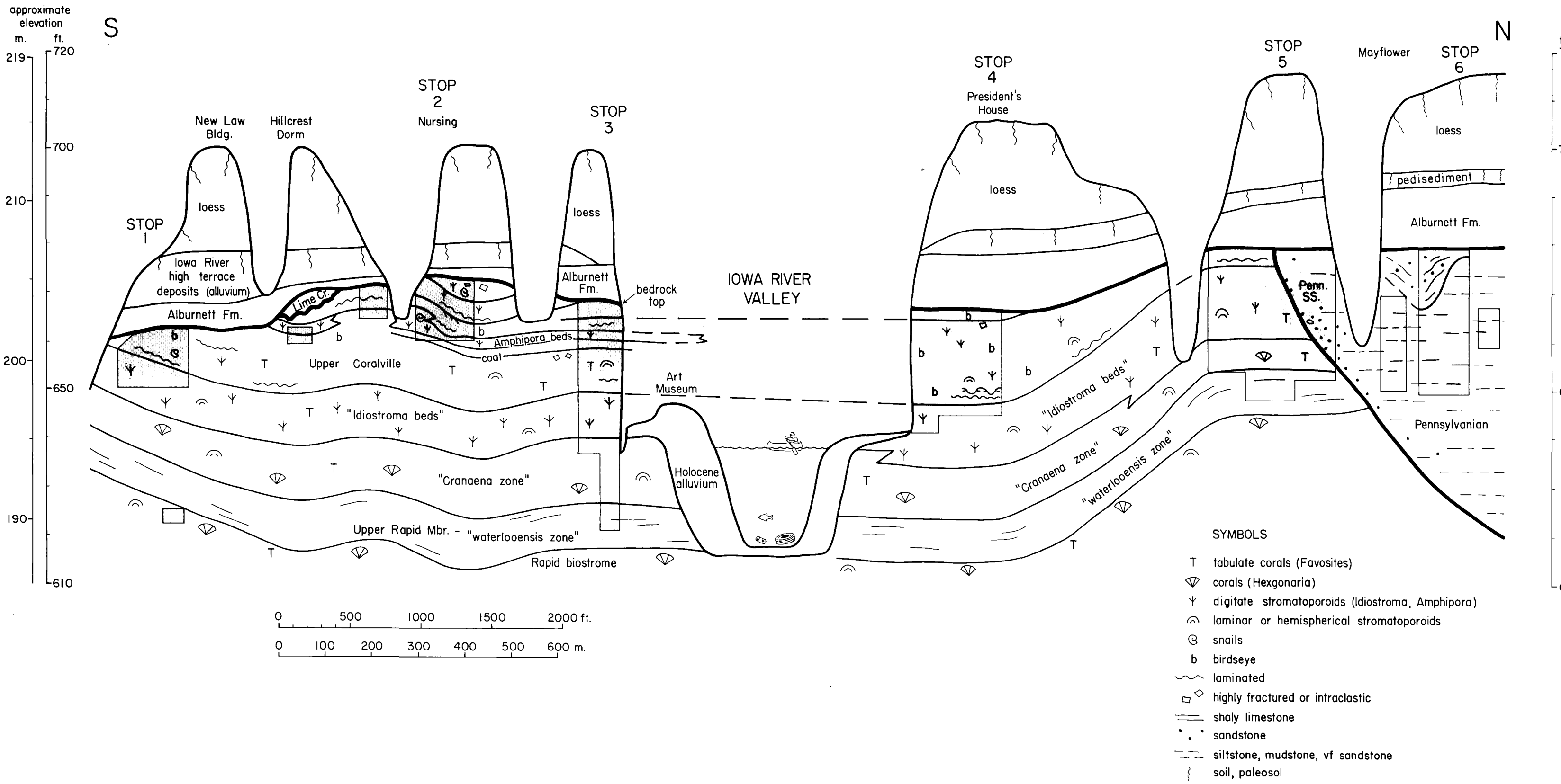


Figure 4. Generalized north-south cross-section of Devonian (Upper Rapid, Coralville, Lime Creek), Pennsylvanian, and Quaternary strata in the campus area. Shaded regions correspond to areas of bedrock exposure. Surface topography is schematic.

brachiopods, algae, bryozoans, and crinoid debris.

The Rapid biostromes faunally resemble the coral-and stromatoporoid-rich beds in the lower Coralville Member ("*Cranaena* zone"), perhaps suggesting some similarities in benthic conditions during deposition. In one interpretation, the coralline biostromes in Johnson County may have accumulated during a shallowing depositional episode. The Rapid biostromes probably correlate to a regressive (shallowing) carbonate interval in northern and central Iowa (Witzke and Bunker, 1984), lending support to this interpretation. The presence of overturned and abraded coral heads, as well as skeletal calcarenites, in the biostromes suggests either that disruption of the bottom occurred during episodic storm events or that deposition occurred, in part, near or above effective wave base. Kettenbrink (1973, p. 160) stated that the occurrences of "coral-stromatoporoid 'biostromes' in the midst of argillaceous calcilutites in the upper Rapid of Johnson County are anomalous." He did not interpret marine environments any shallower during Rapid biostrome deposition than during preceding and subsequent phases of Rapid argillaceous calcilutite deposition. Rather, Kettenbrink suggested that a "slowdown in deposition" was sufficient to explain the initiation and development of coral-stromatoporoid biostromes in the sequence. The colonial corals and stromatoporoids "flourished until overwhelmed by the next influx of detrital material" (ibid.). However, the overturned coral heads in the biostromes "indicate the presence of at least short-lived curents" during deposition (ibid.). The occurrence of minor submarine disconformities and glauconitic "lags" near the base of the biostromes lends support to this interpretation.

The "Waterlooensis Zone"

The "*waterlooensis* zone" (Stainbrook, 1941a) includes the upper 3 m (10 ft) of the Rapid Member in Iowa City. The upper half of this interval can be visited at Stop 5. The "zone" is named for the characteristic large atrypid brachiopod, *Desquamatia waterlooensis*. The strata are characterized by argillaceous skeletal calcilutites which are typically soft and crumbly on outcrop. The interval averages about 9% insoluble residues, predominantly illite (Kettenbrink, 1973). The calcilutites commonly contain about 20 to 35% skeletal grains, although thin calcarenitic lenses are also present. The unit is glauconitic and dolomitic to varying degrees. The "*waterlooensis* zone" locally contains chert nodules in the Iowa City area, but no chert has been noted at Stop 5. Some skeletal grains are partially silicified or pyritized, and disseminated pyrite occurs in the calcilutites (ibid.). The unit is extensively bioturbated (ibid.).

The "*waterlooensis* zone" contains a diversity of invertebrate fossils, with brachiopod and crinoid grains forming the greatest volume. Bryozoans also are volumetrically significant in some beds. The diverse brachiopod fauna is typically dominated by atrypids (*Desquamatia waterlooensis*), spriferids (*Orthospirifer, Eosyringothyris, Tylothyris, Crytina)*, and strophomenids *(Strophodonta)*, but many additional brachiopod taxa are noted (*Schizophoria, Athyris,* additional strophomenids, rhynchonellids, and terebratulids). Many articulated specimens of echinoderms have been collected from the "*waterlooensis* zone," including exposures in the Iowa City area. However, the great bulk of echinoderm fossils in these beds are disarticulated plates and columnals, most of which are taxonomically indeterminate. Rhombiferan cystoids (*Strobilocystites*) and blastoids (*Nucleocrinus*) have been collected from Stop 5 (Thomas, 1920), and Strimple (1970) included these beds within the "*Strobilocystites* zonule." The known crinoid fauna is diverse and includes camerates (*Megistocrinus, Melocrinites, Stereocrinus)*, inadunates *(Botryocrinus, Corematocrinus, Decadocrinus, Halysiocrinus)*, and flexibles *(Eutaxocrinus)* (Thomas, 1920; Strimple, 1970; Calhoun, 1983).

Bryozoans are common fossils in the "*waterlooensis* zone," but remain poorly studied. Ctenostomes, cryptostomes (especially encrusting fistuliporids, lacy fenestellids, and *Sulcoretopora)*, and possible trepostomes are noted (Thompson, 1998; Kettenbrink, 1973). Corals are generally uncommon in these beds, but small solitary rugosans occur, and small branching tabulates (pachyporids) are noted especially in the uppermost beds. *Tentaculites* is locally abundant in these strata (ibid.). Mollusks are generally rare; straight-shelled nautiloids from Stop 3 may have been recovered from this interval (Thompson, 1898); small gastropods are present in some beds. Scolecodonts are common in residues from the "*waterlooensis* zone," and other worm groups may have been responsible for the extensive bioturbation in the unit. Trilobites form a minor component of the fauna, primarily phacopids and proetids (Walter, 1924). The ostracode fauna remains unstudied. Chitinozoans are present (Dunn, 1959). Conodonts are common in residues from the "*waterlooensis* zone"; occurrences of *Icriodus expansus, I. subterminus*, and *Polygnathus xylus* are noteworthy. Finally, fish teeth and bones are occasionally found in these beds, primarily placoderm tritors *(Ptyctodus calceolus)* and small conical teeth (probably form acanthodian, dipnoian, and/or crossopterygian fish).

The abundance of carbonate mud and clay in the calcilutites of the "*waterlooensis* zone" indicates that winnowing processes did not operate on a regular basis during deposition. Kettenbrink (1973) suggested that deposition occurred below effective wave base, in an environment protected from significant wave and current agitation. The presence of an abundant benthic invertebrate fauna indicates that gentle water currents were needed to supply nutrients and maintain stable salinities across the bottom. The preservation of articulated crinoids in the "*waterlooensis* zone" is important to an understanding of depositional processes, since crinoids readily and rapidly disarticulate in most depositional environments. In general, episodes of rapid sedimentation are necessary to bury the crinoids before they disarticulate. However, subsequent current reworking of the sediment could not occur if the articulated specimens were to be preserved. Calhoun (1983) "proposed that storm related deposits probably account for many of the crinoid occurrences in the Rapid Member." In addition, crinoidal calcarenite lenses in the upper Rapid may be storm-related deposits. The brachiopod associations in the "*waterlooensis* zone" and lower Rapid strata were assigned to the "spiriferid-atrypid community" by Koch (1978). He suggested that this brachiopod community inhabited low-energy environments during the deepest-water phases of Cedar Valley deposition.

As interpreted by Witzke and Bunker (1984), the "*waterlooensis* zone" probably correlates to a transgressive open-marine carbonate interval in northern and central Iowa that occurs between intervals of shallower-water restricted-marine carbonates. If these regional relationships hold true, the "*waterlooensis* zone" would represent the maximum transgressive phase of a second Cedar Valley depositional cycle. Kettenbrink (1973) did not interpret upper Rapid deposition in this way, but suggested that variations in sedimentation rates could account for the faunal and lithologic contrasts between the Rapid biostromes and "*waterlooensis* zone" strata. Sedimentation apparently slowed significantly toward the end of Rapid deposition. A submarine dicontinuity surface, commonly burrowed, marks the upper Rapid surface in Johnson County and other areas of eastern Iowa. This discontinuity surface developed coincident with a widespread shallowing of the Cedar Valley seas. The surface characteristically occurs at the contact between argillaceous calcilutites below and calcarenites above, and is presently used to define the contact between the Rapid and Coralville Members.

The "Cranaena Zone"

The basal stratigraphic unit of the Coralville Member has been termed the "*Cranaena* zone" by Stainbrook (1941a). This unit can be seen at Stop 5, and uppermost "*Cranaena* zone" strata are visible at Stop 3. The interval is represented in the Iowa City area by coral- and stromatoporoid-rich biostromal strata termed the "*Acervularia davidsoni* reef" by earlier workers. This coralline unit is best developed in Iowa City, and "*Cranaena* zone" strata elsewhere in eastern Iowa include skeletal calcarenites which commonly are not coral- or stromatoporoid-rich. The unit ranges from 2.1 to 4 m (7 to 13 ft) in thickness in Iowa City. The "*Cranaena* zone" in this area is a skeletal calcarenite which includes two or more zones with abundant corals and stromatoporoids. Corals make up to 48% of the rock volume in portions of the "*Cranaena* zone" (Kettenbrink, 1973), and massive stromatoporoids are common to abundant. The matrix calcarenite is dominated by crinoid and brachiopod grains; calcareous algae, foraminifera, bryozoans, rostroconch mollusks, and other skeletal grains are noted (ibid.). The unit is slightly argillaceous.

The coral fauna in the "*Cranaena* zone" of Iowa City is dominated by colonial rugosans (*Hexagonaria*) and massive to ramose favositid tabulates. Colonial corals reach dimensions to 30 cm (12 in) in diameter. Alveolitids are present in some beds. Solitary rugosans are common and become abundant in some beds: *Tabulophyllum* and *Tortophyllum* are characteristic (Pitrat, 1962). Massive stromatoporoids are common in the interval. Although no systematic study of the stromatoporoids has been undertaken, the massive forms are usually assigned to *Stromatopora*. Corals and stromatoporoids in these biostromal beds commonly are overturned or reworked, and some specimens display one or more generations of stromatoporoid encrustation.

The "*Cranaena* zone" in the Iowa City area contains a relatively diverse brachiopod fauna (Stainbrook, 1938a, 1938b, 1940a, 1941b, 1942, 1943a, 1943b; Koch, 1978). Atrypid brachiopods are conspicuous in some of the coralline beds; *Desquamatia waterlooensis* occurs in the basal portion of the unit, and other atrypids, most apparently assignable to *Pseudoatrypa*, occur throughout much of the unit. *Schizophoria* occurs in the basal bed. Species of the terebratulid genus, *Cranaena*, from which the zone derives its name, are scattered in the unit. *Pentamerella*, a pentamerid genus, is also noted in the Iowa City exposures. Species of strophomenids (*Strophodonta, Pholidostrophia*) are common, and chonetids (*Rhyssochonetes, Chonetes*) are locally abundant (Upper bed at Stop 5). Spiriferids occur throughout much of the "*Cranaena* zone" (*Orthospirifer, Tylothyris, Cyrtina, Elita*). Athyrid (*Athyris*) and rhynchonellid brachiopods have also been reported from these beds in Iowa City (Stainbrook, 1942). Koch (1978) included the "*Cranaena* zone" brachiopod fauna within the "*Pentamerella-Orthospirifer-Cranaena* community"; he suggested this brachiopod community inhabited "high-energy" environments.

Although crinoid debris is abundant in the "*Cranaena* zone," the taxonomic composition of the echinoderm fauna remains indeterminate because of extensive disarticulation. Calhoun (1983) reported a species of the inadunate crinoid, *Botryocrinus*, from near Iowa City. Bryozoans occur in the unit, but are significantly less abundant than in underlying "*waterlooensis* zone" strata. Rostroconch mollusks (*Conocardium)* are not uncommon in the "*Cranaena* zone." Trilobites occur rarely in the upper beds at Stop 5, where *Crassiproetus searighti* has been collected recently. Several types of calcareous foraminifera and algae have been identified in these beds (Kettenbrink, 1973). Conodonts have been recovered from the upper portion of the "*Cranaena* zone" at Stop 5 and include *Icriodus expansus* and *Polygnathus* sp.

"*Cranaena* zone" calcarenites were deposited during a regressive (shallowing) phase of Cedar Valley sedimentation. Water currents were of sufficient magnitude to winnow out much of the carbonate mud, and a position generally above effective wave base has been proposed (Kettenbrink and Heckel, 1975). Overturned corals and calcarenite-filled channels with flaser bedding have been identified in the "*Cranaena* zone" of Johnson County (Kettenbrink, 1973), indicating the importance of wave-generated and/or tidal currents during deposition. The relatively abundant biota includes several stenohaline groups, suggesting that open marine salinities were maintained during deposition of the "*Cranaena* zone."

Thicknesses of the "*Cranaena* zone" and overlying "*Idiostroma* beds" are complementary in the campus area (fig. 4; compare Stops 3 and 5). These relationships suggest that the upper "*Cranaena* zone" and lower "*Idiostroma* beds" may share a partial facies relationship in the Iowa City area, as shown on figure 4. The contact between these two units is drawn at the base of the beds containing common to abundant ramose or stick-shaped stromatoporoids ("*Idiostroma*"). No "*Idiostroma*" have been identified in the "*Cranaena* zone" on campus.

The "Idiostroma Beds"

The interval in the lower Coralville Member that occurs above the coralline "*Cranaena* zone" and below the laminated, pelleted, or sparsely fossiliferous calcilutites of the upper Coralville is termed the "*Idiostroma* beds" in this report. Stainbrook (1941a) labelled this interval the "*Stromatopora* zone." Nevertheless, Calvin's (1897) term, "*Idiostroma* beds, has precedence and is more descriptive of the unit, which is characterized by an abundance of branching and stick-like stromatoporoids assigned to *Idiostroma* by most previous workers (locally known as "finger-stroms"). However, no taxonomic study has verified the generic identity of these forms. The "*Idiostroma* beds" are best developed in the Iowa City area, and the term does not have general application outside the area. Kettenbrink and Heckel (1975, p. 14) used the term in a slightly more restrictive sense than in this report, limiting it to the zone of packed *Idiostroma*. The "*Idiostroma* beds" are here used to include the entire calcarenitic interval in the upper half of the lower Coralville that contains scattered to abundant *Idiostroma*. A sharp change in lithology is noted immediately overlying the "*Idiostroma* beds," forming a convenient stratigraphic boundary. *Idiostroma* is characteristically rare to absent in the overlying unit, but is locally scattered in the lower portion.

The "*Idiostroma* beds" are exposed at Stops 1, 3, 4, and 5, as discussed in this field guide. The interval ranges from 2.9 to 4.4 m (9.5 to 14.5 ft) in thickness in the campus area. Faunal content is observed to vary both laterally and vertically within the "*Idiostroma* beds." Branching and stick-like stromatoporoids (*Idiostroma*), most about 2 to 6 mm in diameter, occur throughout the unit; they are generally extremely abundant and commonly form packstones. Locally, *Idiostroma* is only sparsely represented in some beds, especially in the top 0.5 to 1 m (1.5 to 3 ft) of the interval. Massive sheet-like and hemispherical stromatoporoids, generally termed *Stromatopora*, occur throughout the "*Idiostroma* beds," but are less abundant than the branching forms. These massive stromatoporoids typically range between 4 and 30 cm (1.5 to 12 in) in diameter, but specimens as large as 50 cm (20 in) are noted. At Stop 5, sheet-like stromatoporoids are observed to change their morphology vertically into a series of stick-like growth forms; the supposed taxonomic distinction of massive ("*Stromatopora*") and branching ("*Idiostroma*") stromatoporoids in the sequence thereby is brought into question.

Cylindrical, branching, and massive favositid tabulate corals also occur throughout the "*Idiostroma* beds"; they range from 2 to 20 cm (1 to 8 in) in diameter. Colonial rugose corals (*Hexagonaria)*, which range from 6 to 30 cm (2 to 12 in) in diameter, are not present throughout the "*Idiostroma* beds," but appear to be restricted to specific intervals within the sequence at different localities. *Hexagonaria* ranges through most of the sequence at Stop 3 but is restricted to the top 60 to 90 cm (2 to 3 ft) of the exposure at Stop 1; it is present only in the lower 1.2 m (4 ft) of the "*Idiostroma* beds" at Stop 5, and has not been recognized at Stop 4. Likewise, solitary rugose corals, ranging from 1 to 7 cm (0.5 to 3 in) in diameter, occur only within portions of the "*Idiostroma* beds" interval. They are noted in the lower 90 cm (3 ft) of the unit at Stop 3, the upper 90 cm (3 ft) at Stop 1, and the lower 60 cm (2 ft) and upper 90 cm (3 ft) at Stop 5; they are rare at Stop 4.

The "*Idiostroma* beds" represent a stromatoporoid-and coral-rich biostrome. Calcarenite is the dominant lithology. Abudant skeletal grains were produced by the "mechanical destruction of stromatoporoid coenostea" (Kettenbrink, 1973, p. 89). Calcareous foraminifera and algae form a minor component of the skeletal grains, and bryozoans are essentially absent (ibid.). Brachiopod and crinoid grains are present in portions of the "*Idiostroma* beds." Crinoid debris is evident in the lower and upper portions of the interval at some localities. Unlike the underlying "*Cranaena* zone," brachiopods are generally rare to absent in the "*Idiostroma* beds"; atrypids, spiriferids, and *Cranaena* (?) have been observed. The rostroconch mollusk, *Conocardium*, has been noted near the top of the unit at Stop 4. Conodonts have not been recovered from the "*Idiostroma* beds."

The stromatoporoid-rich calcarenites in the "*Idiostroma beds*" were deposited in agitated conditions above effective wave base. The mechanical destruction of branching and hemispherical stromatoporoids occurred in high-energy environments. Massive stromatoporoids and colonial tabulate and rugose corals are commonly overturned or randomly oriented within the calcarenites, indicating that water currents of sufficient magnitude to move objects up to 30 cm (12 in) across were operant, at least periodically, within the depositional environments. Kettenbrink (1973, p. 158) suggested that the sequence of lower Coralville calcarenites ("*Cranaena*" and "*Idiostroma* beds") "were deposited in progressively shallower and more restricted marine water, perhaps with greater salinity variations." The "*Idiostroma* beds" contain a lower diversity fauna than the underlying "*Cranaena* beds," suggesting a more stressful environment of deposition. The absence or sporadic distribution of several stenohaline biotic groups in the sequence lends support to the idea that salinity stresses may have been important during deposition. Overlying upper Coralville strata were deposited in restricted-marine and supratidal settings, which marked further shallowing and increased salinity stresses in the carbonate environments during offlap of the Cedar Valley sea.

Upper Coralville Strata

The upper Coralville Member in Iowa City represents the most complex and lithologically variable portion of the Cedar Valley sequence. The stratigraphy of the upper Coralville Member in Iowa was first discussed by Calvin (1897) and Thompson (1898), who described a sequence, in ascending order, that included: 1) gray limestone, 6 ft; 2) "upper *Idiostroma* bed," 2 ft; and 3) "white limestone," brecciated in part, and "sometimes crowded with shells of *Straparollus*" (gastropod), 20 ft. Keyes (1913) included these strata within the "Lucas" Member and the upper portion of this Coralville Member. He later reassigned the upper beds to the "Hutchinson" Member (Keyes, 1931), named after the Iowa City quarry (Stop 3 of this guidebook). Kettenbrink (1973, p. 49) divided the upper Coralville sequence at the Conklin Quarry near Iowa City into five lithologic subdivions which, in ascending order, are: 1) "gastropod-oncolite calcilutite," 1.5 m (5 ft); 2) "laminated 'lithographic' limestone," 0.9 m (3 ft); 3) "*Amphipora*-rich pelleted calcilutite," 1.5 m (4.8 ft); 4) "intraclastic calcilutite to calcirudite," 2.1 m (7 ft); and 5) "'birdseye' calcilutite," 1.5 m (4.9 ft). The upper Coralville sequence in the campus area can be roughly equated with Kettenbrink's subdivisions, although significant differences are noted.

Lower Beds. The basal portion of the upper Coralville on campus is highly variable and includes several different lithologies. Correlation between localities has proved difficult. The "*Idiostroma* beds" at Stop 1 are overlain by a 18 to 30 cm (0.6 to 1 ft) thick bed of faintly-laminated calcilutite containing scattered small favositid corals and *Idiostroma* near the top. This unit is, in turn, overlain by a 43 to 106 cm (1.4 to 3.5 ft) thick, irregular to nodular-bedded, slightly argillaceous calcilutite interval containing scattered to abundant favositid corals and some *Idiostroma* and *Stromatopora*; thin shaly partings are present in places. This interval contains dense, gastropod-bearing "sublithographic" calcilutites in the upper portion at the north end of the Stop 1 exposure. Although bedding is difficult to trace at this locality, there appears to be up to 50 cm (1.5 ft) of erosional relief developed on these beds in a broad swale-like cut-out north of the central exposures.

The old Hutchinson Quarry exposure (Stop 3) reveals a slightly different lithologic interval overlying the "*Idiostroma* beds." An irregularly-bedded unit, 1.5 m (5 ft) thick, of slightly argillaceous calcilutite with scattered thin shaly partings characterizes the lower portion of the upper Coralville at that locality. Shaly and stylolitic partings in the middle portion of the unit impart a faintly laminated appearance. The lower 50 cm (1.7 ft) locally contains scattered medium to dark brown chert nodules up to 8 cm (3 in) in diameter; these represent the only chert nodules identified in the Coralville Member of Johnson County. The irregularly-bedded limestones take on a nodular appearance in the middle portion of the unit; the calcilutite nodules are 2 to 30 cm (1 to 12 in) in diameter and are slightly darker colored than the enclosing matrix. Although generally unfossiliferous, the unit at Stop 3 locally contains scattered small favositid corals, especially in the upper portion. The unit generally resembles the slightly argillaceous calcilutite interval above the "*Idiostroma* beds" at Stop 1, but is less fossiliferous.

The basal portion of the upper Coralville is significantly different at Stop 4, the old Public Quarry area. Immediately above the "*Idiostroma* beds," a 58 cm (1.9 ft) thick, irregularly-bedded, slightly argillaceous calcilutite unit, containing scattered to abundant subhorizontal and vertical burrow mottles, is observed. Excluding the burrows, the unit is unfossiliferous. This, in turn, is overlain by a thinly-bedded to laminated calcilutite unit up to 52 cm (1.7 ft) thick. The unit is slightly burrowed near the base, and includes abundant "birdseye" fenestrae and laminations in the middle portion. This unit is erosionally truncated by overlying laminated and coral/stromatoporoid-bearing beds. Up to 35 cm (1.2 ft) of relief is developed within two small channel-shaped cut-outs visible below the President's House.

The lower beds of the upper Coralville interval at the old Sanders Quarry, Stop 5, display further lithologic variations. The beds at that locality are unfossiliferous, dense to fractured, "sublithographic" calcilutites; they are, in part, prominently "birdseye" laminated. The basal portion of the upper Coralville sequence undergoes significant facies variations within the campus area. The southern sequences are slightly argillaceous and include scattered fossils, especially tabulate corals. The northern exposures are generally unfossiliferous and become progressively less argillaceous to the north; "birdseye" laminations become prominent to the north. An episode of erosional channeling locally occurred following deposition of the lower part of the upper Coralville sequence.

Middle Beds. Strata in the middle portion of the upper Coralville sequence, below the "*Amphipora* beds," display numerous lateral facies variations and are extremely difficult to correlate in the campus area. The lower portion of the upper Coralville is overlain by a sequence of dense calcilutite, in part "sub-lithographic," at Stop 1. This interval includes some favositid corals, branching stromatoporoids, and gastropods near the base, and "birdseye" laminations are noted above in portions of the sequence. At the old Hutchinson Quarry, Stop 3, a 52 cm (1.7 ft) thick calcilutite containing scattered to abundant cylindrical favositid corals and hemispherical stromatoporoids (to 12 cm) is observed above the sparsely fossiliferous to unfossiliferous, slightly argillaceous limestone unit in the lower part of the upper Coralville. Indeterminate brachiopods are noted in the coralline beds. This unit is replaced laterally by an irregularly-bedded calcilutite containing scattered favositids, which is indistinguishable from underlying strata; a thin shaly parting is recognized at the top. The coral-bearing unit is, in turn, overlain by a thin- to irregularly-bedded unfossiliferous calcilutite 88 cm (2.9 ft) thick; this unit includes calcite-filled fractures and "stromatactis" structures, and is locally brecciated, in part. A thin coal or carbonaceous shale is present above this unit.

A thin coal bed in the upper Coralville of Iowa City was first noted by Owen, who described a seam "of an earthy, carbonaceous substance, a kind of coal or humus" (1852, p. 86). It is one of the oldest coals in North America. Dow (1960) described the coal in the campus area at Stop 2, and noted its occurrence in Hillcrest Dormitory excavations and at the Hutchinson Quarry (Stop 3); he also recorded coals in a similar stratigraphic position at other quarry localities in the Iowa City area. The coal seam ranges from 0.6 to 3.8 cm (0.25 to 1.5 in) in thickness. The coal is black to brownish-black, finely laminated, and includes shiny black and resinous reddish-brown organic material; it is calcareous to varying degrees (ibid.). Residues of the coal contain scolecodonts, fish debris, and miospores. Dow suggested that the coal is composed primarily of spore material, and proposed that it accumulated in shallow, low-oxygen waters in a restricted depositional setting. The coal grades to the north into a carbonaceous shale parting at Stop 3, and is absent in the campus area farther north. The Iowa City coal is a localized accumulation which was probably deposited in algal-rich shallow-water environments protected from oxygenating water currents in a "lagoonal" or nearshore setting.

The coal seam is overlain by 15 cm (6 in) of dense, unfossiliferous limestone at Stop 2. At the Hutchinson Quarry (Stop 3), 40 to 50 cm (1.3 to 1.6 ft) of dense, generally unfossiliferous limestone overlies the coal seam; the unit contains some skeletal debris and rare small favositids. Abundant *Chondrites* burrows are recognized at the south end of the quarry. Branching stromatoporoids appear in the overlying strata ("*Amphipora* beds") at both localities, and the upper portion of the "middle beds" of the upper Coralville probably shares a facies relationship with these strata.

The "middle beds" of the upper Coralville in the Public Quarry area (Stop 4) represent a different facies. The basal portion is a dense to vuggy limestone which is, in part, faintly laminated, and locally contains "birdseye" fenestrae; this bed infills and drapes the channel-like depressions visible below the President's House. A complex limestone unit, in part microbrecciated and containing favositid corals and hemispherical stromatoporoids, fills in the swales above the channels; it ranges from 0 to 45 cm (0 to 1.5 ft) in thickness. The largest massive stromatoporoids observed on campus occur within and adjacent to the swales; one specimen, turned 90° on edge, measures 45 cm high by 70 cm across (1.5 x 2.3 ft). The overlying unit, 95 to 130 cm (3.1 to 4.3 ft) thick, contains scattered hemispherical stromatoporoids and locally includes brachiopod-rich calcarenites in the lower portion. The middle and upper portions include scattered *Amphipora* and gastropods. These beds apparently are replaced laterally in the Public Quarry area by dense "sublithographic" limestones, in part brecciated and containing scattered "birdseye" and "stromatactis" structures. The stromatoporoid-, coral-, and brachiopod-bearing beds at this locality probably correlate, in part, to the fossiliferous unit in the lower part of the "middle beds" at the Hutchinson Quarry. The unit below the President's House is overlain by a sequence of dense limestone, in part "sublithographic" and locally containing scattered "birdseye" structures. A portion of this sequence probably correlates to the "*Amphipora* beds."

<u>The "Amphipora beds."</u> Branching stromatoporoids locally become prominent in an interval in the upper Coralville in the Iowa City area. This interval was termed the "upper *Idiostroma* bed" by Calvin (1897) and Thompson (1898). Kettenbrink and Heckel (1975) identified the slender branching stromatoporoid as *Amphipora* and termed this interval the "*Amphipora* bed." Kettenbrink (1973, p. 50, 124) identified the lithology of these beds as an "*Amphipora*-rich pelleted calcilutite," commonly containing calcareous algae and foraminifera. The "*Amphipora* beds" in the campus area display complex facies variations. The term has only local application in the Iowa City area. Strata laterally equivalent to *Amphipora*-rich beds are also discussed in this section.

At Stop 2, *Amphipora* ranges through much of the section, but only the lower beds, up to about 2.4 m (8 ft) thick, are included with the "*Amphipora* beds." *Amphipora* -bearing calcilutites and calcarenites at this locality locally contain small globular stromatoporoids, brachiopods, and gastropods. Gastropods, most of which are referrable to *Straparollus*, are locally abundant and reach dimensions to over 6 cm (2.5 in). The *Amphipora*-bearing beds interfinger with and are laterally replaced by "sublithographic" limestones at Stop 2. These limestones are sparsely fossiliferous to unfossiliferous, and are locally "birdseye"-bearing, laminated, brecciated, or intraclastic. A prominently-laminated limestone sequence replaces the "*Amphipora* beds" to the south below Quadrangle Dormitory. Fractures and "stromatactis" structures are locally infilled with laminated, ostracode-rich sediment, especially along the north end of the exposure at Stop 2. The lower sequence of *Amphipora*-bearing and "sublithographic" limestone is erosionally bevelled beneath a prominent bedding plane, and truncation of individual beds is apparent in the middle sections at Stop 2. Brecciation and fracturing is locally prominent beneath the bedding plane. Calvin (1897, p. 65) also observed gradation of the dense limestones "into a peculiar brecciated phase six to eight feet in thickness" near this locality.

Amphipora-rich beds at the Hutchinson Quarry (Stop 3) are markedly thinner than at Stop 2, ranging from 58 to 82 cm (1.9 to 2.7 ft) in thickness. The *Amphipora*-bearing calcilutites and calcarenites also contain scattered thin sheet-like stromatoporoids. The overlying beds include dense to vuggy limestones, in part faintly laminated to "sublithographic"; they contain scattered *Amphipora* and sheet-like stromatoporoids, and "stromatactis" structures are abundant in places. The beds are, in part, fractured to brecciated. These upper beds probably correlate to a portion of the lower sequence at Stop 2.

Amphipora-bearing beds are only locally developed in the Public Quarry area (Stop 4). *Amphipora* is scattered to abundant in an interval 2.1 m (6.9 ft) thick in the middle section; limestone with scattered "birdseye" structures are interbedded with the *Amphipora*-bearing beds. This sequence is replaced laterally by dense to vuggy limestones, in part "sublithographic" to brecciated. Some gastropods and hemispherical stromatoporoids occur in laterally equivalent strata at the north end of the quarry area. A dense, "sublithographic" limestone bed with scattered "birdseye" structures, occurs above the *Amphipora*-bearing beds in the Public Quarry area.

The "*Amphipora* beds" represent local accumulations of branching stromatoporoids in the Iowa City area. Kettenbrink (1973, p. 124) noted that "*Amphipora* is restricted to very shallow 'lagoonal' environments and likely to have tolerated salinity and temperature extremes greater than most other marine organisms." He suggested (p. 161) that the "*Amphipora*-rich pelleted calcilutite represents that shallowest portion of the intertidal environment in which invertebrates flourished . . ." and were probably "deposited in very shallow, calm lagoonal or 'backreef' environments." *Amphipora*-rich environments interfingered with and were ultimately buried by supratidal and shallow water environments in which salinity and temperature fluctuations were "too extreme to support life other than calcareous algae and ostracodes" (ibid., p. 162). Brief periods of emergence followed in which the carbonate sediments were erosionally bevelled, and mudcracks, "stromatactics" cavities, and fracture breccias developed. Later sedimentation infilled the fractures and cavities with laminated ostracode-bearing sediment, geopetal microspar, and blocky to bladed calcite.

Uppermost Coralville beds. The uppermost beds of the Coralville Member are well exposed on campus at Stop 2. These strata occur higher in the Coralville sequence than any known exposure of the member in Johnson County (see fig. 4, cross-section), and reach thicknesses to 2.3 m (7.4 ft). In general, they closely resemble the underlying "*Amphipora* beds" and their lateral facies equivalents. Dense, pelleted limestones, in part "sublithographic," contain scattered to abundant *Amphipora* and small globular stromatoporoids; large gastropods to 6 cm (2.5 in) are locally abundant, and rare brachiopods, probably athyrids, are noted. The beds are locally brecciated to intraclastic, and some "birdseye" structures are present. The interval is commonly fractured, and "stromatactis" cavities are abundant in places; the fractures and cavities are commonly geopetally infilled with laminated sediment, in places ostracode-rich, and blocky calcite.

A prominent bedding plane near the top of the sequence marks a possible subaerial exposure surface. The environments of deposition for the uppermost

Coralville beds are undoubtedly similar to those described for the underlying unit. Shallow restricted-marine environments in which stromatoporoids flourished were replaced laterally by shallow-water and supratidal environments that were too stressful for most invertebrate organisms. Periodic exposure of the sediments to supratidal and vadose settings resulted in the development of extensive fractures, mudcracks, and microkarst.

Upper Coralville deposition. The complex sequence of restricted-marine, supratidal, and vadose environments that developed during upper Coralville deposition is difficult to resolve. In general, wave and current activity was progressively damped in the shallowing environments of upper Coralville deposition. Favositid corals and hemispherical stromatoporoids, occasionally associated with brachiopods, lived in the most hospitable environments; salinity fluctuations probably were not extreme, and agitated water current activity was periodic. Nevertheless, many stenohaline organisms, such as the echinoderms, were not capable of surviving in these environments.
As salinity fluctuations became more pronounced and water currents were further damped, *Amphipora* thickets developed in the shallow-water environments, where abundant pelleted mud also accumulated. Further shallowing and restriction in the nearshore and intertidal environments resulted in the deposition of pelleted and intraclastic calcilutites with low biotic diversity. Ostracodes flourished in these stressed environments, and large gastropods grazed on the algae that grew in the shallow subtidal and intertidal zones.

"Birdseye"-bearing "sublithographic" limestones include scattered to abundant spar-filled bubble-like or planar voids ("birdseyes"), generally less than 2 mm in diameter and often alligned parallel to bedding. "Birdseye" structures originally form when gas bubbles are generated by decomposition of organic matter in the sediments, usually in supratidal environments. The "birdseye" calcilutites are composed of abundant small mud intraclasts with spar-filled interstices (Kettenbrink, 1973, p. 188). Upper Coralville "birdseye" calcilutites are "characterized by an almost complete lack of organisms, by the presence of multiple horizons of large mud cracks, and microkarst surfaces with associated vadose pisoliths"; they were "probably deposited completely in the supratidal environment" (Kettenbrink and Heckel, 1975, p. 5). "Birdseye" limestones are observed to interfinger with *Amphipora*-bearing beds and pelleted calcilutites on campus, indicating that mud flats and shallow-water environments existed in close proximity. At times, a series of islands and lagoons probably formed along the low-energy shoreline.

Although Kettenbrink (1973) interpreted the upper Coralville sequence to represent a progressively-shallowing depositional sequence formed during offlap of the Cedar Valley seas, the complex facies relationships apparent in the campus area suggest that multiple episodes of shallowing and deepening occurred locally. "Birdseye" beds in the lower portion of the upper Coralville were deposited as supratidal environments developed locally; erosional truncation of these beds is apparent in places. Subsequent submergence of this surface enabled corals and stromatoporoids to become established. Another shallowing episode, coincident with and following deposition of the "*Amphipora* beds," spread supratidal environments across the campus area; vadose processes affected these sediments, and erosional bevelling is noted locally. A similar sequence of depositional environments recurred above this bevelled surface, as evidenced by uppermost Coralville strata at Stop 2. Watson (1974) correlated the marine-channel calcarenites of the State Quarry Limestone with a portion of the upper Coralville sequence.

An open-marine seaway apparently existed in a basinward direction from Johnson County at that time. Final regression of the seas from the area, approximately at the close of Middle Devonian time, exposed the carbonate strata to subaerial erosion, and a regional unconformity developed in eastern Iowa.

THE PENNSYLVANIAN STRATIGRAPHIC SEQUENCE OF IOWA CITY

by Brian J. Witzke
with a section by Robert T. Kay

Pennsylvanian detrital sediments are recognized within an ancient channel incised into the Cedar Valley limestones in the northern part of Iowa City (Stops 5, 6). Similar sediments locally fill karst openings in the Devonian limestones on campus along the Iowa River Valley (Stops 3, 4). The strata are characterized by shaly sandstone, siltstone, and mudstone. The beds are cemented locally by calcite into large concretionary shapes 0.3 to 2.1 m (1 to 7 ft) in diameter. Conglomeratic sandstone with mud clasts locally occurs (Stop 5), and a thin seam of coal has been reported in Iowa City (Calvin, 1897, p. 82). Later-stage erosion has stripped Pennsylvanian strata from most of Johnson County. The basal Pennsylvanian rocks are preserved only as scattered outliers in the area (fig. 2), commonly within depressions on the Devonian bedrock surface. Pennsylvanian strata are overlain by Pleistocene deposits in Iowa City.

Pennsylvanian Channel Geometry and Sedimentary Structures

Pennsylvanian rocks in the northern part of Iowa City occur within a steep-walled channel cut into the Devonian limestones (fig. 4). The western margin of the channel is exposed at the north end of the old Sanders Quarry (Stop 5). Based on reports by Calvin (1897) and Kay et al. (1935), the channel width is as narrow as 300 m (1000 ft). A series of exposures and well penetrations within the channel indicate that it extends in a north to northwesterly direction for at least 2 km (1.25 mi), but the strata are erosionally truncated at the northern and southern ends. The southernmost exposures were observed along Kimball Road east of Dubuque Street. Up to 21 m (70 ft) of Pennsylvanian strata occur within the channel.

The Pennsylvanian rocks are horizontally bedded at most exposures, and many of the sandstone beds contain faint to prominent carbonaceous shale laminae. The horizontally-bedded strata display a slight easterly dip at Stop 6, apparently towards the channel center. Some burrow mottles are observed locally in the laminated beds. Subvertical burrows (3 to 5 mm wide by 1 to 2 cm long) cut across the laminae in some beds. The horizontally-bedded sequence contains few current-formed sedimentary structures, although some small-scale low-angle cross-sets have been observed in the excavations at Stop 6. Individual lenticular cross-beds range from 1 to 10 cm (0.4 to 4 in) in height and extend horizontally 20 to 100 cm (8 to 40 in). Series of cross-beds display mutally cross-cutting relations, and some truncate up to 5 cm (2 in) of underlying laminated strata.

A large-scale channel feature containing inclined beds of sandstone, siltstone, and mudstone truncates up to 3 m (10 ft) of the underlying horizontally-bedded strata at Stop 6. This later-stage channel-filling sequence includes a series of lenticular fine-to medium-grained sandstone beds inclined at angles to 20°. The bulk of the sequence is characterized by horizontal to inclined beds of siltstone and mudstone. Ripple marks have been recognized in the sandstones, including possible interference ripples. The complex bedding outlines a series of smaller-scale channel features that truncate strata within this upper unit. The lateral dimensions of the smaller-scale channels within the larger channel-filling sequence vary between about 4.5 and 20 m (15 to 65 ft).

Lithology and Composition of the Pennsylvanian Rocks

by Robert T. Kay

The lower interval of Pennsylvanian strata exposed at Stop 6 and along the north edge of the Mayflower Dormitory is dominantly a laminated, shaly and silty, very fine-to fine-grained sandstone. A small percentage of medium sand grains are present. The sandstones are moderately to poorly sorted and contain angular to rounded grains. Medium to dark gray silty shale laminae are common in the sandstones, and some gray mudstone beds also occur. Small-scale cross-beds and burrows are noted in places. The sandstones and shale laminae contain scattered to abundant carbonaceous plant debris. The unit is generally light medium gray, but is commonly oxidized to a light yellow orange. Leisegang occurs in the oxidized zones. Pyrite nodules, generally 0.5 to 3 cm (0.3 to 1 in) in diameter, are noted in some beds and are commonly oxidized to limonite. Calcite cements are present locally, forming large globe-shaped concretionary masses. Ironstone (limonite, siderite?) cements are noted in thin lenticular zones. Fractures in the sequence are lined locally with post-Pennsylvanian travertine. Up to 5.7 m (19 ft) of this lower interval was exposed in excavations at Stop 6, but only the upper portion is presently accessible.

Similar horizontally-bedded and laminated strata occur above the lower interval, which are bevelled by later-stage incision. This unit reaches thicknesses up to 3.4 m (11 ft) at Stop 6. It is dominantly a shaly and sandy siltstone containing some fine- and very fine-grained sand. Shale laminae are common in the siltstones and some burrowing is evident. Small-scale lenticular and cross bedded strata occur, and mudstones are more abundant than in the underlying unit. Carbonaceous plant debris is common throughout most of the interval. The unit contains pyrite and limonite nodules. Calcite and ironstone (siderite?) cementation patterns cut across bedding at various angles, but much of the unit is poorly consolidated. Leisegang is present in the oxidized zones.

The highest unit in the Pennsylvanian sequence lies above an eroded surface on the underlying siltstones. It reaches thicknesses to 3.3 m (10.7 ft), and includes a variety of lithologies, primarily siltstone and shaly siltstone. Very fine- to medium-grained sandstone lenses and inclined beds also occur, and are commonly moderately well sorted. Sandstone and siltstone beds are inclined at various angles and display a complex channel geometry. The unit contains scattered plant debris, and thin lenses of carbonaceous or coaly material occur. The channel margin at Stop 5, where it overlies the Coralville Member, includes fine- to medium-grained sandstone. These sandstones are cross-bedded, in part; they are conglomeratic in some beds, containing scattered to abundant mud clasts to 3 cm (1 in), which can be armored. Burrows and carbonaceous plant debris are present, and impressions of woody material up to 15 cm (6 in) long are noted.

The Pennsylvanian sandstones of Iowa City contain a variety of mineral grains. Quartz is the dominant grain, but thin-section analyses also identified an average of 27% feldspar grains. Compositionally, the sandstones can be categorized as arkoses and subarkoses. In addition, about 2% rock grains are present, primarily chert. Accessory heavy mineral grains include rutile, tourmaline, corundum, and zircon. The sandstones are generally micaceous, and mica grains (muscovite) are visible in shale, siltstone, and sandstone hand specimens.

Paleontology and Correlation

Fossils of "coal age" plants were noted in the sandstones at Iowa City by early workers in the area (Owen, 1852; Whitney in Hall, 1858; McGee, 1891). Calvin (1897, p. 83) identified specimens of *Lepidodendron* (scale tree) and *Calamites* (arborescent arthrophyte) in these strata. Recent collections also identified scale-tree leaves (presumably *Lepidodendron*) and fern-like foliage (*Neuropteris*, a possible seed-fern) in the lamainated shaly sandstones. Unidentified woody fossil impressions are common at Stop 5, where *Calamites* has been noted.

The limited fossil flora in the sandstones of Iowa City is highly suggestive of a Pennsylvanian age. Repeated attempts to extract spores from the unoxidized carbonaceous shaly sandstones and siltstones have failed (Bob Ravn, Charles Kithcart, pers. comm.), and more precise biostratigraphic determination of the age of these Pennsylvanian deposits is not yet possible. Additional attempts to recover spores will be made in the future.

Pennsylvanian strata are well exposed in the Muscatine-Quad Cities area (e.g., Wildcat Den State Park); the outcrop belt of these beds is present only 48 km (30 mi) to the east-southeast of Iowa City. Two stratigraphic units occur in that area: 1) the Lower Pennsylvanian Caseyville Formation and 2) Pennsylvanian Spoon Formation. The Caseyville fluvial sandstones are mature quartzarenites, whereas the Spoon fluvial sandstones are immature feldspathic litharenites (Fitzgerald, 1977). The Iowa City sandstones are compositionally unlike the Caseyville quartzarenites, but more closely resemble the immature Spoon sandstones. The Middle Pennsylvanian Cherokee Group sandstones of central Iowa also contain appreciable amounts of feldspar (1 to 7%), rock fragments, and mica (Burggraf et al., 1981), and do not resemble the Lower Pennsylvanican Caseyville quartzarenites. On lithologic grounds, the Iowa City Pennsylvanian strata are tentatively correlated with Middle Pennsylvanian strata of eastern and central Iowa.

Depositional Environments

The Iowa City channel-filling Pennsylvanian sequence was deposited in fluvial environments as base levels rose. Infilling of karstic openings in the Devonian limestone sequence with detrital sediments may have accompanied or preceded fluvial deposition. The cross-bedded and conglomeratic sandstones, as seen at Stop 5, probably accumulated within active river channels. The well-exposed, horizontally-bedded, laminated, shaly and silty sandstone sequence at Stop 6 contains few current-formed sedimentary structures. These strata are interpreted to be floodplain deposits that accumulated within the limestone-walled valley during periods of high water. Some small-scale cross-beds in the sequence probably formed when flood currents were active. The shaly laminations may have formed during periods of slack water. These sediments are not rooted; the floodplain probably was not heavily vegetated, possibly due to frequent flooding or sedimentation rates too rapid to accommodate plant growth. Freshwater or terrestrial burrowing organisms lived on or within the sediments at times.

The floodbasin deposits were incised by later channeling, perhaps when base levels dropped or as river channels migrated within the valley. The upper sequence at Stop 6 displays a series of channel cut-outs, formed when channels shifted. Inclined sandstone bodies may have accreted as point-bars along the channel margins. The upper channel-filling sequence is dominated by siltstone and mudstone, possibly suggesting that stream flow was relatively sluggish at times. Alternatively, some of the siltstone and mudstone may have accumulated as floodbasin deposits within abandoned channels.

Iowa City occupied a position in equatorial latitudes in the Middle Pennsylvanian, and the humid climate supported a cover of tropical vegetation in the area, including large scale-trees and calamites. The plant fossils found in the Iowa City strata were probably derived from environments adjacent to the valleys and in the upland regions.

QUATERNARY STRATIGRAPHY AND HISTORY OF THE IOWA CITY AREA

by E. Arthur Bettis III, Timothy J. Kemmis, and George R. Hallberg

Introduction

The Quaternary strata of Iowa record a complex history of terrestrial deposition, erosion (both glacial and subaerial), and soil formation (relative stability). The complexity of the Quaternary stratigraphy of the Iowa City area is a product of this varied history.

The following discussion first reviews the lithostratigraphy of the Iowa City area (the depositional record) involving regional units (tills, loesses) and local units (primarily fluvial deposits associated with the Iowa River). The next section briefly outlines Quaternary landscape evolution in eastern Iowa (the record of surficial erosion and soil formation). The last section presents a generalized map of the Quaternary deposits of the Iowa City area, discusses the mapping units, and describes specific Quaternary exposures and their importance to understanding the Quaternary history of the area.

Regional and Local Lithostratigraphy

The formal Quaternary lithostratigraphy of eastern Iowa is based on the stratigraphy of Pre-Illinoian glacial tills and Wisconsinan loesses because these deposits are regional in extent and thus provide "marker" units to which more localized fluvial and colluvial units can be stratigraphically related. Recent investigations (Hallberg, 1980; Hallberg, ed., 1980) have substantially revised the stratigraphy of Pre-Illinoian tills in Iowa. In the field, the tills may all look remarkably similar. Previous stratigraphic subdivision of the tills was based solely on relationships to buried soil (paleosol) "markers." Detailed geomorphic, outcrop and subsurface investigations on a regional scale combined with extensive laboratory work and careful synthesis and reevaluation of previous work has resulted in the abandonment of the classical glacial and interglacial stage terms: Kansan, Aftonian, and Nebraskan. This work demonstrated that the buried soil markers that had been used to distinguish the glacial deposits were frequently miscorrelated and that there is a much more complex sequence (i.e., more tills, more glaciations, and more buried soils) than previously recognized. Today all Quaternary deposits older than Illinoian are referred to in a time-stratigraphic sense as Pre-Illinoian Stages undifferentiated.

Documentation of the lithology of the Pre-Illinoian till package, based on laboratory analyses of clay mineralogy, matrix texture (percent sand, silt, clay), matrix carbonate mineralogy, and sand fraction lithology, has allowed development of a rational lithostratigraphy. The defined lithostratigraphic units can thus be characterized and correlated on the basis of their lithologic (in this case, laboratory-derived) properties and physical stratigraphy. The Pre-Illinoian tills are now divided into two formations, the Wolf Creek Formation and the older Alburnett Formation, based on differences in clay mineralogy. Both formations are dominated by expandable (smectite) minerals in the clay fraction, but the Wolf Creek Formation has a much higher expandable clay mineral content (averaging 60 percent) than the Alburnett Formation (averaging 45 percent; Table 1). Localized alluvial, colluvial, and eolian deposits associated with the tills are included as part of the respective formations, and have not yet been given separate lithostratigraphic designations (Hallberg, 1980; Hallberg et al., 1980).

Each formation consists of multiple till units and paleosols (Table 2). Thus, the Alburnett and Wolf Creek Formations are lithostratigraphic units, and not time-stratigraphic units. The tills of the Wolf Creek Formation can be further differentiated into members, based on differences in matrix texture and matrix carbonate content (Hallberg, 1980; Hallberg et al., 1980). Members of the Wolf Creek Formation are, youngest to oldest, the Hickory Hills Till Member, the Aurora Till Member, and the Winthrop Till Member. Where complete sequences are preserved, buried soils are developed in the top of the till members and local overlying sediments (Table 2). The buried soil that occurs stratigraphically beneath the Hickory Hills Till Member and is developed in the upper part of the Aurora Till Member and associated overlying local sediments is the Dysart Paleosol (Hallberg, 1980). The buried soil occurring stratigraphically beneath the Aurora Till Member and which is developed in the upper part of the Winthrop Till Member and associated overlying local sediments is the Franklin Paleosol.

The Alburnett Formation also contains multiple till units. At present, there are no recognizable lithologic differences between these till units, and so they are not formally subdivided into members. The Alburnett and Wolf Creek Formations are strictly lithostratigraphic units. They do not correspond to time-stratigraphic stages such as Kansan and Nebraskan. The multiple tills and paleosols as well as the wide range of dates for volcanic ashes interbedded with the tills in southwestern Iowa and adjacent areas indicate numerous glacial and interglacial stages during what were formerly classified as the Nebraskan, Aftonian, and Kansas Stages (Boellstorff, 1978; Hallberg, 1980; Hallberg et al., 1980).

Wisconsinan eolian deposits, dominantly loess (windblown silts), but locally including sands, mantle uplands and older terrace deposits over much of Iowa (Ruhe, 1969; Prior, 1976). Where the full eolian sequence is preserved, the deposits consist of two increments: a very thin lower unit, and a markedly thicker upper unit (Table 2). Neither increment has been given formal stratigraphic definition in Iowa, and they are referred to by several different informal names (Ruhe, 1969; Hallberg et al., 1978a; Hallberg, 1980; Hallberg, ed., 1980). The lowermost loess increment typically varies from 0.3 to 1.0 m thick over much of east-central Iowa. It typically is sandier than the overlying loess increment, reflecting an additional component of local hillslope sediments derived from erosion of and biogenic mixing with underlying glacial, fluvial, or colluvial deposits. The lower increment is generally leached of primary carbonates, and incipient soil development has taken place, often merging with the soil previously developed in older, underlying deposits. The soil developed in the deposits of this lower loess increment is usually referred to as the "Basal loess paleosol" (Hallberg, 1980). The Basal loess paleosol is variable from site to site. In a few cases it exibits recognizable soil structure and soil horizons, and may have a distinct dark brown to grayish brown organic-rich A horizon. Most commonly, however, it merely contains very small scattered charcoal flecks and exhibits weak granular or platy soil structure, which contrasts with the more massive, lighter colored overlying loess of the upper increment.

The upper increment of eolian deposits is significantly thicker than the basal increment, generally ranging from 2 to 8 m thick in the Iowa City area. Eolian sands frequently occur in the lower or middle portions of this increment, but the bulk of the unit is composed of loess. The upper increment is informally referred to as Wisconsinan loess in Iowa (Ruhe, 1969). With depth,

Table 1. Summary of clay-mineralogy data for the the Wolf Creek and Alburnett Formations from eastern Iowa (data from Hallberg, 1980; Hallberg, ed., 1980).

	Clay Mineralogy*		
	Ex.	ILL.	K + C
		%	
	Wolf Creek Formation (N=476)		
Mean	61	18	22
s.d.	4	3	3
(range)	(50-74)	(4-24)	(14-34)
	Alburnett Formation (N = 207)		
Mean	43	25	32
s.d.	6	4	4
(range)	(28-51)	(15-35)	(21-48)

*Ex = expandable clay minerals; Ill = illite; K + C = kaolinite plus chlorite

Table 2. Present stratigraphic nomenclature for the Iowa City area.

Time Stratigraphy		Rock Stratigraphy	Soil Stratigraphy
PLEISTOCENE SERIES	WISCONSINAN STAGE	Wisconsinan loess (upper increment)* Basal loess sediments and peat (lower increment)*	Basal loess* paleosol
	SANGAMON through YARMOUTHIAN STAGES	unnamed sediments;* includes Late-Sangamon Pedisediment and Alluvium, and Yarmouth-Sangamon sediments.	Late Sangamon and Yarmouth-Sangamon Paleosols
	PRE-ILLINOIAN STAGES (undifferentiated)	WOLF CREEK FORMATION (including unnamed, undifferentiated sediments) Hickory Hills Till Member Aurora Till Member Winthrop Till Member	Dysart Paleosol Franklin Paleosol Westburg Paleosol
		ALBURNETT FORMATION unnamed sediments unnamed till members	

*Informal names

systematic changes in color and carbonate status (leached or unleached) may occur. These are related to weathering zones and loess thickness variations (Hallberg et al., 1978b). The modern soil has developed in the top of the Wisconsinan loess.

Various deposits associated with the Iowa River occur in the Iowa City area. These deposits have not yet been given formal lithostratigraphic definition. These deposits occur in three different groups of terraces in the valley. The oldest group of terraces is pre-Wisconsinan in age. This group is referred to as the "Early Phase High Terrace of the Iowa River" (EPHT) (Esling, 1984). Deposits of the EPHT consist of a generally fining upward alluvial sequence which have a "Late Sangamon" paleosol developed in their upper part. These terrace deposits are mantled by both increments of Wisconsinan eolian deposits. The Late Sangamon paleosol and overlying Wisconsinan loess increments indicate that these fluvial sediments were deposited prior to the late-Wisconsinan. Geomorphic relationships suggest that the terrace deposits are the depositional equivalent of the Late Sangamon erosion surfaces on the uplands (Esling, 1984).

There is no buried soil developed in the deposits of the next youngest group of terraces, the "Late Phase High Terrace of the Iowa River" (LPHT) (Esling, 1984). These terrace deposits are mantled by Wisconsinan loess, but the loess is thinner than on the EPHT, and the basal loess increment is usually absent. Thus, these deposits are late-Wisconsinan in age, and probably contemporaneous with the deposits which regionally constitute the lower loess increment. These terrace deposits are, in part, the depositional correlatives of the Wisconsinan (Iowan) erosion surfaces (Esling, 1984).

The youngest group of terraces in the valley are latest Wisconsinan and Holocene in age. A series of low terraces lacking a loess cover and including the present floodplain constitute this group (Esling, 1984). Deposits in this group usually consist of a basal increment of sand and gravel which fines upward into silty and loamy deposits.

Quaternary Landscape Evolution

The landscape in the Iowa City region has been evolving since the end of the Pre-Illinoian glaciations. Well-integrated drainage has developed and the landscape is comprised of a consistent set of multi-leveled, stepped erosion surfaces which differ in age (Ruhe, 1969; Hallberg et al., 1978a). These stepped surfaces indicate that the erosional development of the landscape was episodic, with periods of relatively rapid downcutting followed by periods of relative stability, rather than continuous, uniform erosion since the last Pre-Illinoian glaciation. There are four groups of surfaces (Figure 5), as one descends from the divide to the valley floor (where parts of all of the surfaces have been preserved): the Yarmouth-Sangamon surfaces, Late Sangamon erosion surfaces, Wisconsinan or "Iowan" erosion surfaces, and the Holocene alluvial valley floor (Hallberg et al., 1978a; Ruhe, 1969).

The loess-mantled, Yarmouth-Sangamon surfaces remain as narrow, nearly flat upland divides in this area. These surfaces may be a remnant of the youngest Pre-Illinoian drift plain which was subjected to weathering (soil formation) and local modification until burial by Wisconsinan loesses. Generally, a thick, gray (poorly drained) soil (now buried) formed in the surficial deposits of this surface. This soil was named the Yarmouth-Sangamon Paleosol (Ruhe et al., 1967) because it was presumed to transgress Yarmouth through Sangamon time.

Late Sangamon surfaces consist of a series of stepped erosion surfaces cut into, and inset below the Yarmouth-Sangamon surfaces of the primary

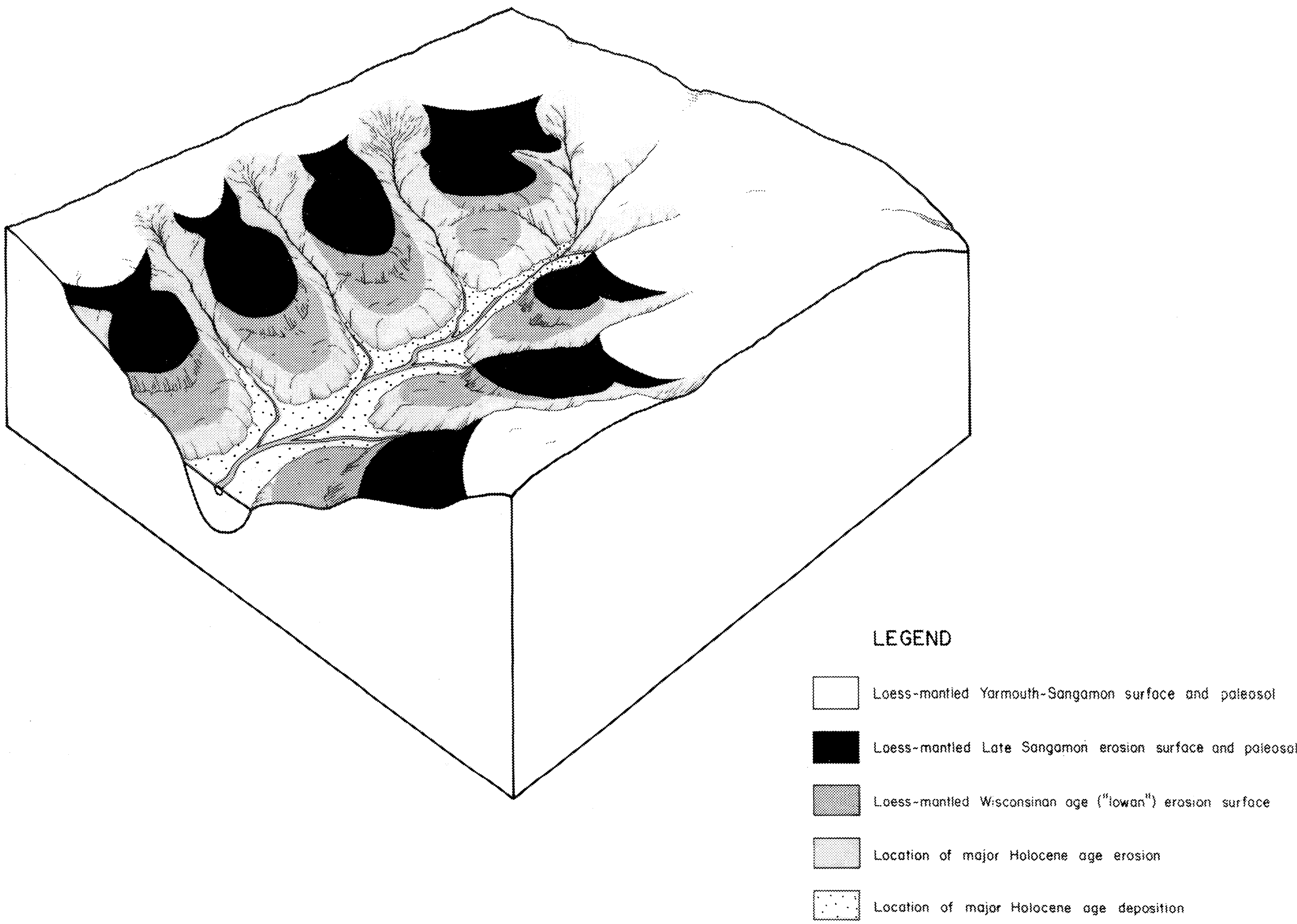


Figure 5. Schematic diagram of stepped erosion surfaces in an idealized low-order drainageway in eastern and southern Iowa.

divides. The break between the Yarmouth-Sangamon and Late Sangamon surfaces is marked by topographic, geomorphic, and pedologic discontinuities (Ruhe et al., 1967; Hallberg et al., 1978a). In this area Late Sangamon surfaces consist of gently sloping, loess-mantled pediments. Today, only remnants of these surfaces are present, preserved as a step (level) down along interfluves. In some areas, many elements of the Late Sangamon landscape may be preserved, from the pediment to the valley-slope fan to the floodplain (Ruhe et al., 1967). Seldom are large segments of this paleo-landscape exposed because of the mantle of Wisconsinan loess. After, and in part during, the latter stages of the cutting of the Late Sangamon erosion surfaces, a soil formed, indicating a change to relatively stable hillslope conditions. This soil, called the Late Sangamon paleosol, continued to develop until buried by the Wisconsinan loesses. Late Sangamon paleosols are distinctive. They are generally less weathered, have thinner sola, and are better-drained than Yarmouth-Sangamon Paleosols, and usually exhibit red to red-brown colors (Ruhe et al., 1967; Hallberg et al., 1978a, 1980). Upland Late Sangamon paleosols are typically developed in multiple parent materials: 1) an upper unit of pedisediment--a sediment derived from the erosion of the surface upslope which has been transported down the pediment; 2) a stone line or gravel lag marking the pediment-erosion surface; and 3) underlying glacial deposits (Ruhe, 1960; Ruhe et al., 1967).

In the Iowa City area many elements of the Late Sangamon landscape are preserved beneath a Wisconsinan loess mantle. Detailed work by Esling (1984) south of Iowa City as well as certain exposures in and around Iowa City indicate that the EPHT of the Iowa River, at least in part, was deposited during cutting of the Late Sangamon erosion surfaces on the uplands. Late Sangamon paleosols are developed on the deposits of this terrace level.

Inset below the Late Sangamon surfaces is another set of erosion surfaces, the Wisconsinan or "Iowan" erosion surfaces. The break between the late Sangamon and the Wisconsinan erosion surfaces is again marked by topographic, geomorphic, and pedologic discontinuities. In this area the Wisconsinan erosion surfaces consist of short, gently sloping, loess-mantled pediments which are generally shorter in length than the Late Sangamon pediments. Again, only remnants of the Wisconsinan erosion surfaces are present, preserved as steps or levels down the interfluves. These erosion surfaces represent a renewed period of relatively rapid downcutting. They are again marked by a stone line or gravel lag which caps the pediment-erosion surface and by a thin increment of overlying pedisediment. The erosion surfaces were being cut during the period of Wisconsinan loess deposition in Iowa. This is shown both by younger radiocarbon dates at the base of the loess on the Wisconsinan erosion surfaces in this area (as compared to those on the adjacent Yarmouth-Sangamon and Late Sangamon surfaces) and by the thinner increment of loess on the Wisconsinan surfaces (Ruhe et al., 1968; Hallberg et al., 1978a). Loess was continuously being deposited on the relatively stable Yarmouth-Sangamon and Late Sangamon surface while early increments of loess were eroded away, along with the older sediments, in lower portions of the landscape while the Wisconsinan erosion surfaces were actively developing. During the deposition of Wisconsinan loess, the Wisconsinan or "Iowan" erosion surfaces stabilized and the youngest portion of the upper loess increment was deposited on them. No buried soil is found on these surfaces. Erosion was great enough to remove all of the Late Sangamon or Yarmouth-Sangamon Paleosols which might have been present. A soil was not formed on these erosion surfaces in this area because they were immediately buried by loess after stabilization.

Most of the literature on the Wisconsinan erosion surfaces refers to these areas as the "Iowan surface" (Ruhe et al., 1968; Prior, 1976), "Iowan Erosion Surface" (Ruhe, 1969; Hallberg et al., 1978a), and "Early Wisconsin pediment" (Ruhe et al., 1967). In fact, this "surface" actually consists of a set of surfaces or levels of similar geomorphic and stratigraphic setting (Fenton, 1966; Ruhe, 1969; Hallberg et al., 1978a); i.e., there are often multiple levels or pediments associated with this general period of erosion. (This also appears to be the case with the Late Sangamon "surface.")

Deposits making up the LPHT of the Iowa River exibit stratigraphic relationships identical to the Wisconsinan erosion surfaces. They cut into (and usually through) older, Pre-Illinoian deposits, do not have a soil developed into them and are usually buried by a thinner and less complete Wisconsinan loess sequence (Esling 1984). Often the upper part of these alluvial deposits interfingers with the loess. The Wisconsinan erosion surfaces descend to and merge with the LPHT. The LPHT then is the valley depositional correlative of the upland Wisconsinan "Iowan" erosion surfaces.

A final episode of downcutting to the Holocene alluvial valley has occurred since deposition of the Wisconsinan loess. The alluvial valleys also consist of a series of multiple, often subtle terrace surfaces of different age.

In different areas of the state different geomorphic surfaces may dominate the landscape (Hallberg et al., 1980, 1978a; Ruhe, 1969). In much of east-central through southern Iowa the loess-mantled Late Sangamon surfaces are dominant. In the Iowa City area, near the Iowa River, development of Late Sangamon erosion surfaces was so extensive that virtually none of the original Yarmouth-Sangamon surface area survived. The depositional equivalents of the Late Sangamon and Wisconsinan erosion surfaces are found in the loess-mantled Early and Late Phase High Terraces of the Iowa River.

A Quaternary Materials map of the Iowa City Area

Stack-unit maps (Kempton, 1981) are a convenient way of describing the vertical and horizontal succession of materials across an area. On the accompanying map (Figure 6), the units consist either of one symbol or two symbols separated by a horizontal line. Where there are two symbols, the upper symbol stands for the surficial material while the symbol beneath the line indicates the next underlying material. Because of poor subsurface control in much of the area only the surficial and immediately underlying materials were mapped. The following is an explanation of the map units and the variability found with the units.

$\frac{\text{wl}}{\text{pit}}$ - Two to eight meters of Wisconsinan loess burying Pre-Illinoian till (undifferentiated). The till may have a Late Sangamon or Yarmouth-Sangamon paleosol developed into it (Late Sangamon or Yarmouth-Sangamon surfaces) or the paleosols may be erosionally truncated (Wisconsinan "Iowan" erosion surfaces). On Late Sangamon and Yarmouth-Sangamon surfaces the basal increment of the loess is present but this increment is usually missing on the Wisconsinan erosion surfaces. Lenses of eolian sand are often present in the upper Wisconsinan loess increment.

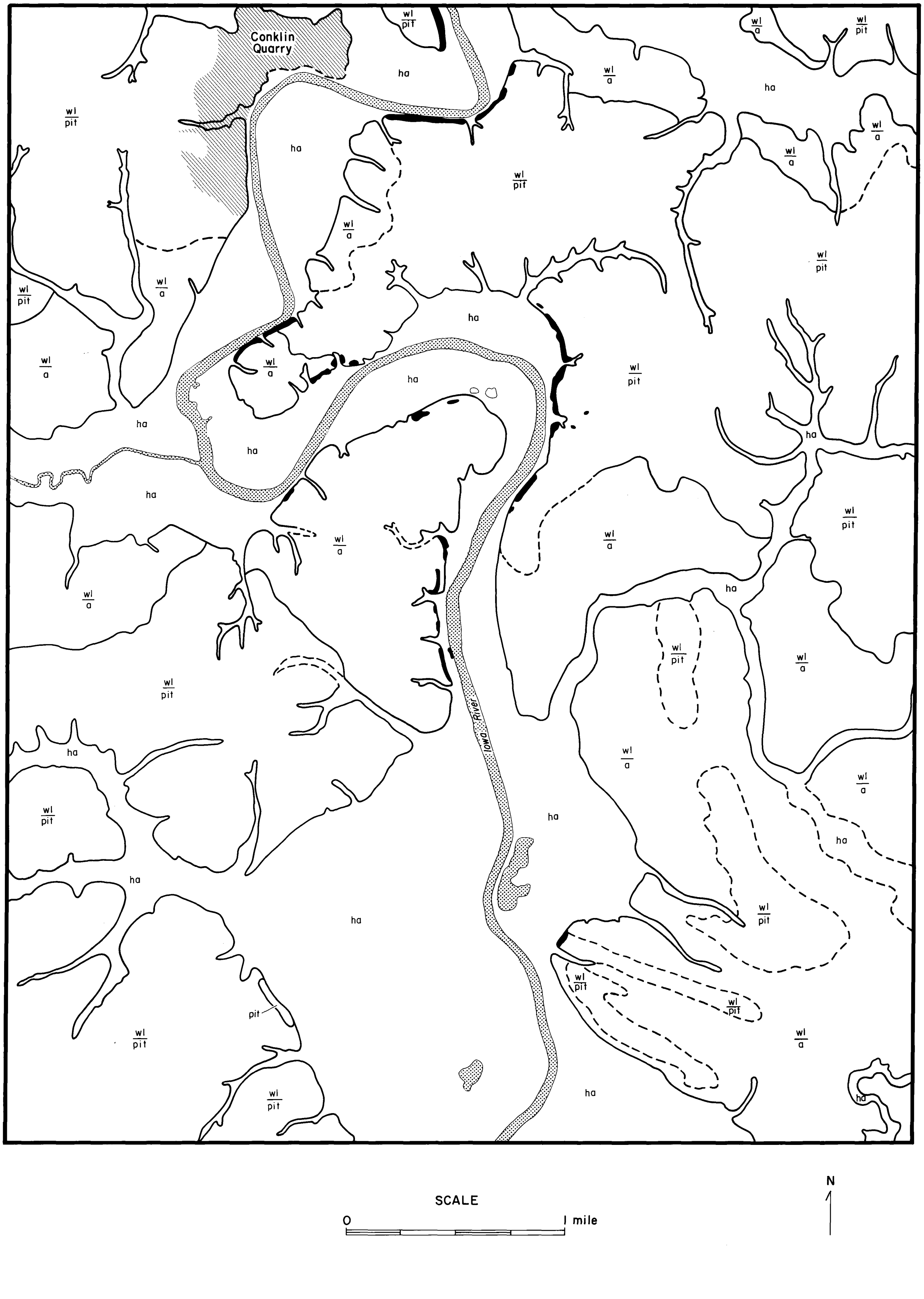
pit - Pre-Illinoian till (with paleosol erosionally truncated) at the surface. This is a Holocene erosion surface.

wl/a -Two to seven meters of Wisconsinan loess burying Iowa River High Terrace alluvium (undifferentiated). The alluvium may have a Late Sangamon paleosol developed in it (Early Phase) or a paleosol may be absent (Late Phase). Often the Late Phase High Terrace overlaps the Early Phase High Terrace, burying the Late Sangamon paleosol developed in the Early Phase deposits (Figure 7). This map unit also includes: 1) local side-valley alluvium which accumulated during development of the High Terrace system; and 2) small isolated areas of Pre-Illinoian till with Wisconsinan erosion surfaces developed on them. Both increments of the Wisconsinan loess are present on the Early Phase terraces while the lower increment is usually missing on the Late Phase terraces. Lenses of eolian sand are often present in the upper loess increment. Late Phase High Terrace deposits often interfinger with or grade upward into the upper loess increment.

Figure 6. Generalized stack-unit map of Quaternary deposits in the Iowa City area (see Figure 8 for base map).

<u>Legend for Stack Units</u>

	bedrock; Devonian carbonates and small areas of Pennsylvanian siltstone, mudstone, and sandstone
wl/pit	2-8 meters of Wisconsinan loess over Pre-Illinoian till; till may have Late Sangamon paleosol developed into its surface or the paleosol may be truncated (Wisconsinan "Iowan" erosion surfaces)
pit	Pre-Illinoian till
wl/a	2-7 meters of Wisconsinan loess over Iowa River High Terrace alluvium; alluvium may have a Late Sangamon paleosol developed into its surface (Early Phase High Terrace) or the paleosol may be absent (Late Phase High Terrace); small areas of Pre-Illinoian till with Wisconsinan "Iowan" erosion surfaces developed on them are included in this unit
ha	Late Wisconsinan and Holocene alluvium


Conklin Quarry
Iowa River
wl
pit
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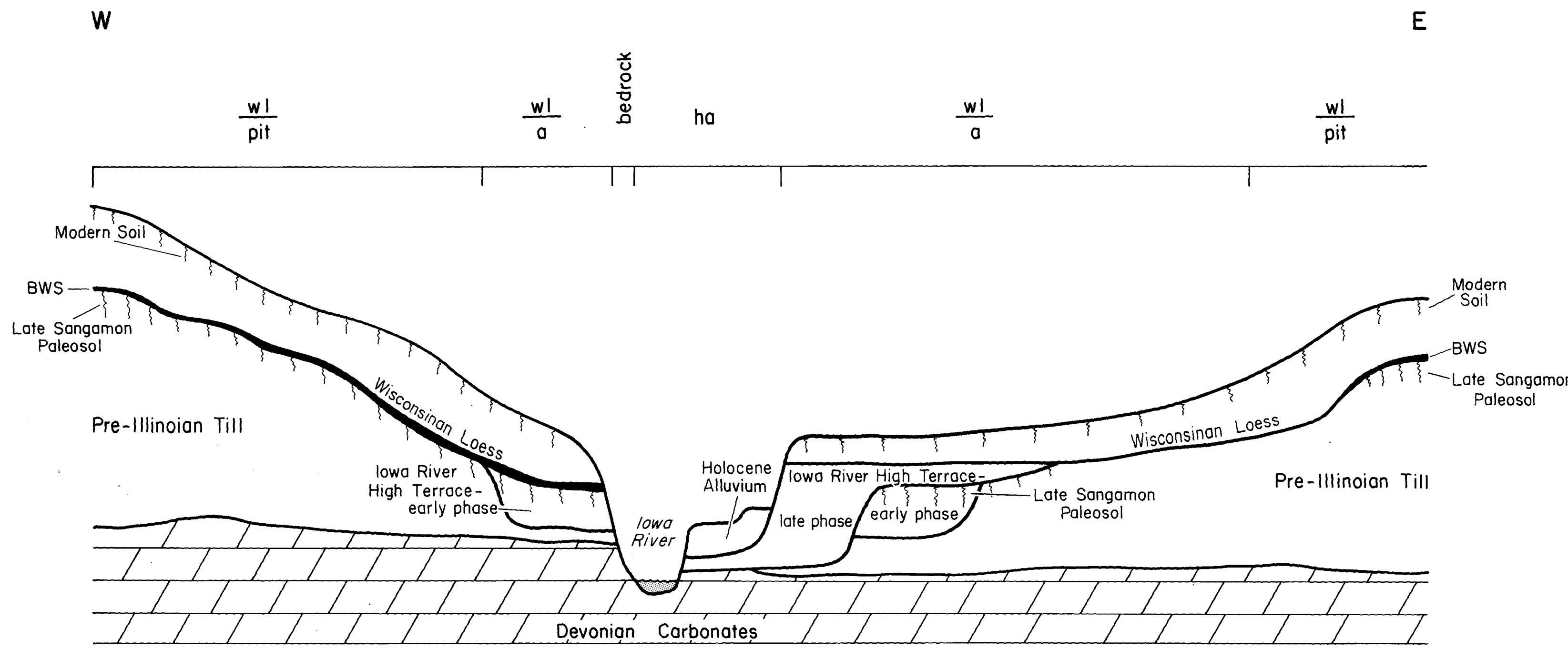

Figure 7. Idealized west-east cross section through Iowa City.

ha - Late Wisconsinan and Holocene alluvium. This unit often contains multiple terrace levels. A loess cover is absent from these areas. Generally the lower portions of this alluvium contain gravel grading upward into sand, silt, and clay. Thicknesses of this unit are variable and not known in detail.

The solid symbol indicates rock outcrop. Devonian carbonates dominate these outcrops, but exposures of Pennsylvanian siltstone, mudstone, and sandstone are present in the vicinity of the Mayflower dormitory along North Dubuque Street.

Figure 7 presents an idealized east to west cross section through Iowa City showing stratigraphic relationships between the map units.

Selected Exposures of Quaternary Deposits

Several exposures of Quaternary deposits are present in the Iowa City area. With the exception of quarry exposures such as those at Conklin Quarry (Hallberg et al., 1984) and Klein Quarry (Canfield et al., 1984), most of these outcrops are short lived. The following discussion focuses on four well-documented exposures, two of which no longer exist.

The two existing exposures are in areas mapped as wl/pit. These exposures show both Wisconsinan loess increments over Late Sangamon erosion surfaces and paleosols developed on and into Pre-Illinoian tills, although different till units are present at the two sites. The first exposure is located in a borrow pit on the northwest side of Highway 1 northwest of the Iowa City Municipal Airport (C on Figure 8). A detailed description of the deposits exposed in this pit is given on Table 3. Clay mineralogy indicates that the till in which the Late Sangamon paleosol is developed is Wolf Creek Formation (58% expandables, 16% Illite, 26% Kaolinite + Chlorite; compare to Table 1). A stone line at the base of the lower increment of the Wisconsinan loess indicates that a Wisconsinan erosion surface developed on and partially truncated the Late Sangamon paleosol. The basal loess paleosol is developed in the lower increment of the Wisconsinan loess in this exposure. A modern surface soil is developed into the upper meter of the upper loess increment. Another exposure of the Late Sangamon erosion surface is present in an excavation made for construction of condominiums just north of the Mayflower dormitory along North Dubuque Street (Stop 6 on Figure 8). At this location the Late Sangamon erosion surface is developed on Pre-Illinoian till (diamicton) of the Alburnett Formation (42% expandables, 20% Illite, 38% Kaolinite + Chlorite; compare to Table 1). Two Alburnett Formation tills are present in this exposure, separated by faulted and deformed alluvium (Figure 9). The lower till or diamicton rests unconformably on Pennsylvanian fine sandstone, siltstone, and mudstone (see discussion of this exposure by Witzke, this volume). The upper diamicton exhibits a fluted, or glacially-molded, lower contact. Numerous subvertical iron-stained joints are evident in the upper diamicton. The upper diamicton is mantled by a complex unit of Late Sangamon pedisediment. Two stone lines are evident in this unit indicating that the Late Sangamon surfaces are composed of multiple erosion and accumulation episodes. In the central portion of this exposure a small, shallow side-valley filled with Late Sangamon alluvium is exposed. A Late Sangamon paleosol is developed into the alluvium and pedisediment. The lower Wisconsinan loess increment is present in this exposure and buries the Late Sangamon deposits and paleosol. A thin, leached upper loess increment buries the lower loess increment. The upper increment here is very coarse for loess, and it is possible that this deposit was reworked during and following loess deposition.

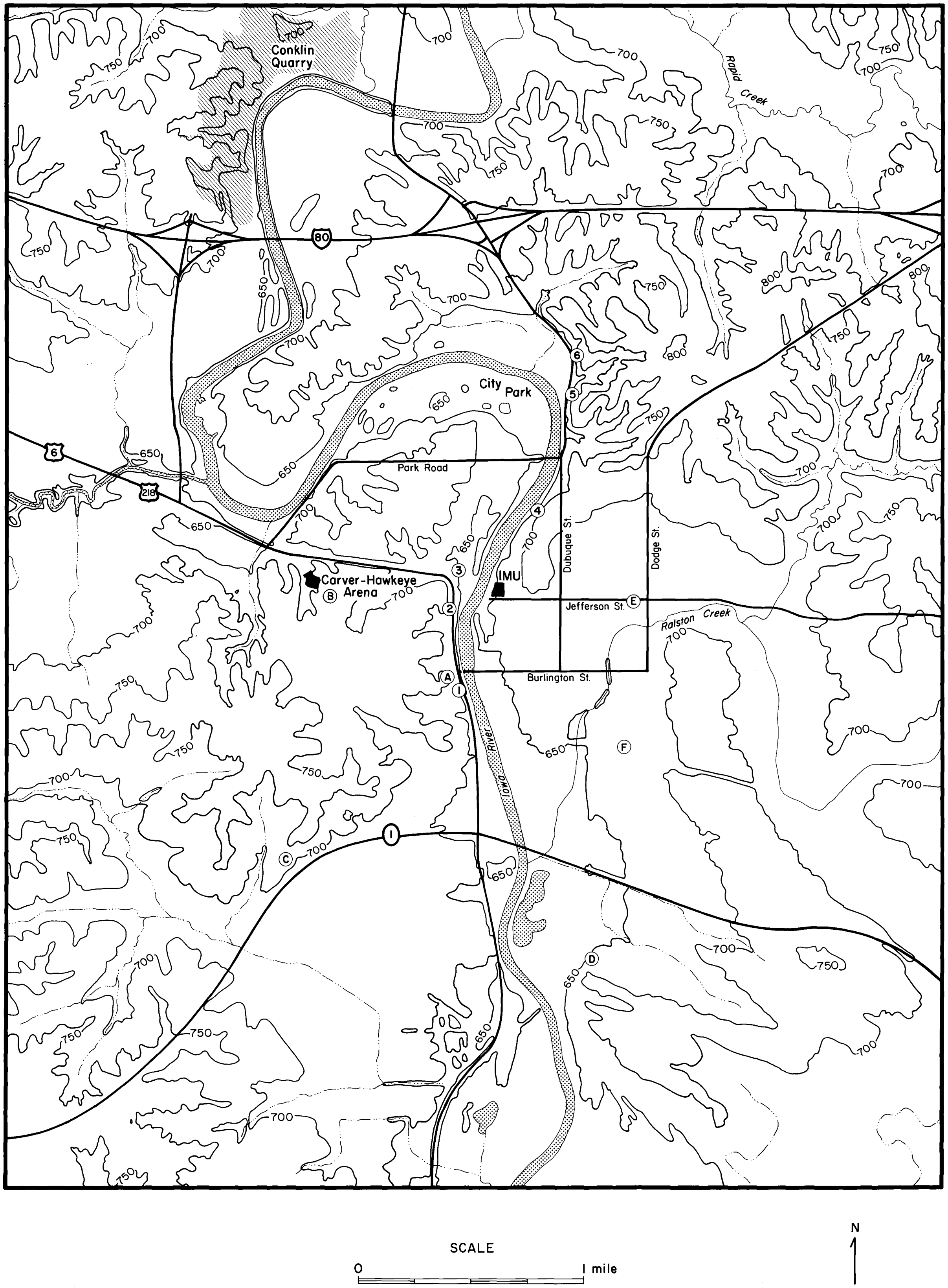

Figure 8. Topographic map of the Iowa City area (50 ft. contour interval). Numbers and letters indicate sites discussed in the guidebook.

Table 3. Description of section exposed along Highway 1, NE 1/4, SW 1/4, section 16, T.79N., R.6W., on the southwestern corner of Iowa City.

52 HWY-1 Depth (m)	Soil Horizon (weathering zone)	Description
		Wisconsinan Loess
0-3.35	(MOU)	Tama solum developed in upper meter, lamallae at base of solum; common gastropod shells below solum.
3.35-3.66	(MOU)	Dark yellowish brown (10YR4/4) silt loam; massive; friable; common coarse light brownish gray (2.5Y 6/2) mottles abrupt undulatory boundary; common gastropod shells.
		Basal Wisconsinan Paleosol and Sediments
3.66-4.04	2Ab	Brown (10YR4/3) silt loam with more sand than above; massive; friable; common fine grayish brown (2.5Y 5/2) mottles; common medium blobs of yellowish brown (10YR5/4) loam and brown (7.5YR 5/4) clay loam derived from underlying material; abrupt undulatory boundary; abundant charcoal flecks; horizon varies in thickness from 0 to 38 cm.
		Late Sangamon Paleosol in Pedisediment
4.04-4.33	3Eb	Brown to yellowish brown (10YR5/3-5/4) loam; massive to very weak platy structure; friable; common burrows with brown (7.5YR5/4) clay loam infilling; occasional pebbles; discontinuous stone line at base, occasional charcoal flecks; clear smooth boundary; horizon varies in thickness from 3 to 29 cm.
		Late Sangamon Paleosol in Pre-Illinoian Wolf Creek Formation till
4.33-4.47	4Bt1b	Reddish brown to brown (5YR4/4 -7.5YR4/4) clay loam; strong fine angular blocky structure; friable; abundant fine dark red (2.5YR3/6) mottles and accumulations; thin continuous cutans (secondary--illuival--clay coatings); few fine oxide accumulations; gradual smooth boundary.
4.47-4.59	4Bt2b	Reddish brown (5YR4/4) clay loam; strong fine angular blocky structure; friable; mottles and accumulations as above; thin continuous cutans; very few fine oxide accumulations; occasional slickensides; occasional pebbles; gradual smooth boundary.
4.59-4.76	4Bt3b	Strong brown (7.5YR5/6) clay loam; strong fine to medium angular blocky structure; friable; occasional fine light gray (5Y6/1) mottles; thick continuous yellowish red (5YR4/6) cutans; few fine oxide accumulations; common pebbles; gradual smooth boundary.
4.76-4.96	4Bt4b	Reddish yellow to brownish yellow (7.5YR6/6 -10YR6/6) clay loam to loam; strong medium angular blocky structure; firm; occasional fine light gray (5Y6/1) mottles; thick continuous brown (7.5YR4/4 -5/4) cutans; occasional pebbles; gradual smooth boundary.
4.96-5.34	4Bt5b	Brownish yellow (10YR6/6) loam; moderate medium to coarse angular blocky structure; firm; common medium light gray (5Y6/1) mottles; thick continuous brown (7.5YR4/4 -5/4) cutans; common fine to medium oxide accumulations; common pebbles; occasional small sand inclusions; clear smooth boundary.
5.34-5.64	4BCb	Brownish yellow (10YR6/6) loam; moderate medium subangular blocky structure; friable; abundant fine to medium light brownish gray (10YR6/2) mottles; common pebbles and cobbles; common joints with thick continuous brown (7.5YR4/4 -5/4) cutans; common medium to coarse oxide stains; abundant burrows filled with brown (7.5YR5/4) clay loam; common medium to coarse sand inclusions, some with secondary carbonate accumulations; clear undulatory boundary.
5.64-base of exposure (6.34)	4C (MJOL2)	Yellowish brown (10YR5/6) loam; massive; friable; abundant fine to medium light brownish gray (10YR 6/2) mottles --continuous along joints; occasional joints with thick continuous brown (7.5YR5/4 -4/4) cutans; abundant pebbles and cobbles; abundant secondary carbonate accumulations; occasional sand inclusions.

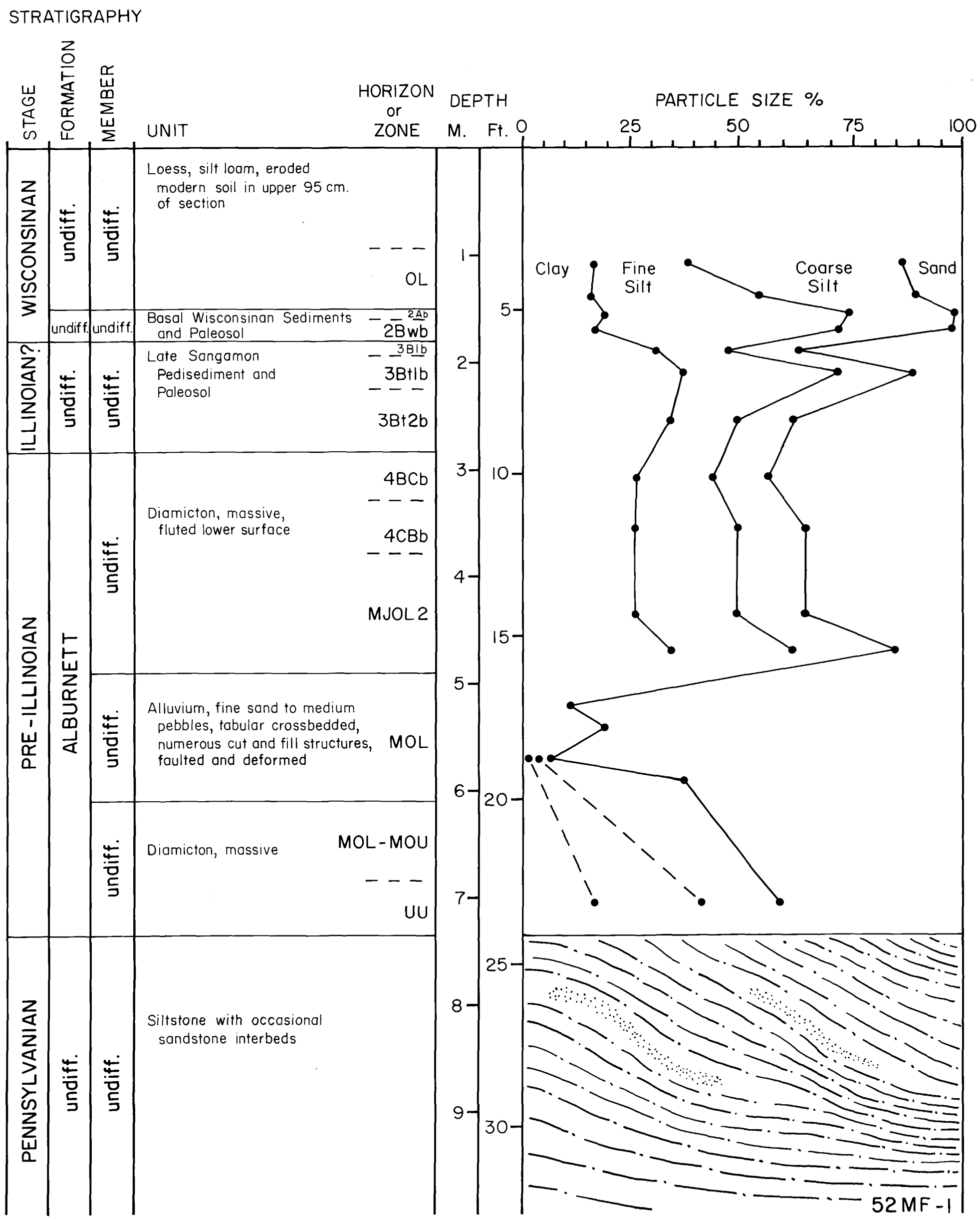

Figure 9. Stratigraphy and particle-size data for the Mayflower excavation.

On the University of Iowa campus two excavations have been examined in detail in areas mapped as wl/a. Both exposures are of the EPHT of the Iowa River, showing both increments of Wisconsinan loess mantling Late Sangamon paleosols developed in EPHT alluvium. The EPHT alluvium is incised into Pre-Illinoian glacial deposits of the Alburnett formation.

The first section was exposed during foundation excavation for the Carver-Hawkeye Sports Arena on the west end of the University of Iowa campus (B on Figure 8). Devonian Cedar Valley Limestone was present at the base of the exposure (Figure 10). Overlying the bedrock was a thin layer of stratified sandy alluvium which was diapirically deformed into an overlying Pre-Illinoian Alburnett Formation diamicton (till) (38% expandables, 22% Illite, 40% Kaolinite + Chlorite). The diamicton contained ice-wedge (?) casts in its upper part which were filled with overlying Early Phase Iowa River High Terrace deposits. These terrace deposits were variable across the section ranging from medium sand to small cobbles. The alluvium fined upward and a Late Sangamon paleosol was developed into it. Overlying the Early Phase High Terrace deposits and Late Sangamon paleosol was a meter thick basal loess increment. A very thick upper loess increment dominated the section. This interval is anomalously thick for the Iowa City area. The sandy nature of the loess interval between 5 and 9 meters indicates an influx of eolian sand blown from the adjacent Iowa River valley during deposition of the upper Wisconsinan loess increment, and it is possible that local colluvium, which accumulated during deposition of the loess, is also included within this interval. These two factors may account, in large part, for the thick loess at this site.

A similar exposure was recorded during foundation excavations for the new University of Iowa Law Building on the southwest corner of the intersection of Burlington Street and Riverside Drive (A on Figure 8). Once again Cedar Valley Limestone was encountered on the floor of the excavation (Figure 11). This was overlain by a thin, discontinuous layer of alluvium. Alburnett Formation diamicton (44% expandables, 18% Illite, 38% Kaolinite + Chlorite) capped the lower alluvium. A complex sequence of stratified Early Phase Iowa River High Terrace alluvium buried the diamicton. The High Terrace alluvium fined upward and a Late Sangamon paleosol was developed into its upper part. A basal loess paleosol was developed in the lower Wisconsinan loess increment which buried the Late Sangamon paleosol and EPHT alluvium. At this location the basal loess paleosol was rather well developed and exhibited moderately well differentiated soil horizons. At least six meters of oxidized Wisconsinan loess (upper increment) in turn overlie the basal loess paleosol. A thin, laterally continuous lens of eolian sand was observed in this unit at a depth of about four meters.

At this site the Late Sangamon paleosol became progressively truncated toward the river and the basal Wisconsinan loess increment disappeared. This indicates that a Wisconsinan erosion surface had developed on those portions of the EPHT in close proximity to the late-Wisconsinan Iowa River floodplain.

Other sites in the Iowa City area, which have not been studied in detail, show the stratigraphy of various mapping units. An easily accessible exposure of Early Phase High Terrace deposits is present on the east side of Sand Road opposite the Iowa City Municipal Airport in the southern portion of Iowa City (D on Figure 8). At that locale a Late Sangamon paleosol is developed into the EPHT deposits. Wisconsinan loess buries these deposits. Immediately to the east on the slope above this exposure, Pre-Illinoian till is present beneath the loess. Thus, this exposure is along what was the edge of the valley wall during deposition of the EPHT.

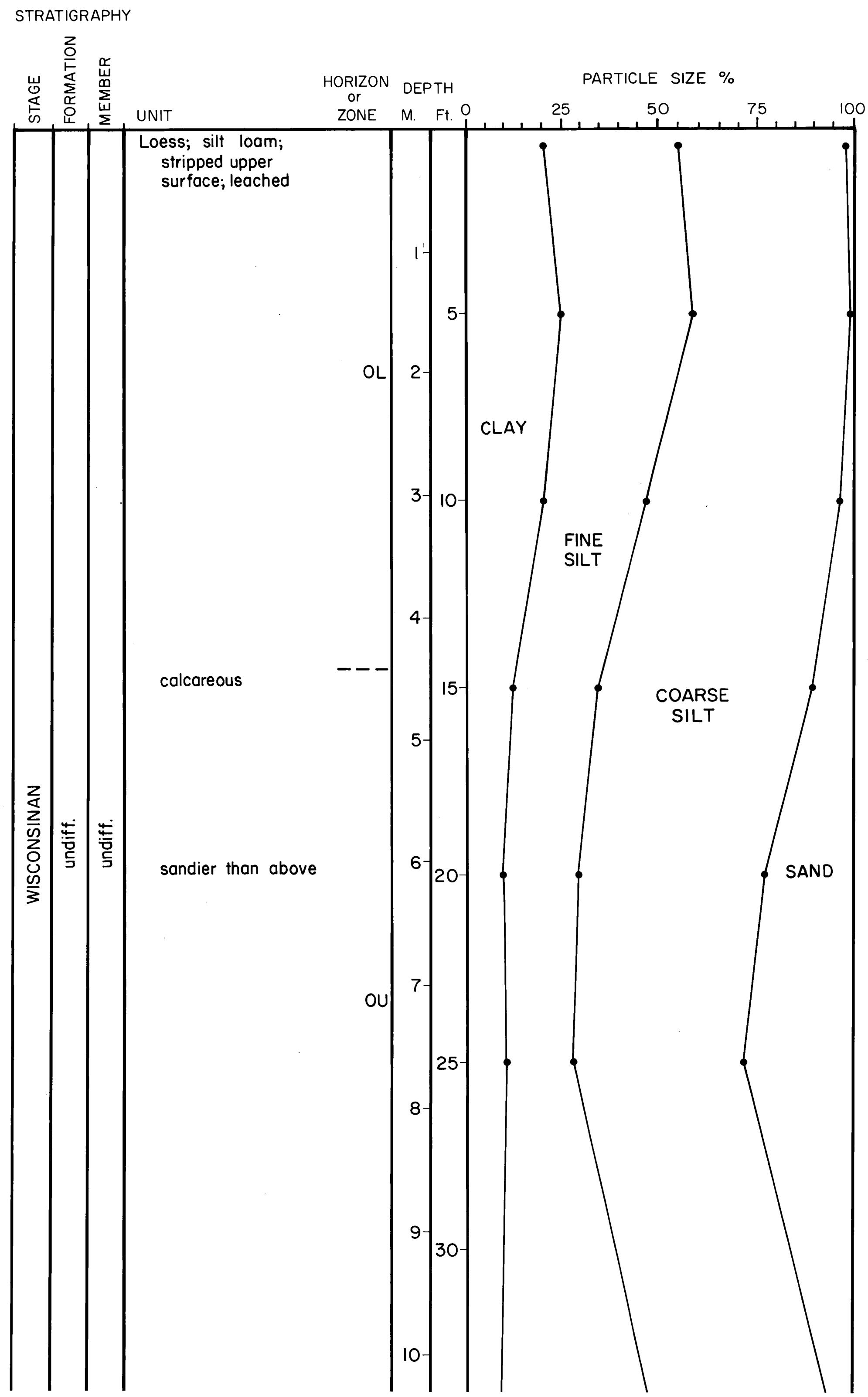

Figure 10. Stratigraphy and particle-size data for the Carver-Hawkeye Sports Arena.

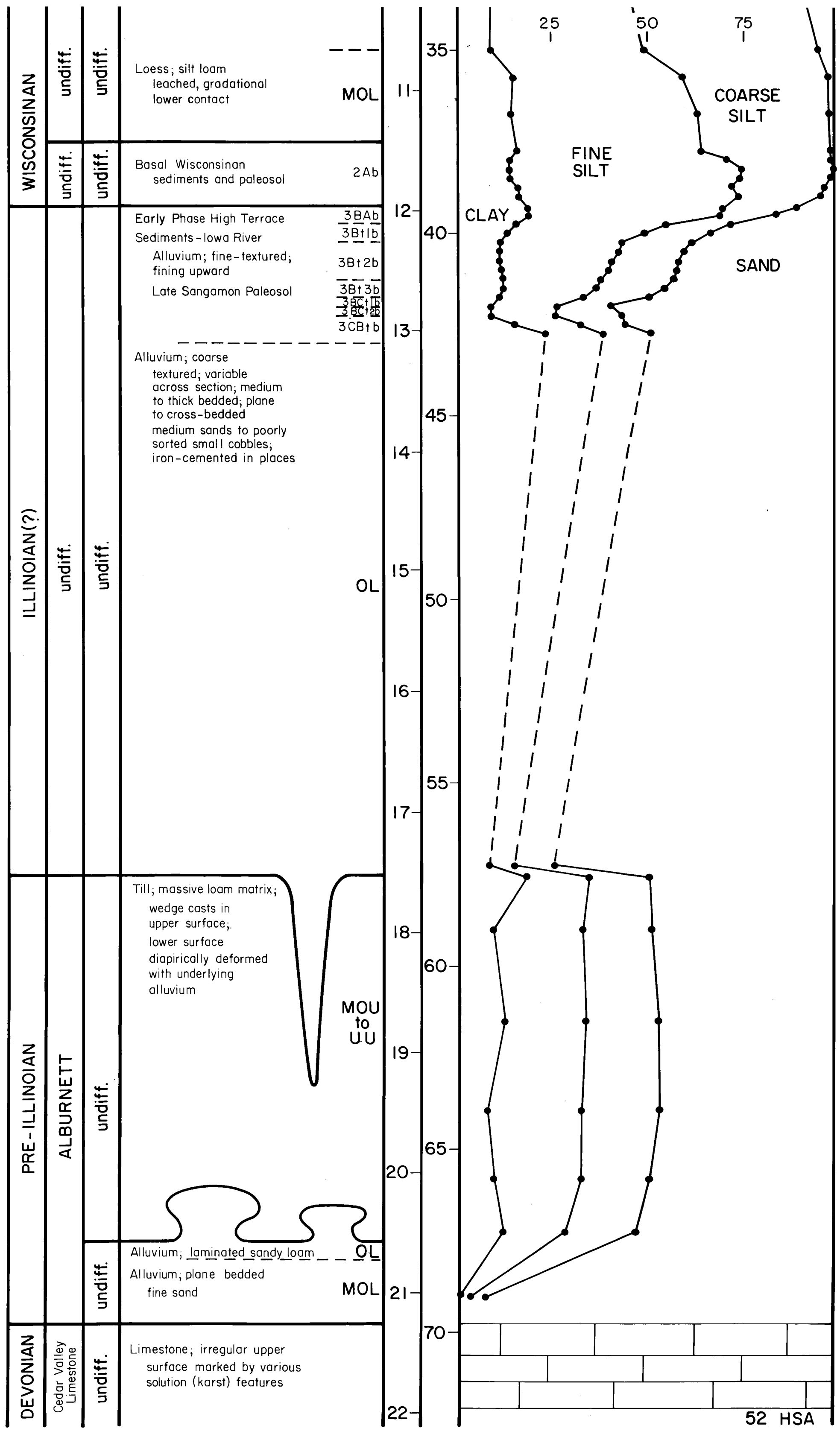

Figure 10. (continued)

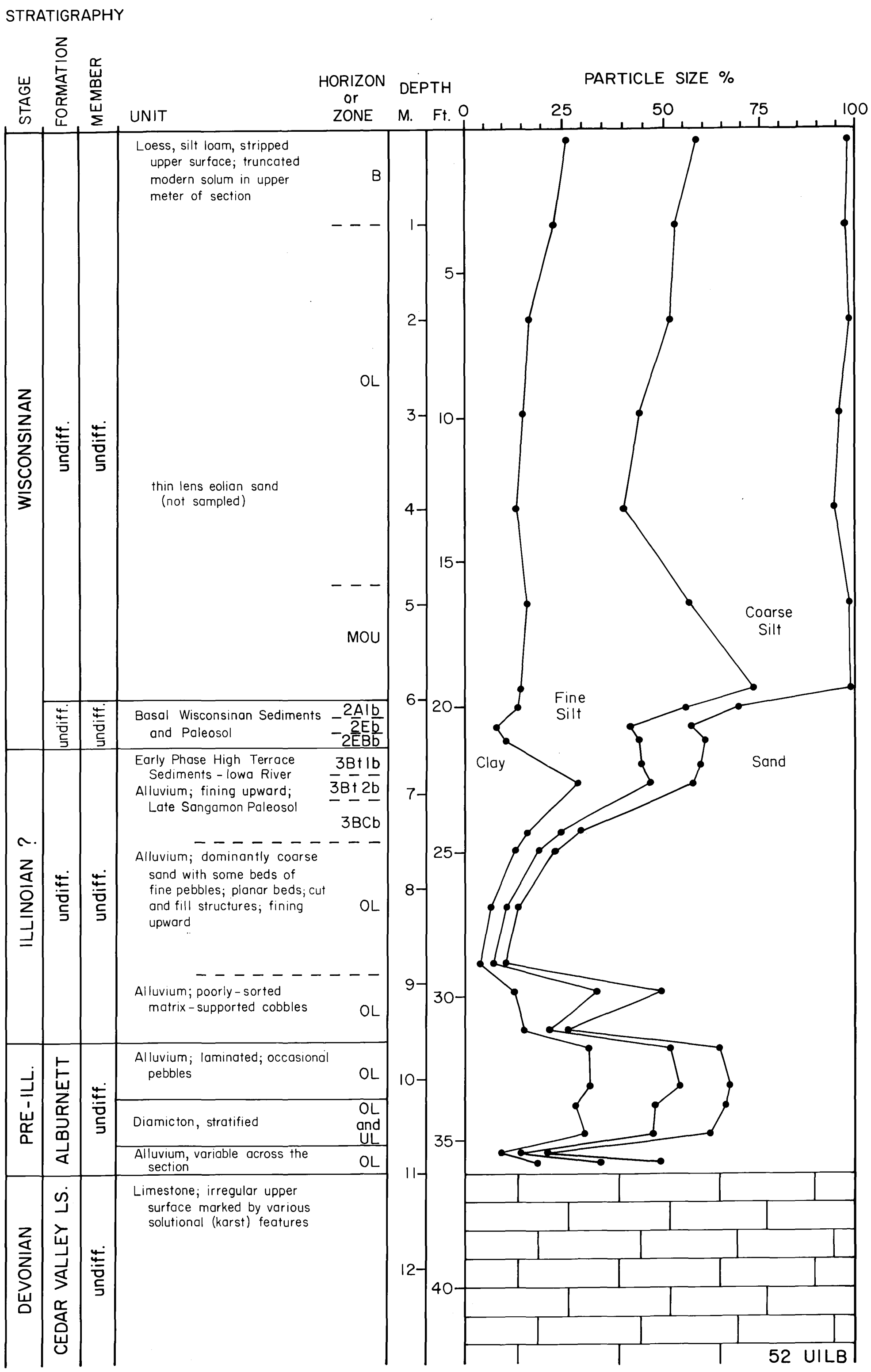

Figure 11. Stratigraphy and particle-size data for the new University of Iowa Law Building.

Exposures of the Late Phase High Terrace of the Iowa River are poorly documented in the Iowa City area. A foundation excavation for apartments on the southeast corner of the intersection of Jefferson and Johnson Streets (E on Figure 8) exposed two meters of the upper loess increment grading into sandy alluvium of the LPHT. The foundation excavation for the new Holiday Inn Hotel in downtown Iowa City revealed the upper loess increment grading into sandy alluvium of the LPHT. Another exposure of LPHT deposits was observed in foundation excavations for an apartment complex at the southern end of Johnson Street, along the CRI&P railroad tracks (F on Figure 8). At that exposure sandy LPHT alluvium graded into two meters of upper increment Wisconsinan loess.

Within the area mapped wl/a on the east side of the Iowa River the LPHT overlaps, and in some places cuts out, the EPHT (Figure 7). Poor subsurface control precludes a detailed description and understanding of this area at this time.

Good exposures of the upper increment of the Wisconsinan loess are present beneath the Woolf Avenue overpass over Highways 6 and 218 near the V.A. Hospital and along Highway 1 west at the previously discussed borrow pit (C on Figure 8).

Summary

During the Quaternary, the Iowa City area has been subjected to various periods of deposition, erosion, and relative landscape stability. Pre-Illinoian glaciation deposited a complex sequence of glacial deposits which lithostratigraphically comprise the Wolf Creek and Alburnett Formations. Near the Iowa River various periods of erosion have removed all of the Wolf Creek Formation deposits, and only Alburnett Formation deposits remain. The remaining Alburnett Formation deposits are variable, as differing lithofacies assemblages are present at different sites (compare the Alburnett Formation stratigraphies at the Mayflower site, Figure 9, the Carver-Hawkeye Sports Arena, Figure 10, and the new University of Iowa Law Building, Figure 11). Younger Wolf Creek Formation deposits are preserved only on higher divides away from the river on the western- and eastern-most edges of Iowa City.

Wisconsinan loesses were deposited in two general increments. Both increments mantle older buried soils developed in various Pre-Illinoian age glacial tills, the Late Sangamon erosion surfaces, and the depositional equivalents of the Late Sangamon erosion surfaces of the Iowa River valley, the Early Phase High Terrace deposits. Only the youngest loess increment, or part of the youngest loess increment, mantles areas of Wisconsinan or "Iowan" erosion surfaces and the depositional correlative of the Wisconsinan erosion surfaces in the Iowa River valley, the Late Phase High Terrace sediments.

Renewed downcutting in the latest Wisconsinan and Holocene has developed a new set of erosion surfaces, while a series of terraces lacking a loess mantle have been deposited in the Iowa River valley.

BUILDING STONES OF THE UNIVERSITY OF IOWA CAMPUS AREA

by Raymond R. Anderson

Buildings on the University of Iowa campus are dominated by two types of construction, dimension stone and brick with dimension stone trim. Much of the newer construction, however, incorporates brick and precast concrete, precast concrete exclusively, or other combinations of man-made building materials. The most commonly utilized building stones include the State Quarry Limestone and limestone from the Cedar Valley Formation, especially the Coralville Member, taken from a series of quarries along the Iowa River in the area of the Coralville Reservoir and, perhaps, from the old Public Quarry in Iowa City. A third commonly used building stone in the campus area is granite from southern Minnesota. The most frequently used of these granites is the Rockville Gray from the area of Rockville, Minnesota. These granites are used predominantly in foundations and steps of numerous campus buildings. Other building stones that can be observed include: Anamosa Stone (Silurian dolomite from eastern Iowa), Pennsylvanian Spoon sandstone, red Precambrian sandstone, black slate and phyllite, Pennsylvanian sandstone-siltstone, and black and white gneiss.

In order to facilitate the discussion of these buildings and building materials, the individual stone types will be discussed with references to the specific buildings which provide exceptional examples of the rocks under discussion. Table 4 lists individual buildings in the campus area, noting foundation, building, and trim stone identification and other features of specific interest.

Salem Limestone

The Salem Limestone is the upper formation of the Sanders Group (Mississippian) in south-central Indiana. The rock is a gray to light buff-colored medium-grained skeletal calcarenite, composed dominantly of echinoderm fragments but also including brachiopod fragments and rare small whole brachiopod shells. The formation has an oolite facies and frequently displays cross-bedding, which may be seen in some of the cut blocks. The Salem Limestone is quarried at a number of locations along a belt running in a north-northwesterly direction from the Ohio River west of Louisville, Kentucky, to about 20 miles west of Indianapolis, Indiana. The Salem Limestone has been marketed under a number of names over the last 125 years. These names include "Bedford Limestone," "Indiana Limestone," "Bedford Oolite," and a number of other local names, but all names refer to rock quarried from the building stone facies of the Salem Limestone. The Salem Limestone is equivalent to the Spergen Formation in southern Iowa.

The Salem limestone is the most commonly used building stone in the University of Iowa campus area. It is the major construction stone used in all of the buildings on the Pentacrest except the Old Capitol, including Schaeffer, MacLean, Macbride, and Jessup Halls. The stone is the dominant building stone in Gilmore and Phillips Halls and the Zoology Building. The Salem Limestone is the most commonly used trim stone in buildings of brick construction on campus. These buildings include Trowbridge and North Halls, the Iowa Memorial Union, the Chemistry-Botany Building, and the Main Library. The Salem Limestone is also used in a number of non-University buildings around the campus area, such as the United Methodist Church and the First

Table 4. Building Construction Materials Used in the University of Iowa Campus Area.

--East Campus--

BUILDING NAME	FOUNDATION	BUILDING	TRIM	NOTES
Calvin Hall	Br	Br	AS	red ss ornaments
Chemistry-Botany	Br	Br	Sa	RG front step
English Philosophy	Cc	Br	Cc	
Gilmore Hall	Gr	Sa	--	Marble trim inside
Iowa Memorial Union	RG	Br	Sa	RG steps, M trim
Jessup Hall	Gr	Sa	--	
Macbride Hall	RG	Sa	Sa	carved trim
MacLean Hall	Gr	Sa	--	
Main Library	RG	Br	Sa	exposed RG found
North Hall	Br	Br	Sa	
Old Capitol	CV	CV, SQ	SQ, AS	RG steps, AS patio
Phillips Hall	Sa	Sa	Sl	
Schaeffer Hall	CV	Sa	--	Gneiss threshold
Seashore Hall	CV	Br	Sa, RG	
Trowbridge Hall	Br	Br	Sa	Gr front steps
Van Allen Hall	Cc	Cc	--	
Zoology	RG	Sa	--	RG steps

--West Campus--

BUILDING NAME	FOUNDATION	BUILDING	TRIM	NOTES
Armory & Field House	Br	Br	Sa	
Art Building	Br	Br	Sa	
Art (south addition)	Cc	Br	Cc	
Art (east addition)	Cc	Cc	--	
Art Museum	Cc	Cc	--	Ph on patio
Basic Sciences	Cc	Br	Cc	
Carver-Hawkeye Arena	Cc	Cc	--	large AS blocks
Carver Pavilion	Cc	Cc	--	
Clapp Recital Hall	Cc	Cc	--	
College of Medicine	Br	Br	Sa	
Colloton Pavilion	Cc	Cc	--	
Dental Science	Cc	Cc	--	
General Hospital	Cc	Br	Cc	
Hancher Auditorium	Cc	Cc	--	
Health Science Library	Cc	Cc	--	
Hillcrest Hall	Br	Br	Sa	
Kinnick Stadium	Br	Br	Sa	
Lagoon Shelter	AS	AS	AS	
Medical Lab. Building	Br	Br	Sa	
Medical Research	Br	Br	Sa	
Music Building	Cc	Cc	--	
Nursing Building	Cc	Cc	--	
Pharmacy Building	Br	Br	Cc	
Psychiatric Hospital	Br	Br	Sa	
Quadrangle	Br	Br	Sa	
Rienow Hall	Cc	Br	Cc	
Slater Hall	Cc	Br	Cc	
Steindler Building	Br	Br	Sa	
South Quardrangle	Br	Br	Sa	
Theater (addition)	Cc	Cc	--	
University Theater	Br	Br	Sa	
Westlawn	Br	Br	Sa	

--Off-Campus--

BUILDING NAME	FOUNDATION	BUILDING	TRIM	NOTES
Davis Hotel	Br	Br, SQ	SQ	
First United Methodist Church	--	Sp	Sa	
Murphy-Brookfield Books	Pen	Pen	SQ	
Old Brick Church	Cv	Br	SQ	
410 East Market	Pen	Pen	--	

Sa -- Salem Limestone
CV -- Cedar Valley Limestone
AS -- Anamosa Stone
Gr -- unknown Granite
Pen -- Pennsylvanian siltstone from Mayflower Quarry
SQ -- State Quarry Limestone
Br -- brick
RG -- Rockville Granite
Sp -- Spoon Sandstone
Cc -- concrete
Ph -- unknown phyllite
M -- marble
Sl -- unknown slate

National Bank.

State Quarry Limestone

The State Quarry Limestone is a coarse-grained skeletal calcarenite and is known only from Johnson County. The formation in Johnson County is a marine channel-fill deposit, incised as much as 40 feet into the underlying Cedar Valley Formation. State Quarry building stones were quarried at the old State Quarry along the present-day Coralville Reservoir beginning over 140 years ago. Building stones may also have been produced at quarries southeast of Solon. The old State Quarry also produced foundation stones for the new State Capitol Building in Des Moines, which were laid in the 1870s. Large blocks of State Quarry Limestone were used in the construction of the Old Capitol and Davis Hotel Buildings. These blocks appear to be from two distinct facies. The blocks in the Old Capitol are composed of a brachiopod "coquina" composed almost entirely of broken and whole shells. These blocks can most easily be observed in the lowest, visible row of dimension stone and in the walls that side the steps on the east and west sides of the building. State Quarry stone is also used in the upper part of the building, beginning at about the level of the uppermost windows, and smaller blocks are used as window sills.

The second facies of the State Quarry Limestone can be oberved in the south wall of the Davis Hotel, from the foundation to the second floor level. This facies is an echinoderm "coquina," composed dominantly of broken crinoid plates and columnals. Some of the blocks in this wall were quarried from the brachiopod facies as were most of the blocks in the east wall.

The State Quarry Limestone is also used in trim associated with brick construction on a number of buildings. These include the Old Brick Church and the Murphy-Brookfield Books Building.

Cedar Valley Limestone

The Cedar Valley Limestone was quarried locally at a number of locations, including the Sanders, Hutchinson, and the old Public Quarries. This stone is used extensively for foundations of a great many buildings both on the campus and in the city proper. Cedar Valley foundation stone can be observed in Old Capitol, Schaeffer Hall, and Old Brick Church. Cedar Valley Limestone was also used in the construction of a major part of the Old Capitol, including all of the building stone between the base of the basement-level windows and the uppermost windows. This stone was quarried from the old Public Quarry, and includes rock produced from the Coralville Member of the Cedar Valley Formation. It is quite variable in appearance, ranging from a buff-colored calcarenite with abundant solitary and colonial corals and stromatoporoids, to a brown-colored, barren, laminated calcilutite. Much of the brown, laminated Cedar Valley is of poor quality, a fact which led to the switch to State Quarry Limestone for completion of the Old Capitol Building.

Rockville Granite

The Rockville Granite is a quartz monzonite characterized by large pink and white feldspar crystals in association with smaller quartz and biotite crystals. This rock is Precambrian in age (about 1780 million years old) and is quarried extensively around the town of Rockville in south central Minnesota. This rock is used extensively in foundations and steps of numerous buildings in the campus area. It can best be observed as the high foundation for the Main Library, especially visible on the north side of the building near Shambaugh Auditorium, and on the west side of the building. It is also used as a foundation for the Iowa Memorial Union, Macbride Hall, and the Zoology Building. It is used as step stone for the Chemistry-Botany Building, the Iowa Memorial Union, and the Old Capitol. The Rockville Granite is used as a paving stone and as benches on the east side of the Old Capitol.

Anamosa Stone

Anamosa Stone is the name given to rock from the "Anamosa Facies" of the Gower Formation (Silurian), quarried extensively near the towns of Anamosa and Stone City in Jones County, Iowa. The quarries at Stone City are one of only two building-stone quarries presently active in Iowa. Anamosa Stone is a tan- to buff-colored, fine- to medium-grained, generally laminated dolomite. Fossils are rare in this unit, but unusual structures, known as "rods," linear elements about 1/2 inch long and 1/10 inch wide, ramdomly oriented, and of unknown affinity, commonly occur in these rocks. These rods are visible on the west patio of the Old Capitol, near the entrance.

"Wavy-Bed" Anamosa Stone is a particularly appealing stone, produced by slabbing along a hummocky bedding plane of a finely-laminated facies, resulting in a stone with concentric circular patterns. This type of Anamosa Stone can be observed on the patio at the east entrance of the Old Capitol. Anamosa Stone quarried along the Cedar River in northeastern Johnson County near Sutliff forms a prominent, brown ledge at the first floor level of the Old Capitol. The Lagoon Shelter ("canoe house") along the Iowa River, just north of Hancher Auditorium, is constructed entirely of Anamosa Stone.

Pennsylvanian Sandstone-Siltstone

A Pennsylvanian buff-colored, argillaceous siltstone and sandstone, quarried near the present-day location of the Mayflower Dormitory in the mid-1800s, was used in the construction of a few buildings in the University of Iowa campus area. The best examples of this building stone can be seen in the Murphy-Brookfield Books Building (219 North Gilbert St.) and a small building at 410 East Market Street.

Spoon Sandstone

An unusual building stone near the University of Iowa Campus is a sandstone used in construction of the First Methodist Church (corner of Dubuque and Jefferson Streets). This sandstone was quarried from the Spoon Formation (Middle Pennsylvanian) near the town of Colona, just east of Moline, Illinois. The sandstone is a cream-colored, dominantly subangular but ranging from angular to rounded, medium-grained, quartz sandstone and is the only known example of Spoon Sandstone in the area.

Other Building Stone

A number of additional types of building stones can also be observed in the University of Iowa campus area. These are granite, gneiss, phyllite, and sandstone. Three granites, in addition to the Rockville Granite, can be viewed on the campus. A white muscovite, biotite granite was used as a foundation stone for Gilmore Hall (where it is spalling-off on its west wall) and MacLean Hall. A second white granite, displaying large euhedral feldspar crystals, was used as a foundation for Jessup Hall. A third granite was used for steps on the east entrance of Trowbridge Hall. A quartz biotite gneiss can also be seen at the north and south entrances of Schaeffer Hall. A black phyllite of unknown origin was used as trim to cap steps leading to the south patio of the University Art Museum. A dark-gray, slaty sandstone was used along much of the west-facing wall of Phillips Hall. Finally a red sandstone, probably Precambrian Keweenawan sandstone from northern Wisconsin or Michigan, was carved and used as decoration high on the south wall of Calvin Hall.

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TOUR GUIDE AND STOP DESCRIPTIONS

by Brian J. Witzke and Bill J. Bunker

The walking tour of the geology of the University of Iowa campus area traverses exposures in the valley of the Iowa River from south to north. Figure 8 illustrates the general topography of the area and the location of the six field trip stops. A graphic section of the stratigraphy at each stop is illustrated using the lithologic and paleontologic symbols shown in figure 12. Individual stop descriptions are abbreviated, since a more detailed discussion of Devonian, Pennsylvanian, and Quaternary stratigraphy and deposition is included in previous chapters. Please be cautious along the steep quarry walls, not only for your own protection, but also to ensure the safety of others.

STOP 1: Hydraulics Annex Quarry Area

A laterally extensive quarry exposure of Coralville limestone strata is easily accessible in the area of the Hydraulics Annex Building and the adjacent parking lot south of Burlington Street on Riverside Drive. This region of bedrock exposure is one of the southernmost in the Iowa City area, and the bedrock suface drops sharply beneath the Quaternary cover a few hundred meters farther south. The upper portion of the "*Idiostroma* beds" and lower portion of the upper Coralville are visible (fig. 13). The strata display a northward dip, and progressively higher beds are encountered proceeding in that direction. The bulk of the "*Idiostroma* beds" exposed here is characterized by calcarenite with abundant branching stromatoporoids, but locally only scattered *Idiostroma* are noted in some beds. Hemispherical stromatoporoids, favositid corals, and some crinoid debris are associated with the abundant branching stromatoporoids. *Idiostroma* is scattered to abundant in the upper portion of this interval, where it occurs with solitary and colonial rugose corals (*Hexagonaria*), favositids, and hemispherical stromatoporoids. This interval, which is irregularly-bedded, thins to the north at Stop 1.

A dense, faintly laminated limestone of variable thickness overlies the "*Idiostroma* beds" and marks the base of the upper Coralville. Scattered branching stromatoporoids and favositids occur above. These beds thicken at the north end and may be partially cut-out in a "swale" three quarters north. The upper portion of the sequence includes dense "sublithographic" limestones, in part with "birdseye" laminae. The overlying Quaternary sequence near Stop 1 was exposed in excavations for the new Law Building (fig. 11), but is no longer accessible.

The bed of the Iowa River immediately below Stop 1 and beneath the Burlington Street dam exposes bedrock during periods of extremely low water, and the Rapid biostromes have been recognized in this area. From Stop 1, proceed northward along the west side of Riverside Drive. Small exposures of upper Coralville strata are visible at the base of Hillcrest Dormitory. Upper Devonian Lime Creek shales were encountered during excavation for the dorm addition, but are no longer visible. Farther to the north below Quadrangle dormitory, an exposure of faintly laminated to brecciated upper Coralville limestone is visible (fig. 14).

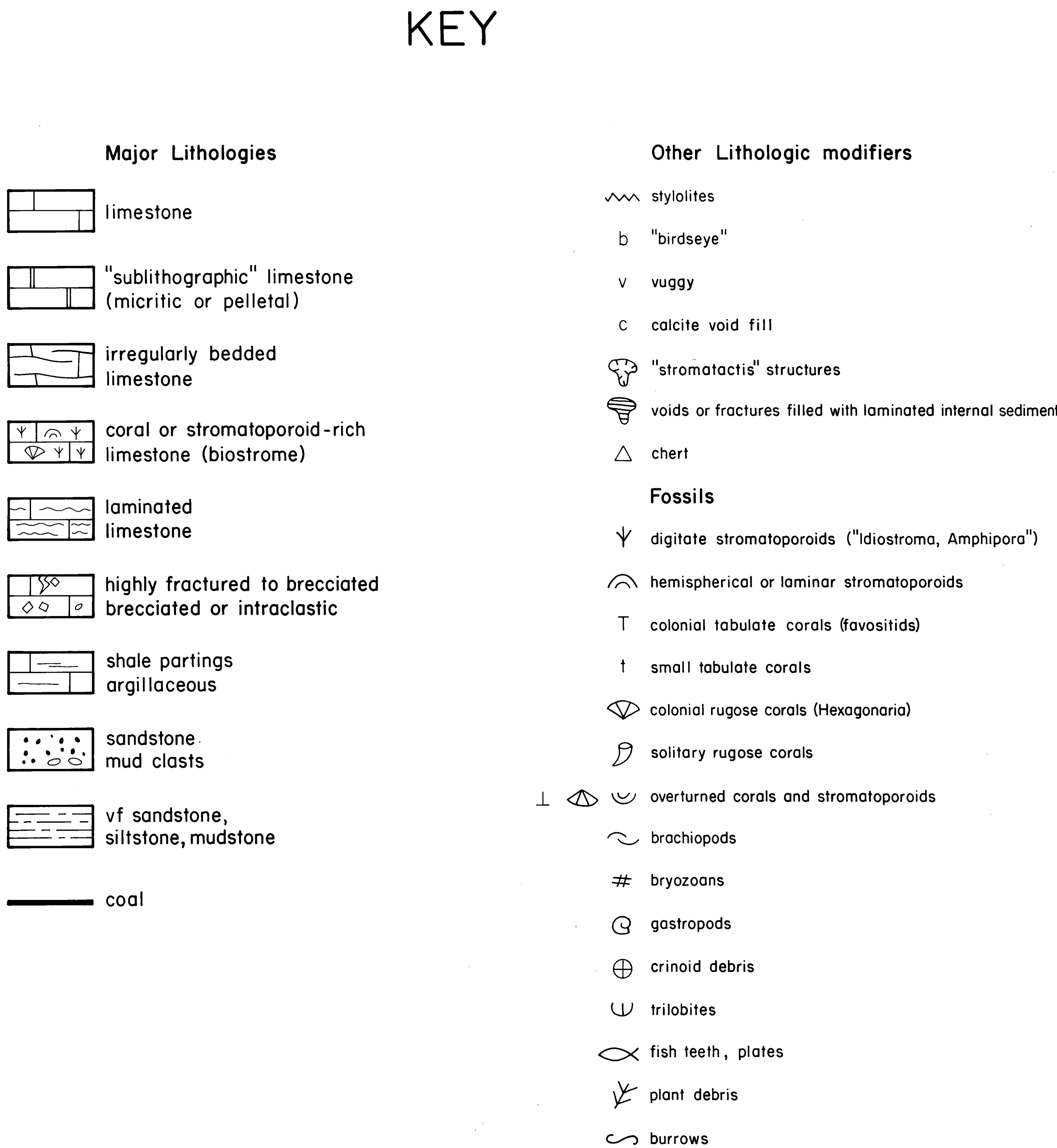

Figure 12. Lithologic and paleontologic symbols used on figures 13 through 18.

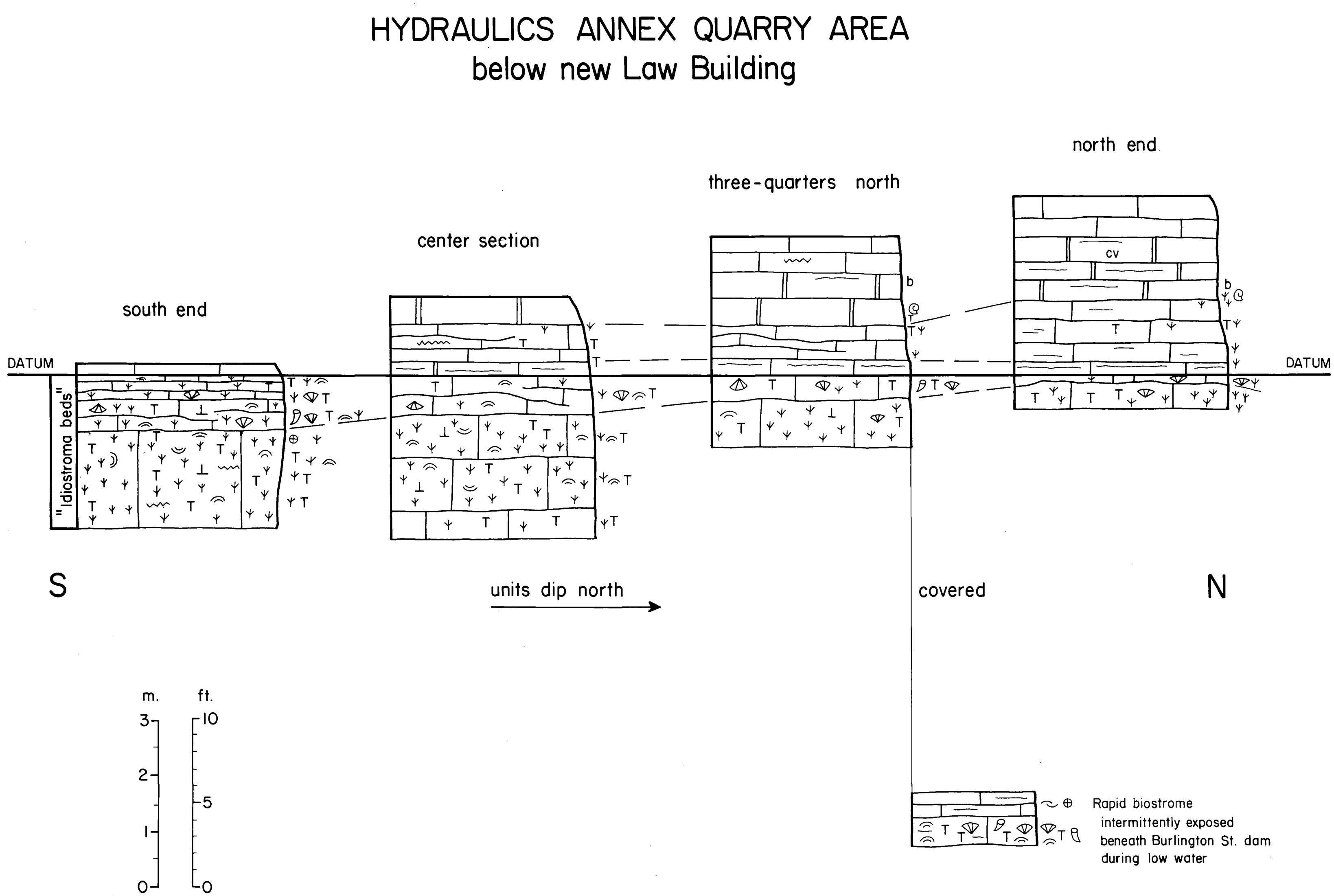

Figure 13. Stop 1: Coralville strata in the Hydraulics Annex quarry area. Datum is top of "*Idiostroma* beds."

STOP 2: Nursing Building Section

Beneath the Nursing Building along Riverside Drive, immediately north of Newton Road, a laterally extensive roadcut exposure of upper Coralville strata is visible (fig. 14). A thin coal seam forms a re-entrant at the base of the exposure at the southeast corner (Dow, 1960). The lower unit (Unit 1 on fig. 14) displays lateral facies changes at this stop. Biostromal beds with abundant *Amphipora* at the south end, which locally contain numerous large gastropods, interfinger with and are replaced by "birdseye" laminated, fractured, and brecciated beds. Truncation of beds beneath a prominent bedding plane (marker plane 1 on fig. 14) is evident in the middle sections. Overlying beds (Units 2 and 3 on fig. 14) resemble Unit 1, but occur higher in the Coralville sequence than any other exposure in Iowa City (see fig. 4). The pelleted and stromatoporoidal limestones seen at Stop 2 accumulated in extremely shallow restricted-marine environments. Evidence for episodes of shallowing and subaerial exposure in the upper Coralville sequence can be observed at Stop 2. "Birdseye" laminated beds accumulated in supratidal settings. "Stromatactis" cavities, truncation of beds, extensive fractures and voids, and brecciation developed during periods of subaerial exposure. Alternating periods of subaerial exposure and shallow-water deposition enabled some of the cavities and fractures to be infilled with laminated internal sediment.

Cross Highway 6/218 and proceed north along North Riverside Drive under the railroad bridge.

STOP 3: Hutchinson Quarry

The old quarry area along North Riverside Drive across from the Art Building has been known as the Hutchinson Quarry since the last century. Calvin (1897, p. 96) stated that the quarry employed six to eight men during the working season in the late 1890s, supplying building stone to Iowa City and the surrounding countryside. The quarry is the type locality of the upper Cedar Valley "Hutchinson limestone" (Keyes, 1931), although "Hutchinson limestone" strata are now included in the upper Coralville Member. The uppermost portion of the lower Coralville "*Cranaena* zone" is exposed near water level (fig. 15).

Strata in the lower part of the quarry, now flooded, were briefly described by Calvin (1897); based on his descriptions, the lower quarry section apparently included coralline "*Cranaena* zone" and uppermost Rapid strata (fig. 15). The full thickness of the "*Idiostroma* beds" is accessible at Stop 3; *Idiostroma* is scattered to abundant throughout. Corals and hemispherical stromatoporoids are also common in the unit, some of which are overturned and encrusted with stromatoporoids. A small karst opening filled with Pennsylvanian detrital sediments can be seen near the base of the exposure south of the flooded quarry section.

The basal unit of the upper Coralville (unit 1 on fig. 15) is irregularly-bedded and slightly argillaceous; scattered chert nodules locally occur in the lower portion, and nodular bedding is apparent in the middle portion. Scattered favositid corals and *Idiostroma* are locally noted in unit I. Unit II is local coral- and stromatoporoid-rich accumulation that probably correlates with Unit C at Stop 4. Unit III (fig. 15) is a largely unfossiliferous interval that contains scattered "stromatactis" and displays brecciation. A thin coal seam is developed within this unit, the same coal that occurs near the base of the section at Stop 2. The coal is best developed in

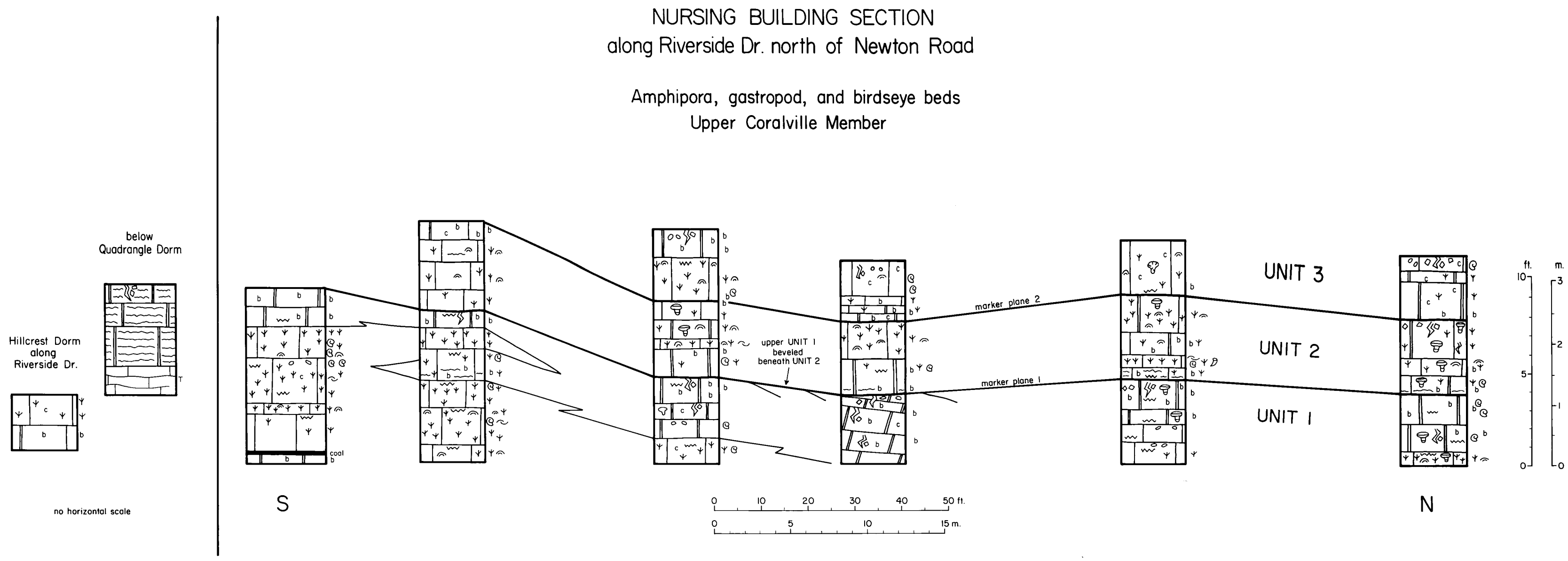

Figure 14. Stop 2: Upper Coralville section exposed on west side of Riverside Drive north of Newton Road below the Nursing Building. Two sections south of Newton Road are also illustrated.

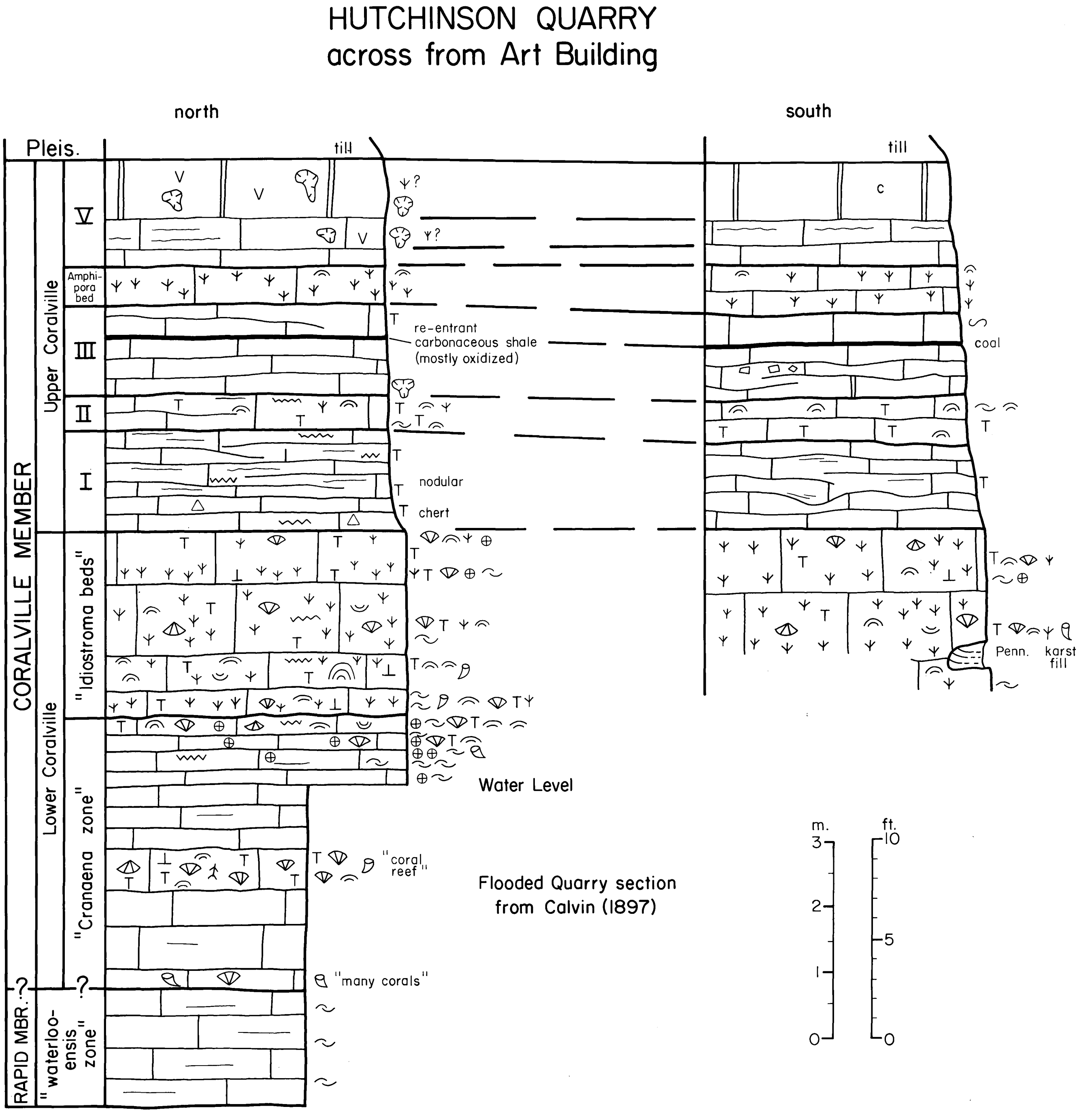

Figure 15. Stop 3: Cedar Valley limestone section in Hutchinson Quarry across from Art Building. Lower quarry section adapted from Calvin (1879).

the southern portion of the quarry, but is replaced by a carbonaceous shale parting at the north end. The upper part of unit III contains scattered small favositids and is burrowed at the south end of the exposure. The "*Amphipora* beds" overlie unit III and contain abundant branching stromatoporoids with scattered sheet-like and hemispherical stromatoporoids. The uppermost interval, unit V (fig. 15), is faintly laminated in the lower part and locally includes abundant "stromatactis" or calcite-filled stromatoporoid molds.

Cross North Riverside Drive past the Museum of Art, and proceed north along the Iowa River to the footbridge immediately north of the Lagoon Shelter House. Stop 4 is located on the east bank of the river, beginning beneath Stanley Hall near the east end of the footbridge.

STOP 4: Public Quarry Area

Coralville limestone exposures in the lower bluff face along the east bank of the Iowa River, extending from near Stanley Hall on the south to below the President's House on the north, are remnants of workings in the old Public Quarry (see fig. 3). This area was quarried in the mid-1800s and supplied stone for the construction of the Territorial Capitol. This quarry area also has been termed the North Capitol Street Quarry. An exceptional weathered exposure of the "*Idiostroma* beds" is accessible at the south end (fig. 16). A series of upper Coralville exposures begin immediately north of the walkway. The "sublithographic" limestones include some "birdseye" structures and locally display brecciation and "stromatactis." Karst openings are filled locally with Pennsylvanian detrital sediments. In the middle section, an interval containing scattered accumulations of the branching stromatoporoid, *Amphipora*, is noted (fig. 16), but these fossils are not as abundant as in equivalent strata at Stops 2 and 3.

The Coralville sequence at the base of the bluff face north of the President's House is especially interesting. The upper "*Idiostroma* beds" at this locality lack branching stromatoporoids at the base of the section, where brachiopods, rostroconchs (*Conocardium*), favositids, and hemispherical stromatoporoids are noted. The uppermost portion contains abundant *Idiostroma*. The basal portion of the upper Coralville is extensively burrowed (unit A, fig. 16). The overlying interval (unit B, fig. 16) is, in part, prominently laminated and includes "birdseye" fenestrae in the upper part. Unit B is truncated locally beneath unit C in two small channel-like cut-outs (fig. 16). Unit C is faintly laminated near the base, and includes scattered to abundant massive and hemispherical stromatoporoids in the middle portion; extremely large massive stromatoporoids occur in the area above the "channels." Brachiopod calcarenites locally occur above the massive stromatoporoid-bearing bed. The upper part of unit C contains scattered branching stromatoporoids and gastropods. Unit D is a dense to vuggy limestone interval, in part, "sublithographic," that contains scattered "birdseye" structures and is brecciated locally in the upper part. Stromatoporoids and gastropods occur near the top. Unit D is a partial equivalent of the *Amphipora*-bearing beds to the south. The uppermost bed, unit E, is a dense "sublithographic" limestone.

Proceed north along the Iowa River past the fraternity houses to the intersection of Park Road and Dubuque Street. Coralville limestone exposures can be seen in the fraternity house parking lot east of this intersection. Continue north along the sidewalk bordering the Iowa River. A small limestone quarry is visible at the southeast corner of the intersection of Kimball Road and Dubuque Street. To the north, the roadway extending up the bluff to the

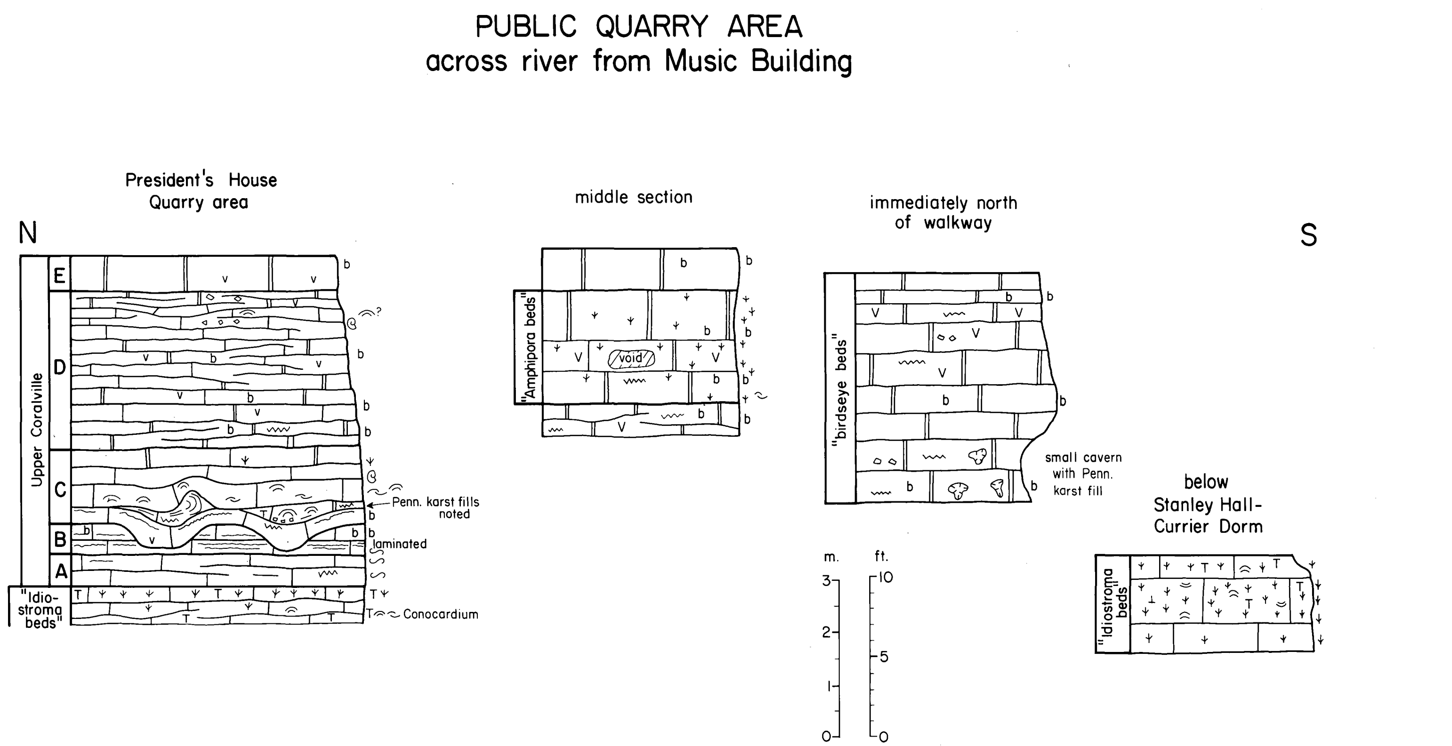

Figure 16. Stop 4: Coralville sections exposed in Public Quarry area across river from Music Building.

Pi Kappa Alpha House exposes a fine sequence of Coralville strata. Stop 5, the old Sanders Quarry, is located between the Pi Kappa Alpha House and the Mayflower Dormitory on the east side of Dubuque Street.

STOP 5: Sanders Quarry

Calvin (1897, p. 65) noted that "a very instructive section is found at the Euclid Sanders quarry south of the old Terrill mill near Iowa City." The quarry was "worked for some years by Mr. Gilbert Irish," and annually furnished "a large amount of rock" for "market in the towns and farming communities of the county" (ibid., p. 66, 69). A photo taken by Sam Calvin of the quarry workings can be seen on the cover of the guidebook. The lowest beds exposed at the Sanders Quarry are accessible near the southern end of the quarry area, where the uppermost portion of the Rapid Member ("*waterlooensis* zone") can be seen (fig. 17). These argillaceous calcilutites are highly fossiliferous, and numerous brachiopods are visible (especially *Desquamatia waterlooensis*, *Strophodonta*, *Orthospirifer*, and *Cyrtina*). Specimens of crinoids, blastoids, cystoids, and trilobites have been collected at this locality. Echinoderm debris and bryozoans are common, and small branching tabulate corals (pachyporids) occur in the upper portion. The abrupt change from argillaceous calcilutite to coral-rich calcarenite marks the Rapid-Coralville contact.

The lower Coralville "*Cranaena* zone" is well exposed at Stop 5. Much of the "*Cranaena* zone" is a coralline biostrome, and overturned coral and stromatoporoid heads are common. The uppermost portion of this interval is less coral-rich and contains abundant brachiopods and other fossils. The fauna of the "*Cranaena* zone" at this locality is discussed in greater detail in an earlier chapter of this guidebook. The overlying "*Idiostroma* beds" are exceptionally thick at this locality, and can be accessed along the hillslope in the southern portion of the quarry area. The basal beds of the upper Coralville are largely inaccessible, but are characterized by "sublithographic" limestone, in part laminated.

The Coralville sequence is truncated to the north beneath Pennsylvanian sandstone strata. The sandstones overlie the "*Cranaena* zone" at the north end of the quarry area. The fine- to medium-grained sandstones locally contain mud clasts and are cross-bedded in places. Impressions of wood fossils are apparent in some of the sandstone beds.

Proceed north through the back parking lot of the Mayflower Dormitory. An excellent exposure of Pennsylvanian sandstone/siltstone strata can be examined near the northwest corner of the back parking lot and along the north edge of the building. The Pennsylvanian exposures continue along the east edge of the north parking lot. Proceed along the bluff line to the exposures adjacent to the new condominium construction north of the Mayflower Dormitory (Stop 6).

STOP 6: Exposures of Pennsylvanian and Quaternary Strata North of the Mayflower Dormitory

Recent condominium construction has exposed Pennsylvanian and Quaternary strata in the bluffs at Stop 6, in what was once an old quarry area. Pennsylvanian sandstone was quarried at this site during the 1840s and 1850s. Our ability to examine the strata at this locality will depend on the extent of construction activity at the time of the field trip. A tracing of a photo mosaic illustrates the stratigraphy at the site as of Jaunary, 1984 (fig. 18).

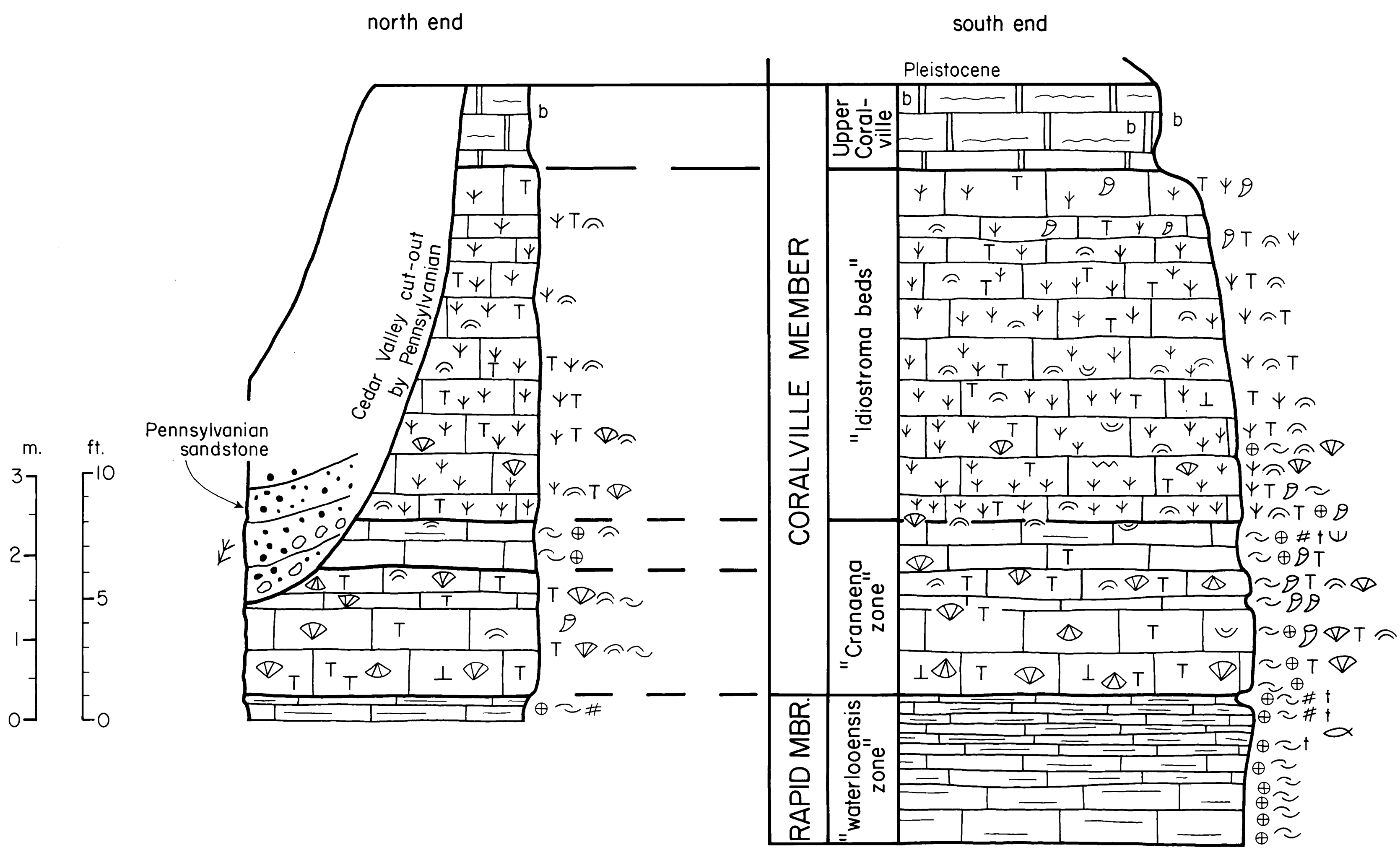

Figure 17. Stop 5: Upper Rapid and Coralville section in Sanders Quarry along North Dubuque Street. Pennsylvanian sandstone can be seen at the north end.

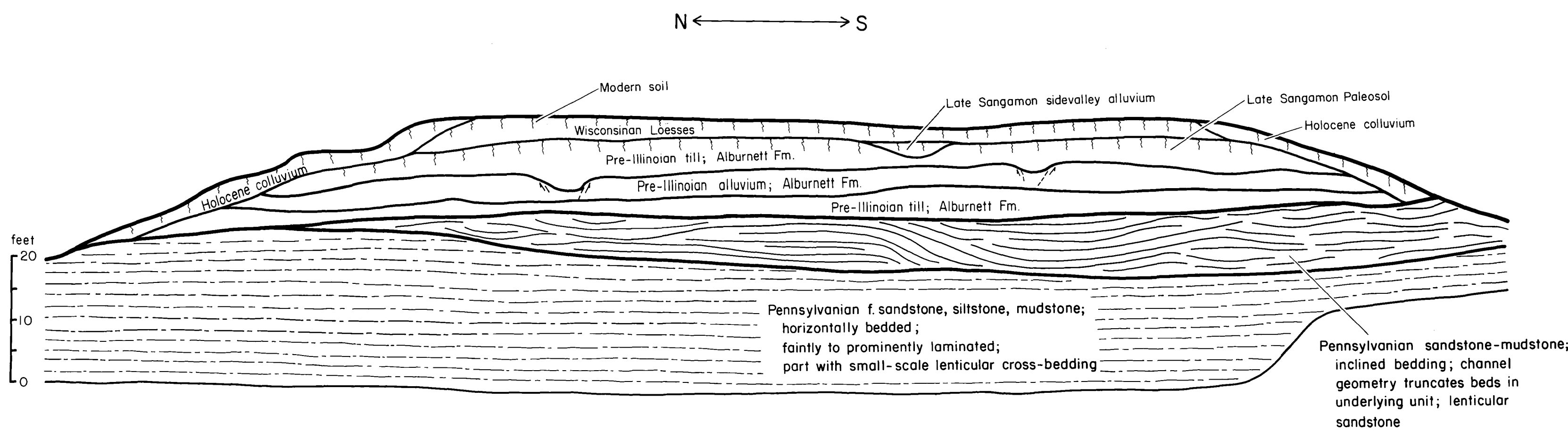

Figure 18. Stop 6: Recent excavations have exposed Pennsylvanian and Quaternary strata north of Mayflower Dormitory. The illustrated section is a tracing of a photo mosaic of the site taken January, 1984. Note complex bedding in the upper portion of the Pennsylvanian sequence.

The Pennsylvanian sequence at Stop 6 is discussed in greater detail in an earlier chapter. The lower interval is dominated by horizontally-bedded, shaly and silty, fine-grained sandstone. The unit is laminated and contains abundant small pieces of plant debris. Small-scale cross-bedding is apparent in some beds. The upper portion of the horizonally-bedded interval is dominated by siltstone and contains proportionately more mudstone; some beds display small-scale cross-beds. This unit is truncated by a channel-filling sequence up to 3.4 m (11 ft) thick. The upper sequence contains inclined beds of sandstone, siltstone, and mudstone outlining a complex channel geometry.

The Quaternary sequence exposed at Stop 6 is illustrated in figures 9 and 18. *The upper bluff face at this site is hazardous, and we discourage trip participants from climbing up (and falling off) the exposure face.* However, significant features can be seen from a distance, including: 1) small-scale normal faults developed beneath incisions in the Alburnett Formation alluvium as a result of glacial overriding; and 2) Late Sangamon sidevalley alluvium unit incised into the upper Alburnett Formation till (fig. 18).

This ends the walking tour of the campus area. To return to Trowbridge Hall and the Iowa Memorial Union, proceed south on Dubuque Street and turn west on Market Street (a return walk of 2.1 km; 1.3 mi). Alternatively, a university Cambus departs on regular intervals from the Mayflower Dormitory and can be taken to the Pentacrest area of campus.