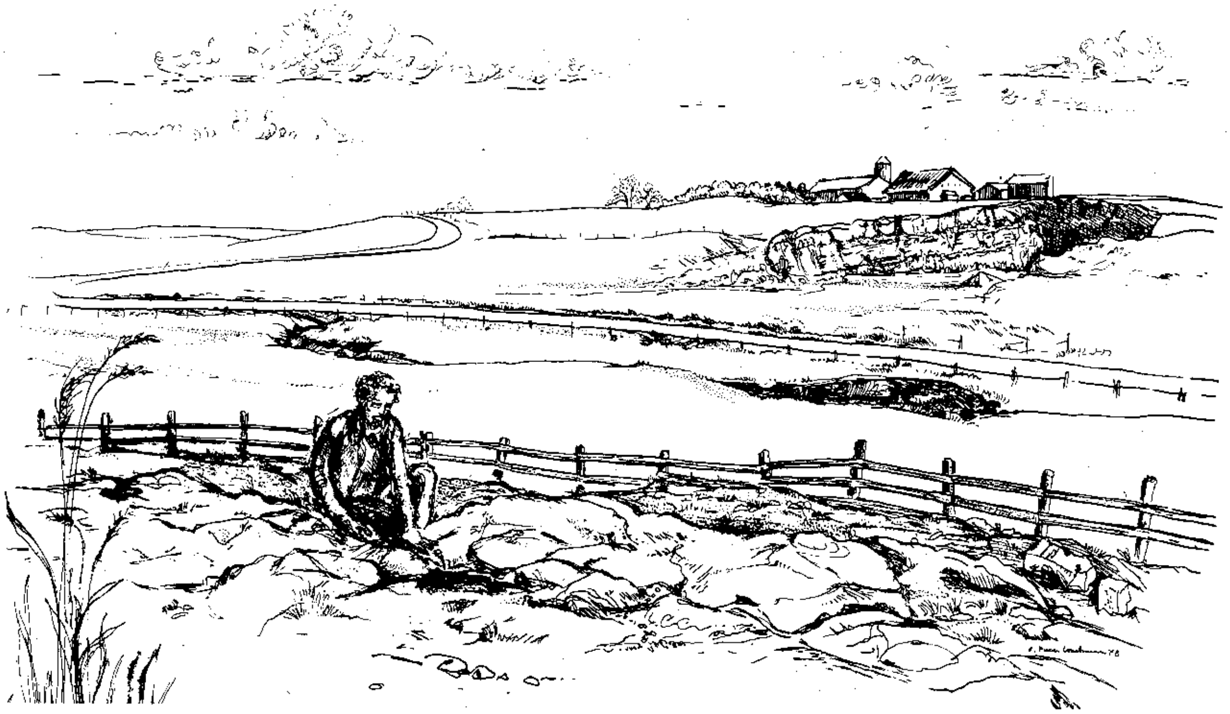

42nd Annual
TRI-STATE GEOLOGICAL FIELD CONFERENCE GUIDEBOOK

October 13-15, 1978
Kirkwood Community College
Cedar Rapids, Iowa
Sponsored by the
Iowa Geological Survey

IOWA GEOLOGICAL SURVEY
Iowa City, Iowa

42ND ANNUAL TRI-STATE GEOLOGICAL FIELD CONFERENCE
ON

GEOLOGY OF EAST-CENTRAL IOWA

OCTOBER 13-15, 1978

-GUIDEBOOK-

Edited by
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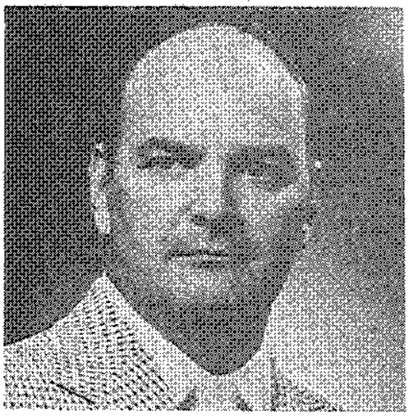
Cover sketch: Devonian carbonates (Pleasant Hill outlier) in the foreground are faulted into juxtaposition with Silurian carbonates exposed in the Freeman Quarry, in the background, along the Plum River fault zone in southern Jones County, Iowa. See field trip 1, stop 1. Sketch by Edith Couchman.



FORWARD

Tri-Staters,

Welcome again to Iowa. In this decade the University of Northern Iowa, Cedar Falls (1972); the University of Iowa, Iowa City (1975) and now the Iowa Geological Survey, Iowa City have sponsored the TRI-STATE Geological field conference. Those of you who are long-term students or faculty may have participated in these Iowa trips before and perhaps you feel that the geology of Eastern Iowa is already known to you. However, the science of Geology is dynamic just as our Earth id dynamic. We move ahead as new discoveries are made.

In the TRI-STATE area new discoveries are being made each year in mineral, water, and land resources, in structural geology, paleontology, and stratigraphy. Developments in environmental and engineering geology, and geophysical applications are also important.

In Iowa we are finding new structures, defining new stratigraphic boundaries, evaluating water resources and developing more information on mineral resources. We are examining the basement rocks with geophysical methods and studying magnetic anomalies. We are also increasing geotechnical services to industry, government, and citizens of the state.

With new or expanding programs in mind we have arranged some exciting field experiences for you. Pleistocene/geomorphology, Paleozoic structure/stratigraphy, and applied geology trips are planned.

The chairperson of the 42nd Annual Tri-State Conference is Ray Anderson who has been ably assisted by most of the Iowa Geological Survey staff. We are indebted to a great many people who provided assistance in the production of the six field trips which comprise this year's conference. Their names appear on the following page.

It is our hope that you will find this Tri-State experience valuable to you as a geological professional.

Thank you for participating.

Iowa Geological Survey

Stanley C. Grant

Stanley C. Grant
Director & State Geologist

ACKNOWLEDGEMENTS

We would like to express our deep appreciation to the many people who assisted our authors in the production of this year's Tri-State Geological Field Conference. We would especially like to thank:

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Thanks,
Ray
Ray Anderson
Tri-State Chairman

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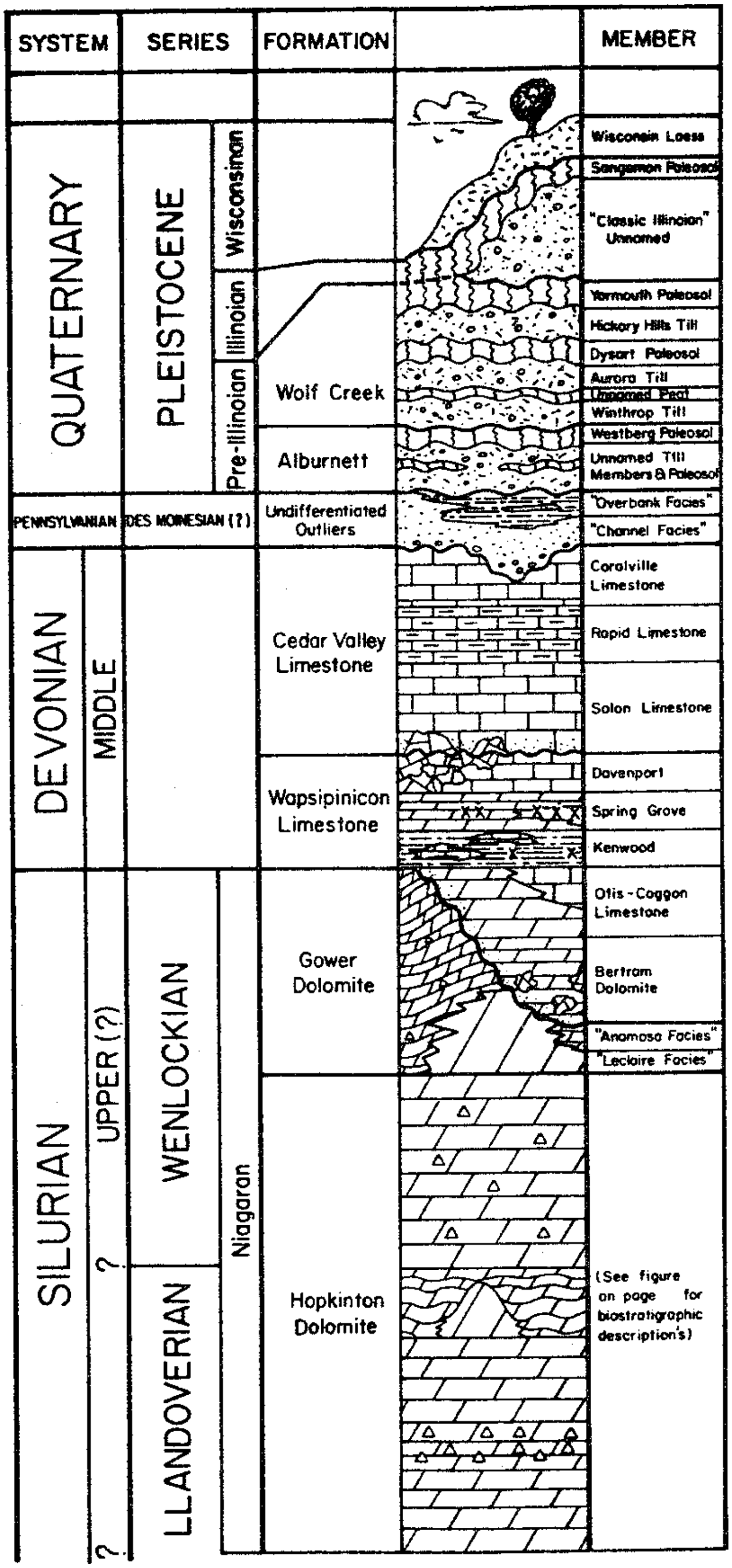
SYSTEM
SERIES
FORMATION
MEMBER
QUATERNARY
PLEISTOCENE
Wisconsinan
Illinoian
Pre-Illinoian
Wolf Creek
Alburnett
Wisconsin Loess
Sangamon Paleosol
"Classic Illinoian" Unnamed
Yarmouth Paleosol
Hickory Hills Till
Dysart Paleosol
Aurora Till
Unnamed Peat
Winthrop Till
Westberg Paleosol
Unnamed Till Members & Paleosol
PENNSYLVANIAN
DES MOINESIAN (?)
Undifferentiated Outliers
"Overbank Facies"
"Channel Facies"
DEVONIAN
MIDDLE
Cedar Valley Limestone
Coralville Limestone
Rapid Limestone
Solon Limestone
Wapsipinicon Limestone
Davenport
Spring Grove
Kenwood
SILURIAN
UPPER (?)
?
?
WENLOCKIAN
LLANDOVERIAN
Niagaran
Gower Dolomite
Otis-Coggon Limestone
Bertram Dolomite
"Anamosa Facies"
"Leclaire Facies"
Hopkinton Dolomite
(See figure on page for biostratigraphic description's)

a.

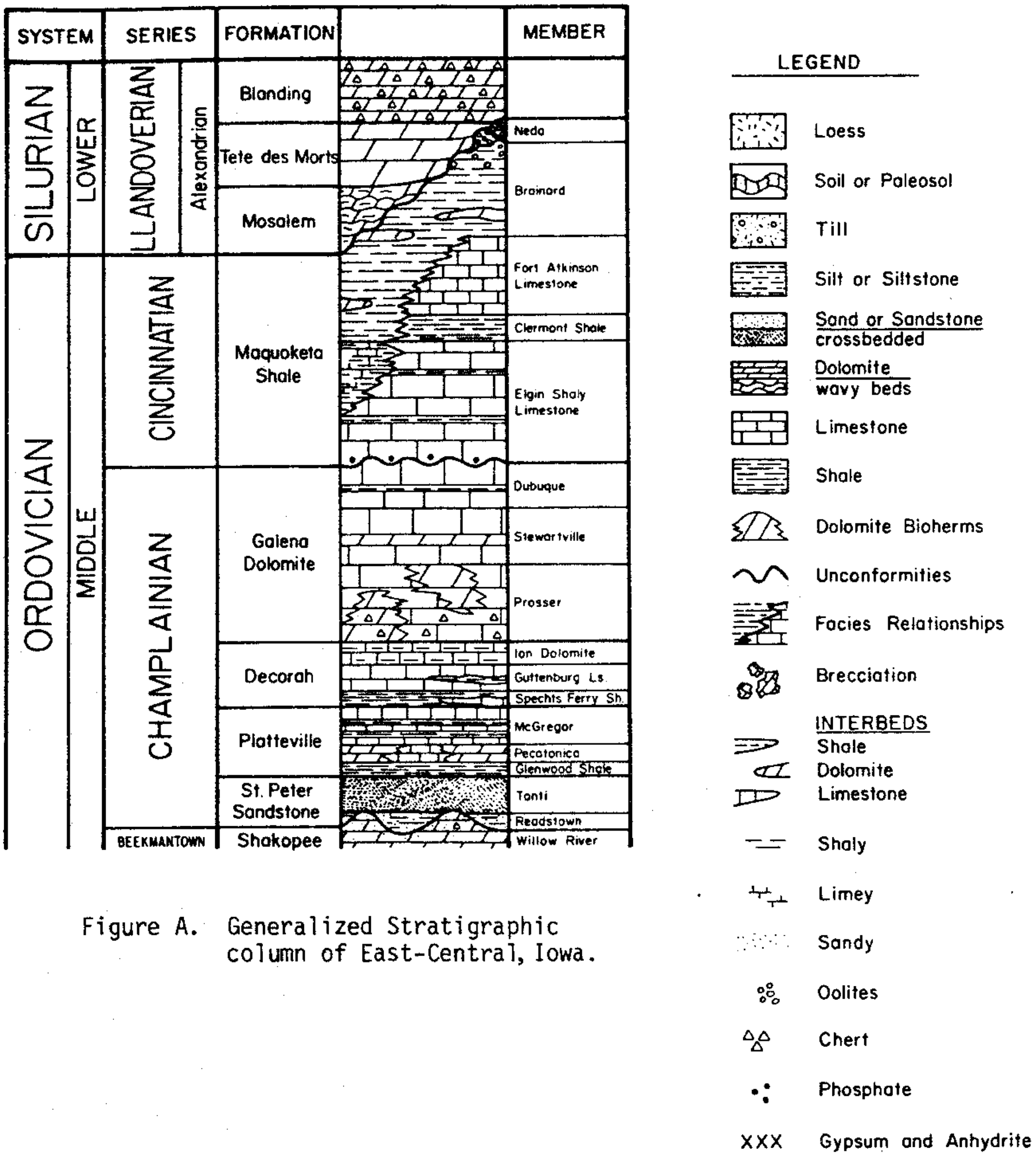

Figure A. Generalized Stratigraphic column of East-Central, Iowa.

The Relief Map of Iowa

by Ray Anderson

Although not a true Relief Map, this map displays the variety of topography to be found in Iowa. The map was produced by joining the 50 foot interval contour lines from 15 USGS, NK Series, 1:250,000 scale topographic maps. Reduction of this mosaic produced the map displayed on the facing page. Iowa's northern and southern borders were the only annotation added.

Areas of high relief appear dark on the map due to the increased density of contour lines produced by the steep gradients. One such area in northeastern Iowa is the Paleozoic Plateau, a region of limited till cover and deeply disected drainages forming steep cuestos. Another high relief area can be seen in southwestern Iowa where the dramatic loess bluffs extend east from the Missouri River. The southern ½ of Iowa also appears relatively dark on the Relief Map. This is an area of highly-disected, pre-Illinoian till with loess capped hills. The flattest major landform and the lightest on the map, is located in northcentral Iowa. This represents Iowa's most recent glacial advance, the Cary Lobe of Wisconsinan age. Drainage has not yet had time to develop in this area, and the landscape retains much of its post-depositional flat-lying terrain. Flanking the Cary Lobe on the northwest and east is the Iowan Surface, an area of Wisconsinan age erosional leveling of pre-Illinoian till (see Tri-State Trip 2, in this Guidebook).

Drainage patterns are also evident on this map. Low-relief floodplains and divides often appear lighter while, steeper valley walls are dark.

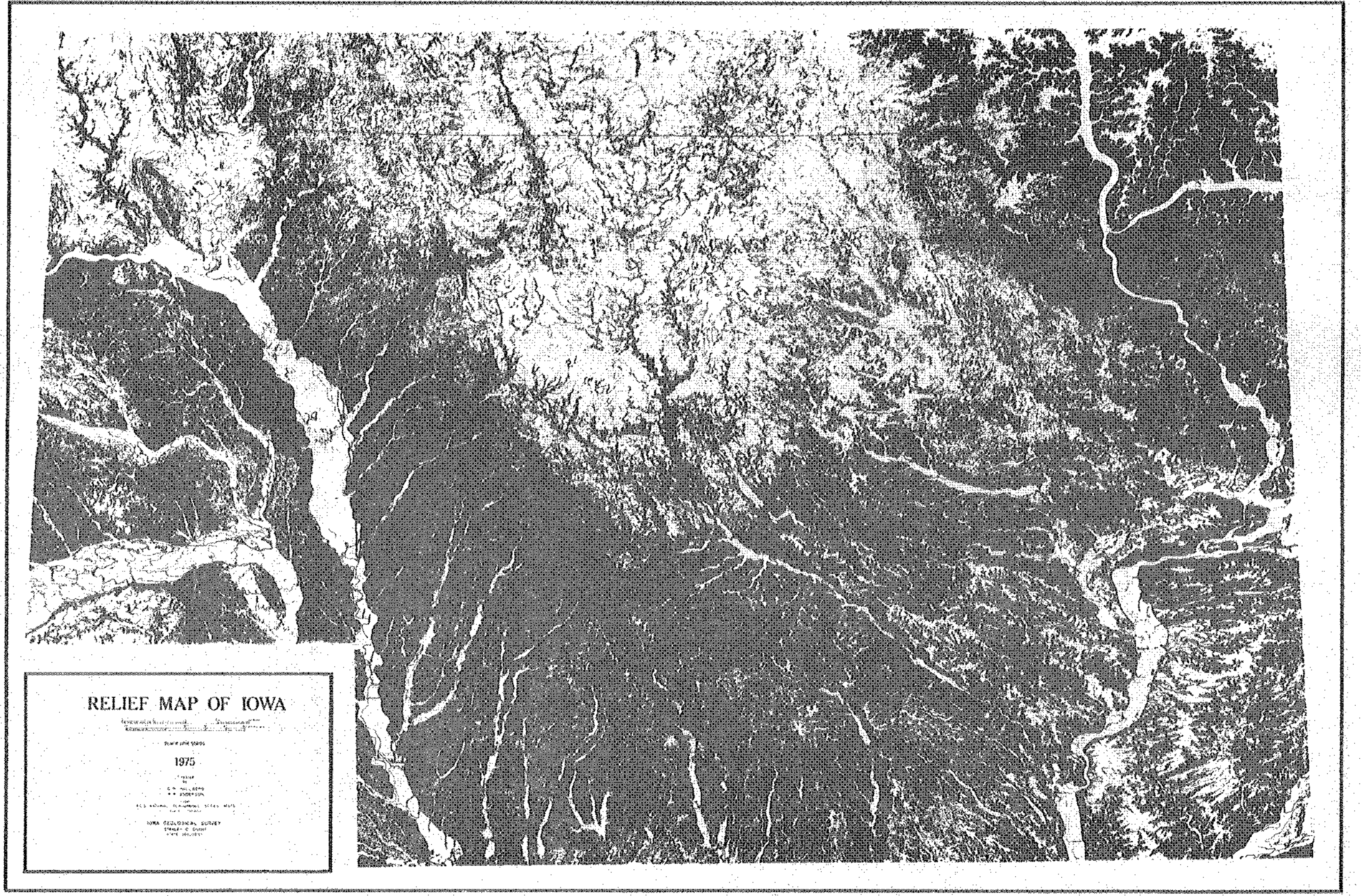

Figure B.

QUATERNARY GEOLOGY OF IOWA

by Jean C. Prior

Unconsolidated Quaternary deposits of glacial, fluvial and eolian origins mask the relief of Iowa's bedrock surface. Only in extreme northeast Iowa, where these materials are thin or absent, does bedrock dominate the present surface topography. North-central Iowa, the most recently glaciated (Wisconsinan) portion of the state, has no loess cover on the Cary drift, and retains the distinctive characteristics of recently glaciated terrain. The Tazewell drift to the west is loess-mantled and has a well integrated drainage system. The remainder of the state is dominated by older, more dissected and weathered Illinoian, Kansan* and Nebraskan* glacial drift which is draped with a mantle of Wisconsinan loess; the Illinoian till is confined to a narrow band in southeastern Iowa. Topography of the loess-mantled Kansan drift in the southern half of Iowa is steeply rolling, with valleys frequently eroded into bedrock. In contrast, the Kansan materials of the Iowan Erosion Surface comprise a gently rolling, stepped landscape, with isolated elliptical hills (paha) remaining as erosional remnants along the valley interfluves in the southern portion of the area. The Kansan deposits of northwest Iowa display similar Iowan Surface terrain characteristics and erosional history, but with the addition of a continuous loess cover. Unusually thick Wisconsinan as well as Illinoian loess deposits are present along the Missouri Valley, and dissection of this wind-blown silt has developed a unique landscape of sharply ridged hills. Extensive alluvial plains exist along the Missouri and Mississippi Valleys as well as in the Lake Calvin area of southeastern Iowa. The distribution of Quaternary deposits in Iowa is shown on the facing map.

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*Review of the classical pre-Illinoian section is presently underway at the Iowa Geological Survey; see Field Trip 2.

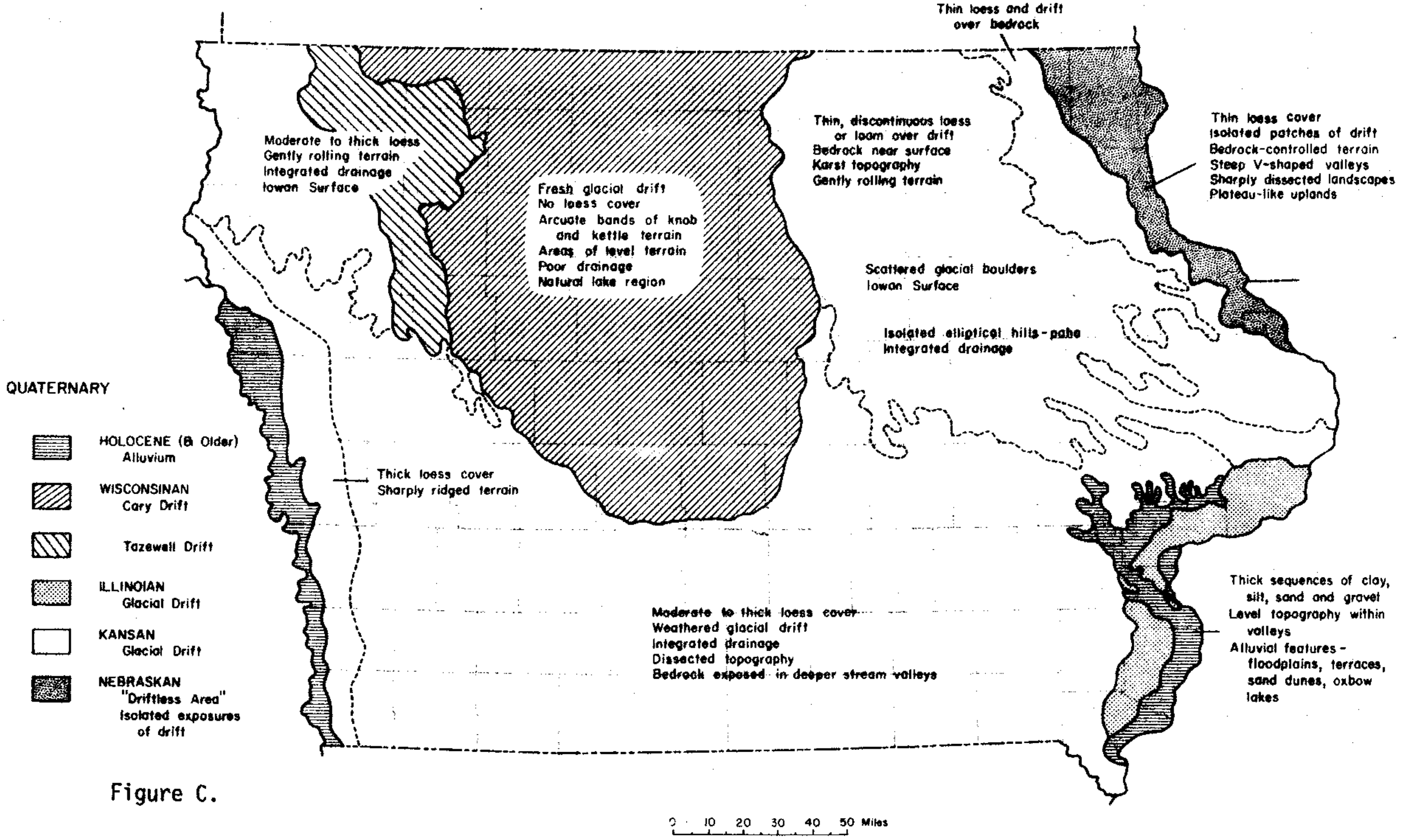


Figure C.

QUATERNARY TERRAIN AND MATERIALS IN IOWA.
(From: Prior, J.C., 1976)

Iowa Geological Survey
1976

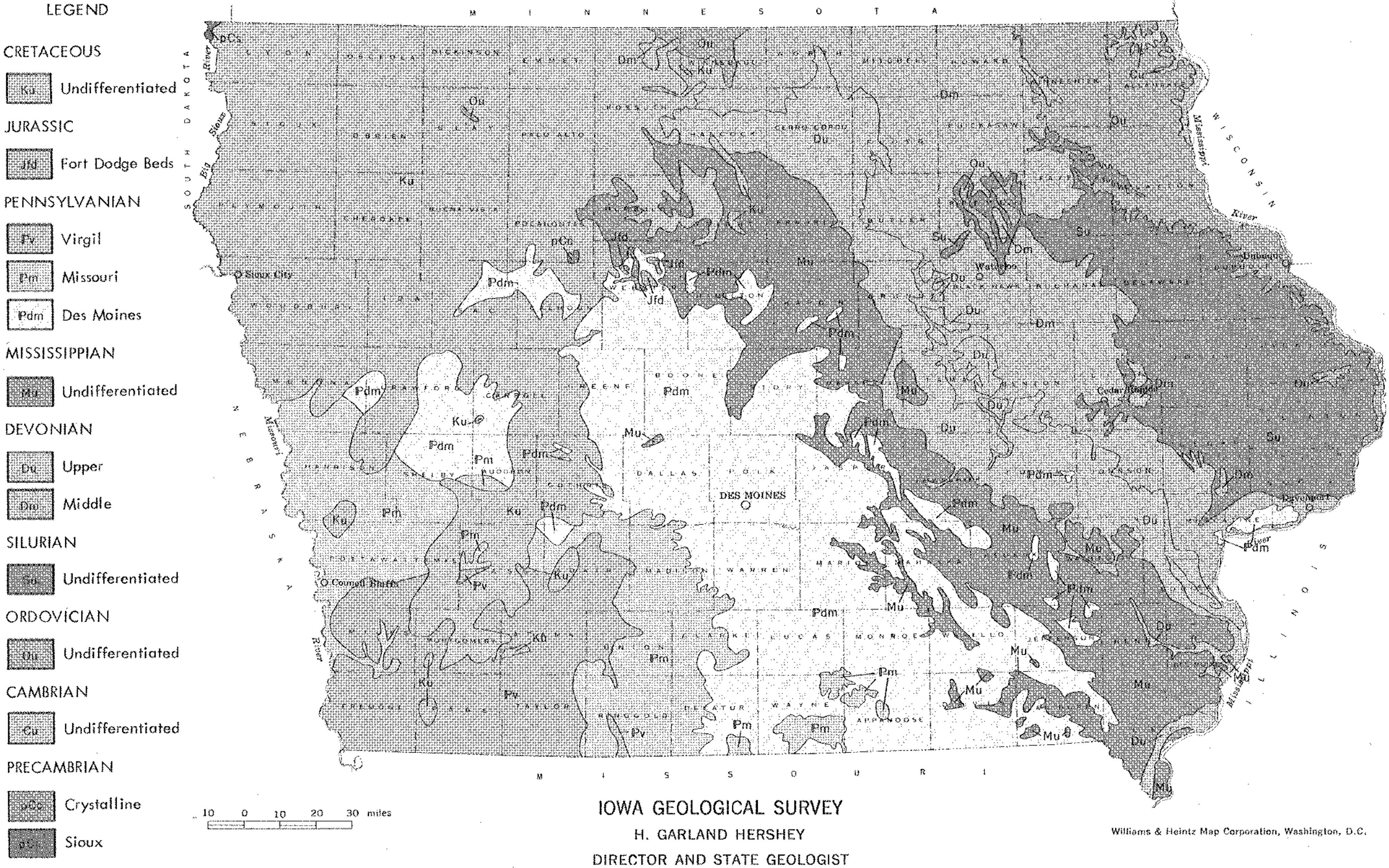
BEDROCK GEOLOGY OF IOWA

by Jean C. Prior

As with much of the Upper Midwest, Iowa's bedrock geology is characterized by generally horizontal sedimentary rock units, overlain by unconsolidated Quaternary deposits. These sedimentary units represent deposition during Precambrian through Pennsylvanian, Jurassic (?) and Cretaceous time and consist primarily of limestones, dolostones, sandstones, and shales. Broad regional warping has resulted in a gentle southwesterly dip of the state's Paleozoic strata. The resulting subcrop and outcrop units display an onlapping pattern, with the oldest rocks exposed in northeastern Iowa and progressively younger units encountered toward the southwest. Igneous and metamorphic rocks of the crystalline basement complex are deeply buried, except for an anomalous rise in Pocahontas County referred to as the "Manson Disturbed Area," and outcrops of Precambrian Sioux Quartzite in extreme northwest Iowa. The distribution of bedrock units across Iowa is shown on the bedrock geology map on the facing page. Extended periods of erosion following Paleozoic time and again during Tertiary time resulted in an irregular bedrock surface with much greater relief than is exhibited by Iowa's present land surface.

The Iowa Geological Survey is presently involved in a study of the Cretaceous System in northwest Iowa. This regional drilling program is providing significant new structural and stratigraphic information on the Cretaceous as well as the underlying Paleozoic and Precambrian units. Other recent Survey drilling projects in Pennsylvanian and Silurian-Devonian units also show a more complex structural and stratigraphic history of the state's geology than was previously realized.

BEDROCK OF IOWA



IOWA GEOLOGICAL SURVEY
H. GARLAND HERSHEY
DIRECTOR AND STATE GEOLOGIST
1969

Williams & Heintz Map Corporation, Washington, D.C.

TRIP 1

A FIELD GUIDE TO THE PLUM RIVER FAULT ZONE IN EAST-CENTRAL IOWA

by G.A. Ludvigson, B.J. Bunker, B.J. Witzke, and M.J. Bounk

The Plum River fault zone as named by Kolata and Buschbach (1976) is an east-west trending zone of closely-spaced faults along the Savanna-Sabula anticline in northwestern Illinois and east-central Iowa (see fig. 1-1A). Subsequent field investigations in Iowa (Bunker and Ludvigson, 1977), integrated with data obtained from test drilling in Devonian and Silurian rocks in and around Linn County, demonstrated that the fault continues westward and is continuous with the Skvor-Hartl area structures described by Dow and Mettler (1962) in southern Linn County (see fig. 1-1B).

The fault zone in Iowa consists of a 300 to 3,000 foot-wide band of cataclastic rocks, in which the primary depositional fabrics have been obliterated by tectonic granulation and secondary mineralization. The northern, downthrown side of the cataclastic zone in bordered by a series of sub-parallel synclines; the southern side is bounded by a group of sub-parallel anticlines. Field studies suggest that block faulting is present both within and proximate to the cataclastic zone.

The Plum River fault zone occurs in a terrane of otherwise flat-lying Ordovician, Silurian, and Devonian sedimentary rocks in the "stable interior region." The net vertical displacements reported along the zone in Illinois (Kolata and Buschbach, 1976) range from 100 to 400 feet. Similar vertical displacements are indicated in Iowa, with the maximum throw occurring in Jackson County between Maquoketa and Preston. The 110 mile length and the structural configuration of the fault zone suggest the possibility of significant strike-slip components of movement. To date no studies have been undertaken to evaluate this possibility.

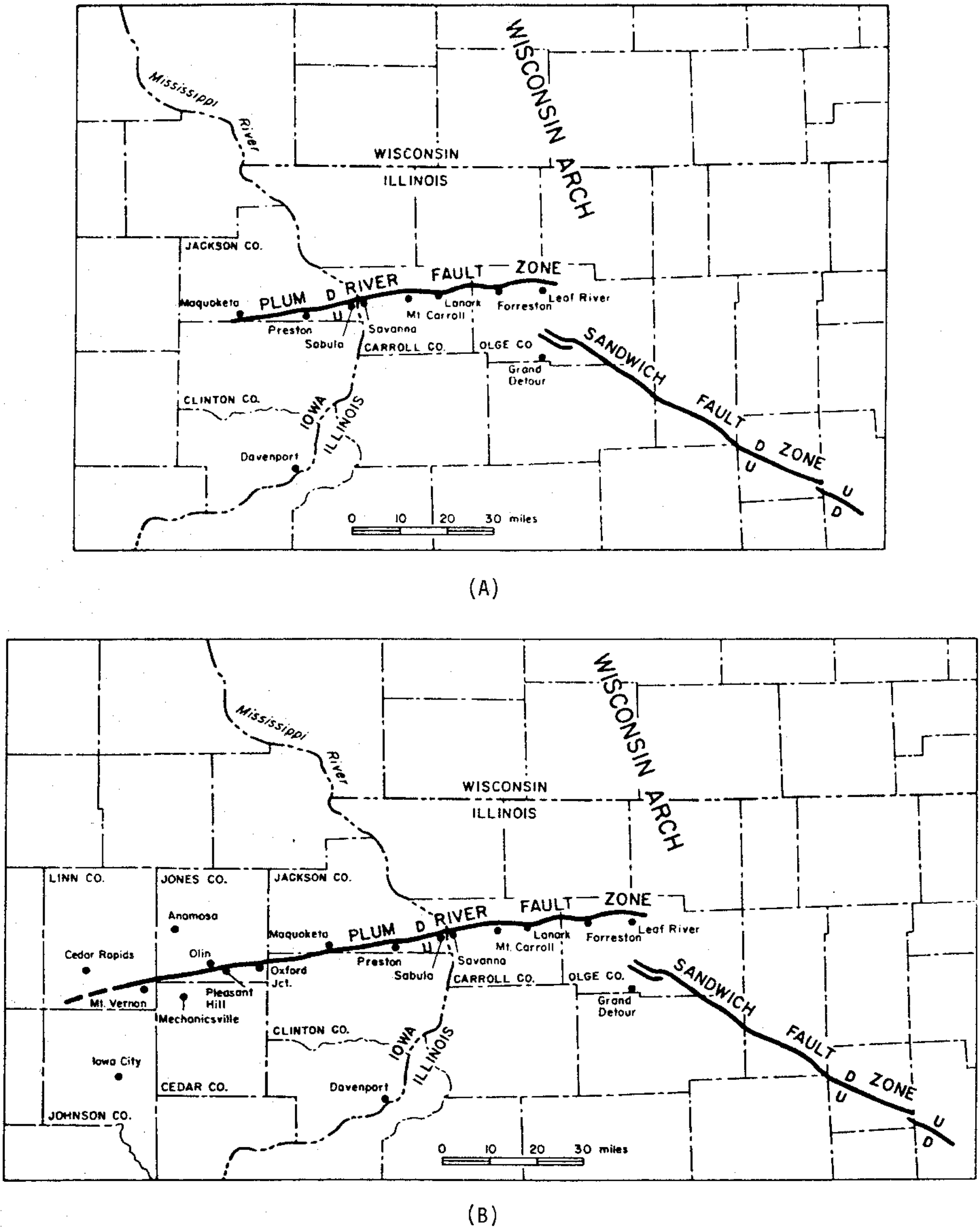


Figure 1-1. Location and Length of the Plum River fault zone: (A) as determined by Kolalta and Buschbach (1976), (B) as defined by this paper.

STRATIGRAPHY ALONG THE PLUM RIVER STRUCTURAL ZONE
A Guide to the Late Ordovician Through Middle Devonian Deposits of Eastern Iowa

Introduction

Ordovician, Silurian, and Devonian marine and restricted marine rocks have been identified adjacent to the Plum River structural zone in eastern Iowa. Defining the stratigraphic and facies relationships of these sediments is essential for a proper understanding of the structural features in eastern Iowa. A brief stratigraphic summary is included below.

ORDOVICIAN OF EASTERN IOWA

Upper Maquoketa Formation

The upper part of the Maquoketa Formation (Brainard Member) is present along the Plum River structural zone in southern Jackson County. The Brainard (see fig. 1-2) is primarily a blue-gray to greenish-gray clay shale (commonly dolomitic) sequence containing numerous carbonate interbeds that vary from 1 to 10 inches (2 to 25 cm) in thickness. The shales are usually unfossiliferous, although bryozoans and brachiopods may occur. Argillaceous, fine-grained, unfossiliferous dolomite interbeds are scattered throughout the Brainard. These carbonate interbeds become most prominent in the upper portions of the Brainard ("*Cornulites* zone") where they contain abundant megafossils, most notably the brachiopod *Eoplectodonta*. Twelve additional genera of brachiopods have been identified with *Strophomena*, *Diceromyonia*, *Onniella*, *Lepidocyclus*, *Plaesiomys*, *Zygospira* the most noteworthy. Also, abundant bryozoans, echinoderm debris, large bivalves (Pterinea, Ambonychia), gastropods, nautiloids, trilobites, and Cornulites. The sequence of carbonate interbeds is not consistent from outcrop to outcrop, and the carbonates are most likely lensatic in their distribution. Some contain varying amounts of pyrite crystals and small disseminated limonite blobs; limited ankerite void fill has also been noted. Ironstone ooids, identical to those in the Neda Ironstone Member, have been recovered within carbonate interbeds as much as 13 ft (4 m) below the top of the Brainard Member in Dubuque County; this suggests that iron deposition occurred sporadically during Brainard time and a genetic relationship between the Brainard and Neda is inferred.

Phosphatic (carbonate fluorapatite) molds of microfossils very similar to the basal Maquoketa "depauperate" microfossils are abundantly represented in some of the Brainard carbonate beds (Witzke, 1978). These microfossils occur in beds that lack benthic macrofossils and in beds of mixed macrofossils and microfossils (especially in bryozoan-echinoderm-rich horizons that lack Eoplectodonta). The Brainard "depauperate" phosphatic microfossils include a diverse assemblage of gastropods (10 spp.), bivalves (4 spp.), tiny bryozoans (5 spp.), scaphopods, hyolithods, conularids, brachiopods, ostracodes, crinoids, and starfish. Conodonts are sparsely represented in the Brainard.

The Neda Ironstone Member includes the uppermost few feet (to 2 m) of the Maquoketa Formation in Iowa. Although the Neda has not been noted along the Plum River zone (probably due to pre-Silurian erosion), it does crop out in the Dubuque area (Brown & Whitlow, 1960). It is predominantly a red dolomitic shale containing abundant ironstone ooids (with hematite, apatite, and chamosite rinds) about 1 mm in diameter and larger phosphatic nodules. A "depauperate" fauna similar to that in the Brainard is also preserved in the Neda. The Neda probably represents the final regressive phase of Maquoketa deposition.

SILURIAN OF EASTERN IOWA

A 480 ft (148 m) section of Silurian rocks is present along the downthrown side of the Plum River Fault zone near Olin (Jones County) and is the thickest known Silurian section in the state (see page 1-25 of this report). Pre-Wapsipinicon erosion removed significant portions of the Silurian section over most of the state, and many of the stratigraphic relations, particularly of the uppermost Silurian rocks, are still not completely understood. In eastern Iowa the stratigraphic sequence of Silurian rocks used in this report essentially follows that of Johnson (1975), and his informal classification of the sequences within the Hopkinton Dolomite is utilized. The Hopkinton-Gower contact is defined for the first time in this report.

Mosalem and Tete Des Morts (Edgewood) Formations

The lowermost Silurian rock units in eastern Iowa include the Mosalem and Tete des Morts beds, originally described as members of the Edgewood Formation by Brown and Whitlow (1960). However, the type locality of the Edgewood in northeast Missouri includes limestones of Late Ordovician age and dolomites of late Llandoverian age (Thompson & Satterfield, 1975). Because of the lithostratigraphic and time-stratigraphic discrepencies between the Iowa and Missouri Edgewood sections, the term Edgewood is inappropriate in eastern Iowa; the Mosalem and Tete des Morts are here elevated to formational rank in accord with Willman's (1973) classification for northwest Illinois. The stratigraphic interval that today includes the Mosalem and Tete des Morts was first named the Winston Formation by Savage (1914), but the term has fallen into general disuse.

The Mosalem rests unconformably upon an eroded Maquoketa surface (see fig. 1-2). It is predominantly a thin-bedded, fine-grained, argillaceous dolomite varying from 0 to about 100 ft (30 m) in thickness, and it apparently fills channels cut into the Maquoketa (Willman, 1973, p. 33). Locally the basal Mosalem beds incorporate coarse material derived from the weathered Maquoketa beds including Neda (phosphatic nodules, iron ooids) and Brainard lithologies (Brown & Whitlow, 1960, p. 39). Mosalem fossils are rare and include brachiopods (lingulids, rhynchonellids), bryozoans, trilobites, graptolites, and stromatolites (ibid.; Johnson, 1975). The graptolites suggest an early Llandoverian age (Ross, 1964).

The Tete des Morts (see fig. 1-2) is a prominent cliff-forming unit consisting of fine- to medium-grained, massive dolomite. It ranges from about 7 to 29 ft (2 to 9 m) in thickness (usually about 6 m), is often vuggy, and may have a nodular chert band near the middle of the thickest sections (Johnson, 1977, p. 31). Tabulate corals are conspicuous (Favosites, Syringopora, Halysites); echinoderm debris and stromatoporoids are also observed.

Blanding Formation

In eastern Iowa the Blanding Formation is a 35 to 50 ft (11 to 15 m) thick, interval of fine-grained dolomite with abundant nodular to bedded chert bands and has previously been called the Kankakee Formation (IGS strat. column). The term Kankakee was "eroneously introduced to Iowa" (ibid.), and the rock unit is both time- and lithostratigraphically different from the type Kankakee in eastern Illinois. Instead, Willman's (1973) northwest Illinois unit, the Blanding, is the preferred name in the eastern Iowa section (see fig. 1-2). Corals, gastropods, brachiopods, trilobites, and echinoderm debris are noted. Johnson (1975) suggests a a middle Llandoverian age for the Blanding.

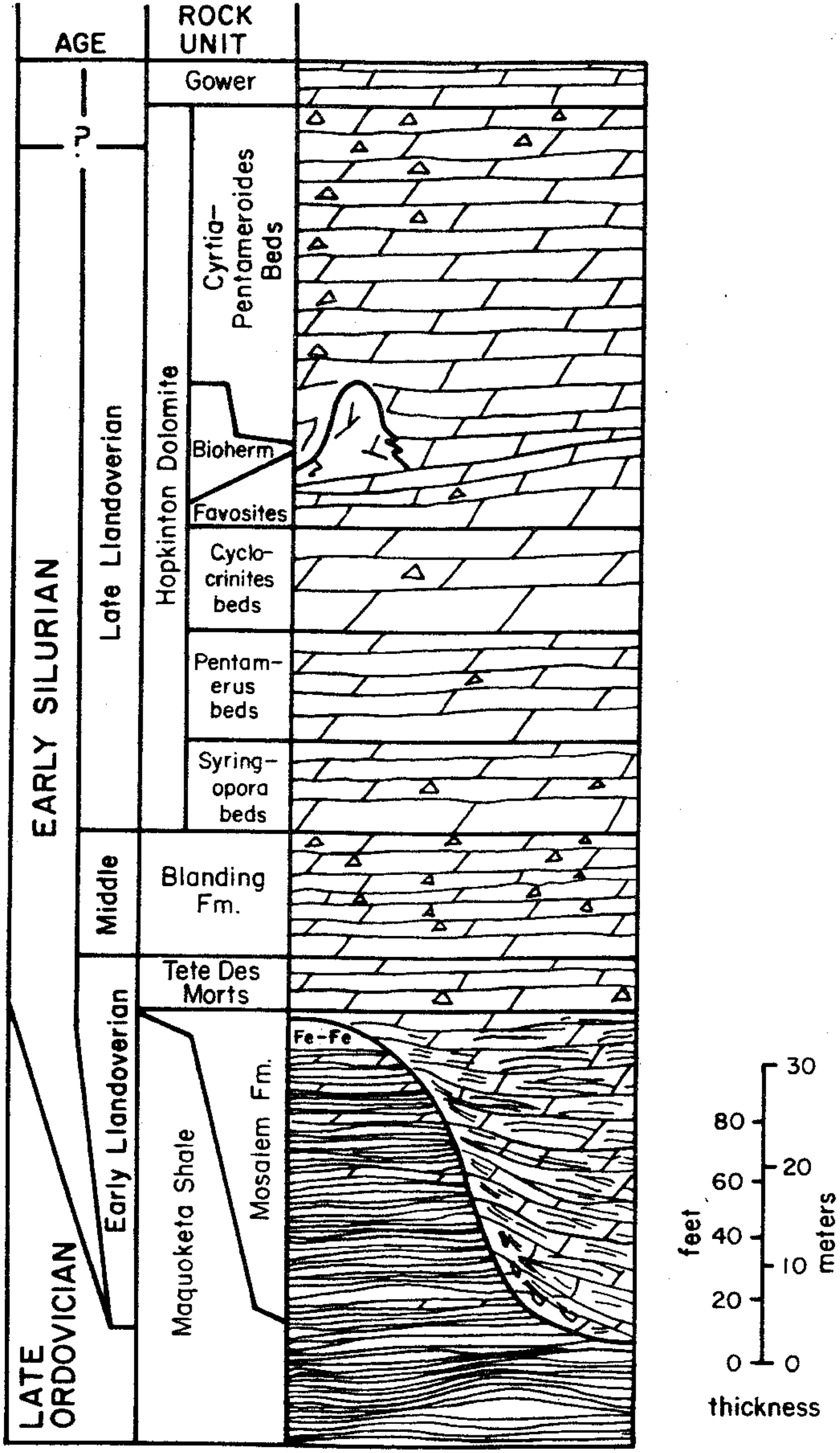


Figure 1-2. Generalized Upper Maquoketa Shale through Hopkinton Dolomite stratigraphic section, eastern Iowa.

The Hopkinton Dolomite

The Hopkinton Dolomite attains a thickness up to 260 ft (80 m) and is primarily of late Llandoverian age. It was divided into distinct "members" by Calvin and Bain (1900) and later revised and expanded by Johnson (1975). The Hopkinton Dolomite is not accepted as a valid lithostratigraphic unit in northwest Illinois where similar rock units have been termed the Sweeney, Marcus, and, in part, the "Racine" Formations (Willman, 1973). The type locality of the Racine Dolomite in eastern Wisconsin includes reef buildups of Wenlockian age. While it is true that the Port Byron and Cordova, Illinois reefs are both litho- and time-stratigraphically similar to the type Racine Dolomite, the lower portion of the northwest Illinois "Racine" includes late Llandoverian dolomites correlative with the Hopkinton Dolomite of Iowa.

"*Syringopora* *beds*" - The first 29 to 36 ft (9 to 11 m) interval of the Hopkinton Dolomite in Iowa is informally called the "*Syringopora* beds"; it is typically a thick-bedded, fine-grained, vuggy dolomite containing silicified corals (*Syringopora*, *Favosites*, *Halysites*), stromatoporoids, and echinoderm debris. Near the middle of this unit a dense, cherty horizon contains abundant stricklandian brachiopods of early late Llandoverian age (Johnson, 1975). The Sweeney Formation of northwest Illinois is equivalent to the "*Syringopora* beds", although it is generally a thicker section of "dolomite in thin, wavy beds separated by green clay partings" (Willman, 1973, p. 36).

"*Pentamerus* *beds*" - The "*Pentamerus* beds" are most readily distinguished from adjacent Hopkinton beds by the great abundance of molds of the brachiopod *Pentamerus* *oblongus* (often in life position). This 32 to 36 ft (10 or 11 m) thick unit is characterized by medium-bedded, fine-grained, sometimes cherty dolomite (Johnson, 1975). Although *Pentamerus* is by far the dominant fossil in this interval over much of eastern Iowa, additional brachiopods, corals, trilobites, echinoderm debris, and infaunal borings (along discontinuity surfaces) are noted (Johnson, 1975, 1977a). The Marcus Formation is the equivalent unit in northwest Illinois (Willman, 1973). In Linn County (sec 16, T84, R7W) a core through the Silurian section (see fig. 1-3) reveals a faunal variation. Within the "*Pentamerus* beds" interval in this area corals have replaced *Pentamerus* as the abundant fossil.

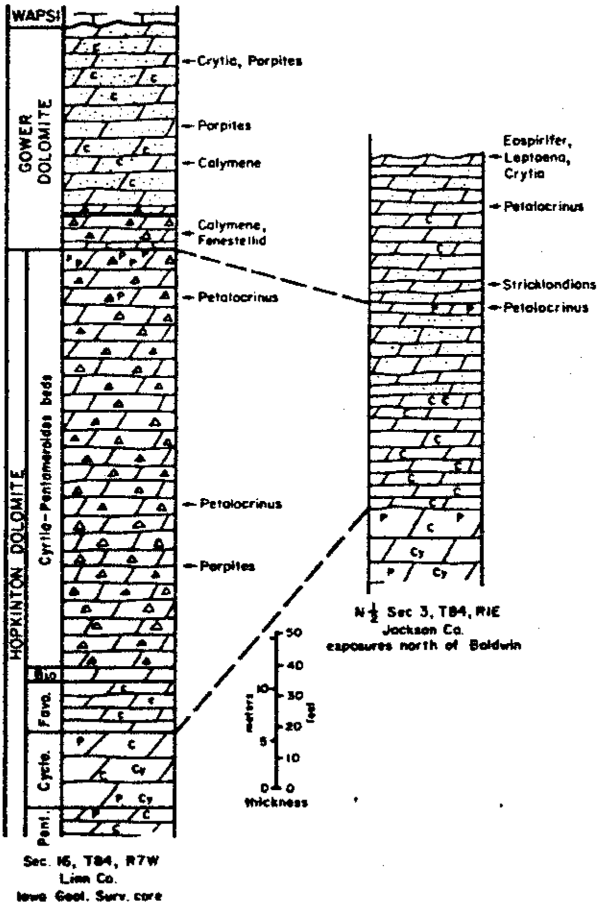


Figure 1-3. The Upper Hopkinton - Gower Dolomite transition. Δ=chert, ⁘=very crinoidal intervals, c=tabulate corals and stromatoporoids, P=pentameran brachiopods, Cy=*Cyclocrinites* (a green algae).

"Cyclocrinites beds" - The "Cyclocrinites beds" are a 32 to 40 ft (10 to 12 m) thick interval of generally thick-bedded to massive, often vuggy, very fine-grained dolomite containing scattered cherty zones (Johnson, 1977). Cyclocrinites, a golf-ball-shaped green algae, and Pentamerus "maquoketa" (distinguished from P. oblongus by its usually smaller and more globular shape) are the most readily recognizable fossils characteristic of this interval. Fossils are usually very abundant in the "Cyclocrinites beds" and include a great variety of brachiopods (including stricklandians of mid late Llandoverian age), corals and stromatoporoids, bryozoans, trilobites, and the most diverse molluscan fauna noted in the Hopkinton (bivalves, a great variety of small to very large gastropods, and abundant nautiloids). Echinoderm debris is very abundant in some horizons, especially near the contact with the overlying "Favosites beds", and at least 20 species of echinoderms have been identified including cystoids, abundant crinoids (several new genera noted), and rare paracrinoids (Witzke, 1976). The "Cyclocrinites beds" are the main cave-forming interval in the Hopkinton (e.g. Maquoketa Caves State Park), and it also is an important aquifer in many areas.

"Favosites beds" - The "Favosites beds" vary dramatically in thickness between about 16 and 40 ft (5 to 12 m). The development of thick sections of these coral-bearing beds may be related to contemporaneous structural movements during deposition, primarily to the north of the present Plum River fault zone (see Johnson, 1977, p. 35). This suggests that structures related to the Plum River fault zone may have been initiated as early as Hopkinton time. The "Favosites beds" are medium-bedded to massive, fine- to coarse-grained, usually vuggy dolomite with occasional chert bands (recalcitized limestones are noted near Manchester in

Delaware Co.). A coral-stromatoporoid fauna is conspicuous (Favosites, Syringopora, Halysites); brachiopods and trilobites are also present. Echinoderm debris is abundant and in many horizons is responsible for the medium-grained textures. Conodonts in conjunction with the brachiopod lineages suggest a late late Llandoverian (C_5) age.

"Bioherm beds" - Bioherms in the Hopkinton Dolomite were first noted by Philcox (1970a) who observed small unbedded coral-crinoid-mud mound developments near Monticello in Jones County (20 to 30 ft thick, spaced 50 to 100 ft apart). These bioherms are flanked and buried by coarse crinoidal debris. In the interreef areas fine-grained, bedded dolomites 0 to 16 ft (5 m) in thickness contain deeper-water associations of Pentameroides, stricklandian brachiopods, and Petalocrinus of late late Llandoverian age (Johnson, 1975).

The "Cyrtia beds-Pentameroides beds" interval - The exact contact relationships between Johnson's (1975) "Cyrtia beds" and "Pentameroides beds" have not yet been clarified by any known surface exposure. However, the recently examined core section (sec 16, T84, R7W, Linn Co.) has revealed an uninterrupted lithologic sequence 134 ft (41 m) thick that includes these two beds, and the "Cyrtia beds" and "Pentameroides beds" are here treated as a single lithologic unit. The "Cyrtia beds", as originally defined by Johnson (1975, 1977) from outcrops in Dubuque, Jackson, Clinton, northeast Cedar, and Jones Counties, are very fine-grained, richly bioclastic, non-cherty dolomites. They characteristically contain abundant echinoderm debris with 32 species of crinoids (5 new genera) and 3 species of cystoids (1 new genus) described from locally abundant concentrations of articulated cups and thecae (Witzke, 1976). Eucalyptocrinites, *Siphonocrinus*, *Dimerocrinites*, *Caryocrinites*, *Marsupiocrinus*, and *Petalocrinus* are the most common echinoderms. Brachiopods may be very numerous with *Eospirifer*, *Atrypa*, "*Plicostricklandia*", *Camerella*, *Ferganella* being notable; stricklandians have been used to assign a C_6 late Llandoverian age to the "*Cyrtia* beds". Fenestellids and other bryozoans may predominate in some of the lower horizons; corals, stromatoporoids, sponge spicules, molluscs, trilobites, and ischaditid algae are also noted. The bioclasts are typically preserved as molds only, although some echinoderm debris may be replaced by dolomite. The lower portion of the "*Cyrtia* beds" includes the deepest water paleocommunities of the entire Hopkinton, with the overlying "upper *Pentameroides* beds" displaying a return to shallower water deposition (Johnson, 1975).

The "*Pentameroides* beds" occur near the top of the Hopkinton Dolomite and superficially resemble the lower "*Pentamerus* beds". Abundant molds of *Pentameroides subrectus* as well as corals, *Petalocrinus*, and stricklandians are present in a cherty, fine-grained dolomite. The stricklandians (Johnson, 1975, 1977) and *amorphognathoides* Zone conodonts suggest a latest Llandoverian or early Wenlockian age for the top of the Hopkinton.

The "*Cyrtia-Pentameroides* beds" interval in the previously mentioned Linn County core (see fig. 1-3) is characterized by a very fine-grained, generally poorly fossiliferous (except the top 6 ft) dolomite with abundant chert bands and irregularly-shaped chert nodules. The lower part of this interval ("*Cyrtia* beds") undergoes a significant facies change from a non-cherty, abundantly bioclastic unit in the north and east to a very cherty, largely unfossiliferous unit further west. An excellent reference section illustrating the cherty facies can be seen where Hwy 151 crosses the Wapsipinicon River near Anamosa (SE sec 4, T84, R4W, Jones Co.).

Fossils are much rarer in the cherty facies and include the button coral Porpites, arm-fans of Petalocrinus, and scattered debris of small echinoderms. Conodonts present include Ozarkodina polinclinata, Panderodus unicostatus, and Kockelella sp. (J. Barrick, 1977, pers. comm.). Even where the "Cyrtia beds" are non-cherty, the overlying "Pentameroides beds" are usually abundantly cherty.

The Hopkinton-Gower Contact

The previously mentioned Linn County core (fig. 1-3) has helped clarify some of the long-standing problems in resolving the contact between the Hopkinton and the overlying Gower Dolomites. Within the cored interval, a prominent lithologic and paleontologic change is noted at a depth of 263 ft, and it is at this level that the contact between the Hopkinton and Gower Dolomites can most easily be drawn. The uppermost Hopkinton beds are fine-grained, very chert, dense, dark gray dolomite crowded with molds of Pentameroides. A thin, dark shale-parting separates the Gower from the underlying Hopkinton. The overlying Gower lithology rapidly changes to a porous, coarsely crinoidal, non-cherty, gray dolomite containing prominent corals ("Cyathophyllum", Halysites, Favosites). The coarse-grained, abundantly crinoidal textures grade upward to fine-grained moderately crinoidal textures at a depth of 260 ft (1 m thick). Cherty, very fine-grained textures (much like those of the underlying Hopkinton cherty dolomites) with a fauna of cup corals, Atrypa, Calymene, and fenestellid bryozoans are noted at a depth of 253 to 260 ft (2 m thick). Above this a 10 inch (25 cm) thick porous, crinoidal, non-cherty dolomite appears which grades upward once again into a 3 ft (1 m) interval of cherty, fine-grained dolomite. At a depth of 249 ft the cherty zone abruptly disappears and a 58 ft (18 m) section of porous, often vuggy, coral-rich, highly crinoidal dolomite characteristic of the lower Gower Formation occurs beneath the Wapsipinicon Formation. Thus, although lower Gower and upper Hopkinton types of lithologies alternate three times within 14 ft (4 m) of the contact in the cored interval, the base of the Gower can be conveniently located at the first horizon of coarsely crinoidal, coral-bearing, non-cherty dolomite (which in this case also corresponds to the last appearance of *Pentameroides*). Although not stated as such, Philcox's (1970, p. 176) sections 89 and 90 in Palisades-Kepler State Park (Linn Co.) may include the Hopkinton-Gower contact.

A series of roadcuts and natural bluff exposures in the N½ sec 3, T84, R1E, Jackson County reveals a section (fig. 1-3) roughly comparable to the Linn County core, although certain differences are evident. The Jackson County section may occur along a zone that was structurally active in the Silurian (see "*Favosites* beds" discussion), and may therefore be atypical; at present, it is one of the few known surface outcrops that exposes the critical interval. There, a comparatively thin interval of crinoidal, non-cherty "*Cyrtia* beds" rests on a thick interval of "*Favosites* beds". Although the "*Cyrtia* beds" are covered in part near the top, a very fine-grained, non-cherty horizon containing numerous molds of *Callipentamerus* is observed near the base of the overlying Gower Dolomite. The *Callipentamerus* beds contain *amorphognathoides* Zone conodonts, and the horizon is probably roughly the lateral equivalent of the more widespread *Pentameroides* horizon at the top of the Hopkinton Dolomite. A short interval of fine-grained to crinoidal dolomite overlies the *Callipentamerus* zone, and is in turn overlain by a horizon of stricklandian brachiopods. Above this, 44 ft (13.5 m) of coarse crinoidal and coralline dolomites characteristic of the lower Gower are observed. By analogy with

Johnson's (1975, 1977) depth-related paleocommunities, shallowing-deepening-shallowing conditions (or perhaps even more complex relations) are inferred across the contact.

The Gower Dolomite

The Gower Dolomite (fig. 1-4) includes a complex array of reef, inter-reef, and post-reef-building facies that have been the subject of much controversy since the time of James Hall. The lower portion of the non-reefal Gower Dolomite is characterized by horizontally-bedded, fine- to coarse-crinoidal dolomites that contain lesser numbers of corals, bryozoans, brachiopods, trilobites, and nautiloids; it is apparently highly variable in thickness, and, to complicate matters further, may not always be crinoidal. The crinoidal debris most commonly occurs as molds, although many beds contain packstones of dolomite-replaced debris. Interspersed at one or more levels within the crinoidal layers may be fine-grained, dense dolomite beds containing such fossils as Eospirifer, Leptaena, Cyrtia, Calymene, Porpites. The presence of the conodonts Panderodus serratus and Ozarkodina excavata excavata (J. Barrick, 1977, pers. comm.) in the uppermost levels north of Baldwin (see strat. section) suggests a Wenlockian age. The upper levels of the Freeman Quarry, on the up-thrown side of the Plum River Fault (SE SW 20, T83, R2W, Jones Co., field trip Stop 1) have yielded Ozarkodina excavata and a primitive Kockelella walliseri (ibid.), and an early to middle Wenlockian age is suggested.

The main reef- or bioherm-forming phase of the Gower has been called the LeClaire facies, and mound-like developments as thick as 100 ft (30 m) are noted. This facies at Palisades-Kepler is typified by coarse crinoidal dolomites with local coral- and stromatoporoid-rich developments; these

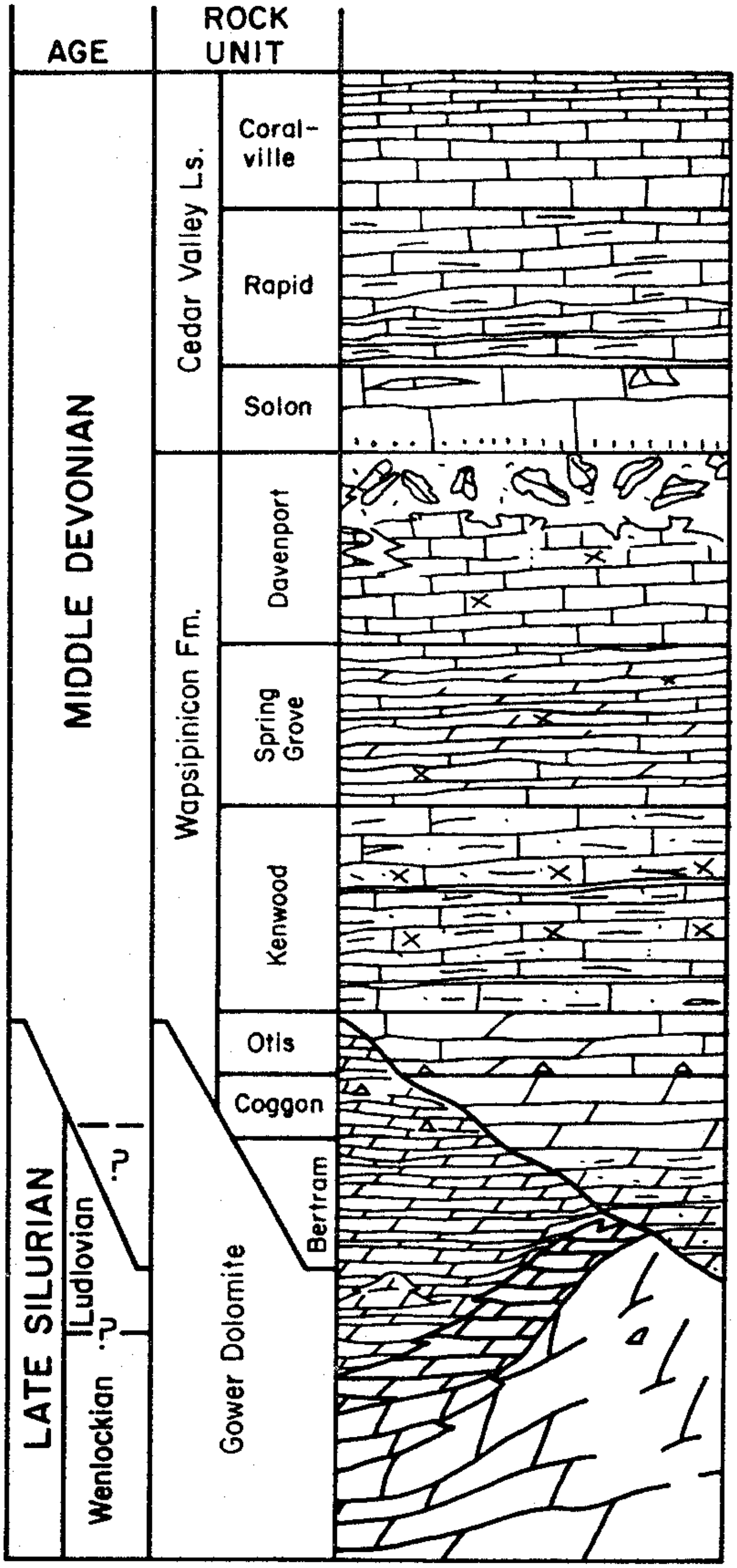


Figure 1-4. Generalized Gower Dolomite through Cedar Valley Limestone stratigraphic section, eastern Iowa (same scale as Figure 1-2).

are flanked and buried by finer-grained skeletal dolomites (Philcox, 1970). Massive dolomite "cores" may form the central portions of these bioherms which are flanked by bedded skeletal dolomites (Hinman, 1968). In addition to the ubiquitous crinoids and corals, bryozoans, brachiopods, nautiloids, bivalves, gastropods, and trilobites are commonly noted. The crinoidal LeClaire facies is, at least in part, laterally equivalent to the crinoidal dolomites of the lower Gower (discussed in the previous paragraph).

The Brady facies (Philcox, 1970) and the related Anamosa beds are lithologically and faunally distinct from the rest of the Gower and, wherever the basal relationships are known, are consistently underlain by the crinoidal dolomites of the LeClaire or lower Gower. The Brady facies is closely associated with the bioherms and has been noted at a variety of structural attitudes (including 90° dips and over-turned folds). These anomalous dips are not related to any tectonic movements but probably were formed during penecontemporaneous slumping and compaction of algal muds over the rigid underlying bioherms. The Brady facies includes laminated, stromatolitic dolomites (3 ft diameter algal heads have been reported) and brachiopod-coral-rich beds that include athyrid (commonly preserving the delicate spiralia) and rhynchonellid brachiopods, small tabulate and rugose corals, small gastropods, and ostracodes. This facies may represent a second stage of reef development (Philcox, 1972). Small satellite reefs of similar faunal composition are noted interbedded with the Anamosa facies which is, in part, contemporaneous with the Brady facies (ibid).

The Anamosa facies at the type locality of the Gower Dolomite (Bealer's Quarry at Cedar Valley, Cedar Co.) reaches a thickness of 108 ft

(33 m), although only the upper 29 ft (9 m) are still accessible. The "laminate-Anamosa" (Philcox, 1972) is a laminated to thin-bedded, dense, organic-rich dolomite; thicker, dense dolomite beds may occur. The "crenulate-Anamosa" includes distinctive algal stromatolite laminations (apparently subtidal; no birdseye or supratidal features); chert may locally be common. Crinoids are usually conspicuously absent from the Anamosa and Brady facies, although interspersed low-diversity brachiopod and coral faunas are commonly noted. The Anamosa/Brady facies completely surrounds and buries the LeClaire bioherms leaving the contemporaneity of portions of the LeClaire and Anamosa as a matter of conjecture. The LeClaire is largely Wenlockian in age, whereas the Anamosa probably includes sediments as young as Ludlovian.

THE DEVONIAN OF EASTERN IOWA

In general, the stratigraphy of the Wapsipinicon and Cedar Valley Formations is more clearly understood than the underlying Silurian rocks, and only a very cursory review will be given here. The poorly understood Silurian and/or Devonian LaPorte City Chert (limestones and dolomites) will not be considered in this report.

Wapsipinicon Formation

The Wapsipinicon Formation may overlie Ordovician or Silurian rocks. The lower part of the Wapsipinicon Formation (see fig. 1-4) includes, in ascending order, the Bertram, Coggon, and Otis Members which occur in a 4, 8, and 11 County area, respectively, in eastern Iowa. The Bertram is a brown to gray, unfossiliferous, vuggy, usually laminated, sometimes intraclastic, fine-grained dolomite with abundant sand grains; sandy shales may also occur. It attains a maximum thickness of 96 ft (30 m). The

Coggon attains a maximum thickness of 30 ft (9 m) and is typically a massive, yellowish-brown, friable, fine-grained dolomite; small brachiopods (Emanuella) may occur. The Otis, also attaining thicknesses of up to 30 ft (9 m) is commonly represented by brown to gray fine-grained limestones to fine- or medium-grained dolomites, often with chert bands near the base. The Otis, the most fossiliferous member of the Wapsipinicon, is composed of biomicrites and pelletal intrasparites containing several species of brachiopods (Emanuella predominates), rare corals and bryozoans, gastropods, trilobites (Dechenella), and conodonts indicating a Middle Devonian age (more details to be published later).

The upper three members of the Wapsipinicon are more widely distributed and occur across about half to two-thirds of the state. The Kenwood Member achieves the greatest geographic extent of all the members reaching thickness to 125 ft (38 m) including bedded anhydrite and gypsum evaporite facies where the unit is thickest. The Kenwood is a very argillaceous, sandy, unfossiliferous, bluish-gray to pale-orange carbonate with rare shales. The Spring Grove overlies the Kenwood and achieves a maximum thickness of 70 ft (22 m) of fine-grained dolomites and limestones (often with abundant gypsum and anhydrite) which are easily distinguished by the dark brown, organic rich laminations which emit a characteristic fetid odor when freshly broken. Ostracodes have been identified in Spring Grove Rocks. The uppermost member of the Wapsipinicon is the Davenport, a brown, often highly brecciated (in part by solution collapse), fine-grained limestone; thicknesses to 80 ft (25 m).

Cedar Valley Formation

The Cedar Valley Formation (see fig. 1-4) is a predominantly carbonate unit, generally of Middle Devonian age. In the Iowa City area the entire Cedar Valley section is a fossiliferous limestone with minor shale, although to the east, north, and west dolomite facies may become more prominent. The Solon Member, ususally about 20 ft (6 m) thick, is the basal member of the Cedar Valley Formation; a thin sandstone or sandy calcarenite separates it from the underlying Davenport Member, and the Solon sands and fossiliferous limestone lithoclasts may leak far down into the brecciated Davenport. The Solon is typically a thick-bedded to massive, fine-grained skeletal calcarenite with a diverse assemblage of marine fossils; coral-stromatoporoid biostromes may occur in the upper part of the Solon. The overlying Rapid Member is about 50 ft (15 m) thick and is characteristically a medium-bedded, bluish-gray, argillaceous skeletal calcilutite (shale layers may be present in the lower portion). A diverse marine biota is present, and coral biostromes commonly are developed. The Coralville Member, about 40 ft (12 m) in thickness, is separated from the Rapid by a pronounced burrowed discontinuity. The Coralville has a lower skeletal calcarenite interval (with prominent corals and stromatoporoids) and an upper pelleted calcilutite (including oncolites and birdseye structures). In general, the Cedar Valley represents a transgressive-regressive carbonate sequence.

STRATIGRAPHIC SIGNIFICANCE OF THE PLUM RIVER FAULT ZONE

Introduction

Stratigraphic anomalies associated with the fault zone suggest that the fault experienced repeated activity during the mid to late Paleozoic era. In eastern Iowa, Pennsylvanian, Middle Devonian, Early to Late Silurian, and late Ordovocian rocks are readily available for study along the fault in outcrop or in the shallow subsurface. Early Paleozoic activity is considered possible, but difficult to analyze because of deeper burial of associated rocks. The possibility of recent movement cannot be properly evaluated until the Quaternary stratigraphy of the area is better understood.

SILURIAN STRATIGRAPHY

In the spring of 1976, an IGS-USGS test hole was drilled near White Oak Creek in southern Jones County, to test for the presence of the Plum River fault. Drilled on the northern, downthrown side, the borehole confirmed that the units of the immediate vicinity are structurally depressed (see fig. 1-5). Probably the most remarkable aspect of the drillhole was the 480 feet of Silurian rocks penetrated (see fig. 1-6). Until then, the greatest known thickness of the Silurian system of Iowa was 380 feet although structure contouring in the vicinity of the fault had already suggested the presence of as much as 500 feet. The thick Silurian section penetrated at White Oak Creek can best be explained by structural preservation, suggested by its proximity to the Plum River fault zone. Surprisingly,

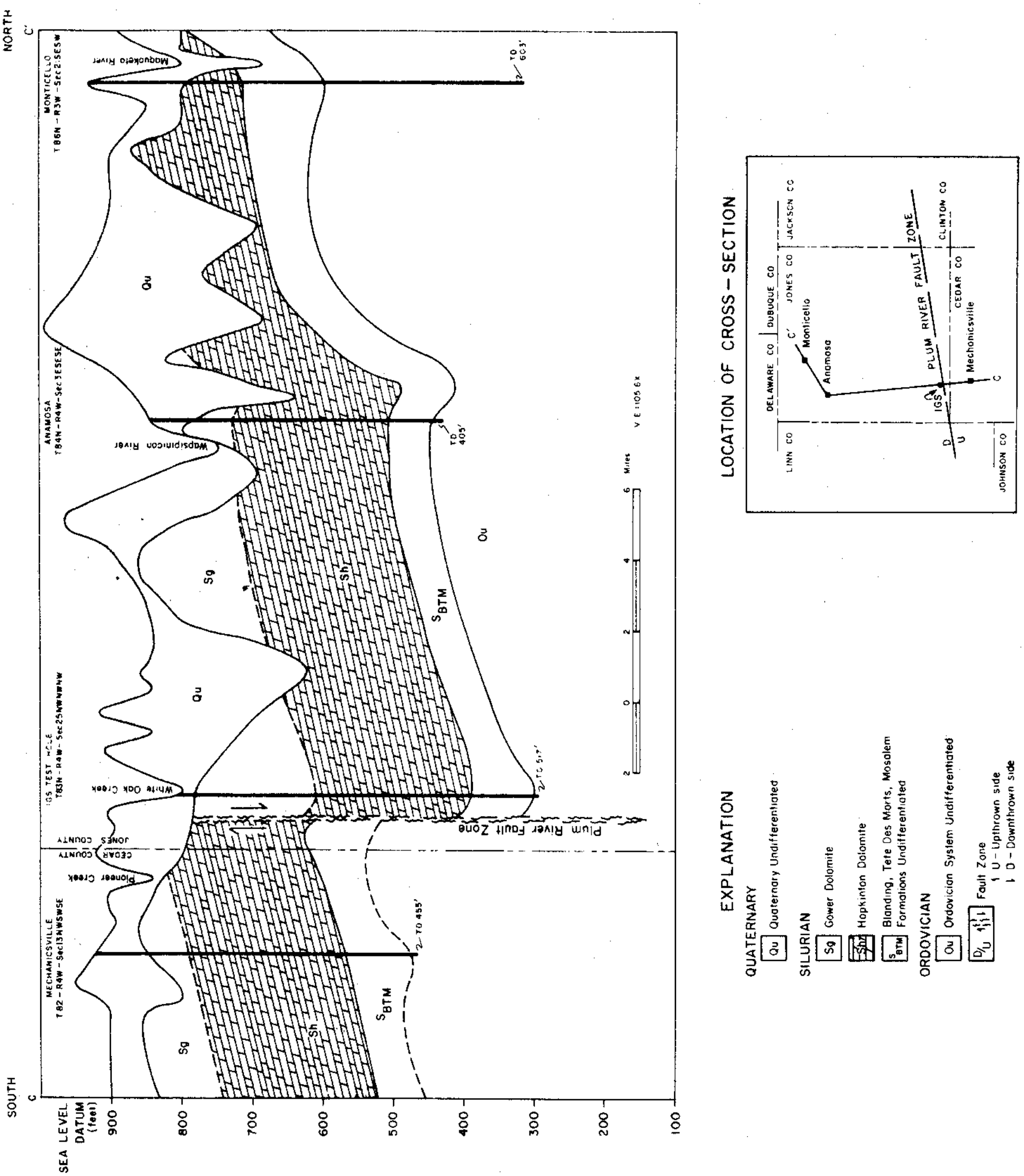


Figure 1-5. A north-south cross section across the Plum River fault zone, showing the location of the IGS-USGS test hole at White Oak Creek.

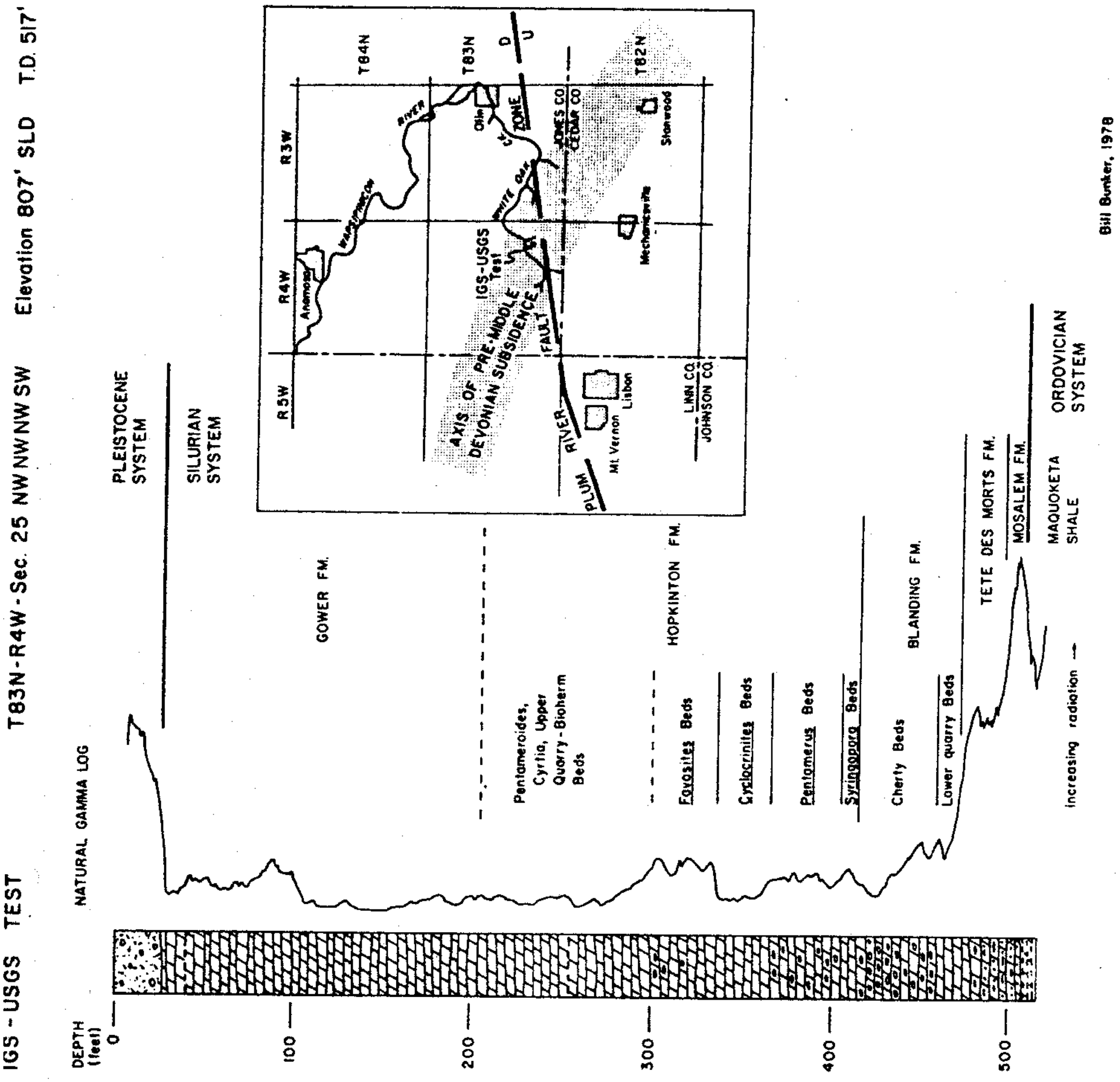


Figure 1-6. Geologic and natural gamma log of the IGS-USGS White Oak Creek test hole, and map showing the location of the hole in relation to mid-Paleozoic structures.

Silurian rocks in Iowa attain their greatest thickness within their outcrop belt, along a northwest to southeast trending axis of subsidence and attendent structural preservation which was active prior to Middle Devonian deposition (see Ham and Wilson, 1967). The White Oak Creek test hole occurs near the intersection of the Plum River fault zone and the axis of greatest thickness of the Silurian rocks (see fig. 1-6). This coincidence has afforded an opportunity to estimate the total thickness (+500 feet) of the Silurian carbonates in this region prior to the extensive erosional stripping and truncation by mid-Paleozoic tectonism.

DEVONIAN STRATIGRAPHY

All of the Middle Devonian units of eastern Iowa have been deformed and displaced along the fault. The basal unit of the Devonian sequence, the Bertram member of the Wapsipinicon Formation, bears an important relationship to the structure. The Bertram has a relatively small elliptically-shaped area of occurrence (see fig. 1-7). The unit thins to the northwest, and thickens to the southeast, toward the Plum River fault zone. In the subsurface, the Bertram attains a maximum penetrated thickness of 67 feet a short distance north of the fault zone, and abruptly pinches out at the fault trace. The overlying Coggon member is present on both sides of the fault. This relationship strongly suggests that the fault was active before or during the onset of Middle Devonian deposition in the area. At the Pleasant Hill outlier in Jones County (field trip stop 1), the thickness of the Bertram is calculated to be greater than 96 feet (fig. 1-7). This suggests that at least 100 feet of the total vertical displacement of the fault at Pleasant Hill occurred prior to or contemporaneous with the earliest Middle Devonian sedimentation in the area.

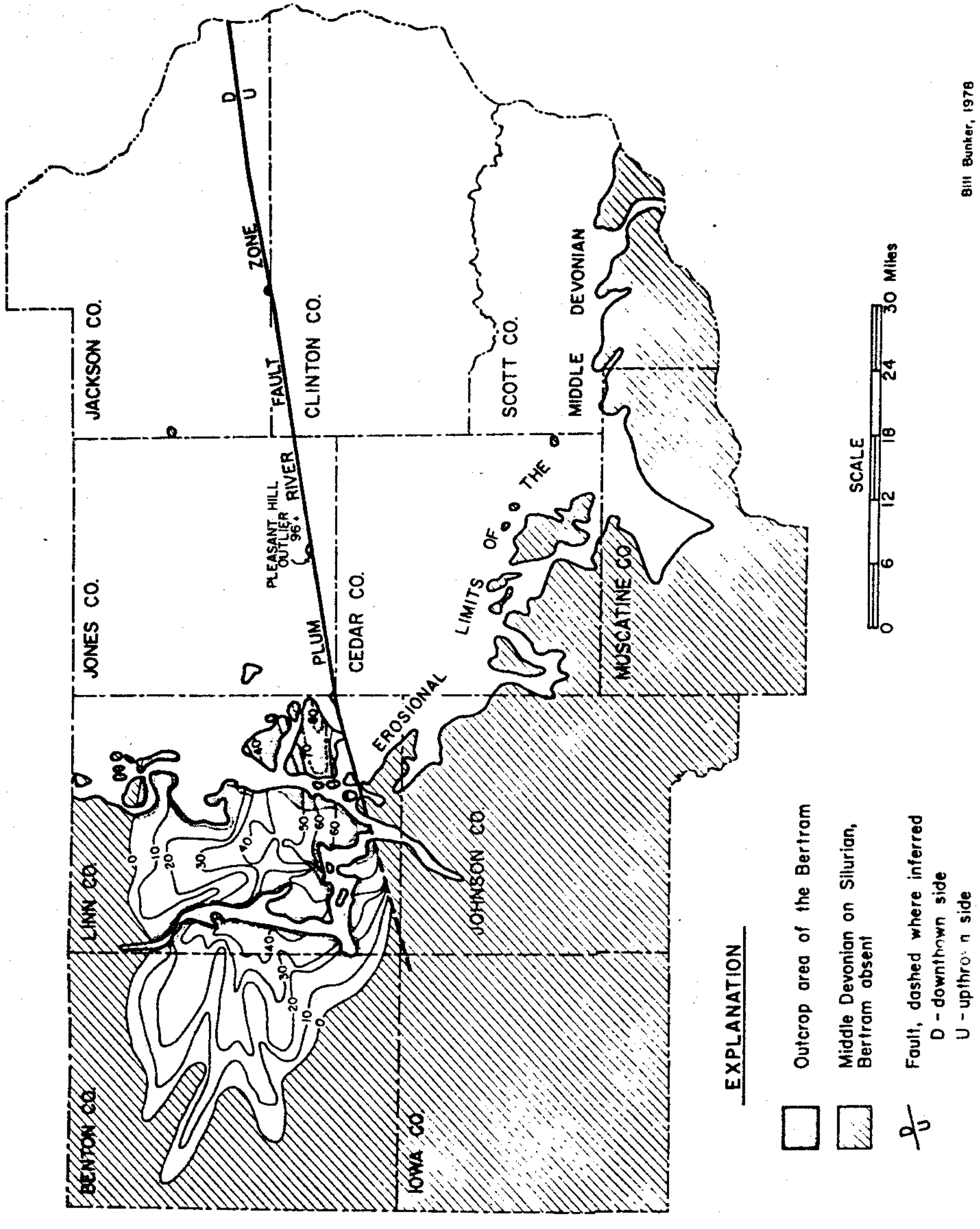


Figure 1-7. Isopach map of the Bertram member of the Middle Devonian Wapsipinicon Formation (contour interval 10 feet).

PENNSYLVANIAN STRATIGRAPHY

Small outliers of sandstone, presumably of Pennsylvanian age, are found scattered throughout eastern Iowa. These outliers repeatedly occur in intimate association with the Plum River fault zone, and at least one can be used to interpret the chronology of movement of the fault. This sandstone outlier occurs in southern Jackson County, near field trip stop 4. The outlier is exposed immediately to the south of the cataclastic zone and truncates Silurian and Ordovician units which are dipping away from the fault. Continuous exposures of sandstone crossing northward into the Silurian-derived cataclastic zone are not present, but sandstone float is found in a southward draining ravine which is cutting into the cataclastic rocks. This implies that the outlier crosses the fault, and that almost all of the vertical throw of the fault at this location preceded the deposition of the sandstone. From the exposures, it is impossible to ascertain whether or not the channel sandstone has been displaced by subsequent faulting.

TRIP 1 ROAD LOG

Mileage

0	Entrance to Kirkwood Community College at Kirkwood Blvd. Turn right, to the north.
0.7	Turn right on Lincoln Freeway (Hwy. 30 east).
6.2	Bridge over Cedar River.

Skvor-Hartl Area

You are now passing along the western portion of the Plum River fault zone, which is located just to the south of the Cedar River (see fig. 1-8). Dow and Mettler (1962) mapped the geology of this area and recognized a southwest plunging syncline bordered to the south by a southwest plunging anticline. The cataclastic zone is not exposed here, but closely spaced outcrops indicate that faulting has occurred between the two flanking folds. The Silurian dolomites exposed on the south side of the fault are the northernmost to appear along the channel of the Cedar River. A short distance to the southeast, the dolomites are dramatically exposed in a narrow gorge of the Cedar River at Palisades-Kepler State Park (see fig. 1-8), a marked contrast to the gentler valley walls to the north, held up by the less resistant Devonian carbonates. The exposures to the left (north) of the highway at the intersection with route 13 are of the Devonian Wapsipinicon Formation.

7.8	Martin-Marietta Quarry in the Silurian Gower Dolomite to the right, across the Cedar River (see fig. 1-8).
8.7	Crossing the Plum River fault zone, here covered by eolian deposits.
9.3	Entrance to Palisades-Kepler State Park. Here the Cedar River has cut a bedrock gorge into the LeClaire (biohermal) facies of the Silurian Gower Dolomite.
13.0	Junction of route 30 and route 1 at Mt.Vernon. Continue east on route 30.

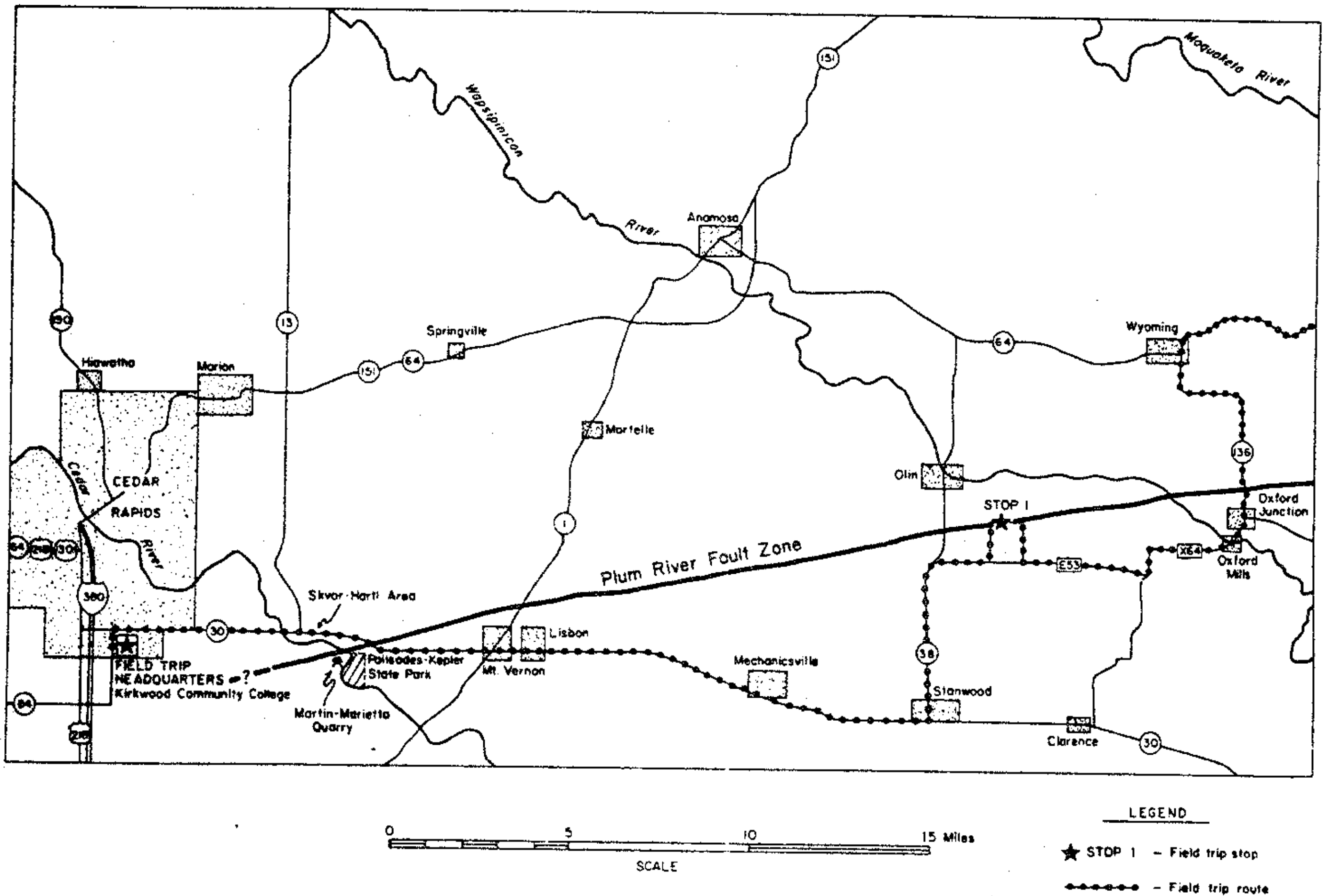
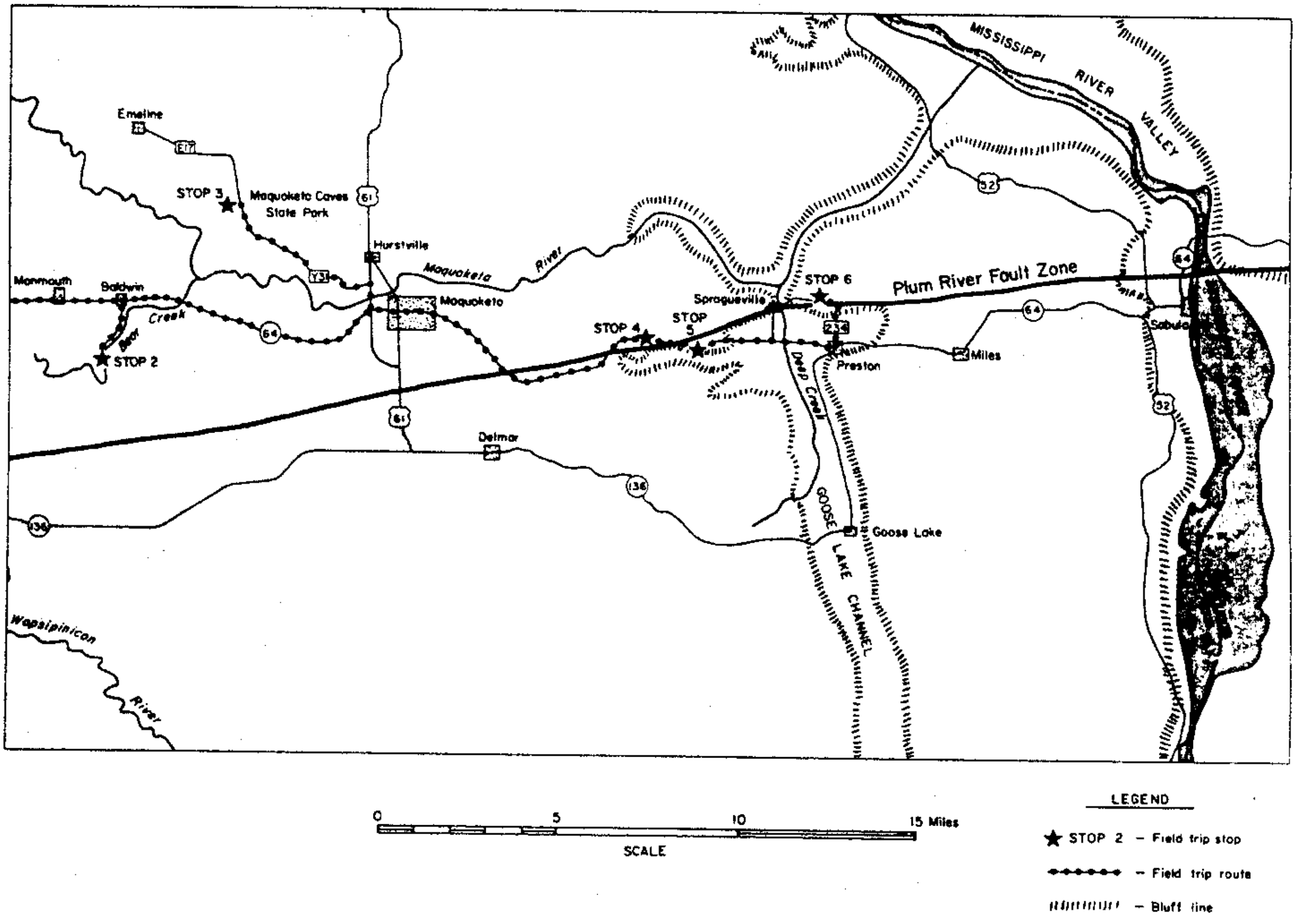


Figure 1-8. Location map showing the field trip route, field stops, and the major highway routes.



MISSISSIPPI RIVER VALLEY
Emeline
E17
STOP 3
Maquoketa Caves State Park
61
Hurstville
Maquoketa River
Y31
Monmouth
Baldwin
Bear Creek
64
Maquoketa
STOP 2
STOP 4
STOP 5
Spragueville
STOP 6
Plum River Fault Zone
52
234
Preston
Miles
Sabula
61
Delmar
136
Deep Creek
GOOSE LAKE CHANNEL
Goose Lake
Wapsipinicon River
0
5
10
15 Miles
SCALE
LEGEND
STOP 2 – Field trip stop
– Field trip route
– Bluff line

13.6 The quarry on the left (north) side of the highway is in the Anamosa (inter-reef) facies of the Gower Dolomite.

15.1 Passing through Lisbon.

21.8 Passing through Mechanicsville.

27.8 Turn left at the junction with route 38, at Stanwood.

33.1 Turn right on county blacktop road E-53.

34.7 Turn left on gravel road.

35.9 The small creek you are crossing is controlled by the Plum River fault zone.

36.0 Turn right on the gravel road just north of the creek and stop at the top of the first rise.

36.1 STOP 1

STOP 1 - Pleasant Hill Outlier

This outlier of Devonian rocks was discovered in the spring of 1977 by Bunker and Ludvigson, while studying field exposures of the Plum River fault zone. Structurally preserved units of the Devonian Cedar Valley and Wapsipinicon Formations have been faulted into juxtaposition with the Silurian Gower Dolomite. The estimated vertical displacement here is approximately 300 feet. This area best exemplifies the structural and petrologic features associated with the fault zone, and has been nominated to become a state geological preserve.

PLEASE REFRAIN FROM USING YOUR GEOLOGIC HAMMER

The geology of this locality is best understood by examining the exposures immediately to the north side of the stopping point and continuing in a clockwise direction; from west to east on the north side of the road, then from east to west on the south side.

The cataclastic zone here is mostly buried under the alluvium of the fault-controlled creek. The few exposures of these brecciated rocks are

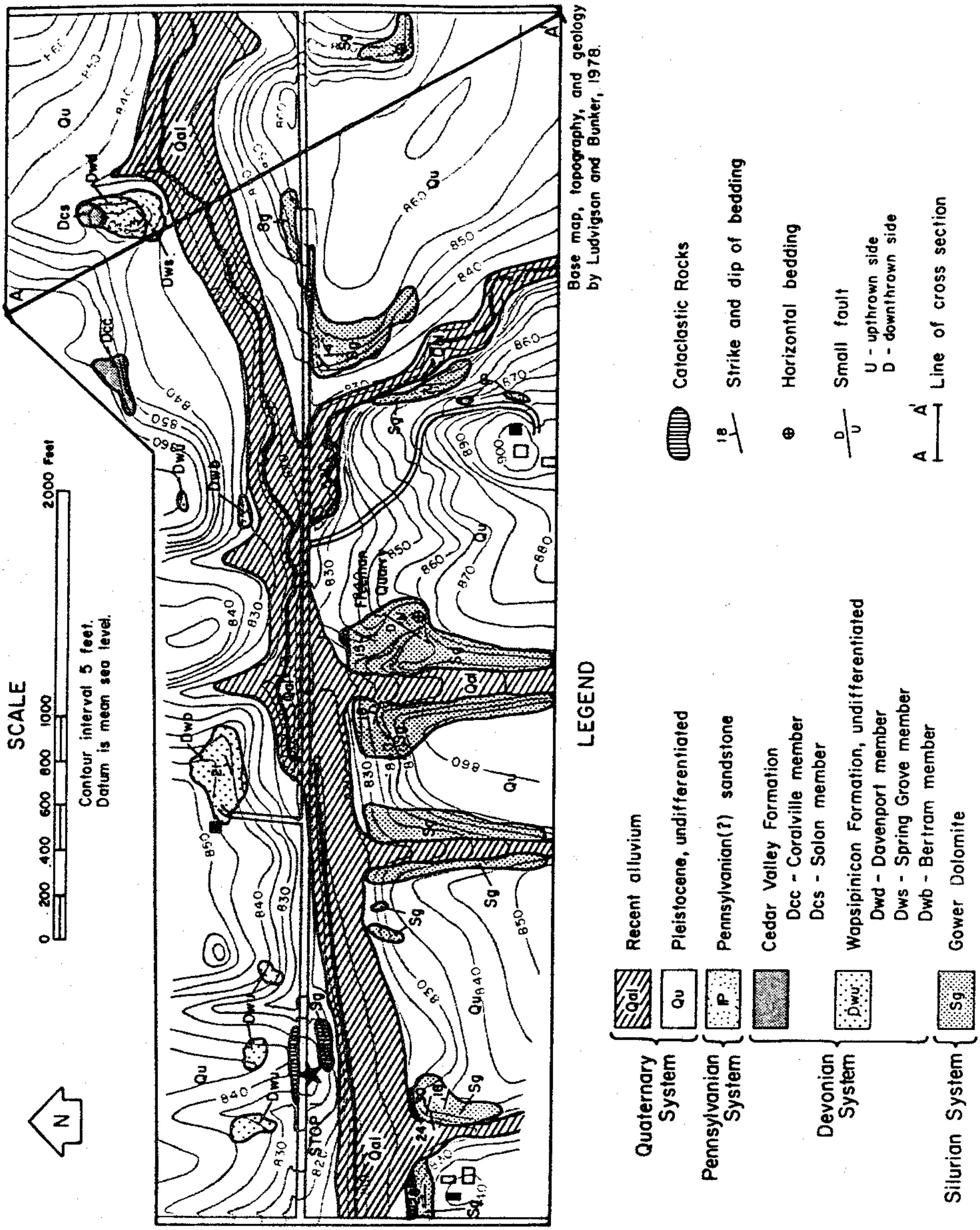


Figure 9. Geologic map of the Pleasant Hill outlier and the Plum River fault zone.

mapped on figure 1-9. Cataclastic rocks derived from Devonian units can be found immediately to the north of the stopping point, and those from Silurian units can be found just to the south. Both have been recrystallized by secondary mineralization. The Silurian exposure presumedly is part of a narrow fault block. Away from the cataclastic zone, folding, drag folding, and minor block faulting can be observed (see fig. 1-10). Aside from the drag folded Silurian rocks in the southwest corner of figure 1-9, the rocks of the area have not been folded into perfect parallelism with the fault zone, but rather strike in a more northeasterly direction. This structural grain appears consistently in rocks adjacent to the fault zone in eastern Iowa. This angular relationship could reflect dextral strike-slip movements along the fault zone.

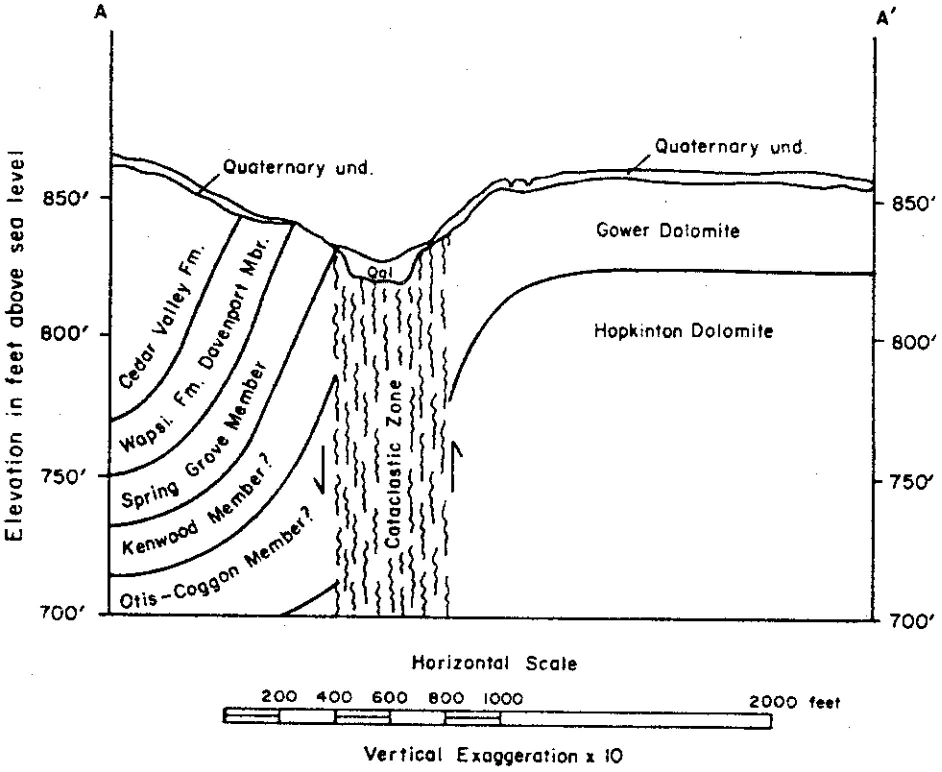


Figure 1-10. Cross section A-A' through the Plum River fault zone. Line of cross section shown in figure 1-9.

The Bertram member of the Wapsipinicon Formation is well exposed in the barnyard of the abandoned farmhouse on the north side of the county gravel road. Note the closely-spaced northeast trending fractures. The northward dipping beds here, just on the downthrown side of the fault, have a calculated thickness of 96 feet, which if proven by drilling, would make this the thickest known section of the Bertram. Across the valley is the Freeman Quarry, in the Silurian Gower Dolomite (see sketch on the guidebook cover).

Further to the east, the two upper members of the Wapsipinicon Formation, and the Solon member of the Cedar Valley Formation can be observed in continuous exposure at the small knob-shaped cuesta marked in the northeast corner of figure 1-9. To the west and uphill from the knob is an exposure of the Coralville member of the Cedar Valley Formation, identified as the *Idiostroma* beds by Prof. Brian Glenister of the University of Iowa Department of Geology.

South of the knob, just on the south side of the county gravel road is an excellent exposure of fault breccia derived from the Gower Dolomite. Note that this exposure occurs along a rise in the road. The road here is ascending an escarpment formed by an east-northeast trending alignment of faceted spurs of the Gower Dolomite. This topographic linear marks the southern limit of the cataclastic zone.

The area around the farmstead on the hilltop south of the gravel road is strewn with sandstone float. Sandstone float is commonly found near the fault zone, and it is very likely that the rounded summit at the farmstead is underlain by a sandstone outlier.

The Freeman Quarry exhibits several interesting features associated with the fault zone. The mouth of the quarry exposes the southern edge of the cataclastic zone. The brecciated carbonates here have been replaced by microcrystalline and drusy quartz to form dark-colored jasperoid. In this section, much of this quartz exhibits undulose extinction, indicating that the jasperoid has been strained by deformation after the silification. The Freeman Quarry is cut by several northeast trending high angle faults, all apparently downthrown to the north, with displacements of up to 10 feet. One of these faults, mapped on figure 1-9, displays vertical slickensides; separated by approximately 1 inch of gouge, along the southern part of the west wall. At the northeast corner of the quarry, blocks of massive dolomite, bounded by faults, have apparently been rotated into a drag fold configuration (see strike and dip, figure 1-9). Based upon the fauna of the dolomite beds, Brian Witzke places these units in the lower Gower Dolomite.

The outcrops mapped in the southwest corner of figure 1-9 display drag folded Gower Dolomite and the transition into the cataclastic zone. Dips of up to 30° are common just to the south of the boundary, and gradually become less steep further to the south. North of the farmhouse is an exposure of jasperoid marking the southerly limit of the cataclastic zone.

Return to the stopping point and continue east on the county gravel road.

37.0	Turn right onto county gravel road.
38.3	Turn left on county blacktop E53.
42.3	Turn left on county blacktop X64.
46.2	Enter Oxford Mills, turn left.
46.4	Bridge over Wapsipinicon River.
47.2	Passing through Oxford Junction, continue straight ahead on what is now route 136 north.

47.9 Crossing the Plum River fault zone

52.1 Wyoming Quarry on right side of the road, in the Silurian Hopkinton Dolomite.

54.4 Passing through Wyoming. Turn right onto route 64.

61.2 Passing through Monmouth.

63.4 Turn right at the DX station in Baldwin.

65.5 Bridge over Bear Creek.

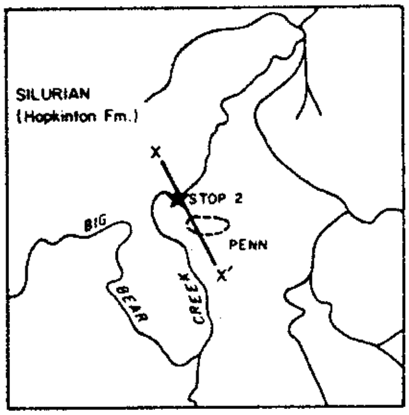
65.7 Turn left into the parking lot of Eden Valley Interpretive Center. STOP 2.

STOP 2 - Pennsylvanian Outliers at Big Bear Creek

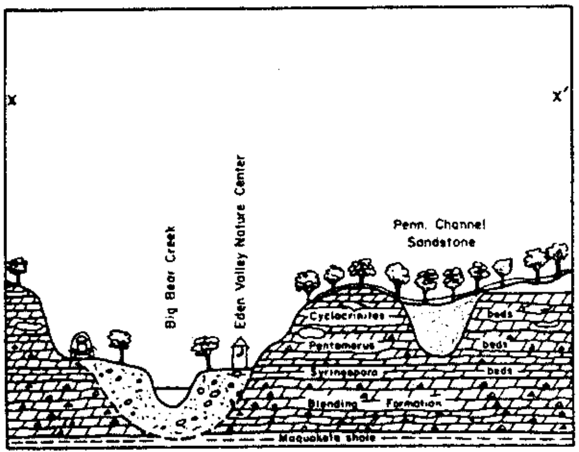
This stop will provide a chance to review the stratigraphy of the Silurian Hopkinton Dolomite, and to observe one of the Pennsylvanian (?) sandstone outliers that are found in eastern Iowa. Here, Big Bear Creek has incised a meandering gorge through an east-west trending bedrock ridge of Hopkinton Dolomite (roughly defined by the forested area in figure 1-11) The walls of the bedrock gorge expose several sandstone outliers which follow the sinuous course of Big Bear Creek. Savage (1905) who described these features, suggested that the creek may follow an exhumed Pennsylvanian valley.

The most accessible of the sandstone outliers occurs on the east side of the county gravel road a short distance south of the Eden Valley Interpretive Center. Blocks of coarse-grained conglomeratic sandstone are found along the road ditch. The sandstone occurs in a cleft in the bluff face, and broadens toward the top to overlap the Silurian rocks. An old, small quarry at the top of the bluff was used for dimension stone in the early settlement history of the area (Savage, 1905).

Adjacent to the sandstone channel, the *Cyclocrinites*-*Pentamerus* contact is marked by a ledge at the top of the *Pentamerus* zone. There are



Generalized Geologic Map



Generalized Cross-Section X-X'

Adopted from Baldwin SE 7½ minute orthophoto quadrangle

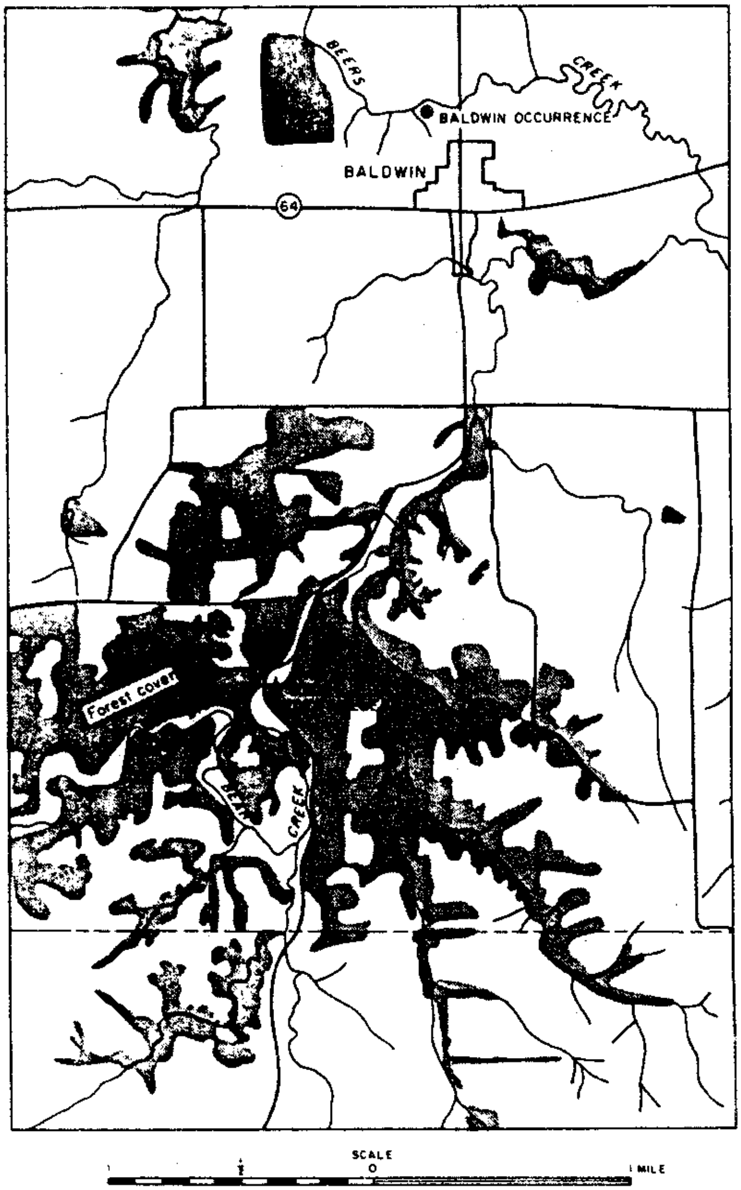


Figure 1-11. Location map and the general geology of the Big Bear Creek bedrock gorge.

numerous solution cavities in the overlying *Cyclocrinites* beds which are filled with oxidized pyrite and calcite. These are similar to but smaller than an occurrence of disseminated pyrite and calcite in the *Cyclocrinites* zone north of Baldwin (see fig. 1-11), which at one time was prospected for lead (Heyl, 1959).

LUNCH BREAK

Return to Baldwin on same route.

67.9	Turn right on route 64.
72.4	Roadcut in the Silurian Hopkinton Dolomite. Numerous exposures in the area are of the Hopkinton Dolomite.
76.9	Turn left at the junction of routes 64 and 61 onto route 61 north. Follow signs to Maquoketa Caves State Park.
77.3	Bridge over Maquoketa River.
77.8	Turn left on county blacktop Y-31.
83.6	Turn left to Maquoketa Caves State Park.
83.9	Entrance to park.
84.0	Stop at parking area. STOP 3.

STOP 3 - Maquoketa Caves State Park

Maquoketa Caves State Park, which was established in 1921, contains fourteen known solution caves (fig. 1-12). Of these, thirteen (Dancehall, Wide Mouth, Twin Arch, Hernandos Hideaway, Up-N-Down, Dug Out, Window, Match, Tourists Delight, Barbell, Rainy Day, Icebox, and Sager Caves) are located in the ravine around which the park is centered (Hedges 1974).

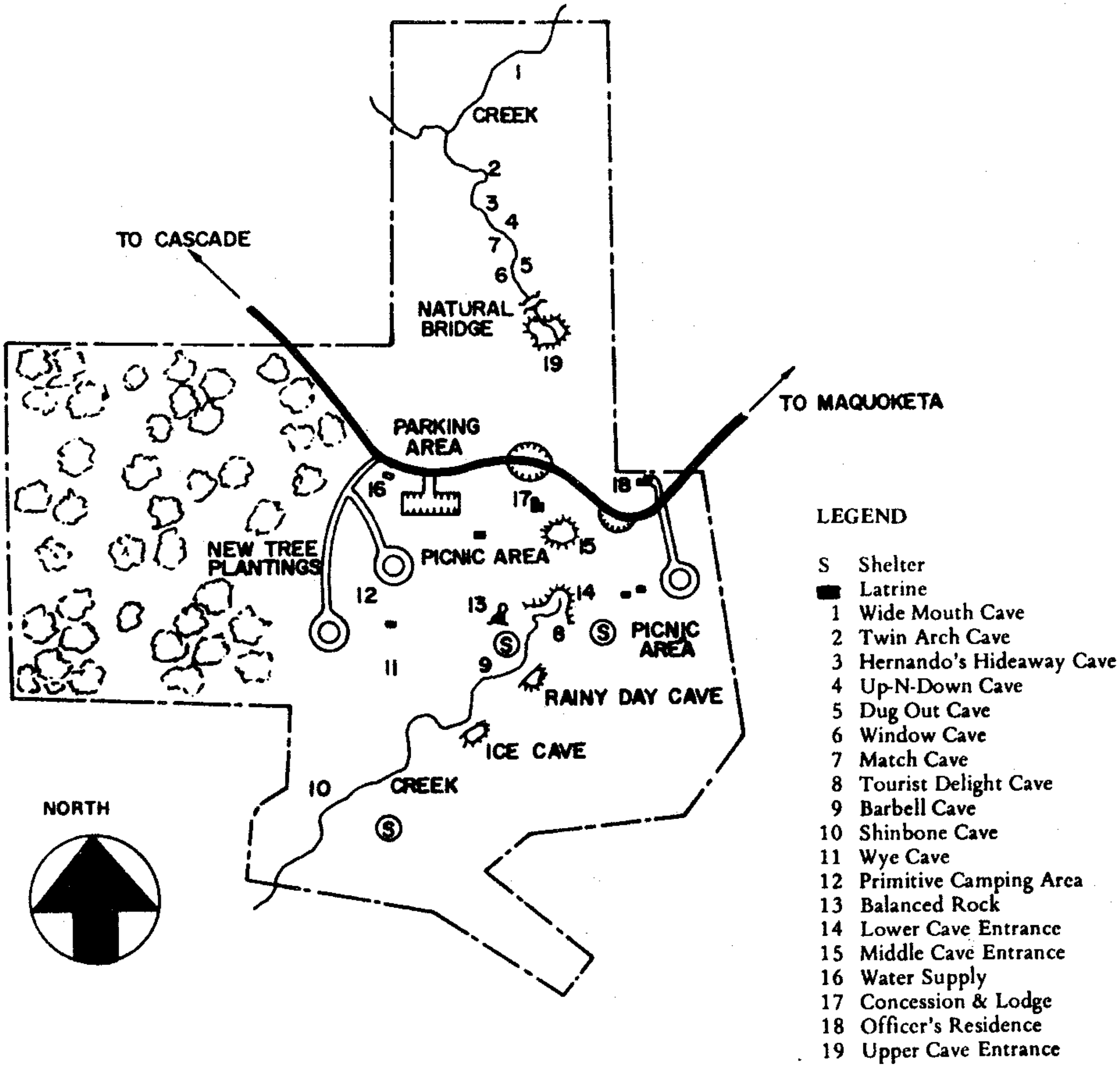


Figure 1-12. Location map; Maquoketa Caves State Park (from Iowa Conservation Commission)

The longest of these caves, Dancehall Cave, has an 800 foot passage opening at both ends into the ravine (fig. 1-13). Dancehall is believed by Hedges (1958) to have been 1/3 longer at one time, extending upstream beyond the natural bridge and downstream for an indeterminate distance. Subsequent roof collapse has reduced its original length. Many of the other caves located in the walls of the ravine were probably side passages of this older, larger cave,(Hedges 1958).

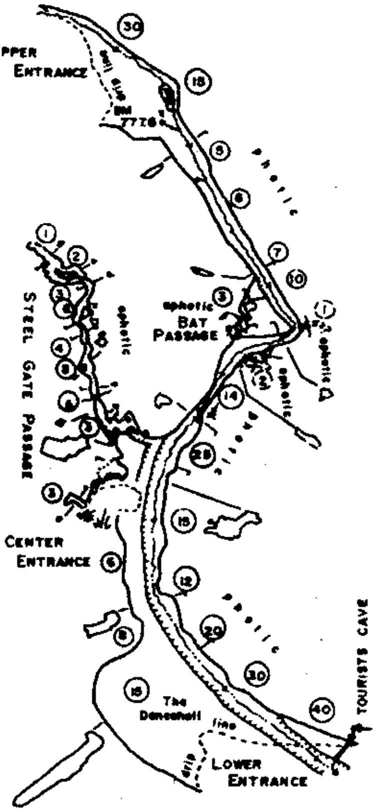


Figure 1-13.
Dance Hall Cave
(Hedges, 1974)

According to Bunker and Ludvigson (pers. com.), Dancehall is formed in the <u>Cyclocrinites</u> beds (Johnson, 1977), of the Hopkinton Dolomite. In the upstream part of Dancehall, the contact between the <u>Cyclocrinites</u> and <u>Favosites</u> beds occurs within 2-7 feet of the ceiling. The presence of other caves that are developed within this interval, and data from recently acquired cores indicates that the Cyclocrinites zone is a major horizon of karstification and water well production in the Silurian strata of eastern Iowa.

The main passage of Dancehall Cave, upstream from the central entrance, appears to be controlled by joint sets, or fractures, trending N78°E, N28°E, and N28°W (Fig. 1-14). The Steel Gate passage appears to be controlled, at least in part, by a number of joint or fracture trends. This relationship, however, needs further study, as does the overall relationship between karst development, and the structure and stratigraphy of eastern Iowa.

The main passage of Dancehall Cave has electric lighting and a concrete walk, making it readily accessible. Portable lights, however, are needed to visit the other caves, as well as the side passages of Dancehall. Tourists Delight cave is normally inaccessible because of flooding.

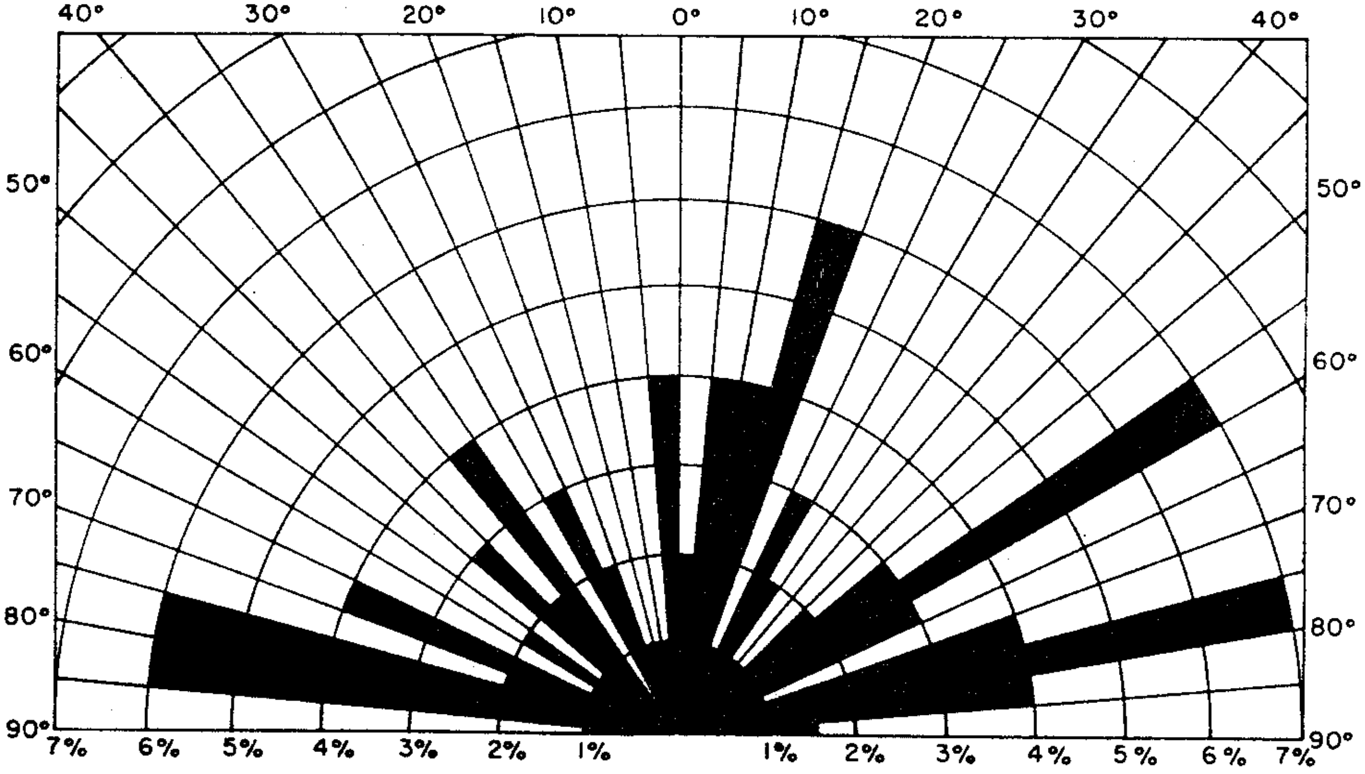


Figure 1-14. Joint or fracture rose diagram: based on 100 fractures measured primarily in the Cyrtia zone in Maquoketa Caves State Park.

If you visit Dancehall, note the contact between the Cyclocrinites beds and the much more vuggy Favosites beds at the central and upstream entrances. Note also the sharp bends in the passage due to joint control in this part of the cave. Keep in mind, however, that the cave and especially the stream have been modified by human activity.

Return to Maquoketa by the same route.

84.5	Turn right on county blacktop Y-31.
90.3	Turn right on route 61 south.
91.1	Turn left on route 64 east.
92.0	Passing through downtown Maquoketa.
93.0	Junction with route 62. Continue straight ahead on route 64 east.
99.9	Pennsylvanian sandstone which possibly truncates the Plum River fault zone is exposed in the valley on the right side of the highway (see fig. 1-15, northeast quarter of section 31).
101.8	Pull off the highway at the K. Nolting farmhouse along the ridgecrest (see fig.1-15, southwest quarter of section 28). STOP 4

STOP 4 - Cataclastic rocks of the Plum River fault zone

Recent excavations and natural exposures here clearly display cataclastic textures typical of the fault zone in eastern Iowa. Road construction to the southwest of the Nolting farmhouse (see fig. 1-15) has cut into soft, variegated breccias which are punctuated by vertical seams of clay-sized gouge. To the west of the Nolting farmstead are outcrops of fine-grained dolomite breccias laced with vertical anastomosing fractures.

South of the excavations, the Mosalem-Brainard (Silurian-Ordovocian) contact is exposed on the south wall of the eastward draining ravine, which is eroded along the southern edge of the cataclastic zone. Note the frequent slumping of blocks of Mosalem over the plastic shales of the Brainard. Further upstream, to the west, the stream bed cuts through drag folded beds of the Brainard, dipping 45 deorees to the north.

This area has been investigated by previous workers who attributed varying degrees of structural significance to the exposures. Savage (1905 p. 607) noted the folding in the Maquoketa Formation, along what he recognized as the crest of an east-west trending anticline (later named the Savanna-Sabula anticline, now redefined as the Plum River fault zone). He also observed the apparent juxtaposition of the northward dipping Maquoketa Formation with Silurian strata, but erroneously interpreted the phenomenon as an erosional unconformity.

Aten and Herzog (1977) described the geology of this location in a report on the fault zone in Jackson County. They correctly interpreted the juxtaposition of the units as a faulted contact. They also noted the extreme brecciation of the Silurian rocks, which they identified as the Marcus and Sweeney Formations (the Hopkinton Dolomite of Iowa).

Aten and Herzog interpreted the fault to be a single line corresponding to the vertical contact between the Silurian and Ordovician rocks. Our interpretation differs, as the brecciated and demonstrably sheared Silurian rocks must be included as part of a wide fault zone, rather than a single line trace. At present, tectonically granulated rocks have been traced at least 1200 feet north of the faulted Silurian-Ordovician contact.

Structure contouring in the area indicates approximately 400 feet of net vertical throw along the fault zone in this vicinity. The presence of the Gower Dolomite on the downthrown side thus can be inferred. No detailed investigations have been conducted to confirm this possibility. Indeed, the possibility of juxtaposed Devonian and Ordovician units exists in this area, as a small preserved block of Devonian rocks has been noted (Dorheim, 1953) some 7 miles west of here.

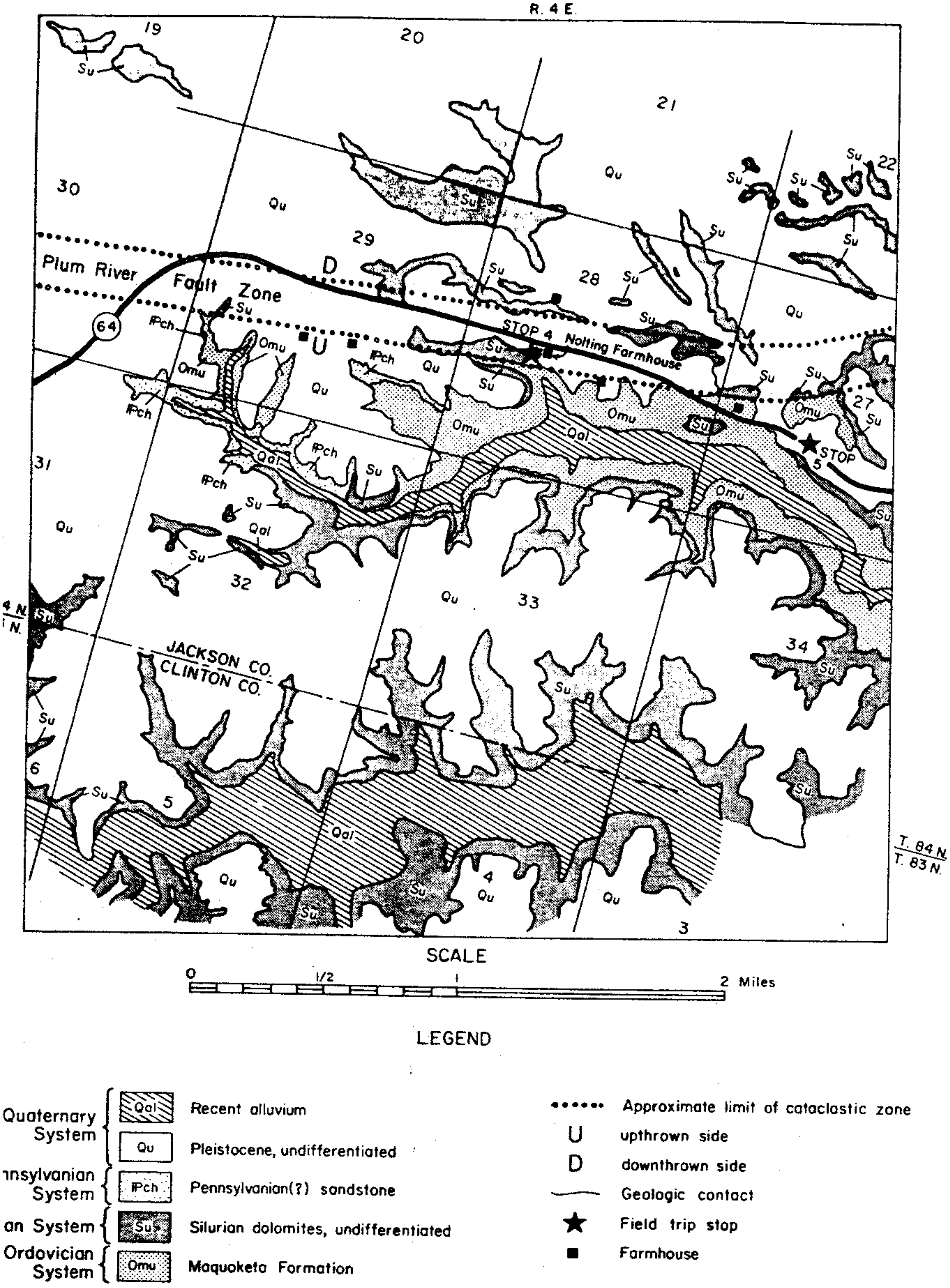


Figure 1-15. Photogeologic map of a portion of the Plum River fault zone in Jackson Co., interpretation from IGS color infrared aerial photography.

The sandstone outlier located southwest of here (fig. 1-15) was examined by Jean Mapes and Jeff Schabilion of the University of Iowa. Plant macrofossils recovered from outcrops of the sandstone strongly suggest a Pennsylvanian age, and thus date movement in this area (see discussion in section on Pennsylvanian Stratigraphy).

Continue east on route 64.

102.5 The saddle here along the ridge crest indicates an area where the Maquoketa Formation has been uplifted to the uppermost elevations of the present landscape on the south side of the fault. Excavations in the barnyard of the farm on the left side of the highway (fig. 1-15 reveal the presence of the Brainard at the surface.

102.8 Pull off the highway just past the farm on the left side of the highway and stop about halfway up the rise in the roadbed. STOP 5.

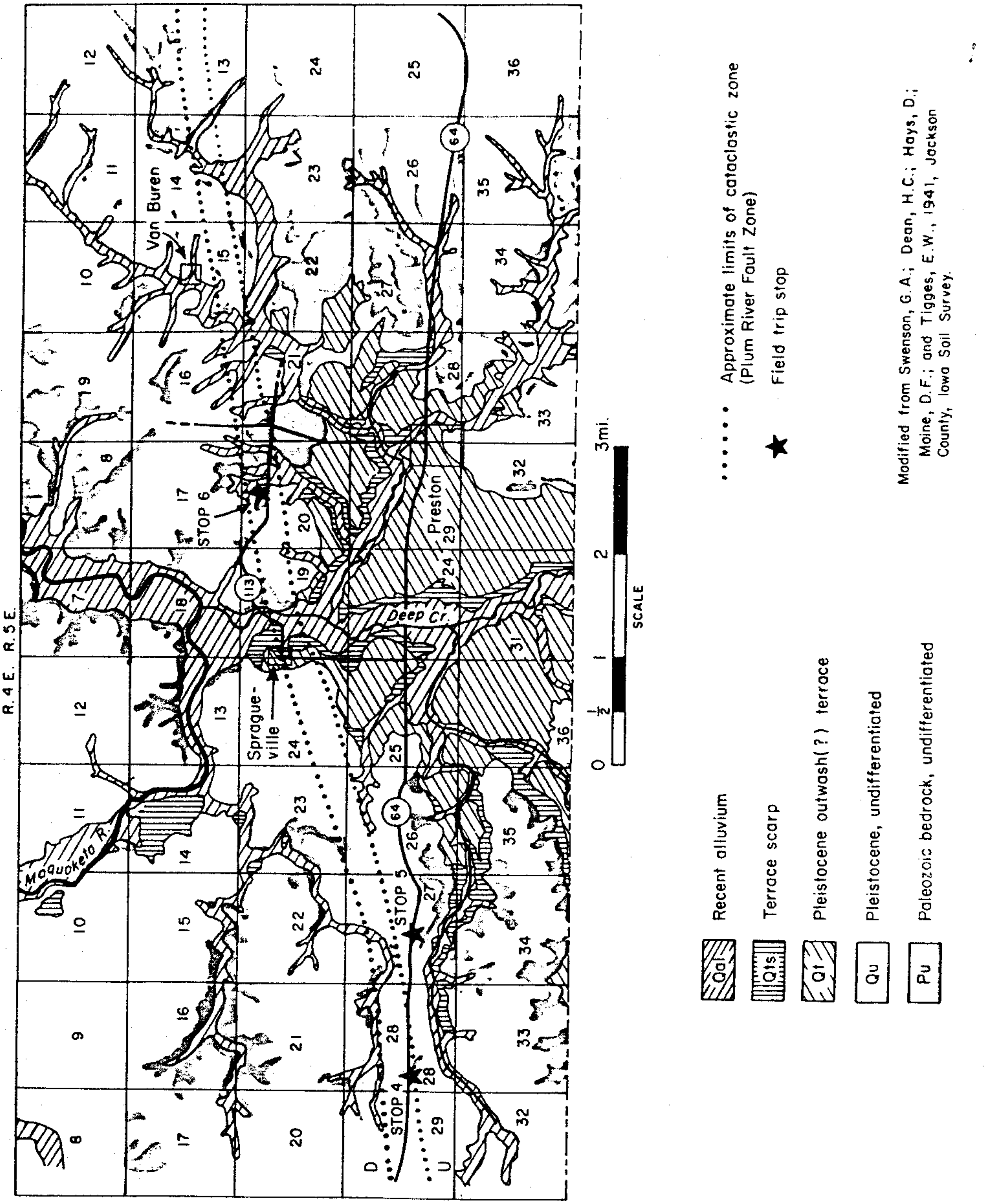
STOP 5 - Overlook viewing the faulted Silurian-Ordovician contact

You are now near the center of section 27 (see fig. 1-15). About 1,000 feet to the north of the highway, about half way down the slope into the neighboring valley, is a northeast trending line of low knobs of brecciated dolomite. These knobs mark the faulted contact between the downthrown Silurian rocks of the cataclastic zone, and the less resistant shales of the Ordovician Maquoketa Formation. This topographic relationship will also be seen a few miles to the east, where the southern edge of the fault zone corresponds to an abrupt constriction of the Pleistocene Goose Lake Channel.

Continue east on route 64.

104.2 You are now passing over the rim of the western bluff line overlooking the Goose Lake Channel, an Illinoian ice-dammed diversion of the ancestral Mississippi River (see figs. 1-8 and 1-16). The east-northeast trending line of bluffs to the left (north) follow the southern edge of the Plum River fault zone.

105.6 Junction with route 113. Continue straight ahead on route 64. You are now on the surface of the terrace deposits (fig. 1-16) which fill the Goose Lake Channel.



Modified from Swenson, G.A.; Dean, H.C.; Hays, D.; Moine, D.F.; and Tigges, E.W., 1941, Jackson County, Iowa Soil Survey.

Figure 16. Surficial materials map of the Preston area in southern Jackson County, showing approximate location of the Plum River fault zone.

105.9 Drop off terrace surface and cross bridge over Deep Creek. Note terrace scarp ahead (fig. 1-16).

107.4 Entering Preston.

107.7 Turn left, past the Lutheran Church onto White Street.

108.6 Begin ascent of scarp, marking the southern edge of the Plum River fault zone. Note the outcrops on the right side of the highway. They do not occur in normal stratigraphic sequence (Brian Witzke, 1977, pers. com.) and thus have probably been block faulted.

109.0 Crest of fault scarp.

109.1 Turn left on to county gravel road. The highly fractured exposures of the Hopkinton Dolomite here have apparently been sliced into narrow fault blocks. The road ahead follows the cataclastic zone.

109.4 Cataclastic rocks are exposed in an excavation to the left of the road.

109.7 Cataclastic rocks are exposed along the roadcut on the right side of the road.

110.0 Pull off the road at the base of the hill. STOP 6.

STOP 6 - Secondary mineralization in the cataclastic zone

Although the limits of the fault zone have not been mapped in this area, it is believed that the zone exceeds one-half mile in width. The roadcut exposures of cataclastic rocks on the north side of the county gravel road from here to the intersection at the top of the hill have been mineralized by quartz, dolomite, calcite, and goethite pseudomorphous after pyrite. Note the reddish coloration of the rocks in the area. Disseminated pyrite has weathered to produce abundant iron oxides. Heyl (1959) noted this area as one of several sites of former lead prospecting activity along what is now known to be the fault zone. These sites were originally described by Owen (1840). Most of the mineralization occurs as intersecting veinlets and cavity fillings, although near the top of the hill to the west the rocks have been replaced by calcite in large, optically continuous domains.

Although the cataclastic zone has not previously been recognized per se, Savage (1905, p. 612) described a number of outcrops within the zone which he termed the "granular phase of the Niagaran", and interpreted as a bedded deposit. Horizontal partings suggestive of bedding are apparent in many outcrops of the cataclastic rocks, but are considered to be unloading phenomena rather than a primary depositional fabric.

Local landowners report that large blocks of sandstone float are common in the area around this stop. The frequent occurrence of sandstone outliers in intimate association with the fault zone suggests that the fault may have controlled Pennsylvanian (?) drainage.

END OF TRIP

Return to Cedar Rapids.

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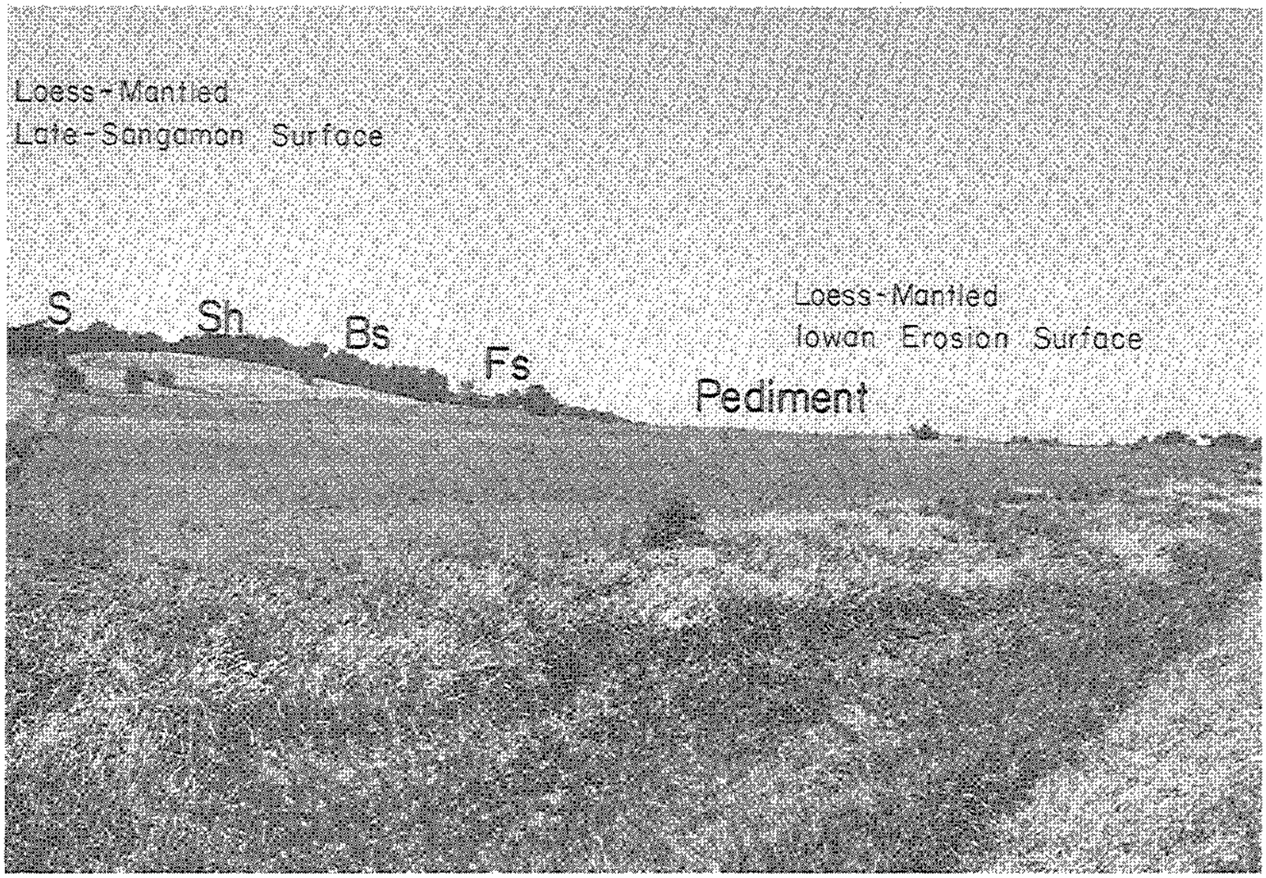

Plate 2-1. Hillslope profile of stepped erosion surface; from s-summit, of loess-mantled Late-Sangamon surface, sh-shoulder, bs-backslope, and footslope to the pediment of loess-mantled Iowan Erosion Surface. This erosion surface stands about 60 feet above the south side of the Iowa River Valley, approximately 9 miles south of the classical "Iowan" border.

TRIP 2

THE IOWAN EROSION SURFACE: AN OLD STORY, AN IMPORTANT LESSON, AND SOME NEW WRINKLES.

by George R. Hallberg[1], Thomas E. Fenton[2],
Gerald A. Miller[3], and Alan J. Luteneggar[4]

Preface

The Iowan area, of northeastern Iowa has long been a subject of controversy. From its initial description by McGee in 1891 to the resolution of the problem by R.V. Ruhe and associates (Ruhe, et al., 1968) in the 1960's, it had a long and volatile history. Even though the major controversy of the Iowan area has been resolved, it still is not fully understood by many Quaternary scientists, and the Iowan continues to be misused and abused in the literature (see for example Valencia, 1977; and in particular the comment on this paper by Hallberg and Fenton, in press.).

The Tri-State field trip has historically been an educational trip. Consequently, we feel that the Iowan problem is a good topic for a field excursion: to reiterate the resolution of this problem; to point out the important lessons to be learned; and to show what new work is being done in this area.

Several of the stops on the trip were used as part of the 16th Annual Meeting of the Midwest Friends of the Pleistocene, in 1965, led by R.V. Ruhe and company. Some of the information contained herein comes

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from this guidebook, and the Iowa Geological Survey, Report of Investigations 7, by Robert V. Ruhe, Wayne P. Dietz, Thomas E. Fenton, and George F. Hall (Ruhe, et al., 1968). Much of the data and figures used here are modified from Fenton's Ph.D. dissertation (Fenton, 1966).

As will be obvious, the landscape of this area does not lend itself to providing too many exposures. Any authoritative work on the stratigraphy and soil-geomorphic relations of this area must involve detailed and systematic study of sub-surface drill cores. It was such studies that resolved the Iowan problem and which continue to be the main tool for our new investigations. Many cross-sections from drill cores will be shown, and some of our stops will be to look at cores, as documentation of the stratigraphy. Unfortunately, we do not have time nor money to lay out the complete drilling transects, as has been done on prior field trips. At core stops please be patient and do not destroy the cores until everyone has had some chance to view them. There will be many outcrops for you to "beat on," during the trip.

As a final note, it will be obvious that much of the classical work presented here was directed or done, and authored by Dr. R.V. Ruhe. So much so, in fact, that we should make him an honorary trip leader. Although, he might not care for any of "the new wrinkles" we will show on this trip, it is his work, guidance, and example which have set the pace for our continuing efforts. Even though he is now dissecting the state of Indiana, we continue to take his name in vain in Iowa. There will be numerous citations of Ruhe's work which appear in this guidebook, and we urge the Quaternary student--new and old--to review these. The research method for detailed landscape analysis and the concept of the stepped erosion surface put forth by Ruhe, are not just interesting approaches for soil-geomorphic-stratigraphic studies in Iowa; they are applicable everywhere, and should become basic tools in the repertoire of Quaternary scientists. There is one basic requirement for the application of these tools--a lot of hard work. But the results are invariably profitable.

"AN OLD STORY,"*

The "Iowan drift" has long been a subject of controversy. Early arguments questioned whether the Iowan drift existed, and if so was it of pre-Wisconsinan age, a separate glacial stage, or part of the Wisconsinan? Related arguments involved the relationship of the loess and "pebble band" (stone line) to the "Iowan till and drift." McGee (1891), Calvin (1899), Alden and Leighton (1917), and Kay and Apfel (1929) developed the ideas through the years that the Iowan did exist and was a separate stage between the Illinoian and Wisconsinan. Later, however, the Iowan was assigned to the earliest substage of the Wisconsinan (Leighton, 1931, 1933; Kay and Graham, 1943). Accordingly, the stone line and loess were recognized as being closely related in time to the drift. On the other hand, Leverett (1909, 1926, 1939) contended: that the Iowan was a late phase of Illinoian glaciation; that the stone line had been formed by running water and much time was involved in its formation; and that the loess was much younger than the drift. Leverett (1942) later conceded that the Iowan was an early Wisconsinan drift.

During the 1940's and early 1950's the existence of the Iowan was not questioned. In 1950, Leighton and Willman formalized the Farmdale substage of the Wisconsinan, and placed the Iowan as the next <u>younger</u>

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*adapted in part from Ruhe, et al., 1968.

Wisconsinan substage. With the advent of radiocarbon dating, the Farmdale was dated as 22,000 to 26,000 RCYBP (radio-carbon years before present). Now the Farmdale is dated as 22-28,000 RCYBP (Willman and Frye, 1970). However, all radiocarbon dates of wood extracted from the drift (or from peat immediately below), that was identified by previous workers as Iowan, were "greater than" or "dead" values. Accordinly, Ruhe and others (1957, 1959) proposed and reaffirmed that the Iowan was older than Farmdale. Leighton (1958, 1960, 1966) objected to this, and rationalized that somehow the Iowan glacier continually dug up old wood rather than the younger trees in its advance. Suffice it to say, that the radiocarbon dates and this line of reasoning speak for themselves.

The Iowan drift area also had a number of other unusual features for what was presumed to be a Wisconsinan age drift. All of these features have been discussed at length in the voluminous literature on the Iowan, and are only listed here in narrative fashion; pertinent features will be discussed in other sections. Topographic features are: 1. lack of any end moraines or classical glacial constructional features; 2. extension of narrow "sublobes" many miles beyond the main drift border down interstream divides (see fig. 2-1); 3. descendance of undulated and rolling slopes to a region-wide integrated drainage net; 4. occurrence of many areas of isolated topographic highs (paha and inliers, with Kansan-age drift) within the Iowan region; 5. directional orientation of longitudinal axis of paha from northwest to southeast; 6. local discordance of trend of paha axis with the axis of adjacent sublobe; and 7. lower absolute elevation of the presumed Iowan plain where it abuts the older Kansan drift areas.

Stratigraphic features that were considered to be the typical relations of the Iowan area are: 1. region-wide occurrence of stone line (pebble-band) at top of till where buried by loess or loamy sediments; 2. under thin leached loess, a leached zone is present in the subjacent till; 3. under thick calcareous loess, no leached zone in subjacent till; 4. thick loess around the border of Iowan in the Kansan area; 5. thin loess on Iowan at and for distances behind the border; 6. thick loess on the paha and inliers; 7. in the "Kansan area," a pre-Wisconsinan paleosol (Yarmouth-Sangamon or Late-Sangamon paleosols) occurs between the loess and the till; 8. in the Iowan area, as inferred above, no paleosol between loess and till; 9. the paha and inliers were considered to be remnants of "Kansan areas," and pre-Wisconsinan paleosols occur between the loess and till.

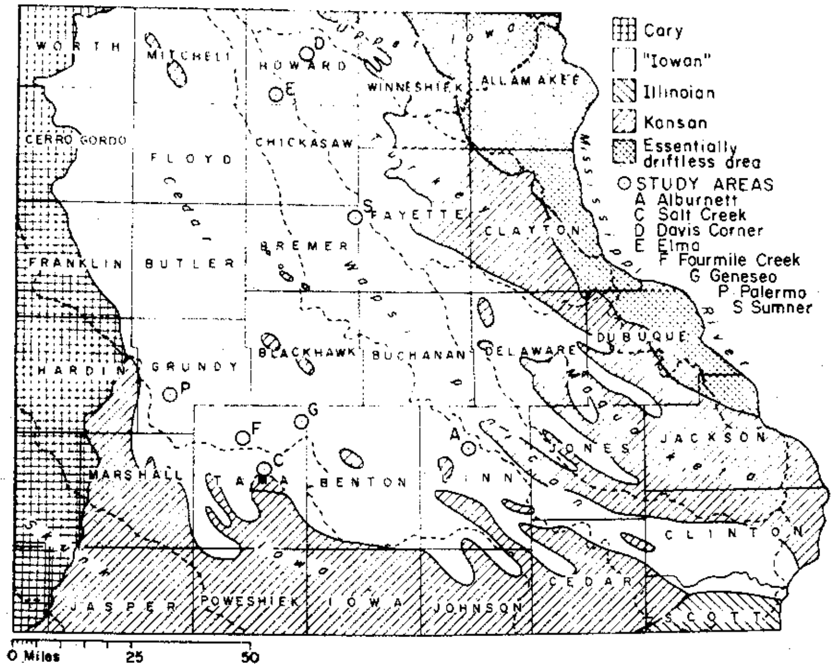


Figure 2-1. "Iowan drift" of northeastern Iowa, after Alden and Leighton, 1917; with study areas of Ruhe, et al., 1968 (from Ruhe, et al., 1968).

These various physical features also required certain interpreted or inferred features, which in retrospect are somewhat difficult to comprehend: these are 1. that the integrated drainage and the Iowan topography was inherited by the deposition of thin Iowan drift on the dissected "Kansan" surface--this obviously infers that relatively little modification was made by the "Iowan glacier;" 2. that the "Iowan ice", which had flowed all the way from central Canada, was so thin that it was unable to override some of the "Kansan" topographic highs--the paha and inliers. This required that the ice separated and moved around these highs "depositing Iowan till" against all flanks of the ridge; 3. during this time, thick loess accumulated on the paha and inliers, but loess was not deposited on the lower Iowan till until it had been uncovered by the glacier ice, and thus, the loess is thinner around the paha.

To continue the chronology of our story we must leave northeast Iowa for a short while and journey into the heart of the "Kansan" area in southwestern Iowa. Here we find our protagonist, R.V. Ruhe and company, hard at work in the mid-1950's. (The detailed results of this work are published in the classic bulletin by Ruhe, Daniels, and Cady, 1967; and are recapped in Ruhe's, 1969, Quaternary Landscapes in Iowa, for which he won the G.S.A. Kirk Bryan award, and other less-notable awards.) To quote Ruhe (1969, p. 88):

> The land surface in southern Iowa is not so simple as our previous descriptions may have implied. Staircases of ridges and tabular divides are some components that may be set apart. If one starts on a divide and moves along the axis of an interfluve toward a stream valley, he does not descend one long continuous slope. (An *interfluve*, by the way, is the land area between two adjacent streams.) Instead, the long slope is interrupted at several places by distinctly steeper slope gradients. We are back to the staircase

> again. The steeper gradients that intervene are like the risers of the staircase, whereas the alternate shallower interfluve slopes are like the treads of the staircase.

These treads and risers are what we now call stepped-erosion surfaces, which form a multi-leveled landscape. "Why are there such levels? The answer can be found in systematically drilling through the Wisconsinan loess, measuring each vertical section, and accurately locating each drill hole geographically and in elevation. Three-dimensional reconstruction is then possible (Ruhe, 1969, p. 88)." Under the divides and beneath the loess is the Yarmouth-Sangamon surface, with thick, and generally gray or mottled paleosols (fig. 2-2). On the first step down and beneath the loess is the Late-Sangamon surface, with its stone line, marking the fluvial erosion surface, and its pedisediment--or erosion sediments above the stone line, which are incorporated in the generally reddish-colored paleosols. On the lowest step, and beneath the loess, is a stone line surface, still on Kansan till, but there is no paleosol developed in the till.

To quote again (Ruhe, 1969, p. 90):

> What is the significance of the steps? The Yarmouth-Sangamon surface is a remnant of the Kansan drift plain that has remained and weathered since Kansan glaciation. The Late Sangamon surface is an erosion surface that was cut into the Kansan till and below the Yarmough-Sangamon surface and in the process removed the Yarmouth-Sangamon paleosol and also parts of the Kansan till. The Late Sangamon surface rises from a lower level along the valley slope to the higher Yarmouth-Sangamon surface. The lowest level has the same kind of relationship to the Late Sangamon surface as the latter does to the Yarmouth-Sangamon surface.
>
> What is the age of the lowest level? Wisconsin loess mantles the surface, but no paleosol intervenes. Therefore, deposition of loess must have rapidly followed the cutting of the lowest erosion surface so that time was not available to form a soil in Kansan till prior to burial by loess.

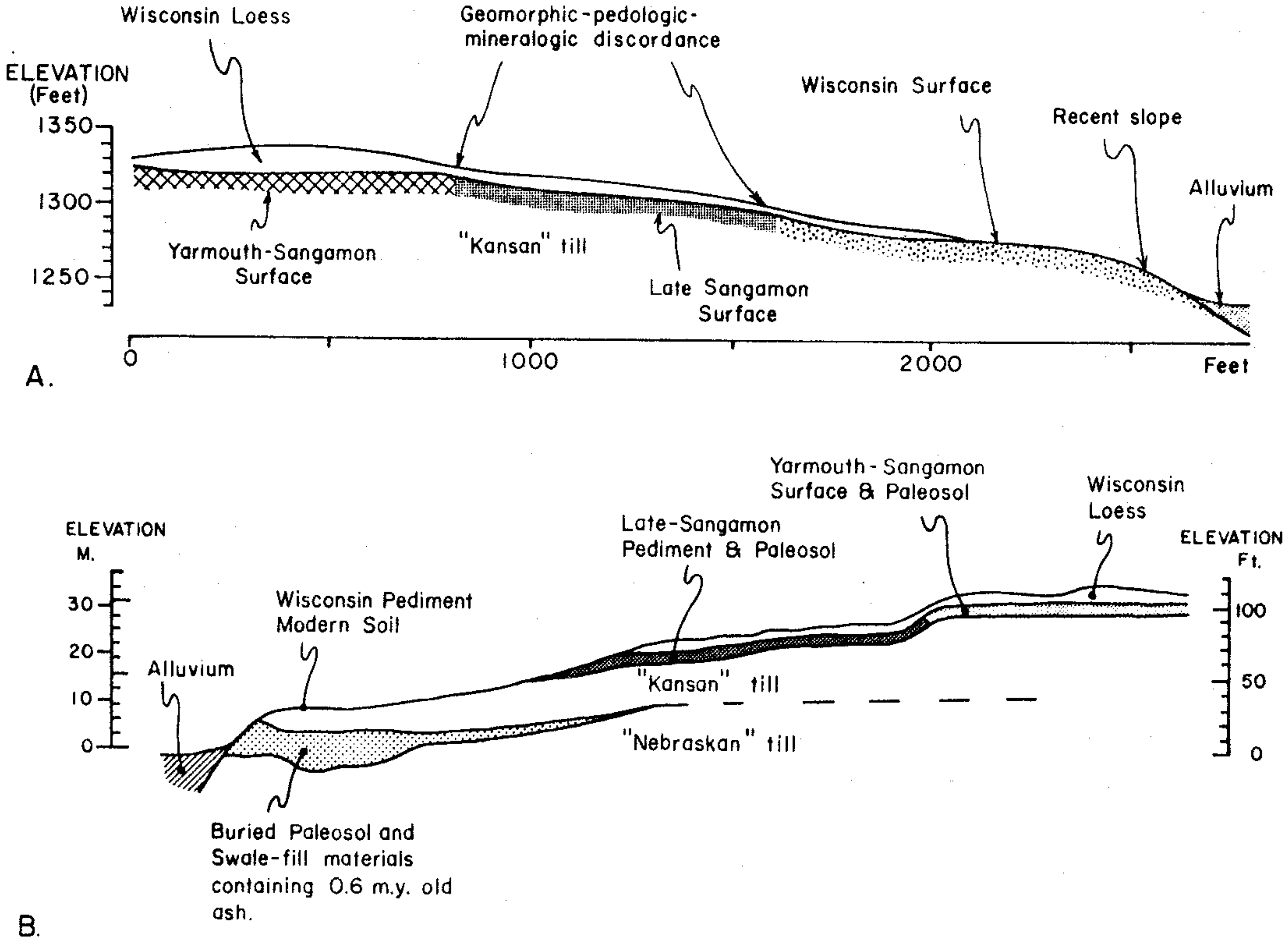


Figure 2-2. Typical sequence of stepped erosion surfaces in southern Iowa; A. Adair Co., after Ruhe, 1969; B. Ringgold Co., Hallberg and Boellstorf. 1978.

> This lowest erosion surface, then, had to be cut during Wisconsin time and during the time of loess deposition. The surface is of Wisconsin age.

Another important note is that the loess thickness will systematically decrease from the older summit positions down to the youngest erosion surface positions. On the paleosol surfaces, the base of the loess is marked by a weakly developed A-C soil profile--informally called the basal loess paleosol or basal Wisconsinan paleosol, in Iowa. This weak paleosol forms a compound soil profile with the Yarmouth-Sangamon or Late-Sangamon soils. This basal loess paleosol and the older (lower) loess increments are missing on the Wisconsinan-age erosion surface. Also, as shown in figure 2-2, the stepped surfaces of southern Iowa will also totally truncate the classic Kansan-age deposits, exposing the classic Aftonian and Nebraskan age deposits at the land-surface.

This then was the background when Ruhe, Fenton, Dietz, and Hall, began their geomorphology and soil study in the Iowan area in 1960. This work finished nearly 18 man-years later in 1966. Their studies and conclusions were based on the systematic study of drill cores and three-dimensional reconstructions. This had hever been done before and certainly helps explain why so many erroneous ideas were formed about the Iowan prior to this time.

In many respects the resolution of the Iowan began at STOP 1 of this field trip--what was then known as the 402 road cut (now it is called Highway 21, or the Hickory Hills section) on the west side of Casey's Paha. In the center of this cut nearly 20 feet of loess, with a basal loess paleosol overlies a Yarmouth-Sangamon soil, and classic Kansan till. The Yarmouth-Sangamon soil was essentially level through the cut. On the north and south ends the paleosol is sharply truncated by a sub-loess erosion surface, and thick loess overlies the truncated paleosol and till on the flanking erosion slopes. Adjacent lower surfaces were the Iowan-drift plain of previous workers, and these surfaces reveal systematically thinner loess (1-10 feet); no basal loess paleosol; loess over pedisediment over a stone line, on glacial till. This presented an obvious strong resemblance to the relations demonstrated in southern Iowa between the loess-mantled Yarmouth-Sangamon surface, and the thin loess-mantled Wisconsinan erosion surface (fig. 2-2). To complete the analogy, the loess-mantled Late-Sangamon surface occurs on the east end of Casey's paha, and exhibits similar relations to the surrounding "Iowan plain."

Consequently, our fearless team of R, F, D. and H, drilled their way from the pahas and inliers along continuous divides (uninterrupted by stream valleys) onto the lower lying Iowan plain. The detailed study areas in Linn, Tama, Grundy, and Howard counties are shown in fig. 2-1 and discussed in detail in Ruhe, et al., 1968.

Their detailed three-dimensional reconstructions showed, time after time, in every case, that the same stratigraphic units and even the same weathering zones in the till, could be traced from the "Iowan plain" directly under the pahas and the Yarmouth-Sangamon soil. Where was the so-called Wisconsinan-age Iowan till? It did not exist. The lower lying landscape, below the paha, is a wide-spread, loess-mantled erosion surface that was cut into Kansan till and from which the thick Yarmouth-Sangamon and Late-Sangamon paleosols were stripped. In places the erosion surface cuts entirely through the Kansan till, revealing what classically would be considered the Aftonian paleosol and even

Nebraskan till. The stone line (or the famous "Iowan pebble band") on the Kansan till generally marks the erosion surface.

Many of the conclusions of this study will be demonstrated later in this presentation. Some of the major points will be outlined here: 1. the erosion surface origin certainly explains the basic problematical features of the Iowan, much better than the rather awkward Iowan glacier stories, such as: a. lack of any end moraines; b. the "greater than" radio-carbon dates--obviously Kansan and Nebraskan materials should be "dead;" c. the problem of narrow sublobes having to flow around 30 foot hills of easily erodible loess, etc; 2. the pahas and inliers are better explained as erosional remnants, with the full increment of Wisconsinan loess preserved, whereas the lower lying Iowan erosion surface has systematically thinner and younger loess-analogous to southwestern Iowa; 3. the "Iowan plain" is not just "undulating and rolling," but is comprised of a series of discrete multilevel erosion surfaces that step down from divides to an integrated drainage net; 4. detailed analysis shows that the presumed typical stratigraphy on the Iowan surface, is not typical but was a gross overgeneralization--e.g.--thin leached loess, or thicker calcareous loess may overlie either leached or calcareous till, or even deeply weathered "Aftonian" paleosols.

In relation to previous work the results of Ruhe and others work (1968) would: 1. agree with Leverett's evaluation, prior to his conciliation in 1942, that the Iowan till does not exist. Here, there is disagreement with the conclusions of McGee, Calvin, Alden and Leighton, Kay and associates, and Leighton. There is also disagreement with Leverett that the till is a late phase of Illinoian. The till on the Iowan erosion surface is either the classic Kansan or Nebraskan; 2. this work would agree with Leverett's evaluation that the stone line (Iowan pebble band) was formed mainly by the erosion of running water, but there is disagreement that "much" time was involved in its formation. But this involves a side-argument of quantifying how much is "much." In this regard there is agreement with Kay and others, and Leighton that the stone line and the loess are closely related in time. The current studies show that the Iowan erosion surface formed during loess deposition time; 3. there is agreement with Leverett that the loess is much younger than the drift. The loess is Wisconsinan and the tills, etc., are "Kansan and Nebraskan." Consequently, there is disagreement with Kay and others, and Leighton, that the loess and stone line are closely related in time to the drift.

The work of Ruhe, Fenton, Dietz, and Hall, proved that the Iowan drift did not exist, and they replaced it with the theory of the Iowan erosion surface. The test of any theory is its ability to explain the observed facts (which has been demonstrated in this case), and to stand the test of time. And indeed, all serious work done in the Iowan area since the work of R, F, D, and H, has affirmed and further documented the basic conclusions of the Iowa erosion surface study (see Vreeken, 1972, 1975; Kleiss, 1969, 1970; Miller, 1974; Hallberg 1978a, b, d; and Szabo, 1975). This theory of the Iowan erosion surface also forms a predictive model of the general relationships between geomorphic features and subsurface materials. In studying soil-geomorphology this forms a landscape model of how the geomorphology and stratigraphy affect the distribution of soils on the landscape. The Iowan erosion surface has formed the model for the detailed mapping of soils in this part of Iowa. As such, this model has been applied almost daily, for nearly

15 years by numerous soil scientists, and its validity continues to be verified and expanded. The Iowan drift did not exist; the Iowan erosion surface is fact.

"AN IMPORTANT LESSON,"

There are many obvious lessons to be learned from the Iowan saga. This thing we call science should indeed be self-improving. With time as our conceptual basis changes, as our tools improve and our research methods improve, we may have to re-evaluate and reinvestigate accepted theory. For example, our present story; in light of today's knowledge of glacier dynamics, much of the "thin-ice" Iowan theory seems hard to comprehend - yet 50 years ago they were quite plausible; also, the conceptual basis of the stepped - erosion surfaces of southern Iowa, allowed a more rational explanation for the Iowan. Examples, of tools and research methods, were the introduction of radiocarbon dating to the problem, and the possibility and use of detailed drill-core transects.

Beyond these philosophical points is a more basic lesson - a conceptual one. The Iowan problem points out the importance of understanding (and applying) the concept of stepped-erosion surfaces. This is one of the most important concepts and tools of recent time, for any earth scientist who works with the relations of materials, stratigraphy, landforms, and soils. Yet the idea of stepped-erosion surfaces are not widely understood, and are only applied by very few geologists and geomorphologists. These ideas are much more widely applied by soil scientists, pedologists, and those who work in soil geomorphology. There is some reason for this; much of the research dealing with stepped landscapes is published in soils - related literature. Perhaps, more importantly, scientists engaged in soil-geomorphic research or soil survey scrutinize the landscape in much closer detail than do most geologists. As part of the "important lesson" of the Iowan, we will review some of the principles. (For more detailed discussion see Ruhe, 1975a; 1975b, chapters 6 and 7).

First, we must start with a basic description of the hillslope (see fig. 2-3). In an open-system with intergrated drainage, there are certain geomorphic components to the landscape. Starting at the upland divide these are: the head slope - occurs at the head of the drainageway, and is concave along the slope width, the slope lengths converge downward into the drainageway; the side slopes border the drainageway along its sides, and are generally linear along the slope width; the nose slope - forms a convex curve between opposed side slopes, between the open ends of adjacent drainageways; on the nose slope, slope lengths generally diverge downward. Between adjacent drainageways is an interfluve, which protrudes out from the divide and is bordered by sideslopes and a noseslope.

On any of these three kinds of slopes, there is a hillslope profile (fig. 2-3). On the highland of the divide or interfluve is the summit. As one moves from the summit toward a drainageway a convexly rounded slope forms, which is called the shoulder. Below the shoulder is the backslope, which is generally linear and descends to a concave footslope, which is an alluvial surface. The backslope is most susceptible to erosion, the footslope and toeslope are generally areas of deposition. Obviously, not all of these profile components will occur

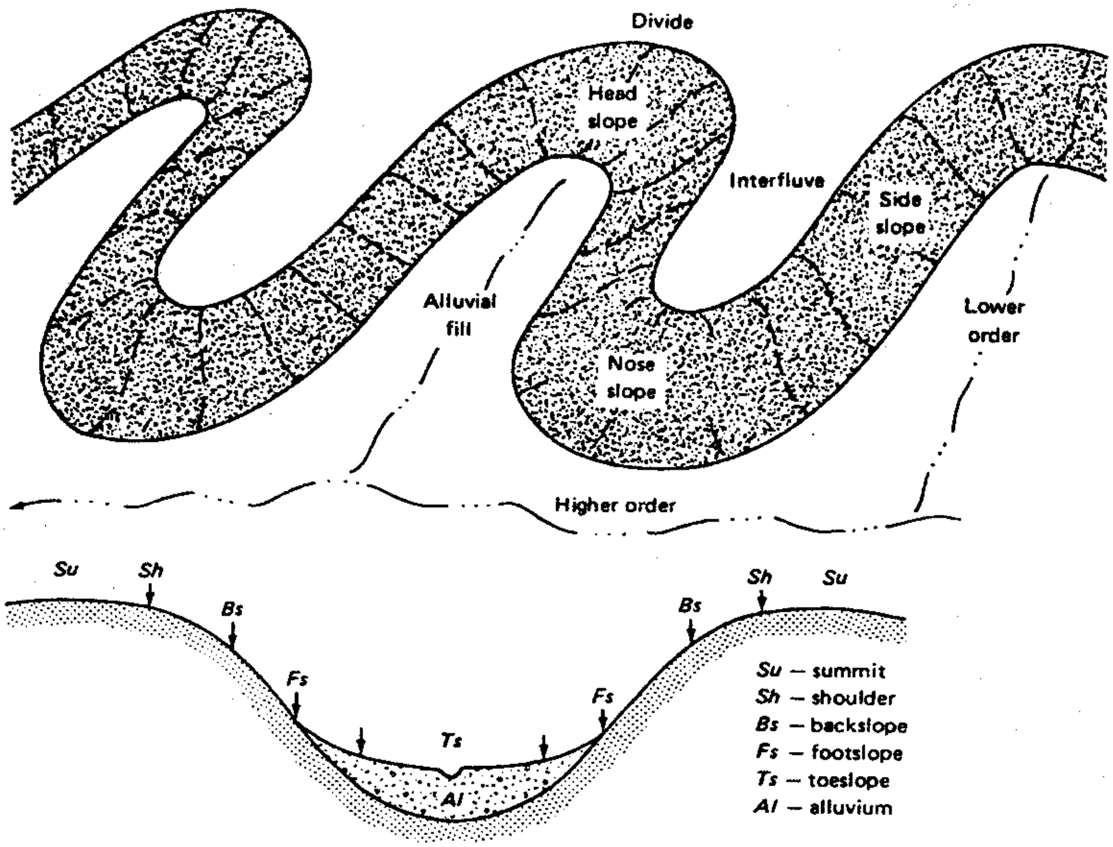


Figure 2-3. The geomorphic components of a slope bounding an open-system watershed and along hillslope profile. From Ruhe and Walker (1968).

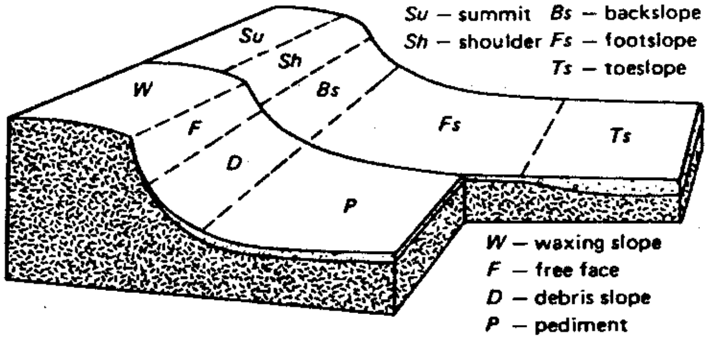


Figure 2-4. The elements of a "fully developed hillslope." Foreground from Wood (1942) and L. C. King (1957). Background from Ruhe (1960).

on every hillslope - for example, where a stream cuts directly into a backslope.

These components are also an integral part of the soil - landscape (Ruhe, 1960) and the soil catenas of Milne (1936). The variable soils that will be found in a hillslope profile such as discussed, are called a toposequence. The catena is a special toposequence where the parent-material remains the same throughout the hillslope profile. Then the variations in the soils can be attributed to the landscape position and the erosion and sedimentation processes taking place on the profile.

Hillslope profile components are directly analogous to the concept of the "fully developed slope" (Wood, 1942; King, 1957; Ruhe, 1975a). Fig. 2-4 compares the model and terminology of Ruhe, with that of Wood and King. The terminology of Wood and King is more widely used, and perhaps more appropriate to bedrock-controlled landscapes. Instead of a rounded shoulder, they describe the free-face, a bedrock outcrop, which is the source of talus, etc., in the debris slope below. The pediment is a broad concave-upward surface, sloping away from the debris slope toward lower surfaces, often the alluvial plain of nearby streams. The pediment a familiar landform, may cover broad areas, and as such our discussion passes from hillslope components, into the realm of erosion surfaces.

An erosion surface, such as the pediment, has stripped or removed part or all of the bed that makes up the debris slope or backslope. The surface may cut across different stratigraphic units, and sometimes even bevel geologic structures. Perhaps it is easiest to see the elements of the fully developed slope and its component erosion surface where these features are developed on bedrock - such as in the pediments of the Western U.S., or even in the Niagaran escarpment of Iowa where Silurian Dolomites form the resistant free-face and the lower-lying pediment cuts across the lower Silurian, the Ordovician Maquoketa Shale, and levels off on the Galena Dolomite. These features are often more subtle where developed on soil materials where the differences in erodibility of the various materials and the consequent relief is much less.

As already inferred, in the discussion about southern Iowa, it is common for multiple erosion surfaces to occur in an area, arranged in step-like fashion from divide to master stream, within a watershed. As an example, figure 2-5 shows a schematic cross-section of the landscape that will be visited on the field trip. Seven distinct surfaces can be identified and mapped in the area (see also figs. 2-11 through 2-14). Each stepped surface exhibits the hillslope components discussed; at the drainage-divide we have a narrow summit on the loess-mantled Yarmouth-Sangamon surface; this surface steps down through the shoulder, backslope, and footslope - not to an alluvial toeslope, but to the lower-lying pediment of the Iowan erosion surface. This pediment, in turn forms the summit, for the next slope which descends to a still lower and younger pediment surface, and so on. The lowest four surfaces are alluvial surfaces; number 4 being a Wisconsinan-age terrace with a thin veneer of loess. This surface is in part constructional (by fluvial deposition) and in part erosional, as the terraces often exhibit a stoneline or "sand-line" with pedisediment similar to the till-cut surfaces.

In a strict sense the pediment proper underlies the loess and is marked by a stone-line (lag of stones left by the hillslope processes,

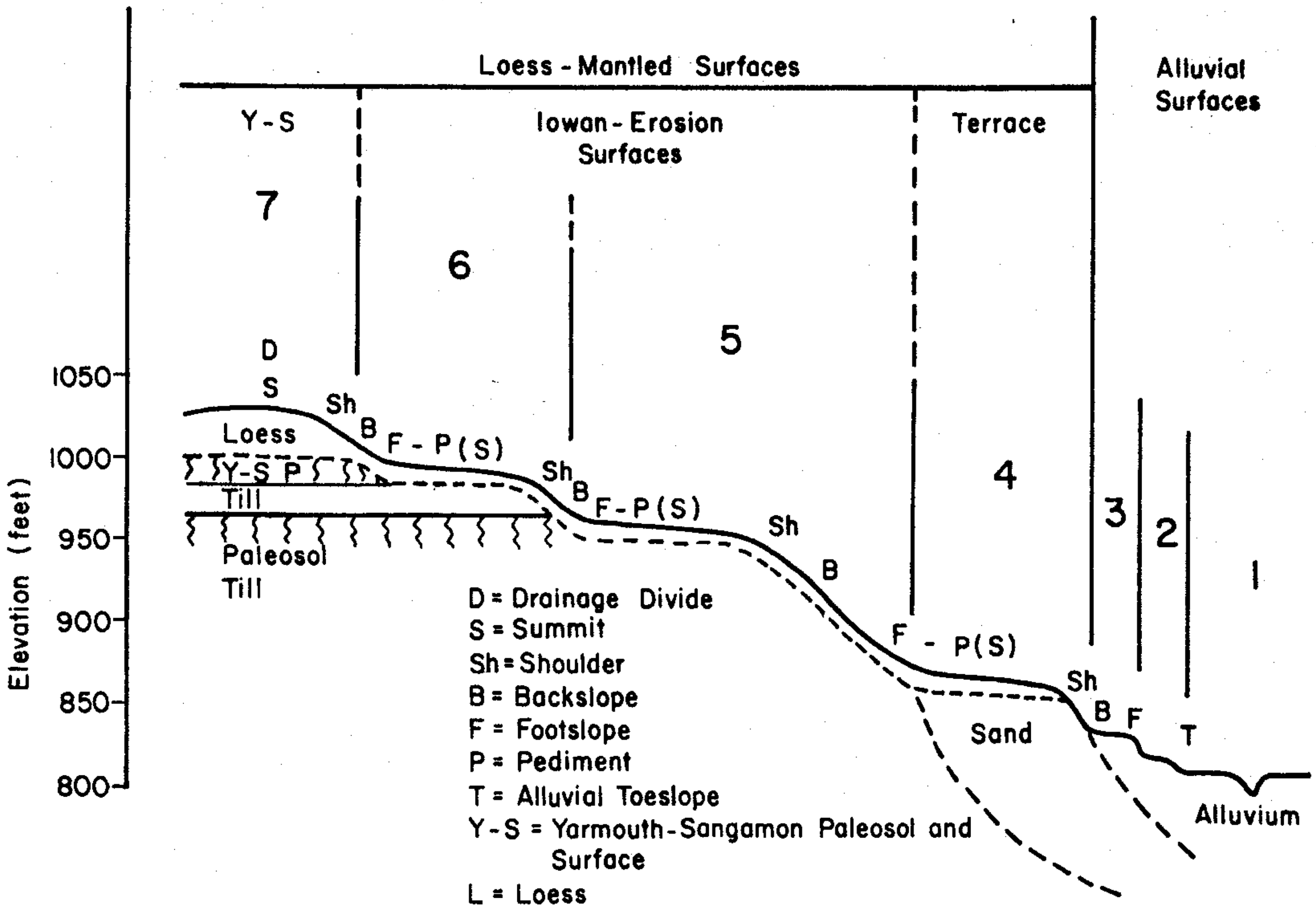


Figure 5. Schematic section of landscape in Hayward's Paha area (see also fig. 2-11).

such as sheet wash, etc., which cut the pediment) and its veneer of pedisediment. This in turn is simply mantled by loess and/or eolian sands.

In a classic sense it may be "heresy" to call these features pediments in Iowa. After all, pediments have classically been considered the product of erosion in an arid environment. The peneplane has been the classical result of erosion in a humid environment. But, alas, as with the Iowan Drift, the peneplane is becoming a casualty of progress. Multi-stepped pediment landscapes exist the world over (Geyl, 1961) and have been recognized in the Great Plains (Frye, 1954) and Iowa (Ruhe, 1956) for years. As shown recently by Ruhe (1975b) these surfaces indeed represent the fully developed slope. He has documented stepped pediments in great detail from Africa, Puerto Rico, New Mexico, Hawaii, and Iowa; developed on everything from till to andesite tuffs. Even with the climatic diverstiy of these international examples, these "fully-developed slopes" or pediments are alike in kind, right down to their $y=ae^{bx}$--mathematical expression (Ruhe, 1975a). These types of surfaces do differ in detail and clarity of expression, because of differences in relief, the material they are developed on, and possibly climate (Toy, 1977). However, their general form and their accompanying concepts can be applied in almost any older landscape region.

Along with recognition of stepped landscapes come two important principles, which also should be reiterated. These are the <u>principles of ascendancy and descendancy</u> (Ruhe, 1969). Briefly, an erosion surface must be relatively younger than the youngest deposit or structure which it cuts across - the Iowan erosion surface is much younger than the classic Kansan and Nebraskan tills which it cuts across (see figs. 2-2 and 2-5). A land surface is also younger than the youngest land surface that it truncates - the hillslope where erosion is taking place develops a younger surface on it than the stable summit. A hillslope is the same age as the alluvial fill to which it descends, but conversely must be younger than the higher surface to which it ascends. Likewise, any erosion surface is younger than an erosion remnant or erosion surface which stands above it at a higher level, but must be older than any surface inset below it. In fig. 2-5 surface 7, is older than 6, which is older than 5, etc.

These principles are simply a geomorphic extension of the Principle of Superposition - the bulwark of geology. However, they sometimes cause confusion with the Principle of Superposition as well. In figure 2-5 surface 5 is clearly developed on a paleosol and till, which by superposition is older than the materials on which surfaces 6 and 7 are developed on. Yet surface 5 must be younger than surfaces 6 and 7, because 5 is inset below them, even though it is cut into older materials (also see fig. 2-2).

This also helps to illustrate that one can hardly even do effective Quaternary stratigraphy without understanding the erosion surfaces. Obviously an outcrop on surface 5 would have little validity in determining anything about the character of the youngest till in the area, which is only present on surfaces 6 and 7.

The concepts and principles of stepped erosion surfaces are obviously the "important lesson" of this trip.

"...AND SOME NEW WRINKLES."

Although the major controversy of the Iowan has been resolved, there are still many questions to be answered. Our continuing work in the "Iowan area" of interest here, is concentrated in four areas: 1. mapping the actual distribution of the erosion surface; 2. the details of the Pleistocene till stratigraphy; 3. the relations of loess thickness to the erosion surface; 4. the difficult and nagging question of why?

With the modern knowledge of the Iowan as an erosion surface the classic boundaries of the "Iowan" area make little or no "geomorphic sense." Sublobes cut across drainage basins (fig. 2-1), which is inconsistent with the systematic geomorphic development of a fluvial erosion surface where the materials are the same (which they are). Consequently, the authors with the help of numerous soil scientists (notably Norm Helzer, Doub Oelman, Ron Keuhl, Dale Lockridge, John Wooster, and John Highland, of the Soil Conservation Service, and Nyle Wollenhaupt, presently with Midwest Consulting Laboratories) have been mapping the actual extent of the erosion surface.

This phase of study really began in Cedar County, Iowa, with G.A. Miller's (1974) dissertation on the soil geomorphology of the area. Prior to Miller's work the Iowan had only been mapped in the northern portion of the county (fig. 2-1) where the loess was quite thin. In the southern part of the county the loess is considerably thicker, and this was calssically mapped as the "Kansan" drift area. Yet his detailed analysis of core holes in continuous landscape transects showed that the Iowan erosion surface was continuous over wide areas even under the thick loess. The thick loess Iowan has essentially the same morphology as the thin loess Iowan, so why was this not classically considered Iowan as well? If we return to our "old story" you will recall that the "Iowan drift" presumably only had thin loess on it, while the Kansan had thick loess. The explanation for this was that the terminus for the Iowan was the source of the loess. In much of the older Iowan literature (Alden and Leighton, 1917), and especially in the county reports of the Iowa Geological Survey Annual Reports it is often admitted that the Iowan-Kansan boundary was drawn on the basis of loess thickness, even where the distinctive morphology of the low-relief Iowan plain continued into the thick loess areas. There is some circular reasoning here, and in circular fashion we will return to it.

With the knowledge of the Iowan as an erosion surface, we now know it extends far beyond the rather strange boundary of the "Iowan drift." The maps (figs. 2-6 and 2-7) of the field trip area show the actual distribution of the Iowan, and we will visit one of these "outlying" areas during the last stop on the trip.

Another aspect of continuing research is on the Pleistocene stratigraphy in the Iowan area. Our present concept of the stratigraphy is more complex than the classical idea of one Kansan till and one Nebraskan till. Again, this is in large part because of changes in our conceptual basis and research methods. From a conceptual standpoint, it has been shown in Illinois and Nebraska in particular (Willman and Frye, 1970; Reed and Dreeszen, 1965; Boellstorff, 1973) that these early Pleistocene sequences are considerably more complex than our classical concepts. Until recently, however, a modern Quaternary stratigraphic investigation had not been undertaken in Iowa. Even the studies of Ruhe and others, which employed subsurface drill cores, was principally a geomorphic study. In that study the deepest core holes were 80 to 90 feet and ended within the Pleistocene sequence. Our present stratigraphic studies have cored the entire Pleistocene sequence, from the land surface to the Paleozoic bedrock, to depths of nearly <u>400</u> feet. This has revealed much more to the stratigraphic section than previously recognized. Also, previous studies have only described the physical stratigraphy and correlation was only by the inference that if two tills were present at different sites they were obviously the same - because that was all that was believed to exist. In our present studies, the stratigraphic units have been characterized quantitatively by their mineralogy, particle size analysis, and even chemically, thus allowing a "quantitative" correlation from site to site. This has enabled the development of a comprehensive stratigraphic framework, which is shown in Table 2-1. On the field trip we will only be looking at the uppermost part of the sequence; the Wisconsinan loess down through the Wolf Creek Formation.

Throughout this report these early Pleistocene glacial deposits are referred to by their rock-stratigraphic designation, or where they are discussed in relation to prior work they may be referred to as "classical Kansan or Nebraskan" deposits. Note in Table 2-1 their present "formal" designation is Pre-Illinoian. The reason for this is that ongoing work in the classic type area of Kansan and Nebraskan deposits, in southwestern Iowa and Nebraska also shows a complex series of glacial deposits, which range in age from less than 600,000 y.b.p. to over 2.2 million y.b.p. (Hallberg and Boellstorff, 1978; Boellstorff, 1978). Stratigraphic analysis of the rock units shows that these classical terms have been widely misused and miscorrelated. Until the terminology of these deposits is resolved, the designation of Pre-Illinoian will be used for their time-stratigraphic reference.

Table 2-1. Stratigraphic nomenclature for field trip area (from Hallberg, 1978d).

Time Stratigraphy	Rock and Soil Stratigraphy
Wisconsinan Stage	Wisconsinan Loess (informal name) Basal loess paleosol (informal name)
Sangamon through Yarmough	Yarmouth-Sangamon and Late-Sangamon Paleosols
Pre-Illinoian	Wolf Creek Fromation Hickory Hills Till Member 1 Dysart Paleosol 2 Aurora Till Member 3 Unnamed peat and organic paleosols Winthrop Till Member Westburg Paleosol Alburnett Formation Unnamed till members

1, 2, 3. These units, in the field trip area, were previously called:

1. Kansan till
2. Aftonian paleosol
3. Nebraskan till

Although this new work reveals more stratigraphic complexity, it has only served to amplify the basic theory of the Iowan erosion surface previously outlined.

As promised, in circular fashion, let us return to the question of loess thickness in relation to the Iowan. As outlined the "Kansan" areas, the inliers and paha, were found to have thicker loess than the "Iowan drift." In turn, the "Iowan drift" border was frequently mapped based on discontinuities in loess thickness. In turn again (to complete our circle) the "Iowan drift" terminus was interpreted to be the source of the loess. Simple - but then circles tend to be simple. Again, as outlined, recent work shows that extensive areas of Iowan erosion surface extend under the thick loess areas. This removes the erosion surface from contention as the source of the loess - as it is mantled by it, and particularly because the age of the erosion surface is the same under thick loess as where the loess is thin (Miller, 1974).

It is well documented though that even minor valleys within the erosion surface (which were carrying debris from the cutting of the surface) served as local sources of eolian sand, and thus likely some silt (Vreeken, 1975; Ruhe, et al., 1968). However, the regional loess thickness relations (fig. 2-7) can be more simply explained by application of the loess dispersion model. This will be outlined during the trip as well.

On last item was listed under continuing investigations - the ultimate question of why? In reality this should not be discussed as a "new wrinkle," because this was the ultimate objective of all previous investigations. Unfortunately, we will not and cannot answer the question at this time. In the summary at the end of this field guide, we will try to present some of our present insights.

TO THE FIELD

No detailed road log will be provided on this trip. Figures 2-6 and 2-7 show the route and also the mapped distribution of landscapes and loess thickness. Discussion will be provided by the trip leaders enroute. Follow the route on the maps and try to get a feel for the landscapes that we will be viewing today. Try to pick out the multileveled or stepped landscapes. Also look at the landscapes in comparison to the classical "Iowan" boundary.

You will (hopefully) notice some dramatic differences between the "Iowan" areas and the multi-stepped landscape or classical Kansan areas (see fig. 2-6). These classic Kansan areas have higher relief and steeper slopes. The differences in morphology can be quantified:

Frequency distribution of slopes in typical Iowan and Kansan areas (from Hall, 1965):

Slope Group %	Frequency %	
	Iowan	Kansan
0- 3	50.7	8.6
3- 6	22.9	10.7
6-16	26.3	27.1
16-40	0.0	53.7

In the following discussion of the field sites laboratory data on mineralogy and particle size will be shown. Standard procedures for these lab analyses are described in "Standard Procedures for Evaluation of Quaternary Materials in Iowa (Hallberg, 1978c). Also, standard descriptive nomenclature is used; soils and paleosols are described using standard pedologic nomenclature and horizon abbreviations (Soil Survey staff, 1951, 1975): C-horizon or geologic materials are described using standard weathering zone terminology (Hallberg, Fenton, and Miller, 1978). Weathering zone terms and abbreviations are defined in terms of moist-Munsell-color-related terms, mottles and iron-segregations, and the presence or absence of carbonates.

Standard symbols and abbreviations are (from Hallberg, et al., 1978):

Loess

Standard symbols, terms, and their defined use for loess are:

First Symbol - color reference;

0 - oxidized; 60% of matrix with hues of 2.5Y or redder, values of

3 or higher, and may have segregation of secondary iron compounds into mottles, tubules, or nodules.

D - deoxidized; 60% of matrix with hues of 10YR, 2.5Y, and 5Y, values of 5 and 6, chromas of 1 and 2 with segregation of iron (ferric oxides) into tubules (pipestems) or nodules.

U - unoxidized; matrix with hues of 5Y, 5GY, 5GB, and 5G, values of 4, 5, and 6, chromas of 1 or less (except 5Y 6/1 is deoxidized), with no segregation of iron into tubules or nodules. May include hues of N or values of 3 or less with the presence of zones with abundant organic matter; these are often described as organic bands.

Second Symbol - leached or unleached state.

U - unleached; primary carbonates present.

L - leached; no carbonates detectable (with dilute HCl).

L2 - leached; primary carbonates absent, secondary carbonates present. Examples: OL - oxidized (yellowish brown or strong brown matrix) and leached; UU - unoxidized (dark greenish gray matrix) and unleached.

Modifier Symbols - when used precedes first symbol

M - mottled; refers to zones containing 20-50% contrasting mottles. Examples: MOL - yellowish brown or strong brown matrix with gray mottles, leached; MDU - graish brown matrix with strong brown pipestems and strong brown mottles, unleached.

Till

Standard symbols, terms, and their defined use for till are:

First Symbol - color reference

O - oxidized; 60% of matrix with hues redder than 2.5Y (ex.-10YR, 7.5YR); hues of 2.5Y, with values of 5 or higher, but including 2.5 Y 4/4; may have segregation of secondary compounds into mottles, tubules, or nodules, etc.

R - reduced; 60% of matrix with hues of 2.5Y, with values of 3 or less, hues of 2.5Y value of 4, with chromas of 2 or less; hues of 5Y, N, 5GY, 5G, 5BG, and 5G, values of 4 or higher (generally values in this zone are 5 or higher). Colors in this zone are nearly always mixed as weak mottles, diffuse blends of color, or as discrete bands. Discrete vertical bands of reduced colors may occur for some distance adjacent to joints. These bands may eventually grade into uniform unoxidized material. In this zone there may be considerable segregation of secondary iron compounds (with oxidized colors) into mottles, nodules, or sheets along cleavage planes, or joints.

Figure 2-6. Landscape regions for Linn, Benton, Tama, and Marshall Counties, Iowa.

▨ Major alluvial valleys; Holocene alluvium and some older terrace deposits.

▥ Des Moines Lobe; Late-Wisconsinan till (ca.-14,000 R.C.Y.B.P.)

□ Iowan Erosion Surface - where extensive enough to map.

Multi-Stepped Landscapes;

<u>Loess-Mantled</u>

▓ 1. Yarmouth-Sangamon and Late-Sangamon surfaces with frequent small areas of Iowan Erosion Surfaces occuring along interfluves.

░ 2. As above in 1, but only occassional Iowan Surfaces occur.

<u>Paha Areas</u> - ridged areas with thick-eolian deposits.

● 1. Thick-loess and eolian sand over paleosols.

⬬ 2. Thick-loess and eolian sand on Iowan Erosion Surface; some with minor remnant areas with paleosols.

⬭ 3. Thick loess and eolian sand over Iowa Erosion Surface (see Figure 7).

‐ ‐ ‐ Classical Iowan Drift border.

— Field trip route.

┼┼┼ Major roads.

∘4 Field trip stop.

Figure 2-7. Thickness of Eolian Deposits - Superimposed on Landscape Regions

▨	Major alluvial valleys; Holocene alluvium and some older terrace deposits; no loess (except for minor inclusions of loess-mantled terrace).
▥	Des Moines Lobe; Late Wisconsinan till (ca.-14,000 R.C.Y.B.P.) -- no loess.
░	Essentially no loess--Iowan Erosion Surface mantled with approximately 1m (2 to 4 feet) of loamy sediments, minor eolian sand.
■	Areas of approximately 1m (2 to 4 feet) loess mantle on Iowan Erosion Surface north and west of the Cedar River.
▒	Areas of abundant, thick eolian sand and minor loess.
—4—	Loess thickness contours in meters. (1.5m = 4.9 ft.; 3m = 9.8 ft.; 4.5m = 14.8 ft.; 6m = 19.7 ft.; 9m = 29.5 ft.). Contours show regional loess thickness, which is the thickest loess found in the area; in general this occurs on the highest upland divide surfaces.
14	Maximum known thickness of loess and eolian sand in adjacent paha belt, to nearest meter.

Note: The loess thickness in this area is very complicated and changes thickness very rapidly. It is not possible to show all the contours in many areas. Only the most prominent paha belts are contoured.

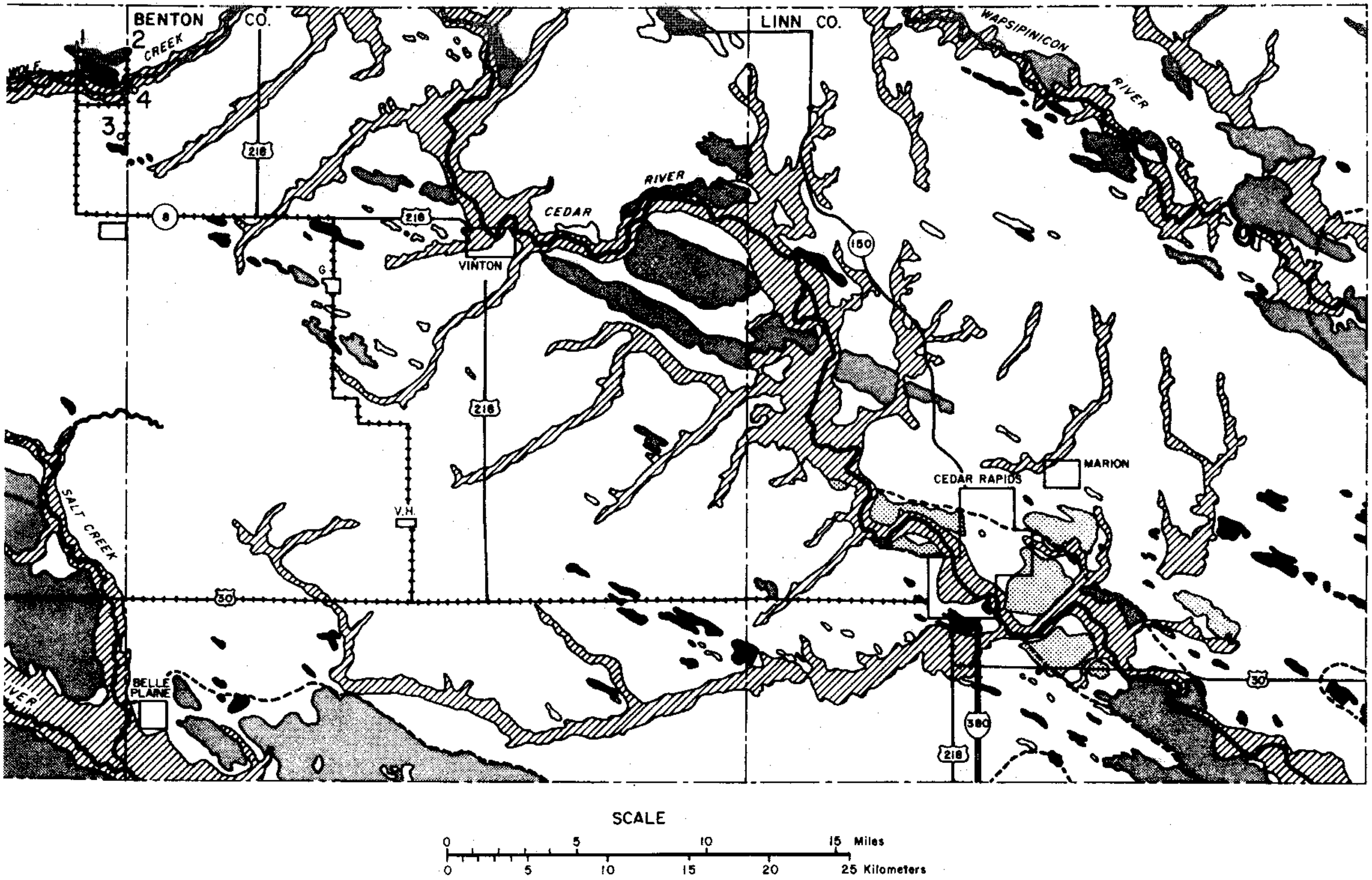


Figure 2-6 east

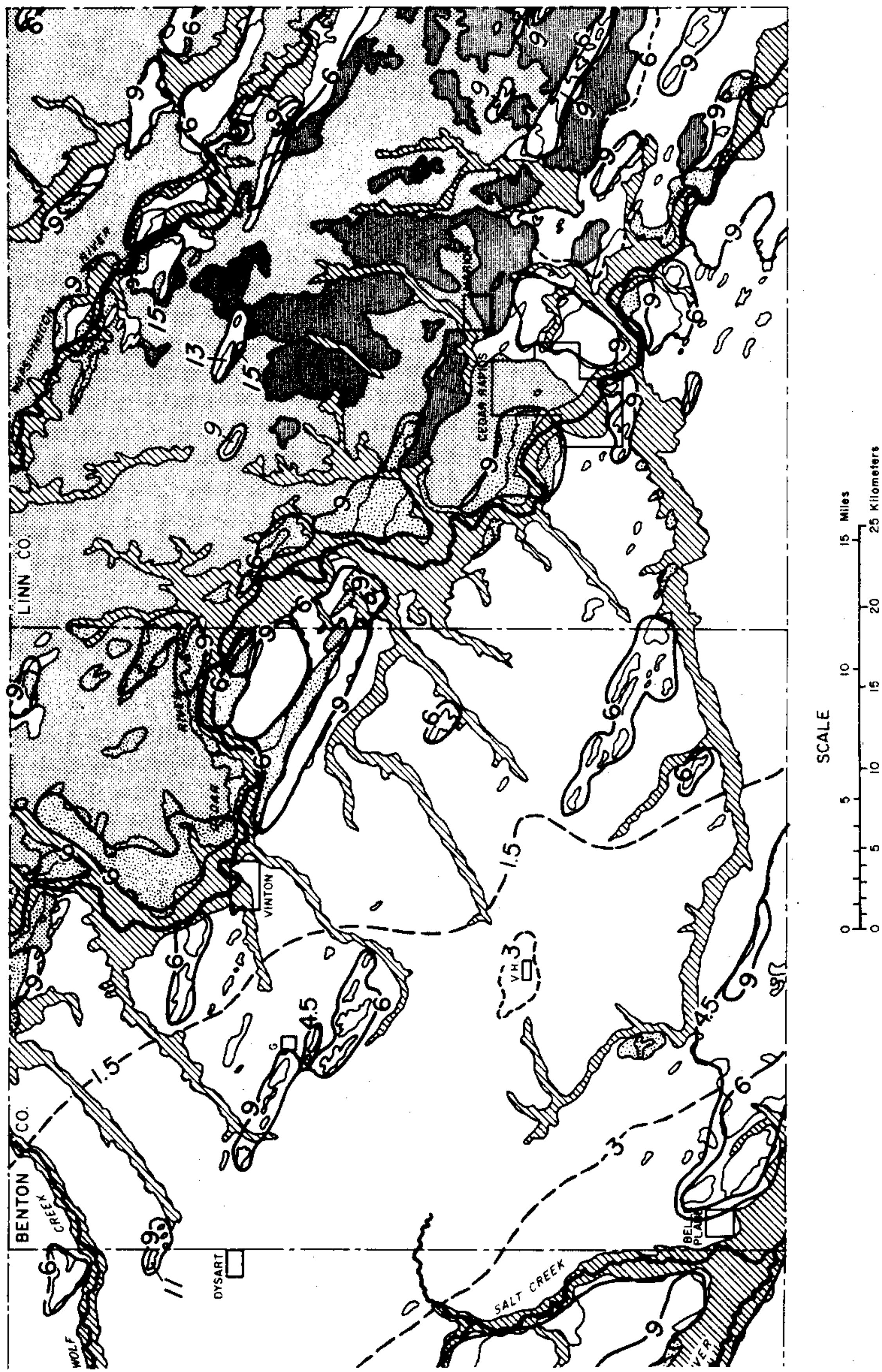


Figure 2-7 east

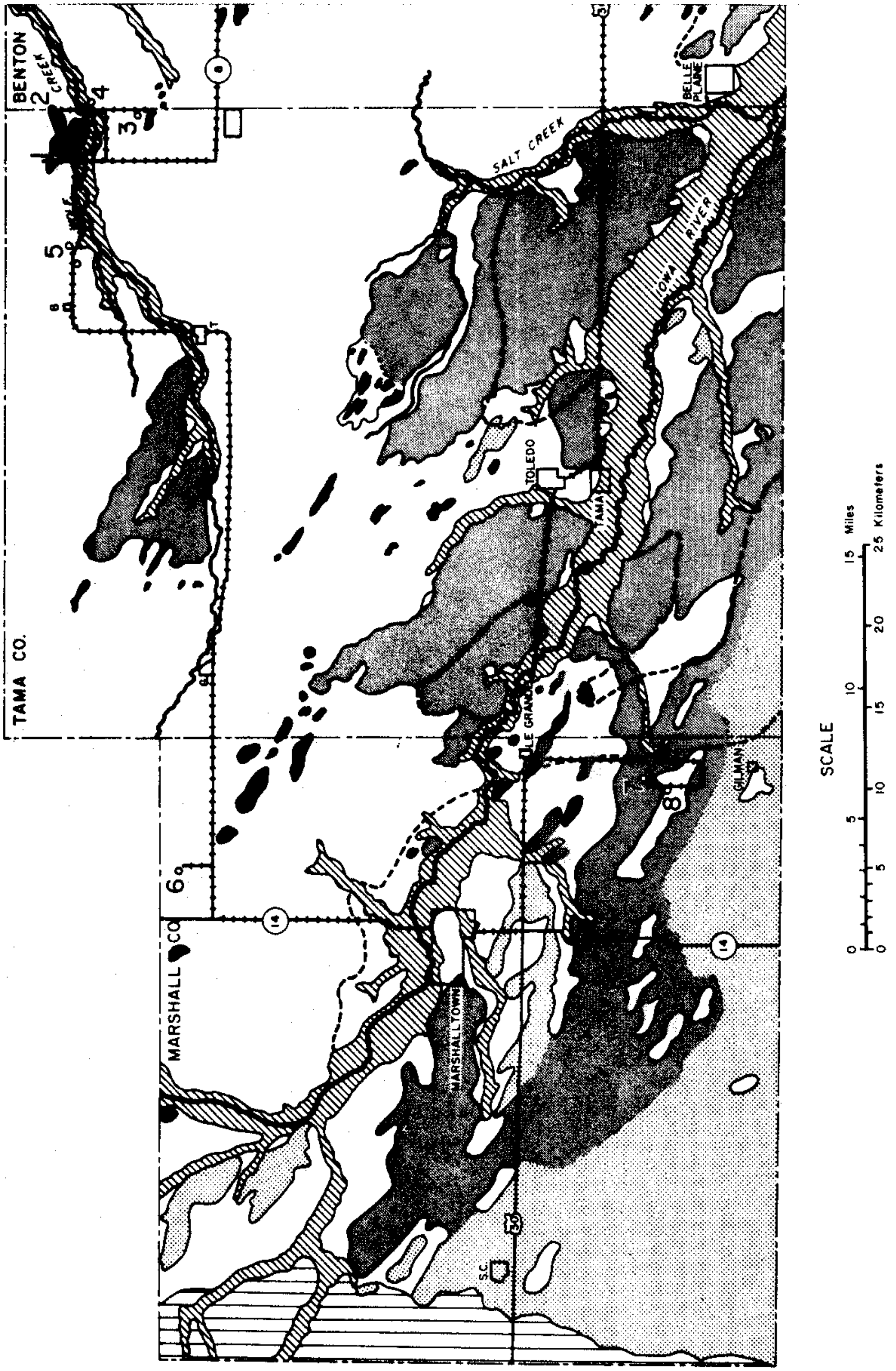


Figure 2-6 west

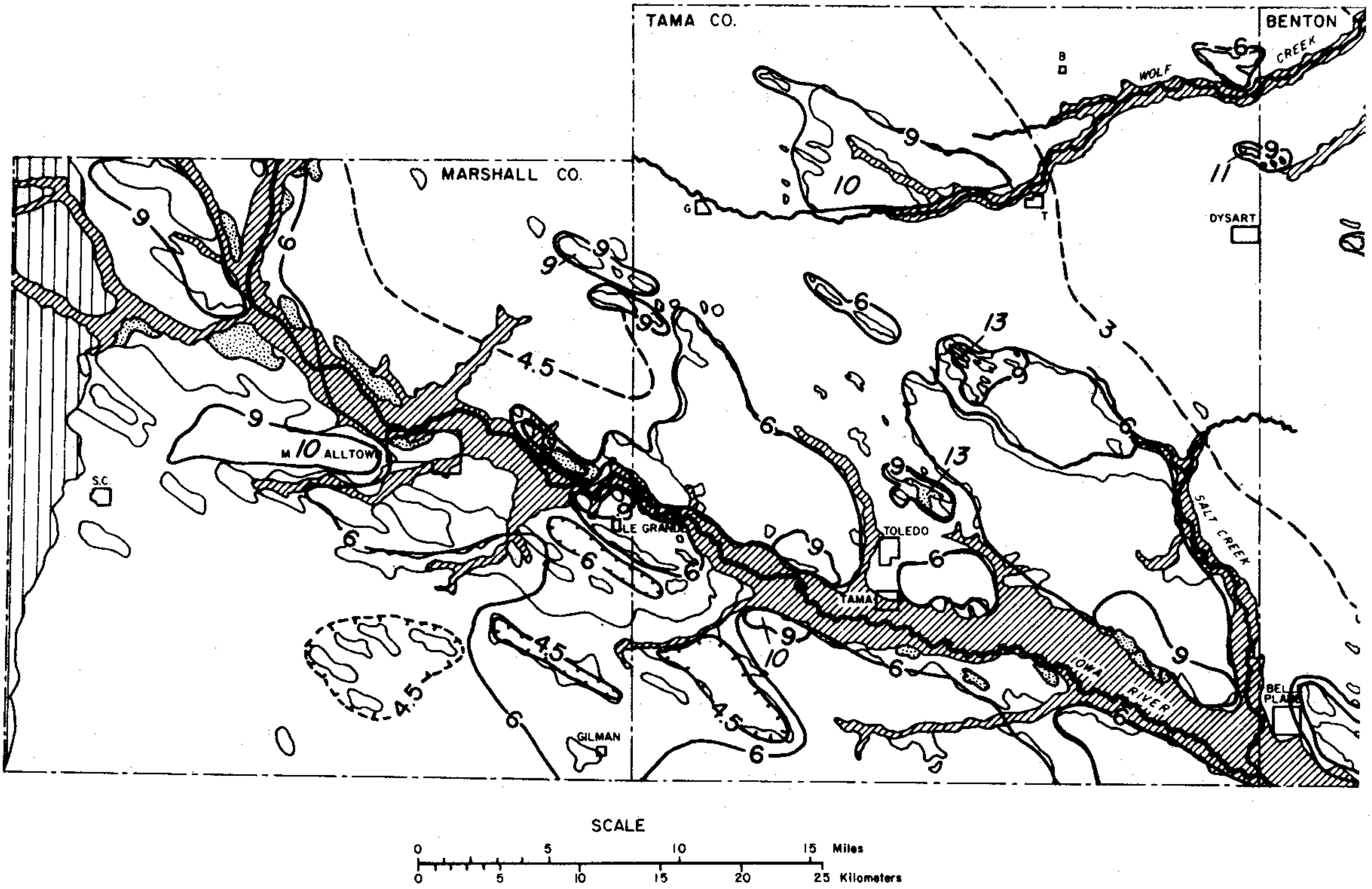


Figure 2-7 west

U - unoxidized; matrix uniform hues of 5Y and N, values of 5 or less, 5GY, 5G, 5BG, 5G, with values of 6 or less; with no segregation of iron compounds into mottles, nodules, etc.

Second Symbol - if used

J - jointed; describes the presence of well-defined vertical joints in the till; joints often show oxidized and reduced colors; often have coatings or rinds of secondary iron-oxides; occasionally other secondary minerals such as calcite or gypsum.

Second or Third Symbol - leached or unleached state; same as for loess.

U - unleached.

L - leached.

L2 - leached of primary carbonates, but secondary carbonates present.

Modifier Symbols - when used precedes first symbols, as with loess;

M - mottled; zones with 20-50% contrasting mottles; when used with the unoxidized zone designation it infers 20% or <u>less</u> mottles of reduced colors.

Examples: JRU; jointed reduced unleached-mixed olive (5Y4/4 and 5Y4/3) and very dark grayish brown (2.5Y 3/2), with common gray (5Y5/1) and light olive brown mottles (2.5Y 5/4) mottles; prominent vertical joints, with 1cm strong brown (7.5Y 5/8 segregations along the joint; unleached.

JUU - jointed, unoxidized, unleached-uniform dark greenish gray (5GY 4/1) matrix, with few thin vertical joints, joints, which have mottled light olive brown (2.5Y 5/6) and olive gray (5Y 5/2) faces, and a 3 cm rind of greenish gray (5GY 5/1); unleached.

MUL - mottled, unoxidized, leached - dark greenish gray (5GY 4/1) matrix with few, small gray (5Y 5/1) mottles; leached.

<u>STOP 1</u> - <u>402 Road Cut</u> - <u>Highway 21; Casey's Paha</u>

This site was briefly discussed in the introductory material. Since it was initially described as the 402 road cut, the highway has been renumbered as state highway 21. The cut is located on the west end of Casey's Paha, which is also the location of Hickory Hills Park. STOPS 1 and 2 are reference localities for the Hickory Hills Till member.

The cut is covered with vegetation, except for one vertical gully in the center of the cut; and horizontally along the outcrop of the Yarmouth-Sangamon paleosol. In figure 2-8 the stratigraphy, and particle size data, are summarized for the cut and a core below it, to a total depth of about 80 feet. An abbreviated description for the site is presented in Description 1-1.

The trip will start at this stop because this is the "top of the world." When working in eroded landscapes it is imperative to start at the "top of the world," or on the stable upland divide, where the stratigraphy is most completely represented. As previously discussed, the Yarmouth-Sangamon surface forms the highest upland surface and paleosol in the older Pleistocene regions in Iowa (fig. 2-2). We will work our way down to the Iowan plain from here.

Review and look over the stratigraphy; thick loess, weak basal loess paleosol, thick Yarmouth-Sangamon paleosol, Hickory Hills Till member of the Wolf Creek Formation. After reviewing the stratigraphy we will assemble at the top of the cut and look out over the wide "Iowan Plain," lying generally 40 to 60 feet below the paha.

We will proceed south and east and then north, around the flanks of Casey's Paha, and on the north edge of the valley of Wolf Creek (fig. 6). Note the lower-lying surfaces on the flanks of the paha. You may also see outcrops of eolian sand.

STOP 2 - Road Cut - East end Casey's Paha

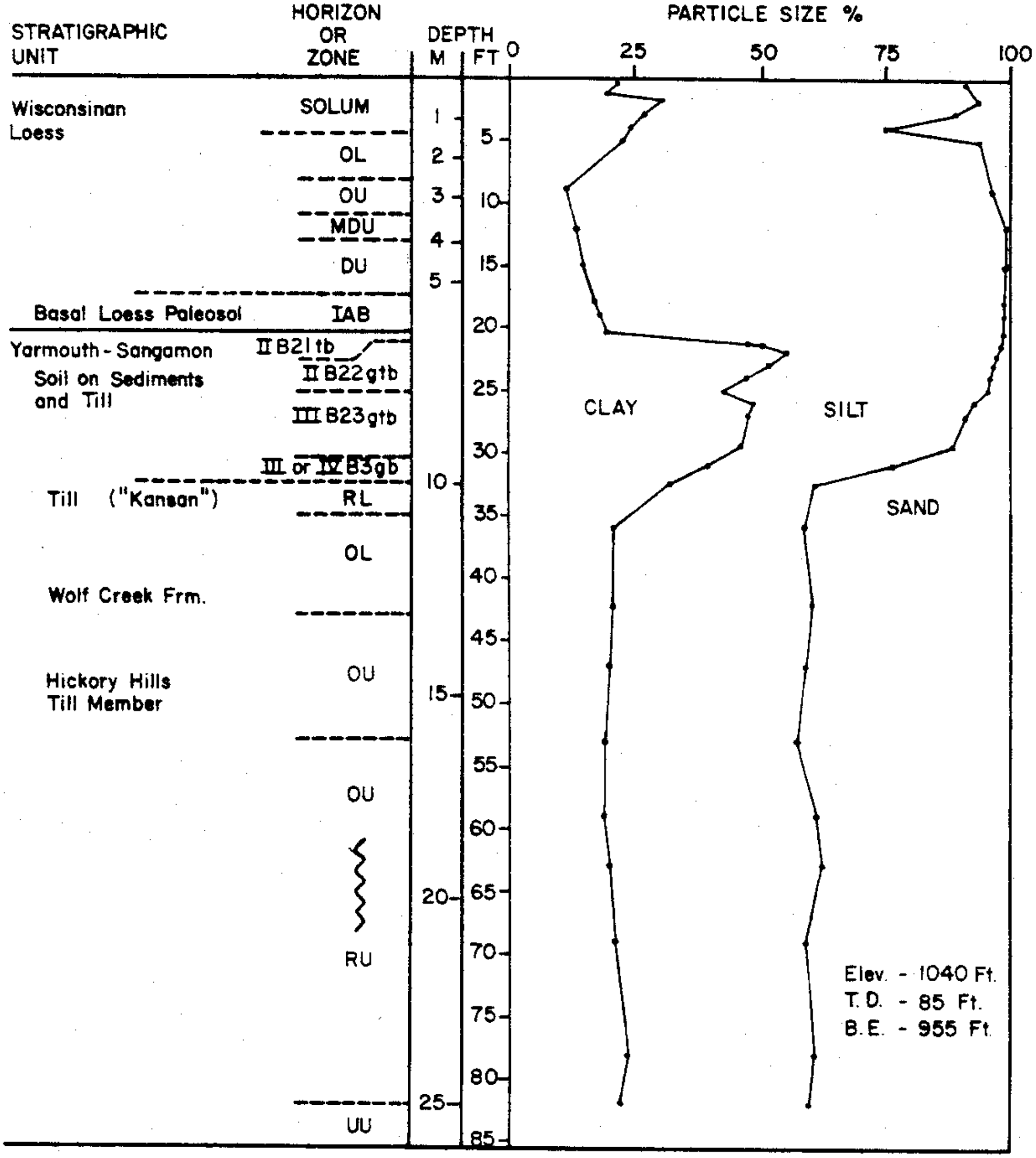
At this stop, we will come down in the world 1 step. Description 2-1 describes the cut and core on the west side of the road. Both cuts

Description 1-1. Yarmouth-Sangamon site, H-21 road cut (from Fenton, 1966)

Feet from surface	Weathering Zone	
	WISCONSINAN LOESS	
0 - 4		Soil solum
4 - 8	OL	10YR 5/4, yellowish brown, gritty silt loam; few fi blk Mn spk; few fi str brn mot; mod med pr; few sand lenses; loess.
8 -11	OU	10YR 5/4, yellowish brown, gritty silt loam; few med lt brnish gray mot; few fi blk Mn spk; loess.
11 -13	DU	3.5Y 6/2, light brownish gray, silt loam; com med ylish brn mot; com fi str brn mot; many fi blk Mn spk; secondary carbonates present; loess.
13 -17.5	DU	2.5Y 6/2 light brownish gray, silt loam; few med ylish brn & str brn mot; com fi blk Mn spk; faunal zone at 13.5; com Fe tbl; loess.
	BASAL LOESS PALEOSOL	
17.5-20.1	IAb	10YR 5/2, grayish brown, silt loam; few fi str brn mot; com charcoal flecks; lower 4 inches many med ylish red mot; noncal; loess.
	YARMOUTH-SANGAMON PALEOSOL	
20.1-21	IIB21b	10YR 4/1, dark gray, silty clay; com med gray, few fi dark red, mny fi ylish red mot; str vf abk; thick cont clay films; Y-S paleosol.
21 -25	IIB22b	5Y 5/1, gray, silty clay; many fi ylish red mot; com fi str brn mot; str v f abk; thick cont clay films.
25 -30.5	IIIB23b	5Y 4/1, dark gray, clay; com med str brn & few fi ylish red mot; str vf abk; thick cont clay films.
30 -32.2	IIIB3b	5Y 4/1 & 5/1, dark gray and gray, clay; same w/ few fine weak red mot; mod f abk; cont clay films; inc in co material.
		(Hickory Hills Till Member)
32.2-35	RL	2.5Y 5/2, grayish brown, clay loam; com co str brn mot; com med Mn spk; till.

Description 1-1. (Continued)

35 -36.5	OL	10YR 5/6-5/8 & 10YR 6/1, yellowish brown and gray, loam; com med & co str brn mot; few pebbles; till.
36.5-43	OL	10YR 5/6, yellowish brown, loam; same w/few med lt brnish gray mot; few pebbles; till.
43 -53	OU	Same w/ carbonates.
53 -83	OU	10YR 5/6, yellowish brown, loam; com fi str brn & com med gray mot; few med Mn spk; few pebbles; till.
83 -84.5	UU	N 4/0, dark gray, loam; few pebbles; till.



DATA FROM FENTON, 1966; RUHE ET AL., 1965.

Figure 2-8. Stratigraphy and particle size data from Stop 1; 402 road cut, and core.

Description 2-1. Late Sangamon site, east end of Casey's Paha (from Fenton, 1966).

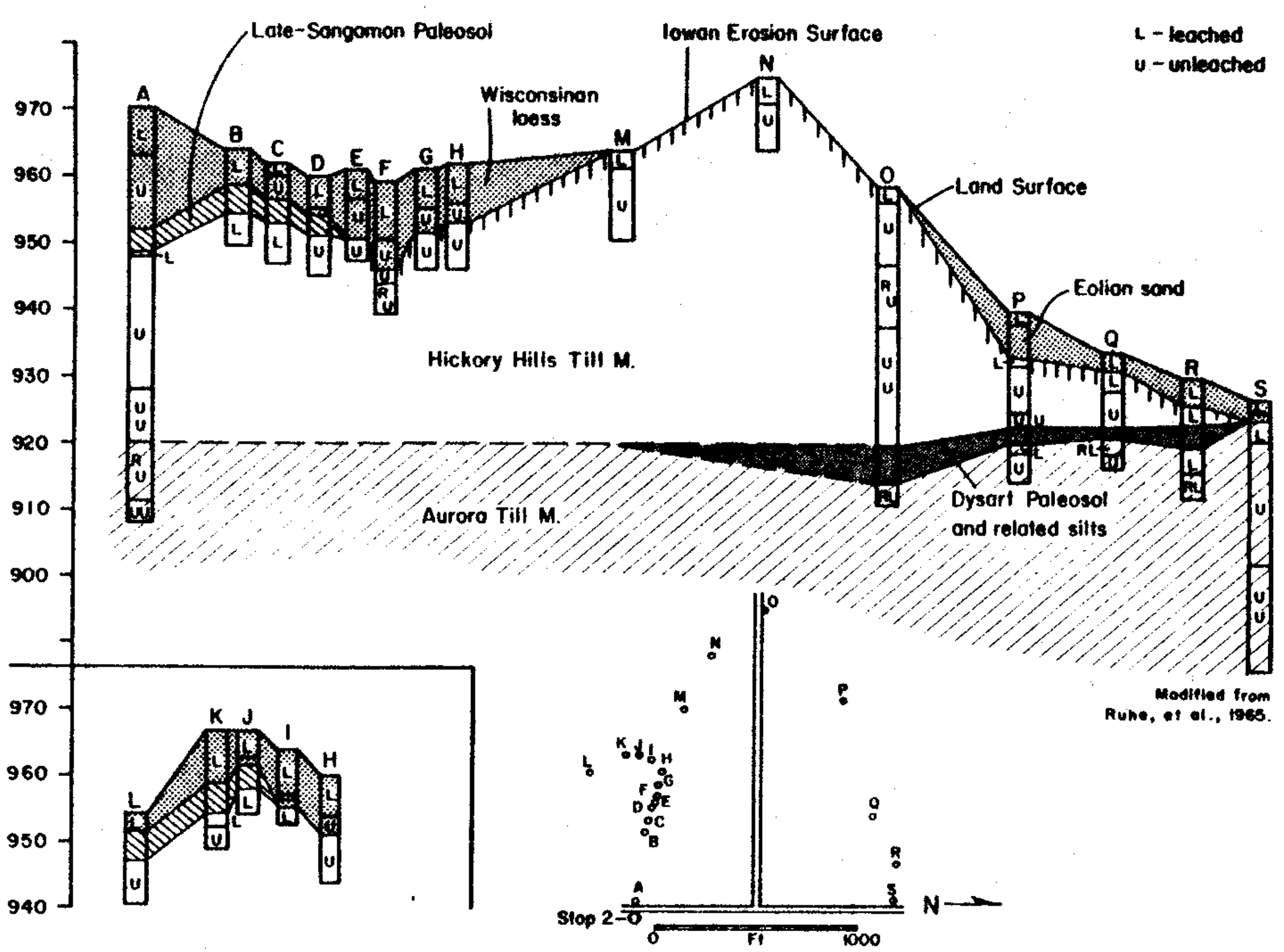
Feet from surface	Weathering Zone	
WISCONSINAN LOESS		
0 - 4.0		Soil solum.
4.0- 8.0	OL	10YR 5/4, yellowish brown, silt loam; leached loess.
8.0-16.5	OU	10YR 5/4, yellowish brown, silt loam; few fi 10YR 5/6-5/8 mot; cal loess.
16.5-18.5	OU	2.5Y 5/3, gray brown to light olive brown, silt loam; str thin & med pl brk to mod fi & med gr.; calcareous loess.
BASAL LOESS PALEOSOL		
18.5-19.0	OL	10YR 5/6, yellowish brown, silt loam; mny med 7.5YR 5/6-5/8 mot.; loess.
LATE SANGAMON PALEOSOL		
19.0-19.5	IIAb	10YR 4/4, dark yellowish brown, clay loam; few fi 7.5YR 5/6-5/8 mot; Late Sangamon, pedisediment.
		(Hickory Hills Till Member)
19.5-20.5	IIIB2b	7.5YR 4/4, dark brown, clay; str med sbk; com med Mn spk; 5YR 4/4 clay flows; Late Sangamon.
20.5-21.5	IIIB3b	10YR 5/6 & 5Y 6/2, yellowish brown and light olive gray, clay loam; str med sbk; com med Mn spk; 5YR 4/4 clay flows on ped surfaces; Late Sangamon.
21.5-22.0	OL	5YR 4/6-4/8 & 7.5YR 5/6-5/8, dark yellowish brown and strong brown, silt loam; leached "Kansan" till.
22.0-22.5	OL	10YR 5/6-5/8, yellowish brown, loam; com fi Mn spk; few 2.5Y 6/2 patches; 5YR 4/4 clay flows on ped surfaces; leached "Kansan" till.
22.5-25.0	OU	10YR 5/6, yellowish brown, loam; com fi & med 7.5YR 5/6-5/8 mot; few 5YR 4/6 mot; lg ca nod; cal "Kansan" till.
25.0-27.5	OU	10YR 5/6, yellowish brown, loam; com fi & med 7.5YR 5/6-5/8 mot; few 5Y 6/2 mot; cal "Kansan" till.

are badly slumped. As a consequence we will look at an exposure on the east side. Here, we will observe loess over the Late-Sangamon soil developed in Late-Sangamon pedisediment and the Hickory Hills till. The various Late Sangamon surfaces, form the second step of the typical sequence of surfaces and well-developed paleosols (see fig. 2-2) in the older Pleistocene regions in Iowa (Ruhe, et al., 1967).

The Late Sangamon surface is an erosion surface, stepped below the Yarmouth-Sangamon (fig. 2-2). It is not possible to view these relations at Casey's Paha because the loess and eolian sand of the paha mask the underlying land-surface. The paleosol at this site, however, is fairly representative of the Late-Sangamon paleosols; it shows a two-story soil profile developed in a loam to clay loam pedisediment, overlying a stone-line, and the underlying till. The reddish colors are typical of many Late-Sangamon paleosols, at least in part, because of their well-drained positions on the old landscape.

Review the stratigraphy of the site. Also, from this stop look over the drilling transect shown in figure 2-9. Site A on this transect is across the road. As the very closely spaced drill-hole transect proceeds to the northwest the Late-Sangamon paleosol is progressively truncated, and the loess of the paha then lies directly on the eroded till. As the transect continues out onto the "Iowan" plain this eroded till surface is exposed--essentially devoid of loess.

Also, note that at an elevation of approximately 920 feet, a second buried soil, the Dysart Paleosol (formerly called Aftonian), or an abrupt contact with the lower lying Aurora Till occurs. As the transect (fig. 2-9) comes back toward the northeast, lower surfaces are encountered and by site S, the loess lies directly upon the Aurora till. The erosion



Modified from Ruhe, et al., 1965.

Figure 2-9. Drilling transect at east end of Casey's Paha -- Late-Sangamon Surface on to Iowan Erosion Surface.

surface has truncated the Late-Sangamon Paleosol, the Hickory Hills Till, and the Dysart Paleosol. There is no "Iowan Drift" butting up against the paha. The Hickory Hills Till and other units can be traced directly onto the erosion surface.

Also, we have discussed the Late Sangamon soil as occuring on a younger surface, and consequently being a younger soil. Figure 10 shows a comparison of clay content, solum thickness, depth of leaching, and weathering ratios of light and heavy minerals, between the Yarmouth-Sangamon soil at STOP 1 and a Late-Sangamon soil in this area (but not this stop), which is very similar to the paleosol examined here. As indicated on figure 2-2, not only is there a geomorphic and pedologic unconformity, between the Yarmouth-Sangamon and Late-Sangamon surfaces and paleosols, but there is also a mineralogic discontinuity. Note on fig. 2-10 the greater clay content with depth, the greater solum thickness and greater depth of leaching, and the greater weathering of minerals in the older Yarmouth-Sangamon soils.

This is not exactly a fair comparison because the Late-Sangamon soil is essentially an "in-situ" soil, developed primarily in till (and analogous to a modern forested soil), while the Yarmouth-Sangamon soil at STOP 1, has an upper increment of accretionary material deposited in a swale on the Yarmouth-Sangamon surface (and is analogous to a modern "humic-gley" soil). However, the data are typical of the differences in weathering between the two different age surfaces and soils (see Ruhe, et al., 1967).

En route to STOP 3 we will drive south and circle Hayward's paha, then return north to STOP 3. While driving we will point out the 7

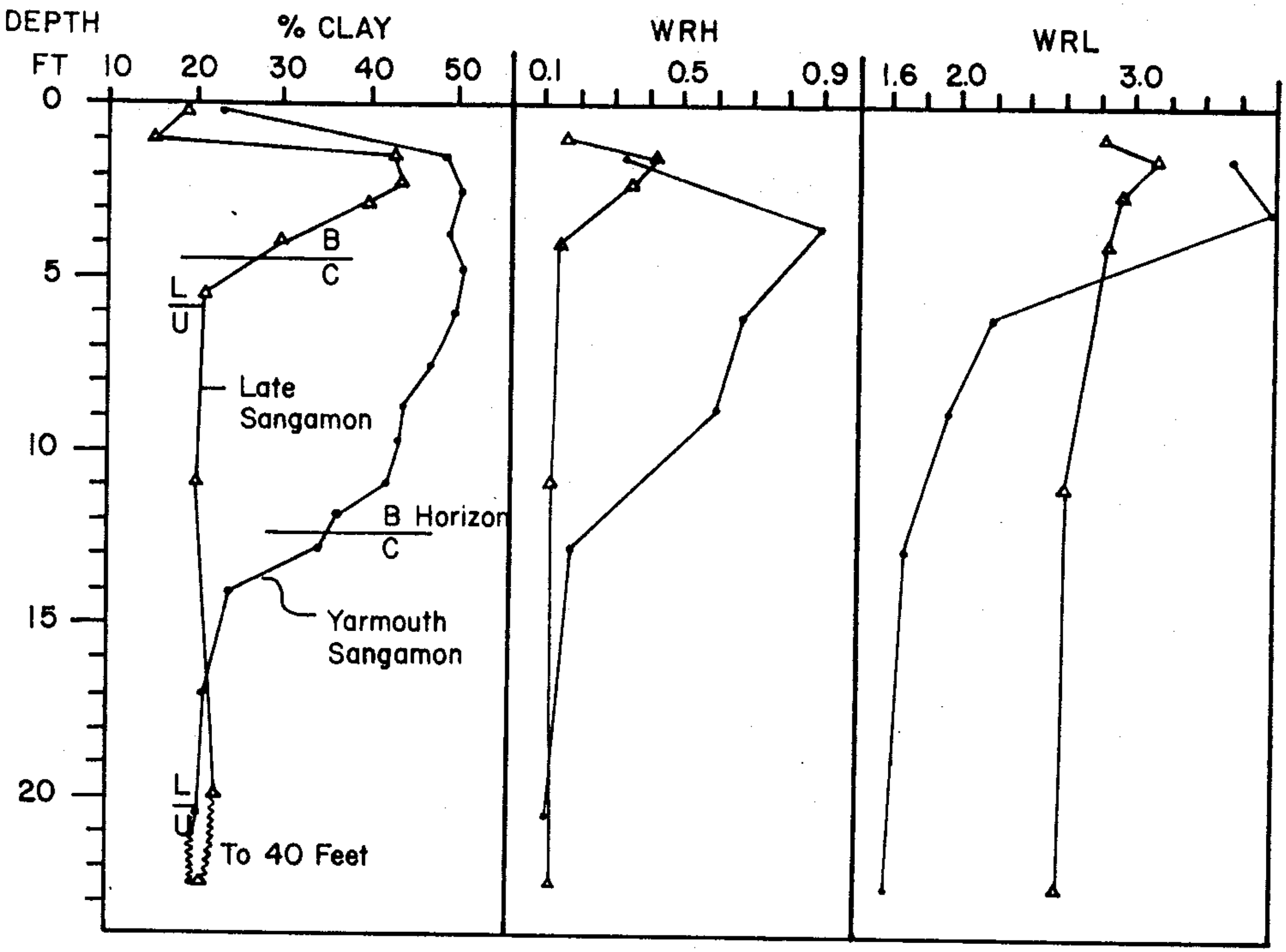


Figure 10. Clay content, and weathering ratios of heavy (WRH) and light (WRL) minerals for Yarmouth-Sangamon Paleosol at Casey's Paha and a Late-Sangamon profile (data from Milling, 1968).

landscape levels (7-count 'em) in the area, shown schematically on fig. 2-11 (see fig. 2-5, also).

Hayward's paha forms level 7, the highest level, and like STOP 1 at Casey's Paha shows thick loess over a basal loess paleosol over a Yarmouth-Sangamon paleosol on the Hickory Hills Till. STOP 3 is on level 6, the uppermost level of the Iowan Erosion Surface.

STOP 3 - Core Site - Level 6; Iowan Erosion Surface

We have now come down one more step in the world from STOP 2. We have also come across to the south side of Wolf Creek. On this side of Wolf Creek, Hayward's Paha forms the top of the world, or the highest landscape position. We will review many things at this site, but to be accurate once again, we must start our story from the "top of the world". Fig. 2-12 is a portion of the Dysart 7.5 minute topographic quadrangle, which shows our location and 3 cross-section lines (fig. 2-13-15). Note the prominent NW ridge--Hayward's Paha--to the SW of our stop.

Cross-sections 1 and 2 (figs. 2-13 and 2-14) cut across Hayward's Paha, on level 7, and continue out onto level 6. Site G-22 (on figs. 2-13 and 2-15) is just west of our location at STOP 3. Once again note the thick loess (over 30 feet), over the basal loess paleosol, and the Yarmouth-Sangamon paleosol in the core of the Paha (see fig. 2-16 for data from WZ-1 on fig. 2-14). Again, as we traverse across the flanks of the paha, the Yarmouth-Sangamon paleosol is progressively truncated, and thinner loess comes to rest on lower stratigraphic units.

Again, at a relatively shallow depth the Hickory Hills Till overlies the Dysart Paleosol and the Aurora Till member. In this area, this contact

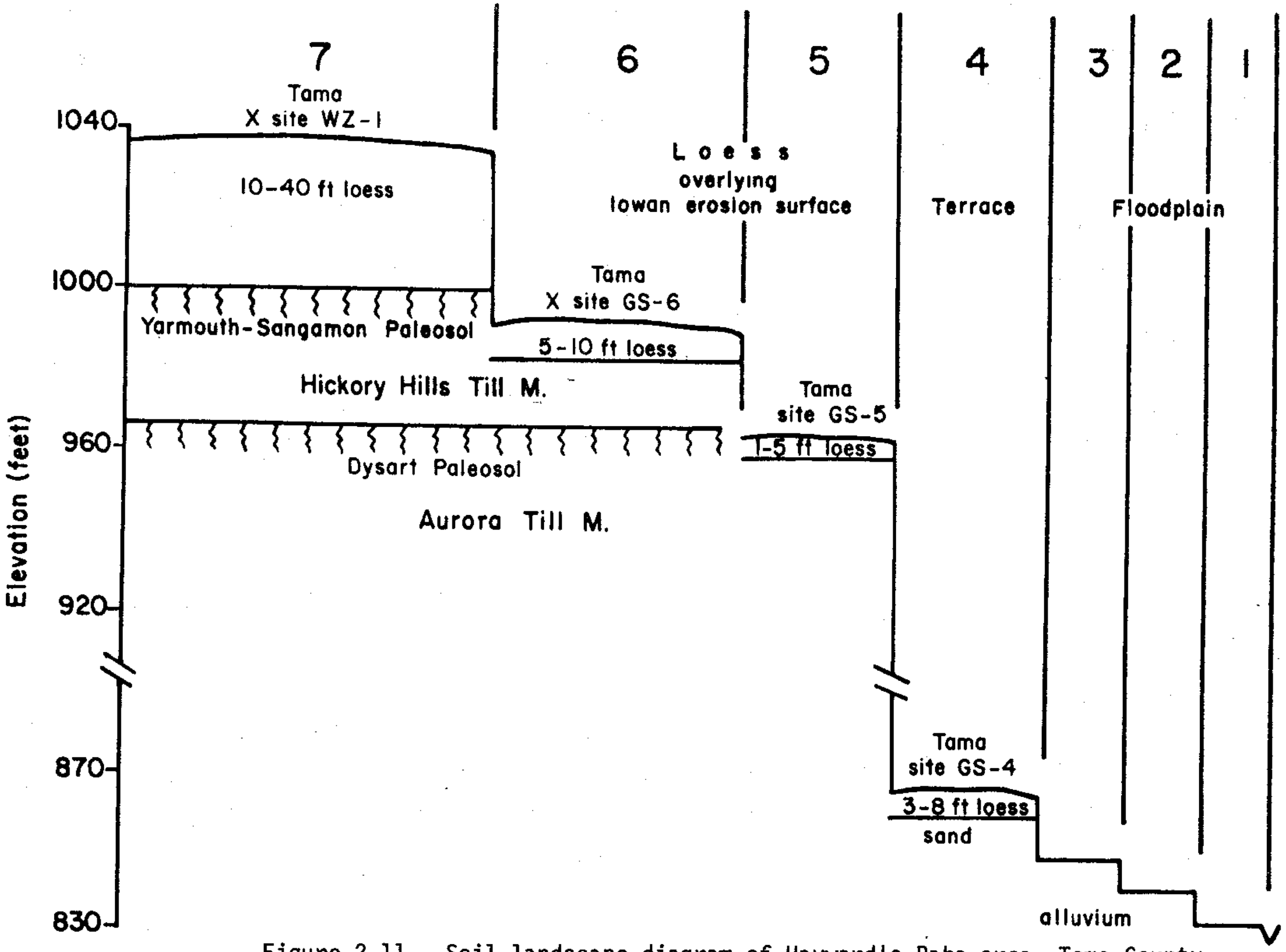


Figure 2-11. Soil-landscape diagram of Hayward's Paha area, Tama County (see fig. 2-5), after Fenton, 1966.

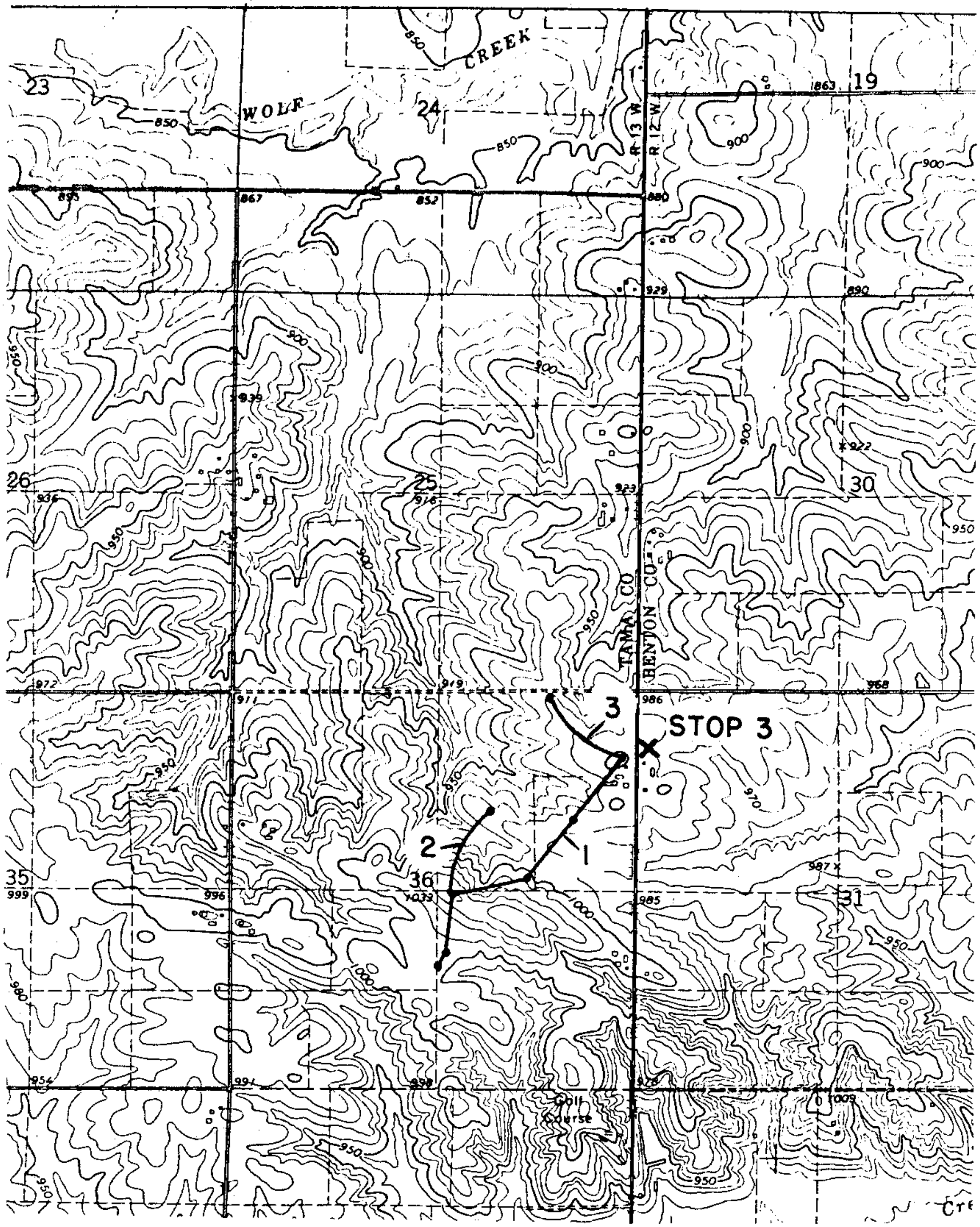


Figure 2-12. Portion of Dysart, 7½ min. Quad., showing drilling transects in Hayward's Paha area, and Stop 3.

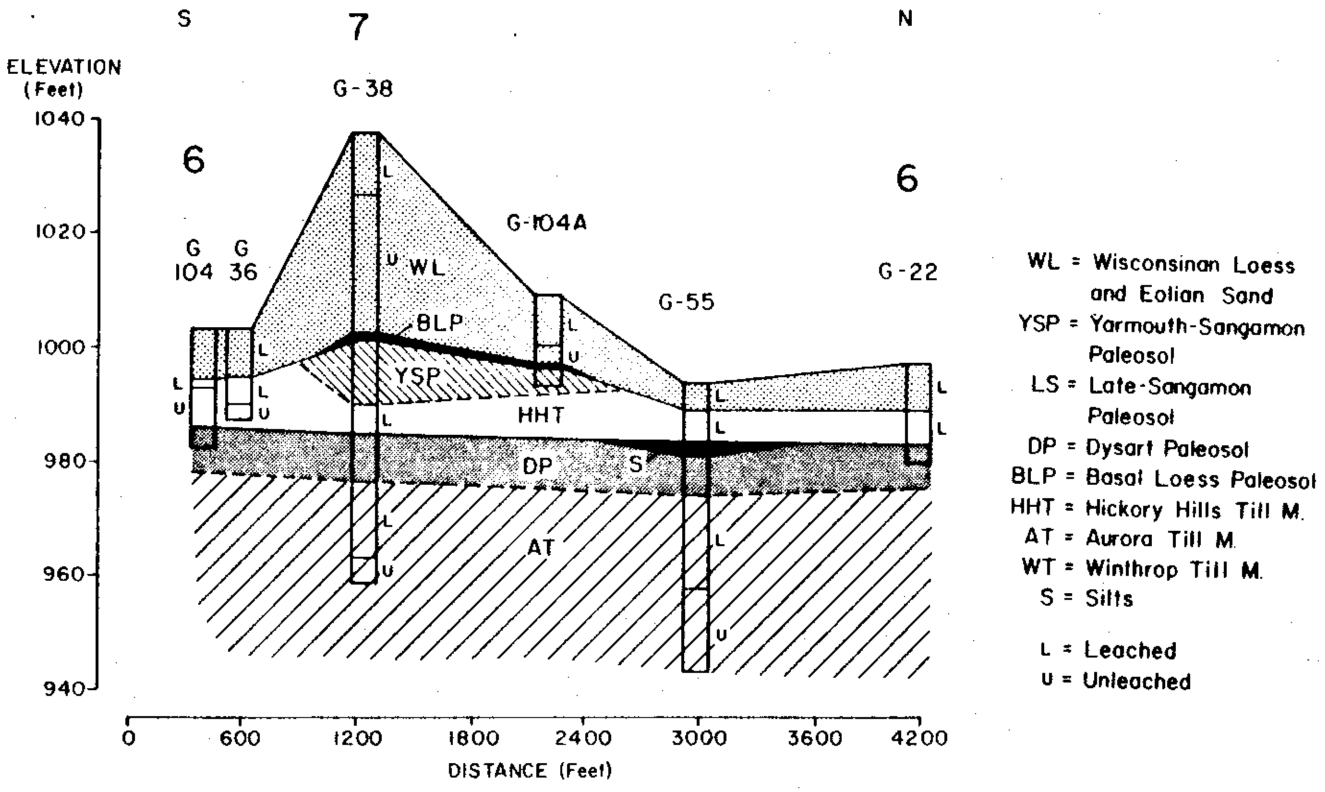


Figure 2-13. Cross-section 1 (see fig. 2-12) showing stratigraphy from level 7 to level 6 (after Fenton, 1966).

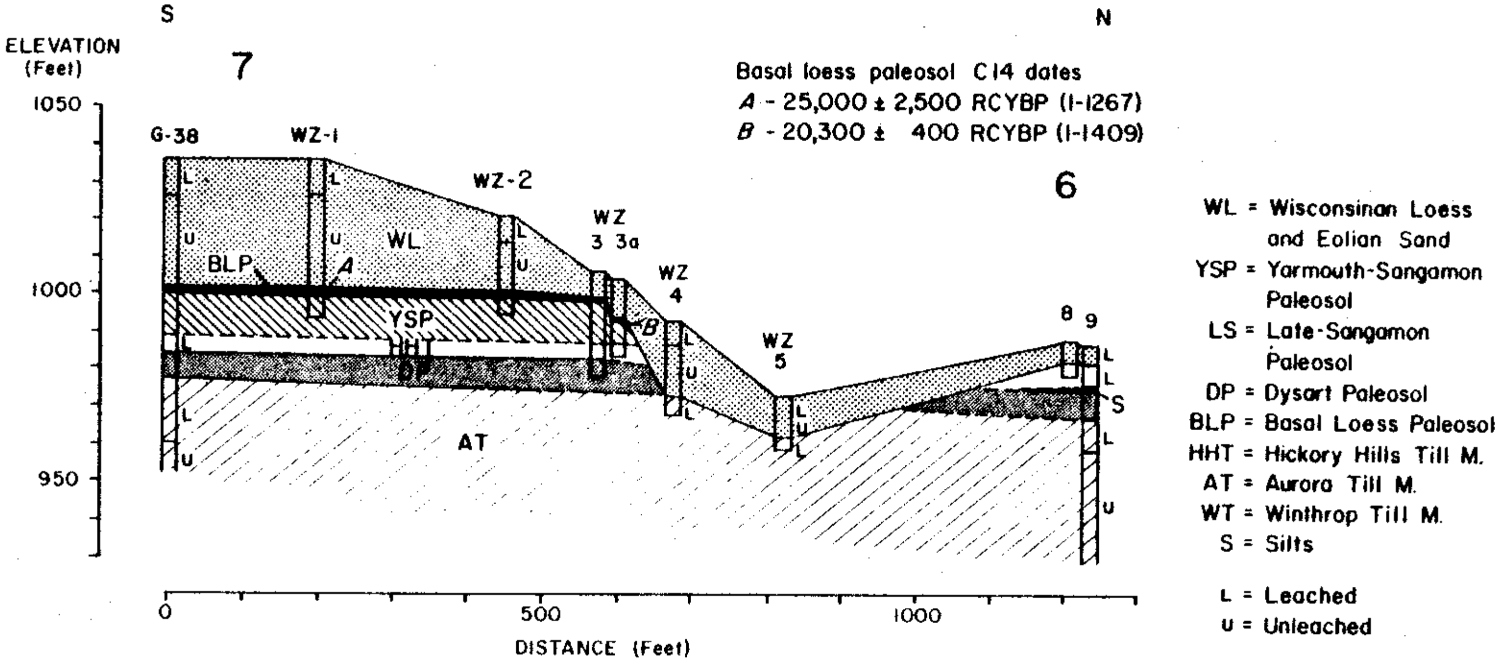


Figure 2-14. Cross-section 2 (see fig. 2-12) showing stratigraphy from level 7 to level 6 (after Rhe, et al., 1968).

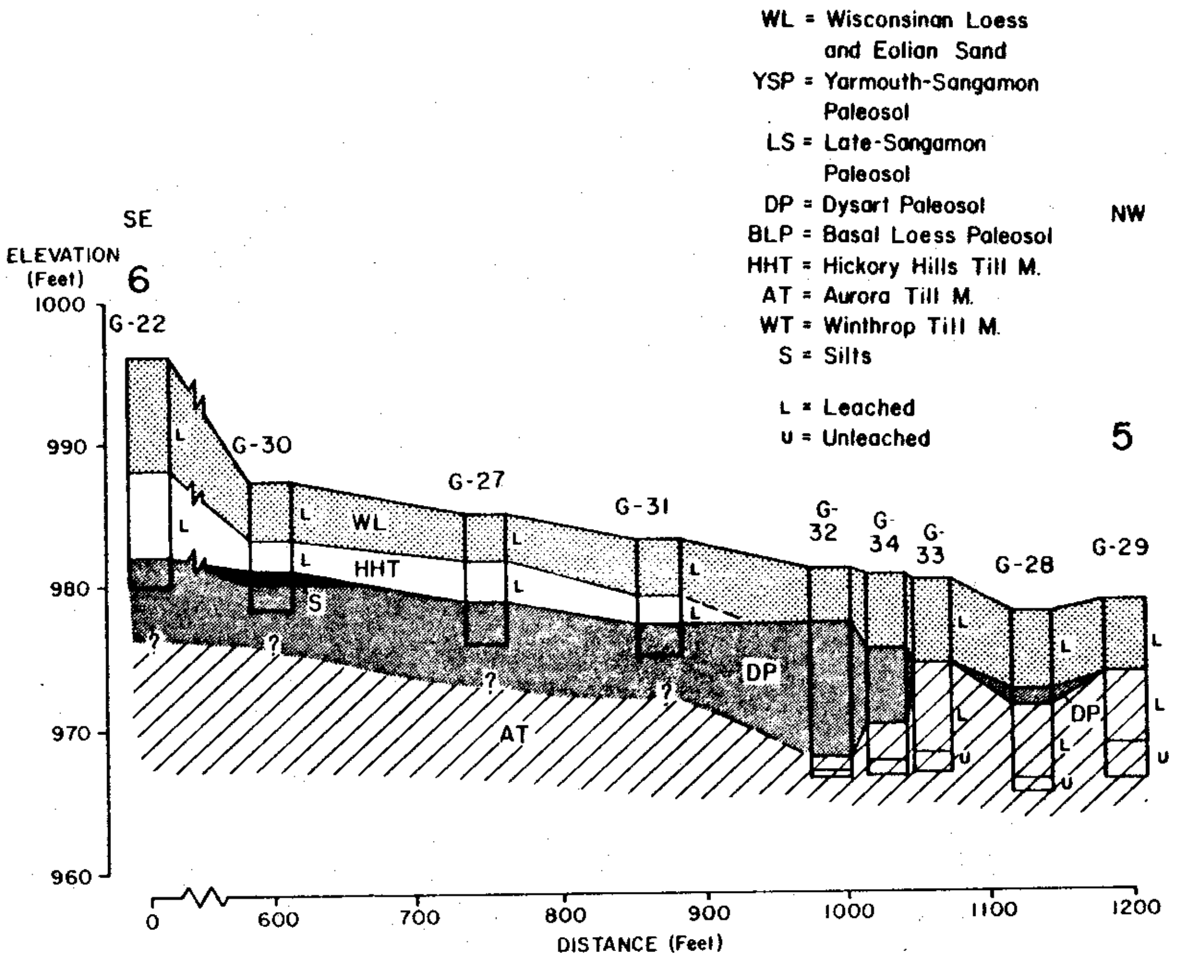


Figure 2-15. Cross-section 3 (see fig. 2-12) showing stratigraphy from level 6 to level 5 (after Fenton, 1966).

lies at a rather consistent elevation again, between about 970 to 985 feet. Fig. 2-17 shows this stratigraphy, and particle size data for site WZ-3 (in fig. 2-14).

At STOP 3 we will look at cores which shows essentially the same stratigraphy as at G-22. There is approximately 7 feet of loess at this site. The core is from the road ditch and the section form the ditch surface down is:

0- 24 in.(-2 ft.; .6m) - ditch fill and, mottled-oxidized, leached loess.

24- 46 in.(-3.8 ft.; 1.2m) - MOL, basal sandy loess, or eolian sand.

46- 60 in.(-5.0 ft.; 1.5M) - mottled-reduced, leached, MRL; Hickory Hills Till; narrow vertical crack, filled with sand from above.

60- 80 in.(-6.7 ft.; 2m) - OL, Hickory Hills till.

80- 91 in.(-7.6 ft.; 2.3m) - OU, Hickory Hills till.

91-102 in.(8.5 ft.; 2.6m) - mottled-reduced unleached, MRU; Hickory Hills Till.

102-115 in.(-9.6 ft.; 2.9m) - reduced, jointed, unleached, RJU; Hickory Hills Till.

115-123 in.(-10.3 ft.; 3.1m) - Banded, black, organic silts; silty clay loam texture; may form complex Ab horizon with paleosol below.

123-227 in. (18.9 ft.; 5.8m) - Dysart Paleosol; gleyed, variable texture, clay, silty clay, clay loam; paleosol developed in crudely stratified fine-textured materials, and underlying till.

227-267 in.+(-22.3 ft.; 6.8m) - reduced, leached, RL; Aurora Till.

Here, on the Erosion Surface, on level 6, the loess is over 20 feet thinner than on the crest of the Paha; the Yarmouth-Sangamon soil has been eroded off, and thin loess lies directly on the Hickory Hills till. If this begins to sound like a broken record--good. That is the point--the relations on the Erosion Surface are very similar from place to place and it forms a conceptual and predictive model.

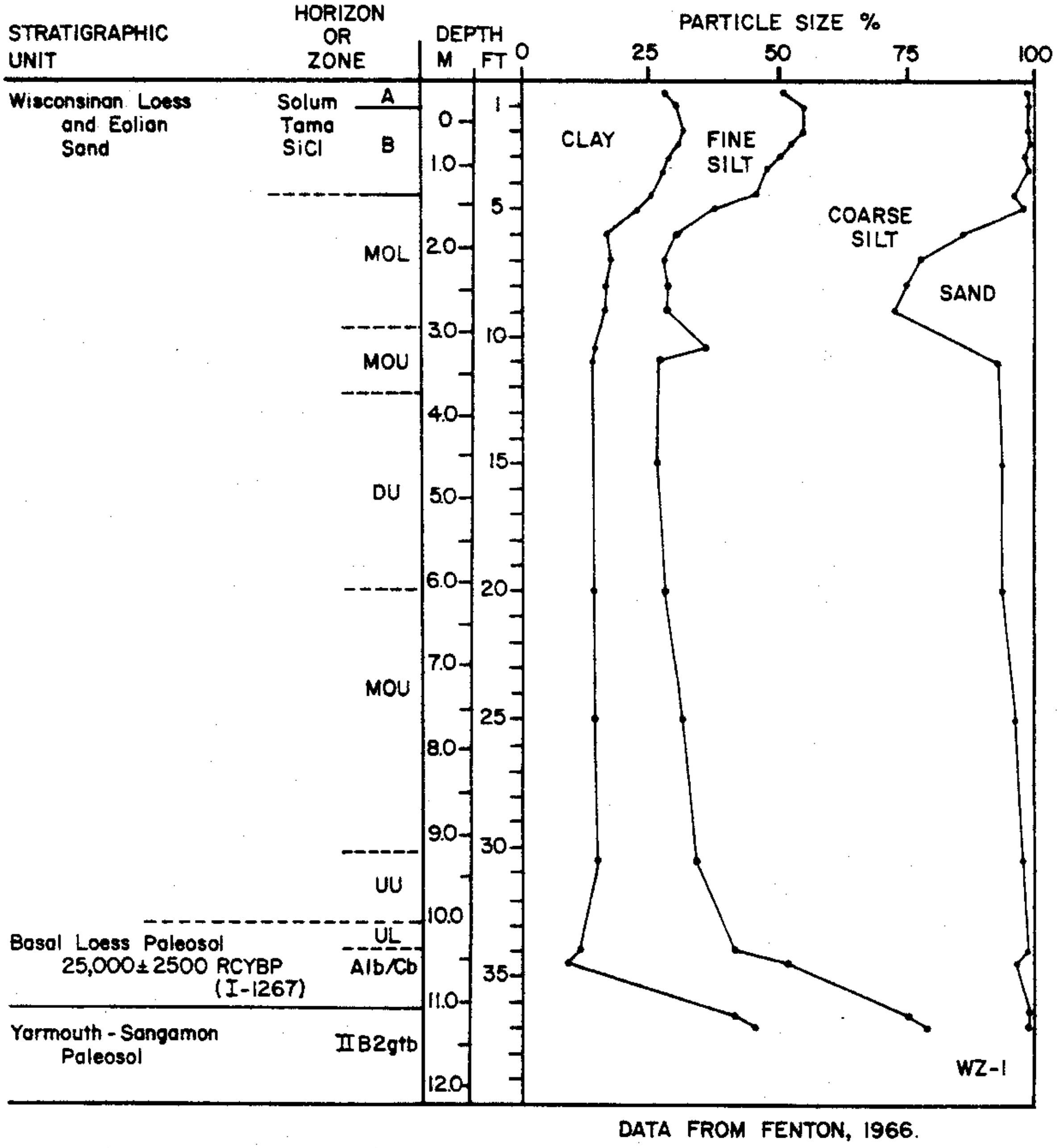


Figure 2-16. Stratigraphy and particle size data for core site WZ-1, Hayward's Paha (see fig. 2-14).

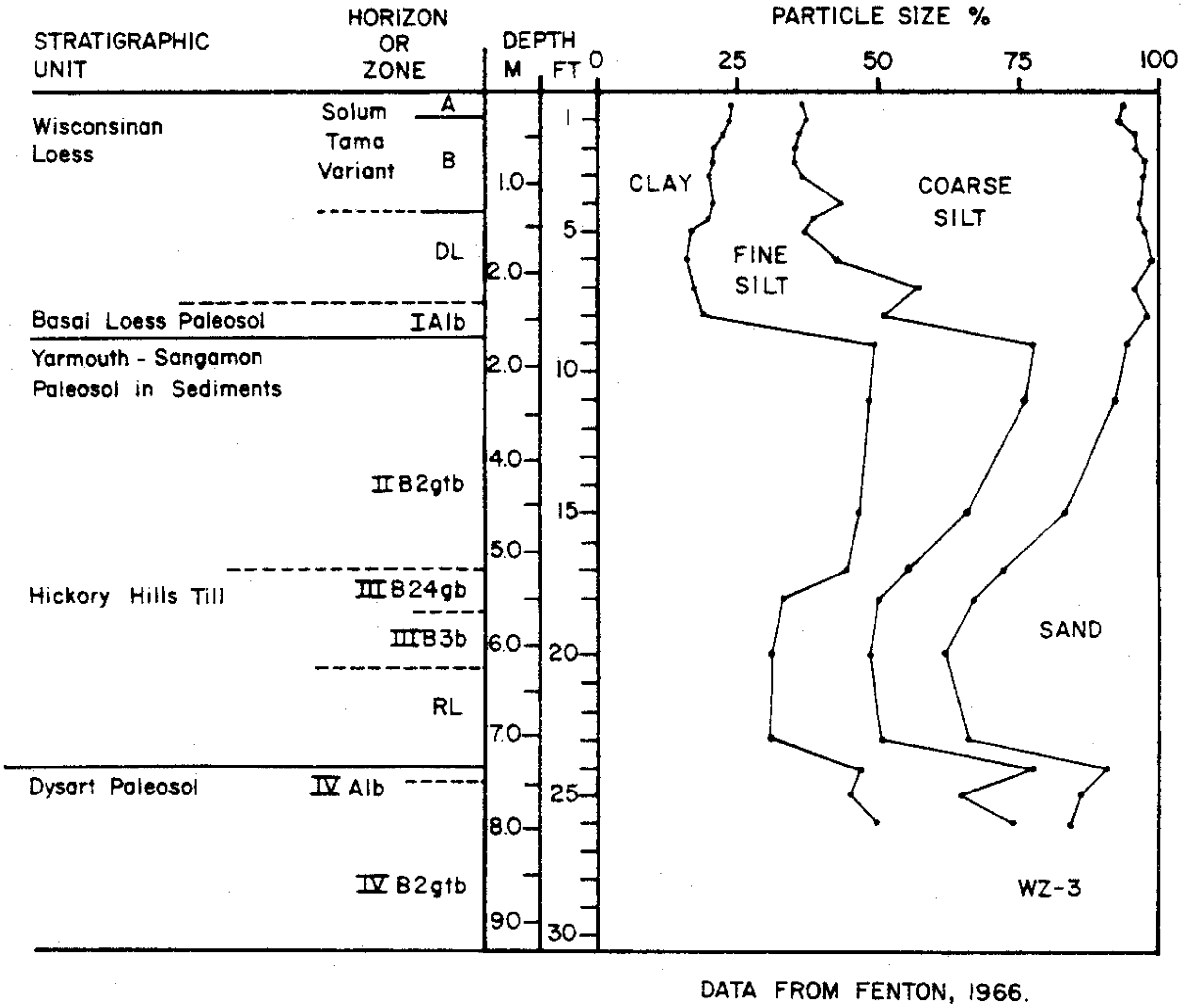


Figure 2-17. Stratigraphy and particle size data for core site WZ-3, Hayward's Paha (see fig. 2-14).

Thirty years ago this section, isolated by itself, would likely have been interpreted as thin loess, over thin "Iowan till," over Kansan gumbotil (the Dysart Paleosol) and Kansan till (the Aurora Till). The detailed drilling transect again shows that the upper till is not Iowan, but is the Hickory Hills till (classically the Kansan till) from which the Yarmouth-Sangamon Paleosol has been stripped by erosion.

Now, let us trace cross-section 3 (fig. 2-15) from our position on level 6, down 1 more step to level 5. As we progress along the closely spaced drilling transect from level 6 (site G-22; our present site at STOP 3) we descend a long gentle backslope to the flat portion of the pediment, of level 5. As we traverse this area the erosion surface progressively truncates the Hickory Hills Till, and the Dysart Paleosol. On level 5 and the slopes that descend from level 5 to lower levels (fig. 2-5 and 2-11), thin loess directly overlies the Aurora Till member.

Hopefully, these transects through the landscape and the stratigraphy should make it very clear that one <u>cannot</u> make any interpretations about surficial materials or even the stratigraphy, from isolated outcrops, without <u>first</u> placing the location in the framework of the Erosion Surface. Obviously, interpretations about the nature of the till exposed on level 5 (the Aurora Till) have little bearing on the nature of the youngest till in the area (the Hickory Hills) which is only preserved on levels 6 and 7. In other parts of northeast Iowa even older tills (the Alburnett Formation; see Table 2-1) are exposed, and further complicate the picture.

At STOP 3, view the core and the stratigraphy, review the cross-sections, and look to the north to pick out the lower levels in the landscape. Also, Casey's Paha (level 7) can easily be seen to the north, standing high above the surrounding landscape.

Before we leave this site we need to review a few other pertinent points.

Till stratigraphy - besides the observations of the physical stratigraphy, the till deposits are also being characterized by their mineralogic properties so that we can correlate the stratigraphy from site to site. We characterize these materials where the physical stratigraphy is clearly developed, such as where the Dysart Paleosol separates the Hickory Hills and Aurora Tills. This allows us to extrapolate to other areas where the paleosol may be eroded and one till is in contact with the other (such as site A, fig. 2-9). Table 2-2 shows the mineralogic data for the two tills we have looked at in this area. Both tills show similar clay mineralogy, being high in expandable clay minerals (smectite or montmorillonite). However, in the coarse sand fraction the Hickory Hills Till generally shows higher total carbonate grains, higher total sedimentary grains, but a much lower calcite-limestone/dolostone ratio, than the Aurora Till. We will return to this later.

Loess-eolian sand relationships - within the loess in northeast Iowa there is often a sedimentological zonation (see Ruhe, et al., 1968). In complete, thick loess sequences, such as on the paha (see fig. 2-16) there is often a basal zone that is low in sand content, an intermediate zone which contains considerable sand, and an upper zone which is relatively sand-free again. As we trace the middle sand-zone from the paha to the erosion surface, the sand zone descends, from its interbedded position (fig. 2-16) to the base of the loess, where we see it here at STOP 3. Figs. 2-18 and 2-19 show the particle size data and stratigraphy for two of the transect core holes on the Erosion Surface. Note the basal

Table 2-2. Till Mineralogy data from Casey's and Hayward's Paha.

	% Clay Mineral				% Lithology of Sand Fraction			
	Stop	Ex.	Ill.	K & C	C/D	CO_3	T.S.	T.X.
ickory Hills	1	63	16	21	2.0	36	36	64
ill Member	1	70	11	19	6.0	18.6	24.8	75.2
	1	64	15	21	1.3	19	20	80
	1	65	16	19	2.3	27	37	63
	1	67	16	17	5.2	29	30	70
	2	67	15	18	7.8	26	38	62
	2	59	17	24	NOD.	27	27	73
	2	63	15	23	3.0	20	29	71
	3	66	20	14	18.0	31	31	69
	3	65	16	20	3.2	25	34	66
	3	65	16	19	4.1	21	21	79
mean =		65	16	20		25.4	29.8	70.2
rora	3	56	24	20	18	18	19	81
ill	3	62	18	20	NOD.	11	13	87
mber	3	64	17	19	NOD.	20	22	78
	3	67	13	20	4.0	18	20	80
	2	66	14	20	NOD.	23	25	75
	2	62	19	19	13	14	16	84
mean =		63	18	20		17.3	19.2	80.8

Ex - Expandable clays-Smectite
Ill. - Illite
K & C - Kaolinite plus chlorite
CO_3 - Total carbonate rock fragments
C/D - "Limestone/Dolostone" ratio; NOD = No dolostone.
T.S. - total sedimentary grains
T.X. - total nonsedimentary grains

increment of loess increases from generally less than 5% sand above to 21 to 45% sand in the lower increments.

The basal sand-free loess zone, which is present in complete sequences, and represents the early part of loess deposition, is missing on the Erosion Surface (along with the basal loess, the Y-S and L-S paleosols!). This brings us to final point of review at this time-the age of the loess and the erosion Surface.

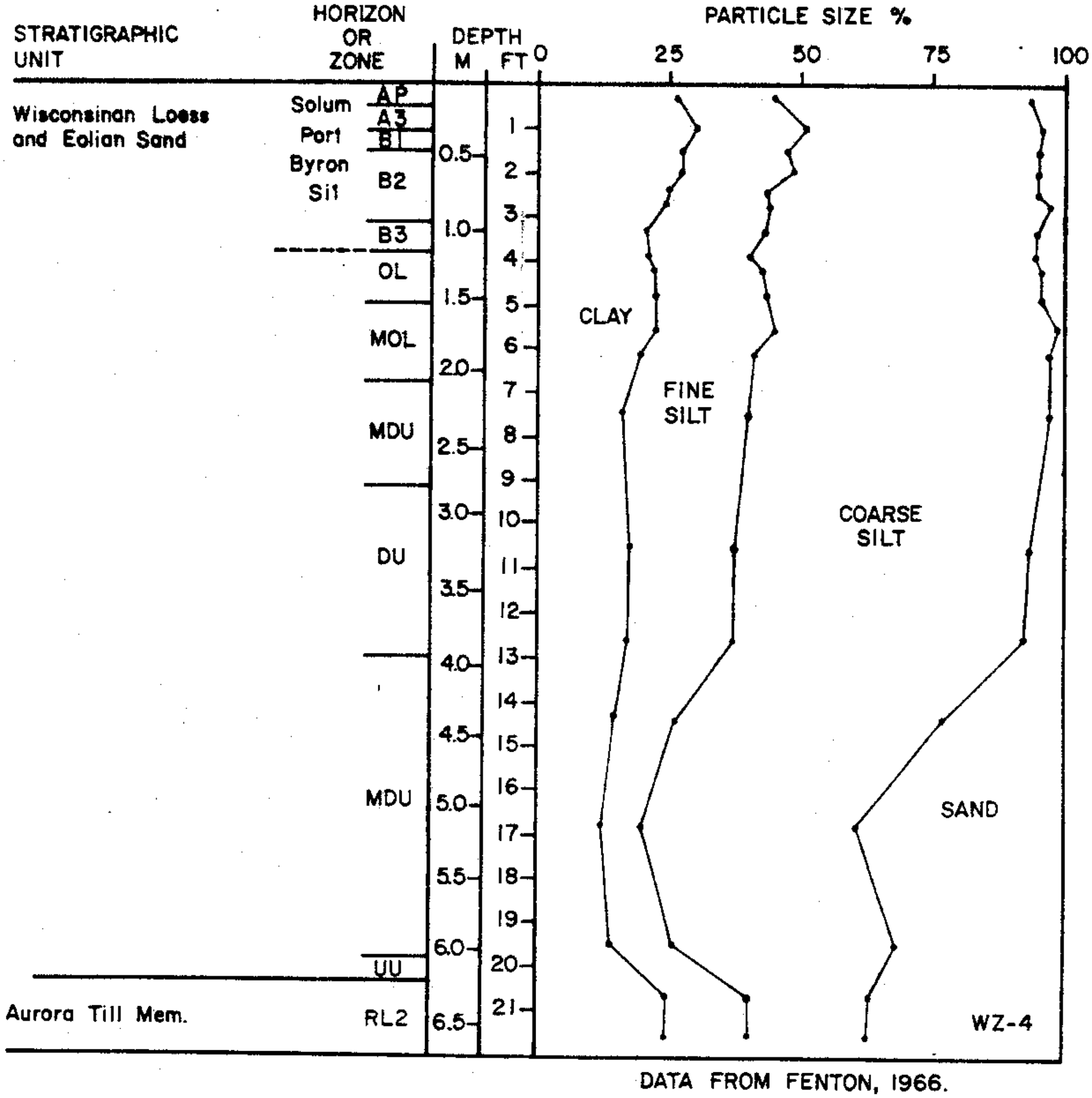
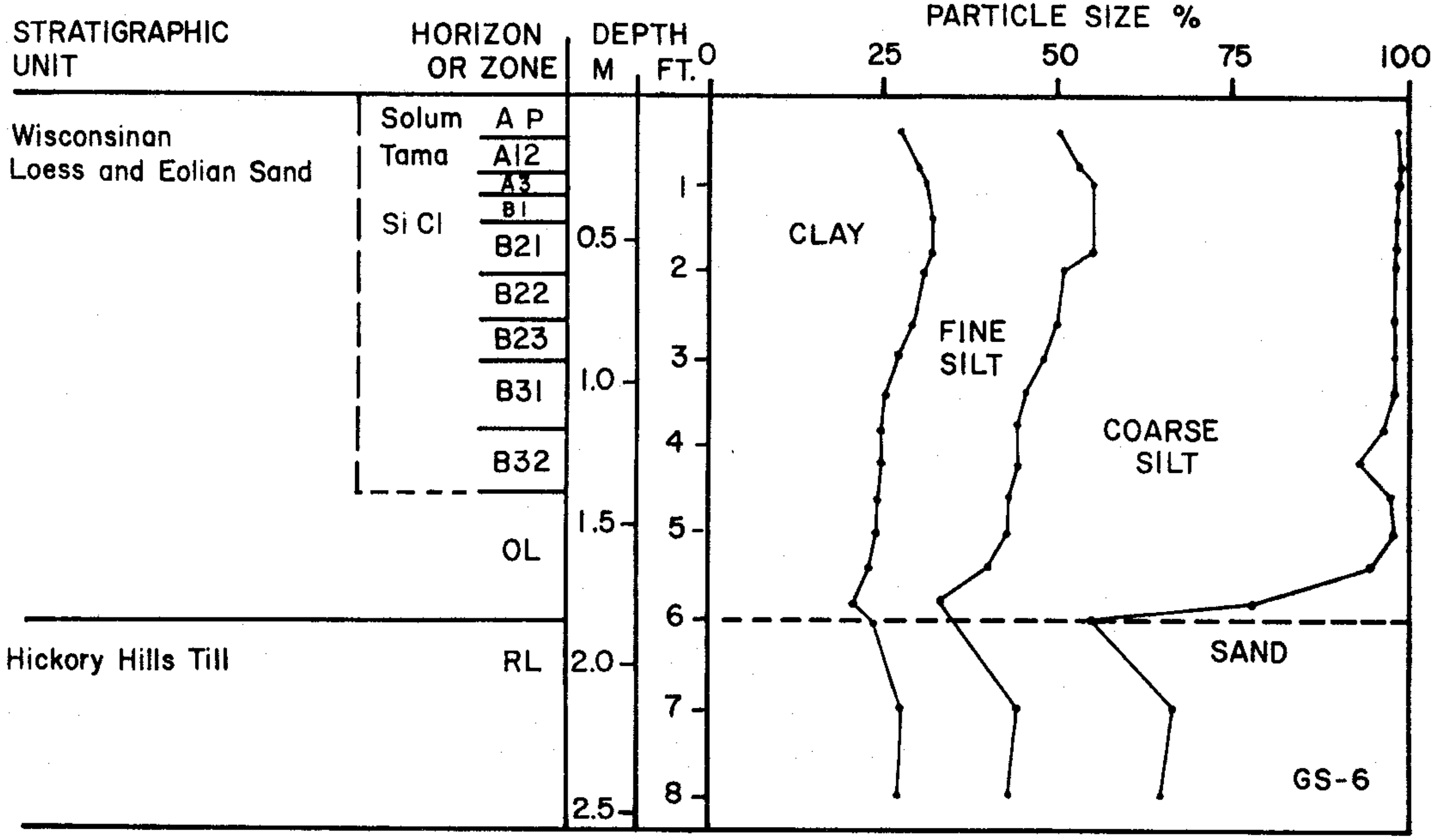


Figure 2-18. Stratigraphy and particle size data for core site WZ-4, Hayward's Paha (see fig. 2-14).



DATA FROM FENTON, 1966.

Figure 2-19. Stratigraphy and particle size data for core site GS-6, Hayward's Paha (see fig. 2-11).

On fig. 2-14 and 2-16, a radiocarbon date is shown for the basal loess paleosol, where it overlies the Yarmouth-Sangamon paleosol in the axis of the paha; this date is 25,000 ± 2,500 RCYBP. Also, on fig. 2-14, a second radiocarbon is shown, from organic material at the base of the loess, on the backslope of the Erosion Surface; this data is 20,300 ± 400 RCYBP. Table 2-3 summarizes radiocarbon dates from around the Iowan area. These same basic relations are obvious, elsewhere. In the Salt Creek area, the basal loess paleosol on the Y-S surface dates 29,000 ± 3,500 RCYBP; whereas the base of the loess on the Iowan Surface dates 18,300 ± 500 RCYBP. In Cedar County, the basal loess paleosol, from the Bennett Paha dates 25,100 ± 700 RCYBP; whereas the base of the loess (below the sand zone) on the Erosion Surface dates 17,810 ± 280 RCYBP. Further, an organic band in the loess of the Paha is cut off laterally by the younger loess which drapes onto the Erosion Surface, and this band dates 21,150 ± 420 RCYBP.

This is the Principle of Ascendancy and Descendancy in action. In the higher landscape positions loess buries the basal loess and Y-S or L-S paleosols, and the date of burial regionally is 25 (29) to about 22,000 RCYBP. The lower lying Erosion Surfaces, are younger and regionally are dated by their burial with loess at about 22 to 17,000 RCYBP. These younger surfaces are also missing the oldest increment of loess, as shown by the relative position of the sand-zone.

Again, to reiterate principles the age of these buried surfaces is established by the basal-age of the material which buries them - not by the age of the underlying materials.

Table 2-3. Basal loess radiocarbon dates, in Iowan Erosion Surface area.

Lab. No.	Age	Location	Notes
		On Erosion Surface	
I-7295	17,810 ± 280	Bennett, Cedar Co.	On truncated Y-S paleosol.
W-1687	18,300 ± 500	Salt Creek, Tama Co.	
I-2329	18,400 ± 310	4-mile Creek, Tama Co.	OC from alluvium below Iowan Surface
I-1409	20,300 ± 400	Haywards Paha, Tama Co.	On truncated Y-S paleosol
I-2332	20,700 ± 500	Alburnett Paha, Linn Co.	
I-7277	21,150 ± 420	Bennett, Cedar Co.	OC Band truncated by younger loess of Erosion surface
W-1681	21,600 ± 600	Palermo Area, Grundy Co.	
I-1404	22,600 ± 600	Palermo Area, Grundy Co.	Same sample as W-1681.
		On Paleosols	
I-3653	21,350 ± 750	Hills, Johnson Co.	
I-9475	21,960 ± 480	Iowa City, Johnson Co.	
I-1403	23,900 ± 1,100	Grinnell, Poweshiek Co.	
I-1406	24,600 ± 1,100	Kinross, Keokuk Co.	
I-1267	25,000 ± 2,500	Haywards Paha, Tama Co.	
I-6750	25,100 ± 700	Bennett, Cedar Co.	
ISGS-512	25,300 ± 650	Garnavillo, Clayton Co.	
I-1269	29,000 ± 3,500	Salt Creek, Tama Co.	

Now that everyone is thoroughly confused, we will proceed north, to either optional STOP 4 or Hickory Hills Park. At the park over lunch we will try to review what we have seen and straighten out the confusion. As we drive north from STOP 3, again we will view levels 5 through 1 (fig. 2-11).

OPTIONAL STOP 4 - Smith Quarry Section

We will stop here, only if time permits. If time permits, it probably means that no one is asking questions, or that no one has understood anything well enough to ask a question, so...? If we stop -

As we enter the quarry property from the road, you can see a pronounced weathering zone or color break in the lower part of the till section to the east. The stratigraphy at the site is:

0 - 4 ft. (-1.2m) - Loess and eolian sand; solum.

4 - 8 ft. (-2.4,) - 0.5 ft. pedisediment and stone-line; grades laterally into sand and gravel channel cut in till surface, OL-oxidized and leached.

4.5-17 (-5.2m) - loam till, OJL.
(Upper Till)

17 -19 (-5.8m) - loam till, MOJL.

19 -22 (-6.7m) - loam till, RJU.

22 -32 (-9.8m) - loam till, unoxidized, jointed, unleached; UJU; 5Y3 and 4/1 matrix. Generally massive blocks, with some vertical joints.

32 -38 (-11.6m) - loam till; siltier, with less coarse sand and pebbles than above; abrupt color change, especially on weathered face; reduced, jointed, unleached; RJU: 2.5Y 4/2. In upper foot, prominent horizontal planes, produce a coarse platy-like structure, with dark-reddish brown, 5YR 3/3-4 stains along joints. In places some wood and silts at contact with upper unit. Abundant wood in this till unit.
(Lower till)

The two till units are both high expandable clay mineralogy tills; the upper averaging (3 samples): Ex - 62%; Ill. - 18%; K & C - 20%. The lower till averages (4 samples): Ex - 62; Ill. - 17%; K & C - 21%.

The first argument that might be started is over the question - Are there two till units? Color related weathering zones in till normally change in a gradational fashion, from oxidized to reduced to unoxidized with depth; as shown in the upper till from 4.5 to 32 feet. The abrupt color or weathering zone change is abnormal and generally indicates a contact between different materials or stratigraphic units. Although the clay mineralogy shows these units to be nearly identical, other physical properties are different; these are summarixed in Table 2-4.

Table 2-4. Particle size and Mineralogy data; Smith Quarry Site

	Sand Fraction %			Particle Size %			
	C/D	CO_3	T.S.	Sand	Silt	Clay	C-VC
Upper Till (Mean 5 samples)	14-NOD	18.5	19.7	44.2	33.1	22.8	14.0
Lower Till (Mean 5 samples)	NOD	12.0	14.6	38.8	42.6	18.6	7.2

Abbreviations as in Table 2-2; C-VC-% coarse and very coarse sand.

As noted in the description of the site, the upper till has more clay and sand, than the lower till. The lower till is siltier and has only about half as much coarse and very coarse sand as the upper till unit. Before we review the sand fraction lithology data, let us look at our local landscape relations.

The drilling transects both north (fig. 2-9) and south (fig. 2-13 and and 2-15) of the site show that at the elevation of the quarry site, on the slope from level 5 down to the alluvial surfaces of levels 1-3, the surface till should be the Aurora. This is shown schematically in cross-section in fig. 2-20. Indeed the mineralogy of the upper till at the quarry is typical of the Aurora (compare tables 2-4 and 2-2); high expandable clay mineralogy; high C/D ratio, moderate total carbonates. The whole picture fits togehter nicely.

The lower till unit has slightly different properties, high expandable clay mineralogy again; no dolomite in the sand fraction (really only indicating a high C/D ratio), but lower total carbonates and total sedimentary fragments than the Aurora. If we resolve argument 1 and agree that this is a different till unit--because of the abrupt contact, marking a change in weathering zone, structure, texture, and mineralogy--we also begin a second argument. What is the significance of this stratigraphic break?

Many points could be argued long and loud but let us summarize only two. First, obviously no time significance can be given to this stratigraphic break at this site. There is no evidence of any weathering at all--both tills are unleached on either side of the contact. There are some traces of wood and organic silts at the contact--but this could be just chance, because wood occurs throughout the lower till. However, if we examine our regional stratigraphy, these same mineralogic changes occur elsewhere, where the Aurora Till is separated from a lower till of high expandable mineralogy, but lower sand fraction carbonates, by a buried peat and some leached alluvial sediments. Even the peat and leached sediments may not represent a great deal of time--but they are a stratigraphic break worth noting. This till unit because of its high expandable clay mineralogy, is placed within the Wolf Creek Formation, and is the lowest identified member--the Winthrop Till Member (see Table 2-1; Hallberg, 1978d).

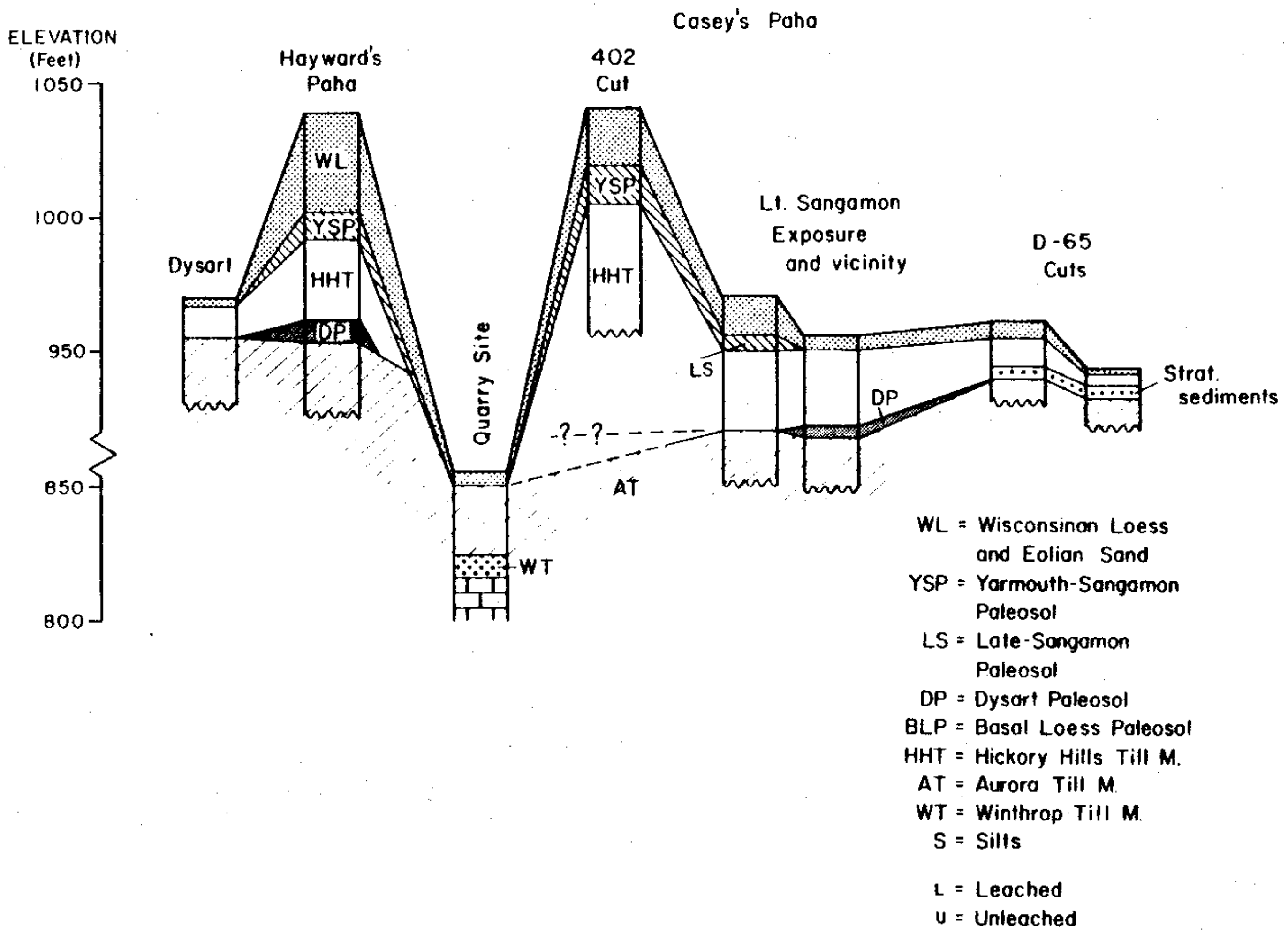


Figure 2-20. Schematic view of topographic and stratigraphic relations of stops in in the Dysart-Geneseo-Buckingham area, Tama County.

Through the use of our three-dimenstional landscape-stratigraphic reconstructions, and mineralogic characterization, it is possible (most of the time!) to sort out a composite stratigraphic framework.

To Lunch - Hickory Hills Park. Questions will be answered between courses of the Gobling Gourmet's Mobile Cuisine.

We will proceed west a few miles along Tama County road D-65 (see fig. 2-6) to STOP 5.

STOP 5 - Road cuts - Buckingham Section

Stop 5 consists of two road cuts. We will start (as we always should) at the local "top of the world." Stop 5A is along the summit of a long interfluve. From here we can look back to the east, to the lower stepped erosion surface in the cut at 5B.

The stratigraphy in the shallow road cut at 5A is:

0- 4.2 ft. (-1.3m) - loess with basal sandy increment (max. thickness); in solum.

4.2- 4.3 ft. (-1.3) - loam pedisediment, with pebbles. Weak stone line.

4.4- 7.1 ft. (-2.2m) - loam till, uniform; OL.

7.1-10.2 ft. (-3.1m) - loam till, uniform OU.

Cores to depth below the cut show an abrupt till-till contact, or a series of discontinuous inclusions of stratified silts, sand, and gravel in an irregular contact zone, at about 14 feet in depth. Fig. 2-21 shows particle size and stratigraphy of two examples.With cores and hand auger this stratigraphy can be traced down to the lower-lying erosion surface at 5B. The relations are shown schematically in fig. 2-22.

Site 5A, shows thin loess, over till, and it should be clear by now that we are out on the Iowa Erosion Surface. It should also be clear that we may be missing a significant portion of our stratigraphic section because of the erosion surface.

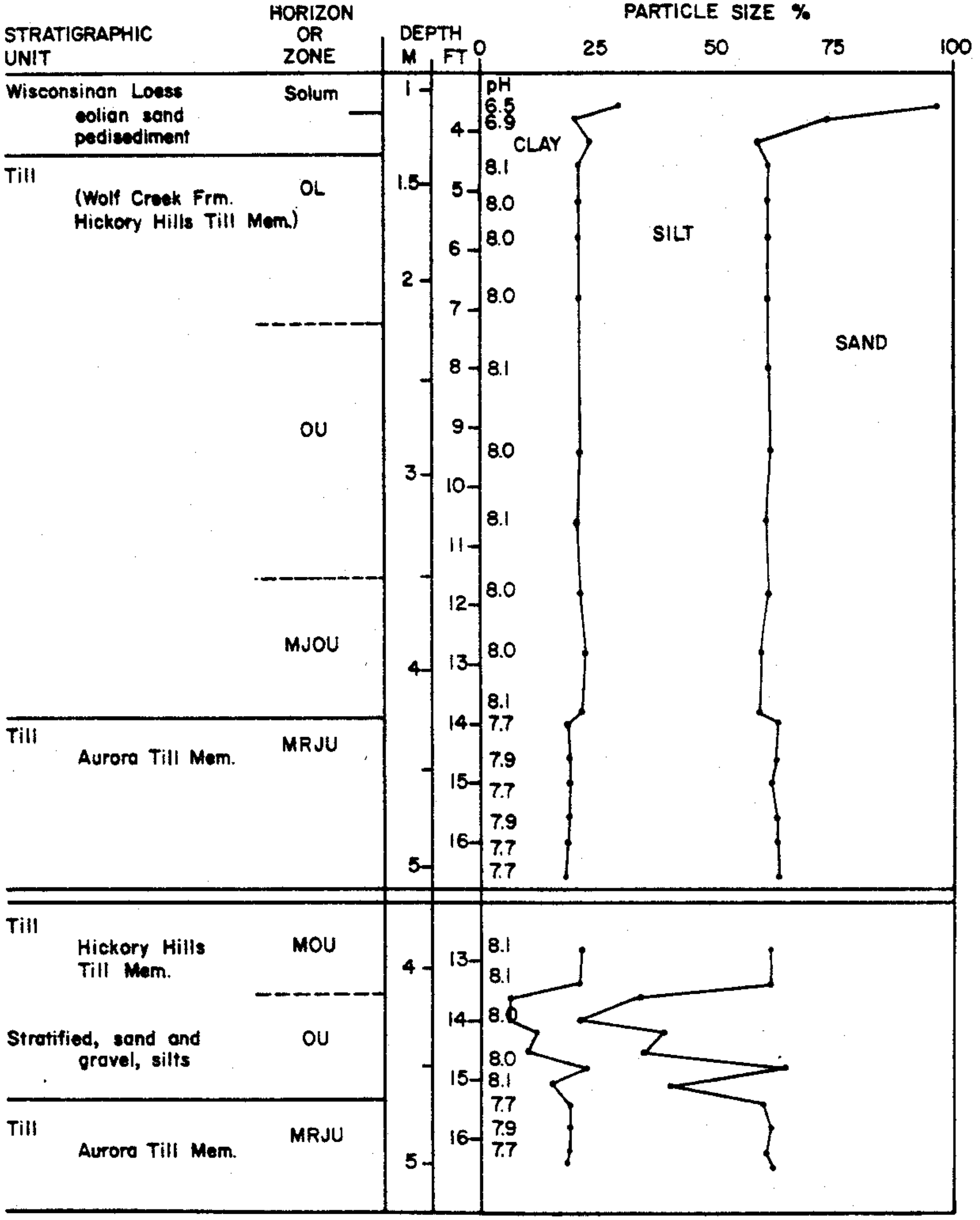


Figure 2-21. Stratigraphy and particle size data of two representative cores, Buckingham section, Stop 5A.

As we work our way down to the cut at 5B notice on the cross-section that the lower-part of the upper till and the stratified sediments outcrop at the top of the erosion surface and road cut. In one section at 5B north, the stratigraphy shows:

0- 1.5 ft. (-.5m) - loam and fine sandy loam sediments.
1.5- 3.0 ft. (-.9m) - loam till; MOL
3.0- 3.5 ft. (-1.1m) - loam till; MOL2
3.5- 6.0 ft. (-1.8m) - sand and gravel; OL
6.0- 9.5 ft. (-2.9m) - S & G; OU
9.5-17.3 ft. (-5.3m) - loam till; MOJU grading to MRJU.

Laterally, the sand and gravel pinch out into discontinuous lenses (?) of sandy loam, and sandy loam diamicton. On the south side there is abundant fine stratification within an upper till-like unit. In places this material shows an abrupt contact with the lower-lying uniform till.

Review the regional picture by returning to the cross-section in fig. 2-20. The cut at 5A is essentially on level 6, of the Hayward-Casey's Paha area. The stratified sediments and the till-till contact here occur within the same range of elevations we have veiwed just to the east of here, in which the contact of the Hickory Hills and Aurora Tills occur.

Examine the mineralogy. Here we can get into problems because of the diffuse contacts between the till units. Three samples in particular were questionable, but were put in with the data for the lower till (these are shown with asterisks in Table 2-5). Both tills are high expandable: upper till (mean 4 samples): Ex.-64%; Ill.-17%; K & C - 19%; lower till (mean 5 samples); Ex.-66%; Ill. 14% K & C-20%. Table 2-5 summarizes the sand fraction data. Even using the 3 questionable samples

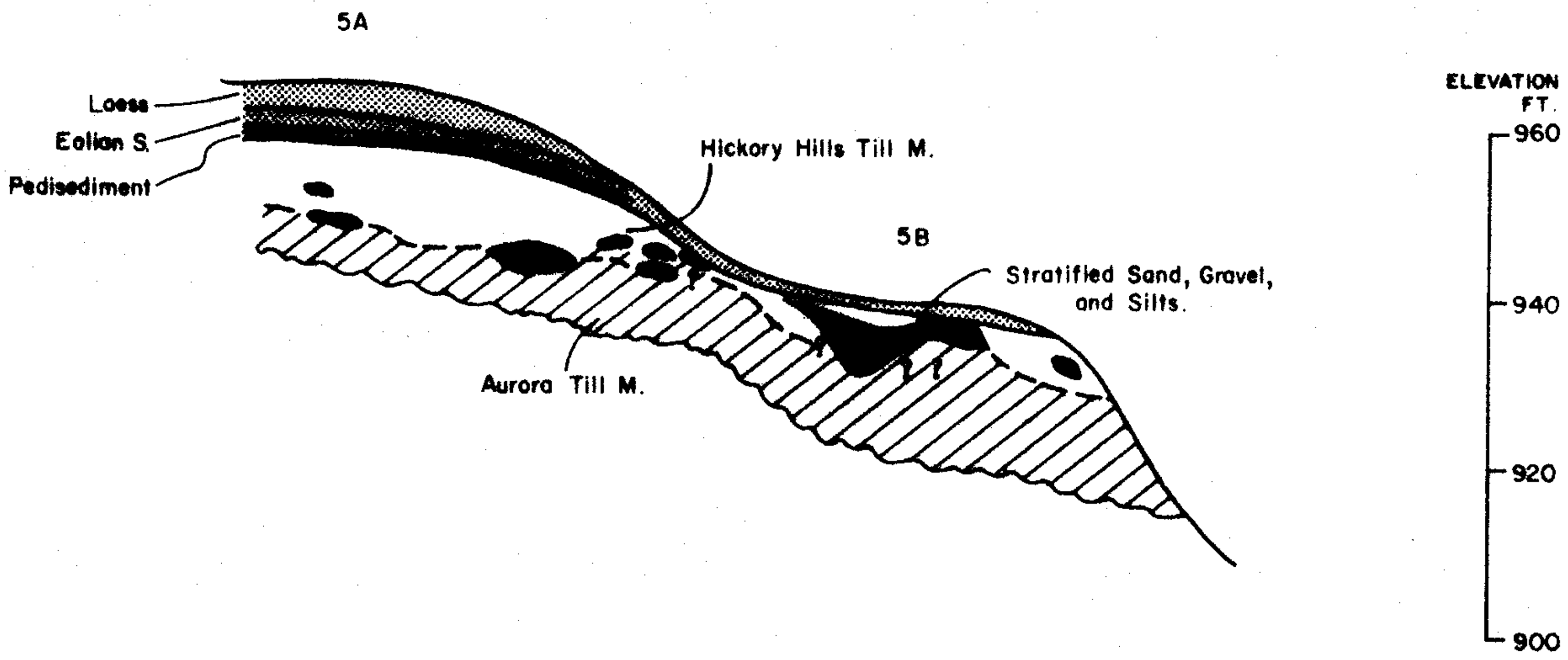


Figure 2-22. Schematic cross-section from road cuts and borings at Stop 5.

the trends are obvious - the upper till shows a low C/D, and high total carbonates - the Hickory Hills Till member. The lower till shows a high C/D, but lower total carbonates, typical of the underlying Aurora Till Member. Again, the regional relations and data make an interpretable package.

Outcrops of stratified and contorted drift and till such as this are common on the Erosion Surface. In all areas where we have investigated such materials, in Tama, Marshall, Grundy, Linn, Buchanan, Cedar, Delaware, and Butler Counties, these materials can be traced into the lower portion of the overlying till unit. (Remember where we are, presently on the Erosion Surface, we may be missing a significant portion of the thick-uniform Hickory Hills Till viewed at Casey's Paha - see fig. 2.8).

Geotechnical properties of the till associated with these deposits show the till to be over consolidated, as a result of loading from the overlying glacial ice during deposition. This indicates some form of basal or englacial depositional mode. Also, detailed studies (Hallberg, 1978b) and test drilling show that: 1. till associated with these deformed stratified materials exhibit structure and fabric resembling sheared lodgement till; 2. stratified deposits outcrop on the Erosion Surface from as many as 4 different stratigraphic positions, and are widely different in age. Our best model, at present, suggest that these deposits represent a frontal apron of stratified glacial deposits, subsequently overriden by advancing ice, and then overlain by thick uniform basal till deposits. Without the engineering and structural data, an isolated outcrop wuch as this might legitimately be interpreted as ablation till. However, the whole point of this exercise is to demonstrate that

Table 2.5. Sand Fraction Lithologies at site 5, from cuts and core samples

	C/D	CO_3	T.S.	T.X.
Upper Till (Hickory Hills)	1.4	29	34	66
	2.1	31	32	68
	2.0	36	36	64
	2.2	29	29	71
	3.2	39	40	60
	3.5	29	31	69
	3.9	29	35	65
	3.1	33	33	67
	2.5	28	28	72
	1.8	32.3	32.2	67.8
	2.1	37	37	63
	2.6	36	36	64
Mean -		32.4	33.6	
Lower Till (Aurora Till)	NOD	19	29	71
	18.5	29	29	71
	2.3	20	25	75
	11.0	27	28	72
	17.0	20	21	79
	* 6.1	23	25	75
	* 6.7	36	36	64
	* 3.5	29	29	71
	NOD	22	22	78
	NOD	16	17	83
Mean -		24.1	26.1	

*Questionable samples - see text.

in these eroded landscapes you cannot interpret from an isolated outcrop. When placed in the full picture, the ablation till hypothesis is not tenable. These materials cannot be correlated from place to place, either, without a stratigraphic framework. They outcrop from under as many as 4 separate till units.

Again, hopefully this points out that when working in these old and eroded landscapes, you cannot make interpretations of materials or stratigraphy without understanding where you are in the 3-dimensional landscape - stratigraphic system.

Chew this over as we proceed west to STOP 6. Follow our route on figure 2-6. Our route will take us through pahas and adjacent to a variety of stepped-landscape areas. Try to pick these out as we roll along.

STOP 6 - Coulter Farm: Soil Toposequence - Loess Distribution

The main purpose of this stop is to examine a toposequence of soils. First, let us quickly reiterate the simple concept of soil forming factors (Jenny, 1941); in basic form a soil is the product of 1. the parent material it forms in; 2. the climatic regime; 3. the vegetation and other biological influences; 4. the amount of time the soil has had to develop; 5. the topography - landscape position or slope. In the toposequence to be examined the first 4 factors are essentially constant - these soils are all developed in loess, and have undergone the same climatic and vegetation history, and are all considered to be soils formed under prairie vegetation. The only variable in the soils of this toposequence is their slope or topographic position. They all belong to the order of Mollisols because of their thick, dark "mollic epipedons." Soils are an integral part of any hillslope, as previously discussed. Further, Iowa is first and foremost an agricultural state. As such, Iowa's most important geologic resource is her soils. Yes - a geologic resource, because the geologic materials, which soils form in, are a very important factor in determining the nature of the soil or pedon. Geologists can always stand more indoctrination into the fine art of pedology - and hence this stop.

Also, there is great concern today over the preservation of "prime agricultural land." It is an important social and perhaps, political, issue to all of us. Can we continue to put parking lots and shopping centers on our most productive soil? For this reason we will examine three of the - "primest" of prime soils - the Tama, Muscatine, and Garwin soils. These soils are the standards of productivity against which all other soils in Iowa are rated; they are some of the most productive soils in the world.

A soil pit will be provided in the Tama silty clay loam; cores of the Muscatine and Garwin soils will be available for comparison. Our many thanks to the Robert Coulter's for the "use of their soil." They were very kind to allow us to use their farm. Our thanks also to Gene Nevin, Marshall County Extension Director, and Mr. Marvin Lundstedt, District Conservationist for making these arrangements.

The Tama-Muscatine-Garwin soils form a continuum on the landscape. The basic difference in these soils is their natural drainage class, which is influenced by topography or slope and is reflected by their position in the landscape. We will view these soils on a very gentle slope (less than 2%), with total relief of about 7 feet. Even on this gentle slope, the landscape position shows its effects on the soil profile. The moderately-well drained Tama soil occurs on the shoulder of the slope. The somewhat-poorly drained Muscatine profile occurs on the lower backslope and footslope, whereas the poorly drained Garwin profile is in the toeslope, in the head of a minor drainageway. The natural drainage class of a soil is determined by how long the soil stays wet during the year. A water table is present for a much longer period of time in the Garwin soil than in the Tama soil.

This degree of wetness, or difference in internal drainage of the soil effect the amount of aeration and oxidation that takes place. Compare the descriptions of the three soils (Descriptions 6-1 to 6-3); note that the B and C horizons of the Tama soil are yellowish-brown in color, with few mottles, reflecting aerated or oxidizing conditions. Conversely, Description 6-1: Tama silty clay loam (from Collins, 1977).

Horizon	Depth in.	Depth cm.	Description
Ap	0-11	0- 28	10YR 2/2, very dark brown, light silty clay loam, weak fine granular structure.
A12	11-17	28- 43	10YR 2/2-3/2, very dark brown-grayish brown, silty clay loam, weak fine granular to weak medium subangular blocky structure.
B1	17-23	43- 58	10YR 3/3-3/2, dark brown to very dark grayish brown, silty clay loam, weak fine subangular blocky structure.
B2t	23-35	58- 89	10YR 4/3, dark brown, with 10YR 3/2, very dark grayish brown clay coats, silty clay loam, moderate fine and medium subangular blocky structure.
B3	35-43	89-109	10YR 4/3, dark brown, with 10YR 3/1; areas of few fine faint 10YR 4/4, dark yellowish brown mottles, light silty clay loam, weak fine subangular blocky structure.
C	43-48	109-122	10YR 5/3, brown, with few fine prominent 10YR 4/6, dark yellowish brown, and many fine prominent 7.5 YR 5/6 strong brown mottles, heavy silt loam, massive structure.

Description 6-2: Muscatine silty clay loam (from Collins, 1977)

Horizon	Depth in.	Depth cm.	Description
Ap	0- 7	0- 18	10YR 2/1, black, light silty clay loam, weak fine granular structure.
A12	7-15	18- 38	10YR 2/1, black, silty clay loam, weak fine subangular blocky structure.
A13	15-22	38- 56	10YR 2/2-3/2, very dark brown-grayish brown, heavy silty clay loam, moderate medium subangular blocky structure.
B1	22-27	56- 69	10YR 4/2-4/3, dark brown-grayish brown, silty clay loam, weak fine and medium subangular blocky structure.
B2t	27-36	69- 91	10YR 4/2-4/3, dark grayish brown-brown, with 10YR 3/3, dark brown discontinuous clay coats, and with few fine faint 10YR 5/2, grayish brown, and many coarse prominent 7.5YR 5/6, strong brown mottles, silty clay loam, weak fine prismatic to weak fine subangular blocky structure.
B3	36-45	91-114	10YR 5/2-4/2, grayish brown to dark grayish brown, with many coarse distinct 7.5YR 5/6, strong brown mottles, heavy silt loam, very weak fine and medium subangular blocky structure.

Notes: Mn segregation at 36 in. (86 cm).

Description 6-3: Garwin silty clay loam (from Collins, 1977).

Horizon	Depth in.	Depth cm.	Description
Ap	0- 9	0- 23	10YR 2/1, black, silty clay loam, cloddy to moderate fine granular structure.
A12	9-15	23- 38	10YR 2/1, black, silty clay loam, moderate fine granular structure.
B1g	15-21	38- 51	10YR 3/1, very dark gray, with common fine prominent 10YR 5/6, yellowish brown mottles, silty clay loam, weak moderate prismatic to moderate fine subangular blocky structure.
B21tg	21-26	51- 66	10YR 5/2, grayish brown, with 2.5Y 4/2, dark grayish brown continuous clay coats, common fine prominent 10YR 5/6 to 5/8, yellowish brown mottles, heavy silty clay loam, moderate medium prismatic to moderate fine subangular blocky structure.
B22tg	26-33	66- 83	10YR 5/2, grayish brown, with 2.5Y 4/2, dark grayish brown continuous clay coats, common fine prominent 10YR 5/6 to 5/8, yellowish brown mottles, silty clay loam, moderate fine subangular blocky structure.
B23g	33-43	83-109	10YR 5/2, grayish brown, to 10YR 5/6 to 5/8 yellowish brown, light silty clay loam, weak medium prismatic to moderate medium and coarse subangular blocky structure.
B31g	43-48	109-121	10YR 5/2, grayish brown, with common fine prominent 7.5YR 5/6 to 5/8, strong brown mottles, light silty clay loam, weak medium prismatic to weak coarse subangular blocky structure.

the Garwin soil is various shades of gray, grayish-brown, and greenish-gray, with many mottles of various color, reflecting wet reducing conditions which produced gleyed (or "ferrous iron") colors, and segregated-oxidized mottles.

These soils also differ in other important attributes. Figure 2-23 graphically shows these. As we go from well drained to poorly drained (and downslope in this case) the clay content of the surface horizon increases; also the poorly drained soil tends to have a higher clay maximum, in the B horizon.

Again as we progress from well-drained to poorly-drained, we increase the amount of organic carbon in the upper part of the soil profile. As we change environment the soil acidity or pH also change in distribution. Other important differences that can be seen, even over this small distance, are differences in the natural fertility of soils--as shown by the difference in the distribution of plant available phosphorus in fig. 2-23.

All of these differences in natural soil properties affect the use and particularly the management of these soils. The poorly-drained Garwin soil may require tile to relieve excess wetness. The differences in pH, organic carbon, clay content, and fertility, will affect the necessary application rates for fertilizer, herbicides, and other pesticides, etc.

Examine the soil pit and cores and try to see the described differences in soil color, mottling, structure, and texture. Recognizing soil properties and describing soil profiles are a fine art, but an important one for Quaternary scientists.

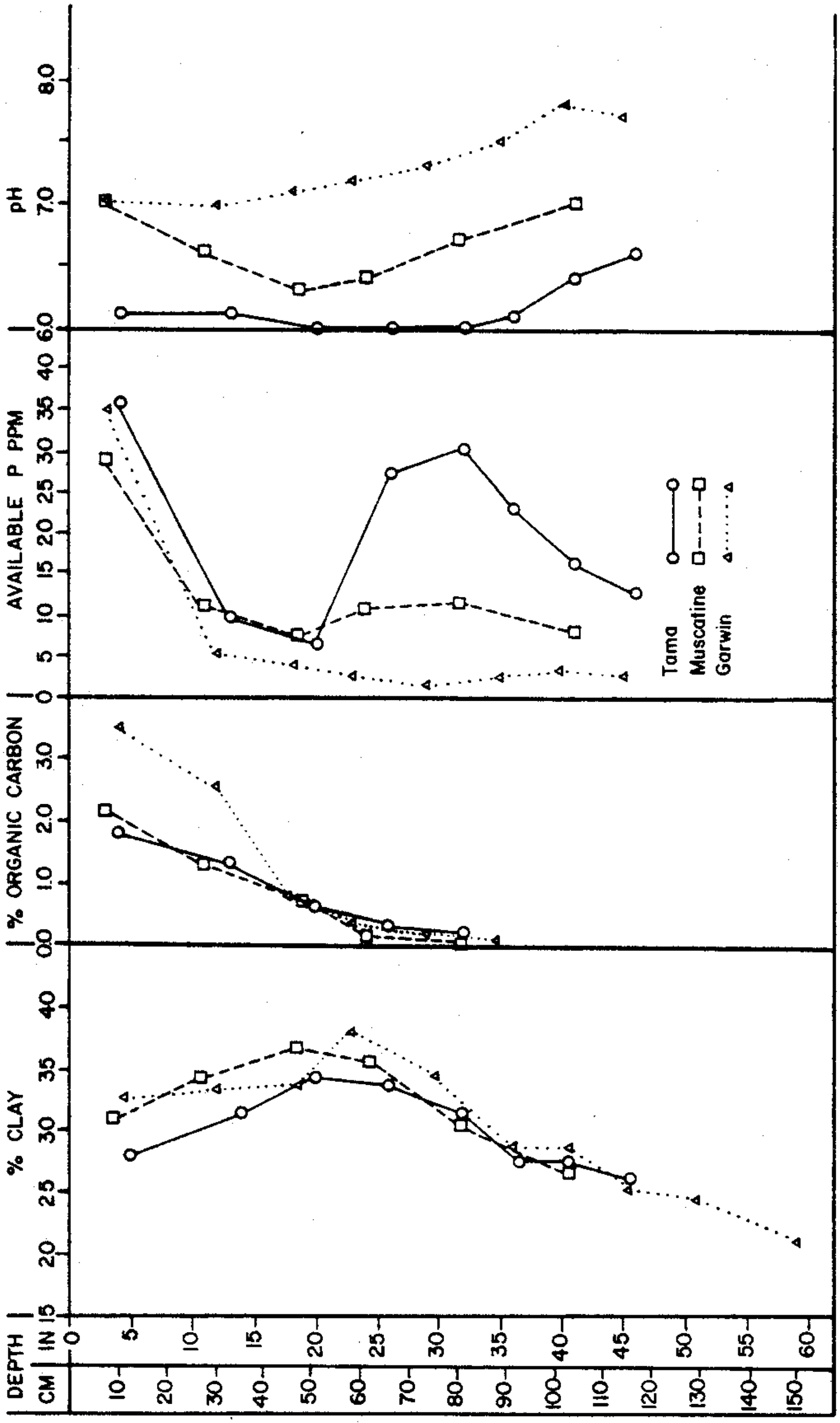


Figure 2-23. Lab data for Tama-Muscatine-Garwin soil toposequence (from Collins, 1977).

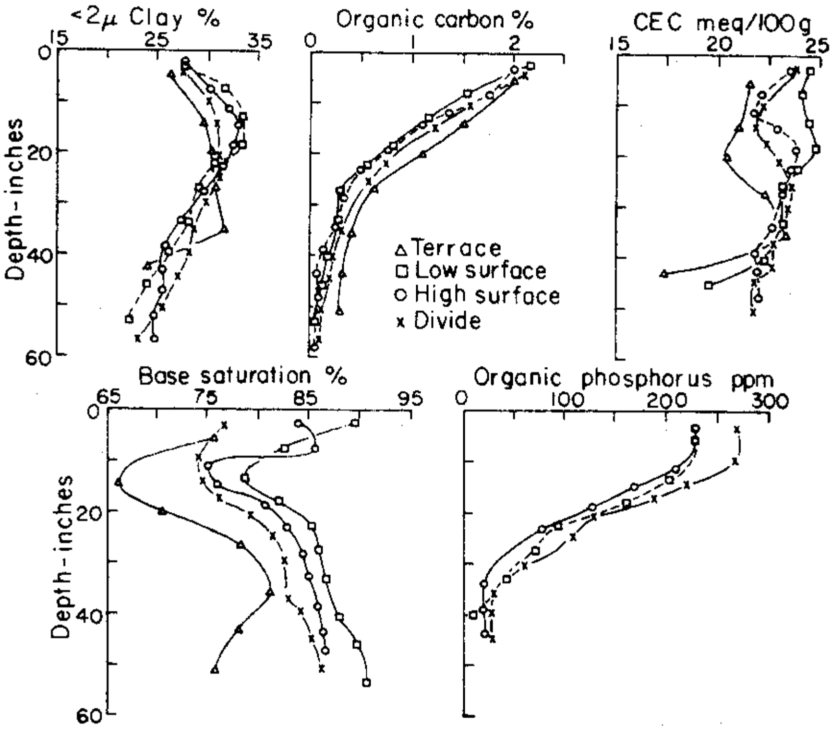


Figure 2-24. Soil property data of Tama silt loam formed in Wisconsin loess. Each profile is a similar site on four different landscape levels (from Ruhe, et al., 1968).

For the purposes of management, farm planning, assessment, and land-use planning, soil surveys are conducted, to map and inventory our soil resources. In Iowa soils are mapped in great detail at a scale of 4 inches to 1 mile (1:15,840). Quality control is an obvious, but difficult, necessity, because a delineation of a Tama soil should indicate certain levels of productivity, and certain management procedures. As a consequence, a great deal of quantitative research goes into maintenance of "quality control". As an example of this research, and as an example of the incredible similarity of different profiles of the same soil series, figure 2-24 shows data from four different Tama soils from four different landscape positions. The sites are from landscape levels 4, 5, 6, and 7 in the Wolf Creek area (stops 1 through 4). The sampling position are shown on fig. 2-11.

While we are here let us make a brief examination of the loess also. In the Wolf Creek area the loess, on the highest erosion surface level, varies from about 7 to 10 feet (2.1-3m) in thickness. In this area the loess varies from 10 to 12 feet (3-3.7m) on the erosion surface. As we proceed south toward Marshalltown over 15, and up to 20 feet (4.6-6.1m) of loess occur on the erosion surface (see fig. 2-7). In fact the thick loess, and the dissection in the Marshalltown area, because of the proximity to the Iowa River, are the apparent reason for the placement of the classic "Iowan drift" boundary in that area (see figs. 2-6 and 7).

In the perspective of our current research let us briefly review a few pertinent points about the loess dispersion model (see Ruhe, 1973, for an historical review). First, essentially all of our significant Midwestern loess deposits have been documented to have been derived from river valley sources. Second, the loess thickness systematically decreases in a curvilinear or log-linear (linear distance vs. log thickness) fashion away from the source. (see Ruhe, <u>1976</u>, for many examples). As Handy (1976) has summarized, there is generally a zone of "extraordinary" thickness very near the source which may complicate the relationship. Third, as the loess thickness decreases, and distance from the source increases, particle size sorting is also evident. In general, the amount of sand and coarse silt decrease and fine silts and sometimes clay increase, with distance from the source. One prerequisite for making these measurements to analyze loess dispersion is that the thickness be measured on the stable upland divides (Ruhe, 1954) where the maximum loess thickness will be preserved.

Can we apply the loess dispersion model to the source of the loess around this portion of the Iowan surface? Yes - but with difficulty. One major problem in applying the model is that the erosion surface is so extensive (see fig. 2-6) that it is very difficult to find a stable divide area where meaningful loess thickness measurements can be made. One area adjacent to the Iowa River is appropriate. In Iowa and Benton Counties both sides of the Iowa River are dominated by multi-stepped landscapes or "classic Kansan" topography. A loess-thickness traverse in this area is shown on fig. 2-25. All thicknesses were measured on divides, with a complete loess sequence - including the basal loess paleosol over a Yarmouth-Sangamon paleosol. To the north of the Iowa River we quickly run into the Iowan Erosion Surface and few measurements could be made. Even so, as fig. 2-25 shows, loess thickness systematically (curvilinear) decreases away from the Iowa River. Perhaps even more important, the amount of coarse silt declines in linear fashion away from the Iowa River, while fine silts systematically increase (Lutenegger, 1978). There are even areas of "extraordinarily" thick loess adjacent to the south side of the valley.

The obvious conclusion is that the Iowa River valley is the source of loess in this area. Even with the complexitites of the Iowan Erosion Surface the systematic relations of loess thickness with the Iowa River are still apparent (see figs. 2-6 and 7). Even on the Erosion Surface the loess thickness decreases to the north and east, from the Iowa River valley, from a maximum of about 20 feet (6.1m). On figs. 2-6 and 2-7 a very localized belt of thick loess and eolian sand is also apparent along the other major river valleys.

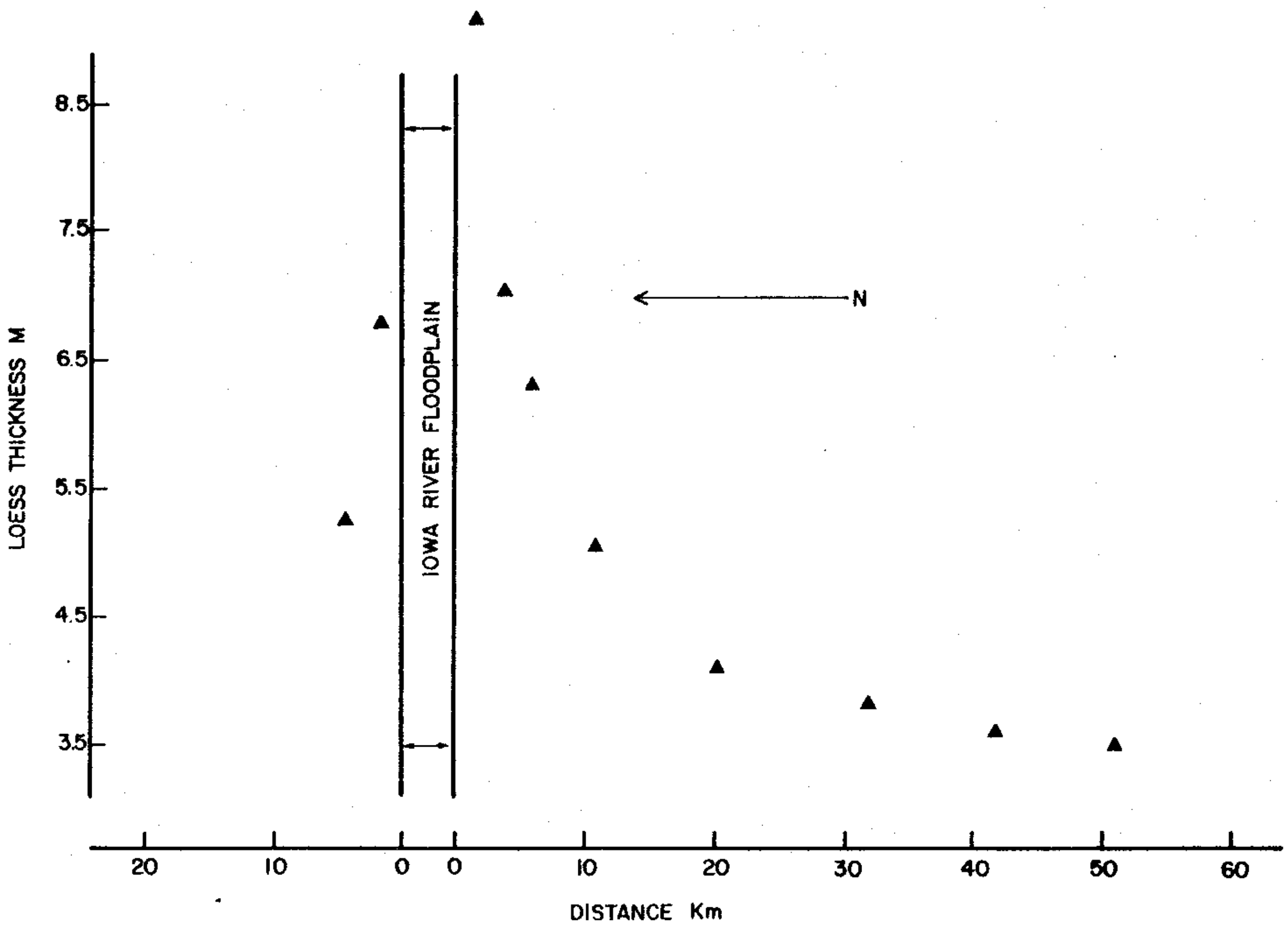


Figure 2-25. Loess thickness vs. distance from Iowa River, Iowa and Benton Counties (from Lutenegger, 1978).

In the field the general aspects of the loess dispersion model (Handy, 1976) will be discussed. Some reprints of Handy's paper will also be available.

En route to STOP 7 and 8 we will drive south toward and across the Iowa River. Follow our route on figs. 2-6 and 7. Note that we will cross the classic "Iowan" boundary. Also the loess thickness will increase toward the river. Even after we cross the classical "Iowan" boundary we will be on the Erosion Surface. In the area around Marshalltown, there is thick loess on the Erosion Surface. The apparent increase in dissection and relief are because of the proximity to the Iowa River. These features were previously thought to indicate that this was part of the "Kansan" topographic region.

STOP 7 - E-63 Road Cut

We will make a brief stop to examine the stratigraphy in a cut along Marshall County Road E-63. The cut is on the edge of a "multi-stepped" landscape area (see fig. 2-6) which has a thick loess mantle over Yarmouth-Sangamon and Late-Sangamon surfaces.

The stratigraphy at the site shows: 1. approximately 200 inches (16.7 feet; 5.1m) of Wisconsinan loess; 2. 6 inches, weak basal loess paleosol; 3. 66 inches Late-Sangamon paleosol; 4. 58 inches, oxidized and leached till; and 5. 80 inches (exposed), oxidized and unleached till.

The top of the cut is at approximately 1,015 feet elevation. We are on a long interfluve which is stepped slightly lower than the divide to the north and west. The site appears to be on the loess-mantled Late-Sangamon surface. At the east end of the cut the Late-Sangamon soil becomes exhumed on the modern land-surface at about 990 feet elevation. The loess section is overgrown and badly slumped. The till is a high expandable - clay mineralogy till (mean 3 samples: Ex. = 63%; Ill. = 15%; K & C = 23%) of the Wolf Creek Formation. The sand fraction lithology shows (mean 3 samples): 28% total carbonates, and C/D ratio of 8.3. The data indicates this is most likely the Hickory Hills Till.

At the east end of the cut thin loess can be viewed over the paleosol and the till. The cut on the south side of the road reveals a paleosol with mottled reddish colors, similar to that seen at STOP 2. On the north side we will view an exposure which shows some relief on the stone-line which marks the Late-Sangamon Erosion Surface. Along with this is a variable thickness of fine-textured sediments over the stone-line. Figure 2-26 shows the particle size data for the paleosol where the sediment is thick. This paleosol may be developed on gleyed Late-Sangamon side-valley alluvium (see Ruhe, et al., 1967) and the underlying till. Other interpretations are possible, but to prove or disprove these conclusively would require drilling out the "paleo-landscape" at this site.

Notice, however, that the strongly developed B horizon is developed in both the sediment and the till. This occurs in many Late-Sangamon paleosols, and is the reason that the pedisediment is considered to be Late-Sangamon in age. In some exposures the Late-Sangamon pedisediment is thin and only forms an A2b horizon over the stone-line, and the "pedologic welding" with the soil profile in the till is not as evident.

Before leaving this stop climb to the top of the cut and view the lower-lying landscape to the southwest. This will be our next stop. Also, view the higher ground to the north and west. In this area we should find slightly thicker loess over a Yarmouth-Sangamon paleosol. In this part of Iowa the break in topography between the Yarmouth-Sangamon divides

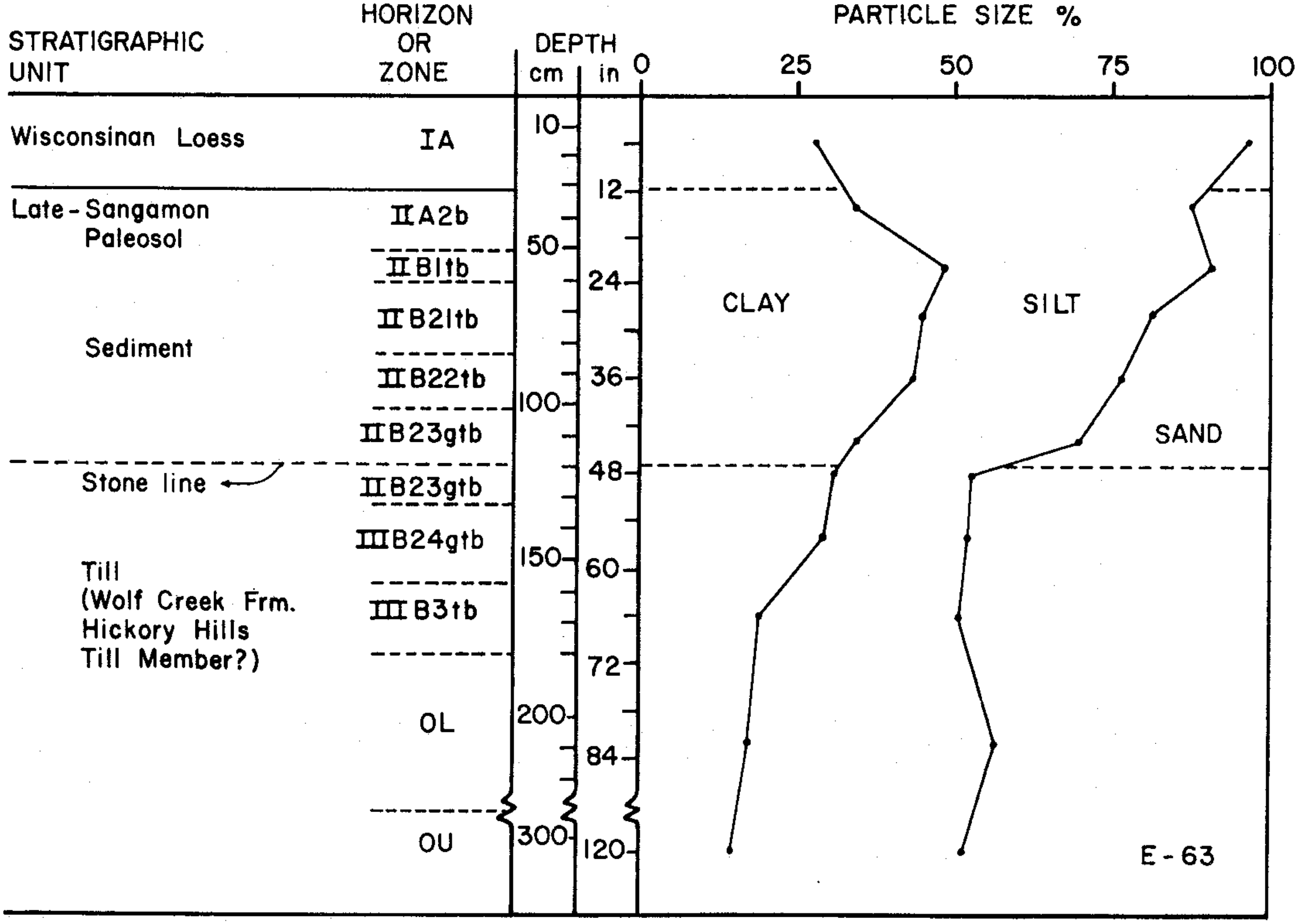


Figure 2-26. Particle size data, E-63 road cut, Stop 7.

and the Late-Sangamon pediments (see fig. 2-2) is not well expressed. There is not as much relief between the surfaces as in other areas, and the loess tends to mask the backslope between the surfaces, also.

We will proceed just around the corner to the next stop.

STOP 8 - Core Site (64LH1) on Stepped Erosion Surface

From our core site along the gravel road view the surrounding landscape. To the south and west is a broad, low-relief, loess-mantled pediment or erosion surface. Immediately across the road, to the northeast, view the footslope, backslope, and shoulder, which rise abruptly about 15-17 feet to the summit of the loess-mantled Late-Sangamon surface at the last stop. These relations are very apparent to the northwest also. Compare this view with plate 2-1 at the beginning of this guidebook.

The stratigraphy at this site and the particle-size data for the materials in the cores exhibited is shown in figure 2-27. At this site there is 151 inches of loess (12.6 feet; 3.8m), about 4 inches of a gritty silt loam pedisediment, with a few pebbles, which overlies mottled-oxidized and leached till (with some secondary carbonates). The stratigraphy and morphology of STOP 7 and this stop should be familiar by now. Thick loess, basal loess paleosol, over a well-developed paleosol vs. thinner loess, and no paleosols lying directly on till (fig. 2-28) on a lower-lying erosion surface. The broad low-relief surface we are on is the Iowan Erosion Surface--south (and west) of the classic "Iowan" border. Large areas of Erosion Surface such as this occur in the area south of the Iowa River as pediments flanking stream valleys. On occassion these surfaces "cut through" divide areas and join Erosion Surfaces on either side of these divides.

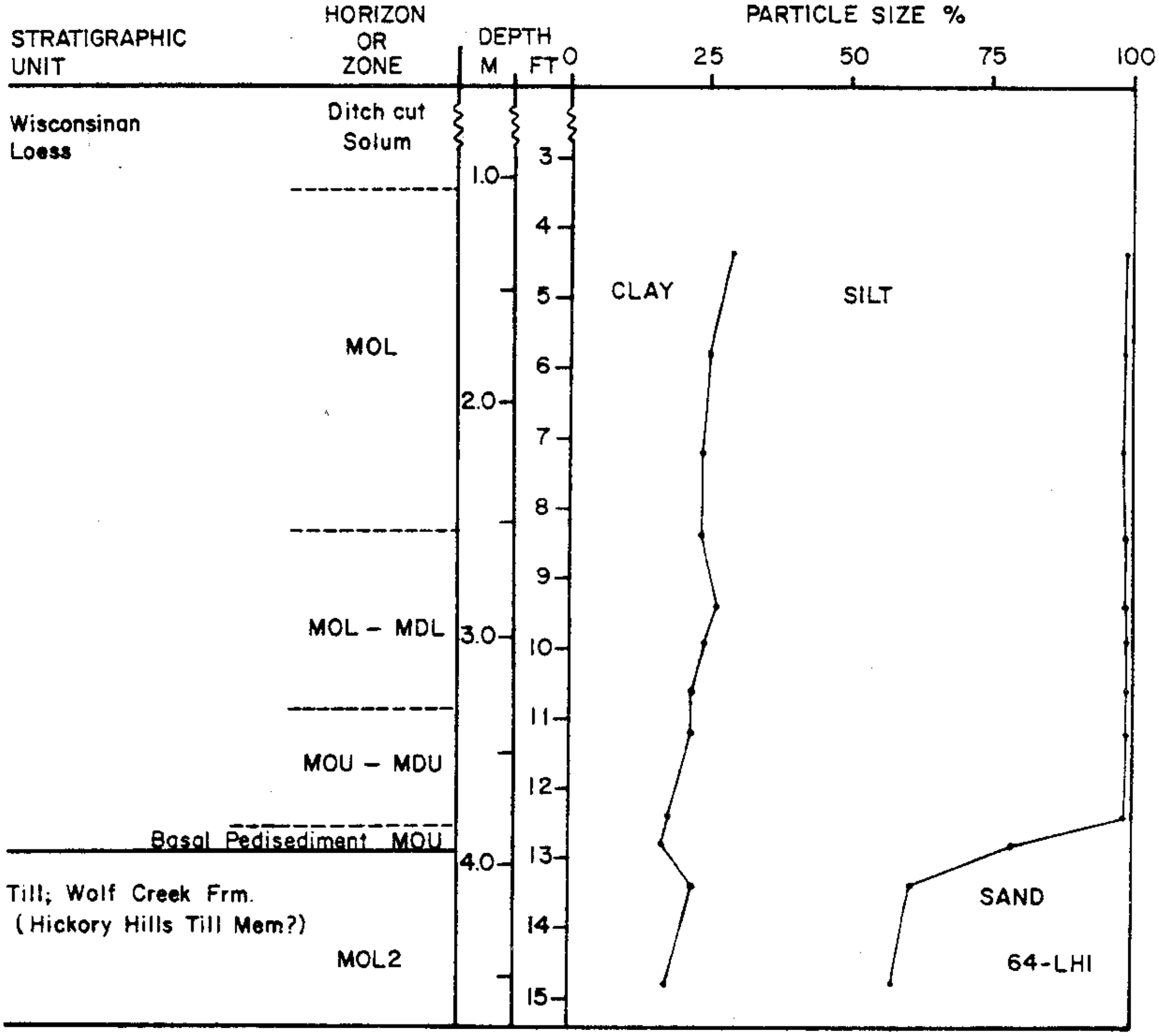


Figure 2-27. Stratigraphy and particle size data, core site 64-LH1, Stop 8.

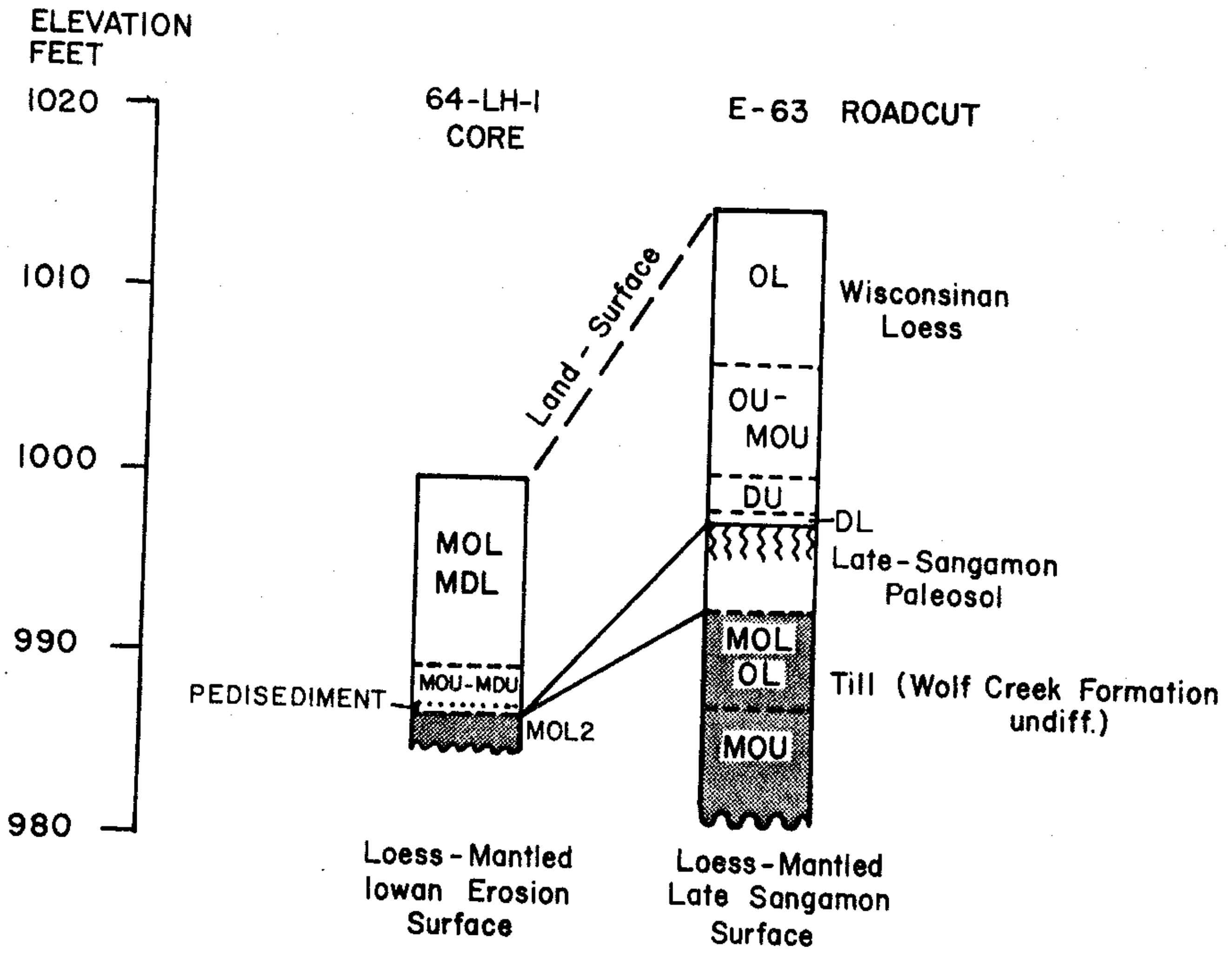


Figure 2-28. Schematic relations between Stops 7 and 8.

As a sidelight to the trip, fig. 2-29, is an example of some of our applied Quaternary research. In the cores, you will notice a zone between about 9 and 10 feet (2.7-3.1m) with a consistency somewhere between play-dough and thick gravy. Informally, we have called this material "loess mush" (our German scholar insists on löess möesch...), in reference to its consistency. Material this soft is an obvious hazard for foundation conditions.

The mush is apparently underconsolidated. In fig. 2-29 the second column shows a profile of the in-situ moisture content (solid-line); the Ps show the moisture content at the plastic limit, and the Ls show the moisture content at the liquid limit. (These are known as Atterberg limits--and mark the approximate lower limit of moisture content where the material assumes plastic and liquid behavior, respectively.) Notice in fig. 2-29 that in the mush zone the natural moisture content is in excess of the liquid limit. This is the reason for the "mushy" consistency--the material is essentially a liquid, i.e.--it flows or deforms under its own weight. Work is continuing on the occurrence and reason for the mush. We feel the mush is part of the problem of understanding "collapsible loess (see Handy, 1973)."

Leaving our final site of the field trip, we will circle the section, driving on the Erosion Surface south and east, and then head north on State Highway 149. Follow our return to Cedar Rapids on U.S. 30. Hopefully on our return trip you will recognize the stepped erosion surfaces along the way. Trip leaders will provide discussion, answer questions, as well as review the summary (below) which was promised earlier.

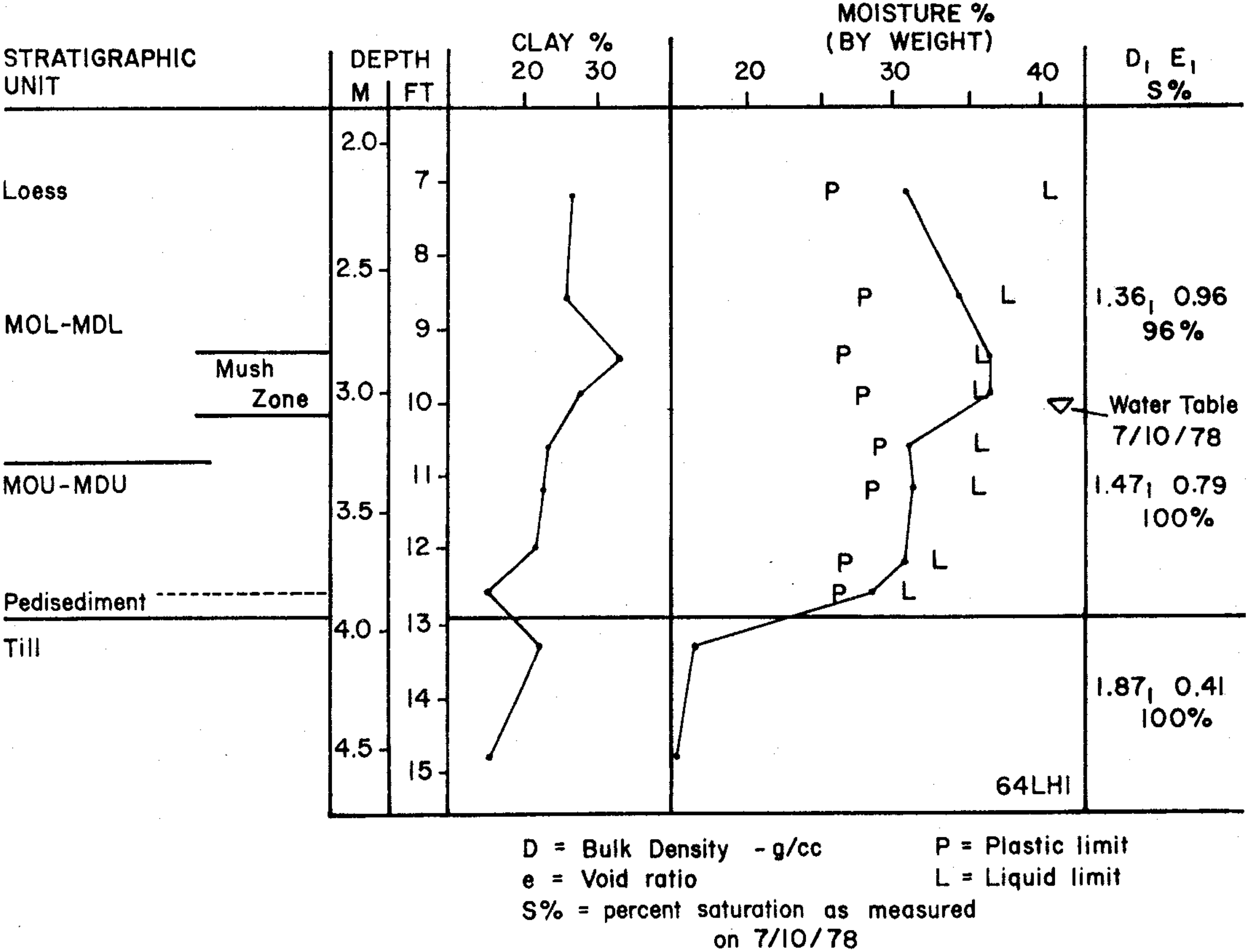


Figure 2-29. Loess-mush data, Stop 8.

SUMMARY - STATE OF THE ART

Earlier a summary of present insights into the why of the Iowan Erosion Surface was promised. Let us summarize this in journalistic style, using the 5 W's and an H.

Who - our who is the Iowan problem, present and past.

What - The Iowan is clearly an Erosion Surface developed on Pleistocene and even older materials (such as - loess over Paleozoic bedrock).

How - Basically, it is a fluvial erosion surface, although wind erosion may have played a minor role.

Where - Everywhere to some degree. The important aspect of where is that the Iowan Erosion Surface is widespread beyond the classic borders of the Iowan drift. Our present knowledge of its distribution makes much more geomorphic sense. It is obviously most widespread in northeast (and northwest) Iowa, but is present throughout the older landscape regions of Iowa. Ruhe, et al., (1967) documented its existence in southern Iowa, as a minor stepped erosion surface (see fig. 2-2). The authors have recently documented that it continues under the thick loess of northeast Iowa all the way to the Mississippi River - through what was considered the Kansan and the Driftless area (see fig. 2-1). The present question of Where - is why do we have so much or so little in a given area: We are presently trying to summarize the Where of the Iowan on maps such as fig. 2-6, in hopes this will divulge some key as to why we have so much - wherever.

When - In study areas where the Erosion Surface is devoid of loess (such as the Sumner area), Ruhe, et al. (1968), have stated that the Iowan Erosion Surface is as young as 2,390 RCYBP. However, these younger dates record erosion which was taking place on hillslopes in all landscape regions of Iowa (see Ruhe, 1969, chapter 4, for example). The unique morphology of the Iowan Surface is the same where it is loess-mantled or loess free. Where it is loess-mantled it clearly evolved between about 21,000 and 17,000 RCYBP. It is during this time period that we must look for a cause.

Why - That's a good question!!!

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TRIP 3

APPLIED GEOLOGY PROBLEMS IN THE CEDAR RAPIDS AREA

by Stanley C. Grant, Raymond R. Anderson, and Fred C. Dorheim

Introduction

The applied geology trip is included this year to provide opportunities to observe and react to work being done in geology and the related professions of engineering, soils, landscaping, recreation site preparation, drainage problems, and dam, road, bridge, and building site preparation and construction. Engineering geology and environmental geology are featured. Today, more than ever, geologists are being called upon to provide special services to the engineering community. Engineering geology is a proven field and environmental geology, though non-specific as a field of work, is an important source of professional employment. Today we will visit three unique and quite dissimilar projects.

After an introductory film we will proceed to the nuclear power complex known as the Duane Arnold Energy Center. This includes the power plant, pumping station, and its pumped storage reservoir being developed by the Iowa State Conservation Commission as a public recreation facility. Though we will not enter the power plant we will discuss the engineering and environmental considerations associated with its planning, construction, and operation. You will see the plant and its relationship to the Cedar River and the nearby reservoir/recreation site. We will observe the constructed dam and the plans for the recreational site development noting the geological and hydrological conditions that influenced the design and materials.

Quarry stop prior to, and after visiting the energy center will allow you to see how a problem with riprap materials at the pumped storage reservoir developed. These stops will also present some interesting problems in interpreting events which affected the exposed Middle Devonian rocks in this area.

Soon afterwards we will travel to the site of a large new enclosed shopping center called Westgate Mall. We are not so much interested in the buildings themselves as we are in the geological, hydrological, and pedological work that took place before site preparation and then the design of the site. We will look at the soils on this site and the Pleistocene environment. We will determine the reasons for the modifications of the site prior to construction and note any problems that have developed since construction began.

Our final stops will be at the Five-in-One bridge and dam in downtown Cedar Rapids where we will see an award winning structure that is environmentally good, economically sound, exceptionally functional, and designed for energy and materials saving. The structure is a flood control dam with adjustable gates, an 8-lane interstate highway, an on-off ramp, and a combined bridge for two major streets. The structure replaced an obsolete flood control/power dam and one old bridge with a much improved dam and three two-way river crossings with a total of 12 traffic lanes. The structure will not only control flood waters on the Cedar River, but will also funnel more than 60,000 autos and trucks in an out of downtown Cedar Rapids on a given business day.

ROAD LOG

Mileage	
0	Depart parking lot behind Iowa Hall, Kirkwood Community College
0.5	Turn right (north) on to Kirkwood Blvd.
1.4	Intersection with US 30. Turn left (west) on US 30.
2.4	Intersection with US 218. Turn right (north) on US 218 (6th St.)
4.9	Turn left (west) on 16th Ave. (stop light). US 218/30 also turns at this intersection. Continue west on US 218 (16th Ave.)
6.5	Intersection with Iowa 149 (stop light). Continue west on US 218.
6.9	Intersection with Edgewood Road (stop light) turn right (north) on Edgewood Road and continue.
7.6	Intersection with Johnson Ave. (stop light) continue north on Edgewood Road.
8.0	Intersection with Iowa 94 (stop light) turn left (west) on Iowa 94.
9.6	Crawford Quarry on left, turn left into quarry for STOP 1.

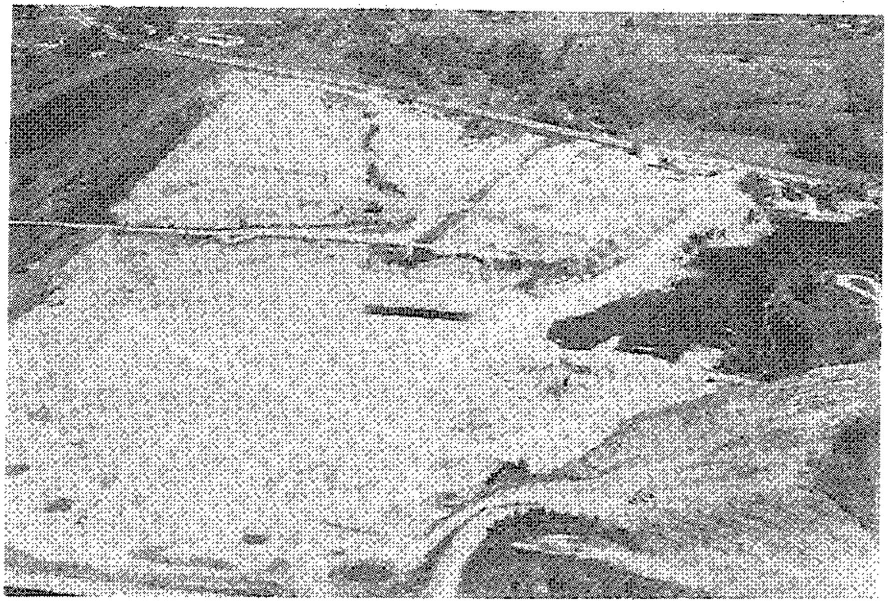


Figure 3-1. An aerial photo of the Crawford Quarry

STOP 1 - Lee Crawford Quarry Company

The Crawford Quarry, located in section 23 of township 83N, range 8W, is one of the largest limestone producers in the area. First opened in 1943 the quarry produces 350,000 to 400,000 tons of limestone annually, with an estimated value of almost a million dollars. The quarry produces roadstone, agricultural lime, and riprap. Despite the rapid encroachment of residential areas of Cedar Rapids, to the south, the quarry owns sufficient land around the present pits to prevent noise or vibration damages to nearby homes as well as providing for future expansion. However, city ordinances controlling dust necessitates implementation of dust control procedures or even temporary shut-downs in times of high northerly winds.

The quarry presently produces stone from the Rapid and Solon Limestone Members of the Cedar Valley Limestone Formation and the top of the Davenport Member of the Wapsipinicon Limestone Formation. This section includes about 40 feet of Rapid, 20 feet of Solon, and 20 feet of Davenport. Underlying the Davenport is about 20 feet each of the Spring Grove and Kenwood Members of the Wapsipinicon. In the future the quarry will be deepened to extract stone from these members.

A geologically interesting problem encountered in this quarry is the appearance of large, clay filled pockets. These pockets were formed by karst development in the Middle Devonian limestones, and filled with clays of Upper Devonian or Pennsylvanian age, often incorporating subrounded cobbles and boulders of the Cedar Valley and Upper Wapsipinicon rocks. Since these pockets contain no usable stone they are generally quarried around. One such pocket can be seen in the lower pit.

Stratigraphy

In this quarry we see exposed a sequence of Middle Devonian rocks (see figure 3-2). The lowest visible unit is the Davenport Member of the Wapsipinicon Limestone Formation, a brecciated limestone in this quarry. The angular clasts are of variable sizes, ranging from fractions to tens of inches across and commonly displaying alternating medium and dark brown laminar bedding. The clasts display a lithographic texture, and may be of evaporite origin. The matrix material in the Davenport ranges from the limey shale to argillaceous limestone, is generally coarse to medium grained, and medium gray in color. Algal stromatolites (rare) are the only fossils found in the clasts. The matrix is also, in most locations, unfossiliferous, however, an exception can be seen in this quarry (see the following section-Structure). The brecciation of the Davenport will also be discussed in the following section

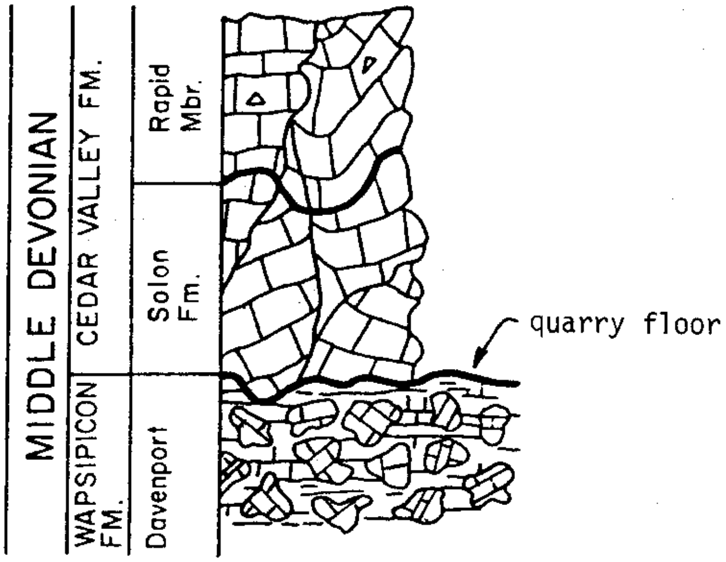
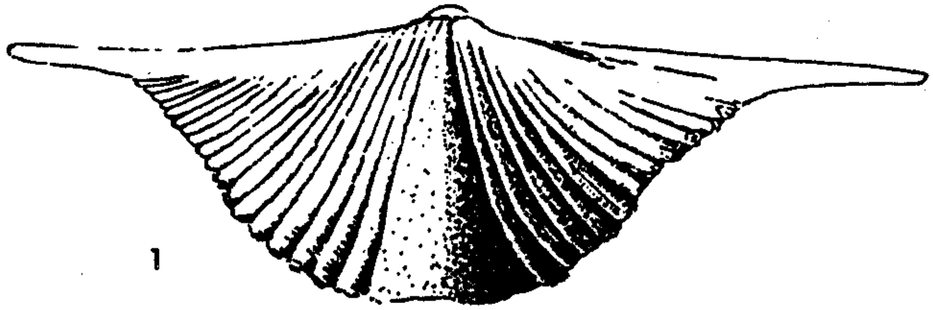
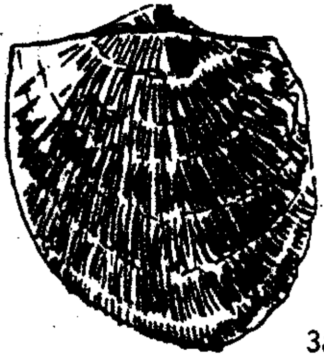


Figure 3-2. Stratigraphic section exposed at Crawford Quarry.





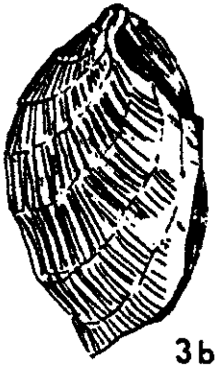
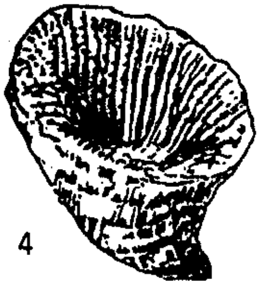


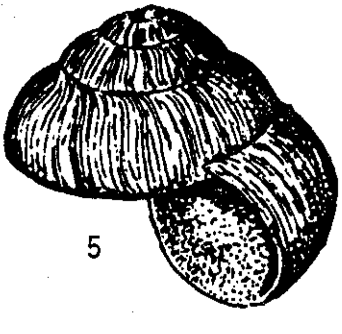
Figure 3-3. Some Typical Fossils from
the Cedar Valley L.S. formation

1. *Platyrachella iowensis,* a spiriferid from the Solon Member of the Cedar Valley Limestone. Brachial view of a large specimen with unbroken "wings" extending from the hinge line. Note lack of costae (radial ribs) on the fold (same is true on the sulcus on the pedicle valve, not shown). The genus *Mucrospirifer* closely resembles *Platyrachella,* but has costae on the fold and sulcus.



2. *Hexagonaria* spp., a colonial rugose coral found in many Devonian formations in Iowa and elsewhere. *a,* portion of a colony showing the walls between individuals and the axial pit or depression of each member of the colony; *b,* sketch of a whole colony, much reduced, showing manner of growth.

3. *Atrypa independensis,* a large *Atrypa* characteristic of the Solon Member of the Cedar Valley Limestone. *a,* brachial exterior; *b,* lateral view.



4. *Zaphrentis* sp., a solitary rugose coral, particularly abundant in the Cedar Valley Limestone; one of the common Devonian "horn corals".

5. *Straparollus* sp., one of many very similar Paleozic gastropods (snails). Common in certain zones of the Cedar Valley Limestone and other Devonian and some Mississippian formations in Iowa. Preservation is very rarely as good as that shown here.

6. *Atrypa bellula,* an atrypacean spiriferid. This somewhat spiny species of *Atrypa* is characteristic of the base of the Rapid Member of the Cedar Valley Formation; some authors place it in a separate genus, *Hystricina.*

Overlying the Davenport is the Solon Limestone Member of the Cedar Valley Limestone Formation. The Solon in this quarry is a fine grained, porous limestone which weathers chalky gray. Thin shale partings may be found between the medium to thick carbonate beds. Although not abundantly fossiliferous a variety of fossils can be found without great difficulty. These include the brachiopods Platyrachella iowensis and Atrypa independensis, corals such as the colonial Hexagonaria and Favosites and solitary rugose types, crinoidal debris, and gastropods such as Straparollus (see figure 3-3).

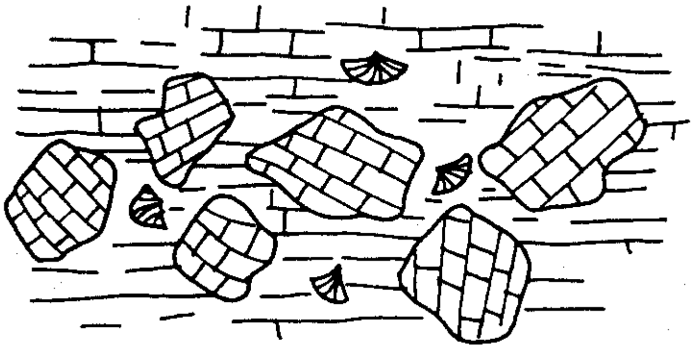


Figure 3-4. Clasts of Davenport in a Solon matrix containing whole-shell brachiopods.

The upper unit exposed at the Crawford Quarry is the Rapid Limestone Member of the Cedar Valley Limestone Formation. The Rapid is a cream colored, slightly argillaceous limestone which weathers to a chalky buff.

Scattered white to brown chert nodules may be found, and fossils are more abundant in the Rapid than the Solon. For the most part the fossil assemblage in the Rapid mirrors the Solon. The Solon/Rapid contact is conformable. The uppermost Solon is marked by a zone of Hexagonaria profunda coral ranging from 2 to 6 inches in thickness. The bottom of the Rapid Member can be identified by the first appearance of the small brachiopod Atrypa bellula (see figure 3-3).

Structure

The most striking features of the rocks exposed at the Crawford Quarry is the extensive folding, faulting, and brecciation. Although no definative explanation for this disturbance has yet been proposed, two theories seem to be most popular.

One explanation of this folding, faulting, and brecciation is solution collapse. Most of south-central Iowa (to within 15 miles of this quarry) is underlain by thick sequences of gypsum and an hydrite, primarily in the Spring Grove and Kenwood Members of the Wapsipinicon Formation. These evaporites reach thicknesses of over 90 feet and are mined in the subsurface at Sperry, Iowa, 70 miles south of Cedar Rapids. It has been proposed that groundwater moving through these rocks dissolved and removed the evaporites, allowing the overlying Davenport and Cedar Valley strata to collapse and fracture.

A second theory explaining the folding, faulting, and brecciation evident at the quarry is tectonic activity. The Plum River Fault, the topic of another Tri-State trip, extends from central Illinois at least to Cedar Rapids, 110 miles. Vertical displacements of 100 to 400' locally attest to the activity of this feature. The Iowa Geological Survey geologists who have been studying the fault feel that it is an expression of a basement feature and has been periodically active at least through the middle Paleozoics (B. Bunker and G. Ludvigson, personal communication, 1978). Tectonic activity associated with the development of this fault may have produced the folding, faulting and brecciation visible at the Crawford Quarry today.

Whether solution collapse, tectonic activity, or most probably a combination of both created the structural features visible at the Crawford Quarry, the activity must have been, at least in part, contemporaneous with deposition. An examination of the Davenport/Solon contact reveals the brown, lithographic limestone clasts of Davenport surrounded by a matrix of argillaceous Solon limestone. The Solon matrix can be identified by the presence of such fossils as Atrypa independensis among the clasts. Such brachiopods are often whole-shell suggesting original deposition around already brecciated Davenport (see figure 3-4). Subsequent movement folded and faulted the overlying Cedar Valley units.

Riprap

Stone produced at this quarry was used as Riprap at the Duane Arnold Energy Center pumping station and Pleasant Creek Reservoir (stops 3 and 4 of this trip). You may already be able to predict some of the problems this produced. Be on the lookout for the riprap from this quarry at these future stops.

9.6	Leave Crawford Quarry and turn left (northwest) on Iowa 94
10.0	Turn left (south) on Morgan Creek Road
10.3	Turn right (west) on road to Morgan Creek Park
10.5	Turn left (south) into Morgan Creek Park THIS IS A REST STOP
10.5	Leave park turn right (east) on road from Morgan Creek.

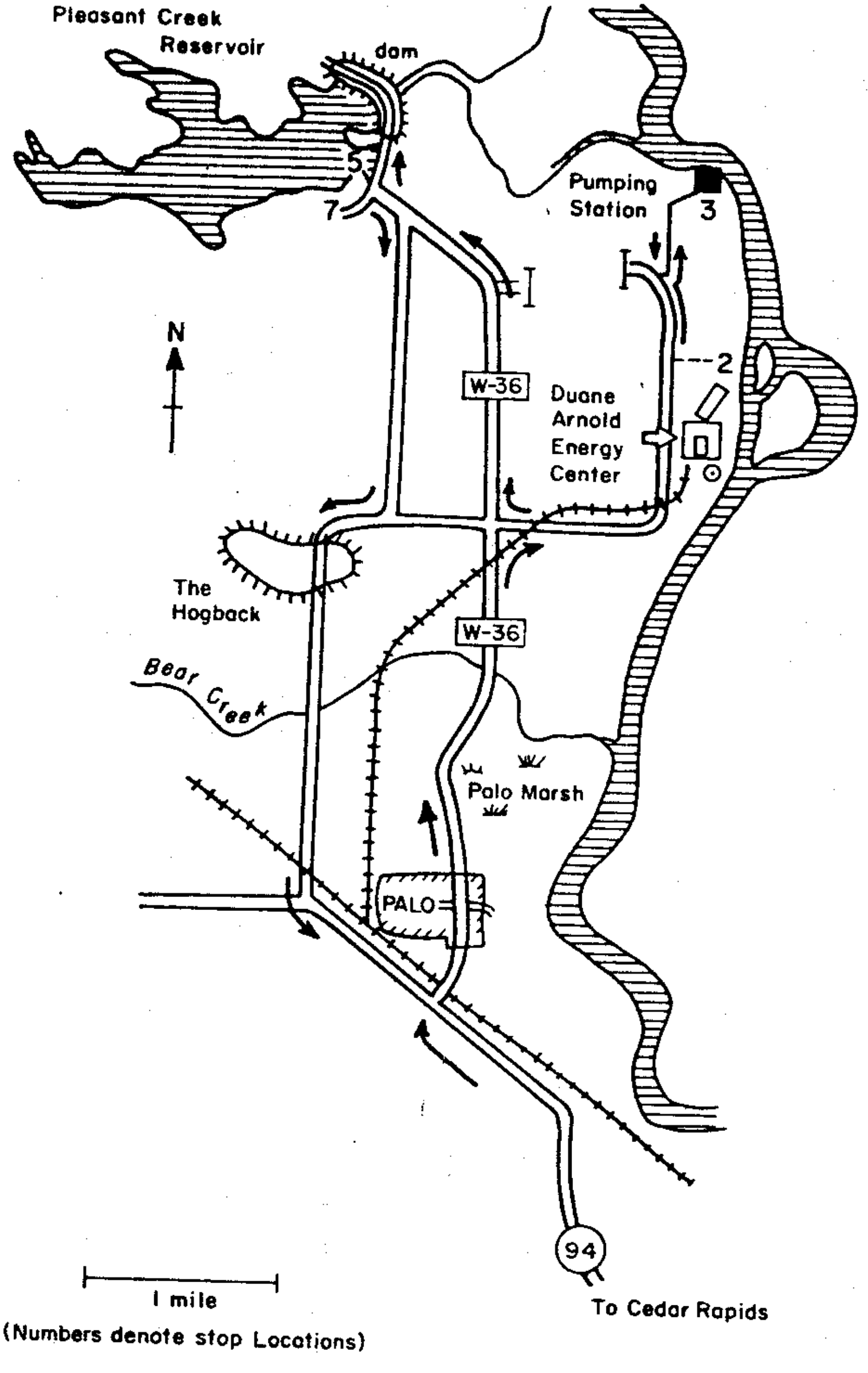


Figure 3-5. Map of the area surrounding the Duane Arnold Energy Center and its support facilities.

10.7 Turn left (north) on Morgan Creek Road.

11.0 Turn left (northwest) on Iowa 94 and continue.

12.1 Pass through the town of Covington

12.3 Cross 2 bridges (Silver Creek and the Chicago, Milwaukee, St. Paul, and Pacific Railroad)
-Note the outcrop along the road in this area. These are rocks of the Solon Member of the Cedar Valley Formation.

16.3 Turn right (northeast) on the road to Palo (turn opposite Phillips 66 Service Station) cross railroad tracks (Chicago, Rock Island and Pacific) with CAUTION. Continue to palo.

16.8 Intersection in downtown Palo (stop sign) continue straight ahead (north) on Linn County road W-36. (see figure 3-5).

17.5 Note Palo Marsh on east side of road.

18.9 Cross railroad tracks (spur line for power plant construction) Observe stop sign and turn right (east).

19.7 Road curves left (north). Observe the Duane Arnold Energy Center (DAEC) nuclear power plant to the northeast (see figure 3-6).

20.1 Continue past DAEC and north up the hill.
NOTE: The United States Nuclear Regulatory Commission establishes the security perimeters for all nuclear power plants in this country. There is NO public access beyond the parking area in front of the Duane Arnold Energy Center. We have secured special permission to proceed beyond the barracades for the Tri-State trip ONLY. Special clearance is necessary for any future access to this area.

20.4 STOP 2 - in road opposite the lane to an abandoned farm (right side of road). Walk to overlook of the DAEC.

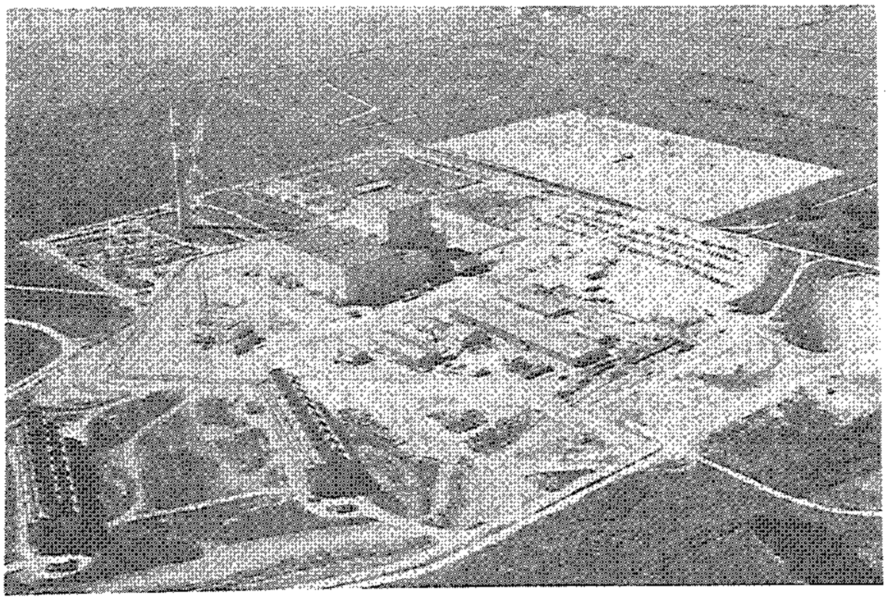


Fig. 3-6. Aerial Photo of Duane Arnold Energy Center

STOP 2 - Duane Arnold Energy Center

Construction of the Duane Arnold Energy Center (DAEC), Iowa's first nuclear power plant, began shortly after the U.S. Atomic Energy Commission issued a construction permit in June of 1970 to a corporate group including the Iowa Electric Light and Power Company, the Central Iowa Power Cooperative and the Corn Belt Power Cooperative. Prior to issuance of the permit the group submitted an Environmental Report to the Atomic Energy Commission. The report (Iowa Electric Light and Power Co., 1971) describes the environment of the site area and the environmental impact of the construction and operation of the facility. As a part of this report, the geology and seismology of the area was studied. Much of the information provided at this stop was drawn from the report.

Stratigraphy

Eastern Iowa lies in the area classically known as the Central Stable Region and is bounded on the northeast by the Wisconsin Dome, on the northwest by the Transcontinental Arch, on the southwest by the Forest City Basin on the south by the Ozark Uplift, and on the southeast by the Illinois Basin. Within this area, generally flat-lying sedimentary rocks are locally disturbed by low relief, northwest trending anticlines and synclines. The extent of faulting in eastern Iowa is only recently being developed (see Trip 1 Plum River Fault).

At the site of the DAEC, the Precambrian crystalline basement lies at a depth of about 2600 feet below the surface. Aeromagnetic information (Aero Services Corp., 1969) suggests that the crystalline rocks are acidic in composition, and deficient in magnetic minerals. Overlying the Precambrian are about 700 feet of Cambrian sandstone and about 400 additional feet of primarily dolomite and sandstone. Above these units lie about 1200 feet of Ordovician, Silurian, and Devonian sediments, primarily carbonates with some shales and sandstones. Bedrock under the DAEC is Middle Devonian, lower Wapsipinicon Formation.

About 40 feet of unconsolidated materials are present at this location. Above the bedrock about 20 feet of pre-Illinoian glacial till remains (this was deposited by the continental glaciations classically called "Nebraskan" and "Kansan"). Much of the original till was removed during "Wisconsin" time in this and other areas collectively called the Iowan Erosional Surface. Post Iowan alluvial sediments from the Cedar River deposited an additional 20 feet of silt-to gravel-size material on the till. The hills surrounding the site are built primarily of recent loess.

Structure

The DAEC sits on an island of the Devonian Wapsipinicon Formation, surrounded on all sides by channels cut into the underlying Silurian Gower Formation. The closest known fault occurs about 10 miles to the north of the site (Iowa Electric, 1971) and 13 miles to the south, the Plum River Fault extension (B. Bunker, personal communication, 1978). Aeromagnetic interpretation, however, indicates a northwest-trending fault in the basement about 8 miles to the southwest of the facility (Aero Services Corp, 1969).

Seismisity

The area of the Central Stable Region, and especially Iowa, have experienced relatively few earthquakes. Only nine earthquake epicenters have been recorded in Iowa, none of them representing major quakes. The epicenter nearest the DAEC was an April 1948 disturbance with an epicenter reportedly south of Oxford, Iowa, 23 miles to the south (J. Docekal, 1970). This quake had a Modified Mercalli Intensity of IV.

20.4 Board busses and continue north.

21.0 Turn right (east) on narrow dirt land and follow it around and to the north (see map, figure 3-5).

21.1 STOP 3. DAEC pumping station and pump storage intake.

STOP 3 - DAEC Pumping Station

The pumping station for the DAEC withdraws water from the Cedar River to be used for power plant cooling. The pumping station is located on the outside of a bend in the river to assure proximity to the main channel and a continuing supply of water even in times of low flow. Should the river flow become extremely low, its volume will be supplemented by water from the DAEC's pumped storage facility, the Pleasant Creek Reservoir (STOP 4 on this trip).

The raw water is pumped by three vertical motor driven turbine pumps with a below-base discharge capacity of 3500 gpm at a total dynamic head of 168 feet and a maximum pump speed of 1800 rpm. These pumps are powered by 460 volt, 3-phase motors.

The pipeline connecting the pumping station with the Pleasant Creek Reservoir will carry water to fill the reservoir when it is low and withdraw water from it when river flow is low. The pipeline is about .8 miles in length and lifts the water about 70 feet from river level to the reservoir. To accomplish this lift the pipeline must be capable of withstanding pressures of 100-150 pounds per square inch. The pipe used is 24 inch inside diameter (i.d.) extra strong concrete lined steel pipe. This pipe runs to the Pleasant Creek Dam, where it joins a 30 inch i.d. reinforced concrete gravity pipe.

The pumping station insures the river's ability to provide water for the power plant at a maximu, continuous flow of 11,000 gpm. Of this a calculated 7000 gpm maximum will be lost to evaporative cooling and the remaining 4000 gpm returned to the river. In actual operation, however, evaporative losses generally do not exceed 6000 gpm in the summer, and 3000 gpm in the winter.

To date the flow of the Cedar River has not dropped below 225,000 gpm, even during the mid-1970's drought. Hence, water from the Pleasant Creek Reservoir has not yet been used to increase river flow. Also, natural rainfall has thus far kept the Reservoir at capacity and no river water has yet been pumped to it.

Riprap

Please note the riprap used to stabilize the bank near the pumping station. Some is from the Crawford Quarry. (STOP 1).

Note: Please do not contribute to the breakdown of the riprap. DO NOT use your rock hammers.

21.1 Board busses and proceed south, retracing previous route.

22.1 Pass DAEC, continue south. Follow road curve to right (west) and continue.

22.3 Cross railroad tracks and stop at intersection with County W-36. Turn right (north) on W-36 and continue under power lines. Follow map figure 3-5.

22.8 Turn left (northwest) and continue.

23.2 Pass around "Road Closed" sign and continue

23.5 Turn right (northeast) on gravel road.

23.6 Turn left (northwest) onto paved overlook and STOP 4.

STOP 4 - Pleasant Creek Reservoir

The Pleasant Creek Reservoir was constructed as a pumped storage facility by Iowa Electric Light and Power Company. It's function is to supplement river water at times of low flow, thus insuring an adequate

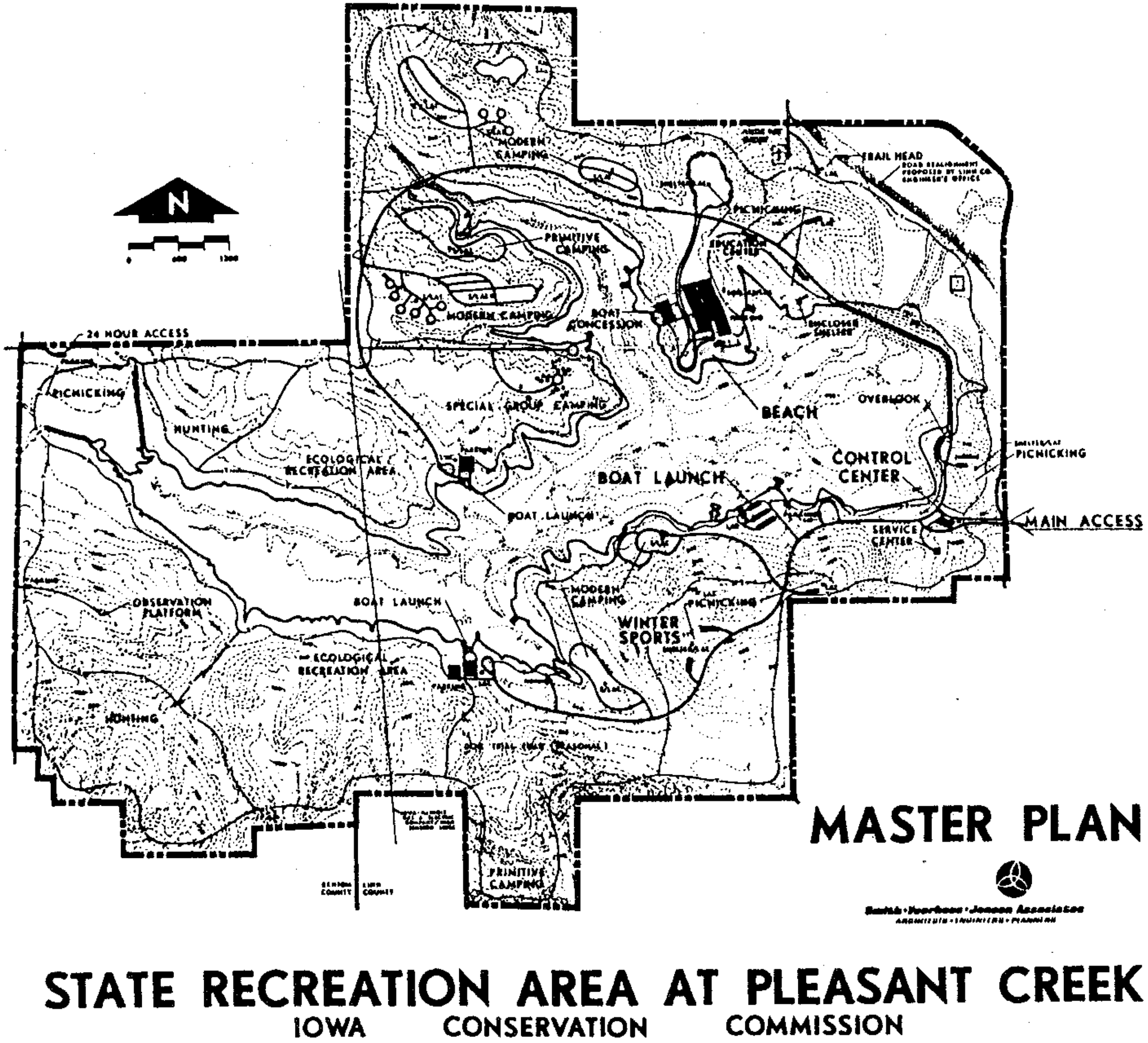


Figure 3-7. Master plan for the development of the Pleasant Creek State Recreation Area.

supply for cooling at the Duane Arnold Energy Center. The Iowa Conservation Commission soon became interested in the facility and in now developing the lake as the State's first 24 hr/day, 365 day recreational facility (see figure 3-7).

When filled to the maximum, the lake lies 819 ft. above sea level and impounds 7100 acre-feet of water in an area of about 410 acres. Should the flow of the Cedar River drop to below 500 cfs, water will be pumped from the reservoir and introduced into the river. A total of 4100 acre-feet of reservoir water is available for this river recharge, a quantity calculated to be sufficient to maintain power plant cooling for at least six months--hopefully long enough to withstand any projected low flow periods of the river.

The Iowa Conservation Commission (ICC) has developed a comprehensive plan to create a multi-use, full time public recreation area around the reservoir. The facility will serve an urban and rural population of over 600,000 with a wide variety of recreational options, both on the lake and on 1517 acres of land surrounding it. When development is completed (present estimates suggest completion in the fall of 1984) the Pleasant Creek Reservoir area will offer the following recreational options (ICC, 1976).

<u>Picnicking</u> - 94 acres will handle 2660 picnickers with tables, charcoal grills, latrines, hydrants, and 5 shelters.

<u>Swimming</u> - a 5 acre beach area will provide 1100 feet of shoreline, food concession, first-aid station, changing facilities, showers and a latrine. More than 1000 people can use this facility.

Camping - accommodations will be available for all forms of camping from primative walk-in sites to modern all weather surfaced pads. 70 acres of campground and 350 acres of support land should provide for up to 1600 campers in 395 camp sites including special group campgrounds.

Boating - 4 boat launching areas with 8 ramps will be in service. Boat rental, docking, and storage facilities will be available. Motors are limited to 6 hp on the lake.

Trails - the area will provide 37.6 miles of trails for hikers, bikers, equestrians and snowmobilers. Interpretive and educational trails will be included in this system.

Fishing - the lake will be stocked with large mouth bass, crappie, bluegill, channel catfish and northern pike.

Winter activities - these will include facilities for cross country skiing, sledding, skating, snowmobiling, tobogganning, hunting, fishing and camping.

Education - on-site conservation education programs will include wildlife studies, conservation techniques, hunting, fishing, boating and swimming as well as limited historical and archaeological programs.

23.6 Board busses and drive out onto dam.

24.0 STOP 5 at dam spillway.

STOP 5 - Pleasant Creek Reservoir Dam

The dam which empounds the Pleasant Creek Reservoir is an earthen dam containing approximately 500,000 cubic feet of fill, primarily glacial till. The dam is faced with riprap on the upstream side and has a reinforced Portland Cement concrete outlet and drawdown facility.

Geology of the Area

The center of the Pleasant Creek Reservoir is situated on a preglacial (pre-Wisconsinan) channel eroded into carbonates of the Cedar Valley Limestone Formation, of Middle Devonian age. Local wells produce water at 10-15 gal/min from these fractured and occasionally cavernous (karst) limestones. The pieziometric surface lies at about 810 ft. above sea level and presumably dips to the Cedar River.

Above the bedrock lies 0-34 ft. of glacial till, 0-67 ft. of alluvial sand and 0-15 ft. of loess. These unconsolidated materials represent a sequence of glaciation, deposition of till, and erosion by flowing run-off water with concurrent deposition of water-sorted sediments ranging in size from coarse sand to silty-clay. Subsequent erosion during Iowan time (mid-Wisconsinan 38,000-12,000 YBP) stripped away or greatly reduced the thickness of these unconsolidated sediments. This left a very thin confining unit overlying the permiable bedrock at the reservoir location.

Work by Donald Koch, Assistant Iowa State Geologist, for the Committee on Appropriations for Natural Resources of the Iowa Senate in 1971 showed the extent of the problem created by lack of an adequate confining unit under the lake. He estimated that vertical water loss from the lake at its original planned elevation (830 ft.) could have exceeded 3,800,000 gal/day. This would have necessitated pumping

2700 gal/min into the lake to maintain the water level. He suggested installing a bentonite seal on all portions of the basin lying below the 800 ft. contour.

Because of these and other suggestions the lake's maximum level was lowered to 819 ft., reducing potential vertical water loss to 718,000 gal/day. To further reduce this loss a clay seal was applied to the lower portions of the basin.

24.0 Continue ahead.

24.3 Picnic Area. Turn around and return across dam and past overlook turn out.

25.1 Intersection with road we came in on. Turn right (west) and follow lake shore to T-intersection. STOP 6. Leave busses and walk to jetty to inspect riprap.

STOP 6 - Riprap Problems

Early in the construction of the Pleasant Creek Reservoir, riprap was placed on the shore to control erosion. This original riprap apparently came from the Rapid and/or Solon Members of the Cedar Valley Limestone Fromation. This material deteriorated badly after only one season. To replace the riprap consulting engineers suggested that stone be used which passed Iowa Department of Transportation tests for concrete aggregate, and was not taken from the Rapid Member or brecciated Solon Member. Acceptable rock was identified and quarried from the Otis and Coggon Members of the Wapsipinicon Formation. However less than a year after this riprap was installed it was already badly deteriorated, and the consulting engineer contacted Fred Dorheim at the Iowa Geological Survey for assistance. At Fred's suggestion, dolomite from the LeClaire facies of the Gower Formation (Silurian) was tested by the Army Corps of Engineers of Rock Island. Their tests included repeated freeze-thaw cycles, with the LeClaire stone showing no evidence of break-down. The stone was accepted and delivered to the site. To date there is still no sign of deterioration of the LeClaire riprap. It has now become common quarry practice to "cure" riprap stone by leaving it exposed for a season prior to delivery.

25.1 Board busses. Turn left (south) at T-intersection and continue.

26.3 T-intersection. Turn right (west) and follow the road around a left (south) curve and up a hill.

27.1 You are now on the crest of the Hogback, a bedrock high.

28.9 Cross tracks of the Chicago, Rock Island and Pacific Railroad.

30.0 Intersection. Turn left (east).

30.1 Bear right (southeast). Road becomes Iowa 94. Continue southeast.

36.1 Intersection with Morgan Creek Road turn right and proceed to Morgon Creek Park for lunch stop.

36.6 LUNCH STOP - <u>Morgan Creek Park</u>.

36.6 Depart Morgan Creek Park and turn right (south) on Morgan Creek Road.

37.0 Turn right (west) into B.L. Anderson Inc., Morgan Creek Quarry. STOP 7.

STOP 7 - Morgan Creek Quarry

This quarry was, like the Crawford Quarry, an early source for riprap used at the Pleasant Creek Reservoir. Here we see rock of the Davenport Member (Wapsipinicon Formation), as well as the Solon and Rapid Members (Cedar Valley Formation). See figure 3-8. The Davenport crops out at the base of the northern end of the western face of the quarry. Since the units in this quarry generally dip to the south, the stratigraphically highest exposed unit, the Rapid, can be found at the top of the Southern face. The bulk of the quarry is in the Solon. These rocks are heavily folded, faulted and brecciated, much like those at he Lee Crawford Quarry (STOP 1). They are, however, much more fossiliferous than the Crawford Quarry. It is an excellent locality for collecting. Of note is the abundance of the coral *Favosites* in the Solon. For fossil identification refer to Figure 3-3.

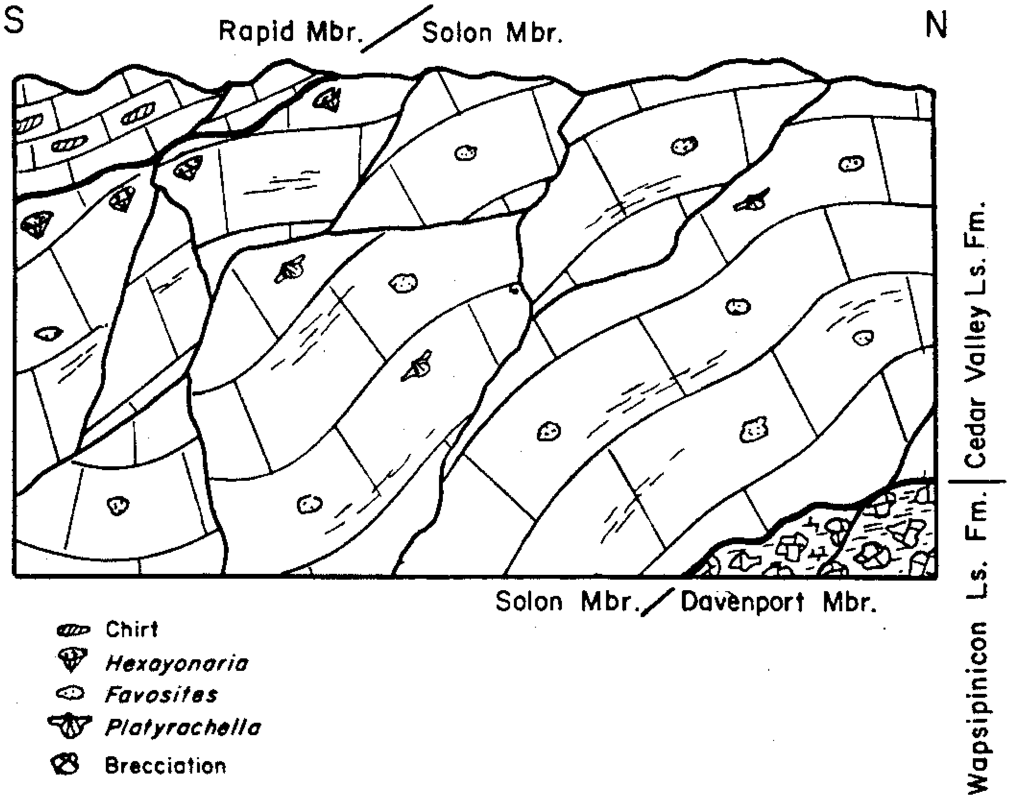


Figure 3-8. Stratigraphic Section of Rocks Exposed in the west wall of the Morgan Creek Quarry.

37.1 Depart Morgan Creek Quarry and turn right (south) and continue. southwest.

37.4 Intersection with County E-48 (E Avenue). Continue straight ahead (south).

38.4 Intersection with U.S. 30. Turn left (east) and proceed towards Cedar Rapids.

40.5 Intersection with Edgewood Road. Turn right (south) on Edgewood Road.

41.1 Intersection with Iowa 149. (Williams Blvd) (stop light). Continue across, then turn into the Westdale Mall - STOP 8.

STOP 8 - The Westdale Mall

The Westdale Mall, soon to be one of Iowa's largest enclosed shopping centers, is located in the southwest quadrant of the intersections of Williams Boulevard and Edgewood Road in southwestern Cedar Rapids (figure 3-10). The Mall covers 87 acres, 16 of which will be buildings with remainder designed for parking, driveways, and landscaping. Construction began in October 1977, and the project will be completed in August 1979.

The original topography of the site (figure 3- 9) was substantially altered in order to provide the large, flat areas for the project. Material from the topographically high area in the northeast corner of the site was used to fill a stream valley on the southern end. As much as 20 feet of material was stripped and the stream valley filled to a depth of about 25 feet.

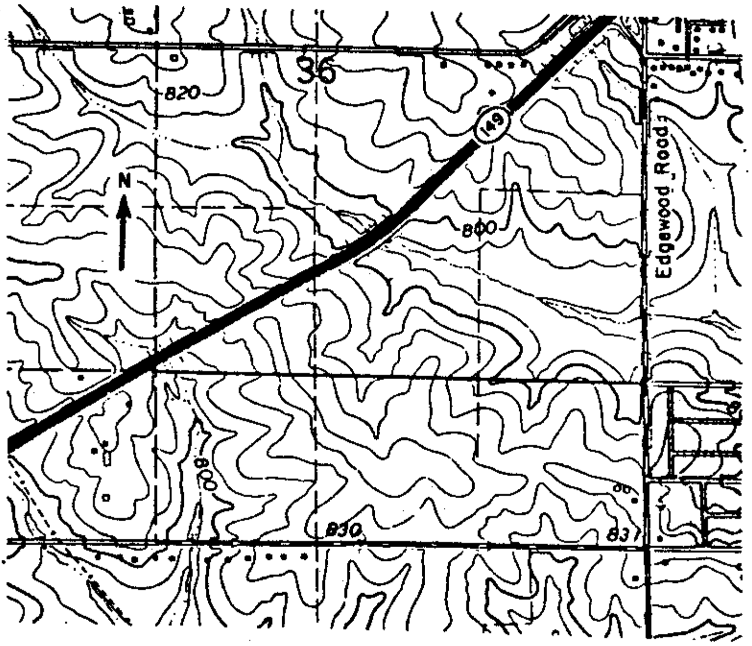
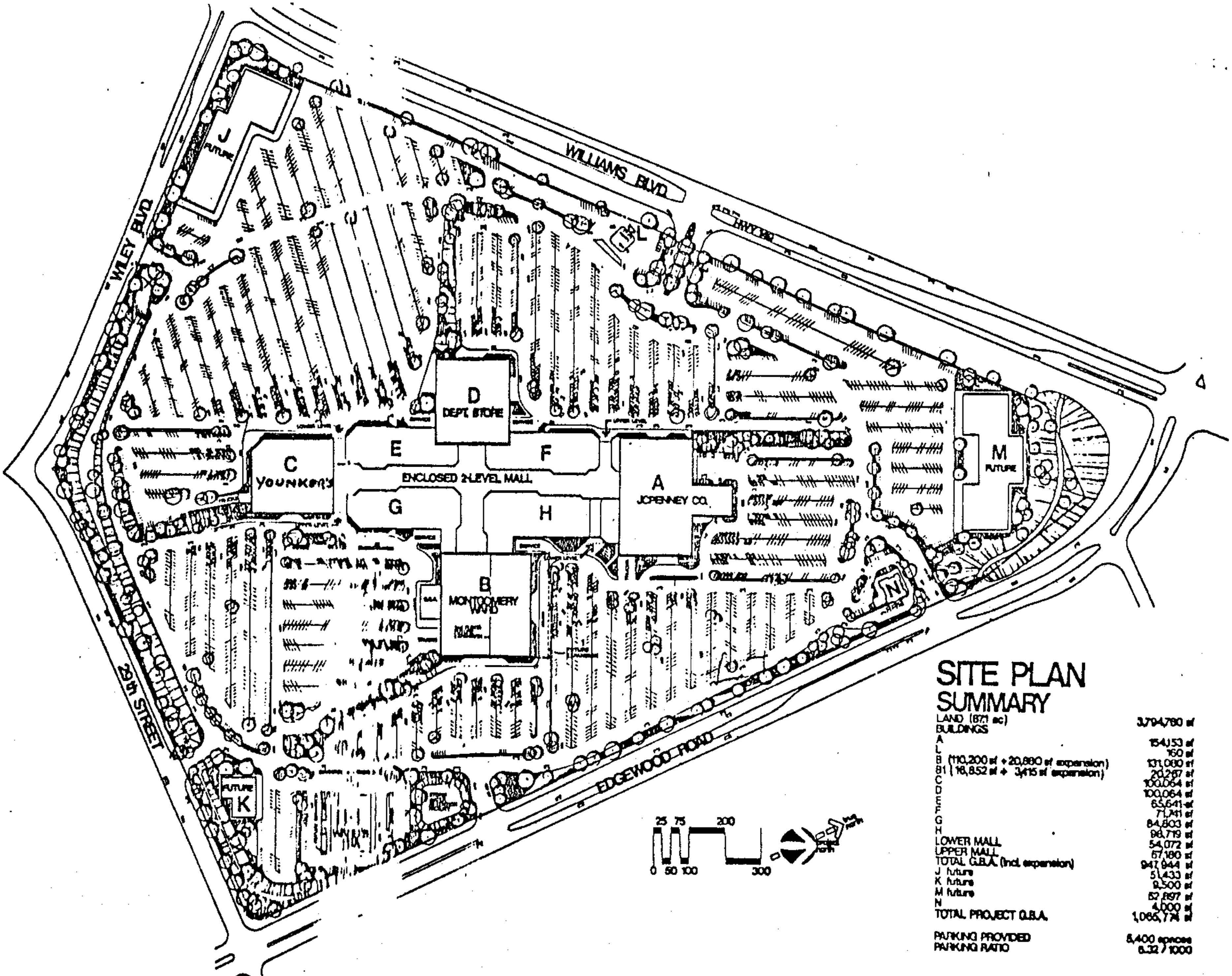


Figure 3-9. Original topography of Westdale Mall site.



SITE PLAN SUMMARY

LAND (87.1 ac)	3,794,780 sf
BUILDINGS	
A	154,153 sf
L	160 sf
B (110,200 sf + 20,880 sf expansion)	131,080 sf
B1 (16,852 sf + 3,415 sf expansion)	20,267 sf
C	100,064 sf
D	100,064 sf
E	65,641 sf
F	71,741 sf
G	84,803 sf
H	96,719 sf
LOWER MALL	54,072 sf
UPPER MALL	67,180 sf
TOTAL G.B.A. (incl. expansion)	947,944 sf
J future	51,433 sf
K future	9,500 sf
M future	62,897 sf
N	4,000 sf
TOTAL PROJECT G.B.A.	1,066,774 sf
PARKING PROVIDED	6,400 spaces
PARKING RATIO	6.32 / 1000

Figure 3-10. Westdale Mall site plan.

With these dramatic alterations of the natural topography came the necessity to install major drainage control structures. Surface run-off from the now burred stream's 420 acre basin to the northwest of the site is now routed through an 8 foot square concrete culvert. The culvert passes under the Mall and empties into an open drainage-way which, in turn, routes the water back into its old channel just west of Edgewood Road. Run-off from the site itself drains into the culvert via storm drains or into the drainage-way via surface flumes.

Geology

The Mall site is located on the Iowan Erosion Surface. This area is characterized by thin loess cover overlying pre-Illinoian till. The Yarmouth-Sangamon paleosol and varying amounts of till were removed during the development of this feature (see Hallberg, Trip 2 of this Guidebook).

The extensive excavations at the site produced two excellent exposures of the upper portion of the Pleistocene section (see figure A) These along with date from numerous test borings, made it possible to document the stratigraphy of the site as well as the mineralogical and engineering characteristics of the two tills.

The two tills, separated by a discontinuous stone line, were sampled, and the samples analyzed to provide textural and mineralogical data. The results of these tests are presented in Figures 3-11 and 3-12; T1 is the upper till, T2 the lower till unit. Both the tills (T1 and T2) are high in expandable clays. T1 has a high CO_3 content, a low calcite to dolomite ratio, and a high total sedimentary materials component. T2 has a lower CO_3 content, a high calcite to dolomite ratio, and a low total sedimentary component.

Figure 3-11. Mineralogical Analysis (by George Hallberg)

	sample	C/D	CO_3	Tsed.	Txst.	Ex.	Ill.	K & C
Till 1	1	NOD	30	30	70	--	--	24
	2	1.4	26	29	71	62	14	24
	3	3.3	28	32	68	--	--	--
	4	5.4	22	25	75	--	--	--
	$\bar{x}$	3.37	26.5	29.0	71.0			
		2.00	3.4	2.94	2.94			
Till 2	1	20	18.8	18.8	81.2	69	15	16
	2	NOD	19	21	79.0	--	--	--
	3	19	14	15	85.0	--	--	--
	4	NOD	12.5	14	86	--	--	--
	5	1.3	14.6	16.2	63.8	--	--	--
	$\bar{x}$	13.43	15.8	17.0	83.0			
		10.52	3.0	2.87	2.87			

Figure 3-12. Textural Analysis (by George Hallberg)

	sample	clay	silt	sand
Till 1	1	15.2%	44.8%	40.0%
	2	13.6	52.9	33.5
	3	15.4	49.8	39.8
	4	15.7	51.1	33.2
	5	12.9	53.5	33.6
	6	14.1	63.4	22.5
sheared zone	7	11.8	85.5	2.7
	8	5.2	6.0	88.8
Till 2	1	13.3	45.8	40.9
	2	15.2	43.8	41.0
	3	13.1	43.0	43.9
	4	12.7	46.8	40.5
	5	16.1	43.8	40.1

Based on these analyses, and the study of similar Iowan Erosion Surface sequences, it was concluded that T1 is equivalent to the Hickory Hills Member of the Wolf Creek Formation and that T2 is equivalent of the Aurora Member of the same formation (see Hallberg, this guidebook Trip 2). Using this information and field notes a stratigraphic column of the exposed section was prepared (figure 3-13).

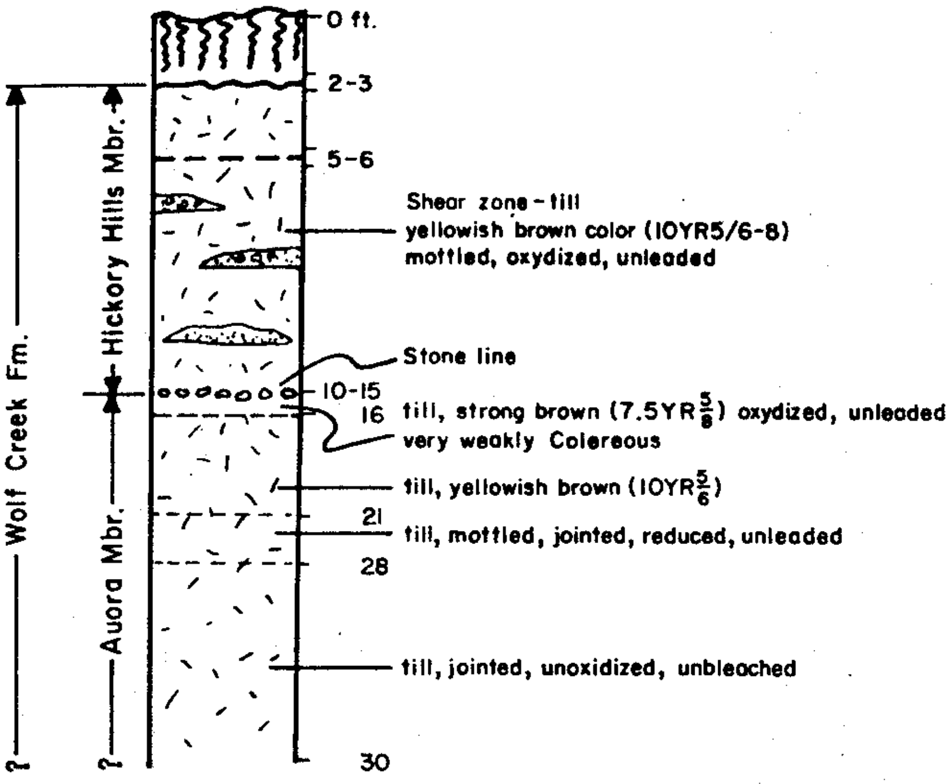


Figure 3-13. Stratigraphic Section of till units at the Westdale Mall site.

Geological Interpretations

At the Westdale Mall the basal 4-6 feet of the Hickory Hills Member is characterized by the occurrence of sheared inclusions of silt, sand and gravel, till, and silt loam diamictions. Such features have previously often been interpreted as stagnant ice deposits or ablation till. In this instance this is not the preferred explanation of their origin.

The mean bulk density of the remnant of the Hickory Hills Member present at the mall site is 107.8 lbs/ft.^{3} (1.73 g/cc). Data from similar sites in Cedar Rapids (Hallberg, 1978) show that: (1) these deposits occur at the base of the uniformly thick Hickory Hills till; (2) they are exposed because of extensive Erosion Surface development which has removed up to 40 feet of overlying till and Yarmouth-Sangamon

Paleosols; (3) geotechnical data indicates that they are moderately over consolidated as the result of the pressure of overlying glacial ice during subglacial deposition; (4) some of the sheared inclusions exhibit structures and till fabrics resembling sheared lodgement till. Clearly, the sediments contained in the Hickory Hills Till Member, including the basal shear zone, do not represent ablation till deposits.

A more acceptable explanation for the origin of the sheared inclusions is the overriding of a frontal apron of glacial sediments by the advancing ice sheet. It also provides a mechanism for the emplacement of a moderately overconsolidated till above the shear zones.

Site Engineering Characteristics

In addition to distinct mineralogical differences, the two till units have greatly different engineering properties. The section of the Hickory Hills till above the shear zone has a mean bulk density (Dd) of 110.5 lbs/ft.^{3} (1.77 g/cc) and a mean unconfined compressive strength (Qu) of 2821.1 lbs/ft.^{2} (figure 3-14). In the shear zone the mean Dd is 105.7 lbs/ft.^{3} (1.66 g/cc) and the mean Qu is 3023.9 lbs/ft.^{2}/ The standard deviation of Dd and Qu are larger in the shear zone, reflecting the variable nature of the sediments.

Figure 3-14. Engineering Characteristics (by George Hallberg)

	$\bar{x}$Qu	sQu	$\bar{x}$Dd	sDd
Hickory Hills	2906.6 lbs/ft^2	1376.9 lbs/ft^2	107.8 lbs/ft^3	6.85 lbs/ft^3
unsheared	2821.1	1168.3	110.5	4.63
sheared	3023.9	1658.8	103.7	7.74
Aurora	9263.5	2649.9	122.4	4.05

$\bar{x}$Qu = mean unconfined compessive strength
sQu = standard deviation of Qu
$\bar{x}$Dd = mean bulk density
sDd = standard deviation of Dd
(g/cc = lbs/ft.^{3} x 62.4)

The Aurora till is highly overconsolidated. The mean Dd is 122.4 lbs/ft.^{2}, a value that is 14% greater than the Hickory Hills till. The mean Qu of the Aurora proved to be 9263.5 lbs/ft.^{2}, 3 times greater than the value calculated for the Hickory Hills deposits. These increases are the result of compaction by the overriding Hickory Hills ice sheet.

The bearing capacity of a material is a function of, among other factors, Dd and Qu. All other factors being constant, increasing Dd and Qu will increase a unit's bearing capacity. Hence, the Aurora till should provide a more suitable footing for large structures. However, this till is unoxidized, indicating that it is usually saturated with ground water (Hallberg, Fenton, and Miller, 1978). This would necessitate the installation of appropriate drainage control. Also, the density contact observed at the Hickory Hills/Aurora contact commonly produces lateral ground water movement, another indication of the need for drainage control around structures footed in the Aurora.

Mall Construction

Approximately one-half (the northern half) of the Westdale Mall structure is footed in the Aurora Member. Drainage control under this portion of the Mall is provided by 4 inches of crushed stone with tile drains at 30 foot centers. The remainder of the complex is constructed on fill materill with 4 inches of crushed stone providing drainage. The structure itself does not abut the Hickory Hills/Aurora contact (which has been stripped away during construction) eliminating the lateral seepage threat to the buildings. This contact does create the possibility of bank instability where it is exposed at the margins of the parking area.

41.6 Board busses and depart Westdale Mall by turning left (northwest) onto Edgewood Road

41.7 Intersection Iowa 149 (Williams Blvd.) (stop light) Turn right (northeast) on Williams Blvd.

42.3 Intersection jct. Iowa 149, US 30, 218, 151 (16th Ave.) (stop light). Continue straight ahead on Williams Blvd. (US 151).

43.2 Williams Blvd. bends to the right (east) and becomes 1st Ave.

44.7 1st Ave. passes under Interstate 380 (I-380).

45.2 Pass over Cedar River.

45.3 Intersection with 2nd Street East (stop light). Turn left (northwest) and proceed on 2nd Street NE.

45.7 Cross under I-380 and park in the Quaker Oats Co. parking lot just east of river. STOP 9.

STOP 9 - The Five-In-One Bridge

The engineering design of bridge structures has made major strides towards convenience and ease of maintenance over the last 20 years. Costs, however, have also increased swiftly. Inflation and the costs of new technology and materials have been the major factors in this increase, along with the requirements for skilled labor.

The "5-in-1" bridge (figure 3-15) in Cedar Rapids is an award winning design for its money, energy, and material saving. The structure is a flood control dam with adjustable gates, an 8-lane interstate highway, an on-off ramp, and a combined bridge for two major streets. (figure 3-16). It replaced an obsolete flood control/power dam (figure 3-17) and one old bridge with a much improved dam and three two-way river crossings with a total of 13 traffic lanes. The structure will not only control flood waters on the Cedar River, but will also funnel more than 60,000 autos and trucks in and out of downtown Cedar Rapids on a given business day (figure 3-18).

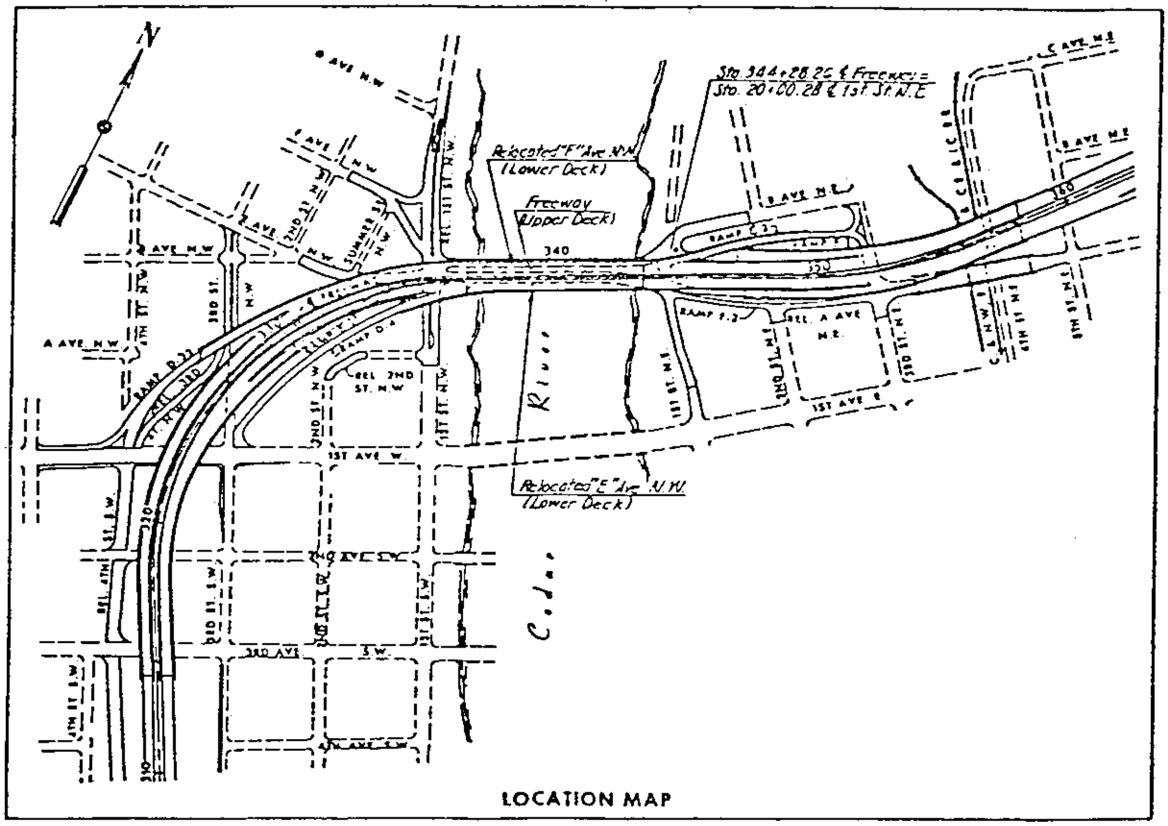
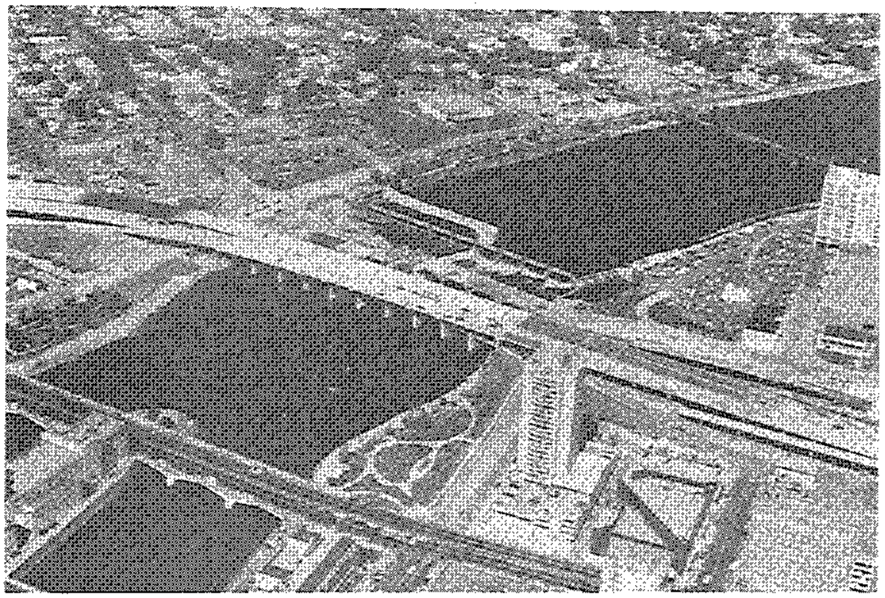


Figure 3-15. Map and photo of the 5-in-1 bridge and approaches.



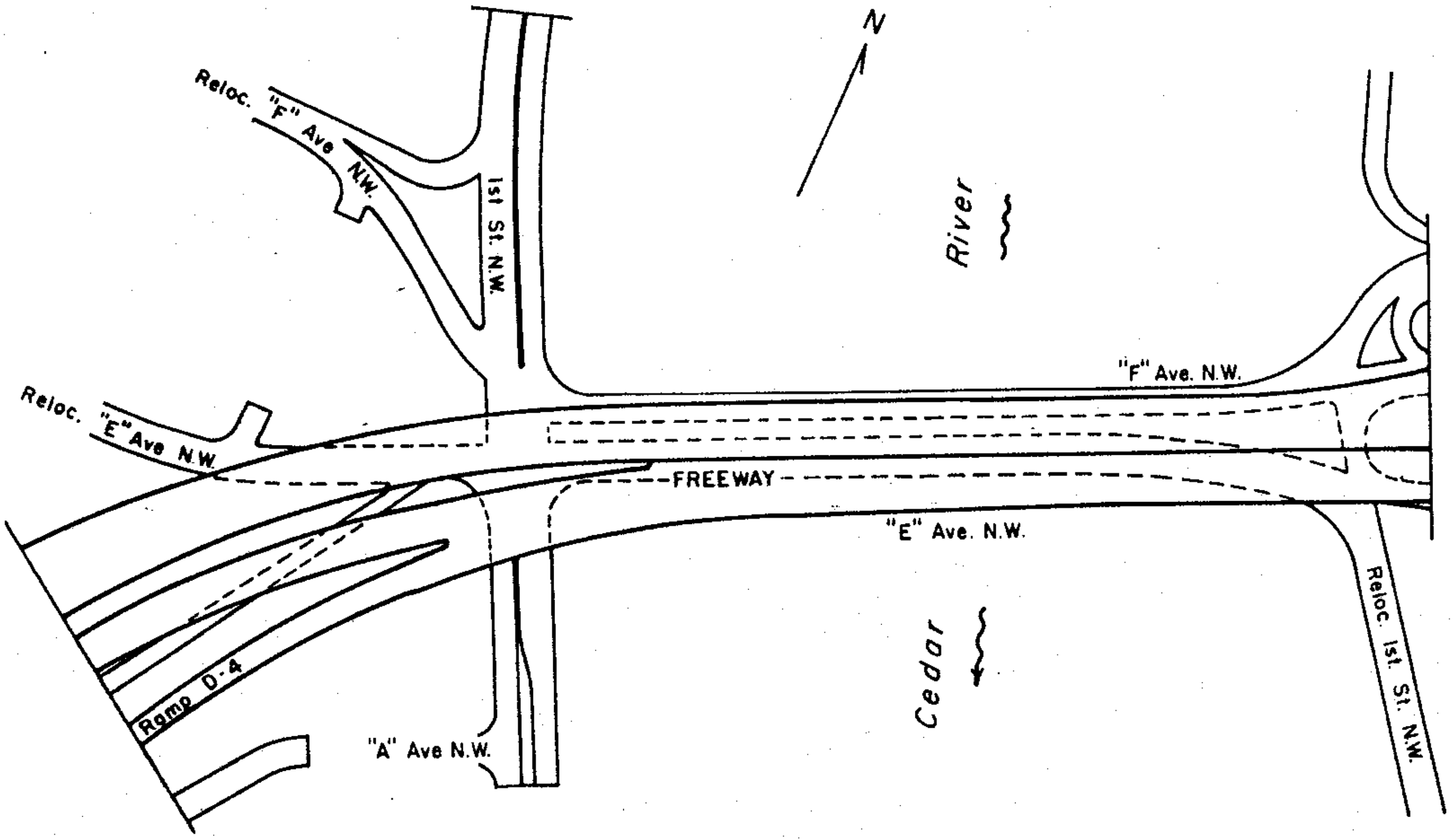


Figure 3-16. Road configuration in the 5-in-1 bridge and dam.

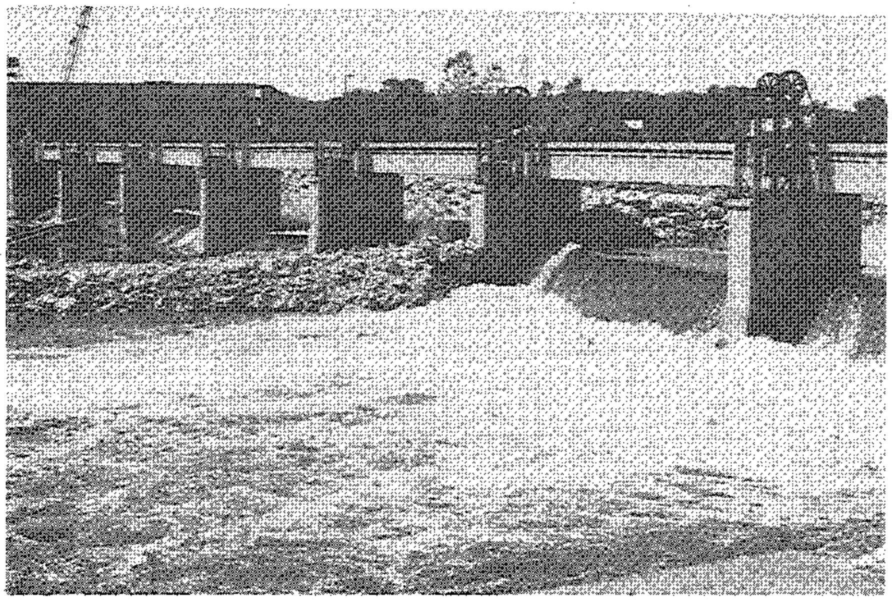


Figure 3-17. Photo of old dam being dismantled

The structure crosses the river at a location where bedrock of Cedar Valley Limestone Formation (Middle Devonian) is exposed in the river bed. The setting of pillars in this area was, then, relatively simple (see figure 3-19 and 3-20). Test drilling for the approaches, however, revealed quite a different base. Deep preglacial and glacial valleys filled with fluviatile sediment underlies both approaches (see figure 3-21). Unlike the rocks of the Cedar Valley Formation that we studied at the Crawford Quarry (STOP 1) and the Morgan Creek Quarry (STOP 7), the limestone underlying the bridge is denser, and folding and fracturing is not pronounced. This created a situation where the excavation for the bridge itself was less of a problem than was the work necessary at either approach. The west approach is elevated on a

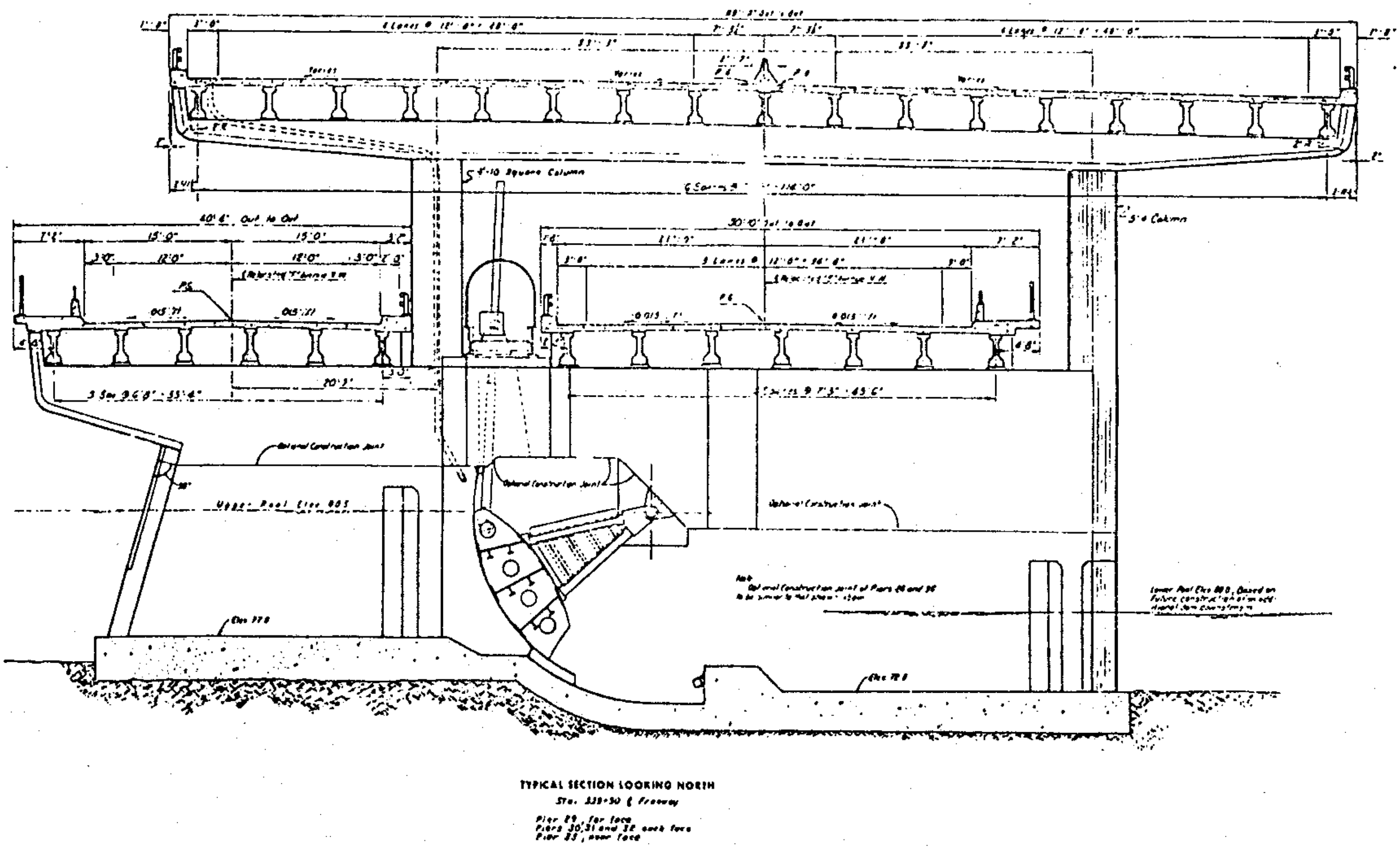


Figure 3-18. A typical cross-section of the 5-in-1 bridge and dam (looking north).

HOWARD, NEEDLES, TAMMEN & BERGENDOFF

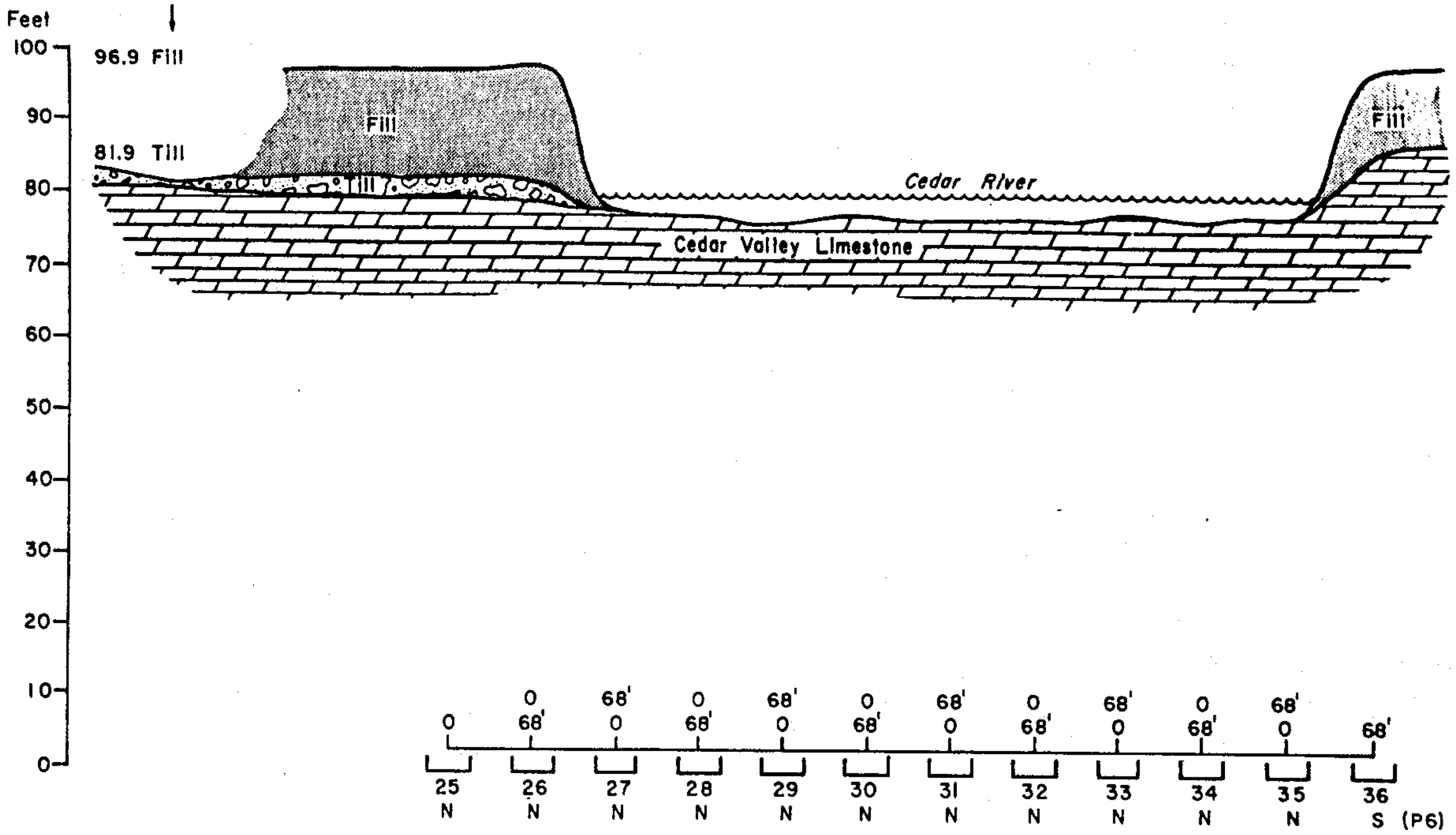


Figure 3-19. A cross-section of the Cedar River valley at the site of the 5-in-1 bridge and dam.

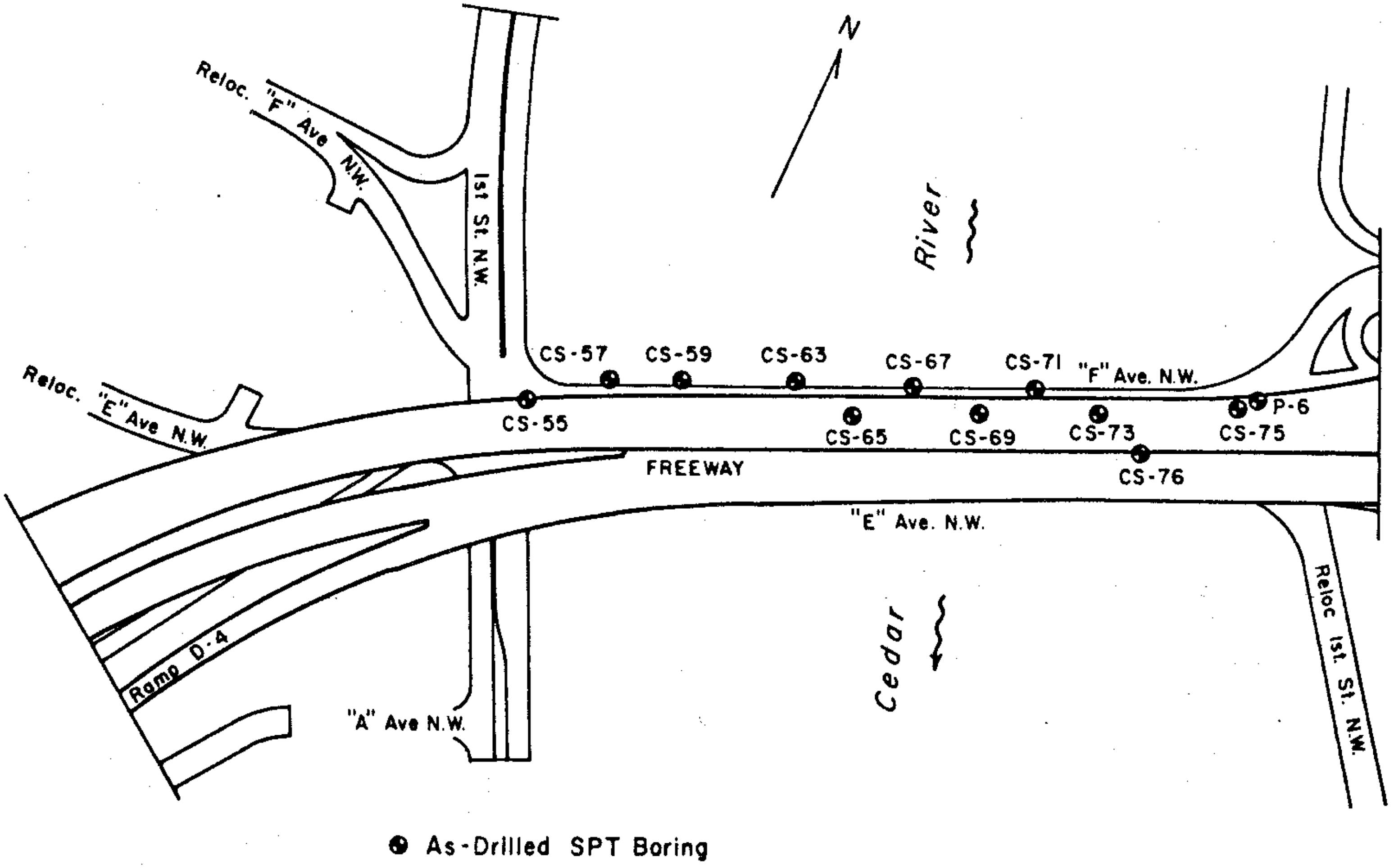


Figure 3-20. Map view of the 5-in-1 bridge showing pier borings.

filled corridor; the east approach was extensively excavated beyond the river floodplain. The material removed from this excavation was moved away from the river where it was encorporated into the filled corridor upon which the highway is constructed as it bends to the north. Upon departing from this STOP we will visit the Masonic Temple, allegedly damaged as a result of this excavation. Iowa Department of Transportation geologist Kermit Dirks has stated that special problems were encountered as the excavation crossed an old power plant fly ash dump.

Bridge and Pier Data

Base line elevation for this project was 627.42 feet above mean sea level. All vertical measurements are calculated from the base line elevation (0). Eleven concrete footings (piers) are set at +68 ft. on the south side of the bridge and +73 ft. on the north. A four feet concrete pad covers the river bed at the upper and lower ends of the spillway. A 2.5 foot concrete pad underlies the flood control gates (figure 3-18).

The bridge is designed to maintain an upper pool level of +90.5 feet. Lower pool levels will vary with flow conditions pending construction of a downstream dam.

The 8 lanes of I-380 which compose the top level of the structure were constructed at an elevation slightly below 135 feet. This means that the structure rises 67 feet (more than 5 stories) above the footings. The bridge is 684 feet long, and the 8 lane upper deck is 120 feet wide. An estimated 18,000 cubic yards of concrete and 1650 tons of structural and reinforcing steel went into the bridge (exclusive of materials used in the flood control gates and equipment).

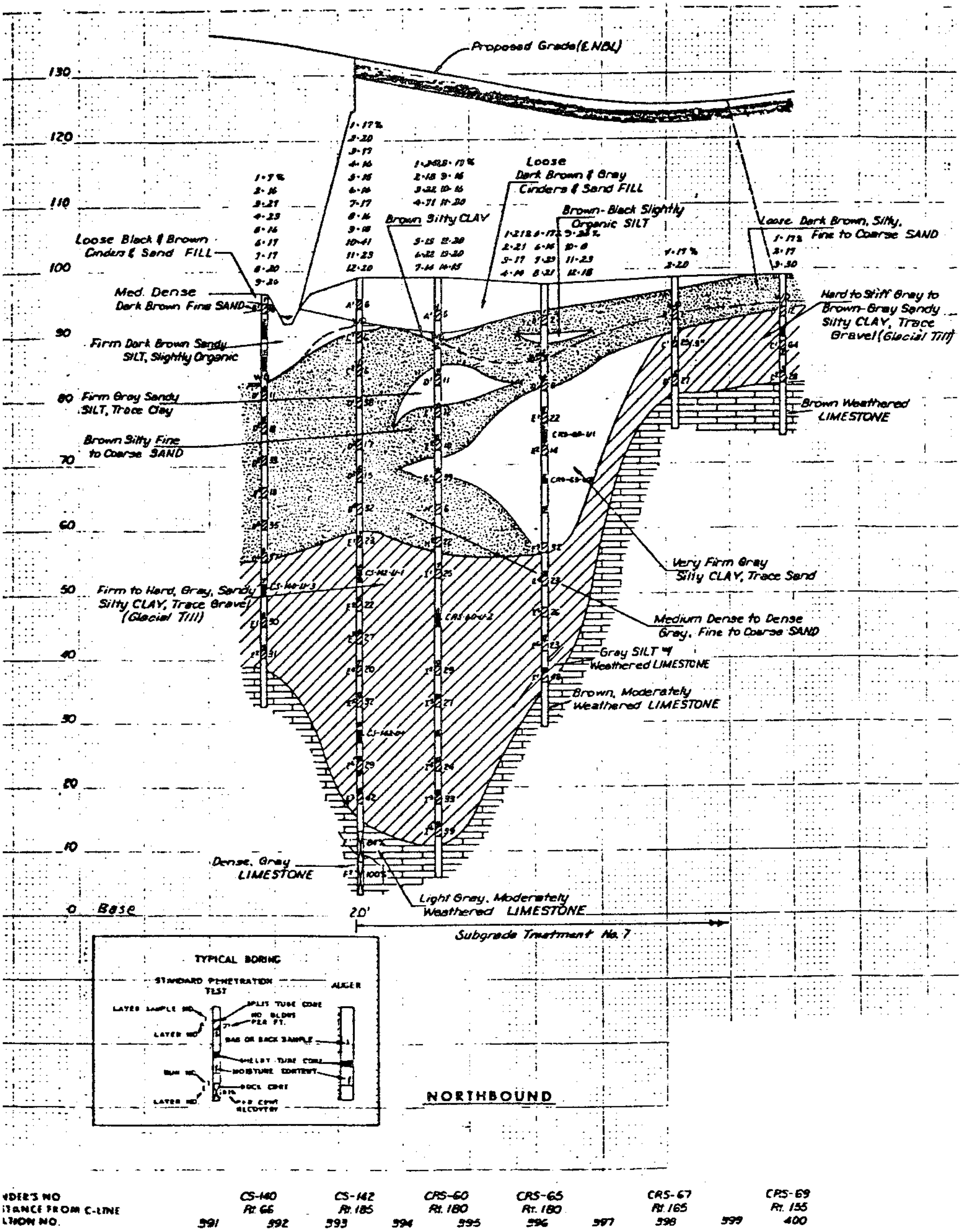
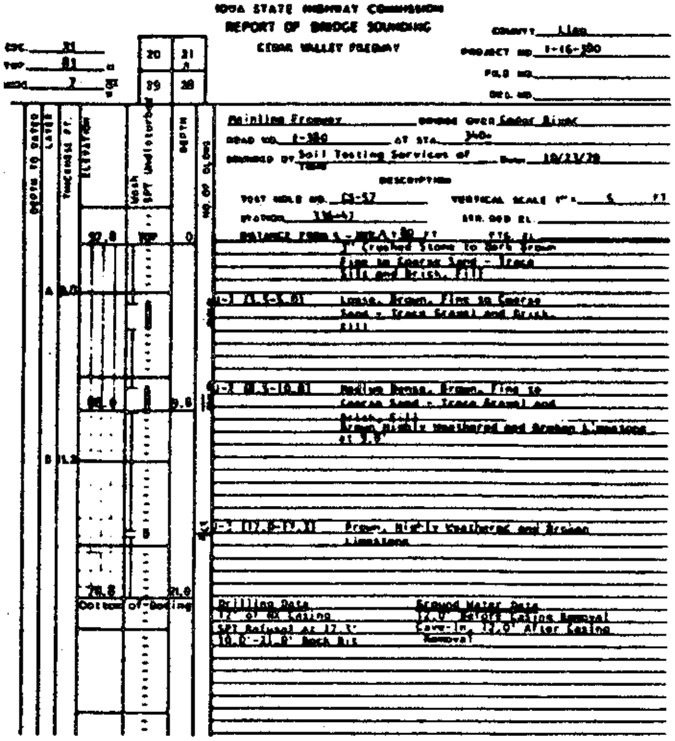


Figure 3-21. Channel cut into Cedar Valley Limestone on the east approach to the 5-in-1 bridge.



IOWA STATE HIGHWAY COMMISSION
REPORT OF BRIDGE SOUNDING
CEDAR VALLEY FREEWAY

County Linn
Project No. I-IG-380
Sec. 21 Twp. 83 N Rge. 7 W

Mainline Freeway — Bridge over Cedar River
Road No. I-380 at Sta. 340+
Sounded by Soil Testing Services of Iowa — Date 10/23/70
Test Hole No. CS-57 — Vertical Scale 1" = 5 ft.
Station 336+47

3" Crushed Stone to Dark Brown Fine to Coarse Sand - Trace Silt and Brick, Fill

S-1 (3.5-5.0) Loose, Brown, Fine to Coarse Sand - Trace Gravel and Brick, Fill

S-2 (8.5-10.0) Medium Dense, Brown, Fine to Coarse Sand - Trace Gravel and Brick, Fill
Brown Highly Weathered and Broken Limestone at 9.8'

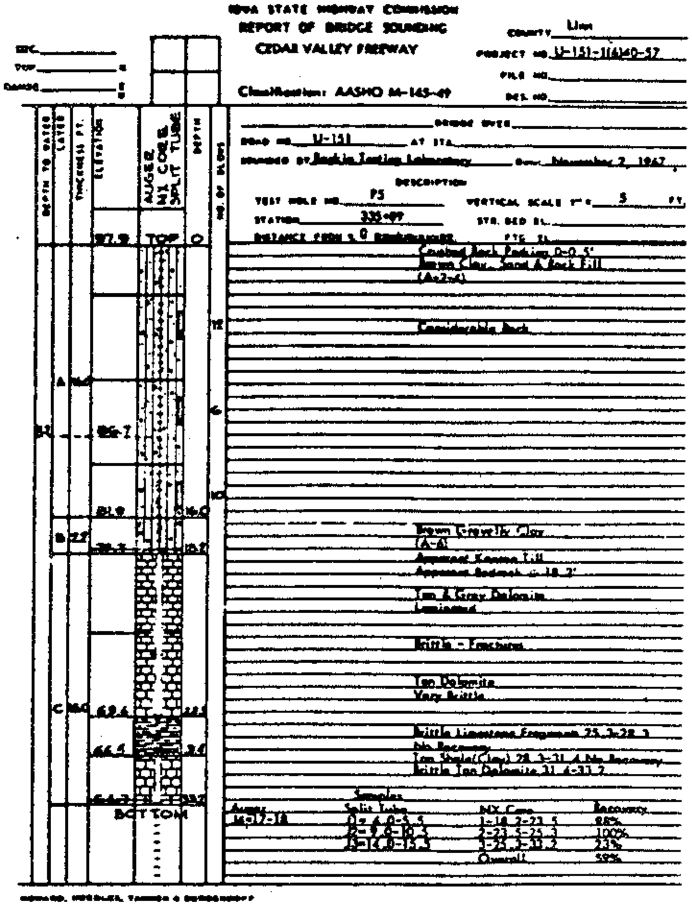
S-3 (17.0-17.3) Brown, Highly Weathered and Broken Limestone

Bottom of Boring

Drilling Data
17' of NX Casing
SPT Refusal at 17.3'
10.0'-21.0' Rock Bit

Ground Water Data
12.0' Before Casing Removal
Cave-In, 12.0' After Casing Removal

PIER 26 S.B.



IOWA STATE HIGHWAY COMMISSION
REPORT OF BRIDGE SOUNDING
CEDAR VALLEY FREEWAY
Classification: AASHO M-145-49

County Linn
Project No. U-151-1(4)40-57
Road No. U-151
Sounded by Bockin Testing Laboratory — Date November 2, 1967
Test Hole No. P5 — Vertical Scale 1" = 5 ft.
Station 335+97

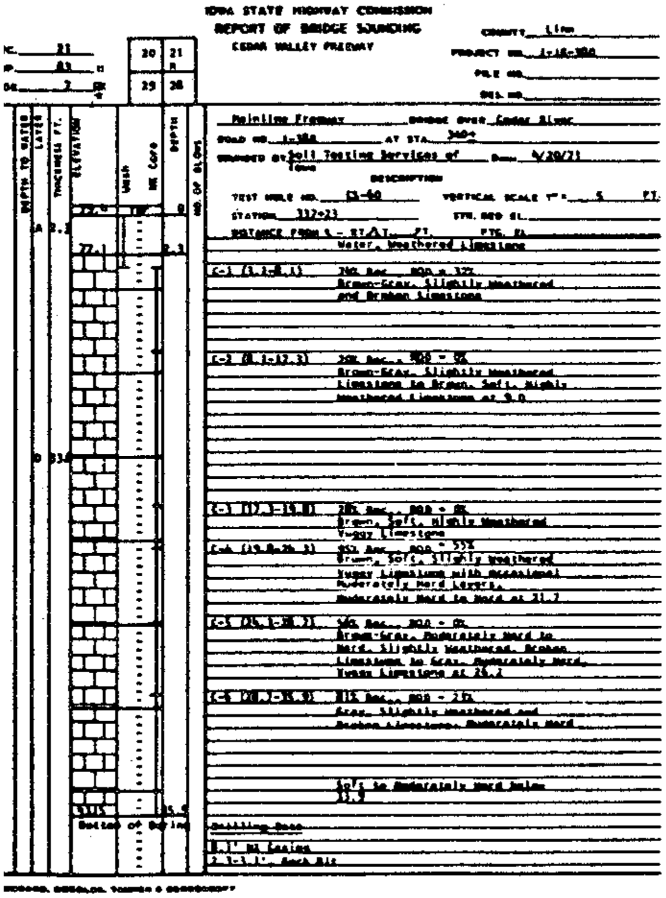
Crushed Rock Padding 0-0.5'
Brown Clay, Sand & Rock Fill (A-2-4)
Considerable Rock
Brown Gravelly Clay (A-6)
Apparent Kansan Till
Apparent Bedrock @ 18.2'
Tan & Gray Dolomite Laminated
Brittle - Fractures
Tan Dolomite Very Brittle
Brittle Limestone Fragments 25.3-28.3 No Recovery
Tan Shale(Clay) 28.3-31.4 No Recovery
Brittle Tan Dolomite 31.4-33.2

BOTTOM

Samples

Auger	Split Tube	NX Core	Recovery
16-17-18	1 = 4.0-5.5	1-18.2-23.5	98%
	2 = 9.0-10.5	2-23.5-25.3	100%
	3 = 14.0-15.5	3-25.3-33.2	23%
		Overall	59%

PIER 25 N.B.



IOWA STATE HIGHWAY COMMISSION
REPORT OF BRIDGE SOUNDING
CEDAR VALLEY FREEWAY

County Linn
Project No. I-IG-380
Sec. 21 Twp. 83 N Rge. 7 W

Mainline Freeway — Bridge over Cedar River
Road No. I-380 at Sta. 340+
Sounded by Soil Testing Services of Iowa — Date 4/20/71
Test Hole No. CS-60 — Vertical Scale 1" = 5 ft.
Station 337+23

Water, Weathered Limestone

C-1 (3.3-8.1) 74% Rec., RQD = 32% Brown-Gray, Slightly Weathered and Broken Limestone

C-2 (8.1-12.3) 30% Rec., RQD = 0% Brown-Gray, Slightly Weathered Limestone to Brown, Soft, Highly Weathered Limestone at 9.0

C-3 (17.3-19.8) 28% Rec., RQD = 0% Brown, Soft, Highly Weathered Vuggy Limestone

C-4 (19.8-24.3) 85% Rec., RQD = 55% Brown, Soft, Slightly Weathered Vuggy Limestone with occasional Moderately Hard Layers, Moderately Hard to Hard at 21.7

C-5 (24.3-28.3) 56% Rec., RQD = 0% Brown-Gray, Moderately Hard to Hard, Slightly Weathered, Broken Limestone to Gray, Moderately Hard, Vuggy Limestone at 26.2

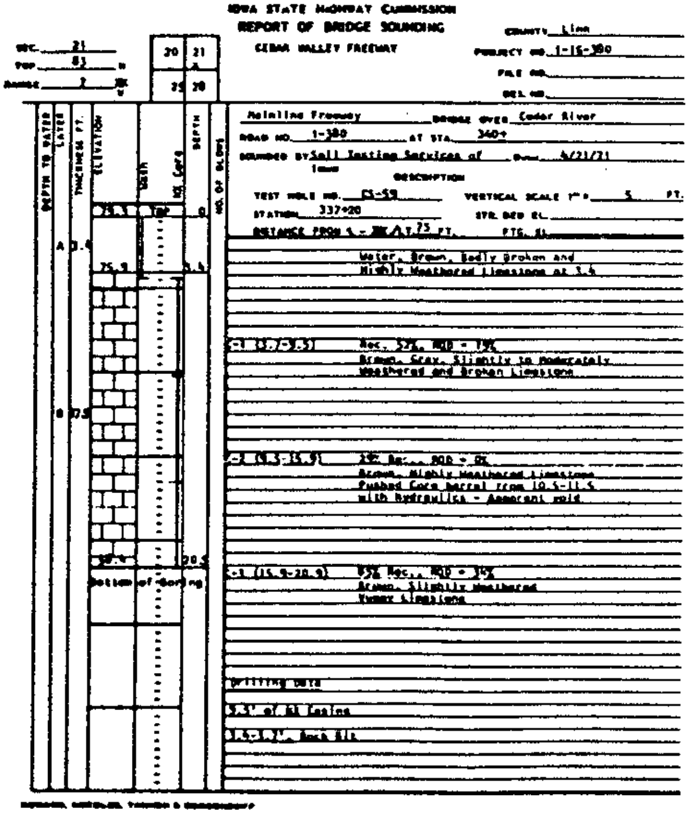
C-6 (28.3-35.9) 81% Rec., RQD = 21% Gray, Slightly Weathered and Broken Limestone, Moderately Hard

Soft to Moderately Hard below 33.9

Bottom of Boring

Drilling Data
3.3' NX Casing
2.3-3.3', Rock Bit

PIER 27 N.B.



IOWA STATE HIGHWAY COMMISSION
REPORT OF BRIDGE SOUNDING
CEDAR VALLEY FREEWAY

County Linn
Project No. I-15-380
Sec. 21 Twp. 83 N Range 7 W

Mainline Freeway — Bridge over Cedar River
Road No. I-380 at Sta. 340+
Sounded by Soil Testing Services of Iowa — Date 4/21/71
Test Hole No. CS-59 — Vertical Scale 1" = 5 ft.
Station 337+20

Water, Brown, Badly Broken and Highly Weathered Limestone at 3.4

C-1 (3.7-9.5) Rec. 57%, RQD = 19% Brown, Gray, Slightly to Moderately Weathered and Broken Limestone

C-2 (9.5-15.9) 29% Rec., RQD = 0% Brown, Highly Weathered Limestone Pushed Core barrel from 10.5-11.5 with hydraulics - Apparent void

C-3 (15.9-20.9) 95% Rec., RQD = 34% Brown, Slightly Weathered Vuggy Limestone

Bottom of Boring

Drilling Data
3.3' of NX Casing
3.5-3.7', Rock Bit

PIER 27 S.B.

Figure 3-22. Four sample logs of bridge pier boreholes.

All piers were set into the Cedar Valley Limestone, which is locally covered by glacial till, alluvium, or soils. Frequent zones of deep scouring and weathering of the bedrock as a result of preglacial exposure and/or glacial and periglacial action were discovered. These zones, creating significant irregularities in the bedrock surface, were encountered beneath both east and west approaches preglacial valleys were also encountered in test borings east of the river. This includes a 60 foot deep channel identified 1500 feet east of the bridge (figure 3-21). A similar channel at a Waterloo (90 miles north) bridge site is 180 feet deep. Typical logs from test borings are displayed on figure 3-22.

45.7 Board busses. Proceed south to A Avenue and continue east across railroad tracks on viaduct.

45.9 Turn left (northwest) into parking lot at west end of Masonic Temple. STOP 10.

STOP 10 - Excavation Damage ?

Examine the structural damage evident at the northwest corner of the Masonic Temple. This damage is allegedly a result of excavation for I-380.

45.9 Board busses and proceed southwest to 3rd Street (or the closest open I-380 interchange). Enter I-380 and head southeast.

46.2 Cross the 5-in-1 bridge.

49.9 Kirkwood Blvd. and US 30 east exit. Exit and follow route to Kirkwood Blvd.

51.1 Intersection with Kirkwood Blvd. Turn right (south) and return to Kirkwood College).

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TRIP 4

GEOMORPHOLOGY AND BASAL MAQUOKETA STRATIGRAPHY IN THE VICINITY OF DUBUQUE

Jean C. Prior[1] and Richard C. Heathcote[2]

DISCUSSION

Northeast Iowa is well known among geologists for the excellent opportunities it provides to examine the stratigraphy and paleontology of the Lower Paleozoic section as well as to observe geomorphic features which contrast significantly with the familiar glacial plains of the Midwest. This trip is designed to briefly sample these relationships in the vicinity of Dubuque.

Most of Iowa's bedrock geology lies buried beneath deposits of glacial drift and loess (fig. C) which have obscured the high relief of the pre-glacial surface and have developed their own distinctive landscape patterns (Prior, 1976). However, the Upper Mississippi Valley area of northeast Iowa, southeast Minnesota, southwest Wisconsin and northwest Illinois comprises a region of unusually rugged relief to which people are drawn for its scenic beauty and to which midwestern geologists make seasonal migrations to reacquaint themselves with bedrock geology.

For years this area has been referred to as the "Driftless Area" in the belief that it had been by-passed by the Pleistocene glaciers. However, isolated deposits of drift are known to exist in a number of places throughout northeastern Iowa (Trowbridge, 1966) which indicate at least some contact with an early glacial episode and may even suggest

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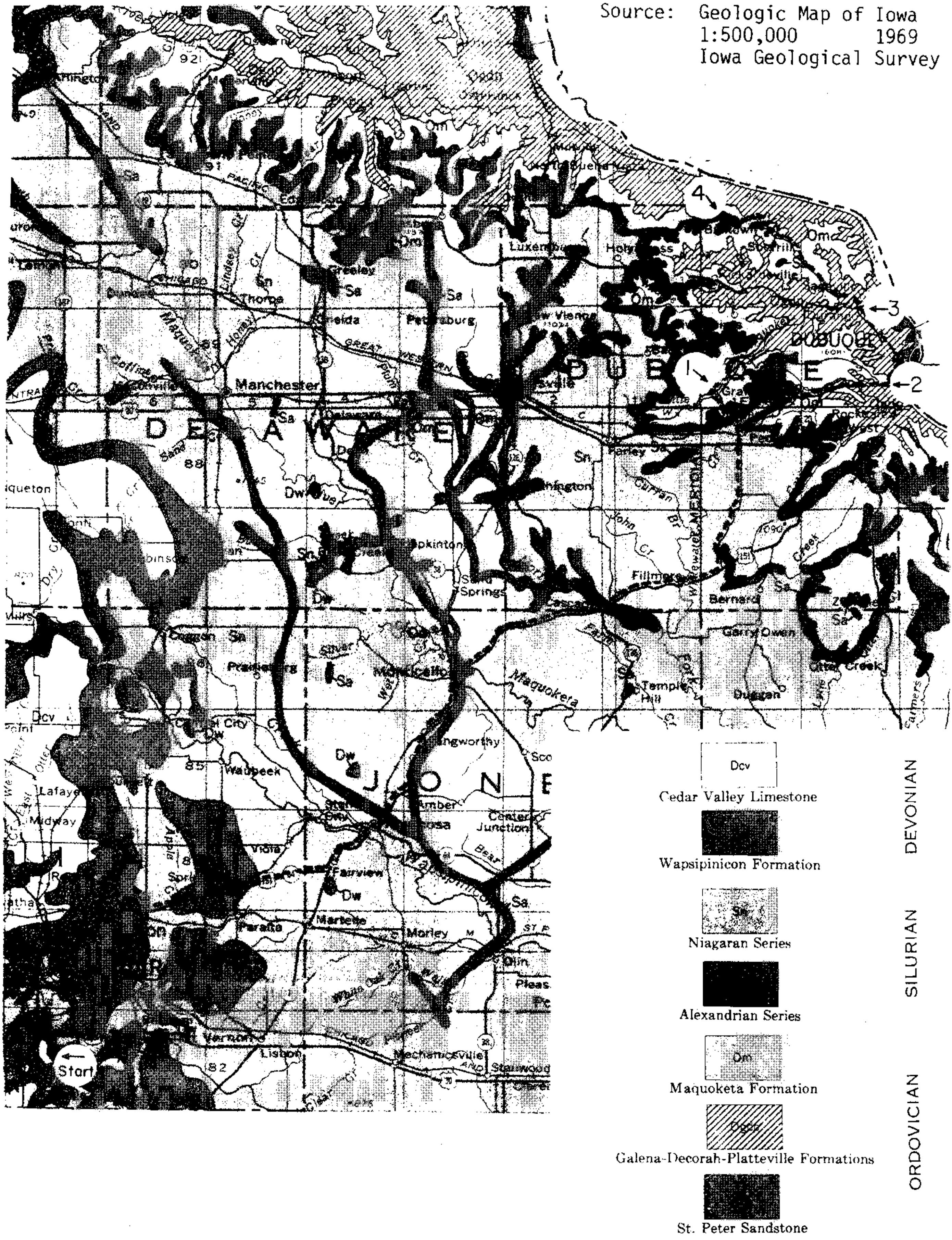
more extensive glacial cover at one time, with subsequent removal by erosion during the time of development of the Iowan Erosion Surface (Hallberg, Personal Communication, 1978).

Since occurrences of glacial drift in the Upper Mississippi Valley area are rare and the loess covering is thin, their effect on the terrain is minimal, and the topography is dominantly related to differential weathering and erosion of the gently dipping (SW) Paleozoic rock formations immediately beneath the land surface. The result is a landscape characterized by level to gently rolling, plateau-like uplands, an angular stepped skyline, deep V-shaped and entrenched valleys, sharply ridged interstream divides, numerous bedrock exposures and, on a smaller scale, such geologic features as caves, waterfalls, rapids, springs, and sinkholes.

The city of Dubuque is situated at the southern gateway to this distinctive and picturesque bedrock-controlled terrain. Approached from the south or west, the road descends quickly through a series of rock-lined cuts which mark the leading edge of the Silurian Escarpment. Composed of resistant Llandoverian dolomite formations (fig. A), this conspicuous bluff line traces a sinuous and prominent route across the northeastern Iowa landscape (fig. 4-1). Beneath the Silurian, the Ordovician-age Maquoketa Shale and Galena Dolomite are exposed. From Dubuque nearly to Guttenberg, the landscape is rich in scenic terrain features which clearly reflect control by these rock units (fig. B).

The Maquoketa Shale formation (Cincinnatian) of Dubuque County occurs above the massively bedded Galena Dolomite, and underlies the broad slopes which support small agricultural operations. The Elgin Shaley Limestone, Brainard, and Neda Members of the Maquoketa have been recognized in this area.



Source: Geologic Map of Iowa
1:500,000 1969
Iowa Geological Survey

Figure 4-1. Bedrock Geology with field trip stops.

The Elgin Shaley Limestone is 8-18m (26-60 ft.) of brown to blue-gray shaley dolomite and limestone underlain by 1-2m (3-6 ft.) of black to brown, richly fossiliferous phosphorite. In most of northeastern Iowa the Clermont Shale and Fort Atkinson Limestone Members overlie the Elgin; however, in the Dubuque area these facies of the Maquoketa Shale are not recognized, and the undifferentiated shales above the Elgin Shaley Limestone are called "Brainard". Thin dolomite beds which may range from a barren microsporite to nearly a coquina are developed sporadically throughout the Brainard.

The top of the Brainard Member is marked by a para-conformable contact which features up to 30m (100 ft.) of erosional relief. The Neda oolitic ironstone 0-2m (0-7 ft.) occurs above the thicker portion of the Brainard Member--that is, atop the highest hills of the upper Ordovocian landscape. Silurian-age dolomites overlie the Brainard and Neda Members (fig. 4-2).

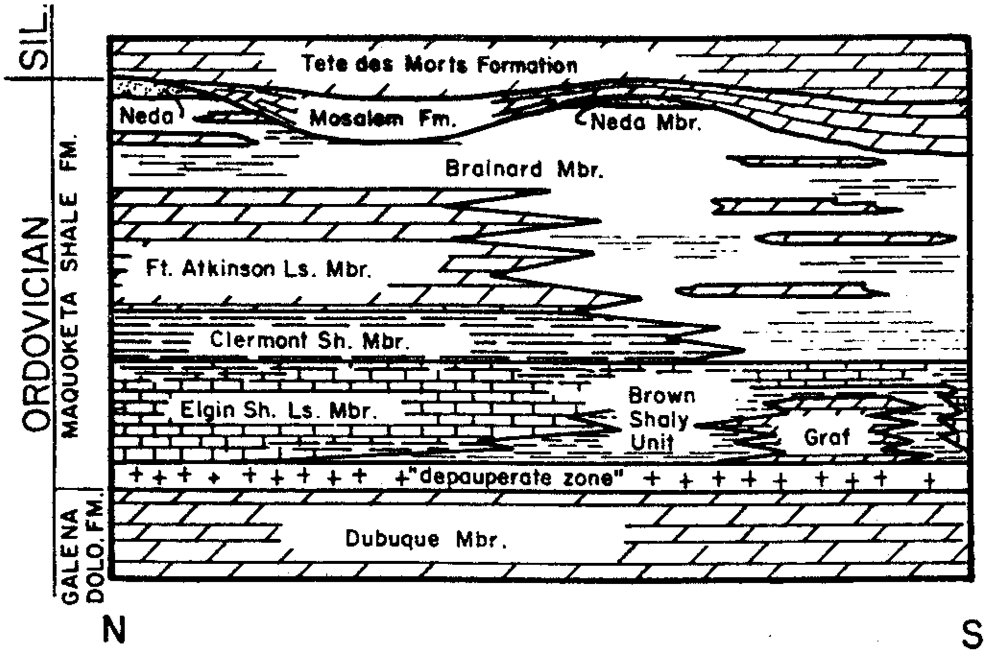


Figure 4-2. Northwest-southeast schematic section of the Maquoketa Formation in eastern Iowa.

A consistent picture of Maquoketa deposition is now developing from research in progress at the University of Iowa by Brian Witzke and Richard Heathcote. During Maquoketa time a shallow trough existed in Iowa between the emergent Ozarkia landmass to the south and an as yet poorly defined mass to the north (Siouxia ? see fig. 4-3).

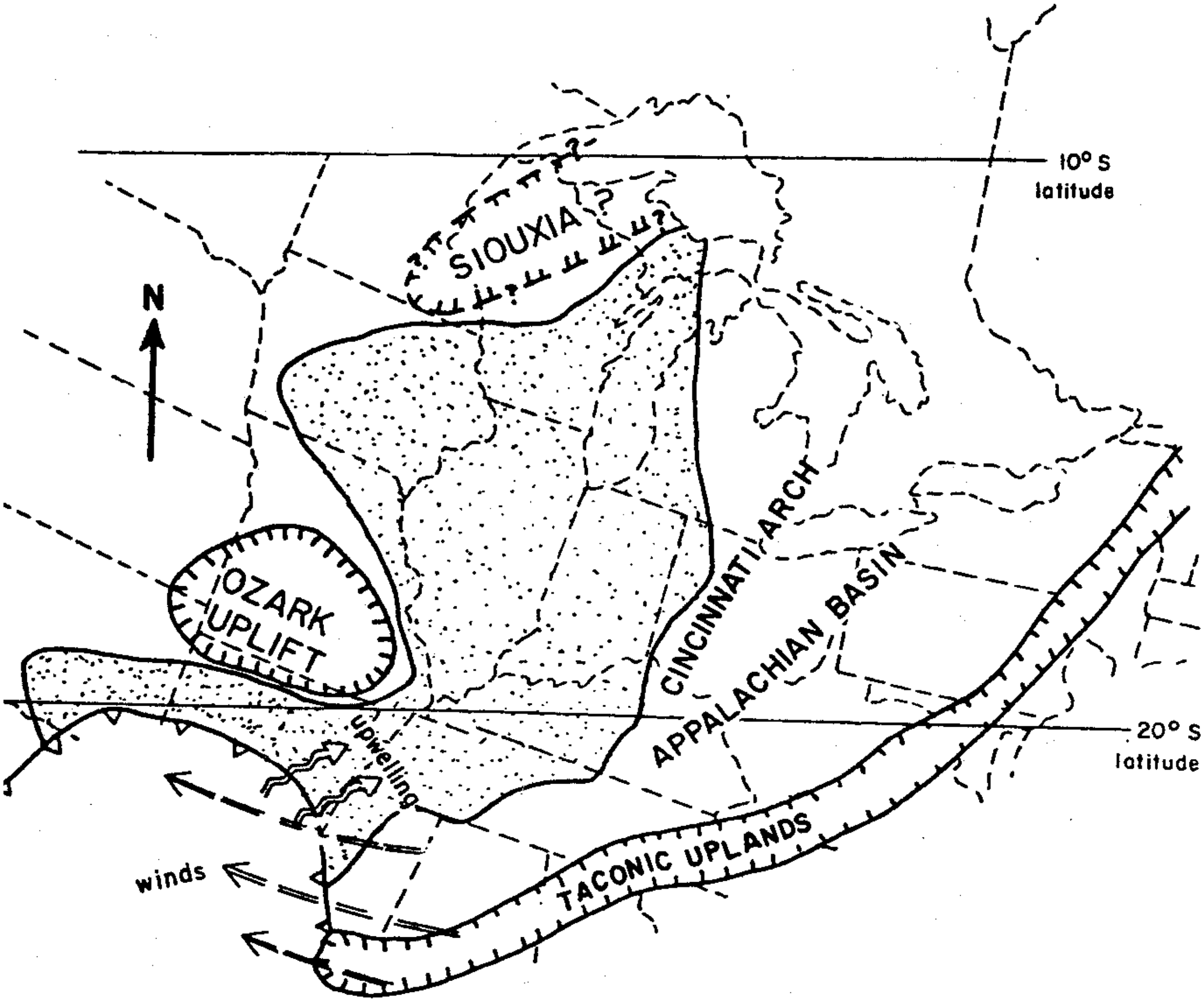


Figure 4-3. Palinspastic reconstruction of Late Ordovician (Maysvillian) epicontinental sea. Stippled area delimits phosphatic deposits, generally with diminutive fauna.

The phosphatic beds at the base of the formation represent a deepening of the sea after deposition and dolomitization of the underlying Galena Dolomite. Subsequent upwelling in the deeper portions of this Ordovician sea (Alabama, Mississippi region) ultimately circulated phosphate-rich waters throughout the basin (fig. 4-3). At this time the Utica/Queenston and Juniata delta complexes were building westward from the Taconic upland in southern New England and Virginia. Between the Taconic and Ozarkia landmasses counterclockwise basinal circulation winnowed fine clastic material from these deltaic systems and transported it westward while other clastic material was being shed into the Iowa region from Ozarkia and the northern landmass.

The blanket of shales and shaley limestones created by the steady flow of clastic material into Iowa was punctuated locally by development of shallow carbonate banks. These banks commonly supported abundant molluscs, brachiopods, trilobites and bryozoans.

The "dwarfed fauna" which is well known from the "depauperate zone" of the basal phosphorite actually recurs throughout the Maquoketa Shale formation whenever carbonates are present. The "depauperate" notion has been discarded in favor of a paedomorphic fauna composed of those species whose fecundity allowed them to adapt quickly to high stress environments such as the suboxic bottom waters of a phosphorite depositing system.

ROAD LOG

Mileage

0.0 South parking lot, Iowa Hall, Kirkwood Community College.

Iowa Hall is located on a paha, one of numerous elongate hills which trend northwest-southeast along the lobate southern margins of the Iowan Erosion Surface (fig. C). Core-drilling under the direction of R.V. Ruhe of selected paha and their surrounding plains led to the conclusion that the "Iowan" was not a separate Wisconsinan drift sheet, nor was the topography characteristic of ice-modified terrain (Ruhe, et. al., 1968). Rather, the Iowan Surface is a widespread erosion-surface complex developed by normal processes of subaerial erosion on a paleosol-covered landscape of Kansan till during Wisconsinan loess deposition. The paha stand above the stepped erosion surface as topographic and stratigraphic remnants of the uneroded Kansan till with its paleosol intact, and capped the total thickness of loess deposited in this area during Wisconsinan time.

0.5 Leave campus area and turn right (north) on Kirkwood Blvd.

1.2 On-ramp to U.S. 30 (east).

6.5 Bridge over the Cedar River.

The Cedar Valley Limestone, a Middle Devonian formation, is named for exposures along this river valley.

7.1 Junction with Iowa Rt. 13; turn right for Rt. 13 (north).

7.6 Exposures of Wapsipinicon Formation in roadcut.

9.6 New sewage disposal plant for the city of Cedar Rapids under construction on the left. Just beyond the hill to the right is the type section of the Bertram, lowest member of the Middle Devonian Wapsipinicon Limestone.

13.5 Squaw Creek Park, one of many fine municipal parks maintained by the city of Cedar Rapids.

15.0 Junction with U.S. Rt. 151; turn right (east).

For the next 12 miles we will be crossing one of the larger extensions of the irregular southern margin of the Iowan Surface. The terrain is characteristic of this distinctive topographic region, with a level to gently rolling land surface, long slopes, low relief and open views.

17.8 Alpha Stone Company gravel pit on right.

20.2 Town of Springville.

24.8 Jones County line; sign to Weber Stone Company.

The Weber Stone Company Quarry at Stone City is the site of today's alternative field trip. Here the distinctive dimension stone known as "Anamosa Stone" has been quarried since the early 1860's. The Anamosa is an inter-reef facies of the Silurian Gower Formation.

26.2 Junction with Iowa Rt. 1; continue east.

Rough terrain for the next few miles is associated with dissection along the Wapsipinicon River valley. Loess-mantled Kansan drift.

29.5 Wapsipinicon River with Silurian rock exposed in quarry on left.

31.2 Junction with Iowa Rts. 428 and 64. Continue northeast on Rt. 151. The town of Anamosa is to the left.

37.7 Town of Langworthy. Route continues to cross small extensions of Iowan Surface.

41.0 Town of Monticello.

42.2 Cross the Maquoketa River.

51.4 Town of Cascade. Cross the North Fork of the Maquoketa River. Enter Dubuque County.

54.4 Silurian exposures.

56.7 Cross White Water Creek.

59.9 Junction with County Y-21; turn left (north); Fillmore Sacred Heart Church on NE corner of intersection.

67.5 Junction with U.S. Rt. 20; continue north.

68.2 Town of Peosta.

69.2 Junction with old U.S. 20; turn left (west).

69.7 Junction with gravel road on right; turn right (north); note rolling upland topography to the west composed of loess-mantled Kansan drift (thin) over Silurian bedrock.

70.4 Scenic view to the northeast as we begin descent of the Silurian Escarpment.

This prominent physiographic feature is formed by the leading edge of the outcrop belt of Silurian (Niagaran) dolomite. This resistant rock unit may be traced through several states east of Iowa, to its type section and most famous effect on the landscape--Niagara Falls, New York.

71.4 Bear left; cross Little Maquoketa River.

71.7 Turn right toward the hamlet of Graf, and right again.

72.0 Graf Section - STOP 1

This stop to examine the Basal Maquoketa section and its fauna, also provides a good opportunity to view the characteristic break in slope that marks the contact between the resistant, timber-covered Silurian dolomites, and the more easily weathered, and pastured or cultivated slopes developed on the underlying Maquoketa Shale.

At Graf, the phosphorite described in the disucssion section is no longer exposed, but grades upward into a black to blue-gray phosphatic shale and shaly dolomite typical of the Elgin Shaly Limestone Member. Above this, however, lay 7m (23 ft.) of enigmatic shaly dolomite including the famous "*Orthoceras* beds" (fig. 4-4). These beds are not known to occur elsewhere in the Maquoketa system, and the geometry and local marine conditions which formed them, and resulted in the telescoping of as many as five nautiloids together remain a mystery. The concept of a high-energy, shoal environment, as is often invoked, does not explain why the fragile fossils were not extensively broken and abraded, or the absence of high-energy sedimentary features (bottom scours, etc.). Figure 4-4 is the measured and described section of the Maquoketa Shale at Graf. Figure 4-5 is an abbreviated faunal listing of the Elgin Member in Iowa.

Turn around and return to old U.S. 20.

74.9 Junction with old U.S. 20; turn left (east).

76.2 Town of Centralia.

77.7 Begin descent from Silurian uplands to Maquoketa slopes.

79.4 Town of Julien.

80.2 Junction with new U.S. Rt. 20; turn left (east).

82.0 City of Dubuque.

The city was founded in 1788 by Julien DuBuque, a French-Canadian who, with permission of the Indians and Spanish authorities, developed lead mines in the area which became known as the "Mines of Spain". These mines were part of what is now the Upper Mississippi Valley Lead-Zinc District.

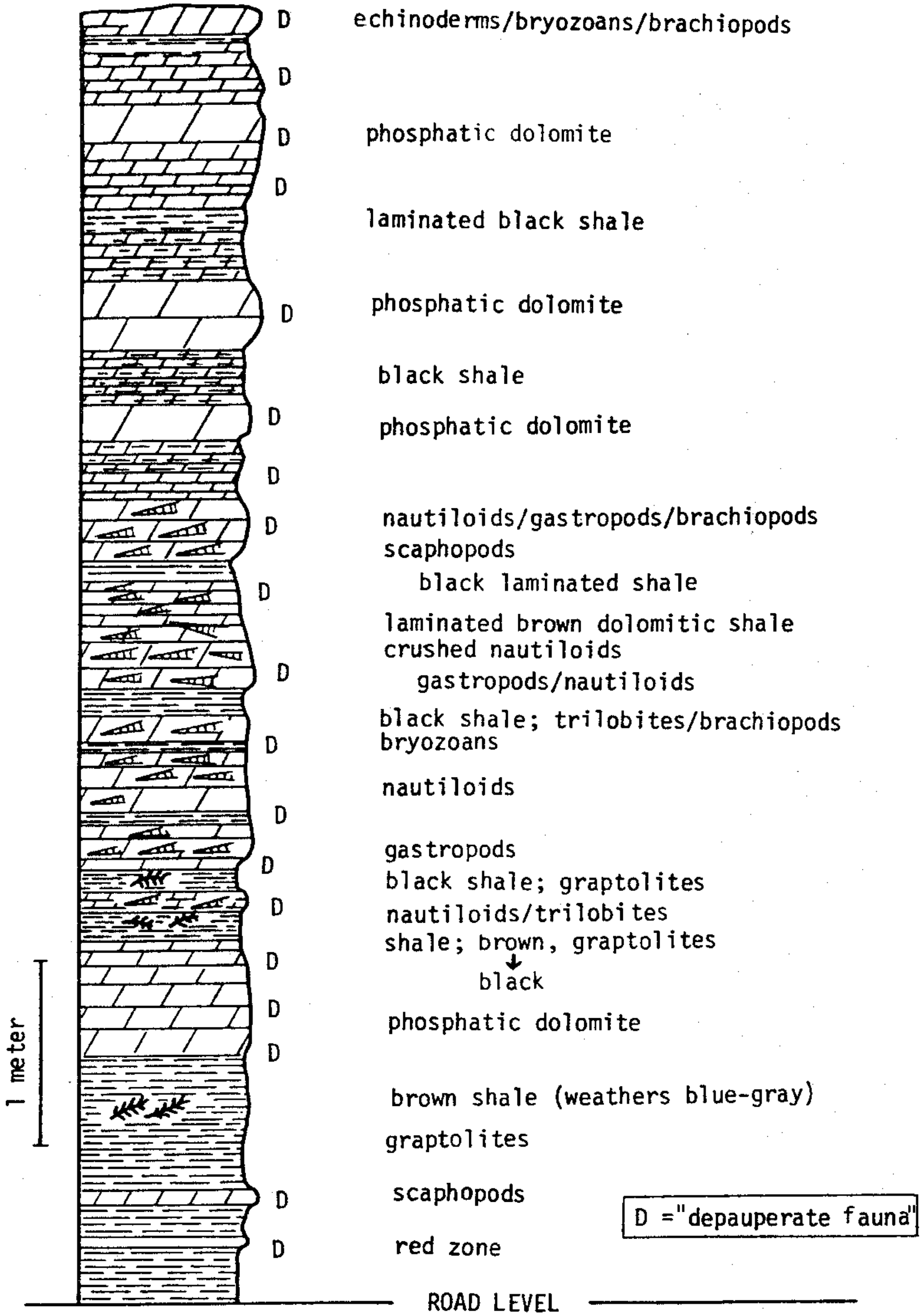


Figure 4-4. The Graf section of the Elgin Shaly Limestone Member of the Maquoketa Shale Formation. (B. Witzke, 1977)

Figure 4-5

Elgin Member: Abbreviated Faunal List for Iowa.

*Bivalves:
Praenucula
Palaeoconcha
Palaeoneilo
Nuculites

Nautiloids:
Pseudorthoceras
Endoceras
Cyclendoceras

*Gastropods:
Cyrtolites
Bucanella
Tropidodiscus
Liospira
Loxoplocus
Pleurotomoria
Holopea
Bucania
Cyclonema
Murchisonia
Hormotomaria
Cyclora

*Amphineurans: Septemchiton

*Hyolithids: Hyolithes

*Scaphopod: Plagioglypta

Brachiopods:
*Leptobolus
*Contreta
*Scaphelasma
Glyptorthis
Plasiomys
*Diceromyonia
Austinella
Parastrophinella
Rhynocotrema
Lepidocyclus
Strophomena
Tetraphalerella
Onniella

Trilobites:
Flexicalymene
Ceraurinus
Ectenaspis
Homotelus
Thaleops
Pterygometopus
Ceraurus
Ceratocephala
Vogdesia
Isotelus
Amphilichas
Thelecalymene
Gravicatymene
Encrinurus
Brachyaspis
Bumastus
Sphaerocoryphe

Graptolites:
Orthograptus
Climacograptus

Sponge: Hindia

*Echinoderms: include crinoids and starfish

*Bryozoans: Numerous, undetermined genera

Ostracodes: Numerous genera

Conodonts and Scolecodonts.

*Denotes diminutive forms.

83.8 Leath Furniture - STOP 2; turn left at stop light and into parking lot.

The purpose of this stop will be to observe and collect the diverse diminutive fossils of the "depauperate" fauna of the basal Maquoketa Shale. The Maquoketa is highly weathered here, concentrating fossils and phosphatic pebbles in a weathered residium atop the resistant beds of the Dubuque Member of the Galena Dolomite (Ordovician).

Return to U.S. Rt. 20.

84.7 Turn left (north) on Grandview Avenue.

85.3 Turn right (east) on Loras Blvd.

85.7 Loras College campus on left; begin descent through the Galena Formation to the Mississippi Valley.

85.8 Type section, Dubuque Member of the Galena Dolomite.

The exposure on the Loras College campus at the northwest corner of the intersection with Cox St. contains the type section of the Dubuque beds, upper-most member of the Galena. The exposure is characteristically crinoidal in the upper portion, and is a uniformly bedded dolomite with thin shale partings.

85.9 Mississippi River valley and Sinsinawa Mound in Wisconsin, an erosional outlier of the Maquoketa Shale standing above the surrounding Galena plain, can be glimpsed to the east.

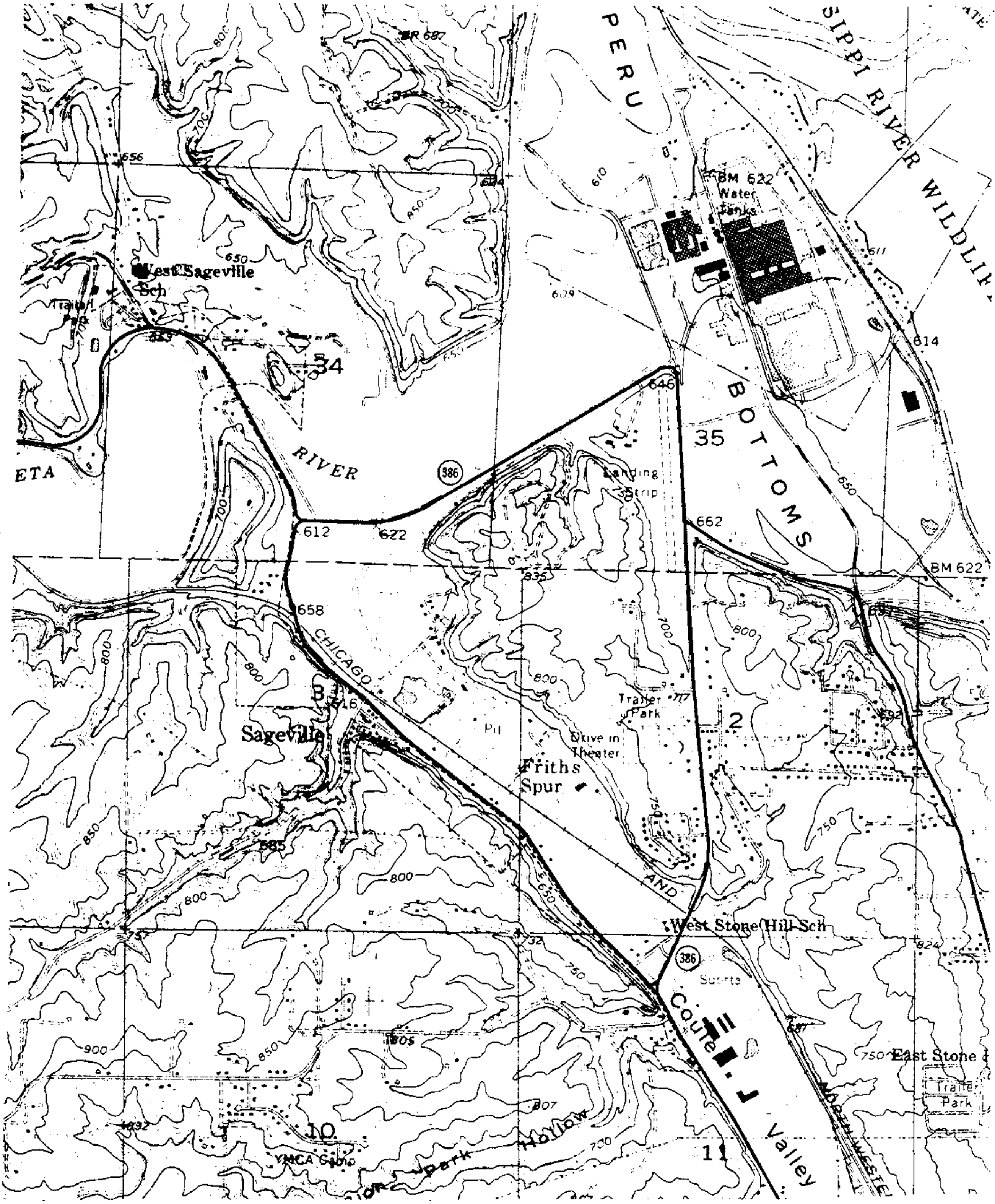
86.4 Turn left (north) on White St. (one-way) and stay in left lane.

87.3 Left to U.S. Rt. 52. (Central Avenue).

From downtown Dubuque north for the next four miles, the field trip route passes through Couler Valley, an abandoned river channel one-half mile wide and nearly 200 feet deep (fig. 4-6).

91.0 Couler Valley Stream Piracy - STOP 3; junction with Iowa Rt. 386.

Couler Valley was formerly the course of the Little Maquoketa River. The valley appears to have been strongly influenced by joint trends in the bedrock--note the sharp-angled bend around the bedrock promontory between Sageville and West Sageville, as well as the continuing lineation north along the valley of Bloody Run. This channel was abandoned when headward erosion by small, high-gradient tributary drainage of the Mississippi River breached the narrow divide between the two valleys, captured the Little Maquoketa waters and diverted them eastward along the more direct route to the Mississippi Valley (Calvin and Bain, 1899). This classical example of stream piracy (Thornbury, 1957) occurred



igure 4-6. Couler Valley (an abandoned channel of the Little Maquoketa River), terrace and floodplain deposits, as well as erosional outliers and steep bluffs in the Dubuque area indicate a complex alluvial history during the Pleistocene. Dubuque North 7½' Quadrangle. Scale 1:24,000.

during Kansan time, with reoccupation and deposition of glaciofluvial materials to a depth of 85 to 100 feet during Wisconsinan time (Trowbridge, 1948). Terrace remnants can be seen in a number of places within this alluvial complex. Calvin and Bain also note a historic occupation during an 1853 flood. The juncture of all three valleys may be observed from this location, and their routes traced on the topographic map reproduced in figure 4-6.

The route of the north segment of the Great River Road in Iowa extends from Dubuque north to Lansing and coincides with this portion of the field trip. Last summer the Great River Road route was the subject of a multi-disciplinary survey designed to identify and inventory features of significant geologic, biologic and archaeologic interest and value. The prominent wooded spur of Galena Dolomite to the west at the head of Couler Valley (fig. 4-6) was identified as an important Indian burial mound complex, a significant natural woodland, and an excellent vantage point from which to view this scenic and instructive example of stream piracy. The land was recently purchased with state and federal Great River Road highway funds and will be managed by the State Preserves Board.

91.4 Cross Little Maquoketa River; observe terrace remnants in the vicinity.

91.7 Turn right (north) at West Sageville, following the Great River Road signs.

From West Sageville, we ascend through the sequence of Galena, Maquoketa and Silurian rocks whose character dominates the terrain nearly to Guttenberg. Silurian rock units formerly covered an extensive area east of the present Escarpment. Evidence of this former coverage can be seen in isolated, higher hills and ridges where the resistant dolomites form erosion-resistant caps.

92.8 Silurian Escarpment seen at far left (west).

94.0 Sherrill Mound to the northwest.

Sherrill Mound (fig. 4-7) is characteristic of these Silurian-capped outliers. The difference in elevation between Sherrill Mound and Peru Bottoms at the mouth of the Little Maquoketa River is over 600 feet, over half of the relief in the state of Iowa. The Mound is rimmed by slopes that are too steep and rocky for cultivation and are almost always heavily wooded. The break in slope to more gently rounded, cultivated or pastured fields marks the contact between the resistant Silurian formations and the more easily eroded clay shales of the underlying Maquoketa Formation.

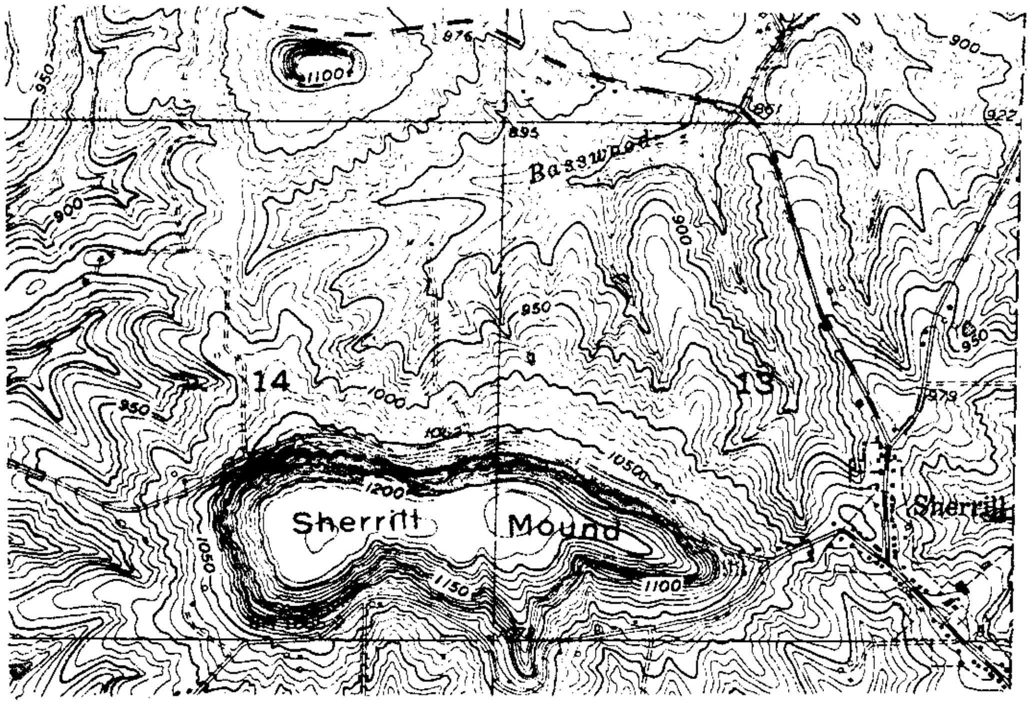


Figure 4-7. Sherrill Mound, with abrupt, rocky and wooded slopes, is an erosional outlier capped by Silurian dolomite. Sherrill 7½' Quadrangle. Scale 1:24,000.

95.7	Town of Sherrill.
96.5	Silurian-capped knobs to the northwest, with gentle slopes on the Maquoketa descending to the rolling plain underlain by Galena.
97.7	Silurian-capped erosional outliers, with the main Silurian Escarpment seen to the far west.
98.8	Scenic view to the north.
99.4	Large slump blocks of Silurian dolomite on the left.
100.2	Scenic Galena Dolomite palisades along the Mississippi Valley to the far east.
101.1	Slump blocks of Silurian dolomite on left.
101.7	Silurian Escarpment seen in the far west.
102.2	Town of Balltown.
103.0	Balltown Ridge - STOP 3.

Probably the most scenic area formed by the Silurian, Maquoketa and Galena units lies along Balltown Ridge, the last stop on this trip. This ridge projects eastward from the main Silurian

Escarpment (fig. 4-1). The following features are observed as we look across the landscape: 1) massive Silurian dolomite which defends the ridge top and roadway; 2) loose slump blocks of dolomite which have weathered and broken away from the main outcrop; and 3) the longer slopes of Maquoketa Shale which gradually descend to an intermediate rolling plain developed on the Galena Dolomite. The Galena, as we have already seen, forms the gorge in which the Mississippi River has excavated its deep valley. Occasional glimpses of the bare, perpendicular cliffs of Galena can be seen at a distance on the east side of the valley.

This concludes our trip. Breitbach Bros. restaurant and grocery in Balltown know we are coming, and in addition to their usual fare, promised to cook up an extra large batch of homemade chili. Lunch preparations may also be purchased at the grocery. Thanks for your company and have a safe trip home.*

*Return to West Sageville for U.S. Route 52 southbound, or continue north along the Great River Road to U.S. 52 northbound through Guttenberg.

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TRIP 5

GEOLOGY AND HISTORY OF STONE CITY

by Fred H. Dorheim and Raymond R. Anderson

Introduction

Historic Stone City is located near Anamosa, about 30 miles northeast of Cedar Rapids. The city has a rich history based on a dimension stone industry and later artist's colony. Many old stone buildings including a 20 room mansion and large horse barn keep the area's history alive. The Weber Stone Company continues to produce dimension stone as well as other cut-stone products, concrete aggregate, road metal and agricultural lime at Stone City. Rock is taken from underground mines, and open quarries into the Anamosa Facies of the Gower Formation, a Silurian carbonate unit. On this trip we will visit the mine and quarry, observe cutting and polishing in the Weber plant, and visit several of the old stone buildings.

TRIP 4 ROAD LOG

Mileage	
0	Parking lot, south side Iowa Hall. This building is on a paha (a constructional ridge of windblown sand, silt and clay-McGee, 1891)
0.5	Leave the Kirkwood College Campus, turn right (north) on Kirkwood Blvd.
1.2	Junction U.S. 30. Turn right (east) on U.S. 30 East.
6.8	Pass over Cedar River bridge.
7.4	Junction Iowa 13, turn right on interchange exit for Iowa 13 North, continue north over U.S. 30 on Iowa 13.
8.0	Road cut exposure, Middle Devonian limestones of the Cedar Valley and Wapsipinicon Formations exposed.

10.0 New Cedar Rapids sewage disposal plant under construction on the left, about ½ mile west of the highway. Over the hill on the right is the type section of the Bertram, the lowest member of the Wapsipinicon Limestone Formation.

12.7 At this point you are on the crest of one of many pahas in this area.

14.5 Intersection gravel road. 1.5 miles east of this point is a large commercial peat bog (SW/c sec. 2, T. 83N., R. 6W., Linn County, Iowa). In this bog a complete skeleton of *Bison occidentalis* was discovered. Stephen A. Hall (1971) studied this bison and other fauna and flora of the bog and obtained carbon dates of 5000 to 5600 years BP on the occurrence.

15.1 Viaduct crossing tracks of the Chicago, Milwaukee, St. Paul and Pacific Railroad.

15.6 Junction Iowa 13 and U.S. 151. Turn right (east) on 151.

18.6 Alpha Stone Co. gravel pit on right (south). This is a dredging operation. Serious consideration is being given by the company to creating a lake and housing development at this site when the pit is worked out.

20.5 Alpha Stone Company's Bowser quarry on the left (north). The uppermost unit present here is the Bertram member of the Wapsipinicon Formation (Middle Devonian). In the lower part of the quarry is in the LeClaire facies of the Gower Formation (Silurian). Between the Gower and the Bertram is an Upper Devonian shale. This stratigraphic leak was first described by Dorheim, 1967.

20.9 City limits, Springville; continue east on U.S. 151.

25.6 Weber Stone Co. sign pointing north to Stone City. Because of dust and construction we will not take this route. Continue east on U.S. 151.

27.1 Junction U.S. 151, Iowa 1, and Jones County Road E-34. Four-way stop. Turn left (north) on County E-34.

27.5 Passing through the village of Fairview. E 34W turns left. Continue northeast on E 34E. (Do *not* take E 34W.)

29.0 This rolling topography, approaching valley of the Wapsipinicon River is typical of the landscapes painted by artist Grant Wood.

30.2 Pass the entrance to Wapsipinicon State Park on right. Cross bridge over Wapsipinicon River and enter Anamosa (see fig. 5-1)

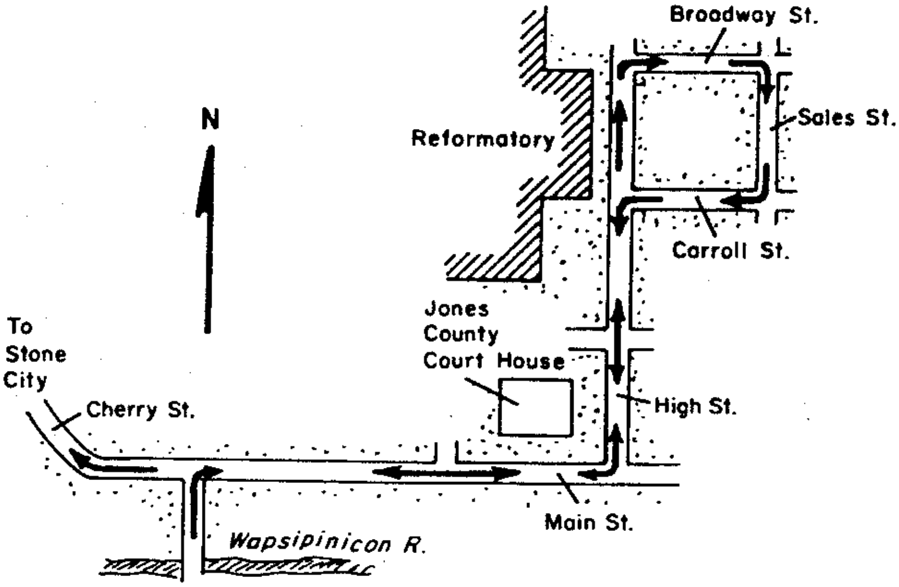


Figure 5-1. Route map in Anamosa.

30.8 Turn right (east) on Main Street, continue east for 2 blocks
Turn left (north) on High Street (at east side of Jones County Court House), continue north for 3 blocks.
- Notice the use of Anamosa Stone and the architecture of the Anamosa Reformatory buildings.

Turn right (east) on Broadway and circle around the block and return to the intersection with High Street.
Turn left (south) on High Street and return to Main Street.
Turn right (west) on Main Street and continue west beyond the intersection we came in on.

31.8 Angle right (northwest) on Cherry Street, the road to Stone City.

32.1 Bridge over Buffalo Creek, note use of stone in Reformatory Farm buildings at right.

32.2 Follow curve and continue northwest. We are now on county road E-28.

32.8 Reformatory cemetary on right. Note the use of Anamosa facing stone in many of the homes that have recently been built along this ridge road.

34.9 Turn left (southwest) off E-28 onto Stone City road.

35.3 Pass entrance to Weber Stone Co. yard and continue down hill (see fig. 5-2).

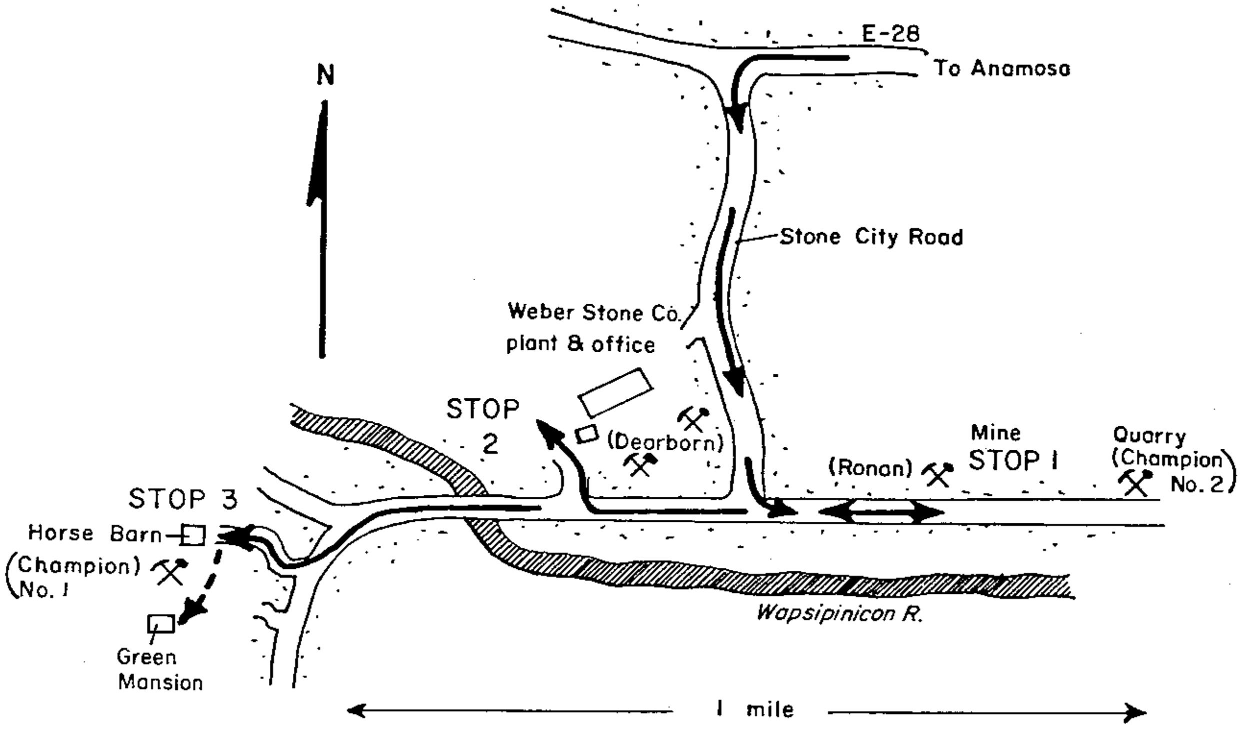


Figure 5-2. Map of Stone City.

35.4 Turn left onto mine and quarry road; park cars in line along road. STOP for visit to mine and quarry.

STOP 1 - Weber Mine and Dimension Stone Quarry

Both this mine and quarry are in the Anamosa Facies of the Gower Formation, Llandoverian (Niagaran) Series, Silurian System. The mine, opened in 1969, has been developed in what was historically known as the Ronan quarry (fig. 5-3).

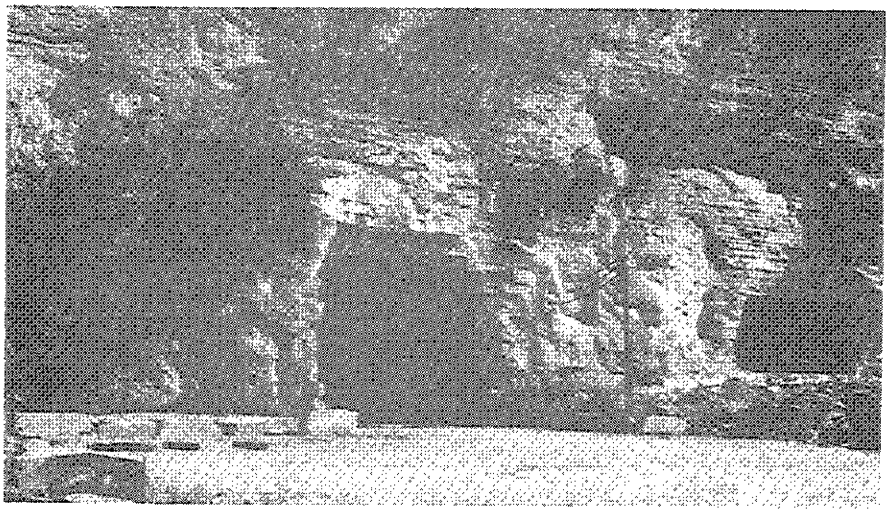


Figure 5-3. The entrance to the Weber Mine.

The rock in the upper part of the mine is not suitable for dimension stone but is crushed for road stone and agricultural lime. The lower ledges are taken out for dimension stone which is used for buildings, for exterior and interior facing and for fireplaces and furniture. Although stone from this source goes dominantly to markets in the Upper Mississippi Valley, it is shipped as far as the west coast and south to the Gulf of Mexico.

History of the Stone Industry at Stone City

The history of the stone industry at Stone City began about the middle of the 19th century when the army engineers extracted stone from this area for railroad bridge construction. Soon afterwards an Irishman by the name of James A. Green came to Stone City with little other than experience and started a dimension stone quarry in what is known as the Champion Quarry No. 1. Under his management train loads of dimension stone went out of Stone City daily. With the growth of the industry other quarries were opened: the Dearborn, where the Weber Stone Co. office and plant are located; the Ronan, where the Weber mine is located; and the Champion No. 2, where the Weber open pit quarry is located. All of these earlier operations are now collectively known as the Weber quarries (except Champion No. 1 which is no longer active).

During the "good years" of the dimension stone industry (about 1875-1910) Green became a millionaire and a senator. With the advent of the Portland Cement industry and the decline of railroad construction the market for dimension stone dropped appreciably and in 1919 Green sold his estate and left the area.

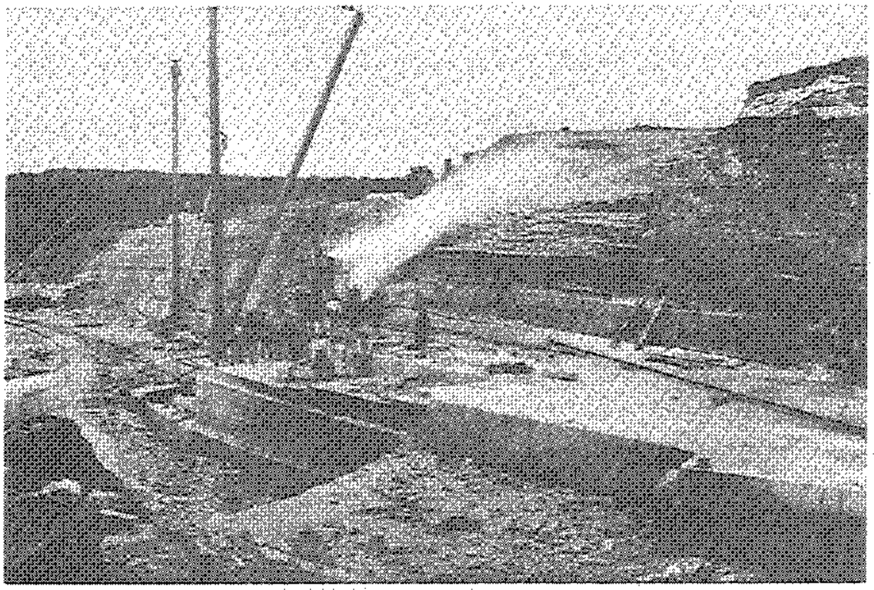


Figure 5-4. A late 1800's photo of the Champion #1 quarry.

In 1940 C.B. DeWees, of Marion, purchased the Dearborn and the Champion No. 2 quarries. He crushed stone for road construction, agricultural-lime and for flux stone. In 1952 William C. Weber bought into the operation and in 1959 took over the whole operation and again started making dimension stone. In 1969 the Weber Stone Co. bought the Ronan quarry and started the underground mine. Under Mr. Weber's management the dimension stone industry has grown again to a significant part of Iowa's stone production. Production at the Weber quarries is nearly 100,000 tons per year and is distributed as follows: 16% agricultural-lime, 73% crushed stone, 8% landscaping stone, and 3% dimension stone for buildings and for furniture.

From the Ronan mine we will walk to the Champion No. 2 quarry to observe the section of stone being quarried for dimension stone and for other purposes. (fig. 5-5). This mine was opened in the late 1800's by

J.R. Green. Here you will see, in the rock face, a "white ledge". This is not a desirable stone for dimension stone but is growing in popularity for other architectural purposes.

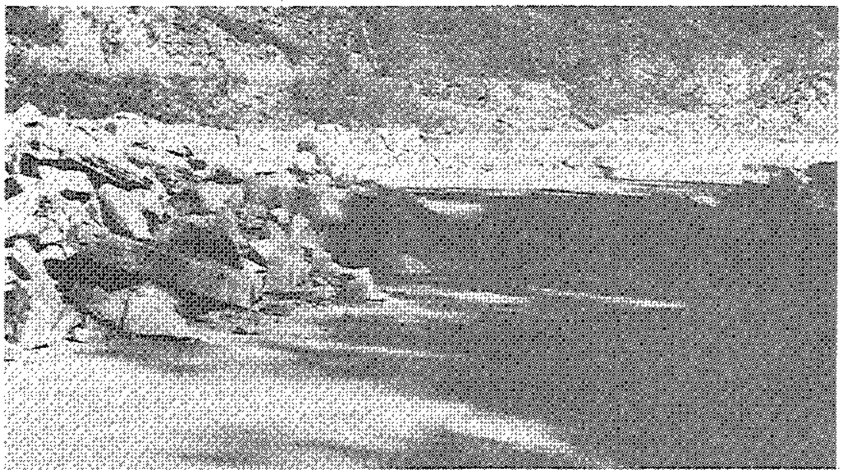
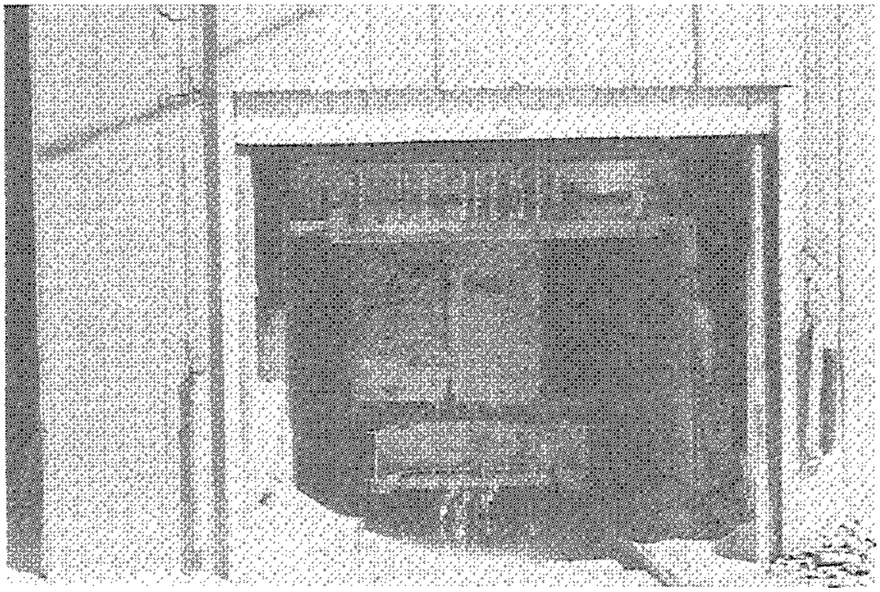


Figure 5-5. The Weber dimension stone quarry.

35.4 Return to cars, and proceed to Weber Stone Co. plant (passed at mile 35.3) following the route displayed in figure 5-2. At this stop we will observe cutting and polishing of the stone and view the stock of dimension stone in the yard. STOP 2.

STOP 2 - Tour of the Weber Stone Co. Plant

Figure 5-6. The slabbing saw at the Weber Stone Co. plant.



35.6 Return to cars and proceed according to figure 5-2 to the Horse Barn in the now inoperative Champion #1 quarry.

STOP 3 - The Old Horse Barn and Mansion

The old mine office, on the left as you entered the Champion #1, the even older office on the right (now in ruins), as well as the Horse Barn ahead were constructed by James Green. He also constructed many other buildings in the area including a 20 room, Victorian mansion (which we will visit later) complete with a stone water tower and ice house on the hill overlooking this quarry. A hotel-opera house also constructed by Green in southwest Stone City was later destroyed and the stones removed and used in another building, not in Stone City. The horse barn, recently restored, was used by Green to house thoroughbred race horses.

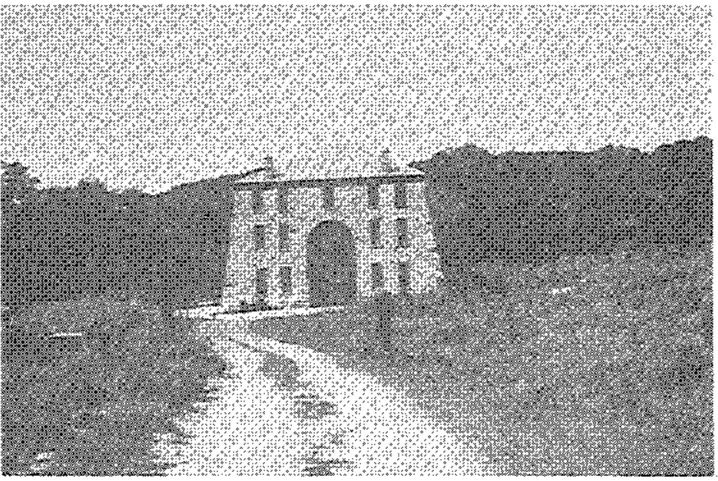


Figure 5-7. The Horse Barn in the abandoned Champion #1 quarry.

Proceed by foot up the trail to the ruins of the Green mansion.

Figure 5-8. The Green Mansion and Ice House.

Stone City Culture

Stone City has enjoyed two periods of cultural activity, in part related to the stone industry and in part related to the beauty of the landscape along the Wapsipinicon River.

During the prime years of the industry personalities of international fame were performers in the old oper house. Two such performers were Jenny Lind, an operatic soprano, and General Tom Thumb.

In 1932-33 Grant Wood, Adrian Dornbush, and Marvin Cone established a summer art colony at Stone City using the old mansion, the hotel and opera house as the centers of activity. The Nissen family, of Cedar Rapids owned (and still own) the property. After the second summer the art school ran into financial difficulty and the school was discontinued.

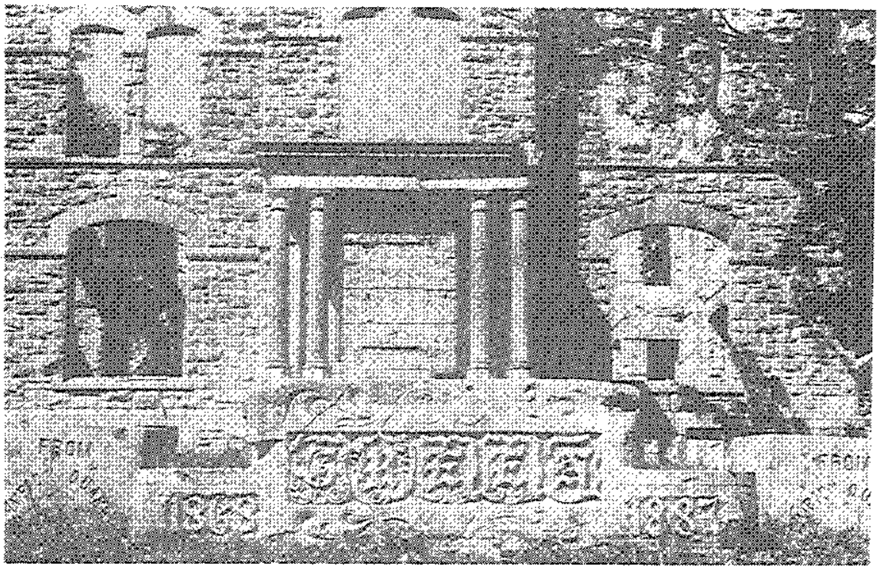


Figure 5-9. View of the front of the Green Mansion.

Later, the well known Iowa poet, Paul Engles, and his wife, Mary Nissen Engles, occupied the mansion until the fall of 1963 when it was destroyed by fire. The Nissen family have recently restored the horse barn and have started restoration of the mansion.

This completes our field trip. We hope you have enjoyed it and that you have a safe and enjoyable trip home.

References Cited

McGee, W.J., 1891. Constructional Ridges of Windblown Silt and Clay in Area of Iowan Glacial Drift in Northeastern Iowa, USGS 11th Ann. Rept. pt. 1, p. 255.

Hall, S.A., 1971. Paleoecological Interpretation of Bison, Mollusks, and Pollen from Hughes Peat Bed, Linn County, Iowa. MS Thesis, Dept. of Geology, Univ of Iowa, Iowa City.

Dorheim, F.H., 1967. Stratigraphic Leak and Springville Quarry, Proc. Iowa Acad. Sci., vol. 74, pp. 142-146.

APPENDIX

GEOLOGY IN THE VICINITY OF PALISADES-KEPLER STATE PARK

by Brian Witzke

The group camp area within Palisades-Kepler State Park has been reserved for those Tri-State Field Trip participants who desire to camp. It is conveniently located 9 miles east of Kirkwood Community College and 3½ miles west of Mt. Vernon. Most of the area within the park is characterized by densely wooded hillslopes. Indian burial mounds can also be seen. The spectacular cliffs forming the Palisades are exposed along both banks of the Cedar River, and the park has long been a favorite spot among Iowa rock climbers.

The nearly continuous rock exposures along the river reveal a cross-section through a Silurian reef complex included within the Gower Dolomite. At least seven interconnected mounded structures form the central portion of the complex; crinoid- and coral-rich dolomites typify this zone which reaches thicknesses to 100 ft. A later stage of reef growth and burial ("Brady facies") is preserved on top parts of the central complex, especially along the northwestern edge. The dipping dolomite beds associated with the reefs are replaced by horizontally-bedded skeletal to laminated dolomites off-reef. Middle Devonian Wapsipinicon Formation carbonates are observed above the Palisades in places particularly on the west bank of the river. The Gower Dolomite exposures within the Palisades-Kepler area are among the best and most instructive in the state. However, since the area has state park status, collecting of fossils and rocks is not permitted. For further information see the article in this guidebook on the stratigraphy along the Plum River fault zone and the cited references, especially those by Philcox.

Schedule of Events
42nd Annual Tri-State Geological Field Conference
Sponsored by
The Iowa Geological Survey
October 13, 14, 15, 1978
Headquartered at Cedar Rapids, Iowa

Friday, October 13

*Registration: 5:00 p.m. to 10:00 p.m.
Iowa Room, Iowa Hall, Kirkwood College: Displays on various facets of geology in Iowa; Iowa Geological Survey and Tri-State Conference personnel will be available for discussion; refreshments will be available.

Saturday, October 14

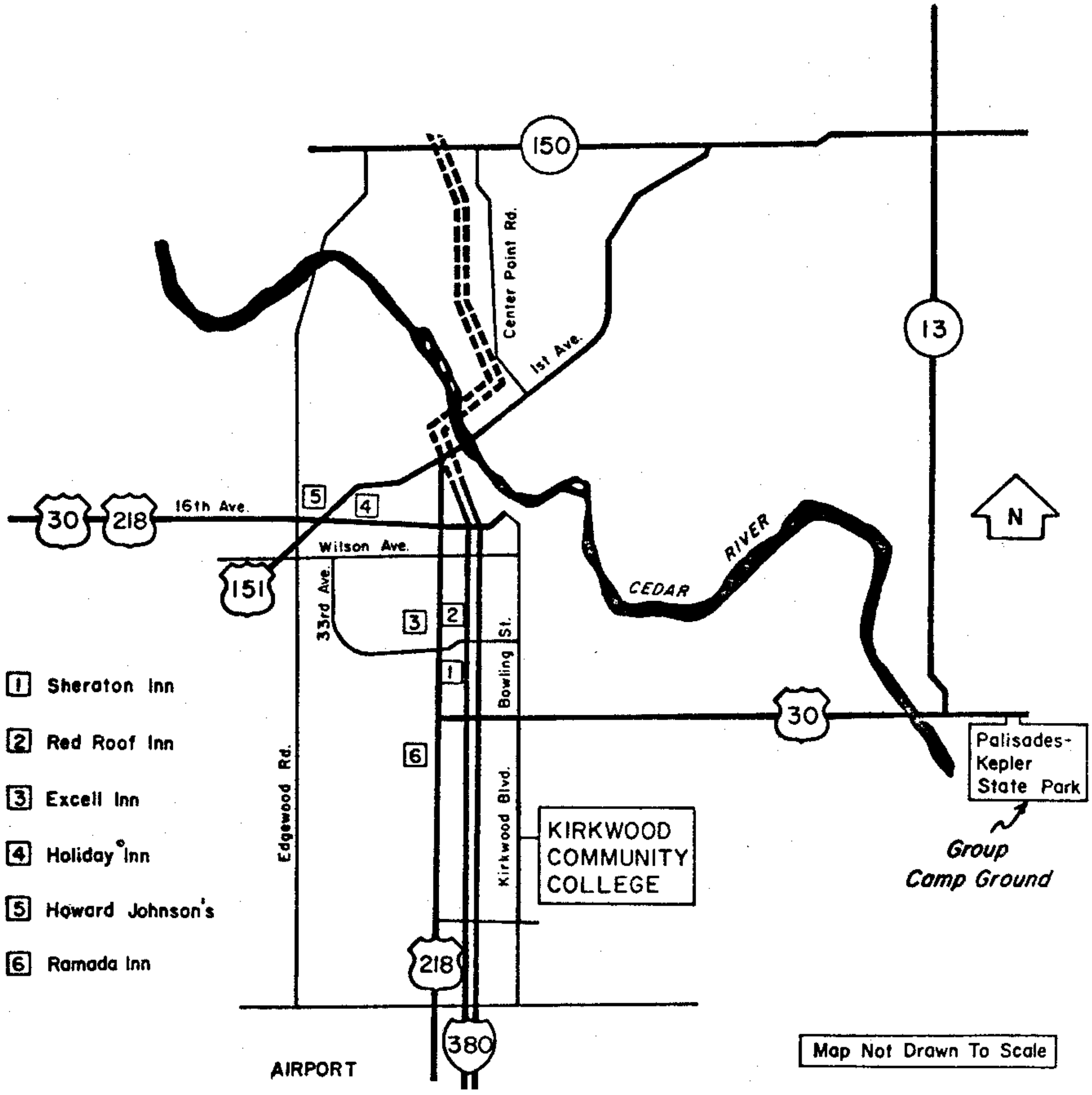
Field Trips: 7:00 a.m. to 5:00 p.m. Meet in parking lot behind Iowa Hall.*
Social Hour: 5:30 to 6:30 p.m. Iowa Room--coffee and bar available.
Banquet: 6:30 to 8:00 p.m. Cafeteria, Iowa Hall.
Evening Program and Business Meeting: 8:00 to 10:00 p.m.
Keynote Address--Dr. Carl Vondra, Iowa State University: "Ancient Environments and Early Man at Lake Turkana, Kenya."

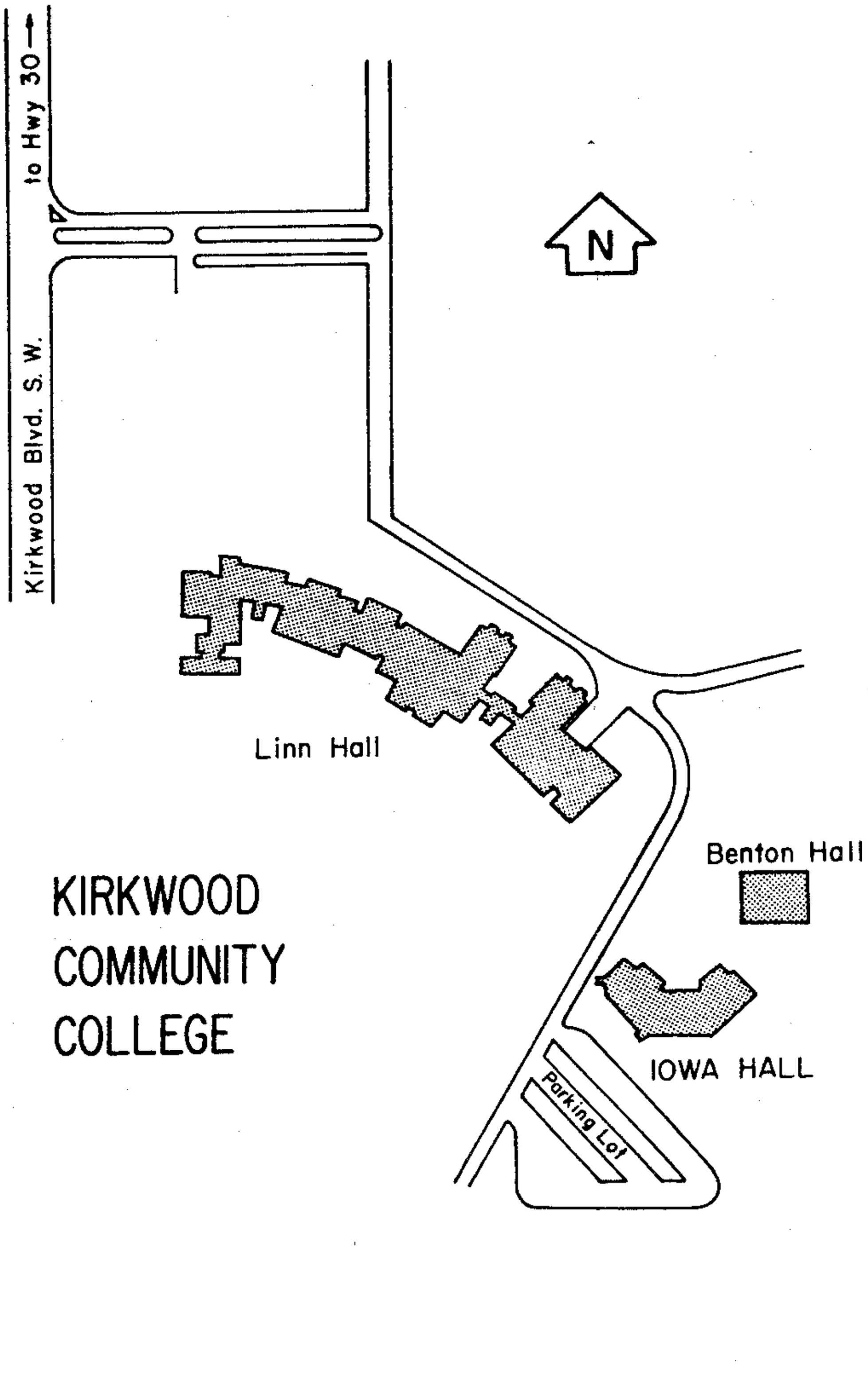
*Field Trip 3, Applied Eng. Geo., Meet in the Amana Room, Iowa Hall, 8:00 a.m.

Sunday, October 15

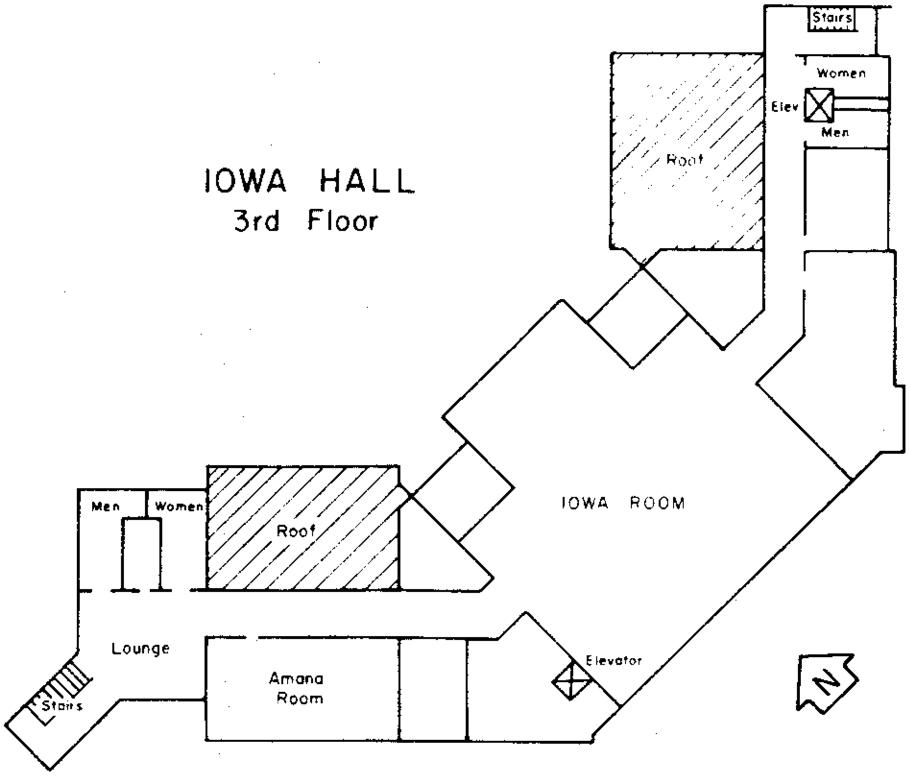
Field Trips: 7:30 a.m. to 12:00 noon. Meet in parking lot behind Iowa Hall.
Adjourn: 12:00 noon.

CEDAR RAPIDS AREA MAP

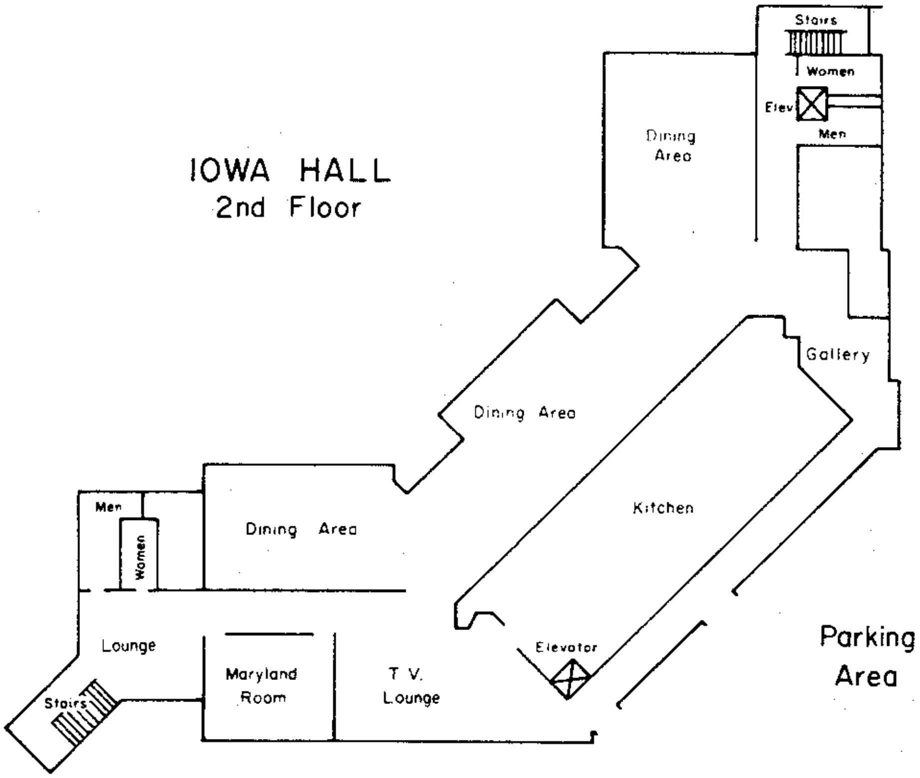


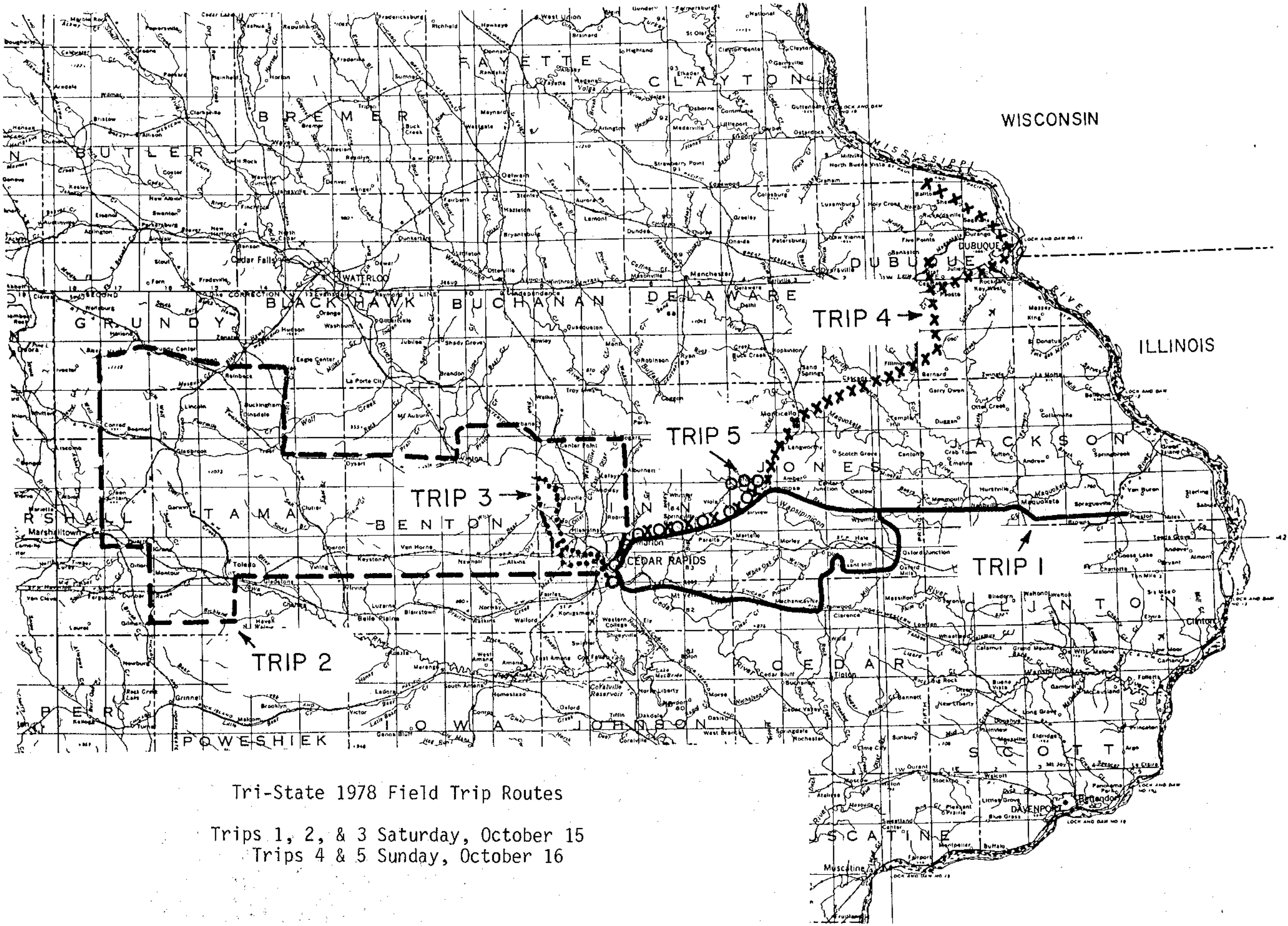

to Hwy 30
N
Kirkwood Blvd. S. W.
Linn Hall
Benton Hall
KIRKWOOD
COMMUNITY
COLLEGE
IOWA HALL
Parking Lot

IOWA HALL
3rd Floor



IOWA HALL
2nd Floor





Tri-State 1978 Field Trip Routes

Trips 1, 2, & 3 Saturday, October 15
Trips 4 & 5 Sunday, October 16