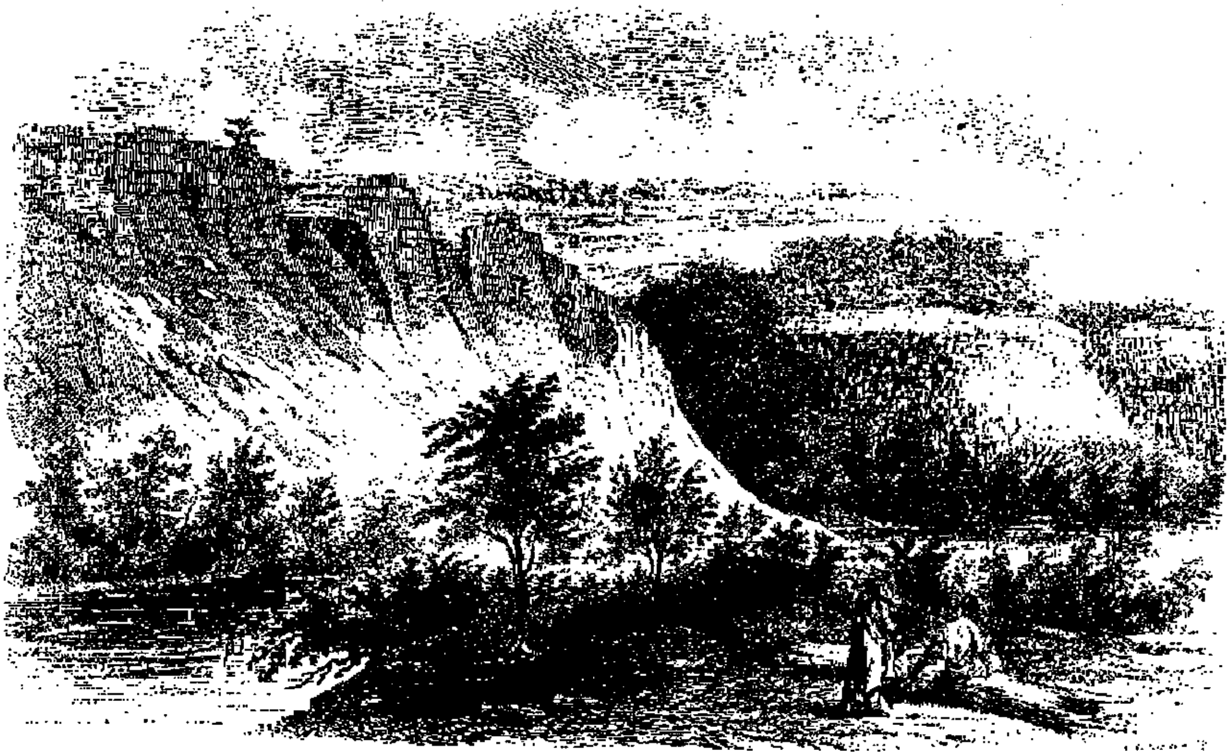
SELECTED ASPECTS OF LOWER ORDOVICIAN AND UPPER CAMBRIAN GEOLOGY
IN
ALLAMAKEE AND NORTHERN CLAYTON COUNTIES

Robert M. McKay



CLIFFS OF LOWER MAGNESIUM LIMESTONE, UPPER IOWA RIVER

Geological Society of Iowa

April 25, 1993

Guidebook 57

"The scenery on the Rhine, with its castellated heights, has furnished many of the most favourite subjects for the artist's pencil, and been the admiration of European travellers for centuries. Yet it is doubtful whether, in actual beauty of landscape, it is not equalled by that of some of the streams that water this region of the Far West. It is certain that, though the rock formations essentially differ, Nature has here fashioned, on an extensive scale, and in advance of all civilization, remarkable and curious counterparts to the artificial landscape which has given celebrity to that part of the European Continent."

David Dale Owen (1852, p. 64)

[From Owen's description of the region of the
Upper Mississippi Valley and its tributaries in
the vicinity of Allamakee County.]

Cover Illustration: Wood-cut of scenery along the Upper Iowa River used by Owen (1852, p. 68) to illustrate the bold cliff-forming nature of his "Lower Magnesian Limestone" which is now known as the Prairie du Chien Group.

SELECTED ASPECTS OF LOWER ORDOVICIAN AND UPPER CAMBRIAN GEOLOGY IN ALLAMAKEE AND NORTHERN CLAYTON COUNTIES

Robert M. McKay
Iowa Department of Natural Resources
Geological Survey Bureau
109 Trowbridge Hall
Iowa City, Iowa 52242-1319

With Contributions by:

Lynette S. Seigley
Iowa Department of Natural Resources
Geological Survey Bureau
109 Trowbridge Hall
Iowa City, Iowa 52242-1319

James J. Wellman
United States Geological Survey
Water Resources Division
P. O. Box 1230
Iowa City, Iowa 52244

Thomas Munson, Superintendent
Effigy Mounds National Monument
National Park Service
United States Department of the Interior
R. R. 1, Box 25A
Harpers Ferry, Iowa 52146

William M. Furnish (Emeritus)
Department of Geology
The University of Iowa
121 Trowbridge Hall
Iowa City, Iowa 52242

GEOLOGICAL SOCIETY OF IOWA
Guidebook 57
April 25, 1993

Geological Society of Iowa, 109 Trowbridge Hall, Iowa City, Iowa 52242-1319

TABLE OF CONTENTS

ACKNOWLEDGMENTS

I would like to express thanks and appreciation to the following individuals and groups for their assistance and cooperation during the preparation of this field trip guidebook: Michael J. Bounk, Orrin W. Plocher and Roland Scal for fieldwork assistance; Iowa Department of Natural Resources-Geographic Information System section for assistance with computer-mapping, and the Geology and Mineral Resources section for logistical support; the Weymiller family for access to their quarry; National Park Service staff at Effigy Mounds National Monument; Bob Honeywell at Yellow River State Forest; Patricia J. Lohmann for graphic designs; Michael J. Bounk and Gregory A. Ludvigson for structural geology comments; and Bill J. Bunker for editorial assistance.

INTRODUCTION

As the title of the guidebook suggests, the field trip today will focus primarily on the geology of Cambrian and Ordovician rocks in Allamakee and northern Clayton counties, however two other subjects will also be addressed. At Stop 8, the last stop of the day, Lynette Seigley will discuss new research and monitoring activities of surface water quality within the Sny Magill Watershed Project. The Sny Magill Project is designed to monitor and assess expected improvements in surface water quality resulting from modified agricultural land treatments within the watershed over a period of approximately ten years. At Stop 6, Thomas Munson has explained some of the historical activities at the Hanging Rock Site within Effigy Mounds National Monument. At Hanging Rock participants will be able to look at some recent archeology plus the geology.

During most of the field trip participants will be examining Lower Paleozoic strata of Late Cambrian to Early Ordovician age (Fig. 1). These are the oldest Paleozoic rocks exposed in Iowa and they are located along the southwestern edge of the classic Cambro-Ordovician outcrop belt of the upper Mississippi Valley. The route of the trip (back cover) is entirely within the Paleozoic Plateau landform region (Prior, 1991), an area of shallow to exposed bedrock which has often been called the "Driftless Area". Deep incision by the Mississippi River and its tributary network during the late Pleistocene has exposed roughly the upper half of the total thickness of these strata in Allamakee County. The massive dolomite (Oneota) and cemented sandstone (Jordan) units form spectacular bluffs and escarpments while the weakly cemented finer-grained strata form the steep, colluvium-covered underlying slopes (cover illustration). The southwestward regional dip of the strata off the Wisconsin Arch is gentle, at roughly 18 feet per mile, but that is steep enough to tilt the formations completely into the subsurface south of east-central Clayton County (Fig. 2). The newly prepared geologic map (Fig. 2) illustrates the intricate dendritic outcrop pattern of formational contacts in this dissected region of well-exposed, "flat lying" to gently dipping rocks. But not all the rocks are so inclined as is evident from a structure contour map on the top of the Jordan Formation within its outcrop belt (Fig. 3). This newly prepared map shows the distribution and magnitude of flexures that affect the strata. Names have been proposed for a number of the more prominent anticlines and synclines, and Stop 5 will be devoted to an illustration of the largest of these subtle structures.

The Cambrian and Lower Ordovician strata collectively encompass the Sauk Sequence, the first large-scale transgressive-regressive cratonic marine cycle of the Phanerozoic (Sloss, 1963). The formations within the Sauk Sequence record four smaller-scale unconformity-bounded transgressive-regressive sea level cycles which span approximately 45 million years of early Paleozoic earth history (Fig. 1; Ostrom, 1970, 1978; Byers and Dott, 1990; and Smith et al., 1993). Our trip today will afford a look at selected portions of this rock sequence and we will view facies varying from clear-water subtidal stromatolite "reefs" and grainstone shoals to nearshore cross-stratified submarine sanddunes to intertidal and supratidal tidal flats.

Please drive safely and enjoy your trip.

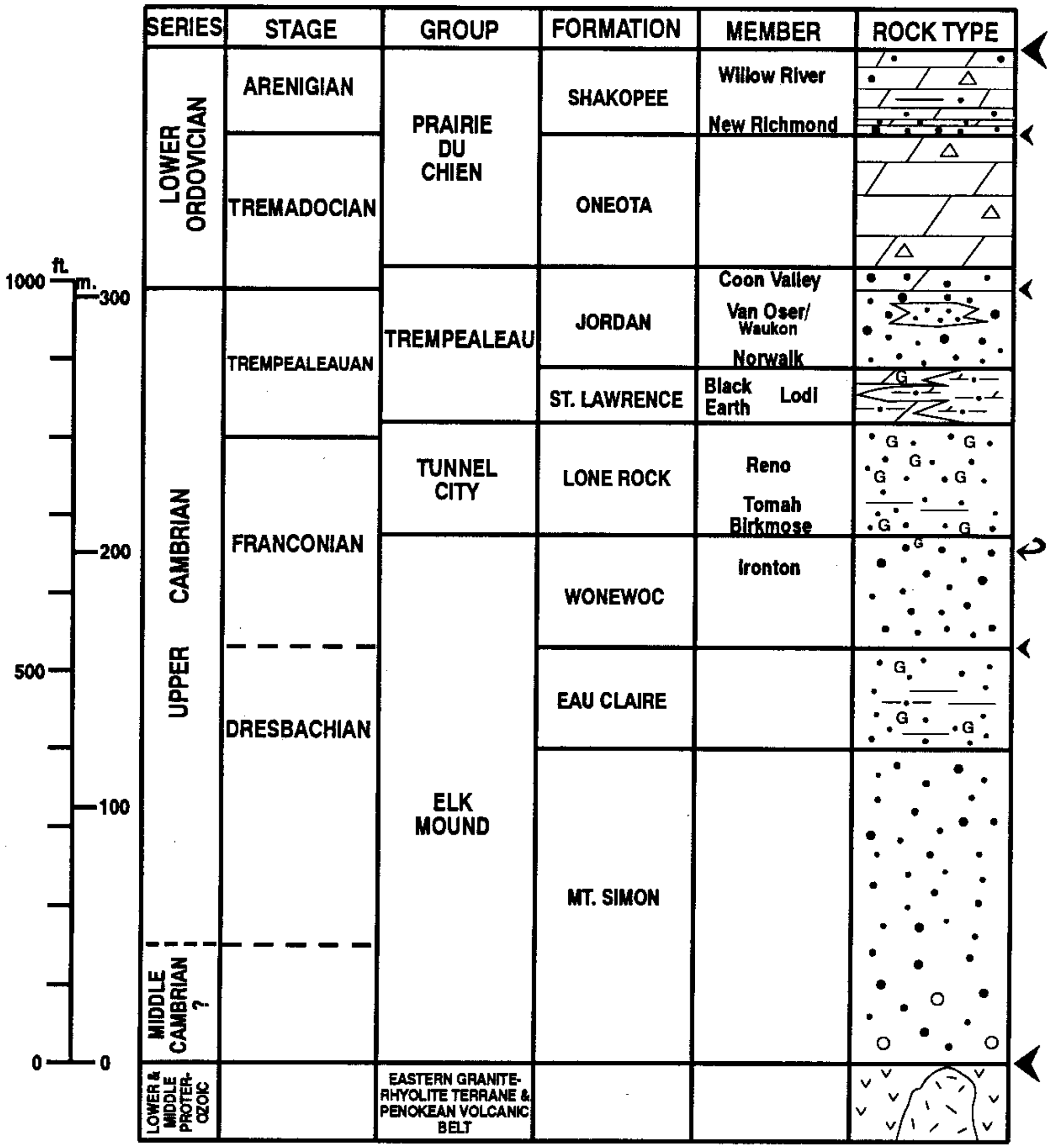


Figure 1. Stratigraphic column of Upper Cambrian and Lower Ordovician rocks in Allamakee County. Oneota and Waukon are the only names that originate from Iowa, all other names originate from Wisconsin or Minnesota. Curved arrow on right denotes lowest level of outcropping strata in Allamakee County; section below from deep wells at Lansing, Iowa. Large arrows on right mark positions of large-scale unconformities bounding the Sauk Sequence; smaller arrows denote position of smaller-scale unconformities within the Sauk Sequence. Stage names from Palmer (1983).

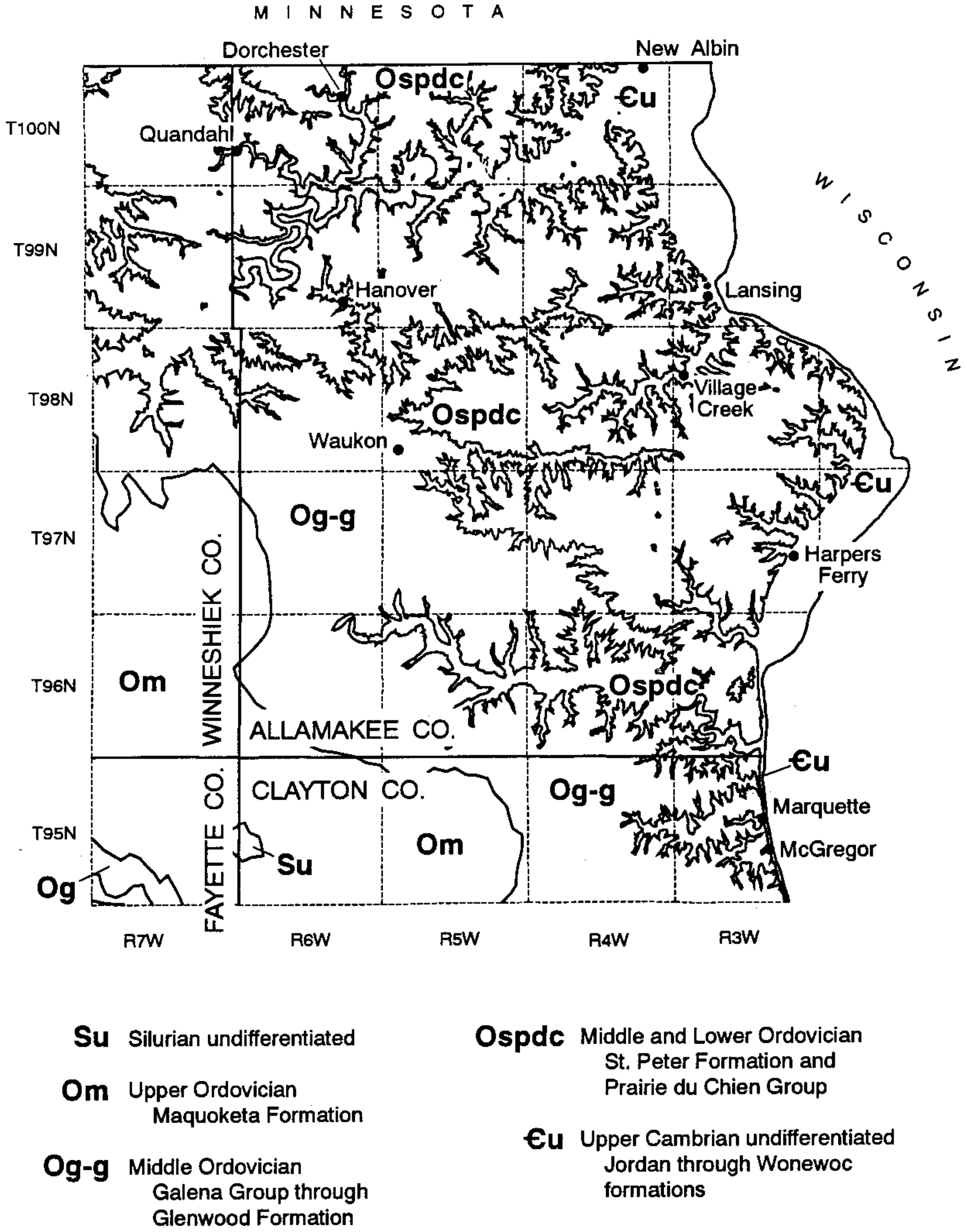


Figure 2. Geologic map of bedrock units. Highly crenulated contacts from 1991-1992 mapping by Geological Survey Bureau staff. Broader and smoother contacts from Hershey (1969).

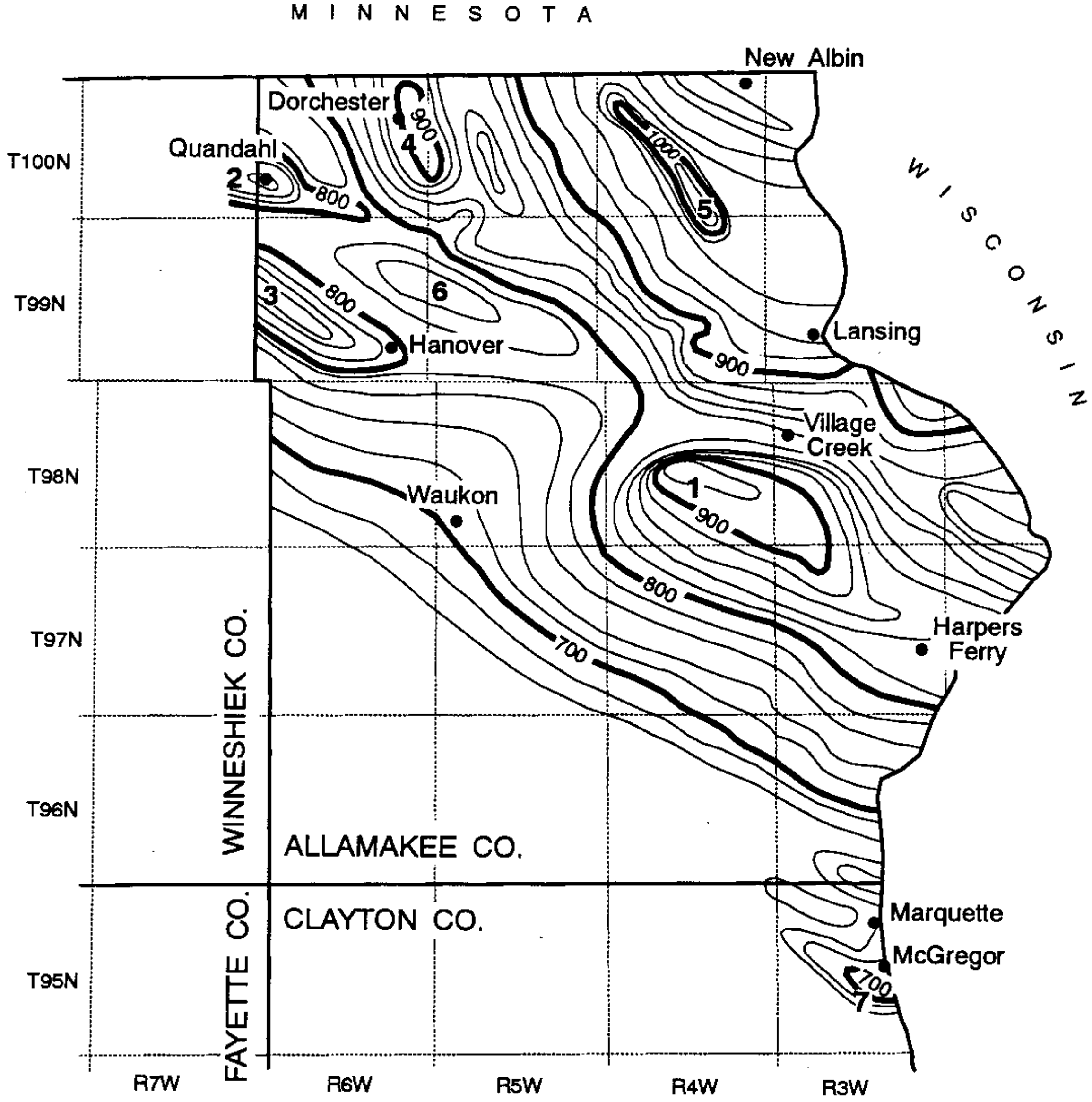
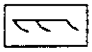
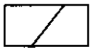
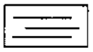
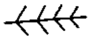
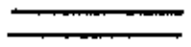


Figure 3. Structure contour map of the top of the Coon Valley Member, Jordan Formation. Compiled principally from outcrop data. Contour interval equals 20 feet. 1 - Village Creek Anticline; 2 - Quandahl Anticline; 3 - Hanover Anticline; 4 - Dorchester Anticline; 5 - Irish Hollow Anticline; 6 - Mineral Creek Syncline; 7 - McGregor Anticline. Area within T98N, R5W (Makee Township) is probably more complex than depicted.

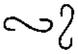
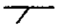
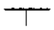
STOP DISCUSSIONS AND DESCRIPTIONS

SYMBOL KEY TO GRAPHIC SECTIONS

 f-c	sandstone grain size: vf very fine f fine m medium c coarse vc very coarse		siltstone slty silty
	dolostone Gr grainstone M mudstone		shale

	trough cross-strata		lenticular bedding
	tabular cross-strata		herringbone cross-strata
	low-angle cross-strata		deformed cross-strata
	horizontal strata		small-scale hummocky stratification
	wavy strata		ripples with clay drapes

• • • • •	sandy to silty	⊙	ooids to coated grains
○	peloids	/	clay flake to clast
⬭	intraclasts (sandy to silty dolomite, or dolomitic sandstone to siltstone)		chert nodules
⬬	phosphatic intraclast	△	small chert clusters or silicified grains

	digitate stromatolite boundstone		burrows (horizontal/vertical)
	laterally-linked hemispheroid stromatolites		burrows
	laterally-linked hemispheroid stromatolites (transitional to wavy mat)	m	grain-moldic porosity
V	vugular porosity	f	fracture porosity
	dolomite cement		snail
	calcite cement		cephalopod
	inarticulate brachiopod shell	%	indeterminate fossil grains
G	glauconite		dessication mudcracks

STOP 1. WEYMILLER QUARRY
A digitate stromatolite boundstone buildup in the lower Oneota Formation

DISCUSSION: This stop is at a small quarry in the lower half of the Oneota Formation, and is an excellent example of typical North American Lower Ordovician digitate stromatolite boundstone mounds and intermound channel grainstones. Additionally, this site is unique for the Oneota in that the boundstones contain a moderately common invertebrate molluscan fauna of snails and cephalopods.

The floor of this quarry, at an elevation of approximately 940 ft, is about 45 to 50 feet above the top of the Coon Valley Member of the Jordan Formation. This positions the boundstone buildup within the lower part of the middle third of the Oneota according to the classification currently in use in Iowa (Fig. 1). Application of stratigraphic terminology of Davis (1970); or Smith et al. (1993) would result in the assignment of this interval to the Hager City Member, while the use of Raaschs' (1952) southwest Wisconsin Oneota member scheme would probably result in this interval being assigned to the upper Genoa or lower Stoddard members.

There are four digitate stromatolite units at this site, all of which are exposed in the wall of the first bench. The digitate stromatolites are color-mottled and appear as discontinuous, vertically-oriented, finger-size areas of dense, light grey dolomite alternately with light tan more porous dolomite. The largest exposed buildup consists of two thick massive beds stacked on top of one another, but separated by a bedding plane reentrant. The bedding plane separation of these units probably is a manifestation of two separate mound growth phases. Both these stromatolite units contain molds of small snails and cephalopods (discussed here by Bill Furnish).

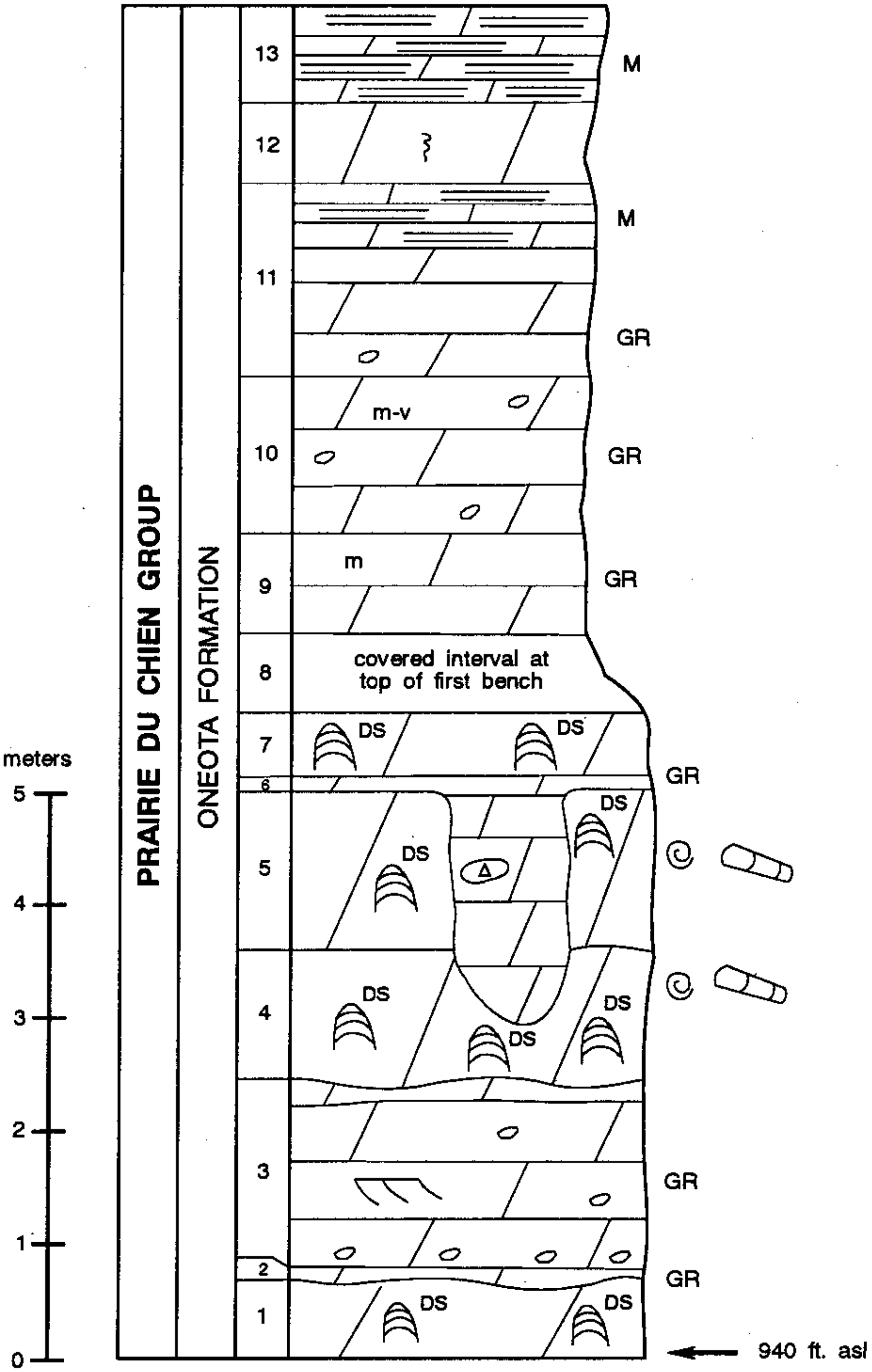
The two main boundstone intervals are partially to totally truncated in parts of the quarry by an intermound channel that is filled with dolograinstone. The grainstone fabric of the intermound-fill is best observed by examining the white to grey colored chert nodules within the grainstone. These have preserved some of the original fabric and coated-grain structure. The interval above the boundstones is dominated by more dolograinstones which grade up to a laminated mudstone unit. This carbonate cycle of subtidal stromatolites and grainstones shallowing to probable intertidal mudflat conditions is typical of Lower Ordovician carbonate platform strata throughout North America, and is similar to Bahama Type carbonate platform sedimentation occurring today.

Discussion of the molluscan fauna
by William M. Furnish

Except for massive stromatolitic structures, megafossils are seldom observed in the Oneota Formation of Iowa, Wisconsin, and Minnesota. Brachiopods and trilobites have been found in comparable strata elsewhere but are practically unknown in the Upper Mississippi Valley

WEYMILLER QUARRY

W-32944
NW, NE, NE, NE, sec. 35, T100N, R5W
Allamakee County, Iowa



area. Molluscan faunas have been recorded, although they are considered to be rare. Most of these fossils have been secured from residual chert, where they occur as molds. Gastropods are most common. About sixty years ago Fred Luthe collected a significant number of cephalopods in the vicinity of McGregor, Clayton County, Iowa. Material deposited with the University of Iowa was described in GSA Special Papers 49 and 58 by Ulrich, Foerste, Miller, and Unklesby, 1943 and 1944. *Eremoceras*, *Levisoceras*, and *Oneotoceras* are characteristic breviconic forms. A smaller number of minute orthocones such as *Ellesmeroceras* also occur. These same genera have now been discovered in a new lower Oneota locality in Allamakee County, where they occur as molds in granular stromatolitic dolomite. Collectively, the fauna is indicative of lowermost Ordovician. Conodonts from these beds have been proven to be more definitive for time zonation.

WEYMILLER QUARRY (W-32944)

NW1/4, NE1/4, NE1/4, NE1/4, Section 35, T100N, R5W, Allamakee Co.
Waukon NW 7.5' Quad
Elevation at base approximately 940 ft.
Measured by R. M. McKay, April 5, 1993

PRAIRIE DU CHIEN GROUP
ONEOTA FORMATION

Unit 13	84 cm.	Dolomite, light grey to whitish, very fine to fine crystalline, laminated mudstone, horizontal to slightly wavy laminae. Section continues upward another 5 m. but not measured for this guidebook.
Unit 12	75 cm.	Dolomite, color mottled light tan to light grey, fine crystalline, one massive bed, pockmarked surficial expression, some orangish tan fine crystalline dolomite burrow? traces (possibly a bioturbated fabric).
Unit 11	1.7 m.	Dolomite, light tan, fine crystalline, medium-bedded in lower half becoming thinner-bedded and horizontally laminated in upper third. Probable fine grained dolograinstone with trace intraclasts in lower part and dolomudstone in upper part, minor moldic porosity.
Unit 10	1.33 m.	Dolomite, light tan, fine to medium crystalline, medium-bedded, moderately moldic to vuggy porosity, irrregularly bedded, laterally displays intraclastic dolograinstone fabric, intraclasts to 1 cm. in upper part.

Unit 9	90 cm.	Dolomite, light tan, fine crystalline, thick-bedded, dolograinstone with moderate grain-moldic porosity.
Unit 8	75 cm	Covered interval at top of first bench.
Unit 7	50 cm.	Dolomite, digitate stromatolite boundstone, poorly exposed and inaccessible at south end of quarry, better exposed in older portion of quarry at north end.
Unit 6	0.1-1.9 m.	Dolomite, light tan to light grey to orangish-tan, appears as a broken-up to brecciated zone lateral to and in between digitate stromatolite boundstone of unit 5. Unit is dominantly a fine crystalline dolograinstone, composed dominantly of coated grains and mudstone intraclasts. Contains white to medium grey chert nodules up to 10 cm. in diameter with well-preserved grainstone fabric. Forms the uppermost exposed unit of the first bench.
Unit 5	0-1.45 m.	Dolomite, digitate stromatolite boundstone, undulose base and top, moderately common snail and cephalopod molds. Towards the middle part of the quarry face this boundstone unit is truncated by a dolograinstone (unit 6)-filled channel.
Unit 4	0.5-1.12 m.	Dolomite, digitate stromatolite boundstone, undulose bottom and top, crystalline fabric similar to unit 1, sparse snail and cephalopod molds in upper part. Upper portion of this unit is truncated by dolograinstone (unit 6)-filled channel along the middle portion of lower bench.
Unit 3	1.56-1.66 m.	Dolomite, light tan, four beds, fine crystalline, dolograinstone, common very light tan dolomudstone intraclasts up to 3 mm. in length, basal 10-20 cm. is very intraclastic. Faint cross-strata in places, uppermost bed is the thinnest and varies from 3-18 cm. with undulose top.
Unit 2	3-11 cm.	Dolomite, light tan, fine crystalline, dense, basal part is coarser crystalline and displays minor grain-moldic porosity, dolograinstone to dolopackstone, variable thickness is due to draping over underlying digitate stomatolite boundstone. Upper surface is marked by medium grey metallic oxide stain.

Unit 1 64-74 cm. Dolomite, digitate stromatolite boundstone, fabric appears as vertically oriented finger-size columns of dense, light grey, fine crystalline dolostone with light tan, porous, fine to medium crystalline dolostone in interfinger area. Undulose upper surface with 10-20 cm relief. Minor calcite filled vugs in upper 20 cm.

Section begins at the southeast corner of quarry.

STOP 2. ZEZULKA QUARRY
The St. Lawrence Formation, Lodi and Black Earth members, and an elevated view of Sand Cove

DISCUSSION: This is a relatively new quarry and the exposure is rather fresh, hence it is a good locality to view the stratification and sedimentary structures within an interval which is normally poorly exposed in Allamakee County. The quarry is situated along the northwest flank of the Irish Hollow Anticline (Fig. 3), and the view to the south, across the Upper Iowa River valley, is toward Sand Cove, a rock-cored meander perched 120 feet above the modern flood plain of the Upper Iowa River (Calvin, 1895; and Roosa et al., 1983). Sand Cove is apparently coincident with the axis of the Irish Hollow Anticline (Fig. 3) and the flexure and probable fracturing of the bedrock units along the crest of the anticline may have influenced the location of the meander.

The St. Lawrence Formation in Allamakee County (Fig. 1) and most of southeast Minnesota and southwest Wisconsin consists of two members: thin to medium-bedded silty dolomites of the Black Earth Member, and thin-bedded dolomitic siltstones to silt-rich very fine-grained sandstones of the Lodi Member. At almost all localities the Lodi is the dominant member. However, to the south and west in the subsurface of Iowa the formation undergoes a rapid lithologic transition and dolomite becomes the dominant facies. Similar facies transitions occur in the southern Wisconsin and northern Illinois subsurface (Ostrom, 1978).

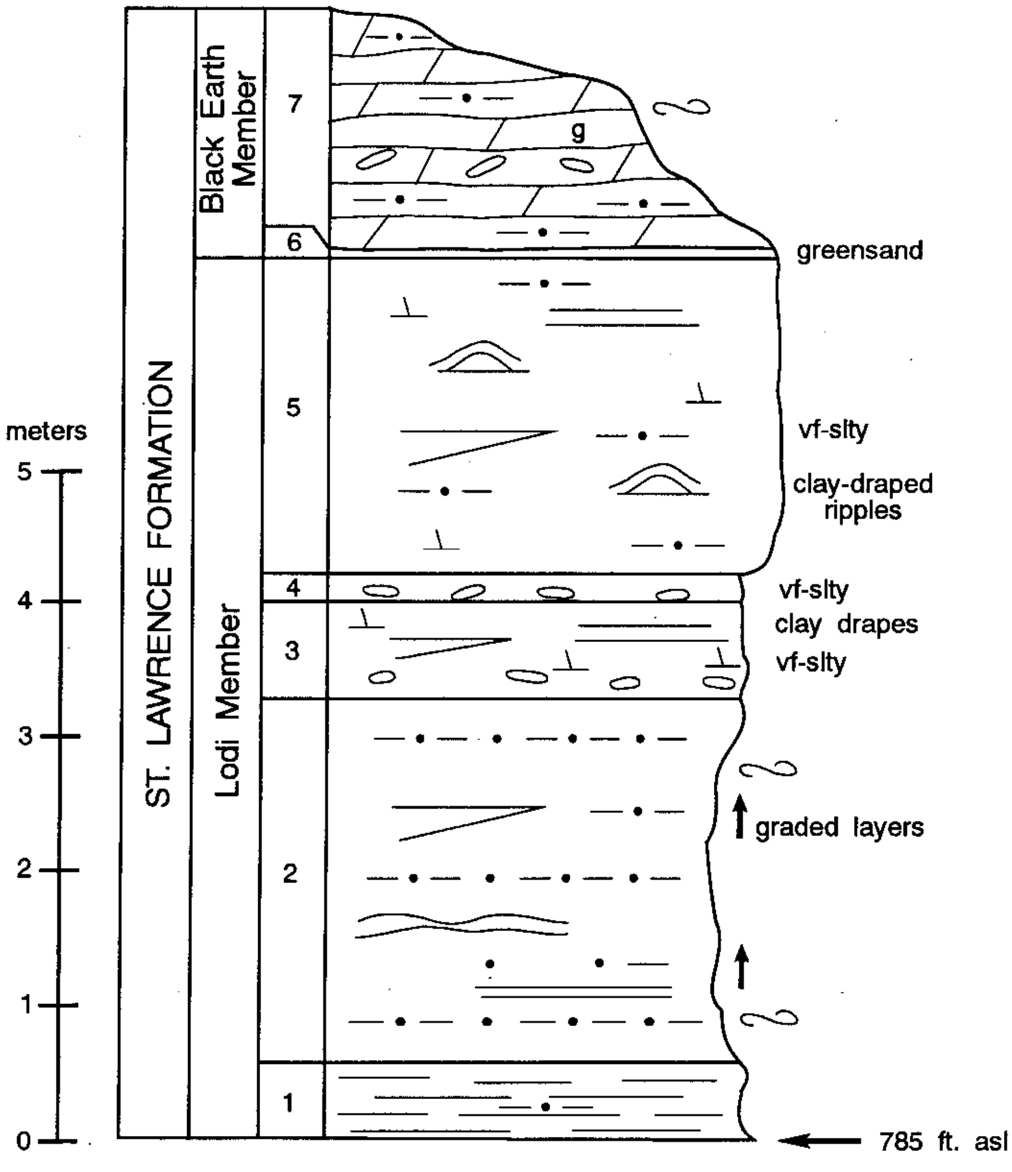
The stratification and depositional structures of the Lodi at this stop include: symmetrical and asymmetrical wave-ripples (some with well-developed clay drapes), graded wavy bedding, lenticular bedding, low-angle cross-stratification, possible small-scale hummocky cross-stratification, and the development of several intraclast conglomerate beds. Bioturbation is sparse but is manifest as both small and large diameter horizontal burrow traces. Body fossils have not yet been observed here but other Lodi localities in northeast Iowa and adjacent states have yielded trilobites, aglaspid merostome arthropods, inarticulate and articulate brachiopods, gastropods, conodonts, hyolithids, and graptolites (Twenhofel et al., 1935; Ruedemann, 1947; and, Witzke and McKay, 1987).

The Black Earth dolomite facies caps the section. A thin but well-developed greensand (glaucarenite) occurs at the base of the member on the top of the quarry bench. The greensand is poorly exposed, but pieces of it which have fallen can be found on the quarry floor and talus slope. The remainder of the unit consists of thinly bedded, bioturbated, silty dolomite with an intraclast conglomerate bed in the middle. In adjacent areas the Black Earth has yielded orthoid brachiopods, trilobites, gastropods, and hyolithids (Twenhofel et al., 1935), and Byers (1978) notes at least two localities where algal stromatolite mats and hemispheroidal to columnar stromatolite mounds occur.

Various authors have discussed the environment of deposition of the St. Lawrence Formation. Twenhofel, Raasch and Thwaties (1935) interpreted the interval as having been

ZEZULKA QUARRY

W-32947
NW, NW, NW, NW, sec. 20 T100N, R4W
Allamakee County, Iowa



deposited under conditions of slow marine sedimentation. Ostrom (1970 and 1978) echoed their simple interpretation and expanded upon it by placing St. Lawrence sediment accumulation in an offshore subtidal-shelf position during a transgressive-regressive sea-level cycle. Byers (1978) has argued that the St. Lawrence was deposited within the intertidal realm and possibly portions of it as onshore as the supratidal environment. I interpret the depositional environment to be one of an offshore shelf setting where the seafloor was frequently subject to pulses of sediment-charged water masses that were the result of sediment entrainment and transport by tropical storms. The depositional sedimentary structures suggest to me, that strong and repetitive unidirectional flows (currents), such as typical of many modern tidal-flat environments today, were rare. In contrast the structures are consistent with formation under wave-induced orbital flow with occasional strong bottom-scour capable of eroding and transporting clasts of firm- or hard-ground sea floor. The rather diverse invertebrate fauna of the St. Lawrence, although sparse, is also supportive of a subtidal environment of deposition. The localized development of stromatolites does not, as suggested by Byers (1978), necessarily support the presence of tidal flat sedimentation, for we are now aware of modern examples of subtidal stromatolites (Dravis, 1983; and Dill et al., 1986), and there remains the possibility that the dolomitized and poorly preserved reported structures, are not typical Shark Bay type intertidal stromatolites, but rather more complex calcified microbial/cyanophyte mounded accumulations which are frequently interpreted as having grown in a subtidal environment in other Cambrian and Lower Ordovician rocks.

ZEZULKA QUARRY (W-32947)

NW1/4 NW1/4 NW1/4 NW1/4 Section 20, T100N, R4W, Allamakee Co.
New Albin 7.5' Quad
Elevation at base approximately 785 ft.
Measured by R. M. McKay, April 2, 1993

ST. LAWRENCE FORMATION
Black Earth Member

Unit 7	1.75 m.	Dolomite, light tan, silty to very silty, very thinly to thinly bedded, sparse large diameter (1.0 cm.) horizontal burrows. Intraclast conglomerate (7 cm. thick) 60 cm. above base, silty, glauconitic. Upper 75 cm. poorly exposed as float pieces.
Unit 6	6 cm.	Greensand, dolomitic, poorly exposed at top of quarry highwall.

Lodi Member

Unit 5	2.5 m.	Sandstone, light tan, very fine-grained to silty, calcitic to very calcitic, ledge former, difficult to access but loose

		blocks on quarry floor display small-scale ripples. Ripples are low-amplitude (height approx. 1 cm.) and short wavelength (wavelength approx. 8 cm.), symmetrical and asymmetrical, draped by green clay up to 1 cm. thick.
Unit 4	15 cm.	Intraclast conglomerate, upper and lower intraclast conglomerate beds separated by 5 cm. thick sandstone. Matrix is very fine-grained sandstone, very silty.
Unit 3	70 cm.	Sandstone, very fine-grained, silty, calcitic to very calcitic, thin to very thin bedded, beds well-laminated internally, displays horizontal to low-angle cross-lamination, green clays drapes on some beds. At 10 cm. above base is a 12 cm. thick intraclast conglomerate, intraclasts are silty, very fine-grained sandstone, disc-shaped and up to 8 cm.; matrix is silty, very fine-grained sandstone displaying low-angle cross-stratification, draped by a 0-2 cm. green clay.
Unit 2	2.85 m.	Siltstone, light tan to medium tan, main recessive unit above quarry floor, porous, poorly cemented, very well stratified, very thin to thin bedded. typical beds 1-5 cm. thick, thicker beds can be traced laterally several meters, many beds thicken and thin or pinch and swell laterally. Internally beds are horizontally to very low-angle cross-stratified with some pinch and swell cross-laminae (similar to small-scale hummocky stratification), some beds display vertical grading from silt at base to finer silt and clayey silt at top, sparsely glauconitic, sparse lamination plane wrinkle marks, sparse to moderate large- and small-scale sinusoidal horizontal burrow traces (length 1.5 -10.0 cm, 3 cm diameter).
Unit 1	55 cm	Shale, medium green, fissile, silty with minor tan siltstone laminae, nondolomitic. Present as covered unit at base of quarry face and in road ditch.

STOP 3. WONEWOC STREAMCUT

The marine trough cross-stratified facies of the Wonewoc Formation

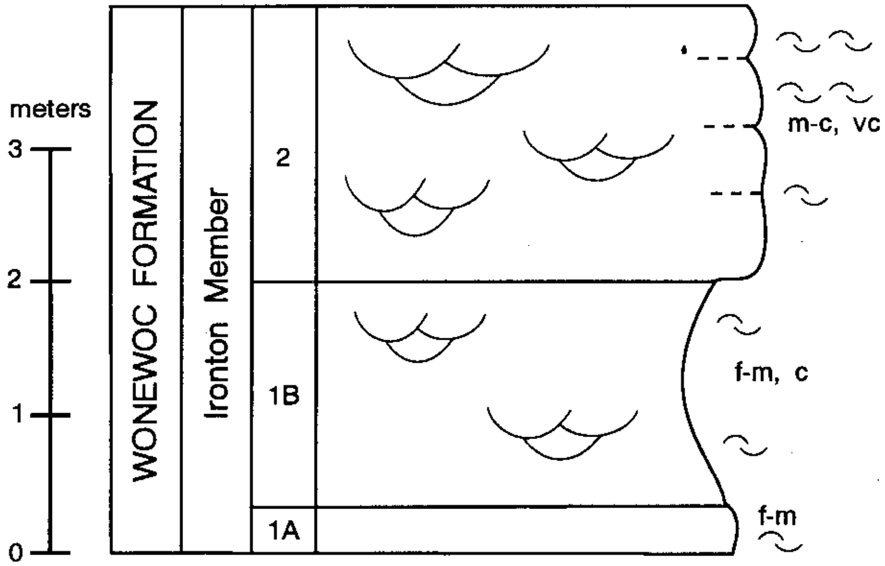
DISCUSSION: At this stop we will view a small stream cut outcrop of the oldest Paleozoic rock unit exposed in the state, the Ironton Member of the Wonewoc Formation. The formational name of Wonewoc was introduced into Wisconsin stratigraphic nomenclature by Ostrom (1966, and 1967) and is conveniently applied to similar strata in Iowa (Fig. 1). In Wisconsin and Minnesota, the Wonewoc Formation can often be readily subdivided into a lower Galesville Member, and an upper Ironton Member, however in Iowa, where the unit is almost exclusively in the subsurface, this subdivision is frequently not tenable.

The Wonewoc Formation averages 140 feet thick in Allamakee County, but the maximum thickness presently exposed is the upper 14 feet at this outcrop. Fifty years ago Schuldt (1940) reported an exposed thickness of 21 feet here. This exposure is here, at least partially, due to its location along the axis of the southeast end of the Irish Hollow Anticline (Fig. 3), a fact originally noted by Schuldt (1940). The exposure is typical of the upper Ironton Member throughout the Upper Mississippi Valley and is an excellent example of the formations trough cross-stratified facies as described by Ostrom (1970), and more recently by Dott et. al. (1986). Whole and broken valves of inarticulate oboloid brachiopods are common throughout and form coquinid accumulations in the upper meter. Fragments of the trilobite *Camaraspis convexa* (*Elvinia* Zone of the lower Franconian Stage) are found throughout the region in the upper 5 feet of the Ironton (e.g. Upper Iowa River Valley near New Albin), but have not been reported from this exposure. Twenhofel et. al., (1935) notes gastropods and additional trilobite and inarticulate brachiopod genera from the Ironton in Wisconsin. The weakly cemented and porous, fine- to coarse-grained sandstone sequence of the Wonewoc forms the uppermost unit of the Dresbach Aquifer System, a geographically limited yet important municipal and industrial aquifer in eastern Iowa (Horick and McKay, 1990).

The Wonewoc Formation of the western Wisconsin outcrop area, is interpreted by Dott, et. al. (1986) to have been deposited in nonmarine aeolian and fluvial to marine shelf environments. They judge the lower portion (Galesville Member) to represent the deposits of a central Wisconsin aeolian erg and aeolian to fluvial sand plain which was transgressed by an early Franconian seaway in which the overlying Ironton Member was deposited. The Wonewoc attains its maximum thickness in this portion of the Upper Mississippi River Valley and thins in wedge-shaped fashion to the west and south in the Iowa subsurface where the unit appears to be entirely marine in origin. In central Iowa the Wonewoc sandstone facies is absent but faunally correlative (*Elvinia* and *Linnarsonella* zones) fossiliferous shale and carbonate strata are present. These strata are representative of deposition within a deeper, less energetic offshore shelf setting that was beyond the limits of sand dispersal.

WONEWOC STREAMCUT

SW, NE, SW, NE, sec. 12, T99N, R4W
Allamakee County, Iowa



WONEWOC STREAMCUT
SW1/4, NE1/4, SW1/4, NE1/4, Section 12, T99N, R4W, Allamakee Co.
New Albin 7.5' Quad
Elevation at base approximately 625 ft.
Measured by R. M. McKay, April 5, 1993

WONEWOC FORMATION
Ironton Member

Unit 2 1.9 m. Sandstone, four ledges approximately subequal in thickness, light tan, medium- to coarse-grained, some very coarse-grained sand, moderately sorted, quartz arenite, slightly calcitic to dolomitic, weakly cemented, stratification composed entirely of truncated trough-cross-strata sets, sets 10-20 cm. thick and generally 1 m. or less in width, broken and whole valve inarticulate oboloid brachiopod shell material common but very abundant in upper half approaching a coquina in places.

Unit 1		2.0 m.	Sandstone, forms a recessive lower unit in the section, divided into two subunits.
	1B	1.7 m.	Sandstone, light tan, fine- to medium-grained, minor coarse-grained sand, moderately sorted, quartz arenite, highly trough-cross-stratified, sets 10-15 cm. thick, trough widths up to 1.5 m., common broken and whole valve inarticulate oboloid brachiopod shell material along cross-strata laminae, most valves oriented concave-up, trough axes trend south to southwest.
	1A	30 cm.	Sandstone, light tan, forms a ledge at base of exposure, fine- to medium-grained, well sorted, quartz arenite, very weakly cemented, friable, porous, bears broken to whole valve inarticulate brachiopod shell material.

STOP 4. LANSING NORTH ROADCUT
The St. Lawrence Formation and underlying greensands of the Reno Member, Lone Rock Formation

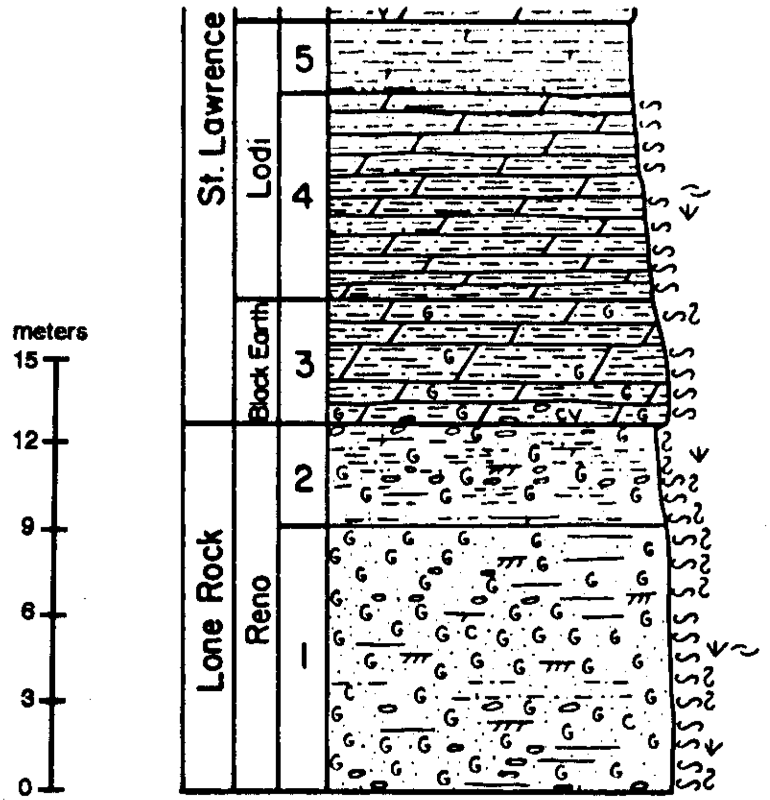
DISCUSSION: This stop will afford the opportunity to examine late Franconian and early Trempealeauan age strata of the Lone Rock and St. Lawrence formations. The formational name of Lone Rock was introduced in Wisconsin by Ostrom (1966 and 1967) to replace the long-used term Franconia Formation. Iowa has adopted Ostrom's terminology, but Minnesota retains use of the name Franconia. The member name Reno was introduced by Berg (1954) and has been adopted by Iowa, Minnesota and Wisconsin. Reno strata, being shaly in part and generally weakly cemented, are characteristically poorly exposed slope formers, and this roadcut is perhaps the best exposure in the state.

The Reno Member is composed chiefly of very fine- to fine-grained feldspathic and glauconitic sandstones that constitute over half the total thickness of the Lone Rock Formation in Allamakee County and adjacent areas to the north and east (Fig. 1). The strata are generally thin-to medium-bedded and display: horizontal laminations to low-angle cross-laminations, rippled bedforms with shale and siltstone interlaminae and drapes, flat-pebble intraclast conglomerates, "greensands" containing up to 80 percent or greater glauconite as framework grains, and "wormstones" which exhibit varying intensities of bioturbated fabric. The carbonate content is dominantly dolomite and lessor amounts of calcite in intergranular cement positions, but a minor carbonate volume is probably related to thorough recrystallization of detrital carbonate grains. The faunal content of the Reno consists of trilobites and sparse inarticulate brachiopods. Trilobites occur as fragmentary molds within horizontally laminated beds and are difficult to find and collect. Collections from Lansing (Walter, 1924) and near New Albin (Schuldt, 1940) include genera characteristic of the *Ptychaspis-Prosaukia* Zone (late Franconian). The uppermost part of the Reno contains sparse trilobites characteristic of the basal *Saukia* Zone of the Trempealeauan Stage (Berg,1954; Witzke and McKay, 1987). Collectively the Lone Rock and St. Lawrence formations comprise a major confining layer between the underlying Dresbach Aquifer System and the overlying and widely used Cambrian-Ordovician Aquifer System in eastern and central Iowa (Horick and Steinhilber, 1978).

The depositional environment of the Reno has been interpreted by Berg (1954), Ostrom (1970 and 1978), and Odom (1978) to represent deposition within glauconitic storm-influenced offshore shelf environments, but Byers (1978) has suggested that the unit is a product of nearshore very shallow subtidal to intertidal sedimentation. Based on the units sedimentary structures, fauna, and lateral time-equivalent lithofacies relationships I concur with the interpretations of the former authors.

LANSING NORTH ROADCUT

NE, sec. 29, T99N, R3W
Allamakee County, Iowa



LANSING NORTH ROADCUT

NE1/4, Section 29, T99N, R3W, Allamakee Co.
Lansing 7.5' Quad
Elevation at base approximately 660 ft.
Measured section from Witzke and McKay (1987)

ST. LAWRENCE FORMATION

Lodi Member

Unit 5	2.0 m.	Siltstone to silty very fine sandstone, slightly argillaceous, trace glauconite, finely laminated, part ripple cross-laminated; difficult accessibility.
Unit 4	7.0 m	Siltstone, dolomitic, trace very fine sand, part finely laminated, slightly argillaceous, scattered ripples and starved

ripples, scattered horizontal burrows; rare trilobites (*Dikelocephalus minnesotensis*), aglaspid fragments, lingulids, articulate brachiopods (*Finkelnburgia* sp.).

Black Earth Member

Unit 3	4.3 m.	Ledge former; siltstone, dolomitic, and dolomitic siltstone to very fine sandstone, glauconitic to nonglauconitic (glauconite pellets locally to 1mm), part slightly argillaceous; some silty dolomitic; part finely laminated; ripple cross-laminated, intraclastic, clay drapes, and calcite void fills in basal part; horizontal argillaceous burrows common.

LONE ROCK FORMATION (Franconia Formation of Minnesota classification)
Reno Member

Unit 2	3.5 m.	Siltstone to very fine sandstone, nonglauconitic to very glauconitic, some greensand, part micaceous, part finely laminated to low-angle cross-beds, some clay drapes, ripple cross-laminae in lower part, scattered intraclastic beds; horizontal and vertical burrows common; scattered trilobite molds (*Dikelocephalus posterectus*, *Saukiella minor*, *Illaenurus* sp.).
Unit 1	9.0 m.	Sandstone, very fine, some very fine to fine in lower one-third, glauconitic to very glauconitic, common greensands, slightly micaceous, part calcite-cemented, horizontal laminated to low-angle planar cross-beds, common ripple cross-laminae, clay and siltstone interlaminae and drapes, scattered mudchip intraclasts in some beds; scattered to common horizontal and vertical burrows, rare trilobite molds (*Ptychaspis* sp.) and inarticulate brachiopod fragments.

STOP 5. THE VILLAGE CREEK ANTICLINE

Sections 15, 16, 20, and 21, T98N, R4W, Allamakee Co.
Church 7.5' Quad

DISCUSSION: This stop on the field trip is included to let participants gain an awareness of some of the subtle structural folds that deform what at first glance appear to be flat-lying Lower Paleozoic strata in the region (Fig.3). The early geological investigations of Iowa (Owen, 1852; and Hall, 1858) recognized and described the gentle southwestward dip of geological formations across the state but McGee (1891) and Calvin (1895) were the first to note and describe anticlinal and synclinal structures from Clayton and Allamakee counties. McGee (1891) broadly mapped, through southwest Allamakee and northeast Clayton counties, the northwest to southeast trending axis of a deformation that he named the Snymagil Anticlinal. Calvin (1895) discussed the presence of a paired northwest trending anticline and syncline through the central and northwest portion of Allamakee County. He observed, within the St. Peter and Trenton strata, that the anticline, in the vicinity of southeast Makee Township (T98N, R5W) has an amplitude of 150 feet and is sharply asymmetric towards the northeast. Calvin (1895) noted less pronounced effects of the same anticline in the neighborhood of Quandahl and commented that many other flexures, though only cursorily observed, were manifest throughout the county.

Schuldt (1940) prepared the first detailed structural contour map of Allamakee County and defined four distinct northwest trending structural highs mapped on the top of the "Madison" sandstone (upper Jordan Formation). Schuldt's map, based upon 78 control points, was the first to depict the geometry of a large northwest trending anticline across Village Creek in Center Township (T98N, R4W). However, he did not assign names to any of his mapped anticlines.

Heyl, et. al. (1959), during his exhaustive investigation of the Upper Mississippi Valley zinc-lead district, named the anticline discussed by Calvin (1895) the Allamakee Anticline and considered it as a northwest trending extension of the east-west trending Mineral Point Anticline of southwest Wisconsin. He classified the Allamakee and Mineral Point anticlines as the northernmost of three first-order folds in the district; the first-order folds being large-scale structures at least 40 miles long, and from 3 to 6 miles wide, with amplitudes as much as 200 feet. The term Allamakee Anticline, and its generally defined trend, is often used today by authors investigating mineralization on the fringes of the main zinc-lead district (Runkel, et.al., 1993; Brannon, et. al., 1993).

Recent mapping programs of the Geological Survey Bureau has allowed a more detailed portrayal of the Allamakee Anticline. Structure mapping on the top of the Coon Valley Member, Jordan Formation, within its outcrop area in northeast Allamakee County (Fig. 3), has permitted the delineation of several anticlines and synclines. Some of these are coincident with features mapped by Schuldt (1940) while others are not. The recent mapping utilized 160 newly acquired data points and combined these with Schuldt's data where appropriate. The feature here named the Village Creek Anticline (Fig. 3) is coincident in magnitude and aerial extent to the unnamed anticline mapped by Schuldt (1940). This anticline may not be the same as the one discussed by Calvin in Makee Township (T98N, R5W) for the locations of the axes apparently differ by approximately 3 miles. The Village Creek Anticline displays an amplitude of 120 feet and is asymmetric towards the north-northeast, a characteristic typical of the first-order folds delineated by Heyl et. al., (1959). The region on the southwest limb of the fold, towards the area of Calvin's southeast Makee Township structure is probably more complex than portrayed on figure 3 and will be the subject of future mapping efforts.

To gain a sense of the Village Creek Anticline the trip will stop at a Van Oser Member (Fig. 1) outcrop at an elevation of approximately 760 feet and then travel about one mile to the southwest up to an elevation of approximately 780 feet to view an outcrop of St. Lawrence Formation. This slight gain in altitude takes us about 70 to 80 feet downward in the stratigraphic section and places us to the southwest of the anticlinal axis. The steeper north limb of the Village Creek Anticline achieves a maximum dip of approximately 200 feet per mile, roughly a 3.5 degree dip. This is about ten times as steep as the regional dip of 18 feet per mile. A portion of this steep dip at the western end of the anticline may possibly be fault-related, but further fieldwork is needed to gain a more thorough understanding of the feature.

STOP 6. HANGING ROCK
EFFIGY MOUNDS NATIONAL MONUMENT
The Van Oser and Coon Valley members of the Jordan Formation

DISCUSSION: The Jordan Formation of Iowa, named after the type section in Jordan, Minnesota is the most prominently exposed Cambrian formation in northeast Iowa, being well exposed in roadcuts and cliff faces beneath the overlying dolomite escarpment of the Oneota Formation. The Jordan is divided into four members in northeast Iowa (Fig. 1), similar to that in Wisconsin (Odom and Ostrom, 1978). The basal member, the Norwalk, is the least well exposed. It is predominantly a very fine to fine-grained feldspathic sandstone which contains hummocky cross-stratification and bioturbated fabrics (Dott and Byers, 1980). The Van Oser Member is a fine to coarse-grained highly cross-stratified quartz arenite which contains common dolomitic siltstone intraclasts, scour surfaces and zones of *Skolithos* bioturbation. The Waukon Member is a relatively new member term which was introduced by Odom and Ostrom (1978) for a very fine to fine-grained feldspathic sandstone facies in the upper part of the Jordan. The Waukon usually occurs as a facies enclosed by the coarser-grained Van Oser member, but at this stop it lies almost entirely above the Van Oser. Odom and Ostrom (1978) correlate the Waukon to a similar facies (Sunset Point Member) in Wisconsin. The uppermost facies, presently called the Coon Valley Member (name introduced by Odom and Ostrom, 1978), has been bounced back and forth between being included as a member of the Oneota or Jordan formations. Although Iowa currently includes the Coon Valley interval within the Jordan Formation recent work in Wisconsin and Minnesota has moved the unit back into the Oneota Formation where it is called the Stockton Hill Member (Smith, et al., 1993). The Coon Valley member contains a spectrum of sandstone and quartz-sandy carbonate rock types including ooid and intraclastic grainstones, stromatolite boundstones, cross-stratified sandstones, and rippled to mudcracked thinly bedded fine sandstone and shale. Conodont studies of the Coon Valley in Wisconsin documents its age as early Ordovician (Miller and Melby, 1971; and Smith, 1991). The Jordan Formation in northeast Iowa rarely yields invertebrate fossils, but sparse trilobites, brachiopods, conodonts, echinoderms and molluscs are known from other areas.

At this stop participants will be able to view a well exposed and relatively accessible section of the Van Oser through lower Oneota Formation. The Van Oser facies was deposited in a high energy nearshore marine shelf environment as evinced by the common scour surfaces and cross-stratification. Runkel (1992) has recently reported the recognition of tidal inlet facies and shoreline beachrock deposits in the Van Oser of Minnesota. The Waukon facies is exposed but difficult to access. It records the deposits of a finer-grained but still energetic environment, perhaps that of a tidal-flood delta. The contact of the Coon Valley Member with the underlying Van Oser or Waukon , though not well exposed, appears to be channeled and may represent an unconformity and overlying surface of transgression similar to that recently described by Smith, et al., (1993) from the Wisconsin outcrop belt. The bulk of the Coon Valley records warm water aggradational shallow subtidal to supratidal sedimentation that grades upward into nonsandy subtidal stomatolite boundstones of the overlying Oneota.

THE HANGING ROCK AND RED HOUSE LANDING SITES

by

Thomas Munson

In an attempt to document the activities in the Hanging Rock vicinity I have found that written descriptions are basically non-existent. References are sketchy and made in passing. Much of what we think we know actually exists in the collective consciousness of the Park Rangers who have worked here since 1949 when the monument was established. Perhaps it cam from a snippet they read somewhere, or got from a conversation with an old timer, or surmised from their own observations so, while I can summarize it, I cannot document it.

When the rangers talk among themselves about the Hanging Rock Site, they usually mean they usually mean the prehistoric Native American site and when they talk about the Red House Landing site, they mean the historic remains dating from the early 19th century. In reality, the sites are all jumbled together with the railroad slicing through the middle of it.

The large prehistoric site, some say it extends downstream as far as the mouth of the Yellow River, has never been thoroughly investigated. There is a large clamshell midden with associated potsherds, points, etc., between the tracks and the river at the base of Hanging Rock. Scattered surface finds and limited testing support the idea that it may extend some two to three miles downstream to the FTD site, near the Yellow. At one time, fairly recently, because I have seen them, there were petroglyphs carved into the base of Hanging Rock, however time and vandals have pretty well obliterated them.

Most recently we have learned that the Luther College Archaeological Research Center has applied to test the Hanging Rock site this summer. Jurisdictionally our boundary is west of the railroad right-of-way and the State of Iowa (DNR) is east.

Red House Landing, also known as York's Landing, was established in the draw below Hanging Rock in the 1840's as the west-bank terminal of a ferry operating out of Prairie du Chien. A wagon road was pushed through to the top of the bluffs paralleling the intermittent stream bed - still visible if you look closely. Timber was taken off the bluffs and sold in Prairie du Chien. At some indeterminate date a building was put there which consisted of two fairly large rooms. The stone footings are still there and visible. A short distance behind it on the toe of the north facing bluff, a root cellar was dug with a corbelled arch entrance. The entranceway has collapsed however I have crawled through it. The interior of the cellar shows evidence that the floor was planked. The walls are sandstone, and have names and dates scratched into them dating to around 1900.

These dates jibe with other scattered references that indicate the landing was used as a fueling stop for steamboats between the period of the Civil War and the late 1800s. My impression is that one room of the building was used as a kitchen and the other room for serving repasts while the boat took on fuel, i.e. wood. How common were wood-fired steamboats?

I don't know. The proximity of the "kitchen" to the root cellar, which seems to have a fairly constant cool temperature, supports the idea that meals were served there. The remnants of a planked floor and what appears to be remnants of kegs in the cellar, also tends to support it. The late 1800s date is also supported by a tree-coring project of our that showed the oldest tree in the Hanging Rock vicinity was about 100 years old.

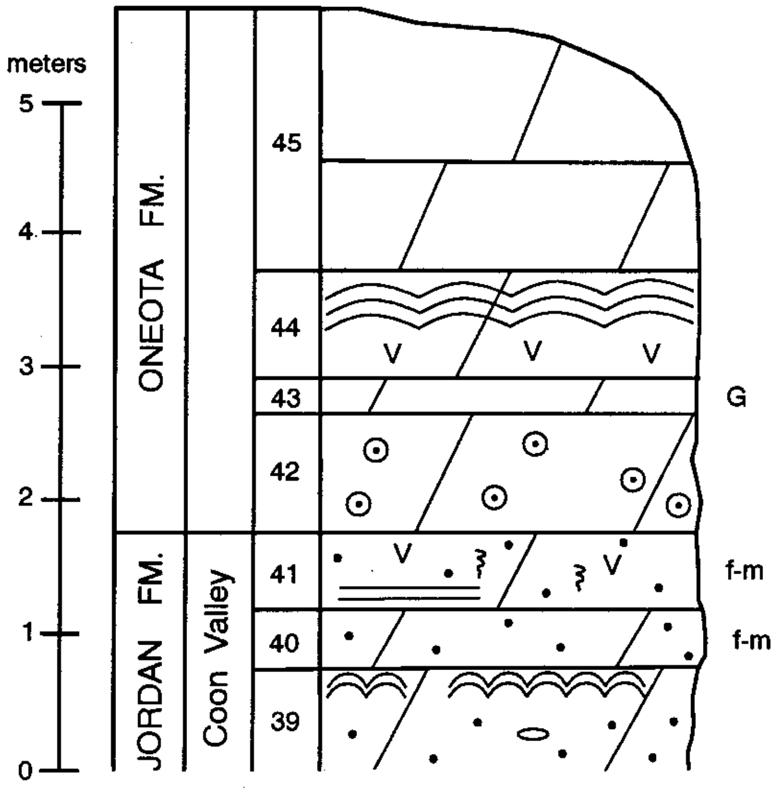
As an interesting footnote, the corbelled arch entryway to the root cellar was once reported as being of Native American origin which is an idea that is patently false. That "assumption" was made by an historian, not an archeologist, and an attempt was made to link it to corbelled arches in Mexico or Mayan origins. As we all know, once an idea like that gets in print, it's repeated forever despite all attempts to set the record straight.

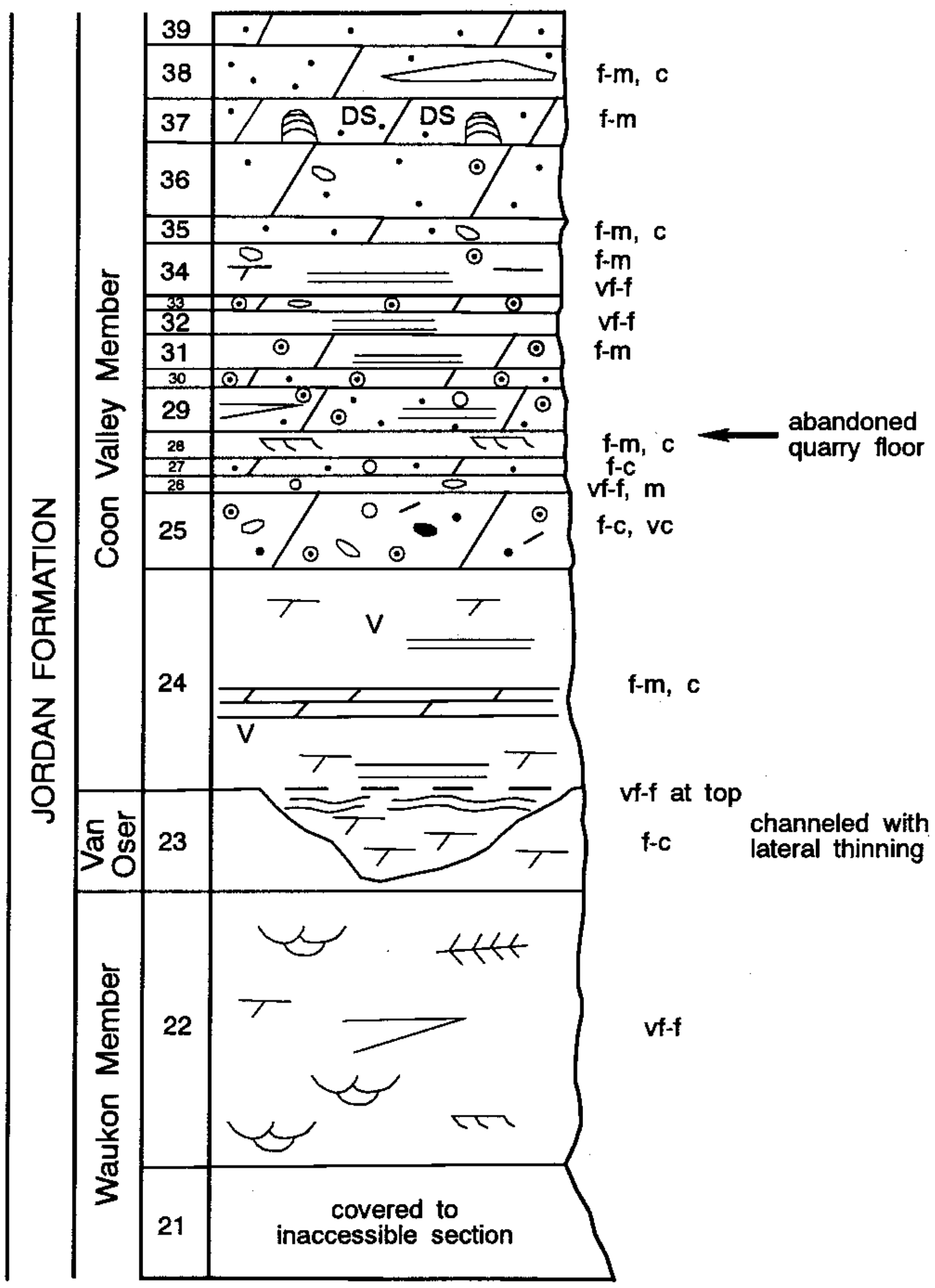
Sometime around 1900, following the demise of Red House Landing as a ferry terminal/ fueling stop, a camp was made there by clammers. They were engaged in the pearl-button industry operated largely out of Prairie du Chien. Incidental to the mussel shell "pearl buttons," they also were looking for fresh water pearls that were sold in Prairie du Chien to traveling buyers who worked up and down the river. In 1903 there is a reference to York's Landing and 100 clammers more or less permanently camped there. Old photographs show a variety of structures - tents, wooden shanties, fire pits - in and around the draw right down to the main channel. Along the water's edge you can still see old mooring blocks, chains, clam hooks, etc. About the time of WWI, the pearl-button business went belly-up. By 1916 there were fewer than a dozen clammers working out of Prairie du Chien. It is interesting to note, however, that there are still clammers working now and selling their harvest in Prairie du Chien but not for pearl buttons. My understanding is that they are mostly ground up for fertilizer but some are sent to Japan where blanks are punched out, tumbled and polished, and used to "seed" oysters to produce perfectly round cultured pearls.

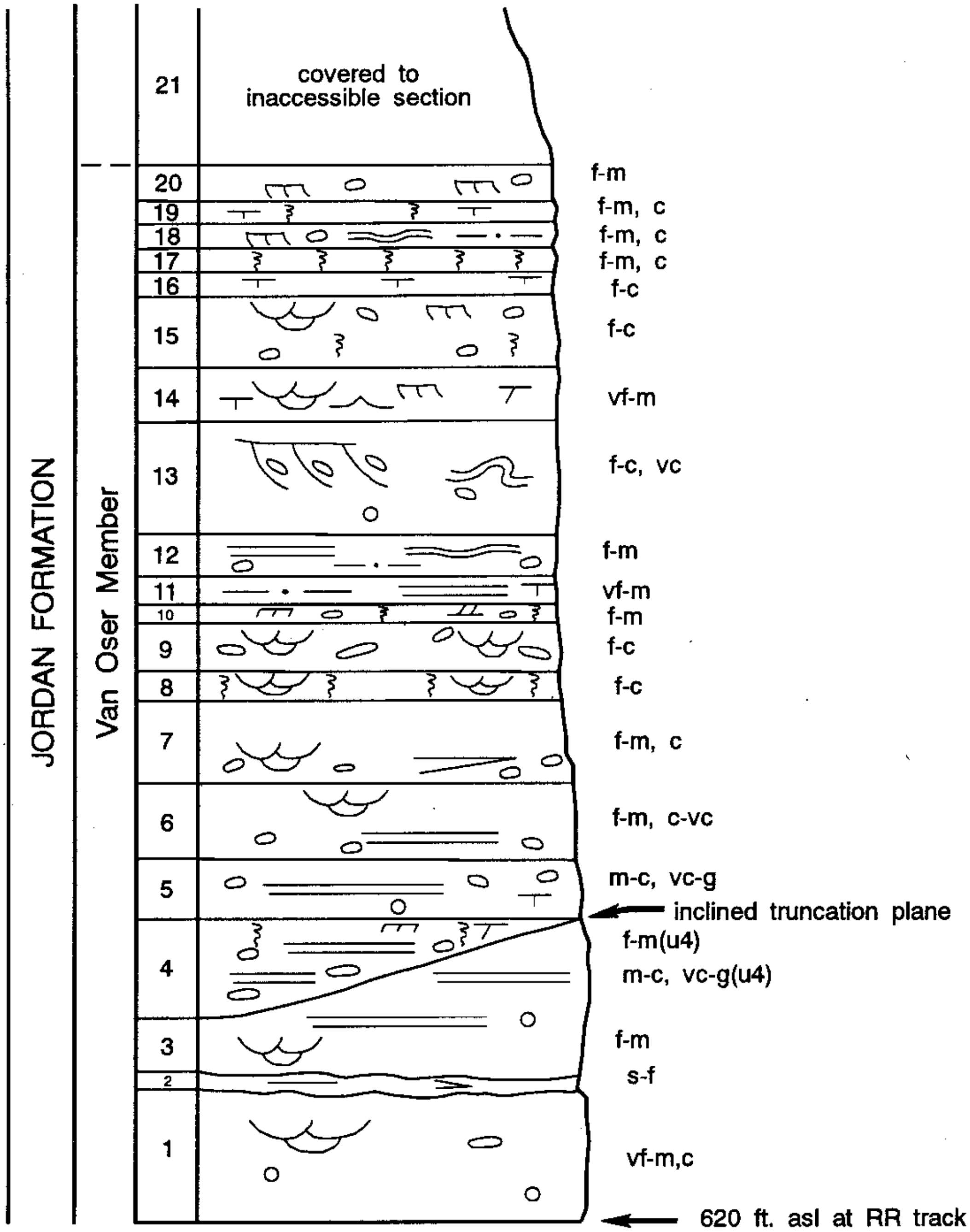
That pretty much summarizes what we think we know about the comings and going s at Hanging Rock except for a few rumors, perhaps fancified, in ranger folklore. We do know that the Milwaukee Road Railroad blew the top off Hanging Rock. Postcards from the 1920s, which still surface now and then, show the real Hanging Rock leaning out over the tracks. The story has it that it is the rock near the west bank with a navigational aide on top. It is also widely believed that stone from the quarry was used in building Red House Landing. My favorite is one about a cave up in the big draw that connects to a "blow hole" down by our visitor center. Who knows? It makes a good story.

EFFIGY MOUNDS NATIONAL MONUMENT

Hanging Rock Section
W-31274 (EMHR)
NW, SE, NE, SW, NE, sec. 27 T96N, R3W
Allamakee County, Iowa




JORDAN FORMATION
Coon Valley Member
Van Oser
Waukon Member
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
DS
DS
V
V
covered to inaccessible section
f-m, c
f-m
f-m, c
f-m
vf-f
vf-f
f-m
f-m, c
f-c
vf-f, m
f-c, vc
f-m, c
vf-f at top
f-c
vf-f
abandoned quarry floor
channeled with lateral thinning


JORDAN FORMATION
Van Oser Member
21
covered to inaccessible section
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
f-m
f-m, c
f-m, c
f-m, c
f-c
f-c
vf-m
f-c, vc
f-m
vf-m
f-m
f-c
f-c
f-m, c
f-m, c-vc
m-c, vc-g
inclined truncation plane
f-m(u4)
m-c, vc-g(u4)
f-m
s-f
vf-m,c
620 ft. asl at RR track

HANGING ROCK SECTION (W-31274)
EFFIGY MOUNDS NATIONAL MONUMENT

NW1/4, SE1/4, NE1/4, SW1/4, NE1/4, Section 27, T96N, R3W, Allamakee Co.
Prairie du Chien 7.5' Quad
Elevation at base approximately 620 ft.
Measured by R. M. McKay, 1991

PRAIRIE DU CHIEN GROUP
ONEOTA FORMATION

Unit 45	2.0 m.	Dolomite, light grey, fine crystalline, nonsandy, hemispheroidal stromatolites in part.
Unit 44	80 cm.	Dolomite, lower half fine crystalline, dense, nonsandy, vuggy, upper half dominated by low-amplitude (2-3 cm.) stromatolites.
Unit 43	23 cm.	Dolomite, one bed, medium to coarse crystalline, probable grainstone.
Unit 42	90 cm.	Dolomite, tan, fine to medium crystalline, nonsandy, minor ooids and oomoldic porosity.

JORDAN FORMATION
Coon Valley Member

Unit 41	56 cm.	Dolomite, fine to medium crystalline, sandy to very sandy, sand is quartzose and fine to medium-grained, basal part very sandy and poorly cemented, appears to be horizontally stratified, some vertical *Skolothos* burrows, vuggy in part.
Unit 40	42 cm.	Dolomite, extremely sandy, sand is quartzose and fine to medium-grained.
Unit 39	90 cm.	Dolomite, one massive bed which in places parts to four beds of subequal thickness, fine to medium crystalline, dense, sandy to very sandy in lower half with trace intraclasts, nonsandy in upper half with small amplitude stromatolites (5 cm.) in upper 17 cm.
Unit 38	43 cm.	Dolomite, extremely sandy to sandstone with two sandstone lenses up to 10 cm. thick, sand is quartzose, fine to

		medium-grained with minor coarse-grained sand.
Unit 37	40 cm.	Dolomite, very fine to fine crystalline, digitate stromatolite boundstone, fine to medium-grained quartz sandy.
Unit 36	56 cm.	Dolomite, tan, dense, one bed, sandy to very sandy, minor intraclasts and ooids.
Unit 35	19 cm.	Dolomite, tan, one bed, fine to medium-grained sandy, minor coarse, minor intraclasts.
Unit 34	40 cm.	Sandstone, very fine to fine-grained in lower half, fine to medium-grained in upper half, well cemented, horizontal laminations in part, minor amount of intraclasts and ooids in upper half.
Unit 33	12 cm.	Dolomite, ooid grainstone, sandy, hard, dense, minor intraclasts.
Unit 32	18 cm.	Sandstone, very fine to fine-grained, horizontally stratified, hard, probable siliceous cement.
Unit 31	28 cm.	Dolomite, lower part is fine crystalline and horizontally stratified, grades up to fine to medium-grained sandy dolomite with minor ooids.
Unit 30	10-12 cm.	Dolomite, tan, ooid grainstone, slightly sandy.
Unit 29	35 cm.	Dolomite, tan, sandy to very sandy ooid grainstone, horizontal to low-angle laminae, quartzose sand fine to coarse-grained.
Unit 28	20 cm.	Sandstone, very light grey, fine to medium-grained, minor coarse-grained, quartzose with minor feldspar, friable, cross-stratified.
Unit 27	11 cm.	Dolomite, tan, fine to coarse-grained sandy, minor vugs, trace relict peloids.
Unit 26	12 cm.	Sandstone, very fine to fine-grained, minor medium to coarse, friable, porous, quartzose to slightly feldspathic, trace intraclasts to 6 mm., some dolopeloids.
Unit 25	60 cm.	Dolomite, tan, one thick bed, very sandy (fine to coarse-

grained, less very coarse) quartz-cored ooid to peloidal grainstone, intraclastic (intraclasts are silty to sandy, micritic to microsparic dolomite containing some peloids and ooids and trace fine crystalline phosphatic matrix/cement content), some clay-flake clasts.

Unit 24	1.7 m.	Sandstone, thick bedded, fine to medium-grained, minor coarse, dolomitic to very dolomitic, vuggy to microcavernous (10-20 cm.) in part, thin 1-2 cm. thick fine crystalline dolomite layers in middle, indistinct horizontal laminae.

JORDAN FORMATION

Van Oser Member

Unit 23	10-80 cm.	Sandstone, fine to coarse-grained, dolomitic appears to in part be truncated by channel,. Upper part that fills apparent channel is sandstone, silty to fine-grained, very dolomitic, hard, well cemented, fine wavy laminations (stromatolitic?) in upper part. The apparent channeled division between upper and lower parts of unit is a probable disconformity.

Waukon Member

Unit 22	2.6 m.	Sandstone, very fine to fine-grained, dolomitic, composed of multiple sets 5-15 cm. thick of tabular to trough cross-strata with minor low-angle cross-laminae in middle, trough axes and tabular foresets dip toward southeast through southwest, possible herringbone cross-strata also.
Unit 21	2.6 m.	Covered to inaccessible slope. *Possible Waukon Facies.*

Van Oser Member

Unit 20	30 cm.	Sandstone, fine to medium-grained, intraclasts to 3 cm., one set tabular cross-strata in lower 20 cm., indistinct structure in upper 10 cm.
Unit 19	20 cm.	Sandstone, fine to medium-grained, some coarse, calcareous, ledgey, no distinct sedimentary structures besides vertical burrows at top.

Unit 18	20 cm	Sandstone, fine to medium-grained, some coarse, lower half has one set tabular cross-strata, upper half has minor intraclasts and discontinuous to wavy sandy-silty laminae.
Unit 17	20 cm.	Sandstone, fine to medium-grained, minor coarse, lower 10 cm. strongly bioturbated, upper part moderately bioturbated.
Unit 16	20 cm.	Sandstone, fine to coarse-grained, calcite cemented ledge, no distinct sedimentary structures.
Unit 15	60 cm.	Sandstone, fine to medium-grained in lower 25 cm., medium to coarse-grained in upper 35 cm. Lower part has indistinct cross-strata, minor intraclasts, and burrows in upper 5 cm. Upper part has trough to tabular cross-strata with common intraclasts to 4 cm.
Unit 14	40 cm.	Sandstone, very fine to medium-grained, variably calcite cemented ledges, small-scale trough and tabular cross-strata, some symmetrical ripple form present.
Unit 13	98 cm.	Sandstone, tan to white, fine to coarse-grained, minor coarse, large-scale cross-strata set, lower part has deformed foreset laminae of tan sandy siltstone, upper part dominated by medium to coarse-grained sand with very coarse-grained and abundant sandy dolomitic (contains microspar peloids) siltstone clasts (to 4 cm.) along foreset laminae.
Unit 12	33 cm.	Sandstone, tan, fine to medium-grained, faintly horizontally stratified with discontinuous planar to wavy silty laminae, minor silty intraclasts.
Unit 11	22 cm.	Sandstone interlayered with siltstone. Sandstone, very fine to medium-grained. Siltstone, very fine to medium-grained sandy. Horizontal planar to slightly wavy laminae, calcareous, silty laminae 1-2 mm. thick.
Unit 10	14 cm.	Sandstone, tan to white, fine to medium-grained, tabular cross-strata in lower 7 cm., small-scale ripple cross-strata above, capped by slightly bioturbated zone at top, minor intraclasts, friable.

Unit 9	37 cm.	Sandstone, tan, fine to coarse-grained, common silty sandstone intraclasts (1 cm. thick by up to 11 cm long and very common smaller intraclasts 1-2 mm.), cross-stratified in part to massive in part, apparent foreset dip to west.
Unit 8	22 cm.	Sandstone, tan to whitish, fine to coarse-grained, friable, trough cross-stratified in lower 10 cm., moderately to strongly bioturbated in upper 12 cm., burrows are vertical *Skolithos* 2-3 cm. long and 2-3 mm. wide and orange in color and silt-filled, burrow density increases towards top.
Unit 7	70 cm.	Sandstone, tan, fine to medium-grained, minor coarse, friable, low-angle planar to trough cross-strata, sets to 20 cm., common silty intraclasts in lower 20 cm. along foreset laminae, intraclasts commonly 1-2 mm. but up to 1 cm.
Unit 6	60 cm.	Sandstone, tan, fine-medium-grained, minor coarse to very coarse and very coarse to granular intraclasts in basal 20 cm., friable, mostly horizontally stratified, minor cross-strata with apparent foreset dip to west.
Unit 5	45 cm.	Sandstone, tan, medium to coarse-grained, minor very coarse to granule, calcareous cement in part, abundant tan intraclasts (common 2-3 mm. up to 1 cm.), intraclasts are light tan silty to very fine-grained and dolomitic with rounded edges, unit is horizontally stratified.
Unit 4	80 cm.	Sandstone, tan, lower 30 cm. is medium to coarse-grained with some very coarse to granules, common flat dolomitic siltstone intraclasts to 4 cm. long, coarse clasts concentrated with coarse sand band near base, horizontally stratified. Upper 50 cm. is fine to medium-grained, friable, horizontally stratified with a few *Skolithos* near top, upper 10 cm. has minor small-scale cross-strata.
Unit 3	0.45-1.3 m.	Sandstone, tan, fine to medium-grained, minor coarse, minor trough cross-strata sets to 10 cm. thick, mostly horizontal stratification, slightly dolomitic. Unit thickens to north below major inclined truncation plane which spans sixty percent of the outcrop width.

Unit 2	0-10 cm.	Sandstone, tan, silty to fine-grained, with several 1 mm. thick green clay laminae, horizontal to low-angle cross-stratification, possible hummocky cross-strata with pinch and swell laminae, green clay laminae concentrated in swales and pinches out laterally.
Unit 1	1.1 m.	Sandstone, tan, fine to medium-grained, trough cross-strata sets 10 -30 cm. thick with a maximum width of about 1 m., friable, scattered tan dolomitic siltstone clasts to 3 mm. in length, trace micritic dolopeloids.

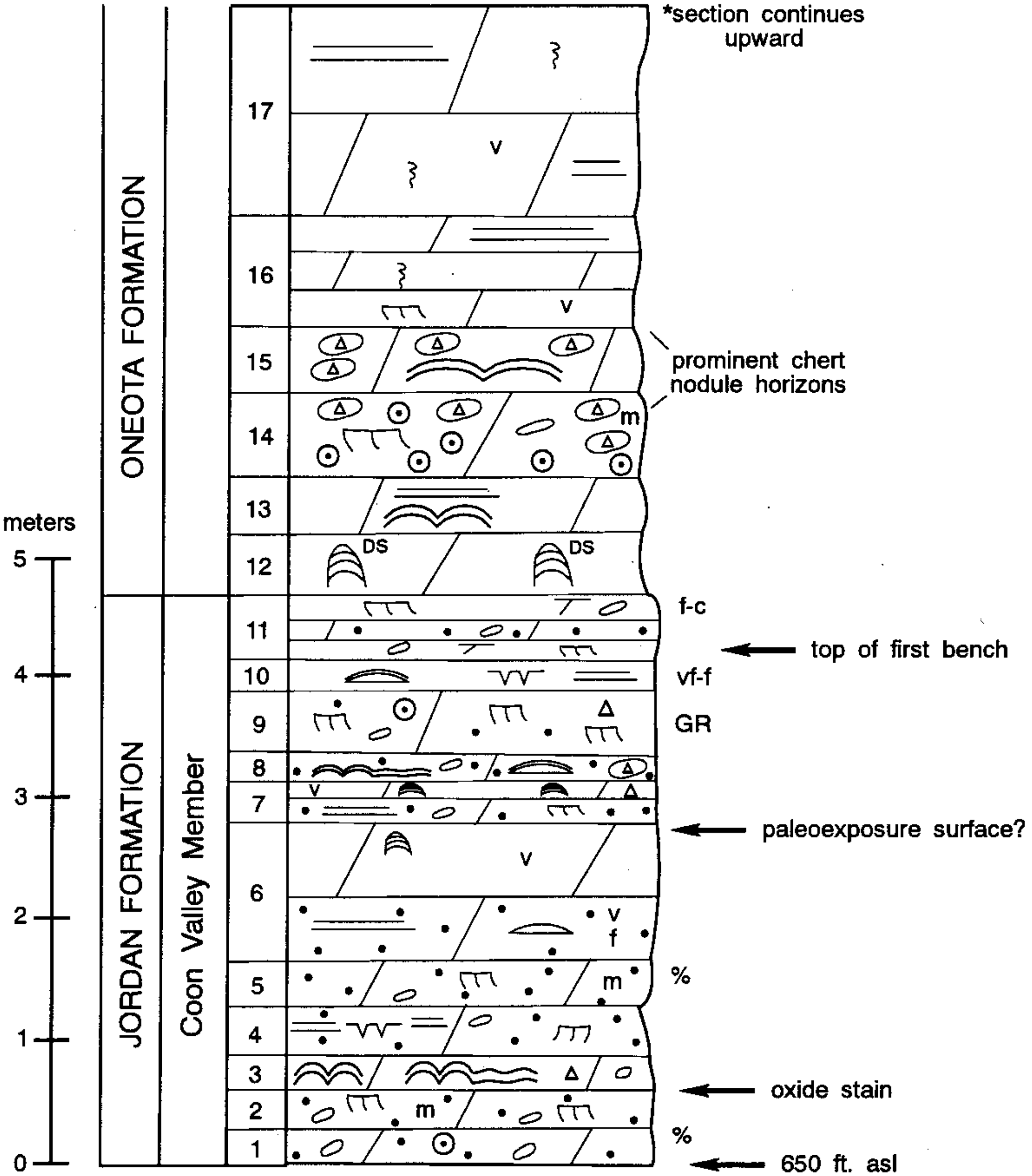
STOP 7. MARQUETTE WEST ROADCUT 2
The Coon Valley Member of the Jordan Formation and the lower Oneota Formation

DISCUSSION: At this stop the base of the section begins in the middle part of the Coon Valley Member. In this area, the Coon Valley is about 7 to 8 meters thick but only the upper 4.5 meters is exposed here. Coon Valley lithologies here are similar to those of the previous stop but access is easier. One of the more interesting aspects of this exposure is the well developed dessication-cracked carbonate and shale layers, and the presence of a probable paleoexposure surface. Dessication mudcracks are prominently developed in units 4 and 10. These are excellent evidence of an intertidal to supratidal setting for the enviroment of deposition. The top of unit 6 is marked by an irregular zone of porous coarse crystalline dolomite containing small white chert masses. The chert is botryoidal chalcedony and the microscopic fabric of the rock appears to be similar to silcrete recently described by Smith (1991, 1992) from the basal Oneota Formation in Wisconsin. This zone of inferred paleoexposure possibly represents an extended time interval of subaerial exposure during which paleosol development occurred. Its occurrence between two mudcracked intervals supports the interpretation that the environmental setting was at times supratidal.

The contact of the Coon Valley with the overlying Oneota Formation is marked by the transition from sandstones and sandy dolomites of the Coon Valley to essentially nonsandy relatively pure dolomites of the Oneota. The basal two meters of the Oneota contains stomatolite boundstones and ooid dolograinstones, facies similar the underlying Coon Valley, however there is a distinct absence of a sand component within the Oneota beds. The basal Oneota sequence at this stop is highlighted by the presence of two closely spaced prominent chert nodule horizons within units 14 and 15. These are continuous along the roadcut and are visible from the highway. The Oneota appears massive for several meters above the stromatolites and grainstones. This is a faintly horizontally to wavy laminated facies that appears to be a moderately bioturbated mudstone to fine-grained (perhaps peloidal) packstone. The unit is moderately vuggy, the larger vugs being calcite crystal-lined. The massive biotubated facies represents subtidal shelf deposition distant from siliciclastic sand sources and removed from frequent and energetic bottom-scouring currents.

MARQUETTE WEST ROADCUT 2

W-31706
SE, NW, NE, SE, sec. 16 T95N, R3W
Clayton County, Iowa



MARQUETTE WEST ROADCUT 2 (W-31706)

SE1/4 NW1/4 NE1/4 SE1/4 Section 16, T95N, R3W, Clayton Co.
Prairie du Chien 7.5' Quad
Elevation at base: approximately 650 ft.
Measured by: Robert M. McKay and Michael J. Bounk, winter 1992-93

PRAIRIE DU CHIEN GROUP
ONEOTA FORMATION

Unit 17	1.75 m.	Dolomite, light tan to light grey color mottled, very fine crystalline, probable horizontally bioturbated fabric, generally dense but contains a moderate number of vugs. Small vugs (1 mm.-1 cm.) not crystal lined, larger vugs up to 6 cm. are calcite crystal lined. Section continues upward but was not measured for this guidebook.
Unit 16	99 cm.	Dolomite, divided into three beds.
16C	34 cm.	Dolomite, light tan, fine crystalline, dense, nonsandy, faint horizontal laminations.
16B	44 cm.	Dolomite, light tan, fine crystalline, dense, nonstratified, nonsandy, possible bioturbated fabric in upper 10 cm.
16A	21 cm.	Dolomite, light tan, fine crystalline, nonsandy, dense but with sparse 0.5-1.0 cm. angular vugs especially in upper half. Lower part faintly cross-stratified.
Unit 15	42-52 cm.	Dolomite, light brownish grey, fine crystalline, stromatolite boundstone, broad low-amplitude domes to wavy mat with 1-2 cm. relief. White chert nodules scattered throughout, some are flattened to lenticular, others oval to circular and they generally lie along stromatolite layers. Unit capped by a 5-15 cm. thick bed of white chert. This is the upper of two prominent white chert beds which is visible from the highway.
Unit 14	40-67 cm.	Dolomite, one thick bed of ooid dolograinstone, faintly cross-statified, intraclastic with some intraclasts partially moldic, prominent white disc-shaped ooid grainstone chert nodules (1-10 cm. in diameter and 1-3 cm. thick) throughout, nonsandy to very slightly sandy?. Upper 10-17 cm. is a very prominent chert nodule horizon. Chert is white to light grey and displays some concentric color banding, fabric is ooid grainstone. This is the

lower of two closely spaced prominent chert horizons visible from the highway.

Unit 13	37 cm.	Dolomite, very fine crystalline, stromatolite boundstone, low amplitude laterally linked domes in lower part which grade upward to flatter and lower amplitude (1 cm.) stromatolites, nonsandy.
Unit 12	52 cm.	Dolomite, digitate stromatolite boundstone, discontinuous vertical columns of dense light brown fine crystalline dolomite separated by areas of porous dark brown fine crystalline dolomite, nonsandy. Unit is slightly recessive. Gradational upperward into the base of overlying unit.

JORDAN FORMATION
Coon Valley Member

Unit 11	55 cm.	Interbedded Sandstone and Dolomite, approximately four sets of interbedded dolomitic sandstone and very sandy dolograinstone, high to low angle cross-stratified, some horizontal stratification, three sets contain disc-shaped sandy dolostone intraclasts (1-8 cm. diameter, up to 1 cm. thick). Sand is fine to coarse grained, quartzose, rounded, frosted.
Unit 10	24cm.	Sandstone, light tan to light green, very fine to fine grained, lower third is two sets of horizontally stratified to lenticular with green shale drapes and interlaminated sand, trace possible dessication cracks. Upper two thirds consists of three sets of small-scale cross-stratified (rippled) sandstone with horizontally interlaminated clay, fine to coarse grained, grades up to a 2-3 cm. green claystone containing very well developed sand-filled dessication cracks. Sand from overlying unit fills dessication cracks. Sharp basal contact and sharp upper contact. Bedding plane exposure of this rippled and dessication-cracked interval is present along the top of the first bench at the east end of the roadcut.
Unit 9	46cm.	Dolomite, dolograinstone, color mottled light to dark tan, five to six poorly defined cross-strata sets, peloidal to oolitic and coated grain in part. Sparsely quartz sandy, fine grained. Upper 5-8 cm. is darker colored

		dolograinstone, intraclastic with greenish colored clasts of clay or dolostone (possibly glauconitic), and abundant white (silicified) flat intraclasts up to 1 cm diameter. Upper contact sharp. Sample 9 from upper greenish zone. Sample 9A from the middle of unit 9.
Unit 8	18-25 cm.	Dolomite, stromatolite boundstone, fine crystalline, nonsandy, lower 5-8 cm. is small laterally linked hemispheroids and grades upward into broader low-amplitude domes to wavy mat, sparse white chert nodules. Thickness varies laterally, grades laterally to and locally capped by horizontally stratified layers. Stratified layers, four to five, partially lenticular, very fine sandy, very fine crystalline dolostone with sandy to clayey mud drapes, scattered intraclasts in upper part and possible localized paleoexposure surface crusts of coarse crystalline porous dolomite.
Unit 7	30-35cm.	Dolomite, divided into two subunits.
7B	15-20 cm.	Dolomite, sharply overlies intraclast conglomerate of 7A, probable digitate stromatolite boundstone, composed of discontinuous vertical columns of dark, dense, fine crystalline dolostone separated by light tan porous fine crystalline dolostone. Grades up into a moderately dense fine crystalline partially vuggy dolostone, contains sparse porous, white chert masses 1-4 cm. in diameter. Upper few cm is small-scale laterally-linked domal stomatolites with dome diameters 2-3cm.
7A	10-15 cm.	Dolomite, two sets of cross-stratified dolograinstone, fine crystalline, sandy to very sandy. Lower set is horizontally stratified in upper few cm. Upper set is intraclast conglomerate, intraclasts up to 3 cm. in diameter with rounded edges. Sharp upper contact.
Unit 6	100-110 cm.	Dolomite, divided into two subunits 6B and 6A which are about subequal in thickness. Sharp base and sharp top.
6B		Dolomite, light grey, fine crystalline, very dense with numerous pockets where it is punky and porous to friable. Massive, nonstratified, nonsandy to only slightly sandy, vugular in places with vugs 2-3 cm. Upper 0-15 cm appears to be a subaerial paleo-exposure surface or profile, and the upper 2-5 cm. is overlain by digitate stomatolite forms. The paleoexposure surface crust

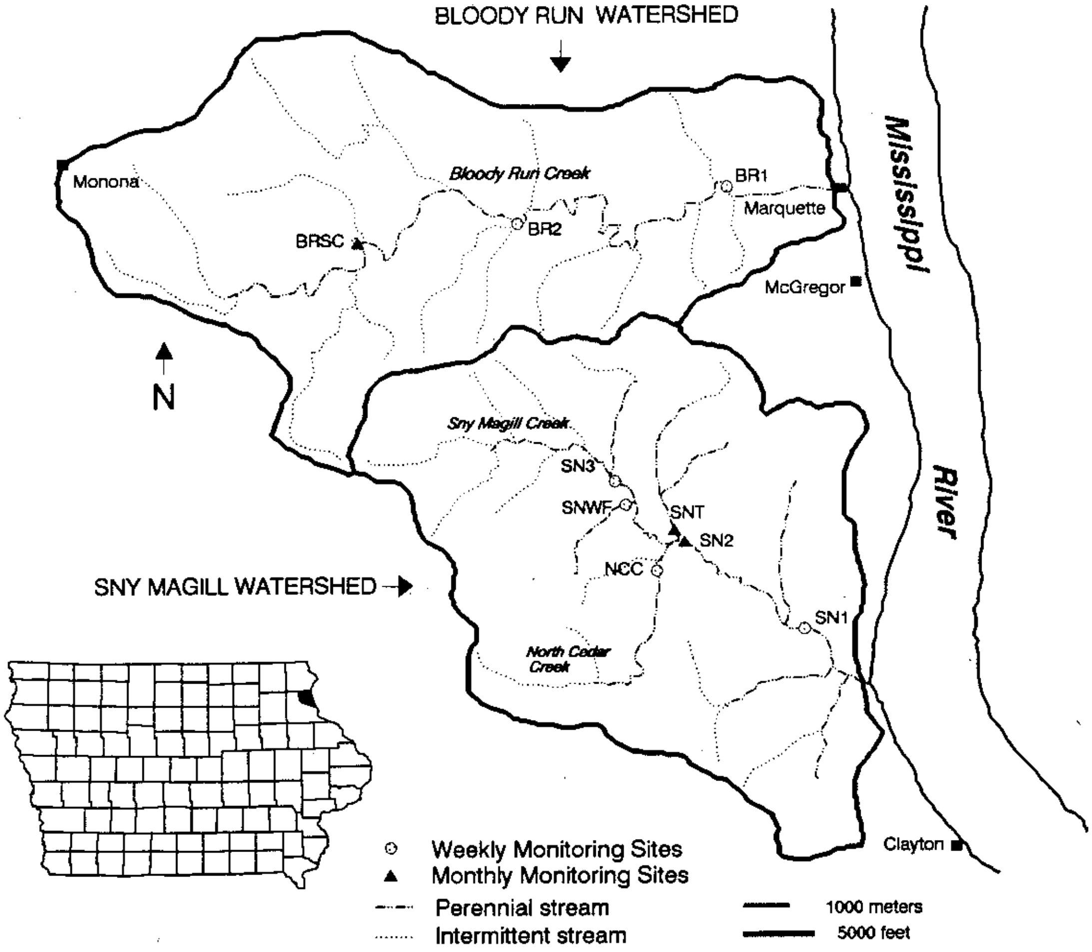
		pinches out laterally over highs and thickens into lows. Paleoexposure profile is composed primarily of porous, coarse crystalline dolomite that contains small (<1.0-3.0 mm.) clusters of white chalcedonic chert (both dolomite and chalcedony are brown and inclusion-rich in thin section). Upper contact of the paleoexposure surface profile with overlying unit 7 is very sharp, but the lower contact of the exposure surface profile is irregular and scalloped. Sample 6B from upper part.
6A		Dolomite, fine crystalline, irregularly bedded, interlayered less sandy to very sandy dolostone with very sandy dolostone lenses 2-3 cm. thick and overlying dolomudstone drapes. Bedding is very discontinuos, possibly brecciated in a few places. Sand is quartzose, fine to coarse, rounded, frosted. Unit is quite styolitic, common fracture and vuggy porosity.
Unit 5	35 cm.	Dolomite, fine crystalline, dense, peloidal, sandy to very sandy, quartz sand, fine to coarse grained, frosted, subround , trace intraclasts of partly moldic sandy dolomite, 2-3 sets of cross strata. Upper 10 cm. displays moldic porosity, molds 1-3 mm., somewhat circular, possibly fossil molds, like unit 4 is distinctly color mottled between a light tan to medium brown color. Sharp basal contact; upper contact irregular and displaying up to 10 cm. of relief, but having sharp contact with overlying unit.

**Section offset to the west to the main highwall.*
The lowest unit on the main highwall is the base of unit 5.

Unit 4	36-42 cm.	Dolomite, fine crystalline, sandy to very sandy, sand is quartz, fine to coarse, subrounded to rounded, frosted, trace dolostone intraclasts, color mottled light tan to medium brown. Composed of 3-4 sets of cross-strata. In the middle to upper half there is some horizontally stratified very sandy (fine sand) dolomudstone with prominent mudcracked horizon about 10-15 cm. below the top. Mudcracks are vertical, v-shaped somewhat compacted cracks filled with very fine to fine sand in sandy dolostone. Mudcracks are most prominent towards the middle of the first bench exposure; mudcrack zone is discontinuous; some intraclasts in cross-set overlying

		mudcracked zone. Unit thickens to the east. Upper contact is sharp and forms bedding plane reentrant. Sample 4 collected from the upper 10 cm.
Unit 3	16-20 cm.	Dolomite, fine crystalline. Lower half of unit is structureless, fine crystalline dolostone, probably mudstone or tightly packed peloidal packstone. The upper half is stromatolite boundstone. Stromatolite structure ranges from flat laminated mats to small linked hemisspheroids with a maximum diameter of 6 cm. Parts of the unit have conspicuous scattered grains of white to light gray cauliflower fabric chert, 1-5 mm. disseminated throughout. Unit thins to a thickness of 16 cm. to the west where it is mostly flat laminar stromatolites. Upper contact is sharp.
Unit 2	35-38 cm.	Dolomite, appears to be four sets present as one thick bed. Each set is about 9 cm. thick. Unit is distinctive in displaying abundant moldic porosity; molds consistently 2 - 4 mm. across. Lowest set is intraclast conglomerate; most intraclasts in the 1-4 cm size with max size to 10 cm. and flat-pebble shaped clasts; sand component is quartz sand, very fine to medium, subrounded to round, frosted. Lower contact with unit 1 appears to be sharp; upper contact is a wavy , irregular, horizontal zone 5-10 cm. thick which is solutionally vuggy and has a black Mn oxide stain on either side of it. Sample collected from the middle of unit 2 (Sample 2). Next two sets are faintly cross-stratified sandy, peloidal dolostone and the uppermost set is also sandy, peloidal dolostone. The upper of the four sets is only sparsely sandy and is also finer crystalline dolostone.
Unit 1	30 cm.	Dolomite, intraclast conglomerate, intraclasts are in part moldic, spherical to oval to flat pebble upto three cm long ; some are clayey chert ;matrix is quartz sandy to very sandy, fine to medium crystalline dolomite. Some sand cored ooids, some possible moldic fossil debris, trace green clay (possible glauconite); intraclasts appear to be silicified, clayey, and white, and the sandy nature of the matrix is quartz, rounded and frosted.

****Section begins at the base of the first bench at the east end of the roadcut.***



STOP 8. Figure 1. Location of Sny Magill and Bloody Run watersheds in Clayton County. Sampling locations are indicated by circles and triangles.

STOP 8

SNY MAGILL WATERSHED NONPOINT SOURCE POLLUTION MONITORING PROJECT: AN EPA SECTION 319 NATIONAL MONITORING PROGRAM PROJECT

SW1/4, SW1/4, Section 16, T95N, R3W, Clayton Co.
Prairie du Chien 7.5' Quad

Discussion by Lynette S. Seigley and James J. Wellman

Introduction

Nonpoint source (NPS) pollution is considered to be the major cause of remaining impairment to water quality in the United States. In an agricultural state such as Iowa this is particularly true; recent assessments show that agricultural landuse is the source of diffuse, nonpoint source pollution affecting approximately 96% of Iowa's stream miles and the majority of impaired lakes and wetlands (Agena, Bryant, and Oswald, 1991). Numerous programs are being implemented in Iowa, by many agencies, to work to mitigate NPS pollution from agriculture. The ultimate test of the success of such efforts must be improved water quality. Hence, there is a clear need for programs that can monitor water quality and begin to document the improvements that should accrue over time from the implementation of NPS control projects. The Sny Magill Project is attempting to monitor such improvements.

The surface water quality of both Sny Magill and North Cedar creeks is impaired by nonpoint agricultural pollutants, particularly sediment, nutrients, and pesticides (Iowa's Nonpoint Source Assessment Report, 1988). Both streams, located in northern Clayton County (Figure 1), are coldwater streams managed for "put and take" trout fishing by the Iowa Department of Natural Resources (IDNR). Both are two of the more widely used streams for recreational fishing and have been identified as a priority for project action to improve water quality (Iowa's State Nonpoint Source Management Report, 1989). To address the water quality problem, the Environmental Protection Agency (EPA), through Section 319 of the Clean Water Act, has funded a long-term surface water quality monitoring project in the Sny Magill Watershed (Seigley et al., 1992). The project began October 1991 and is an interagency effort designed to monitor and assess improvements in surface water quality resulting from the implementation of two U.S. Department of Agriculture land treatment projects in the watershed (the Sny Magill Hydrologic Unit Area Project and the North Cedar Creek Water Quality Special Project).

Geology

Sny Magill Watershed is located in the Paleozoic Plateau region of northeast Iowa (Prior, 1991). The Sny Magill Watershed is marked by narrow, gently sloping uplands that break into steep slopes with abundant rock outcrops. Up to 550 feet of relief occurs across the watershed. The landscape is mantled with approximately 10-20 feet of loess, overlying thin remnants of glacial till on upland interfluves, which in turn overlie Paleozoic age bedrock formations. The bedrock over much of the area is the Ordovician Galena Group rocks, which comprise the Galena aquifer, an important source of groundwater and drinking water in the area. Some sinkholes and small springs are developed in the Ordovician-age limestone and dolomite. Also exposed at lower elevations in the watershed are the St. Peter Sandstone Formation and the Prairie du Chien Group.

Upland soils in cropland portions of the area are primarily the loess-derived soil series Tama, Downs, and Fayette on 3 to 14 percent slopes. Areas of 10 to 18 percent slopes are dominated by permanent pasture and wildlife areas with Fayette and Dubuque soils. Woodlands are found mainly on Fayette, Dubuque, and Steep Rock Land on 10 to 45 percent slopes. Land use is variable on the alluvial plain of Sny Magill Creek, ranging from row cropped areas, to pasture and forest, to areas with an improved riparian right-of-way where the IDNR owns and manages the land in the immediate stream corridor.

The stream bottom of Sny Magill and its tributaries is primarily rock and gravel with riffle areas frequently found. Along the lower reach of the creek where the gradient is less steep, the stream bottom is generally silty.

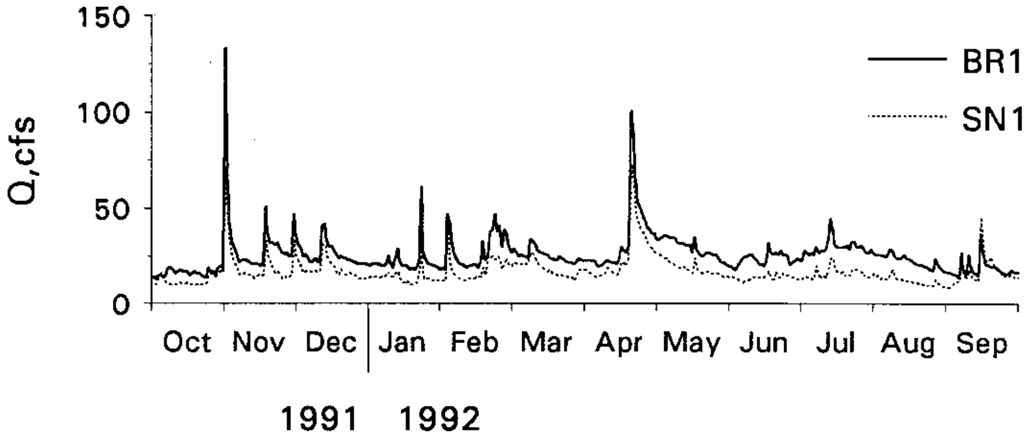
More detailed stratigraphic information is provided in this guidebook.

Paired Watershed Approach

A paired watershed approach is being used for the Sny Magill Watershed Project. Bloody Run Creek Watershed (adjacent to the north and draining 24,065 acres) will serve as the comparison watershed (Figure 1). The two watersheds are well suited: both are similar in size, their groundwater hydrogeology and known surface hydrologic characteristics are very similar (both receive groundwater baseflow from the Ordovician Galena aquifer and share a groundwater flow system divide), and their close proximity limits rainfall as a variable. In addition to the primary monitoring sites being paired for Sny Magill and Bloody Run, an upstream/downstream comparison will be utilized.

Groundwater And Surface Water Relationships

Both Sny Magill and Bloody Run creeks receive groundwater baseflow from the Ordovician Galena aquifer. Figure 2 shows a surface water hydrograph (discharge through time) for Sny Magill and Bloody Run. A hydrograph has two components: a direct surface runoff component and a groundwater or baseflow component. Hydrographs for streams such as Sny Magill are dominated by the groundwater component. Analysis of the hydrographs (Figure 2) suggests that 79% of discharge for Sny Magill Creek is groundwater and 81% is groundwater for Bloody Run Creek. Streams in other parts of Iowa tend to have lower groundwater baseflow inputs and a greater surface runoff component. For example, groundwater baseflow for various tributaries of the Des Moines River varies from 19-81% (Thompson, 1984). Baseflow contributions to larger streams are more variable because of a greater runoff component.



STOP 8. Figure 2. Hydrograph of discharge (in cubic feet per second) from water-year 1992 for gage site on Sny Magill (SN1) and Bloody Run (BR1).

Groundwater and surface water basins are not necessarily one and the same. Surface water basins represent an area drained by a stream and surface water divides are marked by topographic highs. The surface water basins for both Sny Magill and Bloody Run are well defined. The groundwater basin, however, is not as well defined in these two areas. The Big Spring basin, the area adjacent to the west of Sny Magill and Bloody Run, is a groundwater basin. Part of the Big Spring basin overlaps the western most part of the Bloody Run surface water basin.

Water Quality Of Private Wells In Sny Magill And Bloody Run

An inventory of private wells in the Sny Magill and Bloody Run watersheds was conducted in October 1992 to determine baseline groundwater quality for these two watersheds. A total of 151 wells were sampled for total coliform bacteria, fecal coliform bacteria, and nitrate. A well questionnaire was completed at each site to gather information on well characteristics (total depth, casing depth, age), well placement (topographic position, distance from septic system, feedlot, fuel tanks, chemical storage and handling), previous water quality problems, use of water treatment systems, and presence of sinkholes or abandoned wells near active wells.

The presence of total coliform bacteria in a well-water sample indicates that water from the land surface and/or shallow groundwater may be entering the well or water distribution system. The presence of total coliform bacteria by itself is not a health hazard, but it does indicate that disease-causing organisms may also be able to enter the water supply. The presence of fecal coliform bacteria indicates contamination from a relatively fresh waste source such as animal feedlot runoff, septic tank or cesspool leakage, etc. Their presence indicates that the water may be contaminated with organisms that can cause disease. For private wells, the USEPA has established a *health advisory* for nitrate of 45 milligrams/liter (mg/L). Water containing nitrate greater than the health advisory should not be used in preparing infant formula or for consumption by infants less than six months old. This health advisory was set to avoid methemoglobinemia (blue-baby syndrome), a blood disorder that reduces the ability of an infant's bloodstream to carry oxygen throughout the body. Nitrate concentrations exceeding 45 mg/L indicate pollution from such sources as nitrogen fertilizers, manure, septic tank wastes, etc., and are more likely to occur in relatively shallow wells, wells with shallow casing, and in wells which are poorly located, constructed, or maintained.

Table 1 summarizes the water quality data for these wells. Well depths ranged from 45 feet to 570 feet with two springs being sampled. Average well depth was 221 feet. Nitrate concentrations ranged from <1 mg/L (below detection limit) to 215 mg/L with an overall average nitrate concentration of 49 mg/L. Forty percent of the water samples were above the USEPA health advisory of 45 mg/L for nitrate. Forty-two percent of the samples were positive for total coliform bacteria and 10% were positive for fecal coliform bacteria. Further analysis of the data and the information from the well questionnaires will be conducted during 1993.

Water Quality Monitoring Design

A paired watershed approach is being used to compare Sny Magill to Bloody Run Creek. There are five monitoring components to the project: (1) a U.S. Geological Survey (USGS) stream gage to measure daily discharge and suspended sediment, (2) an annual habitat assessment along stretches of both stream corridors, (3) biomonitoring of benthic macroinvertebrates on a bi-monthly basis (April - October), (4) an annual fisheries survey, and (5) weekly to monthly monitoring of nine sites on Sny Magill and Bloody Run for chemical and physical water quality variables.

U.S. Geological Survey Gages

Two U.S. Geological Survey (USGS) surface water gages were installed on Sny Magill and Bloody Run creeks. Both gages are located approximately one mile upstream of the Mississippi River to avoid any influence of backwaters from the Mississippi River. The gages measure continuous gage height (creek stage) and rain data. The gage height is obtained by a water gage II instrument which is a pressure sensor system. Gage height and rain data is stored at the Sutron 8200 data collection platform (DCP) every 15 minutes. Every four hours the data is transmitted to a satellite and then to a down link station in Texas. The data is then decoded and sent to the computer system at the USGS office in Iowa City. This is known as real time data. For small drainage basins, real time data is very useful since those basins respond very quickly to rainfall events. By having real time data, the USGS is able to determine whether personnel need to be sent to the area to monitor the rainfall event more closely.

Discharge measurements are obtained on a monthly basis to determine stream discharge and changes in channel shape. These measurements are essential in developing a rating curve for each stream. A rating curve defines the discharge-stage relationship for a stream. Suspended

Well depth range (feet)	# of wells	% of all wells	% of known well depth	Mean nitrate (mg/L)	% unsafe for nitrate (%)	Range in nitrate concentration (mg/L)	% positive total coliform bacteria (%)	% positive fecal coliform bacteria (%)
0 - 99	18	12%	16%	40	28%	<1 - 119	39%	0%
100 - 199	44	29%	40%	54	34%	<1 - 215	43%	11%
200 - 299	23	15%	21%	43	35%	<1 - 173	43%	4%
> 300	26	17%	23%	39	23%	<1 - 187	15%	0%
unknown	40	26%	-----	51	30%	3 - 148	23%	3%
All wells	151			49	40%	<1 - 215	42%	10%

STOP 8. Table 1. Well-water quality of private wells sampled October 1992 in Sny Magill and Bloody Run watersheds by well depth categories.

sediment samples are collected daily by a local observer, and collected more frequently during high water (storm events) by an automatic water-quality sampler in the gage station. Sampling is initiated by the DCP when the stream rises to a pre-set stage, and terminates when the stream falls below this stage. On a monthly basis, the USGS technician collects suspended sediment samples from a cross section of the stream to verify observer samples. The combination of gage height record and monthly discharge measurements is critical to obtain a mean daily discharge and a mean daily sediment discharge. Discharge data and water quality data are used to estimate watershed losses of nutrients.

Temperature and conductance are measured with each stage measurement and sediment sample. In addition to suspended sediment concentrations, particle size information is determined for each sample. The median daily discharge at the gage site on Bloody Run Creek (site BR1) for water year 1992 (October 1991 to September 1992) was 24 cubic feet per second (CFS) and the maximum daily mean discharge was 133 CFS (see Figure 2). The median daily discharge for Sny Magill Creek (site SN1) was 15 CFS and the maximum daily mean discharge was 73 CFS. The maximum sediment concentration for BR1 was 1750 mg/L and 2700 mg/L for SN1. Monthly median sediment concentrations ranged from 11 mg/L to 84 mg/L for BR1 and 10 mg/L to 55 mg/L for SN1 (personal communication, Steve Kalkhoff).

Habitat Assessment

An annual habitat assessment is conducted at all locations except BRSC to measure instream and streamside habitat (Figure 1). A variety of habitat variables are evaluated including channel morphology, instream habitat (type of cover, amount of pool area), substrate composition, stream channel and reach dimensions, and streambank and riparian conditions. Baseline evaluation of habitat conditions during 1991 indicate generally good conditions at all eight locations (Wilton, 1993). These habitat data are based on a single evaluation and should be used in general terms. The data is not intended to be sensitive to all degradation or limitations of habitat for any one species or type of biological community (e.g., fish, macroinvertebrates). Evaluation of habitat characteristics suggest a relationship between drainage area size and channel slope for each site to habitat character.

A trout habitat model was used to evaluate habitat quality for brown trout and rainbow trout at each site. Trout species prefer areas where visibility is obscured by such things as aquatic vegetation, deep water, overhanging streambank vegetation, or undercut banks. Based on the model, the downstream site on both Sny Magill and Bloody Run had better habitat for trout than the other locations.

Benthic Biomonitoring

Benthic macroinvertebrates inhabiting the Sny Magill and Bloody Run creeks are inventoried at all locations except BRSC (Figure 1) on a bi-monthly basis from April to October. These organisms are being studied to determine if any significant changes occur in the types or numbers of organisms present during the duration of the water quality monitoring project. The presence/absence of certain species of organisms serve as indicators of water quality and habitat quality.

A modified Hess bottom sampler was used to collect samples which were fixed in a 10% formalin solution and returned to the lab for processing. A pilot study to collect baseline data was done in the fall of 1991 and 52 taxa of organisms were identified (Schueller et al., 1992). Organisms identified include various types of worms, snails and clams, beetles, mayflies, and damselflies. Analysis of the benthic macroinvertebrate data involves use of various metrics from the EPA Rapid Bioassessment Protocol III (Plafkin et al., 1989). These metrics measure species richness, measure overall pollution tolerance of a benthic community (Hilsenhoff Biotic Index), and the diversity of the benthic community. Evaluation of macroinvertebrate metric data indicates that the stream reaches sampled have water quality ranging from "good" to "excellent." This baseline data will be compared to subsequent years of macroinvertebrate data to evaluate trends in changing water quality.

Fisheries Survey

An annual fisheries survey will be conducted (usually in September or October) to see what improvements in diversity and numbers of fish species occur over the duration of the project. Four sites on Sny Magill were surveyed in 1991 and a site on North Cedar Creek and a site on Bloody Run were included in 1992. The fish population in 1991 was dominated by fantail darters, southern redbelly dace, blacknose dace, johnny darters, bluntnose minnow, white sucker, longnose dace, and creek chub (Wunder and Stahl, 1992). The list for 1992 for Sny Magill differed from 1991 with the addition of brook stickleback and central stoneroller and the absence of white sucker (Wunder and Stahl, 1993). These fish are all species typically found in Iowa coldwater streams.

In 1992, fantail darter, blacknose dace, creek chub, bluntnose minnow, central stoneroller, and burbot were sampled in North Cedar Creek and slimy sculpin, blacknose dace, fantail darter, and longnose dace were found in Bloody Run Creek. In 1992, autopsies were performed on ten creek chubs from Sny Magill to determine if any irregularities or problems existed with the fish population. All fish were in normal condition and in good health.

Chemical and Physical Water Quality Monitoring

Surface water quality is measured at nine locations in both Sny Magill and Bloody Run Watersheds on a weekly to monthly basis (Figure 1). Field measurements include temperature, specific conductance, turbidity, and dissolved oxygen. Water samples collected for lab analysis will determine nutrient inputs and fecal coliform bacteria levels. Variables include measurement of biological oxygen demand, total phosphorus, various forms of nitrogen (nitrite plus nitrate-nitrogen, organic-nitrogen, ammonium-nitrogen), common anions, fecal coliform bacteria, and a measurement of the triazine herbicides. All lab analyses are completed by the University Hygienic Laboratory and the University of Iowa Sedimentary Geochemistry Laboratory.

Nitrate concentrations tend to be higher in Bloody Run Creek than Sny Magill Creek. Both streams show a decline in nitrate concentrations from upstream to downstream locations, possibly related to in-stream processing of nitrate. Similar declines in nitrate concentrations in surface water occur in the Big Spring basin and Bear Creek north of Ames (Bachmann et al., 1991; Isenhart and Crumpton, 1989). These studies show that the major mechanisms for the depletion of nitrate in these stream systems is bacterial denitrification (conversion of nitrate or nitrite to nitrogen gas) in the anaerobic stream-sediment interface and algal assimilation of nitrate and ammonium to the organic form of nitrogen which is not available to plants (Bachmann et al, 1991; Isenhart and Crumpton, 1989). Fecal coliform bacteria results show the greatest fluctuation of all analyses, ranging from below detection limit to greater than 1,000,000 organisms in a 100 milliliter sample.

National Monitoring Program

Sny Magill is part of the U.S. Environmental Protection Agency's (USEPA) Section 319 National Monitoring Program. This program is designed to support 20 to 30 watershed projects nationwide to document the effectiveness of nonpoint source (NPS) pollution controls in restoring water quality. The watershed projects meet a minimum set of project planning, implementation, monitoring, and evaluation requirements. The requirements are designed to lead to successful documentation of project effectiveness with respect to water quality protection or improvement. These projects comprise a small subset of NPS pollution control projects funded under Section 319 of the Clean Water Act Amendments of 1987.

The focus of the National Monitoring Program is on stream systems, although USEPA intends to approve groundwater, lakes, and estuaries as suitable project criteria are developed. To date, three surface water monitoring projects have been selected as Section 319 National Monitoring Program projects: Elm Creek (Nebraska), Long Creek (North Carolina), and Sny Magill (Iowa) (Osmond et al., 1992). Snake River Plain (Idaho) is a pilot groundwater project.

The Sny Magill Watershed Project is designed to monitor and assess improvements in surface water quality resulting from two land treatment projects in the watershed. These land treatment projects provide technical and cost sharing assistance to farmers to install sediment control measures (i.e., terraces), water and sediment control basins, and animal waste management systems. Long-term goals of 50% reduction in sediment delivery to Sny Magill Creek and a 25% reduction in fertilizer and pesticide inputs have been established. The Sny Magill Watershed Project is designed to run for ten years under the National Monitoring Program, if funding allows.

* This project is supported, in part, by the Iowa Department of Natural Resources, and the U.S. Environmental Protection Agency Nonpoint Source Pollution Program (Region VII).

** The following is a list of agencies involved in this project: Agricultural Stabilization and Conservation Service, Iowa State University Extension, Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources - Environmental Protection Division, Fisheries Bureau, Geological Survey Bureau, Preventive Medicine - Analytical Toxicology Laboratory, Soil Conservation Service, University Hygienic Laboratory, U.S. Forest Service, U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. National Park Service.

LIST
OF
REFERENCES

Agena, U., Bryant, B., and Oswald, T., 1991, Agriculture: environmental problems and directions: *in* Proceedings of the 1990 Crop Production and Protection Conference, Iowa State University, p. 219-229.

Bachmann, R.W., Crumpton, W.G., and Hallberg, G.R., 1991, Nitrogen losses in an agricultural stream: Verh. Internat. Verein. Limnol., v. 24, p. 1641-1643.

Berg, R.R., 1954, Franconia Formation of Minnesota and Wisconsin: Geological Society of America Bulletin, v. 65, p. 857-882.

Brannon, J.C., Podosek, F.A., and McLimans, R.K., 1993, Isotopic compositions of gangue versus ore minerals in the Upper Mississippi Valley zinc-lead district: 27th Annual North-Central Section, Geological Society of America Meeting, Abstracts with Programs, v. 25, p. 9.

Byers, C.W., 1978, Depositional environments of fine-grained Upper Cambrian lithofacies: *in* Lithostratigraphy, petrology, and sedimentology of Late Cambrian-Early Ordovician rocks near Madison, Wisconsin, Wisconsin Geological and Natural History Survey, Field Trip Guidebook No. 3, p. 67-81.

Byers, C.W., and Dott, Jr., R.H., 1990, Sequence stratigraphy of Cambro-Ordovician strata, northern Mississippi Valley (abs.): Geological Society of America, Abstracts with Programs, North-Central Meeting, v. 22, no. 5, p. 5.

Calvin, S., 1895, Geology of Allamakee County: Iowa Geological Survey, Annual Report, v. 4, p. 35-111.

Davis, R.A., 1970, Lithostratigraphy of the Prairie du Chien Group: Wisconsin Geological and Natural History Survey, Information Circular No. 11, p. 35-44.

Dill, R.F., Shinn, E.A., Jones, A.T., Kelly, K., Steinen, R.P., 1986, Giant subtidal stromatolites forming in normal salinity waters: Nature, v. 324 no. 6, p. 55-58.

Dott, Jr., R.H., Byers, C.W., Fielder, G.W., Stenzel, S.R. and Winfree, K.E., 1986, Aeolian to marine transition in Cambro-Ordovician cratonic sheet sandstones of the northern Mississippi Valley, U.S.A.: Sedimentology, v. 33, p. 345-367.

Dott, Jr., R. H., and Byers, C.H., 1980, SEPM research conference on modern shelf and ancient cratonic sedimentation - the orthoquartzite - carbonate suite revisited: Sponsored by Society of Economic Paleontologists and Mineralogists, and the Department of Geology and Geophysics, University of Wisconsin, Madison, Wisconsin, Field Trip Guidebook, 62 p.

Dravis, J.J., 1983, Hardened subtidal stromatolites, Bahamas: Science, v. 219, p. 385-386.

Hall, J., 1858, Report of the Geological Survey of the State of Iowa: Iowa Geological Survey Annual Report, v. I, part I: Geology. State of Iowa.

Hershey, H.G., 1969, Geologic map of Iowa: Iowa Geological Survey, scale 1:500,000, .

Heyl, Jr., A.V., Agnew, A.F., Lyons, E.J., and Behre, Jr., C.H., 1959, The geology of the Upper Mississippi Valley Zinc-Lead Distric: U.S. Geological Survey Professional paper 309, 310 p.

Horick, P.H., and McKay, R.M., 1990, The Dresbach Aquifer of Iowa: *in* Iowa's principal aquifers, A review of Iowa geology and hydrogeologic units, A compendium compiled by the Iowa Groundwater Association, October 1990, p. 23-26.

Horick, P.H., and Steinhilber, W.L., 1978, Jordan Aquifer of Iowa: Iowa Geological Survey, Miscellaneous Map Series 6, scale 1:1,000,000.

Iowa Department of Natural Resources, 1988, State Nonpoint Source Assessment Report - Iowa, 73 p.

Iowa Department of Natural Resources, 1989, State Nonpoint Source Management Report - Iowa, 68 p.

Isenhart, T.M., and Crumpton, W.G., 1989, Transformation and loss of nitrate in an agricultural stream: Journal of Freshwater Ecology, v. 5, no. 2, p. 123-129.

McGee, W.J., 1891, The Pleistocene history of northeastern Iowa: U.S.G.S. Eleventh Annual Report, p. 199-586.

Miller, J.F., and Melby, J.H., 1971, Trempealeauan conodonts (and comments): *in* Clark, D.L. (ed.), Conodonts and biostratigraphy of the Wisconsin Paleozoic, Wisconsin Geological and Natural History Survey, Information Circular No.19, p. 4-9, 78-81.

Odom, I.E., 1978, Mineralogy of Cambrian sandstones, Upper Mississippi Valley: *in* Lithostratigraphy, petrology, and sedimentology of Late Cambrian-Early Ordovician rocks near Madison, Wisconsin, Wisconsin Geological and Natural History Survey, Field Trip Guidebook No. 3, p. 46-51.

Odom, I.E., and Ostrom, M.E., 1978, Lithostratigraphy, petrology, and sedimentology of the Jordan Formation near Madison, Wisconsin: *in* Lithostratigraphy, petrology, and sedimentology of Late Cambrian-Early Ordovician rocks near Madison, Wisconsin, Wisconsin Geological and Natural History Survey, Field Trip Guidebook No. 3, p. 23-45.

Osmond, D.L., Gale, J.A., Line, D.E., Mullens, J.B., Spooner, J., and Coffey, S.W., 1992. Iowa - Sny Magill Watershed Section 319 National Monitoring Program Project: *in* Summary Report Section 319 National Monitoring Program Projects, Nonpoint Source

Watershed Project Studies, North Carolina State University Water Quality Group, p. 10-19.

Ostrom, M.E., 1966, Cambrian stratigraphy in western Wisconsin: Wisconsin Geological and Natural History Survey, Information Circular No. 7, p. 79.

Ostrom, M.E., 1967, Paleozoic stratigraphic nomenclature for Wisconsin: Wisconsin Geological and Natural History Survey, Information Circular No. 8.

Ostrom, M.E., 1970, Sedimentation cycles in the Lower Paleozoic rocks of western Wisconsin: *in* Field trip guidebook for Cambrian-Ordovician geology of western Wisconsin, North-Central Section Geological Society of America, Wisconsin Geological and Natural History Survey, Information Circular No. 11, p. 10-34.

Ostrom, M.E., 1978, Lithostratigraphy, petrology, and sedimentology of Late Cambrian-Early Ordovician rocks near Madison, Wisconsin: prepared for Eigthth Annual Meeting Great lakes Section, Society of Economic Paleontologists and Mineralogists, University of Wisconsin-Extension, Wisconsin Geological and Natural History Survey, Guidebook No. 3, 142 p.

Owen, D.D., 1852, Report of a geological survey of Wisconsin, Iowa, and Minnesota: Lippincott, Grambo and Company, Philadelphia.

Palmer, A.R., 1983, The decade of North American geology 1983 geologic time scale: Geology, v. 11, p. 503-504.

Plafkin, J.L., Barbour, M.T., Porter, K.D., Gross, S.K., and Hughes, R.M., 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish: U.S. Environmental Protection Agency, EPA/444/4-89-001, Washington, D.C.

Prior, J.C., 1991, Landforms of Iowa: University of Iowa Press, Iowa City, 154 p.

Raasch, G.O., 1952, Oneota Formation, Stoddard Quadrangle, Wisconsin: Illinois Academy of Science Transactions, v. 45, p. 85-95.

Roosa, D.M., Prior, J.C., Smith, D.D., Knutson, R.M., Henning, D., and Bettis III, E.A., 1983, Natural history of the Upper Iowa Valley between Decorah and New Albin: Iowa Natural History Association, Field Trip Guidebook #1, 16 p.

Ruedemann, R., 1947, Graptolites of North America: Geological Society of America Memoir 19, 652 p.

Runkel, A.C., 1992, Deposition of the Upper Cambrian Jordan Sandstone, Upper Mississippi Valley Region (abs.): Geological Society of America, Abstracts with Programs, v. 24, no. 7, p. A350.

Runkel, A.C., Morey, G.B., Lively, R.S., and Mossler, J.H., 1993, Outlying Mississippi Valley-type sulfide mineralization, Fillmore County, Minnesota: 27th Annual North-Central Section, Geological Society of America Meeting, Abstracts with Programs, v. 25, p.76.

Schueller, M.D., Hausler, M.C., and Kennedy, J.O., 1992. Sny Magill Creek Nonpoint Source Pollution Monitoring Project: 1991 Benthic Biomonitoring Pilot Study Results: University of Iowa Hygienic Laboratory, Limnology Section, Report No. 92-5, 78 p.

Schuldt, W.C., 1940, Cambrian strata of northeastern Iowa: unpublished Ph.D. dissertation, University of Iowa, 229 p.

Seigley, L.S., Hallberg, G.R., Wilton, T., Schueller, M.D., Hausler, M.C., Kennedy, J.O., Wunder, G., Link, R.V., and Brown, S.S., 1992. Sny Magill Watershed Nonpoint Source Pollution Monitoring Project Workplan: Iowa Department of Natural Resources, Geological Survey Bureau Open File Report 92-1, 31 p.

Sloss, L.L., 1963, Sequences in the cratonic interior of North America: Geological Society of America Bulletin, v. 74, p. 93-114.

Smith, G.L., 1991, Sequence stratigraphy and diagensis of the Lower Ordovician Prairie du Chien Group on the Wisconsin Arch and in the Michigan Basin: unpublished Ph.D. dissertation, University of Wisconsin, Madison, 265 p.

Smith, G.L., 1992, Silification associated with the Sauk-Tippecanoe and older unconformities, Praire du Chien Group (L. Ord.), Wisconsin: Geological Society of America, National Meeting, Abstracts with Programs, v. 24, no. 7, p. 111.

Smith, G.L., Byers, C.W., and Dott Jr., R.H., 1993, Sequence stratigraphy of the Lower Ordovician Prairie du Chien Group on the Wisconsin Arch and in the Michigan Basin: American Association of Petroleum Geologists Bulletin, v. 77, p. 49-67.

Thompson, C.A., 1984. Hydrogeology and Water Quality of the Upper Des Moines River Alluvial Aquifer: Iowa Geological Survey Open File Report 84-5, 170 p.

Twenhofel, W.H., Raasch, G.O., and Thwaites, F.T., 1935, Cambrian strata of Wisconsin: Geological Society of America Bulletin, v. 46, p. 1687-1744.

Ulrich, E.O., Foerste, A.F., and Miller, A.K., 1943, Ozarkian and Canadian cephalopods, Part II: Brevicones: Geological Society of America Special Paper No. 49, 240 p.

Ulrich, E.O., Foerste, A.F., Miller, A.K., and Unklesbay, A.G., 1944, Ozarkian and Canadian cephalopods, Part III: Longicones and summary: Geological Society of America Special Paper No. 58, 226 p.

Walter, O.T., 1924, Trilobites of Iowa and some related Paleozoic forms: Iowa Geological Survey Annual Report, v. 31, p. 167-389.

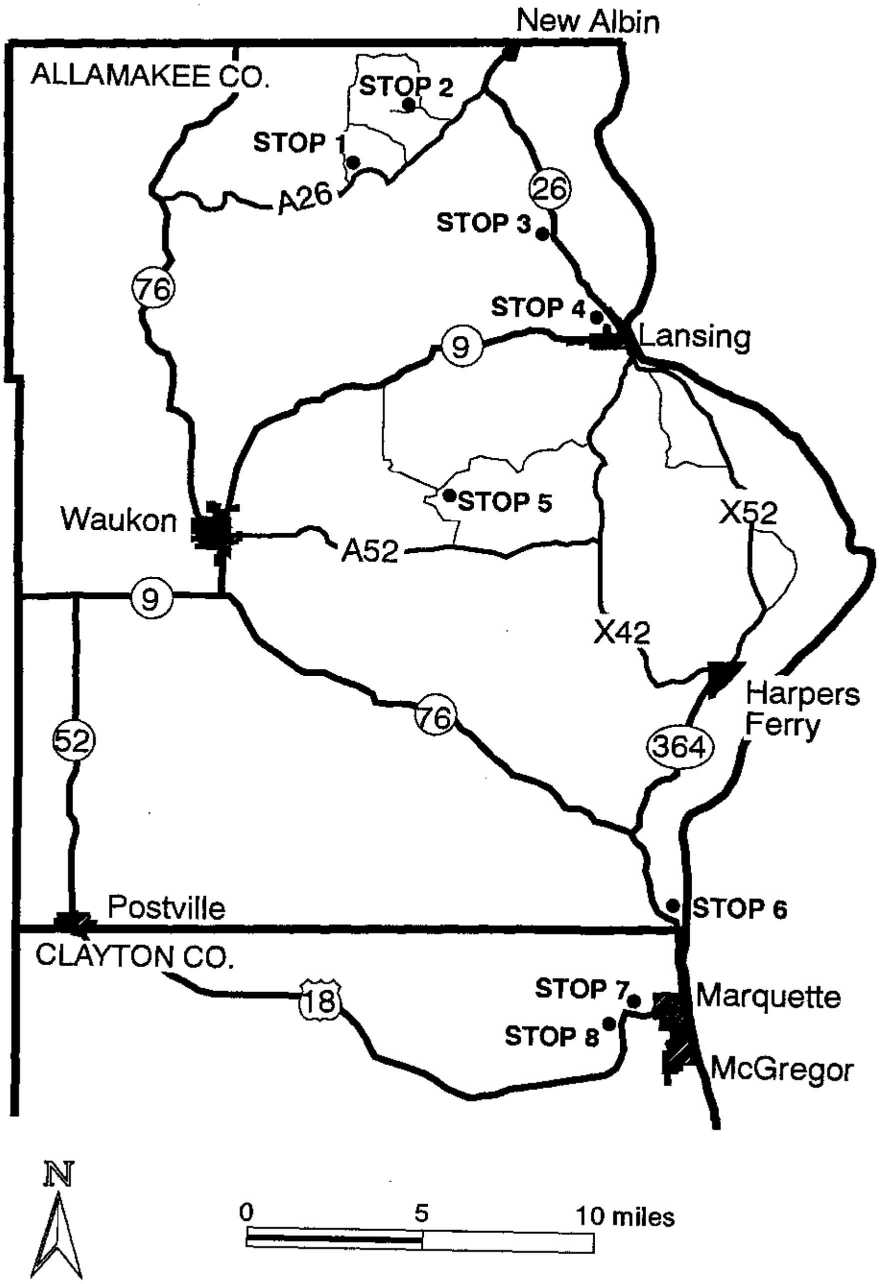
Wilton, T.F., 1993. Sny Magill Watershed Nonpoint Source Monitoring Project: 1991 Habitat Evaluation Results: unpublished report, Iowa Department of Natural Resources, Environmental Protection Division, 21 p.

Witzke, B.J., and McKay, R.M., 1987, Cambrian and Ordovician stratigraphy in the Lansing area, northeastern Iowa: Geological Society of America Centennial Field Guide — North-Central Section, v. 3, p. 81-87.

Wunder, G., and Stahl, L., 1992. Sny Magill Creek Fishery Assessment: 1991 Baseline Monitoring: unpublished report, Iowa Department of Natural Resources, Fisheries Bureau, 4 p.

Wunder, G., and Stahl, L., 1993. Sny Magill Creek Fishery Assessment: Water Year 1992: unpublished report, Iowa Department of Natural Resources, Fisheries Bureau, 5 p.

Geological Society of Iowa
109 Trowbridge Hall
Iowa City, Iowa 52242-1319
http://www.igsb.uiowa.edu/gsi/



Location map of field trip stops