Information Circular
Number 7

University of Wisconsin
GEOLOGICAL AND NATURAL HISTORY SURVEY
George F. Hanson, State Geologist and Director

MICHIGAN BASIN GEOLOGICAL SOCIETY

Annual Field Conference

CAMBRIAN STRATIGRAPHY

IN

WESTERN WISCONSIN

1966

Information Circular
Number 7

CAMBRIAN STRATIGRAPHY

OF

WESTERN WISCONSIN

by

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Wisconsin Geological and Natural History Survey

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COVER PHOTOGRAPH

Wonewoc Formation exposed in high bluffs along the Baraboo River 1.5 miles east of Wonewoc on State Highway 33 and located in the SE$\frac{1}{4}$, SE$\frac{1}{4}$, sec. 36, T.14N., R.2E., Juneau County. Picture by P.L. Salstrom (Figure 3, 1962).

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ILLUSTRATIONS

GENERAL DISCUSSION

Classification of Cambrian rocks in Wisconsin is based in large measure on the summary work of Twenhofel, Raasch, and Thwaites (1935) with modifications of the Franconia by Berg (1954) and of the Trempealeau by Nelson (1956). This classification is shown in Figure 1 together with others proposed since 1935 for Wisconsin and for the Upper Peninsula of Michigan.

The classification of Twenhofel, Raasch, and Thwaites (1935) is based chiefly on paleontology. Unfortunately fossils are not generally abundant in the Cambrian rocks of Wisconsin and they do not occur in all formations. Those found are commonly either undiagnostic or are macrofossils in such poor state of preservation as to be unrecognizable, and thus unusable for either surface or subsurface work. For these reasons fossils are of limited value for correlation or for field mapping purposes.

There is, therefore, an immediate need for a usable classification of these rocks for geologic and economic purposes in Wisconsin. Both geologic field mapping and minerals investigations require a classification based on specific, easily recognizable, lithologic criteria, namely a lithostratigraphic classification. Berg (1954) and Nelson (1956) realized this need and redefined the Franconia Formation and Trempealeau Group, respectively, in lithologic terms. No such classification has been attempted for rocks assigned to the Dresbach.

As might be expected development of a lithostratigraphic classification for pre-Ordovician rocks in Wisconsin involves a consideration of items other than the rocks themselves, namely the nomenclature in use today, priority of terminology, and applicability of present classification to a lithostratigraphic system.

Of major concern is the use of the terms St. Croix, Dresbach, Franconia and Trempealeau. Without going into the precise history of use of these terms it can be said that originally they were applied to rock units in a parochial sense but that since approximately 1935 they have been used as time terms in a national and even international sense (Lochman-Balk, 1958). The St. Croixan is recognized as a series which includes the Dresbachian, Franconian, and Trempealeauan stages.

There would be no problem if these stages coincided with easily recognized lithologic boundaries. Unfortunately in Wisconsin, and in the rest of the upper Mississippi valley area, the boundaries of rock- and time-stratigraphic units do not always coincide. This is not unusual and is the situation that one should expect wherever lithologic units are time-transgressive. However in such circumstances it is awkward or impossible to extend time-stratigraphic boundaries based on fossils into the subsurface for mapping and correlation purposes or to identify such boundaries where fossils cannot be identified from drill cuttings or where fossils are rare or absent in outcropping rock.

How can this problem be resolved? In view of the fact that the terms St. Croix, Dresbach, Franconia and Trempealeau have since about 1935 been widely recognized and used in a time-stratigraphic sense, it is believed that

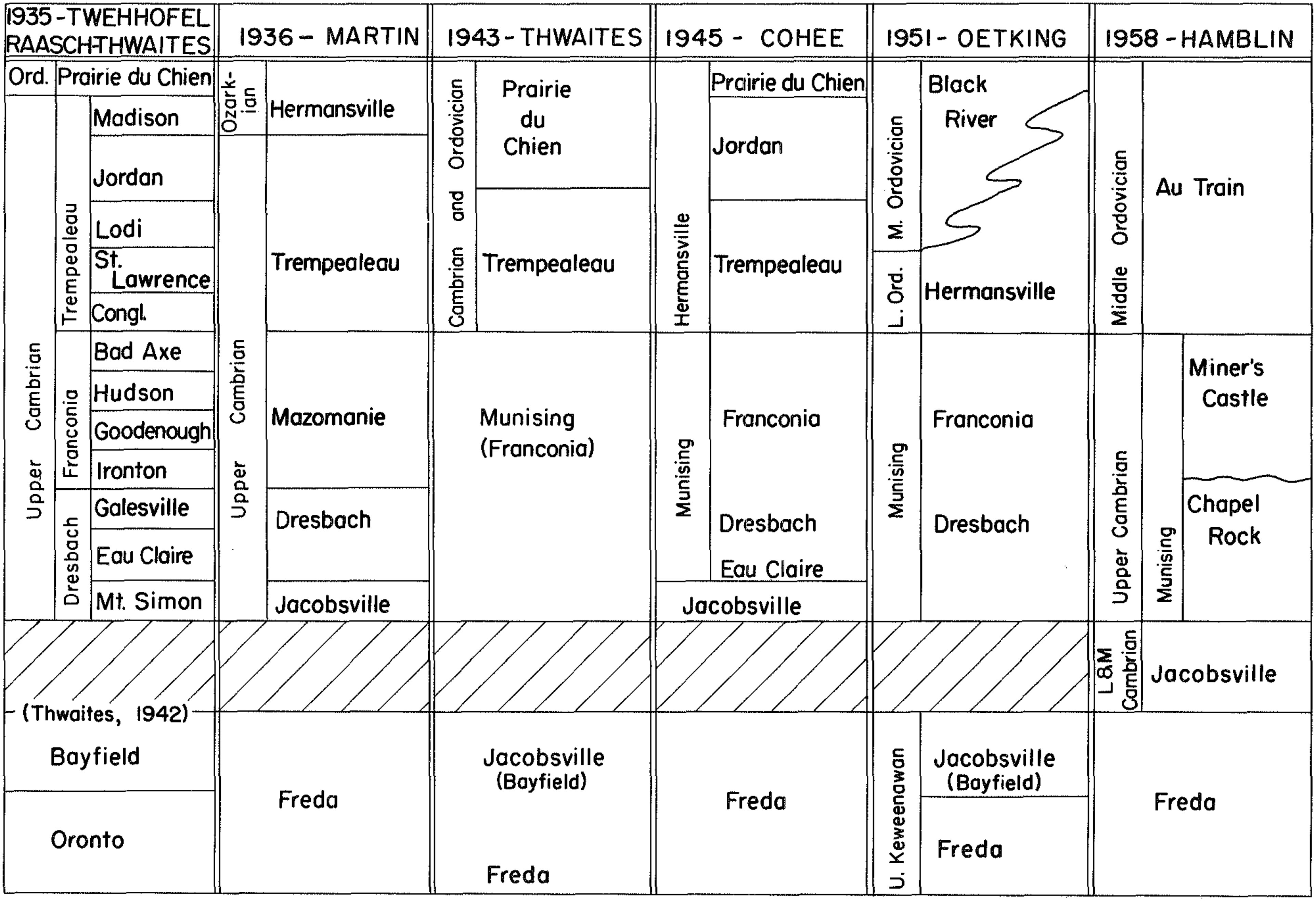

FIGURE 1. Summary of Cambrian nomenclature and correlation in Wisconsin and the Upper Peninsula of Michigan, 1935 to 1958.

they should continue to be used for this purpose and that they should be dropped from the lithostratigraphic classification.

With this belief in mind, a nomenclature and classification for the Cambrian of Wisconsin based on lithostratigraphy was developed (Figure 2; Ostrom, in press). In addition, it was decided that the need for this classification should be demonstrated on the outcrop and that obviously the most effective way of doing this would be to hold a field conference covering the rocks themselves. Toward this end this field trip was conceived.

In addition to problems of classification and nomenclature there is the problem of correlation of Cambrian rocks in Wisconsin with those in the Upper Peninsula of Michigan. The lack of fossils in Cambrian rocks of the Upper Peninsula requires a lithostratigraphic approach to correlation. It is believed that the lithostratigraphic classification used for this field conference provides the basis for correlation of Cambrian rocks of the two areas. Proposed correlation is shown in Figure 3.

Figures 4, 5, 6, and 7 are intended as reference material for the field trip and are, respectively, a bedrock geologic map of Wisconsin, a glacial geologic map of Wisconsin, a cross-section of stops to be made on the field trip, and a road map indicating stops for the First Day. Stops for the Second Day are indicated in Figure 10.

SYSTEM	GROUP	FORMATION	MEMBER	STAGE	SERIES
Ordovician	Prairie du Chien	Oneota			Canadian
Upper Cambrian		Jordan	Sunset Point	Trempealeau	St. Croixan
			Van Oser		
			Norwalk		
		St. Lawrence	Lodi		
			Black Earth		
	Tunnel City	Mazomanie / Lone Rock	Reno	Franconian	
			Tomah		
			Birkmose		
	Elk Mound	Wonewoc	Ironton		
			Galesville	Dresbachian	
		Eau Claire			
		Mt. Simon			

FIGURE 2. Conference stratigraphic nomenclature for Cambrian rocks in Wisconsin

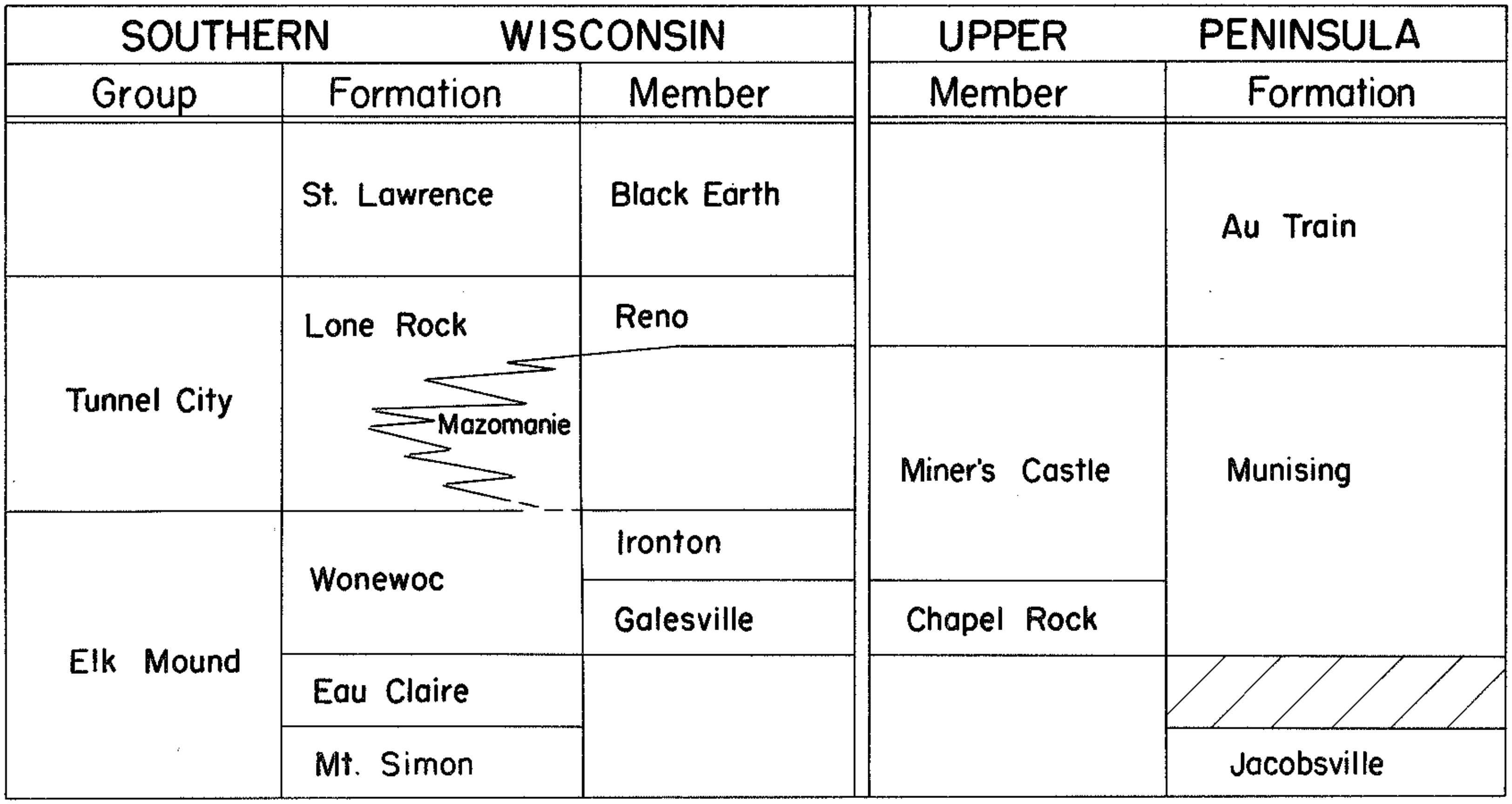

FIGURE 3. Correlation of Cambrian lithostratigraphic units of southern Wisconsin with those of the Upper Peninsula of Michigan (Ostrom, 1966).

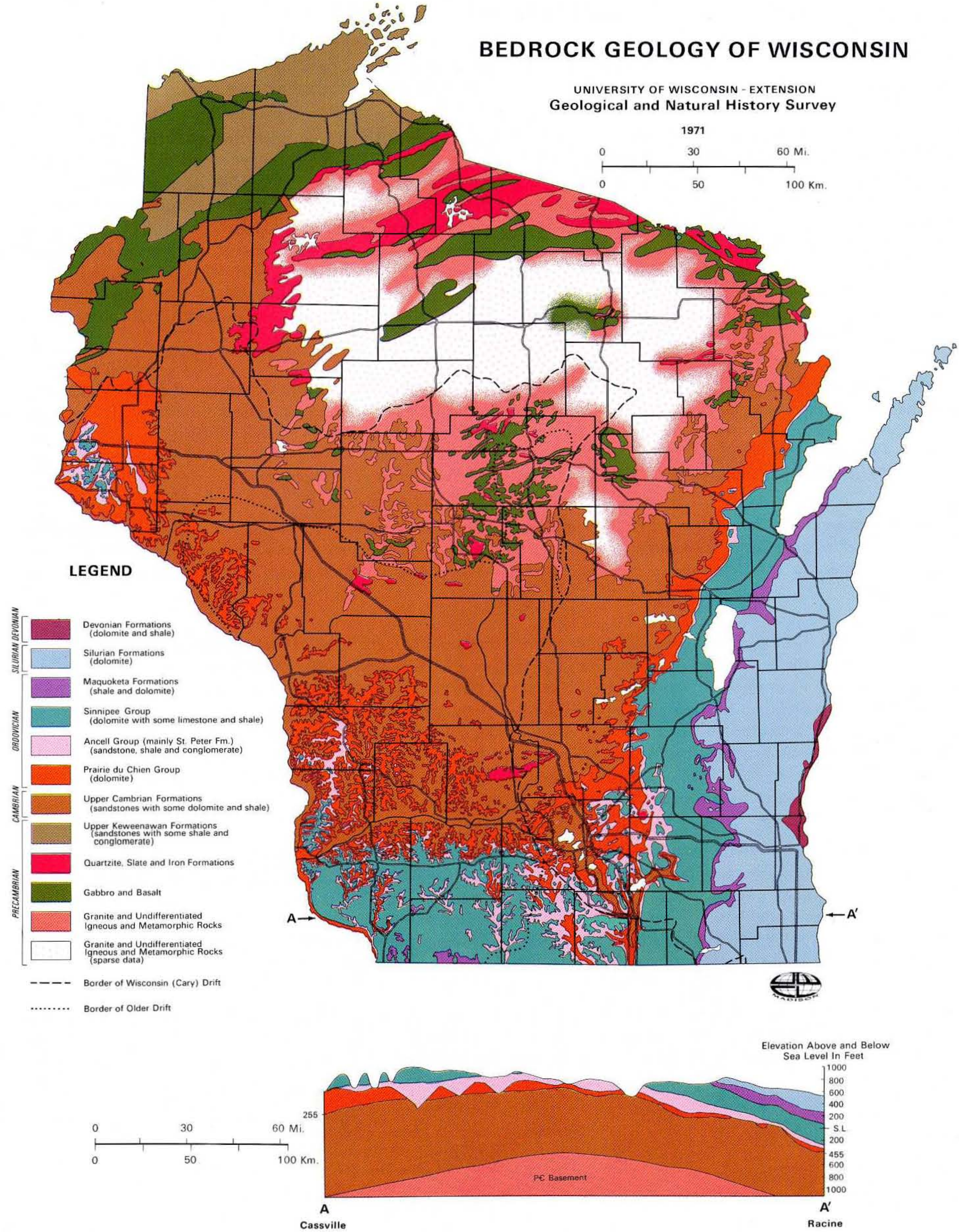
BEDROCK GEOLOGY OF WISCONSIN
UNIVERSITY OF WISCONSIN - EXTENSION
Geological and Natural History Survey
1971
0 30 60 Mi.
0 50 100 Km.
LEGEND
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
PRECAMBRIAN
Devonian Formations (dolomite and shale)
Silurian Formations (dolomite)
Maquoketa Formations (shale and dolomite)
Sinnipee Group (dolomite with some limestone and shale)
Ancell Group (mainly St. Peter Fm.) (sandstone, shale and conglomerate)
Prairie du Chien Group (dolomite)
Upper Cambrian Formations (sandstones with some dolomite and shale)
Upper Keweenawan Formations (sandstones with some shale and conglomerate)
Quartzite, Slate and Iron Formations
Gabbro and Basalt
Granite and Undifferentiated Igneous and Metamorphic Rocks
Granite and Undifferentiated Igneous and Metamorphic Rocks (sparse data)
Border of Wisconsin (Cary) Drift
Border of Older Drift
A
A′
Elevation Above and Below Sea Level In Feet
1000
800
600
400
200
S.L.
200
455
600
800
1000
255
0 30 60 Mi.
0 50 100 Km.
P€ Basement
A
Cassville
A′
Racine

FIGURE 4.

SHORT GEOLOGIC HISTORY OF WISCONSIN

The bedrock of Wisconsin is separated into two major divisions: (1) older, predominantly crystalline rocks of the Precambrian Era; and (2) younger relatively flat-lying sedimentary rocks of the Paleozoic Era.

The Precambrian Era lasted from the time the earth cooled, over 4,000 million years ago, until the Paleozoic Era which began about 600 million years ago. During this vast period of 3,400 million years sediments, some of which were rich in iron and which now form iron ores, were deposited in ancient oceans; volcanoes spewed forth ash and lava; mountains were built and destroyed, and the rocks of the upper crust were intruded by molten rocks of deep-seated origin. Only a fragmentary record of these events remains but, as tree stumps attest to the presence of former forests, the rocky roots tell the geologist of the presence of former mountains. Nowhere does any trace of the original crust remain, and the oldest rocks yet found in the state are about 2,000 million years old. With the exception of the Upper Keweenawan formations that outcrop in the northwest, all of these rocks have been extensively deformed, and in many areas they are so highly altered that their original nature and origin are extremely difficult to interpret.

In the north-central part of the state surface outcrops are so sparse, due to a cover of glacial deposits, that details of the bedrock are obscured. In such areas the only clues to the underlying rocks are obtained indirectly by such geophysical methods as airborne magnetics. In the past much high-grade iron ore was produced from the Precambrian rocks of northern Wisconsin, and much low-grade ore ("taconite") awaits development. Recent geologic work indicates that the area has a high potential for finding ores of other metals such as copper.

At the close of the Precambrian Era most of Wisconsin had been eroded to a rather flat plain upon which stood hills of more resistant rocks as those now exposed in the Baraboo bluffs. There were still outpourings of basaltic lava in the north and a trough formed in the vicinity of Lake Superior in which great thicknesses of sandstone were deposited.

The Paleozoic Era began with the Cambrian Period, the rocks of which indicate that Wisconsin was twice submerged beneath the sea. Rivers draining the land carried sediments which were deposited in the sea to form sandstone and shale. Animals and plants living in the sea deposited calcium carbonate and built reefs to form rocks which are now dolomite—a magnesium-rich limestone. These same processes continued into the Ordovician Period during which, as indicated by the rocks, Wisconsin was submerged three more times. Deposits built up in the sea when the land was submerged were partially or completely eroded at times when they were subsequently elevated above sea level. During the close of the Ordovician Period, and in the succeeding Silurian and Devonian Periods, Wisconsin is believed to have remained submerged.

The youngest rocks outcropping in Wisconsin are of Devonian age and are about 350 million years old. Absence of younger rocks makes interpretations of post-Devonian history in Wisconsin a matter of conjecture. If the dinosaurs roamed Wisconsin, as well they might have some 200 million years ago, no trace of their presence remains. Available evidence from neighboring areas, where younger rocks are present, indicates that towards the close of the Paleozoic Era, perhaps some 250 million years ago, a period of gentle uplift began which has continued to the present. During this time the land surface was carved by rain, wind and running water.

The final scene took place during the last million years when glaciers invaded Wisconsin from the north and sculptured the land surface. They smoothed the hill tops, filled the valleys and left a deposit of debris over all except the southwest quarter of the State where we may now still see the land as it might have looked a million years ago.

University of Wisconsin - Extension
GEOLOGICAL AND NATURAL HISTORY SURVEY
M.E. Ostrom, Director and State Geologist
1815 University Avenue,
Madison, Wisconsin, 53706

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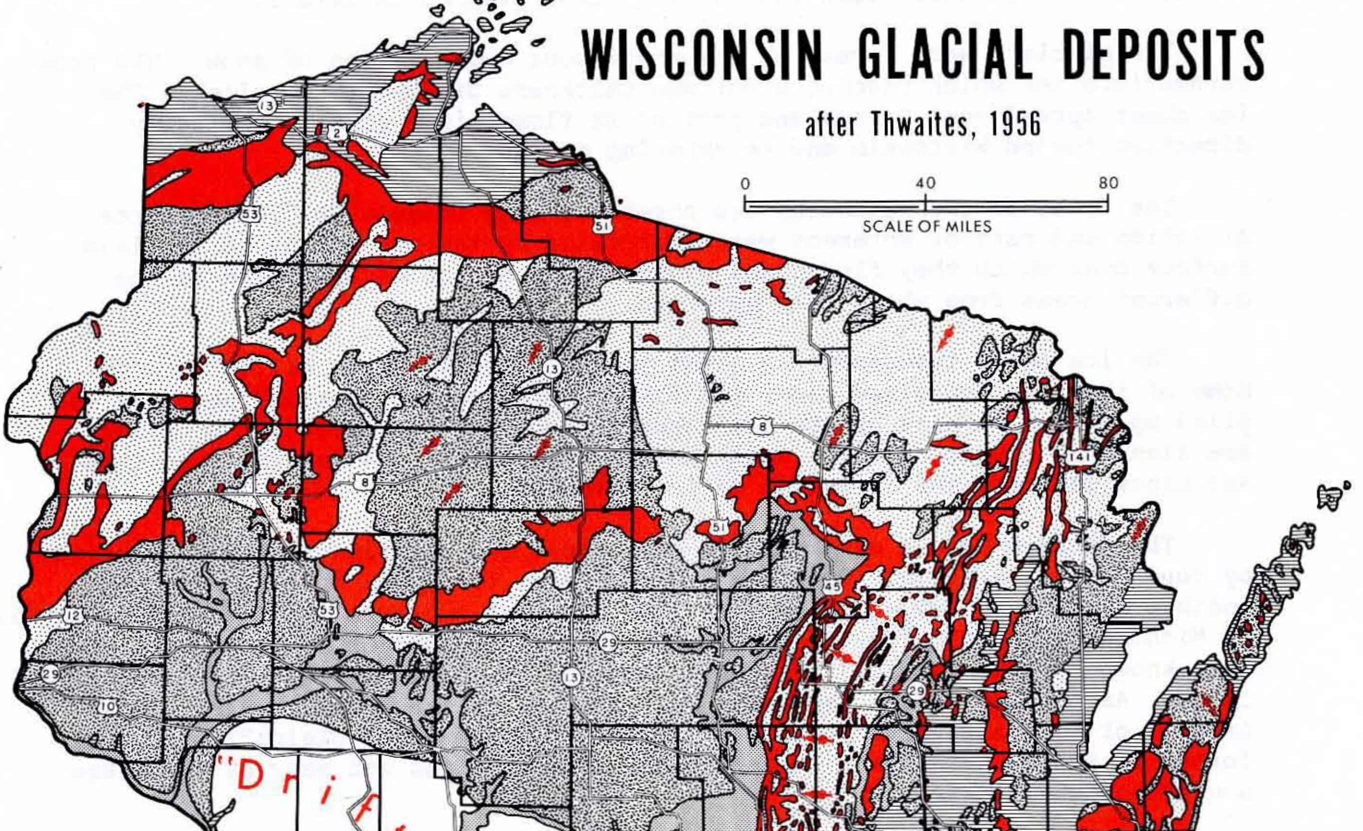
FIGURE 5.



University of Wisconsin

Wisconsin Geological and Natural History Survey

George F. Hanson, Director and State Geologist

SHORT HISTORY OF THE ICE AGE IN WISCONSIN

The Pleistocene Epoch or "Ice Age" began about 1,000,000 years ago which, in terms of geologic time, is a very short time ago. There were four separate glacial advances in the Pleistocene each followed by an inter-glacial period when the ice receded. The fourth glacial stage is called the Wisconsin Stage because it was in this State that it was first studied in detail.

The glaciers were formed by the continuous accumulation of snow. The snow turned into ice which reached a maximum thickness of almost two miles. The ice sheet spread over Canada and part of it flowed in a general southerly direction toward Wisconsin and neighboring states.

The front of the advancing ice sheet had many tongues or "lobes" whose direction and rate of movement were controlled by the topography of the land surface over which they flowed and by the rates of ice accumulation in the different areas from which they were fed.

The ice sheet transported a great amount of rock debris called "drift". Some of this was deposited under the ice to form "ground moraine" and some was piled up at the margins of the ice lobes to form "end moraines". "Drumlins" are elongated mounds of drift which were molded by the ice passing over them and hence indicate the direction of ice movement.

The pattern of end moraines, in red, shows the position that was occupied by four major ice lobes. One lobe advanced down the basin of Lake Michigan, another down Green Bay, a third down Lake Superior and over the northern peninsula of Michigan and yet a fourth entered the state from the northwest corner. The well-known "Kettle Moraine" was formed between the Lake Michigan and Green Bay lobes. As the ice melted the drift was reworked by the running water. Large amounts of sand and gravel were deposited to form "outwash plains"; pits were formed in the outwash where buried blocks of ice melted and many of these are now occupied by lakes.

The action of the ice profoundly modified the landscape, smoothing off the crests of hills and filling the valleys with drift. In some places it changed the course of rivers forcing them to cut new channels such as that of the Wisconsin River at the Dells; elsewhere it dammed the valleys to create lakes such as those of the Madison area.

During recent years there have been intensive studies made of the polar ice caps, and methods have been developed for dating glacial events from the radioactivity of the carbon in wood, bones, etc. which are found in many of the deposits. The results of these studies are causing many previously accepted concepts to be changed or challenged.

We once thought that there were rather extensive glacial deposits older than Wisconsin age in the State, but age determinations do not support this. It was also thought that the ice left Wisconsin some 20,000 years ago but a forest at Two Creeks in Manitowoc County was buried under an advancing ice tongue only 11,000 years ago. Evidence is accumulating to indicate that ice may have occupied the so-called "Driftless Area" of the southwestern part of the State which hitherto has been held to be unglaciated.

Most scientists now believe that the cause of the Pleistocene "Ice Age" was due to variations in the solar energy reaching the earth, but how these may have occurred is still a matter of conjecture. We are still in the Ice Age and it is anybody's guess whether future millenia will see the melting of the ice caps and the slow drowning of our coastal cities, or the regrowth and once more the inexorable advance of the glaciers.

Prepared by the University of Wisconsin Geological & Natural History Survey, August 1964

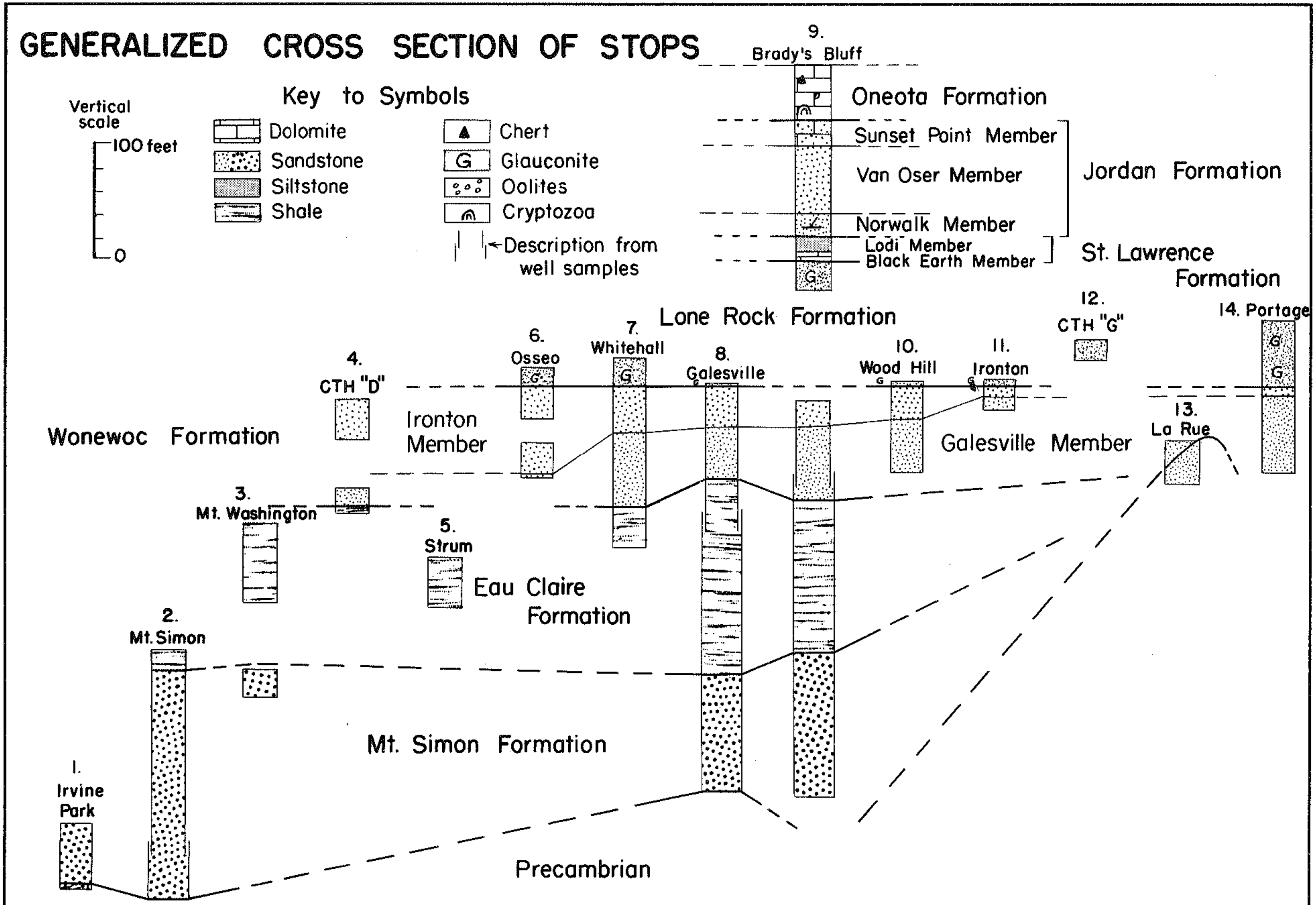
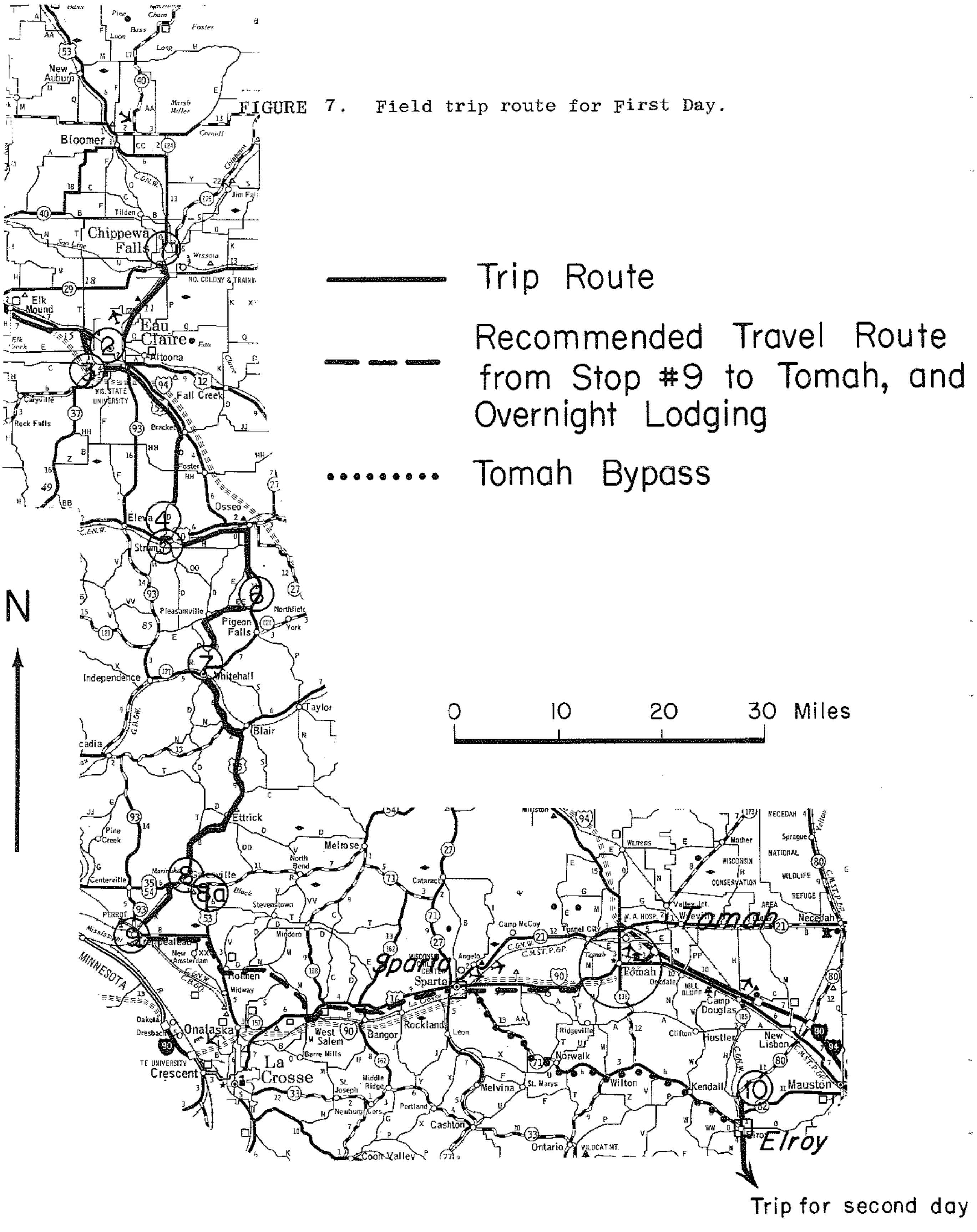

GENERALIZED CROSS SECTION OF STOPS
Key to Symbols
Vertical scale
100 feet
0
Dolomite
Sandstone
Siltstone
Shale
Chert
Glauconite
Oolites
Cryptozoa
Description from well samples
9. Brady's Bluff
Oneota Formation
Sunset Point Member
Van Oser Member
Norwalk Member
Jordan Formation
Lodi Member
Black Earth Member
St. Lawrence Formation
Lone Rock Formation
12. CTH "G"
14. Portage
4. CTH "D"
6. Osseo
7. Whitehall
8. Galesville
10. Wood Hill
11. Ironton
13. La Rue
Ironton Member
Galesville Member
Wonewoc Formation
3. Mt. Washington
5. Strum
Eau Claire Formation
2. Mt. Simon
Mt. Simon Formation
1. Irvine Park
Precambrian

FIGURE 6.

FIGURE 7. Field trip route for First Day.



Road Log
FIRST DAY

Chippewa Falls to Trempealeau

Description of stops by M.E. Ostrom, Wis. Geological & Natural History Survey.

Cumulative
Mileage

0.0 STOP #1. Stream cut in east bank of Duncan Creek just north of first bridge south of Glen Lock dam in Irvin Park near the north city limits of Chippewa Falls and in the NW$\frac{1}{4}$, SW$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 31, T.29N., R.8W., Chippewa County (refer to Chippewa Falls 15' topographic quadrangle). Exposure can best be reached by following footpath south from Glen Lock dam which is located 150 yards west of Highway 54 at Moyers Glen Lock Bar.

Cambrian System
(St. Croixan Series - Dresbachian Stage)
Elk Mound Group
Mt. Simon Formation

14.	52.5'- 61.5'	9'	Sandstone, light yellow brown, grain size ranges from very coarse to fine, massive. Conglomeratic in basal 3 inches with pebbles scattered throughout but chiefly along cross bedding planes.
13.	49.5'- 52.5'	3'	Sandstone, gray, coarse to fine, massive bedded, cross bedded. Bottom not seen.
12.	46.5'- 49.5'	3'	Shale, green gray, with some lenses and beds of sandstone. Upper part covered.
11.	43.5'- 46.5'	3'	Sandstone, light brown, grain size ranges from fine to very coarse, lower 2" conglomeratic, medium bedded, some cross bedding. Appears thin bedded where weathered.
10.	43.0'- 43.5'	0.5'	Sandstone, light brown streaked pale green gray, very fine to coarse, silty, thin bedded. Bedding surfaces show evidence of reworking by animals and are marked by numerous trails.
9.	34.0'- 43.0'	9'	Sandstone, yellow gray, conglomeratic, grain size of sand ranges from very coarse to medium with little fine; massive bedded and cross bedded, some cross beds conglomeratic.

8.	24.5'- 34.0'	9.5'	Conglomerate, yellow gray, mostly subrounded to rounded quartz pebbles in a quartz sand matrix; massive bedded and cross bedded. Finer grained toward top.
7.	18.5'- 24.5'	6'	Sandstone, very light yellow gray, coarse to fine grained with little very coarse, locally conglomeratic, massive bedded to thick bedded, cross bedded. Lower 8" locally shaly with rolling or mildly contorted bedding.
6.	15.5'- 18.5'	3'	Conglomerate, yellow gray, mostly subrounded to rounded quartz pebbles in a matrix of chiefly quartz sand; massive bedded and cross bedded. Beds are not laterally continuous and some contain only scattered pebbles.
5.	9.0'- 15.5'	6.5'	Sandstone, yellow gray, medium and fine grained, some coarse near top, moderately well sorted, subangular, with rare conglomeratic beds one pebble in thickness; massive bedded with some cross bedding. Weathers to thin beds of $\frac{1}{4}$" to $\frac{1}{2}$" thickness.
4.	6.0'- 9.0'	1.3'	Conglomeratic, yellow gray, mostly subrounded to subangular quartz pebbles in a matrix of sand and silt with a trace of clay; some cross bedding.
Precambrian			
3.	3.0'- 6.0'	3'	Granite, highly weathered, blue green to light yellow brown, with much blue green clay.
2.	1.0'- 3.0'	2'	Granite, highly weathered, pink. Uneven upper surface with 6" to 1' relief.
1.	0.0'- 1.0'	1'	Granite, highly weathered, green gray with some pink, appears gneissic.
			BASE OF EXPOSURE at stream level.

At STOP #1 the Mt. Simon Sandstone Formation, presumably the oldest of our Cambrian deposits in Wisconsin, can be seen resting on Precambrian rocks. This contact is one of marked unconformity due to Pre-Paleozoic erosion. Thwaites (1957) constructed a map based on existing subsurface data to show this surface (Figure 8). On the basis of well data it is known that Paleozoic deposits as young as Champlainian rest on the Precambrian in Wisconsin.

The Mt. Simon Sandstone can be traced laterally into Minnesota, Iowa, Illinois, and the Southern Peninsula of Michigan. It has been traced to Tennessee and correlated with the Erwin Sandstone of that area (Calvert, 1962). In Tennessee the Mt. Simon is assigned an Early Cambrian age. The difference in age of the Mt. Simon between Tennessee and Wisconsin, where it is Late Cambrian, is ascribed to transgression during deposition. Thus, the Mt. Simon is a time-transgressive lithostratigraphic unit.

Is the Mt. Simon Formation present in the Upper Peninsula? The formation has not been traced via outcrop or subsurface into that area and there are at present no rocks in the Upper Peninsula assigned equivalence to the Mt. Simon.

If one applies the techniques of lithostratigraphy to pre-Franconian sedimentary rocks of Wisconsin and the Upper Peninsula a correlation becomes obvious. The Mt. Simon correlates with the Jacobsville, the Galesville with the Chapel Rock and the Ironton (and possibly Mazomanie) with the Miner's Castle (Ostrom, 1964: in press).

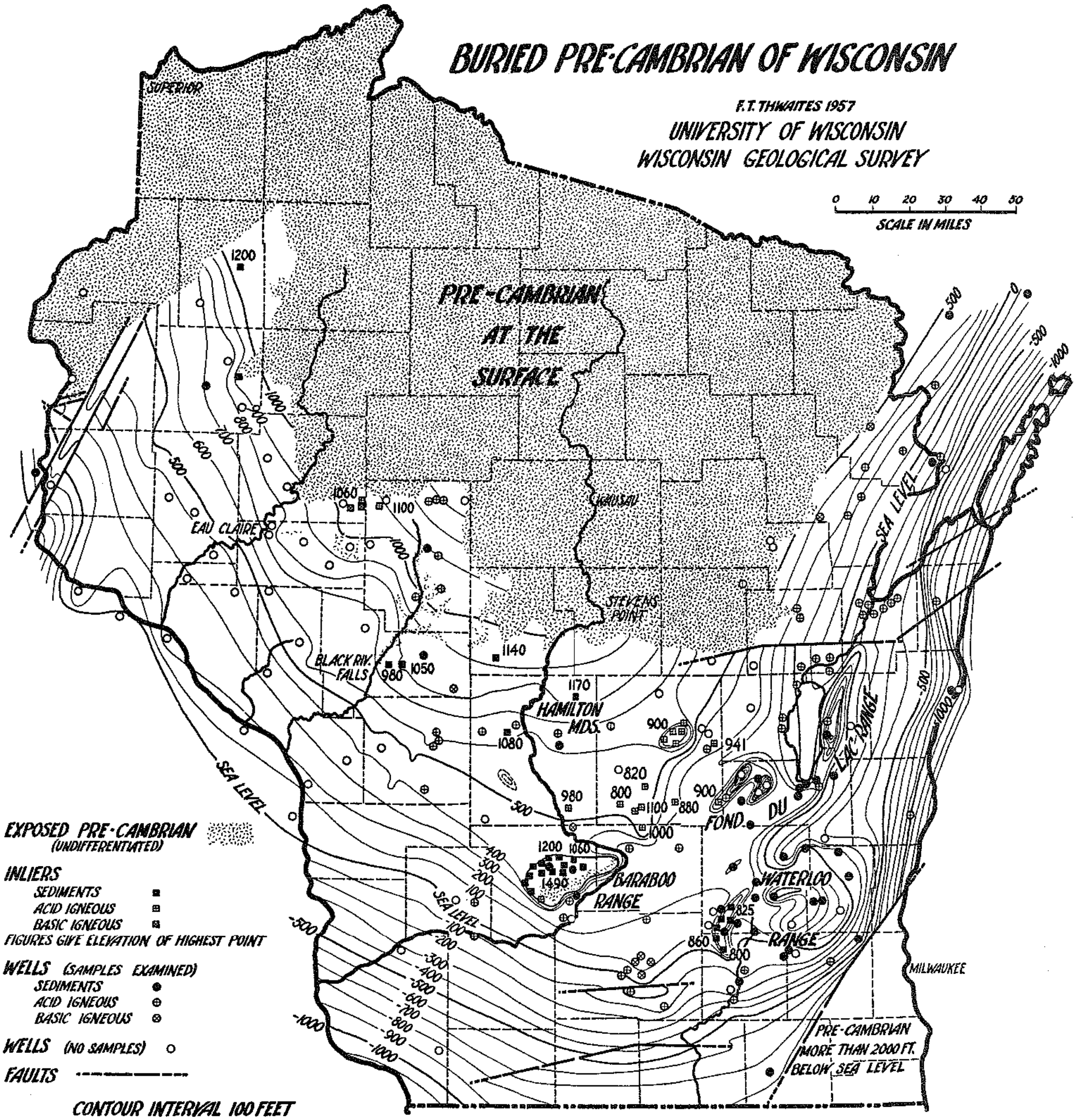
Criteria which can be used for correlation include relationship to major structural features in the area (Figure 9), superposition of strata, lithology, and unconformities.

The major structural features are the Wisconsin dome and the structure manifest as the midcontinent gravity high. In lows at the southeast flank of the midcontinent gravity high the section begins at its base with Precambrian volcanics. These are overlain by feldspathic sandstone called either Fond du Lac or Oronto, which is most often described as being unconformable with an overlying quartz sandstone, called either Hinckley or Bayfield. The feldspathic sandstone is characterized by a heavy mineral suite which includes epidote and/or apatite, minerals rare or absent in younger rocks.

Superposition of strata reveals additional similarities. In Minnesota and southern Wisconsin the feldspathic sandstone is overlain by quartzarenite which is in turn overlain by shale or shaly sandstone of the Eau Claire Formation. In northern areas the shaly unit is absent due either to nondeposition or to later removal. It has been suggested (Ostrom, 1964) on the basis of the southwest to northeast wedge-out of Eau Claire lithology across Wisconsin (Twenhofel, Raasch and Thwaites, 1935), and the fact that its position in Michigan is marked by an erosional unconformity and a conglomerate between the Jacobsville and Munising formations (Hamblin, 1958; Ostrom, 1964), that the Eau Claire was removed from northern areas by erosion.

If one reverses the process and proceeds down the section, then the logical starting point is rocks of Franconian age, the Ironton Member of Wisconsin and the Miner's Castle Member of the Upper Peninsula. These rock units have been correlated many times on the basis of fossils, most recently by Stumm (1956). They are underlain by quartz sandstones, the Galesville of southern Wisconsin and Minnesota and the Chapel Rock of the Upper Peninsula. There is little disagreement to this point in the discussion. However, as one continues down the section the Eau Claire Formation is next encountered in

FIGURE 8.


BURIED PRE-CAMBRIAN OF WISCONSIN
F.T. THWAITES 1957
UNIVERSITY OF WISCONSIN
WISCONSIN GEOLOGICAL SURVEY
0 10 20 30 40 50
SCALE IN MILES
PRE-CAMBRIAN AT THE SURFACE
SUPERIOR
EAU CLAIRE
WAUSAU
STEVENS POINT
BLACK RIV. FALLS
HAMILTON MDS.
BARABOO RANGE
WATERLOO RANGE
FOND DU LAC RANGE
MILWAUKEE
SEA LEVEL
PRE-CAMBRIAN MORE THAN 2000 FT. BELOW SEA LEVEL
EXPOSED PRE-CAMBRIAN (UNDIFFERENTIATED)
INLIERS
SEDIMENTS
ACID IGNEOUS
BASIC IGNEOUS
FIGURES GIVE ELEVATION OF HIGHEST POINT
WELLS (SAMPLES EXAMINED)
SEDIMENTS
ACID IGNEOUS
BASIC IGNEOUS
WELLS (NO SAMPLES)
FAULTS
CONTOUR INTERVAL 100 FEET

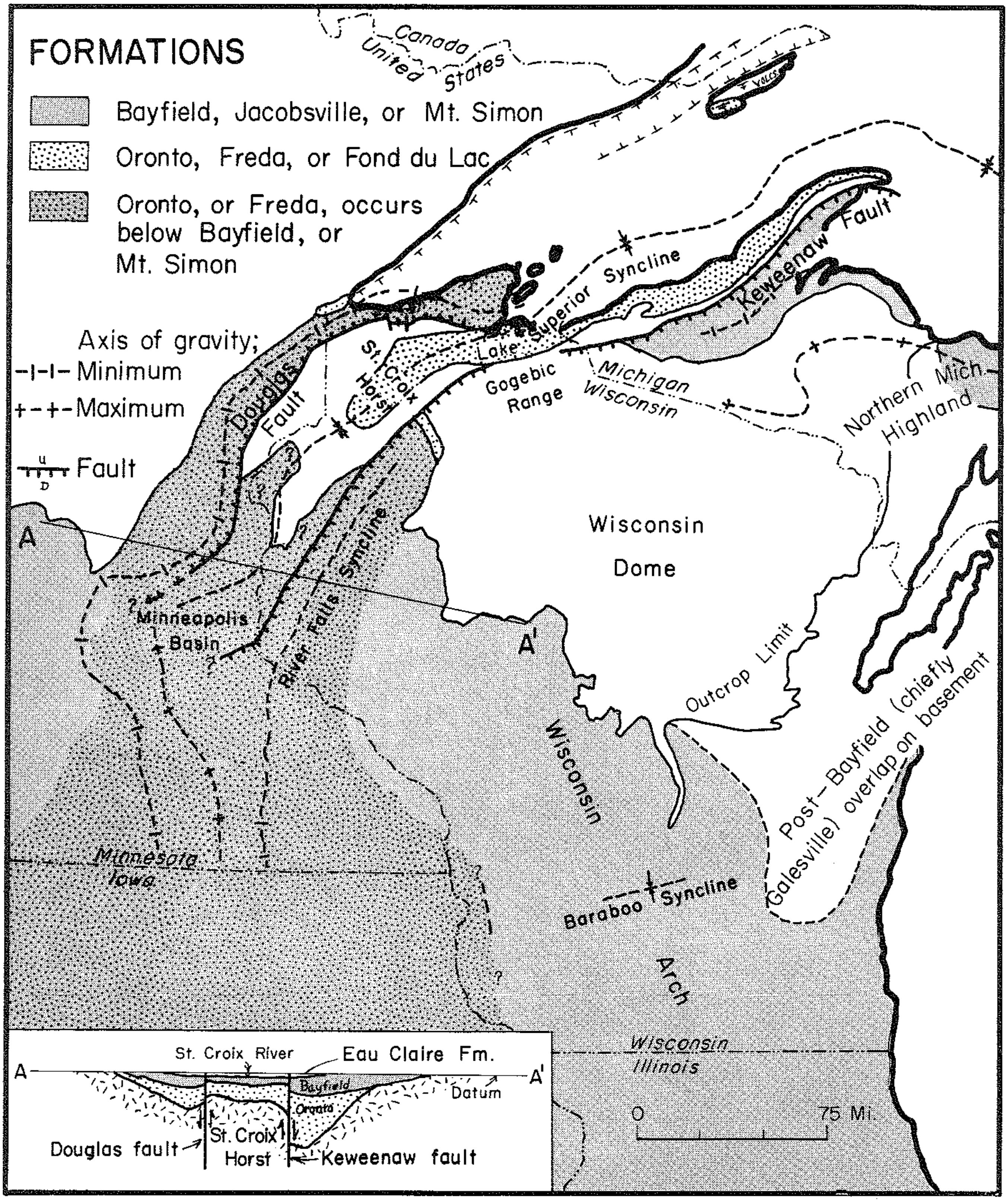


FIGURE 9. Distribution of basal sandstone formations and of related tectonic features in Wisconsin and vicinity. Modified from Van Hise and Leith (1911), Thwaites (1912), Thwaites (1935-2), Hamblin (1958), Bacon (in Hamblin, 1958 Fig. 31), Bean (1959), U.S.G.S. & A.A.P.G. (1962), Craddock, Thiel and Gross (1963), Snider (1963), and Patenaude (1965).

Minnesota and southern Wisconsin whereas in the Upper Peninsula we once again arrive at the erosional unconformity overlain by conglomerate which separates Chapel Rock from Jacobsville strata.

Is the similarity of these features a matter of coincidence? Possibly yes, but the line of reasoning followed to arrive at the correlation indicated here is at least as rational as that used to discount correlation. Until it can be proven one way or the other the Wisconsin Geological and Natural History Survey will subscribe to the correlation shown in Figures 3 and 9. The age of the Freda-Fond du Lac-Oronto is unknown. Until it can be correctly dated it will not be assigned to either the Precambrian or the Cambrian.

STOP #1 (Alternate). Stream cut in north bank of Eau Claire River at Big Falls about 4 miles north of Village of Fall Creek and in the SW$\frac{1}{4}$, SW$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 13, T.27N., R.8W., Eau Claire County (refer to Chippewa Falls 15' topographic quadrangle).

Cambrian System
(St. Croixan Series - Dresbachian Stage)
Elk Mound Group
Mt. Simon Formation

3.	15'-	45'	30'+	Outcrop discontinuous. Quartz sandstone and conglomerate, medium bedded, cross bedded.
2.	10'-	15'	0'-5'	Clay, green, plastic.

Precambrian

1.	0'-	10'	10'+	Quartzite, gray with thin dark green bands of amphibole, thin bedded. Attitude of beds is: dip, 85°SW, strike, S.30°E.

0.0 Leave STOP #1. Stop sign. Caution when entering onto Highway 53. Observe 30 mph speed limit. Follow Highway 53 through city.
2.0 Cross bridge over Chippewa River.
8.8 Enter City of Eau Claire.
9.5 Enter Eau Claire County.
12.1 Turn right (west) on County Trunk Highway "Q" via turn-off before underpass.
12.2 STOP SIGN. Turn right (west) on Birch Street (CTH"Q"). Caution on left. Observe 25 mph speed limit.
12.3 Mount Tom on left (south).
13.3 STOP SIGN. Turn right (north) on Dewey Street.
13.4 Turn left (west) on Eddy Street and follow across railroad overpass.
13.8 Stay to left on Sheridan Road.
14.1 Take diagonal right (north) on Snelling Street.
14.5 STOP #2. Type section of the Mt. Simon Sandstone Formation. Exposure in bluff of Chippewa River and in hill called Mt. Simon in the City of Eau Claire in the SW$\frac{1}{4}$, SW$\frac{1}{4}$, sec. 8, T.27N., R.9W., Eau Claire County (refer to Elk Mound 15' topographic quadrangle). Section includes all

rock exposed from top of Mt. Simon northward to base of river bluff. (Description by M.E. Ostrom and Virendra Asthana).

Cambrian System
(St. Croixan Series - Dresbachian Stage)
Elk Mound Group
Eau Claire Formation

41. 215.5'-224.5'	9.0'	Sandstone, light yellow gray, predominantly coarse grained, massive bedded and cross bedded. Contains abundant brachiopods (Obolus namouna). Trace of glauconite. Some beds are burrowed. These are the only rocks at this exposure assigned by Twenhofel, Raasch, and Thwaites, (1935, p. 453), to the Eau Claire Formation.
40. 211.5'-215.5'	4.0'	Sandstone, very light yellow gray, predominantly medium and fine grained with some coarse grains. Becomes coarser grained toward top.
39. 210.8'-211.5'	0.7'	Sandstone, very light yellowish gray, fine and very fine grained, in single bed with green shale layer at top.
38. 210.5'-210.8'	0.3'	Sandstone, yellow gray to white, fine and medium grained, massive bedded and cross bedded, with 2" green shale layer at top.
37. 208.5'-210.5'	2.0'	Sandstone, light yellow brown to light yellow gray, fine and very gine grained, thick and massive bedded. Bed of sandstone with thin green shale layer in upper 6".
36. 207.1'-208.5'	1.4'	Sandstone, light yellow brown, very fine grained, thin bedded, with green gray shale layer up to 2" thick at base. Contains fossil fragments.

Mt. Simon Formation

35. 206.1'-207.1'	1.0'	Sandstone, light yellow gray, predominantly coarse grained with little very coarse and medium.
34. 205.6'-206.1'	0.3'-0.7'	Sandstone, light yellow gray, very fine grained, silty, with green shale partings.
33. 199.6'-205.6'	6.0'	Sandstone, pink orange, predominantly coarse grained with little very coarse, massive bedded, cross bedded.

32.	197.6'-199.6'	2.0'	Sandstone, light yellow gray, grains range from coarse down to very fine sand; silty and burrowed.
31.	196.9'-197.6'	0.7'	Sandstone, predominantly coarse grained with little very coarse, massive bedded. Upper limit marked by concentration of iron oxide. Upper surface ripple marked and when viewed from above has a mottled gray coloration.
30.	190.9'-196.9'	6.0'	Sandstone, light yellow gray, grain size ranges from coarse down to very fine sand, silty, burrowed, in beds 6" to 8" thick separated by thin green gray shale layers.
29.	189.9'-190.9'	1.0'	Sandstone, light yellow gray, fine grained, silty, very argillaceous with green gray shale turning to reddish brown toward top.
28.	185.9'-189.9'	4.0'	Sandstone, light yellow gray, grain size ranges from coarse to very fine sand, slightly silty, massive bedded with low angle cross bedding.
27.	177.9'-185.9'	8.0'	Sandstone, light yellow gray, predominantly coarse grained with little medium and fine, appears massive bedded but weathers thin bedded and even bedded with laterally persistent thin layers of green gray shale along bedding planes, cross bedded. Some trail markings. Weathers in stair-step pattern.
26.	167.3'-177.9'	10.6'	Sandstone, light yellow brown, coarse grained, massive bedded, weathers to irregular beds.
	105.3'-167.3'	62.0'	COVERED INTERVAL. Base of covered interval at parking lot level north of Mt. Simon marks approximate base of Eau Claire Formation according to Templeton (1951).
25.	95.3'-105.3'	10.0'	Sandstone, light yellow brown, predominantly coarse grained with granules; coarsest grains concentrated along bedding planes and cross beds. Weathers to regular beds 2" to 1' in thickness.
24.	92.3'- 95.3'	3.0'	Sandstone, forms marked reentrant; light yellow brown, sand grain size ranges from fine to very coarse with scattered granules, cross bedded. Persistent green shale in upper 16 inches.

23.	92.0'- 92.3'	0.3'	Sandstone, light yellow brown, fine grained with thin horizontal shale partings.
22.	91.3'- 92.0'	0.7'	Sandstone, light yellow brown, predominantly coarse grained with scattered granules, massive bedded and cross bedded at top of prominent ledge.
21.	89.8'- 91.3'	1.5'	Sandstone, light yellow brown, medium and coarse grained with some very coarse grains and granules in base, massive bedded and cross bedded.
20.	88.2'- 89.8'	1.6'	Sandstone, yellow green, predominantly medium grained with abundant coarse grains and granules in lower 2" and scattered throughout upper part, massive bedded and cross bedded.
19.	87.5'- 88.2'	0.7'	Sandstone, light yellow brown, fine and medium grained with small pits on weathered surface.
18.	87.0'- 87.5'	0.5'	Sandstone, light yellow gray, sand grain size ranges from very coarse down to very fine, granules concentrated along cross beds and may be locally abundant in beds up to 5" thick, becomes finer grained toward top, massive bedded and cross bedded. Cross bedding is very low angle.
17.	85.5'- 87.0'	1.0'-4.0'	Sandstone, same as no. 18, noticeably cross bedded, occurs as single bed ranging from 1'0" to 4.0" in thickness; cross beds sharply truncated at top.
16.	84.0'- 85.5'	0.5'-3.5'	Sandstone, same as no. 18. Thins beneath unit #17.
15.	83.0'- 84.0'	0.5'-1.0'	Sandstone, light yellow brown, fine grained with little medium, scattered granules, massive bedded.
14.	80.0'- 83.0'	3.0'	Sandstone, light yellow brown, grain size ranges from very fine to very coarse with some granules which are concentrated along cross beds, massive bedded; uneven top.
	77.0'- 80.0'	3.0'	COVERED INTERVAL

13.	74.0'- 77.0'	3.0'	Sandstone, light yellow gray, grain size ranges from coarse to fine, horizontally streaked yellow brown, massive bedded and cross bedded.
	71.0'- 74.0'	3.0'	COVERED INTERVAL
12.	67.0'- 71.0'	4.0'	Sandstone, light yellow gray, grain size ranges from coarse to fine with little very coarse and few granules concentrated along cross beds.
	59.0'- 67.0'	8.0'	COVERED INTERVAL
11.	57.0'- 59.0'	2.0'	Sandstone, light yellow brown, grain size ranges from coarse to fine with little very coarse, massive bedded and cross bedded; forms a prominent ledge.
10.	55.0'- 57.0'	2.0'	Sandstone, light yellow gray with thin horizontal green gray shale layers, medium to very fine grained; forms prominent reentrant.
9.	51.0'- 55.0'	4.0'	Sandstone, very light yellow brown, fine to very coarse grained with scattered granules, massive bedded and cross bedded; occurs as a prominent ledge between two equally prominent reentrants.
8.	50.5'- 51.0'	0.5'	Sandstone, yellow gray, medium to very fine grained, massive; occurs beneath prominent overhang.
	48.5'- 50.5'	2.0'	COVERED INTERVAL
7.	45.0'- 48.5'	3.5'	Sandstone, yellow gray, coarse to fine grained with little very coarse and some granules in lower 6". Cross bedded in beds 2" to 6" thick, massive bedded.
6.	43.5'- 45.0'	1.5'	Sandstone, yellow brown, streaked with pale green gray clay, cross bedded. Forms reentrant on weathered surface.
5.	37.5'- 43.5'	6.0'	Sandstone, light yellow brown, medium to very coarse grained with little fine, massive bedded with horizontal color banding and distinct cross bedding.
4.	31.0'- 37.5'	6.5'	Sandstone, light yellow brown, grain size ranges from medium to coarse with little

fine, massive bedded with horizontal color banding and some low angle cross bedding.

BASE OF EXPOSURE near water level at location of concrete water intake structure.

Following section is report from a well in the area (Twenhofel, Raasch, and Thwaites, 1935, p. 453).

3.	3.0'- 31.0'	28.0'	Sandstone, light gray and light yellow gray, coarse to fine grained.
2.	0.0'- 3.0'	3.0'	Sandstone with granules to $\frac{1}{4}$" diameter.

Precambrian

1.			Granite

The Mt. Simon Sandstone grades upward into the Eau Claire Formation at its type exposure. Although the formation contains no fossils it is assigned a Dresbachian age because it is gradational with the overlying Eau Claire Formation which has a Dresbachian fauna (Crepicephalus and Cedaria).

Mineralogical analyses of the Mt. Simon here indicate a range in feldspar content of from 2.06% to 5.0% (Stauffer & Thiel, 1941; Crowley & Thiel, 1940; Potter & Pryor, 1961). Predominent heavy minerals are ilmenite, leucoxene, zircon, tourmaline, and garnet (Tyler, 1936). The only mineralogical information available on the Eau Claire Formation is an analysis by Potter & Pryor (1961) which indicates 12.5% feldspar in outcrops near Merrillan in northwestern Jackson County. Other analyses from scattered outcrops show variable amounts of tourmaline and zircon, ilmenite, magnetite, and garnet.

Of particular interest at this exposure are the transitional beds. These have been recognized at many outcrops in this vicinity but have not been traced to other areas due to lack of outcrops showing this part of the section. The transitional beds here, above the quartzarenite and below the argillaceous sandstone, are lithologically very similar to those of the Ironton Member which occurs between the Galesville and the Lone Rock and which will be seen at subsequent stops (Ostrom, 1964).

14.5 Leave STOP #2 via Snelling Street.
14.9 STOP SIGN. Turn right (northwest) on Sheridan Road. Caution on left.
15.0 Pass under railroad overpass. Follow Forest Street to first stop sign at Madison Street.
16.2 STOP SIGN at Madison Street. Turn right (west), cross bridge over river and proceed to first stop light.
16.5 STOP LIGHT. Turn left (south) on Bellinger Avenue at stop light, proceed 4 blocks south and jog left for 1 block and then continue 4 more blocks south on 5th Avenue to Grand Avenue.
17.1 Turn right (west) on Grand Avenue and proceed to parking area in Carson Park.

17.6 REST STOP. Sandstone exposed in park bluffs is the Mt. Simon Formation. Return via Grand Avenue to Stop Sign at 5th Avenue.

18.1 STOP SIGN at 5th Avenue. Turn right (south) and proceed to stop sign at Water Street.

18.5 STOP SIGN at Water Street. Turn right (west) for 5 blocks, jog 1 block left (south) on 9th Avenue and continue west on Menomonie Street to Stop light at junction with Highway 12.

19.3 STOP LIGHT at Junction with Highway 12. Continue straight ahead on Menomonie Street.

CAUTION! THIS IS A DANGEROUS INTERSECTION! Note Mt. Washington in foreground.

19.4 Continue straight ahead on Menomonie Street.

19.6 Mt. Simon Sandstone exposed in roadcuts at both sides of street at south side of school building.

19.7 Turn left (east) on Mt. Washington Avenue. Oncoming traffic does not stop. Proceed to junction with Cleveland Street.

20.3 Turn right on Cleveland Street and park west of hospital.

20.4 STOP #3. Type section of the Eau Claire Formation. Outcrop is located in abandoned quarries near the top of the east bluff of Mt. Washington below abandoned concrete water storage tank north of hospital in the city of Eau Claire in the SE$\frac{1}{4}$, NE$\frac{1}{4}$, NW$\frac{1}{4}$, sec. 25, T.27N., R.10W., Eau Claire County (refer to Elk Mound 15' topographic quadrangle). Description modified from Twenhofel, Raasch, and Thwaites (1935).

Cambrian System
(St. Croixan Series - Dresbachian Stage)
Elk Mound Group
Eau Claire Formation

4.	131'- 156'	25'	Sandstone, gray and light yellow, medium and fine grained, little glauconite, predominantly massive bedded with some thin bedded and argillaceous zones; some cross bedding. Exposed in upper quarry. (Crepicephalus beds).
3.	94'- 131'	37'	Sandstone, light yellow gray, fine grained, thin bedded, some thin shale seams near top. Abundant sedimentary structures such as ripple marks, mud cracks, and fucoids. Many brachiopods. (Cedaria beds). Much is covered. Exposed in cliff below upper quarry.
2.	84'- 94'	10'	Sandstone, light yellow gray, grain size ranges from coarse to fine, beds from thick to thin with some Obolus namouna (Walcott); abundant black shale partings. Fucoids, mud cracks, and ripple marks common. Exposed in lower quarry. Believed by Twenhofel, Raasch, and Thwaites (1935)

				to correlate with the rocks exposed at the top of Mt. Simon.
	24'-	84'	60'±	COVERED INTERVAL
Mt. Simon Formation				
1.	0'-	24'	24'	Sandstone, light yellow gray, predominantly coarse grained, massive bedded, cross bedded. Some quartz granules and pebbles. No fossils. Exposed across street southwest of grade school yard and on the south side of Menomonie Street at mileage 19.6.
				BASE OF EXPOSURE at southwest corner of school yard.

The type section of the Eau Claire Formation exposed in Mt. Washington at this stop is no longer either well exposed or readily accessible. The upper quarry, unit #1 of the description, is easily reached but is on private land Unit #2 of the description occurs in the bluff below the upper quarry and is now mostly covered by slump and vegetation. Unit #3 of the description is the lower quarry described by Twenhofel et al (1935) and is now on private land and mostly covered by slump and vegetation.

It is important to examine, in the upper quarry especially, the lithology, bedding characteristics, and sedimentary structures preserved in the Eau Claire Formation. These features are important to paleoenvironmental interpretation and for comparing the Eau Claire with Cambrian and Ordovician rock units such as the Lone Rock Formation, which occur in similar cyclical sequences.

The environment of deposition of the Eau Claire Formation is believed to have been similar to the shelf depositional environment described by Van Andel and Curray (1960, p. 348 and 354-8) for the Northwest Gulf of Mexico. This environment is located seaward of the littoral environment and its regional distribution is described by these authors (p. 354) as a "function of the location of clay sources and of the distribution pattern of marine currents". Deposits in this environment are predominantly clay and silt but may also consist of alternating fine-grained sands and muds in areas located nearer to shore (Curray, 1960, p. 234). Glauconite and shell fragments are common. Curray (p. 232) also shows that the probable frequency of fine sand movement by significant wave surge decreases with increasing water depth which suggests that we can expect greater variation in shallower waters, namely more sand, and more variation in lithology from bed to bed.

It is believed that the Eau Claire and Lone Rock formations developed under essentially similar environment conditions. This should be kept in mind when examining the Lone Rock at Stops numbers 6, 7, 12, and 14.

20.4 Leave Stop #3. Return to Highway 12 via same route used to reach Stop #3, namely Mt. Washington Avenue and Menomonie Street.
21.3 Turn right (east) from Mt. Washington Avenue to Menomonie Street. Caution from left.

21.5 STOP SIGN. Proceed straight ahead. Caution both straight ahead and to the right. Approaching traffic does not stop.

21.8 STOP LIGHT. Junction with Highway 12. Turn right (east).

22.0 Bridge over Chippewa River.

25.6 STOP SIGN. Follow Highway 53 diagonal to the southeast.

34.4 Enter Village of Brackett.

34.6 Turn right (southwest) on County Trunk Highway "D".

37.4 Eau Claire Formation exposed in quarry on right (west).

39.3 Eau Claire Formation exposed in quarry on left (east) and in roadcut on right (west).

40.0 Cross northern border of "Driftless Area".

43.3 Eau Claire Formation exposed in quarry on left (east).

43.4 Enter Trempealeau County.

44.1 STOP #4. Roadcut at west side of County Trunk Highway "D" about 2 miles north of the Village of Strum and in the W½, SW¼, sec. 5, T.24N., R.8W., Trempealeau County (see Strum 15' topographic quadrangle map). Description begins at top of exposure west of highway. Small exposure of younger rock believed to belong to the Ironton Member occurs at side of farm road at top of hill and east of highway (not included in description).

Cambrian System
(St. Croixan - Franconian Stage)
Elk Mound Group
Wonewoc Formation
Ironton Member

15.	96.7'-102.7'	6'+	Sandstone cobble (up to 6") conglomerate. Cobbles are yellow brown sandstone and are arranged with long axis horizontal. Matrix consists of coarse grained gray brown sandstone.
14.	93.7'- 96.7'	3'	Sandstone, light yellow brown, medium grained, with scattered thin silty and clayey seams; massive bedded.
13.	89.2'- 93.7'	4.5'	Sandstone and quartz conglomerate, light yellow brown, grains up to 4 mm in size and down to very fine sand; massive bedded.
12.	85.7'- 89.2'	3.5'	Sandstone, light yellow brown, poorly sorted, grains range in size from very coarse sand down to silt, dolomitic, with few thin green shale seams; thin bedded. Bed thickens to almost 12' toward north end of cut where there is abundant green shale in upper 18 inches.
11.	77.2'- 85.7'	8.5'	Sandstone, yellow brown, grain size ranges from very coarse sand down to silt, massive bedded; few burrows. Bed thins to disappearance as bed number 12 thickens to 12 feet northward in the roadcut.

9.	75.6'- 75.9'	0.3'	Sandstone, yellow brown, medium and coarse grained, massive bedded. Has $\frac{1}{4}$" to $\frac{3}{4}$" iron oxide band at top.
8.	74.7'- 75.6'	0.9'	Sandstone, light yellow gray, poorly sorted, grain size ranges from very coarse sand down to silt; clay abundant in top. Some irregular iron oxide bands near base.
7.	73.4'- 74.7'	1.3'	Sandstone, light gray, coarse and medium grained, trace of very coarse; cross bedded and massive bedded; few burrowings in top 6 inches.
6.	72.1'- 73.4'	1.3'	Sandstone, yellow brown predominantly coarse grained with much medium, little very coarse and trace of fine; little silt; abundant burrows. Iron oxide enrichment in upper $\frac{1}{4}$".
5.	70.6'- 72.1'	1.5'	Sandstone, yellow brown, predominantly coarse grained, little medium and very coarse, trace fine; few burrows; massive bedded, faint cross bedding.
4.	68.5'- 70.6'	2.1'	Sandstone, light yellow gray, coarse grained, much fine and medium, little very coarse; massive bedded, cross bedded. Silty in upper 3".
	22.5'- 68.5'	46'	COVERED INTERVAL (Includes Ironton-Galesville contact. Several ledges near top of covered interval are Galesville lithology which, if true, means that the Galesville is about 63 feet thick and that there is 35 feet of Ironton above).

(Dresbachian Stage)
Galesville Member

3.	5.5'- 22.5'	17'	Sandstone, white to yellow brown, medium and fine grained, little coarse; massive bedded and cross bedded. Locally has iron oxide enrichment.
2.	5'- 5.5'	0.5'	Sandstone, vari-colored (black, yellow brown, red brown, white), poorly sorted with materials grading down from very coarse sand to green shale. Shale most

				common in base. Contact with underlying Eau Claire Formation slightly irregular (1 foot vertical relief over 10' horizontal distance).
Eau Claire Formation				
1.	0'-	5'	5'	Sandstone, yellow gray streaked light yellow brown, very fine and fine grained, silty, little mica, trace glauconite. Brachiopods abundant in sandstone 3' to 5' below contact. Medium and thin bedded to irregularly bedded. Twelve feet of Eau Claire exposed in base of outcrop 60 feet to south.
				BASE OF EXPOSURE at road level.

This roadcut and that of Stop #7 are good examples of why it is thought that the Ironton and Galesville lithic units should be combined into a single formation.

On the basis of fossils contained in the Ironton the two units have been assigned to two different stages, namely the Galesville to the Dresbachian Stage and Ironton to the Franconian Stage. Fossils are rare in the Galesville and those found are oboloid brachiopods and worm burrows which are not diagnostic of age (Stauffer and Thiel, 1941).

Twenhofel, Raasch, and Thwaites (1935, p. 1699) state that the Ironton represents "the initial deposits of the Franconia waters" and thus they infer a break in deposition and possibly erosion between Galesville and Ironton time. On the other hand the beds of the Ironton are described also as "transitional" because the contact is often obscure as it is at this exposure. As an alternative it is suggested that the Ironton is the product of subaqueous reworking of Galesville sand in an area located seaward of the nearshore zone in deeper waters where energy was generally lower than that of the nearshore area and where consequently less sediment was in transport. Under such a circumstance there is no need to have emersion of Galesville sand prior to deposition of Ironton sand, and there is no reason for a major time break at this horizon.

To pursue this idea further it should be remembered that at Stop #2 transitional beds of a similar character were observed in the top of the Mt. Simon Formation separating the lower part of the Mt. Simon from the overlying Eau Claire Formation. In consideration of the fact that, aside from grain size, the composition and gross textural characteristics of the Mt. Simon and Galesville sandstones are similar it is peculiar that the Mt. Simon which is unfossiliferous, is assigned to the Dresbachian on the basis of fossils contained in the underlying unit. It would seem in consideration of a sequence of cyclic sediments that one should apply the same criteria to analogous subdivisions of different cycles in the interest of uniformity if for no other reason.

At Stop #1 we saw the Mt. Simon Sandstone resting on an eroded and weathered surface of Precambrian crystalline rocks. Obviously the Mt. Simon must represent a deposit laid down by an advancing sea and most likely developed in the beach and nearshore, or littoral, zone. The areal extent of such deposits in the Gulf of Mexico today is limited to the length of the shoreline and a maximum width of about 20 miles (Van Andel & Curray, 1960). The present broad extent of the Mt. Simon and Galesville sandstones as shown by Cohee (1948) & Emrich (1962) is believed to be the result of similar beach deposits having been laid down as a blanket during transgression (Ostrom, 1964). For example, Calvert (1962) shows that the Mt. Simon, or its lithostratigraphic equivalent the Erwin Sandstone, overlaps to the northwest from Tennessee to Wisconsin, that it was deposited during a period of transgression, and that its age is Early Cambrian in Tennessee and Late Cambrian in Wisconsin. If the Mt. Simon was deposited over a erosional unconformity is it not also probable, in fact essential assuming the paleoenvironmental reconstructions described herein to be accurate, that the Galesville was also deposited on an erosional surface? The contact of the Galesville with the underlying Eau Claire can be seen at the base of unit #14 at this stop. The contact surface is slightly undulating and is overlain by up to 6 inches of vari-colored shaly sandstone that is believed to be the basal Galesville deposit composed of reworked and redeposited Eau Claire Sandstone. As was pointed out in the discussion of Stop #1 this surface is probably the same as that which separates the Jacobsville from the Munising in the Upper Peninsula of Michigan where the Eau Claire Sandstone is absent. The contact will also be seen at Stops number 7 and 8.

If, in fact, the contact of the Eau Claire with the Galesville is an erosional unconformity, as is presumed here, then one must re-evaluate the position of the Galesville with respect to its assignment to the Dresbachian Stage rather than the Franconian Stage. The Galesville is separated from older rocks by an unconformity, it contains no diagnostic fossils, and it is transitional with the overlying Ironton Member which contains fossils of Franconian age. These facts suggest that the Galesville should be assigned a Franconian age because the Mt. Simon, a sandstone of similar lithologic character, is assigned to the Dresbachian on the basis of similar evidence except that the name Mt. Simon is substituted for Galesville and "Upper Mt. Simon transitional beds" for Ironton.

The Ironton thickens away from the Wisconsin dome and arch. At this exposure only the lower 34 feet of Ironton is exposed. At Stop #7, located about 12 miles to the south all of the member is exposed and it is 43 feet thick. Traced east and south it thins to disappearance over the arch as can be seen at exposures south of Lone Rock in the south bluff of the Wisconsin River. Across the arch and into northeastern Illinois the Ironton increases to a maximum of 150 feet in thickness (Buschbach, 1964; Emrich, 1962).

In northeastern Illinois the Ironton is a poorly sorted medium and coarse grained white sandstone which is coarser than the underlying Galesville and which generally contains some light pinkish buff dolomite as cementing material. Buschbach (1964) notes that the lower 20 to 80 feet of Ironton in this area is more variable in grain size than are the other Ironton members with a maximum grain size of 1.2 mm. In this same area he describes the Galesville as a "white to light buff, clear to slightly silty sandstone that is fine grained, moderately well sorted and largely nondolomitic".

It is believed that the Galesville of Wisconsin is equivalent to the Chapel Rock of Minnesota and that the Ironton, and possibly a portion of the overlying Mazomanie of Wisconsin, is equivalent to the Miner's Castle of the Upper Peninsula. The lithology and paleontology of the Galesville and Chapel Rock members and the Ironton and Miner's Castle members is similar. The differences of lithology and paleontology between the Galesville and Ironton in Wisconsin, and the Chapel Rock and Miner's Castle in the Upper Peninsula, are also similar. In each area the members are transitional and the Upper members, namely the Ironton and Miner's Castle, are assigned a Franconian age on the basis of fossils.

44.1 Leave Stop #4

46.2 STOP #5. Exposure of the Eau Claire Formation in an abandoned quarry at the east side of County Trunk Highway "D" about 0.2 miles north of its junction with Highway 10 at the north edge of the Village of Strum and located in the NE¼, NE¼, SE¼, sec. 18, T.24N., R.8W., Trempealeau County (refer to the Strum 15' topographic quadrangle).

Cambrian System
(St. Croixan Series - Dresbachian Stage)
Elk Mound Group
Eau Claire Formation

7.	42'-	47'	5'+	Sandstone, massive (inaccessible).
6.	39'-	42'	3'	Sandstone, light yellow gray, fine and medium grained, shaly, thin bedded and irregularly bedded; trace glauconite.
5.	32'-	39'	7'	Sandstone, light yellow brown, medium grained, massive and thick bedded.
4.	25'-	32'	7'	Sandstone, light yellow brown and yellow gray, grain size ranges from medium down to silt, medium and thin bedded. Fossils, notably trilobites, occur midway in this member at north end of quarry.
3.	21'-	25'	4'	Sandstone, light yellow gray, medium grained, massive bedded
2.	13'-	21'	8'	Sandstone, light yellow brown, very fine grained, very silty and argillaceous, very glauconitic with abundant ripclasts, thin bedded.
1.	0'-	13'	13'	Sandstone, light yellow brown, very fine grained, very silty and argillaceous, thin bedded.
				FLOOR OF QUARRY.

This stop is one of the better exposures of the Eau Claire Formation in Wisconsin and is intended to show lithology. As one proceeds eastward across

Wisconsin this lithology is lost. It is believed that the Eau Claire lithology is at least in part laterally transitional with that of the Galesville and Mt. Simon as was described by Twenhofel, Raasch, and Thwaites (1935). It is also believed that its disappearance eastward is in part due to pre-Galesville erosion as was discussed under Stop #4. In support of this latter contention it must be stated that Twenhofel, Raasch, and Thwaites (op. cit) indicated the Eau Claire can be subdivided into two faunal zones in this area and that traced eastward these disappear, first the upper and then the lower, suggesting a cut-off at the top of the Eau Claire. If the Eau Claire was deposited during transgression as is now believed, then it is difficult to explain an apparent off-lap of beds except by post-Eau Claire erosion.

46.2 Leave STOP #5.
46.4 STOP SIGN. Junction with Highway 10. Turn left (east). Use extreme caution.
47.9 Eau Claire Formation exposed in roadcut on left (north).
50.1 Eau Claire Formation exposed in quarry on left (north).
52.5 Eau Claire Formation exposed in roadcut on left (north).
55.3 Enter Village of Osseo. Follow Highway 54.
55.5 Turn right (south) and continue on Highway 54.
61.3 Ironton Sandstone exposed in outcrops on left (east).
62.7 STOP #6. Roadcut on Highway 53 south of the Village of Osseo and about 2.0 miles south of highway junction with County Trunk Highway "E" in the SW$\frac{1}{4}$, NW$\frac{1}{4}$, sec. 11, T.23N., R.7W., Trempealeau County (refer to Blair 15' topographic quadrangle).

Cambrian System
(St. Croixan Series - Franconian Stage)
Tunnel City Group
Lone Rock Formation
Tomah - Birkmose members

39.	61.9'- 76.9'	15.0'+	Sandstone, green gray weathers yellow brown, fine and very fine grained, abundant glauconite, thin bedded and cross bedded.

Wonewoc Formation
Ironton Member

38.	61.3'- 61.9'	0.6'	Sandstone, yellow brown, medium grained with little coarse and fine and trace of very coarse and very fine, little glauconite, massive bedded and cross bedded; abundant brachiopod fragments.
37.	60.2'- 61.3'	1.1'	Sandstone, yellow brown, medium grained with little coarse and fine and trace of very coarse and very fine, massive bedded and cross bedded.
36.	60.0'- 60.2'	0.2'	Sandstone, light gray spotted yellow brown, medium and coarse grained with little fine

			and very fine and trace of very coarse, little silt; dolomitic matrix.
35.	59.5'- 60.0'	0.5'	Sandstone, gray mottled yellow gray, medium and coarse grained with a little fine and very fine, trace of silt.
34.	58.8'- 59.5'	0.7'	Sandstone, light brown, medium grained with little coarse and fine and trace of very fine, silty dolomitic matrix, massive bedded with thin layer of iron oxide at top.
33.	58.1'- 58.8'	0.7'	Sandstone, yellow gray mottled gray and yellow brown, medium grained with little coarse, fine, and very fine; much silty dolomitic matrix.
32.	55.6'- 58.1'	2.5'	Sandstone, yellow brown, medium grained with a little coarse and fine and trace of very coarse, trace of fossil fragments, massive bedded and cross bedded; weathered surface of upper 6" somewhat pitted.
31.	55.1'- 55.6'	0.5'	Sandstone, gray spotted yellow brown, medium grained with much fine and very fine and trace of coarse; much silty dolomitic matrix.
30.	54.0'- 55.1'	1.1'	Sandstone, yellow gray mottled yellow brown, medium and coarse grained with much fine and very fine; much silty dolomitic matrix and abundant brown iron oxide mottling.
29.	53.8'- 54.0'	0.2'	Sandstone, yellow gray, medium grained with little coarse and fine and trace of very coarse, massive bedded, weathered surface pitted.
28.	53.7'- 53.8'	0.1'	Siltstone, light gray, dolomitic, trace of sand; very irregular boundaries, generally flat at top and uneven at bottom.
27.	52.7'- 53.7'	1.0'	Sandstone; upper part is light yellow brown, medium grained with little coarse and fine and trace of very coarse, massive bedded and contains scattered tube-like vertical iron oxide concentrations; lower part is yellow brown mottled light yellow brown, medium and coarse grained with little fine and very fine, much silty dolomitic matrix, a few brachiopod fragments

			and abundant tube-like vertical iron oxide concentrations.
26.	52.2'- 52.7'	0.5'	Sandstone, yellow brown, mottled and streaked gray, medium grained with much coarse and fine and little very fine, much silty dolomitic matrix and some brachiopod fragments.
25.	50.7'- 52.2'	1.5'	Sandstone, yellow gray, fine and very fine grained with trace of medium and coarse, massive bedded and cross bedded, some brown iron oxide streaks and thin shale partings. Iron oxide-filled tube-like vertical concentrations in upper 6".
24.	50.2'- 50.7'	0.5'	Sandstone, yellow brown, fine and very fine grained with trace of medium and coarse, massive bedded and cross bedded.
23.	49.4'- 50.2'	0.8'	Sandstone, yellow gray mottled yellow brown, medium and coarse grained with little fine and very coarse and trace of very fine, much silty dolomitic matrix and abundant small concentrations of iron oxide.
22.	46.9'- 49.4'	2.5'	Sandstone; upper part is yellow gray some mottled yellow brown, medium and coarse grained with little fine and trace of very coarse, massive bedded; lower part is yellow gray mottled yellow brown, medium and coarse grained with little fine and very coarse and trace of very fine, much silty dolomitic matrix.
21.	46.5'- 46.9'	0.4'	Sandstone, yellow brown, medium grained with little fine and coarse; uneven upper and lower contacts, upper appears to be due to ripple marks.
20.	44.5'- 46.5'	2.0'	Sandstone, yellow gray locally mottled yellow brown, medium and coarse grained with little fine, massive bedded.
19.	42.4'- 44.5'	2.1'	Sandstone, yellow gray mottled yellow brown, medium and coarse grained with much fine and very fine and trace of very coarse. Abundant silt. Poorly bedded.
18.	30.3'- 42.4'	12.1'	Sandstone, yellow gray, medium and coarse grained with little fine and trace of very fine and very coarse, trace of silt, massive bedded. Some thin beds which are shaly, silty, and dolomitic.

Description resumes at exposure located in road cuts in south slope of hill along Highway 53 and south of above locations and in the SE$\frac{1}{4}$, SE$\frac{1}{4}$, sec. 10, T.23N., R.7W.

17.	25.0'- 30.3'	5.3'	Sandstone, yellow gray, medium and coarse grained with little fine and trace of very coarse, massive or thick bedded and cross bedded, scattered silty dolomitic partings.
16.	24.8'- 25.0'	0.2'	Sandstone, yellow gray, coarse and very coarse grained with little medium and fine and trace of granules.
15.	23.5'- 24.8'	1.3'	Sandstone, yellow gray, medium and coarse grained with little very coarse, fine, and very fine and trace of granules. Much silty dolomitic matrix and few scattered silty dolomitic partings.
14.	21.2'- 23.5'	2.3'	Sandstone, yellow gray, medium and coarse grained with little fine and very fine and trace of very coarse, massive bedded; little silty dolomitic matrix.
13.	20.4'- 21.2'	0.8'	Sandstone, light yellow brown, medium and fine grained with little coarse and very fine, very silty. Appears nodular with shaly partings and a dolomitic matrix.
12.	19.1'- 20.4'	1.3'	Sandstone, yellow gray, medium and fine grained with little very fine and trace of coarse and very coarse, massive bedded. Dolomitic matrix with undulating silty partings.
11.	18.6'- 19.1'	0.5'	Sandstone, light yellow brown, medium grained with coarse and fine, interbedded with green gray dolomitic shale.
10.	17.5'- 18.6'	1.1'	Sandstone, yellow gray, medium and fine grained with little coarse and very fine and trace of silt; silty dolomitic matrix.
9.	17.3'- 17.5'	0.2'	Sandstone, yellow brown, medium and fine grained with little coarse and very fine; matrix consists of silt, dolomite, and iron oxide.
8.	16.1'- 17.3'	1.2'	Sandstone, yellow brown, medium and fine grained with little coarse and very fine; little silty dolomitic matrix.

7.	15.8'- 16.1'	0.3'	Sandstone, yellow brown, medium and fine grained with little very fine and trace of coarse, very silty and dolomitic; shaly in upper 1".
6.	15.4'- 15.8'	0.4'	Sandstone, yellow brown, medium and coarse grained with little fine, thinly and irregularly bedded; little silty dolomitic matrix.
5.	14.9'- 15.4'	0.5'	Sandstone, light yellow brown, medium and coarse grained with little fine and very fine, massive bedded; little silty dolomitic matrix.
4.	14.4'- 14.9'	0.5'	Sandstone, light yellow brown, medium and coarse grained with little fine, massive bedded and cross bedded.
3.	7.9'- 14.4'	6.5'	Sandstone, very light yellow brown, medium and fine grained with trace of coarse, massive bedded and cross bedded.
2.	4'- 7.9'	3.9'	Sandstone, very light yellow brown, medium grained with much coarse and fine, some beds coarser than others, massive bedded and cross bedded.

(Dresbachian Stage)
Galesville Member (?)

1.	0'- 4'	4.0'	Sandstone, light gray, fine and medium grained with trace of very fine, massive bedded and cross bedded.
			COVERED TO ROAD LEVEL

Relationships of the Galesville and Ironton members were discussed in conjunction with Stop #4. At Stop #6 we are exposed to the Tunnel City Group for the first time.

The Tunnel City Group (Ostrom, in press) includes all the rock strata above the Wonewoc Formation (see mileage 12.0) for Second Day) and below the St. Lawrence Formation. The name is taken from the Village of Tunnel City in and near which these rocks are exposed in railroad cuts, roadcuts, quarries, and natural outcrops. Those member units designated as the Birkmose, Tomah, Reno, and the Mazomanie, are included in the Tunnel City Group.

The reasons why a new name was introduced for these rocks are: (1) the unit consists of two major lithologies which interfinger laterally, a glauconitic and/ or shaly and micaceous fine-grained sandstone, and a nonglauconitic and calcareous sandstone; (2) the name Franconia, which has been used, is taken from outcrops of the nonglauconitic facies at Franconia, Minnesota; (3) the name Franconia is now widely accepted as a stage name and thus connotes time; and (4) the lithologic and time boundaries do not coincide.

A description of the Tunnel City Group is given below as modified from that of Twenhofel, Raasch, and Thwaites (1935, pp. 1732-33) and is taken from exposures along the Chicago and Northwestern Railroad east and west of Tunnel City, natural exposures and quarries above and south of the railroad tunnel, roadcuts on Highway 21 northwest of the village, and the highway quarry and natural exposures north of the highway commencing with the tunnel in the SW$\frac{1}{4}$, SW$\frac{1}{4}$, NW$\frac{1}{4}$, sec. 25, T.18N., R.2W., Monroe County (refer to Millston 15' topographic quadrangle).

Cambrian System
(St. Croixan Series - Trempealeauan Stage)
St. Lawrence Formation
Lodi Member

14.	221'-	244'	23'	Siltstone, dolomitic, yellow-gray, interbedded with fine grained white sandstone, some cross bedding; top foot contains what appear to be contraction cracks.

(Franconian Stage)
Tunnel City Group
Lone Rock Formation (For definition see discussion of Stop #12)
Reno Member

13.	215'-	221'	6'	Sandstone, fine grained, yellow to gray, nodular, glauconitic, dolomitic; a thin conglomerate with pebbles of fine grained yellow dolomitic siltstone at top.
12.	194'-	215'	21'	Greensand much like zone below but poorly exposed in the dugway heading to the quarry.
11.	165'-	194'	29'	Greensand, medium and fine grained, more or less massively bedded, burrowed, quantity of glauconite varies in different beds; fossiliferous.

Mazomanie Member

10.	146'-	165'	19'	Sandstone, fine grained, yellow, little or no glauconite.
	131'-	146'	15'	CONCEALED
9.	127'-	131'	4'	Sandstone, very light yellow gray, fine grained, medium bedded.

Reno Member

8.	117'-	127'	10'	Sandstone, poorly sorted, grain size ranges from silt to fine sand, thin bedded, burrowed; moderately glauconitic.
7.	102'-	117'	15'	Greensand; yellow gray, fine and very fine grained, glauconitic, cross bedded.
	92'-	102'	10'	CONCEALED

Tomah Member

6.	72'-	92'	20'	Sandstone, yellow gray, very fine and fine grained, very silty and micaceous with interbedded gray shale.

Birkmose Member

5.	67'-	72'	5'	Greensand conglomerate, much calcite; pebbles of fine grained yellow siltstone and sandstone; layers of fine grained yellow sandstone, fossiliferous.

Wonewoc Formation
Ironton Member

4.	46'-	67'	21'	Sandstone, yellow brown, coarse and medium grained, cross bedded, alternating with beds of sandstone, white, fine and medium grained, with burrows.
3.	39'-	46'	7'	Sandstone, yellow brown, grain size ranges from medium to very coarse with some granules near base, cross bedded.
2.	30'-	39'	9'	Sandstone, light yellow brown, grain size ranges from coarse to fine, thin bedded.

(Dresbachian Stage)
Galesville Member

1.	0'-	30'	30'+	Sandstone, white, fine and medium grained, massive bedded and cross bedded. Some irregular green shale layers in lower 7 feet along railroad track.

BASE OF EXPOSURE

62.7 Leave Stop #6.
64.4 Turn right (west) on County Trunk Highway "EE".
66.9 Turn left (southwest) on County Trunk Highway "E".
69.3 Caution. Enter Pleasantville. No stop signs at intersections. Turn left (south) and follow County Trunk Highway "O".

69.5 Turn left and follow "O".
72.5 This is why we like Wisconsin!
74.0 STOP SIGN. Junction with County Trunk Highway "D".
74.3 STOP #7. Exposure extends to mileage 76.7. Quarry and roadcuts along County Trunk Highway "D" about 1.5 miles north of Village of Whitehall and located mainly in the SW$\frac{1}{4}$, SW$\frac{1}{4}$, sec. 12, T.22N., R.8W., Trempealeau County (refer to Whitehall 15' topographic quadrangle). Description modified from that of G.O. Raasch in Twenhofel, Raasch, and Thwaites (1935, p. 1738).

Cambrian System
(St. Croixan Series - Franconian Stage)
Lone Rock Formation
Reno Member

8. 161.5'-171.5'	10.0'+	Sandstone, light yellow brown and gray green, fine grained, very glauconitic, thin bedded and cross bedded.

Tomah Member

7. 149.5'-161.5'	12.0'	Sandstone, and siltstone, micaceous; sandstone is gray brown, fine grained, silty and argillaceous, thin bedded; siltstone is sandy and argillaceous.

Birkmose Member

6. 147.0'-149.5'	2.5'	Sandstone, glauconitic and dolomitic and dolomite glauconitic. Ripclasts of clean sandstone in matrix of greensand and near base.

Elk Mound Group
Wonewoc Formation
Ironton Member

5. 104.0'-147.0'	43.0'	Sandstone, consisting of layers of medium and coarse grained sandstone alternating with layers of silty sandstone with some vertical borings. Oboloids common in upper 3 to 6 feet. Granules and very coarse sand common in lower part.

(Dresbachian Stage)
Galesville Member

4. 59.0'-104.0'	45.0'	Sandstone, very light yellow gray mottled brown gray, medium and coarse grained, massive bedded and cross bedded, friable. Colored red and yellow in lower part and contains abundant fine grains. Some oboloid fragments in basal few feet.

	53.0'- 59.0'	6.0'	COVERED INTERVAL
3.	35.0'- 53.0'	18.0'	Sandstone, light yellow gray mottled and streaked yellow and brown, predominantly coarse grained with poorer sorting in lower part. Base irregular and overlain by uneven bed composed of sand and pebbles derived from underlying rocks.

Eau Claire Formation

2.	15.0'- 35.0'	20.0'	Sandstone, light yellow gray and light green gray, fine grained, argillaceous; little glauconite and some cross bedding. Abundant oboloids.
1.	0.0'- 15.0'	15'+	Sandstone, green gray, fine grained, thin bedded, glauconitic, with thin shale seams. Fossils appear as red brown stains on rock.
			BASE OF EXPOSURE

The discussion of this outcrop is similar to that for Stop #4 with regard to the Eau Claire lithology, the contact of the Eau Claire and Galesville, and the Galesville-Ironton relationship.

It can be noted here that there is a marked difference in lithology between the Elk Mound Group and overlying Tunnel City Group and that the lithology of the Lone Rock Formation in the base of the Tunnel City is similar to that of the Eau Claire.

The difference in lithologies of the two groups is significant to both outcrop and subsurface work, but especially to the latter. If one is to trace lithostratigraphic units from the outcrop to the subsurface it is essential that these units be distinctive to be useful for mapping purposes.

We have seen that the contact of the Galesville with the Ironton is very difficult to identify on the outcrop. By the same token it is virtually impossible to identify in the subsurface. The best that can be said for this contact in terms of its use in lithostratigraphic work is that it is poor. The difference between the units is certainly not distinctive enough for their interface to qualify as a group contact and it is a poor contact even for formational distinction. For this reason, and because it is believed that the Ironton and Galesville are genetically related as discussed under Stop #4, these two units are regarded as members (Ostrom, in press) of the Wonewoc Sandstone Formation which is described and discussed at mileage 12.0 of the Second Day.

Special attention should be given the lithology of the Lone Rock Formation at this stop. The similarity of this unit to the Eau Claire Formation seen at Stops numbers 2, 3, and 5 is striking and is interpreted to indicate a repetition of the environmental conditions that produced the Eau Claire lithology.

When traced southward into the Illinois basin and on into Missouri the Eau Claire Formation can be seen to divide into upper and lower shaly sandstone units separated by carbonate. The upper shaly sandstone unit can be traced to the lower part of the Elvins Group of eastern Missouri. By the same token if one traces the Lone Rock Formation from Wisconsin southward to the same area it can be traced into the upper part of the Elvins Group. The lower and upper parts of the Elvins Group are distinguished only with difficulty if at all in that area.

It is believed that the environment of Eau Claire and Lone Rock deposition persisted through time from the first appearance of Eau Claire lithology beneath carbonates of the Bonneterre Dolomite Formation in the south, as for example in Missouri, and that subsequently this environment transgressed northward into Wisconsin then southward again to Missouri as is manifest by Eau Claire lithology above carbonate deposits of the Bonneterre Formation, and then readvanced northward into Wisconsin to form the Lone Rock Formation (Ostrom, 1964).

Correlation of the glauconitic greensands of the Lone Rock Formation with rocks in the Upper Peninsula is indefinite. On the basis of stratigraphic position and lithology the Lone Rock should be equivalent to at least a portion of the lower part of Hamblin's Au Train Formation (1958) even though the Au Train contains more carbonate. However, Hamblin designated the Au Train as Ordovician in age.

Disregarding fossils, the greensand lithology of the Lone Rock occurs in the correct stratigraphic position in the Upper Peninsula as is indicated by outcrops on Highway 28 about 1 mile south of Munising and in the south bank of the secondary road which goes east just north of Miner's Castle. The fossils used for identification were listed by Hamblin (Plate 5) as Michelinoceras?, Liospira?, and Ophileta?. This would suggest that a more intensive search should be made for fossils and that more attention be given lithology until unquestionably diagnostic fossils are found.

74.3 Leave Stop #7.
75.7 Eau Claire Formation exposed in quarry on left.
76.0 STOP SIGN. Junction with highways 53 and 121. Turn right (west) with caution and follow route 53 to Galesville.
79.6 Galesville Formation exposed in outcrops on right (west).
84.6 Follow Highway 54 to right.
87.9 Excellent exposures of the Galesville, Ironton, and Frangonia sandstones.
94.3 Village of Ettrick on left (east).
102.0 Enter city of Galesville. Observe posted traffic speeds.
102.6 STOP #8. Type section of the Galesville Sandstone exposed in bluff in High Cliff Park above dam over Beaver Creek in City of Galesville in the NE$\frac{1}{4}$, NW$\frac{1}{4}$, sec. 33, T.19N., R.8W., Trempealeau County (refer to Galesville 15' topographic quadrangle). Description by M.E. Ostrom and Grover Emrich (1960).

Cambrian System
(St. Croixan Series - Franconian Stage)
Tunnel City Group
Lone Rock Formation
Birkmose Member

24. 125.5'-127.0'	1.5'	Sandstone, light green gray, fine grained, glauconitic; thin bedded and cross bedded; some brachiopod fragments.

Elk Mound Group
Wonewoc Formation
Ironton Member

23. 123.5'-125.5'	2.0'	Sandstone, light yellow gray, fine to very fine grained with trace of medium and coarse; some brachiopod fragments.
22. 120.5'-123.5'	3.0'	Sandstone, light yellow gray, medium and coarse grained with little fine; some brachiopod fragments.
21. 119.0'-120.5'	1.5'	Sandstone, brown, medium and fine grained with trace of coarse, massive bedded.
20. 118.5'-119.0'	0.5'	Sandstone light yellow brown, fine and very fine grained with trace of medium, silty, thin bedded and flaggy, cross bedded.
19. 117.0'-118.5'	1.5'	Sandstone, brown, fine and medium grained with trace of coarse, massive bedded and cross bedded.
18. 116.0'-117.0'	1.0'	Sandstone, light yellow brown, medium grained with trace of coarse and fine.
17. 114.0'-116.0'	2.0'	Sandstone, light yellow gray, medium grained with little coarse and fine, slightly silty to silty, beds 3" to 4" thick.
16. 89.0'-114.0'	25.0'	Sandstone, yellow brown to red brown, coarse to medium grained with trace of fine, massive bedded with some thin beds (2"), cross bedded uneven weathered surface.

(Dresbachian Stage)
Galesville Member

15.	83.5'- 89.0'	5.5'	Sandstone, light yellow gray, fine to medium grained with little coarse, silty, massive with few thin beds.
14.	82.5'- 83.5'	1.0'	Sandstone, light yellow gray, fine to very fine grained with trace of medium, silty thin bedded with little cross bedding.
13.	82.0'- 82.5'	0.5'	Sandstone, light yellow gray, coarse to medium grained with little fine. Some grains appear to have been derived from Baraboo quartzite. Massive bedded and cross bedded.
12.	79.5'- 82.0'	2.5'	Sandstone, light yellow gray, fine to medium grained with a little coarse, medium to massive bedded and cross bedded.
11.	78.5'- 79.5'	1.0'	Sandstone, light yellow gray, medium grained with little fine and trace coarse, massive bedded and cross bedded.
10.	66.5'- 78.5'	12.0'	Sandstone, very light yellow gray, fine to very fine grained with trace of medium, massive bedded and cross bedded.
9.	64.5'- 66.5'	2.0'	Sandstone, very light yellow gray, medium to fine grained, massive bedded.
8.	63.5'- 64.5'	1.0'	Sandstone, very light yellow gray, medium grained with little fine and coarse, massive bedded and cross bedded, grades down to
7.	61.5'- 63.5'	2.0'	Sandstone, very light yellow gray, fine grained with little fine and coarse, massive bedded and cross bedded, grades down to
6.	60.5'- 61.5'	1.0'	Sandstone, very light yellow gray, medium grained with little fine and coarse, massive bedded with a few thin beds and cross bedded.
5.	57.5'- 60.5'	3.0'	Sandstone, very light yellow gray, fine grained with little very fine and silt, massive bedded and cross bedded.

4.	55.0'- 57.5'	1.5-3.0'	Sandstone, very light yellow gray, fine grained with little very fine and silt, massive bedded and cross bedded.
3.	47.0'- 55.0'	7.5-9.0'	Sandstone, very light yellow gray, medium and fine grained with little very coarse and fine, massive bedded and cross bedded.
	44.0'- 47.0'	3.0'	COVERED INTERVAL
2.	40.0'- 44.0'	4.0'	Sandstone, light yellow gray, fine grained, massive. Base slightly irregular and may indicate erosion.

Eau Claire Formation

1.	0.0'- 40.0'	40'±	Sandstone, yellow gray, fine and very fine grained, silty, massive bedded and cross bedded; some brachiopod fragments.
			BASE OF OUTCROP (Elev. approx. 710')

Log of Village Well #2, located in the NW¼, sec. 33, T.19N., R.8W., Galesville (description by F.T. Thwaites). Elevation = approximately 720'. Base of outcrop 10' below top of well.

Alluvium

0'- 5'	5.0'	No sample.
5'- 20'	15.0'	Sand, brown yellow, grain size ranges from medium sand down to silt.

Eau Claire Formation

20'- 25'	5.0'	Shale, green gray, silty.
25'- 35'	10.0'	Silstone, yellow gray.
35'- 45'	10.0'	Siltstone, gray.
45'- 50'	5.0'	Siltstone, yellow gray
50'- 60'	10.0'	Shale, gray, silty.
60'- 80'	20.0'	Siltstone, yellow gray.
80'- 95'	15.0'	Siltstone, gray.
95'- 100'	5.0'	No sample.
100'- 130'	30.0'	Shale, gray, silty.

130'-	135'	5.0'	Siltstone, light gray.
135'-	145'	10.0'	Sandstone, light gray, grain size range from medium sand down to silt.

Mt. Simon Formation

145'-	150'	5.0'	Sandstone, light gray, grain size ranges from coarse sand down to silt.
150'-	160'	10.0'	Sandstone, light gray, medium and coarse grained.
160'-	210'	50.0'	Sandstone, light gray, coarse and medium grained.
210'-	215'	5.0'	Sandstone, light gray, grain size ranges from coarse sand down to fine.
215'-	225'	10.0'	Sandstone, light gray, coarse and medium grained.
225'-	230'	5.0'	Sandstone, light gray, grain size ranges from medium sand down to silt.
230'-	235'	5.0'	Siltstone, light gray.
235'-	240'	5.0'	Sandstone, light gray, grain size ranges from medium sand down to silt.
240'-	245'	5.0'	Sandstone, light gray, grain size ranges from coarse sand down to silt.
245'-	252'	7.0'	Sandstone, light gray, grain size ranges from fine sand down to silt.

BOTTOM OF HOLE

Discussions presented for Stops numbers 4, 5, and 7 apply equally to this exposure. Of special interest here is the Eau Claire-Galesville contact surface which varies from sharp to obscure along the outcrop face and is slightly uneven.

An interesting note regarding the Birkmose Member in the base of the Lone Rock Formation in this area (see alternate Stop 8a) is that it thins toward the Wisconsin arch from 15 feet just east of Galesville to less than 6 inches at Ferry Bluff north of Mazomanie (Berg, 1954). We will see the Birkmose again at Stops number 10, 11, and 14.

STOP #8a (if time allows). Exposure at north side of Highway 53 in roadcut 1.2 miles east of Galesville at Decorah Peak in the SW$\frac{1}{4}$, SE$\frac{1}{4}$, sec. 34, T.19N., R.8W., Trempealeau County (refer to Galesville 15' topographic quadrangle).

Cambrian System
(St. Croixan Series - Franconian Stage)
Lone Rock Formation
Reno Member

15.	57.2'- 77.2'	20.0'+	Sandstone, gray green and brown, fine grained, thin bedded and cross bedded, glauconitic; some beds of ripclast; much "wormstone" in lower 10 feet.

Tomah Member

14.	47.2'- 57.2'	10.0'	Sandstone, light yellow gray, fine and very fine grained, shaly and micaceous, dolomitic, thin bedded, trace of glauconite.

Birkmose Member

13.	39.2'- 47.2'	8.0'	Sandstone, very fine grained, and siltstone,gray, thin bedded and uneven bedding, dolomitic, trace glauconite.
12.	34.2'- 39.2'	5.0'	Dolomite and greensand conglomerate and interbedded greensand.
11.	31.7'- 34.2'	2.5'	Sandstone, gray green, fine grained with little medium and very fine, massive, cross bedded, very glauconitic.

Elk Mound Group
Wonewoc Formation
Ironton Member

10.	26.7'- 31.7'	3.5'	Sandstone, light yellow gray, fine grained with little very fine and medium, slightly silty, massive bedded with poorly defined cross bedding. Base slightly uneven.
9.	23.2'- 26.7'	3.5'	Sandstone, light yellow gray, coarse and medium grained with little fine, massive bedded and cross bedded; scattered brachiopod fragments.
8.	20.2'- 23.2'	3.0'	Sandstone, light yellow brown, medium and coarse grained, massive bedded, scattered brachiopod fragments.

7.	18.7'- 20.2'	1.5'	Sandstone, light yellow gray, fine grained with little medium and trace of very fine, silty, massive bedded. "Wormstone bed".
6.	17.7'- 18.7'	1.0'	Sandstone, light yellow gray, medium and coarse grained, massive bedded and cross bedded.
5.	16.7'- 17.7'	1.0'	Same as #8 but predominantly fine and medium grained.
4.	7.7'- 16.7'	9.0'	Sandstone, light yellow brown, medium and coarse grained, massive bedded and cross bedded.
3.	2.7'- 7.7'	5.0'	Sandstone, brown, medium and coarse grained with a little very coarse, slightly silty. "Wormstone bed".
2.	2.0'- 2.7'	0.7'	Sandstone, light yellow brown, very fine and fine grained with a trace of medium and coarse.
1.	0.0'- 2.0'	2.0'	Sandstone, light yellow brown, coarse and medium grained, massive bedded.
			BASE OF EXPOSURE

102.6 Leave Stop #8.
102.8 Turn right and continue on Highway 54 through city.
104.5 Caution. Turn left (south) on County Trunk Highway "K". Approaching Highway 54 traffic does not stop.
104.6 STOP SIGN. Proceed straight ahead to Trempealeau on "K".
110.3 Turn right (west) on black top city street.
110.6 Danger. Railroad crossing.
110.7 STOP SIGN. Junction with Highway 93. Proceed straight ahead.
110.8 DANGER. Cross roads with no stop signes. Turn right with caution.
112.9 Jog left at intersection.
113.5 North entry to Perrot State Park. It is reported that the first white man to see Perrot State Park was Father Louis Hennepin in 1680. The park takes its name from Nicholas Perrot who in 1685 established a trading post on this site. Perrot was instrumental in maintaining peace between warring Indian tribes on the one hand and the invading white men on the other. It was here in 1689 that the French laid claim to all land drained by the Upper Mississippi.

Follow road marked "To Boat Ramp" to left.

STOP #9. Outcrop exposures in the west bluffs of Perrot State Park east of the mouth of the Trempealeau River and about 2 miles west of the Village of Trempealeau on the river road. Park at west end of bluffs in the SE¼, SW¼, NW¼, sec. 20, T.18N., R.5W., Trempealeau County and follow Brady's Bluff trail eastward to top of bluff (refer to Galesville 15' topographic quadrangle). Composite of exposures in bluffs between Village of Trempealeau and Perrot Park modified from Twenhofel, Raasch, and Thwaites (1935)

Ordovician System
(Canadian Series)
Prairie du Chien Group
Oneota Formation

21. 374.5'-379.5'	5.0'	Dolomite, gray, medium and coarse crystalline, dense, medium bedded.
20. 360.5'-374.5'	14.0'	Dolomite, light gray and very light yellow brown, medium crystalline, dense, massive bedded.
19. 346.5'-360.5'	14.0'	Dolomite, gray, medium and fine crystalline, slightly porous, thick bedded.
18. 336.5'-346.5'	10.0'	Dolomite, gray, fine and medium crystalline, dense, massive bedded, with abundant quartz sand grains.
17. 329.0'-336.5'	7.5'	Dolomite, light gray, fine and medium crystalline, with beds of Cryptozoa, little glauconite and dark green clay, and abundant quartz sand grains.

Cambrian System
(Trempealeauan Stage)
Jordan Formation
Sunset Point Member

16. 308.0'-329.0'	21.0'	Dolomite, light yellow gray and light yellow brown, fine and medium crystalline with scattered quartz sand grains interbedded with sandstone, white, medium and coarse grained. A 6" bed of conglomerate 4 feet below top. Argillaceous in lower 6".

Van Oser Member

15. 296.0'-308.0'	12.0'	Sandstone, light yellow gray, medium grained with little coarse and fine, thin bedded and cross bedded.
14. 287.0'-296.0'	9.0'	Sandstone, light yellow gray, medium and coarse grained, massive with buckshot-sized sandstone concretions near top.
13. 247.0'-287.0'	40.0'	Sandstone, light yellow gray, medium and coarse grained with little fine, massive bedded, some cross bedded, some iron oxide staining. Basal contact gradational.

Norwalk Member

12. 225.0'-247.0'	22.0'	Sandstone, light yellow gray and very light yellow brown, fine and very fine grained, slightly silty, massive bedded. Pebbles of siltstone in lower 6" to 1 foot.

St. Lawrence Formation
Lodi Member

11. 211.0'-225.0'	14.0'	Siltstone, with abundant very fine and fine grained sand, and sandstone, very fine and fine grained very silty; light gray with some mottled pink, dolomitic and thin bedded. Upper content sharp to gradational.

Black Earth Member

10. 204.0'-211.0'	7.0'	Dolomite, gray some mottled pink, medium and fine crystalline, thin bedded, silty with few quartz sand grains.

(Franconian Stage)
Lone Rock Formation
Reno Member

9. 197.0'-204.0'	7.0'	Sandstone conglomerate consisting of a matrix of fine and very fine quartz sand grains with abundant glauconite and of pebbles of dolomitic siltstone and of white fine grained sandstone.
8. 177.0'-197.0'	20.0'	Sandstone, green gray, fine and very fine grained, thin bedded and cross bedded, very glauconitic, slightly dolomitic interbedded with yellow gray siltstone.
77.0'-177.0'	100'±	CONCEALED INTERVAL

Wonewoc Formation
Ironton Member

7. 55.0'- 77.0'	22.0'+	Sandstone, light yellow gray and light yellow brown, predominantly coarse grained with much medium, massive bedded and cross bedded. Forms resistent overhang along lower part of Brady's Bluff Trail.

Galesville Member

6. 41.0'- 55.0'	14.0'	Sandstone, white to light brown, medium and fine grained, medium and even bedded.

5.	30.0'- 41.0'	11.0'	Sandstone, light yellow brown, medium grained with much coarse and fine, much iron oxide staining.
4.	24.0'- 30.0'	6.0'	Sandstone, light yellow brown, predominantly medium grained with little fine; massive bedded and cross bedded.
3.	14.0'- 24.0'	10.0'	Sandstone, light yellow gray with light yellow streaks, massive bedded and cross bedded.
2.	5.0'- 14.0'	9.0'	Sandstone, very light gray with some yellow, medium and fine grained, medium to massive bedded, irregular beds, some iron oxide staining.
1.	0.0'- 5.0'	5.0'	Sandstone, light gray yellow, medium and fine grained, irregularly bedded, medium to massive bedded.
			RIVER LEVEL (Elevation 650' ETM).

Log of village well at Trempealeau drilled in 1938. Sample description by F. T. Thwaites modified by M. E. Ostrom. Land surface elevation 710'. Base of outcrop at river level is 60 feet below top of well.

Cambrian System
(St. Croixan - Dresbachian Stage)
Elk Mound Group
Wonewoc Formation
Galesville Member

0'- 20'	20.0'	Sandstone, yellow gray, medium grained.
20'- 73'	53.0'	Sandstone, yellow gray, medium and fine grained. (Base of outcrop described at Brady's Bluff occurs about 13 feet above base of this unit).

Eau Claire Formation

73'- 82'	9.0'	Sandstone, yellow gray, fine grained, dolomitic, glauconitic.
82'- 117'	35.0'	Shale, gray and siltstone, light gray, slightly dolomitic.
117'- 140'	23.0'	No sample.
140'- 210'	70.0'	Shale, gray, and siltstone, light gray.

Mt. Simon Formation

210'-	230'	20.0'	Sandstone, gray, grain sizes range from fine to coarse sand.
230'-	280'	50.0'	Sandstone, gray, grain sizes range from very coarse to fine sand.
280'-	290'	10.0'	No sample.
290'-	340'	50.0'	Sandstone, light gray, grain sizes range from very coarse to fine sand.
			BOTTOM OF WELL (Elevation 370').

F. T. Thwaites (1957) estimates elevation of the Precambrian surface to be about 200 feet.

Much of the type section of the Trempealeau Group, which is located about 1.5 miles east-south-east of Brady's Bluff in the first bluff west of the Village of Trempealeau, has been obscured by a lush growth of vegetation and by slumping since it was last described by Twenhofel, Raasch, and Thwaites in 1935. STOP #9 at Brady's Bluff was selected as an alternate because it contains a nearly complete section of the Trempealeau.

Following Brady's Bluff trail eastward from the west end of the bluff we will pass a thick section of Galesville Sandstone capped by the Ironton Sandstone. The trail then doubles back to the west above the Ironton, circles the bluff, and then levels off heading east at about the level of the contact of the Lone Rock Formation with the Trempealeau Group. The St. Lawrence Dolomite Formation in the base of the Trempealeau can be seen in a small bluff at the north side of the trail. By checking outcrops on and north of the trail an almost complete section of Trempealeau can be examined.

The St. Lawrence Formation here consists of the Black Earth Dolomite Member in its base and the Lodi Siltstone Member in its top. Traced toward the Wisconsin Arch the Black Earth Dolomite thins to disappearance as a wedge in the Lodi Siltstone (Nelson, 1956). Southward into Illinois the Black Earth increases in thickness and the Lodi thins to disappearance and is equated with the Potosi Formation of that state.

The St. Lawrence is overlain by the Jordan Formation which consists of three members. The basal member of the Jordan is the Norwalk Sandstone of Thwaites (1923) which is predominantly fine grained and more or less calcareous. The Norwalk was traced eastward toward the arch by Ahlen (1952) and by Boardman (1952) although they did not refer to it by name. They showed that the Norwalk is uneven in thickness, but that it thins eastward toward the arch between the underlying St. Lawrence and the overlying coarser sandstone unit which is herein called Van Oser following the nomenclature of Stauffer (1925) in Minnesota.

The contact of the St. Lawrence Formation with the overlying Jordan Formation is of unknown significance. The surface of contact is believed to represent a situation similar to that described for contacts of both the Precambrian - Mt. Simon and the Eau Claire-Galesville, namely erosional unconformity (Ostrom, 1964). At this exposure as well as several others in Wisconsin there is a siltstone pebble conglomerate in the base of the Norwalk; in addition the change in lithology across the contact is locally sharp although there is slight evidence to indicate deep dissection. Disregarding the obvious similarities to the two older contacts mentioned above there are two items which must be considered in terms of possible erosional unconformity, namely areal extent of the Jordan Formation and the lithology of the St. Lawrence Formation.

The Jordan Formation does not extend as far south as do the other sandstones of the Cambrian and Ordovician in the Upper Mississippi Valley area (Ostrom, 1964). Assuming that the southerly limit of Jordan Sandstone marks the seaward limit of the environment in which it formed, presumably the near-shore-beach environment, then regression was less than that prior to Mt. Simon or Galesville deposition. Consequently, sea level was relatively higher than before and elevation of the land surface was less. The resultant low relief would retard erosion and dissection of the land surface. Nearness of present day outcrops to the former southerly limit of retreat of the sea would explain why it is difficult to define an erosion surface in the area.

Another factor important to understanding this contact is lithology. All of the clastic material found in the Norwalk Member could have been obtained from the Lodi which is a calcareous sandy siltstone. The Norwalk lithology compares very closely with that of the Lodi except that the Norwalk contains only small amounts of carbonate and silt. Conceivably the carbonate and silt could have been removed by reworking of the Lodi.

A third point to be considered is that in a sequence of cycles one would expect a repetition of the elements which comprise a cycle. Well-defined erosional unconformities occur at the bases of two of the five Cambrian and Ordovician quartzarenites in the upper Mississippi valley area, namely the Mt. Simon and the St. Peter sandstones, and erosion surfaces are strongly suspected as occurring beneath the Galesville, Jordan, and New Richmond sandstones (Ostrom, in press).

Above the Norwalk Member is the Van Oser Member. Although the contact of the Norwalk with the Van Oser is not well defined in Minnesota it is easily recognized in Wisconsin as was shown by Ahlen (1952) and Boardman (1952) although they made no attempt at correlation with the Van Oser of Minnesota. The Van Oser and Norwalk can be seen at many outcrops in western Wisconsin some of which were stops visited by the 1965 Tri-State Field Conference (Ostrom, 1965).

The Van Oser Sandstone is characteristically medium and coarse grained and massive bedded and cross bedded in contrast to the Norwalk which is fine grained and varies from thin bedded to thick bedded. It is shown by Ahlen (1952) and Boardman (1952) to overlap the Norwalk from west to east onto the Wisconsin arch. It is overlain by the Sunset Point Member of the Jordan Formation.

The Sunset Point Member was originally called Madison (Wanenmacher, Twenhofel, & Raasch, 1934; Twenhofel, Raasch, & Thwaites, 1935; Ulrich, 1936) and was believed to be confined to the area near Madison, Wisconsin. In 1952 Raasch published the results of investigations carried on in the early 1930's in the Stoddard Quadrangle located in Vernon County just south of LaCrosse, Wisconsin, and noted the presence of the Madison unit. He decided the name Sunset Point should be substituted for the name Madison which he believed to be preempted for use elsewhere.

The Sunset Point Member is characteristically a uniformily bedded, medium bedded, sandy dolomite or very dolomitic sandstone which shows evidence for being reworked by burrowing organisms in individual beds. It is distinguished from the underlying Van Oser by its high carbonate content, its finer grain size, and its massive bedding character, and from the overlying Oneota Dolomite Formation because it lacks the chert, cryptozoa, and oolites found in the Oneota. The basal contact is usually well defined and may be slightly uneven and covered by up to 6 inches of a quartz granule conglomerate. This uneven surface and overlying conglomerate were the basis for Ulrich's (1924) Cambrian-Ozarkian separation. He believed the contact to be one of major unconformity. This contact is thought to be similar to the one found at the base of the Ironton Member in terms of genesis, namely that it represents the reworking of underlying deposits in an environment located seaward of the beach near-shore area where less sediment is being transported. Elsewhere the contact is even and is selected at the upward change from non-calcareous, massive bedded, white quartzarenite to calcareous, medium bedded, buff, sandy dolomite. The upper contact is selected at the base of the first bed of dolomite which contains either cryptozoa, chert, or oolites and which bed is sometimes underlain by a bed of green argillaceous sandstone or sandy shale or shale. The Sunset Point has a maximum thickness of about 50 feet (Ostrom, 1965) and thins to disappearance over the Wisconsin arch. East of the arch it is recognized in the Madison area.

The Sunset Point Member is assigned to the Cambrian on the basis of its trilobite fauna which was collected by Raasch and is on file with the Geology Department at the University of Wisconsin.

The Oneota Dolomite Formation is the oldest Ordovician deposit in Wisconsin. It is about 160 feet thick in this state and consists essentially of dolomite with beds of sandy dolomite and of sandstone in the lower 50 feet. The Oneota is distinguished from the underlying Jordan Formation by its gross lithology as well as its content of chert, oolites, and cryptozoa. Raasch (1952) was able to subdivide the Oneota into four members in Vernon County using these criteria. The members can be recognized in exposures near Madison although they have not been traced there directly.

Correlation of the Mazomanie, Lone Rock, and St. Lawrence formations of Wisconsin with rocks in the Upper Peninsula is not clearly established. As has already been mentioned under Stop #4 the Wonewoc Formation of Wisconsin is believed to correlate approximately with the Munising Formation of the Upper Peninsula with the exception that very likely the Munising also includes the Mazomanie of Wisconsin.

The Mazomanie Formation on the Wisconsin dome and arch and the Munising Formation in the Upper Peninsula are overlain by a thickness of from 5 feet to more than 20 feet of glauconitic sandstone. In Wisconsin this glauconitic sandstone is assigned to the Reno Member of the Lone Rock Formation; in the Upper Peninsula it is assigned to the base of the Au Train Formation (Hamblin, 1958).

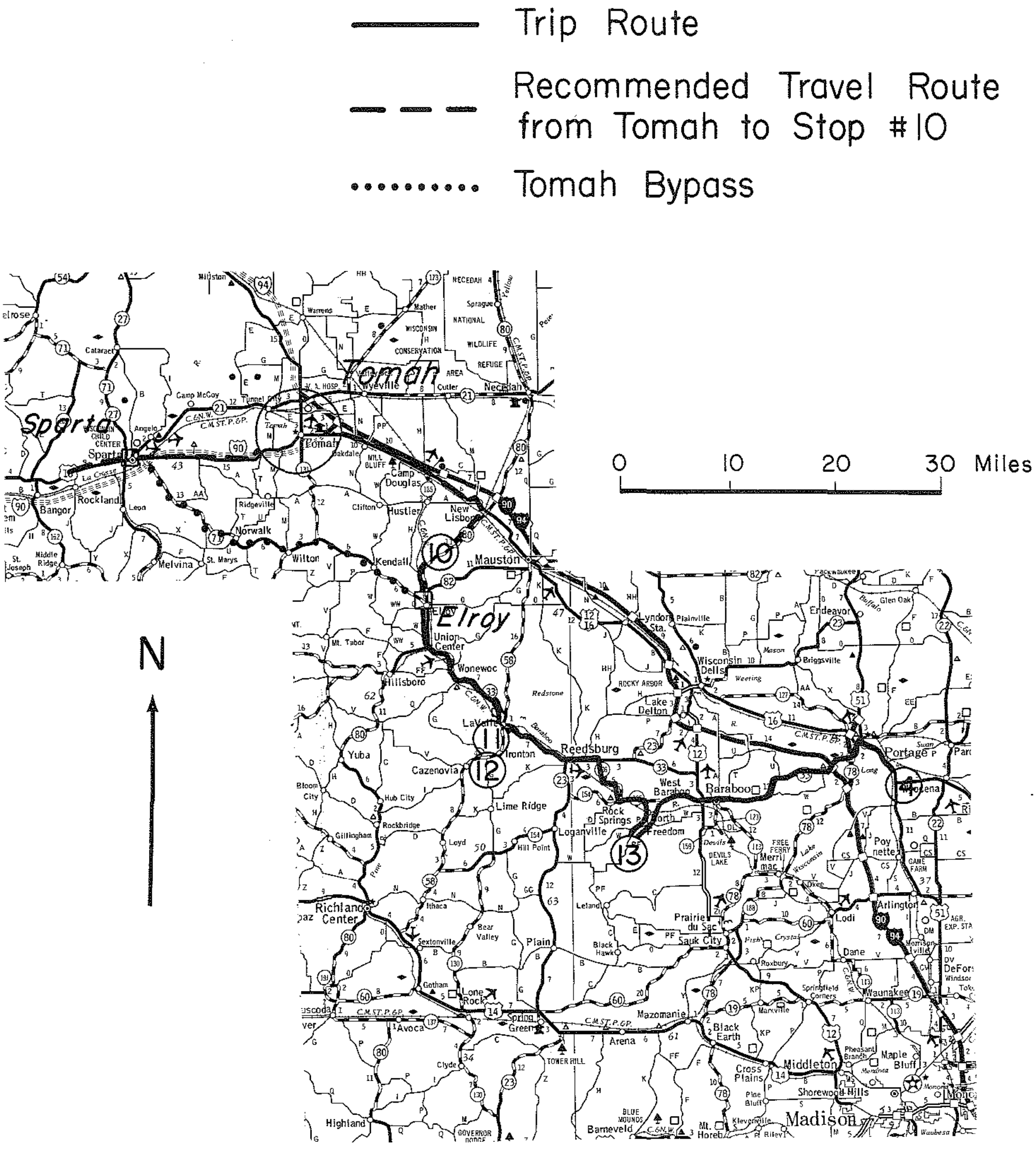
In Wisconsin the glauconitic greensands of the Reno Member are overlain by the St. Lawrence Dolomite Formation. In this dolomite cryptozoa, sand grains, and glauconite are locally abundant. The St. Lawrence is distinguished lithologically from the younger Oneota Dolomite Formation by its lack of chert and oolites. In the Upper Peninsula the glauconitic sandstone in the base of the Au Train Formation is overlain by glauconitic and sandy dolomite which in turn is overlain by nonglauconitic dolomite that contains oolites (op. cit., Fig. 70). Although correlation of these rocks between the two areas is still open to question the lithologic evidence indicates a close resemblence.

Available fossil evidence for correlation is based on three admittedly questionable genera (Hamblin, 1958, p. 120 & Plate 5). This data is rather tenuous evidence on which to base a gap in the rock record extending from Franconian to Lower Blackriverian in time as is suggested. This is especially true when one can make a reasonable correlation on the basis of lithologies, lithologic succession, and relationship to major structural features. Until additional data is gathered this problem will be open to speculation.

114.0 Leave Stop #9. Proceed to Tomah for evening meal. Follow river from Perrot Park to Trempealeau.
116.3 Trempealeau Mountain on left, type section of rocks assigned to the Trempealeau Formation by E. O. Ulrich (1924).
116.8 STOP SIGN. Turn left and proceed for two blocks to junction with Highway 93.
116.9 Turn right on Highway 93.
125.3 STOP SIGN. Junction with highways 35 and 53. Turn right (south) and follow Highway 35 into Onalaska. Caution from left. Bluffs on left (east) have Galesville Sandstone in face and are capped by Ironton Sandstone.
127.4 Enter Village of Holmen.
133.1 Enter Village of Onalaska. Watch for sign indicating Highway 157 to the left (east).
134.1 Turn left on Highway 157. CAUTION: oncoming traffic does not stop.
135.4 Caution: sharp turn to right (south).
135.5 Caution: sharp turn to left (east).
137.3 STOP SIGN. Junction with Highway 16. Caution. Turn left and follow Highway 16 to Tomah 936 miles).
138.9 Galesville, Ironton, and Franconia sandstones exposed in roadcuts.
173.3 Enter Tomah.

END OF FIRST DAY'S TRIP.

FIGURE 10. Field trip route for Second Day.



Road Log
SECOND DAY

Wood Hill (Elroy) to Portage

Cumulative Mileage

0.0 STOP #10. Type section of Berg's (1954) Woodhill Member of the Franconia Formation herein recognized as the Ironton Member of Thwaites (1923) and Ulrich (1924) and assigned to the Wonewoc Formation. Road cut near Wood Hill on Highway 80 about 9.5 miles southwest of Mauston and 3.6 miles northeast of Elroy. Cars will assenble at north side of Highway 80 and east of the outcrop headed southwest toward Elroy. Location of exposure is in the SE$\frac{1}{4}$, sec. 3, T.15N., R.2 E., Juneau County (refer to Kendall 15' topographic quadrangle). Description modified from Berg (1954).

Cambrian System
(St. Croixan Series - Franconian Stage)
Tunnel City Group
Lone Rock Formation
Birkmose Member

7.	80.5'- 81.0'	0.5'	Shale, red brown, glauconitic, highly weathered.

Wonewoc Formation
Ironton Member

6.	77.5'- 80.5'	3.0'	Sandstone, gray and brown, predominantly medium grained with little fine and trace of coarse, cross bedded, glauconitic. Contains *Camaraspis sp*.
5.	76.0'- 77.5'	1.5'	Sandstone, yellow brown, predominantly medium grained with little coarse and fine. Contains *Camaraspis sp*.
4.	63.0'- 76.0'	13.0'	Consists of sandstone, very light yellow gray and light gray, predominantly fine grained with little medium and coarse and cross bedded which is interbedded with 6" to 10" beds of sandstone, very light gray, coarse and medium grained with little fine, cross bedded. Few pale green shale seams at base.
3.	54.0'- 63.0'	9.0'	Sandstone, light gray and very light yellow gray, medium and fine grained, with pale green shale partings along some bedding planes.

2.	50.0'- 54.0'	4.0'	Sandstone, light yellow gray, medium and coarse grained with little fine, cross bedded. Coarse and very coarse sand abundant in lower few inches above even basal surface.

(Dresbachian Stage)
Galesville Member

1.	0.0'- 50.0'	50.0'+	Sandstone, very light gray, medium and fine grained with little very fine, massive bedded and cross bedded.

BASE OF OUTCROP

Berg (1954) proposed the name Woodhill, taken from this exposure, to replace the name Ironton introduced for the same unit but taken from exposures in the Village of Ironton (STOP #11) by Thwaites (1923) and later by Ulrich (1924).

In the original description Thwaites (1923) merely described the Ironton Member as "a few feet of hard calcareous coarse grained sandstone" in the base of the Franconia Formation. The following year Ulrich expanded on this description. He stated that:

> "The Ironton Member is composed mainly of reworked washed and relatively coarse residual grains of Dresbach sandstone, the surface of which had previously been subjected to subaerial leaching and wear. The line of break between the two formations -- Dresbach and Franconia -- lies at the undulating plane where washing and sorting of the loose quartz grains of the underlying formation is first indicated. In other words, the Ironton Sandstone member extends downward to the lowest plane indicating reworking and redeposition of the weather-loosened top sands of the underlying Dresbach formation. Commonly the new deposit includes a few grains of glauconite and other material that is not present in the undisturbed underlying beds of Dresbach sandstone."

If Ulrich had stopped here with his definition future generations of geologists would have had little reason to question and ponder the identity of the Ironton. However, the next paragraph of his description continued as follows:

> "But to make sure of the identification of the Ironton Member it is advisable to search for its characteristic fossils. In the Dresbach proper no organic remains -- except perhaps worm burrows -- have so far been observed. The overlying basal sandstone of the Franconia (the Ironton), however, only rarely fails to reward a few minutes' use of the hammer with indubitable evidence of the presence of such remains. The most abundant and characteristic of these are the nearly hemispheric cephalic shields of several species of a new genus of trilobites, ... *Camaraspis convexus* (Whitfield) Ulrich and Resser."

Although this last paragraph has been interpreted to mean that the limits of the Ironton are defined by Camaraspis what he actually stated was that "to make sure of the identification of the Ironton Member it is advisable to search for its characteristic fossils". Thus what Ulrich said was that the limits are defined lithologically and the identity is based on fossils. He did not say the Ironton was limited by the extent of fossils. Thwaites' description (1923) and that of Ulrich (1924) as stated above combine to place rather definite lithologic limits on the Ironton but Ulrich, in this same paper, and later Twenhofel, Raasch, and Thwaites (1935), coupled the lithologic definition with paleontology.

Unfortunately up to 1935 geologists who studied these rocks placed a major time- and/or rock-stratigraphic break at the base of the Ironton. As has been observed at several previous stops the break between the Galesville and Ironton is often indistinct regardless of whether it is based on lithology or fossils. Berg (1954) apparently followed the lithologic definition suggested by these earlier geologists but renamed the unit Woodhill and persisted in assigning this unit to the Franconia Formation, a unit recognized as having faunal limits as reflected by the now widely accepted usage of Franconian Stage.

From a lithostratigraphic point of view there appears to be little if any justification for separating the Ironton from the Galesville and very little or no lithologic justification for assigning it to the same unit as the overlying glauconitic and calcareous fine grained sandstone herein called the Lone Rock Formation. For this reason the name Ironton is retained as a lithostratigraphic term for the upper member of the Wonewoc Formation following what is believed to be Ulrich's intention. The lower limit of Camaraspis convexus or the Elvinia zone is taken as the beginning of the Franconian Stage and may or may not coincide with the base of the Ironton.

Cumulative Mileage	
0.0	Leave Stop #10 and proceed southwestward on Highway 80.
3.6	Enter Village of Elroy. Continue on Highway 80.
4.5	Cross railroad tracks and bear left on Highway 80.
8.4	Enter Village of Union Center.
9.0	STOP SIGN. Junction with Highway 33. Turn left. Caution from right. Rock exposed along Highway 33 in this area is Galesville Sandstone with a cap of Ironton Sandstone.
12.0	Enter Village of Wonewoc. Reference exposures for the newly named Wonewoc Formation, composed of the Galesville and Ironton sandstones, in quarry at north city limit and in bluffs at south city limit. Composite section taken from bluffs in and around the Village of Wonewoc located in sections 26 and 35, T.14N., R.2E., Juneau County (refer to Reedsburg 15' topographic quadrangle). Description modified from Sahlstrom (1962).

Cambrian System
(St. Croixan Series - Franconian Stage)
Lone Rock Formation
Birkmose Member

9.	82.2'- 83.2'	1.0'	Sandstone, gray green, fine and very fine grained, dolomitic glauconitic, with few ripclasts of white sandstone.

Wonewoc Formation
Ironton Member

8.	82.0'- 82.2'	0.2'	Sandstone, red brown, medium and coarse grained, much iron oxide cement.
7.	80.0'- 82.0'	2.0'	Sandstone, dark brown, medium and coarse grained with little fine, massive bedded, glauconitic, weathered surface is pitted. Contains Camaraspis.
6.	78.0'- 80.0'	2.0'	Sandstone, light red brown, predominantly medium grained with much fine and coarse, massive bedded.
5.	75.5'- 78.0'	2.5'	Sandstone, light yellow brown, medium grained with little coarse, thin bedded and even bedded.
4.	74.5'- 75.5'	1.0'	Sandstone, very light yellow gray, medium grained with little coarse and fine, massive bedded, tightly cemented.
3.	73.0'- 74.5'	1.5'	Sandstone, light yellow gray, medium grained with little coarse and fine, trace glauconite, massive bedded and cross bedded.
2.	70.0'- 73.0'	3.0'	Sandstone, light yellow gray, predominantly medium grained with little fine and coarse, massive bedded and cross bedded, trace of glauconite. Coarse and very coarse sand concentrated above uneven basal surface.

(Dresbachian Stage)
Galesville Member

1.	0.0'- 70.0'	70'+	Sandstone, very light gray and white with some zones stained red brown, fine and medium grained with little coarse, massive bedded and cross bedded.
			BASE OF EXPOSURE.

Wonewoc Village Well #2 commenced in bedrock approximately 40 feet below the base of the above section and proceeded to a total depth of 300 feet through medium and fine grained light gray sandstone without encountering any of the Eau Claire Formation lithology. The Wisconsin Cooperative Creamery Association well located 4 miles to the northwest along Highway 33 and at about the same elevation encountered Precambrian at a depth of 385 feet with no indication of the Eau Claire Formation.

20.4 Pass junction with Highway 58 on left. Outcrop on left is Eau Claire and Galesville sandstones.
20.9 Enter Village of LaValle.
21.2 STOP SIGN. Turn right (west) and follow Highway 58. Caution left.
22.1 Outcrop of Galesville Sandstone on right (west).
22.7 Ironton Sandstone "bench" can be seen in cut above stream on right (west).
23.7 Cross the Ironton Sandstone "bench".
23.8 Enter Village of Ironton.
23.9 Turn right (west on first village street.
24.0 STOP #11. Type section of the Ironton Member of the Wonewoc Formation at the north side of the Village of Ironton in bluff and roadcuts where Little Baraboo River makes sharp turn from west to north and located in the NW$\frac{1}{4}$, SE$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 4, T.12N., R.3E., Sauk County (refer to Reedsburg 15' topographic quadrangle).

Cambrian System
(St. Croixan Series - Franconian Stage)
Lone Rock Formation
Tomah Member

8.	24.5'- 27.5'	3.0'+	Sandstone, light yellow brown, fine and very fine grained, thin bedded and irregularly bedded, argillaceous and micaceous.

Birkmose Member

7.	23.5'- 24.5'	1.0'$\pm$	Sandstone, gray green and yellow brown, fine and very fine grained, very argillaceous, dolomitic, glauconitic, with scattered ripclasts.

Wonewoc Formation
Ironton Member

6.	21.5'- 23.5'	2.0'	Sandstone, yellow brown, medium and coarse grained, massive bed; contains *Camaraspis* in upper few inches.
5.	19.5'- 21.5'	2.0'	Sandstone, light yellow gray and yellow brown, medium and coarse grained with little fine and very coarse, thick bedded and even bedded, coarse grains concentrated along cross beds; scattered fragments of brachiopod shells.

4.	14.5'- 19.5'	5.0'	Sandstone, light yellow brown and very light yellow gray, medium and fine grained with little coarse, massive bedded, surface of outcrop is pitted. Some fragments of brachiopod shells in upper part.
3.	13.0'- 14.5'	1.5'	Sandstone, light yellow gray and light yellow brown, medium and coarse grained, massive bedded. Some fragments of brachiopod shells and abundant vertical burrows. Bottom slightly uneven.
(Dresbachian Stage) Galesville Member			
2.	11.0'- 13.0'	2.0'	Sandstone, light yellow brown, predominantly medium grained with little coarse, even bedded and cross bedded.
1.	0.0'- 11.0'	11.0'	Sandstone, light yellow gray weathered yellow brown on surface, medium grained with little coarse and fine, massive bedded.
			BASE OF EXPOSURE.

This is the type section of the Ironton Member named by Thwaites (1923). A discussion of the Ironton is given following the description of Stop #10.

The Village of Ironton derived its name from the fact that iron ore was mined here from 1850 to 1873. The mine is located about 1 mile south of the village and in the hillside east of the main valley. About 25,000 tons of ore, producing 11,000 tons of iron, was mined from what Ulrich, Bean, Thwaites and Edwards (field notes dated 8/21/19) describe as what "seems to be an old fault in which chert and iron oxide were deposited -- in part at least secondary after marcasite and deposited in the openings in the fault rubble".

24.0 Leave Stop #11 and turn left (south).
24.1 STOP SIGN. Rejoin Highway 58. Proceed straight ahead (south) on highway.
25.4 Turn left (south) on County Trunk Highway "G".
25.6 STOP #12. Exposure in roadcut 1.2 miles west of the Village of Ironton via Highway 58 and County Trunk Highway "G" and located in the SEc, NW$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 8, T.12N., R.3E., Sauk County (refer to Reedsburg 15' topographic quadrangle).

Cambrian System
(St. Croixan Series - Franconian Stage)
Tunnel City Group
Mazomanie Formation

0'-	15'+	15'+	Sandstone, light yellow brown, fine and very fine grained with little medium, thin bedded and cross bedded with abundant vertical burrows which terminate sharply at upper bed contacts.
			BASE OF EXPOSURE.

The Mazomanie Formation was named by Ulrich (1920, p. 73-76) for "a more or less decidedly calcareous sandstone formation, approximately 100 feet in thickness" which contains considerable disseminated glauconite and which is found in outcrops in the Wisconsin River bluffs in the vicinity of Mazomanie, Dane County, Wisconsin. He believed it to be younger than the Franconia and older than the St. Lawrence. Thwaites (1923) described the Mazomanie Formation as a fine to medium grained gray to dark red sandstone irregularly cemented by dolomite and which locally contains beds of red, green, and gray calcareous shale. He believed it to thin westward and to overlap the Franconia greensands. In 1934 Trowbridge and Atwater recognized the Mazomanie and Franconia to be the same. Wanenmacher, Twenhofel, and Raasch (1934) and Twenhofel, Raasch, and Thwaites (1935) believed the name Mazomanie should be abandoned or given member rank because of its equivalence to the Franconia which had priority. Ulrich still maintained in 1936 that the Mazomanie Sandstone is quite distinct from the Franconia both faunally and lithologically and that it is younger.

Twenhofel and Thwaites (1919) as well as several students at the University of Wisconsin, notably Ericson (1951), recognized and described the lithologic subdivisions in the rocks assigned to the Franconia. In 1954 Berg named these and proposed that the name Mazomanie be revived for the nonglauconitic sandstone which is interbedded with the Franconia greensands of his Reno Member in western Wisconsin and which thickens "until in central Wisconsin the entire Franconia above the Tomah Member is composed of nonglauconitic and dolomitic sandstone".

Berg (op. cit.) describes the Mazomanie to consist of:

"....quartzose, fine-grained, well-sorted sandstone that has nearly 80 per cent of the grains in the 1/3 mm grade size. The sandstone is yellow to white and cross-bedded. Glauconite grains are usually lacking and never exceed 5 per cent. Brown cross-bedded, dolomitic sandstone beds 1 to 3 feet thick are commonly interbedded with yellow sandstone, and the contact between the beds is everywhere gradational. Coarse-grained dolomite constitutes about 40 per cent of the most highly dolomitic beds with 10 per cent calcite cement and 50 per cent detrital quartz. Garnet is the dominant heavy accessory mineral (Pentland, 1931).

"Another type of nonglauconitic sandstone included in the member is fine to very fine-grained and thin-bedded. Bedding is generally horizontal, but long, gently inclined cross laminations are common. It is similar to Tomah sandstone but lacks interbedded shale. The thin-bedded sandstone in central Wisconsin overlies the Tomah Member and underlies the cross-bedded dolomitic Mazomanie...."

"It does seem that the lateral and upward change is from Franconia greensand (including Tomah Sandstone) through thin-bedded Mazomanie and cross-bedded Mazomanie, and that cross-bedded Mazomanie represents the nearest-shore phase of the nonglauconitic facies."

The lithologic differences described by Berg for the Mazomanie on the one hand and the greensands on the other are believed to be sufficient to merit their distinction as separate but interfingering formations. The relationships of the formations to each other are shown in Figures 11 and 12. The figures show that the Mazomanie lithology occupies a position that corresponds roughly to the Wisconsin dome and arch and that it thins to disappearance outward as a southward extending tongue encased in greensands.

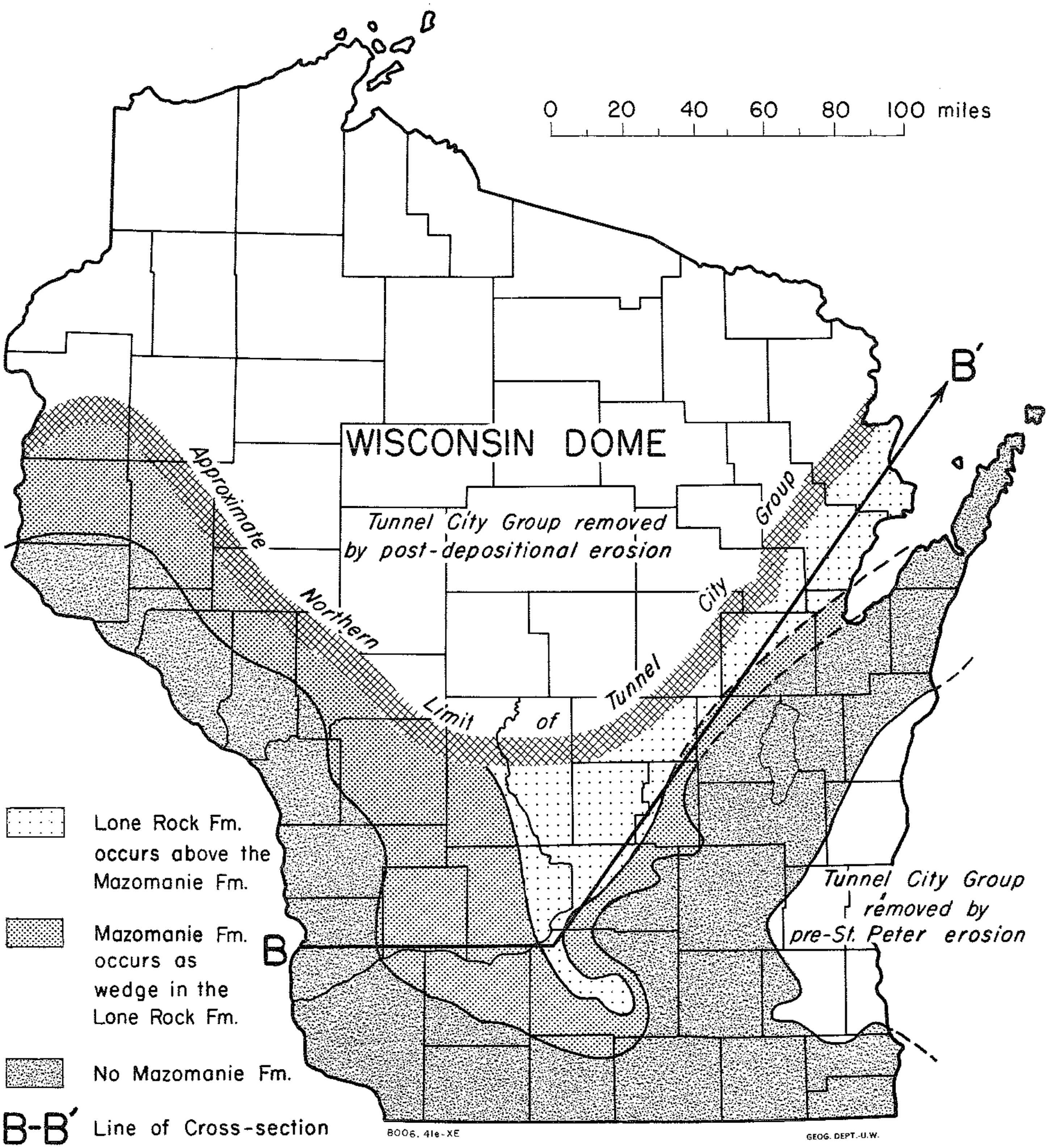
Using lithology, heavy minerals, and stratigraphic succession, it is believed that the Mazomanie can be traced from Wisconsin into the Upper Peninsula. In the central area of the Mazomanie tongue on the Wisconsin dome there is very little greensand above the formation and it is very difficult to distinguish the Mazomanie from any of the underlying units downward through the Galesville Member of the Wonewoc Formation. In the Upper Peninsula the Miner's Castle Member is overlain by less than 20 feet of greensand and is very difficult to distinguish from underlying rocks down through the Chapel Rock Member. In addition, the Mazomanie of Wisconsin has been equated with the Miner's Castle on the basis of lithology and heavy accessory minerals, as was pointed out in the discussion at Stop #4. If one traces the Mazomanie from the Wisconsin dome area to the type area of the Franconia Formation at Franconia, Minnesota, it will be seen that the whole of the type Franconia consists of Mazomanie lithology and that heavy minerals and order of succession are similar (Berg, 1954).

The fact that the type section of what has been called Franconia consists of Mazomanie lithology presents a problem, namely that the name Franconia has priority so that logically the name Mazomanie should be abandoned. However, there are other considerations which it is believed dictate that the name Franconia is no longer useful as a lithic term. The name Franconia should be dropped as a lithostratigraphic term because in its type area the unit does not include those lithologies recognized as characterizing the Franconia, but rather only one of the five different lithologies it is indicated as containing in southeastern Minnesota and southwestern Wisconsin (Berg, 1954). In addition the name Franconia is now widely used to refer to a stage of time (Lochman-Balk, 1958) and time-stratigraphic units do not necessarily coincide with rock stratigraphic units. For these reasons, and because the lithology of the Mazomanie is significantly different from that of the other rocks assigned to the Lone Rock Formation, the Mazomanie Formation is given formational rank.

The greensands, shales, and shaly sandstones above the Wonewoc Formation and below the St. Lawrence Formation are grouped together as a single formation and assigned the name Lone Rock after exposures in the roadcut on Highway 137 south of the Village of Lone Rock and in the south bluff of the Wisconsin River in Iowa County (Ostrom, in press). A description of the Lone Rock expo-

Figure 11.

AREAL DISTRIBUTION OF TUNNEL CITY GROUP IN WISCONSIN



List of locations for wells and outcrops used in Figure 12.

Wisconsin

1. Roadcut near Victory in SW$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 12, T.12N., R.7W., Vernon County.
2. Well near Lynxville at U.S. Lock and Dam No. 9 in NE$\frac{1}{4}$, sec. 33, T.9N., R.6W., Crawford County.
3. Well in Mt. Sterling in NE$\frac{1}{4}$, sec. 26, T.10N., R.5W., Crawford County.
4. Well in Fennimore in SE$\frac{1}{4}$, NW$\frac{1}{4}$, sec. 19, T.16N., R.2W., Grant County.
5. Roadcut near Sextonville in SW$\frac{1}{4}$, SW$\frac{1}{4}$, sec. 3, T.9N., R2E., Richland Co.
6. Roadcut near Lone Rock in NE$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 24, T.8N., R.2E., Iowa Co.
7. Roadcut near Spring Green in NE$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 36, T.9N., R.3E., Sauk Co.
8. Outcrop near Leland in SE$\frac{1}{4}$, NW$\frac{1}{4}$, sec. 13, T.10N., R.4E., Sauk Co.
9. Outcrop in Ferry Bluff in SW$\frac{1}{4}$, sec. 20, T.9N., R.6E., Sauk Co.
10. Outcrop in Mazomanie in SE$\frac{1}{4}$, NW$\frac{1}{4}$, sec. 16, T.8N., R.6E., Dane Co.
11. Outcrop near Black Earth in SE$\frac{1}{4}$, SW$\frac{1}{4}$, sec. 25, T.8N., R.6E., Dane Co.
12. Outcrop in Gibralter Bluff in NW$\frac{1}{4}$, SW$\frac{1}{4}$, sec. 18, T.10N., R.8E., Columbia Co.
13. Well in Martinsville in center of sec. 13, T.8N., R.7E., Dane Co.
14. Outcrop in Gibralter Bluff in NW$\frac{1}{4}$, SW$\frac{1}{4}$, sec. 18, T.10N., R.8E., Columbia Co.
15. Outcrop near Merrimac in NW$\frac{1}{4}$, NW$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 16, T.11N., R.8E., Columbia Co.
16. Outcrop in Fox Glen in NE$\frac{1}{4}$, sec. 22, T.12N., R.8E., Columbia County.
17. Quarry near Portage in NE$\frac{1}{4}$, NW$\frac{1}{4}$, sec. 26, T.12N., R.9E., Columbia Co.
18. Well near Marcellon in SE$\frac{1}{4}$, sec. 16, T.13N., R.10E., Columbia Co.
19. Well in Markesan in NW$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 7, T.14N., R.13E., Green Lake Co.
20. Well near Green Lake in NW$\frac{1}{4}$, sec. 36, T.16N., R.12E., Green Lake Co.
21. Well near Green Lake in NW$\frac{1}{4}$, sec. 21, T.16N., R.13E., Green Lake Co.
22. Well near Berlin in SW$\frac{1}{4}$, SW$\frac{1}{4}$, sec. 17, T.17N., R.13E., Green Lake Co.
23. Well in Koro in SE$\frac{1}{4}$, sec. 8, T.17N., R.14E., Winnebago Co.
24. Well in Omro in NE$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 18, T.18N., R.15E., Winnebago Co.
25. Well in Winneconne in sec. 21, T.19N., R.15E., Winnebago Co.
26. Well in Neenah in NE$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 1, T.19N., R.16E., Winnebago Co.
27. Well in Appleton in sec. 34, T.21N., R.17E., Outagamie Co.
28. Well in Seymour in sec. 32, T.24N., R.18E., Outagamie Co.
29. Well in Green Bay in SW$\frac{1}{4}$, NW$\frac{1}{4}$, sec. 33, T.24N., R.20E., Brown Co.
30. Well in Oconto Falls in sec. 25, T.28N., R.19E., Oconto Co.
31. Well in Lena in NW$\frac{1}{4}$, NW$\frac{1}{4}$, sec. 35, T.29N., R.20E., Oconto Co.
32. Well in Coleman in sec. 14, T.30N., R.20E., Marinette Co.
33. Well in Porterfield in sec. 29, T.31N., R.22E., Marinette Co.

Michigan

34. Well in Escanaba in SW$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 18, T.39N., R.22W., Delta Co.
35. Well in Gladstone in NE$\frac{1}{4}$, SE$\frac{1}{4}$, sec. 22, T.40N., R.22W., Delta Co.
36. Core near Rock in sec. 35, T.43N., R. 23W., Delta Co.
37. Core near Turin in sec. 9, T.44N., R.23W., Marquette Co.
38. Roadcut near Munising in NE$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 14, T.46N., R.19W., Alger Co.
39. Outcrop at Miner's Castle in NW$\frac{1}{4}$, SW$\frac{1}{4}$, sec. 3, T.47N., R.18W., Alger Co.

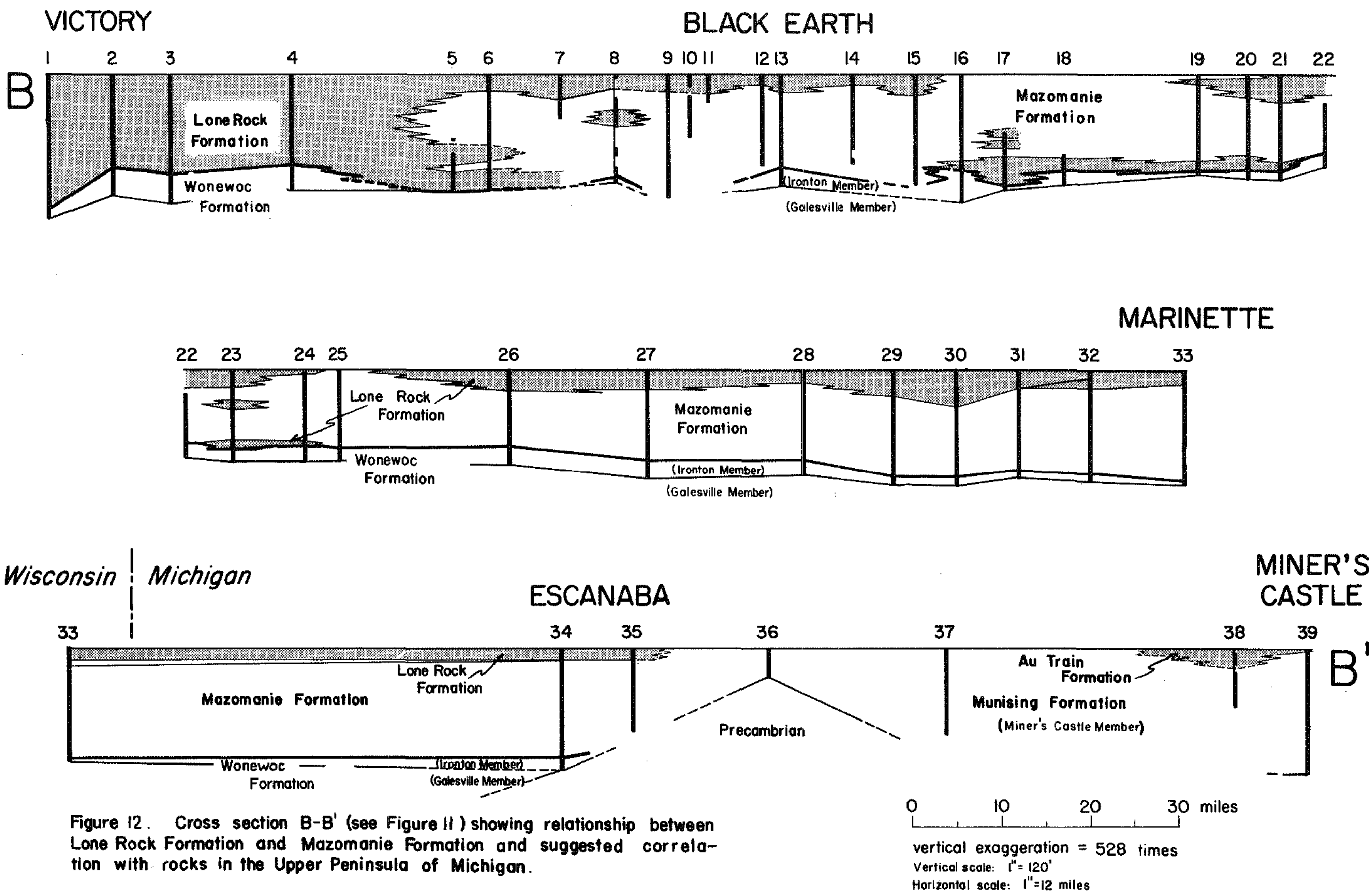


Figure 12. Cross section B-B' (see Figure 11) showing relationship between Lone Rock Formation and Mazomanie Formation and suggested correlation with rocks in the Upper Peninsula of Michigan.

sure is given below. Interfingering of the Mazomanie facies with the greensand facies as described by Berg (1954) can be seen at this exposure.

Cambrian System
(St. Croixan Series - Trempealeauan Stage)
Lone Rock Formation
Reno Member

11. 85.0'- 91.0'	6.0'	Sandstone, light green gray to yellow brown, fine and very fine grained, glauconitic and dolomitic, medium and thin bedded.

Mazomanie Member

10. 75.0'- 85.0'	10.0'	Sandstone, very light yellow brown and light yellow gray, very fine and fine grained, massive bedded and cross bedded with some burrowed beds.

Reno Member

9. 70.5'- 75.0'	4.5'	Sandstone, light green gray, fine and very fine grained, very glauconitic with ripclasts in base and few thin conglomerates between beds, cross bedded. Some beds burrowed.

Mazomanie Member

8. 64.5'- 70.5'	6.0'	Sandstone, yellow brown mottled brown, fine very fine grained, very silty and dolomitic with few thin clean sand layers. Appears to have been reworked.
7. 57.5'- 64.5'	7.0'	Sandstone, light green gray, fine and very fine grained, very glauconitic and dolomitic, with a few beds of conglomerate, cross bedded.

Mazomanie Member

6. 52.5'- 57.5'	5.0'	Poorly exposed. Same as bed #4.

Reno Member

5. 29.5'- 52.5'	23.0'	Sandstone, green gray, fine and very fine grained, very glauconitic, dolomitic, slightly argillaceous, with at least 9 beds of ripclast one of which is at base (12").

Tomah Member

4. 22.5'- 29.5'	7.0'	Sandstone, yellow gray, very fine and fine grained, very shaly and micaceous, mica on bedding places. Bedding thin and irregular. More shaly and micaceous near base.

Birkmose Member

3. 21.5'- 22.5'	1.0'	Sandstone, green gray, conglomerate of ripclast, very glauconitic and dolomitic.
2. 20.0'- 21.5'	1.5'	Dolomite, red brown, very sandy and glauconitic. Slightly uneven basal surface.

Wonewoc Formation
(Ironton - absent or very thin)
Galesville Member

1. 0.0'- 20.0'	20'+	Sandstone, very light yellow gray, fine and medium grained, massive and thick bedded, cross bedded. Some beds have thin discontinuous green shale layers that follow cross beds.
		ROAD LEVEL.

The upper contact can be observed in roadcuts north of Spring Green (Ostrom, 1965) and at exposures along Highway 14 between Mazomanie and Cross Plains, in Dane County.

25.6 Turn around and leave Stop #12.
25.8 STOP SIGN. Junction with Highway 58. Turn right (east and return to LaValle via Highway 58.
27.1 Enter Village of Ironton. Continue on Highway 58.
29.5 Reenter Village of LaValle.
30.0 Junction of Highway 58 with Highway 33. Proceed straight ahead (east) on Highway 33 East.
30.2 Outcrop of Galesville and Ironton sandstones in roadcut.
30.5 Outcrop of Ironton and Franconia sandstones.
34.2 Outcrop of Galesville Sandstone.
36.8 Enter Village of Reedsburg. Continue on Highway 33 East.
40.6 Franconia Sandstone exposed in quarry on left. Straight ahead the Galesville Sandstone can be seen in contact with the underlying Precambrian Baraboo Quartzite Formation.

Here we cross the steeply dipping (85°S) north limit of the Baraboo syncline while passing through the Upper Narrows of the Baraboo River.

45.1 Van Hise Rock on left in Upper narrows of the Baraboo River (discussion modified from M. E. Ostrom, in Guidebook to Field Trips in Southern Wisconsin, prepared for the first annual meeting of The Clay Minerals Society, Madison, Wisconsin, 1964).

The upper narrows of the Baraboo River reveals a cross section of the steeply dipping north limb of the Baraboo Syncline. The gorge was cut about 100 feet deeper than we see today by a stream which eroded its way downward through a mantle of Paleozoic formations. Although the gorge is located in the "unglaciated" region the level of the river bed was subsequently raised about 100 feet by filling with glacial outwash sands and gravels.

The north limb of the quartzite range is about ½ mile wide and has a dip of approximately 70 degrees to the south. The south limb dips 15-35 degrees northward. A look at the quarry faces will show that bedding in the quartzite is vertical and ripple marks indicate that the top of the beds is to the south.

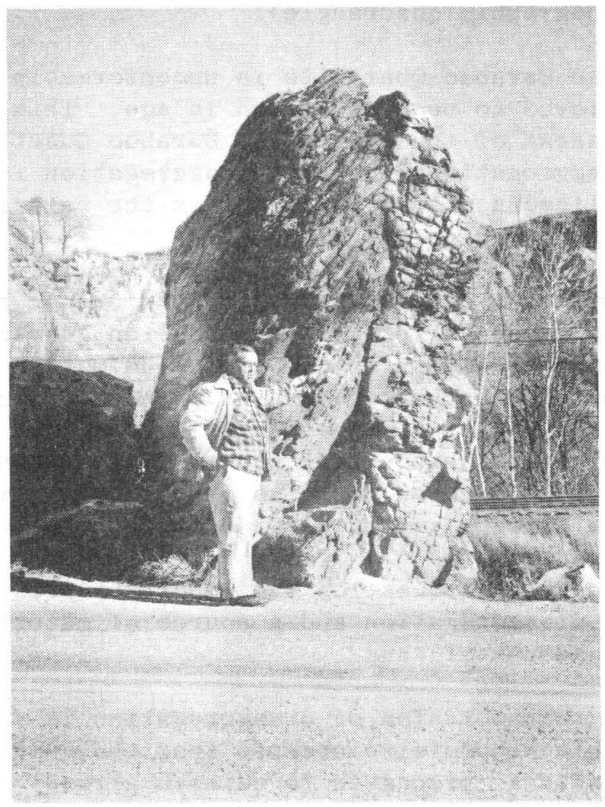
In the process of folding which formed the syncline shearing occurred along the bedding planes and cleavage structures similar to those illustrated in Van Hise Rock were produced (Figure 13). The top of the rock formation in Van Hise Rock is to the south or the right as shown in the photograph. The bed on the left is slate and that on the right is quartzite. Van Hise Rock has long been used by the faculty of the University of Wisconsin as an aid to teaching. The most recent interpretation of the structures in Van Hise rock is that of Prof. Ian Dalziel, University of Wisconsin Department of Geology, who has identified at least three north-dipping cleavages in the slate (personal communication). The latest and most prominent of these is refracted to dip south at low angle in the quartzite.

A zone of breccia cemented by vein quartz crosses the strike of the beds diagonally at the south end of the northernmost quarry. The clay mineral dickite occurs in this zone as do cavities lined with doubly-terminated quartz crystals.

Near the top of the quarry faces and in the opposite valley wall younger Cambrian conglomerates and sandstone can be seen to overlie the quartzite with angular unconformity. Rounded and subangular boulders of quartzite are scattered in the Cambrian near the contact, and crevices in the quartzite are filled with Cambrian sandstone.

Economic deposits found in the gorge include the quartzite used as ganister (open-hearth furnace lining), for abrasives, crushed rock, road surfacing, and railroad ballast. The Cambrian Sandstone has been used extensively for building, bridges, and paving and molding sand.

45.3 Note attitude of quartzite beds in quarry on right (west). Beds are standing nearly vertical with slight inclination to the south. Ripple marks can be seen on certain of the bedding surfaces.
45.6 Enter Village of Rock Springs. Here both the Galesville and Franconia Sandstone rest with angular unconformity on the Precambrian Baraboo Quartzite.
46.0 STOP SIGN. Turn left on Highway 136. Caution.
48.5 Turn right (south) on County Trunk Highway "I".
49.0 Enter Village of North Freedom.
49.5 Railroad crossing.
49.6 STOP SIGN. Continue straight ahead on County Trunk Highway "PF". Caution.



The late Dr. Stanley A. Tyler, Professor of Geology, the University of Wisconsin, standing by Van Hise Rock, near Rock Springs, Wis.

50.8 Turn right (west) on "PF" and "W".

51.5 Iron ore was mined from the Precambrian Seeley Slate in this area. Dumps and foundations of some of the buildings can be found on and just south of the bluff on the left (south).

52.0 Continue straight ahead on "PF".

52.3 Enter Village of LaRue.

52.5 Cross bridge over Seeley Creek.

52.6 Turn left (south) on black top road. Quarry destination can be seen in distance straight ahead.

53.3 STOP #13. Quarry in Precambrian Baraboo Quartzite Formation located southwest of the Village of North Freedom and south of the hamlet of LaRue in the NW$\frac{1}{4}$, sec. 22, T.11N., R.5E., Sauk County (refer to North Freedom 15' topographic quadrangle).

At this site the Baraboo Quartzite is unconformable with younger deposits of sandstone believed to be Dresbachian in age. This exposure is significant because in some areas of the quarry the Baraboo Quartzite can be seen in various stages of disaggregation and this disaggregation is proceeding through a breakdown of the siliceous matrix which causes the release of already rounded to subrounded quartz sand grains.

The implications of this disaggregation phenomenon are readily apparent, namely that through some natural process Precambrian quartzite is being disaggregated by means of a breakdown in the siliceous matrix which causes the release of already rounded quartz sand grains. These grains of sand then go to make up the body of the overlying sandstone of Dresbachian age. The obvious question at this point is to what extent are the silica sands contained in the widespread Cambrian and Ordovician deposits of the upper Mississippi valley area were derived from disaggregation of Precambrian quartzites?

In order to answer this question two important points must be considered, namely a mechanism of disaggregation and a source of material large enough to produce the necessary amount of sand.

The problem of the mechanism of disaggregation is apparently answered by the fact that at this exposure we observe that the quartzite can in fact be disaggregate through natural processes to release already rounded quartz sand grains. That is not to say we understand how disaggregation occurs but rather that we recognize the fact it does occur, and detailed investigation would undoubtedly provide the answer.

So far as the question of sufficiency of source material is concerned there will probably never be an adequate answer, at least not one adequate to satisfy everyone. Nonetheless it is significant to point out that here, in the Baraboo area, the Baraboo Quartzite Formation is estimated to be about 4,000 feet thick and that it occurs in a tabular shape which is folded into the synclinal form we see. Presumably this quartzite, or its unmetamorphosed equivalent, as well as other quartzites, formerly extended over much of the upper Mississippi valley and western Great Lakes area as quartzites having similar or nearly similar properties occur in many other areas of Wisconsin not to mention neighboring states to the north and west.

In most of these areas the quartzites can be seen dipping at moderate to steep angles. Can we logically assume that these deposits formerly covered large areas, were coextensive, and uniform in thickness and that the missing portion consisted of either quartz sandstone or of quartzite which disaggregated to provide the quartz sand which comprises our Cambrian and Ordovician sandstone deposits, or was their distribution as local as their present remains and did the sand come from another source?

At this stop pebbles, cobbles, and boulders of quartzite occur with rounded sand grains in a mixture which rests on the quartzite. At Stop #14 we will see quartzite pebbles and quartz sand in a deposit located about 10 miles east of outcropping quartzite and over 200 feet above a Precambrian basement of granitic rock. There seems little reason to doubt that the source of the sand and pebbles at Stop #14 was the quartzite. Pebbles and sand grains with the characteristic purple-pink color of the Baraboo Quartzite are found in all Cambrian and Ordovician sandstones of Wisconsin. This is interpreted to indicate that the Baraboo Quartzite and its equivalents, or deposits composed of material derived from the quartzite or its equivalent, were the major contributors of sand which went to form the Cambrian and Ordovician sandstone deposits of the upper Mississippi valley area.

53.3 Turn around and leave Stop #13. Retrace route to Highway 136.
54.0 STOP SIGN. Turn right on County Trunk Highway "PF".
55.8 Continue straight ahead on "PF".
56.6 Reenter Village of North Freedom.
56.9 STOP SIGN. Continue straight ahead (north) on County Trunk Highway "I". Caution.
58.0 STOP SIGN. Rejoin Highway 136. Turn right (east). Caution.
58.6 Franconia Sandstone in pit on left.
63.5 Enter City of Baraboo. Approximate eastern edge of "Driftless" area.
63.9 STOP LIGHT. Continue straight ahead and rejoin Highway 33. Follow Highway 33 East to Portage.
The hills to your right (south) are in the south limb of the Baraboo syncline and consist of some 3500 feet of resistant Baraboo Quartzite Formation, which dips gently to the north. The notch in these hills, which can be seen due south from the east city limit of Baraboo is the site of Devil's Lake State Park. This notch is a gorge believed to have been cut by the ancestral Wisconsin River. Glacial damming at both ends of the gorge prevented the river from resuming its former course and also caused formation of a water-filled depression in the gorge, namely Devil's Lake.
70.9 Quarry in hillside straight ahead (north) is in Baraboo Quartzite Formation. Product is used mainly as abrasive, refractory, and ganister.
72.0 Passing through Lower Narrows of the Baraboo River in the steeply dipping north limb of the Baraboo syncline.
72.8 Precambrian rhyolite is exposed in cuts on right (south).
74.4 Enter Columbia County.
78.3 Continue on Highway 33 over Interstate Highway 90-94.
80.5 Continue on Highway 33 over Highway 78.
81.9 Cross bridge over Wisconsin River and enter City of Portage. Follow Highway 33 to junction with Highway 51 in town of Portage.
82.0 STOP LIGHT. Turn right (south) on Highway 51.

83.5 Marquette and Joliet monument on left. It was near there that these early explorers made the short half mile portage from the Fox River, whose waters enter the Great Lakes and eventually join the Gulf of St. Lawrence, to the Wisconsin River, whose waters join those of the Mississippi and flow to the Gulf of Mexico. Hence the name of the town, Portage.

87.0 STOP #14. Exposure of the Galesville Sandstone, Ironton Sandstone, and Tunnel City Sandstone in a quarry of the Manley Sand Division of Martin-Marietta Corporation located about 2.5 miles southeast of the City of Portage on Highway 51 in the NE$\frac{1}{4}$, NW$\frac{1}{4}$, sec. 26, T.12N., R.9E., Columbia County (refer to Portage 15' topographic quadrangle).

Cambrian System
(St. Croixan Series - Franconian Stage)
Tunnel City Group
Lone Rock Formation
Reno Member

14. 125.5'-131.5'	6.0'	Sandstone, light yellow brown, fine and very fine grained, cross bedded, dolomitic with little glauconite, little shale with some vertical burrows.

Mazomanie Formation

13. 122.5'-125.5'	3.0'	Sandstone, very light yellow brown, fine and very fine grained, cross bedded, trace of glauconite.

Lone Rock Formation
Reno Member

12. 114.5'-122.5'	8.0'	Sandstone, light yellow brown, fine and very fine grained, cross bedded, little glauconite and shale, dolomitic, with some vertical burrows.

Mazomanie Formation

11. 104.5'-114.5'	10.0'	Sandstone, very light yellow brown, fine very fine grained, cross bedded, trace of glauconite.

Lone Rock Formation
Reno Member

10. 96.5'-104.5'	8.0'	Sandstone, light yellow brown, fine and very fine grained, cross bedded, dolomitic with little glauconite and shale and some vertical burrows.
9. 95.5'- 96.5'	1.0'	Sandstone, green gray, fine and very fine grained. Very glauconitic.

8.	92.5'- 95.5'	3.0'	Sandstone, green gray, fine and very fine grained, dolomitic and very glauconitic. Contain cavities up to 10" long by 3" high which may be lined with dolomite crystals. Some ripclasts.
7.	91.5'- 92.5'	1.0'	Sandstone, yellow brown, fine and very fine grained, dolomitic, much glauconite. Some small cavities lined with dolomite crystals.
6.	89.5'- 91.5'	2.0'	Sandstone, yellow brown, fine and very fine grained, very dolomitic, glauconitic.
5.	86.5'- 89.5'	3.0'	Sandstone, yellow brown, fine and very fine grained, glauconitic, very dolomitic.

Tomah Member

4.	76.5'- 86.5'	10.0'	Sandstone, light yellow brown, fine and very fine grained, shaly and slightly glauconitic with several beds of conglomerate and "wormstone".

Birkmose Member

3.	75.5'- 76.5'	0.5-1.0'	Sandstone, light yellow brown, fine and very fine grained, glauconitic; very dolomitic in upper 6"-1' and conglomeratic in lower 0"-6". Basal contact slightly uneven.

Elk Mound Group
Wonewoc Formation
Ironton Member

2.	70.0'-75.5'	5.5-6.0'	Sandstone, very light yellow brown to yellow gray, medium and coarse grained with little very fine and trace of very coarse, massive bedded and cross bedded. Base is slightly uneven and is marked by occurrence of pebbles in the Ironton and their absence from underlying beds. Camaraspis in base with scattered oboloid brachiopods above. Contact with overlying Tunnel City Group occurs about 10 feet above upper quarry floor on east face. Contact with underlying Galesville Sandstone is exposed in low cut in stripping and above north quarry face.

(Dresbachian Stage)
Galesville Member

1.	0.0'- 70.0'	70.0'+	Detailed description not made. Proceeding down the rock face it will be noted that the upper 40 feet is predominantly medium grained quartz sand with some fine and coarse and a trace of very coarse. Some pebbles noticed 20 feet below top. Lower 30 feet of section, but especially the lower 10 feet, contains abundant pebbles of Baraboo Quartzite and several burrowed beds. These can best be seen in south quarry face below water storage tanks and southeast of plant. All of the Galesville is massive to thick bedded and cross bedded.
			FLOOR OF QUARRY.

We are indebted to the owners and operators of this quarry of the Manley Sand Division of the Martin-Marietta Corporation for the privilege of visiting their operation. Please observe utmost caution while in the quarry. The sandstone is very friable and will easily collapse and could cause a disastrous fall.

At this stop one can see a continuous rock section beginning in the Galesville Member at the base and extending well upward into the Lone Rock Formation at the top. Previous discussions of stops numbers 7 through 13 apply equally to this exposure.

Of particular note here are the pebbles of pink Baraboo Quartzite which occur in the Galesville Member, especially where it is exposed behind the workshed at the south end of the quarry. Presence of this material indicates the Baraboo Quartzite was a contributor to the Galesville Formation. It follows that if the Baraboo contributed pebbles, then it could also have contributed already rounded quartz sand grains. That this can happen was demonstrated at Stop #13. The implication here is that the sand and pebbles of the Galesville could all have come from disaggregated Baraboo Quartzite.

Outcrops and wells drilled in this area and north indicate the absence of Eau Claire lithology from the Elk Mound Group. The Eau Claire Formation is identified in scattered wells located about 10 miles to the south. The formation becomes prominent as one proceeds in that direction.

The sand from this quarry is used chiefly for molding purposes in the steel casting industry and for the manufacture of glass. Typical analyses indicate more than 99.5% silica and less than 0.019% iron oxide.

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