University of Wisconsin—Extension

GEOLOGICAL AND NATURAL HISTORY SURVEY
Meredith E. Ostrom, State Geologist and Director

GUIDEBOOK TO THE PRECAMBRIAN GEOLOGY OF NORTHEASTERN AND NORTHCENTRAL WISCONSIN

19th Annual
Institute on Lake Superior Geology

Madison, Wisconsin, 1973

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with Special Papers on

Chronology of Precambrian Rocks in Wisconsin
W.R. Van Schmus
The Wolf River Batholith--a Late Precambrian Rapakivi Massif in Northeastern Wisconsin
L.G. Medaris, Jr., J.L. Anderson, and J.R. Myles
Precambrian Geology of Marathon County
G.L. LaBerge and P.E. Myers

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DEDICATION

This guidebook is dedicated to Carl E. Dutton in appreciation for his continual encouragement and advice to us all and in recognition of his contributions toward an understanding of the Wisconsin Precambrian.

INTRODUCTION

With the exception of early bulletins of the Wisconsin Geological and Natural History Survey produced between about 1900 and 1930 little had been published on the Precambrian geology of Wisconsin until the appearance in 1970 of "Lithologic, Geophysical, and Mineral Commodity Maps of Precambrian Rocks in Wisconsin" by Carl E. Dutton and Reta E. Bradley, which was the product of a cooperative effort of the State Survey and the U.S. Geological Survey. That publication is a compilation which drew together in concise form at a scale of 1:500,000 all that was generally known about Precambrian geology of Wisconsin and, thus, served to focus attention on the mineral potential of Wisconsin's Precambrian rocks and to indicate the inadequacy of available geological and geophysical information. As a direct consequence of the publication company exploration activity increased markedly and the interest of university and survey geologists was revived.

As a part of this revival the Wisconsin Geological & Natural History Survey has initiated a program to survey and map the Precambrian geology of the state in cooperation with geologists on the faculty of the University of Wisconsin System at its various campuses. At the present time Professors Gene L. LaBerge (UW-Oshkosh), Paul Myers (UW-Eau Claire), and Joe Mengel (UW-Superior) are supported by the Survey on a part-time basis during summer months to map Precambrian geology in Wisconsin. Other university geologists contributing to the program have obtained support from various grant programs including the University-Industry Research Program, the Wisconsin Alumni Research Foundation and from industry.

The Survey will soon publish a bouguer anomaly gravity map of the state prepared by Professors C. Patrick Ervin (formerly UW-Madison, now Northern Illinois University) and Sigmund Hammer (UW-Madison) at a scale of 1:500,000, utilizing over 16,000 stations. In addition, the Survey has begun a program under the leadership of Prof. John Karl (Department of Physics, UW-Oshkosh) to produce an aeromagnetic map of the northern two-thirds of the state at a north-south flight line spacing of one-half mile. This study was initiated by a grant from the Upper Great Lakes Regional Commission and has been strongly supported by a substantial grant from NL Industries and by aerial photograph prints provided by INCO.

This field guide and accompanying maps, printed for the 19th Annual Institute on Lake Superior Geology, will be included in what is hoped will eventually be a complete series of Precambrian field guides and maps for Wisconsin at a scale of 1:250,000, published as Geological and Natural History Survey Information Circulars. When used in combination with the bouguer gravity anomaly map and the aeromagnetic map they will provide a basis for identification of areas of above average mineral potential in Wisconsin which can then be made the subject for detailed study.

M.E. Ostrom
State Geologist & Director

SPECIAL PAPERS

Chronology of Precambrian Rocks

by

W.R. Van Schmus

The Wolf River Batholith--a Late Precambrian Rapakivi Massif in Northeastern Wisconsin

by

B.G. Medaris, Jr., J.L. Anderson, and J.R. Myles

Precambrian Geology of Marathon County

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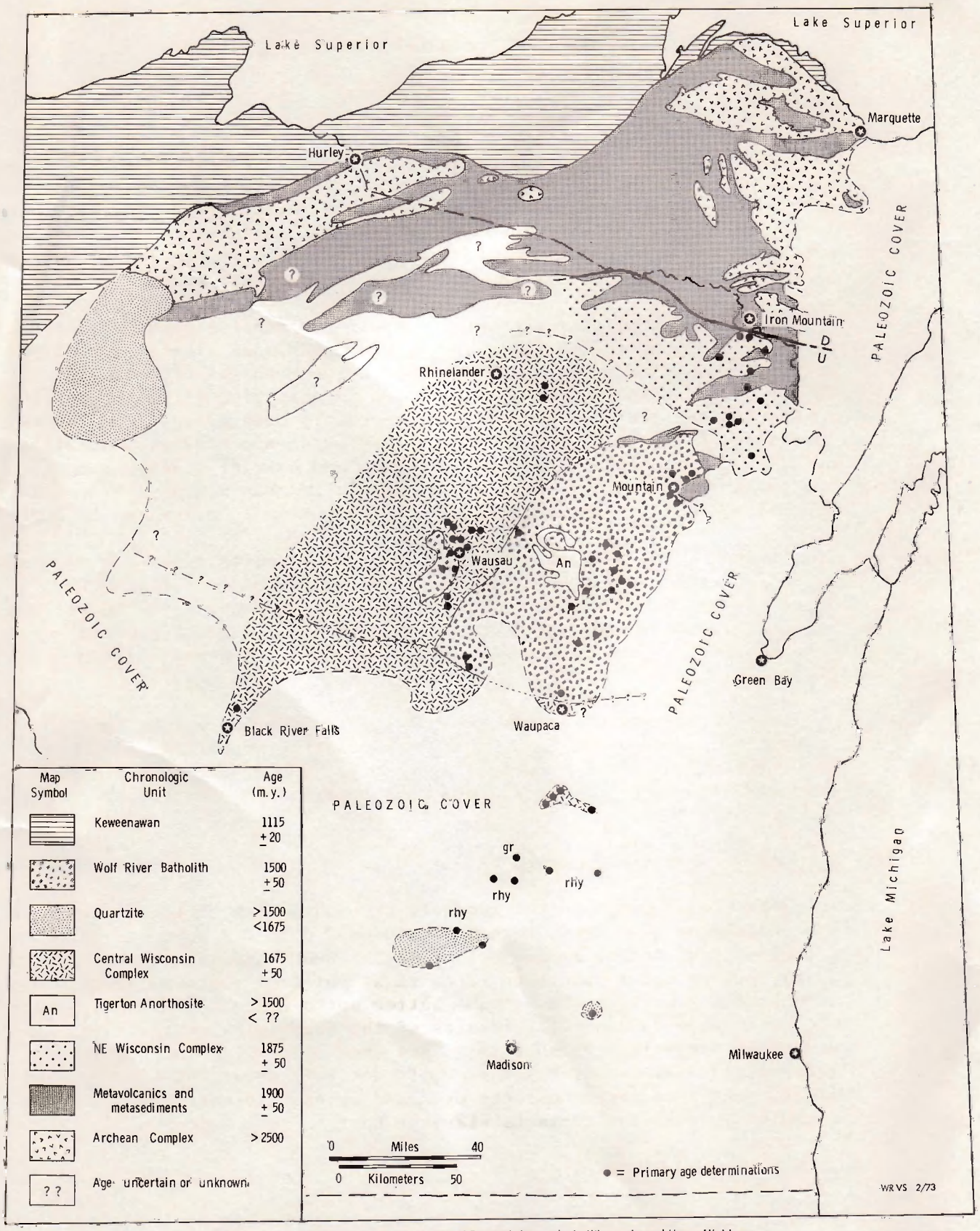

Figure 1. Generalized geochronologic map of Precambrian rocks in Wisconsin and Upper Michigan.

Chronology of Precambrian Rocks in Wisconsin

by
W.R. Van Schmus*

Geochronologic data for Precambrian rocks in Wisconsin have existed for more than a decade, but until recently the data were limited to analyses of separate minerals and were widely distributed, so that exact interpretation of primary formational ages and delineation of chronologic provinces was not possible. These early data were summarized by Dutton and Bradley (1970) and will not be reviewed in detail here.

In terms of obtaining primary ages of Precambrian rocks, as opposed to metamorphic ages, the geochronologic methods most likely to yield reliable results are the Rb-Sr whole-rock isochron method and U-Pb analyses on cogenetic suites of zircons. Application of these procedures to Precambrian rocks in Wisconsin has recently been done by P.O. Banks (Banks and Cain, 1969; Banks and Rebello, 1969; and unpublished data), by Z.E. Peterman (unpublished data), Dott and Dalziel (1972), and by the author (Van Schmus, 1972, 1973; Thurman and Van Schmus, 1973; and unpublished data). A summarization of these data is presented in Table 1.

Based on the available geologic and geochronologic data, a generalized chronologic map has been prepared for Precambrian rocks of Wisconsin and Upper Michigan (Figure 1). A few comments on the various chronologic units and a brief discussion of their significance is presented below, but space does not permit detailed description or discussion.

The "Precambrian X", etc. terminology used below refers to the current U.S. Geological Survey subdivisions of Precambrian time: Precambrian Z, base of Cambrian to 800 m.y. ago; Precambrian Y, 800 to 1600 m.y. ago; Precambrian X, 1600 to 2500 m.y. ago; and Precambrian W, older than 2500 m.y.

Archean Complex (Precambrian W)

The oldest rocks in the area are exposed in the northern part. In Upper Michigan these have been shown to be 2.5 to 2.7 b.y. old or older (Aldrich, and others, 1965; Woolsey, 1971; Banks and Van Schmus, 1971, 1972), but no dates have been reported as yet from presumed Archean rocks in northwestern Wisconsin. These latter units unconformably underlie the metasediments and metavolcanics of the Gogebic Range (Aldrich, 1929) and there seems little doubt that they are in fact Archean. However, the southward extent of these rocks is not well known, as outcrops are widely scattered throughout the area and lithologic correlation of Precambrian crystalline rocks is risky at best.

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Table 1. Summary of Primary Geochronologic Data for Precambrian Rocks in Wisconsin.

1. Northeastern Wisconsin Complex:

Quinnisec Fm. (rhyolite)	1905 ± 25 m.y.	(Z) Banks and Rebello, 1969.
Hoskin Lake granite	1890 ± 15	(Z) Banks and Cain, 1969.
Dunbar gneiss	1880 ± 15	(Z) Banks and Cain, 1969.
Newingham granodiorite "Amberg pink granite" (Athelstane quartz monzonite)	1860 ± 15	(Z) Banks and Cain, 1969.
Marinette quartz diorite	1930 ± 50	(Z) Aldrich and others, 1965.
Athelstane quartz monzonite Hoskin Lake granite	1810 ± 50	(R) Van Schmus, Unpub.*
Overall composite estimate:	1875 ± 50	

2. Central Wisconsin Complex:

Baraboo rhyolite	1640 ± 40 m.y.	(R) Dott and Dalziel, 1972.
So. Wisconsin rhyolites	1665 ± 40	(R) Thurman and Van Schmus, 1973.*
Wausau-Monico volcanics	1640 ± 40	(R) Peterman, Unpub.*
Waushara Co. granites	1645 ± 70	(R) Thurman and Van Schmus, 1973.*
Wausau area granites	1600 ± 85	(R) Peterman, Unpub.*
Jackson Co. granites	1690	(R) Klemic and Peterman, 1972.
Overall composite estimate:	1675 ± 50	

3. Wolf River Batholith:

Wolf River-Red River quartz monzonites	1450 ± 30 m.y.	(R) Van Schmus, Unpub.**
Belongia granite	1500 ± 20	(Z) Banks, Unpub.**
Wolf River batholith combined Wolf River quartz monzonite Red River quartz monzonite Hager complex Belongia granite Waupaca wiborgite granite Big Falls med-gr. granite Stevens Point gray granite Wausau syenite complex Stetin syenite complex Hogarty hornblende granite	1460 ± 25	(R) Van Schmus, Unpub.**
Overall composite estimate:	1500 ± 50	

(Z) denotes zircon U-Pb concordia intercept age; (R) denotes whole-rock Rb-Sr isochron age.

* Van Schmus, Thurman, and Peterman, in preparation.

** Van Schmus, Medaris, and Banks, in preparation.

No Archean rocks are conclusively present in northeastern Wisconsin. Although the Quinnesec metavolcanics have often been referred to as possibly being Archean, it now seems probable that they are much younger, as will be mentioned below. The lack of Archean rocks in this area is a major geologic problem, for they are exposed just to the north in Michigan (James, and others, 1961). Recent maps of the area (Dutton, 1971, Dutton and Bradley, 1970) show the presence of a major east-west trending fault system separating strongly deformed Quinnesec Formation rocks on the south from much less deformed Badwater Greenstone on the north; and this fault system may therefore coincide with or be part of an old major tectonic boundary.

Some of the other major remaining problems are to determine how far south Archean rocks can be recognized, to determine their ages, and to determine the nature of their disappearance (burial, faulting, orogenic destruction, etc.).

"Animikie" Metasediments and Metavolcanics (Precambrian X)

These rocks represent the major units of sedimentary and volcanic origin in the northern part of the area and include the economically vital sedimentary iron formations. Geochronologic data (Aldrich, and others, 1965; Banks and Van Schmus, 1971, 1972) indicate that these rocks in the Iron Mountain area are about 1900 m.y. old. Banks and Rebello (1969) obtained a 1900 million year age for zircons from a Quinnesec Formation rhyolite in Wisconsin, and the author regards these rocks as approximately, if not exactly, equivalent to the units in Michigan (for example, the Badwater Greenstone). No direct data exist for similar rocks from the northwestern part of the state, namely the Gogebic Range, but with the lack of any evidence to the contrary, the commonly used correlation with rocks to the east is accepted here. Clearly, however, direct analytical confirmation is required.

As with the Archean rocks, the maximum southern extent of these rocks is unknown.

Northeastern Wisconsin Complex (Precambrian X)

In the northeastern corner of the state are exposed several gneissic and plutonic units which are younger than the Quinnesec Formation, and in places intrude it (Cain, 1964). U-Pb ages on zircons and Rb-Sr whole-rock isochrons (Table 1) show that these rocks are about 1875 m.y. old. They can be traced southward for more than 50 Km. south of the Michigan-Wisconsin border, but their maximum southern limit is not known. Although these rocks are important in northeastern Wisconsin, only small plutons of this age exist in Michigan (Peavy Complex and scattered dikes and pegmatites in the Felch Trough area; Aldrich, and others, 1965; Banks and Van Schmus, 1971, 1972). Again, it appears that the E-W fault system may be part of a major boundary.

The westward extent of these 1875 m.y. old rocks is also not known, but it is quite possible that many of the rocks in the northern part of the state (north and west of Rhinelander) are similar in age. These and the older rocks are truncated on the south by the volcanic-plutonic rocks of the Central Wisconsin Complex, but the exact nature of the transition is also unknown (intrusive, fault, suture zone?).

Central Wisconsin Complex (Precambrian Y)

Rocks which yield Rb-Sr whole-rock ages of 1650 to 1700 m.y. appear to make up the bulk of the Precambrian basement of Wisconsin, extending from Rhinelander in the north to at least as far south as Baraboo and for at least 150 Km. in an east-west direction (Figure 1). These rocks are mainly volcanic, volcaniclastic, and associated granitic intrusives; the exposures of these rocks in the Wausau area are described in a later section of this guidebook. Other areas of these rocks are the Monico area, the granites of Waushara County and the rhyolites to the south, the rhyolites underlying the quartzite at Baraboo, and some of the rocks in the Black River Falls area (Table 1). Although several types of rock are represented, outcrop control is presently insufficient for purposes of major correlations. The full extent of these rocks is unknown, particularly to the south and west, and represents a major problem in Midcontinent Precambrian geology.

The geochronologic control on this complex to date is only by Rb-Sr whole-rock isochrons, and it is possible that the 1675 m.y. age given here is a time of widespread alteration of slightly older rocks. U-Pb zircon ages will be measured for many of these units in the near future in order to get a better handle on the true age of these rocks and to look for any resolvable age differences within the complex.

Quartzites (Precambrian Y)

Dott and Dalziel (1972) have recently extensively summarized the Precambrian quartzites in Wisconsin. The age of the quartzites is bounded by the underlying 1675 m.y. old rhyolite at Baraboo and 1450 to 1500 m.y. old intrusive rocks at Waterloo (pegmatite) and at Wausau (syenite intruding Rib Mountain Quartzite).

Wolf River Batholith (Precambrian Y)

The youngest plutonic event in the state was the formation of a large complex referred to in this guidebook as the Wolf River batholith. It includes a large variety of felsic intrusive rocks which occur from Mountain to Wausau to Stevens Point to Waupaca and are all about 1500 m.y. old (Table 1; Figure 1). This complex is described in detail in later sections of this guidebook and will not be elaborated on here. Published mineral ages from several localities (Bass, 1959) indicate that this event was the last major thermal event in Wisconsin except for the Keweenawan activity to the north.

This complex is relatively well defined as to its areal extent, and it is surrounded on all sides by older units. However, the exact shape still needs to be better defined, and more U-Pb ages on zircons will have to be determined on individual units to fully tie down their absolute age(s).

Keweenawan Rocks (Precambrian Y)

Keweenawan volcanics, sediments, and intrusive rocks occur in the northern part of the area, but will not be discussed here. The age of 1115 m.y. for these rocks (Figure 1) is primarily based on the U-Pb zircon data of Silver and Green (1963, 1972). Chaudhuri (1972) and Chaudhuri and Faure (1967, 1968) have also reported Rb-Sr ages on similar rocks in Michigan.

Miscellaneous

The major rocks included in this category are the granites, gneisses, schists, and migmatites in central Wisconsin, extending westward from Waupaca to Stevens Point-Wisconsin Rapids, and west. These rocks have apparently been intruded by the 1675 m.y. old complex, and Bass (1959) has obtained some mineral ages as old as 1900 m.y. from these rocks. Thus, it would appear that these rocks are at least 1900 m.y. old and may even be Archean. Clearly, exact determination of the primary ages of these rocks is important since it will help define the minimum southern limit of sialic rocks younger than 1900 m.y. in North America.

Regional Significance

Several major discrete igneous, metamorphic or sedimentary periods or events can now be recognized in Wisconsin and Upper Michigan. The 2500 m.y. and older rocks represent the southern edge of the Superior Province of the Canadian Shield. The 1850 to 1900 m.y. old rocks represent a major period of sedimentation, volcanism, and orogeny and is considered by the author to represent the so-called "Penokean Orogeny" in the area (Van Schmus, 1972). The 1650 to 1700 m.y. old rocks can be correlated roughly with rocks of similar age in the Rockies and the Southwest, although exact correlations will need to await further data. In any case, it appears that rocks with ages of 1650 to 1750 m.y. comprise a major structural belt from Arizona to Wisconsin. The 1500 m.y. old complex correlates well in age, lithologic character, and tectonic setting with 1450 to 1500 m.y. old plutons throughout the Southwest and volcanic and plutonic rocks in Missouri. These rocks probably are part of another structural province south of and partially overlapping the 1650 to 1750 m.y. old rocks (Bickford and Van Schmus, 1973).

In summary, it now appears that the various chronologic units recognized in Wisconsin can be related to other rocks throughout North America, and these correlations may ultimately provide the framework upon which we can determine the detailed evolution of the continent during Precambrian times.

Acknowledgements

This work has been largely supported by National Science Foundation Grants GP-1362 and GA-15951. The author gratefully acknowledges the cooperation of all his colleagues who are mapping and carrying out petrologic studies in the area and whose work provides the base necessary for sample collection and data interpretation.

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THE WOLF RIVER BATHOLITH--A LATE PRECAMBRIAN RAPAKIVI MASSIF IN NORTHEASTERN WISCONSIN

by

L.G. Medaris, Jr.*, J.L. Anderson*, and J.R. Myles**

INTRODUCTION

Classic rapakivi texture, in which grains of ovoidal alkali feldspar are mantled by plagioclase, has been described from several localities of Precambrian granite in northeastern Wisconsin (Gates, 1953; Elders, 1968), but until the present time, the regional distribution and petrologic significance of these rocks have not been fully appreciated. Our investigation, in conjunction with chronologic studies by W.R. Van Schmus (this guidebook), has established that an extensive rapakivi massif, the Wolf River batholith, underlies an area of at least 3600 square miles and represents a major feature of the Precambrian terrain in northeastern Wisconsin (Fig. 1). This anorogenic, epizonal batholith, 1450 to 1500 million years in age, consists predominantly of reddish, hypersolvus quartz monzonite and granite. In addition to the widespread occurrence of rapakivi texture, the Wolf River batholith has textural, mineralogical, chemical, and structural features that are similar in every respect to those of the classic rapakivi massifs in Finland.

LITHOLOGY

General Characteristics

A variety of rock types have been recognized in the Wolf River batholith, including granite, quartz monzonite, monzonite, trachyandesite, syenite, and rhyolite. Quartz monzonite and granite are by far the most abundant rock types in the batholith, accounting for 94% of the exposed area (Table 1, Fig. 1). The predominance of alkali feldspar over plagioclase in the batholith is illustrated by a plot (Fig. 2) of modal quartz, alkali feldspar, and plagioclase for representative specimens, obtained by point counts of both thin sections and stained polished surfaces of hand specimens.

Rapakivi texture is one of the most characteristic features of the Wolf River batholith, being most extensively developed in the Waupaca quartz monzonite, but occurring in minor amount in all of the other granite and quartz monzonite units. Equally characteristic is the development of porphyritic texture in all lithologic units of the batholith. Typically, phenocrysts[1] of alkali feldspar, and to a lesser

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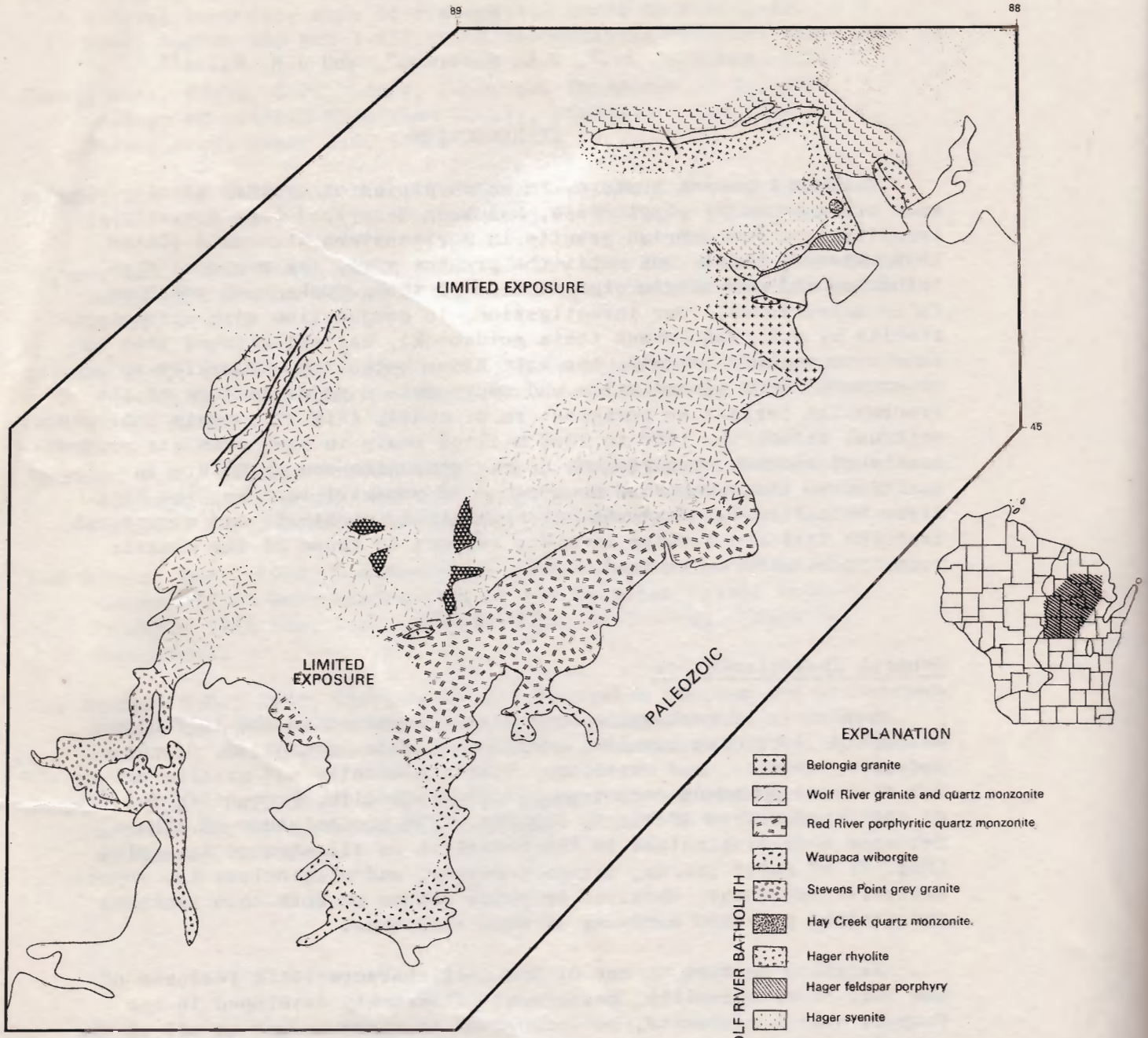
1 A non-genetic descriptive term, such as megacryst, might be more appropriate to describe the large alkali feldspar grains, but since phenocryst is still the term accepted by Finnish geologists, this convention will be followed here.



GEOLOGIC MAP OF THE WOLF RIVER BATHOLITH

BY L.G. MEDARIS, JR., J.L. ANDERSON,
W.R. VAN SCHMUS, AND J.R. MYLES

10 0 10 20 30 MILES

Table 1

Proportions of lithologic units in the Wolf River batholith (exposed areas only) and key to symbols used in Figures 1-7.

Symbol	Unit	Areal extent, %
○	Belongia granite, fine-grained	2.7
●	Belongia granite, coarse-grained	
▲	Wolf River granite and quartz monzonite	51.0
▼	Red River porphyritic quartz monzonite	20.6
▽	Waupaca quartz monzonite (wiborgite)	10.5
■	Hager rhyolite	3.6
□	Hager feldspar porphyry	0.2
◪	Hager syenite	1.9
⊠	Hay Creek quartz monzonite	0.1
◇	Peshtigo trachyandesite	0.4
◆	Peshtigo monzonite	
Not Shown	Stevens Point grey granite	5.0
Not Shown	High Falls granite	4.0

extent plagioclase and quartz, are present in a medium- to fine-grained granitic matrix, consisting of quartz, microcline, plagioclase, and mafic minerals. In all cases, matrix plagioclase is more sodic than plagioclase phenocrysts. Quartz is interstitial to feldspars in some units, but in others, particularly in granite and some varieties of quartz monzonite, quartz displays a distinctive idiomorphic habit and apparently was one of the earliest phases to crystallize.

Iron-rich biotite and amphibole are the most common mafic minerals in the batholith, although orthopyroxene, clinopyroxene, and olivine occur in some of the darker rocks, such as monzonite. Biotite and amphibole are anhedral to subhedral and typically occur in areas interstitial to feldspar and quartz. Such an occurrence suggests that biotite and amphibole appeared relatively late in the crystallization sequence of the granitic rocks.

Descriptions of the Lithologic Units

Twelve lithologic units have been distinguished in the Wolf River batholith, and the following descriptions are intended to summarize only the most salient features of each unit. Actually, some lithologic units are quite heterogeneous with respect to variations in texture and grain size, and the brief descriptions given here are not intended to encompass every conceivable variant that might exist within each of the twelve units.

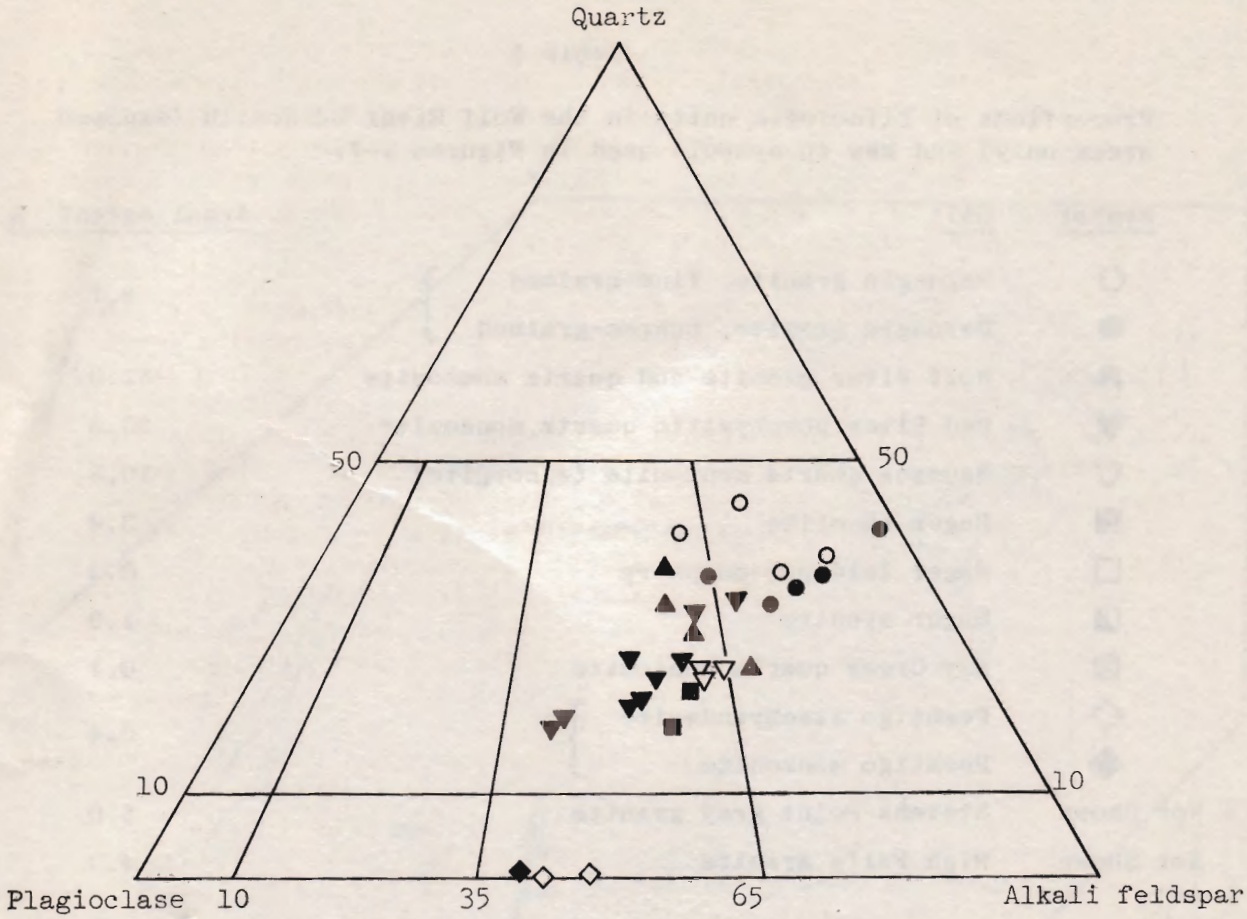


Figure 2. Modal analyses of lithologic types from the Wolf River batholith. (Symbols listed in Table 1)

Waupaca quartz monzonite (wiborgite). This coarse-grained quartz monzonite has abundantly developed rapakivi texture and closely resembles the classic wiborgite in Finland. Approximately 70 to 80% of the pink ovoidal alkali feldspar grains (1.5 to 5.0 cm in length) are mantled with a layer of plagioclase 1 to 6 mm thick, and multiple layers are common. The thicker a plagioclase mantle is, the smaller and more rounded is the alkali feldspar in the core. A porphyritic texture is characteristic, with the large mantled feldspars, plagioclase, and idiomorphic quartz set in a medium-grained matrix of microcline, plagioclase, quartz, biotite, and amphibole.

Wolf River granite and quartz monzonite. The Wolf River granite and quartz monzonite resembles the Waupaca quartz monzonite in being coarse-grained and prophyritic with prominent ovoidal alkali feldspars (1 to 3 cm in length), except that rapakivi texture is much less abundant, plagioclase rims occurring on only 3 to 10% of the alkali feldspar ovoids,

Alkali feldspar and plagioclase phenocrysts are set in a medium-grained matrix of interstitial subhedral to anhedral quartz, microcline, plagioclase, biotite, and amphibole. The bulk of the Wolf River unit is quartz monzonite, but towards the contact with the Belongia granite to the northeast, plagioclase and amphibole decrease in amount, biotite becomes richer in iron, quartz appears as idioblastic grains, and granite becomes the predominant rock type.

Red River porphyritic quartz monzonite. In comparison to the Waupaca and Wolf River quartz monzonites, this unit contains fewer phenocrysts in proportion to matrix and angular, rather than ovoidal, alkali feldspar phenocrysts. Typically, subhedral alkali feldspar phenocrysts (0.5 to 2.0 cm in size) constitute about 20% of the rock, with the remaining 80% consisting of a medium-grained (1 to 2 mm) matrix of idiomorphic to anhedral quartz, two feldspars, of which plagioclase is predominant, and usually biotite as the sole mafic mineral, although amphibole is present at some localities. Rapakivi texture is not conspicuous, although thin, discontinuous plagioclase mantles on up to 15% of the alkali feldspar phenocrysts are apparent in stained slabs. The feldspar phenocrysts are commonly aligned, imparting a planar fabric to the rock.

Belongia granite. Two types of Belongia granite exist: a coarse-grained equigranular variety and a fine-grained porphyritic variety.

The coarse-grained granite is pink, massive, and predominantly even-grained (3 to 5 mm), consisting mainly of subhedral alkali feldspar and idiomorphic quartz, with small amounts of plagioclase and biotite as the sole mafic mineral. At some localities, however, this unit acquires a porphyritic texture in which phenocrysts of alkali feldspar and quartz (35 to 45%) are set in a medium-grained matrix (2 mm). Small amounts of rapakivi and granophyric texture are present.

The fine-grained granite is made up of phenocrysts (15 to 20%) of idiomorphic quartz (3 to 5 mm) and ovoidal alkali feldspar (0.5 to 2 cm) in a fine-grained (1 mm) matrix. The quartz phenocrysts commonly show resorbed boundaries, and a minor amount of rapakivi texture is present. Biotite is the only mafic mineral and occurs as clusters of grains in the matrix. A characteristic feature of this granite is the presence of granophyric texture, in which intergrowths of alkali feldspar and quartz occur around euhedral cores of alkali feldspar. The alkali feldspar in the granophyric rim is in optical continuity with that in the core.

Peshtigo monzonite and trachyandesite. These rocks are distinguished by their dark grey to brown color, paucity of quartz, and relative abundance of mafic minerals. The monzonite is medium-grained (3 mm) and slightly porphyritic, containing plagioclase and alkali feldspar in subequal amounts and olivine, orthopyroxene, clinopyroxene, amphibole, biotite, opaques, and traces of interstitial quartz. The trachyandesite is a porphyritic equivalent of the monzonite, with 40% feldspar and olivine phenocrysts in a fine-grained groundmass.

Hager rhyolite. The Hager rhyolite contains conspicuous idiomorphic quartz phenocrysts (3 to 4 mm) and less prominent feldspar phenocrysts (4 to 5 mm) in a very fine-grained matrix (0.1 mm) of quartz, feldspar, and clusters of biotite, and to a lesser extent, amphibole. The phenocrysts, constituting 30 to 45% of the rhyolite, commonly show resorption features. The rhyolite is massive and homogeneous, without evidence of brecciation or pyroclastic activity, and thus is thought to be intrusive, rather than extrusive.

In hand specimen the Hager rhyolite somewhat resembles the fine-grained Belongia granite, except that the Hager rhyolite has a much finer grained groundmass and tends to be pinkish-grey, rather than pink, on a fresh surface.

Hager feldspar porphyry. The Hager feldspar porphyry is somewhat similar to the rhyolite, differing in that the feldspar porphyry is darker grey in color and contains more abundant and conspicuous feldspar phenocrysts compared to quartz. Biotite is the only mafic mineral in the feldspar porphyry.

Hager syenite. The syenite is grey to reddish-grey, foliate, and porphyritic, with aligned phenocrysts (25%) of anhedral alkali feldspar and minor plagioclase in a fine-grained matrix of feldspars, biotite, amphibole, and small amounts of quartz. Granophyric intergrowths of quartz and alkali feldspar occur adjacent to some alkali feldspar phenocrysts.

Hay Creek quartz monzonite. This quartz monzonite is massive and porphyritic, containing pink alkali feldspar phenocrysts (1 cm) in a medium-grained matrix (2 mm) of anhedral quartz, two feldspars, biotite, amphibole, and sphene.

Stevens Point grey granite. We have not yet studied this unit in detail. One sample collected north of Stevens Point is actually a grey porphyritic quartz monzonite with about 10% subhedral alkali feldspar phenocrysts (0.5 to 1 cm in length) in a fine-grained allotriomorphic granular matrix of quartz, microcline, plagioclase, and biotite. This rock is lithologically similar to some of the finer grained varieties of the Red River porphyritic quartz monzonite.

High Falls granite. The High Falls granite is a rather heterogeneous unit, consisting mainly of medium-grained allotriomorphic granular granite and quartz monzonite. Shear zones are extensively developed in some outcrops, a feature absent from other units of the Wolf River batholith with the exception of the Eau Claire River mylonite zone (LaBerge, field trip locality 8, this guidebook). It is uncertain whether the High Falls granite is truly part of the batholith or whether it might represent part of the older, surrounding terrain. In the absence of isotopic dates it has tentatively been assigned to the batholith because it intrudes the Macaslin quartzite and is spatially related to the Hager rhyolite, Belongia granite, and Peshtigo monzonite.

Anorthosite. Anorthosite, containing plagioclase of about An 50 in composition, occurs within the batholith, where it is intruded by granite (Fig. 1 and Weis, field trip locality 7, this guidebook). Interestingly, anorthosite of similar nature is associated with Finnish rapakivi, where it is also intruded by granite. A genetic relation between anorthosite and rapakivi has been suggested by Kranck (1968), among others, but some Finnish geologists believe that the spatial association is simply fortuitous and that there is no direct genetic connection (Savolahti, 1956).

LITHOLOGIC CORRELATION OF THE WOLF RIVER BATHOLITH AND FINNISH RAPAKIVI MASSIFS

From published descriptions of rock types in the Finnish rapakivi massifs (Vorma, 1971) and from examination of rapakivi specimens in the petrology collection at the University of Wisconsin, it is apparent that each of the lithologic units in the Wolf River batholith corresponds to one of the distinctive rock types recognized in the Finnish occurrences. A correlation of rock types from the two regions, based on textural, mineralogical, and chemical characteristics, is given in Table 2. The only dubious correlation is that of the Hager rhyolite and feldspar porphyry with granite porphyry and quartz porphyry dike rocks. Texturally, the correlation seems to be valid, and perhaps the only difference is a higher level of emplacement for the Hager rhyolite and feldspar porphyry compared to the rapakivi dike rocks described by Vorma.

ROCK CHEMISTRY

Bulk chemical analyses of specimens from the eastern part of the batholith, including Wolf River quartz monzonite, Belongia granite, Peshtigo monzonite, and Hager rhyolite, feldspar porphyry, and syenite have been obtained by electron probe analysis of fused rock samples, following the method described by Gulson and Lovering (1968). From the analyses listed in Table 3, it is evident that these rocks are relatively rich in SiO_2 and alkalies, particularly K_2O, and poor in Al_2O_3, CaO, and MgO, features shared by the Finnish rapakivi granites (Sahama, 1945).

A Peacock plot of analyzed specimens (Fig. 3) illustrates the alkalic or alkali-calcic nature of the Wolf River batholith. Despite the alkalic affinities of the batholith, all of the lithologic units so far recognized are peraluminous or metaluminous. However, syenite and associated nepheline syenite in the Wausau area yield isotopic ages of 1450-1500 m.y. (Van Schmus, LaBerge, and Myers, this guidebook) and may represent the peralkaline complement to the peraluminous granitic rocks of the Wolf River batholith proper.

To illustrate the chemical compositions of the granitic rocks, mesonorms have been calculated after the method suggested by Parslow (1969) (Fig. 4). Such a calculation takes into account the amount of potassium incorporated in biotite, thereby reducing the amount of normative Or and presumably providing a more realistic comparison of normative Q-Ab-Or with experimental data in the "granite" system.

Table 2

Correlation of lithologic units in the Wolf River batholith with those in the Wiborg rapakivi massif in Finland.

Wolf River batholith	Wiborg rapakivi massif
Peshtigo monzonite	Tirilite
Waupaca quartz monzonite	Wiborgite
Wolf River granite and quartz monzonite	Pyterlite
Red River porphyritic quartz monzonite	Porphyritic granite
Belongia granite, coarse-grained	Even-grained biotite granite
Belongia granite, fine-grained	Porphyry aplite
Hager rhyolite and feldspar porphyry	Dike rocks; granite porphyry and quartz porphyry

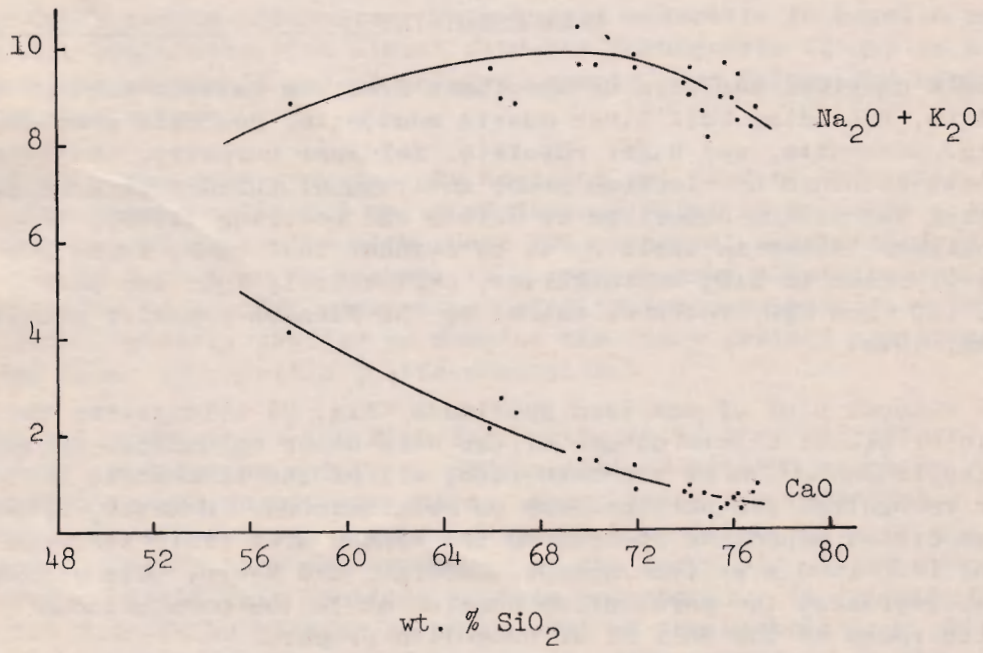


Figure 3. Peacock graph for specimens from the Wolf River batholith

Table 3

Bulk Chemical Analyses

	1	2	3	4	5	6	7
SiO_2	69.6	74.5	76.2	69.6	71.4	66.4	57.8
TiO_2	0.39	0.20	0.28	0.67	0.68	1.13	1.45
Al_2O_3	14.3	12.14	11.80	14.3	13.42	14.33	16.6
Fe_2O_3*	4.18	2.53	2.29	3.72	4.29	6.31	10.8
MnO	0.06	0.03	0.02	0.02	0.02	0.03	0.12
MgO	0.33	0.13	0.08	0.18	0.37	0.90	1.36
CaO	1.69	0.58	0.58	1.38	1.14	2.39	4.07
Na_2O	3.83	3.13	3.22	4.42	3.34	3.64	4.49
K_2O	5.83	5.85	5.56	6.02	6.28	5.41	4.35
Total	100.21	99.09	100.03	100.31	100.94	100.54	101.04

* Total Fe as Fe_2O_3

1 Wolf River quartz monzonite

2 Belongia granite, coarse, average of four analyses

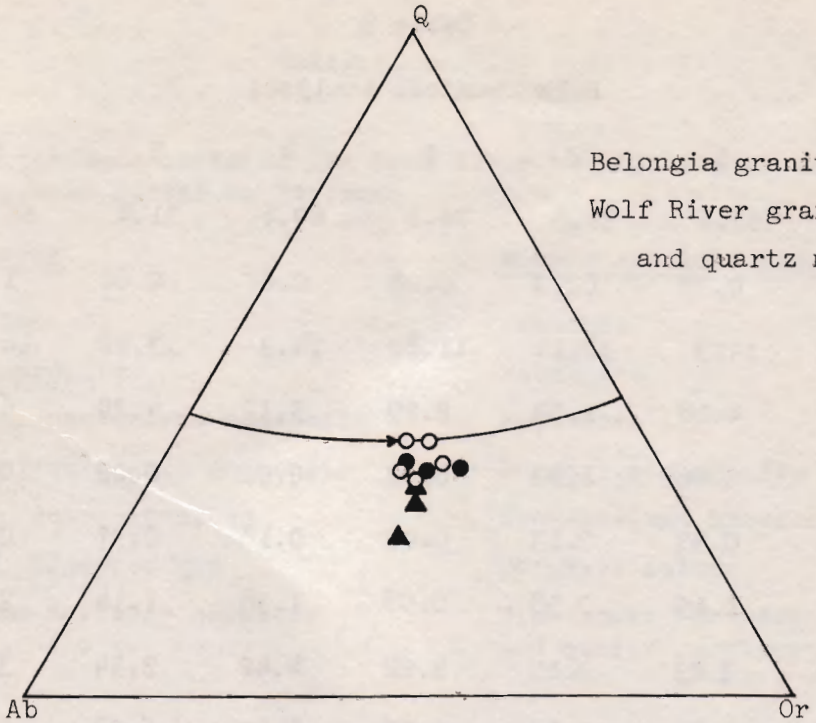
3 Belongia granite, fine, average of five analyses

4 Hager rhyolite

5 Hager feldspar porphyry, average of three analyses

6 Hager syenite, average of three analyses

7 Peshtigo monzonite



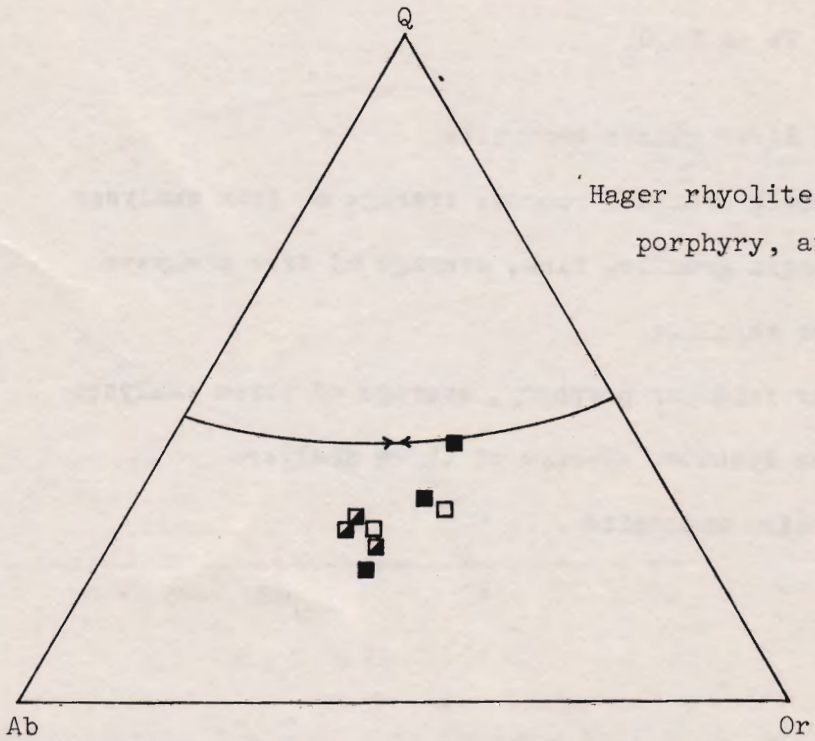


Figure 4. Bulk compositions of specimens from the Wolf River batholith in terms of mesonormative Q, Ab, and Or. Boundary curve for P_{H_2O} = 1000 bars shown for comparison. (Symbols listed in Table 1)

Mesonorms for the granitic rocks plot near the granite minimum and extend along the thermal trough toward the Ab-Or join. A significant feature is that, despite reduction in the amount of normative Or by calculation of mesonorms, the Belongia granite and Hager rhyolite are still displaced from the granite minimum toward the Or corner, a feature shared by the Finnish rapakivi granites. Such a displacement could conceivably reflect crystal-melt equilibria in a magma undersaturated with respect to H_2O (Luth, 1969).

MINERALOGY

Rocks of the Wolf River batholith are made up predominantly of perthitic alkali feldspar and quartz, with smaller amounts of sodic plagioclase, iron-rich biotite and amphibole, and locally, olivine and pyroxene. Fluorite is the most widespread and characteristic of the accessory minerals.

Biotite. Biotite from 47 representative specimens have been analyzed for eleven elements by means of the electron probe, and the analyses have been plotted in terms of end-member phlogopite, annite, eastonite, and siderophyllite in Fig. 5. The biotite is iron-rich, with values of 100xFe/Fe+Mg ranging from 70.1 to 98.6. As might be expected, Fe-Mg ratios are highest in the most silica-rich rocks, being consistently greater than about 90 for the Hager rhyolite, Belongia granite, and granitic portion of the Wolf River.

The number of Al atoms, calculated on an anhydrous basis of 22 oxygens, ranges from about 2.35 to 3.10 for all units except the fine-grained Belongia granite, most specimens of which contain biotite with 3.2 to 3.5 Al atoms. With the exception of the Belongia granite and Red River porphyritic quartz monzonite, octahedral Al in biotite is low, amounting to less than 0.5 atoms per formula unit.

As previously recognized by Nockolds (1947), where biotite occurs as the sole mafic mineral in a rock, it tends to be more aluminous than biotite from a rock containing amphibole as well. This pattern is followed by biotite from the Wolf River batholith, the most aluminous biotite occurring in amphibole-free lithologies such as the fine-grained Belongia granite, some members of the Red River porphyritic quartz monzonite, the Hager rhyolite, and the Wolf River granite. An exception to this rule is provided by the coarse-grained Belongia granite, in which biotite is the sole mafic mineral but contains relatively small amounts of aluminum, particularly octahedral Al, when compared with biotite from the fine-grained Belongia granite. The difference in aluminum content of biotite from the two varieties of granite may be due to a larger amount of Fe^{+++} substituting for octahedral Al in biotite of the coarse-grained Belongia granite.

A characteristic feature of biotite from the Wolf River batholith is a high content of halogens. So far, contents of Cl up to 1.8% and F up to 1.5% have been determined.

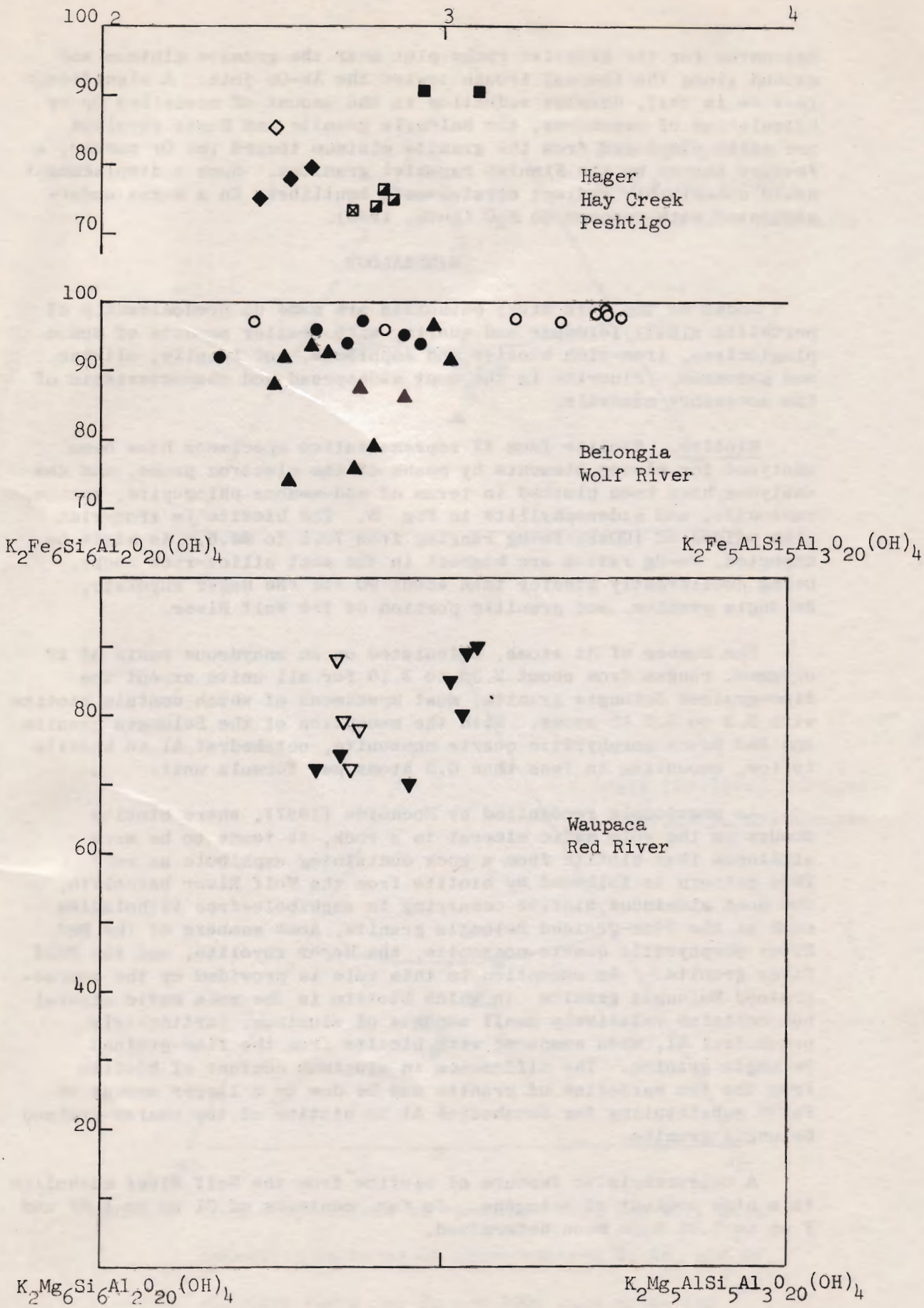


Figure 5. Composition of biotite from the Wolf River batholith. (Symbols listed in Table 1)

Biotite from the Wolf River batholith is similar to that from the Finnish rapakivi granite in displaying high Fe-Mg ratios, relatively low Al contents, especially octahedral Al, and enrichment in halogens (Simonen and Vorma, 1969).

A ubiquitous textural feature exhibited by the Wolf River rocks is an intimate intergrowth of biotite and alkali feldspar wherever these two phases are in contact. Configuration of the contact suggests that biotite has grown at the expense of alkali feldspar, perhaps reflecting a change of intensive variables during or after crystallization, with a resultant change in equilibria among alkali feldspar, biotite, and magnetite, as studied experimentally by Wones and Eugster (1965) and Rutherford (1969).

Amphibole. Electron probe determinations were made for ten elements in amphibole from eleven specimens. According to the classification proposed by Leake (1968), most of the amphibole is a hastingsitic hornblende, with values of Ca+Na+K ranging from 2.54 to 2.71, Si from 6.33 to 6.50, and 100xFe/Fe+Mg+Mn from 77.3 to 93.4, calculated on an anhydrous basis of 23 oxygens. In a few samples Si values around 6.6 were obtained, indicating ferroedenitic hornblende, according to Leake's classification. Like biotite, amphibole contains appreciable amounts of halogens.

For comparative purposes the analyses have been plotted in terms of atomic Ca, Fe, and Mg (Fig. 6). Amphibole from the more silica-rich rocks tend to have higher Fe-Mg ratios than that from syenite and monzonite. Coexisting amphibole and biotite have similar Fe-Mg ratios, but generally the Fe-Mg ratio in amphibole is slightly higher than that in biotite.

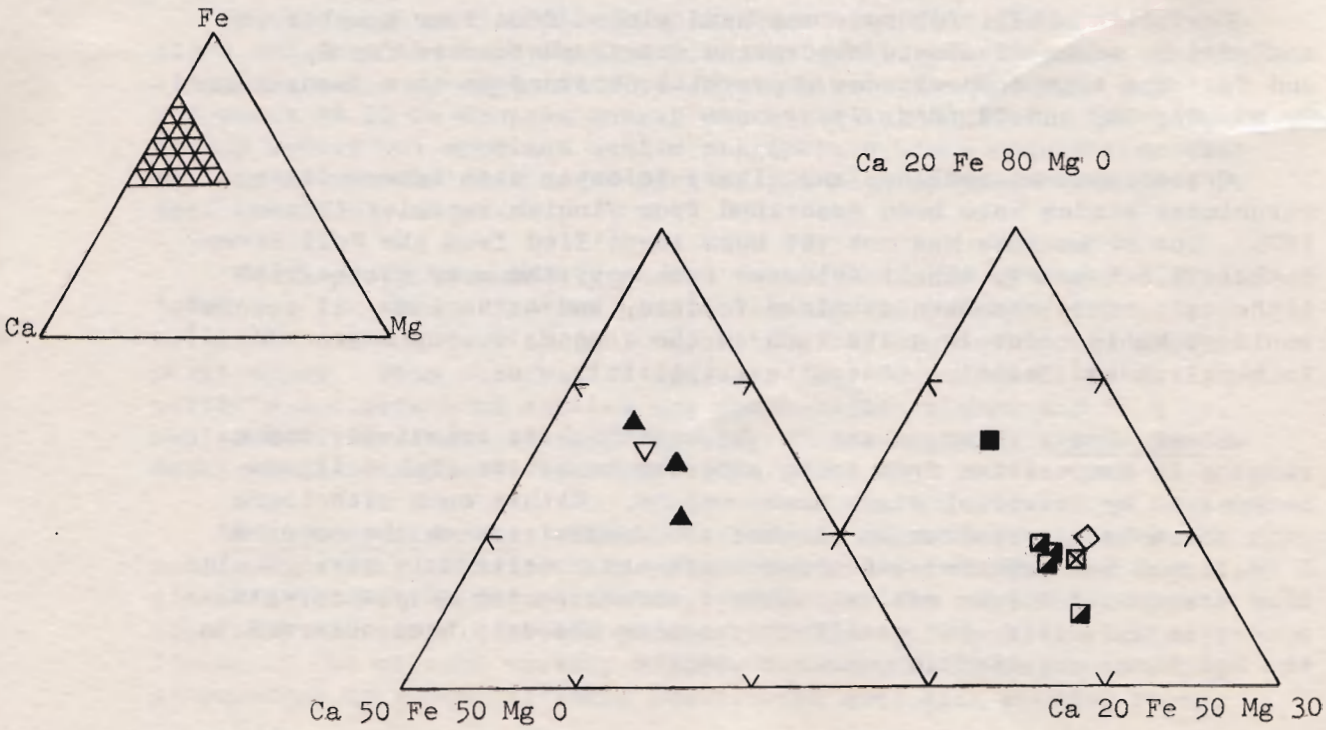


Figure 6. Composition of amphibole from the Wolf River batholith. (Symbols listed in Table 1)

The hastingsitic hornblende in the Wolf River batholith is closely similar in chemical composition to ferrohastingsite from Finnish rapakivi described by Simonen and Vorma (1969).

Anhydrous mafic minerals. Olivine, clinopyroxene, orthopyroxene, amphibole, and biotite occur in the Peshtigo monzonite and trachyandesite, where olivine is generally surrounded by pyroxene or amphibole, and pyroxene, by amphibole. Electron probe analyses have only been completed for olivine from one specimen, yielding an iron-rich composition of Fa 92.2 to 92.8. However, it is evident from optical properties that olivine from other specimens, and pyroxenes as well, will prove to be iron-rich when analyzed by electron probe.

Similar iron-rich olivine from green and gray varieties of Finnish rapakivi have been described by Simonen (1961).

Alkali feldspar. The Wolf River batholith is characterized by hypersolvus granite and quartz monzonite, in which pink, perthitic alkali feldspar is the predominant mineral. A variety of perthitic textures are exhibited, including film, vein, and patch perthites, as well as combinations of these. In general, alkali feldspar in granite contains larger amounts of perthite and more extensively developed grid twinning than does alkali feldspar in quartz monzonite.

To date, alkali feldspar has been examined in detail from only four units, including Belongia granite, Hager rhyolite, Hager feldspar porphyry, and Wolf River granite and quartz monzonite. X-ray study of nine specimens, utilizing the method described by Wright and Stewart (1968), reveals that the host portion of perthitic alkali feldspar in these units consists of maximum microcline with compositions of Or 99 to 100, except for two specimens that yielded values of Or 95 and 97.

Perthitic alkali feldspar was hand picked from four samples and analyzed by means of atomic absorption spectrophotometer for K, Na, and Ca. The bulk compositions of perthite obtained in this fashion are Or 83, 77, 76, and 72 (Fig. 7).

Orthoclase, microcline, and alkali feldspar with intermediate structural states have been described from Finnish rapakivi (Vorma, 1971), but orthoclase has not yet been identified from the Wolf River batholith. However, alkali feldspar from only the more silica-rich lithologic units has been examined to date, and orthoclase, if present, would probably occur in units such as the Waupaca quartz monzonite (wiborgite) and Peshtigo monzonite (tirilite).

Plagioclase. Plagioclase in the batholith is relatively sodic, ranging in composition from sodic andesine to albite (Table 4), as determined by universal stage measurements. Within each lithologic unit there is a variation in plagioclase composition on the order of 5 to 15 mol % anorthite, and phenocrysts are consistently more calcic than associated matrix grains. Slight normal zoning of phenocrysts occurs in all units, but oscillatory zoning has only been observed in the Red River porphyritic quartz monzonite.

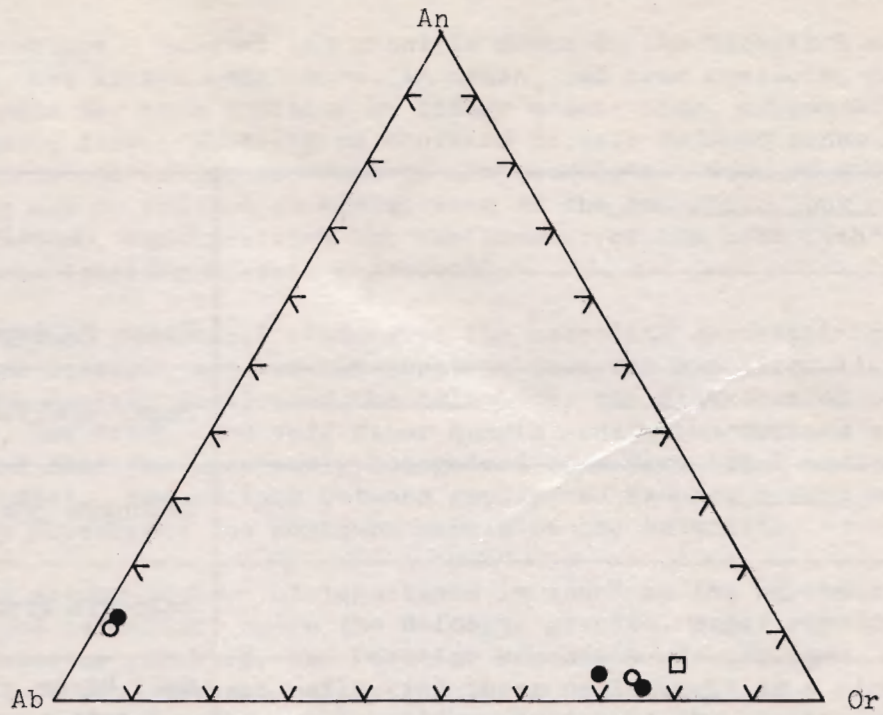


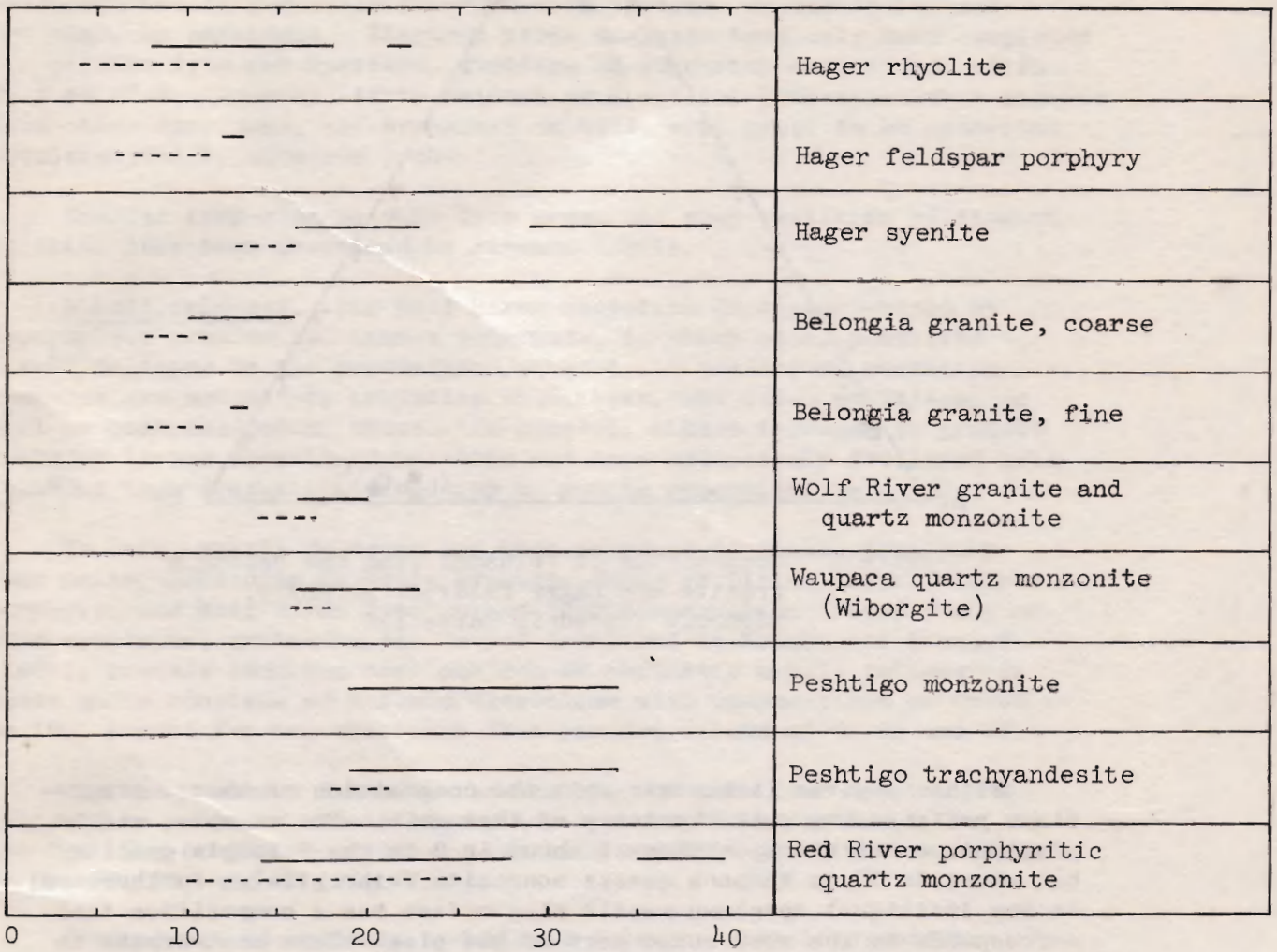
Figure 7. Composition of feldspar from the Belongia granite and Hager feldspar porphyry. (Symbols listed in Table 1)

Within a given lithologic unit the composition of mantle plagioclase reflects the bulk chemistry of that unit. For example, mantle plagioclase has a composition of about An 9 in the Belongia granite, but about An 23 in Waupaca quartz monzonite (wiborgite). Furthermore, in any individual specimen mantle plagioclase has a composition that corresponds to the most sodic part of the plagioclase phenocrysts in that specimen.

Patch perthite commonly occurs within the core of mantled alkali feldspar. In this situation plagioclase in the parch perthite is optically continuous with and compositionally similar to the mantle plagioclase. This observation suggests that formation of patch perthite and growth of mantles are genetically related and that replacement of alkali feldspar by plagioclase may play a role in the development of rapakivi texture.

Accessory minerals. Fluorite, zircon, magnetite, ilmenite, rutile, apatite, allanite, and sphene are present in various combinations in the Wolf River batholith. Fluorite, the most ubiquitous accessory mineral, is also common in the Finnish rapakivi granites. Zircon is the malacon variety (Tyler, and others, 1940), consisting of euhedral to subhedral zoned overgrowths enclosing rounded cores.

Table 4. Composition of plagioclase from the Wolf River batholith



Phenocrysts or large grains
Matrix grains

STRUCTURE AND CONTACT RELATIONS OF THE BATHOLITH

Structure. Many of the granitic rocks in the batholith are massive, but within some units, in dikes, and near contacts, feldspar phenocrysts may have a planar or linear orientation, presumably due to magmatic flow. Shearing is confined to well defined zones along the eastern and western borders of the batholith. Some of this shearing may be related to emplacement of the batholith, but some may be later than, and unrelated to, emplacement of the batholith (LaBerge, field trip locality 8, this guidebook).

Although structural studies of the batholith are still in progress, two major features are readily apparent from the map (Fig. 1). In the south-central portion of the batholith, the distribution of the Waupaca, Red River, and Wolf River quartz monzonites defines a major ENE trend that was previously recognized on a more local scale by Borst (1958). The contact between gneiss and Waupaca quartz monzonite probably represents the southern margin of the batholith.

The second feature of importance is found at the northeastern end of the batholith, where the Belongia granite, Hager rhyolite, Hager feldspar porphyry, and Peshtigo monzonite are arranged in an arcuate pattern, perhaps reflecting their emplacement in a ring complex. Such an interpretation is supported by the distinctly porphyritic textures and high-level characteristics of the lithologic units involved. In addition, metasedimentary rocks that occur in the postulated ring complex dip steeply and have strikes that are concordant to the arcuate arrangement of the enclosing igneous rocks. (Ring structures occurring in rocks of similar age occur in the Wausau area, LaBerge and Myers, this guidebook.)

Internal contacts of the batholith. Contacts between different lithologic units within the batholith have been found so far in only a few places, with the following relations:

1. Peshtigo monzonite and trachyandesite have been intruded by dikes of Belongia granite at High Falls reservoir on the Peshtigo River and on the Oconto River near Mountain.

2. A foliated, gradational zone about six inches thick occurs between the Hager rhyolite and feldspar porphyry. The feldspar porphyry is believed to represent a border phase of the rhyolite.

3. Dikes of Red River porphyritic quartz monzonite intrude the Wolf River quartz monzinite at several localities along the Wolf River.

4. The contact between the Wolf River quartz monzonite and Belongia granite is inferred to be gradational, because of the change in lithologic and mineralogic character displayed by the Wolf River quartz monzonite in proximity to the Belongia granite, as summarized previously.

External contacts of the batholith. In the northeastern part of the batholith there are several well exposed contacts where the Belongia granite and Hager feldspar porphyry intrude metavolcanic and metasedimentary rocks. In all cases the contacts are sharp and discordant, and chilled margins are commonly present in the intrusive rocks.

On the basis of textures and mineral assemblages, much of the contact metamorphism induced by intrusion of the granitic rocks can be assigned to the hornblende hornfels facies. However, the discovery of the apparently stable assemblage, quartz-biotite-muscovite-potassium feldspar-andalusite, in a specimen of pelitic metasedimentary rock suggests that conditions of the pyroxene hornfels facies may have been attained locally. Scapolite is relatively abundant in the contact metamorphic rocks, attesting to the halogen-rich nature of the batholith.

CONCLUSIONS

The purpose of this paper has been to point out the existence of a major rapakivi massif in northeastern Wisconsin and to describe its petrologic and mineralogic characteristics. It seems appropriate, in conclusion, to offer a working hypothesis for the origin of this batholith and to outline the direction of future studies.

Any scheme for the origin of the Wolf River batholith must take into account the following features:

1) hypersolvus quartz monzonite and granite constitute the bulk of the batholith,
2) the batholith is epizonal in nature,
3) the compositions of granitic members of the batholith plot near the granite minimum in terms of normative Q-Ab-Or, but are displaced toward Or,
4) there is extensive mantling and replacement of alkali feldspar by plagioclase ranging in composition from albite to oligoclase,
5) hydrous mafic minerals tend to be interstitial with respect to quartz and feldspar, and
6) there is an apparent late-stage growth of biotite at the expense of alkali feldspar.

We suggest that the Wolf River batholith may have originated from a quartz monzonitic parent magma, initially undersaturated with H_2O, that was derived by partial melting of pre-existing crustal material. An average value of 0.705 for $(^{87}Sr/^{86}Sr)_o$ in the batholith precludes derivation from older granitic crust but is compatible with an origin from an older terrain of basic and intermediate volcanic and plutonic material, such as that in northeastern Wisconsin. For example, partial melting of Athelstane quartz monzonite or Hoskin Lake granite (mean Rb/Sr, 2.5; $(^{87}Sr/^{86}Sr)_o$, 0.7021) after a period of 350 million years would produce a rock with an initial strontium isotope ratio of 0.714. However, the older terrain in northeastern Wisconsin contains an abundance of basic to intermediate volcanic rocks and chemically equivalent plutonic rocks, and values of Rb/Sr for this crustal material would be much less than 2.5 (Peterman, and others, 1967; Hart, and others, 1970).

If the mean value of Rb/Sr were 0.6 or less in such crustal material, partial fusion after a period of 350 million years would yield a rock with an initial strontium isotope ratio like that in the Wolf River batholith.

Future investigation of the Wolf River batholith will include:

1) additional mineralogical studies that should enable us to evaluate intensive parameters, such as T, P_{Total}, f_{H_2O}, f_{O_2}, and f_F, and
2) detailed chemical studies of major, minor, and trace element contents in the batholith that should provide constraints on the mode of origin of this rapakivi massif.

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PRECAMBRIAN GEOLOGY OF MARATHON COUNTY

by

Gene LaBerge* and Paul E. Myers**

INTRODUCTION

The Wisconsin River Valley in central Wisconsin constitutes the southernmost extent of the continuously exposed Canadian Shield. Available radiometric ages indicate that these rocks are mainly of late Middle Precambrian age (Dutton and Bradley, 1970, and Van Schmus, this guidebook), yet the character of these rocks, their relationship to one another and to Precambrian rocks of other parts of the Lake Superior region has been largely unknown.

The only comprehensive account of the regional geology of north central Wisconsin, including Marathon County was published by Weidman (1907). He recognized many of the major aspects of the geology, although his work was mainly reconnaissance in nature. The geology of the Wausau-Wisconsin Rapids area was examined in 1917 to 1921 as part of a land classification survey of the Wisconsin Geological and Natural History Survey (W.G.N.H.S.). These data are on file in Madison. An unpublished W.G.N.H.S. report by Emmons and Snyder (1944), and geophysical studies by Vickers (1956), Allingham and Bates (1961) and Henderson, Tyson, and Page (1963) cover parts of Marathon County. Selected aspects of the geology in central Wisconsin were presented as the topics for field trips by Emmons (1953), LaBerge and Weis (1968) and Weis and LaBerge (1969). Theses prepared at the UW-Madison and at UW-Milwaukee have also dealt with certain aspects of the geology. Recent cooperative work by the U.S.G.S. and the W.G.N.H.S. to compile the geological and geophysical data on the Precambrian of Wisconsin was published by Dutton and Bradley (1970), and Dutton (1971) showed some volcanic-sedimentary belts and sulfide occurrences in Wisconsin.

In 1969 the W.G.N.H.S. initiated a program of regional mapping of the Precambrian in Marathon County at a scale of 1:24,000. Approximately twelve $7\frac{1}{2}$ minute quadrangles (about half of Marathon County) have been mapped to date. Progress reports and data maps of this work have been placed on open file by the Survey (LaBerge 1969, 1971, LaBerge and Myers 1972, 1973). This field work has provided much new data and has identified a number of problems in the area.

Some of these problems are included as stops on this field trip. Tentative interpretations of the geology of some of these areas are presented below. However, we emphasize that the interpretations are based almost entirely on field relations, with little petrographic work, and almost no chemical or isotopic studies. Therefore, the interpretations presented here may be subject to change as additional field and laboratory studies are completed.

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General Geology

The Wausau region in Marathon County west of the Wolf River granite batholith is characterized by a northeast-trending patchwork of folded and block faulted (?) mafic to felsic volcanic rocks which have been intruded and mylonitized during succeeding plutonic and deformational events. The plutonic rocks were intruded in the generalized sequence: (1) gabbro-anorthosite(?), (2) diorite-quartz diorite, (3) quartz monzonite, (4) syenites, and (5) granite. The granite is cut by ENE-trending diabase dikes. Some granitic intrusions, such as the Granite Heights granite, evidently predate this sequence, as indicated by the fact that it has been mylonitized in zones along which some of the younger plutons were intruded. Peterman (1970) established a 1600 m.y. age for the Granite Heights granite, and 1450 m.y. for the Wausau pluton. Thus, these ages are consistent with the field relations. Some of the plutonic units are intrusive breccias; their contacts tend to be highly contaminated and are commonly mylonitized. Strongly discordant contacts, abundant, well-oriented xenoliths, and absence of middle to high grade metamorphic wallrocks except as rafted xenoliths suggests lower epizonal emplacement. NE and ENE-trending shear zones appear to converge in a broad mylonite zone near and parallel to the western margin of the Hogarty hornblende granite (Wolf River batholith).

Volcanic Rocks

Volcanic rocks occur as large masses, generally separated by shear zones and/or plutons. The volcanic rocks are basaltic to rhyolitic and trachytic. The mafic volcanics include pillowed, massive, and fragmental units and associated sediments. The intermediate volcanics are less chloritic and more commonly fragmental than the "basaltic" varieties. The predominantly pyroclastic, felsic volcanics include tuffs, welded tuffs, lahars and associated volcaniclastic sediments. East of the Wisconsin River (nearer the western batholith contact) the volcanic segments have a northeasterly strike as evidenced by lithologic trends and magnetic "lines" on township maps (W.G.N.H.S. Land Classification Maps). West of the Wisconsin River their trend is more northwesterly. No stratigraphic base to the volcanics has yet been recognized.

It is not yet known whether the various "blocks" of volcanic rocks are dismembered segments of a once-continuous sequence (a volcanic-sedimentary "greenstone" belt) or whether they represent different volcanic episodes. The answer may not be forthcoming from field work alone.

Plutonic Rocks

Hogarty Hornblende Granite: (Stop 8) The largest mass of plutonic rocks mapped is the "Hogarty hornblende granite" which underlies eastern Marathon County. This pluton probably extends eastward to the Tigerton Anorthosite mass in Shawano County, is lithologically indistinguishable from the coarser part of the Wolf River quartz monzonite (Medaris, Anderson, and Myles, this guidebook), and locally intrudes volcanic rocks along its western margin. It is mylonitized along the Little Eau Claire River.

Other Felsic Plutons: Several other felsic plutons have been intruded into the volcanic complex. They include the Kalinke quartz monzonite, the Granite Heights granite, which intrude volcanics north and east of Wausau, and are cut by several shear zones. A granite aplite intrusion of, as yet, undetermined size extends southwest from Marathon City. A leucocratic granite, which interrupts the Eau Claire River mylonite zone and cuts gneissosity in the Hogarty hornblende granite, occurs south of Callon.

Alkalic Plutons; Wausau, Stettin: The larger (17 x 8 mile) Wausau pluton (Stop 9) is elliptical in plan and comprises: (1) a core of younger hornblende-biotite granite (Ninemile granite), (2) a semicircular intermediate zone of quartz syenite containing large lensoidal quartzite and schist xenoliths, and (3) a crescentic north rim of xenolith-rich pyroxene-amphibole-syenite. The southwest rim of the pluton is breached by the Ninemile granite which "spills out" to form a nearly circular mass to the southwest. Abundant xenoliths are found in the granite where the "xenolith circle" should close. Although the Ninemile granite intrudes the syenite, the contact between the two is gradational. In general, where the syenite intrudes mafic volcanic rocks it is alkalic, and where it intrudes more siliceous volcanics and sediments it is granitic.

The nearly contiguous, smaller (5 x $3\frac{1}{2}$ mile) Stettin pluton (Stop 10) to the northwest is more alkalic and has more pronounced concentric structure. A border zone comprises gneissic nepheline syenite and tabular syenite. A more massive intermediate zone of coarse amphibole-bearing syenite has swirled flow structures. The core margin (1 mile diameter) of nepheline syenite is donut-shaped, rich in magnetite, and encloses a core of massive, gray pyroxene-amphibole syenite.

Although elongated northeasterly these two alkalic plutons interrupt several major shear zones, and appear to have been "punched up" through rocks having a pronounced northeast structural grain. They are probably the roots of volcanoes, and their concentric structure must be due in part to caldera collapse.

Mafic Intrusive Masses: Several small mafic bodies separated by granitic rocks occur southeast and south of Wausau. The largest mass is a gabbro body which interrupts the Eau Claire River mylonite zone near Callon. Smaller blocks of quartz diorite, gabbro, hornblendite, altered pyroxenite, and anorthosite enclosed mainly in leucogranite extend southwest from the Callon gabbro. Inclusions of pyroxenite and layered gabbro occur in diorite-quartz diorite southwest of Mosinee. It is possible that these mafic rocks are uprafted fragments of an older, subjacent, differentiated gabbro-anorthosite pluton. (Stop 11).

Diorite, quartz diorite, and quartz monzonite intricately intrude volcanic rocks in the region northwest of Marathon City. Alignment of metavolcanic xenoliths is northeasterly.

Structural Geology

Shear zones are the dominant structural feature in Marathon County. The major zones comprise a wide variety of sheared rocks, including gneisses, schists, and mylonites. Nature of displacement across these zones is unknown. Several shear zones extend completely across Marathon County and an unknown distance beyond. The most conspicuous shear zone mapped thus far is the N30°S Eau Claire River zone (Stop 8) which parallels, and in places is coincident with, the western margin of the Hogarty hornblende granite (Wolf River Pluton). Other shear zones approximately parallel to this trend are present farther west in Marathon County, but none appears to be equal in volume of rock affected to the Eau Claire River zone. Thus, intensity of shearing seems to diminish westward away from the batholitic front.

Lithology of rocks in shear zones, which varies along and across strike, is probably controlled by mineralogy and texture of the original rock, intensity of shearing, temperature and partial pressure of H_2O during shearing, and post-shearing history of the rock. Mafic rocks are converted to banded amphibolites or chloritic phyllonites. Granitic rocks are converted to augen gneisses, phyllonites, and mylonites. From map scale to thin section, shear zones are characterized by interlensing slip planes.

Several small plutons have intruded shear zones. For example, gabbro and leucogranite interrupt the Eau Claire River zone near Callon. Shear zones with approximately the same trend also occur northeast and southwest of the discordant Stettin pluton. The Granite Heights granite and Kalinke quartz monzonite have been sheared and therefore are probably pre-kinematic (or pre-shearing).

Most of the Precambrian rocks in Marathon County have been repeatedly sheared and intruded by magmas of widely differing compositions. The shear zones evidently provided channelways for some of the intrusions. The relationship of shearing to intrusion of the many small plutons and the emplacement of the Wolf River batholith (Hogarty hornblende granite) remains one of the major problems in the Precambrian geology of Marathon County.

Major Problems

Many major problems remain. Some of the more important ones are listed below in the hope that they may stimulate discussion and research.

Shear Zones - Cataclasis:

1. How are cataclastic rocks best classified and mapped?

2. Can mylonites be dated? How?

3. How are type and amount of displacement determined?

4. What, if any, are the time and space relationships between shearing and magmatic intrusion?

Plutonic Geology:

1. Depth and mechanisms of emplacement?

2. Which plutons are comagmatic?

3. Relations between plutons and volcanics (e.g. syenite - trachyte near Brokaw)?

4. When and how were the syenites intruded? Subvolcanic?

5. Significance of xenoliths - orientation and lithologic variation? Are they uprafted samples of subjacent older terranes?

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Field Guide to the Precambrian Geology of Northeastern and Northcentral Wisconsin

Locality 1: Quinessec volcanics in northeastern Wisconsin
G. Mursky and G.I. Hall

Locality 2: Athelstane pink quartz monzonite and Amberg gray quartz monzonite
L.G. Medaris, Jr., W.R. Van Schmus, M.M. Lahr, J.R. Myles, and J.L. Anderson

Locality 3: Belongia granite and Peshtigo trachyandesite
L.G. Medaris, Jr., J.R. Myles, and J.L. Anderson

Locality 4: The Hager rhyolite and feldspar porphyry and geology of the Mountain area
M.M. Lahr, L.G. Medaris, Jr., and W.R. Van Schmus

Locality 5: The Wolf River quartz monzonite
L.G. Medaris, Jr., J.L. Anderson, and W. R. Van Schmus

Locality 6: The Red River porphyritic quartz monzonite
L.G. Medaris, Jr., J.L. Anderson, and W.R. Van Schmus

Locality 7: The Tigerton anorthosite
L.W. Weis

Locality 8A: Eau Claire Dells County Park
8B: Contact between Wolf River batholith and mafic volcanics
G.L. LaBerge

Locality 9: Wausau quartz syenite-Old Technical Institute
P.E. Myers

Locality 10: Stettin syenite pluton-wall zone
P.E. Myers

Locality 11: Sheared quartz diorite intrusive breccia
P.E. Myers

Additional Locality: Gabbroic Masses and leucogranite
G.L. LaBerge

In pocket

Plate 1 Field trip itinerary and geologic map of the Precambrian terrain in northeastern and northcentral Wisconsin, scale, 1:500,000

Plate 2 Preliminary geologic map of the Iron Mountain Sheet, Wisconsin, scale, 1:250,000

Plate 3 Preliminary geologic map of the Green Bay Sheet, Wisconsin, scale, 1:250,000

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Field Trip Locality 1

TITLE:

Quinessec Volcanics in Northeastern Wisconsin

LOCATION:

Center, sec. 1, T.37N., R.20E., Marinette County

AUTHORS:

Gregory Mursky, Department of Geological Sciences, UW-Milwaukee
George I. Hall, Hudson Bay Mining & Smelting Ltd., Calgary

DATE:

February 1, 1973

SUMMARY OF FEATURES:

Northeastern part of Marinette County in northeastern Wisconsin is underlain by Quinessec volcanics which consist of pillowed and fragmental basalts, massive basalts, amygdaloidal basalts, myrmekitic basalts and a very small percentage of tuffs and rhyolites (Fig. 1). The volcanics display shearing as a dominant structural feature with two distinct trends at N60°E and S60°E and signs of regional metamorphism which varies from quartz-albite-epidote-chlorite subfacies, away from the granitic intrusions to quartz-albite-epidote-almandine subfacies near the Hoskin Lake granite (Hall, 1971).

The Quinessec volcanics have chemical characteristics comparable to the Archean volcanic assemblages from the Superior Province of the Precambrian Shield in Manitoba, Ontario, and Quebec, and thus show the following similarities:

(1) Nigli silica: alkali values from Quinessec volcanics, when plotted in reference to oceanic alkaline and orogenic calc-alkaline curve of Wilson (1965), plot in the same orogenic calc-alkaline field as suites from the Superior Province (Fig. 2).

(2) The cation equivalent percent of An-Ab-Or for Quinessec volcanics is quite similar to Goodwin's (1968) Archean assemblages from the Superior Province (Fig. 3).

A plot of oxide ratios relative to stratigraphic thickness (Fig. 4) does not show any pronounced chemical trends although there appear to be three separate zones within the pillowed and fragmental basalts.

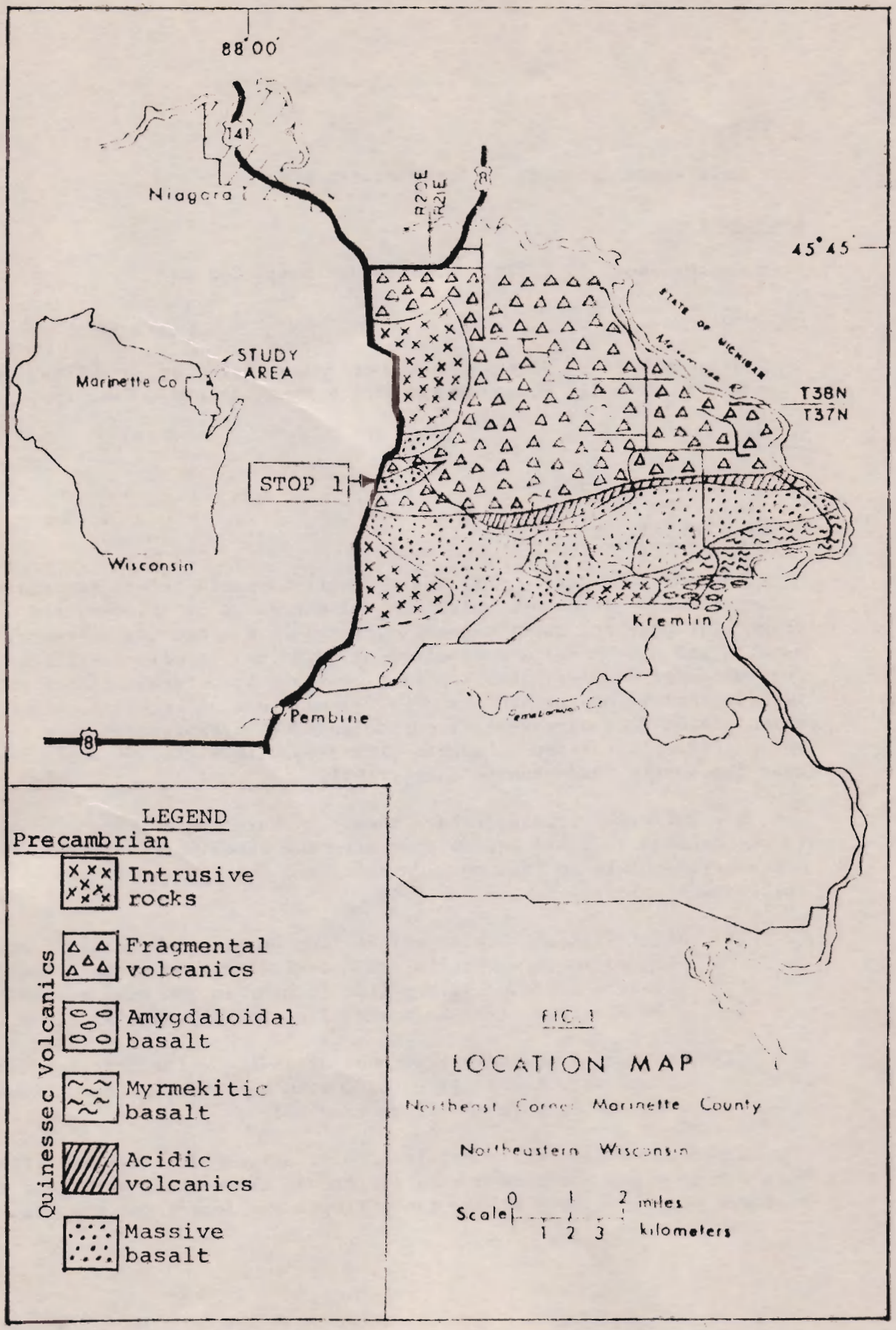

FIG. 1

LOCATION MAP

Northeast Corner Marinette County

Northeastern Wisconsin

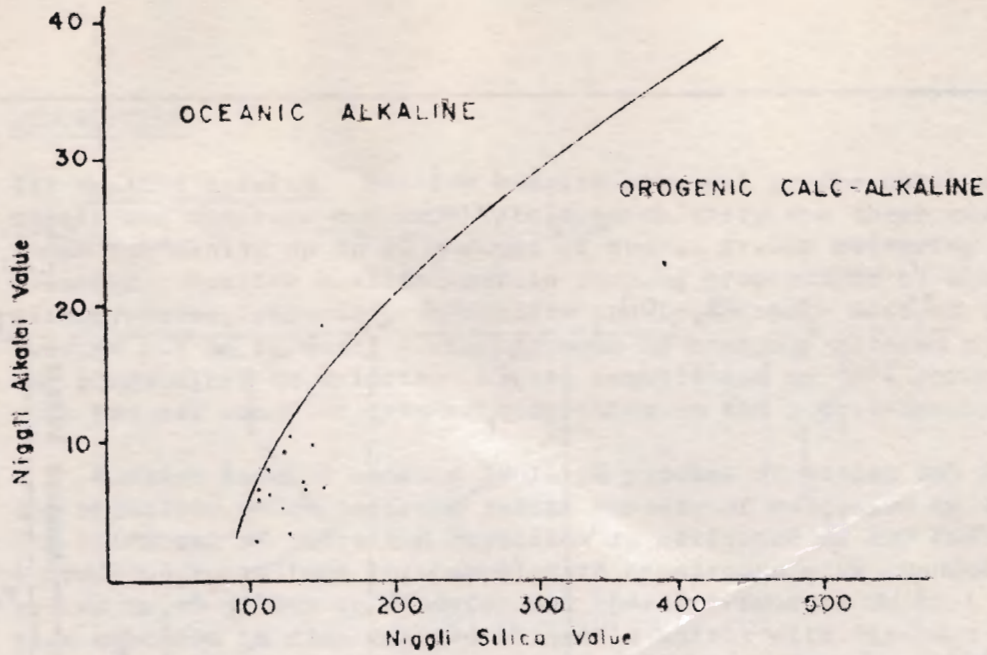

Figure 2. Plot of Niggli silica-alkali values of analyzed basic and acidic volcanic rocks in NE Marinette County, Wisconsin. A comparison is made with Wilson's (1965) standard curve separating oceanic alkaline rocks from orogenic calc-alkaline rocks. (After Hall, G. I., 1971)

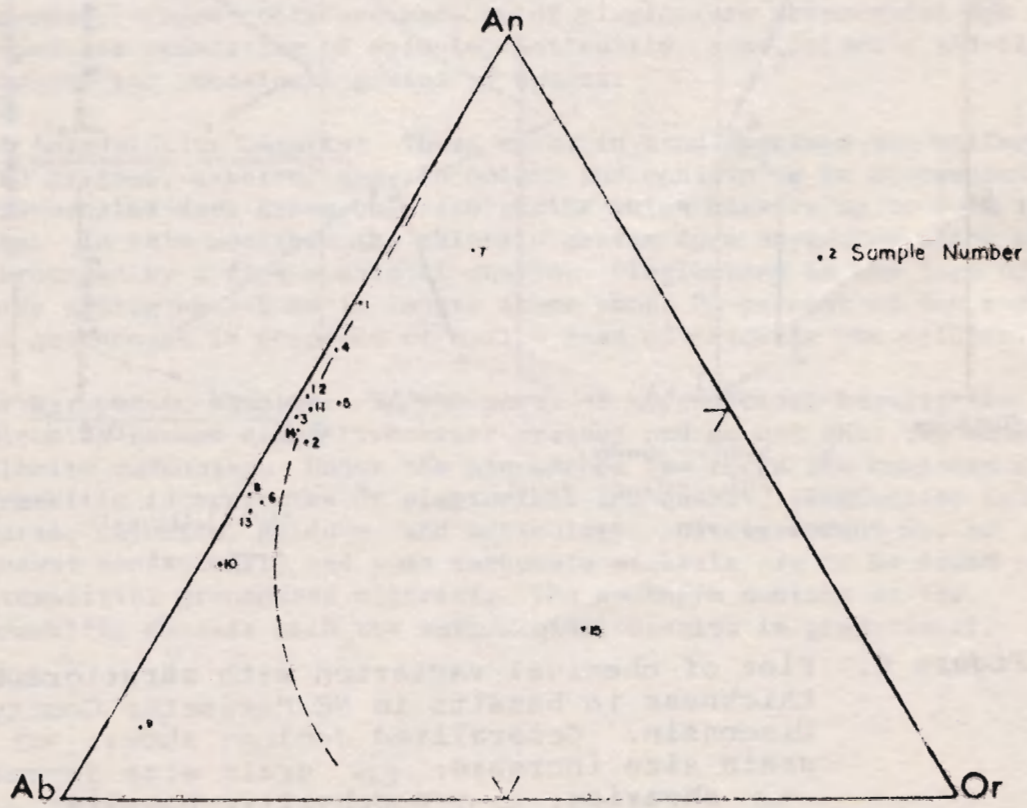

Figure 3. Cation equivalent percent Ab-An-Or in basic and acidic volcanic rocks in NE Marinette County, Wisconsin. Dashed curve is Goodwin's (1968) trend for three Archean volcanic assemblages in the Superior Province of the Canadian Shield. (After Hall, G. I., 1971)

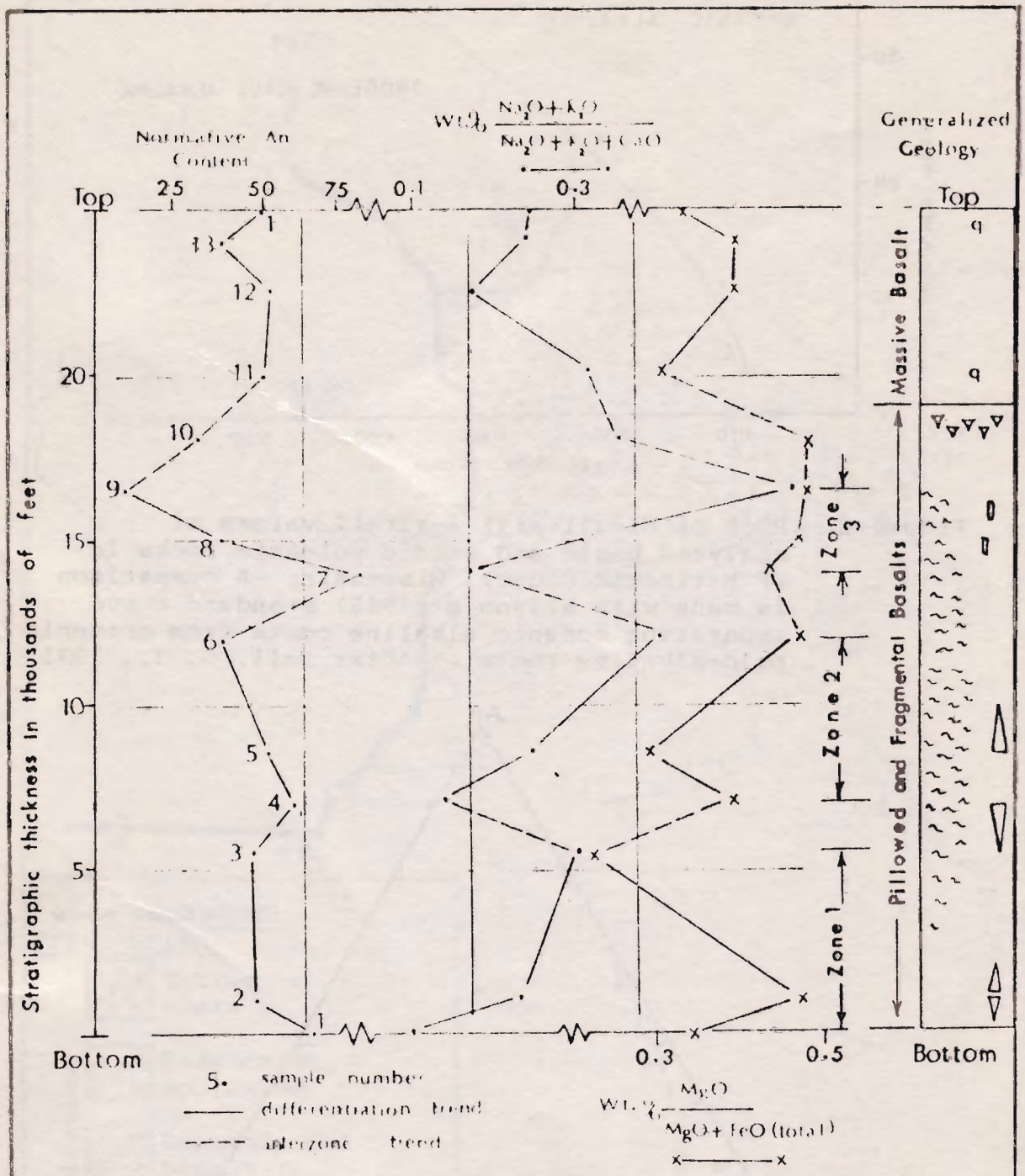

Figure 4. Plot of chemical variation with stratigraphic thickness in basalts in NE Marinette County, Wisconsin. Generalized geology shows: ◁ grain size increase; ▷ grain size decrease; ~~ shearing; ▭ ▭ porphyritic basalts; △ △ fragmental basalts; q modal quartz. (After Hall, G. I., 1971)

DESCRIPTION:

(1) Massive basalts: Massive basalts crop out to the north of myrmekitic basalt and comprise one unit within which there are three quartz-rich zones containing up to 10 percent of quartz grains measuring 0.15 mm in diameter. Massive basalts contain varying proportions of albite, epidote, clinopyroxene, chlorite, actinolite and leucoxene. Most of these minerals average 0.2 mm in size. Clinopyroxene is commonly altered to actinolite and plagioclase to epidote. Pyrite constitutes up to 1 percent of the rock but may occur in greater quantities in the quartz-basalt zones.

Massive basalts contain isolated patches of welded ash flow tuffs and rhyolites which indicate acidic variety of volcanism in this region. The thickness of tuffs and rhyolites is estimated at 400 feet. The tuffaceous rocks tend to show clastic appearance with rounded quartz grains up to $\frac{1}{4}$ inch in diameter and cherty fragments up to 1 inch in size embedded in fine grained chloritic matrix with distinct shards which have devitrified to quartz and feldspar. The rhyolites are dark gray to black and very fine grained and contain quartz, orthoclase, cherty material and plagioclase.

(2) Pillowed and fragmental basalt: Rocks to the north of massive basalts are fragmental and pillowed with well developed shearing and flow structures. The fragments are mostly angular, at times elongated, and measure up to 5 inches in length. The pillows, where present, are deformed. These rocks are made up of plagioclase phenocrysts and a groundmass consisting of epidote, actinolite, some chlorite and clinopyroxene and occasional grains of quartz.

(3) Amygdaloidal basalts: These rocks in hand specimen are uniformly fine grained, massive, gray in color, and contain up to 20 percent of disseminated dark green chlorite grains which measure up to $\frac{1}{2}$ mm in size. In thin sections the chlorite grains form amygdules which are surrounded by a fine mosaic of quartz. Plagioclase in the form of laths averaging 1-2 mm in length forms about 30 percent of the rock. The groundmass is composed of a fine mass of chlorite and epidote.

(4) Myrmekitic basalts: To the north of amygdaloidal basalts the volcanics become slightly coarser grained and do not show the abundant chlorite amygdules. Under the microscope the rocks are composed of myrmekitic intergrowths of plagioclase and quartz, plagioclase laths, quartz, chlorite, epidote, and actinolite. Clinopyroxene may be present occasionally and some carbonate minerals are to be found as interstitial groundmass material. The southern contact of the myrmekitic basalts with the amygdaloidal basalts is gradational.

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Field Trip Locality 2

TITLE:

Athelstane pink quartz monzonite and Amberg grey quartz monzonite

LOCATION:

NW$\frac{1}{4}$, SW$\frac{1}{4}$, sec. 10, T.35N., R.20E., Marinette County

AUTHORS:

L.G. Medaris, Jr., UW-Madison; W.R. Van Schmus, Univ. of Kansas; M.M. Lahr, Cotter Corp., Colorado; J.R. Myles, Univ. of California-Santa Barbara; and J.L. Anderson, UW-Madison

DATE:

Summer, 1972 to March, 1973

SUMMARY OF FEATURES:

Dikes of Amberg grey quartz monzonite are intrusive into Athelstane pink quartz monzonite.

DESCRIPTION:

Granitic rocks in the Athelstane-Amberg area originally were given the name Amberg granite by Cain (1963), and pink and grey varieties subsequently were recognized by Cain and Beckman (1964). Banks and Cain (1969) reported an age of 1860 ± 15 m.y. (U-Pb, zircon) for a sample of pink Amberg granite and presented a map on which Amberg granite (pink) and a separate Amberg granodiorite (grey?) were distinguished.

Field mapping has established that the grey variety is predominant in the vicinity of Amberg, occurring in four distinct plutons, and that the pink variety has a wide distribution, being particularly abundant in the Athelstane area (Plates 1 and 2). Because of the geographic distribution of the two lithologies, we propose that the pink variety be called the Athelstane pink quartz monzonite and the grey variety, the Amberg grey quartz monzonite.

An age of 1810 ± 50 m.y. (Rb-Sr, whole rock isochron) has been obtained for the Athelstane pink quartz monzonite, in good agreement with the age of 1860 m.y. given by Banks and Cain (1969). Preliminary isotopic data suggest that the Amberg grey quartz monzonite is younger possibly being 1640 to 1670 m.y. in age.

At this locality Athelstane pink quartz monzonite is intruded by dikes of Amberg grey quartz monzonite, thus confirming the relative age of these rock types indicated by isotopic dates. About $\frac{1}{2}$ mile to the east, extensive areas of Amberg quartz monzonite are exposed in quarries.

The Athelstane quartz monzonite has a medium- to coarse-grained, allotriomorphic granular texture, contains both biotite and hornblende, and has a distinctive appearance due to the presence of pink perthitic microcline and white plagioclase (An 23-28). Biotite from five specimens yielded values of 100xFe/Fe+Mg from 71 to 78, but two other samples gave values of 85 and 91. Amphibole is hastingsitic hornblende or magnesian hastingsitic hornblende. Foliation is common in this unit, as are recrystallization textures, such as aggregates of quartz grains with mosaic outlines. Saussuritization of plagioclase is widespread, and epidote is usually associated with biotite and hornblende.

The Amberg grey quartz monzonite has a medium- to fine-grained, hypidiomorphic granular texture. Although hornblende occurs in a few samples, biotite is by far the most abundant mafic mineral. Values of 100xFe/Fe+Mg of 67 and 69 have been obtained for biotite from two specimens. As in the Athelstane quartz monzonite, foliation and recrystallization textures are common in the Amberg. Plagioclase (An 22-39) is extensively saussuritized, biotite is partially altered to chlorite, and epidote is present in plagioclase and associated with biotite.

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Field Trip Locality 3

TITLE:

Belongia granite and Peshtigo trachyandesite

LOCATION:

NW$\frac{1}{4}$, sec. 1, T.32N., R.18E., Marinette County, west end of High Falls Dam

AUTHORS:

L.G. Medaris, Jr., UW-Madison; J.R. Myles, Univ. of California-Santa Barbara; and J.L. Anderson, UW-Madison

DATE:

Summers, 1971 and 1972

SUMMARY OF FEATURES:

Peshtigo trachyandesite has been intruded by Belongia granite. A syenitic border phase of the Belongia occurs at contacts between granite and trachyandesite and as veinlets in the trachyandesite.

DESCRIPTION:

Belongia granite and Peshtigo trachyandesite are in contact at this locality, but we were initially puzzled by the rather ambiguous relations displayed here. However, after examination of thin sections, chemical analysis of rock and mineral specimens, and discovery of more explicit Belongia-Peshtigo outcrops near Mountain, we believe that the Belongia granite has intruded the Peshtigo trachyandesite and that the syenitic rocks occurring here are a border phase of the Belongia.

In thin section the Belongia granite is typical in appearance, consisting of euhedral to subhedral phenocrysts of alkali feldspar and quartz in a fine-grained matrix of biotite, quartz, and feldspar. Granophyric texture, a characteristic feature of the fine-grained Belongia granite, is present at the margins of alkali feldspar phenocrysts. In contrast, the Peshtigo trachyandesite clearly shows evidence of recrystallization. Relict feldspar phenocrysts are set in a fine-grained granoblastic matrix, and the phenocrysts are surrounded by a well-defined rim that is intergrown with minerals of the matrix. In addition, anhedral poikiloblastic hornblende and biotite are scattered throughout the matrix. Thus, thin section study suggests that the Peshtigo has been recrystallized, presumably due to intrusion by the Belongia.

The occurrence of syenite at contacts between the Belongia and Peshtigo and as veinlets cutting the Peshtigo, suggest that the syenite is a border phase of the Belongia. Chemical analyses demonstrate that the composition of syenite is intermediate between that of granite and trachyandesite (Table 1), but analyses of biotite and amphibole (Table 2) reveal that Fe-Mg ratios are higher for mafic minerals from granite and syenite than for those from trachyandesite. Although development of the syenite could have been due partly to contamination of granite by reaction with trachyandesite, perhaps reflected in the TiO_2 content of the syenite (Table 1), Luth and Tuttle (1969) have shown experimentally that a syenitic border phase may form in a granite due to vapor transport of material between the crystallized margin of an intrusive body and the interior portion, still partially molten.

Syenite has been observed at several other localities where Belongia granite has intruded either Peshtigo monzonite or Waupee volcanics. For example, Belongia granite is clearly intrusive into Peshtigo monzonite in a railroad cut near Mountain (at the boundary between secs. 14 and 23, T.31N., R.16E., Oconto County), where granite grades over several inches into a syenite zone 18 inches thick that has a sharp contact against Peshtigo monzonite.

Table 1. Electron probe analyses of Belongia granite, Belongia border phase, and Peshtigo trachyandesite

	1	2	3	4
SiO_2	76.8	65.2	68.3	57.8
TiO_2	0.21	0.70	0.64	1.45
Al_2O_3	11.62	15.31	14.28	16.60
Fe_2O_3*	3.20	6.67	4.48	10.80
MnO	0.03	0.02	0.05	0.12
MgO	0.10	0.57	0.63	1.36
CaO	0.75	1.52	1.74	4.07
Na_2O	3.16	3.66	3.76	4.49
K_2O	5.15	6.69	5.73	4.35
Total	101.02	100.40	99.61	101.04

* Total Fe as Fe_2O_3

1 Belongia granite, TM 2C

2 Syenitic veinlet in Peshtigo trachyandesite, TM 2B

3 Average of two analyses, Belongia border phase at localities near Mountain, 171.2G and 69 M2

4 Peshtigo trachyandesite, PP3

Table 2. Electron probe analyses of biotite and amphibole from Belongia granite, Belongia border phase, and Peshtigo trachyandesite

	1	2	3	4	5
SiO_2	34.07	34.17	37.81	40.97	41.40
TiO_2	0.92	3.72	2.81	1.92	1.59
Al_2O_3	14.26	13.22	13.07	8.37	8.81
FeO*	34.96	34.98	33.18	32.07	28.91
MnO	--	--	--	0.95	0.74
MgO	0.74	1.02	3.23	1.06	3.85
CaO	--	--	--	9.76	10.00
Na_2O	--	--	--	1.75	1.76
K_2O	8.59	8.61	9.12	1.33	1.45
Total	93.54	95.72	96.22	98.18	98.51

* Total Fe as FeO

$\frac{100 \times Fe}{Fe + Mg}$	96.4	95.1	85.2	94.5	80.8

1 Biotite from Belongia granite, TM 2C

2 Biotite from syenitic veinlet, TM 2B

3 Biotite from Peshtigo trachyandesite, PP1

4 Amphibole from syenitic veinlet, TM 2B

5 Amphibole from Peshtigo trachyandesite, PP1

REFERENCE

Luth, W.C., and Tuttle, O.F., 1969, The hydrous vapor phase in equilibrium with granite and granite magmas: Geol. Soc. Amer. Mem. 115, p. 513-548.

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Field Trip Locality 4

TITLE:

The Hager rhyolite and feldspar porphyry and geology of the Mountain area

LOCATION:

NE$\frac{1}{4}$, SE$\frac{1}{4}$, sec. 1, T.31N., R.16E., Oconto County

AUTHORS:

L.G. Medaris, Jr., UW-Madison; W.R. Van Schmus, Univ. of Kansas; and M.M. Lahr, Cotter Corp., Colorado

DATE:

Summers, 1971 and 1972

SUMMARY OF FEATURES:

Relations between the upper member of the Waupee formation, Baldwin conglomerate, Hager rhyolite, and Hager feldspar porphyry are illustrated at this locality. A sketch map and outline of the geologic history of the Mountain area are presented.

DESCRIPTION:

GEOLOGY OF THE MOUNTAIN AREA

A complex Precambrian history is preserved in the Mountain area, including the following events, from oldest to youngest:

1. Deposition of the Waupee formation, consisting of volcanic flows and agglomerates and volcaniclastic, tuffaceous, calcareous, and quartz-feldspar sedimentary rocks.

2. Emplacement of the Macauley gneiss (granodiorite to quartz monzonite) with attendant contact metamorphism.

3. Deformation and metamorphism (Events 2 and 3 may have been contemporaneous).

4. Emplacement of the Hines quartz diorite and contact metamorphism of older rocks.

5. Erosion and subsequent deposition of the Baldwin conglomerate, which contains clasts of Waupee metavolcanics and metasediments, Macauley gneiss, and quartzite.

6. Emplacement of the Wolf River batholith (1450-1500 m.y.), including the Peshtigo monzonite, Hager syenite, feldspar porphyry, and rhyolite, and Belongia granite, with contact metamorphism of older rocks.

The Waupee formation dips steeply and strikes about N55E. Relict graded bedding and cross-stratification consistently indicate that tops of beds are to the north; there is no evidence for repetition of beds within the Waupee formation.

The Waupee formation has been divided into three units (Fig. 1): a basal member consisting of metavolcanic and volcaniclastic metasedimentary rocks, a middle metasedimentary member, and an upper tuffaceous metasedimentary member. Within the basal member, basalt is the predominant type of volcanic rock, but andesite and rhyolite occur toward the top of the unit. Chemical analyses of 18 specimens demonstrate that the volcanic rocks belong to a calc-alkaline sequence and could have originated in an island arc setting (Lahr, 1972).

Metamorphic assemblages in the Waupee formation have not been completely evaluated yet because of complexities introduced by overlapping metamorphic events. Most specimens display assemblages characteristic of amphibolite facies metamorphism, but garnet, idocrase, scapolite, and andalusite of contact metamorphic origin occur in rocks of appropriate composition near the Belongia granite and Hager rhyolite and feldspar porphyry.

FIELD TRIP LOCALITY

In the woods south of County Highway W are outcrops of tuffaceous metasedimentary rocks in the upper member of the Waupee formation. On the north side of the highway are outcrops of Baldwin conglomerate. The highest, most prominent outcrop in this area consists of Hager feldspar porphyry, and an intrusive contact between feldspar porphyry and Baldwin conglomerate is exposed along the southern base of the outcrop. On the north side of the prominent outcrop a gradational contact between Hager rhyolite and feldspar porphyry is exposed.

REFERENCE

Lahr, M.M., 1972, Precambrian geology of a greenstone belt in Oconto County, Wisconsin and geochemistry of the Waupee volcanics: M.S. Thesis, Univ. Wisconsin, Madison.

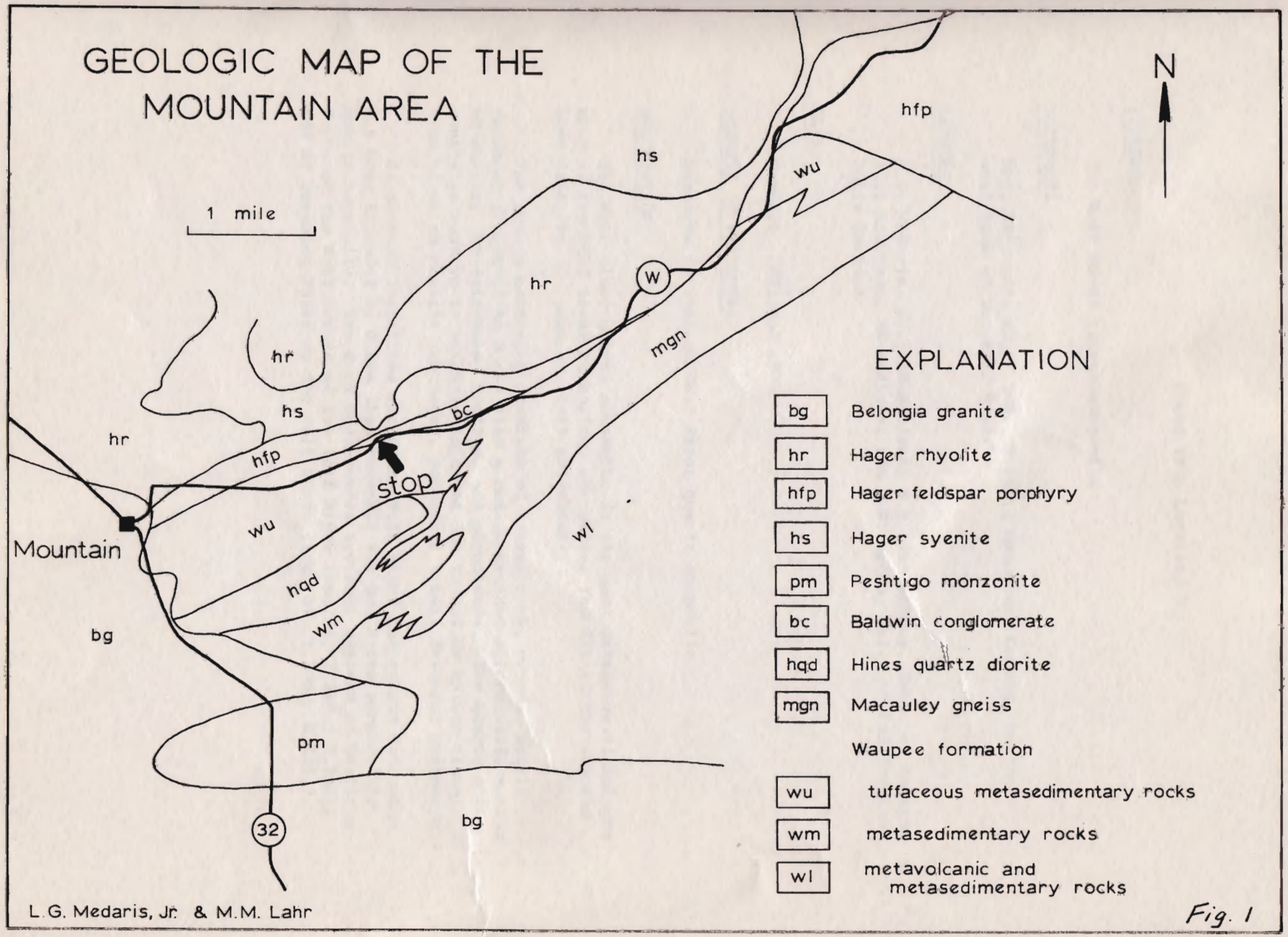
GEOLOGIC MAP OF THE MOUNTAIN AREA
N
1 mile
hfp
hs
wu
hr
W
mgn
hr
hs
bc
hr
hfp
stop
Mountain
wu
wl
hqd
wm
bg
pm
32
bg
EXPLANATION
bg Belongia granite
hr Hager rhyolite
hfp Hager feldspar porphyry
hs Hager syenite
pm Peshtigo monzonite
bc Baldwin conglomerate
hqd Hines quartz diorite
mgn Macauley gneiss
Waupee formation
wu tuffaceous metasedimentary rocks
wm metasedimentary rocks
wl metavolcanic and metasedimentary rocks
L.G. Medaris, Jr. & M.M. Lahr

Fig. 1

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Field Trip Locality 5

TITLE:

The Wolf River quartz monzonite

LOCATION:

NE$\frac{1}{4}$, SE$\frac{1}{4}$, sec. 22, T.28N., R.15E., Menominee County, on the west bank of the Wolf River

AUTHORS:

L.G. Medaris, Jr., UW-Madison; W.R. Van Schmus, Univ. of Kansas; J.L. Anderson, UW-Madison; and J.R. Myles, Univ. of California-Santa Barbara

DATE:

Summers, 1971 and 1972

SUMMARY OF FEATURES:

Exposure of typical Wolf River quartz monzonite.

DESCRIPTION:

The Wolf River quartz monzonite is the most extensive lithologic unit in the Wolf River batholith, accounting for 51% of the exposed area (see Fig. 1, page 10, this guidebook).

The quartz monzinite consists of large, pink, ovoidal alkali feldspar grains (1 to 3 cm) with a medium-grained interstitial matrix of quartz, two feldspars, biotite, and hornblende. The quartz monzonite is massive to slightly foliated and is cut by aplite dikes, some of which contain scattered, subhedral alkali feldspar phenocrysts.

At several localities along the Wolf River the quartz monzonite has been intruded by dikes that resemble the Red River porphyritic quartz monzonite. Two such occurrences are well exposed at Beartrap Falls on the West Branch of the Wolf River (sec. 4, T.28N., R.15E.) and at Ducknest Falls on the Wolf River (sec. 27, T.30N., R.15E.).

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Field Trip Locality 6

TITLE:

The Red River porphyritic quartz monzonite

LOCATION:

SW$\frac{1}{4}$, SE$\frac{1}{4}$, sec. 2, T.27N., R.14E., Shawano County, on the Red River

AUTHORS:

L.G. Medaris, Jr., UW-Madison; W.R. Van Schmus, Univ. of Kansas; and J.L. Anderson, UW-Madison

DATES:

Summer, 1972

SUMMARY OF FEATURES:

Exposure of typical Red River porphyritic quartz monzonite

DESCRIPTION:

The Red River porphyritic quartz monzonite constitutes 20.6% of the exposed area of the Wolf River batholith and is located in an ENE-trending belt between the Wolf River quartz monzonite and the Waupaca quartz monzonite (see Fig. 1, page 10, this guidebook).

At this locality the quartz monzonite consists of 10 to 20% subhedral alkali feldspar phenocrysts (0.5 to 2.0 cm in length) in a medium-grained matrix (1 to 2 mm) of idiomorphic to subhedral quartz, two feldspars, and biotite. The quartz monzonite displays a prominent foliation due to alignment of feldspar phenocrysts.

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Field Trip Locality 7

TITLE:

The Tigerton Anorthosite

LOCATION:

NW$\frac{1}{4}$, SW$\frac{1}{4}$, SW$\frac{1}{4}$, sec. 23, T.27N., R.12E., Shawano Co., Middle Branch Embarrass River & Co. Road J.

AUTHOR:

L. W. Weis, UW Center System-Fox Valley

DATES:

Summers, 1962, 1963, 1972.

SUMMARY OF FEATURES:

Contact relationship of the Tigerton anorthosite.

DESCRIPTION:

The Tigerton anorthosite may cover 125 sq. mi. in western Shawano Co. Most exposures are anorthosite, hornblende anorthosite, biotite anorthosite, or gabbroic anorthosite; a few are anorthositic gabbro. The plagioclase ranges from An_{32} to An_{64}, with most of it An_{45} to An_{56}. Grain size of the plagioclase is variable; 5 cm. grains are common and grains up to 20 cm. occur in porphyritic parts. There is local foliation. Hornblende is the most conspicuous mafic mineral. Biotite is second. At some localities pyroxene occurs as cores within hornblende, occasionally it is discreet. Ilmenite/magnetite are common, with ilmenite far more abundant than magnetite. Locally, as in the SW$\frac{1}{4}$, NE$\frac{1}{4}$, Sec. 33, T.28N R11E, these affect the compass.

The Tigerton anorthosite outcrops always include granitic material. The anorthosite exposures generally are small with the largest continuous masses exposed only about 35 meters long. The contact with the Wolf River batholith is sharp, both megascopically and microscopically.

The composition of the plagioclase by outcrops has a median value of An_{53}, with only one outcrop having an average over An_{56} (An_{60}). The larger common inclusions in the plagioclase are hematite, hornblende, biotite, ilmenite and magnetite. Very fine rods of these plus rutile also occur commonly in the 010 plane.

The most common twin is the Albite twin. Pericline and Carlsbad twins are common, the latter has reentrant angles. External optical scatter occurs. Grain size reflects cataclastic deformation, with some outcrops, e.g. SW$\frac{1}{2}$, Sec.11, T27N, R11E, appearing almost layered.

Reference

Weis, L. W., 1965, The Origin of the Tigerton Anorthosite. U. Wis., unpubl. Ph.D Dissertation.

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Field Trip Locality 8A

TITLE:

Eau Claire Dells County Park

LOCATION:

SW$\frac{1}{4}$, sec. 7, T.29N., R.10E., Marathon County

AUTHOR:

Gene L. LaBerge, UW-Oshkosh

DATE:

Summers 1970, 1971, 1972

SUMMARY OF FEATURES:

Eau Claire Dells is on the western margin of the Wolf River batholith, consisting of a large expanse of relatively homogeneous "granite". This is in marked contrast to the volcanic rocks with a myriad of small plutons and large scale shearing which characterizes the geology of Marathon County mapped by LaBerge and Myers.

A major shear zone which strikes approximately N30°E occurs at or near the western edge of the Wolf River batholith (informally called the Hogarty hornblende granite by LaBerge, 1971). This shear zone is particularly well exposed at Eau Claire Dells, where it is more than a mile wide and consists mainly of mylonite. However, the zone has been mapped for about 30 miles along strike, and reconnaissance to the southwest indicates that it probably continues for at least another 10 miles. A number of other shear zones parallel to this trend have been recognized farther west in Marathon County. The magnitude and number of these shear zones thus constitute a major aspect of the Precambrian geology of central Wisconsin.

DESCRIPTION:

At Eau Claire Dells county park the exposed rocks are moderately to well banded. The banding dips vertically and strikes approximately N30°E. At the Dells proper (just downstream from the highway bridge) the rocks are relatively fine grained, felsic, and homogeneous, and do not display conspicuous banding. However, further downstream (near the foot bridge) the rocks are more mafic and are more banded. Upstream from the highway bridge the rock is well banded with alternating mafic and felsic lenses and well developed quartz lenses (boudinage structures) evident near the dam. Small garnets are abundant in several zones immediately below the dam on the north side of the river. East of the swimming and picnic area are outcrops of banded amphibolite. Thus,

EXPLANATION
FOR MAPS OF EAU CLAIRE DELLS AREA, MARATHON CO.

Scale 1:24,000

cd	Cary drift; terminal moraine.
m	Mylonite and related cataclastic rocks.
kqm	Kalinke quartz monzonite.
hhg	Hogarty hornblende granite.
d	Diabasic intrusions.
mv	Mafic volcanics (locally metagabbro and amphibolite).
	Outcrops, or outcrop areas
	Geological contacts
△	Rockpiles
⚒	Quarries

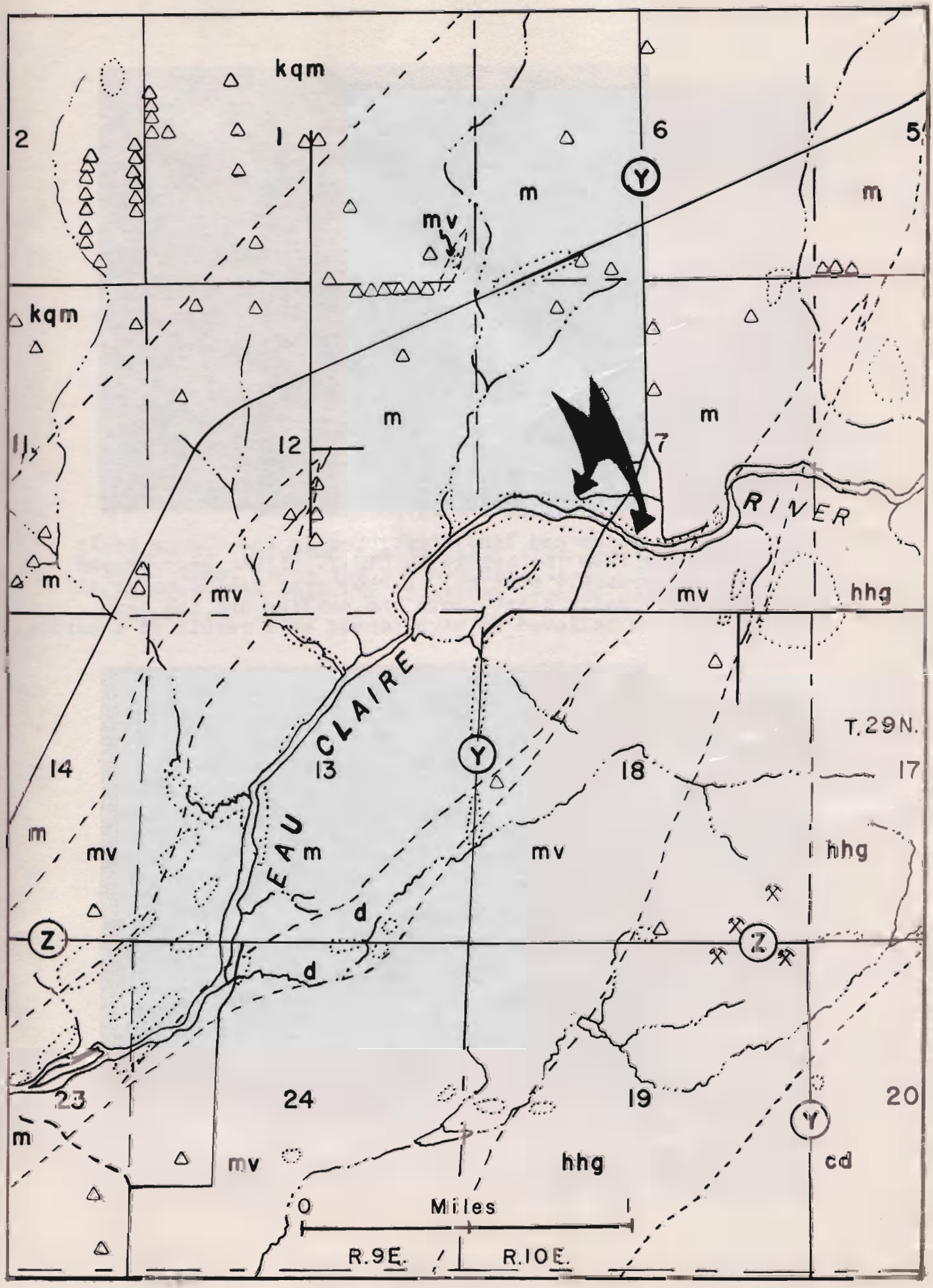

kqm
2
1
6
5
Y
m
mv
kqm
m
m
11
12
7
RIVER
m
mv
mv
hhg
EAU CLAIRE
T.29N.
14
13
Y
18
17
m
mv
m
mv
hhg
Z
d
Z
d
23
24
19
20
Y
m
mv
hhg
cd
0
Miles
1
R.9E.
R.10E.

Figure 1. Banding and lens-structures in Eau Claire Dells Park upstream from the bridge on CTH-Y. Light gray lenses are quartz, probably boudins. Darker gray banded material is relatively mafic rich. Both the banding and the lens structures are believed to have formed as a result of shearing.

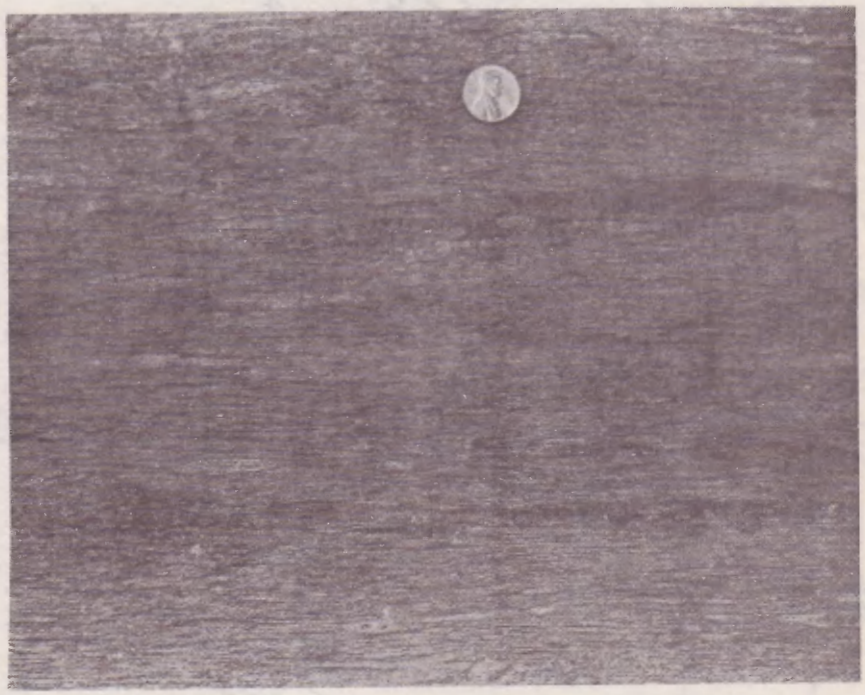


Figure 2. Banding and lens structures in felsic mylonite just downstream from the bridge on CTH-Y. Where the rock is more homogeneous, the banding and lens structures are less obvious, but they are still a common feature.

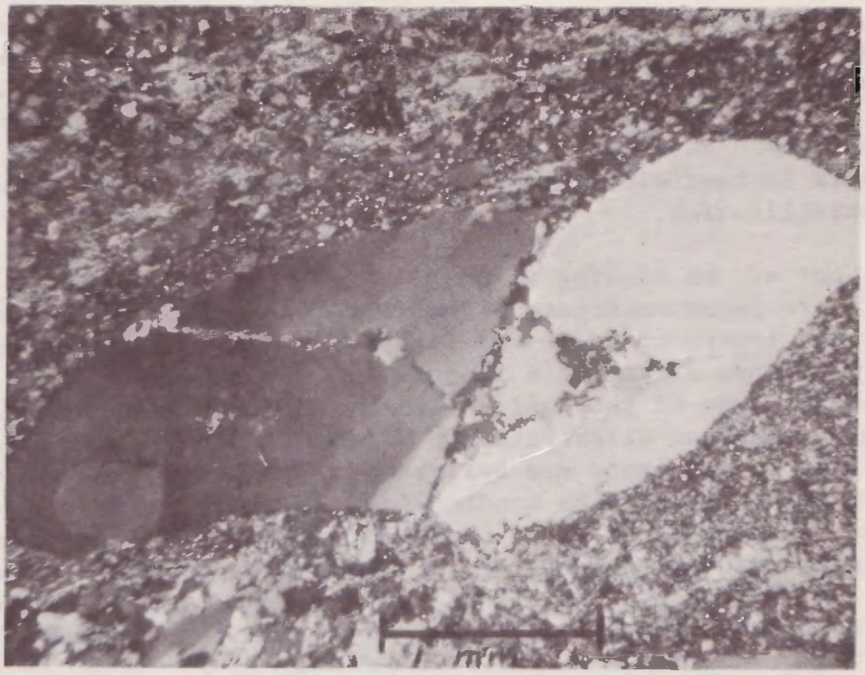


Figure 3. Deformed quartz "eye" from the Eau Claire River shear zone. Note the overall lens shape of the quartz grain, and note also that the fractures produce smaller lens-shaped fragments. X30.

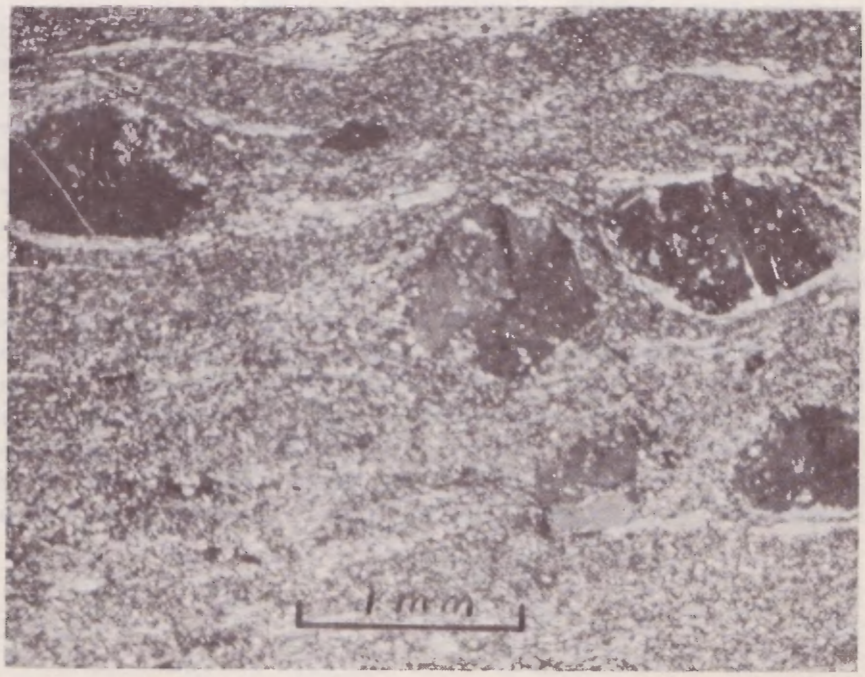


Figure 4. Feldspar "eyes" in a fine grained matrix. Note the lens shape of most of the feldspars and the flow structure of the surrounding groundmass.

the composition of the mylonitic rocks range from "basaltic" on the east to "granitic" in the Center Dells area and back to "basaltic" downstream along this cross-section of the shear zone. Compositional variations are common both along and across the strike of the shear zone with the result of a variation in the appearance and character of the zone. Variations also arise depending upon whether hydrous minerals (micas, etc.) or anhydrous minerals (feldspars) formed during recrystallization.

Most of the banding at Eau Claire Dells and elsewhere along the Eau Claire River zone actually consists of variously flattened and elongated lenses of mafic and felsic material which range in length from more than a mile to a fraction of an inch. Figures 1 and 2 illustrate some of the smaller lenses. Microscopically cataclastic features, such as illustrated in Figures 3 and 4 are common. Thus, the rocks in this zone are believed to have formed tectonically. Shearing may produce the banding (as well as cataclasis) from an initially homogeneous rock, and when a shear zone approaches or crosses a contact between contrasting lithologies the banding may be pronounced. This latter situation is evidently represented by the rocks between the road bridge and the dam upstream.

Field Trip Locality 8B

TITLE:

Contact between Wolf River batholith and mafic volcanics

LOCATION:

NW$\frac{1}{4}$, NE$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 18, T.29N., R.10E., Marathon County

AUTHOR:

Gene L. LaBerge, UW-Oshkosh

DATE:

Summers 1971, 1972

SUMMARY OF FEATURES:

The locality is typical of the contact between the Wolf River batholith (Hogarty hornblende granite) and mafic volcanics. Near the granitic rocks the greenstone has been converted to an amphibolite and, as at this locality, when shearing occurs the amphibolite may be well banded. Although lack of outcrops prevents determining the width of the contact metamorphic effects with certainty, it is recognizable in the field in a zone about one half mile wide.

Although the contact between the "granite" and greenstone is poorly exposed, it was mapped on the basis of lithology of rockpiles. Rockpiles along what is believed to be the contact consist of a mixture of amphibolite (meta-greenstone), granite (commonly pegmatitic), vein quartz and in places metagabbro. Small dikes and veins of granite and vein quartz cutting the amphibolite blocks were observed at a number of places. Rockpiles east of the "contact zone" consisted almost entirely of porphyritic granitic rocks, whereas west of the "contact zone" the rockpiles and small float in fields consisted almost entirely of slabby amphibolite and greenstone. This change in rock type was generally restricted to a 40 acre ($\frac{1}{4}$ mile) width or less, and at least locally the change in lithology takes place on opposite sides of a creek bed. Thus even without outcrops one can locate bedrock contacts quite closely in many (but not all) areas on the basis of the lithology of rockpiles and/or float. Trenches dug for burying telephone cables were especially useful in providing information on underlying bedrock.

EXPLANATION
FOR MAPS OF EAU CLAIRE DELLS AREA, MARATHON CO.

Scale 1:24,000

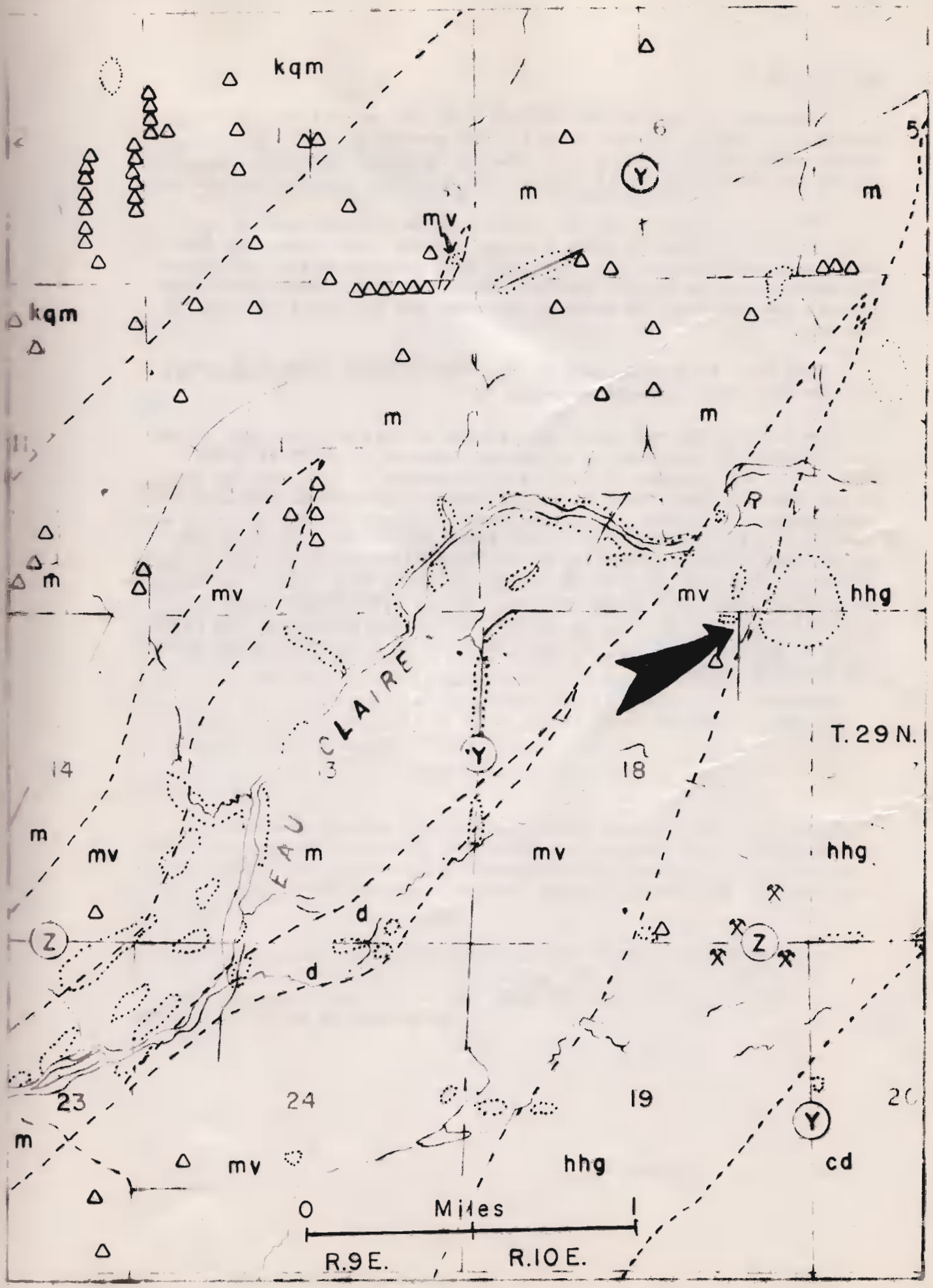
cd	Cary drift; terminal moraine.
m	Mylonite and related cataclastic rocks.
kqm	Kalinke quartz monzonite.
hhg	Hogarty hornblende granite.
d	Diabasic intrusions.
mv	Mafic volcanics (locally metagabbro and amphibolite).

Outcrops, or outcrop areas

Geological contacts

Rockpiles

Quarries


kqm
kqm
m
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hhg
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EAU CLAIRE
T. 29 N.
14
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d
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24
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20
m
mv
hhg
cd
0
Miles
1
R.9E.
R.10E.

DESCRIPTION:

Outcrops of "granite" within 100 feet of the contact are coarse grained and typical of the "granite" for several miles to the east. Indeed the rock is strikingly similar to "granite" throughout much of the Wolf River valley in Shawano and Menominee counties to the east.

The contact itself has not been found in outcrop, but is conveniently in a valley or under a swamp. Along this valley one can find numerous blocks of the "granite" with abundant mafic inclusions. The inclusion-rich blocks, however, evidently form a very narrow zone between the amphibolitic rocks on the west and the granitic rocks on the east.

This stop is also typical in that the plutonic rocks mapped all intrude the older volcanic sequence.

An interesting and important problem in this general area is the relationship of the shearing to the emplacement of the Wolf River batholith. At a number of localities southwest of here one can demonstrate that the Wolf River batholith (Hogarty hornblende granite) has been sheared to produce a gneissic granite, augen gneiss, mylonite and other cataclastic rocks on a rather large scale. This problem will be examined further as mapping by the Wisconsin Geological and Natural History Survey continues to the southwest along this zone. The presence of a major shear zone along the front of the batholithic rocks may indicate that the shearing is related to the emplacement of the batholith, or perhaps that the batholith behaved as a buttress along which the shearing occurred.

Field Trip Locality 9

TITLE:

Wausau quartz syenite - Old Technical Institute

LOCATION:

NE$\frac{1}{4}$, sec. 35, T.29N., R.7E., Marathon County

AUTHOR:

Paul E. Myers, UW-Eau Claire

DATE:

February, 1973

SUMMARY OF FEATURES:

An early, medium-grained pyroxene-amphibole quartz syenite containing NW-oriented quartzite, schist, and volcanic xenoliths is cut by coarser-grained, flow-lineated quartz syenite of similar composition (Figure 1). Average xenolith orientation here is structurally continuous with the concentric lamination of the Wausau syenite pluton whose granite core is in Ninemile Swamp 5 miles southwest of here. "Rootless", lenticular pegmatite with walls of coarse K-feldspar and cores of quartz were probably differentiated from the nearly crystallized syenite at places of greatest quartzite assimilation. Thin screens of biotite schist and quartzite were rafted up(?) and brecciated in the viscous syenite magma (Figure 2).

DESCRIPTION:

According to Weidman (1907, p. 203-208) the "Wausau-type" quartz syenite is composed of alkali feldspars (orthoclase, microcline, albite, and microperthite), barkevikite, hedenbergite, fayalite, biotite, and quartz. Accessories include fluorite, apatite, magnetite, zircon, and allanite(?).

Structures and cross-cutting relations of the syenite phases exposed here typify those seen throughout the crescentic northern rim of the Wausau syenite pluton. They are listed and described below in order of decreasing age.

Figure 1 - Amphibolite (a) xenolith with swirled lineation and thin seams of syenite is cut by coarse pyroxene syenite (psy). Lenticular veins with walls of K-feldspar (Kf) and cores of quartz (q) show mutually cross-cutting relations with an intervening offset along a small fault. Joint coatings are of coarse, sodic amphibole.

1. The oldest rocks here are xenoliths in the syenite. They include thoroughly recrystallized, schistose, amphibolitic metavolcanics(?), quartzite, and virtually unaltered felsic tuff(?). Note that long dimensions of xenoliths tend to be parallel to lamination and/or foliation and that, despite lithologic disparity, their mutual alignment imparts a distinct structural "grain" to the enclosing syenite - a factor believed to be of considerable significance in working out emplacement mechanisma for this pluton.

2. An early, fine-grained, flow-laminated lensoidal quartz syenite may represent a chilled phase.

3. Coarse-grained, flow-lineated pyroxene-amphibole quartz syenite cuts the fine-grained phase with sharp discordance. This unit contains irregular, lensoidal and tabular inclusions of amphibolite, schist, and quartzite most of which show little assimilation. Although most of these inclusions show northwesterly elongation, the enclosing quartz syenite displays highly discordant flow-lineation with swirls and eddies suggesting considerable turbulence and viscosity in the quartz syenite magma. After gaining access to the xenolith along its banding or schistosity, the magma pulled loose segments from its surface. With increasing magma/xenolith ratio the xenoliths became plastic and were strongly deformed in the flowing magma. Quartzite xenoliths appear to have been more readily plasticized presumably because of lower melting point. A screen of schistose metadiabase(?) crosses the south end of the outcrop. Its thin western end shows plastic deformation and "pull-outs", whereas its more brittle eastern end is segmented into many angular fragments (Figure 2).

4. Late-stage, lenticular granite pegmatite veins with quartz cores probably represent residual liquid segregations along incipient contraction fractures in the already crystallized syenite. They appear to be "rootless" and of local derivation - perhaps from zones of abnormally high quartzite assimilation.

5. Coarse, sodic amphibole crystallized along joint surfaces.

Figure 2 - Segmented metadiabase(?) screen in flow-banded, quartz syenite.

It is suggested that many of the structures in the syenites and quartz syenites of the Wausau pluton indicate forceful, subvolcanic injection of dry, viscous syenite magma. Careful structural analysis may in time reveal the mechanisms of magma flow and xenolith mixing within the magma. Do the xenoliths, for instance, represent fragments from a fault breccia formed initially during caldera collapse and later invaded by upwelling syenite magmas?

REFERENCE

Weidman, Samuel, 1907, The geology of north central Wisconsin: Wisconsin Geological and Natural History Survey, Bulletin XVI.

Field Trip Locality 10

TITLE:

Stettin syenite pluton - wall zone

LOCATION:

NW corner, Stettin Rd. & C.T.H. O: SE$\frac{1}{4}$, sec. 22, T.29N., R.6E., Marathon County

AUTHOR:

Paul E. Myers, UW-Eau Claire

DATE:

February, 1973

SUMMARY OF FEATURES:

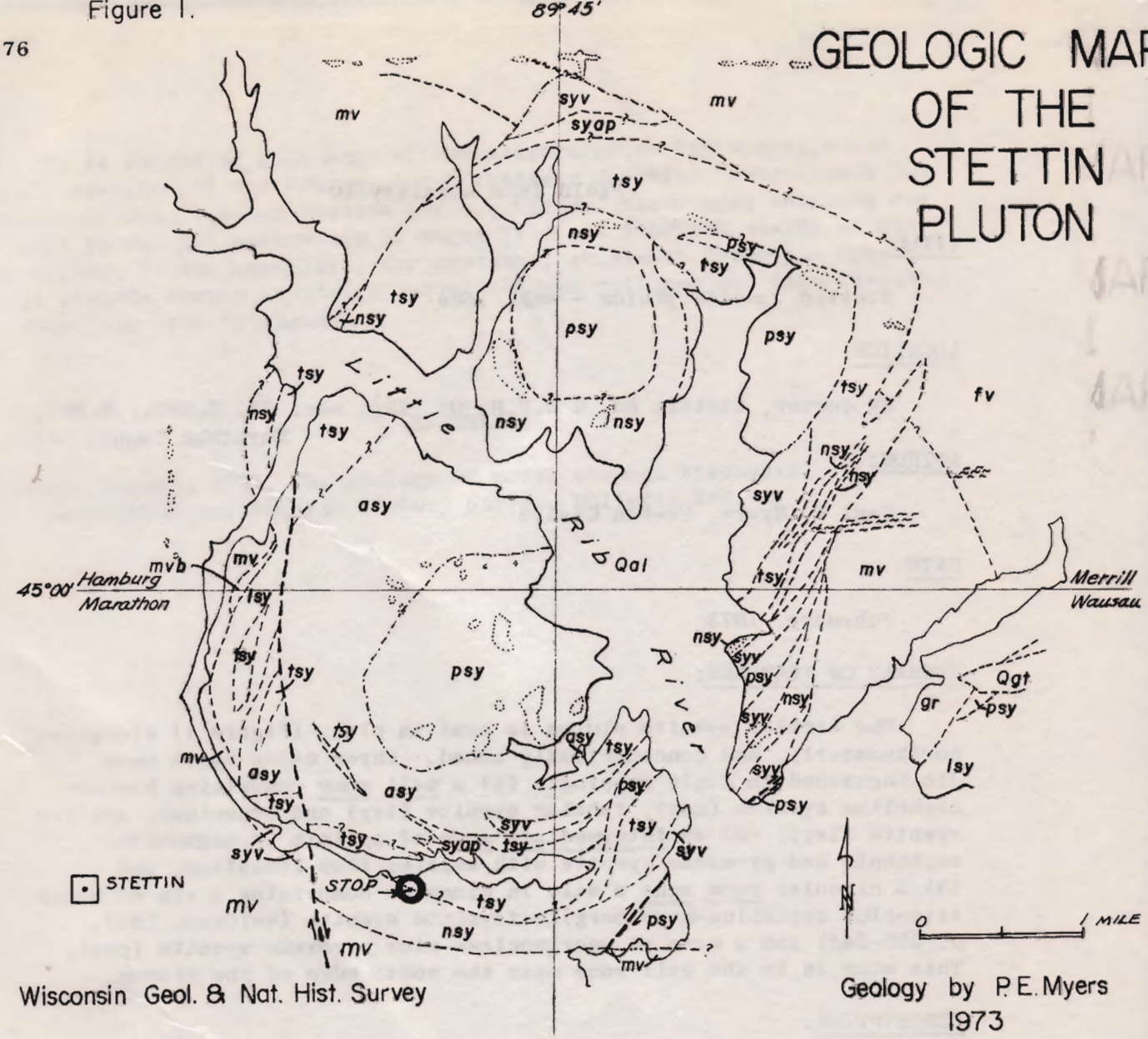
The Stettin syenite pluton is oval in plan, (Figure 1) elongate northeasterly, and concentrically zoned. Three major zones were distinguished in field mapping: (1) a wall zone comprising banded nepheline syenite (nsy), tabular syenite (tsy) and lensoidal, aplitic syenite (lsy), (2) an intermediate zone of aplitic to pegmatitic amphibole and pyroxene syenite with swirled flow lineation, and (3) a circular core zone a mile in diameter comprising a rim of magnetite-rich nepheline-hedenbergite-fayalite syenite (Weidman, 1907, p. 235-245) and a core of anorthoclase-rich pyroxene syenite (psy). This stop is in the wall zone near the south edge of the pluton.

DESCRIPTION:

The contact between banded nepheline syenite and tabular syenite strikes east-northeasterly across the abandoned zircon mine property at this location.

According to Weidman (1907, p. 235-264) the nepheline syenite here is composed mainly of anorthoclase, microperthite, nepheline, aegirine, sodalite ± sodic amphibole (arfvedsonite) and brown mica (lepidomelane). Accessories include zircon (unusually abundant here), fluorite, apatite, (red) thorogummite, cancrinite, clinochlore(?) and allanite(?). Compositional banding in the nepheline syenite is strongly contorted: feldspar crystals were locally lenticulated and segmented by mylonitization during emplacement of the pluton. Mafic bands and lenses in the nepheline syenite suggest derivation from contiguous mafic volcanics to the south.

Figure 1.



EXPLANATION

Quaternary	Qal	Alluvium
	Qgt	Till
	UNCONFORMITY	
Precambrian	gr	Granite
	psy	Pyroxene syenite
	asy	Amphibole syenite
	syap	Syenite aplite
Precambrian	tsy	Tabular syenite
	nsy	Nepheline syenite
	lsy	Lensoidal syenite
	syv	Syenitized volcanics
	mvb	Brecciated mafic volcanics
	fv	Felsic volcanics
	mv	Mafic volcanics

Figure 2A

Figure 2B

Porphyroblastic(?) tabular syenite with mafic lenses (Fig. 2A) in a matrix of alkali feldspar and interstitial sodic pyroxene and amphibole. With increase in mafic content, the tabular syenite becomes poikilitic (Fig. 2B)

Figure 3 -- Tabular syenite with abundant mafic lenses. Note parallel alignment of feldspars in mafic lenses and serrated margins. (3/4 x)

Figure 4 -- Detail of mafic tabular syenite from NE$\frac{1}{4}$ Sec. 22, T.29N.,R.6 E. Porphyroblasts(?) of microperthite (white) Black crystals are sodic amphibole.

Zircons and some thorogummite may be collected from pegmatitic phases of the nepheline syenite along the pit wall and just west of the mill headframe, where a jig table was set up to separate zircons. Please stay out of the building as it is very dilapitated.

The tabular syenite at this location (Weidman, 1907, p. 255-264) is pale orange with long, slender porphyroblasts (?) of gray microperthite and mafic lenses (Figure 2A). Smaller feldspar laths are pinkish. The feldspar crystals show considerable size variation in this rock. Why? All are in planar array so that the rock is banded but not conspicuously lineated. Some of the microperthite porphyroblasts(?) contain zoned mafic inclusions and some have mafic rims. Concordant mafic lenses (altered mafic volcanic xenoliths) are composed of sodic amphibole, brown mica, and green pyroxene and contain perthite porphyroblasts(?) of similar size, shape, and orientation to those in the enclosing pink syenite - a feature strongly suggesting metasomatic origin of the microperthite. Tabular syenite $1\frac{1}{2}$ mile east of here consists dominantly of poikilitic sodic pyroxene and amphibole (Figure 2B). At another location 0.8 mile north-northwest of here the tabular syenite contains much more abundant mafic lenses (Figure 3). Some boulders at this same location are composed entirely of this mafic rock (Figure 4).

It is suggested that shearing and mylonitization accompanied forceful subvolcanic injection of the Stettin syenite pluton. Fragments of mafic volcanic rocks broken loose from the walls were rafted up along them in the viscous syenite magma. These fragments locally acted as nuclei for crystallization of the syenite, although they appear to have been resistant to assimilation. Considerable metasomatic alteration of the early wall zone complex followed its original emplacement as evidenced by the coarse, euhedral microperthite porphyroblasts(?). Textures in poikilitic phases of the tabular syenite suggest nearly simultaneous crystallization of feldspars and mafic minerals, although the amphibole is younger than the pyroxene.

Your ideas are solicited! These tentative conclusions are presented to stimulate discussion and debate.

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Field Trip Locality 11

TITLE:

Sheared quartz diorite intrusive breccia

LOCATION:

Wisconsin River at Mosinee: SE$\frac{1}{4}$, sec. 29, T.27N., R.7E.

AUTHOR:

Paul E. Myers, UW-Eau Claire

DATE:

February, 1973

SUMMARY OF FEATURES:

Flow-lineated hornblende quartz diorite containing abundant, angular xenoliths of banded gabbro, pyroxenite, schist and quartz was mylonitized along a branching, ENE-trending shear zone, thus affording a rare opportunity to compare behavior of specific rock types under different conditions of shearing stress.

DESCRIPTION:

This excellent outcrop is near the sheared contact between contaminated hornblende quartz diorite and volcanic rocks, which are exposed in outcrops $\frac{1}{2}$ mile east of here. Pyroxene gabbro, some showing depositional(?) banding, metapyroxenite, chlorite-epidote schist, and quartz are the dominant rock types found here as xenoliths, yet none of them is found in place around the quartz diorite body, which probably extends at least 4 miles southwest from here and at least 2 miles northeast. This suggests considerable vertical transport of xenoliths in the quartz diorite magma.

At Location #1, (Figure 1) compositional banding in a large pyroxene gabbro xenolith was open-folded and then incorporated in the quartz diorite. The fold axes are nearly vertical, and their axial planes strike NE. The quartz diorite cuts into the banding in the gabbro with strong discordance. "Stair-step" crenulations in plagioclase layers in the gabbro (see detail in Figure 2) probably represent disturbances of stratification before complete consolidation of the gabbro. Note: this location may be reached from the west end of the bridge only at times of low water.

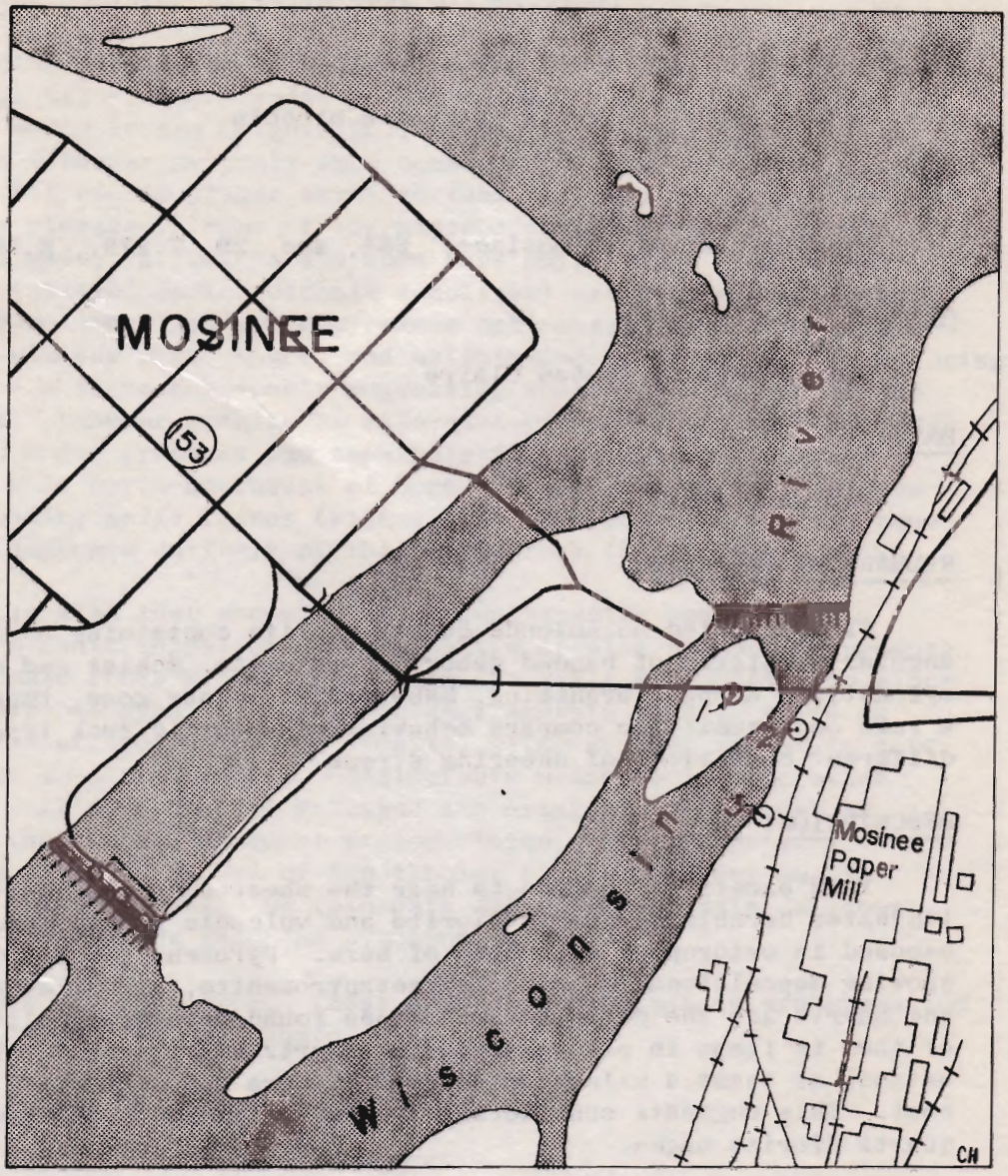


Figure 1 -- Location index map.

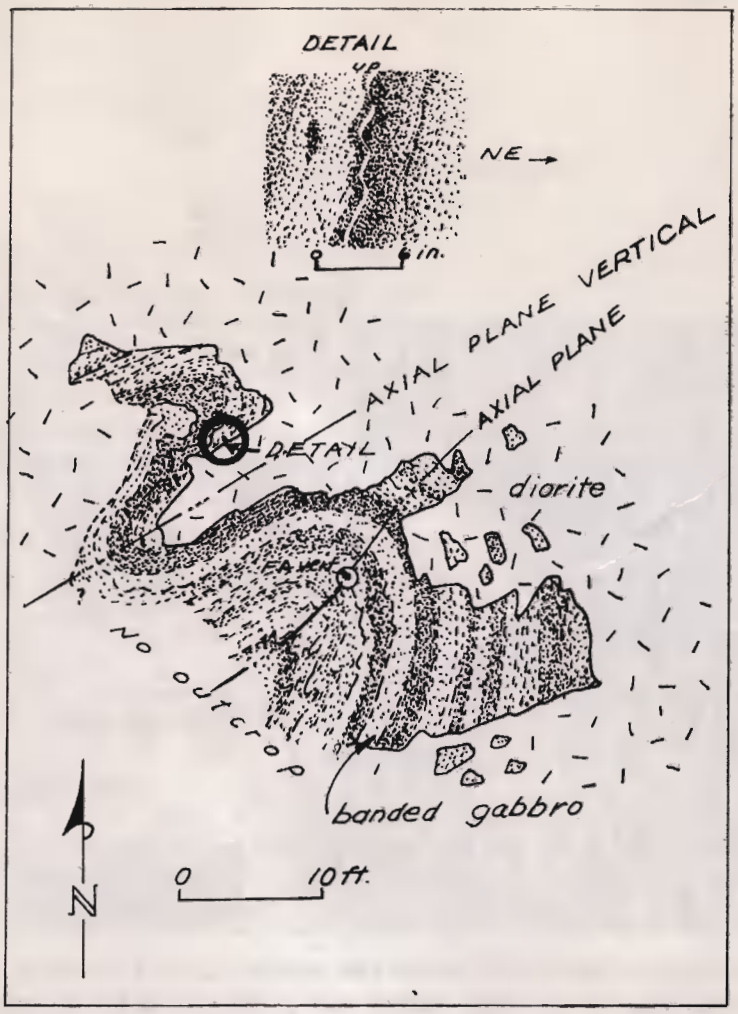


Figure 2 - Folded pyroxene gabbro in quartz diorite. Banding locally crenulated (Detail.)

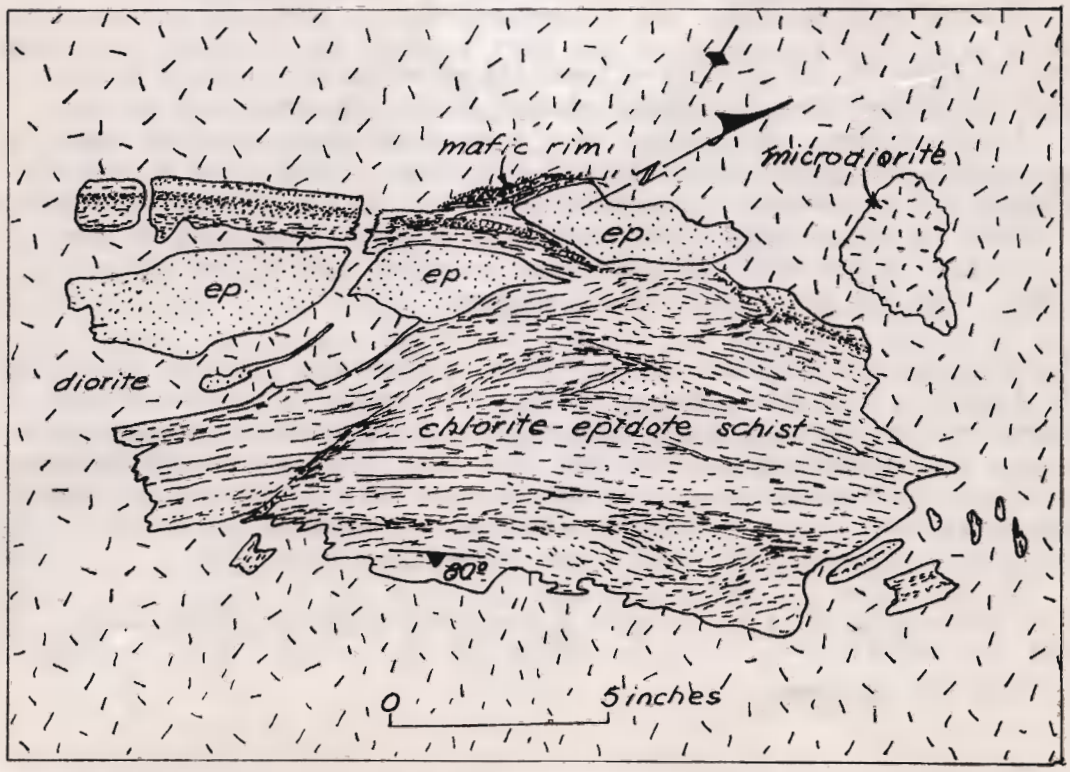


Figure 3 - Epidote-chlorite schist xenolith in quartz diorite.

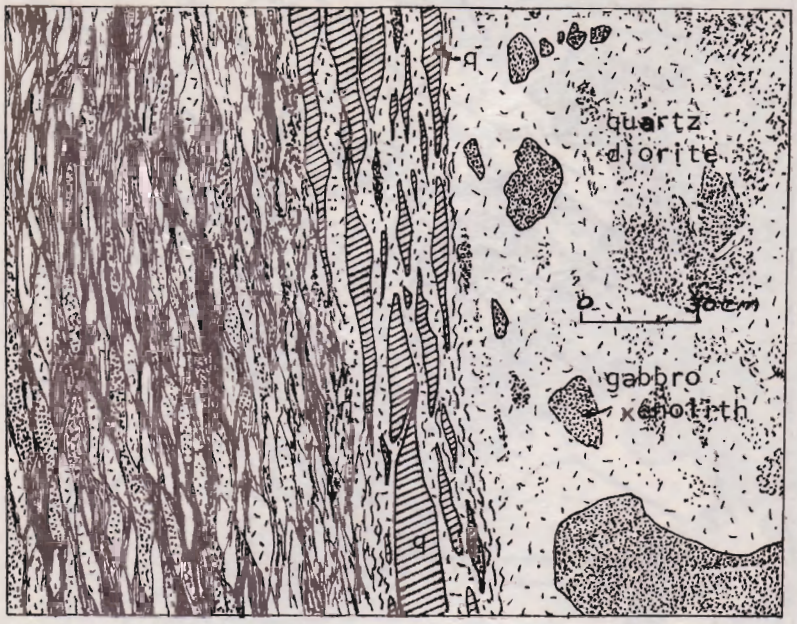


Figure 4 - Sheared intrusive breccia with quartz lenses (cross-ruled) along the contact with quartz diorite containing gabbroic xenoliths.

At Location #2, (Figure 1) a xenolith of chlorite-epidote schist is segmented by interlensing shear planes which are truncated by the quartz diorite (Figure 3). It is therefore clear that shearing (and metamorphism?) preceded quartz diorite intrusion. Thus, two episodes of shearing are validated. Was development of the schist contemporaneous with folding of the gabbro? The absence of syenite xenoliths in the quartz diorite is the only indication of relative age of the two units since they have not yet been seen in contact.

At Location #3, (Figure 1) the intrusive breccia has been converted by shearing to a lensoidal gneiss showing differential lenticulation and segmentation of xenoliths with resultant length/width ratios largely a function of xenolith mineralogy and texture. Several intermediate stages of xenolith attenuation can be observed at this location. There is throughout this region a curious association between intrusive contacts (rich in xenoliths) and shear zones. See Figure 4.

Did the quartz diorite intrude a subjacent layered gabbro body and raft the xenoliths up to this level? If so, is this body related to the Tigerton anorthosite?

Additional Locality

TITLE:

Gabbroic masses and leucogranite

LOCATION:

W$\frac{1}{2}$, W$\frac{1}{2}$, sec. 31, T.28N., R.9E., Marathon County. Low outcrops and float along CTH J southeast of Callon.

AUTHOR:

Gene L. LaBerge, UW-Oshkosh

DATE:

Summers 1970, 1972

SUMMARY OF FEATURES:

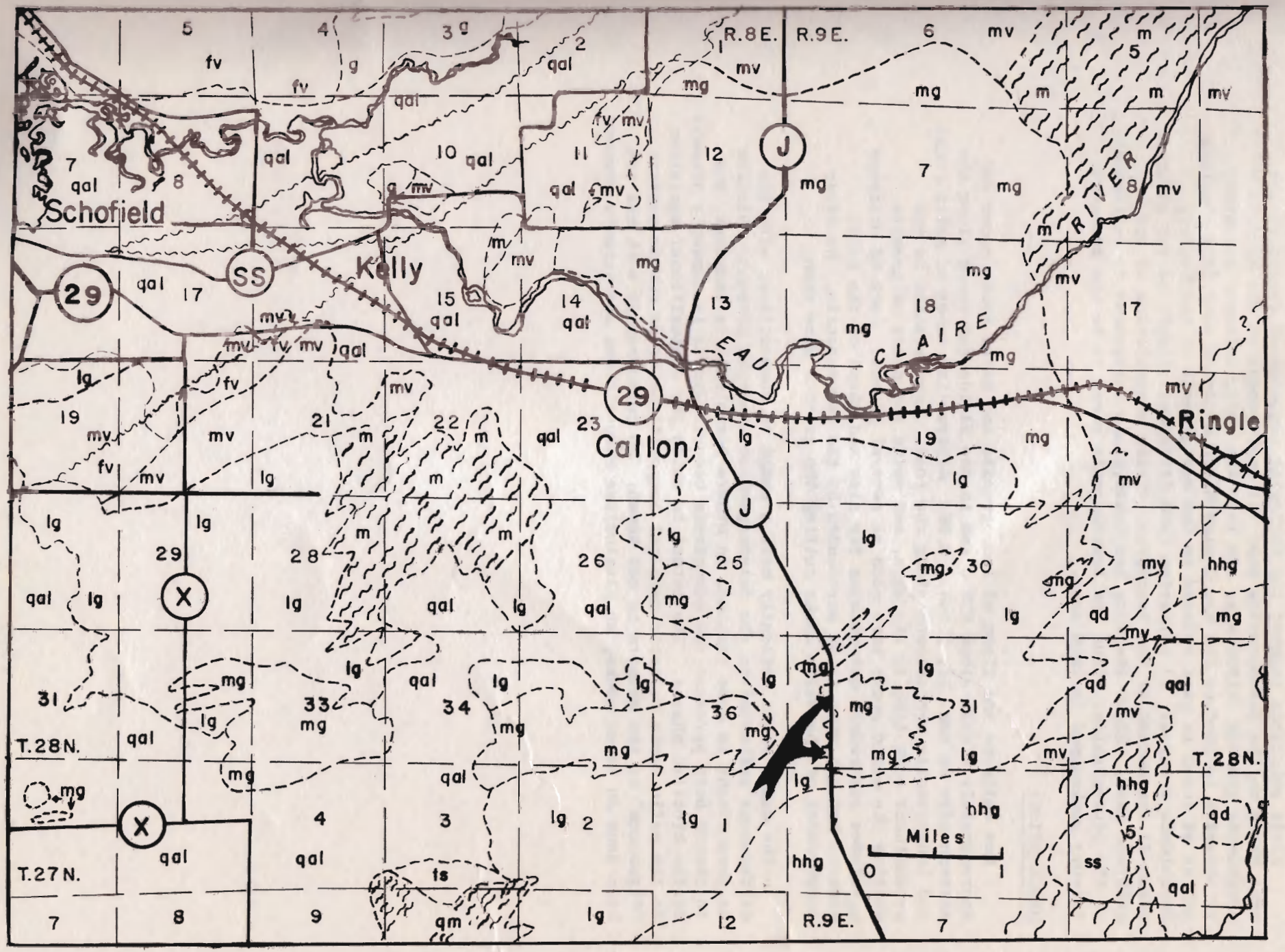
These exposures will not be visited on this trip but constitute an interesting part of the overall geology along the trend of the Eau Claire River shear zone.

The Eau Claire River mylonite zone is interrupted in the vicinity of Callon by a gabbroic mass, at least some of which appears metamorphosed (mg). Although the gabbro mass lies athwart the shear zone, it is substantially unsheared, and it contains inclusions of banded amphibolite (sheared meta-greenstone?) and other sheared rocks. Thus this mass seems to be younger than the major shearing in this area.

Southwest of the Callon area are numerous blocks of mafic rock surrounded and intimately intruded by leucocratic granite (lg). The mafic rocks have a range in composition, including hornblendite, gabbro, diorite, quartz diorite; the leucogranite contains much pegmatite and graphic granite. A small altered pyroxenite (now talc-serpentine-actinolite, etc.) (ts) which outcrops near the N$\frac{1}{4}$ corner, sec. 10, T.27N., R.8E. and a number of probably indigenous blocks of anorthosite near the SE corner sec. 8, T.27N., R.8E. may also be related to the gabbroic masses. And inclusions of pyroxenite and what appears to be layered gabbro are present in the dioritic rock in the Wisconsin River Valley at Mosinee (NW$\frac{1}{4}$, SE$\frac{1}{4}$, sec. 29, T.27N., R.7E.). If all these rocks are related, it would indicate the presence of a well-differentiated mafic intrusion which was subsequently segmented and intruded by granitic rocks, mainly the leucogranite. An additional piece of this mafic jigsaw puzzle may be the large roadcut of granophyre just north of the intersection of U.S. 51 and Wis. 153 at Mosinee (near the center of SW$\frac{1}{4}$, sec. 28, T.27N., R.7E.).

EXPLANATION FOR CALLON AREA MAP

qal	Quaternary alluvium
ss	Lower Paleozoic sandstone
lg	Leucocratic granite
mg	Metagabbro and related(?) gabbro-diorite rocks
ts	Talc-serpentinite
m	Mylonite and related sheared rocks
g	Small granitic bodies
hhg	Hogarty hornblende granite
qd	Quartz diorite - granodiorite masses
fv	Felsic volcanics and associated volcanogenic sediments
mv	Mafic volcanics and associated volcanogenic sediments
- - - -	Geologic contact
~~	Shear zone

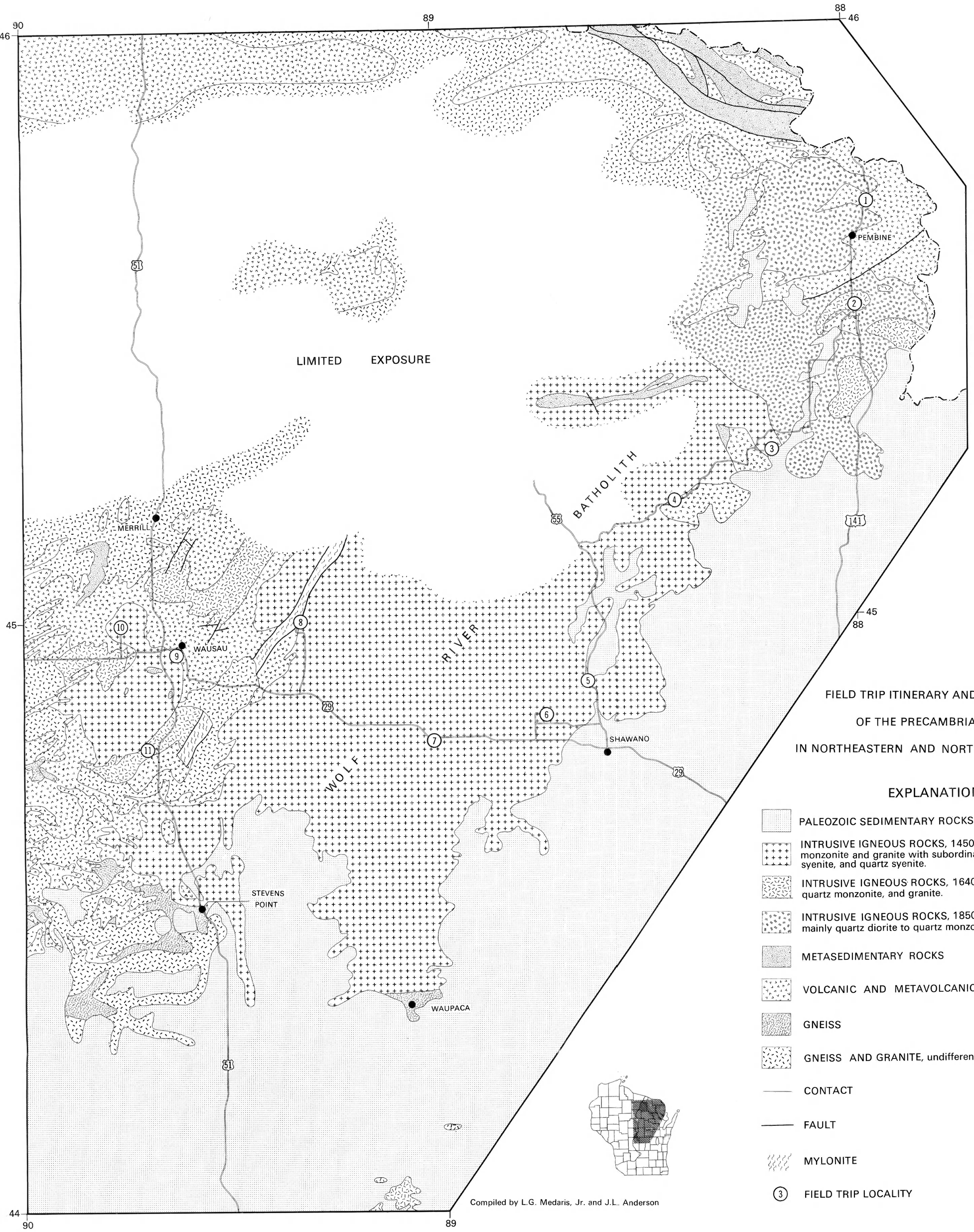

Schofield
Kelly
Callon
Ringle
EAU CLAIRE RIVER
R.8E.
R.9E.
T.28N.
T.27N.
Miles
0
1
29
SS
J
X

Field relations suggest the following sequence of events in the area shown on the accompanying map: 1) emplacement of the Hogarty hornblende granite ≃1500 m.y. ago into the mafic volcanic sequence; 2) shearing to produce the Eau Claire River mylonite zone (the shearing may be at least in part related to the emplacement of the Hogarty hornblende granite); 3) intrusion (and differentiation?) of the gabbroic mass; 4) intrustion of the leucogranite with segmentation of the gabbroic mass. Minor shearing has taken place subsequent to emplacement of the leucogranite. Thus the leucogranite seems to be the youngest igneous rockmapped in this area.

DESCRIPTION:

Low outcrops and float of leucogranite and mafic rocks occur for approximately a mile along CTH J and in the fields and woods along the western edge of sec. 31, T.28N., R.9E. Alternating zones of mafic rocks and leucogranite are present along the road. Leucogranite is the predominant rock type in the area, and veins and dikes of granite cutting the mafic rocks were seen at several places. Lack of outcrops precludes accurately determining the size and shape of the mafic masses, but all seem to be surrounded by the leucogranite. No clear occurrences of the mafic rocks cutting the granite were seen.

The mafic rocks evidently have a range in composition, with the differences reflected in the ferromagnesian minerals present. Biotite is predominant in some samples, in others hornblende is abundant, and in others both pyroxene and hornblende occur. Quartz is commonly present in the biotitic phases. The extent to which the compositional variation in the mafic rocks reflects original compositions or is due to partial "digestion" by the granite is not known. No petrographic work has yet been done on these rocks, so plagioclase compositions are largely unknown.



FIELD TRIP ITINERARY AND GEOLOGIC MAP

OF THE PRECAMBRIAN TERRAIN

IN NORTHEASTERN AND NORTHCENTRAL WISCONSIN

EXPLANATION

- PALEOZOIC SEDIMENTARY ROCKS; undifferentiated
- INTRUSIVE IGNEOUS ROCKS, 1450 - 1500 M.Y.; mainly quartz monzonite and granite with subordinate amounts of monzonite, syenite, and quartz syenite.
- INTRUSIVE IGNEOUS ROCKS, 1640 - 1670 M.Y.; diorite, quartz monzonite, and granite.
- INTRUSIVE IGNEOUS ROCKS, 1850 - 1910 M.Y.; mainly quartz diorite to quartz monzonite.
- METASEDIMENTARY ROCKS
- VOLCANIC AND METAVOLCANIC ROCKS
- GNEISS
- GNEISS AND GRANITE, undifferentiated
- CONTACT
- FAULT
- MYLONITE
- (3) FIELD TRIP LOCALITY

Compiled by L.G. Medaris, Jr. and J.L. Anderson

SCALE 1:500 000

10 0 10 20 30 40 50 MILES

10 0 10 20 30 40 50 KILOMETERS

PRELIMINARY GEOLOGIC MAP OF THE IRON MOUNTAIN SHEET

EXPLANATION

PALEOZOIC Pz Paleozoic sedimentary rocks, undifferentiated

PRECAMBRIAN

Ages Based on Isotopic Dates

Age	Wausau Area	Wolf River Batholith	Mountain-McCaslin	Florence-Amberg
Uncertain, may be younger than 1450-1500 m.y.	my Mylonite			
1450-1500 m.y.	sy Syenite and nepheline syenite hg Hogarty hornblende granite	bg Belongia granite wrqm Wolf River hornblende granite and quartz monzonite hr Hager rhyolite hfp Hager feldspar porphyry hs Hager syenite		
Uncertain, possibly 1450-1500 m.y.	kqm Kalinke quartz monzonite	hqm Hay Creek quartz monzonite pm Peshtigo monzonite and trachyandesite hfg High Falls granite		
1640-1670 m.y.	ghg Granite Heights granite fv Felsic volcanic and volcaniclastic rocks			
Uncertain, possibly 1640-1670 m.y.	di Diorite and quartz diorite t Trachyte mv Mafic volcanic rocks			amqm Amberg gray quartz monzonite
1850-1910 m.y.				
Uncertain, possibly 1850-1910 m.y.				atqm Athelstane pink quartz monzonite ngd Newingham granodiorite hlg Hoskin Lake granite mqd Marinette quartz diorite dgn Dunbar gneiss tfqd Twelve Foot Falls quartz diorite mg Montagabbro pfv Pemene felsic volcanic rocks miv McAllister intermediate volcanic rocks
Uncertain, equal to or older than 1850-1910 m.y.				bfv Beecher felsic volcanic rocks qfv Quinnesec felsic volcanic rocks qmv Quinnesec mafic volcanic rocks

Ages Based on Stratographic Classification

Middle Precambrian				pu Paint River Group, undifferentiated pr Riverton iron formation pd Dunn Creek slate bb Badwater mafic volcanic rocks bmsl Michigamme slate sf Saunders Formation

Lithologic Units of Uncertain Age Designation

sl Slate

an Anorthosite (intruded by granitic rocks of the Wolf River Batholith)

bc Baldwin conglomerate

mcqt McCaslin quartzite

hqd Hines quartz diorite } possibly 1850-1910 m.y.

mgn Macauley gneiss }

wv Waupee volcanic and volcaniclastic rocks

General Lithologic Terms, Ages Uncertain

gu Granite to quartz diorite and equivalent gneiss undifferentiated (in Rhinelander area, 1640-1670 m.y.)

fvu Felsic volcanic rocks, undifferentiated (in Rhinelander area, 1640-1670 m.y.)

mvu Metamorphosed mafic volcanic rocks, undifferentiated

Symbols

Contact, dashed where approximate or inferred

Fault, dashed where approximate or inferred

Shear zone, mylonite

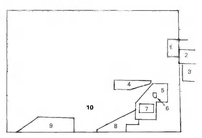
Isotopically dated samples

1450-1500 m.y. 1640-1670 m.y. 1850-1910 m.y.

Rb-Sr, whole rock

U-Pb, zircon

Rb-Sr and U-Pb on same sample



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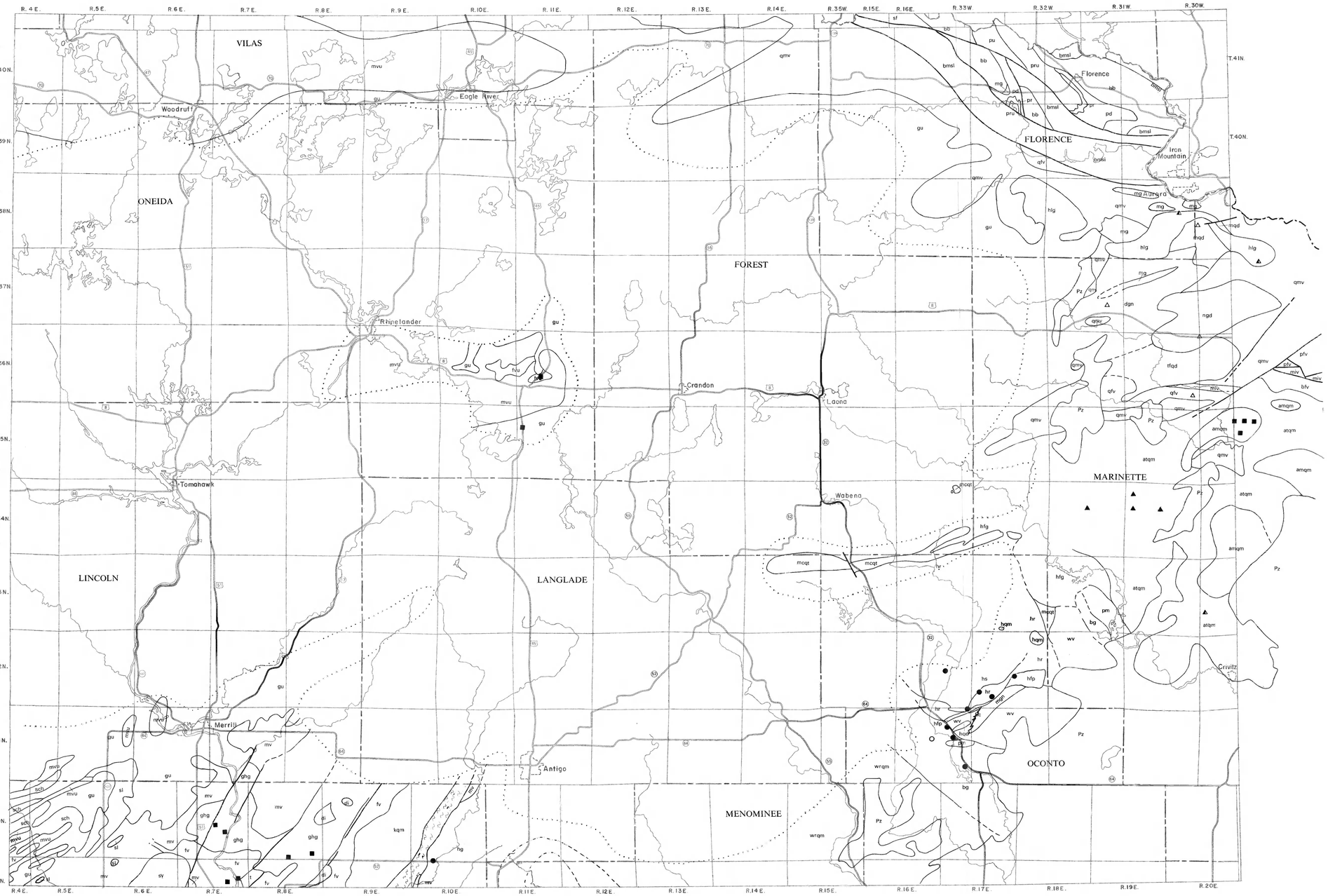


Scale 1:250,000

20 Statute Miles

30 Kilometers

Compiled by L.G. Medaris, Jr. and J.L. Anderson

CARTOGRAPHIC LABORATORY, UNIVERSITY OF WISCONSIN

PRELIMINARY GEOLOGIC MAP OF GREEN BAY SHEET

EXPLANATION

CENOZOIC Qal Quaternary alluvium

PALEOZOIC Pz Paleozoic sedimentary rocks, undifferentiated

PRECAMBRIAN

Age	Wausau Area		Lohrville-Redgranite Area	Wolf River Batholith	
Uncertain, possibly younger than 1450-1500 m.y.	lg	Leucogranite			
	mg	Metagabbro			
	my	Mylonite (various ages, but some younger than 1450-1500 m.y.)			
1450-1500 m.y.	ng	Ninemile granite		rqm	Red River porphyritic quartz monzonite
	qsy	Quartz syenite		wrqm	Wolf River hornblende granite and quartz monzonite
	lsy	Lensoidal syenite			
	sy	Syenite and nepheline syenite		wqm	Waupaca quartz monzonite
	spg	Stevens Point grey granite			
	hg	Hogarty hornblende granite			
Uncertain, possibly 1450-1500 m.y.	a	Aplite			
	kqm	Kalinke quartz monzonite			
	ibc	Intrusive breccia complex			
Uncertain, possibly between 1450-1500 and 1640-1670 m.y.	qt	Quartzite			
1640-1670 m.y.	ghg	Granite Heights granite	g	Granite	
	qm	Quartz monzonite			
	fv	Felsic volcanic and volcaniclastic rocks			
Uncertain, possibly 1640-1670 m.y.	di	Diorite and quartz diorite			
	t	Trachyte			
	mv	Mafic volcanic rocks			
Uncertain, equal to or older than 1900 m.y.	gn	Gneiss			
Lithologic units of uncertain age designation	gu	Granite to quartz, diorite and equivalent gneiss, undifferentiated		an	Anorthosite (intruded by granitic rocks of the Wolf River Batholith)
	m	Metamorphosed mafic rocks			
	sch	Schist			

Symbols

Contact, dashed where approximate or inferred

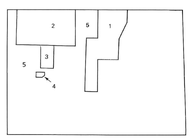
Fault, dashed where approximate or inferred

Shear zone, mylonite

Samples dated by Rb-Sr whole rock methods

● 1450-1500 m.y.

■ 1640-1670 m.y.



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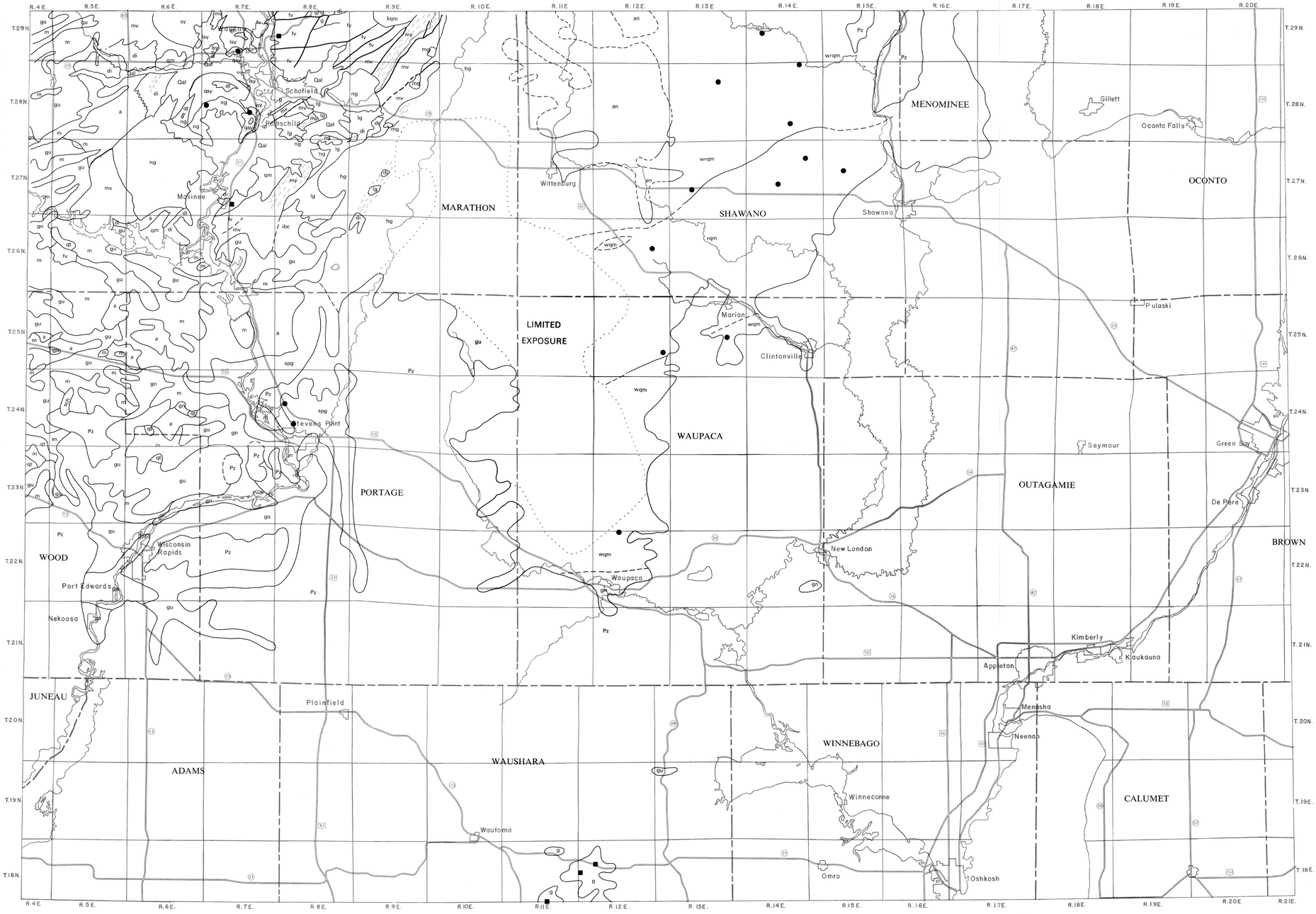

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Scale 1:250,000

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

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