INTRODUCTION TO PRECAMBRIAN ROCKS OF SOUTH-CENTRAL WISCONSIN

by

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THE INLIERS

Introduction and Geologic Setting

Exposures of Precambrian rocks in south-central Wisconsin are for the most part granites, quartzites and rhyolites (Smith, 1978a). Basalts, andesites, and dacites are subordinate rock types and occur as thin dikes. Each exposure (inlier) is surrounded and partially covered by Cambrian sandstone and Pleistocene drift and outwash. Except for the Waterloo Quartzite that crops out in the Crawfish River Valley, most of the Precambrian inliers are located in the Fox River Valley (Figure 1), (Table 1). To the west of the Fox River Valley, in the Baraboo Range, Precambrian quartzite stratigraphically overlies a terrain composed of acidic igneous rock and isolated intrusions of gabbro (Stark, 1932; Gates, 1942; Dalziel and Dott, 1970).

The Fox River Valley exposures are composed of two varieties of rhyolite, and granite. Porphyritic rhyolites are found in the Berlin, Utley, Endeavor, Observatory Hill and Taylor Farm inliers and contain large (1 to 5 mm) pink to white feldspar, and quartz phenocrysts set in a black, dark gray or reddish brown matrix. Texturally variable rhyolites occur in the Marquette, Marcellon and Baraboo exposures, and are characterized by the change from phenocryst-rich, quartz-bearing rhyolites to phenocryst-poor rhyolites with a paucity of quartz and abundant plagioclase. These rocks are black to dark gray in color and vary considerably in texture. The rock may be banded, brecciated, spherulitic or massive. Both varieties of rhyolite are interpreted as ash-flow tuffs. Pink to red fine- to medium-grained granites are exposed at Montello and in the Redgranite area. Quartz and alkali feldspar comprise 90 to 98% of the rock; perthitic, granophyric and myrmeketic textures are common. More information on the petrology of these and other rock types of Precambrian age in south-central Wisconsin is presented in Smith (1978a) and in the guidebook to these rocks that follows.

U-Pb dating of zircons in the Fox River Valley rhyolites and granites (Van Schmus, 1976; 1978) indicates an average age of 1765 ± 10 m.y. B. P. for these rocks. Rocks of this age are not restricted to the Fox River Valley and occur throughout the state (Figure 2). Rhyolites and granites in the Baraboo area are most likely of the same age as the Fox River Valley rocks. The dates of the Fox River Valley rocks are distinctly younger than those obtained for volcanic rocks in the Wausau area (1850 ± 30 m.y. B.P.; Van Schmus, 1976), and for volcanic rocks in northeastern Wisconsin (1850-1900 m.y.; Banks and Cain, 1969). On the other hand, the inliers are significantly older than the Wolf River Batholith in north-eastern Wisconsin that is dated at 1500 m.y. old (Van Schmus and others, 1975a).

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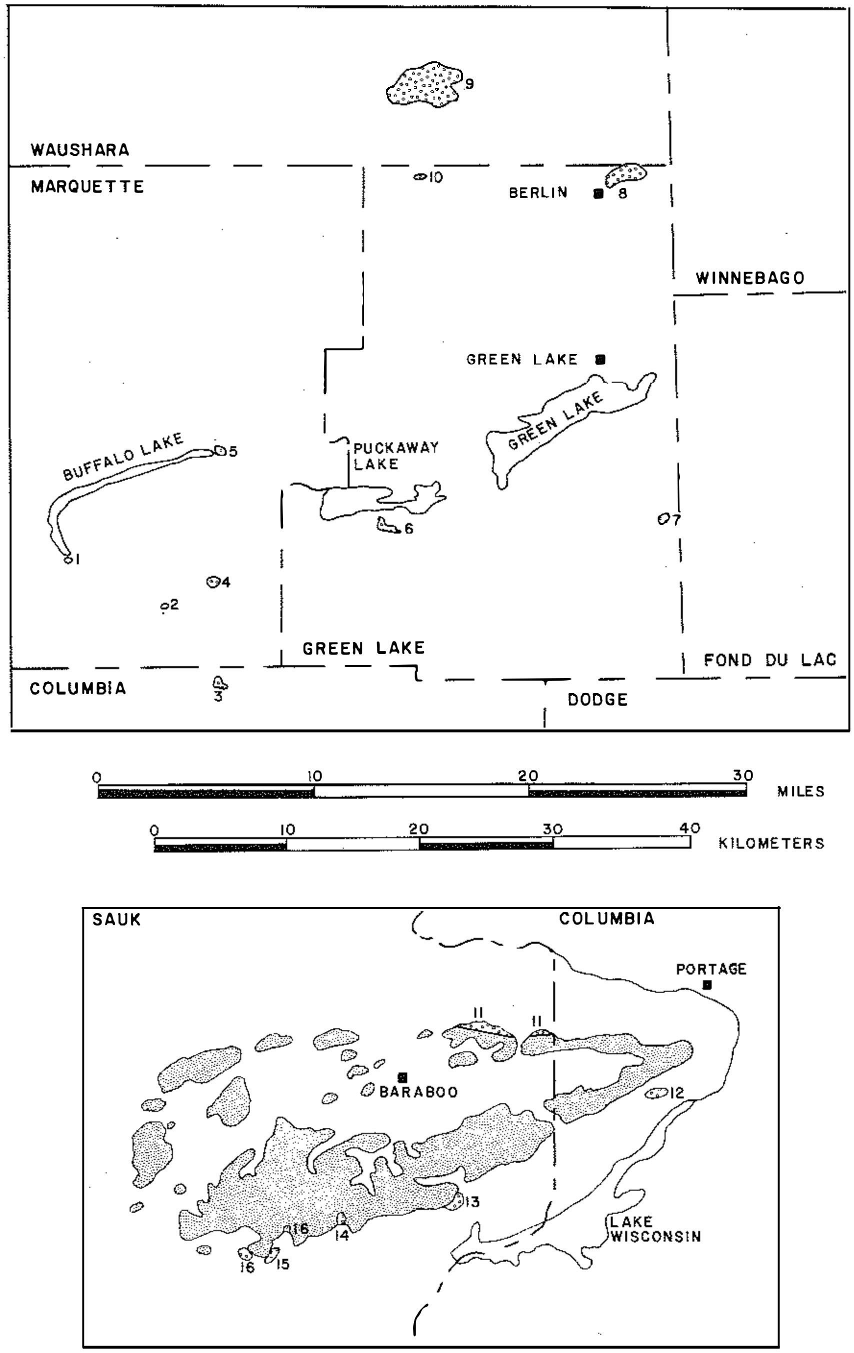

Figure 1. Index map of rhyolite and granite inliers and associated Precambrian exposures in the Fox River Valley (upper map) and the Baraboo area (lower map). (1) Endeavor rhyolite. (2) Taylor Farm rhyolite. (3) Marcellon rhyolite. (4) Observatory Hill rhyolite. (5) Montello granite. (6) Marquette rhyolite. (7) Utley rhyolite. (8) Berlin rhyolite. (9) Granite at Redgranite. (10) Granite at Pine Bluff. (11) Lower Narrows rhyolite. (12) Caledonia Church rhyolite. (13) South Limb rhyolite. (14) Naxter Hollow granite. (15) Denzer rhyolite. (16) Denzer diorite. Dotted pattern on lower map is the Baraboo Quartzite. (From Smith, 1978a).

Table 1

SUMMARY OF THE GEOLOGY OF THE FOX RIVER VALLEY RHYOLITES AND GRANITES, AND THE IGNEOUS ROCKS IN THE BARABOO AREA

Exposure	Location	Important Rock Types	Comments	References
Montello	sec. 9, T15N, R10E.	Granophyric granite, metabasalt.	Rock contains less than 2% chlorite and opaque minerals.	(Buckley, 1897)
Red Granite	sec. 1, T17N, R11E; NW¼, T18N, R12E; NE¼, T18N, R11E.	Granophyric granite, metabasalt, porphyritic granite.	Rock contains less than 5% chlorite and opaque minerals.	(Buckley, 1897) (Weidman, 1904)
Berlin	SE¼, sec. 3, T17N, R13E.	Porphyritic rhyolite	Rhyolite is locally sheared.	(Buckley, 1897)
Marquette	sec. 34-35, T15N, R11E; sec. 1-2, T14N, R11E.	Porphyritic and fine-grained rhyolite, breccia, andesite dike.	Rhyolite is folded and faulted.	(Smith, this paper)
Observatory Hill	SW¼, sec. 8, T14N, R10E.	Porphyritic rhyolite, dikes of coarse-grained rhyolite and metabasalt	Little or no textural variation.	(Hobbs and Leith, 1907)
Taylor Farm	NE¼, sec. 13, T14N, R9E.	Porphyritic rhyolite	Location incorrect in many earlier references.	(Hobbs and Leith, 1907)
Endeavor	S½, sec. 5, N½ sec. 8, T14N, R9E.	Porphyritic rhyolite	Little or no textural variation	(Hobbs and Leith, 1907)
Marcellon	sec. 7, T13N, R10E.	Texturally variable rhyolite, metabasalt	Folded into a northeast trending antiform	(Smith, this paper)
Utley	N½, sec. 36, T15N, R13E.	Porphyritic rhyolite, felsic and metabasalt dikes.	Zones of spherulites and lithophysae trend N50W.	(Gram, 1947)
Baraboo	sec. 21,22,23, T12N, R7E.	Texturally variable rhyolite.	Lies below Baraboo Quartzite.	(Dalziel and Dott, 1970)
Caledonia Church	NE¼, sec. 3, T11N, R8E.	Fine-grained rhyolite and breccia.	Lies below Baraboo Quartzite.	(Dalziel and Dott, 1970)
Baxter Hollow Granite	SW¼, sec. 33, T11N, R6E	Fine-grained granite	Intrusive into rhyolite, relationship to Baraboo Quartzite unclear.	(Gates, 1942)
Denzer Rhyolite	SE¼, sec. 11, T10N, R5E.	Fine-grained bedded rhyolite.	Volcanoclastic sandstone ?	(Stark, 1932)
Denzer Diorite	sec. 9 and 10, T10N, R5E.	Coarse-grained diorite	Contacts with adjacent units not exposed.	(Stark, 1932)

Other rhyolite inliers shown on Dutton and Bradley (1970) could not be located in the field. They probably do not exist.

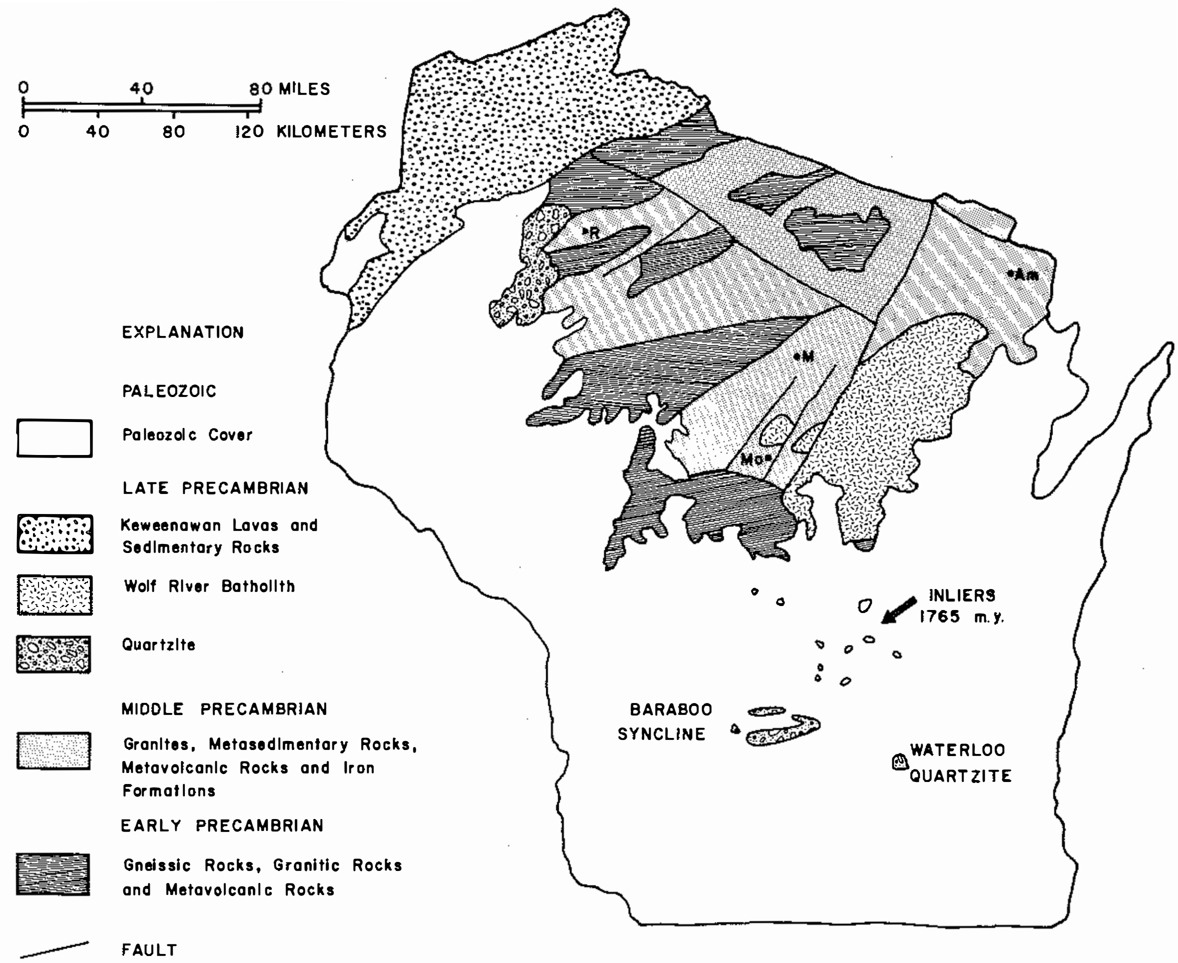

Figure 2. Location of Fox River Valley inliers. Other possible 1765 m.y. old exposures (Van Schmus and others, 1975b) include the Amberg Quartz Monzonite (AM), a granite near Monico (M), a granophyric granite near Mosinee (Mo), and a porphyritic granite at Radisson (R) (Van Schmus, Personal Communication). Geology of northern Wisconsin modified from Sims (1976) and LaBerge (1977) (From Smith, 1978a).

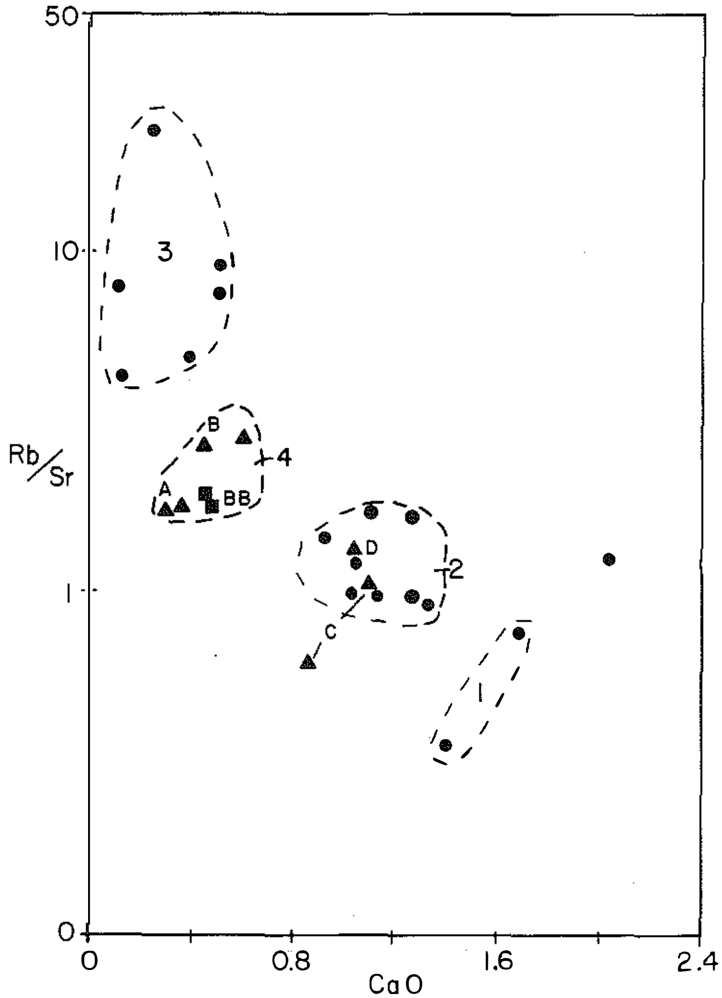

Figure 3. The rhyolites and granites in the Fox River Valley and Baraboo area can be divided into four groups on the basis of this CaO-Rb/Sr plot. Letters A-D represent Marcellon rhyolite units. BB is the Baraboo rhyolite. Unlabelled data point at about 2 percent CaO is Marquette unit C sample 91 (from Smith, 1978a).

New chemical data for the rhyolite and granite inliers (Smith, 1978a) divide the Fox River Valley and Baraboo rocks into four chemical groups (Figure 3): Group 1 - fine-grained granite at Baxter Hollow and a coarse-grained dike at Observatory Hill are characterized by high CaO ($\bar{x}$ = 1.58%) and low Rb/Sr ratio ($\bar{x}$ = 0.54); Group 2 - fine-grained and porphyritic rhyolite at the Marquette exposure and a fine-grained plagioclase-bearing rhyolite at the Marcellon inlier have intermediate CaO contents ($\bar{x}$ =1.22%), and Rb/Sr ratios ($\bar{x}$ = 1.01); Group 3 - porphyritic rhyolite and granophyric granite are characterized by low CaO ($\bar{x}$ = 0.40%), and high Rb/Sr ratios ($\bar{x}$ = 7.8); Group 4 - rhyolites at the Marcellon and Baraboo exposures are intermediate in chemistry between groups 2 and 3 ($\bar{x}_{CaO}$= 0.51%, $\bar{x}_{Rb/Sr}$= 1.53).

Chemical correlation and geologic mapping indicate that the chemical groups occur geographically as northeast trending bands across south-central Wisconsin

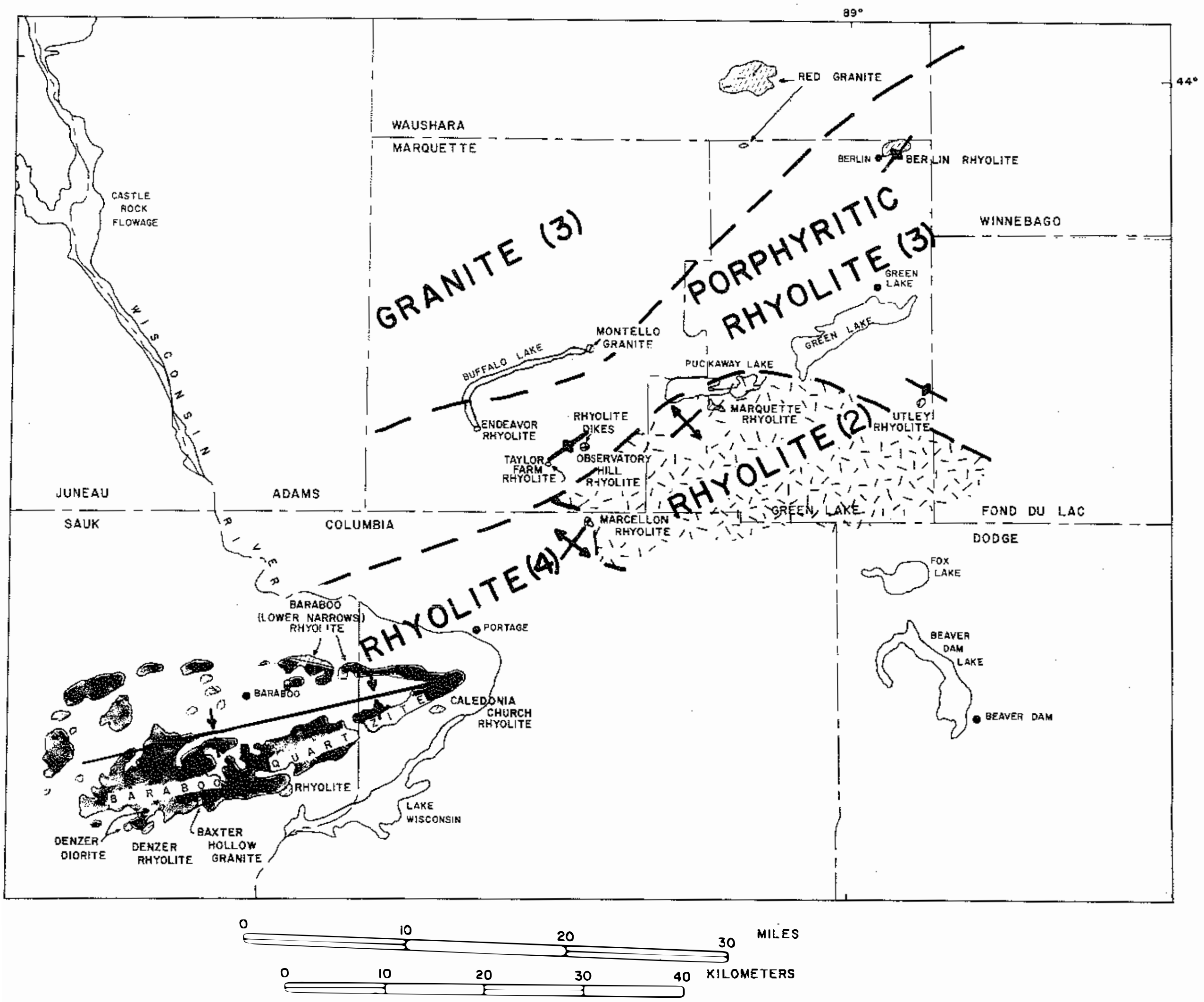

Figure 4. Map of the Fox River Valley-Baraboo area showing the geographic distribution of the chemical groups. Dashed lines are inferred contacts between chemical groups. Since these contacts parallel structures in exposures, patterns on this map probably reflect the geology of the buried Precambrian basement in this area. Foliation symbol indicates trend of banding in rhyolites, fold symbols indicate mean direction of axial plane traces, and shaded areas are outcrops of Baraboo Quartzite (from Smith, 1978a).

(Figure 4). Structural trends within the inliers parallel contacts between the chemical groups, suggesting that the chemical trends reflect the geology of a large area of buried Precambrian rock in south-central Wisconsin.

Historical Summary of Research on the Fox River Valley Inliers

The Fox River Valley igneous rocks were first described by Percival (1856) in the Annual Report of the Geological Survey of Wisconsin. He reported bedding in the rhyolites and probably regarded them as metasedimentary rocks. Chamberlin (1877 and Irving (1877) indicated that the origin of the rhyolite (their quartz-porphyry) in the Fox River Valley and the Baraboo area was in doubt, and suggested either an eruptive or metamorphic (metasedimentary) mode of formation for these rocks. Irving (1877) described several of the inliers in some detail and noted the parallel orientation of "bedding" in the quartzite and rhyolite inliers to the northeast. Accordingly, he placed the rhyolites (quartz-porphyry), quartzites and granites into "a great quartzite series". Both Chamberlin and Irving mistakenly interpreted the rhyolite at Baraboo as younger than the quartzite (they did not recognize the overturned nature of the north limb of the Baraboo syncline) and extended this age relationship to the inliers in the Fox River Valley.

Weidman (1895) correctly recognized the igneous nature of the rhyolites (his quartz-keratophyre) on the north range of the Baraboo syncline. Weidman (1898) also published accounts of the Berlin and Utley rhyolites, and presented the first chemical data for these rocks. Weidman (1904) demonstrated that quartzite lies stratigraphically above rhyolite in the Baraboo area by correctly interpreting the structural geometry of the Baraboo syncline. Buckley (1898) described quarrying operations in the Fox River Valley, especially at Montello, Utley and Marquette. In this work, he concentrated on the physical and visual properties of rocks in these quarries.

The most significant early contribution on the Fox River Valley inliers was made by Hobbs and Leith (1907). They mapped in some detail the Marcellon, Marquette, Observatory Hill, Montello and Endeavor inliers and described the chemical composition of these igneous rocks by providing 12 new chemical analyses made by W. W. Daniells. Part of their work was based on a B.S. thesis by W. W. Pretts (1895). Hobbs and Leith described a sequence of rock types passing from granite to the north through rocks of intermediate texture (the porphyritic rhyolites) to "typical surface volcanics" to the southeast. In the surface volcanics they recognized spherulites, perlitic fractures, axiolitic texture and brecciated rhyolite. Hobbs and Leith noticed the similarities in chemistry and mineralogy between the rhyolites and granites and suggested a genetic relationship between the two rock types. Alden (1918) reviewed pre-1918 research on the Precambrian and Pleistocene geology of south-central Wisconsin.

These early studies were followed by geologic investigations by Stark (1930, 1932) on the rhyolite and gabbro in the Baraboo range, and Gates (1942) on the Baxter Hollow Granite. In 1935 the area was visited by a field trip organized by the Kansas Geological Society (Leith, 1935). Asquith (1964) identified microscopic shard and axiolitic structures in the Fox River Valley and Baraboo rhyolites, and interpreted them as ash-flow tuffs. Dalziel and Dott (1970) observed faint shard-like relicts in the more deformed Baraboo rhyolites and concluded that most of the rhyolite section at Baraboo was composed of ash-flow tuffs. Abstracts by Smith and Hartlaub (1974), Smith (1975a and 1975b) and Smith (1976a) and a paper (Smith, 1978a) described the geology of the Marquette and Marcellon rhyolites, related rhyolites and granites between inliers and provided the first modern chemical data for these rocks.

The Fox River Valley igneous rocks were first dated by Goldich and others (1966) by the Rb-Sr technique at 1490 m.y. B.P. (for the Utley Rhyolite). This date is reported by Dott and Dalziel (1972) as 1.576 $\pm$ 70 m.y. B.P. Earlier, they (Dalziel and Dott, 1970) reported an age of 1540 m.y. B.P. for the Baraboo rhyolite. Van Schmus and others (1975b) published a Rb-Sr date of 1650 m.y. B.P. for the Fox River Valley igneous rocks, but were quick to point out in the same article that this age is probably low by at least 150 m.y. U-Pb dating indicated that the rocks are 1800 m.y. old (Van Schmus and others, 1975b). The 1650 m.y. old date was equated to a mild "hydrothermal" event (1630 m.y. B.P. in Van Schmus, 1978. Van Schmus, 1978 refined the U-Pb date on the Fox River Valley rocks by the addition of new data and the use of a new decay constant. The presently accepted date for the emplacement of these rhyolites and granites is 1765 $\pm$ 10 m.y. B.P.

THE BASEMENT

Introduction

Because exposures of Precambrian rock in south-central Wisconsin are widely separated, information about the Precambrian basement must be obtained from well cuttings, core and geophysical data. Chemical data and structures within the inliers can also be used to determine the distribution of basement rock types and to suggest the trend of basement structures.

Drill records and well cuttings for Wisconsin were first systematically examined and compiled by F. T. Thwaites. His results were published as surface contour maps of the buried Precambrian of Wisconsin in 1931, 1940, and in 1957. Dutton and Bradley (1970) refined the work of Thwaites by the addition of new deep well data. The maps presented here use the data of both Thwaites and Dutton and Bradley. In addition, new well data compiled by the Wisconsin Geological and Natural History Survey, and well data obtained by the author in the field during the summer of 1977 are incorporated into these maps.

Even though metric units are used throughout this report, English units are retained on the surface contour map and in discussion of the deep well data.

Basement Geological Map

The distribution of major rock types in the Precambrian basement of south-central Wisconsin is depicted in figure 5. Granite and quartzite are the dominant rock types. Rhyolite and mafic rocks are rarely found in well cuttings. Granites in the basement from Green Bay to Pewaukee are lithologically similar to those exposed in the Redgranite-Montello area. Granite in cuttings is characteristically a quartz, pink alkali feldspar, biotite-bearing rock with microscopic intergrowths of quartz and alkali feldspar. Similarities in lithology between exposed and buried granites suggest that there may be a large composite batholith of post-Penokean age (1765 m.y. old) under much of south-central Wisconsin. However, since it is common for granites of widely different ages to have a similar lithology, additional chemical, petrographic and geochronological information is required to confirm the existance of such a composite batholith. A biotite-rich, very fine-grained granite is found in well cuttings from the south margin of the Baraboo range to Sauk City. This granite is similar in lithology to the Baxter Hollow granite (Gates, 1942) and may represent a southward extension of this intrusion. Granite containing abundant muscovite is encountered near Appleton and Pewaukee. Granites are locally cut by gabbro and diroite dikes (?), particularly in the Madison area. The complexity of the Precambrian basement as revealed by closely spaced wells in the Madison area is probably typical of the Precambrian basement as a whole (Note - rhyolites identified by Thwaites in the Madison area are in fact fine-grained granites).

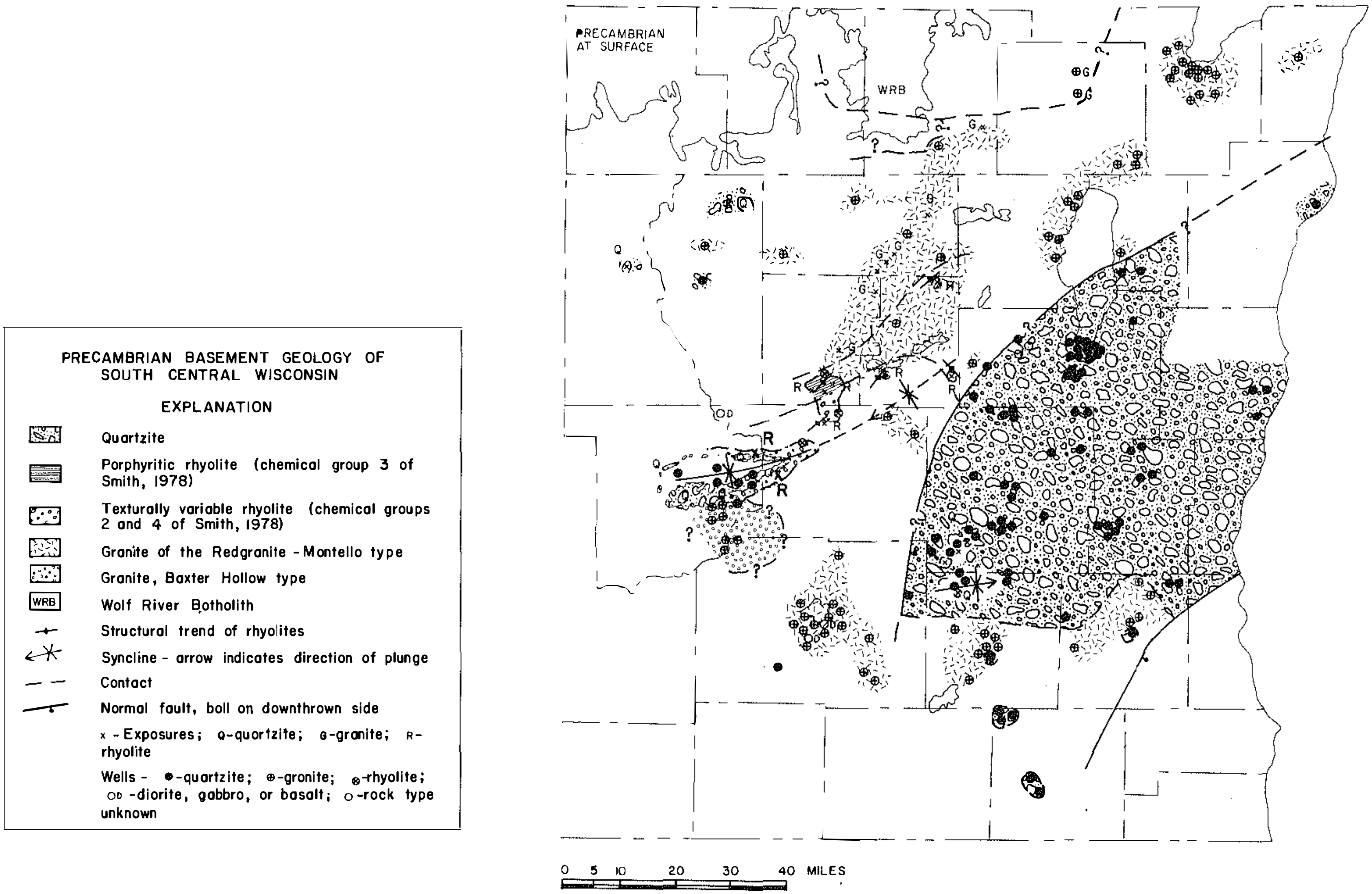

Figure 5. Precambrian basement geology map of south-central Wisconsin.

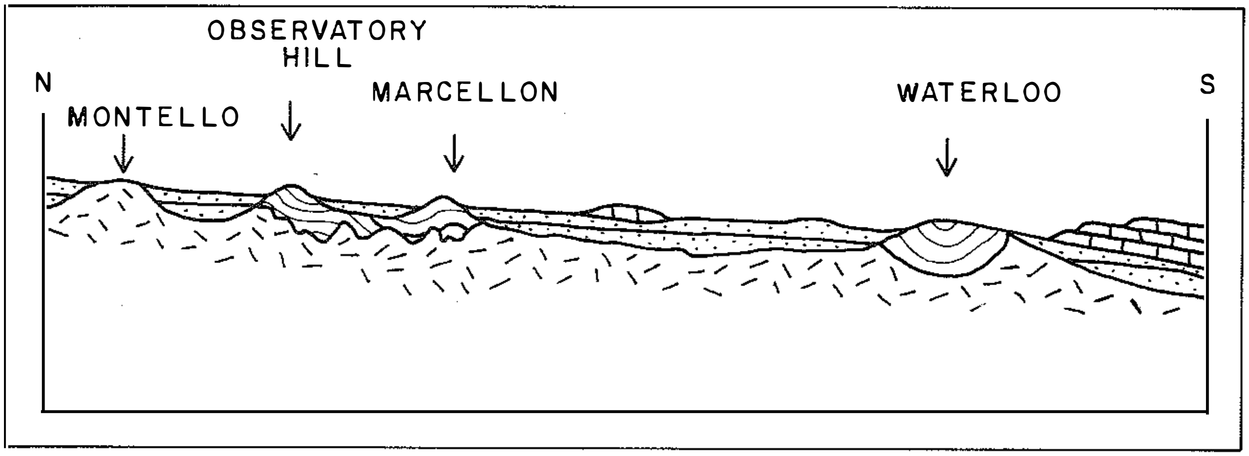

Figure 6. Schematic geologic section across south-central Wisconsin from Montello to Waterloo. Stippled pattern is the composite granite batholith. Folded patterns at Observatory Hill and Marcellon represent the rhyolite roof pendants. The Waterloo Quartzite is infolded into the granite basement. The Precambrian rocks are overlain by Cambrian and Ordovician sedimentary rocks.

Rhyolite is rarely encountered in deep wells except adjacent to rhyolite exposures. Rhyolite inliers are commonly surrounded by granite, suggesting that they are roof pendants within the granite batholith (Fig. 6). The shape of the rhyolite knobs (inliers) reflects the shape of the rhyolite roof pendants. Most of the rhyolite is fine-grained and dense, hence it is highly resistant to erosion. The surrounding granite is less resistant and trends to erode more easily than the rhyolite, thus leaving the rhyolite roof pendants as topographically high areas.

Quartzite occurs as a broad sheet of complex structure. In the Waterloo area there is a poorly exposed, east-plunging syncline (Buell, 1892; Warner, 1904). Quartzite overlies the igneous basement to the south, but in the west there may be a normal fault downthrown to the east separating quartzite from the igneous terrain.

To the west of Seymour in Outagamie County, a coarse-grained, alkali feldspar, biotite, blue-quartz granite was located in a well at a depth of 500 feet. This rock is similar in lithology to rocks of the Wolf River Batholith and especially to the Waupaca Rapikivi (Wiborgite) that crops out to the north of Waupaca (Van Schmus and others, 1975a). The Wolf River Batholith according to this information may extend as far to the east as Seymour. Since granite at Green Bay is of the Redgranite-Montello type, the contact between Wolf River granites and the older basement must run between Green Bay and Seymour.

Precambrian Surface Contour Map

The Precambrian surface slopes gently to the east, southeast and south off the Wisconsin arch (Fig. 7). This surface may be a peneplain, and because of the difference in contour spacing between northeast and south-central Wisconsin, Martin (1965) speculated that the surface may consist of two peneplains. Standing above this surface as monadnocks are ridges and knobs of resistant Precambrian

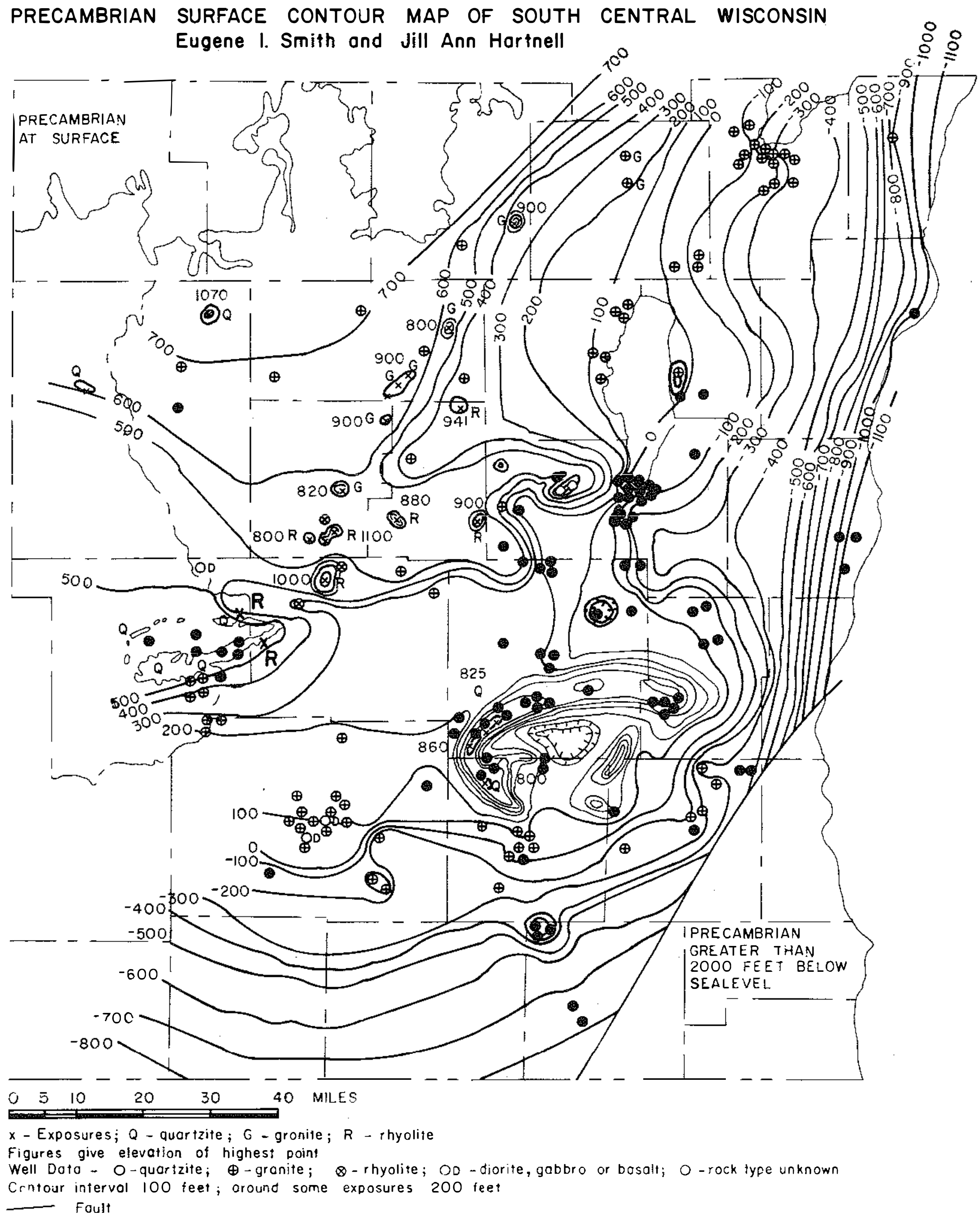

Figure 7. Surface contour map of the buried Precambrian basement of south-central Wisconsin.

rock. The majority of the known Precambrian topographic highs protrude through the Paleozoic and Pleistocene cover as inliers (for example, at Baraboo, in the Fox River Valley, and at Waterloo). In addition, there are at least four buried knobs of Precambrian rock in this area. Both the exposed and buried knobs rise quite abruptly from the peneplained Precambrian surface; for example, the rhyolite knob at Berlin stands over 600 feet above the surface. This change in elevation occurs over a lateral distance of only 1 km. Other Fox River Valley knobs have similar relief (Fig. 7).

The ridges of Quartzite that form the eastward plunging Waterloo syncline show clearly on the contour map. Surface contours of the Waterloo area are based on a geophysical study by Sumner (1956). The nose of the Waterloo fold is in the Portland area. The north limb extends from the Portland area to the east as far as Hartford in Washington County, and the south limb terminates abruptly near Fort Atkinson. The south limb may continue to Whitewater in Walworth County as indicated by a quartzite knob beneath that city (Fig. 7). The quartzite ridge may in fact continue to Delavan in central Walworth County.

Buried Precambrian knobs occur at Ripon (granite), Rosendale (rock type unknown), Brothertown (quartzite), Whitewater (quartzite) and Waupun (quartzite). Thwaites (1957) connected the Rosendale high to the Brothertown high to form the Fond du Lac quartzite range. Present data neither support nor refute the existence of this quartzite ridge. The buried knob at Hartford (described by Thwaites, 1957) is in fact part of the Waterloo range.

BRIEF COMMENT ON THE METAMORPHIC GRADE OF SOUTH-CENTRAL WISCONSIN PRECAMBRIAN ROCKS

The rhyolites and granites and overlying quartzites in south-central Wisconsin were metamorphosed in general to the lower greenschist facies. Dalziel and Dott (1970) suggest lower greenschist facies metamorphism for the Baraboo Quartzite on the basis of the occurrence of pyrophyllite in phyllite beds interlayered with the quartzite. This mineral is not stable at temperatures above 400 to 430° C at 1 to 3.9 kb pH_2O (Hemley, 1967; Kerrick, 1958). Weidman (1904) reports the "probable" presence of andalusite in the Seeley Slate (stratigraphically above the Baraboo Quartzite). This occurrence, if confirmed, would indicate that metamorphism reached the upper part of the greenschist facies.

The rhyolites also show the effects of a mild metamorphic event. Alkali feldspar is commonly altered to sericite, and plagioclase to sausserite. Mafic minerals are altered to epidote-clinozoisite and/or chlorite. In several specimens aligned grains of epidote, chlorite and secondary biotite penetrate the matrix. For the most part, however, the matrix of the rhyolites is unaltered; original pyroclastic textures are well preserved. Weidman (1904) suggested that rhyolites at Berlin and perhaps Utley were sheared and highly metamorphosed. Recent examination of these rocks indicates no evidence for high grade metamorphism, and suggests that Weidman may have mistaken primary flow foliation formed by flattened pumice for shear surfaces.

Recently identified in core from a well drilled at Waterloo (Haimson, 1978) are zones of phyllite rich in reddish-brown subhedral to anhedral andalusite porphyroblasts. In section the andalusite is broken and partially altered to sericite (Fig. 8). Some grains are cut by a weak penetrative foliation revealed

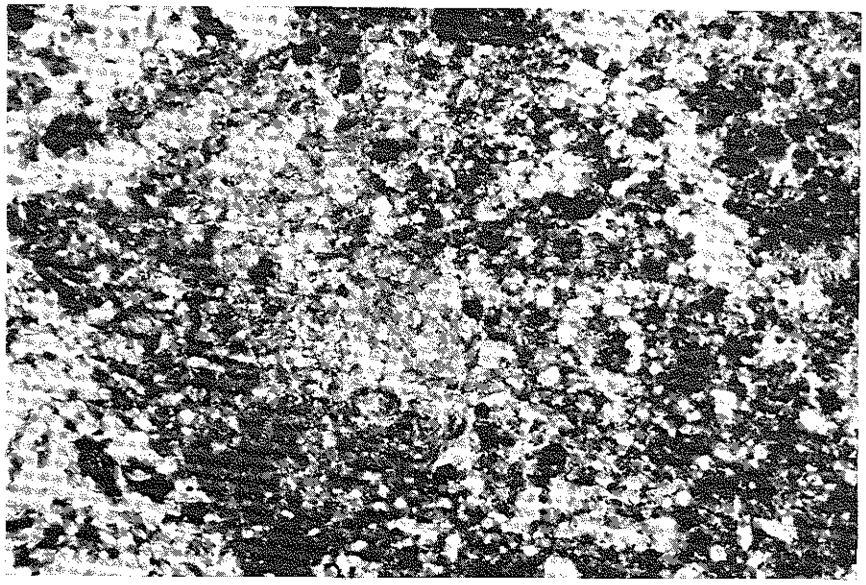

Figure 8. Photomicrograph of a subhedral andalusite porphyroblast in phyllite interbedded with the Waterloo Quartzite. The andalusite was recently identified in core from a deep diamond drill hole drilled by Haimson (1978). This porphyroblast is entirely altered to sericite. Several andalusite grains, however, retain unaltered cores. Bar scale is 1 mm.

by aligned sericite grains. The assemblege andalusite-muscovite-quartz suggests that metamorphism reached upper greenschist facies in the Portland area. The foliation that cuts the andalusite may reflect a later retrograde overprint. A shallow intrusion is perhaps responsible for this zone of higher grade metamorphism (a thermal node?).

GEOLOGIC HISTORY

The major late- and post-Penokean aged events in south-central Wisconsin are (stops refer to field trip stops of Smith, 1978c):

1) Intrusion of granite (stop 1) and extrusion of genetically related ash-flow tuffs (stop 2).

2) Eruption of the texturally variable ash-flow tuffs (stops 3 and 4). Granite formed in step 1 probably continued to rise, engulfing most of its volcanic cover and leaving surviving rhyolites as roof pendants.

3) Deposition of sediments on a eroded volcanic-plutonic terrain. Later, folding and low grade metamorphism resulted in the Baraboo and Waterloo synclines and the folding of the rhyolite ash-flow tuffs.

An alternate, more complex interpretation of the structural geometry of this terrain involves two episodes of folding. Notice that the prominent bend in the contact between chemical groups 2 and 3 (south of Green Lake) is mirrored by a change in the orientation of structural elements in the rhyolite inliers (Fig. 5). At Marquette, fold axes trend N. 30 to N. 50 E., but at Utley, fold axes and flow foliation strike N. 70° W. (Gram, 1947). It is tempting to extend the axis of the Baraboo syncline into this area to account for this structural bend. More than one episode of folding would be required to explain this structural geometry. During the first episode of deformation the rhyolites were folded. The second episode involved the refolding of episode 1 structures and the formation of the Baraboo and Waterloo synclines. These events were separated by a period of erosion and the deposition of the Baraboo-Waterloo sandstone sheet. If this history is correct, an uncomformable relationship would be expected between quartzite and underlying rhyolite. The only area where this hypothesis can be tested is in the Baraboo range where both rock types crop out in close proximity. On the north side of the Baraboo range, to both the east and west of the Lower Narrows of the Baraboo River, abundant outcrops of rhyolite are found structurally above but stratigraphically below the quartzite (the north limb of the syncline is overturned in this area, Dalziel and Dott, 1970). To the west of the narrows, the rhyolite strikes N. 40 E. and the quartzite trends east-west to N. 80° W. To the east of the narrows, flow banding in the rhyolites varies in strike from N. 40° to N. 80° E., while the quartzite trends N. 80° E. to N. 80° W. At the Caledonia Church locality (Fig. 1) banded and brecciated rhyolite is overlain by Baraboo Quartzite on the south limb of the syncline. Here the rhyolite strikes N. 80° E. and the quartzite trends N. 40° to N. 60° E. These structural data are suggestive of an unconformity between the quartzite and rhyolite at Baraboo and strongly support a model that involves at least two folding events to describe the structural evolution of this area.

4) Intrusion of the coarse-grained rhyolite dikes (stop 2), and the Baxter Hollow Granite (in the Baraboo area). Also intrusion of dacite, andesite and basalt dikes (stops 1 and 4). Dacite dikes are younger than andesite dikes at Marquette, and at Marcellon an andesite dike is younger than a basalt dike. These relationships suggest that the age sequence for the dikes from youngest to oldest is dacite, andesite, basalt. Dike emplacement may have been penecontemporaneous with the events of step 3. The thermal node (?) in the Portland area and an amphibolite dike that cuts Waterloo Quartzite (identified in well core) are additional evidence for igneous activity during this stage.

5) Local intrusion of pegmatite dikes into the Waterloo Quartzite.

Events 1 and 2 occurred 1765 ± 10 m.y. ago. Events 3 and 4 probably occurred 1630 m.y. ago, and step 5, 1500 m.y. ago, contemporaneous with the intrusion of the Wolf River Batholith(?).

Hopefully these comments on the igneous and metasedimentary rocks in south-central Wisconsin will rejuvenate interest in these important exposures and will stimulate professional geologists and students to study these rocks with the care and detail that they deserve.

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