From the Archivist's Corner

Baraboo Revisited

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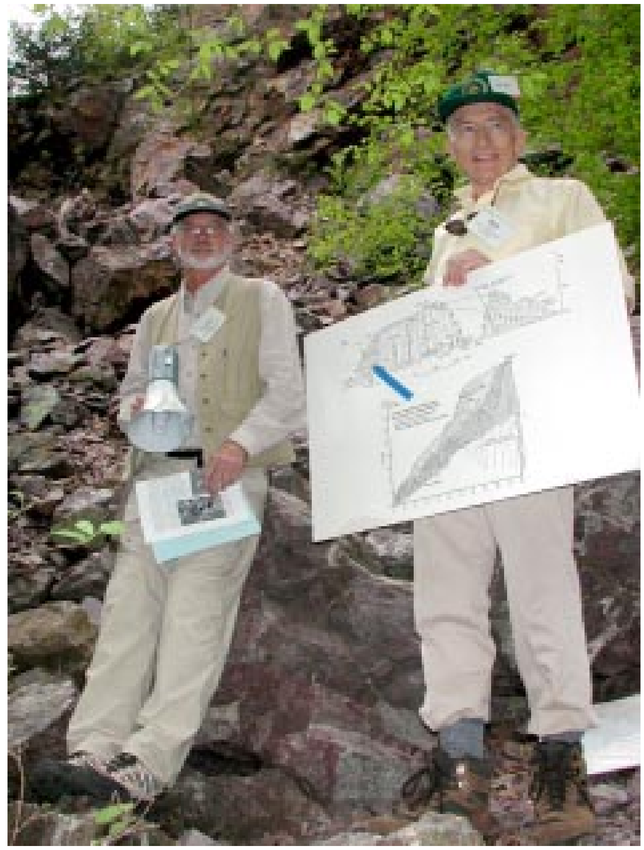
Introduction

The Baraboo District must be familiar to practically all of our alumni. Surely most have visited it on at least one field trip when they were students. Freddie Thwaites' spring vacation plane table mapping course is probably the most famous, at least among older alums, but beginning courses and several advanced courses always featured at least one trip each—and they still do. Moreover, besides the UW-Madison, countless other institutions in the upper Midwest have for years also taken field trips to the area, especially for structural geology, because it is the nearest place to see rocks that are inclined more than a fraction of a degree. In the fall and spring, yellow buses crawl over the Baraboo Hills like a swarm of ants. Even geologists who have never been to Wisconsin are likely to have learned of the Hills in the context of courses or research about Precambrian and/or structural geology.

Why is the Baraboo District such a classic place? It is because there is something here for every specialty. Structural, geomorphic, and paleogeographic relations are clearly displayed in an accessible area. There has been just enough erosion to expose the bedrock and glacial deposits extensively, but not so much that their mutual relationships can only be imagined. These factors make it an exceptional teaching laboratory. Furthermore, as the southernmost exposed extension of the Canadian Shield, Baraboo also has important bearing upon our understanding of North America's Precambrian geology.

Because the area has been studied for 150 years, it may come as a surprise that we have been re-examining it and gaining important answers to some thorny old questions.

Fortunately, working at Baraboo costs relatively little, for in the climate of modern research funding, who would support research by a couple of old retired professors in such a long-studied region in the middle of the craton? It would be natural to suppose that everything of any significance had long since been learned there. Yet, we believe that our project exemplifies an ideal for modern earth science research through collaboration. It sprang from traditional, sound field and petrographic investigations, which continue to be given high priority at Wisconsin. Our new insights have been gained largely, however, through the enthusiastic cooperation of many colleagues and students in the department, who have contributed critical data from modern, sophisticated instruments in their laboratories. These include John Fournelle (electron microprobe), Clark Johnson (radiogenic isotopes), Brad Singer (rare gas geochronology), Phil Brown (fluid inclusions), and John Valley (stable isotopes). In this way, we have been able to ask questions that could hardly have been conceived, much less answered, when we first began going to Baraboo nearly half a century ago. And so it is still possible to learn important things from some of the longest-studied rocks on earth. Our latest results will appear in *The Journal of Geology* in May, 2003.



Gordon Medaris, left, and Bob Dott leading a field trip to Abelman's Gorge in the Baraboo Hills for the annual meeting of the Institute on Lake Superior Geology, May 2001. (photo by Carl Bowser)

History of Studies at Baraboo

Recognition of an inlier with igneous and metamorphic rocks within a large region of flat-lying lower Paleozoic strata dates back to the 1850s. Details of the area were not immediately forthcoming, however. For example, the Baraboo Quartzite was at first considered to be metamorphosed Paleozoic sandstone and its exposures in the North and South Ranges were considered to be parts of a single, very thick, continuous homoclinal succession. None other than James Hall of New York in 1862 first suggested that the quartzite was Precambrian and that it might correlate with the Huronian strata of Ontario. At that time, he held appointments as state geologist for both Wisconsin and Iowa during one of his feuds with the New York legislature, which had suspended his salary.

Roland Irving, the University's first professionally-trained geologist, in 1872 proved the unconformable relationship between the quartzite and surrounding Cambrian sandstones and conglomerates. The first correct interpretation of the synclinal structure of the quartzite was by Samuel Weidman in 1904. He was a product of the famous Wisconsin School of Precambrian Geology, so had learned from C.R. Van Hise and C.K Leith new principles of rock deformation and the techniques for inferring regional structures from outcrop-scale features like slaty cleavage and drag folds. The key at Baraboo was Weidman's recognition that the quartzite is slightly overturned in the North Range, and is repeated in the South Range to form a syncline, rather than being a continuous homocline. Iron mining, which began in 1889, provided many drill cores, which revealed the presence in the subsurface of a substantial thickness of Precambrian metasedimentary rocks, which overlie the Baraboo Quartzite in the axis of the syncline and contain a banded iron formation.

The Baraboo District soon became an important showcase for Van Hise and Leith to illustrate their principles of structural and metamorphic geology. Because of its accessibility, it quickly became a mecca for instructing students and colleagues. The District also provided examples for illustrations in publications such as Leith's 1913 textbook of structural geology, which seems to have been the first on this topic.

Subsequently, several UW student theses dealt with local aspects of Baraboo geology. In 1942 Bob Gates published a detailed and accurate geological map of the Baxter Hollow area and suggested that the Baxter Hollow granite was formed by granitization of the quartzite and associated rocks, reflecting a popular petrological concept at that time. In 1947 University of Chicago student N.A. Riley published an important thesis, which was to become a classic among petrofabric studies. These factors help explain the deification of Van Hise Rock located in Abelman's Gorge eight miles west of Baraboo. Nearly every alum should remember making a pilgrimage to that geological holy place, where the trip leader would genuflect before the bronze plaque dedicated to C.R. Van Hise (See article elsewhere in the *Outcrop*). Con Emmons once told us that the plaque was placed with great ceremony in 1923 to save the rock from being removed by the state highway department. In 1999 The Rock was elevated to National Historic Landmark status, again with appropriate ceremony and the emplacement of a large sign board.

In preparation for the annual meeting of the Geological Society of America to be held in Milwaukee in 1970, our local Wisconsin planning committee quickly decided that a field trip to the Baraboo Hills was mandatory. Bob Dott and Ian Dalziel volunteered to organize such a trip and state geologist George Hanson enthusiastically agreed to support the preparation of an ambitious guidebook with a colored geologic map and a lot of structural data. The resulting Wisconsin Survey Information Circular No. 14 is still in print and remains the definitive guide to Baraboo geology. Dott took the lead in compiling the geologic map and also made detailed studies of the spectacular Cambrian conglomerates of the district, which he interpreted in terms of tropical storm waves generated when Wisconsin lay in the southern tropics. Dalziel applied the latest techniques of detailed structural analysis, which he had learned at the University of Edinburgh, but which were based ultimately upon the pioneering work of Van Hise, Leith and Mead. Those fundamentals were learned here in 1925-26 by a young English graduate student, Gilbert Wilson, who later introduced them at the Imperial College in London. After World War II, Wilson and his students refined and expanded their applications and created a revolution in structural analysis during the 1950s and 1960s. It is ironic that this new structural analysis was unknown at Wisconsin, however, until Dalziel joined our faculty in 1963.

After 1970, little new research on the bedrock was conducted around Baraboo, but several regional syntheses included remarks about Baraboo rocks. Dott in 1983 presented a sedimentological interpretation of the Baraboo, Sioux and several

Mapping field trip at Devil's Lake, spring of 1926. Left to right: William Brown, Roy Koplin, Loyal Durand, F.T. Thwaites, Ralph Licking, Miriam Wollaeger, Katharine Fowler, Clarence Chapman, Edward Gansen. (photo–department archives)

other red quartzites in Wisconsin and Minnesota. He inferred that these were remnants of a vast, thick wedge of post-orogenic (i.e., post-Penokean), quartz-rich sands, which were deposited by braided fluvial, followed by shallow marine (largely tidal) processes on the southern edge of a Proterozoic craton. The red color of the quartzites was taken to indicate an aerobic atmosphere by at least 1500–1600 million years ago (henceforth abbreviated as Ma).

In the late 1980s and early 1990s, geologists from other institutions offered several alternative interpretations of the Baraboo and related quartzites in the Lake Superior region. These include deposition of the quartzites in fault-bound local basins contemporaneous with 1760 Ma magmatism, a pre-Penokean age for the quartzites, and an allochthonous tectonic position. Such interpretations resulted partly from the misguided notion that all Proterozoic quartzites in the region are correlative, when we know today that quartzites of diverse characteristics and ages (both pre- and post-Penokean) are present.

There was new work on Quaternary geology during the 1980s and 1990s. Lee Clayton and John Attig of the state survey published a new geologic map of Sauk County in 1990, which includes most of the Baraboo Hills. Their field work added much new information about the Quaternary history of the region, including the catastrophic draining of Glacial Lake Wisconsin through The Dells and around the east end of the Hills. They also published *GSA Memoir 173* about the history of Glacial Lake Wisconsin. Meanwhile, Lou Maher was using pollen preserved in cores taken from the bottom of Devils Lake to infer climate changes during the past 14,000 years. The post-glacial warming trend is clearly represented by a decline of spruce, aspen and birch pollen and an increase of such species as oak, elm, maple and grasses; a flood of ragweed pollen clearly marks the arrival of Euro-Americans. New carbon dates by accelerator mass spectrometry indicate that a reversal of the trend occurred for about 1000 years between 12,700 and 11,700 years ago. This indicates a cold period that correlates with a temperature decline recorded also in eastern Canadian lakes and in Greenland ice cores, which is known in Europe as the Younger Dryas interval. Apparently the entire northern hemisphere experienced this post-glacial cold spell.

So What's New?

In 1995, PhD candidate Nik Van Wyck presented new U-Pb ages for zircon from many widely scattered Wisconsin Proterozoic granites. Some of his interpretations of the significance of his data seemed to us to be counter to known field relationships, especially regarding the relative age of the Baraboo Quartzite and the underlying Baxter Hollow Granite. Van Wyck accepted the persistent notion that the Quartzite might be older than the granite, even though intrusive field relations had never been observed. He dated zircons from the granite as 1750 Ma, which agreed with prior-determined ages for the rhyolite that underlies the quartzite at other localities and extends widely across south-central Wisconsin. We wondered how the Quartzite could be older than 1750 Ma, yet could also overlie 1750 Ma rhyolite? Medaris then discovered, in a drill core from Baxter Hollow, a well preserved paleosol, which had clearly developed by deep weathering of the Baxter Hollow Granite before deposition of the quartzite. Following this discovery, Ron Schott analyzed euhedral grains of detrital zircon from the base of the quartzite immediately above the paleosol, which yielded ages clustering around 1750 Ma, proving beyond doubt at last that the Baraboo Quartzite must be younger than the underlying Baxter Hollow Granite.

What about the younger age limit for the Quartzite? Definitive proof still eludes us, but available evidence points to a probable time of deformation and metamorphism of about 1630 Ma. Dott and Dalziel in 1972 had obtained an apparent Rb-Sr age of 1635 Ma from two phyllites interstratified with the quartzite. Although not a very compelling age by itself, it seemed to agree with a widespread resetting of Rb-Sr clocks over a large region in the upper Midwest, which had been documented by R. Van Schmus (University of Kansas) and later recognized independently by Daniel Holm (Kent State University). Both of those workers link the 1630 dates with widespread deformation and heating, which re-set the Rb-Sr ratios in many rocks. More recently, hydrothermal alteration in both the Baraboo and Sioux Quartzites has been determined by the ^{40}Ar-^{39}Ar method to be around 1450 Ma, which matches the age of emplacement of the large Wolf River batholith in central Wisconsin. Not surprisingly, that major magmatic event had far reaching effects, and this date places an absolute younger limit for the age of the Quartzite. We conclude from all available evidence that the most probable depositional age of the Baraboo Quartzite was between 1750 and 1630 Ma, but surely could not have been later than 1450 Ma. Interestingly, the 1630 ages correspond with better dated tectonic deformation and metamorphism far away in the Southwest, the Mazatzal orogeny, which leads us to speculate that a plate collision along the southeastern margin of the continent at that time may account for deformation and metamorphism as far away as Wisconsin. Moreover, the 1450 Ma hydrothermal effects also seem to have occurred very widely, for example in the Athabasca basin of Canada. At that time, A-type granites were intruded widely across the continent, which prompts us to postulate that the regionally extensive, but stratigraphically restricted, 1450 Ma hydrothermal alteration was due to brines migrating away from intrusive igneous centers.

One of the most important implications of our new work at Baraboo is the demonstration by Medaris of the advanced chemical maturity of paleosols beneath the Baraboo and Barron Quartzites and the extreme chemical maturity of the overlying strata, which are among the most mature in the geological record. The sand fraction is nearly pure quartz and the interstratified pelitic layers are almost pure kaolinite (Barron Quartzite of northwestern Wisconsin) or its metamorphic equivalent pyrophyllite (Baraboo and Sioux Quartzites).

How could land surfaces remain stable on a vegetation-free landscape long enough to produce such mature soils and clastic sediments? This seems to us a profound question, which has nagged us for years. In 1983, Dott postulated a flat landscape, but this does not seem an adequate explanation because there had to be stream gradients sufficient to transport abundant sand and even fine pebbles. Since then we have learned about microbiotic crust soils, which are best known today in arid regions. These crusts or mats are complex communities of microscopic cyanobacteria, algae, fungi, and lichens. They lend considerable stability to a soil surface because they possess filaments, which can bind sand and silt particles. Some botanists have postulated that these biotic communities were the first biological inhabitants of land, but until recently there was no known fossil evidence to support this idea. Now there is a little paleobotanical and geochemical support, so we predict that increasing evidence of very ancient biotic crusts will appear during the next few years.

References

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