WATER QUALITY AND LITHOLOGY, MINNESOTA-ONTARIO BOUNDARY

Faculty

Richard C. Stenstrom, Beloit
C. Edward Buchwald, Carleton

Students

Rani Arbo, Amherst
Catherine Inman, Carleton
Eric Miller, Amherst
Benjamin Morris, Williams
David Nemetz, Beloit
Sonja, Wolter, Carleton

THE INFLUENCE OF LITHOLOGY ON THE COLOR AND QUALITY OF SURFACE WATERS ALONG THE NORTHERN MINNESOTA-ONTARIO BORDER: a test of a hypothesis.

Richard C. Stenstrom
Department of Geology
Beloit College
Beloit, WI 53511

When glaciers receded from northern Minnesota and southern Ontario, they left in their wake exposed bedrock with many depressions, and little in the way of soil cover. These depressions are expressed today as one of the world's finest systems of interconnected lakes and rivers, forming the Boundary Waters Canoe Area of northern Minnesota and the Quetico Provincial Park of Ontario. The area lies just north of a triple drainage divide, which separates waters flowing south to the Mississippi and the Gulf of Mexico from those flowing east through the Great Lakes and the St. Lawrence Seaway to the Atlantic Ocean, and those flowing essentially north and east, emptying eventually into Hudson Bay. The area is rich in past history, from the Indian tribes which inhabited the region through the early French fur traders and eventually the loggers, who were responsible for stripping much of the land of its virgin timber. In the early 50s, led by such notable conservationists as Sigurd Olsen, efforts succeeded in setting aside much of the region, now covered by second and sometimes third generation growth of trees. It is now protected against future development by its Wilderness designation. Across the border, in Canada, the adjacent area is protected as one of Ontario's Provincial parks.

Although the region has been marked by human influence, the effects of the clearcutting at the turn of the century have long since been minimized, and cultural influence is today largely restricted to the impact of canoers venturing into the wilderness. Restrictions on the number of people allowed to enter the region and the insistence that no bottles or cans can be brought in have further reduced the impact on the water quality of the area in recent years. Today the quality more closely registers the influence of the surrounding lithology and vegetation. However, since there is little soil to contribute mineral matter to the waters, the low buffering capacity of the lakes makes them subject to airborne particles, and fear of acidification from industrial activities hundreds of kilometers distant has focused attention on the water quality of this region.

Geologic studies over the past 10 years by the Department of Geology at Beloit College has provided the opportunity to indirectly observe the character of the water in the numerous lakes and streams. The waters on the Canadian side of the border have appeared to be substantially clearer than those which drained areas to the south and west on the United States side. Based upon the geologic mapping, this would imply a relationship of clearer waters to the area underlain by the Vermilion Batholith, and waters of higher turbidity or color to regions where metamorphic units were exposed. To test this hypothesis a reconnaissance study of the area along the contact with the batholith was proposed. Data would be collected relating to the clarity of the waters, along with most of the standard chemical and physical characteristics which are typically measured in the field. Samples would also be collected for further analysis. As an extension of the project, it was hoped that if a relationship between lithology and water clarity was substantiated, it might be possible to use other means, such as remote sensing, to delineate these changes, and rapidly extend the projected mapped units to other areas on the basis of the spectral response of the water to various satellite sensing bands.

Development of the project

Following approval of the proposal by the Keck Geology Consortium, a search of the literature revealed that little information had been collected in the Boundary Waters region of interest.

George Rapp of the University of Minnesota had compiled an impressive list of analyses for lakes in this north country, and had compared them to lakes underlain by Precambrian rocks in Wisconsin in an effort to show the impact of acid rain on these regions. Much of the data, collected in cooperation with the EPA, still remains unpublished (personal communication.) The lakes which he sampled, however, with the exception of Crooked Lake, are near the boundary of the wilderness area where access by road is still possible. Extension into the region underlain by the Vermilion batholith remained an objective for future study.

To permit correlation with data produced by the U.S. Geological Survey, methods of collection and preservation were designed to correspond to Survey guidelines and procedures listed in the *National Handbook of Recommended Methods for Water - data Acquisition.* However, the remoteness of the area precluded application of some of the standard procedures, such as refrigerating samples and performing laboratory analyses shortly after collection. Dr. Blair Jones of the Geological Survey at Reston was contacted for advice on the best alternatives, and using his recommendations it was decided to invest in portable Orion pH meters with Ross electrodes, which have a very fast response compared to other electrodes, an essential feature in these poorly buffered waters. In leu of refrigeration, the samples were kept immersed in the lake except during transportation, minimizing influences from widely ranging temperatures. The initial plan was to outfit four parties to collect data, each having a pH meter and buffers, conductivity meter, dissolved oxygen meter, secchi disc for measuring depth of visibility, water sampler, thermometer, Hach color test kit, filtration funnels equipped with 0.45 mμ filters, vacuum pump, sample bottles, nitric acid for fixing reactive elements in the water, and Hach digital titrators with necessary chemicals for alkalinity and other selected titrations. Two bottom samplers were also brought along, one a gravity corer (known affectionately as "the beast",) and the other an Ekman dredge. Once in the field, the party would not have access to civilization for four weeks, except for a resupply run for food and some stored equipment two weeks into the project. At that time, it was planned to ship the samples collected back to the base camp, which was the Wilderness Field Station operated by the Associated Colleges of the Midwest, located on Low Lake at the edge of the Boundary Waters Wilderness. A fresh supply of sample bottles would be brought in with the food.

Equipment was checked at Beloit College before leaving for the field, and the major portion of the food supplies were purchased and packed. Menus for the four weeks were roughly organized, and field support was supplied by a cook and canoeman, whose function it was to run the camp and supply fresh meat through fishing. One day was set aside before entering the Boundary Waters to acquaint students with the use of the equipment. This was to take place at the ACM station. The party consisted of student researchers Rani Arbo and Eric Miller from Amherst, Cathy Inman and Sonja Wolter from Carleton, Ben Morris from Williams, and Dave Nemetz from Beloit, along with Dick Stenstrom from Beloit and Ed Buchwald from Carleton as faculty, and Miquette Gerber as cook and Gary Creaser as canoeman, both from Beloit. Five canoes served as the means of transportation. After entering the Boundary Waters and establishing the first camp on Jackfish Bay, it was discovered that one of the new pH meters was not functioning, and this required an immediate change in plans in the way research was carried out. Only three parties could be supported with the available equipment, as pH readings were regarded as essential. To maximize student involvement, Buchwald and Stenstrom revised their activities to serve as support for the student projects.

Research activity

The initial phase of research involved reconnoitering the waters on both sides of the contact to establish whether the hypothesis of the change in water characteristics with lithology was real. Maps made by previous Beloit field parties were used to indicate where the contact with the Vermilion Batholith should be, and since it followed closely the border between the United States

and Canada, the initial traverse took us down the Basswood River and connected lakes. A main camp was established on a small bay east of Thursday Bay, and from there daily trips were made to surrounding lakes and connecting rivers for sampling and measurement. Readings taken at the site were recorded in field notebooks, and samples were generally split, with one fraction untreated and the other filtered on the spot and acidified. Samples were marked as to location, time, and depth, and the filters saved. Upon returning to camp, which often was early evening, the task of running the titrations would often extend into dusk. An attempt was made to have notes copied from the daily notebooks into a master notebook. Sample locations (shown by circles in figure 1) were periodically plotted on the map . Preparation of the sample bottles with acid, repair of equipment, and distillation of water was left to the faculty. After the region accessible from the first base camp was resonably sampled, three other base camps were established during the course of the study (locations indicated by stars in figure 1), one on Robinson Lake in Canada, one at Lower Basswood Falls, and one on Horse Lake. Robinson Lake placed us within the Vermilion Batholith, and Horse Lake within the metasedimentary units. As the work progressed, some students developed a more focused research project and collected additional samples and measurements at one or two specific sites. At the end of the four weeks samples were collected at the ACM station and records were updated. The samples were brought back to Beloit where they were placed under refrigeration. As needed, portions were sent to other institutions for laboratory analysis. A portion was also dried in preparation for INAA analyses at the University of Wisconsin. The bulk of the analyses and processing were handled by the students, and their results and interpretations are embodied in the following abstracts. From the data collected and the suggested interpretations, planning for the second phase of the study will focus on targeting specific projects with more restricted study sites.

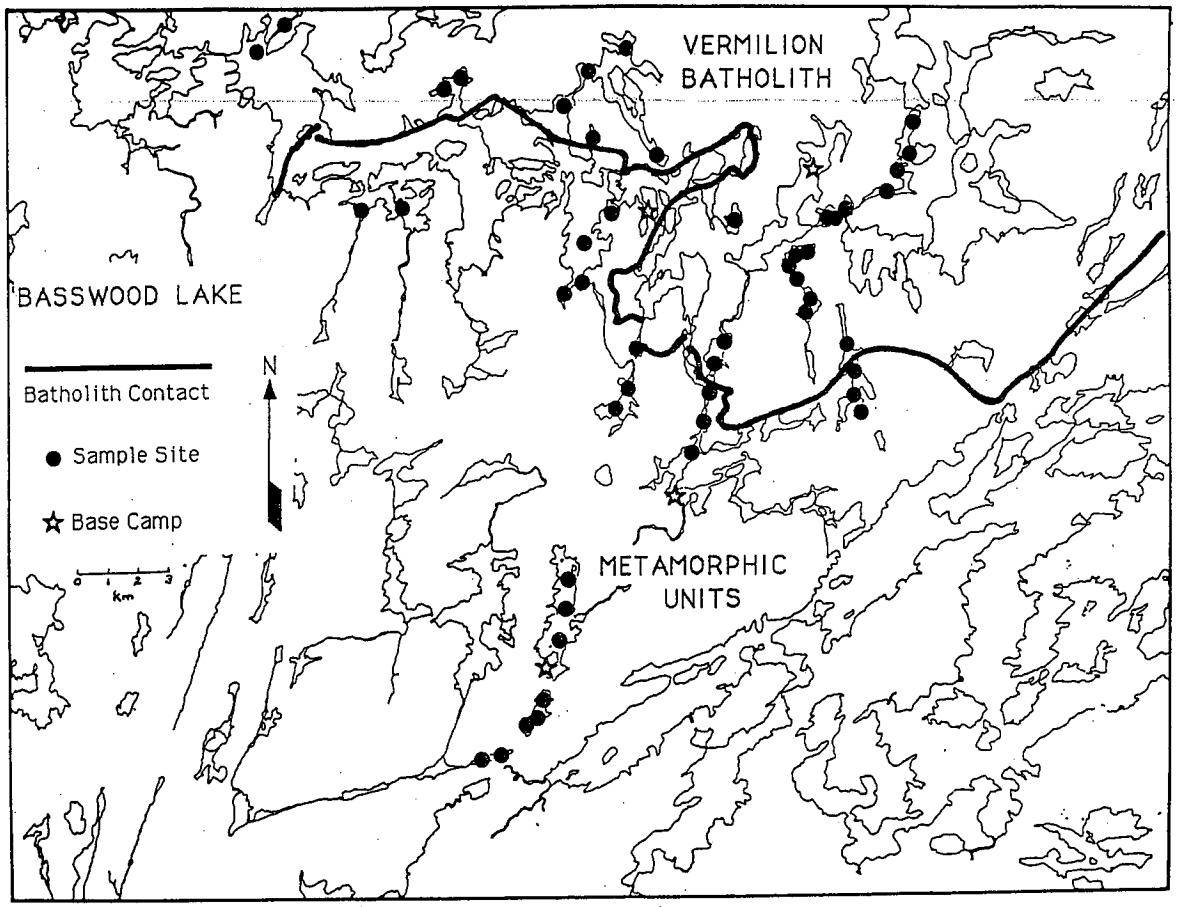

Figure 1. Map of northern Minnesota-southern Ontario showing water sample sites, camp sites, and the contact between the Vermilion Batholith and metamorphic units.