The Granite State Geologist

Newsletter of the New Hampshire Geological Society
PMB 133 • 26 South Main Street • Concord, NH 03301

Number 34 • Summer 2001 http://nhgs.org/NHGS/

President's Message

Lee Wilder

Nearly one-third of our membership attended the Spring 2001 Dinner Meeting, held in mid-April at the Cat n' Fiddle in Concord. A delicious buffet followed a lively social hour. Garret Graaskamp gave a presentation explaining the mission of the American Groundwater Trust. Garrett invites inquiries regarding help with any ground water "education" problems, at: agwtHQ@aol.com

Things are busy on the New Hampshire Geology front. HB 245 is making its way through the legislature and by the time you read this we hope that the NH Office of State Geologist, will have become the NH Geological Survey (NHGS). Our State Geologist, Dave Wunsch, was instrumental in moving this initiative along (see report elsewhere). Most states refer to their geologic branch as the state's Geological Survey, and it seems that New Hampshire should also move into the 21st century. However, the NH Geological Survey initials (NHGS) conflict with the name of this "new" organization. Nationally, organizations like ours are known as "Geological Society of ...". I feel that we need to move in that direction and change our name to the Geological Society of New Hampshire (GSNH). In addition to our re-naming, we can also up-date our by-laws to streamline the structure of the board of directors and establish levels of membership, such as regular and corporate. With the possibility that the New Hampshire Council of Professional Geologists and the Geological Society of NH (GSNH) may merge, these changes would mean one NH geological organization to serve a variety of members and interests. We could consolidate some services and reduce redundant efforts, possibly including the newsletter, treasury, membership database, and dinner meetings. But we need to hear from you as we progress down this path. Remember this is your society and it should operate in such a fashion as to best serve the NH geological community.

NH Geological Society Interviews Gene Boudette, Retired New Hampshire State Geologist, Part 2

Dr. Eugene (Gene) Boudette (GB), who retired last year after being the New Hampshire State Geologist for 14 years, had discussions last year with former NHGS President Jack Jemsek (JJ). Gene provided a comprehensive perspective of his background, contributions, and vision of the future of geology in New Hampshire. Below is the second of a series of articles to be published in The Granite State Geologist.

JJ: After you completed your Antarctic mapping assignment with the U.S. Antarctic Research Program (USARP) program in 1961, what was your next assignment with the U.S. Geological Survey (USGS)?

GB: n the 1960's, I was generally based out of Washington, D.C. and continued summer field studies in Maine. While in Washington, D.C. I also spent two years as a USGS geologic map editor. The field work in Maine was similar to work I did before 1959, but the concepts were shifting from "favorability criteria" to "genetic models" for formation of the strategic reserves of copper (Cu), lead (Pb), and zinc (Zn). The Cu-Pb-Zn reserves were generally found in what is now referred to as volcanogenic massive sulfide (VMS) deposits.

JJ: Did you have a good understanding of VMS deposits back then, and the potential for their occurrence in Maine?

GB: ell, there was a world-class sulfide deposit in Bathurst, New Brunswick with tremendous reserves and active mining operations. Our theory was that if such a VMS deposit occurred in New Brunswick, there was a reasonable probability that similar deposits might be located in the same lithogenic strike-belt found in Maine. Finding such deposits would mean boosting the local economy and raising the known national mineral reserves for ores such as Cu, Pb and Zn, and a host of other ores.

With regard to VMS deposits, we obviously know a lot more about them now than we did back then. Recent

marine geologic studies have indicated that the VMS deposits are seafloor deposits, typically occurring along strike-slip fault zones and spreading centers. Deploying submersibles and application of remote sensing methods have shown us that seafloor vents, such as smokers, are responsible for discharging sulfur-rich solutions that are generated deeper in the crust, and the ore is subsequently deposited on the seafloor.

We had to go through the stage of realizing that there was more than one basic VMS model at work. The seafloor-spreading center became an obvious present-day depositional environment analog. However, in Maine, the extensional tectonic model, i.e., formation at spreading centers, was not the final explanation. For example, mapping of ophiolites has introduced the concept of obduction, so that the tectonic history of these VMS deposits can be quite complicated. As it turns out, we didn't have a viable model for VMS formations because both plate tectonic theory and our knowledge of seafloor processes were still in their infancy.

JJ: Have other VMS deposits been found in New England?

GB: Yes, in several places and situations. A tectonic model that is helpful to think about for New England VMS deposits is a sliver of oceanic crust being obducted onto continental crust along a northeast striking fault plane, and then tilted, creating a northeast plunge line. An erosional surface that is roughly horizontal would then expose relatively deeper paleocrust to the southwest, with resulting higher temperature and pressure-related mineral assemblages. If you start in Connecticut and proceed northeasterly on the same strike line, you will begin with paleocrustal depths of as much as 12 km exposed at the surface. By the time you get to Coos County, NH, it is somewhere between 5 and 7 km, and then if you continue and go to Aroostook County, Maine, paleocrustal depths of 4 or 5 km are encountered in essentially the same rocks that are found in Connecticut. This is a very remarkable segment of a northeast-plunging orogen that is waiting to instruct us.

JJ: Are there exceptions to this general model for VMS deposits in New England?

GB: If you are down at the paleocrustal depth sensed at the New Hampshire-Massachusetts state line, you probably are at too large of paleodepth. A VMS deposit would have likely been mobilized or stripped away by erosion. Here, the application of the plunging orogen concept comes in handy. There are variations along the strike line, as the plunge line will vary due to other tectonic processes. Mines in Orange County, VT, for example, appear to be remnants of VMS deposits where you would normally not expect them using the above simple tectonic model. Thus, both "porpoising" of the orogenic plunge line and late stage major faulting probably enter the picture.

JJ: Sounds like you readily accepted the early elements of plate tectonics. What else comes to mind with regard to your work in the 60's?

GB: The 60's are remembered socially for marriage, children, and home ownership; and professionally for a return to field research in central-western Maine with a return to Dartmouth to continue graduate studies. The latter provided an inspirational reunion and opportunity to work with John Lyons again. These years are also celebrated for another happy return, which was the USGS supervision of Linc Page. It was Linc who had brought me into the USGS in 1953 to work on the Trace Element Cooperative (TEPCO) program on the Colorado Plateau.

JJ: Speaking of Dartmouth, tell us a little bit about your doctoral work there.

GB: I began my doctoral research at Dartmouth in 1986 through funding from Dartmouth and the USGS. My thesis advisor was John Lyons and my thesis topic was the geology of the Kennebago Lake 15' Quadrangle in the Rangeley Lakes - Upper Dead River region of northern Maine, adjacent to the Canadian border. I attempted to use plate tectonics and the three-dimensional perspective that it provides. Unfortunately, I felt that I fell out of favor with some of my USGS colleagues who were not, at that time, intrigued by plate tectonic theory. I was, however, strongly motivated to accept the theory, mainly because of the discovery of the Benioff Zone. As you recall, the Benioff Zone is the plane of earthquake hypocenters that align along the subducting slab below island arcs. I was also fortunate to have Dick Stoiber and Chuck Drake around Dartmouth to field plate tectonic questions.

JJ: Did you end up settling down in New England after your doctoral work at Dartmouth?

GB: Not exactly, in January 1971 I got my marching orders to go to the USGS office in Flagstaff, AZ to participate in the Apollo Field Geology Investigation Team (AFGIT). Before leaving for the west, Bob Moench, Gary Boone and I ran the 1970 NEIGC in northwestern

Maine. I was pretty much out west for the next four years with lots of time spent in Houston and Cape Canaveral.

JJ: Antarctic explorer and planetary geologist, seems like your work has taken you around the world and beyond, so to speak. How was it working with the Apollo program?

GB: My participation in AFGIT was quite demanding due to the time-sensitive nature of the missions and the surface experiments that the astronauts were committed to perform on the moon. I did some photogeologic mapping using imagery taken by astronauts on previous missions. There also needed to be simulated field training of the astronauts appropriate for the landing site that had been selected on the moon. I was associated with Apollo missions 15, 16 and 17.

The Apollo field training sessions were quite intensive with trips about once each month to places like impact craters on the Canadian Shield and volcanic centers in western U. S. including Hawaii. My family tolerated more than I can imagine with regard to my absence during the training sessions and duties at mission control. I remain indebted to them for their support.

JJ: I always understood that one of the perks of doing traditional field geology was the travel, but you remind us that this travel can have its downside as well. When did things settle down for you?

GB: I guess when my position in AFGIT came to an end in 1975. My family and I came back to Washington, DC, where we had lived earlier. The circumstances of my return were related to a restart of the TEPCO uranium resource analysis initiative renamed the National Uranium Resource Evaluation (NURE). My overview was relatively expanded, and I worked on a variety of uranium occurrences ranging from Washington to Colorado and especially in the Appalachians. It was an inspiring assignment that led me to appreciate, among other things, the place of two-mica granite in orogeny. I was also fortunate to participate in an uranium/petrologic research exchange initiative with French geologists.

JJ: What spurred the new interest in uranium resources?

GB: The funding for the NURE program emphasized alternative energy sources more than the military needs that characterized the TEPCO program. The country had just survived the gasoline crisis in 1973, and fossil fuel reserves were providing appropriate anxiety.

JJ: Did you finish your tenure at the USGS working within the NURE program?

GB: Not quite. After NURE I transferred to the Branch of Resource Analysis and worked with Larry Drew where I continued research on mineral resource field investigations emphasizing VMS deposits. This work was concerned with predictive models that could be applied to identify regional mineral resource locations and calculate potential reserves. The initiative was coordinated with the Continental US Mineral Appraisal Program (CUSMAP) of the USGS, which has made several major published contributions to New England geology. One recent publication I was involved with CUSMAP is entitled Tectonic Lithofacies, Geophysical and Mineral Resource Appraisal Maps of the Sherbrooke-Lewiston Area, Maine, New Hampshire and Vermont, United States and Quebec, Canada (R.H. Moench, E.L. Boudette and W.A. Bothner, 1999, USGS Miscellaneous Investigations Series Map I-1898-E). The "Sher-Lew" study is notable in that it does a good job in integrating various geologic and mineral resource data using "machine manipulation" to conduct statistical analyses.

JJ: You seem to have spent a good amount of time mapping in northern Maine. What were you most intrigued with in this area?

GB: I suppose it was the opportunity of working in the infrastructure and roots of an old orogen during the evolution of the plate tectonic model. Also, northwestern Maine contained the mysterious "Chain Lakes massif" characterized by a diamictite without sedimentary structures (e.g., non-sedimentary breccia). Part of the massif was deformed into a cataclasite sheet during the obduction of the Cambro-Ordovician ophiolite.

JJ: Is the Chain Lakes massif an impact structure?

GB: Not the massif as we know it, but the diamictite once could have been part of an impact structure; the genesis of the rock is, to say the least, controversial. I believe that ballistogenesis has a place in the working hypothesis while intensive mapping and petrologic study continues. One must keep Smith's Rule in mind: "If it did happen, it can happen."

JJ: You mentioned use of computers in the data analysis as something new in your 1999 "Sher-Lew" study. When did you first use computers and how do you think computers have changed the way geologists accomplished their work?

GB: My first real exposure to computers came when I was doing some crystal structure work in feldspars about 1958. By about l967, when I could program in BASIC, it became obvious that research geologists were adapting to the machines rapidly, although software was not readily available. The expansion of productive time resulting from computer usage is an important dividend that remains with us.

JJ: Use of computers has upset some of the traditional geologists. We can sometimes limit our analyses to the extent that computers can quantify and display information. Historically geology has been a lot of hard fieldwork and it could be argued that the emphasis on computers has irrevocably changed the heart and soul of geology. What do you think?

GB: Computers are here to stay, but they have not helped the cause of gathering first-order data. Geologists in my generation have been the most affected by this. Even leadership in the USGS entertained the notion that field geology was dead, that individuals will never have to conduct field geology again. There was a great fascination with remote sensing without knowing exactly what remote sensing could do, and more importantly, what it couldn't do. It could not get you the strike and dip of bedding or the details of local structures, for example. The traditionalists had brought geologic mapping to the level of a blend of art and science. The revolutionists argued that it was not cost effective. What seemed to get lost in this face-off was the power of the apprentice-journeyman-master system in the development of a professional geologist. I remain steadfast on the issue of real-time field instruction, and for the professional it's a "school of lifelong learning". Like the petrographic microscope, the computer is just another tool to take advantage of. It is incumbent on the profession, however, to make certain that geologic maps are a source of real data for our users.

JJ. Why do you think that the USGS geologic mapping effort at a 1:24,000-scale was essentially abandoned in New England about 20 years ago?

GB: Traditional "systematic" mapping was impacted by a shift in research emphasis to topical studies or "overview" initiatives, such as New Hampshire groundwater resource evaluations. This impacted both bedrock and surficial deposit mapping support. It is compelling that the protection and proper use of groundwater reserves in glacial terrains has made our knowledge of such features as bedrock fractures and till formations, as well as sand and gravel aquifers, even more relevant.

JJ: Do you think that geologic mapping will make a comeback?

GB: During the "Apollo Years," I picked up on an instructive lament—"the real-time, ground-truth blues." Detailed mapping will never die, but I see a new approach that takes advantage of the expanding technology, such as use of global position satellite (GPS) and geographic information system (GIS) technologies to produce illustrations automatically in the field. It's like espionage—there is nothing to take the place of the agent on the inside that knows the territory and speaks the language. Comprehensive geologic maps will remain as part of the train of decisions in all sorts of projects and initiatives. Geologic maps will always be a fundamental layer used within the data base initiative (e.g., programs), and geologic mapping will become respectable again when "real-time" planning is taken seriously.

Stay tuned for another installment in this series, coming to The Granite State Geologist *soon!*

NHGS Summer Field Trip: The USGS-NH Bedrock Aquifer Assessment Sites in the Windham and Pinardville Quadrangles

On Saturday, July 21, 2001, the U.S. Geological Survey will host the annual NHGS summer field trip. This year the field trip will include stops in the Pinardville and Windham quadrangles in southern New Hampshire and will focus on the results of the New Hampshire fractured bedrock aquifer assessment. The trip will illustrate how remote sensing, geologic mapping, geophysics, and well-yield probability modeling were integrated to assess the bedrock aquifer.

The USGS has been studying New Hampshire's bedrock aquifer statewide in order to provide information that can be used by communities, industry, professional consultants, and other interests to evaluate the potential for ground-water development of crystalline bedrock aquifers. The assessment was done at 3 scales – statewide, regionally, and in well fields – to define relations that would increase the probability of locating high-yield water supplies in fractured-bedrock aquifers.

The statewide assessment identified factors that were associated with probabilities of high well yields. Factors related to bedrock well yields include (1) steeper slopes tend to have decreased yields; (2) regionally, hilltops are associated with decreased yields and valleys are associated with increased yields; (3) wells farther away from water

bodies are associated with decreased yields; (4) large drainage areas to the wells are associated with increased yields; (5) sites within 100 ft of specific types of lineaments are associated with increased well yields; and (6) various geologic map units were found to be significantly related to well yields. A statewide model providing predictive well yield probabilities was developed.

The regional (quadrangle-scale) phase of the investigation was designed to determine the degree to which predictive well-yield relations, developed as part of the statewide reconnaissance investigation, can be improved by use of quadrangle-scale mapping. For the regional analysis, additional geologic, fracture, and lineament data were collected for the Pinardville and Windham, N.H. quadrangles. These quadrangles were selected because they represent differing geohydrologic settings, and because these quadrangles contain the largest number of georeferenced bedrock wells of any in the State of New Hampshire. The rocks in these quadrangles have experienced different degrees of metamorphism, with much of the Pinardville quadrangle containing the Massabesic Gneiss (Migmatitic) Complex and the Rangeley Formation and with the Windham quadrangle containing the Berwick Formation with intrusives such as the Ayer Granodiorite. The large amounts of well data in these two quadrangles have provided an opportunity for modeling the effects of additional variables identified by using quadrangle-scale geologic mapping.

The first two phases of the project can be used to help identify potential high-yield bedrock areas. Locating a high-yield well, however, requires intercepting a fracture or fracture zone that could be a few feet wide or less. To address this problem, a third component of the project assessed the use of geophysical methods to identify bedrock-fracture zones. Seven surface-geophysical techniques were used to characterize the subsurface – seismic refraction, ground-penetrating radar, magnetics, very low frequency electromagnetics, inductive electromagnetic terrain conductivity, two-dimensional direct-current resistivity, and azimuthal square-array resistivity. The successful application of a particular geophysical technique was dependant on the geologic and cultural conditions at each site. Borehole-geophysical survey logs, including standard logs and optical televiewer, were collected at selected sites. Geophysical surveys were used to identify bedrock-fracture zones that correlated with lineaments or geologically mapped fractures at most of the sites investigated.

continued next column

The field trip will visit sites within the Pinardville and Windham quadrangles to demonstrate all three components of the project. The group will meet at 9 a.m. at the Macy's parking lot in Bedford, N.H., near the intersection of Routes 101 and 3. **Reservations are required.** Please RSVP by Monday, July 16, to John Noble, 226 Whitten Road, Milford, NH 03055, 978-452-6535 (w) or 603-673-3919 (h), e-mail: jnoble@secor.com. A box lunch can be provided for $7, make youre check payable to the NHGS.

News from the New Hampshire Board of Professional Geologists

Having held a public hearing on the Initial Proposal for its administrative rules, and having received feedback from the attorneys for the Joint Legislative Committee on Administrative Rules (JLCAR), the NH Board of Professional Geologists has prepared a Final Proposal for its administrative rules. The next step will likely involve a hearing before the JLCAR, which will then vote on the rules, hopefully passing them back to the Board for adoption. Once the rules are finally in place, we will begin processing applications for licensure. Over 375 requests for applications have been received so far! For further information contact Donna Lobdell, Administrative Secretary:

NH Joint Board of Licensure and Certification
57 Regional Drive
Concord, NH 03301-8518
Telephone: 603-271-2219
TDD Access: Relay NH 1-800-735-2964
Fax: 603-271-7928
email: dlobdell@nhsa.state.nh.us

The New Hampshire Geological Survey

David Wunsch, State Geologist

HB 245, the bill to statutorily establish a New Hampshire Geological Survey, has passed the Senate ED&A Committee as well as the full Senate. The bill now has to go through the enrollment process, and then all we need is for the lady in the red dress to sign this bill into law. With the Governor's signature, we will be on our way to a more organized and high profile geology program in New Hampshire. Thanks to all who have helped in moving this bill along to this point.

The text of the bill was published in the last issue of The Granite State Geologist. *For status information, lookup HB245 at http://www.gencourt.state.nh.us/ns/billstatus/quickbill.html*

New Hampshire Geological Society
PMB 133
26 South Main Street
Concord, NH 03301

NHGS News and Events

NHGS is planning a **Family Outing** to Odiorne State Park on August 18th. More details will be sent later in the summer.

The **Mount Washington Observatory** will sponsor a two-day workshop on the glacial geology of northern White Mountains, on October 13 & 14. The workshop will be lead by Woodrow Thompson of the Maine Geological Survey. For more information, check online at http://www.mountwashington.org/, or call 1-800-706-0432 or 603-356-2137.

The fall 2001 **New England Intercollegiate Geological Conference** will be held in New Brunswick, Canada, September 21-23. This will be the 100th meeting of the NEIGC! (http://neigc.org/NEIGC/2001/)

The **Capital Mineral Club's 38th Annual Gem & Mineral Festival** will take place on October 6 and 7, 2001, at Sunapee State Park, Rte. 103, Newbury, NH. For more information, try the web at www.capitalmineralclub.org

The Society's **2001 Annual Meeting** will be October 11, once again during Earth Science Week. Sam Adams is scheduled to speak on "Evolution and the Earth Scientist." More details in the fall issue of *The Granite State Geologist.*

Come One, Come All! on a Geo-Odyssey at the **Geological Society of America's 2001 Annual Meeting** in Boston, November 4-8. In addition to the Technical Program, Exhibits, Short Courses and Workshops, and Special Forums, there will be more than 25 interesting and diverse pre- and post- (and during-) meeting Field Trips (including several led by NHGS members!). For more information, go to: http://www.geosociety.org/meetings/2001/, call: (303) 447-2020 or 1-800-472-1988, Fax: 303-447-0648, or e-mail: meetings@geosociety.org The pre-registration deadline is September 28 (For those wishing to contribute to the meeting, the Abstract deadline is June 24).