Geologic Mapping of Lake Sunapee and Surrounding Area, New Hampshire

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Student: Destiny Saxon

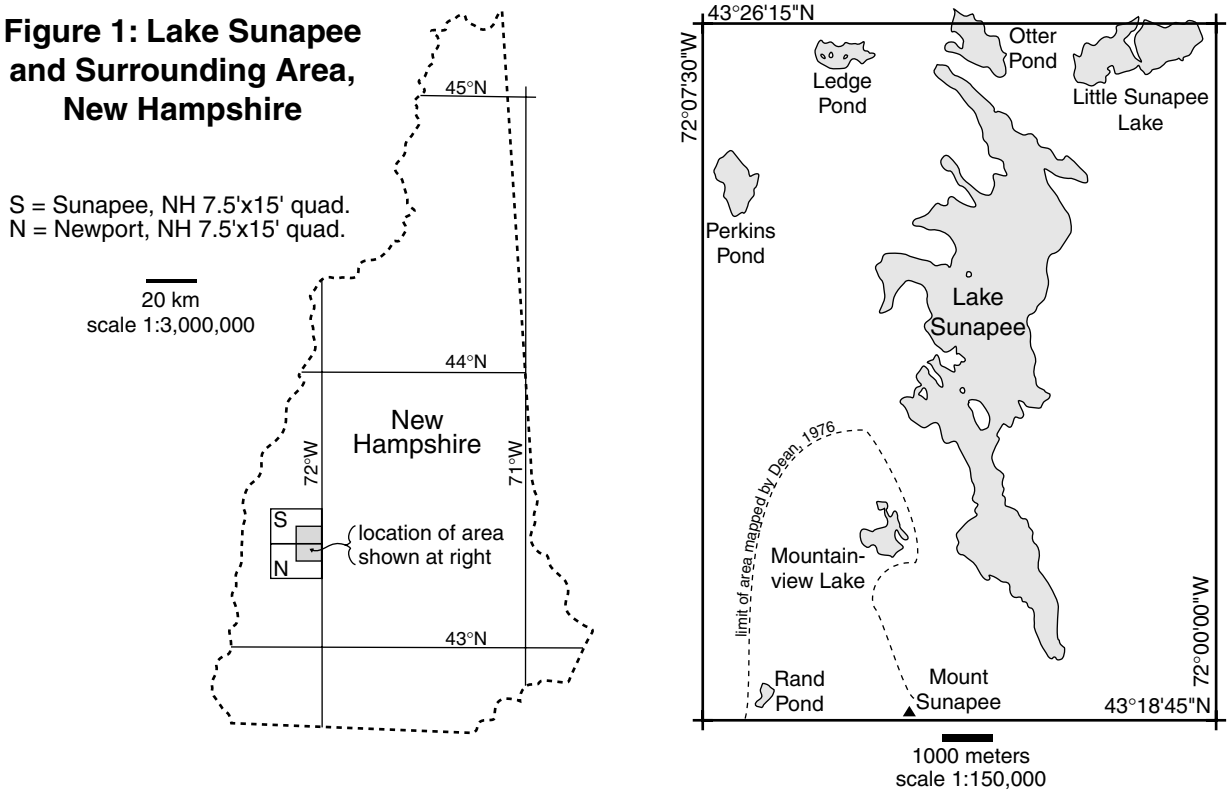
Introduction

In this application, we propose to prepare a detailed 1:24,000-scale geologic map of the area surrounding Lake Sunapee, New Hampshire (NH). Several important features of the Acadian orogen in NH come together in this area, including plutons associated with all four groups of the NH Plutonic Series (NHPS). It is our hope that detailed geologic mapping in this area may ultimately help improve our understanding of the relationships between structural development, magmatism and metamorphism during orogenic events. In addition, geologic mapping in this area has important application to understanding ground water hydrology and water quality. Because of the scenic nature of the Lake Sunapee area, it is expected that the results of this project may be of interest to the lay public, as well. Eugene Boudette, NH State Geologist, supports the proposed project as being in accord with research priorities for the state of NH. Publication of the resulting geologic map product as an open-file report by the NH Geological Survey would be considered on a funds-available basis.

Location and Previous Work

The area to be mapped constitutes the northeast one-quarter of the Newport, NH 7.5x15 quadrangle and the southeast one-quarter of the Sunapee, NH 7.5x15 quadrangle (Figure 1). This comprises an area equivalent to one 7.5x7.5 quadrangle, bounded by latitude 43°18'45"N to the south, latitude 43°26'15"N to the north, longitude 72°00'00"W to the east, and longitude 72°07'30"W to the west. The area encompasses the whole of Lake Sunapee.

Figure 1: Lake Sunapee and Surrounding Area, New Hampshire

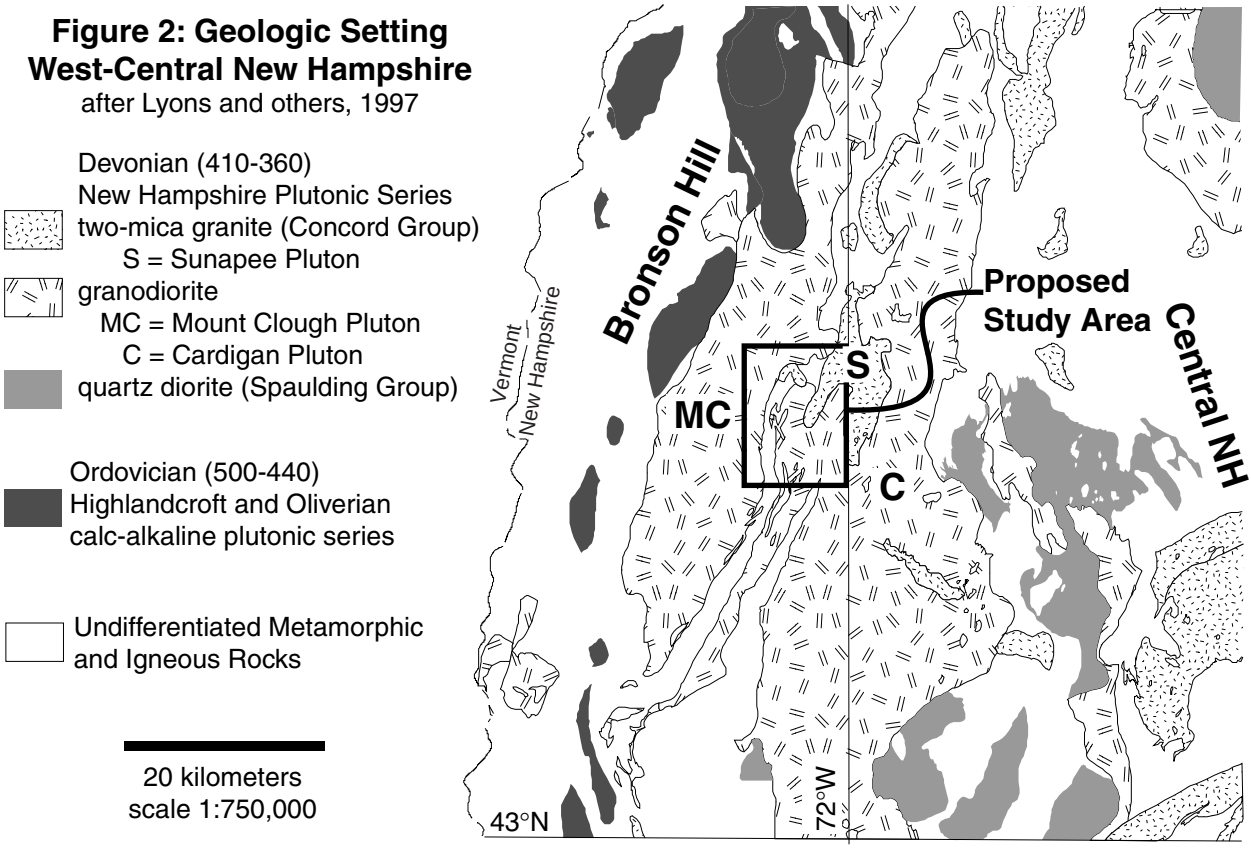


Existing geologic maps for the area outlined above are limited, and dated. Chapman (1952) prepared a 1:62,500-scale *Geologic Map and Structure Sections of the Sunapee Quadrangle, New Hampshire* (15 minute series). Dean (1976) prepared a 1:24,000-scale *Geologic Map of the "Sunapee Septum,"* a feature that extends across both the Sunapee and Lovewell Mountain, NH quadrangles (15 minute series), however Dean's map overlaps less than 1/4 of the project area (Figure 1). Thompson and others (1990), who prepared a 1:250,000-scale *Simplified Geologic Map of the Glens Falls 1°x2° Quadrangle, New York, Vermont and New Hampshire*, cite unpublished manuscript maps by C. P. Chamberlain covering the project area. Our preliminary work in this area suggests that in some cases the detailed geologic relationships are much more complicated than is shown on these existing maps.

General Geologic Setting

Allen (1997) summarized the regional geology of west-central NH. This geology includes (1) fold nappes which transported highly metamorphosed deep-basin sediments from the east towards the west over less-metamorphosed shelf sediments and volcanics, (2) a series of gneiss domes (Bronson Hill, Figure 2) which subsequently deformed (and metamorphosed) these nappes, and (3) large anatectic plutonic sheets (Mount Clough and Cardigan, Figure 2) of the NHPS, whose emplacement may have been intimately involved with the formation of the nappes.

Figure 2: Geologic Setting
West-Central New Hampshire
after Lyons and others, 1997



The Mount Clough and Cardigan plutonic sheets are both heterogeneous granitoids, being predominately granodiorite. Although they differ in texture and mineralogy, the rocks making up these plutons are chemically very similar (Billings & Wilson, 1964) and cannot be distinguished from one another on the basis of detailed isotopic studies (Lathrop et al., 1994, 1996). Thus it has been suggested that the magmas forming these plutons originated from the same parent material. The mineralogical differences may result from different metamorphic conditions during crystallization, or perhaps post-crystallization metamorphism (Chamberlain & Lyons, 1983). Lathrop and

others (1994, 1996) demonstrated that the magmas were formed by anatectic melting of the adjacent metamorphosed sedimentary rocks, with slight geochemical differences attributable to differences between the original deep-basin sediments to the east (central NH) and the shelf sediments and volcanics to the west (Bronson Hill). Differences in texture could be related to the degree to which the plutons were involved in nappe-stage deformation, the Mount Clough pluton being the further west and thus perhaps more closely involved with the west-vergent fold nappes (Allen, 1997). It is possible that the plutons may have at one time been connected, covering the entire area.

In the Sunapee area, the Mount Clough and Cardigan plutons are now separated by a narrow belt of metamorphosed sedimentary rock (Figure 2), known as the Sunapee Septum (Dean, 1976). The septum is truncated by the later Sunapee pluton (two-mica granite of the Concord Group, also part of the NHPS; Figure 2), which obscures relationships between the metasedimentary rocks to the north and south as well as obscuring relationships between the Mount Clough and Cardigan plutons. Also exposed in the area are quartz diorites of the Spaulding Group (also part of the NHPS), which along with rocks of the Concord Group, are found more extensively in central NH (Figure 2), where they may be associated with migmatite zones (Eusden, 1988; Allen, 1996) and are perhaps a key to understanding relationships between structural development, magmatism, and metamorphism in the mid-crust during the Acadian orogenic event.

Purpose and Justification

Among the interesting problems that persist: Were the Mount Clough and Cardigan plutons ever linked? Can textural differences be related to differing involvement in nappe-stage deformation? Structurally, what is the Sunapee Septum? Why does it exist, separating the Mount Clough and Cardigan plutons? Can relationships be established between the metasediments in the septum at Lake Sunapee and those to the north of the Sunapee pluton? Why do rocks of the Spaulding and Concord groups appear here? Can their occurrence be related to the structure of the septum? If so, does this help us further understand their importance in central NH? To begin to answer these questions, we propose to undertake a program of detailed geologic and structural mapping in the Lake Sunapee area.

Additionally, there is much interest in the bedrock aquifer system in NH. In particular, the bedrock aquifer of the Lake Sunapee watershed is likely important in the hydrology of the lake, the State's largest high-altitude lake. Our mapping will necessarily include study of joint and fracture systems, as they are important to addressing some of the structural problems raised above; they also control groundwater flow in the bedrock aquifer. The geology of the bedrock aquifer has important implications for ground water quality, as well. There are anecdotal reports of domestic water wells in the area with radon concentrations greater than 30,000 picocuries per liter!

Finally, there is likely much interest in the geology of this area among the lay public. The area's natural beauty attracts many tourists and summer (as well as year-round) residents, many of whom are interested in natural history. The project area overlaps much of Mount Sunapee State Park, as well as the John Hay National Wildlife Refuge.

Timetable and Strategy

We expect mapping of the entire project area to take two years to complete. For this first year, our focus will be on the area west of the Lake. Specific training for the student will begin in March, 2000, with a review of field mapping procedures she has learned previously, discussion of assigned background readings, and field-trips reviewing the regional geology (e.g., Allen, 1997) to orient the student to the area and the problem. Full-time field work by the student will begin in early July, 2000, and continue through the end of August, 2000, for a total of about 8 weeks in the field. The faculty advisor and student will work together for the first three weeks of the project, to provide the student with additional orientation and "on the job" training. Subsequently the student will work independently, but will get together with the faculty advisor at least once per week for field checks and review. Most of the work will be in the hills surrounding the Lake, although we do plan to spend several days investigating by

boat the geology of the Lake's shoreline and islands. For June and August, the faculty advisor will divide his time between this and other projects, but expects to undertake several additional weeks of his own independent mapping for the project. Compilation and drafting of the interim map from this first year, along with supporting investigations, will be completed during the Fall 2000 semester, during which time the student will receive academic credit for an "independent study project." We will attempt to arrange a field trip in early August to review progress on the project with the State Geologist, available USGS personnel working in the region, and other interested academic geologists.

Support Investigations

Rock samples will be collected and sectioned for petrographic analysis and description. Standard stereographic projection techniques will be used in the analysis and interpretation of structural orientation data. Additional petrologic, geochemical, isotopic, or geochronologic analyses or geophysical investigations are not anticipated in this first year of the project.

Deliverables

An interim 1:24,000-scale *Bedrock Geologic Map of Lake Sunapee and Surrounding Area* (see Figure 1) with accompanying structure sections and geologic report will be delivered by December 31, 2000.

Project Personnel

Student: Destiny Saxon is a senior Geology and Environmental Studies major at Keene State College, from Essex Junction, Vermont. Relevant courses that she will have completed (through the Spring 2000 semester) include: Structural Geology, Mineralogy, and Igneous and Metamorphic Petrology, Environmental Geology (with field-based laboratory) and Geographic Information Systems. In addition, Destiny has participated in extended (two-week) G.E.O.D.E.S. (student geology club) field trips to Wyoming and South Dakota (May 1998) and to western Maryland, West Virginia and Virginia (May 1999). Destiny was involved in a small mapping project on West Hill in Keene, NH, as part of the Structural Geology course she took, as well as a mapping traverse in the Smoke Hole region of West Virginia, on the G.E.O.D.E.S. 1999 spring trip. Additionally, Destiny is a certified scuba diver should under-water mapping in the Lake be warranted.

Faculty Advisor: Timothy T. Allen, Associate Professor of Geology and Environmental Studies, Mailstop 2001, Keene State College, Keene, NH 03435-2001; 603-358-2571; tallen@keene.edu. Tim's previous geologic mapping experience includes preliminary work in the map area of this proposal; mapping in the Carter Dome, NH and Wild River, NH-ME 7.5' quadrangles and adjacent areas of the White Mountains, NH, 1990-1994 (Allen, 1992; Allen, 1996); grid-scale mapping for a mineral resource exploration project in Pittsburg, NH, for Kennecott Exploration, Inc., 1989; reconnaissance-level mapping in the Karakorum Mountains of northern Pakistan, 1987 & 1988 (Allen & Chamberlain, 1991); and detailed mapping on Fall Mountain in the Bellows Falls, NH-VT, quadrangle, 1983 (Allen, 1984), in addition to mapping experience as a student at field camp in Wyoming, 1983. Relevant teaching experience includes Structural Geology with a field geologic mapping component, taught in spring 1999; Environmental Geology with a field-based laboratory, taught every fall semester; and supervision of student mapping projects, including Don Lance in the White Mountains, 1994, and Dina Andretta in the Lake Sunapee area, 1999. In addition, Tim has helped lead students on small mapping exercises incorporated into our annual G.E.O.D.E.S. extended field trips every May. Tim also teaches courses in Introductory Physical Geology, Hydrogeology, and Geochemistry on a regular basis.

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