Geologic Mapping of Lake Sunapee and Surrounding Area, New Hampshire

Principal Investigator & Faculty Advisor: Timothy T. Allen, Keene State College, Keene, NH 03435-2001

Student: Christina Burt

Introduction

Several important features of the Acadian orogen in NH come together in the area surrounding Lake Sunapee, New Hampshire (NH; Figure 1), 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 and after 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.

Mapping on the western side of the lake (Figure 1) by the Principal Investigator and his undergraduate student, Destiny Saxon, during the summer of 2000 (supported by EDMAP 2000) suggests that brittle structures may be more important to interpreting the geology of this area than previously thought. In addition, a variety of cross-cutting relationships and igneous textures suggest an important role for the intrusion of magmas associated with the Spaulding Group of the NHPS. The preparation of an interim map from this work is still in progress. In this application, we propose to complete detailed 1:24,000-scale geologic mapping of the area. Dr. David Wunsch, NH State Geologist, supports the proposed project as being in accord with

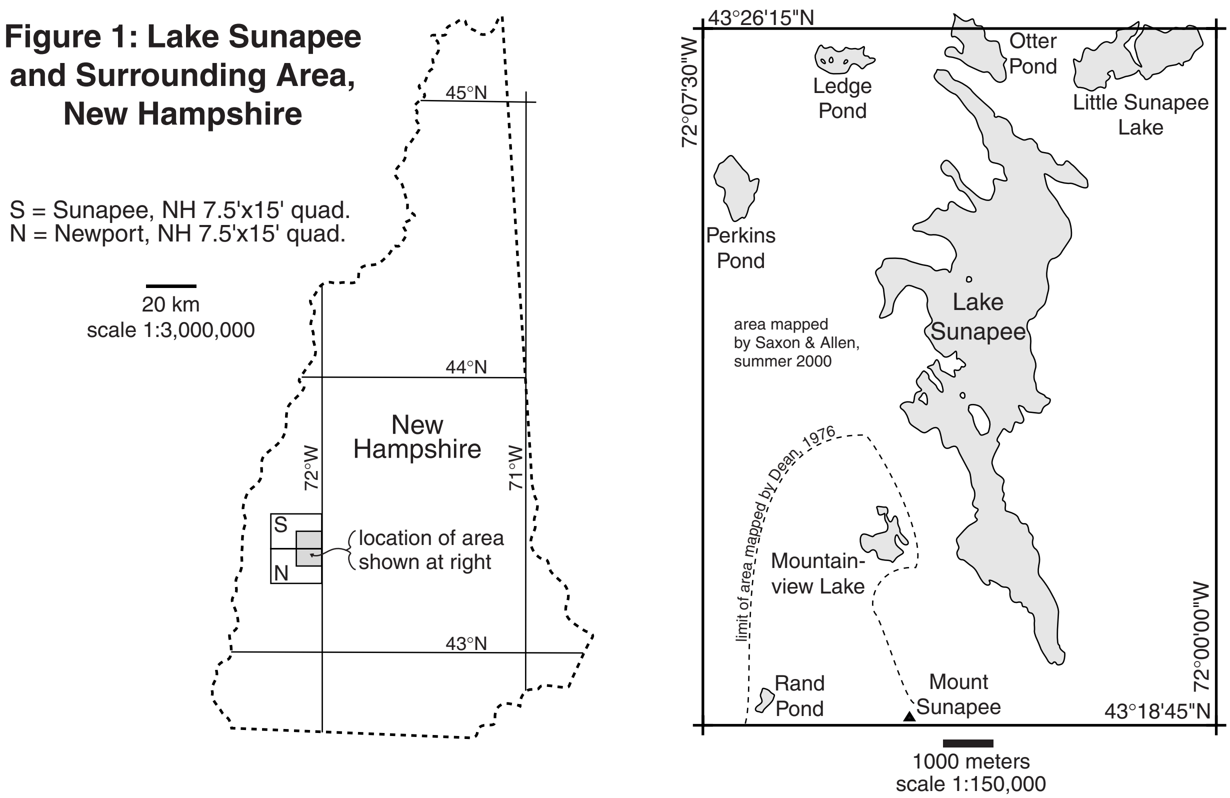


Figure 1: Lake Sunapee and Surrounding Area, New Hampshire

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 7.5′x15′ quadrangle and the southeast one-quarter of the Sunapee, NH 7.5′x15′ quadrangle (Figure 1). This comprises an area equivalent to one 7.5′x7.5′ 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.

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.

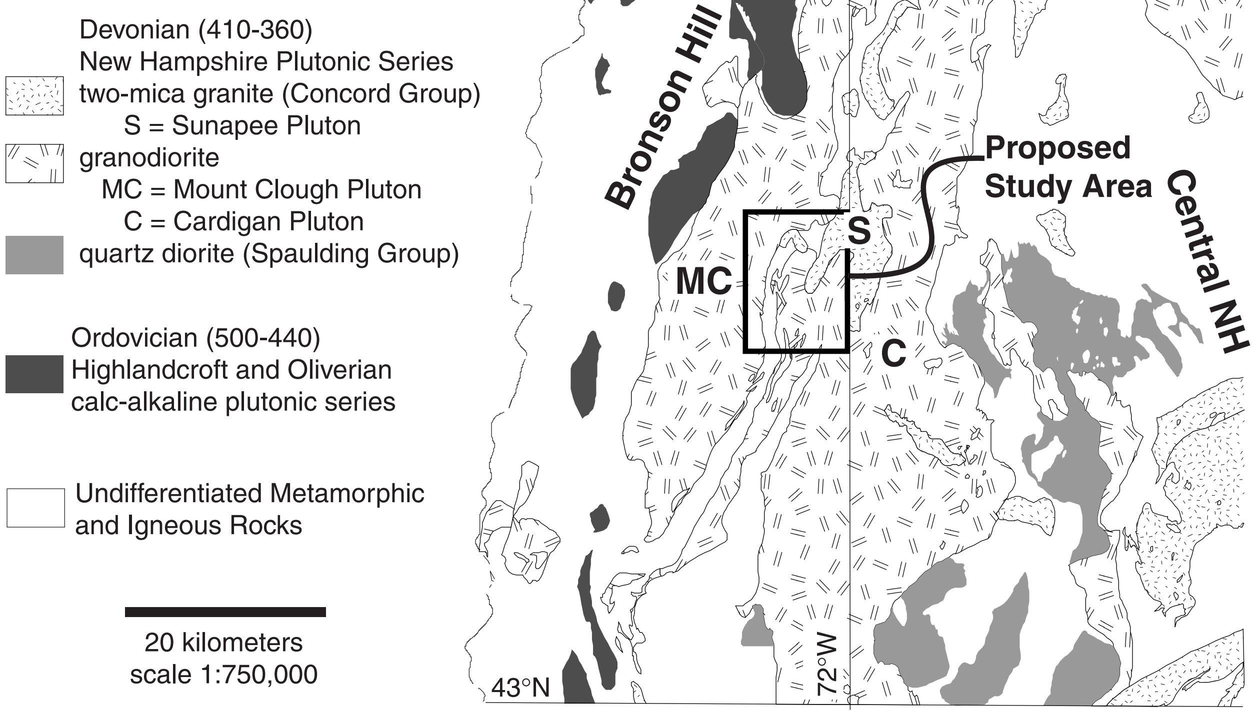
General Geologic Setting

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.

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

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



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 occurring along the septum 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: Can textural differences in the Mount Clough and Cardigan plutons be related to differing involvement in nappe-stage deformation? Structurally, what is the Sunapee Septum and why does it exist, separating the Mount Clough and Cardigan plutons? What is the significance of brittle faulting here? Why do rocks of the Spaulding and Concord groups appear here, isolated from their main occurrences in central NH? Can their occurrence be related to the structures of the septum? If so, does this help us further understand their importance in central NH, and thus the relationships between structural development, magmatism and metamorphism during orogenic events? To begin to answer these questions, we propose to continue 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

The proposed mapping will be the second full year of work in the area. For the first year, we focussed on the area west of the Lake (Figure 1); this year we propose to map the area east of the Lake and fill in additional detail in the area to the west. A new undergraduate student, Christina Burt, will be involved in the project this year, as the student involved last year, Destiny Saxon, will soon graduate.

Specific training for the student will begin in March, 2001. We will review of field mapping procedures, discuss background readings, and take field-trips reviewing the regional geology (e.g., Allen, 1997; Lyons, 1988) to further orient the student to the area and the problem (she is already involved in geochemical research on rocks from the area, in collaboration with Destiny Saxon, through a class project in our Geochemistry course). Full-time field work by the student will begin in Late May or early June, 2001, and continue through the end of August, 2001, for a total of 12 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 about once a week for field checks and review. Most of the work will be in the hills surrounding the Lake, although we do plan to spend one day investigating by boat the geology of the Lake's shoreline and islands. For July and August, the faculty advisor will divide his time between this and other projects. Compilation and drafting of the geologic map for the entire area, along with supporting investigations, will be completed during the Fall 2001 and Spring 2002 semesters, during which time the student will receive academic credit for an "independent study project." We will attempt to arrange a field trip in July or August 2001 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 as a necessary part of the mapping project, but may be carried out independently.

Deliverables

A 1:24,000-scale *Bedrock Geologic Map of Lake Sunapee and Surrounding Area* (Figure 1) with accompanying structure sections and geologic report will be delivered by May 17, 2002.

Project Personnel

Student: Christina Burt is a senior Geology major at Keene State College, from Plainfield, New Hampshire. Relevant courses that she will have completed (through the Spring 2000 semester) include: Structural Geology, Mineralogy, Igneous and Metamorphic Petrology, Environmental Geology (with field-based laboratory), and Geographic Information Systems, and Geochemistry (in which she is currently involved in a geochemical study of rocks from the proposed map area). As an international exchange student, Christina studied geology for the 1998-1999 academic year at Oxford Brookes University in the United Kingdom. In addition, Christina has participated in extended (two-week) G.E.O.D.E.S. (student geology club) field trips to Pennsylvania (May 1997), Wyoming and South Dakota (May 1998), western Maryland, West Virginia and Virginia (May 1999), and the Adirondacks and Ontario (May 2000). Christina participated in small-scale mapping projects on some of these trips, notably in the Smoke Hole region of West Virginia, on the G.E.O.D.E.S. 1999 spring trip.

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 previous work in the map area of this proposal, as supported by EDMAP 2000; 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 Destiny Saxon in the Lake Sunapee area, 2000. 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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